

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. By offering personal aid in a road and traffic environment that does not always allow for the elderly motorist's capabilities and limitations, ADAS could ensure that the elderly road user longer remains a safe motorist. Further research is needed before this becomes reality. For many of the systems relevant to the problem of the elderly motorist are still being developed, and too little research of their acceptance and behavioural effects has been done up till now.

What is the road safety of the elderly motorists like?

The elderly have a higher than average death rate in traffic. For each kilometre travelled, the death 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 motorists have a death rate that is not yet twice as high as the average. The most important cause of the elderly's increased death rate is their larger physical vulnerability. Because of their functional limitations, the elderly are also slightly more often involved in crashes (see also the SWOV Fact sheet [The elderly in traffic](#)).

Aging 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 motorists because ever more of the elderly will possess a driving licence. We also expect the elderly of the future to have a greater mobility/exposure than the present generation. These developments will also cause an increase in the proportion of elderly in the total number of traffic casualties.

In order to keep the elderly safely mobile for as long as possible, it is advisable to decrease their mortality rate. Available possibilities are education/information, adapting the infrastructure (see the SWOV Fact sheet [The elderly and infrastructure](#)), and driver assistance systems (OECD, 2001; 2004). Injury reduction measures, such as protection devices, are of course also important to lower the death rate of elderly road users.

How could ADAS improve the safety of elderly motorists?

By designing measures specifically aimed at those crash types in which the elderly are more often involved, the number of crashes involving the elderly can be reduced. Accident analyses show that, relatively speaking, the elderly motorists (especially those of 75 years and older) are, more often than younger motorists, involved in crashes when turning left at an intersection or while merging or exiting, for example on a motorway. A further analysis of the strengths and weaknesses of the elderly motorist (Davidse, 2004) has shown that the elderly's greatest need of assistance is the result of the following difficulties (the weak points in brackets are those who cause the difficulties);

- 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).

ADAS which offer assistance to the elderly motorist on these points, can contribute to a reduction in the elderly's crash involvement. To achieve this, ADAS should have one or more of the following functionalities (the letters correspond to the above mentioned traffic difficulties):

- 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.

Which systems can offer the necessary help?

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 and/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* shows which systems could be helpful to elderly drivers.

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

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

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 intersect a crossing 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 the motorist about between which two vehicles he/she 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).

It is expected that the type of collision warning system that only indicates that traffic is approaching the intersection, will have greater positive road safety effects than a system that indicates when crossing is safe. Intersection crashes are mainly the result of not noticing the crossing traffic, and 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 motorist to find sufficient space between cars and also ensure that he/she merges at that place. 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 for 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 the collision. At present, only LCCW systems are available. These systems have not yet been assessed for use by elderly motorists. 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 follow the system's indication and steer away from the collision object in time.

Parking assistance systems warn the motorist about objects that are in the blind spot while parking. These systems may not be so relevant for reducing the death rate of elderly motorists, but the elderly find them very useful and are also prepared to pay for them. Such systems are already on the market.

Examples of systems that assist the driver in paying attention to 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 temporarily diverted from the lane he/she is driving in. 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 good or bad for road safety.

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 of such systems have been developed within the framework of European demonstration projects like [PReVENT](#). It will, however, take considerable time until these prototypes are introduced to the market (Schultze et al., 2008).

An information system that assists the driver in safely passing demanding traffic situations has especially been developed as assistance to elderly motorists (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 motorist with step by step information in time to anticipate on coming events. The motorist can visualize 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). Similar results were 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. Neither is much known about their acceptance by various groups of motorists. Insofar as such research has been done, the user groups for testing are often younger motorists. This despite the fact that elderly motorists have considerably larger problems with operating in-vehicle systems. The elderly are only asked to participate in tests if the system has been specifically designed for them. It is therefore essential that evaluations of the safety and utility of systems primarily take the elderly driver into consideration (see also [Control panel of ADAS applications](#)).

Other systems which can be useful to elderly motorists

In the above discussion of driver assistance systems for elderly motorists, 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 dealt with:

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

These systems are helpful for motorists who have trouble with driving in darkness or in an unfamiliar area, or have feelings of insecurity. Therefore, these systems are especially suitable for encouraging elderly mobility. Mayday systems can also shorten the time before receiving medical treatment, thereby lessening injury severity. The other two systems can possibly also reduce the crash rate by compensating for impaired nighttime acuity or by preventing searching. Whether or not the systems will also lead to a reduction in the number of elderly motorist casualties depends on the size of the crash rate reduction, which must be larger than the increase in exposure as a result of system usage (see also [Behavioural adaptation](#)).

What should get extra attention in ADAS use by the elderly?

If the goal of using ADAS is the improvement of the safety of (elderly) drivers, just safer performance of the assisted task is not sufficient. The assistance must not have any negative consequences for other elements of the driving task either. 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 consequences 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 deal with 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.
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 motorists (based on Caird et al., 1998; Gardner-Bonneau & Gosbee, 1997).*

Different ADAS applications in one car

Until now we have only discussed individual ADAS applications. However, installing different 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 clearer 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 the opposite of what ADAS aims at: lessening 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 assist the driver with a whole set of problematic situations instead of designing separate ADAS applications that each assist him with a different problem. Another way of coordinating is achieved by intervention of a mediator which, based on an algorithm, determines when which information may be sent in which way. 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 as a reaction to a system's improvements. See Dragutinovic et al. (2005) for an overview of behavioural adaptations as reaction to the introduction of Advanced Cruise Control (ACC). A type of behavioural adaptation that could occur among the elderly is the withdrawal of compensatory behaviour (For examples of compensatory behaviour see the SWOV Fact sheet [The Elderly in traffic](#)). This can be illustrated by the introduction of night-time vision enhancement systems. Many elderly compensate for their impaired night-time visual acuity and sensitivity to glare, 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 again driving at night with such a system, this may be positive for their mobility and quality of life. It is, however,

doubtful if the safety of these motorists could be warranted just as well by using a night-time vision enhancement system as by their habit of not driving at night, or as little as possible. On the one hand, this requires an awareness of the possibilities and impossibilities of compensation by using night-time vision enhancement systems and, on the other hand, quality standards for night-time vision enhancement systems.

Conclusion

By offering personal assistance in traffic situations that cannot always allow for the possibilities and limitations of the elderly motorist, ADAS could make it possible that the elderly continue to be safe road users. Some systems seem promising in compensating for one or more weaknesses of the elderly body that are important for road safety. These systems are: 1) collision warning systems at intersections, 2) systems for automated merging and lane changing, 3) parking assistance systems, 4) systems that project road signs and warning signs in the vehicle, 5) special intelligent cruise control, and 6) systems that provide information about the characteristics of complex intersections to be crossed. However, many of these systems are still being developed and too little research of their acceptance and behavioural effects has been done.

Before statements can be made about the size of the expected safety benefit of the introduction of ADAS, more research is necessary. In the first place, research should lead to the development of ADAS applications which are aimed at the specific needs of elderly motorists. After all, existing systems or prototypes are needed for testing if these ADAS are indeed capable of providing the necessary assistance, whether they are accepted, and what behavioural effects they cause. In addition, 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 motorists, really do.

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