SWOV Fact sheet

The elderly and Intelligent Transport Systems (ITS)

Summary
The elderly have a higher than average death rate in traffic. The most important cause of this high death rate among the 75 year olds and older is their increased physical vulnerability. In addition, functional limitations can also influence the elderly road users' road safety. These functional limitations are more common among the oldest group of road users, those of 75 years old and older, and they are a group that will show strong growth during the coming decades.
Advanced Driver Assistance Systems (ADAS) can probably remove certain problems by offering specific assistance. In a road and traffic environment that does not always allow for the elderly driver's capabilities and limitations, ADAS could ensure that the elderly road user longer remains a safe driver. Further research is needed before this can become reality, for many of the systems relevant to the problem of the elderly driver are still being developed, and too little research on their acceptance and behavioural effects has been done up till now.

Background and content
The elderly have a higher than average fatality rate in traffic. For each kilometre travelled, the fatality rate is more than five times higher for the 75 years and older than for the average for all ages. The 65-74 year old drivers have a fatality rate that is not yet twice as high as the average. The most important cause of the elderly's increased fatality rate is their larger physical vulnerability. Because of their functional limitations, the elderly are also slightly more often involved in crashes (see also SWOV Fact sheet *The elderly in traffic*).
Ageing will increase the proportion of the elderly in the total number of road users. This will be the case for cyclists and pedestrians, but particularly for drivers because ever more of the elderly will have a driving licence. We also expect the elderly of the future to have a greater mobility than the present generation. These developments will also cause an increase in the share of elderly in the total number of traffic casualties. However, various measures can influence the future prospect in a positive way. An overview of these measures can be found in SWOV Fact sheet *The elderly in traffic*. Of these measures, this fact sheet discusses those Advanced Driver Assistance Systems (ADAS) that can compensate for the functional limitations of elderly drivers. Furthermore, the fact sheet discusses which requirements for design and side effects need to be taken into account when the elderly driver uses ADAS.

Which safety problems do elderly drivers encounter?
Crash analyses show that, relatively speaking, elderly drivers (especially those of 75 years and older) are more frequently involved in crashes when turning left at an intersection or while merging or exiting, for example on a motorway. This type of crash is related to the following difficulties elderly drivers experience in traffic and the functional limitations that cause them (Davidse, 2004):

a. having difficulty in judging whether other road users are moving and how fast they are approaching an intersection (poorer perception of movement);
b. not noticing other road users when merging and changing lanes (reduced peripheral vision and flexibility of neck and trunk);
c. not noticing traffic signs and traffic lights (greater difficulty in selecting relevant information);
d. large increase in reaction time as the traffic situation becomes more complex (slower information processing and decision making, more difficulty in dividing the attention, and worse performance under pressure of time).

Which ADAS are suitable for the difficulties of elderly driver?
ADAS which offer assistance in the elderly motorist's traffic difficulties and specifically take into account the underlying functional limitations, can contribute to a reduction in the elderly's crash involvement. Following the abovementioned traffic difficulties a. to d., ADAS should have one or more of the following functionalities:

a. drawing attention to approaching traffic;
b. pointing out objects that are in the blind spot;

c. providing help in guiding the attention to relevant information;
d. providing prior knowledge about the next traffic situation.

For a long time now, there have been vehicle adaptations to compensate for motor functional limitations, such as a decrease in muscle strength. Examples of such systems are servo-assisted steering, an automatic gearbox, and adjustment of the force which is required to step on the brake or acceleration pedal. In addition, there are ever more ADAS available, such as Advanced Cruise Control and Lane Departure Warning Assistant. (see SWOV Fact sheet *Intelligent Transport Systems (ITS) and road safety*). However, there are hardly any ADAS applications that assist the driver in looking, paying attention and information processing (Wegman & Aarts, 2005). These are exactly the support systems that would be most useful for elderly drivers. *Table 1* gives an overview of the systems that could be helpful to elderly drivers.

Functionality	**Driver assistance systems**
a. Draws attention to approaching traffic	- collision warning systems aimed at intersections - automated lane changing and merging systems
b. Warns about road users located in the driver's blind spot	- automated lane changing and merging systems - blind spot and obstacle detection systems
c. Assist the driver in directing attention to relevant information	- in-vehicle signing systems - special intelligent cruise control
d. Provides prior knowledge on the next traffic situation	- systems that give information on the characteristics of complex traffic situations the driver is about to cross

Table 1. *Desired functionalities and driver assistance systems (Davidse, 2004; 2007).*

Each of the driver assistance systems mentioned in the table will now be discussed in more detail.

