Coping with uncertainties
A multi case study on policies within ITS projects

R.E. Houthoff
Coping with uncertainties

A multi case study on policies within ITS project

By

R.E. (Romke) Houthoff
Student number: 4002393
romke.hout@gmail.com

in partial fulfilment of the requirements for the degree of

Master of Science
in Management of Technology

Delft University of Technology
Faculty of Technology, Policy and Management

Project Thesis
Chair Prof. dr. ir. J. van den Hoven (TU Delft, TPM, FIL)
First supervisor dr. ir. U. Pesch (TU Delft, TPM, FIL)
Second supervisor dr. ir. J.A. Annema (TU Delft, TPM, TLO)

Date 16 August 2017
Executive summary

Every year new Intelligent Transportation System (ITS) projects are initiated by governmental institutes. The Dutch government - for example - recently invested € 70 million to look for technological opportunities in the ITS market. However, although significant sums are invested, the return in realized projects is limited. This is because the ITS projects don’t produce adequate results.

But what causes these inadequate results? The literature implies that, along the process of ITS-projects, a number of challenging issues tend to surface. Policymakers seemingly do not know how to cope with these issues. Examples of these issues are amongst others: (1) uncertainty about the technological performance of the system, (2) an unclear vision of the potential of the system in the market, and (3) potential hurdles in the collaboration process between relevant project stakeholders.

These indications show that ITS projects are subject to a considerable degree of uncertainty. More knowledge about uncertainties looming up during ITS projects, and information of adequate reactions for policymakers on this phenomenon can be of great help to produce more satisfactory project results. Hence, this thesis explores the different types of uncertainties and subsequently aims in providing insights in how policymakers can cope more effectively with these different types of uncertainties.

This thesis starts with the examination of three correlated factors, namely 1) the number and types of uncertainties emerging in ITS projects, 2) the extent of awareness of policymakers on these uncertainties, and 3) the way policymakers tend to act in the face of uncertainties.

By means of three ex-post case studies, insights were obtained on these factors. After analysing these three cases, thirteen different uncertainties were identified and distinguished. The policymakers in these ITS-projects were only partly aware of those uncertainties. I analysed five situations of uncertainty ‘unawareness’. From those five ‘unawareness’ factors, four had an impact on the outcome of the project. This emphasizes the importance of awareness among policymakers of the different types of uncertainty.

In addition, based on policy guidelines supplied by the literature, I evaluated the way policymakers acted when coming across uncertainties. This evaluation showed that policymakers didn’t follow adequate strategies to cope with the different values of uncertainties. Even worse, more than once uncertainties were deliberately ignored. Policymakers tend not to know how to deal with uncertainties in ITS projects and to ignore them.

When policymakers do not ignore uncertainties, they tend to follow strategies and policies that are inadequate to cope with the different types of uncertainties. When comparing the findings of these three case studies with the suggestions made by the literature, we deduce that there is a lack of knowledge on ITS-project policymakers can act effectively when coming across
uncertainties. My case studies support the suggestions of the literature that policymakers do not know how to cope effectively with uncertainties in ITS projects.

The conclusion of this thesis entails, that knowledge and awareness amongst ITS policymakers of the different uncertainties would be a first step in the direction towards more robust policymaking. In addition, policymakers should adopt more active strategies in anticipation of the different types of uncertainties. When coming across an uncertainty during the project, the selection of an appropriate strategy should be based on the type, and the extent of complexity within the uncertainty. The same accounts for policies. Based on a theoretical framework of uncertainties, policymakers should adopt a more appropriate policy in order to cope with them.

**Keywords:** policymakers, uncertainty, policies, strategies, intelligent transportation systems, unawareness, ITS, case study
Preface

This is the graduation thesis for my university degree of Management of Technology (MOT), a master programme provided by the faculty of Technology, Policy and Management (TPM) at the Technical University of Delft. In this master programme, students have to investigate the impact of current and future technological, economic and social developments on the market. In the MOT programme, I specialised in Infrastructure and Environmental Governance (IEG).

In this thesis, I chose to do research on uncertainties in the development and implementation process of emerging and innovative infrastructure systems. My rationale to do so, is that there is a high need for improving traffic flow and traffic safety. Intelligent Transport Systems aim at improving those traffic issues. Yet, ITS-technologies have not been effectively implemented into the market. A few articles clarified where a key problem might be in this area of expertise. The key problem is determined to be ineffective uncertainty management. Sometimes uncertainty factors are not identified by policymakers, or – if they are identified – policymakers do not know how to cope with them effectively.

From a more personal viewpoint it as well an interesting topic. I experience uncertainties every day. It is on a daily basis that I make wrong decisions because of erroneous assumptions, or even ignore the problem in its entirety. Everyone around me often makes the same mistakes when dealing with uncertainties. Because of these personal experiences, in combination with my fascination for transport and infrastructure, I combined the two into my research.

My research was partially executed at the TU Delft and partly at the Advanced Metropolitan Solutions Institute (AMS). The AMS provided me with a very useful set of tools and the network at their disposal. I have gratefully made use of the AMS network, and explicitly want to thank Tom Kuipers for that. With that network and the network from the TU-Delft I was able to contact a variety of professionals. All of them are well known with one of the three expertise that related to my research, namely ITS, uncertainties and policies. All of them helped me to get a better understanding of the complications that arose during ITS projects.

So here I want to thank all who were willing to share their insights and experiences with me for my research. Especially the professionals from Rijkswaterstaat, Dynniq, Gemeente Amsterdam, Connecting Mobility, Praktijkproef Amsterdam, BeterBenutten, AMS, TU-Delft and DTV Consultants. More specifically I want to thank dr. ir. Udo Pesch for mentoring and advising me during the graduation period. Without him I would probably have lost myself in this research. He helped me to shape my research and demarcate the research coverage. Also, I want to thank both prof. dr. ir. Jeroen van den Hoven and dr. ir. Jan-Anne Annema for their advice and input during the meetings that we scheduled along the road.

All in all, I found it was a very interesting and fruitful experience. It was intriguing and I am grateful to have had this opportunity.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS</td>
<td>Advanced Metropolitan Solutions Institute, a knowledge institute.</td>
</tr>
<tr>
<td>AM</td>
<td>Amsterdam Mobiel, a consortium consisting of institutes Arcadis and VID.</td>
</tr>
<tr>
<td>AO</td>
<td>Amsterdam Onderweg, a consortium consisting of institutes TNO, TU-Delft and ARS.</td>
</tr>
<tr>
<td>Apps</td>
<td>Applications for the mobile phone</td>
</tr>
<tr>
<td>ATMS</td>
<td>ITS typology; stands for Advanced Transportation Management Systems</td>
</tr>
<tr>
<td>DA</td>
<td>Decision Analysis, expected-outcomes approach to deal with a level 2 uncertainty.</td>
</tr>
<tr>
<td>DAP</td>
<td>Dynamic Adaptive Policy approach, which deals with the level 5 uncertainty.</td>
</tr>
<tr>
<td>EMA</td>
<td>Exploratory Modelling and Analysis approach. A policy to deal with uncertainties.</td>
</tr>
<tr>
<td>IEG</td>
<td>Infrastructure and Environmental Governance, a master specialization programme.</td>
</tr>
<tr>
<td>I&amp;M</td>
<td>The Dutch ministry of Infrastructure and the Environment.</td>
</tr>
<tr>
<td>MOT</td>
<td>Management of Technology, a master programme.</td>
</tr>
<tr>
<td>OTTR</td>
<td>Observe, Think, Test, Revise. A key data collection and analysis concept (GAO, 1990)</td>
</tr>
<tr>
<td>PCP</td>
<td>Pre-Commercial Procurement, a procedure where competitive parties collaborate.</td>
</tr>
<tr>
<td>PESTLE</td>
<td>tool for analysing Political, Economic, Social, Technical, Legal, and Environmental challenges in the development process of new technologies (Zalengera et al., 2014).</td>
</tr>
<tr>
<td>ROA</td>
<td>Real Options Analysis, expected-outcomes approach to deal with a level 2 uncertainty.</td>
</tr>
<tr>
<td>RWS</td>
<td>Rijkswaterstaat, agency from the Dutch ministry of Infrastructure and the Environment.</td>
</tr>
<tr>
<td>SF</td>
<td>Spookfiles A58, a Dutch ITS project (about shockwave traffic jams) on the A58 highway.</td>
</tr>
<tr>
<td>TNO</td>
<td>Dutch research institute within the applied scientific domain</td>
</tr>
<tr>
<td>TPM</td>
<td>The faculty of Technology, Policy and Management.</td>
</tr>
<tr>
<td>TU Delft</td>
<td>University of Technology in Delft.</td>
</tr>
</tbody>
</table>
Contents

Executive summary ........................................................................................................................................ 4
Preface ......................................................................................................................................................... 6
Abbreviations .............................................................................................................................................. 7
1 Introduction ............................................................................................................................................... 10
  1.1 Research problem .......................................................................................................................... 11
  1.2 Research question, main questions and sub-questions ................................................................. 13
  1.3 Research specifics ......................................................................................................................... 15
  1.4 Defining research scope .............................................................................................................. 17
  1.5 Outline of thesis .......................................................................................................................... 18
2 Methodology ........................................................................................................................................... 19
  2.1 Research approach ...................................................................................................................... 19
  2.2 Research methods ....................................................................................................................... 21
    2.2.1 Literature study .................................................................................................................... 21
    2.2.2 Case study .......................................................................................................................... 21
    2.2.3 Semi-structured interviews ................................................................................................. 23
  2.3 Data gathering ................................................................................................................................ 24
3 Theoretical Framework .......................................................................................................................... 26
  3.1 Uncertainty ....................................................................................................................................... 26
  3.2 Intelligent Transport Systems ........................................................................................................ 29
4 Strategies and policies for uncertainty .................................................................................................. 31
  4.1 The importance of dealing with uncertainties .............................................................................. 31
  4.2 Strategies ........................................................................................................................................ 32
  4.3 Policies in the face of uncertainty .................................................................................................. 33
  4.4 Problems and probable correlated uncertainties in ITS projects .............................................. 35
5 Case study: Dynamax .............................................................................................................................. 39
  5.1 Case description ............................................................................................................................ 39
  5.2 Uncertainty assessment ................................................................................................................. 43
  5.3 Uncertainty Valuation .................................................................................................................... 46
  5.4 Uncertainty influence on out roll .................................................................................................. 48
  5.5 Strategy assessment ...................................................................................................................... 49
  5.6 Policies assessment ....................................................................................................................... 51
6 Case study: PPA In-Car .......................................................................................................................... 53
  6.1 Background information on Praktijkproef Amsterdam .................................................................. 53
    6.1.1 PPA phase 1 ......................................................................................................................... 54
    6.1.2 PPA phase 2 ......................................................................................................................... 54
    6.1.3 PPA phase 3 ......................................................................................................................... 54
  6.2 Case description ............................................................................................................................. 55
  6.3 Uncertainty assessment .................................................................................................................. 58

Pg. 8
6.4 Uncertainty Valuation ................................................................. 61
6.5 Uncertainty influence on out roll .................................................. 63
6.6 Strategy assessment .................................................................. 65
6.7 Policies assessment ................................................................. 67
7 Case study: Spookfiles A58 .............................................................. 69
7.1 Case description ......................................................................... 69
7.2 Uncertainty assessment .............................................................. 73
7.3 Uncertainty Valuation ............................................................... 76
7.4 Uncertainty influence on out roll .................................................. 79
7.5 Strategy assessment .................................................................. 81
7.6 Policies assessment ................................................................. 84
8 Comparative Analysis .................................................................. 86
8.1 General project characteristics ..................................................... 86
8.1.1 Project locations .................................................................... 87
8.1.2 Project period ......................................................................... 87
8.1.3 Project actors ......................................................................... 87
8.1.4 Project ITS types .................................................................... 89
8.2 Comparison of identified uncertainties ........................................... 90
8.2.1 New identified uncertainties ...................................................... 90
8.2.2 Level uncertainty .................................................................... 90
8.2.3 Uncertainty impact on out roll .................................................. 91
8.3 Uncertainty strategies ............................................................... 93
8.3.1 Uncertainty unawareness ......................................................... 93
8.3.2 Ignoring uncertainties ............................................................ 93
8.3.3 Active uncertainty strategies ................................................... 94
8.4 Implemented policies ............................................................... 97
9 Conclusion and reflection .............................................................. 99
9.1 Conclusion ................................................................................. 99
9.2 Additional findings ................................................................. 103
9.3 Recommendations for additional actors ...................................... 104
9.4 Reflection .................................................................................. 105
9.5 Recommendations for further research ...................................... 106
10 References ................................................................................ 107
11 Appendices .............................................................................. 112
11.1 Appendix 1 ............................................................................ 112
11.2 Appendix 2 ............................................................................ 113
11.3 Appendix 3 ............................................................................ 114
11.4 Appendix 7 ............................................................................ 115
1 Introduction

Traffic is all around us. And ever since the diversification of traffic modes, like the introduction of, amongst others, cars, buses and trams, participation in traffic became a rather dangerous activity. Because of a lack in regulation, traffic was extremely unsafe and many accidents occurred. To improve the safety in the transportation network, authorities introduced a multitude of systems to manage and regulate traffic. Currently many of these former and outdated traffic systems are still being used intensively. Yet, there are significantly more vehicles on the road and there is a high demand to regulate and manage traffic in a more efficient way.

Many efforts have been made to improve traffic flow from a rather abstract perspective. For example; traffic lights are set onto morning, afternoon and evening scenarios; freeway ramp metering lights dose the number of vehicles that accede to the freeway; camera’s monitor vehicles on speed to ensure the safety of road users. All these systems are relatively passive in managing traffic as most of the systems are controlled top down by the road authorities basing the system on average daily scenarios. But with the growing number of traffic jams occurring, the need for improvement in traffic management grew. Investments are made into interactive technologies showing promising results. New systems have been recently introduced into the market, which try to adapt to real time traffic situations, aiming to regulate traffic based on data input. These systems are called Intelligent Transport Systems or ITS.

With new technological innovations and with the abundance of data at our disposal a lot of opportunities present itself to develop ITS. However, a complication has arisen in the development and implementation process of ITS. According to available literature, ITS have not yet penetrated the market as effectively as predicted. The key issue that is considered crucial in the effectiveness of ITS market implementation, is the way that policymakers cope with a multitude of uncertainties. These uncertainties relate to, amongst others, technological performance, the effectivity of a business model, or the scalability of ITS. Literature suggests that policymakers in ITS projects do not effectively deal with those uncertainties. This research aims at identifying the different types of uncertainties and subsequently accommodate strategies and policies to effectively cope with them. This is done by means of evaluating and analysing historical data, extracted from ex-post ITS projects, interviews and a literature study.

The structure of this chapter will be as follows; first the research problem will be elucidated. In this section, the emphasis is put on problem exploration. In the next paragraph, the research question and related sub-questions will be set up. Then the research approach will be determined. The next section discusses opportunities to gather useful and recent data from firms, active in the ITS market. In the final paragraph, an overview will be given on the structure of the thesis.
1.1 Research problem

This paragraph will define aspects related to the research problem. To begin with the problem will be identified and explored. The key of this section is to explicitly identify the problem and elaborate on what factors are correlated to the problem. As Russel Ackoff once said; “we fail more often because we solve the wrong problem than because we get the wrong solution to the right problem” (1974). Ackoff therefore acknowledges the importance of identifying the right problem before looking for a solution. The subject of this thesis relates to Intelligent Transport Systems (ITS).

Governments worldwide are investing an estimated total of 2.7 trillion dollars per year in infrastructure (Mooren, Hardy, Cutts, Learmouth, & Rawlinson, 2016). Most of the budget is invested in roadway maintenance and the construction of new infrastructure. The remaining budget is invested in innovative technological projects to improve the safety, durability and efficiency in traffic and mobility. These projects are often referred to as ITS projects. Governmental organisations are increasingly aware of the high potential of ITS to mitigate the problems related to traffic jams in metropolitan areas (Giannoutakis & Li, 2012). Countries with strong economies are rapidly increasing their investments in ITS projects. The Dutch government, for example, is intensively investing in different types of ITS related projects (Bevers, 2016; Rijkswaterstaat, 2016a, 2016e). For the years 2016 – 2018, a budget of €70 million is made available to be invested in new ITS projects (Government of the Netherlands, 2015).

ITS can be defined as “… electronics, communication, or information technology, used singly or in combination, to improve the efficiency or safety of the surface transportation system” (Caltrans, 2010). These systems include for example smart traffic lights, which, by means of so-called real-time data, regulate and manage traffic in a safer, and more efficient way. Another example is traffic navigation systems. By supplying the driver with current data of local traffic situations and adjusting the route based on those situations, the system aims at improving the local traffic flow.

But “despite the significant potential benefits from ITS and the heavy investments by the public and private sectors in R&D projects and pilot studies since the 1980s, the market for ITS has so far failed to develop as predicted” (Giannoutakis & Li, 2012). The literature confirms this statement as it is considered that ITS related projects have a significantly higher rate of failure than traditional technological development projects (Caltrans, 2010; Ezell, 2010; Kulmala, Mans, El-Araby, & Penttininen, 2013).

According to, amongst others, Caltrans (2010) the reason is that the implementation and management process for ITS projects is different in a few critical ways. These differences are due to the multitude of challenges that relate to the development and deployment of intelligent transport systems (Ezell, 2010). Those key challenges consider, inter-alia, high investment costs and a number of uncertainty conditions (Van Geenhuizen & Thissen, 2007). These “uncertainty conditions” relate to a multitude of aspects. For instance, there are uncertainties from a technological perspective. Does it work as promised? Does it meet the expectations of stakeholders? Other uncertainties are related to the market. Question that might arise are, for example, whether the target market is willing to adopt/buy the technology and make use of it? Or, from a long-term perspective, uncertainties can correlate to the financial feasibility and
sustainability of a project, since it often depends on the technological performances (which is again another aspect of uncertainty). Van Geenhuizen and Thissen (2007) therefore discusses in their article the importance of dealing with uncertainties in ITS projects. Most governmental institutes that initiate ITS projects have been very reluctant in dealing with uncertainties, as they implement a “do nothing” strategy when uncertainties are identified (Van Geenhuizen & Thissen, 2007). And if policymakers undertake steps in order to effectively deal with uncertainties in ITS projects, they choose for traditional methods which are often deemed obsolete (van der Pas, Agusdinata, Walker, & Marchau, 2006). Instead, van der Pas et al. (2006) substantiates the importance to look for new approaches that deal with uncertainties as an opportunity instead of a threat (van der Pas et al., 2006).

In accordance with the information, I define the research problem as follows:

1) Uncertainties impede the ITS development process.
2) Project managers of ITS project are not aware of uncertainties or do not know how to effectively cope with them.

In the next chapters, I further elaborate on the related aspects. Hence, first a literature study will be executed in order to accurately define uncertainty and typify the different uncertainties according to available literature. Subsequently a similar process will be initiated for ITS, where first an explicit definition will be set up about what is meant with ITS in this report, to subsequently demarcate the different types of ITS. Next, I will look at a few ex-post projects and analyze those thoroughly. The findings from that analysis, in combination with the extracted data from the literature study, will be substantiated in a selected, concurrent business case. By means of interviews, the findings will then be validated accordingly.

In the rest of this chapter I will set up a research question and related sub questions to clarify the goals of this thesis. Subsequently a discussion will be set up on the relevance of the chosen subject, the objectives of this research and the expected deliverables. Furthermore, a research scope will be specified to accurately demarcate the extent of this research. This chapter will be concluded with a short elaboration on the outline of the thesis.
1.2 Research question, main questions and sub-questions

In accordance with the more generic aspects of a thesis, a research question indicates what the direction of the included research will be about. This paragraph will focus on that aspect. The research question will be divided into three main questions which will be used as guiding questions. The research question will be the central question of this thesis. This research question follows from the findings of the previous paragraph. The research question is:

“How can policymakers more effectively cope with uncertainties that emerge during ITS projects?”

To give structure to way in which the research question will be answered, three correlated main questions have been set up. The three different, yet correlated main questions are:

1. “What types of uncertainties can be distinguished during the process of ITS projects?”
2. “Are policymakers of ITS projects aware of the different types of uncertainties?”

The conclusion of this thesis will provide the answer to the research question and correlated main question. Yet, in order to give answer to these questions, some sub-questions have been set up to, in an organized manner, gather information on the different relevant topics. These sub-questions will be answered within the chapters that follow hereafter.

The sub-questions are as follows;

a. What is meant with ‘ITS’ and ‘uncertainty’ within the context of this thesis?
b. According to the literature, what strategies and policies are deemed most effective in dealing with the different types of uncertainties?
c. How have policymakers tried to deal with uncertainties in ITS projects?
d. To what extent do uncertainties have an influence on the potential of developed ITS?

In the first sub question, I aim to define what is meant with uncertainty and distinguish the different types of uncertainty. The same process will be initiated for ITS. This is fundamental to avoid unclarity. And it will help to qualify and categorize the different types of uncertainties and ITS in the following parts of this thesis. Therefore, the first sub-question is seen as a more explorative question towards setting up a theoretical framework of this thesis.

With the second sub question, the focus is on identifying strategies and policies that deal with uncertainties in ITS projects. By means of a literature study I distinguish the different types of strategy. Next different policies will be analysed. Those policies will be valued in terms of effectiveness in the light of uncertainties. The aim is to become aware of the different strategies and policies that are at the disposal of policymakers when dealing with uncertainties. Additionally, it will help identify the strategies and policies that are implemented in the ITS case studies that will follow. Aiming to set up a more adequate theoretical framework for this thesis.
The third sub question will focus on uncertainties in ex-post ITS projects. A selection will be made of ex-post ITS projects for an in-depth analysis on uncertainties in ITS projects. After selecting the projects, an assessment will be done to identify and distinguish different types of uncertainties. I will then analyse how policymakers in the selected cases have tried to deal with the uncertainties. Defining their actions, their motives to do so, and how those actions have influenced the potential of an ITS project. This is to further explore the ITS market and the way the projects are influenced by uncertainties.

In the final sub question, we will further build on the findings from the previous questions. Since it is essential in the case studies to determine the extent of effectiveness of policies in ITS projects, first an assessment will be made on this aspect. It is therefore crucial to first analyse the key components from which the uncertainties originated, to subsequently determine to what extent the different identified uncertainties had an influence on the potential of the developed ITS.
1.3 Research specifics

In this section, I will discuss the relevance of the research and the need to assess it. This will be done from a societal, scientific and study-related perspective. Consequently, the research objectives are constructed.

Societal and scientific specifics

The scientific relevance for the proposed research originate from the earlier elaborated problems of ITS projects not effectively being implemented into the market (Ezell, 2010) (Caltrans, 2010). Which is why there is a certain urgency to improve effectiveness of ITS projects (van der Pas et al., 2006). But, to improve on the effectiveness of these ITS projects, there is a need to create a better understanding of the project process and what drives policymakers to make certain decisions. This is needed to create a more transparent picture of the decision-making process. By then creating awareness with policymakers on the effectiveness of implemented policies and strategies, it might help policymakers to cope with uncertainties in ITS projects more effectively in the future. This way the proposed research will try to improve the future potential of ITS projects.

The correlated scientific deliverable is (1) to give insight in uncertainties in ITS and (2) to come up with propositions to deal with those uncertainties. Since the scope of the intended research is only directed to ITS in the Netherlands, the results cannot be generalized for other countries. The technological, environmental and cultural differences in other countries may be significantly different. Therefore, results of similar research might be completely different in other countries.

From a societal perspective, the research goal is relevant from a monetary point of view. Governments spend a lot of money on ITS projects (Staley, 2009). As earlier indicated, the Dutch government has invested 70 million euros into ITS projects from 2016 till 2018 (Government of the Netherlands, 2015). It is a waste of money and time if those projects aren’t executed to its full potential.

The societal deliverable is therefore to stimulate governmental agencies to implement a more successful policy to deal with uncertainty in ITS projects. Similar to the scientific deliverable the results will mainly relate to ITS projects in the Netherlands since the scope of the intended research is only directed to ITS projects in the Netherlands. The results may not be generalized for other countries, since the technological, environmental and cultural differences may be significantly different.
Study related relevance.

This thesis aims at making a connection between the generic aspect of the Management of Technology (MOT) programme and the Infrastructure and Environmental Governance (IEG) specialization. The MOT aspect lies within the research itself. By analysing how a technology type, in this thesis ITS, is managed in the present, I try to create a better understanding of technology project processes. The interface with the IEG aspect lies within ITS and the process of how the relevant infrastructural related technologies are managed from a governmental perspective.

Part of the research that is executed in this thesis was done at the Advanced Metropolitan Solutions Institute (AMS) in Amsterdam. This institute studies a range of projects to improve the urban welfare in metropolitan regions like Amsterdam. More specifically, focussing on opportunities to solve complex problems that Amsterdam is facing in the present and in the near future.

The reason to contact AMS for my research was because they identified traffic as the biggest problem in Amsterdam. ITS is considered an important feature in solving this traffic problem. The connection between this research and their interests matched, and as they have a big network at their disposal it was also for my own interest to apply for graduation at AMS.

The objectives of the project

The objectives of the project are developed in accordance with the objectives as distinguished by Verschuren, Doorewaard, Poper, and Mellion (2010). Hence, the objective of this thesis is primarily practice oriented. This means that the proposed research aims at solving a practical problem by triggering a change in the existing situation.

More specifically directed to the topic (uncertainties which emerge during the development processes of newly introduced technologies and software in the intelligent transportation systems market) of this thesis, the following objectives have been distinguished:

- Identify the different issues that trigger uncertainty in new ITS projects (Diagnostic).
- Distinguish types of uncertainties that emerge during ITS projects (Diagnostic).
- Determine to what extent policymakers are aware of uncertainties (Diagnostic).
- Determine how policymakers act in the light of uncertainties (Diagnostic).
- Determine to what extent the different types of policies effectively take care of uncertainties (Design and Evaluation).
1.4 Defining research scope

Because of the limited time available for this research, the limited amount of data and the rather fixed number of resources at my disposal, a number of scopes are incorporated into my research. These scopes will help to make my research achievable within the calculated effort for such research. The scopes also allow me to clarify the problem more extensively and study it in greater depth. By means of literature and substantiated trade-offs, the decisions on the different scopes will be elaborated upon.

Governmental organisations in the Netherlands

First of all, the scope of this research will be limited to ITS projects initiated by governmental organisations in the Netherlands. The Dutch government is intensively investing in different types of ITS related projects (Bevers, 2016; Rijkswaterstaat, 2016a, 2016e). This makes the Netherlands an interesting country to investigate. Also, the network that I have at my disposal via the Advanced Metropolitan Solution Institute (AMS), the TU-Delft and the Rijkswaterstaat (RWS) makes it very convenient to extract data from governmental organisations in the Netherlands. So, the projects analysed in this thesis are ITS projects initiated by the institutes of the Dutch government. Hence, the results of this research are not generalizable for other countries. But of course, results of future comparable studies in countries with a similar culture and alike conditions might resemble the findings in this research.

