Universiteit Utrecht

MSc thesis Science and Innovation Management (SIM)

'Future developments of Intelligent Transport Systems (ITS) in the European automotive sector'

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Msc programme:	Science and Innovation Management (SIM)
Number of ECTS to be obtained:	45 ECTS
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Date:	16-3-2012

Acknowledgements

This research has been carried out as the final part of my master programme Science and Innovation Management at Utrecht University. Although this thesis is written by myself, it would not have been possible without the help and support of a number of people. First of all, I would like to thank all the colleagues at ARCADIS for giving me the opportunity to execute my research within their organization and the good times during this process. Special thanks goes out to Maarten Amelink, my supervisor at ARCADIS, for his valuable input and advice. Furthermore, I would like to thank my supervisor from Utrecht University, Jacco Farla. His interest in the subject, and guidance during the entire process from the initial idea until the final thesis has helped me a lot.

An important part of my research is based on interviews with ITS experts, I would like to thank them for their valuable time, effort, and inspiring answers. Furthermore, I would like to thank my parents for their support during my entire 'career' as a student. Last, but certainly not the least, my gratitude goes out to my girlfriend Denise. Even while she was writing her own thesis, she was always able to keep me motivated and showed me that some things just weren't that complicated.

Hans Bouwhuis

March 2012

Summary

In the past decades, an on-going trend of growing mobility throughout the world is visible. Although this growing mobility has a lot of benefits, it also creates a number of negative externalities, such as traffic congestion, accidents, and pollution. Intelligent Transport Systems (ITS) is often mentioned as a tool to reduce these negative side effects of mobility. In the broadest sense, ITS can be described as a transport system which makes use of information and communication technology (Nijkamp et al., 1996). In this research, the focus is on the European road transport system. To be able to fully benefit from ITS technologies, cooperative ITS systems are needed (Piao & McDonald, 2008) with cooperation between different stakeholders. Important stakeholders in the development of these cooperative ITS systems are the road authorities and the automotive industry. However, the knowledge gap between in-vehicle intelligence (developed by the vehicle manufacturers) and roadway intelligence (the responsibility of road authorities) is currently increasing (Piao & McDonald, 2008). The aim of this research is to get a good overview of future ITS developments in the European Automotive sector in the coming twenty years, and based on these outcomes analyse how this may affect the road authorities throughout Europe and their present tasks. By doing this, the knowledge gap between the different road authorities in Europe and the European automotive industry is aimed to be reduced.

A scenario approach was chosen to develop possible futures of ITS development in the European automotive industry, in a structured way. Based on a literature review on ITS developments in the automotive industry, interviews were held with ITS experts from the automotive industry, consultancy and research institutes, drivers associations, traffic policy makers, and road authorities. The experts were asked about their opinions and uncertainties on future ITS developments. The data derived from the interviews was used to build future scenarios. Based on the two most important critical factors (*Costs and Business Cases for ITS Technologies* and *Role of the Government)* four different future scenarios were developed:

- Scenario 1: United Industry
- Scenario 2: Mutual Benefits
- Scenario 3: Individual Profits
- Scenario 4: Public goals, Private Profits

In scenario 1 there is a united automotive industry with shared ITS business cases, but a government who is not really involved in ITS. Scenario 2 is based on a high rate of governmental involvement and an automotive industry with shared ITS business cases. In scenario 3 the government is not really involved but there are some individual parties who see possible ITS business cases. The government is highly involved in scenario 4, but there are no real shared business cases in the automotive industry.

There is not one scenario that will become the real future, but it will probably be a combination of the four scenarios presented. Nevertheless, there are some developments that will continue to evolve in all four scenarios:

- More 'connected vehicles' become available (either connected to the internet, to the infrastructure, and/or to each other).

- Increased use of nomadic devices and their traffic related services in a vehicle.
- Private parties are able to give individual trip and traffic advice, and by doing this they can influence traffic flows and traffic management.
- More traffic related data becomes available.
- More in-vehicle (safety related) ADAS systems.
- Public acceptance of ITS technology remains uncertain, however, it can be stimulated by the government but not controlled.

Most of these developments will have an effect on the current main tasks of the road authorities namely *traffic management* and *designing, building, and maintaining roads and roadside installations*. The road authorities can influence the technological development of ITS technologies by installing or not installing intelligent infrastructure. When installing intelligent infrastructure to improve traffic safety, the automotive industry will be interested in developing safety features for their vehicles that are able to communicate with the intelligent infrastructure. This creates extra tasks for the road authorities in maintaining and operating the intelligent infrastructure. Furthermore, when looking at traffic management, it is less beneficial for road authorities to invest in intelligent infrastructure. The automotive industry is willing to develop vehicles that are able to communicate with the infrastructure of the road authorities, however, individual traffic advice can also be supplied by private parties such as the nomadic devices industry and their traffic related services and platforms. These private parties are able to take over some of the traffic management tasks of the road authorities. Nevertheless, the road authorities will remain responsible for everything that is happening on their roads. The monitoring of the data and advice given by the private parties will become a new responsibility of the road authorities to assure everything remains within the societal boundaries set by the governments and road authorities.

There are certain issues the (national) road authorities should keep in mind when dealing with ITS developments. These are, among others, creating societal boundaries, approaching ITS as a technology which focusses on traffic safety and traffic flows, staying up-to-date with the latest ITS developments, and keeping local and regional authorities informed about these developments.

List of abbreviations

ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
AHS	Automated Highway System
CAQDAS	Computer Assisted Qualitative Data Analysis Software
DSS	Driver Support Systems
HMI	Human Machine Interface
ITS	Intelligent Transport Systems
LTE	Long Term Evolution (wireless communication standard)
OEM	Original Equipment Manufacturer
V-2-I	Vehicle to Infrastructure communication
V-2-V	Vehicle to Vehicle communication
V-2-X	Communication between Vehicles or Vehicle to Infrastructure

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1. Introduction

In the past decades, an on-going trend of growing mobility throughout the world is visible. People work in a different city than the city they live in, and in the weekends they visit family and friends on the other side of the country. The growing mobility can for instance be seen in the trend of passenger transport by private cars in Europe between 1990 and 2008, which has grown with more than 40 percent (OECD, 2010). Besides having a positive influence on the ability to maintain professional and social relationships over larger distances, increasing transport/mobility can also have a positive effect on the economic growth of a country or region (Van Geenhuizen et al., 2002; Mačiulis et al., 2009).

Nevertheless, the growing mobility also creates numerous negative externalities. Examples are *"traffic congestion, accidents and fatalities, pollution, noise annoyance, destruction of visual landscape beauty, waste of resources, raw materials and energy etc."* (Van Geenhuizen et al., 2002, p.3). One of the possibilities to reduce a number of these externalities, is the implementation of Intelligent Transport Systems (ITS). In the broadest sense, ITS can be described as a transport system which makes use of information and communication technology (Nijkamp et al., 1996). According to Argiolu et al. (2008), ITS developments focus on:

- Supporting vehicle drivers to drive more safely, increase the comfort, and reduce the vehicle's environmental impact.
- Improving efficiency in using scarce infrastructure capacity.
- Improving transport services in chains and networks.

Due to the wide range of improvements that can be made in current transport systems when implementing ITS techniques, ITS gains much attention from governmental bodies. They perceive ITS as an important tool to accomplish transport policy goals (Argiolu et al., 2008). However, there are many uncertainties about the implementation and impacts of ITS when applied on a larger scale in the 'real world' (Van der Heijden & Marchau, 2005).

When implementing ITS technologies in an existing transport system, multiple stakeholders will have different opinions about the innovation(s) that are introduced. Examples of stakeholders are: road authorities, interests groups, vehicle manufacturers, drivers of the vehicle, etc. The success of the ITS implementation depends on the willingness of the stakeholders to accept, or to reject the proposed innovation(s) (Marchau et al., 2008).

The amount of uncertainties on the implementation and impacts of ITS, when applied on a large scale in a real world situation, resulted in a great interest of scientific communities in ITS in the last decades. Up until the mid-90s, the main focus was on the technological feasibility of the ITS systems, assessed under strongly controlled conditions (Marchau & Van der Heijden, 1998). Later on, more attention was also given to other uncertainties such as the complexity and (social) impacts of large-scale implementation (Van der Heijden & Wiethoff, 1999).

In the last decade, the first large-scale implementations of ITS technologies became visible. The automotive industry introduced several in-vehicle ITS technologies (also called Advanced Driver Assistance Systems, ADAS) in mass-produced vehicles such as Adaptive Cruise Control (ACC), automatic emergency braking, and automatic parking (Gusikhin et al., 2007; Xiao & Gao, 2010). Most of these ADAS systems are developed by vehicle manufacturers themselves. By doing this they try to create a competitive advantage for their products. The majority of the big manufacturers have programs to promote the research and development of their own type of ADAS (Piao & McDonald, 2008). This development is in line with the recent demand for more functionalities in new cars. By integrating electronic and information technologies in the car to facilitate new functionalities, car manufacturers can really distinguish themselves from competitors (Seidel et al., 2005).

However, the competition can have a negative influence on the uniformity of an ITS system. Each manufacturer will promote his own autonomous technique, whereas most of the ITS models that predict improvements in for example safety, make the assumption that all vehicles are equipped with an interchangeable type of ITS technology (Piao & McDonald, 2008; Walta, 2011). To be able to fully benefit from ITS technologies, a more cooperative system is needed (Piao & McDonald, 2008). In Europe there are some joint initiatives between the automotive industry and public authorities to develop standardization for ITS technologies such as eCall, ERTICO, and CVIS.

Currently, the knowledge gap between in-vehicle intelligence (developed by the vehicle manufacturers) and roadway intelligence (the responsibility of road authorities) is increasing (Piao & McDonald, 2008). Furthermore, there is imbalance in research means and expertise between car manufacturers and public (road) authorities. This does not seem strange, since road authorities have a wide range of tasks to fulfil. According to Lay (2009), most of the National Road authorities throughout the world are (partly) responsible for:

- Planning, prioritizing, designing, financing, building, operating, and maintaining roads.
- Regulating traffic, vehicles, and drivers.
- Ensuring that the road system meets non-transport objectives for community welfare, the environment, and sustainability.
- Monitoring and reporting on the operation of the road system.

The car manufacturers play an important role in the development process of ITS technologies, but are not willing to share all this information with other actors (such as road authorities) because they are afraid to lose a competitive advantage to their competitors (Van der Heijden & Van Wees, 2001). Based on the knowledge gap on ITS developments between the automotive industry and the road authorities, the following main research question is formulated:

What are the developments of ITS technologies within the automotive industry in the near future (2030) for the European market, and how may this affect the current tasks of road authorities in Europe?

Most of the ITS research and developments take place in the United States, Japan, and Europe. Since this research is conducted in the Netherlands for a Dutch firm, the *scope* of the research will focus on future ITS developments in Europe. The main *aim of the research* is to get a good overview of future ITS developments in the European Automotive sector in the coming 20 years, and based on these outcomes analyse how this may affect the road authorities throughout Europe and their present tasks. By doing this, the current knowledge gap between the different road authorities in Europe and the European automotive industry can be reduced.

In future oriented innovation theories such as transition management, long-term visions (+25 years) are regarded as *"a guide for formulating programmes and policies, as well as designing short- and long-term objectives"* (Loorbach & Rotmans, 2006, p.199). According to Rotmans et al. (2001), a transition can be seen as a long-term process of change in which a society or a subsystem of society fundamentally changes. In this research, it is possible to argue that a subsystem of society, namely road transport, will fundamentally change in the long run by ITS innovations. Constructing future visions of ITS in the automotive industry can give direction to ITS programmes, policies, and objectives. These future visions are especially of use for road authorities trying to get involved in cooperative ITS systems. As mentioned previously, to be able to make full use of the potential benefits of ITS technologies a cooperative system is needed. By giving the road authorities better insights into the future ITS developments in the European automotive sector, they can adapt their policy to these developments to get involved in the design and introduction of cooperative ITS technologies, hereby reducing the negative side effects of mobility for society such as accidents, congestion, and pollution. Trying to gain insights in the ITS developments in the European automotive industry, which can help the road authorities to adapt their policy, and get involved in the deployment of ITS technologies to try to diminish the current externalities of mobility, makes this research of *societal interest.*

This research will use scenario building to describe the developments of ITS technologies within the automotive industry in the near future (2030) for the European market. Although the scientific community pays a lot of attention to the different uncertainties in ITS development, no up-to-date view of future ITS visions within the automotive industry is available. One of the last scientific contributions focusing on future ITS development according to the automotive industry, was made by Marchau & Van der Heijden (1998). In the last ten years, a lot of technological improvements have been made. Therefore an updated ITS view held by the automotive industry is needed. By making this updated ITS view, the *scientific relevance* of the research is addressed.

The infrastructure department of ARCADIS Nederland B.V., the initiator of this research, advices stakeholders (mainly road authorities) on ITS developments and innovations. Their main *goal for this research* is to get better images on the developments of ITS technologies within the European automotive industry. Consequently, they hope to be able to use these images to further improve their advice to road authorities and other stakeholders on future ITS developments.

2. Background information on ITS

2.1 History of ITS

One of the first ideas about ITS (although the ITS terminology emerged later) was made by Geddes (1940) in the book *Magic Motorways*, which was based on Geddes' ideas for the General Motors' Futurama pavilion on the New York world exhibition in 1938. Geddes designed a vision on what the American Highway System should look like in 1960, to overcome possible problems of the increasing traffic in the US, such as congestion and accidents. He expected cars to be able to communicate with each other and with the roadside, and that they would be able to drive automatically on the highway without intervention of the driver. According to Geddes, this would increase traffic safety dramatically.

Despite the clear vision of Geddes, it was not until the 1960s that the first automatic vehicle prototypes were presented, under the terminology of Automated Highway Systems (AHS) (Wetmore, 2003). A more recent large scale AHS project in the United States was 'demo 97', undertaken by the National Automated Highway System Consortium (NAHSC) (Economist, 2004). This demonstration project was performed on seven miles of Interstate just outside San Diego, using twenty different vehicles, magnets in the road, and all sorts of optical recognition systems and radar devices (Wetmore, 2003).

The actual typology of Intelligent Transport Systems (ITS) emerged in the early nineties based on the trend of increasing information and communication technologies (Sussman, 2004). ITS is therefore much more than an Automated Highway System. *"ITS includes a wide range of in-vehicle and/or infrastructure-based electronic devices, which seem to hold many keys to improving the performance of the transport system"* (Argiolu et al., 2008, p. 1744).

2.2 ITS technologies

ITS can be applied to all types and levels of transportation, but also to personal mobility as well as freight (Crainic et al., 2009). Since this research focuses on the automotive industry, the emphasis will be on ITS technologies for road vehicles (cars, trucks and busses). Based on Argiolu et al. (2008), a distinction in ITS technologies can be made between *in-vehicle electronic devices* and *infrastructure based electronic devices*. It is not the idea to choose between one of the two options, a combination of in-vehicle and infrastructure based electronic devices is also possible (e.g. full automatic driving). All devices try to make some kind of improvement in terms of comfort, safety, and/or congestion. Below some examples are given of the different types of devices.

Examples of In-vehicle electronic devices:

- Navigation devices
- Advanced Driver Assistance Systems (ADAS): e.g. adaptive cruise control, lane keeping
- Full automatic driving (in combination with Infrastructure–based devices)

Examples of Infrastructure- based electronic devices:

- Interactive road signing/traffic information
- Automatic toll registration
- Full automatic driving (in combination with In-vehicle devices)

3. *Theoretical framework*

3.1 Literature review on (future) ITS developments in the automotive industry

Multiple scientific articles have addressed the developments and uncertainties of ITS technologies in the automotive industry. Marchau & Van der Heijden (1998) conducted a Delphi study among Driver Support Systems (DSS, an ITS technology) specialists worldwide (including a majority of people working in the automotive industry), to identify future markets for DSS, possible barriers for further development, and policy measures to overcome these barriers.

The experts did not assume problems for the introduction of driver support warning devices before the year 2005 (current data shows they were right, e.g. Piao & McDonald, 2008). For the longer term (2005-2020), the introduction of more advanced driver support systems which can take temporary control over the vehicle, was regarded more uncertain (at this moment (2012), multiple advanced driver support systems, such as adaptive cruise control, are available in ‘normal’ passenger cars). Market entrance and developments would depend on technological progress and consumer acceptance due to costs. Furthermore, the introduction of a fully automated vehicle (autopilot function) between 2005 and 2020 was regarded as highly uncertain by the experts. Main reasons were the questions about the technological feasibility as well as the non-technological conditions such a system should operate on. For all types of DSS, the experts rated consumer costs and legal issues as the most important obstacles. For autopilot functions, the obstacles of limited road applicability and the willingness of public authorities to bear the costs of road adaptation were also addressed.

