DEPLOYMENT SCENARIOS FOR SPEED ASSISTANCE SYSTEMS

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ABSTRACT

Speed assistance systems have a strong potential to contribute to solving road traffic problems regarding congestion, energy consumption and safety. However, most speed assistance systems are not yet commercially available, and when they are, large-scale deployment takes a long period of time due to problems, with respect to technology development, user demand, legal issues and market organization. These problems were analyzed by means of scenario analysis and the construction and application of a scenario model. Four scenarios were considered varying in the level of demand for speed assistance and the level of market organization. The analysis and the scenarios indicated that the deployment of speed assistance systems can lead to penetration rates of up to 50 percent in 2025 in case of high market demand and strong market organization. Cooperation among stakeholders is therefore the first and most important step towards a new traffic situation, which is smarter, safer and cleaner than that of today.

Keywords: speed assistance, deployment factors, scenario analysis, scenario model

1. INTRODUCTION

Speed is one of the key factors in road traffic. It is positively associated to the quality of travel: a high speed implies a short travel time. However, a high speed can also lead to high accident risk or high emission of exhaust gas and noise.

The speed of a vehicle is traditionally controlled by the driver, who takes into account local traffic conditions as well as applicable speed limits. However, decisions by the driver are sensitive to judgment, operational errors and in many cases not all relevant information is available to the driver to make optimal/reasonable decisions. Many accidents are speed-related and partly due to human error. In cases of congestion, human drivers are typically poor controllers.

Speed Assistance (SA) systems support a driver to maintain a safe speed. An example of an SA system that is commercially available is the Adaptive Cruise Control system: by extending a ‘regular’ cruise control system with a radar sensor, the vehicle can maintain a preset speed, but also adapt the speed to a slower predecessor. In addition to sensors on the vehicle, SA systems can also use wireless communication systems to receive information from road-side systems and other vehicles.

In spite of the high expectations of Speed Assistance, the introduction into the market is generally perceived as slow. Apart from the technological development there are many factors that influence the development of the availability and use of SA systems. Important factors are legal issues like product liability, the level of support offered by governments, user demand and market introduction strategies. Stakeholders involved in the deployment of SA systems share a need for a better understanding of the development of the use of SA systems and the contribution of this development to their goals, such as traffic safety, turnover and profit. This better understanding will allow stakeholders to better define strategies for large-scale deployment.

Several approaches exist to explore future development paths of new technologies, such as technology road mapping and Delphi survey. We selected scenario analysis as a methodology. Scenarios are descriptions of alternative images of the future, created from mental maps or models that reflect different perspectives on past, present and future developments. Ideally, they should be internally consistent, plausible and recognizable stories exploring the path into the future (1).

The objective of the research described in this paper is to formulate plausible deployment scenarios for SA systems by means of scenario analysis and the development of a scenario model. The following research questions were addressed:

- What are the most critical factors with regard to the deployment of SA systems?
- How can deployment scenarios be developed based on the critical deployment factors?
- How can the mechanisms of deployment and the deployment scenarios be modelled?

This paper is organized as follows. In Section 2 we outline the approach that we selected, which is based on scenario analysis and derived from a review of literature on deployment scenarios for Intelligent Transport Systems. In Section 3 we focus on the critical deployment factors. In Sections 4 and 5 we describe the scenario landscape and the scenario model, respectively. In Section 6 we discuss the results. We conclude in the final section. A full description of the research on which this paper is based is available in (2).

2. APPROACH

The research reported in this paper focuses on Speed Assistance (SA) systems. SA systems assist the driver in their longitudinal driving tasks by providing speed advice or speed warnings and cruise control-like functionalities. The primary aim of these systems is to calmly reduce the speed of the traffic flow to prevent the formation of shock waves due to abrupt braking manoeuvres and increase the traffic safety. Secondary benefits are expected with regard to throughput, vehicle emissions and driving comfort. We considered three SA system variants: Advisory, Intervening and Controlling. Advisory means information and warnings only by means of icons and sounds. The Intervening variant includes haptic stimuli, whereas the Controlling variant takes over on or more of the driving tasks.