Collision warning systems for conflicts at intersections draw the driver's attention to traffic that approaches an intersection at the same time as he does, or indicate when it is safe to cross an intersecting flow of traffic. Neither of these two systems is yet for sale, although experiments have been carried out with simulated prototypes. Among other things, these tests show that a system that advises between which two vehicles the driver can cross safely, is appreciated by many of the elderly. However, the advice must be tuned to the reaction time of the driver, so that he can merge or cross the intersection at his own pace (Davidse, 2007).
The type of collision warning system that signals approaching traffic is expected to have greater positive road safety effects than a system that only indicates when merging is safe. Intersection crashes are mainly caused by the eldery drivers not noticing the intersecting vehicle, and are not so much a matter of incorrect estimation of the necessary space in between vehicles.

Systems for automated merging and/or lane changing on motorways assist the driver to find sufficient space between cars and also ensure that he/she merges there. These systems go one step further than only drawing the driver's attention: they temporarily take over the vehicle control completely. At present, such a system is not yet technically feasible. A simpler version of assistance in changing lane and merging are Lane Change Collision Warning (LCCW) and Lane Change Collision Warning and Avoidance (LCCWA) systems. LCCW only warns and LCCWA warns and, if necessary, also carries out a steering movement to avoid a collision. At present, only LCCW systems are available, but these systems have not yet been assessed for use by elderly drivers. Tests with younger participants have shown that LCCW systems have various disadvantages, such as a high percentage of false alarms and the small lateral distance between vehicles, that make it difficult to steer away from the collision object in time, even when the system has alarmed the driver.

Parking assistance systems warn the driver about objects that are in the blind spot while parking. Therefore these systems may not be so relevant for reducing the fatality rate of elderly drivers, but the elderly find this help very useful and are also prepared to pay for it. Such systems are already on the market.

Examples of systems that assist the driver in focusing the attention on relevant information, are *systems that project roadside traffic signs and warning signs inside the vehicle.* These systems are known as in-vehicle sign information systems. They give the driver a better and longer view of the sign. The drawback is that the driver's attention is diverted from the carriageway for a longer period of time. Caution is therefore required when in-vehicle information systems are introduced. The position of the in-vehicle display (either a display on the dashboard or a projection on the front windscreen) and the manner in which the information is presented will determine whether these systems are benificial for road safety or not.

Systems which adjust vehicle speed in the vicinity of traffic lights, priority signs, and/or warning signs also draw the driver's attention to relevant information about the surroundings and give him more time to react. These systems may be seen as *special types of intelligent cruise control.* Prototypes have been developed within the framework of European demonstration projects like PReVENT and SAFESPOT; it will, however, take a considerable period of time until these types of systems are introduced to the market (Schultze et al., 2008).

An information system that assists the driver in safely travelling through demanding traffic situations has especially been developed as a support for elderly drivers (Entenmann & Küting, 2000). The system can be described as a navigation system that not only provides route information, but also gives timely information about crucial elements of the next traffic situation. This information is only provided at complex intersections. It is a promising idea to provide the driver with step by step information in time to anticipate upcoming events. The driver can anticipate on what is coming when the task load is still low. The test results indicate that the elderly appreciate this system more than an ordinary navigation system, and that the system also has greater road safety effects (Entenmann et al., 2001). Appreciation and a positive road safety effect were also found in a study which combined several of the above systems into one support system (Davidse, 2007).

Many of the systems shown in *Table 1* are still being developed. That is why little is known about their effects on traffic behaviour. Nor is much known about their acceptance by various groups of drivers. Insofar as such research has been done, the user groups for testing are often younger drivers. The elderly are only asked to participate in tests if the system has been specifically designed for them, despite the fact that elderly drivers have considerably larger problems with operating in-vehicle systems. It is therefore essential that evaluations of the safety and utility of systems primarily take the elderly driver into consideration (see also this factsheet's section *Control panel of ADAS applications*).

Are there other systems that can be useful?

In the above discussion of driver assistance systems for elderly drivers, only those systems were mentioned whose functionality have the greatest potential for improving the road safety of this group of road users. Using this as our starting point, three systems reported in the literature about the elderly and ADAS were not yet dealt with in this factsheet:

1. night-time vision enhancement systems (UV headlights or infrared technology);
2. navigation systems;
3. mayday systems (also known as e-Call systems) that automatically send information about the vehicle location to an emergency service in the case of a breakdown, crash, or other emergency.

These systems are helpful for drivers who have trouble with driving in darkness or in an unfamiliar area, or who feel unsafe. Therefore, these systems are especially suitable for encouraging elderly mobility. Mayday systems can also shorten the time before receiving medical treatment, thereby lessening the final injury severity. The other two systems are not only suitable for increasing mobility, but can also reduce the crash rate, by compensating for impaired nighttime acuity or by preventing searching respectively.

What should be given extra attention in ADAS use by the elderly?