Road traffic related ITS

The second scope relates to the different types of ITS. In general, ITS projects can be segmented based on different types of traffic. This can be air traffic, water traffic and road traffic. These three segments are significantly different in technology and marketing. Therefore, these different segments should be dealt with separately and cannot be generalized. Since most projects in ITS relate to road traffic, more data are available on this sector. So, the scope of this research is limited to road traffic ITS.

Uncertainties

A third scope concerns uncertainty. In this research, the typologies of uncertainty by Walker et. al. (2003) are used as guidelines in order to typify the different sets of uncertainties. The following three characteristics of uncertainty are mentioned in this article, namely level, location and nature uncertainty. Both nature and location uncertainty will be left outside the scope of this research for the valuation of uncertainties. This as knowledge on both do contribute on the evaluation process for determining whether policymakers have effectively dealt with uncertainties in the project process. Hence, both will be excluded in the research. See paragraph 3.1 Uncertainty, for a more detailed explanation on what these different types of uncertainty imply.
1.5 Outline of thesis

To give an indication on the contents of this thesis, the structure will be elucidated shortly. The chapters of this thesis report will be as follows;

1. First, a chapter will be dedicated to the methodology (Chapter 2). In this chapter will be explained (1) how the research has been put into effect (2) how the literature study was approached and executed, (3) what procedure was initiated for the in-depth interviews and (4) how the case study was carried out.

2. The next chapter (Chapter 3) will explain the theoretical framework on which the research is based. Aspects as uncertainty will be more accurately defined and different types will be distinguished. The same accounts for ITS.

3. Thirdly a literature study will be executed for strategies and policies that effectively deal with uncertainties (Chapter 4). Since there is a wide variety of uncertainties, it is essential to determine what type of policy is suitable in each form of uncertainty.

4. With this information at hand, three ex-post ITS projects will be selected and subsequently used as case studies for analysis and evaluation (Chapter 5, 6 and 7). This to identify the type of uncertainty in the case at hand and to subsequently determine how was dealt with this uncertainty by policy makers. Information on these cases will be extracted from internet resources like reports, databases and journals, but also by means of in-depth interviews with key persons of the project.

5. With the findings from the ex post ITS cases and the literature study, a comparative analysis will be laid down to determine what types of uncertainties might arise during ITS project processes (Chapter 8). Then, within that same chapter, an analysis will be done on which policies are considered suitable to deal with the considered uncertainties. A conclusion (Chapter 9) will then follow with all the results of the research, in the end to answer the research question.

6. The thesis concludes with two paragraphs that are included in the conclusion chapter. The first one will relate to a personal reflection on the carried-out research which will add some personal perspective and critique on the subject. The last paragraph will close with recommendations for future research.

7. The additional two chapters that follow evidently consider the literature references (Chapter 10) and the appendices (Chapter 11).
2 Methodology

In this chapter, the methodology will be elaborated. Various considerations are discussed and choices are substantiated, mostly based on existing literature. This was of great help to define research questions and sub-questions in a structured manner. In the first paragraph, the research approach is considered. In the second paragraph, different research methods are discussed and selected. The last paragraph defines which data have to be gathered and how the gathered data should be implied in the thesis.

2.1 Research approach

The research will be divided into six stages in accordance with the six stage approaches from Yin (2009) (The six-stage approach will be further elaborated upon in paragraph 2.2.2). The first two, namely the planning and design stage, are key steps towards the actual research. They are discussed in Chapter 1. Subsequently, the methodology is discussed in chapter two. It functions as a blueprint for the research and can be correlated to the prepare stage. The theoretical framework, which also is set in the prepare stage of Yin, is elaborated upon in Chapter 3. Additional solutions for the problem at hand will be explored corresponding to the discussed literature in Chapter 4 (Collect stage).

![Figure 1, the feedback loop between the analytical phase and the empirical phase (own image).](image)

Then, the collect stage will be resumed when analysing ex-post ITS projects. The projects, which are selected and analysed thoroughly, will be used to to set up conclusions about identified uncertainties, and implemented policies to deal with those uncertainties. This step is related to the analysis phase. Subsequently, I will consider primary empirical research. Hence, I will further build on the findings from the third and fourth stage. These findings will be tested by means of interviews with policymakers of the relevant case study. With the information that is extracted from the interviews, we then revise the conclusions that are made during the prepare stage. Subsequently the interviewed persons are contacted again for verification of the adjusted conclusions (also see Figure 1).
With the gathered information, a sharing phase is structured to adequately articulate for the public and to determine to what extent the information is relevant, sufficient and concrete enough to answer the research question of this thesis. Subsequently follows a conclusion section, a criticism section and a recommendation section. Also, see Figure 2 for a full overview on the research approach.

Figure 2: a full overview on the research approach, divided into four phases (own image).
2.2 Research methods

This paragraph will discuss the different research methods that are included in this thesis. The first section contains the first research method; a literature study. Here I aim to set up a theoretical framework, and collect relevant data which will be used as a handhold for analysing the relevant case studies. The second section elaborates on case studies, which will be discussed in the 5th, 6th, and 7th chapter. Here the theoretical framework will be used to analyse the different case studies on strategies and policies. In addition, the findings from the literature study will also be tested in the case studies. The final research method considers semi-structured interviews and the way they will be put into practice. This method is used to collect additional, in-depth information on the case studies.

2.2.1 Literature study

The literature study is done to identify published and unpublished work found by means of scientific search engines. This way secondary data sources can be found on the “topic of interest” as in accordance with Sekaran and Bougie (2011).

In order to collect a diversity of articles that relate to the subject of this research, scientific databases are browsed through with the aid of search-engines like Web of Science, the TU Delft repository, Science Direct, Google Scholar and Scopus. The search terms used to select articles relevant to this research are a combination of; Uncertainty; Intelligent Transport Systems; Netherlands; Government; Policy. Dependent on the number of results that show up, filters have been used on the following topics; Risk Management; Organization; Business. Based on the Abstracts, and conclusions, which are determined to be one of the key parts of an article (Hengl & Gould, 2002), the articles then are filtered on usefulness and relevance. In order to execute a literature study as correctly as possible, the literature study will be done in accordance with the guidelines that are explained by Krupski, Dahm, Fesperman, and Schardt (2008).

2.2.2 Case study

The lion share of the research will be done by means of case studies. The case study research methodology is a comprehensive study. It is an in-depth analysis “for the purpose of understanding a larger class of similar units” (Gerring, 2004). The reason for selecting a case study as main research method is because case studies are the favourable research method for “how” questions. It implicates that the researcher has limited control over the unit of observation and that the research fixates on a contemporary problem in a real-life context. This research is about such a “how” question and the setting of the problem at hand is a real-life setting. Therefore, a case study methodology is deemed most suited.

In this thesis, there are two units of analysis, which are; uncertainty in ITS projects and the conduct of policies in ITS projects. The case studies will be done in accordance with the six stage framework as developed by Yin (2009). Also, see Figure 2 for an illustration of the framework. Yin’s six stage framework has as main purpose to help execute case study research as correctly as possible. In the past years other authors have improved the framework and have implied
additional aspects and recommendations. This framework and these annotations will be elaborated on in the following sections. Every stage will be discussed in short. We will use the order of the six stages as described in Yin (2009). Also see Figure 3 for a visualization of the framework.

1. The first stage of Yin’s six stage framework is the planning stage, which mainly focusses on defining the research problem and research question.
2. The second step is the design stage and can be seen as the so called “blueprint” for the research at hand (Baskarada, 2014). This stage focusses on defining the unit of analysis.
3. The third stage is the preparation stage which focusses on becoming familiar with the case domain and the methodological issues that are at the core of the research.
4. The fourth stage is the collect stage, which involves setting up a database of all the information that is related to the case at hand. Here a multitude of resources should be used for evidence.
5. The fifth stage is the analysis stage and relates to the “revise conclusions” and “process findings” segment in the research approach (Figure 1).
6. The final stage of Yin’s six stage framework is the share stage. It aims at setting up the findings and conclusions in an organised manner for the targeted audience. Yin accordingly discusses the importance that the reader should come to the same conclusions themselves as the writer (Yin, 2009).

Figure 3: The six stage framework for the case study research method by Yin (2009)

The reason for “only” selecting three projects for case studies is because identifying uncertainties is a complex issue. Uncertainties are not written down and often even not noticed by project members at all. Therefore, in-depth research needs to be executed into internal issues within the project, but also into external issues, like prosperity, the national economy and other external project-dependent factors. This complexity also accounts for the inadequate approach of policymakers who have to deal with uncertainties. Therefore, it is essential to reserve sufficient time to enable myself to do in-depth research. This time enables me look into unknown aspects of the selected ex-post ITS project and determine what the underlying reasons were on certain policy decisions and interventions.
The projects that were used as case study, have been selected based on a few selection criteria. First of all, in line with the scope of this research, it had to be an ITS project in the Netherlands. The project also needed to have governmental institutes like RWS and I&M as one of the main stakeholders in the process. In addition, was sought for an ITS project which was recently completed. The timeframe from which ITS projects were selected was between 2010 and 2017. Subsequently I reached out to designated project managers of the relevant projects by mail with the question on their preparedness to share project relevant information with me by means of an interview. When a positive reply was received on the send request, I included the project in this thesis. Hence can be stated that the case study selection procedure was based on a convenience sampling method, in combination with a response-based process.

2.2.3 Semi-structured interviews

In the subsequent phase, when there is more clarity on the subject, semi-structured interviews will be executed. This will help to identify key issues which need further in-depth investigation (Sekaran & Bougie, 2011). Semi-structured interviews entail that first a specific sequence of questions will be posed that will try to confirm or reject the findings that were deduced from the literature study.

As this research is qualitative of nature, validating these findings is essential in evaluating the results from the case study. Which is why, prior to the interviews, a few findings are set up that are in line with the gathered data (Kvale, 2008). These then need to be validated or rejected during the interviews by posing targeted questions. Dependent if the findings at hand are validated or rejected, a concatenation of subsequent targeted questions will be posed. When validated it helps to get a more comprehensive overview of key aspects that support the hypothesis. When rejected, it helps to ascertain what assumptions at the start were faulty and what was the motivation for these faulty assumptions.

Dependent on the situation and the availability of the contact person of one of the selected projects, the interviews could be executed by phone, face to face, or by means of webcam communication. Also, dependent on the available data retrieved from the analytical phase, two interviews might be initiated. The first one can then be seen as an exploratory interview as main purpose to gather information on the project at hand, whilst the second one then will be initiated as a more structured interview with more targeted questions (Sekaran & Bougie, 2011).

Directly after the interviews have been executed, the whole recorded conversation will be written down. Then, based on those conversations, the main findings from the different interviews will be written down and relevant conclusions will be structured. In order to maintain the validity and reliability of the extracted data from the interviews, those findings and structured conclusions will then be sent back to the interviewee. The interviewee on his turn evaluates the gathered data and supplies feedback on those findings. Then, based on the received feedback from the interviewee, the data will be adjusted accordingly. The aim of this feedback loop is to exclude erroneous conclusions and faulty interpretations of the data.
2.3 Data gathering

With the research methods at hand, the data analysis process will be elaborated upon. Since only with the interviews new data are gathered, this section will mainly elaborate on this research method in relation to qualitative data. Then a short elaboration will be made on where to collect the relevant data. And subsequently the data analysis tools will be briefly discussed to give insight in how the acquired data will be interpreted.

Qualitative data can be described as data that are described in words, such as answers to open end questions or video tape recordings. Primary sources of such data are, amongst others, interviews and open-end survey questions gathered by myself. Qualitative data like reports, news-articles and evaluation documents are considered secondary, since the information is gathered by someone else (Sekaran & Bougie, 2011).

During the analysis phase of the selected cases, secondary qualitative sources are analysed. The validity of these sources, like authenticity, credibility, representativeness and meaning will be carefully checked and interpreted (Scott, 2014). With semi-structured interviews, the acquired data is typically primary qualitative data, as long as the posed questions do not consider solely questions that can be answered with yes/no answers (Sekaran & Bougie, 2011).

<table>
<thead>
<tr>
<th>Quality aspect</th>
<th>Case study strategies</th>
<th>Stage in research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>- Multiple sources of confirmation</td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>- Have project members review case study findings</td>
<td>Composition</td>
</tr>
<tr>
<td>Internal validity &gt; causality</td>
<td>- Pattern matching</td>
<td>Data analysis</td>
</tr>
<tr>
<td></td>
<td>- Do explanation building</td>
<td>Data analysis</td>
</tr>
<tr>
<td>External validity</td>
<td>- In multi-case study use replication logic</td>
<td>Research design</td>
</tr>
<tr>
<td>Reliability</td>
<td>- Use case study protocol</td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>- Develop case study database</td>
<td>Data collection</td>
</tr>
</tbody>
</table>

Table 1: strategies to maintain validity in a multi-case study research methodology in accordance with both Sekaran and Bougie (2011) & Yin (2009)

For a qualitative research, it is key to maintain credibility amongst readers. To do so, a quartet of terms is put forward as key in uphold the credibility, namely; construct validity, internal validity, external validity and reliability (Sekaran & Bougie, 2011). Validity considers from what time the gathered data stem and the extent of relevance in the results. Internal validity refers to the degree of accuracy of the research in presenting the data. External validity is the extent to which the data can be generalized to other contexts and settings. Construct validity entails the extent to which the obtained results match with the theories around. Multiple sources of evidence therefore uphold the construct validity (Sekaran & Bougie, 2011). Finally; Reliability. Reliability refers to the degree of bias in the research. To maintain reliability it is important to check the consistency of the different case study projects and replicability when executing multiple repetitive measurers (Sekaran & Bougie, 2011). Also see Table 1.
Data source & sampling technique

To acquire the data, a nonprobability sampling technique is used. In this case is chosen for a convenience sampling method. This sampling method refers to gathering information from a number of preselected subjects of the population who are conveniently available to provide you with the relevant information (Sekaran & Bougie, 2011). For this research a few organisations, which are active in the ITS segment, are selected on forehand which have indicated upfront to be prepared in sharing data with me. The sample of ITS projects that will be used in this thesis will all originate from the following two organisations;

- Rijkswaterstaat (RWS)
- Advanced Metropolitan Solutions Institute (AMS)

The number of available projects will be first narrowed down to projects of recent completion. Hence is chosen for a time span of 2010 up to 2017. This is done because macro environmental factors change continuously. These variables relate to technological, economic, environmental, political, social and legal factors (Cadle, Paul, & Turner, 2010). The data from older projects might not be as relevant and valid anymore, since the results cannot be used as an archetype for near future ITS projects. In the subsequent step of the ITS project selection process for the case study a mail was sent to the candidate projects. When a positive reply is received the project will be selected. The reason for this approach is because there is limited time to execute the research. Again, referring to the convenience sampling method.

Data analysis tools and techniques.

When gathering data in the fifth stage of Yin’s framework, the analysis stage, the OTTR concept will be implied. The OTTR concept stand for Observe, Think, Test and Revise, which is essential when collecting data and executing analysis (General Accounting Office, 1990). This is to set an adequate basis for the preservation of internal consistency (General Accounting Office, 1990).

As every project is inherently unique, the context in which the projects were set will be studied and defined. This will be done by means of the PESTLE tool. It is a tool to help map out the context and external conditions in which a project is executed. PESTLE addresses Political, Economic, Social, Technical, Legal, and Environmental challenges in the development process of emerging technologies (Zalengera et al., 2014). Also see Appendix 1 (O’Brien, 2014).

One of the techniques that will be used to analyse the gathered information on the selected ex-post ITS projects is the pattern matching technique. This method is the most desirable when it involves the comparison of patterns in project processes (General Accounting Office, 1990). According to Van Geenhuizen and Thissen (2007) there is a framework that identifies a pattern that correlates to uncertainties. This framework will come to discussion in the next chapter, but it is merely to indicate that there are potential patterns traceable in uncertainties in ITS.

The last tool that will be used as a directive in this thesis report is the case study protocol template that matches the guidelines that are described by Yin (2009) but have been developed by Brereton, Kitchenham, Budgen, and Li (2008). The case study protocol template is visualised in the Appendix 2.
3 Theoretical Framework

As mentioned earlier, in order to give answer to the research question, there first needs to be made some elucidation in the definition of the different terminologies that are extensively used in this thesis. This chapter is fully dedicated to this aspect. In the first paragraph will be clarified what is meant by uncertainty and how it is associated with risks and opportunities. Next will be explained what is meant by Intelligent Transport Systems, how it is related and distinguished from Smart mobility, and what type of systems will be discussed in this report.

3.1 Uncertainty

Uncertainty is a relatively broad and vague term which is frequently interpreted different within different literature studies. It is therefore essential for this research to explicitly define what is meant with uncertainty on forehand in order to avoid any misunderstandings. As earlier stated the aspect of uncertainty will be linked to policymaking and project management. Or, in a more elaborated fashion, the way uncertainties manifest during ITS projects and – when identified – how they can be dealt with in policymaking. It is important to note that uncertainty is the core value in policy analysis (Walker et al., 2013). Therefore, policymaking is inherently connected to uncertainty.

The widely accepted, more generic definition of uncertainty as described by the Oxford English Dictionary, is ‘an unclear degree of chance’. It is also described as ‘the status of indeterminacy’ as an extent or a value from both an empirical or theoretical perspective. (Oxford English Dictionary). This definition however is not sufficient within the context of this research as it is too generic and vague in terms of “unclear degree” and “chance”. Walker et al. (2003) further specifies this definition in his article. He describes uncertainty as;

“any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system” (Walker et al., 2003)

In the remaining parts of this thesis, the definition of uncertainty as described by Walker et al. (2003) will be used, because in terms of uncertainty in combination with policymaking this definition is best applicable in the context of the research at hand. In this same article, different characteristics of uncertainty are distinguished which help typify uncertainties. This typology framework that was set up by Walker et al. (2003), will be used as a tool. In this article, three domains of uncertainty are distinguished, namely;

1. Level uncertainty: the magnitude of the uncertainty in the perspective of knowledge.
   In other words; the degree of uncertainty, ranging from completely deterministic knowledge on one side of the spectrum, all the way up to total ignorance on the other side.

2. Nature uncertainty: The type of uncertainty within each cell. This implies to determine whether the uncertainty originates from the imperfection of knowledge or emerges from the inherent qualities of the described phenomenon.

3. Location uncertainty: the segment of the project process in which the uncertainty at hand manifests itself.
Uncertainty as used in this report will only be classified in one fundamental dimension; namely level uncertainty (Walker et al., 2013). This is because in the article of Walker et al. (2013), is discussed that level uncertainty is the main indicator for determining which type of policy is deemed a most suitable candidate.

**Level uncertainty**

Level uncertainty is a fairly straight-forward means to assign a value to uncertainties. The level uncertainty namely considers the extent to which one is aware of all the factors that influence the uncertainty at hand, and the degree of which this person is knowledgeable of those aspects. Or, in other words, the extent to which the policy analyst is conscious of being rationally bounded (van den Bergh, Faber, Idenburg, & Oosterhuis, 2006). Walker et al. (2013) therefore distinguished the following five levels of uncertainty:

Complete certainty: the circumstances in which we know everything precisely. This is the starting point of the uncertainty spectrum as complete uncertainty is the end of the uncertainty spectrum.

Level 1 uncertainty: considers a situation where one admits there is a limited degree of uncertainty, but where the future is clear enough. No major changes have to be made.

Level 2 uncertainty: is a more significant uncertainty from a statistical perspective. That is why a level 2 uncertainty often is dealt with by means of forecasting based on trends, or by means of a scenario planning with a calculated probability per scenario.

Level 3 uncertainty: is a situation where one is, because of available information, sure that there are a multitude of alternative futures in the prospect. Yet these different futures can be ranked on the perceived probability of occurring. Therefore, tools as trend-based analysis on influencing factors can be used to determine the probabilities of the different alternatives up to a certain extent.

Level 4 uncertainty: in this scenario of uncertainty, there is a case of plausible futures where it is practically impossible to assign probabilities to the different alternatives. This can be because of number of issues, for example; lack of available knowledge on the subject at hand, the inadequacy of data to describe causal relations between variables or the shortcomings of the decision maker to rank his preferences on certain aspects. This makes it hard to value the outcomes in terms of preferability and desirability.

Level 5 uncertainty: is the most extreme case of uncertainty and is often referred to as deep uncertainty, or the so called “black swans” of uncertainty. In such conditions, it is only known that we do not know. Therefore, we recognize our ignorance. An example of such an uncertainty is the earthquake of Japan in 2011 and the chain reaction that was initiated by this. Namely the tsunami that followed, subsequently leading to a nuclear catastrophe, which then led to turmoil in the supply chain for, amongst others, automobile parts.

Total ignorance; is seen as the ending point of the uncertainty spectrum.
Level uncertainty will be the key indicator during the case study analysis. The framework that is laid that was developed by Walker et al. (2013), will be used as a handhold. This will be done so for valuing the identified uncertainties from the concerning ITS project and measuring the extent to which the uncertainty manifested. Also, see an overview of level uncertainty in Figure 4.

By assigning a level of uncertainty to identified uncertainties in the analysed cases, we can compare suitable policies that are discussed in Walker et al. (2013) and paragraph 4.3, to the actual implemented policies by the policymakers. This comparison makes it possible to determine the extent to which policymakers use the correct policies to deal with uncertainties.

In order to assign levels to distinguished uncertainties in the relevant cases, the uncertainties first have to be identified. Rolstadås, Hetland, Jergeas, and Westney (2011) state in their research on uncertainties that; “Uncertainty could be both negative and positive for a project. Negative implications of uncertainty are labelled as risk factors. Positive implications of uncertainty are labelled as opportunity factors”. It is therefore that, during the data scrapping and scanning period; a significant emphasis will be put on keywords like “opportunity” and “risk”. These words namely imply that there was no sufficient knowledge, or control on an issue of interest which is deemed important (Rolstadås et al., 2011). On that note is added that uncertainty can be categorized into both “controllable and non-controllable factors” (Hetland, 2003). Which is why is aimed, when going through the data, to identify those factors on which they had control on, and which they did not have control over.
3.2 Intelligent Transport Systems

In a multi-case study like in this research it is key to be aware of the similarities and the differences between the selected ITS projects. This might explain differences in policymaking and decision-making. In this paragraph first a definition is made on what ITS is. Subsequently a section follows where the correlation lies between Smart Mobility. This paragraph ends with the distinguished typologies of ITS in the literature.

Intelligent Transport Systems (ITS), also known as Intelligent Transportation Systems, relate to a series of solutions that consider one or both communication systems and information systems, which are subsequently developed to improve the efficiency and/or safety of transportation systems on the water, on rails, in the air, or on the road (Caltrans, 2010; Hassn, Ismail, Borhan, & Syamsunur, 2016; Perallos, Hernández-Jayo, Onieva, & García Zuazola, 2015). In addition, it is essential to distinguish other types of technologies that are not included by ITS. Those technologies are Data gathering systems (like tracking devices), Transport technologies (like electric vehicles) and new mobility services (Jeekel, 2017).

There is some confusion between what is meant with ITS and Smart Mobility. People might think that the two entail the same, but the literature negates this train of thought. Where ITS only focusses on communication and information systems to improve traffic flow and increase safety, Smart Mobility covers the whole spectrum that is correlated to transport and innovation. Therefore Smart Mobility covers ITS, Data gathering systems (tracking devices), Transport technologies (electric vehicles & autonomous driving) and new mobility services (Jeekel, 2017).

To better qualify and label the different ITS projects that are used for the case studies, the literature on Intelligent Transport Systems by Ezell (2010) will be used as a handhold. Ezell distinguished five categories of ITS, namely:

1. Advanced Traveller Information Systems (ATIS)
2. Advanced Transportation Management Systems (ATMS)
3. ITS-Enabled Transportation Pricing Systems
4. Advanced Public Transportation Systems (APTS)
5. Fully Integrated Intelligent Transportation Systems

The first category, the advanced traveller information systems category, is the most well-known of all the categories. It considers systems that provide the road users with relevant real-time information on their specific route. For example; in-car navigation systems or mobile parking applications with real-time parking space availability (Ezell, 2010).

The second category, advanced transportation management systems, relate more to systems that are out on the road to manage and coordinate traffic on a safe and, up to a certain extent, efficient way. These systems are traffic lights, freeway ramp metering systems and dynamic route information panels (DRIP’s) (Ezell, 2010).
ITS enabled pricing systems are the third category and may mainly refer to electronic toll collection system, variable parking payment applications for mobile phones and Fee-based express lanes. As can be extracted from this information, the emphasis here mainly lies on money related issues for the use of the public infrastructure by the vehicle at hand (Ezell, 2010).

The fourth category relates to advanced public transportation systems, which primarily is focussed on supplying travellers with information on the public transport modes. These systems are for example in-vehicle electronic card payments systems, real-time status information public transit systems, and automatic vehicle location sharing systems (Ezell, 2010).

The last category is the fully integrated intelligent transportation system classification. This category refers to integrated systems which communicate with external systems on the road. These systems are regularly referred to as vehicle-to-vehicle (V2V), and vehicle-to-infrastructure (V2I) systems. Examples of these systems are the integrated collision avoidance system and intelligent speed adaption system. For an overview of all the categories, also see Figure 5.