In order to develop plausible deployment scenarios, the scenario methodology was chosen. Scenarios are an integrated description of a future state of society or special parts of it, and a plausible sequence of events leading to this future state, without the necessity of including statements on the probability of those events (3). Exploring the future is a complex task involving a considerable level of uncertainty. Scenarios are used to address this uncertainty and describe future developments based on explicit assumptions (4). It has to be noted that there is a clear difference between probable *versus* possible developments. At its best, forecasting gives the reader a hint of what *will happen*. This markedly differs from scenarios that usually are developed to describe what *can happen* under a certain set of circumstances and assumptions. Giving the reader a number of scenarios leaves him with the impression that the scenarios represent the outer limits of what realistically *can happen*. The reader is left with an option to judge and choose for himself the most plausible path of events within those limits set by the scenarios (5).

Scenario writing is a technique which tends to set up a logical sequence of events in order to show how, starting from the present (or any given situation), a future state might evolve step by step (5). Building of a coherent and consistent scenario for the problem at hand proceeds along five steps with increasing level of detail (6).

a. *Definition of the problem in general terms* – description of the aspects of which the developments have to be explored and the time horizon considered.
b. *Identification of the problem environment* – identification which factors affect the phenomenon to be explored (or the technology to be assessed) and in what way.
c. *Selection of variables* – stage concerned with a unique representation of the themes, factors and phenomenon to be considered. The scenario environment, the scenario itself and the phenomenon to be studied are presented by so called ‘steering, scenario and output’ variables respectively.
d. *Relationships between variables* – establishment of mathematical relationships between steering variables, scenario variables and output variables with safeguarding of the consistency between scenario variables and time.
e. *Specification of the present state and development of steering variables* – in order to provide the input necessary for computing scenario and output variables, the present state and the development of steering variables must be specified.

Alternative scenarios may be studied by varying the steering variables and/or varying the assumptions and relations regarding the interplay of scenario and steering variables.

Several projects have been studying scenarios and enablers for the deployment of Intelligent Transport Systems. An effective way to provide a concrete, plausible idea of likely developments at a certain moment in time is by means of roadmaps (7). The most recent available work on deployment roadmaps was done by the eSafety Forum (8). For a number of systems a ‘V’-shape roadmap was defined, capturing an implementation strategy to support the deployment process. Deployment roadmaps were developed on the basis of estimates of the penetration rates of these systems in time, with and without the deployment support. As an example, Figure 1 presents the deployment roadmap for the Speed Alert system, which alerts the driver with audio, visual and/or haptic feedback when the vehicle speed exceeds the legal speed limit (8). With deployment support, it is expected that the growth of the penetration rate of the Speed Alert system increases till 2010, and that the penetration will exceed the 'business as usual scenario' by approximately 20 percent in 2020.