More recently, in a research about the influence of actors on the deployment of Advanced Driver Assistance Systems (ADAS, a form of ITS), Walta (2011) concluded that the automotive industry and public authorities are the most important actors in ADAS deployment. The automotive industry showed a wide range of different preferences/strategies for the deployment of ADAS. The deployment of ADAS will initially be started by the automotive industry; the public authorities can stimulate the deployment by mandating specific ADAS technologies in newly sold vehicles or by giving subsidies when buying vehicles with ADAS technology.

Walta’s conclusion that the automotive industry is one of the most important actors in the deployment of ADAS is supported by Piao & McDonald (2008), who argue that the *autonomous* ADAS systems are mainly developed by the car manufacturers. According to Piao & McDonald (2008), to be able to fully benefit from ADAS technologies, *cooperative systems* are needed. With the autonomous system all the intelligence is inside the vehicle, whereas the cooperative systems are also supported by the roadways and/or other vehicles. *“Cooperative systems make it possible for wide and balanced interests, such as safety and traffic operation, to be considered in the development and implementation of the systems”* (Piao & McDonald, 2008, p.679). Such a cooperative system raises new issues for the road operators including clarification of roles and responsibilities of the automotive industry and road authorities, as well as new funding mechanisms for infrastructure investment (Piao & McDonald, 2008). However, when clear public policy is lacking, the automotive industry will keep its prime focus on developing in-vehicle systems and impacts for individual drivers (Van der Heijden & Marchau, 2005).

The European automotive industry and related stakeholders also presented their own vision(s) on the introduction of ITS technologies in the upcoming years. The FURORE platform (2003) composed the vision that from 2030, the 'accident free vehicle' which informs the driver on potential hazards and intervenes to avoid disaster, will be available. According to FURORE, the major hurdles to reach this goal are perceived to be technological challenges and public acceptance (FURORE, 2003). The ADASE2 (2004) consortium made a roadmap of different (future) ADAS technologies assessed on complexity for different aspects, and the expected contribution to safety improvements. The defined aspects are: system aspects, sensor aspects, HMI (Human Machine Interface) aspects, infrastructure aspects, vehicle-2-vehicle communication, political and societal aspects, safety enhancement, legal aspects, and the degree of driver assistance. The most extensive form of ADAS was defined as autonomous driving. It has an expected high safety enhancement but also a high level of complexity for all aforementioned aspects, except for the HMI aspect which was rated with a mid-level of complexity.

A summary of the important topics found in the literature on (future) ITS developments in the automotive industry is given in table 1 below.

Topics	**Reference**
Technological progress, challenges, and feasibility	Marchau & Van der Heijden, 1998; FURORE, 2003
Public and consumer acceptance	Marchau & Van der Heijden, 1998; FURORE, 2003; ADASE2, 2004
Legal issues (liability)	Marchau & Van der Heijden, 1998;
Costs for different actors	Marchau & Van der Heijden, 1998; FURORE, 2003; Piao & McDonald, 2008.
Important actors in ADAS (ITS) deployment.	Walta, 2011
Wide range of visions on ADAS (ITS) deployment.	Walta, 2011
Focus on in-vehicle technologies by car manufacturers.	Piao & McDonald, 2008; Van der Heijden & Marchau, 2005
ITS knowledge gap between automotive industry and road authorities.	Piao & McDonald, 2008; Van der Heijden & Marchau, 2005
New responsibilities and tasks for actors when introducing cooperative ITS systems.	Piao & McDonald, 2008; ADASE, 2004
Political and societal aspects	ADASE2, 2004
Safety improvements	ADASE2, 2004
Reducing congestion	Argiolu et al., 2008

Table 1: Summary of important topics found in the literature on (future) ITS developments in the automotive industry.

3.2 Scenario building

When trying to study future developments, multiple approaches are possible. Ling (1999) made a selection on which approach to use based on the context that is under investigation.

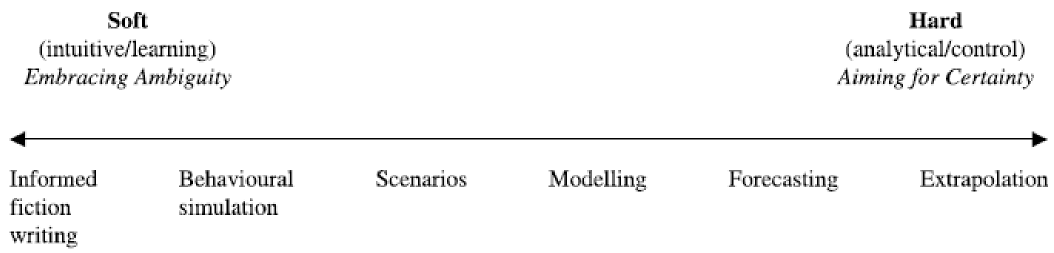

Figure 1: Methods used in the study or prediction of the future (Ling, 1999)

If the context is 'simple', predictable and (to a certain extent) controllable, *hard* methods can be used such as forecasting and extrapolation. However, in this research ITS developments are investigated up until 2030, making hard statements about situations in almost twenty years time not that feasible. Therefore, a more soft *Scenarios* approach is chosen.

The scenarios approach has its origin in military projects. In the 1940s, scenarios were developed to assess the possible effects of hydrogen bombs, since some scientist believed the bomb could literarily ignite the skies (Schoemaker, 1993; Xiang & Clarke, 2003). Later, in the 1970s the scenarios approach was introduced in corporations to be able to plan a company's future strategy. A good example of a company who gained benefits from the scenarios approach in that time is Shell. Before the oil crisis, Shell developed multiple scenarios which took possible oil shortages into account (Schoemaker & Van der Heijden, 1992). During the actual oil crisis, Shell was better prepared than its competitors, resulting in a great improvement of their market share.

Today, the scenario approach is used in all sorts of scientific fields. There are many scientific definitions of scenarios. Rotmans & Van Asselt (1999) define scenarios as archetypal images of the future, created by mental maps or models that reflect different perspectives on the past, present and future developments. Constructing scenarios often starts with identifying predetermined and underdetermined elements. The predetermined elements are the same in each constructed scenario, whereas the underdetermined elements are elaborated in multiple ways, depending on possible future developments, and thus result in different future images (Van der Heijden, 1996).

Börjeson et al. (2006) try to make a clear distinction between different types of scenarios, based on three different questions. If scenarios try to answer the question *what will happen,* it can be regarded as a *predictive* scenario. When the question is *what can happen* it is an *explorative* scenario. If the question is *how a certain target can be reached* it is a *normative* scenario. The predictive scenarios tend to focus on short time periods, whereas the explorative and normative scenarios usually are used in combination with longer time periods.

At first sight, when relating these different types of scenarios to future ITS developments in the automotive industry for the European market, both a predictive scenario, as well as an explorative scenario seem applicable. However, this research focuses on long-term developments (until 2030), and because of multiple influential players in the automotive industry it is not very likely the automotive industry will have one or two clear vision(s) on *what will happen*. Subsequently, this research will produce *explorative scenarios on what can happen* focusing on future ITS developments in the automotive industry for the European market.

Another type of scenario classification is made by Rotmans (2000), who distinguishes four types of scenario classifications. First, the difference between *forecasting* and *backcasting* scenarios is mentioned. Forecasting scenarios pick a starting point and look into the future from there, whereas backcasting scenarios choose a time in the future and go back from there towards the present. Secondly, a distinction can be made between *descriptive* and *normative* scenarios. Descriptive scenarios present a set of possible events without taking into account their (un)desirability. Normative scenarios take values and interests into account, reasoning from certain targets that have to be achieved. The backcasting approach is a good example of a normative scenario. Thirdly, there is the difference between *quantitative* and *qualitative* scenarios. Quantitative scenarios are based on numbers and computer models, whereas qualitative scenarios use narratives to describe future pathways because of missing and/or a lack of data. Finally, a distinction is made between *participatory* and *expert* scenarios. Participatory scenarios involve both different stakeholders as well as the real experts to develop a scenario. Expert scenarios are designed by a small group of experts responsible for the design and development of the scenario.

Relating these distinctions in types of scenarios to the research question results in *forecasting* scenarios, since this research will look at future ITS developments from now until 2030. Furthermore, no target is set for specific future developments, resulting in *descriptive* scenarios. Because of the multiple ITS developments that could occur over a quite long period of time (until 2030) there will not be sufficient numerical data for doing (computer model) quantitative analyses. Sufficient data can be acquired by using *qualitative* scenarios, based on narratives. The main goal of this research is to present future ITS developments in the automotive industry. People who work in the automotive industry or are related to the automotive industry, will have the most knowledge on what to expect from future ITS developments within this industry. Therefore, *expert* scenarios will be delivered.

Van Notten et al. (2003) try to make fundamental distinctions between scenarios visible by using the so-called *Scenario Cartwheel* (Fig.2). First, a distinction can be made between *complex* and *simple* scenarios. The complexity of the scenarios depends on the number of uncertainties and variables. Secondly, there is a demarcation between *exploration* and *decision support* scenarios. Decision support scenarios work towards some predetermined goal or target, whereas exploratory scenarios do not have such a goal or target. Finally, there is the difference between *intuitive* and *formal* scenarios. Intuitive scenarios rely on qualitative data such as interviews. Formal scenarios tend to rely more on quantitative data.

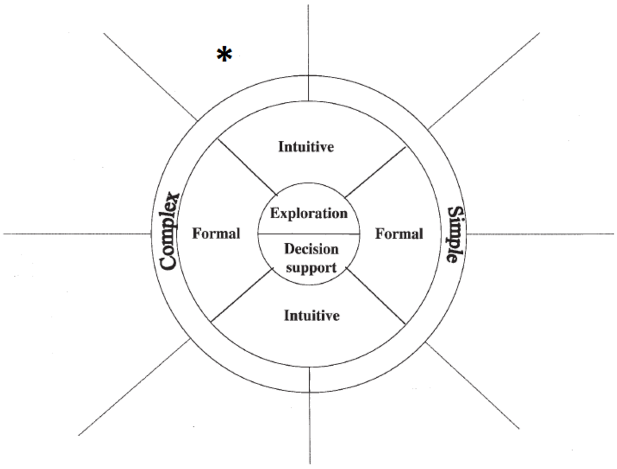

Figure 2: The Scenario Cartwheel (Van Notten et al., 2003)

This research is placed in the Scenario Cartwheel (fig. 2) by using the symbol '*'. Since the categories of the cartwheel are absolute, no gradation within the different sections is possible. The scenario design of this research can be characterized as complex, since the European automotive industry consists of multiple large companies who all have their own visions and opinions on future ITS developments. Furthermore, this research tries to say something about uncertain developments in the next twenty years. As mentioned previously, this research will use qualitative data sources, resulting in intuitive scenarios. Finally, the scenarios will be used for the exploration of the future, instead of working towards a predetermined target or goal.

Method for designing Scenarios

According to Van 't Klooster & Van Asselt (2006), the scenario axes approach is often assumed as a standard method in foresight studies. Nevertheless, the Foresight Horizon Scanning Centre (2009) tries to make a distinction between three types of scenario constructing methods. The *two axes method*, the *Branch analysis method*, and the *Cone of plausibility method*. They argue that the appropriateness of each method depends on the timeframe that is under investigation. The Cone of plausibility method is preferred in a research with a timeframe ranging from a few months up till 2-3 years. The Branch analysis method is suitable for research within a timeframe up to five years. If the research tries to say something about a longer timeframe (10-20 years) the two axes method is favourable. Based on this distinction, the two axis scenario method is chosen for this research.

The two axes technique starts with identifying the two most important developments in the field under investigation. Rating the different developments is done based on the concepts of uncertainty and the impact of the developments. A visualization of this process is given in figure 3 where development A and B are selected as the two most important developments.

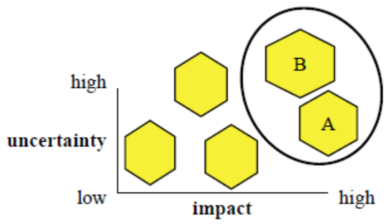

Figure 3: Selecting the most important developments (Van 't Klooster & Van Asselt, 2006)

The two selected developments (A and B) can now be placed on two different axes, resulting in the starting point for four different scenarios (see figure 4).

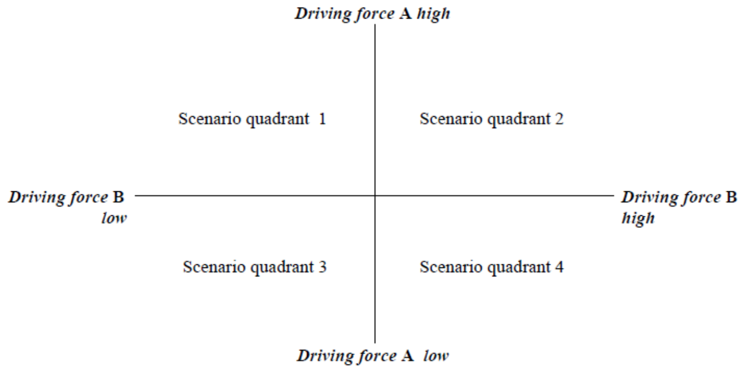

Figure 4: 'Scenario axes' as starting point for scenarios (Van 't Klooster & Van Asselt, 2006)

When developing scenarios, it is important to be aware of only making scenarios that broadly correspond with the worst case scenario, the status quo, and the ideal situation. By doing this, the risk of rejecting the extreme scenarios increases. It is better to develop scenarios that have positive, as well as negative characteristics (Foresight Horizon Scanning Centre, 2009).

Godet (2006) argues that each developed scenario should have a clear but neutral title, and you should always be aware of the risk of making too detailed and smooth stories resulting in 'scenario entertainment'. Furthermore, Godet (2006) makes clear that building a scenario is not an end by itself. *"A scenario only acquires meaning or direction in the form of results and consequences, in other words, action"* (Godet, 2006, p.110). For the researcher, building the scenarios will be the actual goal/end of this research. For ARCADIS however, the scenarios can give direction to their actions to advise road authorities and other stakeholders on future ITS developments.

4. *Methodology*

The research has a descriptive research design since it describes possible future ITS developments in the European automotive sector. These possible futures are presented in four different scenarios. Additionally, the research has a descriptive research structure. The goal is to present different scenarios on how the future could evolve, and how these possible scenarios will (or will not) influence the road authorities and their current activities. No judgments or comparisons are made on which future scenario is most preferable for the road authorities and/or society as a whole.

The future developments of ITS in the automotive industry are highly uncertain. There are no databases with information about the future and because of the high rate of competition, the different companies do not share a lot of information in public documents about their future visions and strategies. Therefore, interviews are conducted with persons who are somehow involved in future (automotive) ITS developments (ITS experts). The choice for performing interviews has been made because it is a well-supported method for obtaining in-depth qualitative information (Hancké, 2009). Hence, this results in a qualitative research approach.

4.1 Target group for data gathering

The European automotive sector has a large impact on the European economy. Over 12.6 million jobs in Europe are related (directly or indirectly) to this sector (ACEA,2010). Besides well-known car manufactures such as Volkswagen and Renault, suppliers of the car manufacturers represent a large share of the European Automotive industry. Another important characteristic of the sector is that it is the largest private investor in R&D in Europe (ACEA, 2010).

The extensive size of the sector and the substantial impact of the final product (vehicles) on society, especially on traffic safety and pollution, draws the attention of several stakeholders who will try to influence the industry. Regulatory institutions such as the European Commission designed the European Emission Standards to reduce pollution, whereas an interest group such as Euro NCAP tries to improve the safety of the European vehicles by doing crash tests.

When looking at ITS developments, the car manufacturers will make R&D investments and cooperate with their suppliers to come up with viable ITS technologies. Subsequently, other stakeholders will get involved to regulate these technologies, or try to influence the development based on the interests of the interest group.

The target group for the data gathering of this research were ITS experts in the European automotive industry. However, as mentioned above, other stakeholders also have (or gain) knowledge on the ITS topic. Therefore, not only experts within the automotive industry itself were contacted but also ITS experts from consultancy and research institutes, drivers associations, traffic policy makers, and road authorities were asked about their opinions on future ITS developments in the automotive industry. Reason for this was also to make sure a broad and complete view of the industry could be created based on a wide range of opinions of experts. Since this research was conducted in the Netherlands the main focus was on ITS experts in the Netherlands.

In total, sixteen ITS experts with different backgrounds were interviewed in sixteen individual interviews about their opinions on future automotive ITS developments in Europe (see table 2). Due to requests of anonymity by the participants, the participant- and company names will not be mentioned.

Automotive industry
▪ Vehicle manufacturers: 3 interviews ▪ Suppliers of vehicle manufacturers: 4 interviews
Research and Consultancy Institutes related to the automotive industry
▪ 4 interviews
Institutes related to traffic safety
▪ 1 interview
Driver associations
▪ 1 interview
European Union ITS initiatives
▪ 1 interview
Road authorities
▪ 2 interviews

Table 2: Professional background of the interviewed ITS Experts

4.2 Taking interviews

Once the ITS experts agreed to participate in the research, appointments were made for face-to-face interviews. In three cases, telephone interviews were held due to major geographical distances. All the interviews were conducted using the same format. The interview format can be found in Appendix I (Dutch) and Appendix II (English).