<table>
<thead>
<tr>
<th>ITS Category</th>
<th>Specific ITS Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Advanced Traveler Information Systems (ATIS)</td>
<td>Real-time Traffic Information Provision</td>
</tr>
<tr>
<td></td>
<td>Route Guidance/Navigation Systems</td>
</tr>
<tr>
<td></td>
<td>Parking Information</td>
</tr>
<tr>
<td></td>
<td>Roadside Weather Information Systems</td>
</tr>
<tr>
<td>2. Advanced Transportation Management Systems</td>
<td>Traffic Operations Centers (TOCs)</td>
</tr>
<tr>
<td>(ATMS)</td>
<td>Adaptive Traffic Signal Control</td>
</tr>
<tr>
<td></td>
<td>Dynamic Message Signs (or “Variable” Message Signs)</td>
</tr>
<tr>
<td></td>
<td>Ramp Metering</td>
</tr>
<tr>
<td>3. ITS-Enabled Transportation Pricing Systems</td>
<td>Electronic Toll Collection (ETC)</td>
</tr>
<tr>
<td></td>
<td>Congestion Pricing/Electronic Road Pricing (ERP)</td>
</tr>
<tr>
<td></td>
<td>Fee-Based Express (HOT) Lanes</td>
</tr>
<tr>
<td></td>
<td>Vehicle-Miles Traveled (VMT) Usage Fees</td>
</tr>
<tr>
<td></td>
<td>Variable Parking Fees</td>
</tr>
<tr>
<td>4. Advanced Public Transportation Systems (APTS)</td>
<td>Real-time Status Information for Public Transit System (e.g., Bus, Subway, Rail)</td>
</tr>
<tr>
<td></td>
<td>Automatic Vehicle Location (AVL)</td>
</tr>
<tr>
<td></td>
<td>Electronic Fare Payment (for example, Smart Cards)</td>
</tr>
<tr>
<td>5. Vehicle-to-Infrastructure Integration (VII) and</td>
<td>Cooperative Intersection Collision Avoidance System (CICAS)</td>
</tr>
<tr>
<td>Vehicle-to-Vehicle Integration (V2V)</td>
<td>Intelligent Speed Adaptation (ISA)</td>
</tr>
</tbody>
</table>

Figure 5: overview of the different typologies of ITS in accordance with the research of Ezell (2010)

Being able to distinguish different types of ITS will be of use in the case-study segment of this thesis. When comparing the different projects with each other, this might give insight into why there are differences in policies and strategies to deal with uncertainties. This information will also be of aid when reflecting on the research in this thesis. Being aware of the differences in typologies of ITS, enables me to be critical in the reflection chapter.
4 Strategies and policies for uncertainty

This chapter will look at the different literature resources available on both strategies and policies that deal with uncertainties. The findings of this chapter will come in use when analysing the conduct of policies in the case studies and evaluating them in the comparative analysis chapter. First is elaborated why it is important to deal with uncertainties from a project management perspective. Subsequently types of strategies will be discussed and distinguished. Then, an analysis will be made on the different policies that are considered effective in dealing with uncertainties within the thematic setting. The final paragraph will look into available literature that consider policymaking for ITS projects, related to dealing with uncertainties.

4.1 The importance of dealing with uncertainties

To start of this chapter, it first is important to consider the “why” question. In this case; why is it important to deal with uncertainties in the first place? The most important, and more generic argument for dealing with uncertainty, is because doing counter wise (ignoring uncertainty) might result in poor project management, creating greater risks and liabilities, probable missed chances and opportunities, and improficient use of resources (Walker et al., 2013). Or as it is also stated by Walker et al. (2013) “Ignoring uncertainty could mean that we limit our ability to take corrective action in the future and end up in situations that could have been avoided”.

Morgan, Henrion, and Small (1992) provide a more elaborated discussion on the importance of dealing with uncertainties. In their article, one of the most important arguments in dealing with uncertainty is because of the limitations of human understanding. Hence, predefined best estimates could not represent the actual approximation. This can be because of numerous factors like lack of understanding of the system, subjective reasoning, and the absence of key variables, just to name a few (Morgan et al., 1992). Just by forcing others to consider the whole scope on which the uncertainty is influenced by, a subsequent analysis can give better insight in opportunities and risks and the consequent best estimates.

An aspect that is deemed of importance when dealing with uncertainties, are the stakeholder values (Morgan et al., 1992). Thoroughly analysing the different stakeholder values will give better insight in the best valued options. This way disagreements can be avoided and choices can better be substantiated afterwards.

Also, from the perspective of policy analysts, it is important to consider all the correlated factors that could influence the process. In a way, they are ethically obliged to supply all relevant information that is of importance in the decision-making process. In addition it is their duty, to also inform and outline the limitations in available information and resources that they had to deal with (Morgan et al., 1992). To supply stakeholders with this information, they might clarify on some issues, and take more informed decisions based on the limitations in information.

Though, it is up to a certain extent that we can limit uncertainties. As is stated in Walker et al. (2013), “Given the lack of crystal balls, uncertainties about the future cannot be eliminated.” But, it is no excuse to throw in the towel and decide to neglect uncertainty. By taking them into consideration in the decision-making process, policymakers can make more deliberate choices. Also by anticipating on uncertainties, policymakers can adjust their policy thereupon.
4.2 Strategies

Before elaborating on the different types of strategies that can be applied by project managers, I will briefly elaborate on the terms “management” and “strategy” to avoid any indistinctness from occurring for the reader. Management is described as: “The process of dealing with or controlling things or people” (Oxford English Dictionary). Managers are therefore often in charge of a group of goods or people which requires control to execute a key task. The term “strategy” is defined as “A plan of action designed to achieve a long-term or overall aim” (Oxford English Dictionary). The definitions of both “Strategy” and “Management” extracted from the Oxford English Dictionary, is set as universal throughout this thesis.

To deal with uncertainties, policymakers can adopt different strategies. Five different strategies are distinguished by Van Geenhuizen and Thissen (2007). It is emphasized that the different strategies may not exclude one another, but can be combined (Van Geenhuizen & Thissen, 2007). The strategies are as follows;

- Ignore; neglect uncertainties in their entirety and maintain a “wait and see” attitude when implying a policy.
- Identify; execute analysis, attempting to single out and specify uncertainties in the process. This enables policy-makers to be conscious about the matter. This strategy is often correlated to a scenario-analysis approach (Schwarz, 1988).
- Reduce; when identified, take action to reduce the uncertainty at hand by means of additional research and better incorporating the different segment of knowledge. This is to explore and identify bottlenecks and crucial events in the process (exploratory modelling).
- Accept; when identified, accept the fact that uncertainties are present and act very consciously in the presence of those uncertainties during decision-making moments. This implies that there is extensive monitoring on issues that are correlated to the uncertainty at hand (Walker, Rahman, & Cave, 2001).
- Opportunity; here uncertainty is seen as an opportunity to shape the future. Therefore, this strategies allows experimenting and an iterative exploring process like the branch method as described by Lindblom (1959).

Sadly the “ignore” strategy, when uncertainties are identified, seems to be most popular with nearly all governments (Van Geenhuizen & Thissen, 2007). According to Van Geenhuizen and Thissen (2007) this is “Because of lack of a vision in the face of the immense uncertainties”.

The list of strategies from Van Geenhuizen and Thissen (2007) does not include a scenario where a policymaker is fully unaware of an uncertainty. Though, it is deemed possible that policymakers are nescient in the light of some uncertainties. Not being aware of all relevant uncertainties results in inconsistent information. Yet, such a scenario could resolve in inconsistent policy alignment by policymakers. If such a scenario occurs during the case studies, it is essential to incorporate such a possibility. Since there is no consistent name lining for such a phenomenon in policymaking, this research reached out to literature in the field of robotics where it is called “uncertainty unaware planner” (van den Berg, Abbeel, & Goldberg, 2010).
4.3 Policies in the face of uncertainty

In order to deal with uncertainties, policies are put forward as the answer. To clarify what is meant with the term “policy”, again I reach out to the oxford English dictionary which describes it as “A course or principle of action adopted or proposed by an organization or individual” (Oxford English Dictionary). In other words, a set of rules for a course action that is adopted/proposed, which then is used for rational decision-making. The definition of “policy” by the Oxford English Dictionary is fixed throughout the whole thesis. Thus, the term policy is used in the broad sense.

To distinguish different policies, the book by Thissen and Walker (2013) will be set as a guideline. Especially chapter 9 (Walker et al., 2013), which focusses on “uncertainty in the framework of policy analysis”. In that chapter, policies are linked to the different levels of uncertainties. Those levels of uncertainty are the same levels that were discussed in the previous chapter for measuring the extent of influence of uncertainties. As a result, the contemplated policies are deemed adequate in dealing with the examined level of uncertainty. In this paragraph, a short summary will be laid down on that book chapter to give insight in the seemingly most suited policies for the five distinguished levels of uncertainty.

To deal with a level 1 uncertainty Walker et al. (2013) suggest the predict-and-act approach as a successful approach. This approach focusses on building a model based on interest. In such a case, one might think of the cost-benefit approach, or a multi-criteria analysis. One footnote on this level of uncertainty; it should be taken into high concern when policymakers are basing a policy on a distinct set of assumptions about the future. This might be a too abstract way of thinking as one’s belief is that the future world will look similar to the present world.

The “expected outcomes approach” is deemed most useful to deal with a level 2 uncertainty. This approach considers a number of future scenarios with probability weighted variables. Two frameworks that connect on this approach are the Decision Analysis (DA) and the Real Options Analysis (ROA). The first one correlates to, amongst others, the so-called decision trees. In these decision trees, a number of futures are outlined with a weighted chance of probability. The ROA approach, additionally to the DA approach, also considers the dynamic characteristics to which uncertainties are subject to. Therefore, for policies valuation, the option of flexibility is also taken into account (Walker et al., 2013).

In the book by Thissen and Walker (2013), again specifically chapter 9, they have left out optional approaches to deal with an uncertainty level 3. This is because no tailored approaches are sufficient in dealing with this level of uncertainty. They therefore discuss that in such a case, one has to reduce the uncertainty at hand to a level 2 uncertainty, or, when deemed more applicable, increase the uncertainty to a level 4 uncertainty (Walker et al., 2013).

For a level 4 uncertainty, two approaches are considered. Both the traditional scenario approach is discussed, as well as the exploratory modelling and analysis approach. The most renowned approach is the traditional scenario approach, an project management policy which already was elaborately analysed by Schwarz (1988) and since then also more broadly implemented by project managers. The foundation of the traditional scenario approach focusses on a future that can be specified decently enough to establish policies which produce favourable outcomes in
one or more plausible scenarios (Walker et al., 2013). Yet, in contrary to the level 1 and 2 uncertainty policies, the scenarios are not predictive of nature, but explorative. The scenarios are defined in order to exclude policies. The best, and therefore most robust policy then is the one which produces the most favourable outcomes across all the different probable scenarios Schwarz (1988).

The second approach to deal with a level 4 uncertainty is the exploratory modelling and analysis (EMA) approach. This approach aims to define “the systems” behaviour by closely observing it. One then aims to put hypothesis to the test. Therefore, with this approach, the manager is not interested in finding the best policy, but trying to get a grasp of the performance of the selected policy (Agusdinata, Marchau, & Walker, 2007). This approach is also a way to deal with level 5 uncertainties.

The final approach, considers a policy to deal with ‘the black swans’ of uncertainty (level 5 uncertainties). This is the Dynamic Adaptive Policy (DAP) approach. In this approach, the policy-maker sets the goal/end-point on forehand or at the start of the project. With the high level of uncertainty, a number of unpredictable events can occur. As a result, the policy has to be adapted in order to stay goal-oriented. Yet, to actively respond to unpredictable events, one needs to stay alert by means of systematic monitoring the environment. In the text of Walker et al. (2013), sailing is used as an example. The destination is set at the beginning of the journey. Though, because of unpredictable weather, one needs to adjust their sails along the way multiple times in order to reach the destination.

Within the case of project management, the project goal is the destination, and the policies are the sails. By staying alert and actively reacting to changing conditions, adapting the policy along the way, the goal will be reached. As Charles Darwin properly describes in his evolution theory; “It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change.” This fits well with the fundamentals of the DAP approach. In this DAP approach, two phases can be distinguished. A policy design phase and the policy implementation phase (Kwakkel, Walker, & Marchau, 2010).

The design phase can be divided into five steps, namely;

1. Stage setting
2. Basic policy assembling
3. Increase robustness of the basic policy
4. Set up monitoring system
5. Preparing trigger responses

The second phase of the DAP approach is the implementation phase. Needless to say, here the five steps of the design phase which are agreed upon, will be put into practice. Steps one to three, will be directly initiated as the journey begins. Step three will be continuously adjusted in accordance with the predefined probable events. The monitoring system of step four is directly established. If the monitored variables are exceeded in value, step five comes into play (Kwakkel et al., 2010). Also see Appendix 3 for a visual overview of the DAP approach.
4.4 Problems and probable correlated uncertainties in ITS projects

As earlier stated, a situation of high uncertainty can, when not managed adequately, lead to big problems and even project failure. Therefore, generic problems and opportunities are at the surface of uncertainties. Recent literature has identified a multitude of problems in ITS projects. This section is therefore dedicated to those, according to the literature, problems. This then will be assessed during the case studies of the subsequent chapter.

The first problem that is identified is scalability. It is seen as one of the main challenges in ITS projects. About 66 percent of the innovative ITS services implemented in the Netherlands is adopted by less than 15,000 users (over a population of 17 million). This is less than 0.1 percent of the Dutch population (Connecting Mobility, 2016). Additionally, to this information, it is expected that this will not be surpassed over the timespan of the project. One of the key obstacles that is at the core of the adoption rate, is the lack of knowledge about end-users and the extent of preparedness to adopt the considered technology (Connecting Mobility, 2016). Therefore, is considered that there might be uncertainty in the aspect of end-user preferences and preparedness to adopt, in advance of the project. This phenomenon/strategy is also known as “technology push”. This implies that a technological based invention is pushed through the development, sales and production phases, without actively investigating the preferences of the end-user (Etzkowitz & Leydesdorff, 2000).

Another issue, is the misplaced perception that there is technological enthusiasm, docility and obedience. Which is why there often is a train of thought which implies that there is one solution that fits all. This is actually inaccurate. Because of fragmentation in the society there is a need for solutions which are fit on a local scale, that are tailormade for the local target groups (Connecting Mobility, 2016). Therefore, uncertainty in ITS projects might be present in the effectiveness of a generic system on local scale.

The ITS market in the Netherlands is mainly government-oriented (Connecting Mobility, 2016). Therefore, almost all the roads in the Netherlands and the correlated infrastructures, are owned or managed by governmental institutes. Because of this, private parties are highly dependent on the public authorities (Connecting Mobility, 2016). It is often necessary for RWS to collaborate with other public and private parties (because of a lack of in-house knowledge availability). This introduces the issue of communication between parties. When collaborating with parties that are new to RWS, communication between those might be questionable (Connecting Mobility, 2016). Not knowing each other’s ambitions, values and capabilities might end up in bad communication between parties. Therefore, there are both opportunities and threats in this aspect of uncertainty.

In addition to the aspect of cooperation, the ITS market in the Netherlands is fragmented. There are a few relatively big firms active in the ITS market, but they are not significant enough to cover all fields of knowledge within the ITS segment (Ommeren; et al., 2016). Therefore, the competitiveness of the Dutch ITS market is questioned, when compared to other promising countries like the United States, Japan and Germany. This results in despair considering the role the Netherlands will play in the further development of ITS, influencing the investment climate (Ommeren; et al., 2016). Introducing uncertainty in potential of ITS in the Netherlands.
There are also problems from a more technological perspective. In the past decades, the Dutch road authorities have invested significantly in roadside systems. ‘Roadside systems’ is an umbrella term for a multitude of technologies that inform and regulate traffic (Rijkswaterstaat, 2016d). Yet, due to these investments, a situation of path-dependency is created, where the choices of the past influence the choices one has to make for the future. This is because some people and organisations gain from the status quo (Ommeren; et al., 2016). This might result in uncertainty in the aspect of project feasibility to switch to the newly introduced ITS due to resistance to change. Indicating there is uncertainty in the sociological context.

Another technological problem that plays with all ITS projects is the technological feasibility of new ITS. When ITS are only tested by means of simulations, or on a very small scale, (or not at all) the obtained results might not be representative when implemented on a large scale. Expectations are set based on predefined project margins, yet those predefined profit margins might not be met in practice (Marchau, Walker, & van Duin, 2008). This introduces uncertainty in the performance of the relevant system. If the expectations are high, and one does not live up to those expectations, it might resolve in a debacle, even if the results are as a stand-alone more promising that the current state.

A more generic problem or threat in nearly every technological related market, is the possibility that disruptive technologies are introduced into the market which makes the relevant technology redundant (Ommeren; et al., 2016). Even though it is unlikely, it has to be taken into account when setting up a policy. Therefore, the problem of unanticipated technologies/entrants into the market relates to context uncertainty. An example, uncertainty exists within the ITS segment because of the introduction of autonomous cars in the market. This could make a multitude of concurrent ITS excessive. This is not necessarily the case on this moment. The influence that autonomous cars could have on the ITS market can be both positive and negative of nature (Ommeren; et al., 2016). It is possible that because of safety and regulation issues and consequent incidents, the development rate of autonomous cars negatively will be influenced.

Another aspect which also correlates to the technological context factor is the possibility that the ITS sector in other countries could impede with that of the Netherlands. Since one could argue that they will not sit around while the Dutch road authorities are constantly aiming to innovate (Ommeren; et al., 2016). Other countries too are aware of the benefits the development and implementation ITS can have on mobility. This problem therefore relates to uncertainty in the segment of competition. Not knowing who the competition is and where they are situated could be crucial for the potential of ITS projects.

In addition to the different issues and correlated uncertainties identified and extracted from the literature, there are also additional context related issues. Generic literature identifies them, yet some of them have not been mentioned as problems in correlation with ITS projects. They are deemed relevant enough to name in the context of this research.

The context issues are related to the earlier mentioned PESTLE tool (Also see Appendix 1). A PESTLE analysis considers those external factors in the operating environment on which an organisation cannot exert influence on (Zalengera et al., 2014). They are, up to a certain extent, uncertainties as it stands. Yet, as already stated, some of them have already been mentioned by the literature within the context of ITS. The ones left out of the discussion by the literature are:
In Kolios and Read (2013), the PESTLE tool is used as an approach for risk assessment within a project context. This source will be used as a handhold to determine how the political, economic, legal and environmental context factors possibly could influence the ITS project process.

An aspect that might be of great importance is the political context. Without support from the government, especially for ITS development, a developed project might not be scaled up because of lack of support (Kolios & Read, 2013), even if the technological performances show promising results (Bloembergen, 2017). Therefore, the aspect of uncertainty lies within the political climate.

The economic context factor mainly considers the funding aspect for a project. Projects are bound to the financial support from key investors (Kolios & Read, 2013). Since, in ITS projects, the core investors are governmental organizations, the contracts are binding, so these organisations cannot withdraw from their investments during the process. Though, the uncertainty lies within the sufficiency of the predefined budget that was made available, and the preparedness for additional investments when project costs exceed the budget.

The legal context factor is a very complex and difficult occurrence, especially in terms of dependency on legislations that correlate to technological and privacy bound issues (Kolios & Read, 2013). This also accounts within the ITS domain. Therefore, to test and imply newly developed systems on the road is has to be in line with the concurrent legislation. For example, the law in the Netherlands does not allow autonomous cars to drive on the road. Legislations might also change over time. Although it is unlikely, it could influence the potential of a technology. Therefore, this issue mainly considers uncertainty in the light legislative change.

The final context factor considers the environment. As the Dutch government has committed itself to achieve the climate directives, which were established during the Paris climate conference, the environment is an aspect that is highly valued. It is important to take the environmental concerns of the ITS industry excessively into consideration (Kolios & Read, 2013). Though, it is safe to say that ITS in general focusses on increasing the safety, traffic flow, and the environment. Which is why, there are mainly opportunities in this segment. The uncertainty in here lies mainly in the extent to which the ITS positively influences the environment.

To conclude this chapter, it is key to keep in mind that every problem and correlated uncertainty could both lead to an opportunity and a threat. Dependent on the considered ITS project, the level of uncertainty and the importance of it for the whole project, the value of those uncertainties will be weighted and a corresponding, most suitable policy will be selected for every single case. For an overview of all the different identified problems, and probable correlated uncertainties that were discussed in the latent paragraph, also see Table 2.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
</tr>
<tr>
<td>Uncertainty in the adoption rate of potential clients when the technology is fully developed.</td>
<td></td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
</tr>
<tr>
<td>Uncertainty in the applicability/effectiveness of a technology under different (local) conditions.</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
</tr>
<tr>
<td>Uncertainty in the effectiveness of the collaboration between (key) stakeholders.</td>
<td></td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
</tr>
<tr>
<td>Uncertainty in the availability of knowledge within the Netherlands to resolve a relevant issue.</td>
<td></td>
</tr>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change (sociological context)</td>
</tr>
<tr>
<td>Uncertainty in the extent of resistance from stakeholders (like incumbent firms) to adopt the new technology.</td>
<td></td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
</tr>
<tr>
<td>When a project focusses on the development of a new technology, the performance of it in practice is uncertain.</td>
<td></td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
</tr>
<tr>
<td>There is a chance of disruptive technologies are introduced into the market, making a relevant project obsolete.</td>
<td></td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
</tr>
<tr>
<td>Uncertainty in the extent of political support staying stable over the course of a project.</td>
<td></td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
</tr>
<tr>
<td>Uncertainty in whether the considered budget is sufficient for this project along the process.</td>
<td></td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
</tr>
<tr>
<td>Uncertainty in the extent that laws might change over the course of a project.</td>
<td></td>
</tr>
<tr>
<td>The environment</td>
<td>Environmental context</td>
</tr>
<tr>
<td>The possibility that a technology, in practice, has several unforeseen indirect consequences on the environment.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2, an overview of all the discussed issues that are correlated to policymaking in ITS projects (in accordance with the literature), and the linked uncertainty factor.
5 Case study: Dynamax

In the upcoming chapters, the different case studies will be elaborated upon. The cases were selected based on the theory as discussed in paragraph 2.3. For every case study (see paragraph 2.2.2), all the available documents on the internet were gathered and thoroughly analysed. After this analysis procedure, semi-structured interviews (see paragraph 0) were executed with the relevant project managers. These interviews were aimed at filling in the gaps on essential information on relevant topics for this thesis. Dependent on which version you are reading, the main findings of these interviews have been integrated in appendices 4 through 6 (in Dutch), functioning as a source and reference for this thesis. When you have downloaded this thesis from a public domain, the findings of the different interviews have been excluded because of confidential reasons. If you are interested in those findings, you are free to ask me. Also see the front page of this thesis for contact information.

5.1 Case description

The first case study that will be dealt with is the Dynamax project. The project is a somewhat older project, as it was first mentioned in 2007 (Stoelhorst, 2007). The project subsequently got executed between 2009 and 2011 (Stoelhorst & Schreuder, 2010), and was lastly evaluated in 2012 (Stoelhorst, 2012). The purpose of the Dynamax project originated out of a request from the Dutch House of Representatives. The request entailed an exploration process of technological opportunities to develop dynamic (or flexible) speed limits on the road.

Therefore, the request was send through to RWS, which subsequently set up a working group. This working group was assembled from relevant representatives from the TU-Delft, TNO and RWS to explore the technological opportunities for implying dynamic speed limits on highways. Out of this cooperative consultation, numerous different trial tests were designed for the implementation of flexible speed limits. These trial tests considered different categories of measures and were all planned at locations that were deemed most suited as candidate (Stoelhorst, 2017). Those locations were spread across highways in the West and Central provinces of the Netherlands. Also see Figure 6 for an overview on the five different test locations of the Dynamax project.

Figure 6, overview of the different test locations of the Dynamax project (own image).
The different tests considered the following measures at the relevant locations (Stoelhorst, 2012; Stoelhorst & Schreuder, 2010):

1. Increasing the speed limit from 100 km/h to 120 km/h during less saturated hours at the A1 near Naarden in the North-Holland province.

2. Decrease the speed limit from 120 km/h to 80 km/h when the concentration of particulate matter reaches a critical level, to improve the air quality. Tested at the A58 highway near Tilburg in the North-Brabant province.

3. Decrease the speed limit from 120 km/h to 60 km/h when a congestion wave is detected, to resolve possible traffic jams before they occur. In addition, a decrease in speed limit from 120 km/h to 100 or 80 km/h will also be realized in case of rainfall. Both were tested at the A12 between Bodegraven and Woerden in the South-Holland province.

4. Increase the speed limit from 80 km/h to 100 km/h in anticipation of rush hour to improve the dynamics of the traffic flow and increase the speed limit at night to reduce travel time. This test was implemented at the A12 near Voorburg in the South-Holland Province.

5. Like the previous test, this final project considered increasing the speed limit from 80 km/h to 100 km/h in anticipation of rush hour to improve the dynamics of the traffic flow and increase the speed limit at night to reduce travel time. This project was tested two years after the Voorburg project, in Rotterdam, in the South-Holland province.

The plan suggests though that it was deemed essential that the experiments would focus on how the drivers’ behaviour was influenced by dynamic speed limit signalling. This, to check which implemented measure would result in change towards the desired behaviour of road users. After the plan was designed and submitted at I&M, the plan was reviewed and approved. To put the developed technological measures into practice, different algorithms had to be developed. Thereupon, assignments were awarded to TU Delft and TNO to develop those algorithm segments. Later in the process was reached out to Technolution for software development for Dynamax (Stoelhorst, 2017).

In order to put the algorithms to the test, the algorithms had to be linked to subsystems that were situated along the road. Accordingly, the different trials considered roadside units. In this project those were matrix speed limit displays, Dynamic Route Information Panels (DRIP), rotational traffic signs, abstract motto signs (similar to the bill boards along highways) and vehicle detection loops. Therefore, the Dynamax project considered ITS that can be classified as ATMS (also see paragraph 3.2). This, because roadside systems are systems that are out on the road to manage and coordinate traffic on a safe and, up to a certain extent, efficient way (Ezell, 2010).
After the trials were executed, the data was analysed and evaluated. In the evaluation report, promising results have been presented (Stoelhoerst & Schreuder, 2010). These results will be briefly elaborated upon, per measure, in the following enumeration (in the same order as presented on the previous page).

1. The results of the A1 trial near Naarden showed promising results. The travel time was reduced with 7% after enabling the system. 39% of the relevant road users profited from the increase in speed limit. The noise charge increased with about 0.35 dB. Based on those statistics was stated that the particular benefits significantly outweigh the disadvantages.

2. The A58 trial near Tilburg showed less promising results. The concentration of particulate matter in the air, caused by traffic, was only reduced with 18%. This was because the follow-up rate was, for the lower speed limit, not as effective as expected on forehand. The average measured speed limit remained between 10 to 25 km/h above the indicated lower 80 km/h. The results are therefore not very adequate. This also accounts for the result considering the increase in travel time.

3. The project at the A12 between Bodegraven and Woerden was deemed as an insightful project. The decrease in speed limit during rainfall was significantly decreased when compared to the (ordinary) situation before the project. A difference of about 11 km/h slower in speed. As a result, the safety indicators showed more favourable numbers. On the same track was aimed to identify and resolve traffic shock wave patterns. The results were limited, as indications show a reduction in vehicle loss hours (VLH) with 1% of the total VLH on the track.

4. The test that was implemented at the A12, near Voorburg, also showed very promising results. By increasing the speed limit at the front of anticipated rush hours, the VLH during the evening rush hours were reduced with 407 hours. The air quality was only minimally negative affected and the noise charge increased with about 0.2 dB. The safety situation did not change significantly. Therefore, these results were most promising of them all.

5. The final test which was executed in 2011 on the A20 in Rotterdam was also deemed successful (which considered the same measures as the previous discussed test). In total, a reduction in VLH was achieved of 660 hours per day. The air quality was, like the previous test, only minimally negative affected and the noise charge increased with about 0.2 dB. On the other hand, the safety on the road was influenced positively because of less congestion.