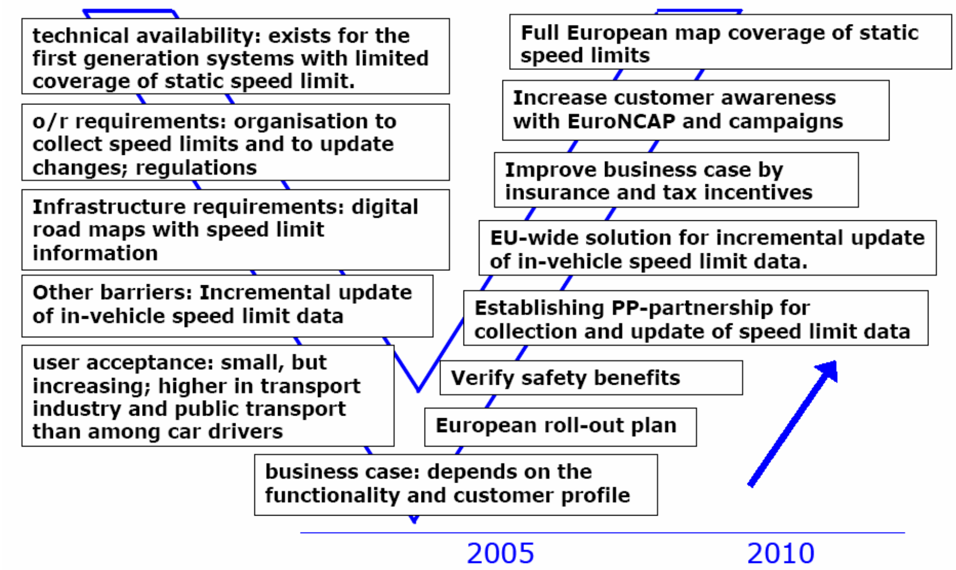

Figure 1 - Deployment roadmap Speed Alert (8)

In summary, the literature review has indicated the need for variables which can be quantified to establish mathematical relations for modelling purposes. Secondly, the complexity of scenarios has become clear, emphasizing the strong need to preserve the logical reasoning and plausible sequences leading to scenarios. By visualising deployment scenarios and creating images of likely development, roadmaps have been helpful to understand the possibilities as seen from various perspectives. It is interesting to note that the different stakeholders that are involved have different expectations of deployment, especially on the long run.

3. IDENTIFICATION OF CRITICAL DEPLOYMENT FACTORS

The *most critical* factors with regard to the deployment of SA systems were identified by means of interviews among experts and stakeholders. Additionally, the results of the interviews were validated and expanded by means of a literature review. In total thirteen experts participated, among them six from research institutes, three policy makers and three representing the industry (suppliers and OEM). There was a general consensus that five deployment factors are most critical.

- **Coordination and cooperation**: The multi-stakeholder environment of (cooperative) SA systems is found very complex and a barrier when it comes to the deployment of these systems. There is a need for better organization, a leading coordinator, and a Code-of-Practice. Interesting point of discussion is whether the use of Advanced Driver Assistance

(ADA) systems should be mandatory or voluntary. In particular car manufacturers do not see the mandatory solution as a realistic one.

- **Vision and strategy**: Currently, there is no clear vision and a lack of a good strategy. Often, stakeholders operating in the same domain aim for different, sometimes conflicting objectives. One conditions for successful deployment is a positive cost-benefit balance for all stakeholders. Since much is uncertain, stakeholders tend to be reserved towards ADA systems which is a huge barrier for an integrated vision and strategy.
- **Technology**: On a strategic level it is often assumed that technology is not the limiting factor for the deployment of SA systems. However, in numerous cases the technology is still too unreliable, unstable or not even released yet. Furthermore, non-technical components like speed limit maps and databases are yet not fully available and reliable. Once market penetration of SA systems reaches some level a lack of standardization can lead to significant problems like inoperability and string stability problems.
- **Awareness and acceptance**: Currently, users as well as policy makers are often unaware of the existence, the benefits and the development of ADA systems. After awareness, system acceptance becomes very important for systems to be successful. Generally, advisory systems are preferred over controlling ones, whereas supporting systems are preferred over enforcing ones. Also the importance of the Human Machine Interface (HMI) has to be considered. Feedback from the system, the feeling of being in control of the vehicle and the possibility to overrule the system are key elements from the perspective of the driver. Finally, a system has to be affordable. This is not restricted to the price of the system, but also depends on the economic situation and the societal need of a system. The latter assumes that with increasing congestion problems, both government and public are willing to spend more money on counter measures like ADA systems. In summary, the system acceptance is subject to the business case for all stakeholders, which should be positive for success.
- **Legal issues**: Liability, legislation and privacy are identified as the most critical issues for system success. Liability, involving high financial cost is most important as ADA systems can never make it to market unless this is solved. Currently, government and car manufacturers both suggest that the other should be responsible. Legislation problems are easily to overcome since the law simply does not suppose that driver tasks are performed by technology instead of the driver. With respect to privacy particularly the industry foresees problems when data communication between vehicles and infrastructure exposes the whereabouts of a vehicle or person. It is feared that the information will be used for other purposes than intended, like enforcement.