The interview format entailed two different parts. At first, some general questions were asked about the organization, their relation with ITS developments, and some background info on the education and working experience of the interviewee. This part serves two purposes. First, it provides some information about the company/institution and who is being interviewed. Secondly, it provides an easier start for the more in-depth questions in the second part of the interview. The second part of the interview consisted of mostly open-ended questions to acquire as much information and visions as possible on future ITS developments, and their possible influence on road authorities throughout Europe. The open-ended questions were based on the topics found in the literature on (future) ITS developments in the automotive industry as mentioned in table 1 in chapter 3.

When the experts mentioned certain statements about future ITS developments, follow-up questions were used to find out why the experts had this opinion, under which assumptions (policy, technological developments, acceptance etc.), and in which context they constructed this opinion. Most of the interviews took about 1,5 hour. However, three participants only had 30 minutes available. In these interviews, some of the general questions were skipped, and a selection of questions was asked, especially focusing on open questions about the future.

4.3 Data analysis

In this research, all the data was gathered by conducting interviews with ITS experts. To acquire as much information possible during the interviews, all interviews were recorded (after approval of the interviewee) and transcribed word by word, verbatim. Subsequently, the transcribed interviews were sent to the interviewees, to give them the possibility to check their statements and, if necessary, adjust their statements. Once all the transcribed interviews were gathered, the data was processed and analysed. Since it is a qualitative study, no statistical analyses were made. Nevertheless, the gathered data had to be organized in such a way that thorough comparisons between the different expert's opinions could be made.

To be able to do this, all the transcripts of the interviews were coded; assigning labels to extracts of data (Green & Thorogood, 2009). Initially, the idea was to gather all the different answers per interview question, label the important developments, and then try to find out which developments created the most discussion or conformity between the different ITS experts. This manner did work for the big developments mentioned by almost every expert. However, it did not work for small differences and nuances in some of the statements. Furthermore, the large amount of data made it very challenging to keep a clear overview on all the labelled data.

To tackle the aforementioned problems of labelling by hand, the decision was made to use Computer Assisted Qualitative Data Analysis Software (CAQDAS). According to Green & Thorogood (2009) the advantages of using CAQDAS are:

- With large projects, it can collect all the different data and analysis in one place.
- Analysis can be done more thorough and systemic than done by hand.
- The analysis will have greater transparency.
- It makes it easier for multiple researchers to work together on the same analysis.

There are also drawbacks, where the most important one to keep in mind is that the software will not do the analysis/coding for you. It helps with managing and retrieving data, but the coding remains the task of the researcher (Green & Thorogood, 2009).

In this research, the Computer Assisted Qualitative Data Analysis Software NVivo7 was used, to manage, label, and analyse the transcribed data retrieved from the interviews. After putting all the transcribed interview data in one project file, the data was processed by labelling all the statements. At the beginning, all interesting statements were labelled. If it was not possible to link a statement to an already formulated label name, a new label name was added.

After this first round of labelling, all labels were analysed. The number of labels was reduced by combining certain labels with more or less the same meaning and changing some of the label names. Finally, a distinction in three types of label groups was made. The label group ‘critical factors’ focuses more on the ‘soft/social’ aspects/demands of (deploying) future ITS technologies, while the label group ‘automotive trends’ concentrates on technical aspects of future ITS technologies. The third label group ‘general trends’, focuses on general statements about future society, that could influence ITS and/or the automotive industry.

The distinction between the label group ‘trends’ (general/automotive) and the label group ‘critical factors’ serves another purpose. The critical factors are used to define the axes of the scenario backbone, by using the ranking method developed by Van ’t Klooster & Van Asselt (2006) on the level of impact and uncertainty. This is operationalized by ranking uncertainty and impact using the following scores: Low (-), Medium (0), and High (+). The trends are used to fill in or give guidance to one of the four different scenarios with future ITS developments in the automotive industry for the European market. Based on these scenarios the main research question is answered.

4.4 Validity and reliability

Making statements about future ITS developments based only on expert statements challenges the concept of *validity*. How can expert opinions about possible future developments be checked for validity? The future developments of ITS in the automotive industry are highly uncertain, and the (different) personal opinions of the ITS experts will be the best data available for this research.

The notion of *reliability* is also important within this research. Reliability in scientific research *“means that if you apply the same procedure for measuring something, you will end up with the same result if nothing else has changed that could influence that”* (King et al., 1994, p.25). In this research reliability is dealt with by supplying (on request) all the transcribed interviews and the digital recordings of the sixteen executed interviews to other researchers.

5. *Results*

5.1 Labelled interview data in NVivo

The first step in developing the scenarios is organizing the data that was retrieved from the interviews with ITS experts. The interview data that was labelled with the NVivo7 software, is divided into three different label groups, namely Automotive Trends, General Trends, and Critical Factors. In table 3 the different label groups derived from the NVivo software are presented. Although this research will not make any quantitative data analysis, the table shows how many times a certain label is mentioned in different interviews and in total. By doing this, an insight is given in how often certain topics were addressed in the different interviews.

Automotive trends	**Mentioned in nr. of interviews**	**Nr. times mentioned**
Trend ADAS	16	58
Trend Automatic driving	15	30
Trend New possibilities with nomadic devices	11	21
Trend Infotainment	7	20
Trend Always the right travel info available	11	16
Trend Multimodal transport	8	15
Trend CO2 reduction	6	14
Trend Individual traffic management	7	14
Trend Rapid developments in wireless communication technology	7	11
Trend Individuality	4	9
Trend Difference in ITS applications in passenger cars and transport vehicles	5	8
Trend New entrants automotive ITS market	3	8
Trend Connected car	2	8
Trend ITS opportunities when using electric vehicles	3	5
General Trends		
Trend Efficient use of resources	11	18
Trend Economic developments	5	5
Critical Factors		
Technological development of ITS	16	73
Role of the government	12	59
Cooperation between ITS stakeholders	15	56
Costs and Business Cases for ITS technologies	14	54
Priority of ITS in Automotive industry	16	51
Public acceptance of ITS technologies	15	45
Compatibility of ITS technologies	16	44
Liability issues with new ITS technologies	14	27
Shared ITS vision(s) automotive industry	15	26
Penetration rate of ITS technologies	6	10

Table 3: The three different label groups derived from NVivo.

When building the scenarios, the different label groups have their own purpose. The critical factors are used to define the axes of the scenario backbone, and the trends (automotive and general) are used to fill in and give guidance to one of the four different scenarios.

5.2 Automotive and general trends

The *automotive trends* describe how different ITS related technologies and topics can develop in the future, from a more technological point of view, without giving too much attention to the more ‘soft/social’ aspects that can influence the development of these technologies/topics. The *general trends* focus on the broader statements that were made about future societies. These are trends that can have an influence on future ITS developments and/or the automotive industry. Short descriptions of all the automotive and general trends can be found in Appendix III.

5.3 Critical Factors as the scenario backbone

As mentioned in the methodology, the two most important critical factors will be used as axes for the scenario backbone. To find these most important critical factors, each critical factor is described and rated based on the level of uncertainty and impact using the following scores: Low (-), Medium (0), and High (+). The level of uncertainty means the uncertainty of the critical factor under investigation. The level of impact rates whether the critical factor has a low, medium, or high impact on the development and deployment of ITS technologies

Critical factor: Technological development of ITS
When asking about possible uncertainties in future technological developments of ITS technologies, it is often mentioned that there are no real insurmountable technological challenges, and almost everything is technologically feasible today. Therefore, the level of impact is ranked *low (-)*. Most of the experts argue that if there are any uncertainties in the technological developments of ITS, they have to do more with topics such as the cooperation between the actors that will be involved. Consequently, the level of uncertainty is ranked *medium (0)*.

Critical factor: Role of the government
The role of the government in future ITS developments is often mentioned. On one hand, the government is seen as an actor that should come up with regulations, subsidies and investments to stimulate the development/deployment of ITS technologies. On the other hand, future ITS developments developed by the industry can have a large influence on the current tasks of the government. This results in both a *high (+)* level of uncertainty, as well as a *high (+)* level of impact.

Critical factor: Cooperation between ITS Stakeholders
The importance of cooperation between ITS stakeholders (users, industry, governments etc.) is mentioned in all the interviews. It is only possible to build cooperative ITS systems, if all actors are involved, and are able to make (long-term) agreements about for example standards. To be able to do this, a common goal supported by all stakeholders is needed. It will be challenging to find such a goal, especially in a competitive market such as the

automotive industry. This results in a *high (+)* level of uncertainty, as well as a *high (+)* level of impact.

Critical factor: Costs and Business cases for ITS technologies

There is a lot of discussion about the possible costs and business cases of future ITS technologies. A difference can be seen between in-vehicle and cooperative ITS systems. For in-vehicle systems it is easier to come up with working (individual) business cases. Especially, the rapid developments in mobile communication creates opportunities for new data services. With cooperative ITS technologies, business cases are a bigger challenge. The different actors all need to visualize a possible business case to want to invest in their own part of the technology, without having the guarantee that the cooperative ITS system will actually be deployed. Governmental parties are often mentioned as an actor to take the leading role in this process, especially in projects focusing on more 'societal' benefits with less clear commercial business case opportunities. This critical factor is ranked with a *high (+)* level of uncertainty and a *high (+)* level of impact.

Critical factor: Priority of ITS in the automotive industry

There were various opinions on the priority of ITS in the automotive industry. When focusing on the comfort/in-vehicle systems, there is conformity between the experts that these technologies are a good way to distinguish vehicle manufacturers from other vehicle manufacturers. They are hereby creating a competitive advantage and thus have a high priority. Some of the experts say this is also the case for more long-term advanced cooperative ITS technologies. They support this opinion by mentioning all sorts of ITS research projects the vehicle manufacturers are involved in, partly driven by the big pressure on the industry to reduce CO_2 emissions.

On the other side, there are experts that state that the automotive industry has a low priority in ITS development. One of the given reasons was the mechanical mind-set of vehicle manufacturers. Because of this traditional mind-set they are never ahead in electronic developments. Another explanation that was given, is that the automotive industry is not innovative and will keep building 'traditional' vehicles until there is a changing demand from their customers, or forcing regulations by governments. The level of uncertainty is ranked *high (+)*, while the level of impact is ranked *medium (0)*.

Critical factor: Public acceptance of ITS Technologies

Opinions about public acceptance can be divided into two different groups. The first group rates the chance that the public will reject ITS technologies as low. As long as there is some kind of personal benefit or incentive for the users of these technologies and people are be able to gradually get familiarized with uniform ITS systems, there will be no issues with the public acceptance of ITS technologies. The second group had more doubts about the public acceptance of ITS technologies. They think that the first introductions are critical, and if the first introductions are not flawless, technologies can be neglected for a long period of time. Privacy issues are also able to have a negative influence on the public acceptance of ITS technologies. This results in a *medium (0)* level of uncertainty and a *medium (0)* level of impact.

Critical factor: Compatibility of ITS technologies

The majority of the experts see uniform standardized ITS technologies as a prerequisite for large scale (cooperative) ITS deployment. The main priority is to standardize V-2-V (Vehicle to Vehicle) and V-2-X (Vehicle to Vehicle/Infrastructure) communication technologies and protocols. Some experts say that these standards are will be developed by the industry itself in different alliances and research projects. Others argue that the standards have to be developed by the government to assure the systems will have benefits not only for individuals, but also for society as a whole. The level of uncertainty is ranked *medium (0)* and the level of impact *high (+)*.

Critical factor: Liability issues with new ITS technologies

The majority of the experts was pointing out how uncertain the topic liability is, especially when there are a lot of actors involved. Some were saying that the driver will always be responsible for operating his vehicle (as stated in the Vienna convention), even with automatic driving (the example of the automatic pilot was mentioned a couple of times). The manufacturers will remain responsible for the quality and safety of their products. A minority was saying that the liability issue was often overrated, with a number of examples to prove this. For example one expert stated that “ADAS systems are available for over 15 years, I can’t think of one lawsuit”. Therefore, the level of uncertainty is ranked *medium (0)*, while the level of impact is ranked *high (+)*.

Critical factor: Shared ITS vision(s) automotive industry

Asking the experts about some kind of ITS vision within the automotive industry resulted in a number of opposing answers. Some said that the automotive industry was lacking any vision, that they are only focusing on short-term developments, and that most of the time they are guided/forced by regulations. Others said that the automotive industry do have clear ITS vision(s). The manufacturers all know that ICT/ITS can have a positive influence on the functionality of their vehicles, and gives them new possibilities to create a distinguishing capacity. More general and/or societal automotive ITS visions are formulated in working groups and consortia such as the C-2-C (Car-2-Car communication) consortium. These visions tend to focus on long-term developments, such as cooperative driving. The consortia/working groups also participate in research projects. However, some of the ITS experts mentioned that there are a lot of consortia/projects doing the same kind of research. The level of uncertainty is ranked with *high (+)* and the level of impact with *low (-)*.

Critical factor: Penetration rate of ITS Technologies

This critical factor is only applicable for cooperative systems. The penetration rate of cooperative ITS systems is an important issue for users, the government, and the automotive industry. This opinion was shared by the majority of the interviewees. None of these players will invest in cooperative systems if they do not have the guarantee that other actors are doing the same. However, the benefits of cooperative ITS will only show with a certain penetration rate. Some of the interviewees were pointing at the government to come up with introduction scenarios to tackle this problem. Furthermore, there was an expert who thought, aftermarket devices will play an important role in a fast penetration of cooperative ITS technologies. The level of uncertainty is ranked with *high (+)* just as the level of impact which is also *high (+)*.

Choosing the two most important critical factors

Below in table 4, a summary of rating the critical factors is given. The critical factors with a high (+) score on the level of uncertainty, as well as the level of impact, can be regarded as the most important critical factors in the future developments of ITS in the European automotive industry.

Critical factors	**Level of uncertainty**	**Level of impact**
Technological development of ITS	0	-
Role of the government	***+***	***+***
Cooperation between ITS stakeholders	***+***	***+***
Costs and Business Cases for ITS technologies	***+***	***+***
Priority of ITS in Automotive industry	+	0
Public acceptance of ITS technologies	0	0
Compatibility of ITS technologies	0	+
Liability issues with new ITS technologies	0	+
Shared ITS vision(s) automotive industry	+	-
Penetration rate of ITS technologies	***+***	***+***

Table 4: Rating the critical factors

The scenario backbone is only able to use the two most important critical factors. The matrix shape implies that the two critical factors are able to influence each other. The critical factor *Penetration rate of ITS technologies* is more dependent on the other three critical factors, than it is able to influence those factors. Therefore, *Penetration rate of ITS technologies* will not be used as one of the axes. When looking at the *Cooperation between ITS stakeholders* vs. the *Role of the government,* one can say that the government is also one of the ITS stakeholders, and it is not realistic for an actor to be influenced by itself. Finally, there is the possibility to choose between:

- *Costs and Business Cases for ITS Technologies* vs. *Role of the government*
- *Costs and Business Cases for ITS Technologies* vs. *Cooperation between ITS Stakeholders*

Eventually, *Costs and Business Cases for ITS Technologies* and the *Role of the government* are chosen as the two most important critical factors supporting the scenario backbone. The critical factor *Cooperation between ITS Stakeholders* was not chosen because there was a too wide range of involved stakeholders depending on the type of technology and their own interests, to use it as a clear concept in the different scenarios.

The scenario backbone

In figure 5 the scenario backbone is presented. The critical factor Costs and Business Cases for ITS Technologies was used as an input for the axis Shared / Individual Business Cases. The Role of the Government has turned into the axis Low / High rate of Governmental Involvement.

