TRAFFIC SAFETY - FROM ROAD INFRASTRUCTURE TO ITS

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SUMMARY

Since 1998 an important element of the Dutch traffic safety policy is the so-called DVI concept for redesign of the road network infrastructure to provide a degree of built-in traffic safety. Its implementation will cover many years and require high investments, and a long-term local political commitment. After an initial phase of five years the programme seems to be stagnant. In the mean time both development and application of Advanced Driver Assistance Systems (ADAS) are showing considerable progress. This paper discusses whether DVI requirements could be met by wide-spread implementation of selected ADAS applications, and which policy measures would be needed to promote such implementation.

INTRODUCTION

Societal costs of road traffic accidents are high (in the Netherlands estimated to amount to EUR 8.2 billion for the year 2000 [30]), and since the 1970's reduction of accidents by improving road safety increasingly became a primary goal of many governments. Dedicated strategies to improve road safety were implemented, especially from the early nineties, marked examples of which are the *Traffic Calming Act* of 1992 in the UK, followed in 2000 by the new strategy *Tomorrow's Roads - Safer for Everyone*, and the *Vision Zero* approach in Sweden, initiated in 1997 [18]. In The Netherlands, in 1992, the concept of *Sustainably (*or *Inherently) Safe* originated [17]. For political reasons and to join in with its poularity, the term duurzaam (*sustainable*), was chosen, although actually *inherent* is meant.The infrastructure related measures are the most prominent part of the Sustainable Safety approach and are known as the concept *Duurzaam Veilige Infrastructuur* (DVI, Sustainably Safe Infrastructure).

Traffic regulations are part of the traffic system, and are primarily intended to reduce road traffic accidents. Drivers are made aware of these regulations by widespread information and education. But drivers may nevertheless make mistakes, or sometimes just ignore the regulations. It is thought that especially the physical structure of the road network could play a fundamental role to support drivers to adhere to the traffic regulations, as well as to assist them to avoid mistakes. Therefore the traffic system, and especially the road infrastructure, should be adapted to prevent unintended use of infrastructure, encounters at high differences in speed and direction, and uncertainty of traffic participants. The concept was further developed during the mid nineties and became part of Dutch national policy as of 1997.

DVI is an extensive programme, covering 30 years and high investments (EUR 15 billion for a limited implementation or EUR 30 billion for a full implementation, partly to be funded by regular local budgets for road maintenance) [24], to adapt the road network according to three principles: functionality, homogeneity and predictability. In essence, these principles imply to make the road network more user-friendly. Objective in the background is to meet the ambitious Dutch policy targets for 2010: reductions of 50% for fatalities and 40% for severe injuries with respect to the 1986 figures [8]. A first modest implementation of DVI measures has taken place in the past five years. In the mean time questions are being asked if this long-term and costly strategy is suitable to meet the targets. In this discussion the possible contribution of ADAS to help meet the policy goals is addressed.

ADAS applications are reaching the stage of market introduction and possible large-scale implementation. Certain ADAS functions have potential to contribute to the improvement of road safety by avoiding or correcting human error. This paper elaborates on the question if part or all of the expected effects of the DVI programme could also be realised by ADAS applications and dedicated measures for their implementation, suggesting a replacement of the DVI programme, or parts of it, by such measures. For this, potential ADAS functions are selected that match present DVI requirements, under the assumption that they may have the same, or similar effects for enhancing road traffic safety. Further, a strategic evaluation model will be proposed.

SUSTAINABLY SAFE ROAD INFRASTRUCTURE

The Dutch concept of *Sustainable Safety* originated in the early nineties [17]. Traffic is the result of the interaction between humans, vehicles, road infrastructure and regulation. In this process the human is a key (and determining) element, but it is also the weakest link, both in terms of behaviour and vulnerability. It was recognised that human error is a major factor in road accidents, and that it is difficult to influence human behaviour in a lasting way. Therefore the concept aims at prevention of accidents, and at minimising the effects of accidents if they happen. Its three principles are to avoid unintended use of the infrastructure, insecure behaviour of traffic participants, and especially encounters at high differences in speed, direction and mass. The concept has a strong focus on infrastructure related measures. These became known as DVI. The layout of the infrastructure should inform the driver in a natural and implicit way about intended use and expected behaviour, and help to prevent encounters at high speed and direction differences, by implementing the following guidelines:

1. never mix motor vehicles with other slower forms of traffic at speeds higher than 30 km/h;
2. never have level road crossings with speeds higher than 50 km/h; and
3. never have opposite traffic without separation at speeds higher than 70 km/h.