In the conclusion of one of the evaluation reports (Stoelhoerst & Schreuder, 2010) was recommended to set up a plan of action for further development and application of the Dynamax systems. Yet, although the results were promising and the technology was proven, the Dynamax systems have not been scaled up afterwards. Currently the sole project that is still operational is the A20 test project in Rotterdam (Stoelhoerst, 2017).
The main reason for not upscaling the most promising technologies, is because of both the significant costs, which were deemed necessary for implementation, and the time to execute the upscaling (Stoelhorst, 2017). Additionally, there were external developments which showed a lot of potential. One of those aspects, which negatively influenced the potential of the developed Dynamax systems, was the introduction of In-Car technology. This technology made it possible to do a similar task as with the developed Dynamax systems, but then a lot cheaper. Next to that, the support from the House of Representatives faded away because of their enthusiasm for another mobility project, “Project 130”. That also negatively influenced further upscaling of the systems (Stoelhorst, 2017).
5.2 Uncertainty assessment

In relation to the identified issues and correlated uncertainties by the literature as in paragraph 4.4, an assessment will be done in the extent of whether those issues were present in the Dynamax project. Therefore, I will aim to look for indications (in the different available resources and the data extracted from the interview) whether those issues were (resolved or not) present during the project. When there are indications of new issues and correlated uncertainty factors, which have not been included in paragraph 4.4, they will be elaborated upon from within the context of the project.

The scalability. Since the project was mainly aimed at exploring promising technological opportunities for dynamic speed limits (Stoelhorst, 2017), the aspect of scalability of relevant technologies was up to a certain extent out of the question (Stoelhorst, 2017). This indicates that there was an issue of market adoption present, where the scalability of the ‘to be developed’ systems was uncertain at the front of the project.

Applicability of solution on scale. As is stated by Stoelhorst (2017), during the design process of the Dynamax project, all the tests were specifically planned on locations that were deemed a most suitable candidate. This indicates that the issue of fragmentation of the society is relevant within the context of the Dynamax project. Although, within the project, there was effectively played into this issue during the process (Stoelhorst & Schreuder, 2010), there are indication that there was uncertainty in the applicability of the systems on other locations.

Effectiveness of the collaboration. The collaboration between the key players of the project was deemed very effective. The reason for this good collaboration was because the key parties like TU-Delft, TNO, Technolution and RWS were familiar with each other (because of the many previous project that they have collaborated with each other) (Stoelhorst, 2017). It introduces the issue on communication. By making a choice to collaborate with familiar actors, one reduces the possibility of uncertainty in the effectiveness of the collaboration process.

Potential of the Netherlands in the ITS market. For the execution of Dynamax, the essential knowledge was already available via knowledge institutes like TNO and the TU-Delft, as can be deducted from the interview (Stoelhorst, 2017). This indicates that the issue of knowledge availability on ITS is relevant within the context of Dynamax. It suggests though that the potential of the Dutch ITS market was, during the Dynamax project, sufficient enough so that all relevant ITS knowledge was within reach. Yet, since the potential of Netherlands in the ITS market is fully dependent on the ITS investment climate that the Netherlands and other countries maintain (Ommeren; et al., 2016), it is not deemed as a relevant uncertainty factor within this project. This is because the only actor that has influence to this aspect of uncertainty is the Dutch House of Representatives. They are responsible to make decisions that relate to the potential the Netherlands have within the ITS market. From the perspective of policymakers that execute ITS related projects for RWS, it is not relevant as they cannot shift the execution of the project towards another country with a higher potential on ITS development. Therefore, this factor is more relevant for private parties in order to determine in which country to settle. Knowing which country has the most potential in ITS development, could be crucial for those parties. In addition, by investing in a project like Dynamax, the Dutch government is, up to a certain extent, aiming at maintaining an attractive investment climate.
Resistance to change. The project was seen as a technological experiment on speed limits. Therefore, road users were only limited involved in the design and development phases (Stoelhorst, 2017). This indicates that there is an issue of preparedness to switch. Therefore, there could be uncertainty in the technological acceptance of key actors during the first stages of the project. Later in the process though, during the evaluation phase, road users were contacted to grade the different measures (Stoelhorst & Schreuder, 2010). This provided insight in the preparedness to change towards the developed system.

Technological performance. As is stated in Stoelhorst and Schreuder (2010), some of the results were disappointing. Specifically, for the measure focussed on reducing the particulate matter in the air, where “the effect is less significant than expected” (Stoelhorst & Schreuder, 2010). This indicates that there were predefined project expectations. This introduces the uncertainty in the technological performance.

Technological context. The interview with (Bloembergen, 2017) reveals that, after the approval of the I&M board, contractual obligations are set up which cannot easily be disbanded. In addition, it was also indicated that in a time span of 2 years, no significant changes were expected in the status quo (Stoelhorst, 2017). This indicates that there is an issue on disruptive technologies. By designing contracts which are set in stone, it becomes difficult to play into a changing technological context in which the Dynamax project was set. Therefore, there is uncertainty in the aspect of technological context, which relate to aspects as technological relevance and the inherently correlated uncertainty on the activities of the competition over the timespan of the project.

Political context. Because of the high interests from the house of representatives and the I&M for increasing the speed limit on highways, a transition was being initiated from political enthusiasm for the Dynamax project, towards the newly introduced “130 project” (Stoelhorst, 2017). This suggests that there was an issue considering a shift in political support. That indicates that there was uncertainty in the political context for Dynamax.

Legislative context. After adequately looking through all the available resources, and the findings from the interview with Stoelhorst (2017), no indications were found in difficulties considering regulation and legislation. Therefore, this issue and correlated aspect of uncertainty will be left out of the discussion.

Economic context. “Because this project had a significant budget available, the policy terms had to be developed adequately” (Stoelhorst, 2017). This indicates that the issue of financial resources was present during the project. It shows the dependency of RWS on financial resources from I&M (Stoelhorst, 2017) and therefore uncertainty in the economic context. Yet, because of the procurement law, where is imposed that the tender is binding, no actual uncertainty was present during the project in the predetermined budget availability. Yet, uncertainty might have arisen in a scenario where the budget was exceeded. For that reason, this uncertainty aspect is included.
**Environmental context.** As discussed in the paragraph 4.4, unforeseen consequences are correlated to the environmental impact that ITS might have. Since it is not known what the extent of the impact might be on the environment, of the designed ITS in front of the project (Stoelhorst, 2007), there is uncertainty in the aspect of environmental impact of ITS.

**Project durability.** During the interview, a new issue presented itself which might indicate that there is another aspect of uncertainty. The issue correlates to project durability. Project durability focusses on the potential of the considered technology, after the project is concluded. For this, policymakers have to determine what the follow-up trajectory might look like. Then, issues become relevant like a setting up a valid business case or approximating the technological performance. Although estimations of the technological performance were present (Stoelhorst, 2007), there was no business case available for the project. Therefore, the described phenomenon will be addressed as the “long-term ambitions” after finishing the project. The uncertainty of this issue relates therefore relates to “project durability”.

All of the findings of this paragraph have been put in Table 3. This, to give a clear overview on all the elaborated issues and correlated uncertainties that were identified (by means of indications) in the Dynamax case.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market adoption</td>
<td><strong>Scalability</strong></td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td><strong>Applicability local scale</strong></td>
</tr>
<tr>
<td>Communication</td>
<td><strong>Effectiveness of collaboration</strong></td>
</tr>
<tr>
<td>Knowledge availability</td>
<td><strong>Potential of the Netherlands</strong></td>
</tr>
<tr>
<td>Preparedness to switch</td>
<td><strong>Resistance to change</strong></td>
</tr>
<tr>
<td>Project expectations</td>
<td><strong>Technological performance</strong></td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td><strong>Technological context</strong></td>
</tr>
<tr>
<td>Political support</td>
<td><strong>Political context</strong></td>
</tr>
<tr>
<td>Legislation</td>
<td><strong>Legislative context</strong></td>
</tr>
<tr>
<td>Financial resources</td>
<td><strong>Economic context</strong></td>
</tr>
<tr>
<td>The environment</td>
<td><strong>Environmental context</strong></td>
</tr>
<tr>
<td>Long term ambition</td>
<td><strong>Project Durability</strong></td>
</tr>
</tbody>
</table>

*Table 3: overview of uncertainties that have been identified in the Dynamax project, the red uncertainties will not be dealt with because of incomplete information, or lack in relevance within the project.*
5.3 Uncertainty Valuation

All the uncertainties that have been identified and distinguished from the previous paragraph, will now be valued in accordance with the theoretical framework on uncertainties as developed by Walker et al. (2003). Also see paragraph 3.1, for an overview on the relevant theory. Therefrom, the levels of the different uncertainty factors will be set.

The scalability. This segment of uncertainty contains a level 4 uncertainty. The reason for this, is because scalability in the Dynamax project has two extreme outcomes, one outcome in which the developed system is not scalable, and one outcome where the developed system is very scalable. Everything in-between is the extent in which the project is scalable.

Applicability of solution on scale. There are multiple options considering the applicability of systems on other locations. There is one scenario where the system is applicable to all other locations, there is a scenario where it is only limited applicable, and one where it is not applicable at all. Yet, there is one future scenario which is most likely to occur, namely the limited applicability scenario. This uncertainty therefore connects seamlessly to a level 3 uncertainty (see Figure 4).

Effectiveness of the collaboration. Similar to the previous discussed, this factor also considers a level 3 uncertainty. The scenario extremes are; a super effective collaboration, and; a collaboration which ends up in a total disaster. Because of the independent roles that the parties occupied, there is one scenario which is deemed most plausible on forehand, (namely that the collaboration went decently) and therefore it relates to a level 3 uncertainty.

Resistance to change. Since the nature of this uncertainty factor is problem solving (see paragraph 4.4), it is not very likely that there will be an excessive case in resistance to change. By means of probabilistic model, (for example, based on earlier experiences that RWS had in resistance to change with roadside system projects) estimates and confidence intervals can be set up. As a result, a level 2 can be assigned to this uncertainty factor.

Technological performance. There is a probability that the technology works as predefined, a probability where it does not work as expected, and a probability where it does not work at all. Based on indications, simulations and previous experiences, a set of probabilistic parameterizations can be defined (see Figure 4). Therefore, the technological performance is considered a level 2 uncertainty.

Technological context. In here there are infinite unknown futures possible. It is possible that there are no disruptive technologies introduced, but also the possibility that the whole market might change because of the introduction of several disruptive technologies. And, dependent on the type of technology, it might influence the potential of the Dynamax systems, could be used as an add-on, or make the relevant system completely redundant. Therefore, uncertainty in the technological context is deemed a level 5 uncertainty (see figure x).

Political context. This segment of uncertainty contains a level 4 uncertainty. The reason for this, is because the political climate during the Dynamax project has two extreme outcomes, one outcome in which the political status quo maintains the same, and one outcome where the political climate changes extremely. Everything in-between is the extent in which the political context changes.
Economic context. Since there was very significant budget available, and because of the procurement law, where is imposed that the tender is binding, this scenario could not have been changed significantly. Therefore, the economic uncertainty has been rated as a level 1 uncertainty where the future is clear enough within the timespan of the Dynamax project.

Environmental context. There are numerical values that correlate to environmental context uncertainty. Those numerical values consider changes in safety, emissions, noise and traffic flow. Though, up to a certain extent, those can be predicted by means of simulations and previous experiences. Yet, because there are multiple values, which combined can create multiple plausible futures (Walker et al., 2013), environmental context uncertainty is valued as a level 4 uncertainty.

Project durability. To establish the level of uncertainty within project durability, the extent of predictability of the uncertainty outcome will be determined. Project durability in the Dynamax project had two extreme outcomes, one outcome in which the developed system had no potential at all, and one outcomes where the developed system is super durable. Everything in-between is the extent in which the project is durable. The durability of the developed systems is dependent on both external and internal factors. Therefore, there are a known range of outcomes (Walker et al., 2013). Yet, because the outcomes cannot be valued in the extent of plausibility, this project durability is valued as a level 4 uncertainty.

All of the findings of this paragraph are presented in Table 4. The findings have been combined with Table 3 from the previous paragraph. This, to give a clear overview on the values that have been assigned to the distinguished uncertainties of the Dynamax case.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
<th>Level uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change</td>
<td>2</td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
<td>3</td>
</tr>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
<td>4</td>
</tr>
<tr>
<td>Long term ambition</td>
<td>Project Durability</td>
<td>4</td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
<td>2</td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
<td>3</td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
<td>1</td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
<td>4</td>
</tr>
<tr>
<td>The environment</td>
<td>Environmental context</td>
<td>4</td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
<td>5</td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
<td>-</td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
<td>-</td>
</tr>
<tr>
<td>Inertia public parties</td>
<td>Implementation speed</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4 Overview on uncertainties and assigned levels to the identified uncertainties of the Dynamax case.
5.4 Uncertainty influence on out roll

Based on indications from the interview, and findings from the literature, now an assessment will be executed in order to determine whether the distinguished uncertainties have had an impact on the potential of the developed Dynamax systems in the actual case. All the findings will be incorporated in Table 5, in the next paragraph.

- **The scalability.** Yes, Scalability of a technology is inherently correlated to the future potential of it. Though, not including it at the front of a project (Stoelhorst, 2017), takes away the pre-orientation aspect for exploring the potential of a technology. Therefore, it presumed that it did have an impact on the role out.

- **Applicability of solution on scale.** According to the findings from the literature and the interview, this uncertainty factor was not seen as a threshold for further implementation. This, as other aspects where more emphasized to have an impact on the further out roll of the developed technologies (Stoelhorst, 2017).

- **Effectiveness of the collaboration.** The collaboration was deemed fairly effective (Stoelhorst, 2017). Therefore, it did not influence the future potential of Dynamax.

- **Resistance to change.** In this project, there was no extensive resistance to change, according to the evaluation report (Stoelhorst & Schreuder, 2010). This indicates that it did not have an impact on the roll out.

- **Technological performance.** Although it is not brought up during the interview, it is fairly unambiguous that technological performance influences the potential of a system. Therefore, up to a certain extent, it had an impact on the out roll.

- **Technological context.** As can be extracted from the interview, the emergence of in-car technology really had a big influence on the potential of the roadside systems that were developed and implemented for Dynamax (Stoelhorst, 2017). Thus, can be concluded that it did have a significant impact on the further roll out of Dynamax.

- **Political context.** Because of a shift in technological enthusiasm in the Dutch House of representatives from Dynamax to “project 130” (Stoelhorst, 2017), there was a case where the political context significantly influenced the potential of Dynamax.

- **Economic context.** Within the Dynamax context, this uncertainty is excluded in having an impact. This is because the economic context is dependent of the political context.

- **Environmental context.** In the evaluation documents, no extreme unforeseen (negative) consequences were measured (Stoelhorst & Schreuder, 2010). For this reason, is concluded that the environmental context uncertainty did not have an impact on the out tole of Dynamax.

- **Project durability.** Not considering the future trajectory of this project (Stoelhorst, 2017) indicates that one might ignore the development of a valid business case to maintain project momentum. Therefore, project durability is deemed to have an impact on the future potential of Dynamax.
5.5 Strategy assessment

This paragraph will focus on the strategy that was implemented in the light of the different identified strategies. Yet, first will be determined whether the policymaker was aware of the identified uncertainties. Since this aspect (of uncertainty awareness by the policymaker) of the research has been added after the interviews were executed, there is aimed to deduce this information from literature resources and indications during the interview. Subsequently, strategies (which are in line with the theoretical framework of paragraph 4.2) will be assigned to the uncertainties of which the policymaker was aware of.

The scalability. As can be deduced from the interview, the scalability was deliberately left out of the consideration (Stoelhorst, 2017). As is stated, the different trails were focussed on determining the whether the systems had potential for national out roll (Stoelhorst, 2017). Indicating, that the ignore strategy was implemented to deal with uncertainty of scalability during the project. Only to be evaluated and determined afterwards (Stoelhorst, 2017).

Applicability of solution on scale. According to Stoelhorst and Schreuder (2010), the experiments were executed on locations that were deemed as the most suitable candidate for the considered measures. This was done by means of additional research on highways in the Netherlands (Stoelhorst & Schreuder, 2010). This indicates that a strategy was implemented that aimed at reducing the uncertainty during the trial project.

Effectiveness of the collaboration. By choosing to reach out to institutes with whom RWS already has shared experiences with, the policymakers (purposefully or not) choose for (up to a certain extent) reliable collaborating partners (Stoelhorst, 2017). Also, because of the work group, RWS was aware of the established support level from within the relevant actors (Stoelhorst, 2017). It indicates that the policymakers were aware of the uncertainty in effectiveness of the collaboration and acted conscious towards it. This relates to the “Identify” strategy of Van Geenhuizen and Thissen (2007).

Resistance to change. There are indications that relevant road-users were excluded during the project design and implementation process (Stoelhorst & Schreuder, 2010). Additionally, that they were only involved during the project evaluation. It therefore suggests that, within the timeline of the project, right up to the very end, the uncertainty in resistance to change was deliberately ignored.

Technological performance. To determine the technological potency of the different measures within the Dynamax project, the different trials were set up. This, so the technologic performance could be ascertained with adequate proof (Stoelhorst, 2017). No other means are deemed more adequately to determine the technological performances in practice. This indicates that the policymakers consciously aimed at reducing the uncertainty in technological performances by means of trials.

Technological context. Although not explicitly expressed during the interview, it is suggested that there was unawareness in the uncertainty that lies within the technological context. The statement, “there normally does not change a lot in a time period of two years”, Stoelhorst (2017) indicates that he was unaware of the significant changes and level of uncertainty that is
present in this segment. Therefore, no strategy is assigned, but instead there is a case of policymaker unawareness about uncertainty in technological context.

**Political context.** Because the Dutch House of Representatives reached out to RWS to explore opportunities in dynamic speed limits (Stoelhorst, 2017), policymakers might presumably have counted on the full support of those representatives, especially after the project was (successfully) concluded. Yet, there are no indications that the policymakers were aware of the possibility political support could fall away. Suggesting that the policymakers were, like in the technological context, unaware of uncertainty in political context.

**Economic context.** “Because this project had a significant budget available, the policy terms had to be developed adequately” (Stoelhorst, 2017). The policy makers, being aware of the procurement law (Stoelhorst, 2017), deemed that little uncertainty was present in financial resources in the predetermined budget availability. It indicates there was awareness on this aspect, but because a large budget was available, it was knowingly ignored.

**Environmental context.** All possible environmental consequences were already included in the research that preceded at the front of the Dynamax project (Stoelhorst, 2007). Indicating that, in front of the project, knowledge was gathered to reduce uncertainties in potential unforeseen consequences.

**Project durability.** Since the Dynamax project mainly considered technological trials, the policymaker intentionally chose to focus on this aspect (Stoelhorst, 2017). In addition, by making estimations on project costs at the front of the project, insight is gained into financial correlated aspect of the systems (Stoelhorst, 2017). Suggesting that the costs were, up to a certain extent, already known on forehand. Yet, it was only at the completion, during the evaluation, that was consequently concluded that the implementation costs were deemed too significant to make a potential roll out (Stoelhorst, 2017). This information suggests that uncertainty in project durability was deliberately ignored. This, while keeping in mind that the procurement law is binding.

In accordance with the findings presented in this paragraph, there are two factors of uncertainty of which the policymakers were (according to indications) unaware of. What is remarkable is that both relate to context uncertainties. The predominant strategies, that have been identified in the light of uncertainties within the Dynamax project, were the “Reduce” and “Ignore” strategy. This also becomes apparent when looking at Table 5, where all the findings of this paragraph are presented. The findings have been combined with Table 4 from the previous paragraph. This, to give a clear overview on the values that have been assigned to the distinguished uncertainties of the Dynamax case. The green rows of the table indicate which uncertainties were considered to have a negative impact on the future potential of the developed Dynamax systems.

*See Table 5 on the end of this chapter*
5.6 Policies assessment

In the final paragraph of this chapter, the emphasis lies on the implemented policies during the Dynamax project. Like in the previous paragraph, the theory will be used that was discussed in paragraph 4.3. By means of indications and strong signals, it is aimed to discover which policies were implemented in the light of uncertainties. Policymakers, in general, only include one or two different policy types in the process of a project (Walker et al., 2013). The implied policies are narrowly correlated to the “active” strategies which are linked to uncertainties. This is because an active strategy (like identify, reduce and opportunity) indicates that the policymaker was aware and acted consciously on the uncertainty at hand.

There are strong indications that the “predict-and-act” policy was implemented. As is expressed during the interview, at the front of the Dynamax project, the policymakers had to set up a plan of action, a time schedule, and a financial proposition (Stoelhorst, 2017). Because of the procurement law, where is imposed that the tender is binding, no extreme adjustments can be made after approval of the plan by I&M (Stoelhorst, 2017). Especially after new contracts have been signed with subcontractors, for outsourcing segments of the project to external institutes like the TU Delft, TNO and Technolution (Stoelhorst, 2017). There are indications that no flexibility clause was integrated in those contracts (Stoelhorst, 2017). All those factors together strongly suggest that the policymakers implemented a “predict-and-act” approach.

The predict-and-act approach also holds for uncertainty in “environmental context”. At the front of the project, different measures were already predicted to have a set of consequences on the environment. This is suggested because the project results of an earlier completed project, on which the Dynamax projects was built on, showed several external consequences (Stoelhorst, 2007). Suggesting that the consequences of the different project were predicted based on the relevant project results. Acting accordingly on those predictions.

Though there are slight indications that there also was a case of “the expected outcomes” approach (also see paragraph 4.3), where a number of scenarios are laid down. These indications relate to the multitude of different technologies and measures that were tested within the Dynamax project. Because of considering numerous different solutions within the concept of flexible speed limits on highways (Stoelhorst & Schreuder, 2010), it suggests that opportunities are diversified to consider a multitude of different scenarios. That, up to a certain extent, refers back to “the expected outcomes” approach. This approach was implemented in correlation towards uncertainty in technological performances and uncertainty in the applicability on the local scale.

Also see Table 5 on the next page for an overview on the implied policies.
<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Level</th>
<th>Impact</th>
<th>Strategy</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>2</td>
<td>No</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>3</td>
<td>No</td>
<td>Identify</td>
<td>Predict-and-act</td>
</tr>
<tr>
<td>Scalability</td>
<td>4</td>
<td>Yes</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Project Durability</td>
<td>4</td>
<td>Yes</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Technological performance</td>
<td>2</td>
<td>Yes</td>
<td>Reduce</td>
<td>Expected outcomes</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>3</td>
<td>No</td>
<td>Reduce</td>
<td>Expected outcomes</td>
</tr>
<tr>
<td>Economic context</td>
<td>1</td>
<td>No</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Political context</td>
<td>2</td>
<td>Yes</td>
<td>Unaware</td>
<td>-</td>
</tr>
<tr>
<td>Environmental context</td>
<td>4</td>
<td>No</td>
<td>Reduce</td>
<td>Predict-and-act</td>
</tr>
<tr>
<td>Technological context</td>
<td>5</td>
<td>Yes</td>
<td>Unaware</td>
<td>-</td>
</tr>
<tr>
<td>Legislative context</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5, an overview of uncertainties that have been identified in the Dynamax project. The in green highlighted rows were the uncertainties that, accordance with the relevant indications, did have an impact on the roll out. Also, a strategy and policy column is added, which is in line with the finding from this end the next paragraph. The last column considers, if applicable, the implemented policies.
6 Case study: PPA In-Car

The second case that will be analysed for uncertainty management is the Praktijkproef Amsterdam Project (PPA). This project is considered a field trial for innovative In-car and roadside ITS. PPA is initiated by RWS and for that reason this project is relevant to analyse as it is initiated by a governmental agency. Since this project touches onto a multitude of different systems and currently is in the last phase of implementation, the case focuses only on a segment of the whole project. Namely the in-car segment of the first phase. To give better understanding on what the PPA project is all about, the next paragraph will first elaborate on some essential background information. Subsequently a more elaborate process analysis will be done into the In-Car segment of the project. After that, an analysis will follow on the different problems and correlated uncertainties that were identified in the project process within available literature. Those uncertainties will then be valued accordingly, in a similar way as was shown in the previous chapter. Then the different strategies and implemented policy will be ascertained. By means of an interview with the project manager is aimed to determine whether those finding are accurate.

6.1 Background information on Praktijkproef Amsterdam

The first plans for PPA stem from 2007 (Bloembergen, 2017). Back then, the project focussed solely on roadside systems to improve traffic flow in and around Amsterdam. Yet, around 2011, the potential of In-Car systems was perceived. As a reaction to this trend, in-car technology was integrated in the project. As a consequence of this In-car integration process in PPA, the goal of the PPA project shifted to interconnecting roadside systems with in-car systems to improve traffic flow (Bloembergen, 2013). This resulted in a new project lay-out (Bloembergen, 2017). According to this new layout, the PPA project was divided into three phases. Also see Figure 7 for an overview on three phases of PPA. To clarify what the distinguished phases implied, the follow-up part of this paragraph will give a short description on this.
6.1.1 PPA phase 1

The first phase implies the testing of the different systems separately. This phase mainly puts the emphasis on roadside units and so called “in-car” systems. Roadside units refer in this project to, amongst others, traffic lights that regulate the flow insertion on the highway and matrix displays at the highway to provide traffic with recommended speed rate. In-car systems are in this case applications which people can use that provide real time data considering relevant traffic. Think for example of personalized navigation advice towards destinations. In PPA this focussed on 1; alignment with other traffic users to distribute traffic flows evenly over the multitude of possible routes and 2; taking parking availability and opportunities into account during the route (Rijkswaterstaat, 2016c).

6.1.2 PPA phase 2

The second phase of the PPA project is divided into three separate experiments, namely PPA North, PPA West and PPA Southeast. Each of these three experiments are attempting, on an incremental basis, to integrate the different systems that were analysed in phase one within their assigned zones. PPA North will execute their experiment in the Northern region of the Amsterdam metropolitan area. They focus on the Roadside units and to what extent they can be improved and applied in other cities. PPA West looks into the opportunities of using floating car data (FCD) to improve traffic flow and reduce the costs within the western region of Amsterdam. PPA Southeast analyses the use of Roadside units in combination with in-car technology to control and distribute traffic evenly over different garage parking locations (Rijkswaterstaat, 2016d).

6.1.3 PPA phase 3

In the third and last phase, PPA attempts to fully integrate all the different systems in the entire metropolitan area of Amsterdam. This is to create a more coherent traffic control platform of a variety of systems to better regulate traffic flows in and around Amsterdam. This subsequently helps Amsterdam to predict traffic flows in and around this area. The PPA project currently is at the second phase (Rijkswaterstaat, 2016e). Also see the website (www.praktijkproefamsterdam.nl) of PPA to get a more detailed view on their progress over the past few years (Rijkswaterstaat, 2016b).
6.2 Case description

As noted earlier, solely the in-car segment of PPA phase 1 will be elaborated upon in this thesis. It can be seen as a standalone project as it is not notably influenced by other segments of the PPA project. Therefore, other segments of the PPA project will be left out of the discussion. Yet, because the previous paragraph is relatively brief in what this segment is all about, a more detailed elaboration follows in this paragraph. In the rest of this thesis this project segment will be referred to as ‘PPA in-car’.