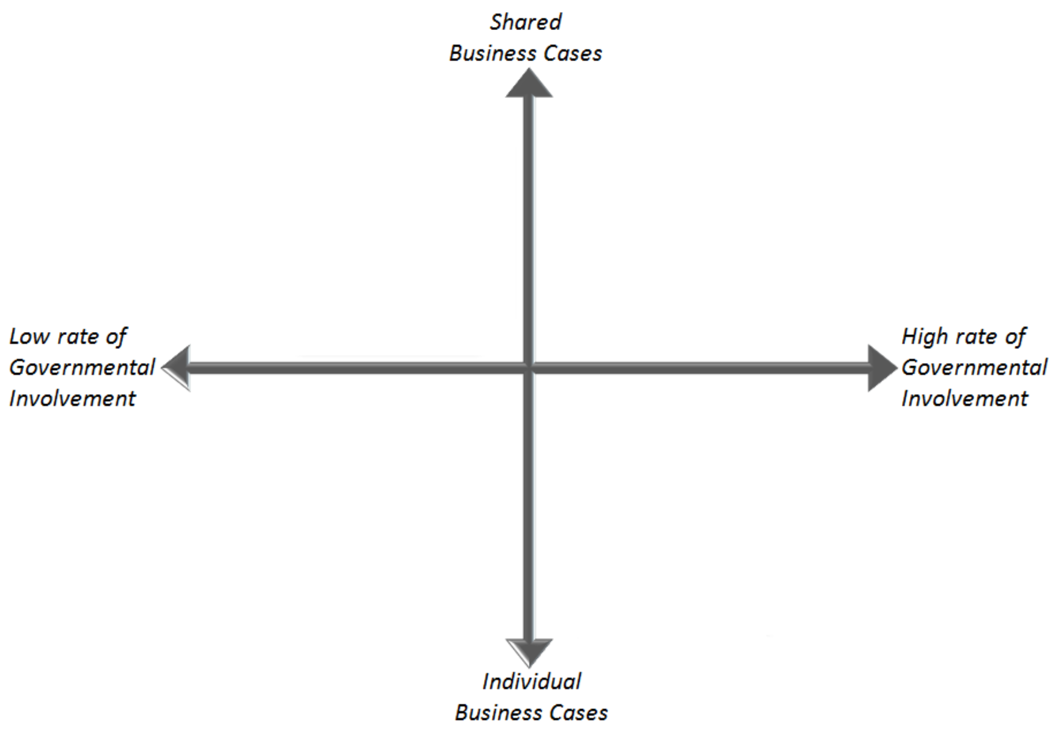

Figure 5: The chosen scenario backbone

During the design of this figure, some assumptions are taken into account. When talking about business cases, the focus is on ‘commercial’ business cases. Putting a price on a number of saved lives due to a certain policy is not seen as a ‘commercial’ business case. With governmental involvement, the involvement of national and European government(s) is meant. Furthermore, the assumption is made that the road authorities are directed by the national/European government(s).

5.4 Four scenarios on future ITS developments in the European automotive industry

In figure 6, the four developed scenarios on future ITS developments in the European automotive industry are presented, and each scenario is given a title for convenience. No judgements will be made on which scenario could or would be the most beneficial for the road authorities or society as a whole. Furthermore, it is possible that the real situation in 2030 will look like a combination of elements from all four scenarios.

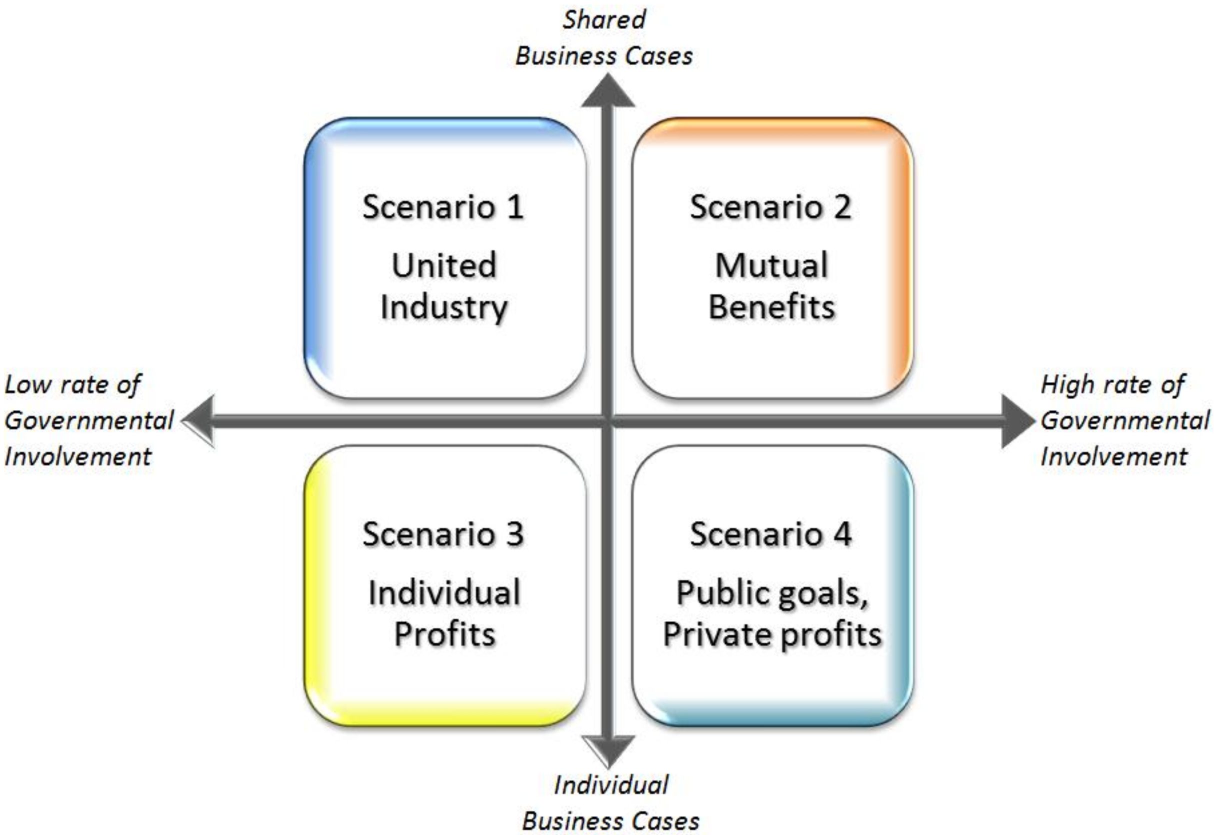

Figure 6: The four developed scenarios

Each scenario starts with mentioning the scenario plot (Schwartz, 1991). All four scenarios make use of the 'action-reaction' scenario plot. For example in scenario 1, the automotive industry takes the initiative (action), and the government does not respond (reaction). Subsequently, a description on how the two axes have influenced each other and what this means for the industry, as well as the governmental parties, is given (setting the scene). Afterwards, the role of the involved stakeholders in each scenario is described. The stakeholders are:

- Automotive industry
- Government(s)
- Road authorities
- Nomadic devices industry
- Telecom providers
- Users/Citizens

Since the aim of this research is to get insight into future ITS developments in the European automotive industry, most attention goes out to the role of the automotive industry. Quotes from the interviews with the ITS experts are mentioned in *italic* and are used to illustrate the four different scenario stories.

5.4.1 Scenario 1: United industry

Scenario plot: The automotive industry takes the initiative, without guidance from the government

In this scenario, the automotive industry is aware of the negative externalities their vehicles and road transport in general are creating for society. The development of ITS technologies is seen as one of the joint tasks for the automotive industry to assure there will still be a profitable industry in the future. This all starts with bigger manufacturers. Vehicle manufacturers also have short-term profit goals with ITS technologies, but these are in line with the shared long-term visions. Although the automotive industry has clear long-term ITS visions, the government has a more resilient attitude. They are not really encouraged to formulate these visions while the uniform vision of the industry can result in tasks such as traffic management that are currently coordinated by the government/road authorities, are taken over by the industry. "*The industry that is taking over some of the tasks of the government can save the government a lot of money".*

Automotive industry
The main research priority of the automotive industry is shifting from efficient/alternative drivetrains towards ITS research. *"They have already done so much research in this field that there is not much more progress to be made. In the field of ITS research there are still a lot of improvements to make, so ITS research is becoming much more important, now and in the future".* In consortia and pilot projects, the vehicle manufacturers and their suppliers try to formulate and standardize the V-2-V/V-2-I communication processes to *"collectively push this technology"*. The government does not play an active role in this process since "*the standardization process is a task for the OEM's, and not for the government or road authorities"*. This high priority in the automotive industry makes it possible that around 2020, *"the first V-2-V and V-2-I systems that go beyond the pilot project phase will be deployed".*

Specifying V-2-V/V-2-I systems and standards with a lot of actors takes some time, and before this period other ITS systems and trends will start to become mature. It starts with the ADAS systems such as lane departure warning, automatic parking, and adaptive cruise control. These systems are a good way for the vehicle manufacturers to distinguish themselves from other competitors. Depending on their *"brand aura"*, they can focus on systems improving the safety, driveability, reliability, or comfort (or a combination of these topics) of their vehicles. Around 2020, *"these driver assistance systems will be available on almost every newly sold car".* Because of the awareness among the manufacturers on the importance of V-2-V/V-2-I communication in the future, they try to develop ADAS systems that are able to communicate which each other, not restricted by the make of the vehicle, to be able to make the step from *"warning systems towards intervening systems".* An example of what is then possible is a cooperative ACC system, which will be possible in 2030.

Not everything can or will be arranged by the automotive industry itself. Things such as mobile communication are not the core business of vehicle manufacturers and will be outsourced to telecom providers. This data connection becomes more and more important due to the rise of the nomadic devices such as navigation devices, smartphones and tablets that bring the ‘outside world’ into the vehicle, *“Companies like Microsoft, Google, and smartphone manufacturers all have the goal to connect everybody with their products and services. A lot of people spend many hours a day in their vehicles, so if these people start making use of these products and services during their journey, it can be seen as a very interesting market”.* One can think of ‘apps’ that are able to reserve a parking place at the next exit, free intelligent navigation software with build in advertisements, or an online driving coach with a competition among your colleagues to become the ‘greenest’ driver.

The automotive industry is not hostile towards these new ‘automotive entrants’, because they are aware of the fact that the development cycles of these nomadic devices are only a fraction of the development cycles of a car or a truck. The same is true for the replacement rate of the nomadic devices in comparison to vehicles. Therefore, the automotive industry sees the nomadic devices as a good way to get a fast deployment of vehicles that are connected to the internet, the ‘connected vehicles’. *“Only by using nomadic devices it is possible to get the right deployment rate of connected vehicles before 2020, if you have to wait until new technologies in the automotive industry are available in every new car, such as a data connection, this often takes more than 10 years”.*

Eventually, the intelligent navigation devices will become integrated in the vehicle, for a ‘luxury feel’. However this is not the case for smartphones (and tablets). The smartphone becomes very important for the driver, *“it is the personal world of the people”*, and the vehicle manufacturers will try to combine the functionalities of the smartphone with the functionalities of the vehicle during the trip but still have the possibility to use the smartphone outside the vehicle.

“In 2030, V-2-V communication will be completely deployed in all newly sold vehicles in Europe.” When looking at V-2-I communication, it depends on which definition of infrastructure is used. If the infrastructure is a back office for intelligent navigation advice, or servers which are able to make linkages between the data of different vehicles, this will be deployed in 2030. If the infrastructure is regarded as the road itself, or traffic lights that are able to communicate with the vehicles in the area, this will not be possible without active participation by the government(s) and/or road authorities. Therefore, in this scenario automatic driving will not be possible in 2030 due to a lack of ‘intelligent infrastructure’.

Government(s)

While the industry is formulating long-term ITS plans, the government is lacking these. *”They live by the day, and the plans developed by the previous government are aborted once the new government is in place. In countries such as Japan and the United States they are much further in formulating long-term ITS policy than we are here in Europe”*. In line with this short-term thinking, the governments do not have the guarantee that a large scale introduction of new ITS-technologies will make an instant improvement for society, while *“the benefits of investing in new roads are visible once the road is completed”*. Moreover, because the industry has a clear vision on the future of ITS, there is not a real urge for the government to intervene in this process.

Because of the low rate of governmental involvement in setting up long-term ITS plans, the plans were made in an ‘technological environment’, where *“engineers often develop certain ITS features because it is possible, instead of asking whether these technologies are really beneficial for the driver itself, or for society as a whole”.* Once these technologies emerge in society, it is possible that questions rise about the reliability/safety of for example V-2-V communication, the possibilities of an information overload for the driver, or whether privacy issues are respected by the commercial parties. This results in an ad-hoc approach of the government in reducing the negative externalities of introduced ITS technologies, which can be very challenging if they were not involved in the development process, and there are already large groups of people using the technologies.

Road authorities

Guided by the European/national government(s), the lack of long-term ITS policy is also visible at the road authorities. Having no additional budgets, it is not possible to start large ITS projects without proven effects. *“Of course they will do some test- and pilot projects here and there, to show to the public they are working on these developments. But these pilot projects have nothing to do with ‘real world’ applications”.*

The first infotainment and ADAS developments will not have a big impact on the road authorities. They will notice the ITS movement started by the automotive industry once there are enough ‘connected cars’, which is expected to be around the year 2020. All ‘connected cars’ are able to communicate with each other and with the internet or back office, which creates an enormous pool of traffic data. This data can be used to make smart individual predictions about travel times and routes. If the users experience that the ‘individual advice’ is better than the general advice of the road authorities, the road authorities start losing grip on managing the traffic on their roads.

By providing traffic data, the industry can take over some of the tasks of the road authorities which, according to the industry, can save the road authorities a lot of money. The question is whether this is really the case. For example when the road authorities try to integrate the new privately developed system into their current systems, the privately developed system will cost money. Besides, without giving subsidies for ‘connected cars’, or demanding that every car on the road is ‘connected’, the road authorities still have to serve the people with conventional ‘ITS-less’ cars with information by using signage with traffic advice.

Nomadic devices industry

The manufacturers of nomadic devices often make more than just a smartphone, tablet or navigation device. Besides the product itself, they also try to sell exclusive services for those devices containing features with individual advice on (in case of road transport) trip planning, traffic situations, the weather, appointments, public transport, road pricing etc. While the automotive industry is not hostile towards players in the nomadic devices industry, the nomadic devices industry itself is highly competitive. When the vehicle manufacturers are trying to integrate the functionalities of the device into the vehicle during the drive, the smartphone and tablet manufacturers will compete with each other to assure their device and thus their services are integrated and not those of the competitor.

Telecom providers

The upcoming trends of nomadic devices and connected cars in the road transport scene makes it an interesting new market for the telecom providers. In addition, *"to develop a system with poles alongside the road especially for automotive applications, will never be feasible. Scalable technology such as the mobile 3G network is needed".* At first, the 3G/UMTS connections will be sufficient. Later on, the more advanced LTE (Long-term Evolution) technology is needed to assure the right transfer speeds are met, needed for 'safety related functions' such as cooperative ACC. Although such a generic communication system will be cheaper than an automotive specific system, there are still some uncertainties about the costs of building new LTE networks. *"The right billing models still have to be developed by the telecom providers".*

Users/Citizens

Once the users/citizens experience that the ITS technologies have benefits for them at a reasonable price, they will accept it. A reasonable price can be possible because of the high rate of cooperation within the automotive industry. *"If the automotive industry really wants to produce something at a low price, they always know how to do this".* The clear long-term ITS plans of the automotive industry and introducing the new technologies step by step, helps the users/citizens to familiarize with the new technology gradually. Nevertheless, "*the notion of private parties who know everything from individuals when looking at their 'connected car' data, could result in a countermovement"*. If the industry, or after that the government, is not able to address the concerns of this countermovement, the ITS developments will slow down.

5.4.2 Scenario 2: Mutual Benefits

Scenario plot: The automotive industry takes the initiative and the government gives direction to this initiative

In this scenario, the automotive industry is aware of the negative externalities their vehicles and road transport in general are creating for society. The development of ITS technologies is seen as one of the joint tasks for the industry to assure there will still be a sustainable and profitable automotive industry in the future. This all starts with the bigger manufacturers. The government is also involved in the process, to assure the systems will really help society. Furthermore, the government itself is also struggling with the problems of congestion, pollution, and emissions. Besides, they are really making long-term plans and programs to make a success of ITS, and they see ITS as a promising development.

Automotive industry

The automotive industry is still strongly focused on developing alternative and more efficient drivetrains in order to keep decreasing the CO_2 emissions of their products, however they become more aware of the fact that only looking inside the vehicle is not enough. The industry realizes that *"an integrated ITS approach is needed, where the vehicle is able to adapt to the outside world".* This integrated approach is developed in consortia and pilot projects, where the vehicle manufacturers and their suppliers try to formulate and standardize the V-2-V/V-2-I communication processes to *"collectively push this technology"*. Triggered by these developments, the government(s) get(s) involved since they see ITS as a proper tool for reducing the negative externalities of the current road transport system such as accidents, congestion, and pollution. They will try to influence the ITS developments of the automotive industry by participating in test projects or giving subsidies for certain ITS research. Besides, they get involved in the standardization process of for example V-2-V/V-2-I communication, because *"governments know that you have to participate in this standardization process to have some influence on the final outcomes".* Because of the governmental involvement, a stronger focus goes out to technologies that are beneficial for society, *"features such as projecting Facebook and Twitter applications all over the windscreen will not be accepted".*

The European automotive industry, governments, and road authorities (supported by research and standardisation institutes) are jointly developing communication standards, and deployment strategies to start using ITS technologies. *"The cooperation between these actors is essential in the development of more cooperative ITS systems"*. Nevertheless, the process of developing standards and deployment strategies will take some time, *"such projects with a lot of different actors involved are not known for their fast results".* When the involved actors created conformity about the communication standards and deployment strategies, the vehicle manufacturers will start to install in-vehicle communication platforms in their new vehicles, and the road authorities will start to set-up an intelligent infrastructure that is able to communicate with the compatible vehicles.