An important element of DVI was the distinction of three different road categories: flow roads, connection roads and local roads, and the definition of their characteristics. As connection roads and local roads inside and outside built-up areas are considered different [5] in fact 5 different categories are distinguished [13]. The three aforementioned principles may be restated as road network functionality, traffic homogeneity and traffic behaviour predictability. Clearly an adaptation of the road network layout was needed. To make the DVI concept more operational for this purpose, the principles were translated to a set of requirements for an inherently safe road network [5], which are presented in table 1 (left column). These are respectively related to: network structure (1-4), selection of routes within the network (5-7), and layout of road segments (8-12).

By an agreement between the four different levels of government [8], in 1997 DVI became an intrinsic part of Dutch traffic road safety policy. It defined the Start Programme (or phase 1) Sustainable Safety as a first modest set of infrastructure related measures, which was implemented in the years 1998-2002. Also, the SWOV Institute for Road Safety Research has been carrying out the VVR project (*Verkenner Verkeersveiligheid in de Regio*), in which the implementation of various DVI measures was modelled in terms of their estimated costs and expected effects (partly, for the costs, based on [6]), on a country-wide and on a region by region basis. One of the aims of this model was to allocate to the regions a fair share of the national targets and the available national budgets. Due to new elections and political dynamics, in 2002 the Dutch Parliament failed to approve the new NVVP (National Transport and Traffic Plan), prepared by the former administration, which included the road safety targets for 2010 and the implementation plan for the phase 2 of the Sustainable Safety programme [20]. Meanwhile concerns were raised about the high investment and the large time scale, and it can be questioned to what extent DVI is still feasible. Also, as this policy will be implemented very decentralised, it will be very dependent on local supporters of the concept that would like to invest time and energy in its success.

Certainly physical infrastructure measures do enhance road traffic safety (CROW, 2001), but they may also have negative effects, such as related to mobility efficiency (particularly for emergency services), emissions, noise, fuel consumption, driving comfort and land use. Furthermore, change of the layout of existing urban residential areas and other parts of the road network is problematical and would be quite expensive.

ADAS APPLICATIONS THAT MATCH DVI REQUIREMENTS

ADAS is a collective name for a whole range of ICT based in-vehicle systems, intended to support the driver in the driving task. ADAS applications are meant to improve the safety, efficiency, and comfort of driving, and hold the promise to also improve driver performance and thereby overall road traffic safety, as well as network capacity. The next step is to consider by which ADAS functions the effects of each of the DVI requirements can be met. The result of this match is summarised in table 1.

1. Create large-size continuous residential areas with 30 km/h roads allow more trips for all modes to take place completely within these areas. Main goal is to enforce a speed limit of 30 km/h when motor vehicles mix with slower forms of traffic (guideline 1). This might also be realised by a wide-spread implementation of a system for speed assistance, which generally reduces accident frequency and severity [27,1]. In addition to low speed limits, also collision avoidance and intersection support systems may contribute to safety in such areas, especially with respect to the protection of pedestrians, cyclists and other vulnerable road users.

#	DVI requirement	possible ADAS solution(s)
1	create large-size continuous residential areas	speed assistance, collision avoidance, intersection support systems
2	minimise part of journey on relatively unsafe roads	navigation system (digital map and system sw adaptation)
3	make journeys as short as possible	navigation system (smart shortest routes, system sw adaptation)
4	let shortest and safest route coincide	navigation system (combination of 2 and 3)
5	avoid search behaviour	navigation system (state of the art)
6	make road categories recognisable	navigation system (digital map and system sw adaptation)
7	limited number of standard traffic solutions	none
8	avoid conflicts with oncoming traffic	lane keeping and/or forward collision avoidance
9	avoid conflicts with crossing traffic	collision avoidance, intersection support systems
10	separate traffic categories	navigation system and speed assistance
11	reduce speed at sites of potential conflict	speed assistance
12	avoid obstacles along the carriageway	lane keeping and/or forward collision avoidance

Table 1 - *Match of DVI requirements with ADAS functions*

2. Minimise part of journey on relatively unsafe roads is a function that might very well be supported by current navigation systems. With unsafe roads in this context basically the roads in residential areas are meant. At a proper setting of the route selection function, navigation systems already tend to limit the part of the route in such areas to a minimum. A more detailed consideration and definition of what unsafe roads are, and a consequent adaptation of the digital map database and the system software may however be necessary.