From the five deployment factors, technology and legal issues were found less important because they are expected to be overcome relatively easy compared to the others. Generally, for these deployment factors solutions are know, only not yet brought into practice. Therefore these factors will not be taken into account for scenario development. For further modelling the following assumptions are made for all scenarios: the liability risk is low, the systems are useful, all systems can be overruled by the driver, all systems are supportive and public and politicians are aware of SA systems.

4. THE SCENARIO LANDSCAPE

The interviews and literature review identified awareness and acceptance, vision and strategy, and coordination and cooperation as the most critical deployment factors. For further analysis these factors were summarized by two main deployment factors: market development (the development of market demand as the result of awareness and acceptance factors) and market organization (market structure as the result of cooperation, coordination, vision and strategy).

To indicate the outer limits of probable future developments a scenario landscape was constructed. Market development and market organization represent the two dimensions of the landscape and the four quadrants represent four scenarios. Extreme projection of the dimensions indicate that market organization can range from 'individual' to 'collective' and that market development can range from 'stable' to 'growth'. Stability and growth represent the state of factors that generate market demand such as system acceptance, societal need and purchasing power. These factors are low in a stable situation and high in a growing situation. Market organization indicates the structure of the supply side of the market in terms of coordination, cooperation and commitment of stakeholders. 'Collective' represents a situation in which stakeholders have a progressive attitude towards the deployment of SA systems and stimulate the market. When the market is individual the reverse of the above mentioned is true. The four quadrants of the scenario landscape represent the four deployment scenarios Conservative, Regulation, Free market and Progressive, which are characterized by six themes (see Figure 2).