To gain experience with the new technology, the system will be gradually deployed. *"Such an ITS system has to be implemented gradually, in small chunks at a time. Taking the people by the hand in the development process is very important, and it doesn't matter whether these* *people are consumers, legislators, or manufacturers".* The deployment will start with launching applications such as warning drivers when entering dangerous crossroads, bringing signs and messages into the vehicle, smart traffic lights that can give way to heavy trucks to maintain certain traffic flows, and being able to give individual traffic advice. The first introductions of these launching applications will be around the year 2015.

Around 2020, the national road authorities have installed a lot of their roads with intelligent infrastructure to be able to communicate with compatible vehicles, and start to manage their traffic flows by giving individual advice to the drivers. At the same time newly sold vehicles are equipped with in-vehicle communication platforms, to be able to receive the individual traffic advice. Although the individual traffic advice is improving the value proposition of a new vehicle, it is harder for *"the vehicle manufacturers to distinguish themselves with such a standardized system"*. By developing a personalized Human-Machine-Interface (HMI), the manufacturers have the opportunity to provide their customers with an individualized system on how the information of the outside world is used and presented inside the vehicle. *"The feeling of making something personal is very important for people in the current society, so the vehicle manufacturers will use the customizing possibilities of their HMI as an important marketing tool".*

One could say that the nomadic devices industry does not have a big role in the traffic management system that is developed in close cooperation by the governments, road authorities and the automotive industry. Nevertheless, the governments also have developed other ideas for reducing the problems of congestion, pollution, and emissions. Multimodal transport is one of these ideas, where *"the government is pushing initiatives that are able to give individual advice on the best carrier possible at that given time, whether this is a car, bike, or a form of public transport".* To be able to keep giving the best individual advice possible in each carrier, nomadic devices are needed that can also be used outside the vehicle. Governments will try to stimulate the use of these devices inside and outside the vehicles to improve the use of multimodal transport. Therefore, some kind of integration or compatibility is needed between the in-vehicle communication platform and the nomadic device. This can also be an 'app' that can be installed on the in-vehicle communication platform, as well as on the nomadic device such as a smartphone or tablet.

When the trend of multimodal transport is picking up, some of the users start to experience that they no longer need to own a vehicle to fulfil their mobility needs. "*The concept of car-ownership is changing. More and more car manufacturers are seeing car-sharing programmes as a promising business case, especially in combination with multimodal transport".*

Whether the vehicles are privately owned or not, it does not affect the development of the safety related ADAS features such as automatic braking or lane departure warning. Before 2020, the vehicle manufacturers all introduced their own developed in-vehicle ADAS systems. However, because of the developed and standardized communication platform, *"the ITS information that comes into or is send by the vehicle can be used for driver assistance systems, and even for autonomous functions within the vehicle".* This development can result in *"platooning and automatic driving features in the year 2030*". However, because there will still be some vehicles without ITS functionalities during this period, automatic driving or platooning functionalities "*will only be possible on dedicated lanes, at for example a very congested highway*". Another application focusing on commercial vehicles is *"the use of platooning technologies on 'the green corridors' that deliver freight in the congested city centres, which are no longer accessible for conventional commercial vehicles".* The automotive industry is confident they are able to develop these automatic driving or platooning functionalities. Nevertheless, a lot of effort will have to be put in the right fall-back scenarios. *"If the system fails, how to get the driver safely 'back in the loop'?".* Furthermore, there are some liability issues that have to be resolved in the law, when it is no longer obvious who is responsible for the guidance of the vehicle. It is not all about liability issues for the vehicle manufacturers, *"there is always a brand on a vehicle. So if something happens with this vehicle, even without a fault of the manufacturer, this can result in branding damage with possible consequences for their brand name and consequently for their business".* Because of these kinds of issues *"automatic driving is certainly not a long-term goal for every vehicle manufacturer".*

Government(s)

The positive and active attitude within the automotive industry to jointly develop ITS technologies is well received by the government(s). Nevertheless, because of the governmental involvement, a stronger focus goes out to developing technologies that are beneficial for society *"If you let the industry decide on what kind of ITS technology should be developed, it will never result in a system that the government is aiming for. The government is aiming at for example reducing the amount of traffic jams, but reducing traffic jams is not the main goal for the automotive industry".* By participating in test projects and giving subsidies for certain ITS research, the government is aiming to develop ITS technologies with societal benefits. Furthermore, they are developing communication standards and deployment strategies to start using ITS technologies, in close cooperation with the automotive industry and the road authorities.

Once the standards are developed, it will be the government that has to make *"the initial investments to support the road authorities and the end users"*. The road authorities will be supported with additional funds to install the intelligent infrastructure and the end users will be supported *"by giving tax exemptions, which proved to be a successful tool for stimulating the use of more energy efficient vehicles".* Furthermore, society will be informed using awareness campaigns. The tax exemptions and awareness campaigns will also be used for stimulating the usage of multimodal transport, but "*once the majority of the people is using the new systems, these regulations will no longer be necessary".*

When the traffic management system that is developed in close cooperation by the governments, road authorities, and the automotive industry is in place, and the platooning and automatic driving features are technologically possible. It will depend on the role of the government if these technologies are deployed on dedicated lanes or on green corridors in the year 2030. The government has to be absolutely sure that the system is safe, *"traffic safety is a must, and these systems will not be introduced if the traffic safety cannot be guaranteed".* Besides, there can be some issues with the public acceptance of this kind of technology, because *"society will only accept automatic driving when it is a clear solution for their problems"*. The question is whether a traffic jam is a real problem for the people in society, since *"a lot of people that are daily stuck in traffic do not see this as a real big issue,* *they can listen to the radio, make phone calls, etc."* Furthermore, the government has to deal with liability issues in the current laws and regulations, for example "*the Vienna convention (1958) is stating that every driver shall at all times be able to control his vehicle".* Changing this type of regulations will take some time, "*it will take much more time than the actual development of automatic driving technology".*

Road authorities

Steered by the initiatives of the European automotive industry and the governments, the road authorities join the initiatives to cooperatively develop communication standards and deployment strategies to start using ITS technologies. Because the road authorities were involved from the beginning in the development of the technology, this helps them in gradually deploying the 'intelligent infrastructure'. Nevertheless, the new infrastructure still has to be integrated into the systems of different national road authorities, all with their own road designs.

The investment that the road authorities have to make to integrate the 'intelligent infrastructure' in their current systems, will be paid by the governments. By gradually deploying the system taking small steps at a time, the road authorities are not only able to get experience with the new technologies, they are also better able to keep updating their system according to the latest technological standards.

Once the platform starts to be deployed and is used by different vehicles, the road authorities are able to give individual advice to the vehicles using the system, and even control the traffic flows on their roads. However, *"the problem is that it will not always be possible to give the best possible advice to every individual".* For example, if every individual is getting the same advice to avoid a traffic jam, a new traffic jam can occur at this detour. It is a big challenge for a public institution to explain to an individual why they have to make a detour of 40 km, while others only have to make a detour of 20 km. *"It is very important to be able to make this decision process clear for society".* Besides giving individual traffic advice, the road authorities also have to make some kind of integration, or linkages with other databases (e.g. public transport trip planner) to support the multimodal initiatives of the government.

Only when the government is really pushing the use of platooning and automatic driving functionalities, the road authorities will get involved in developing dedicated lanes and green corridors around the year 2030. "*Constructing and developing a whole new type of road specifically for automatic driving, does not sound that feasible. The road authorities are already struggling to keep their current road networks up-to-standard".*

Nomadic devices industry

The business model of the nomadic devices industry is based on two different pillars. First, they want to sell their devices. Secondly, they want to sell exclusive services for those devices with features with individual advice on (in case of road transport) trip planning, traffic situations, the weather, appointments, public transport, road pricing etc. Nevertheless, the private parties are not able to compete with the quality of the individual advice given by the ITS platform that is jointly developed by the automotive industry, governments, and road authorities. Because the cooperatively developed ITS platform will be gradually deployed in newly sold vehicles, there will still be an in-between period with a large share of conventional 'ITS-less' cars. For this group of users, getting individual advice on traffic related topics can still be a service they are willing to pay for. Furthermore, there is the trend of multimodal transport as mentioned earlier. When multimodal transport becomes more popular because of governmental involvement, this will have a positive effect on the use of nomadic devices as well as the applications and services that are developed to improve the use of different types of transport carriers during one trip.

Telecom providers

The telecom providers will expand their business by providing vehicles, nomadic devices, and the intelligent infrastructure with mobile communication connections such as 3G/UMTS or even LTE. However, *"it will not always be possible and desirable to manage all this data at one single place".* Especially with safety critical features, the governments and road authorities will never solely rely on the network of telecom providers. Dedicated networks alongside the road will be developed to communicate with the vehicles, using techniques such as Wi-Fi, Bluetooth, and GPS. *"The entire discussion whether general mobile data communication or dedicated communication technology alongside the road will be used, is useless. It will be a combination of those two, having their own tasks and functionalities. Especially, when you want to guarantee the reliability and safety of the total ITS system".*

Users/Citizens

The ITS platform that is jointly developed by the government, automotive industry, and road authorities, is being gradually deployed in society. As long as these parties are able to *"convince people that it is a solution for a problem felt by almost the entire society"*, and they are able to provide the technology at an acceptable price, the people will accept it. Convincing the people will only work when the system is able to give high quality individual advice (this also counts for the multimodal advice), and warn or even intervene when there is really a dangerous situation. In this day and age, technologies only get a limited amount of chances to be accepted by society*, "if technology fails it is often thrown in the garbage bin for the next decade".*

If the government is really pushing the idea of automatic driving on dedicated lanes or green corridors, public acceptance can also play a role. The question is whether society sees automatic driving as a possible solution for traffic jams and accidents. A lot of people that are daily stuck in traffic do not experience these issues as a real big problem. Besides, "*a lot of drivers do not want to miss their driving pleasure".* If the government is not able to make clear to society what the real benefits of automatic driving on dedicated lanes or green corridors are, it is possible society starts to object to the governmental initiatives.

5.4.3 Scenario 3: Individual Profits

Scenario plot: The government is hardly doing anything but still there are different parties starting with their own ITS opportunities and technologies.

In this scenario, the governments (national and European) have formulated long-term ITS visions and goals. Nevertheless, because of a lack of budget and a stronger focus on CO_2 reduction by stimulating the use of alternative fuels and drivetrains, the governments remain very hesitant in the process of deploying ITS projects in order to reach their long-term goals. At the same time, the rapid developments in ITS and ICT in general, trigger companies in- and outside the automotive industry that do see all sorts of ITS business cases and possibilities, even without governmental involvement.

Automotive industry
"The main focus of the vehicle manufacturers is on energy efficiency, cleaner engines, alternative drivetrains/fuels etc. However, they are also working on ITS developments". This al starts with the 'simple' ADAS systems, such as automatic parking, lane departure warning, and adaptive cruise control. These assistance/comfort systems are a new way for the vehicle manufacturers to create a competitive advantage towards consumers in comparison to their competitors. *"Selling a car is no longer about the wheels and the tyres"*. By using ADAS systems they try distinguish themselves from their competitors by putting the accent on their own brand values such as sustainability, reliability, safety, driveability, comfort etc. Around 2020, these types of systems will be available on almost every newly sold vehicle.

The ADAS systems are in line with the in-vehicle perspective the manufacturers used to have for decades. *"In the past there was no information from the outside world to use in your vehicle, but this is going to change".* However, letting this in-vehicle perspective go can be difficult for the manufacturers because *"all of a sudden they have to connect with networks form other vehicle manufacturers, while they were used to work with their own proprietary networks for years. They see it as a development with a lot of threats, although they also see the possibilities".* The combination of seeing the possibilities of 'a connection to the world' and the lack of guidance by the government in developing a general system, results in own private platforms. A good example in the truck sector are the telematics boxes. By installing the telematics boxes, the vehicle manufacturers can get information about the operation of the vehicle, but even more important, the fleet owners have a constant connection with their vehicles. They are able to use this connection to follow their trucks, keep an eye on service intervals, look at how efficient the driver is operating his vehicle, and how they are able to influence this behaviour. Furthermore, the driver can use the telematics connection for comfort features that are connected with a smartphone, such as pre-heating the vehicle. Because of the highly competitive truck market, each manufacturer will develop their own telematics platform to distinguish themselves from their competitors, and the data transfers needed for these telematics platforms create interesting markets for telecom providers.

When looking at passenger cars, the application of telematics boxes by the vehicle manufacturers to distinguish themselves from their competitors is not that obvious anymore. The aim of the telematics systems in trucks is to keep the vehicles operating in the most efficient way and thus at the lowest cost possible. For passenger cars this application is less useful, since drivers of passenger cars are more focused on comfort and safety issues. Without a real clear incentive, and not forced by the government, developing and introducing 'connected cars' takes a long time. "*The vehicle manufacturers are just big traditional companies who have trouble with fast introductions of innovations".* The manufacturers of nomadic devices however, do have an incentive to connect a vehicle to the outside world *"Companies such as Microsoft, Google, and smartphone manufacturers all have the goal to connect everybody with their products and services. A lot of people spend many hours a day in their vehicles, so if these people start making use of these products and services during their journey it can be seen as a very interesting market".* One can think of 'apps', free intelligent navigation software or an online driving coach.

Besides giving information to the users, the nomadic devices are also able to collect data, and by using this large pool of data in their back offices, give the best individual advice to their users on for example unsafe situations, trip planning, travel times, traffic jams etc. *"The quality of this advice depends on the amount of data that is available",* and the amount of data depends on the quantity of users. Different platforms and billing models are battling for the consumer's choice. After a while, the more successful platforms will be integrated by the vehicle manufacturers in their vehicles, and the intelligent navigation devices become integrated in the vehicle for a 'luxury feel'. Smartphones and tablets will be connected to the car to be able to use and manage these platforms inside the vehicle. Furthermore, because of the high priority on alternative drivetrains and electric cars by the government, the electric car becomes more popular. *"The biggest problem with electric vehicles remains the 'range anxiety'. With ITS technologies the industry is able to deal with this issue, by giving intelligent trip advice depending on the weather, traffic jams, and giving additional services such as automatically reserving a fast charging spot*". These developments will really become mature around the year 2020.

The lack of standardization between the different platforms has resulted in *"a patchwork of different systems",* while *"the real power of ITS should not come from a number of private parties".* V-2-V communication is only possible within the boundaries of the different systems. They are not able to communicate with each other and V-2-I communication will only be possible within the private systems itself, using their own infrastructures.

With this patchwork of systems all giving individual advice to their users, it will be very hard for road authorities to keep control on the traffic management. Some kind of compatibility is needed before the road authorities are able to influence this process, or be able to install intelligent infrastructure that is able to communicate with the vehicles. Therefore, automatic driving is not going to be possible in 2030. Besides, the automotive industry will not be very active in automatic driving deployment since *"influencing the vehicle from the outside is something that we as car manufacturers do not want for liability reasons".* Nevertheless, in 2030 *"there will be a significant amount of cars using safety systems based on camera and radar techniques",* even if all those systems are not connected in a way such as connected cruise control, they can still have benefits for society. *"If these systems function well, the amount of fatal accidents with vulnerable road users can be seriously reduced".*

Government(s)
Although the governments (national and European) have clear long-term ITS visions/goals, the lack of initiative has to do with money. *"It is no longer possible for governments to make large investments in new innovative projects, without proven results".* Furthermore, the governments are strongly pushing CO2 reduction by stimulating vehicles with alternative drivetrains and fuels. They are hoping that the rapid developments in ITS, and ICT in general, will result in better and cheaper solutions in the near future which makes the government very hesitant in the process of introducing new ITS projects. *"The passive attitude of the government, is resulting in companies who already have a certain business case with ITS technologies are able to become big, without knowing the consequences for society in the future"*. The companies that are able to become big have their business case in giving the best possible individual advice to their users. The success of these parties is partly based on their data and how the data is used. Using the data from all those individuals could result in discussions about privacy. When it comes to solving the privacy issues, it is expected by society that the government will come up with clear regulations and societal boundaries, because *"it is the task of the government to protect their citizens".* It will be a challenging task for the government to get a grip on all the different systems, especially because *"the government is nothing more than a process director; they do not have the real technological knowledge anymore".*

Road authorities
The road authorities have taken notice of the long-term ITS plans developed by the European/national government. However, without additional budgets, they will continue with their current activities and tasks, since *"those people at the road authorities are stuck in their own dogmas. They keep investing in 'old' technologies such as signage, vehicle detection loops, and roadside units. This is delaying the innovation process and those dogmas should be broken".* The different platforms that are battling for the consumer's choice will try to release the road authorities from their dogmas by selling their traffic data to the road authorities and offering services such as in-car signage and individual travel advice. *"The industry is much more efficient in providing these services than the road authorities, and more efficiency means lower costs".* Because of these developments, the road authorities are struggling to maintain their *"top down traffic management, by giving the same advice to the mass".* But why listen to this general advice if you are able to get customized individual advice?