3. Make journeys as short as possible - This requirement matches a main function of present navigation systems, which calculate and advise the most efficient route (a smart shortest route, i.e. as short as possible, but also as much as possible on higher level roads), again dependent on the setting of the route selection function. Some adaptation of system software may be required though.

4. Let shortest and safest route coincide is again a function that can be performed by a navigation system. In essence it is the combination of functions 2 and 3.

5. Avoid search behaviour is a current and very basic navigation system functionality. The driver is offered detailed guidance for his complete route from origin to destination.

6. Make road categories recognisable - This relates to the three different road categories that have been defined in DVI, with corresponding legal speed limits (which are different though in rural and urban areas). Primary aim is to assist the driver to find the optimal route, i.e. as much as possible on highest level roads. By its nature a navigation system will perform this function much better than any adaptation of the road infrastructure. Secondary aim is to induce as much as possible, both on road segments and at crossings within each category, a uniform traffic behaviour, to make it more predictable for other road users.

In a standard digital map for navigation systems the attribute functional road class (FC) in general distinguishes 5 levels, numbered 1 to 5 [4]. It corresponds largely to the classification proposed in DVI, but is more detailed. FC 1 corresponds to motorways, FC 2 to flow roads not being motorways. FC 3 and 4 are typically connection roads of different speeds and volume, while FC 5 represents the residential roads. The attribute could be used (by adaptation of the navigation system software, and maybe of the map database) to inform the driver about the type of road he/she is driving on. An equally important aspect however is the legal speed limit speed for each category, about which the driver can be informed by some form of speed assistance.

7 - Limited number of standard traffic solutions - This requirement does not really have an ADAS equivalent. It most prominently applies to flow roads, and to a lesser extent also to connection roads, especially for locations where interaction takes place. However, indirectly the use and application of speed information at such interaction locations may help to bring about the desired results. Also, intersection support systems may be applicable. This relates to requirements 8, 9 and 11. A future possibility is to include in map databases information on so-called black spots. These are locations that statistically have shown to have a high accident probability.

8 - Avoid conflicts with oncoming traffic - On motorways (FC 1) there is generally a physical separation of opposite traffic streams. For other flow roads (FC 2) and some collector roads (FC 3 and 4) it is important to know if there is a physical separation or not. Dependent on this, a maximum speed could be chosen, in accordance with DVI guideline 3. The digital map database may contain information on whether a road is a dual carriageway or not, and even about the presence (or absence) of a physical separator. In principle the authorities will have chosen and posted the right speed limit, which will be reflected in the map database. Speed assistance may be used to inform the driver. Still there are a lot of roads, for instance in the Netherlands the 2-lane so-called national roads (N-roads), which have a rather important flow function, and therefore a speed limit of 80 km/h, which is relatively high in view of DVI guideline 3 and the potential severity of accidents. For such roads a combination of lane keeping and forward obstacle detection might contribute to safety enhancement.

9 - Avoid conflicts with crossing traffic - Different types of functions can be thought of here: intersection support, forward collision avoidance, side collision avoidance, speed assistance (automatic deceleration to a safe speed before an intersection), and automated stop at red traffic light.

In the US a common and effective solution for intersections with not too heavy traffic is a stop sign at each entry, and the regulation "first stop, first go". For heavier traffic conditions the principle could be automated by an in-vehicle system communicates position and driving direction with other nearby vehicles, and is able to reach a consensus decision with these other systems. Feasibility studies in this area have been carried out in the US [23, 22] and are ongoing in Europe [25].

Speed assistance based automated speed reduction at non-controlled intersections would implement DVI guideline 2 (*never have level crossings with speeds higher than 50 km/h*), and may help reduce both the likelihood and the seriousness of encounters. Similarly, speed assistance based automated stopping, digital map information about the presence of a traffic light with a DSRC beacon, and information from the beacon about which lights are red, could prevent drivers to ignore a red light. This may especially be valuable where slower traffic crosses the main road by assistance of a traffic signal.

10 - Separate traffic categories - On flow roads of FC 2 this is already generally the case, on connection roads often but not always. Extension of this physical separation where possible is recommendable, and probably an ongoing process even without DVI. But especially for connection roads this is not always possible. Then speed assistance in line with DVI guideline 1 may be the solution. Note that currently for connection roads (FC 2 and FC 3) in cities the speed limit is often 50 km/h (as it is still in many residential areas), but that according to DVI guideline 1 this should be 30km/h. Clearly this has the disadvantage of a low throughput. One could discuss whether a differentiation to 40 km/h would be acceptable for such roads if their width is sufficient and a cycle path is clearly marked on the road. For residential areas separation is not needed, as the speed limit in such areas should (in the future, based on DVI) always be 30 km/h.