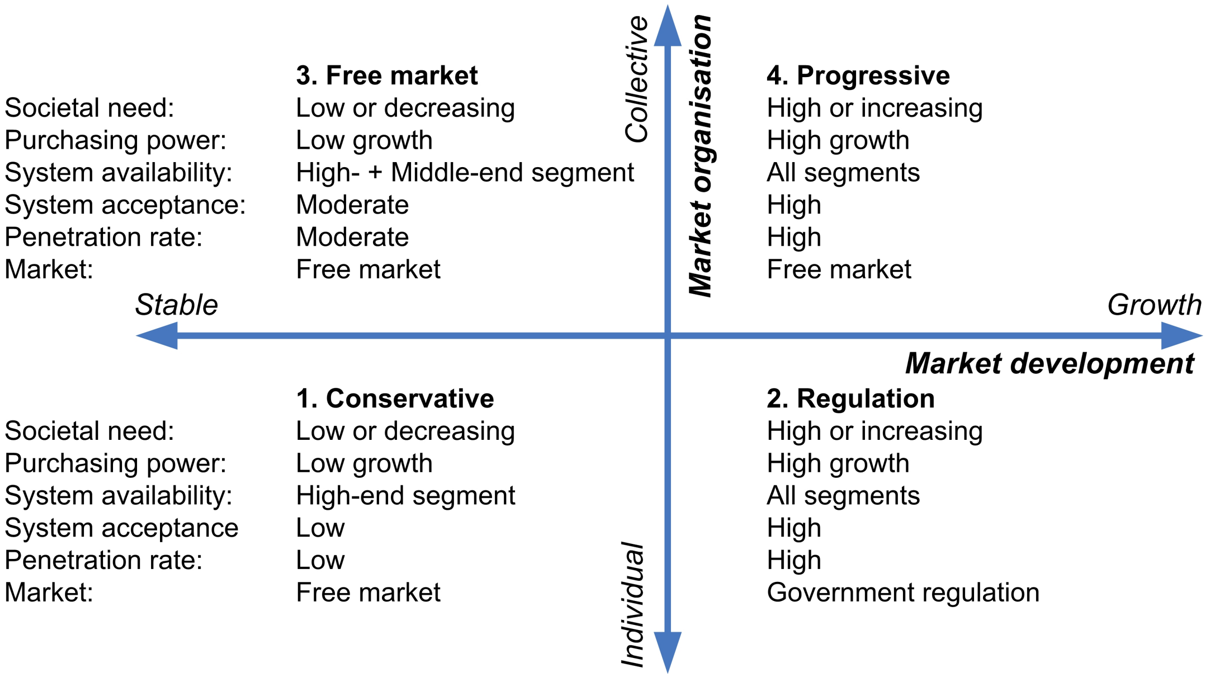

Figure 2 - Scenario landscape with four scenarios for the deployment of SA systems

The four scenarios were characterized as follows:

- *Scenario 1 – Conservative*. This scenario is characterized by a stable market involving low societal need, low growth of the purchasing power and low system acceptance. Due to the lack of a technology push there is neither a strong demand nor a strong supply, which results in poor development of the deployment of SA systems.
- *Scenario 2 – Regulation*. This scenario is characterized by a growing market involving high societal need, high growth of the purchasing power and high system acceptance. Due to the lack of a technology push, the government acts as the manager of the societal

interest and regulates the market, which results in a strong development of the deployment of SA systems.

- *Scenario 3 – Free market*. This scenario is characterized by a stable market involving low societal need, low growth of the purchasing power and initially, low system acceptance. Due to cooperation between the government and car manufacturers a strong technology push arises. As the result of promotion and pricing strategies the system acceptance increases and the deployment of SA systems starts to develop moderately.
- *Scenario 4 – Progressive.* This scenario is characterized by a growing market involving high societal need, high growth of the purchasing power and high system acceptance. Due to cooperation between the government and car manufacturers a strong technology push arises. The combination of strong demand and strong supply result in a strong development of the deployment of SA systems.

5. THE SCENARIO MODEL

The next step to arrive at useful deployment scenarios is the formulation and quantification of scenario variables and output variables. The output variables reflect the development of the deployment of SA systems, indicated as the penetration rate of SA systems. The penetration rate is the percentage of vehicles equipped with a particular system. A number of scenario variables and sub-variables are defined, which are likely to induce values for the penetration rate of the system. A schematic presentation of these variables and the relations between them form the basis of the scenario model and present the mechanisms of deployment (see Figure 3). The output variables are green, the scenario variables are red and the sub-variables are yellow. All variables in the yellow box together represent a scenario.