Because of the lack of compatibility between the different systems, the road authorities are still not able to reach everybody by starting to use (or buy-in data from) one of the platforms with their traffic management services. Furthermore, there will always be an in-between phase. *"There will never be a bang, the implementation process will go slowly. Unless the government is saying that from now on these technologies are mandatory for all vehicles on our roads, but that will never happen".* According to the private parties, the road authorities are able to save a lot of money. The question is whether this is really the case when using the old and the new technologies side-by-side.

Nomadic devices industry
The business model of the nomadic devices industry consists of two parts, on the one hand, they want to sell their devices, on the other hand they want to sell exclusive services for

those devices with features with individual advice on (in case of road transport): trip planning, traffic situations, the weather, appointments, public transport, road pricing etc. Seeing new possibilities, they will try to convince the automotive industry of (partly) integrating their devices in their vehicles and consequently start using their platform. *"With these systems that are giving information, it will be possible that multiple platforms will function side by side, depending on the preferences of the consumer".*

Telecom providers

The increased demand for telematics systems and other platforms connected to the internet, results in new markets for the telecom providers. The vehicle manufacturers are clear in the fact that everything that has to do with data communication will be *"outsourced to the telecom providers".* Furthermore*, "the current technologies such as GPRS and UMTS have enough bandwidth to deal with these developments; sending messages from a back office to a car can be done in seconds, which is fast enough for most information applications".*

Users/Citizens

When the users experience benefits from ITS technologies, they will start to accept them. For the 'simple' ADAS systems, it is important that the systems really work, otherwise *"the users will only get frustrated and stop using these technologies"*. The same is true for the more advanced safety systems based on camera and radar techniques. The lack of uniformity within the automotive industry, and governments that are not really stimulating the use of ADAS technologies, will not result in the best price possible for the users. However, especially when looking at safety related features, this is not an unbeatable issue. People are more and more willing to pay for these features, since *"safety sells".*

If the nomadic devices industry is able to give high quality individual advice to their users at a reasonable price, the users are likely to accept it. However, "*the notion of private parties who know everything from individuals when looking at their 'connected car' data could result in a countermovement"*. The users/citizens will keep the government responsible for solving the privacy issues. If the government is not able to address this issue, the acceptance of ITS technologies will slow down. However, this will not be the case for the truck sector with their telematics platforms *"In the truck sector, it is common practice that the truck company is able to follow their vehicles and drivers".*

Because of the low rate of governmental involvement, the users will not be forced to start using all the different ITS technologies. *"If the drivers do not like the new ITS systems, they are not forced to buy cars with those kind of systems. The driver can always make the decision not to use these technologies".*

5.4.4 Scenario 4: Public goals, Private profits

Scenario plot: The government takes the initiatives, but without a shared vision, the automotive industry makes use of these initiatives for their own profits.

In this scenario, the government is approaching ITS as an important topic, with lots of projects, long-term goals, and developed standards for the automotive industry. The governments try to speed-up the deployment of ITS technologies in order to reduce congestion, pollution, costs, and increase traffic safety. Steered by the government, the automotive industry is developing ITS technologies. However, the automotive is only looking at how to use these ITS technologies and platforms to be able to improve the value proposition towards their own customers.

Automotive industry
Despite the fact that the governments are giving a lot of attention to ITS developments, it is not seen as a major goal within the automotive industry. *"ITS is only seen as a possibility to improve more general features such as safety and comfort for the driver; a better proposition for the user". '*Simple' ADAS systems such as automatic parking, lane departure warning, and adaptive cruise control can be seen as systems to improve the comfort and safety of the vehicle. This type of ITS technologies can still be developed by the vehicle manufacturers within their own 'in-vehicle perspective', and will be broadly deployed around the year 2020. The automotive industry has more difficulties with working together or setting up a more cooperative ITS system with national and European governments. *"Most of the times the automotive industry is very hesitant when it comes to new European regulations"*. Furthermore, the European automotive industry is deeply involved in the decision-making process of European policymakers. *"They know where to pull the right strings"* to delay or adapt certain policies in a direction that is beneficial for them. *"They are just not that innovative, and are only focussing on short-term developments".*

Because of the hesitant attitude of the automotive industry towards ITS research, the governmental parties will try to simulate ITS research projects and FOT's (Field Operational Tests) by providing test facilities, subsidies, and other incentives. A lot of those projects are aiming at the same goals, only with a different scope and participants. *"They are inventing the same type of wheels at the same time, and it is often a waste of money".* To go beyond this long lasting phase of test and pilot projects, *"the European government has to make a clear choice in technology, and start using this technology to tackle the chicken-egg problem".* By installing 'intelligent infrastructure', the European governments (in combination with the national road authorities), make the first step in choosing a certain ITS communication technology or standard, *"and they hope this standard will be picked up by the industry".*

Choosing the standards can be very challenging in markets (data communication) with a high rate of technological development, so the governmental parties have to work together with more experienced standardisation institutions during this process. Once the standards are formulated, launching applications will be the first result of the chosen standards. Examples of launching applications for 'intelligent infrastructures', are smart traffic lights that can give way to heavy trucks to maintain certain traffic flows, warning drivers when entering dangerous crossroads, bringing signs and messages into the vehicle, be able to give individual traffic advice, and advice on multimodal transport.

Around 2015, *"the first intelligent infrastructure systems will be deployed in a setting that goes beyond the pilot project phase".* The clear benefits of the intelligent infrastructure and a government that is pushing the technology by giving subsidies, results in a demand for compatible vehicles by society. Guided by the demand of society, vehicle manufacturers start to integrate the proposed platforms and standards to be able to communicate with the intelligent infrastructure. *"The step-up scenarios developed by the government, are the first steps in deploying V-2-V and V-2-X communication".*

Once the platform starts to be deployed and is used by different vehicles, the government has the attitude that they fulfilled their tasks. Road authorities are able to give individual advice to the vehicles using the system, *"which gives them the feeling they found a new way of informing the drivers and controlling the traffic flows".* However, once the systems are in place, the governments and road authorities are neglecting the trend of rapid developments in ITS technology and data communication, and do not use these developments to update and improve their systems.

The private parties are more aware of the constant developments and new possibilities in the field of ITS. The system created by the governments generates a lot of new traffic data. By using this publicly available data, private parties with their nomadic devices and supporting platforms and services are able to give even better personal advice on trip planning and traffic related information than the 'public' platform. The automotive industry remains a competitive sector, if private parties are able to give better advice than the 'public' system, the vehicle manufacturers will not hesitate to use or integrate these devices and services in their vehicles, because "*some people are willing to pay for a real individual advice"*. Others will be satisfied with the public platform, or even the traditional traffic signs.

While the nomadic devices do have an influence on traffic management related features, the safety related functions *"will remain in-vehicle, and developed by the vehicle manufacturers themselves, due to quality and reliability requirements".* Around 2030, the combination of the ITS communication platform developed by the government and the in-vehicle safety features such as automatic braking, can be combined for cooperative cruise control or for example at a dangerous crossroad to slow down one of the vehicles to avoid a possible accident. Although the government tried to set up a uniform ITS system which could be the basis for automatic driving, this will not be possible in 2030. Real uniformity within the automotive industry on this topic is lacking, *"there will be manufacturers that do see some possibilities in automatic driving, but there will also be manufacturers who do not want automatic driving features at all".*

Government(s)
The European government is putting a lot of time, effort, and money in deploying ITS technologies Europe wide, since "*they believe that ITS is a panacea for all road traffic related problems*". On the one hand, subsidies and information are given to stimulate individuals to start buying and using safety related 'simple' ADAS functionalities such as automatic braking or lane departure warning systems. On the other hand, ITS research projects and FOT's with

involvement of the automotive industry are encouraged by providing test facilities, subsidies, and other incentives. Nevertheless, the automotive industry is not showing initiative to go beyond the development phase.

By investing in intelligent infrastructure, the government hopes to solve the chicken-egg issues by choosing certain ITS communication technology and standards that will be picked up by the industry. The government is also able to create social acceptance of these technologies by solving privacy issues in the law. Furthermore, *"they will play an important role in convincing society of the importance of these technologies. This is not a task for the manufacturers because they will only think about their own profits, while the government is aiming at benefits for society as a whole".*

When the ITS platform, developed by the government, starts to be deployed and the government thinks they have solved the ITS puzzle, their lack of attention for the constant developments and new possibilities in the field of ITS can have a negative influence on the public acceptance of ITS. *"Everybody knows that when the government is investing in certain projects, it will eventually be society that is paying the bills",* and once the people get the idea that these investments result in profits for private parties with their nomadic devices and supporting platforms and services, it is possible society starts to object against the governmental ITS platform. If the government is not able to deal with the concerns raised by the public, the development of cooperative systems that make use of the ITS communication platform, as well as in-vehicle safety features, becomes highly uncertain around the year 2030.

Road authorities
Guided by the European and national governments, the national road authorities are involved in all sorts of pilot- and test projects, which help them to get experienced with new ITS technology. Although these experiences support them when deploying the 'intelligent infrastructure', it is still seen as a big challenge for the road authorities. The choice in technology that was made by the European government has to be integrated into the systems of different national road authorities, all with their own road design which *"is a big challenge in Europe, while in big countries such as the US and China this is will not be a real issue due to their uniform road design".*

Integrating the 'intelligent infrastructure' in their current systems is costing the road authorities a lot of money and is seen as a long-term investment. Once the platform starts to be deployed and is used by different vehicles, the road authorities are able to give individual advice to the vehicles using the system, and even control the traffic flows. However, *"the problem is that it will not always be possible to give the best possible advice to every individual".* For example, if every individual is getting the same advice to avoid a traffic jam, a new traffic jam can occur at this detour. It is a big challenge for a public institution to make clear to an individual why they have to make a detour of 40 km, while others only have to make a detour of 20 km, *"it is very important to be able to make this decision process clear for society".*

Bounded by the long-term investments the road authorities made in their intelligent infrastructure and the efforts it took to integrate it into their organizations, the road authorities are not really able to keep their system up-to-date with the rapid developments and new possibilities in the field of ITS. Driven by profits and by using the large amount of public data that is available, the nomadic devices industry is able to give better individual advice for people who are willing to pay for these services. Nevertheless, there will always be people who will not or cannot afford this paid information and settle for the individual advice of the road authorities or even the 'old' traffic signs.

The idea of the road authorities that by investing large amounts of money in intelligent infrastructure they are able to control all traffic flows on their roads, is not really the case with three systems giving advice side by side. One of the possibilities to keep control over the traffic flows could be *"reducing the amount of traffic signs alongside the road to a bare minimum, which forces people to start using the new systems, and saves the road authorities a lot of money in traffic signs".* Although the road authorities are not completely successful in controlling the traffic flows by using ITS technologies, their ITS platforms do have a positive influence on traffic safety. The combination of this ITS communication platform, and in-vehicle safety features such as automatic braking, can be combined for example at a dangerous crossroad to slow down one of the vehicles to avoid a possible accident.

Nomadic devices industry

The manufacturers of nomadic devices often make more than just a smartphone, tablet or navigation device. Besides the product itself, they also try to sell exclusive services for those devices with features with individual advice on (in case of road transport) trip planning, traffic situations, the weather, appointments, public transport, road pricing etc. When focusing on individual traffic advice, the active role of the government in pushing 'intelligent infrastructure' can be seen as a competitor for the platforms and services of the nomadic devices manufacturers. However, the government also helps to raise acceptance among society, as well as stimulating the automotive industry to start using this type of technology.

When the road authorities are struggling to keep their system up-to-date with the rapid developments and new possibilities in the field of ITS, the nomadic devices industry is seeing opportunities when using the large amount of public data to start giving better individual advice for people who are willing to pay for these services. However, it has to be a real good working system before people are willing to pay for this data. The platforms that are able to provide good working systems, will eventually be (partly) integrated inside the vehicle by the vehicle manufacturers. However, it will not completely take over the ITS platform that was already deployed by the governments and road authorities. There will always be people that settle for the individual advice of the road authorities or the 'old' traffic signs.

Telecom providers

The telecom providers will expand their business by providing vehicles, nomadic devices and the intelligent infrastructure with mobile communication connections such as 3G/UMTS or even LTE. However, *"it will not always be possible and desirable to manage all this data at one single place".* Especially with safety critical features, the governments and road authorities will never solely rely on the network of telecom providers. Dedicated networks alongside the road will be developed to communicate with the vehicles, using techniques such as Wi-Fi, Bluetooth, and GPS. *"The entire discussion whether general mobile data communication, or dedicated communication technology alongside the road will be used, is* *useless. It will be a combination of those two, having their own tasks and functionalities. Especially when you want to guarantee the reliability and safety of the total ITS system."*

Users/Citizens

The governments and road authorities that are pushing their 'intelligent infrastructure', will do everything to convince society of the benefits of their ITS platform. As long as they are able to *"convince people that it is a solution for a problem felt by almost the entire society"* it will be accepted, resulting in the further deployment of the governmental ITS platform that is able to give individual traffic advice. Once the users get the idea that private parties are able to give better individual traffic advice, *"there will always be individuals that are willing to pay for an individual advice that helps them to avoid traffic jams".* Others will be satisfied with the individual advice of the intelligent infrastructure of the road authorities or even the 'old' traffic signs. But if these people have the feeling that private parties with their nomadic devices and supporting platforms and services, are making profits partly based on an infrastructure that was paid by society, it is possible society starts to object against the governmental ITS platform.

5.5 Analysis of the results

The four developed future scenarios, all have their own characteristics and developments. Each scenario will have an effect on the stakeholders that are involved; in Appendix IV a summary of the different stakeholder roles for each scenario can be found. Since there is no guarantee that one of the four scenarios will really become the future, the involved stakeholders are only able to deal with the different futures in the best way possible. How the different stakeholders are able to deal with these futures will be described in this section. Keeping the research question in mind, the main focus will be on the automotive industry and road authorities. For a clear overview, the four developed scenarios are mentioned again below:

- Scenario 1: United Industry
- Scenario 2: Mutual Benefits
- Scenario 3: Individual Profits
- Scenario 4: Public goals, Private Profits

Influence on road authorities

The current tasks of the road authorities according to Lay (2009) that were mentioned in chapter 1, can be summarized as:

- Designing, building, and maintaining roads and roadside installations
- Traffic management

When looking at how the future scenarios can influence the road authorities, there are some developments that will keep evolving in all four futures, and that will or can affect the current tasks of road authorities. Developments that can affect road authorities and their tasks in all four scenarios are:

- More ‘connected vehicles’ become available (either connected to the internet, to the infrastructure, and/or to each other).
- Increased use of nomadic devices and their traffic related services in a vehicle.
- Private parties are able to give individual trip and traffic advice, and by doing this they can influence traffic flows and traffic management.
- More traffic related data becomes available.
- More in-vehicle (safety related) ADAS systems.
- Public acceptance of ITS technology remains uncertain, however, it can be stimulated by the government but not controlled.

For all these developments the road authorities can make the decision to get involved in the described developments, or to give freedom to the private parties and make use of their services and technologies, if that is beneficial. These options can be seen as the choice of road authorities (guided by the government) to install, or not to install intelligent infrastructure. Making this decision, will depend on their expectations and goals (guided by the European or national government) when installing intelligent infrastructure.

If the main goal is to *increase traffic safety*, the road authorities have to see real additional benefits between the in-vehicle safety related ADAS technologies that will be developed by the automotive industry (together in scenario 1, or all on their own in scenario 3), and the ADAS systems that are able to communicate with the intelligent infrastructure to warn or even intervene in dangerous situations (possible in scenario 2 and 4). However, when making the decision of installing intelligent infrastructure, the road authorities have to keep in mind their additional responsibilities when using the intelligent infrastructure to intervene in the guidance of a vehicle to prevent accidents. Furthermore, the road authorities will get additional responsibilities for maintaining intelligent infrastructure, next to the conventional infrastructure.

When *maintaining their current top-down traffic management* in order to manage all traffic flows in the best way possible, is the main aim of the road authorities, they have to install an intelligent infrastructure that is able to communicate with the vehicles and give individual traffic advice. However, the road authorities have to make the first step by investing and will never get the guarantee that the system is used in the way it was meant by the road authorities. The road authorities hope to push the automotive industry in their direction by stimulating the use of their traffic management services, but this only succeeds in scenario 2. Besides, the nomadic devices industry with their traffic related services can also have an influence on traffic management and giving individual traffic advice. If these platforms are able to give better individual advice than the system developed by the road authorities, it will not be possible to maintain the top-down traffic management.