11 - Reduce speed at sites of potential conflict - Speed reduction up to the posted speed limit (based on digital map information on such sites) potentially meets this requirement, which relates in fact to requirements 8 and 9, and also to black spot information (see requirement 7). Adaptation of the map database may be required.

12 - Avoid obstacles along the carriageway - This certainly is a physical measure that should be implemented as much as possible where necessary. On flow roads lane keeping and collision avoidance could contribute to avoid such obstacles. On connection roads lane keeping will probably not work (because of lacking or inadequate marker lines). Only proper speed may help to avoid consequences of accidents with such obstacles.

In summary, there appear to be strong links between DVI implementation and large-scale ADAS implementation. Many of the expected effects of DVI show a strong overlap with potential effects of ADAS. Especially the navigation system, speed assistance, collision avoidance, lane keeping and intersection support seem to have, in view of the DVI framework, a fundamental potential to enhance road safety and to substitute DVI measures.

IMPLEMENTATION SCENARIOS AND CONCEPTUAL FRAMEWORK

Based on the 12 requirements four operational physical infrastructure measures are identified (D1-D4) which can be implemented at the local level, particularly on the secondary national network. These are taken as the DVI scenarios for comparison with ADAS scenarios, and for further research.

Introduce more and/or enlarge *30 km/h residential zones* (D1) by regulation (signs) and enforcement measures, like speed humps, road cavities (inverted humps), road narrowing and horizontal deflections, village gateways, road-markings, rumble strips and other road surface treatments, visibility and visual guidance and traffic calming [28,29].

Build *roundabouts* (D2), both inside and outside build-up areas, to replace conventional intersections [21]. Roundabouts are implemented not only to enhance road safety, but also to improve road throughput.

Physically *separate carriageways* of single-carriageway roads (D3). This principle for infrastructure redesign has so far only scarcely been implemented in the Netherlands.

Create so-called *self-explaining roads* (D4) by standardising and clearly differentiating the design (layout, colour) of different road categories, and provide the driver assistance to find the shortest and safest route [13,14].

From the analysis of the relationship between ADAS functions and DVI requirements for enhancing safety, five ADAS functions (A1-A5) emerged as potential candidates. Of these the (adapted) navigation system (A1) and speed assistance (A2) are based on state-of-the-art technology, and short-term deployable (2-5 years). The most viable option for speed assistance seems to be (haptic) control (throttle-pedal pushback) with the principle that the driver is always in control of the vehicle.

It is questionable if longitudinal collision avoidance (LonCA) will be useful to avoid encounters with opposite traffic, as speed differences are high and the dangerous situation will often occur just before impact. To avoid encounters with crossing traffic LonCA seems to be more feasible than lateral collision avoidance (LatCA), as it is easier to control the car that is going to cause the impact at its front side than the car that is going to be impacted at its side. Even pure LonCA may often not work as two cars will reach the intersection of their trajectories at or nearly at the same time when speeds are high and a collision is to be expected. However, a system that has a 180° view in the forward direction (enhanced combined LonCA/LatCA) may be able to analyse an imminent collision. World-wide research is ongoing on longitudinal (front-end and rear-end) and lateral collision avoidance. As reliability still needs to be drastically improved, we can assume that collision avoidance (A3) is mid-term deployable (5-10 years). See also [19].

Lane keeping (A4) by accurate high resolution positioning (about 25 cm) and a digital map with great absolute accuracy (about 25 cm) and lane information is not a near-term option. A speed of 100 km/h equals 27 m/s. If calculating a position takes 0.5 second, the vehicles has already moved 13.5 m in the mean time. Current ADAS spec maps have an absolute accuracy of 5 m (but a relative accuracy of 1 m). Lane keeping by using cameras is more nearby, but cursed with difficulties, especially in bad weather and lighting conditions. A more viable option is maybe to be found in magnetic tape positioning. The tape requires a considerable investment for installation, but practically no further maintenance until the road surface is renewed, and the positioning is reliable in all weather and visibility conditions [15]. Lane keeping by magnetic tape positioning is current technology, and short term deployable (0-2 years). Other forms of lane keeping are considered long-term options (10-15 years).