If the goal of using ADAS is the improvement of the safety of (elderly) drivers, safer performance of the assisted task only is not sufficient. The assistance must also not have any negative effects on other elements of the driving task. Examples of negative side effects are an increase in the task load and the occurrence of behavioural adaptation (see also the SWOV Fact sheet *Intelligent Transport Systems (ITS) and road safety*). This should be taken into consideration when designing ADAS.

Control panel design for ADAS applications

Elderly drivers are more sensitive to the effects of poorly designed ADAS than younger drivers. In general, the elderly need more time to carry out secondary tasks while driving. That is why it is very important that the design of the control panel of ADAS takes the capabilities and limitations of elderly drivers into account. Various guidelines are available for the design of this kind of control panel (Green, 2001; Stevens et al., 2002). Caird et al. (1998) do not only summarize these guidelines, but also discuss the guidelines that are of specific importance for the elderly user. These guidelines have been summarized in *Table 2*.

Functional limitations	**Relevant design principles**
General sensory deficits	Use redundant cues, like auditory, visual and tactile feedback
Visual acuity (close by)	Increase character size of textual labels
Colour vision	Use white colours on a black background
Diminished low-light vision	Use supplemental illumination for devices used in low-light conditions
Sensitivity to glare	Use matt finishes for control panels and antiglare coating on displays
Hearing	Use auditory signals in the range of 1500-2500 Hz.
Contrast sensitivity and depth perception	Where depth perception is important, provide non-physical cues, such as relative size, interposition, linear position and texture gradient
Selective attention	Enhance the conspicuity of crucial stimuli through changes in size, contrast, colour or motion
Perception-reaction time	Give the user sufficient time to respond to a request by the system and provide advanced warnings to provide the driver with enough time to react to the on-coming traffic situation
Hand dexterity and strength	Use large diameter knobs, textured knob surfaces and controls with low resistance

Table 2. *Functional limitations and relevant design principles for elderly drivers (based on Caird et al., 1998; Gardner-Bonneau & Gosbee, 1997).*

Different ADAS applications in one car
So far we have only discussed individual ADAS applications. However, installing multiple systems in one car can cause new problems. For example, the various displays could compete for the driver's attention. The elderly will have the most trouble with this as age differences become more manifest as tasks get more complex. This leads to longer reaction times. If, moreover, different systems simultaneously send their own message, the pressure on the driver will increase even more. We can say that the presence of a number of independently operating systems generally increases the task load. This effect is contrary to what ADAS aims at: reducing the task load. The problems may be prevented by coordinating the signals of the installed ADAS applications. This can also prevent systems sending conflicting messages or, even worse, carrying out conflicting actions. The coordination between systems can be achieved in various ways. Heijer et al. (2001) have proposed to design an ADAS application that assists the driver in a whole set of problematic situations instead of designing separate ADAS applications that each assist him in dealing with a different problem. Another way of coordinating is achieved by the intervention of a 'mediator' which, based on an algorithm, determines which information is sent when and how this is done. Examples of mediators are described by Vonk, Van Arem & Hoedemaeker, 2002, and Piechulla et al., 2003).

Behavioural adaptation
The phenomenon of behavioural adaptation means that people take bigger risks in reaction to a system's improvements. A type of behavioural adaptation among the elderly could be the withdrawal of compensatory behaviour (for examples of compensatory behaviour see SWOV Fact sheet *The Elderly in traffic*). One example is that many elderly compensate for their impaired night-time visual acuity and glare sensitivity by no longer driving when it is dark. This results in a relatively small number of crashes involving the elderly during the hours of darkness. If a large scale introduction of night-time vision improvement systems resulted in the elderly driving at night again with such a system, this may be positive for their mobility and quality of life. It is, however, doubtful whether the safety of these drivers could be warranted equally well by using a night-time vision enhancement system as by their habit of not driving at night at all, or as little as possible. This requires an awareness of the possibilities and impossibilities of night-time vision enhancement systems on the one hand, and quality standards for night-time vision enhancement system on the other.

Conclusion
In traffic situations that cannot always allow for the possibilities and limitations of the elderly driver, ADAS could make it possible that the elderly continue to be safe road users for a longer time. Some systems seem promising in compensating for one or more problems of the elderly in traffic. However,

most of these systems are still being developed and too little research has been done on their acceptance and behavioural effects. Therefore, it is too early to make statements about the expected safety gains of the use of ADAS by the elderly; this requires more research. This research should in the first place lead to the development of ADAS applications which are aimed at the specific needs of elderly drivers. After all, first systems or prototypes are needed for testing whether these ADAS are indeed capable of providing the necessary assistance, whether they are accepted and what behavioural effects they cause. Moreover, ADAS applications should not only be tested on younger drivers, but also on the elderly. Only then will it be possible to conclude whether or not the systems that seem to have the greatest potential to improve the safety of elderly drivers, really do this.

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