While the initial plans for PPA stem from 2007, the PPA in-car segment was added later on. Around 2011, the aspect of in-car technology was included by I&M. Although no concrete plans were set up, Bloembergen (the project leader) was monitored by a PPA steering committee, which were involved during key decision-making moments (Bloembergen, 2017). The steering committee consisted of key spokespersons from major stakeholders (RWS, I&M, Municipality of Amsterdam, The province of North Holland and City region Amsterdam) (Rijkswaterstaat, 2016b). The initial ambitions in planning, at the start of the PPA in-car project, was to finalize it in the beginning of 2015. Therefore, the in-car segment was, alike the entire PPA, divided into three phases. These were as follows (Bloembergen, 2011):

- Phase 1; This phase focussed on primary activities as a consultation procedure with the market, and a project preparation in anticipation of the consultation results.
- Phase 2; This phase is dedicated to execution, and therefore the actual testing of the different measures of the project in practice.
- Phase 3; The final phase is devoted to the evaluation of the project results. Thereby, will be determined up to what extend the relevant included measures are scalable.

![Figure 8, PPA in-car initial approach (Bloembergen, 2011)](image-url)
Every phase was planned to be executed in the correlated, overarching phases of the generic PPA project (Bloembergen, 2011) (Also see Figure 8). The adjacent goal of the entire in-car segment in PPA was to better advice and inform road users about the concurrent traffic situation and route navigation on a significant scale within the region of Amsterdam (Bloembergen, van den Ancker, Sinkeldam, & Kramer, 2016). Thereby the emphasis was put onto two fields.

➢ The first one considered testing different opportunities for the distribution of traffic information among road users. As a result, in 2012 was decided to divide the first phase into two experiments. One experiment was focussed on event traffic and the other experiment on commuting traffic. The latter one would be aimed at traffic within the whole metropolitan region of Amsterdam. Yet, the event related traffic, would be implemented in two different regions, namely Amsterdam Rai and Amsterdam South-East (Bloembergen, 2012) (see Figure 9).

➢ The second one focusses on enabling the market to become more involved in the mobility segment by giving private parties the opportunity to come up with solutions. Therefore, for PPA in-car, a contest was organized for the market, where they strived to combine both fields into one (Bloembergen et al., 2016). As a result, two different applicants were selected for the project.

When placing this within the ITS framework, as defined in paragraph 3.2, the typology of the ITS system can be identified. These experiments aim on providing users with relevant real-time information on their specific route. Both within the context of event related displacements, as within the context of commuting traffic related displacement. This indicates that the PPA In-car project is correlated to an ATIS typology of ITS (Ezell, 2010).

![Figure 9, a map of the metropolitan area of Amsterdam. The area in the red border is to be covered for the commuting traffic flow experiment, and the yellow and green highlighted areas for the event-traffic flow experiment (Schoemakers & Engelenburg, 2014).](image)

While aiming at achieving the top requirement of the project, another, up to a certain extent, correlated factor was also deemed relevant. This was the evaluation aspect of the different trials. Therefore, the emphasis was put onto the measurability of the developed services (Bloembergen et al., 2016).
During the selection procedure for the contest that was issued by PPA, two of the most promising consortia were selected to which the projects would be attributed to (Rijkswaterstaat, 2013).

The first consortium was called Amsterdam Onderweg (AO). This consortium consisted of the parties TNO, TU Delft and ARS. During PPA In-Car, AO developed two “in-car” mobile phone applications (apps), which were in line with the predefined requirements. These apps were the Superticket (also known as Super-P route), which focussed on event-related traffic, and the app Superroute, which considered commuting traffic (Jonkers, Wilmink, & Duijnisveld, 2016). Gradually in the process, Superticket was integrated into Superroute (Bloembergen et al., 2016).

The second consortium was AmsterdamMobiel (AM), which consisted of the parties Arcadis and VID (a Dutch traffic information service organization). This consortium developed the app EVA, which, like Super-P route, focussed on event-related traffic. The other app, ADAM, was like Superroute, an app for commuting traffic within the metropolitan region of Amsterdam (Immers et al., 2015).

Next to the two discussed consortia, there were several other parties involved during the PPA in-car project like road the road authorities (municipality, the province and RWS) and relevant service providers (Bloembergen et al., 2016). Though, this public-private collaboration process went troublesome. Therefore, the initiation process was considered slow and inefficient. One of the impediments in this aspect was the understanding for each other’s values, and the more generic communication between relevant parties (Bloembergen et al., 2016).

Because of those communication barriers (Bloembergen, 2017), in combination with disappointing results, was decided not to proceed with the ADAM trial of AM (Bloembergen et al., 2016). The other two services (EVA of AM and Superroute (with Superticket integrated) of AO) have been fully completed. In the evaluation phase of the PPA in-car, the two applications were tested on the potential of valid business case. Both projects were not deemed sufficiently cost-effective to scale up the provided services in the light of the achieved results in reduction of VLH (Bloembergen et al., 2016). Though segments of the developed services could be used for other projects (Bloembergen et al., 2016).
6.3 Uncertainty assessment

Like in the previous case study of Dynamax, the uncertainty assessment will be focussed on identifying issues that can be correlated to uncertainties. Therefore, the assessment will be focussed onto the ‘by literature identified’ issues and correlated uncertainties (see paragraph 4.4), as well as the newly identified ones of the Dynamax case. Subsequently, if new issues are identified, those will be included according at the end of enumeration. At the closure of this paragraph an overview will be given on the relevant identified uncertainties. Also see Table 6.

The scalability. During the initiation phase was mentioned that only in the evaluation phase the aspect of scalability will be considered (Bloembergen, 2011). Later, in anticipation of the contest, one of the assessment criteria considered scalability (Bloembergen, 2013). This indicates, that there was existing uncertainty in scalability.

Applicability of solution on scale. The in-car experiment considered an application that supplied a tailormade advice for road users. This was done by determining the concurrent location of the app-user, to subsequently establish the best route, while taking into account the relevant concurrent traffic situation (Bloembergen et al., 2016). This indicates that the issue; applicability of solution on scale, was present in the PPA in-car project.

Effectiveness of the collaboration. The communication between the key players of the project was one of the hurdles in the PPA in-car project process (Bloembergen et al., 2016). The underlying reason for this was conflicting interests in the project that surfaced (Bloembergen, 2017). That indicates there was uncertainty in the effectiveness of the collaboration.

Potential of the Netherlands in the ITS market. Similar as described in the Dynamax case, uncertainty in “potential of the Netherlands” is not deemed relevant within this project. This is because the only actor that has influence to this aspect of uncertainty is the Dutch House of Representatives. Also see paragraph 5.2, for a more elaborated version on why not to include this uncertainty in the PPA in-car project.

Resistance to change. The project was completely dependent on road-users, as the application had to be used on a large scale, to create a measurable effect on the road. Though, to acquire as many application users as possible, (to limit the resistance to change) the application had to be developed in close cooperation with road users. This was being done by means of a feedback based communication clause, in which errors in the software were identified by the users (Bloembergen et al., 2016). This indicates that there was uncertainty in resistance to change from the market.

Technological performance. During the interview on PPA in-car, the aspect of uncertainty in technological potential surfaced. With the selection process for winners of the project contest, twice was chosen for a mobile application. At the time this market was very uncertain, as the smartphone applications market was small, yet potentially emerging (Bloembergen, 2017). The technology was highly dependent on the number of users. Indicating that there was uncertainty in technological performance.
Technological context. As discussed in the previous uncertainty indention, there was uncertainty in the smartphone applications market (Bloembergen, 2017). There were no indications whether the smartphone would become a common product. Which is why, during the consultation phase, there were discussions about the project orientation. Considering whether the project had to be focussed on smartphone applications or on-board units. In the end, by means of a contest, the decision was left to the consortia, resulting in two app-oriented projects (Bloembergen, 2017). This discussion indicates there was a case of uncertainty within the technological context.

Political context. In 2011, the PPA in-car segment was brought forward by I&M to be included into the generic project of PPA. Indicating that the political context exerted influence on PPA by changing the orientation. To subsequently exert influence on the process by means of a steering group (Bloembergen, 2017), suggests that I&M is closely involved in the execution of the project. Implying that uncertainty in political context is present in the PPA in-car project.

Legislative context. In contrast with Dynamax, this aspect of uncertainty is very relevant. Along the PPA in-car project process, emphasis was put on privacy and the protection of personal data (Bloembergen et al., 2016). Yet, at the front of the project, in anticipation of the contest it was not adequately included in the project (Rijkswaterstaat, 2013). Indicating that there was uncertainty in the light of legislative context.

Economic context. “From a financial perspective, no problem were noticed” (Bloembergen, 2017). This indicates that no adequate problems were present in the light of financial resources. Yet, it shows that the issue of financial resources is relevant within PPA in-car. There is financial dependency on the governmental institutes as investors (Bloembergen et al., 2016). Therefore, suggesting that there might be uncertainty in the economic context of the project.

Environmental context. After looking through the available resources and findings from the interview, no indications were found in issues that can be correlated to the environmental context. While leaving personal impressions out of the picture. Therefore, this issue and correlated aspect of uncertainty will be left out of the discussion.

Project durability. This additional uncertainty, extracted from the Dynamax project, will also be looked upon in the uncertainty assessment process of the PPA in-car case. During the contest, the aspect of a business case was included in the selection procedure (Rijkswaterstaat, 2013). By setting up a business case, a company aims at demonstrating what the market value would be of the, in this case, to be developed technology. This way, an attempt is being made to link an earnings model to the developed system, after the project has been concluded (Robinson & Dechant, 1997). Concluding that a business case focusses on project durability. The presence of it at the front of the project, might indicate that this was sufficiently anticipated upon. Yet, during the review was suggested that this was not the case (Bloembergen, 2017). Suggesting that uncertainty in project durability was relevant in the PPA in-car case.

Implementation speed. During the interview, a new issue presented itself which might indicate that there is another aspect of uncertainty. The issue correlates to the inertia of public parties.
As stated during the interview, “inertia is inherent to how the government functions” (Bloembergen, 2017). This issue therefore introduces the aspect of uncertainty in implementation speed. This would be caused by a twofold of factors. The first one correlates to the numerous of committees and organizations that exert influence on project processes. This causes that many intermediate steps have to be executed before actual actions can be taken. The second factor correlates to the risk averseness. When senior officials have to make decisions, those decisions have to be justified to their superiors in the case something goes wrong. Therefore, governmental institutes aim to reduce risks as much as possible (Bloembergen, 2017). Within the project of PPA this was also the case, as there was a steering committee that had to be involved during key decision-making moments (Bloembergen, 2017). Indicating that there was uncertainty in the light of implementation speed.

All of the findings of this paragraph have been put in Table 6. This, to give a clear overview on all the elaborated issues and correlated uncertainties that were identified (by means of indications) in the PPA in-car case.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
</tr>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change</td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
</tr>
<tr>
<td>The environment</td>
<td>Environmental context</td>
</tr>
<tr>
<td>Long term ambition</td>
<td>Project Durability</td>
</tr>
<tr>
<td>Inertia public parties</td>
<td>Implementation speed</td>
</tr>
</tbody>
</table>

Table 6, overview of uncertainties that have been identified in the PPA in-car project, the red uncertainties will not be dealt with because of incomplete information, or lack in relevance within the project.
6.4 Uncertainty Valuation

Like in the Dynamax case, in the uncertainty valuation paragraph, all the uncertainties that have been identified and distinguished in the PPA in-car project from the previous paragraph, will now be valued in accordance with the theoretical framework on uncertainties as developed by Walker et al. (2003). Also see paragraph 4.3 for an overview on the relevant theory.

The scalability. The valuation of uncertainty in scalability within the PPA in-car project is similar to that of the Dynamax project. Therefore, the same argumentation accounts as discussed in paragraph 5.3. Therefore, uncertainty in scalability is valued as a level 4 uncertainty.

Applicability of solution on scale. As the solution is focussed on ‘personalized’ route advice, the extent of uncertainty in “applicability of the solution on scale” is very limited. There is only one scenario which is most apparent. The chances in deviations from this scenario are deemed nil. Therefore, the level of this uncertainty best matches the level 1 uncertainty (Walker et al., 2013).

Effectiveness of the collaboration. This factor considers a level 4 uncertainty. This is because a contest is being organized where private parties can form a consortium themselves. By doing so, the policymaker does not know with which parties they will be collaborating with. The effectiveness in collaboration can therefore be distinguished into two scenario extremes; an excellent collaboration process, and; a collaboration which ends up in a debacle. All the scenarios that fits in-between are also possible. There is no case of a most plausible scenario and therefore it relates to a level 4 uncertainty (Walker et al., 2013).

Resistance to change. In the context of the PPA in-car project, there is a high dependency on the adoption rate of the market. Therefore, it is key that any resistance in change is anticipated upon on forehand. Not knowing what the extent of preparedness is from road-users to use the developed applications, makes this aspect very uncertain. Therefore, it is valued as a level 4 uncertainty, where there are a multiplicity of plausible futures (Walker et al., 2013).

Technological performance. The process of how smartphone application servers gather, and combine data, to subsequently convert this data into useful information and distributes that amongst the network of users, could be a complex process. Yet, this complex process can be tested elaborately without jeopardizing the safety of the road users. In addition, the systems can easily be adjusted in accordance with acquired feedback. This way a policymaker can aim for a goal and adjust the system along the way. Therefore, because the flexibility that is inherent in smartphone application development process, it is seen as a level 2 scenario.

Technological context. Like in the Dynamax project, in PPA there are also an infinite of unknown future scenarios possible in the technological context. It is possible that there are no disruptive technologies introduced, but also the possibility that the whole market might change because of the introduction of several disruptive technologies. Therefore, uncertainty in the technological context is deemed a level 5 uncertainty (see Figure 4).

Political context. This segment of uncertainty contains a level 2 uncertainty. The reason for this, is because the political climate during the PPA in-car project was included in a segment of the project. This, was done by means of a steering group (Bloembergen, 2017). This way political support was maintained, by close involvement of relevant parties (Walker et al., 2013).
**Legislative context.** The Dutch legislation is very stable. Not many laws are being adapted, and even if this is the case, it often considers small adjustments to the status quo. In additions, these adjustments can be monitored effectively as pre-notifications are often elaborately announced about a year in front of the actual adjustment. Therefore, this uncertainty aspect a level 1 uncertainty, as the context is considered clear enough (with sensitivity) (Walker et al., 2013).

**Economic context.** Since there was very significant budget available, and because of the procurement law, where is imposed that the tender is binding, this scenario could not have been changed significantly. Therefore, the economic uncertainty has been rated a level 1 uncertainty where the future is clear enough within the timespan of the project (Walker et al., 2013).

**Project durability.** The valuation of the level uncertainty in project durability is determined to be a level 4. As earlier mentioned, project durability is often correlated to the presence of a valid business case. But, in the context of the PPA in-car project, the validity of the business case only was determined after the project was concluded (Bloembergen, 2017). Indicating that there are a known range of outcomes, but no indications of likelihood in outcomes (Walker et al., 2013).

**Speed of Implementation.** The speed of implementation is often subject to public parties and the inertia to act, which is inherently correlated to this uncertainty. Therefore, the planning often is running late. Indicating there is a multitude of future scenario’s possible, where one is most likely to occur. Suggesting that this is a level 3 uncertainty (Walker et al., 2013).

All of the findings of this paragraph are presented in Table 7. The findings have been combined with Table 6 from the previous paragraph. This, to give a clear overview on the values that have been assigned to the distinguished uncertainties of the Dynamax case.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
<th>Level uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change</td>
<td>4</td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
<td>4</td>
</tr>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
<td>4</td>
</tr>
<tr>
<td>Long term ambition</td>
<td>Project Durability</td>
<td>4</td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
<td>2</td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
<td>1</td>
</tr>
<tr>
<td>Inertia public parties</td>
<td>Implementation speed</td>
<td>3</td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
<td>1</td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
<td>2</td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
<td>5</td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
<td>1</td>
</tr>
<tr>
<td>The environment</td>
<td>Environmental context</td>
<td>-</td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 7 Overview on the values that have been assigned to uncertainties of the Dynamax case.*
6.5 Uncertainty influence on out roll

With the uncertainties that have been identified, an assessment will follow in this paragraph, where will be determined whether the distinguished uncertainties have had a negative impact on the potential of the developed PPA in-car systems in the actual case. All the findings will be incorporated in Table 8, of the next paragraph.

- **The scalability.** The scalability of the PPA project was already significant. Around 20,000 download per application had been achieved (Bloembergen et al., 2016). Yet, it did influence the potential of the ADAM project. After it became apparent that the users described the application as vague and unclear. In addition, the app functionality turned out to be incompatible with the information needs of the users (Bloembergen et al., 2016). Therefore, the issue of market adoption negatively influences the scalability of the ADAM project. Indicating that uncertainty in scalability did have a significant impact on the PPA in-car project potential.

- **Applicability of solution on scale.** According to the findings from the literature and the interview, this uncertainty factor was not seen as a threshold for further implementation. This, as the solution actually focussed on a personalized route advise (Bloembergen et al., 2016). Indicating that this aspect did not have an impact on the further out roll of the developed technologies.

- **Effectiveness of the collaboration.** The collaboration was deemed a hurdle in the project process, and even contributed to the shutdown of the ADAM project (Bloembergen, 2017). Suggesting that the uncertainty in collaboration effectiveness did influence the project results, and therefore the future potential of the developed applications.

- **Resistance to change.** As earlier stated, the PPA in-car project was implemented on a significant scale. And with about 20,000 downloads per application (Bloembergen et al., 2016), it suggests there was a high involvement rate of technological enthusiasts. Indicating that there was no case in resistance to change which might have influenced the potential of the developed applications.

- **Technological performance.** “Due to insufficient participants and an excessive spread in time and place there are no flow effects observed in commuting traffic” (Bloembergen et al., 2016). This indicates that the potential of the system on the market was influenced. Therefore, it is deemed that the technological performance did have an impact on the out roll.

- **Technological context.** Although indications show that there was uncertainty in the technological aspect, when was chosen for smartphone applications in the project (Bloembergen, 2017), it did not negatively influence the potential of the project. This, as the smartphone market gained in penetration rate.
- **Political context.** The technological enthusiasm from representatives (via the steer group) was not changed significantly during the process, to exert influence on the potential of the project within the Dutch House of representatives. And, because the overall PPA project is still being executed nowadays (Bloembergen, 2017), there are strong indications, that the political context did not significantly influence the potential of PPA in-car.

- **Legislative context.** The only legislative related issue that was considered important in the project process was privacy. Since, during the project, no issues on privacy have arisen (Bloembergen et al., 2016), it is deemed that it did not have an effect on the potential of the developed applications.

- **Economic context.** Similar as with the Dynamax project, this uncertainty is excluded in having an impact in the PPA in-car project. This is because the economic context is dependent of the political context.

- **Project durability.** During the review was suggested that a business case was not adequately included in by the two consortia (Bloembergen, 2017). Afterwards, the business case was not deemed sufficient to scale up the projects (Bloembergen et al., 2016). Indicating that project durability did have an impact on the future potential of Dynamax.

- **Speed of implementation.** Although implementation speed is relevant within the uncertainty assessment, it will not be included in the influence on out roll assessment. This is because the considered context uncertainty factors have a higher chance of influencing the process because of the longer project implementation process. Therefore, the influence on out roll within speed of implementation uncertainty is included in those context factors.
6.6 Strategy assessment

This paragraph will focus on the strategy that was included in the light of the different identified strategies. Yet, first will be determined whether the policymaker was aware of the identified uncertainties. Since this aspect (of uncertainty awareness by the policymaker) of the research has been added after the interviews were executed, there is aimed to deduce this information from literature resources and indications during the interview. Subsequently, strategies (which are in line with the theoretical framework of paragraph 4.2) will be assigned to the uncertainties of which the policymaker was aware of.

The scalability. In the contest, the aspect of scalability is left out of the requirements. Yet, the implementation scale is inherent to the project, as the emphasis is put on a large scale trial (Rijkswaterstaat, 2013). Indicating that it was included into the project as one of the main goals. When assigning a strategy to uncertainty in the light of scalability, indications advert to the reduce strategy. This is because, the scalability of the projects is tested by means of a trial. A trial indicates that, by means of an experiment, one aims to reduce uncertainty when aiming to apply such a test on a national scale.

Applicability of solution on scale. As earlier mentioned, the solution of the project focusses on ‘personalized’ route advice (Bloembergen et al., 2016). Therefore, incorporating this aspect of uncertainty into the project making it one of the key focus points. Therefore, indicating that one aims to “reduce” this uncertainty and collecting additional information by means of a trial test.

Effectiveness of the collaboration. When setting up a contest in order to activate private parties to look for opportunities to solve the presented problem, a policymaker creates full uncertainty in the parties with whom he will collaborate in the project. With the relatively superficial selection procedure (Rijkswaterstaat, 2013), is suggested that the policymaker was “unaware” of uncertainty in the aspect of the collaboration.

Resistance to change. There are indications that relevant road-users were excluded during the project design phase. Later in the process, by means of a feedback loop for the application, road users were involved during the implementation and evaluation phase (Bloembergen et al., 2016). It therefore suggests that at the front the project, this aspect was excluded of the process. Only incorporating it, during the process. Because of the adaptability options of smart-phone applications, the uncertainty is approached with an “Opportunity” strategy.

Technological performance. To determine the technological potency of in-car applications, the trials were set up. This, so the technologic performance could be ascertained with adequate proof (Bloembergen, 2017). No other means are deemed more adequately to determine the technological performances in practice. This indicates that the policymakers consciously aimed at reducing the uncertainty in technological performances by means of trials.

Technological context. As can be deduced from the interview, uncertainty in technological context was already present at the front of the project (Bloembergen, 2017). Suggesting that there was awareness on this contextual aspect. Yet, by choosing then for an application, (knowing that the tender is binding) one excludes the possibility of disruptive technologies being introduced into the market. Indicating that the policymaker ignores the aspect of uncertainty within the technological context.
Political context. In the PPA project was chosen to involve governmental representatives (via the steer group) in the project process. By doing so, one (up to a certain extent) assures political support along the project process. Indicating that a strategy was implemented which can be typified as “opportunity”.

Economic context. Because there were no issues on the financial perspective, while knowing the terms correlated to the procurement law (Stoelhorst, 2017), deemed that little uncertainty was present in financial resources in the predetermined budget availability. It indicates there was awareness on this aspect, but as a sufficient budget was available, it was knowingly ignored.

Legislative context. In the process, the aspect of privacy was identified. As a result, the aspect of privacy was incorporated accordingly in the project. “The trials were executed conform the current laws and regulations about privacy and protection of personal data” (Bloembergen et al., 2016). Indicating that this contextual factor was therefore not seen as an obstacle. Suggesting that the included strategy in the light of uncertainty considered “Identify”.

Project durability. Although the policymakers touched upon the aspect of a business case during the contest (Rijkswaterstaat, 2013), it seems to have slipped the mind of the policymakers after the winners of the contest were selected. The underlying rationale was that there was a train of thought where the selected consortia would further build on the development of a business case (Bloembergen, 2017). Yet, it seems as if, right up to the moment of completion of the evaluation report, that the aspect of a business case is elaborated upon (Bloembergen et al., 2016). Indicating that the policymakers were aware of uncertainty in project durability, and implemented the “Identify” strategy at the front of the project.

Speed of implementation. It seems as if there were some issues in the implementation speed, which also confirms the statement of Bloembergen (2017). In the report from Bloembergen (2011), was indicated that the final results would have been completed in 2015. Yet, the evaluation report was released in 2016. Indicating that there was a case of uncertainty in speed of implementation present in the project process. Yet, there are no concrete indications that the policymaker was unaware of this uncertainty. Neither are there indications that a strategy was included in the light of uncertainty within “speed of implementation”. Therefore, no strategy was assigned to this uncertainty.

In accordance with the findings presented in this paragraph, there is one factor of uncertainty of which the policymakers were (according to indications) unaware of. This uncertainty relates to the collaboration process. Furthermore, the predominant strategy in the PPA in-car case study is the “Reduce” strategy. Additionally, the “Ignore”, “Identify” and “Opportunity” strategy are implied evenly frequent. Also see Table 8, where all the findings of this paragraph are presented.

See Table 8 at the end of this chapter.
6.7 Policies assessment

In the final paragraph of this chapter, the emphasis lies on the implemented policies during the PPA in-car project. Like in the previous chapter, the theory will be used that was discussed in paragraph 4.3. By means of indications and strong signals, it is aimed to discover which policies were included in the light of uncertainties. Only uncertainties with a distinguished ‘active’ strategy will be assigned with a policy. This is because; (1) an active strategy suggests uncertainty awareness of the policymakers, and (2) that the policymaker acted consciously in its presence.

The first policy that was implemented is, similar as with the Dynamax project, the “Predict-and-act” approach. Suggestions are being made for this during the procurement phase in 2011, where the in-car segment of PPA was already determined as the key subject. The policymaker thereupon had to look for opportunities within the industry of in-car technology (Bloembergen, 2017). And, as the different contracts are binding (Bloembergen, 2017), it suggests that a process is initiated where the planned actions are based on predefined predictions about the future project context, and technological performances.

This policy approach holds for uncertainty in “Applicability on local scale”. As it is implied that, during the contest, contestants had to develop a technology which supplied road users with a ‘personalized route advice’. Predicting that this solution will be sufficient for the local conditions in Amsterdam. Hence acting accordingly on those predictions. The Predict-and-act approach also is relevant in uncertainty in the legislative context. This is suggested as “the trials were executed conform the current laws and regulations about privacy and protection of personal data” (Bloembergen et al., 2016). It suggests that no big shifts in the legislative context were predicted. Hence the policymaker possibly acted, based on those indications. Project durability is left out of the policy assessment process, since too little information is available on this matter.

By including a steering group of governmental representatives in the project process, the policymaker aims at assuring political support along the project process. Doing so, this makes it possible to adapt to the changing political context along the project process. Suggesting characteristics of the DAP approach.

There are also strong indications that the “expected outcomes” approach is included as a policy. By setting up a contest, one can select the best solution with the most potential, playing into the concurrent trends and relevant technologies. This indicates that there is a certain amount of flexibility incorporated into the policy at the front of the project. All the different applicants play in on a particular scenario, where the by them presented technology has a lot of potential. The most realistic and achievable scenario, with the best solution in combination with high potential is thereupon selected. Giving slight indications that this “contest design” plays into uncertainties like “resistance to change”, “scalability” and “technological performances”. It suggests that the contests design correlates to the “Expected outcomes” approach, where the scenarios are not filled in by the policymakers, but by the applicants. Thereupon the policymaker chooses the scenario to imply.