If the main aim is to *reduce congestion by a more efficient use of the infrastructure*, multiple options are possible with or without intelligent infrastructure. By managing traffic flows in the best way possible, the road authorities can make more efficient use of the (conventional) infrastructure by installing their intelligent infrastructure. However, it is also possible to cooperate with the nomadic devices industry with their traffic related services, to have an influence on traffic management and individual traffic advice. If the road authorities set other targets (guided by the government or not) such as improving multimodal transport or aiming at automotive driving (both only possible in scenario 2) as a solution for reducing congestion, they have to install the intelligent infrastructure.

When the main aim of the road authorities is to *reduce costs* in comparison with the current task and responsibilities, investing in intelligent infrastructure is not an option. Initially, the road authorities have to make high investments without being sure of the benefits of these investments (for example in scenario 4). Additionally, there will always be an in-between phase were the road authorities are responsible for maintaining the conventional infrastructure, as well as the intelligent infrastructure. However the road authorities have possibilities to reduce costs by buying-in certain increasingly available traffic data and services from private parties, and stop using and investing in their current (old) technologies.

If the main goal is *reducing pollution*, it is hard to directly attach this to the deployment of intelligent infrastructure. Improving traffic flows and reducing accidents when using intelligent infrastructure can have a positive effect on reducing the pollution created by traffic jams, but it will always be a side effect and hard to measure. Only when all vehicles are driving automatically in platoons, the reduction of pollution will be obvious. However, this development is highly uncertain and will not be deployed in the next two decades.

In the following table (table 5), an overview is given of the mentioned benefits and drawbacks for road authorities when installing intelligent infrastructure to reach certain goals.

Goals of the road authorities	Benefits of intelligent infrastructure	Drawbacks of installing intelligent infrastructure
Increase traffic safety	- More possibilities in improving traffic safety.	- High initial investments. - Additional tasks and responsibilities. - No guarantee the industry starts using the infrastructure in the way it was meant by the road authorities.
Top-down traffic management	- No benefits because it is almost impossible to reach this goal, with all sorts of private parties that are also able to give individual traffic advice, and manage traffic flows.	- High initial investments. - Additional tasks and responsibilities. - No guarantee the industry starts using the infrastructure in the way it was meant by the road authorities.
Reduce congestion	- First step in setting up automatic driving functionalities, and multimodal transport systems to reduce congestion.	- High initial investments. - Additional tasks and responsibilities. - No guarantee the industry starts using the infrastructure in the way it was meant by the road authorities.
Reducing costs	- No direct benefits when the infrastructure is installed.	- High initial investments. - Additional tasks and responsibilities. - No guarantee the industry starts using the infrastructure in the way it was meant by the road authorities.
Reducing pollution	- No direct benefits when the infrastructure is installed.	- High initial investments. - Additional tasks and responsibilities. - No guarantee the industry starts using the infrastructure in the way it was meant by the road authorities.

Table 5: Benefits and drawbacks for road authorities when installing intelligent infrastructure.

When looking at this table, installing intelligent infrastructure can only have clear benefits for the road authorities in improving traffic safety and reducing congestion. However, even for these two goals, installing the intelligent infrastructure will never be a risk-free activity.

There is always the risk of the automotive industry that is using the infrastructure only for their own benefits, or the risk of users and citizens who are rejecting the developed technologies. The question is whether the road authorities should make high investments in an infrastructure, while there are a lot of developments in the automotive industry as well as the nomadic devices industry that can have a positive effect on the current tasks of the road authorities, without needing this intelligent infrastructure. Some possibilities for road authorities, without installing intelligent infrastructure, are:

- Improved traffic safety by stimulating the right safety-related in-vehicle ADAS functions.
- Use traffic data from private parties instead of collecting it themselves, to reduce costs.
- Give the tasks of controlling traffic flows (partly) to private parties and systems.
- More efficient use of the infrastructure by letting private parties give real individual traffic advice.

Although the road authorities give some of their tasks to private parties, they will still be held responsible for what is happening on their roads. So, the road authorities have to be sure that all the advice given by private parties remains within certain societal boundaries (no speeding, no heavy vehicles allowed in city centres, dealing with privacy issues, etc.). To be able to do this, the road authorities have to monitor the data and advice that is given by private parties, and if necessary protect their societal boundaries.

Influence on automotive industry
Just as for the road authorities there are some (similar) developments that can affect the automotive industry and their business in all four scenarios:

- More 'connected vehicles' become available (either connected to the internet, to the infrastructure, or to each other).
- Increased use of nomadic devices and their traffic related services in a vehicle.
- Private parties are able to give individual trip and traffic advice, and by doing this they can influence traffic flows and traffic management.
- More traffic related data becomes available.
- More in-vehicle (safety related) ADAS systems.
- Public acceptance of ITS technologies remains uncertain.

For the automotive industry it is the question what the additional benefits are of cooperation with other stakeholders (forced by the governments or not) to make full use of and deal with the developments mentioned above. These are benefits of cooperation with the nomadic devices industry, the government/road authorities, or cooperation within the industry itself. The overarching goal for all vehicle manufacturers will always be making a profit. To make this profit instead of their competitors, the vehicle manufacturers will try to distinguish themselves based on topics such as safety, efficiency, and comfort.

When looking from a strong *safety perspective*, the in-vehicle safety related ADAS technologies can evolve into systems that are able to communicate with other vehicles and/or the infrastructure for increased functionalities. This will be possible in scenario 1, 2, and 4. However, the automotive industry always has to work together within the industry (in scenario 1), and in two other scenarios (2 and 4) also with the government(s) and road authorities. The benefits of working together as an industry in scenario 1 can be the standards that are developed together, and the bigger network of vehicles using these standards. However, there is also the downside of opening up to their competitors, and making it harder to distinguish themselves from their competitors.

When looking from a safety perspective, the automotive industry will be interested in cooperation with government(s) and road authorities and their intelligent infrastructure. By developing vehicles that are able to communicate with this infrastructure they increase the functionality and safety of their vehicles. The most important trigger to cooperate with the government(s) and road authorities are their tools to raise *public acceptance* of ITS technologies among users and citizens, by developing clear legislation, giving subsidies, raising awareness, etc.

Getting individual traffic advice as a driver can be seen as a *comfort feature* which vehicle manufacturers are able to supply to their customers. The automotive industry will always have to cooperate with other stakeholders to deliver this individual traffic advice since it is not core business. The automotive industry can cooperate with the nomadic devices industry and their traffic related services and platforms (possible in all scenarios), or they can cooperate with the road authorities' intelligent infrastructure (in scenario 2 and 4) to provide individual traffic advice. The automotive industry will be mainly interested in using the individual traffic advice from the intelligent infrastructure, because of the tools of the government(s) and road authorities to raise *public acceptance* of ITS technologies among users and citizens. These tools are for example developing clear legislation, giving subsidies, raising awareness, etc. If private parties are able to give better individual advice with for example their nomadic devices, vehicle manufacturers will not be bounded by the intelligent infrastructure and are always able to switch to the advice of a private party.

Sub conclusion

Although there are a number of developments that are applicable in each of the four scenarios, the road authorities play an important role in the direction of the ITS developments in the European automotive industry. The road authorities (and governments) can influence the developments by making the choice to install or not to install intelligent infrastructure. If the road authorities decide to install intelligent infrastructure to improve traffic safety, it will have a positive effect on the development of in-vehicle safety related ADAS systems that are able to communicate with each other and the infrastructure, developed by the automotive industry. The automotive industry will be willing to develop these technologies because of the increased functionality of their vehicles, and the tools of governmental parties to raise public acceptance. For the road authorities, installing intelligent infrastructure will result in additional tasks in designing, building, and maintaining this intelligent infrastructure. Furthermore, they will get additional responsibilities for operating with this new infrastructure.

When looking at one of the other current tasks of the road authorities, *traffic management*, it is a different story. If the road authorities are installing intelligent infrastructure to be able to give individual traffic advice to the drivers and manage the traffic flows on their roads, the automotive industry will be willing to make their vehicles compatible to receive this information. However, the automotive industry does not have a big influence on the developments in the nomadic devices industry with their traffic related services and platforms. If the private platforms are able to give better individual advice than the system developed by the road authorities, users and thus the automotive industry are willing to switch to these private platforms. In this situation, it is highly uncertain that the large investments in intelligent infrastructure made by the road authorities will really improve their current top-down traffic management.

A less uncertain approach for the road authorities is to make use of the private platforms instead of competing with them. Private parties can help the road authorities with tasks such as giving individual traffic advice to drivers, providing traffic data, and controlling traffic flows. Nevertheless, the road authorities will still be held responsible for what is happening on their roads. A new task of monitoring the data and advice that is given by private parties will be necessary. By monitoring the data and advice, the road authorities are able to control whether the advice of the private parties remains within the societal boundaries set by the governments and road authorities.

6. Conclusion

The main research question this research tried to answer was:

'What are the developments of ITS technologies within the automotive industry in the near future (2030) for the European market, and how may this affect the current tasks of road authorities in Europe?'

Since the development of ITS technologies is influenced by various stakeholders, it is difficult to give one clear answer to the first part of the research question. This research used scenarios to describe the relation between the different stakeholders and how these relations could develop into different possible futures. Based on interviews with ITS experts on their perceptions of future ITS developments in the European automotive industry, four scenarios were developed:

- *Scenario 1: United Industry*
- *Scenario 2: Mutual Benefits*
- *Scenario 3: Individual Profits*
- *Scenario 4: Public goals, Private Profits*

The four scenarios are created based on the two most important critical factors (*Costs and Business Cases for ITS Technologies* and *Role of the Government)* that are able to influence each other in different ways, resulting in four different future scenarios. In scenario 1, there is a united automotive industry with shared ITS business cases, but a government who is not really involved in ITS. Scenario 2 is based on a high rate of governmental involvement and an automotive industry with shared ITS business cases. In scenario 3, the government is not really involved but there are some individual parties who see possible ITS business cases. The government is highly involved in scenario 4, but there are no real shared business cases in the automotive industry.

This research tried to create an up-to-date view on the development of ITS technologies in the automotive industry. The created scenarios aim to function as a guideline for possible futures. Eventually, what happens in the future will probably be a combination the presented scenarios. It all depends on the stakeholders involved and how they will respond to each other and the developments in society. However, there are some developments that will continue to evolve in all four scenarios:

- More 'connected vehicles' become available (either connected to the internet, to the infrastructure, and/or to each other).
- Increased use of nomadic devices and their traffic related services in a vehicle.
- Private parties are able to give individual trip and traffic advice, and by doing this they can influence traffic flows and traffic management.
- More traffic related data becomes available.
- More in-vehicle (safety related) ADAS systems.
- Public acceptance of ITS technology remains uncertain, however, it can be stimulated by the government but not controlled.

When looking at these developments most of them will have an influence on the current main tasks of the road authorities, namely *traffic management* and *designing, building, and maintaining roads and roadside installations*. Furthermore, the road authorities can play an important role in the direction of ITS developments in the European automotive industry, by making the decision to install, or not to install intelligent infrastructure.

By installing intelligent infrastructure to improve traffic safety, the road authorities are able to stimulate the automotive industry to develop in-vehicle safety related ADAS systems that are able to communicate with each other and with the infrastructure. The automotive industry will be interested in developing these systems because it increases the functionality of their vehicles. The road authorities and governments are able to have a positive effect on the public acceptance of ITS technologies by providing certain tools like subsidies, awareness campaigns, etc. However, installing the intelligent infrastructure will result in additional tasks for the road authorities in maintaining and operating the intelligent infrastructure.

When the road authorities are installing intelligent infrastructure to be able to maintain their current top-down *traffic management,* this will have less effect on the ITS developments in the automotive industry. Traffic related services and platforms are not the domain of the automotive industry, but of the nomadic devices industry. The automotive industry is willing to develop vehicles that are able to communicate with the intelligent infrastructure of the road authorities, however, individual advice also goes via the nomadic devices industry. Their development is one that goes beyond the one of the automotive industry. Therefore, it is highly uncertain that the large investments in intelligent infrastructure made by the road authorities will really improve their current top-down traffic management.

It will be less uncertain for the road authorities to cooperate with private parties that are giving individual traffic advice such as the nomadic devices industry. Some of the current traffic management tasks of the road authorities can be fulfilled by the private parties. However, the road authorities will always remain responsible for what is happening on their roads. Monitoring the data and advice that is given by the private parties, will become a new responsibility of the road authorities to assure everything remains within the societal boundaries set by the governments and road authorities.

6.1 Recommendations for road authorities

Because the real future can be a combination of the constructed scenarios, no scenario-specific recommendations for road authorities are developed. Nevertheless, there are some recommendations that are applicable in each of the four futures.

- The amount of traffic data and information that is coming into the vehicle will continue to grow. It is not possible for road authorities to control all these data flows, but they should be able to monitor this. By creating societal boundaries, the road authorities are able to transfer some of their traffic management tasks to private parties, since they are able to give better advice.

- ITS should not be seen as a panacea for all road traffic related negative externalities. For example, reducing emissions can be a *result* of improved traffic flows, instead of the incentive. The road authorities should therefore approach ITS as a technology that is able to improve traffic safety and traffic flows, and should not use the reduction of emissions as a reason to start investing in ITS technologies.

- Road authorities might struggle with new technologies and plans introduced by the automotive and/or nomadic industry. Therefore, staying up-to-date with the latest ITS developments is very important, for example with pilot projects or formulating future ITS visions, in cooperation with the industries.

- The role of the road authority in this research is approached from a European and national perspective. However, there are a lot of local or regional road authorities who will not be involved in the development or first deployments of future ITS technologies. The national road authorities should have an important task in keeping them informed about possible future ITS developments. At the same time, new ITS developments can emerge in for example a pilot project at local or regional road authorities and they should, on their turn, inform the national authorities about their experiences.

7. Discussion

Especially during the interviews with the ITS experts and the analyses of these interviews, some points of discussion arose:

- When asking questions about the road authority, the Dutch experts often formulated their opinion based on personal experiences with the Dutch National road authority (Rijkswaterstaat). This will not always be representative for all the different road authorities throughout Europe.

- The shift from questions about the near future of ITS developments towards questions about more long-term ITS developments, was rather challenging in some of the interviews. While for the short-term (next 5 to 10 years) the experts described well worked out developments in certain settings, for the longer term (next 10 to 20 years) they often initially did not want to answer these questions, rejected them with a joke or a laugh, and only under certain assumptions they wanted to make a statement, without being able to describe the setting these developments were in.

- In the Netherlands, there is a rather small scene of ITS experts with a focus on the automotive industry. A couple of the Dutch participants were more or less involved in the same research projects and recently visited the same ITS meetings. Sometimes, this resulted in a remarkable resemblance in some of the answers and opinions of those experts on future ITS developments. When this resemblance was noticed, the snowball method of finding Dutch ITS-experts was no longer used. Instead, more attention was given to making appointments with ITS experts in the rest of Europe.

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Appendices

Appendix I: Interview format Dutch

Interview ITS expert

Datum en locatie:

Deel I: Algemeen

1. *Toestemming om interview op te nemen:* Ja □ Nee □

2. *Naam:*

3. *Bedrijf/ Instelling:*

4. *Opleiding:*

5. *Functie (incl. activiteiten)/ afdeling binnen bedrijf/instelling*

6. *Kunt u kort beschrijven op welke manier u bezig bent met ITS (binnen/buiten huidige baan):*

Deel II: Specifiekere ITS vragen

7. *Wat verstaat u persoonlijk onder de term ITS?*

Automotive industrie vragen

8. *Waarom is volgens u het ontwikkelen van ITS technologieën belangrijk voor de Europese automotive industrie?*

9. *Hoe hoog schat u de prioriteit van de Europese automotive industrie in, op het gebied van ITS onderzoek, in vergelijking tot onderzoek naar andere technologische ontwikkelingen?*

10. *Hoe belangrijk is de ontwikkeling van ITS technologieën in de strijd om marktaandeel tussen de verschillende autofabrikanten en toeleveranciers?*

11. *Richt de ontwikkeling van ITS technologieën in de automotive industrie zich op individuele systemen (in-car), coöperatieve systemen (V-2-V, V-2-I, V-2-X) of beide?*

12. *Welke partijen hebben volgens u een grote invloed op de technologische ontwikkeling van ITS technologieën en wat is hun primaire belang om deze invloed uit te oefenen?*

13. *Welke partijen in Europa hebben volgens u de meeste kennis op het gebied van ITS?*

14. *Wat is uw persoonlijke visie, over hoe en in welke markt(en) ITS zal worden toegepast in de komende 10 tot 20 jaar?*

15. *Is er volgens u een gedeelde visie binnen de Europese automotive industrie, over hoe en in welke markt(en) ITS zal worden toegepast in de komende 10 tot 20 jaar? Zo ja, hoe luidt die visie? Zo nee, waar zitten de grote verschillen in, of ontbreekt een visie?*

<u>Verschillende onzekerheden</u>

Technologische vooruitgang

16. Op dit moment zijn ADAS systemen zoals ‘Adaptive Cruise Control’ (ACC) en automatisch inparkeren in ‘gewone’ personenauto’s verkrijgbaar. Meer geavanceerde systemen zijn dit nog niet, zoals communicatie tussen voertuigen onderling en de infrastructuur, of zelfs volledig zelfgestuurde voertuigen.