Intersection support (A5) is based on smart communication between nearby cars and accurate positioning. Technically it is possible, but still a lot of reliability issues need to be solved. Therefore this technology is considered long-term deployable (10-15 years). However fast moving standards work on vehicle-to-vehicle and vehicle-to-infrastructure communications is underway in ISO/TC204/WG16.

From the identified DVI and ADAS functions, some logical combinations (of DVI functions only, of ADAS functions only, and a mix of both types) can be created based on the expected time scale of implementation (based on the current state of the technology). D1 and D2 have been widely implemented in the Netherlands, and are combined in scenario C1. Long-term scenario C2 combines all five identified DVI measures. Scenario C3 combines short-term ADAS options A1 and A2, scenario C4 is a mid-term option as it also integrates A3, and long-term scenario C5 integrates all five ADAS options. Finally, short-term scenario C6 combines C3 with D2.

A preliminary qualitative analysis of the potential social, environmental and economic effects of the different scenarios is presented in table 2 as a conceptual framework for further study.

DISCUSSION

The elaboration of the DVI requirements and DVI guidelines shows that many of the effects could be brought about by intelligent use of dedicated ADAS applications. Several of these applications are already on the market or close to the market.

Navigation systems, which are an alternative for 5 out of 12 requirements, are a standard option these days in many new car models. Adaptation of the digital map to include additional functionality may be necessary. Current implementation of the FC attribute is based on interpretation of the map provider, though often in line with local guidelines and views. The speed category attribute currently provides speed intervals, not the precise speed limit. Both attributes and their values are meant in the first place to support route calculation and route guidance, not for road safety applications. One step forward is that the next generation digital map, with enhanced ADAS specification, should contain the precise speed limits. For the future a closer co-operation between road administrators (setting the speed limits) and map providers will be highly desirable. This will enable the certification of certain road safety related attributes prior to their inclusion in the digital map, and needs further study (see recommendation 11 in [9]). Dynamic traffic information (TMC) may improve navigation and add certain safety benefits (e.g. early traffic queue detection and warning by precise location referencing [12]).

Category	scenarios ➔ ➔ effects	D1	D2	D3	D4	A1	A2	A3	A4	A5	C1	C2	C3	C4	C5	C6
Social	accident frequency	+	++	++	+	+	++	++	+	++	++	+++	++	+++	+++	++
	accident severity	++	++	++			++	++	+	++	++	++	+	++	++	+
	network capacity		+	+		+	+				+	+	+	+	+	+
	comfort & convenience	-	-	+	+	++	+/-		+	+	-	+/-	+	+	++	+
	emergency services	-	-	-		+				+	-	-	+	+	+	+/-
Environmental	reduce emissions	-		+		+	+				-	+/-	+	+	+	+
	reduce noise	+/-		+		+	+				+/-	+	+	+	+	+
Economic	land use		- -	-							- -	- -				- -
	reduce fuel consumption	-		+		+	+				-	+/-	+	+	+	+
	time saving	-		+/-		+					-	+/-	+	+	+	+
…	…															

Note: +, ++ and +++ denote positive effects from low to high level; **-**, **- -** and **- - -** denote negative effects from low to high level; if blank, the relationship is not relevant.

Table 2 - *Conceptual framework of comprehensive effects*

D1 - Extend 30 km/h residential zones
D2 - Build roundabouts
D3 - Physically separate carriageways
D4 - Create self-explaining roads

A1 - navigation system
A2 - speed assistance
A3 - collision avoidance
A4 - lane keeping
A5 - intersection support

C1 = D1 + D2
C2 = D1 + D2 + D3 + D4
C3 = A1 + A2
C4 = A1 + A2 + A3
C5 = A1 + A2 + A3 + A4 + A5
C6 = A1 + A2 + D2

Technical feasibility of speed assistance has been amply demonstrated. The way forward however is not clear, due to acceptance problems both in the (car) industry and at the public (the car users) (see e.g. [11]). The system can be implemented as information, warning or control system. Information or warning based speed assistance however may not be optimal to improve appropriate speed behaviour, as in most cases the information is already clearly available. Also DVI assumes that human behaviour needs to be adapted to some extent by enforcement and is therefore partly based on control mechanisms (e.g. speed humps). Full speed control however seems to be both technically questionable and socially unacceptable. The haptic pedal provides an attractive way to advise drivers, leaving the driving task 100% in the driver's hands, thus making it possible to increase speed for short moments (in urgency situations, so often used as argument against full control). A differentiation in absolute control for local roads, haptic control for connection roads and warning or information only on flow roads could be considered as a sensible way to satisfy all the parties involved in the current animated discussion.