Also see Table 8 on the next page.
<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Level</th>
<th>Impact</th>
<th>Strategy</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>4</td>
<td>No</td>
<td>Opportunity</td>
<td>Expected outcomes</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>4</td>
<td>Yes</td>
<td>Unaware</td>
<td>-</td>
</tr>
<tr>
<td>Scalability</td>
<td>4</td>
<td>Yes</td>
<td>Reduce</td>
<td>Expected outcomes</td>
</tr>
<tr>
<td>Project Durability</td>
<td>4</td>
<td>Yes</td>
<td>Identify</td>
<td>-</td>
</tr>
<tr>
<td>Technological performance</td>
<td>2</td>
<td>Yes</td>
<td>Reduce</td>
<td>Expected outcomes</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>1</td>
<td>No</td>
<td>Reduce</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>3</td>
<td>No</td>
<td>Unknown</td>
<td>-</td>
</tr>
<tr>
<td>Economic context</td>
<td>1</td>
<td>No</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Political context</td>
<td>2</td>
<td>No</td>
<td>Opportunity</td>
<td>DAP</td>
</tr>
<tr>
<td>Technological context</td>
<td>5</td>
<td>No</td>
<td>Ignore</td>
<td>-</td>
</tr>
<tr>
<td>Legislative context</td>
<td>1</td>
<td>No</td>
<td>Identify</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Environmental context</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 8, an overview of uncertainties that have been identified in the PPA in-car project. The in green highlighted rows were the uncertainties that, accordance with the relevant indications, did have an impact on the roll out. Also, a strategy column is added, which is in line with the finding from this paragraph. The last column considers, if applicable, the implemented policies.
7 Case study: Spookfiles A58

The final case that will be analysed for uncertainty management is the Spookfiles A58 (SF) project. In English translated it would be called the Shockwave Traffic Jams A58 project. This project is considered a field trial for exploring In-car technologies to improve traffic flow. This section of the thesis will be completely devoted to the SF project. The chapter will be organized as follows; in the first paragraph, a case description will be done on SF project to provide more insight into what the project was about, and what the process looked like. Then, a similar process will be initiated as in the previous two chapters. Hence, an analysis will be done on the different problems and correlated uncertainties that were identified in the project process within available literature. Subsequently, those uncertainties will be valued accordingly, in a similar way as was shown in the previous chapters. Then the different strategies and implemented policy will be ascertained. By means of an interview with the project managers is aimed to determine whether those finding are accurate.

7.1 Case description

The SF project is a recently completed project, as in March 2017 the final evaluation document was presented (Provincie Noord Brabant, 2017). SF is, like PPA and Dynamax, a project that aims at improving traffic flows on highways. It does so by identifying shockwave patterns in highway traffic that originate from one or several cars that recently abruptly braked, forcing nearby traffic to brake too. This causes a chain reaction in oncoming traffic, sometimes resulting in congestion (Bevers, 2016). Also see Figure 10, for an abstract visualisation of this phenomenon.

By identifying those shockwave patterns, road authorities can respond to this phenomenon by giving upcoming traffic personalized speed advice. This way they try to temper and remedy the shockwave before it becomes a traffic jam. To do so, these authorities make use of roadside units, in-car systems and service providers. By making these systems collaborate with each other, it is possible to supply drivers with segmented, real-time based speed advice (Bevers, 2016). Indicating that the ITS typology of the implemented SF systems correlates to an ATIS typology. This, because the SF project aims on providing users with relevant real-time information and speed advice on their journey. Mainly within the context of improving traffic flow on highways. That indicates that the SF project is considers the ATIS typology of ITS (Ezell, 2010). Additionally, there was a goal set that the in SF developed systems would emphasize in working towards autonomous driving technologies (Van Veggel & Bevers, 2017).
The A58 highway segment, which is situated in the Netherlands between Tilburg and Eindhoven, was chosen as a test location for the SF project. The reason for this location is because, similar with the Dynamax project, the considered shockwave patterns, in terms of percentages, cause the most traffic jams on this highway segment between Tilburg and Breda (Hendrix & Kerstjens, 2014). Also see Figure 11.

SF is one of the projects that is initiated under the overarching BeterBenutten program. In this program the Dutch government, local authorities and private parties work together to improve the accessibility of regions. ITS is one of the focal points in their mission to achieve this goal, which is also reflected in the SF project. With SF, the provincial authority of ‘Noord-Brabant’ and regional authority Samenwerkings-verband Regio Eindhoven (SRE) (a governing body of 21 local municipalities in the Noord-Brabant province) worked with I&M, RWS and private parties to be compliant with the ambitions of the BeterBenutten program (Beter Benutten, 2013).

The first plans for the SF project stem from 2012 (Van Veggel & Bevers, 2017), yet SF was first made public in November 2013 (Beter Benutten, 2013). The initial planning aimed at a project completion of 2015. The main purpose was show that it was likely that a reduction in shockwave traffic jams was feasible on the A58. Additionally, it was emphasized to create a cooperative technology, where functionally independent subsystems were developed which are in line with European technological standards for traffic systems (Hendrix & Kerstjens, 2014).

The reason why emphasis was put on the aspect that the (to be developed) system had to be in line with European standards, was essential to make the relevant commercially viable. This way was attempted to create support from the market. By making every component as an independent subsystem, the different parties are only limitedly dependent on one another. When stating limited dependent, then think of dependency of one party on data input to make a component work. Or a communication component to make two systems interact with each other. Yet, because multiple parties were active in the same segment at the same time, there was no full dependency on one party (Van Veggel, 2016).
The reason that there were multiple parties involved in the same segment was because, at the front of the project, the applicants were free to sign up for the SF project, in three different plots. These were;

- The Data plot: the parties selected for this plot would be responsible for processing, improving and distributing the relevant data for the cooperative system.
- The Roadside plot: for this plot, the selected parties would work on communication between the different systems. This was focussed on V2V and V2I communication.
- The Service provider plot: The service providing plot focussed on supplying the road users with relevant information, advice and driving task support.

Since there was no existing market for the proposed solution, the relevant parties decided to execute this project in accordance with the Pre-Commercial Procurement (PCP) procedure. This PCP procedure enables relevant authorities to, under competitive market conditions, distribute an assignment for research and development among a multitude of private parties. Yet, this procedure requires those private parties to act transparent towards each other as all the participating parties receive the rights on the developed intellectual property in the project process (van Veggel & Hendrix, 2014).

The PCP procedure was divided into three phases. The first phase considered the specification of the ‘solution design’ which was initiated in January 2014. This phase implied that the design of the solution was being determined in collaboration with all the involved parties. Thereupon every consortium would make a design of their own subsystem. In this phase eleven consortia (30 parties in total) were involved (Van Veggel & Bevers, 2016).

![Figure 12](image-url)
In the transition of the first phase towards the second phase, a selection procedure was initiated, where seven consortia were selected with the best plans. Those consortia thereupon continued to execute their plans in the second phase, which focussed on developing a ‘prototype’ for the project, which would function as a proof of concept (Van Veggel & Bevers, 2016).

The third phase considered the ‘field test’ where the developed prototypes were further developed, in order to be tested in practice. Which is why, at the front of the third phase, six companies were selected which would form two consortia. These two consortia would thereupon develop two refined, yet different test products in a parallel procedure (Van Veggel & Bevers, 2016). Also see Figure 12 for an illustration of what the PCP procedure entailed.

The final product consisted of a smart phone application and an on-board unit. The latter one would function as a way to trace the relevant car that was equipped with the on-board system. The application would be used to inform and advice road users on route and speed (Van Veggel, 2016). The applications that were used are named Flowpatrol & ZOOF. These applications were developed earlier in a BeterBenutten related project called Brabant In-Car III (Meijer & Floor, 2015) but were improved and reused for the SF project.

The companies that were involved in the third phase were as follows (in accordance with van Koningsbruggen, Bosma, and Venema (2015)):

- In the “Data plot” the companies of Be-Mobile and Innovactory/Simacan were the contractors for completing the role as data providers.
- In the “Roadside plot” Siemens and Vialis were the contractors. They had to take care of roadside communication systems, and the communication between the systems.
- For the “Service provider plot” Technolution (Flowpatrol app) and V-tron (ZOOF app) were primarily responsible. They supplied in the smart phone applications and in-car systems.

Although the PCP procedure mainly consisted of private market organisations, there were also many public parties involved. Those considered, amongst others the SF project initiators/road authorities like the Noord-Brabant Province, RWS, I&M and SRE. In general, the collaboration process within the public-private-partnership was deemed effective. And with a budget for the SF project of about €15 million (Logghe & Kerstjens, 2016), no extreme financial limitations were set. Therefore, the project was seen as a success (Van Veggel & Bevers, 2017).
7.2 Uncertainty assessment

This paragraph will focus on the assessment of uncertainties in the SF project. The process will look similar to the previous case studies. Therefore, this paragraph will aim on identifying issues that can be correlated to uncertainties. At the closure of this paragraph an overview will be given on the relevant identified uncertainties. Also see Table 9.

The scalability. The aspect of uncertainty in scalability was very relevant as, during the project process, the topic of market adoption was one of the key issues. This can be deduced from the statement; “the participants are very important for making the project successful” (van Veggel & Hendrix, 2014). “The participants” referred to the road-users that would test the developed systems in practice. Indicating that uncertainty in scalability was present in the SF project.

Applicability of solution on scale. The SF project aimed at supplying road users with a tailormade speed advice to prevent shockwave traffic jams from occurring. The test therefore was executed on a highway segment that was deemed very receptive to these shockwave traffic jams, the A58 (Hendrix & Kerstjens, 2014). Yet, this segment of highway is not representative for the rest of the Netherlands (Hendrix & Kerstjens, 2014). Indicating that there is uncertainty in the light of applicability of the SF system on different locations.

Effectiveness of the collaboration. As earlier elaborated upon, the effectiveness of the collaboration was dependent on the selected “winners” of the PCP-procedure (Van Veggel & Bevers, 2017). This indicates that, during the PCP process, there was uncertainty in the light of effectiveness in collaboration. Apart from this aspect, there also were issues considering the public-private partnership (Van Veggel & Bevers, 2017). Indicating that several uncertainties in the communication emerged.

Potential of the Netherlands in the ITS market. This aspect of uncertainty will, alike the other two cases, not be considered. Also see paragraph 5.2, for the argumentation on why not to include this uncertainty in the SF project.

Resistance to change. The project was completely dependent on road-users, as the application had to be used on a large scale, to create a measurable effect on the road (Provincie Noord Brabant, 2017). This indicates that the issue on preparedness to adapt the proposed system was present in the SF project. Suggesting that there was uncertainty in the light of resistance to change from the market.

Technological performance. As can be deduced from the interview, the project expectations in the light of project results were expected to be higher than the definite results of the SF project (Van Veggel & Bevers, 2017). As the project results are inherently correlated to the technological performance, this indicates that there was uncertainty in the light of technological performance.

Technological context. The introduction of the autonomous driving software from Tesla can, up to a certain extent, seen as a disruptive technology (Evans, 2017). As the SF project aimed at developing systems which might be used for autonomous driving (Van Veggel & Bevers, 2017), it was seen as an unforeseen turn of events. Indicating that there was uncertainty present in the light of technological context.
**Political context.** In the SF project process the policymakers were aware of uncertainty in the light of political context. This can be deduced from the tactically anticipation on uncertainty, as this was done by actively involve relevant public parties in the process (Van Veggel & Bevers, 2017). Despite that there was awareness in this aspect of uncertainty, it at the same time suggests that there was uncertainty in the political context.

**Legislative context.** Similar to the PPA in-car project, the legislation relevant aspects of the SF project mainly related to privacy (Provincie Noord Brabant, 2017). Indicating that issue of legislation being a factor of importance in the process. Therefore, suggesting that uncertainty in the context of legislation was relevant in the SF case.

**Economic context.** From a financial perspective, there was certainty in the light that the available budget on forehand was fixed because of the procurement law. Yet, uncertainty existed in a scenario where the available budget was exceeded. As this was the case in the SF project (Van Veggel & Bevers, 2017), that indicates that there was uncertainty from an economic context.

**Environmental context.** After looking through the available resources and findings from the interview, no indications were found in issues that can be correlated to the environmental context. Therefore, like with the PPA in-car project, this issue and correlated aspect of uncertainty will be left out of the discussion.

**Project durability.** “at the front of the project there were already strong indications that a business case would not be commercially feasible” (Van Veggel & Bevers, 2017). This statement suggests that there was uncertainty in the validity of the business case. Suggesting that there also was uncertainty in the light of project durability.

**Implementation speed.** From the interview can be deduced that the decision-making speed of public parties in some cases have hampered the process speed of the SF projects (Van Veggel & Bevers, 2017). Indicating that, at some points in the process, there was a case of uncertainty in implementation speed.

All of the findings of this paragraph have been put in Table 9 (see next page). This, to give a clear overview on all the elaborated issues and correlated uncertainties that were identified (by means of indications) in the SF case.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
</tr>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change</td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
</tr>
<tr>
<td><strong>The environment</strong></td>
<td><strong>Environmental context</strong></td>
</tr>
<tr>
<td>Long term ambition</td>
<td>Project Durability</td>
</tr>
<tr>
<td>Inertia public parties</td>
<td>Implementation speed</td>
</tr>
</tbody>
</table>

Table 9, overview of uncertainties that have been identified in the SF project, the red uncertainties will not be dealt with because of incomplete information, or lack in relevance within the project.
7.3 Uncertainty Valuation

The different uncertainties now have been identified. With those findings, an uncertainty valuation process will be initiated that is in line with the theoretical framework of Walker et al. (2003). Also see paragraph 3.1, for an overview on the relevant theory. Therefrom, the levels of the different uncertainty factors will be set, and the location of every uncertainty will be determined.

The scalability. When considering this aspect of uncertainty, an assessment will be done on possible scenarios. The issue of market adoption is at the core of this uncertainty. Therefore, there are two extreme scenarios that can be sketched. The first one considers complete market adoption of the developed application. The second scenario is one in which there is no market adoption at all because of lacking usability. Everything that fits in-between these two extreme scenarios outcomes can be seen as a probability. The two extremes are relatively improbable in the case. This is because the PCP procedure aims at selecting the most promising project segments (Provincie Noord Brabant, 2017). This suggests that there is a higher probability of an outcome in which there is a case of middle ground. This relates to characteristics of a level 3 uncertainty (Walker et al., 2013).

Applicability of solution on scale. The proposed solution in the SF project aims on personalized speed advice. This indicates that the extent of uncertainty in “applicability of the solution on scale” is definite. This, because the system aims at taking the surroundings of a singular vehicle unit into consideration when providing the personalized speed advice (Provincie Noord Brabant, 2017). Suggesting that, the systems operates on the smallest possible scale. Therefore, there is only one scenario which is most probable. The chances in deviations from this scenario are deemed nil. These characteristics best match with a level 1 uncertainty (Walker et al., 2013).

Effectiveness of the collaboration. In the PCP procedure, the different parties have gotten familiar with each other. This process therefore elucidated the bilateral interaction between private parties (Bevers, 2016). Suggesting that it might have helped in establishing a good cooperation process among these parties. Yet, the public-private-partnership shed another light onto this aspect of uncertainty. Although prominent members were actively involved in key decision-making moments, there were some issues that surfaced. These issues related to essential divisions within the relevant public parties, which were not prepared to collaborate accordingly with the private parties (Van Veggel & Bevers, 2017). Indicating that there was one scenario which was considered most likely. In the end, one of the more negatively alternate scenarios was the case. Suggesting that these characteristics most correspond to a level 3 uncertainty (Walker et al., 2013).

Resistance to change. Similar to the PPA in-car case, the SF project was highly dependent on the market adoption rate of the proposed applications. In the project process, the relevant parties which were responsible for the development of the application, already had significant experiences in these services within similar project contexts (Meijer & Floor, 2015; van Beek, Huiskens, & van der Knaap, 2015). Therefore, there were multiple scenarios possible, but one, which was most likely which would be in correspondence with earlier project results. Indicating that these traits mostly correspond to a level 3 uncertainty.
Technological performance. The technological performance was dependent on a multitude of systems (van Koningsbruggen et al., 2015). In addition, the technological performances were also dependent on the adoption rate of the application by road-users and the speed advice follow-up rate (Bevers, 2016). Suggesting that this aspect of uncertainty, was dependent on a multitude of other uncertainties. Therefore, there are a multiplicity of plausible futures in technological performance. This points out to characteristics of a level 4 uncertainty (Walker et al., 2013).

Technological context. Because of the technological revolution, trends in sustainability, and the digitalization of the world around us, there is continuous change in the technological state of the art. Because of this, there are infinite future scenarios possible in technological context (within the time span of the SF project) which could significantly influence the potential of the SF project. This correlates to a level 5 uncertainty that is defined by Walker et al. (2013).

Political context. In the SF project, relevant public parties were actively involved in the process (Van Veggel & Bevers, 2017). Indicating that one maintains political support for the project across the planning. This suggests that the policymakers could assign possible futures with estimated probabilities. That correlates to a level 2 uncertainty as defined by Walker et al. (2013).

Legislative context. The legislative uncertainty in SF is similar to the one that is discussed in the PPA in-car segment. Hence see paragraph 6.4, for argumentation and elaboration of the uncertainty valuation. This uncertainty legislative context is valued as a level 1 uncertainty. The legislative issue considers a “context” location uncertainty (Walker et al., 2013).

Economic context. The predetermined available budget was fixed because of the procurement law (Van Veggel & Bevers, 2017). Indicating that this budget could not have been changed significantly. Yet, uncertainty existed in a scenario where the available budget was exceeded (Van Veggel & Bevers, 2017). Therefore, only two scenarios could have been assigned to the economic context situation. One in which the budget was sufficient, and another one in which the budget is exceeded. Probabilities can accordingly be assigned, with a higher chance of staying within the budget. Indicating that there is a clear enough future with sensitivity. Therefore, the economic uncertainty in the SF project has been rated as a level 1 uncertainty.

Project durability. To valuate uncertainty in the SF project durability, the emphasis will be put on the business case (also see paragraph 6.4, for the arguments on why was chosen to do so). More concretely, the presence/absence of one, and the extent in which it was deemed valid. As was stated by Van Veggel and Bevers (2017); “At the front of the project there were already strong indications that a business case would not be commercially feasible”. This suggests that there was certainty in the light of the ‘then present’ business case not being valid. By taking note of this knowledge, the policymaker limits the number of possible future scenarios in uncertainty within project durability. Where there is a single system model with sensitivity in accuracy of the predicted outcome. In the SF project, uncertainty in project durability therefore mostly correlates to the characteristics of a level 1 uncertainty (Walker et al., 2013).
Implementation speed. “... because there was a need to make a decision in one day. This gives no room for elaborate discussion and debate ...” (Van Veggel & Bevers, 2017). This suggests that, along with some other indications that can be deduced from the interview (Van Veggel & Bevers, 2017), at some points in the planning there was a case of a tight schedule. Yet, because public parties were essential in some of the key decision-making moments (Van Veggel & Bevers, 2017), there was dependency on decision-making speed of those actors. When setting up scenario’s this introduces two extremes where in one case, there is full collaboration from the public parties, and another where the public parties recalcitrant during the process. Since both extremes are not deemed probable in the SF project, there is one scenario which is most likely which considers the scenario extremes equilibrium. These indications relate to a level 3 uncertainty (Walker et al., 2013).

All of the findings of this paragraph are presented in Table 10, displayed on the following page. The findings have been combined with Table 9 from the previous paragraph. This, to give a clear overview on the values that have been assigned to the distinguished uncertainties of the SF case.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Uncertainty</th>
<th>Level uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparedness to switch</td>
<td>Resistance to change</td>
<td>3</td>
</tr>
<tr>
<td>Communication</td>
<td>Effectiveness of collaboration</td>
<td>3</td>
</tr>
<tr>
<td>Market adoption</td>
<td>Scalability</td>
<td>3</td>
</tr>
<tr>
<td>Long term ambition</td>
<td>Project Durability</td>
<td>1</td>
</tr>
<tr>
<td>Project expectations</td>
<td>Technological performance</td>
<td>4</td>
</tr>
<tr>
<td>Fragmentation of society</td>
<td>Applicability local scale</td>
<td>1</td>
</tr>
<tr>
<td>Inertia public parties</td>
<td>Implementation speed</td>
<td>3</td>
</tr>
<tr>
<td>Financial resources</td>
<td>Economic context</td>
<td>1</td>
</tr>
<tr>
<td>Political support</td>
<td>Political context</td>
<td>2</td>
</tr>
<tr>
<td>Disruptive technologies</td>
<td>Technological context</td>
<td>5</td>
</tr>
<tr>
<td>Legislation</td>
<td>Legislative context</td>
<td>1</td>
</tr>
<tr>
<td>The environment</td>
<td>Environmental context</td>
<td></td>
</tr>
<tr>
<td>Knowledge availability</td>
<td>Potential of the Netherlands</td>
<td></td>
</tr>
</tbody>
</table>

Table 10, Overview on the values that have been assigned to uncertainties of the SF case.
7.4 Uncertainty influence on out roll

The identified uncertainties from the second paragraph will now be assessed in terms of whether they influenced the project potential, or had an impact on the system out roll. All the findings from this paragraph will be incorporated in Table 11, of the upcoming paragraph.

- **The scalability.** In total 5,500 downloads were realised of the two smartphone applications during the SF project (Provincie Noord Brabant, 2017). Indicating that scaling-up the service was possible. Yet, the market adoption rate was considered too small to create a measurable effect (Van Veggel & Bevers, 2017). Suggesting that there was an issue in market adoption which possibly negatively influenced the project results. In addition to this aspect, there was another correlated issue that was seen as a threshold for project success. That was the scale on which the project was executed. Because the highway segment was relatively small to produce a clear effect (Van Veggel & Bevers, 2017). Hence, both arguments imply that uncertainty in scalability did have an impact on the SF project potential.

- **Applicability of solution on scale.** The applications focussed on personalized speed advice for resolving possible shockwave traffic jams before they occur (Provincie Noord Brabant, 2017). Suggesting that the systems operates on the smallest possible scale, while taking into consideration concurrent real-time surroundings of every unit (Provincie Noord Brabant, 2017). As a result, this uncertainty factor was not seen as a threshold for further implementation.

- **Effectiveness of the collaboration.** There were some hurdles in the SF project process, which had to be overcome. Mainly within the public-private-partnership. Yet, they were resolved without significant adverse effects on the project (Van Veggel & Bevers, 2017). Suggesting that uncertainty in the collaboration process did not negatively affect the future potential of SF.

- **Resistance to change.** As mentioned earlier, there were about 5,500 downloads of the two developed applications (Provincie Noord Brabant, 2017). Yet, it is not clear why relevant road-users were motivated to download the application. Nor are there indications on feedback loops or close involvement of relevant application users. Additionally, there are also no indications that there was a negative reception of the system by the relevant road users. Therefore, no comments can be made on the impact that ‘uncertainty in resistance to change’ could have had on the project potential.

- **Technological performance.** “The whole process from data retrieval until message delivery, functions, from a technological perspective, flawless” (Provincie Noord Brabant, 2017). Suggesting that the developed technology performed as earlier anticipated. Implying that it did not influence the potential of the SF project.
o **Technological context.** At one moment during the SF project process there was a case of disruptive technologies. This correlated to the autonomous driving software which was released by Tesla in January of 2016 (Dikmen & Burns, 2016). This was not anticipated upon (Van Veggel & Bevers, 2017). Yet, although Tesla introduced their self-driving software; it is not seen as a disruptive technology. This, as it approaches the self-driving ability for cars from a completely different perspective. This is why the minister of I&M has indicated to proceed the development process towards autonomous driving (Van Veggel & Bevers, 2017). This, up to a certain extent, suggests that the technological context did not influence the potential of the in SF developed systems.

o **Political context.** There are no indications that a political shift has taken place, where political enthusiasm shifted towards another project as with the Dynamax project (Stoelhorst, 2017). Because of the absence in issues that correlate to the political context, there is made an assumption that it did not have a significant impact on the project roll out.

o **Legislative context.** Similar to the PPA in-car case, the sole legislative related issue that was considered important in the SF project process was privacy. During the project, no issues on privacy have arisen (Provincie Noord Brabant, 2017). Therefore, it is deemed that the privacy issue did not have an effect on the potential of the developed applications.

o **Economic context.** Similar as with the other two cases, this uncertainty is excluded in having an impact in the PPA in-car project. This is because the economic context is dependent of the political context.

o **Project durability.** As mentioned earlier, the business case was not deemed feasible at the front of the project. Because of these indications, the policymaker shifted the emphasis from full project durability to segmented project durability. Meaning that segments of the end product had to be commercially viable. To do so, the policymaker activated all the relevant parties to come up with a commercially viable sub product during the first phase. This would therefore be included in the selection process in-between the three phases (Van Veggel & Bevers, 2017). This indicates that segments from the project were deemed commercially viable. Yet, as the end-product was not commercially viable, it is assumed that it had a negative impact on the project durability.

o **Speed of implementation.** The same arguments that have been discussed in the PPA in-car case, also apply for the SF project (also see paragraph 6.5). Therefore, the influence on out roll within speed of implementation uncertainty is not included in this assessment.
7.5 Strategy assessment

With all the relevant information that has been collected on the identified uncertainties, now an assessment will be done on “if” and “how” was responded to those uncertainties by the policymakers. To do so, strategies (which are in line with the theoretical framework of paragraph 4.2) will be assigned to the relevant uncertainties, based on indications and implications that have been deduced from the interview and relevant SF reports.

The scalability. Scalability was one of the core points in the earlier released reports (van Veggel & Hendrix, 2014). As was concluded, the scale on which the project was executed was deemed too small to create a measurable effect on the road. Yet, it is only in the evaluation report of the SF project that ‘the size of the trial scale’ surfaces as a problem, since it was not mentioned earlier as a (potential) issue (Provincie Noord Brabant, 2017). It therefore seems as if there was unawareness in the relevance of scale for the SF project results. Indicating that the policymaker was unaware of the presence of uncertainty in scalability.

Applicability of solution on scale. The project focusses on supplying road users on personalized speed advice. Indicating that the solution aims to be on the smallest possible scale, taking the surroundings of one unit into considerations. Subsequently providing an acuminate personalized speed advice to the road-users to activate them in helping resolve shockwave patterns in traffic (Provincie Noord Brabant, 2017). This indicates that the applicability of the proposed solution can only be tested by means of a trial. Since the SF project has been executed, there are strong suggestions that this uncertainty is anticipated upon by means of the “reduce” strategy. But, instead of doing additional research, one aims to gain knowledge on ‘applicability of the system on scale’ by testing it in practice.