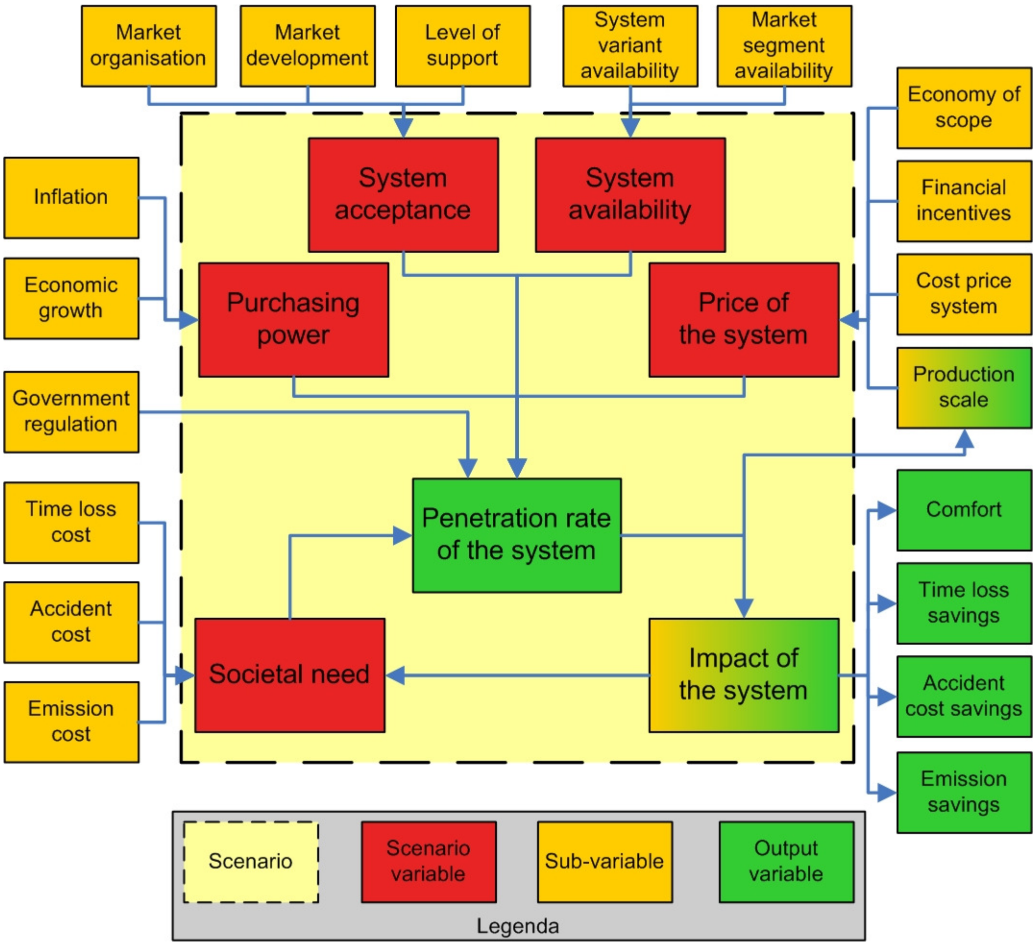

Figure 3 - Schematic presentation of scenario model

Mathematical equations were formulated for the relations between the variables and assumptions, and basic data were collected from the literature. The output of the model consists of penetration rates of SA system variants on passenger cars, in three market segments (high, medium, low), for the years 2006, 2010, 2015, 2020 and 2025. SA systems were assumed to be available on new cars only. For each deployment path, one system variant was considered (i.e. Advisory, Intervening or Controlling).

The penetration rate is directly influenced by the following five scenario variables: societal need, the price of the system, purchasing power, system acceptance and system availability. Scenario variables in their turn are influenced by a varying number of sub-variables. Government regulation is the only sub-variable that directly affects the penetration rate. Beside the impact of the system, all relations are assumed to be linear to minimize complexity. The impact of the system is assumed to be parabolic, with a maximum at a penetration rate of 50%. With regard to the other scenario variables, societal need is an index variable, government regulation a binary, purchasing power is high or low, whereas system acceptance, system availability and the price of the system are defined as high, middle and low. The exact values for the scenario variables and sub-variables, and the motivation can be found in (2).

Using the scenario model involved the specification of the following eight variables for each scenario in each time step: percentages for the economy of scope, financial incentives and purchasing power, the availability of all systems variants in all market segments, the presence of government regulation, the system acceptance of all system variants and the societal need.