Integrated navigation with some kind of speed advisory feature could offer the potential for a mass market, and drop prices considerably. Fiscal measures and lower car insurance premiums may contribute to foster acceptance. Also such platform may be used for other functions, among which is another contentious item, road pricing. Other functions may be easily added on the same platform.

Collision avoidance, lane keeping and intersection support systems are technically feasible, but can only be introduced to the market when they have reached a stage of reliable operation under all conditions, including legal, legislative and socio-political considerations.

Other ADAS functions can be distinguished, which do not directly match a DVI requirement, but have potential to improve road traffic safety. Examples are curve warning (maybe also by haptic pedal control) and night vision (both close to market), and driver alertness monitoring (long-term, e.g. AWAKE project [31]).

Apart from the safety effects all DVI measures and ADAS applications have other effects, both positive and negative, which should be taken into account in any analysis. One critical aspect of ADAS is the human machine interface, which is not discussed in this paper, as it is in the field of ergonomics and psychology.

FURTHER RESEARCH

Thus ADAS offers an attractive and promising future as compared to the high cost and long time scale of DVI. However, various scenarios are cursed with many uncertainties. Further research will focus on quantifying the conceptual framework and on making an operational evaluation model to support decision making on alternative investment strategies. For this an evaluation method needs to be chosen. A fully-fledged societal cost-benefit analysis (CBA) is difficult to implement because not all impacts can be monetised in an acceptable way. Cost-effectiveness analysis (CEA) is less rigorous than CBA, and provides only a static comparison of alternatives. The restriction is that it is difficult or even impossible to quantify all relevant effects such as comfort, convenience. Yet another method is cost-utility analysis (CUA), which is more dynamic than CEA but has similar restrictions [2,3]. Multicriteria evaluation methods like analytic hierarchy process (AHP) [26] and fuzzy sets and fuzzy logic theory based evaluation [16] use artificial scores from expert knowledge.

Instead, a multicriteria evaluation model based on grey relational analysis (GRA) will be developed. GRA is one of the analysis methods based on grey system theory [7], which was first developed (in 1982) and is still mainly applied in China. By applying this method, relevant factors, like costs, effects, penetration, policy measures, etc. can be analysed, modelled and quantified as parameters, and can subsequently be used as inputs, in any applicable unit. Output is a set of grey relational coefficients, which provide a systematical and comprehensive evaluation (ranking) of the considered alternative strategies, which can be used for decision making in transport and road safety policy. Because the model can easily be expressed in a computer algorithm, it will be straightforward to evaluate different scenarios, and to perform sensitivity analyses.

Estimating the parameters is of course the hard part of the modelling. First a qualitative causal model will be constructed. In a next step the relationships in the model will be quantified, largely based on results from other studies (literature review), but also where necessary based on educated guessing of different scenarios. Although the model in the first place will be developed for the Dutch situation, it could as well be easily applied to other countries or Europe as a whole.

CONCLUSION

In this paper the operational physical infrastructure measures which derive from the Dutch DVI programme were identified. Then a link between DVI measures and ADAS applications was established, focusing on a possible substitution of DVI measures by ADAS implementation, with a focus on road safety improvement. A preliminary and qualitative analysis of the pro's and con's of various measures was provided, and a method was proposed for thorough quantitative analysis, which will be able to provide systematic and consise evaluation results for well-founded decision making.

DVI is a Dutch initiative, which was adopted in Belgium as well [10]. In the mean time road safety has become a core issue at the European level, and very ambitious targets have been set by the European Commission for the year 2010. In the European plans the application of ADAS plays a more central role than in the Dutch DVI related plans. The advantage of using DVI as a starting point for the analysis of measures to enhance traffic safety, is that it indicates where measures are needed, as well as and their expected effects. The elaboration of DVI in terms of ADAS applications indicates that many of the safety goals can be reached by ADAS implementation. In the short term, two major building blocks are the navigation system and speed assistance. The best results can be reached by a harmonised and coordinated Europe-wide government stimulated rapid introduction of the relevant systems. Navigation systems show already a considerable market penetration, and their popularity is continuously growing. Some adaptations of these systems may be required, and should be co-ordinated.

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