Effectiveness of the collaboration. The PCP procedure was considered to be an effective collaboration process. Over the three project phases, the different parties get to know each other on a relatively intimate level. This way they explore each other’s values and traits in a slow, but steady pace (Provincie Noord Brabant, 2017). In addition, by including representatives of relevant public parties in the decision-making process (Van Veggel & Bevers, 2017), the public parties also become (up to a certain extent) involved in the collaboration process. This implies that, by means of actively including relevant parties and giving them time to acquaint with one another, the policymaker possibly aimed to reduce uncertainty in effectiveness of the collaboration process. Indicating that the “reduce” strategy was used.

Resistance to change. In the interview was mentioned that, in the early stages of the SF project, a discussion arose about the customers. The discussion considered the issue of “to whom the customers belonged to” (Van Veggel & Bevers, 2017). In this discussion was determined that the customers belonged to the consortia. Additionally, was decided that there would be no intervention in this aspect from the governmental institutes (Van Veggel & Bevers, 2017). Indicating that the policymaker (after the decision was set) could not have influenced this process significantly afterwards. There is no supplementary knowledge on the awareness of the policymaker or possible implemented strategies to deal with uncertainty in resistance to change from the market. Therefore, the assessment considering possible strategies in anticipation of uncertainty in ‘resistance to change’, will be left outside of this research.
**Technological performance.** Similar to the previous cases; in order to determine the technological potency of in-car applications, the SF trial was set up. This was to test the technologic performance in practice (van Veggel & Hendrix, 2014). No other means are deemed more adequately to determine the technological performances. Indicating that the policymakers in the SF project consciously aimed at reducing the uncertainty in technological performances by means of trials.

**Technological context.** The contract that was set up for the SF project was different from the previous discussed cases. There was a possibility in which there is a degree of flexibility processed in the contract. This made it possible to change the technological layout during the process. Therefore, in the SF project, the earlier designed system can be adjusted if there is a case of new and better technological systems introduced onto the market (Van Veggel & Bevers, 2017). Indicating that, in the SF project, uncertainty in the technological context is seen as an opportunity to shape the future. Suggesting that the “opportunity” strategy is implemented.

**Political context.** The policymakers of the SF project chose to involve governmental representatives (by means of setting up a governing body) in the decision-making process (Van Veggel & Bevers, 2017). When the policymakers decided to do so, they (up to a certain extent) assured political support along the SF project process. Indicating that a strategy was included which can be typified as “opportunity”.

**Economic context.** As earlier elaborated upon, the predetermined available budget was fixed because of the procurement law. There are no indications that this budget was deemed insufficient at the time. Yet, in the process, financial aspects were prominent in decision-making moments (Van Veggel & Bevers, 2017). Indicating that they were acting consciously in the presence of uncertainty in the economic context. This correlates to characteristics of the ‘Identify’ strategy (Van Geenhuizen & Thissen, 2007).

**Legislative context.** The strategy that was implemented in anticipation on uncertainty in the legislative context is similar as with the PPA in-car project. Also, the same arguments stand. Those arguments are therefore build on the statement; “When considering privacy protection, the cooperative system is in any case prepared for a safe deployment” (Provincie Noord Brabant, 2017). The implemented strategy for legislative context uncertainty is therefore considered “Identify”.

**Project durability.** Since the business case was not deemed feasible at the front of the project, the policymaker shifted the emphasis from full project durability to segmented project durability. The policymakers therefore emphasised that segments of the end product had to be commercially viable. To do so, the policymaker activated all the relevant parties to come up with a commercially viable sub product during the first phase. This would therefore be included in the selection process in-between the three phases (Van Veggel & Bevers, 2017). Indicating that, because of awareness on a potentially invalid business case, the policymaker transformed a potential project weakness into segmented project opportunities. Suggesting that the “opportunity” strategy from Van Geenhuizen and Thissen (2007) was implemented.
Speed of implementation. “... because there was a need to make a decision in one day. This gives no room for elaborate discussion and debate ...” (Van Veggel & Bevers, 2017). This statement implies that the policymakers did not anticipate upon public party inertia, in terms of needing a longer timeframe to make decisions. Also, two other (more significant) public party related decision-making aspects were big hurdles. Those also had to be overcome in a short timeframe to stay within the planning. These hurdles/discussions related to;

1. Access from private parties to a VPN connection, which was essential for the SF systems.
2. Access from private parties to the electricity network on the highway of RWS.

In the end, both hampered the project speed (Van Veggel & Bevers, 2017). And indications suggest that both were not anticipated upon. As Van Veggel and Bevers (2017) indicated; they gradually found out about the relevant conflicting discussion points. This, while those were at the core of the consequent inert decision-making speed of public parties. Suggesting that they were unaware of the influence that the public parties would have on the implementation speed.

The findings presented in this paragraph show that there are two factors of uncertainty of which the policymakers were (according to indications) unaware of. These correlate to uncertainty in scalability and implementation speed. Furthermore, the predominant strategy in the SF case study is the “Opportunity” and Reduce strategy. Additionally, the “Identify” is included on the lower level uncertainties. Also see Table 11, where all the findings of this chapter are presented.
7.6 Policies assessment

In the concluding paragraph of the SF case study, an assessment will be done on the implemented policy. Like in the previous two case study, the theory will be used that was discussed in paragraph 4.3. By means of indications and strong signals, it is aimed to discover which policies were included in the light of uncertainties.

The PCP-procedure introduces a method of exploratory research. One in which there is an explorative process to select; 1. the technological systems with the most potential and 2. the plans which most adequately resolves the predefined problem during the project process (Provincie Noord Brabant, 2013). It intends to define the problem as effectively as possible, while aiming to build to a most suitable solution. When correlating the PCP-procedure to the policies from paragraph 4.3, the PCP-procedure shows most similarities to the EMA policy (Walker et al., 2013). This, as by means of workgroups, the policymaker let the market parties take its course in defining possible systems for the proposed solution (Van Veggel & Bevers, 2017). Indicating that they are ‘Exploring’ the most suitable ‘model’ for the predefined solution.

That the EMA approach was implemented, is also suggested by including two selection moments in the procedure. In these moments is aimed to select the most promising prototypes (Provincie Noord Brabant, 2013). This is done by ‘analysing’ the feasibility of the individually designed systems, which is done by two administrative bodies (Van Veggel & Bevers, 2017). Indicating that, by means of exploring different opportunities, the best model is selected. Suggesting that an EMA policy is used.

The PCP procedure influenced the uncertainties “effectiveness in collaboration” and “technological performance”. By means of the PCP procedure, the most promising technologies could be selected to improve the potential of the technological performances. Hence the EMA policy was established under these uncertainties. Also see paragraph 7.5 for the substantiation on why the PCP and the considered uncertainties are correlated.

Incorporating flexibility in contracts, indicates that a DAP approach is included to deal with uncertainty in the technological context. By means of this incorporated flexibility, there is the possibility to adapt the designed technological system on relevant unpredictable events (Van Veggel & Bevers, 2017). This characteristic relates, up to a certain extent, to the DAP approach (see paragraph 4.3).

Adding to that, the policy implied in anticipation of uncertainty in “project durability” also contains segments of the DAP approach. By acknowledging the high possibility of a negative business case, the policymaker shifts the “business case” responsibility towards the relevant actors. Doing so, it suggests the aspect of being “adaptive” and responding to change. Those are key characteristics of the DAP approach.

By including a steering group of governmental representatives in the project process, the policymaker aims at assuring political support along the project process. Doing so, this makes it possible to adapt to the changing political context along the project process. Suggesting characteristics of the DAP approach.
For the privacy and economic context uncertainties, there are indications that a “predict-and-act” approach was included. This is because both context uncertainties were explored by means of an abstract concurrent exploration process, where upon the findings of that process, an action plan was set. That can, amongst others, be deduced from the following statement; “When considering privacy protection, the cooperative system is in any case prepared for a safe deployment” (Provincie Noord Brabant, 2017). Indicating that, after an assessment process, a prediction is made on the privacy legislation maintaining its status quo. Whereupon an action was set, which responded to the current privacy legislation situation. Again, suggesting that a predict-and-act approach was implemented (also see paragraph 4.3).

This latter policy also is being implemented in anticipation of uncertainty in “applicability on local scale”. That is being insinuated because a research showed that shockwave traffic jams most often occurred on the relevant A58 highway segment (Hendrix & Kerstjens, 2014). Indicating that, at the time of project initiation, the policymaker predicted that this situation would not change significantly along the project execution process. Suggesting that one acted in line with the predictions.

*Also see an overview of assigned strategies and policies in Table 11.*

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Level</th>
<th>Impact</th>
<th>Strategy</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>3</td>
<td>-</td>
<td>Unknown</td>
<td>-</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>3</td>
<td>No</td>
<td>Reduce</td>
<td>EMA</td>
</tr>
<tr>
<td>Scalability</td>
<td>3</td>
<td>Yes</td>
<td>Unaware</td>
<td>-</td>
</tr>
<tr>
<td>Project Durability</td>
<td>1</td>
<td>Yes</td>
<td>Opportunity</td>
<td>DAP</td>
</tr>
<tr>
<td>Technological performance</td>
<td>4</td>
<td>No</td>
<td>Reduce</td>
<td>EMA</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>1</td>
<td>No</td>
<td>Reduce</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>3</td>
<td>No</td>
<td>Unaware</td>
<td>-</td>
</tr>
<tr>
<td>Economic context</td>
<td>1</td>
<td>No</td>
<td>Identify</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Political context</td>
<td>2</td>
<td>No</td>
<td>Opportunity</td>
<td>DAP</td>
</tr>
<tr>
<td>Technological context</td>
<td>5</td>
<td>No</td>
<td>Opportunity</td>
<td>DAP</td>
</tr>
<tr>
<td>Legislative context</td>
<td>1</td>
<td>No</td>
<td>Identify</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Environmental context</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 11, overview of uncertainties that were identified in the SF project. The green rows were uncertainties that did have an impact on the roll out. Also, a strategy column is added, which is in line with the finding from this paragraph. The last column contains assigned policies that have been implemented in anticipation of the identified uncertainties.
8 Comparative Analysis

This chapter will merge, compare and discuss all the gathered findings which have been elaborated upon in the previous chapters. The comparative analysis will thereupon be focussed on the core issues that have been included in the research questions. Judgements will therefore be made on what knowledge has been acquired within this research. This is done by assigning an extent of significance to the acquired knowledge. Questions like; what meaning to these findings have; how valuable is this knowledge; and why is this knowledge valuable; will be answered. This will help in making knowledge claims on the executed research in the conclusion.

The first paragraph will compare more generic case study characteristics, which are of relevance for the research ‘reflection’ chapter. Thereupon, a paragraph will follow in which the values of the identified uncertainties will be compared. Hence, focussing on key insight for defining an answer on the first research question. Subsequently a case study comparison will be done on the impact of uncertainties on the project potential. Findings on the impact of uncertainties on the project potential could be of value in setting up recommendations. The then two final paragraphs will look into; uncertainty awareness of the policymaker, implemented strategies in the light of uncertainty, and the thereupon carried out policies. Those finding will generate insights that will help answer the other two research questions.

8.1 General project characteristics

In this paragraph, project characteristics will be merged, compared and discussed in a structured way by means of subsections. In these subsections, generic project characteristics will be intensively elaborated upon. By analysing these characteristics, issues might be identified that could be of relevance in the ‘reflection’ chapter. Hence, first a comparison and discussion on the different project locations will be started. Subsequently, the timeframe of the different case studies will be laid down. Thereupon, key actors of the different projects will be elaborated upon, and the relevance of it on the project process will be discussed. The paragraph will conclude with a comparison of ITS typologies from the different cases.
8.1.1 Project locations

The locations of the different ITS trials have all been executed within the borders of the Netherlands. This corresponds to the predetermined scope. Therefore, the relevant legislative contexts are considered similar to each other.

Though, the case study experiments have been executed across four different provinces in the Netherlands. Namely Utrecht, Noord-Holland, Zuid-Holland and Noord-Brabant (See Figure 13). There could be a case of differences in regional conditions. Aspects like time of implementation, stakeholders, the local environment and local customs, could have had an impact on the project progression. Taking these differences in environmental conditions into consideration is deemed relevant as it could have exerted influence on the project process and project results. Possibly affecting the validity of this research as the context in which the different cases have been set were, up to a certain extent, different. These findings can be used when contemplating on the research reflection in the aspect of ‘comparative analysis’ which will follow upon this section.

8.1.2 Project period

The projects all have been initiated and executed within a time span of 10 years (See Figure 14). And, when comparing the different projects, it is noteworthy that the project durations across the three cases are similar to each other. About 4,5 years per project. This could indicate that the extensiveness of the different projects might be similar.

Yet, the initiation moments of the considered cases are relatively different. This becomes particularly evident when examining Figure 14. In this figure, there is a significant difference in time setting, when comparing Dynamax to the PPA in-car and SF project. Again (like in the previous subsection), this might influence the validity of the research when aiming on making firm statements based on data of the extracted cases. On the other side, this gives an opportunity to look for trends in uncertainty management of ITS projects over the past decade. This, as the projects are, in a way, consecutive to one another.

8.1.3 Project actors

When analysing the data that is displayed in Table 12, one might notice that the number of contractors, which are included in the process, have increased significantly over the past decade. Especially when keeping in mind that the time setting of the Dynamax project is significantly different to both the SF and PPA in-car projects. This insight might indicate that more proceedings are being outsourced to the market.
Another aspect which might catch the eye is that regional authorities are becoming more involved in the process. The latter two projects both considered regional municipalities, and provincial authorities. Possibly indicating that there are strong regional ambitions to improve the issues that are correlated to traffic flow. This would be in line with the information which can be deduced from Figure 13.

The latter aspect implies that the different cases consider an increasingly smaller area. If this trend of increasingly smaller testing areas for ITS projects holds true, it could work counterproductive as a small-scale test is not deemed effective for in-car and user dependent ITS project (Bloembergen, 2017; Van Veggel & Bevers, 2017). Possibly increasing uncertainty in scalability and technological performance. Yet, suggestions have been made that newly initiated project are being implemented on increasingly larger scales (Bloembergen, 2017; Van Veggel & Bevers, 2017).

A final phenomenon which is noticed is the increase in private parties that are involved. A notification on this segment is that also fewer parties are incorporated in the project process that have had work experience with governmental institutes. Possibly increasing uncertainty in the effectiveness of the collaboration.

All of these aspects suggest that the governmental institutes like I&M and RWS (which initiate the projects), are aiming towards an ITS market which is more market driven. This would be in line with the ambitions that have been set in the ‘Routemap of I&M’ (de Mooij, 2013). Also see appendix 7.

<table>
<thead>
<tr>
<th>Project&gt;</th>
<th>Dynamax</th>
<th>PPA in-car</th>
<th>Spookfiles A58</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project initiators&gt;</td>
<td>RWS I&amp;M</td>
<td>RWS I&amp;M</td>
<td>RWS I&amp;M</td>
</tr>
<tr>
<td></td>
<td>TU-Delft</td>
<td>Amsterdam municipality</td>
<td>North-Brabant Province</td>
</tr>
<tr>
<td></td>
<td>TNO</td>
<td>North Holland Province</td>
<td>City region Eindhoven</td>
</tr>
<tr>
<td>Key contractors</td>
<td>Technolution</td>
<td>City region Amsterdam</td>
<td>Be-Mobile</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Innovactory/Simacan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Siemens</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vialis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Technolution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V-tron</td>
</tr>
</tbody>
</table>

Table 12: An overview of project initiators and correlated contractors per case. In bold highlighted the actors that were involved in two or more cases of this thesis.

As the scope of my research was focussed on ITS projects, initiated by governmental institutes, one could safely say that this still holds true within the considered cases. But the project management and relevant policymaking is increasingly being outsourced to private parties. This was also more or less the case in the SF project (Van Veggel & Bevers, 2017). Yet, the controlling (decision-making) power still lies primarily within the governmental institutes.
8.1.4 Project ITS types

When analysing the different ITS typologies that have been assigned to the three case studies one trend might be noticed (see Table 13). This trend considers a shift in the ITS market orientation.

With ATMS the emphasis is put on external systems outside the car to coordinate traffic. In contrary, the ATIS focusses on supplying important real-time information to the traveller (Ezell, 2010). Suggesting a prescribed trend where there is a transition in the ITS market. A transition in which the emphasis is being put on systems that are supplying real-time information to road users (Also see Figure 5). This insight is, again, in line with the Routemap that was developed by de Mooij (2013). Also see the ‘I&M Routemap’ in appendix 7. Knowing that this shift is ongoing in the ITS market, policymakers can tune their policy and correlated strategies onto this trend.

Apart from this trend, one could criticize there are differences in ITS orientation between Dynamax and the other two cases. These differences could influence the validity of this research. Yet, when only comparing Dynamax and SF, there are significant similarities. Both the projects consider resolving shock wave patterns and traffic jams on the A58. Suggesting that difference in the ITS orientation of the project, does not mean there are no similarities on the technological aspect of the cases.

<table>
<thead>
<tr>
<th>Project &gt;</th>
<th>Dynamax</th>
<th>PPA in-car</th>
<th>Spookfiles A58</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITS type &gt;</td>
<td>ATMS</td>
<td>ATIS</td>
<td>ATIS</td>
</tr>
</tbody>
</table>

Table 13; An overview of the ITS types that have been developed in, and assigned to, each of the case studies.
8.2 Comparison of identified uncertainties

In this paragraph, a contemplation will be done on the differences and similarities in assigned values to uncertainties. First an assessment and discussion is done on new identified uncertainties. A comparison will follow on the differences and similarities in level uncertainty. We conclude with a discussion on the impact on the outcome.

8.2.1 New identified uncertainties

There are two newly identified uncertainties which have not been found in the literature. As presented, these uncertainties relate to ‘implementation speed’ and ‘project durability’ (for a more elaborate version on what these uncertainties entail, also see paragraphs 6.3 & 7.2).

As can be deduced from the table in paragraph 8.2.3, uncertainty in project durability influenced the potential of all the discussed projects. Uncertainty in implementation speed, on the other hand, is inherent to the project progression (see paragraph 6.3 & 7.2). Suggesting that both of the new identified uncertainties can influence ITS projects.

The two uncertainties have not been identified in the considered literature. Yet, the findings of the interviews and relevant resources indicate that there is a certain extent of awareness on correlated issues. This as the inertia of public parties (correlated to uncertainty in implementation speed) and the relevance of a valid business case (correlated to uncertainty in project durability) are mentioned several times in evaluation reports and the interviews (Bloembergen, 2017; Jonkers, Wilmink, Jöbsis, et al., 2016; Provincie Noord Brabant, 2017; Stoelhorst, 2012, 2017; Van Veggel & Bevers, 2017).

As they are not included in the literature, it is of course relevant to create more awareness on these aspects for policymakers in ITS projects. By excluding them, one introduces more uncertainty in the process, which could negatively influence the potential of a project. Yet, being aware of them, might result in opportunities for the project. Possibly improving the project potential if one effectively tunes its strategies and policies. These insights are therefore deemed very valuable. When correlating these findings to the orientation of this research, it contributes in answering the first research question of this thesis (see paragraph 1.2).

8.2.2 Level uncertainty

When comparing the different assigned level values to the identified uncertainties, two aspects become noteworthy (see Table 14). One considers the remarkable context levels, which all have been assigned a similar level. Those similar assigned levels to context uncertainties suggests that there might be an extent of consistency over all of the ITS projects in the Netherlands.

The second noteworthy issue is that the value in levels of uncertainty are diminishing across the projects. Suggesting that implemented policies influence the levels of uncertainty in ITS projects. This can also be deduced from the different concepts that have been applied over the three consecutive cases. This, as the Dynamax case was fairly straight forward in the planning (Stoelhorst, 2017). The PPA in-car case included the concept of project competition by means of a contest (Bloembergen, 2017). And the SF case considered a concept where there was both competition, and collaboration between parties (Van Veggel & Bevers, 2017). It also suggests increased awareness and anticipation on uncertainties in ITS projects.
This could also be the reason that there is a significant difference between the levels of uncertainty in PPA and SF, as they both consider a similar type of ITS. The difference in included process concepts (the PPA in-car project contest, and the SF PCP procedure), might be the main reason in differences in uncertainty levels. Also see paragraph 6.2 and 7.1 for an explanation on what these project concepts implied.

Knowing the levels of uncertainties across the cases, enables us to determine which policy should have been implemented. This, as in paragraph 4.3, is elaborated which policies, according to the literature, should be used when having knowledge on the levels of uncertainty. When comparing those levels and suggested policies to the actual applied policies enables us to reflect on the policies and the way policymakers acted. Hence, it helps to answer the research question.

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Level Dynamax</th>
<th>Level PPA</th>
<th>Level Spookfiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Scalability</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Project Durability</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Technological performance</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>-</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Economic context</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Political context</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Technological context</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Legislative context</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Environmental context</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 14; A comparison of the levels of identified uncertainties per case. In the cells in dark grey highlighted are uncertainties that have not been identified in the relevant case.

### 8.2.3 Uncertainty impact on out roll

When comparing the different uncertainties, and how it has impacted the potential of the relevant projects, a few things can be noticed. The first one considers the number of uncertainties that had an impact on the ITS projects. The sum of those uncertainties that had an impact on the relevant uncertainties diminished across the discussed cases. The second noteworthy aspect is considering similarities in the relevant projects. When aiming on those similarities one might notice that both uncertainty in ‘scalability’ and ‘project durability’ constantly have influenced the project potential. (For both, also see Table 15)
The observed aspect of diminishing uncertainties might indicate that returning problems and correlated uncertainties are being noticed by initiating parties like RWS or I&M. Subsequently indicating that those parties and relevant policymakers have aimed to effectively deal with those uncertainties across the time period of the three considered cases. This is important to know when taking the second research question into consideration. Which aims at exploring the extent of awareness by policymakers on uncertainties. By taking this suggested ‘diminishing’ trend into consideration, one could consider that there is a case of increased awareness on uncertainties and correlated issues by policymakers.

The other noteworthy facet that was deduced from Table 15, considered the continuity in impact that the uncertainties in both ‘scalability’ and ‘project durability’ have had on project potential of the considered cases. These results imply that it is key for policymakers to actively respond to this trend. This does not mean that other uncertainties, which have not been seen as a continuous problem, can be left out of the scope to deal with. Yet, it does suggest that there is an extent of importance in effectively dealing with these uncertainties in project durability and technological scalability.

This issue hooks on to the second research question. By knowing which uncertainties have a continuous impact on ITS project, one could suggest that an increase is desired on awareness for policymakers on these uncertainties. This possibly could positively influence the potential of new ITS projects in the Netherlands. Also see Table 15.

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Impact Dynamax</th>
<th>Impact PPA</th>
<th>Impact Spookfiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>No</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Scalability</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Durability</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Technological performance</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>-</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Economic context</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Political context</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Technological context</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Legislative context</td>
<td>-</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Environmental context</td>
<td>No</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># of uncertainties with impact</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 15: A comparison of the identified uncertainties which had a (negative) impact on the project results per case. The cells that are highlighted in orange are uncertainties that did have an impact on the project potential.
8.3 Uncertainty strategies

In this paragraph, relevant similarities, remarkable differences, and notable generic information on strategies will be discussed, which are displayed in Table 16. To start of this paragraph an elaboration will be made on uncertainty unawareness by the policymaker within the three discussed cases. The subsequent section will thereupon consider solely the ignore strategies that have been implemented. This to determine the extent of desire to effectively deal with the relevant uncertainty. In the end, a discussion will be started on the other strategies that have been included in the light of uncertainty.

8.3.1 Uncertainty unawareness

There were five different uncertainties across the three cases of which the policymakers were unaware of. According to those indications, two of those five uncertainty unawareness cases took place in the Dynamax project. Only one of those came about in the PPA in-car project. And the final two were relevant in the SF project (also see Table 16).

The uncertainty in which there was unawareness is different across all cases (also see paragraphs 5.5, 6.6 & 7.5 for the indications on which there was deemed policymaker unawareness on the relevant uncertainties). These differences suggest that there is no consistency in unawareness. The sole possibility that could be subject to this irregularity is the individual preferences of the policymaker across the different projects. This, as the policymaker is different in every case. Nevertheless, it is not carved in stone as this assumption (on individual policymaker preferences) is based on far-fetched indications.

On the other side, this information does give firm indications towards the degree of awareness on uncertainties. These indications connect with the second research question which aims on describing the extent of awareness of policymakers considering uncertainties. This is valuable knowledge, since not being aware of all relevant uncertainties could culminate into a less successful project. This is because the relevant uncertainty then could escalate beyond the knowledge of policymakers (Walker et al., 2013). Therefore, suggesting the importance to effectively deal with uncertainties (also see paragraph 4.1). Simultaneously, this also indicates that it is relevant to create more awareness with policymakers in ITS projects of ‘all’ relevant uncertainties.

8.3.2 Ignoring uncertainties

The ‘ignore’ uncertainty strategy is used less and less over the three consecutive cases. Where in the Dynamax case this strategy was used on four uncertainties, in the PPA in-car case this was only done on two uncertainties. The SF project even had none. This shows a trend of diminishing ignore strategies. This trend therefore suggests that, again, there is an increasing awareness on the importance of effectively dealing with issues. Issues (which correlate to uncertainty) that could possibly have a negative impact on the project results.
But could it be desirable to sometimes deliberately ignore a certain aspect of uncertainty? As for example was implied during the interviews with Stoelhorst (2017) and Bloembergen (2017), the available budget was deemed significant for the PPA in-car project and the Dynamax project. If there is a case for sufficient room within the budget, while knowing that the tenders are binding and the expenses are set in the outsourced contracts, it is deemed less relevant to constantly keep track of related financial expenses. Therefore, suggesting that the ignore strategy ‘sometimes’ is desirable up to a certain degree.

Yet, overall, the ignore strategy in the face of uncertainty is not desirable. This is because this strategy does not help reduce uncertainties at a more comprehensive level (Van Geenhuizen & Thissen, 2007). Suggesting that a more active strategy for dealing with more complex uncertainties is desired in ITS projects.

These findings can be useful in answering the third research question which considers how policymakers act in the light of uncertainty. By knowing when an ‘ignore’ strategy could be tolerated in the face of uncertainty, the motives of certain decisions by policymakers can be determined. This gives more insight into how policymakers act and how a possible shift in those actions can be accomplished.

8.3.3 Active uncertainty strategies

The active strategies that have been implemented in the face of uncertainties across the three relevant cases are the ‘Identify’, ‘Reduce’ and ‘Opportunity’ strategies. These strategies are in line with the theoretical framework that was extracted from the article of Van Geenhuizen and Thissen (2007). When looking upon the findings that are displayed in Table 16, a few aspects might catch the eye. First of all, over the consecutive cases, the opportunity strategy is increasingly more included. A second notable aspect, when filtering out the ‘unawareness’ and ‘unknown’ factors of Table 16, the considered strategies are becoming more active of nature. And the last aspect considers similarities in the uncertainties. Specifically referring to the reduce strategies across the uncertainties in ‘technological performances’ and ‘applicability local scale’.