6. RESULTS

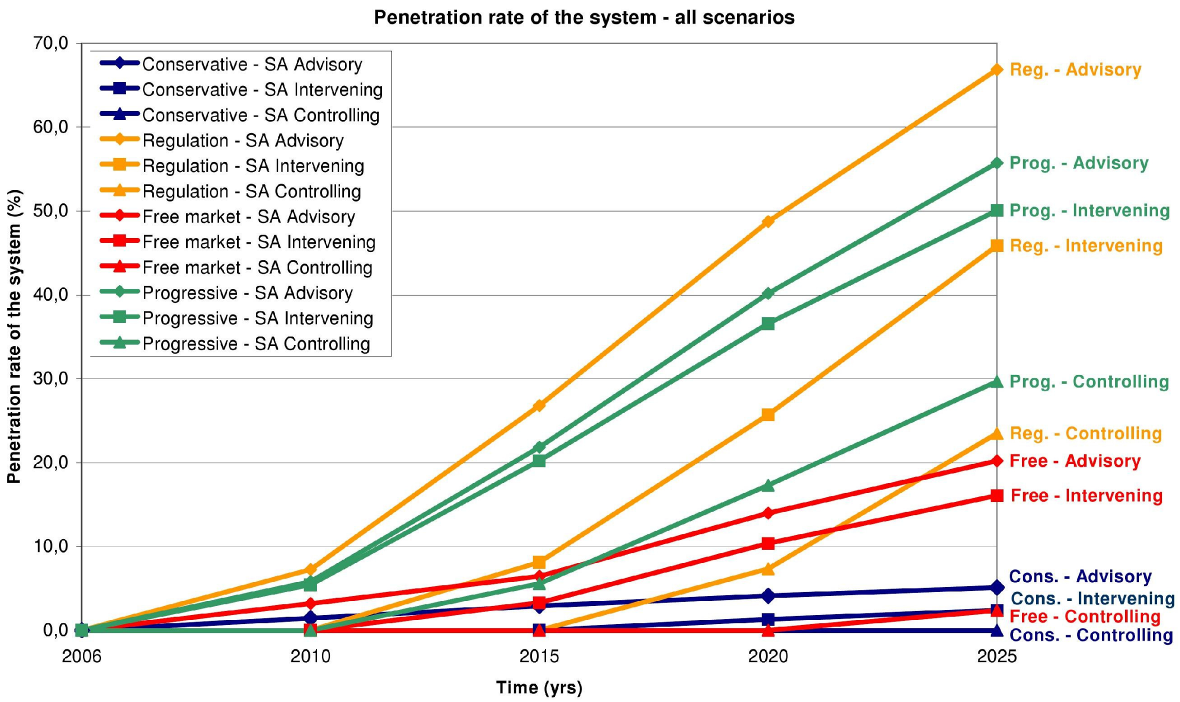

Figure 4 - Results of the scenario model

In the end, the four deployment scenarios were quantified and the expected penetration rates were calculated for each scenario. The results in Figure 4 show that the penetration rate of SA systems increases most in the scenarios 2 and 4. The penetration rate of SA systems develops least in scenario 1, Scenario 3 is a hybrid between the scenarios 1 and 4. From these results it can be concluded that the deployment of SA systems is subject to two key drivers: government regulation (scenario 2) and cooperation between the government and car manufacturers (scenarios 3 and 4). Additionally, with regard to the users, system acceptance, societal need and financial factors like purchasing power and financial incentives can make a significant difference. In general it can be concluded that under specific market conditions penetration rates of up to 50 percent can be reached in 2025. Specifically, the penetration rates of the SA Advisory and SA Intervening variants can develop fast, but the penetration rate of the SA Controlling variant develops much slower. These differences can easily be explained, because the SA Controlling variant was assumed to be more expensive, less accepted and available at a later stage. On the basis of the findings from the interviews, literature review and scenario development, it can be concluded that the scenarios 3 and 4 are most likely. Although these scenarios seem most plausible, it is likely to suggest that scenario 4 is too opportunistic and scenario 3 too conservative. Most plausible seems a hybrid between both scenarios, making the scenarios 3 and 4 the two outer limits of what realistically can happen.

7. CONCLUSIONS

In conclusion, scenario analysis and the development of a scenario model to formulate plausible deployment scenarios for Speed Assistance showed that the deployment of SA systems can be successful if specific scenario conditions are created. Much effort is necessary to create the desired scenario conditions, starting with bringing all stakeholders together. It is likely that cooperation among stakeholders is the first, and most necessary step towards a new traffic situation, which is smarter, safer and cleaner than that of today. Finally, the deployment scenarios developed in this project can serve as a basis for the formulation of business and policy cases in order to define stakeholder strategies.

ACKNOWLEDGEMENT

The research described in this paper was conducted as part of the research program Sustainable Mobility Methodologies for Intelligent Transport Systems (SUMMITS) of the Netherlands Organization for Applied Scientific Research TNO. The research was conducted under the responsibility of the research centre Applications of Integrated Driver Assistance (AIDA) established by the University of Twente and TNO.

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