Welke technologische uitdagingen verwacht u bij de implementatie van dergelijke systemen?

Coöperatieve systemen

17. *Welke partijen zijn volgens u het meest belangrijk tijdens het vormgeven van coöperatieve ITS systemen?*

18. *Welke uitdagingen verwacht u bij het vormgeven van coöperatieve ITS systemen in Europa?*

Acceptatie door gebruikers

19. *Wat zijn volgens u de belangrijkste onderwerpen die invloed kunnen hebben op de gebruikers acceptatie van ITS technologieën? Verschilt dit per type ITS technologie?*

20. *Hoe denkt u dat overheden/wegbeheerders kunnen bijdragen aan de introductie en acceptatie van geavanceerde ITS technologieën?*

Aansprakelijkheid

21. *Wat is uw mening over mogelijke aansprakelijkheidsproblemen, als meerdere partijen (o.a. bestuurder, voertuig en infrastructuur) invloed kunnen uitoefenen op de besturing van een voertuig?*

22. *Welke mening op het gebied van aansprakelijkheidsproblemen hebben de verschillende partijen die betrokken zijn bij ITS ontwikkelingen? Wat zijn de verschillen en de overeenkomsten?*

Kosten voor verschillende partijen

23. *Voor welke partijen denkt u dat de investeringskosten van nieuwe ITS technologieën een grote rol spelen?*

24. *Welke partij zal volgens u relatief gezien de meeste kosten moeten maken bij het opzetten van een coöperatief ITS systeem?*

Overige vragen

25. *Hebben er volgens u gebeurtenissen in het verleden plaats gevonden die de ontwikkeling van ITS technologieën hebben vertraagd en waar vervolgens lering uit is getrokken?*

26. *Welke macro ontwikkelingen zouden invloed kunnen uitoefenen op toekomstige ITS-ontwikkelingen?*

27. Sommige autofabrikanten verkopen niet alleen een auto, maar ook een rijbeleving bijvoorbeeld bij luxe sportauto's.

Hoe staan dergelijke fabrikanten volgens u tegenover ITS technologieën die (deels) de rij taken overnemen?

28. *Zonder teveel stil te staan bij alle onzekerheden voor toekomstige ITS systemen, wat is uw persoonlijke ultieme (positief of negatief) ITS visie voor 2030 en verder?*

Afsluitende vragen

29. *Heeft u verder nog vragen, of wilt u nog wat toevoegen?*

30. *Interesse in de uitkomsten van het onderzoek?* Ja □ Nee □

31. *Kent u verder nog 'ITS experts' die ik zou kunnen benaderen voor mijn onderzoek?*
Ja □ Nee □

Appendix II: Interview format English

Interview ITS expert

Date and location:

Part I: General questions

1. *Permission to record the interview:* Yes □ No □

2. *Name:*

3. *Company/ Institution:*

4. *Education:*

5. *Function (incl. tasks)/ department within the company/institution*

6. *Could you briefly explain how you are involved in ITS (current job / previous jobs)?*

Part II: Specific ITS questions

7. *What is your personal definition of ITS?*

Automotive industry questions

8. *Why is it important for the European automotive industry to develop ITS Technologies?*

9. *How do you rate the priority of ITS research in the European automotive industry in comparison to research on other technological developments?*

10. *How important is the development of ITS technologies for car manufacturers and their suppliers in the competition for increasing market shares?*

11. *Does the development of ITS technologies in the automotive industry focus on in-car systems, cooperative systems (V-2-V, V-2-I, V-2-X) or both?*

12. *Which parties have a large influence on the technological developments of ITS Technologies and what is the prime goal of this influence?*

13. *Which parties in Europe have the most knowledge on ITS?*

14. *What is your personal vision on how, and in which market(s) ITS will be applied in the next 10 to 20 years?*

15. *Is there a common vision within the European automotive industry on how and in which market(s) ITS will be applied in the next 10 to 20 years? If there is a common vision, how does it look like? If there is no common vision, what are the main differences or is the vision just lacking?*

<u>Different uncertainties</u>

Technological developments

16. At this moment, ADAS systems such as 'Adaptive Cruise Control' (ACC) and automatic parking are available in 'normal' passenger cars. More advanced systems are not, such as vehicles communicating with each other and/or the infrastructure or even fully automated vehicles.

Which technological challenges do you expect when implementing those type of systems?

Cooperative systems

17. *Which actors are of great importance when designing cooperative (V-2-X) ITS systems?*

18. *Which challenges do you expect during the design of cooperative (V-2-X) ITS systems in Europe?*

User acceptance

19. *What are the most important topics that could have an influence on the user acceptance of ITS Technologies? Does this differ per type of ITS technology?*

20. *How do you think that governments and road authorities can stimulate the introduction and acceptation of advanced ITS Technologies?*

Liability

21. *What is your opinion on possible liability problems, when multiple parties (such as driver, vehicle, and infrastructure) are able to influence the guidance of a vehicle?*

22. *Which opinions on liability do the different actors have that are involved in ITS developments? What are the differences and/or similarities?*

Costs for the different stakeholders

23. *For which actors do you think the investment costs of ITS Technologies will be of great importance?*

24. *Which actor has to make the highest relative costs when deploying a cooperative ITS system?*

Other questions

25. *Have there been events in the past that delayed the development of ITS technologies and are there any lessons learned from these events?*

26. *Which macro developments could influence future ITS developments?*

27. Some car manufacturers do not only sell a car, they also sell a driving experience (e. g. luxury sport cars).

What is the opinion of those type of car manufacturers on ITS technologies that are interfering with the driving tasks?

28. *Without giving too much attention to the different uncertainties, what is your ultimate personal ITS vision (positive or negative) for 2030 and onwards?*

Final questions

29. *Do you have any questions, or something to add?*

30. *Interested in the results of my research?* Yes □ No □

31. *Do you know other 'ITS' experts that I can contact for my research?* Yes □ No □

Appendix III: Short description of automotive and general trends

Automotive trends	Short description of the trend
Trend ADAS	ADAS features can play an important role for vehicles manufacturers when trying to distinguish themselves from their competitors, and will become more and more popular. ADAS features try to improve the safety, comfort, and/or efficiency of operating a vehicle.
Trend Automatic driving	Automated driving features will continue to be developed and deployed. Eventually, 'real' automatic driving can be feasible on dedicated lanes or green corridors.
Trend New possibilities with nomadic devices	Nomadic devices such as smartphones, tablets and portable navigation devices, , have shorter development times and higher replacement rates than new vehicles. By making linkages with vehicles, new possibilities can be brought into the vehicle such as an internet connection, and all sorts of applications (traffic or not traffic related).
Trend Infotainment	Features that not necessarily improve the safety or efficiency of a car or truck will become available inside the vehicle, either by in-vehicle systems or nomadic devices. Examples are: 'social media apps', or directions to the best restaurants in the area.
Trend Always the right travel info available	People are always able to receive the right individual travel advice. Before, the trip they can get advice on when it is the best time to leave. But also during the trip the driver is constantly informed about the best route(s) possible.
Trend Multimodal transport	Increased use of multimodal transport (take multiple carriers for one trip) stimulates 'Car sharing programs'. Which will become more important for the automotive industry, 'from car ownership to car sharing'.
Trend CO2 reduction	Keep reducing the CO2 emissions of vehicles is one of the main challenges for the automotive industry. Besides developing vehicles that use alternative fuels or alternative drivetrains, ITS technologies can also play a role in developing more efficient vehicles.
Trend Individual traffic management	This trend is in line with the trend *always the right travel info available*, the only difference is that in this trend, the idea is to use all the individual advice to improve/manage the efficiency of the entire road transport system.
Trend Rapid developments in wireless communication technology	Wireless communication technology will continue to evolve. Using these developments will result in constant improvements in data transfer rates, possibilities, and costs for ITS applications in the automotive industry.
Trend Individuality	A car is becoming more and more an individualized item. The car is adapting itself to the wishes and preferences of each individual. This can be done by integrating smartphones, or for example a personalized HMI, and can be seen as one of the marketing tools of the vehicle manufacturers.
Trend Difference in ITS applications in passenger cars and transport vehicles	The actual features of ITS technologies in the automotive industry can differ within the industry. Manufacturers of commercial/transport vehicles are likely to have a stronger focus on improving the efficiency of their vehicles with ITS technology, while for manufacturers of passenger cars it is likely more attention is given to comfort and safety features.

Trend New entrants automotive ITS market	ITS innovations inside the vehicle no longer have to come solely from the vehicle manufacturers and their 'conventional' suppliers. The nomadic devices industry is able to bring new services and functionalities inside a vehicle, and will possibly also try to integrate their systems and platforms in newly developed vehicles.
Trend Connected car	Vehicles will become more and more 'connected'. Connected with the internet, but possibly also with each other, and intelligent infrastructure alongside the road.
Trend ITS opportunities when using electric vehicles	When using electric vehicles, ITS technology can help with 'range-anxiety' issues by using smart (connected) navigation systems that are able to choose the most energy efficient route, assure the vehicle will not run out of electricity, or automatically reserve a fast charging spot.
General Trends	
Trend Efficient use of resources	A general trend that is of importance for all involved actors such as private parties, governments and road authorities, is the demand for more efficient use of resources Whether this is energy(fuel), infrastructure, money, etc. ITS technologies can play a positive role in the trend of more efficient use of resources.
Trend Economic developments	The current negative European economic developments can have an influence on the development and deployment of new ITS technologies. With a stalling or shrinking economy, private parties will have less budget to develop new technology. Besides, an economic crisis can result in less traffic flows, resulting in a lower priority at governments and road authorities to introduce ITS technology. Then again, if the economy picks up at some point, this can have a positive effect on the development and deployment of new ITS technologies.

Appendix IV: Summary of stakeholder roles in the four scenarios

	Scenario 1: United Industry	Scenario 2: Mutual Benefits	Scenario 3: Individual Profits	Scenario 4: Public goals, Private Profits
Automotive industry	▪ Industry is jointly developing V-2-C/V-2-I communication standards. ▪ 'Simple' ADAS systems are used as a distinguishing feature. ▪ Combining ADAS and V-2-V/V-2-I communication to provide 'intervening' systems. ▪ Integrating nomadic devices and their services in the vehicles is seen as a good way for creating a fast deployment of 'connected vehicles' ▪ No intelligent infrastructure. ▪ No automatic driving.	▪ In close cooperation with governments and road authorities, communication standards and deployment strategies are developed. ▪ ITS is part of an integrated approach in the automotive industry to decrease the CO_2 emissions of their vehicles. ▪ Standardized In-vehicle communication platform. ▪ Use HMI as an distinguishing feature within the standardized system. ▪ Car-sharing programs become more important for automotive industry. ▪ Combination of intelligent infrastructure + in-vehicle safety systems (ADAS). ▪ Automatic driving technologically possible in 2030, not a goal for every manufacturer.	▪ Pushing 'simple' ADAS systems for own brand aura/ competitive advantage. ▪ Commercial vehicle manufacturers see possibilities in connecting their vehicle to the internet and back offices (' the outside world') with telematics boxes. ▪ Manufacturers of passenger cars are not innovative, they let the nomadic devices industry develop systems that are able to give individual advice. ▪ Integrating nomadic devices for luxury feel. ▪ Individual advice becomes more interesting when starting to use electric vehicles. ▪ No intelligent infrastructure. ▪ No automatic driving in 2030.	▪ No high priority for developing ITS technologies, focus on other technologies (e.g. alternative drivetrains). ▪ Guided by the governments, communication platforms are installed, that are able to use the intelligent infrastructure. ▪ Not bounded by governmental platform, if private parties can give better individual advice they will switch. ▪ Safety features will remain in-vehicle and are able to function in combination with the (governmental) intelligent infrastructure. ▪ No automatic driving.
Government(s)	▪ No long-term ITS plans. ▪ Ad-hoc approach of the government, in reducing the negative effects of ITS technologies introduced by private parties.	▪ Long-term ITS plans. ▪ High budget and high initial investments. ▪ Close cooperation with road authorities and automotive industry. ▪ Multimodal transport is seen as an important development. ▪ Automatic driving possible on dedicated lanes or green corridors, if the governments are pushing these initiatives.	▪ Long-term ITS plans, but most of the budget and focus on CO_2 reduction by alternative drivetrains/fuels/ electric vehicles. ▪ Waiting for private parties with new technology ('the next best thing'). ▪ Have to solve privacy issues when private ITS platforms become big.	▪ Because ITS is seen as a panacea, large budgets are available. ▪ Try to solve the chicken-egg problem by pushing the road authorities to install intelligent infrastructure. ▪ Have to convince society of the benefits of their investments.

	Scenario 1: United Industry	Scenario 2: Mutual Benefits	Scenario 3: Individual Profits	Scenario 4: Public goals, Private Profits
Road authorities	▪ No long-term ITS policy. ▪ No additional budgets for ITS projects. ▪ Start losing grip on managing the traffic flows on their roads. ▪ Private parties can take over some of their traffic management tasks. ▪ Still have to serve users with 'ITS-less' vehicles.	▪ Long-term ITS plans. ▪ Additional budget available. ▪ Challenge to implement general standards in their own networks/organizations. ▪ Gradually installing Intelligent infrastructure developed in close cooperation with governments and automotive industry. ▪ Able to give individual advice, manage traffic flows, and intervene in dangerous situations. ▪ Make linkages with other carriers (multimodal transport). ▪ Automatic driving can be possible on dedicated lanes in 2030,but it will be a big challenge when the road authorities already have to install and adapt to all the intelligent infrastructure.	▪ No additional ITS budget available. ▪ Stuck in dogmas, keep investing in old technology. ▪ Private parties can sell in car signage traffic advice, traffic data etc. ▪ No top down traffic management anymore. ▪ In between phase, using old and new technology side by side.	▪ Pushed by the government who see ITS as a panacea. ▪ Budget available, for testing and fast instalment of intelligent infrastructure. ▪ Think they are able to maintain their top-down traffic management in combination with individual advice. ▪ Because of the long-term investments, they are not able to keep the system up to date. ▪ The intelligent infrastructure creates a lot of traffic data that is also available for private parties. ▪ Private parties are able to give better individual advice with the public data.
Nomadic devices industry	▪ Try to sell their devices and services, and eventually integrate them in vehicles. ▪ Give individual traffic advice. ▪ Users switch to the traffic management of the industry instead of using the traffic management tasks of the road authorities.	▪ Not able to compete with individual advice developed by the automotive industry, governments and road authorities. ▪ The government that is pushing multimodal transport creates new opportunities.	▪ Competing with each other for: users of individual advice, integration in vehicles and selling their traffic data to road authorities.	▪ At first, the governmental ITS platform is a very strong competitor for their individual advice services. ▪ The governmental platform creates a lot of data. Using this data in a better way than the road authorities creates a lot of business opportunities. ▪ Eventually try to integrate their devices/services in new vehicles.

	Scenario 1: United Industry	Scenario 2: Mutual Benefits	Scenario 3: Individual Profits	Scenario 4: Public goals, Private Profits
Telecom Providers	▪ 'Connected vehicles' create new markets. ▪ No dedicated communication network, developed by the government or road authorities. ▪ Scalable mobile communication technology such as 3G (and later LTE) will be sufficient.	▪ Combination of general mobile networks from telecom providers and dedicated ITS networks.	▪ A lot of new markets with telematics boxes and the services of the nomadic devices industry using scalable mobile communication technology.	▪ Combination of general mobile networks from telecom providers and dedicated ITS networks.
Users/Citizens	▪ When the users experience benefits from ITS technologies, at a reasonable price, they will accept it. ▪ Countermovement because of privacy issues with stored data by private parties.	▪ When the users experience benefits from ITS technologies, at a reasonable price, they will accept it. ▪ Automatic driving can be a challenge. It has to be really clear to society it is a solution for a problem that is felt by society.	▪ Without a push from the government, price can be an issue to buy ITS technology, but safety sells. ▪ Countermovement because of privacy issues with stored data by private parties. ▪ Without governmental involvement: always have the opportunity not to start using ADAS/individual advice systems.	▪ When the users experience benefits from ITS technologies, at a reasonable price, they will accept it. ▪ Choosing the best system available, whether it is public or private. ▪ Countermovement because of private parties that are making profits with infrastructure paid by society. ▪ Countermovement because of privacy issues with stored data by private parties.