To begin with, the first aspect; the ‘opportunity’ strategy which is increasingly being included. It indicates that, like with the diminishing ignore strategies in the previous subsection, there is a trend where policymakers are responding more effectively on issues that correlate to uncertainties. This is also being substantiated by the second aspect; the increase of implemented strategies that are more active of nature.

When looking at the strategy similarities, a repetitive pattern can be noticed in used strategies for two uncertainties. As mentioned, those correspond to the uncertainties in ‘technological performances’ and ‘applicability local scale’. To deal with those uncertainties, the policymakers across the different cases all have implemented the ‘reduce’ strategy. An incentive for policymakers to do so, lies (in uncertainty in ‘technological performance’) with the project initiators. These project initiators in the Netherlands often refer to I&M. They supply policymakers of RWS with an assignment to explore options for dealing with a designated problem by means of a certain adduced solution. After adequately formulating a desired
solution, the relevant solution is being put to the test. Implying that one reduces uncertainty in technological performance by testing it in practice. Which is the reason for similarities in the assigned strategy for dealing with uncertainty in technological performance.

For the uncertainty ‘applicability local scale’, a different argument stands. Here it is deemed that from the process that was prior to the Dynamax case, the relevance of applicability on scale was being noticed by I&M. This was also substantiated by Stoelhorst (2017). Indicating that this brought about a shift in included solutions in the ITS market by governmental institutes. Suggesting that solutions had to be more tailormade and subsequently implemented on locations where deemed most useful.

Both the similarity cases adduce the factor of influence that I&M exerts on the process. This is also substantiated in the interviews. The policymakers of I&M are therefore often considered the initiators of ITS related projects and key players in the decision-making process (Bloembergen, 2017; Stoelhorst, 2017; Van Veggel & Bevers, 2017). It is not elaborated in what way the process progresses from problem to solution. Yet, they put forward a possible solution to a designated, traffic related problem. Therefore an assignment is outsourced to RWS, the executing agency of I&M. From here on RWS has to further elaborate on the plan, and, when approved, subsequently have to test the relevant solution accordingly (Bloembergen, 2017; Stoelhorst, 2017; Van Veggel & Bevers, 2017).

The considered similarities both indicate that the emphasis in the relevant cases still lay in testing the technological feasibility. In addition, this ‘emphasis issue’ perhaps is also subject to influence that is exerted on the process by I&M. Suggesting that the type of strategy that is included in anticipation to the ‘technological segments’ of uncertainty are also, in a way, assigned by I&M. This is due to solution type that is being set (for example an in-car technology for improving traffic flow), and fixing the orientation of the project (an experiment, or a trial). By doing so, a trial is set for a certain type of technology. This way a strategy is set to reduce uncertainty in the technological performance, and applicability on scale by means of a practical oriented ITS experiment.

The insights of this subsection imply that policymakers are not responsible for determining all strategies to effectively deal with ITS related uncertainties. In addition, they are also not in a position to extensively change the orientation of the project without having to justify their actions. Indicating that they have a limited ability in manoeuvring within the set boundaries of the project.

The reason to discuss this information within the research is because it shows the limitations to which policymakers in ITS project are subject to. One can hence take into doubt the extent to which a policymaker is authorized to insert certain strategies and policies. Yet, within those boundaries, indications show that policymakers are improving the way in which they aim to effectively deal with uncertainties in the process. These insights are valuable for the reflection on the reflection of this thesis. Yet, it proves to be valuable knowledge as well for the third research question (also see paragraph 1.2).

Also see Table 16 on the next page.
<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Strategy Dynamax</th>
<th>Strategy PPA</th>
<th>Strategy Spookfiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>Ignore</td>
<td>Opportunity</td>
<td>Unknown</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>Identify</td>
<td>Unaware</td>
<td>Reduce</td>
</tr>
<tr>
<td>Scalability</td>
<td>Ignore</td>
<td>Reduce</td>
<td>Unaware</td>
</tr>
<tr>
<td>Project Durability</td>
<td>Ignore</td>
<td>Identify</td>
<td>Opportunity</td>
</tr>
<tr>
<td>Technological performance</td>
<td>Reduce</td>
<td>Reduce</td>
<td>Reduce</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>Reduce</td>
<td>Reduce</td>
<td>Reduce</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>-</td>
<td>Unknown</td>
<td>Unaware</td>
</tr>
<tr>
<td>Economic context</td>
<td>Ignore</td>
<td>Ignore</td>
<td>Identify</td>
</tr>
<tr>
<td>Political context</td>
<td>Unaware</td>
<td>Opportunity</td>
<td>Opportunity</td>
</tr>
<tr>
<td>Technological context</td>
<td>Unaware</td>
<td>Ignore</td>
<td>Opportunity</td>
</tr>
<tr>
<td>Legislative context</td>
<td>-</td>
<td>Identify</td>
<td>Identify</td>
</tr>
<tr>
<td>Environmental context</td>
<td>Reduce</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 16; A comparison of the three case studies, focussed on the implemented strategies in the light of earlier identified uncertainties.
8.4 Implemented policies

When solely looking into the findings that are presented in the final paragraph of each case study assessment, an evolving process can be identified. Where the Dynamax project mainly focusses on the predict-and-act approach, the PPA in-car project shifts more towards an expected outcomes approach. Thereupon, in the SF project, two additional policies are more emphasized; the EMA and DAP approach. This shift suggests that policymakers are trying to stay flexible and, if possible, adapt to new events.

Some of these policies also have influenced the levels of the different uncertainties that were inherent to the project (also see paragraph 4.3). As can be deduced from paragraph 7.3, there are indications that the PCP-procedure influenced the levels of uncertainties in scalability and effectiveness of the collaboration. Because the PCP-procedure is a stretched process where there is both collaboration and competition, the parties work towards a best solution. This, while an acquaintance process is also going on among relevant parties. This process therefore excludes certain extreme scenarios along the process. And, when at a phase transition moment (also see paragraph 7.1), the policymaker can respond to certain concurrent trends in the market. Therefore, working towards a most likely scenario.

This was also the case in PPA, where, by means of a contest, the policymaker suggests to play into concurrent technological trends. By activating the market (private parties) to come up with solutions that correspond to plausible scenarios, one presumably aims to reduce uncertainty in technological context. Yet, by setting up a contest without including an adequate period of acquaintance, the policymaker unwittingly increases the level of uncertainty in ‘effectiveness of the collaboration’. Which, in this case, resolved in a less successful collaboration process.

In Dynamax the policymaker more adequately dealt with uncertainty in ‘effectiveness of the collaboration’. This was done by including the relevant parties in setting up a plan of action before it was submitted for inspection at I&M (also see paragraph 5.1). This process therefore shows that a partnership was built in advance of the actual project. Indicating, that sometimes a ‘predict-and-act’ approach shows to be an effective policy to deal with some uncertainties.

Although the predict-and-act approach in some cases could be effective, in the overall process it is not deemed an appropriate or effective policy. In addition, one could also state that the strategies that have been implemented in the face of uncertainties, also closely correlate to the relevant policies. By implementing an ‘opportunity’ strategy, also a policy has to be adapted accordingly. Indicating that the two are interdependent of one another.

When looking back to paragraph 4.3, we see that certain policies are deemed more suitable for the distinguished levels of uncertainty. Those were;

- Level 1: The Predict-And-Act approach
- Level 2: The Expected Outcomes approach
- Level 3: Increase uncertainty to a level 2 or 4
- Level 4: The Traditional Scenario approach
- Level 4: The Exploratory Modelling and Analysis approach (EMA)
- Level 5: The Dynamix Adaptive Policy (DAP)
When evaluating these literature guidelines of Walker, and compare those with the actual applied policies in the three cases, an evaluation can take place into the extent in which policymakers have effectively dealt with uncertainties. Some aspects catch the eye when assessing Table 17. One might notice the following:

- It seems that policies for uncertainty in ‘technological performance’ and “applicability local scale” remain sufficient across all cases.
- There are strong signs that the policies for uncertainty in ‘scalability’, ‘resistance to change’ and ‘implementation speed’ are lacking/insufficient across all cases.
- Indications show that there is an increasing number of (sufficient) policies implemented across consequent projects.

We now know how policymakers (in accordance with the literature) should have acted in the light of uncertainty. In addition, knowing how policymakers acted in practice supplies us with valuable information which help answer the main research question (see paragraph 1.2). It namely enables us to compare and reflect on the extent in which policymakers effectively deal with uncertainties in ITS projects.

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Lvl</th>
<th>Policy Dynamax</th>
<th>Lvl</th>
<th>Policy PPA</th>
<th>Lvl</th>
<th>Policy SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>Exp. outcomes</td>
<td>3</td>
<td>Unknown</td>
</tr>
<tr>
<td>Effectiveness of collaboration</td>
<td>3</td>
<td>Predict-and-act</td>
<td>4</td>
<td>Unaware</td>
<td>3</td>
<td>EMA</td>
</tr>
<tr>
<td>Scalability</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>Exp. outcomes</td>
<td>3</td>
<td>Unaware</td>
</tr>
<tr>
<td>Project Durability</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>DAP</td>
</tr>
<tr>
<td>Technological performance</td>
<td>2</td>
<td>Exp. outcomes</td>
<td>2</td>
<td>Exp. outcomes</td>
<td>4</td>
<td>EMA</td>
</tr>
<tr>
<td>Applicability local scale</td>
<td>3</td>
<td>Exp. outcomes</td>
<td>1</td>
<td>Predict and act</td>
<td>1</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Implementation speed</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>Unknown</td>
<td>3</td>
<td>Unaware</td>
</tr>
<tr>
<td>Economic context</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Political context</td>
<td>2</td>
<td>Unaware</td>
<td>2</td>
<td>DAP</td>
<td>2</td>
<td>DAP</td>
</tr>
<tr>
<td>Technological context</td>
<td>5</td>
<td>Unaware</td>
<td>5</td>
<td>-</td>
<td>5</td>
<td>DAP</td>
</tr>
<tr>
<td>Legislative context</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>Predict and act</td>
<td>1</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Environmental context</td>
<td>4</td>
<td>Predict-and-act</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potential of the Netherlands</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 17; overview of the implied policies, displayed in correlation with the identified and distinguished levels of uncertainty. The in green highlighted policies and levels are applied policies which are in line with the suggested policies by Walker et al. (2013)
9 Conclusion and reflection

The final chapter of this thesis starts off with answering the three main questions and the correlated research question. A paragraph then will follow where additional findings are discussed that are beyond the scope of the main questions and research questions. The subsequent paragraph reflects on the findings from this research and the way it was executed. This chapter will conclude with recommendations for further research, which will be structured in a similar manner.

9.1 Conclusion

In this paragraph, an answer will be formulated on the three main questions. Every main question will be answered separately. This is done by first reciting the relevant question. An observation will then be executed on the discussed data from the previous chapters. Interpretations of that data will follow in which the question is answered accordingly. This paragraph will conclude with an answer on the research question.

1. “What types of uncertainties can be distinguished during the process of ITS projects? “

The results of this research show that thirteen different uncertainties have been distinguished. The thirteen uncertainties have been typified as uncertainty in;

- Product market – uncertainty about the number of potential clients when the technology is fully developed.
- Local applicability – uncertainty about the applicability and effectiveness of the technology under different (local) conditions.
- Effectiveness of collaboration – uncertainty about the effectiveness of the collaboration process between key stakeholders.
- Potential of the Netherlands – uncertainty about the availability of knowledge within the Netherlands to resolve a relevant ITS issue.
- Resistance to change – uncertainty about the extent of resistance from stakeholders (like incumbent firms) to adopt the new technology.
- Technological performance – uncertainty about the performance of the new technology in practice.
- Technological context – uncertainty about other technologies being introduced in the market during the project process, that disrupt the ITS project and make it obsolete.
- Political context – uncertainty about the stability of political support for the project during the course of the project.
- Legislative context – uncertainty about possible change of legislation during the course of the project.
- Economic context – uncertainty about whether the considered budget is sufficient for the project.
- Environmental context – uncertainty about unforeseen indirect consequences on the environment of the new technology.
- Project durability – uncertainty about whether the business case is deemed sufficient during the development of the project.
- Implementation speed – uncertainty about the speed with which big stakeholders implement the new technology.

2. "Are policymakers of ITS projects aware of the different types of uncertainties?"

The results show that, over a total of three ITS cases, the policymakers were unaware of five types of uncertainty. In the Dynamax case I identified unawareness of two uncertainty types, namely ‘political context’ and ‘technological context’. In the PPA in-car case I identified ‘effectiveness of collaboration’ as the sole uncertainty of which the policymaker was unaware. In the SF case, it was ‘scalability’ and ‘implementation speed’ of which the policymaker was unaware.

Hence, we can state that policymakers are not aware of all the different types of uncertainty. Five types of uncertainty unawareness over three cases is significant. Four of those five uncertainties had an impact on the future potential of the developed technology. Therefore, it can be concluded that not being aware of those uncertainties has a high chance of negatively influencing the outcomes of the three projects. Policymakers becoming aware of uncertainties would be a first step in the direction towards more robust policymaking in ITS projects.

3. "How do policymakers of ITS projects act in the light of uncertainties?"

The results of the different cases show that the policymakers implemented different strategies and policies to cope with uncertainties. I will give a short survey on how they acted in the face of uncertainty.

In the first case study, the Dynamax project, the policymaker used two different policy typologies, namely the predict-and-act approach and the expected outcomes approach. Indications show that he used different strategies to deal with the uncertainties. Strategies that were most implemented, given the project conditions, were the “ignore” strategy and the “reduce” strategy.

In the second case study, the PPA in-car project, the policymaker mainly used two different types of policies to deal with uncertainties. One of those policies considered the predict-and-act approach. The second policy was the expected outcomes approach, which he implemented more extensively compared to the Dynamax case. In addition to these implemented policies, indications show that other types of strategies were considered as well. These indications
suggest that the “opportunity”, the “reduce” and the “ignore” strategies were equally often put into practice to deal with certain types of uncertainty.

With the final case study, the SF project, indications show that the relevant policymaker included more types of policy than in the other two cases. The policymaker mainly made use of the following three policy typologies; 1) the predict-and-act approach, 2) the Exploratory Modelling and Analysis approach, and 3) the Dynamic Adaptive Policy approach. He tried to explore key features of designated, project relevant, uncertainties. The explored data suggest that different types of strategies were implemented by the policymaker to deal with distinguished uncertainties. These data imply that the policymaker mainly considered the “opportunity” strategy and the “reduce” strategy to deal with uncertainties.

“How can policymakers more effectively cope with uncertainties that emerge in ITS projects?”

The findings of this research show that unawareness of uncertainty negatively impact the project potential. Hence is emphasized that awareness amongst policymakers about uncertainties would be an improvement on the status quo.

The strategies that have been applied aren’t adequate. Too often ‘ignore’ strategies have been implemented in the face of uncertainty. Knowingly ignoring uncertainties increases the potential (negative) impact it could have, when compared to situations where a more active strategy was implemented. To cope more effectively with uncertainties it is, in accordance with the literature and the findings of this research, essential to adopt more active strategies.

A similar conclusion can be extracted for the implemented policies. Comparing the policies suggested by the literature to the effective situation in practice, we can conclude that policymakers in the three cases have not dealt effectively with the uncertainties. Policymakers should value the different types of uncertainties in terms of levels, and subsequently apply tailor made policies to deal more effectively with emerging uncertainties.

There are a few more specific suggestions that can be made towards policymakers in ITS projects. These suggestions are in line with the findings of this research and could supply policymakers with practical knowledge. Knowledge which might help them to cope more effectively with uncertainties in future ITS project;

- Based on indications from the three cases, one can state that a relatively long acquaintance process in ITS project proves to be effective in the subsequent collaboration process. This is especially relevant when new parties are included in the process with which no collaboration experience is developed. This is important in order to prevent miscommunication. A long acquaintance process creates a reliable working relationship among parties.

- Another recommendation considers the inclusion of a valid business case at the start of a project. A strong business case highly contributes to the future potential of a project. However, the policymaker is only limited involved in designing the business case, because I&M directs the core project course (by means of a problem definition and a solution proposition). Therefore, policymakers should determine the validity and feasibility of a
potential business case. When not deemed valid and feasible, the policymaker should look for opportunities to improve the potential of a project.

- The literature, as well as indications from this research, have suggested that the “predict-and-act” policy typology is not deemed a suitable approach for policymakers to deal with complex uncertainties. This was specifically seen in the Dynamax project, where, for higher levels of uncertainty, the predict-and-act approach was applied. The literature suggests that with more complex (high level) uncertainties, policymakers should aim on more active policy typologies. Think for example of the EMA approach, the DAP approach or the traditional scenario approach.

- Another suggestion towards policymakers is to be aware that there could be a case of inertia of public parties. Indications of this research suggest that this could affect the implementation speed of a project. Responding early on these anticipated issues possibly could prevent many discussions from occurring, which might subsequently influence the planning.

- To reduce uncertainty in the political and economic context, policymakers should incorporate relevant stakeholders closely in the decision-making process. Indications have shown that this creates and maintains a supportive attitude from these relevant parties along the project process

- When there is a trial, policymakers should determine whether the scale of a predefined trial is sufficient enough to create a measurable effect. When this is uncertain, policymakers could aim for a greater implementation scale if possible. In addition to uncertainty in scalability, policymakers should also look for the preparedness of relevant people to adopt the technology. Therefore, one should aim to create indicative knowledge on the implementation scale needed to create a measurable effect.

- The issue of disruptive technologies being introduced onto the market have shown to have a certain influence on the project potential. Integrating flexibility loops in contracts with contractors could make it possible to change and react onto the introduction of disruptive technologies up to a certain extent.
9.2 Additional findings

Next to the findings that correlate to the orientation of this research and the correlated questions, a few additional interesting findings can be deduced from the gathered information. This paragraph will elaborate on those additional findings, and give meaning to them accordingly. The additional findings are as follows;

▪ Over the three consecutive cases, an increased awareness in relevant uncertainties is recognized by policymakers in ITS projects. In addition, the findings also show that policymakers more effectively deal with issues that correlate to uncertainty. They do this by implementing more active and opportunistic strategies and policies.

▪ Indications show that a reduction in uncertainty levels can be accomplished because of a certain implemented policy. Suggesting that certain typologies of policies might positively influence the outcomes of distinguished and policy related uncertainties.

▪ Uncertainty in ‘project durability’ and ‘scalability’ have had influence on the project potential across all the three cases. Indicating that policymakers should emphasize these aspects when aiming to improve the project potential.

▪ There are indications that assigned policymakers are not responsible for determining all strategies and policies to effectively deal with ITS related uncertainties. This would be especially the case at the front of an ITS project where a policymaker is not yet assigned.

▪ The same indications also suggest that, when this is the case, key parties like RWS and I&M are the actors that mainly have the decision-making power. In this phase of project initiation, where the problem definition and the solution proposition is defined, key parties often put the focus on technological feasibility. Indicating that the emphasis of ITS projects still lay in testing the solution in practice. Implying that the aspect of a business case at that moment is often not left out of the discussion.

▪ The final aspect considers a fact, as it is widely elaborated across different governmental documents. It considers the emphasis that the authorities place on the “Routemap” of I&M. Here I&M and RWS aim at creating a shift in the ITS market (see appendix 7)
9.3 Recommendations for additional actors

As can be deduced from the findings on the previous page, governmental authorities are considered to be the parties that are involved in the decision-making process towards the problem definitions and solution proposition phase of ITS projects. Therefore, this paragraph will conclude with a few suggestions that are directed towards those governmental authorities. These suggestions are aimed to improve the potential of future ITS projects.

- Governmental authorities should aim at creating awareness in relevant ITS projects on the different types of uncertainty. This increased awareness could improve the extent of project success.

- Before the I&M sends out a plan towards RWS, I&M should aim at creating knowledge. This knowledge creation would be focused on validating the possibility that an effective business case can be realized within the suggested plan. If a valid business case can be realized it could positively influence the potential of a prespecified project.

- In addition to the previous bullet, I&M should on forehand determine whether the scale of a predefined trial is sufficient enough to create a measurable effect. Therefore I&M should go into collaboration with relevant parties that had experience in the light of similar ITS projects. When the scale is deemed not effective, aim for a greater implementation scale if possible.
9.4 Reflection

In this research, a few aspects could not be deemed statistically significant in order to interpret the findings of this research as sufficiently supported. Hence, this paragraph is dedicated to reflect on all debatable aspects and possibly ambiguous elements of this research, which have been used as support for constructing a conclusion to my research.

One of the first, and most doubtful factors which is at the core of this research, is that there are only three case studies executed. When comparing a multitude of cases, which have to provide systematic insight, one has to select at least five cases to produce results of any significance for his research. With three cases, the results could be seen as not adequately supported for making explicit statements on how policymakers act in the light of uncertainty.

In addition, the relevant cases are, up to a certain extend, implemented in different time frames and on different locations. Over a timeframe of five years (difference in time between initiation of the Dynamax project, and the initiation of the SF project), the circumstances under which an ITS project is executed can change. And the locations in which the different experiments are executed are also different. Indicating that these case differences in timeframe and location could influence the validity of the research.

Another point of reflection is the way information is extracted from different resources. Relevant information on uncertainty awareness of the policymaker, strategies on uncertainty, and implemented policies, are in some cases based on indications and suggestive statements. Those indications and suggestive statements are then interpreted in a way which might be incorrect in relation to the actual case. Although there was a feedback moment on the interviewee where the extracted findings of the executed interviews were validated, there still is a case of one person’s perspective on the project process. This indicates that the data could be questioned in terms of reliability.

A final reflection aspect is correlated to distinguishing uncertainty typologies and the valuation of those typologies in accordance with the theoretical framework. With distinguishing uncertainty typologies, there is a personal interpretation at the core of typifying those different uncertainties. Therefore, one could argue the effectiveness in distinguishing those typologies and describing the different uncertainty aspects. For example, aspects like uncertainty in ‘technological performance’ and ‘applicability of solution on local scale’ could easily be merged. This, as these two uncertainties are closely related, and even interdependent, to each other. Another typology which can be questioned is uncertainty in ‘scalability’. Scalability in the context of ITS projects is deemed to be a rather vague term, which could actually touch upon all the different discussed uncertainties.

With the valuation of uncertainties there also is a case where, especially with assigning levels to uncertainty, a personal interpretation is at the core of valuing those different uncertainties. Both aspects of reflection could therefore, like with the antecedent reflection point, show that the reliability of this research could be questioned.

To conclude this paragraph, the suggestions that are made in the conclusion, are no guarantee for project success. As de Wit (1988) stated; “A project can be a success despite poor project management performance and vice versa”.

Page 105
9.5 Recommendations for further research

This paragraph aims at looking for opportunities in which additional, correlated research might be executed. These topics can be used for a graduation research or a PhD student.

▪ In the light of the orientation in this thesis, a recommendation would be to validate this research by means of using more case studies. This to create a more significant statistical basis for more systematic statements and conclusions.

▪ As might be noticed, the process from problem definition towards solution proposition, proceeds in a messy way. And indications show that there are uncertainties already included in this phase of ITS projects. A research can be dedicated to this process where the research aims to identify opportunities to deal with uncertainties more effectively while shaping an ITS project.

▪ The aspect of political support greatly influences the future potential of a project as was seen with the Dynamax project. A research that would connect to that, is one which aims at exploring opportunities to create a shift in political support. Indicating which factors might be at the core of such a shift.

▪ The issue of a business case is one of the key hurdles in project durability. Especially when considering the continuous impact that uncertainty in project durability had on the future potential of a project. A future research that connects to this topic, is why it is deemed such a big hurdle. And potentially exploring how this hurdle can be overcome effectively.
10 References


Kolios, A., & Read, G. (2013). A political, economic, social, technology, legal and environmental (PESTLE) approach for risk identification of the tidal industry in the United Kingdom. Energies, 6(10), 5023-5045.


Mooren, R., Hardy, D., Cutts, M., Learmouth, B., & Rawlinson, S. (2016). *Third Global Infrastructure Investment Index 2016; Bridging the investment gap*. Retrieved from Amsterdam:


An overview of all the factors that are considered for PESTLE analysis. The figure is in accordance with O’Brien (2014).
11.2 Appendix 2

1. Background
   a) identify previous research on the topic
   b) define the main research question being addressed by this study
   c) identify any additional research questions that will be addressed

2. Design
   a) identify whether single-case or multiple-case and embedded or holistic designs will be used, and show the logical links between these and the research questions
   b) describe the object of study (e.g. a new testing procedure; a new feature in a browser)
   c) identify any propositions or sub-questions derived from each research question and the measures to be used to investigate the propositions

3. Case Selection
   a) Criteria for case selection

4. Case Study Procedures and Roles
   a) Procedures governing field procedures
   b) Roles of case study research team members

5. Data Collection
   a) identify the data to be collected
   b) define a data collection plan
   c) define how the data will be stored

6. Analysis
   a) identify the criteria for interpreting case study findings
   b) identify which data elements are used to address which research question/sub question/proposition and how the data elements will be combined to answer the question
   c) consider the range of possible outcomes and identify alternative explanations of the outcomes, and identify any information that is needed to distinguish between these d) the analysis should take place as the case study task progresses

7. Plan Validity (see Figure 2.3 and Chapter 5 in Yin (2003))
   a) general: check plan against Höst and Runeson’s (2007) checklist items for the design and the data collection plan
   b) construct validity - show that the correct operational measures are planned for the concepts being studied. Tactics for ensuring this include using multiple sources of evidence, establishing chains of evidence, expert reviews of draft protocols and reports
   c) internal validity - show a causal relationship between outcomes and intervention/treatment (for explanatory or causal studies only).
   d) external validity – identify the domain to which study finding can be generalized. Tactics include using theory for single-case studies and using multiple-case studies to investigate outcomes in different contexts.

8. Study Limitations: Specify residual validity issues including potential conflicts of interest.


10. Schedule: Give time estimates for all of the major steps: Planning, Data Collection, Data Analysis, Reporting.

11. Appendices
   a) Validation: report results of checking plan against Höst and Runeson’s (2007) checklist items
   b) Divergences: update while conducting the study by noting any divergences from the above steps.

A case study protocol template, developed by Brereton et al. (2008) in accordance with the guidelines as set up by Yin (2009)
An overview of all the Dynamic Adaptive Policy approach and the included steps and segments. Source: Kwakkel et al. (2010)
11.4 Appendix 7

Six transition paths that give direction for a changing market environment. One which, according to de Mooij (2013), provides chances and opportunities for innovation and efficiency in the smart mobility market.