General introduction

This doctoral thesis is concerned with the possibilities offered by road design and driver assistance systems to improve older adults’ safe and independent mobility by compensating for their age-related functional limitations. The focus is on drivers of private cars aged 75 years and above. In this thesis, this group of drivers is called ‘older drivers’. When referring to the mere age group, the interchangeable terms ‘older adults’ and ‘older people’ are used.

The specific attention for the age group of 75 years and above originates in the relatively high fatality rate for drivers of this age. An extensive analysis of the safety of older drivers is part of this thesis (Chapter 1). Among others, their safety is described in terms of involvement in crashes and resulting injuries. The term ‘accidents’ is deliberately not used in this thesis, as it suggests that the events had to do with bad luck and were thus not preventable (Davis & Pless, 2001). Most injuries and their precipitating events are, however, predictable and preventable. In fact, specific preventive measures are the main topic of this thesis. Therefore, the terms ‘crash’ and ‘collision’ will be used instead of the term ‘accident’.

Age-related functional limitations play a central role in the search for measures that can extend the older adult’s safe and independent mobility. Their influence on driving performance directs the selection of measures in this thesis. A functional limitation is not a clearly defined term in itself. However, it can be regarded as a synonym for the term “impairment” used by the WHO in its International Classification of Functioning, Disability and Health (known as ICF; WHO, 2001). Impairments refer to symptoms or characteristics that can be directly related to the “body level”, that is, having a physiological or anatomical causation. They can consist of a defect, lack or loss of, or reduction in for example visual performance, information processing speed or attentional capacity. According to the ICF, impairments can lead to activity limitations and participation restrictions. Activity limitations are difficulties an individual may have in executing activities of daily life which are important for independent functioning, such as driving a car or having a telephone conversation (Brouwer, Van Zomeren, Berg, Bouma & De Haan, 2002; WHO, 2001). Participation restrictions are problems an individual may experience in involvement in life situations, such as going to the bridge club or maintaining a friendship (WHO, 2001). These participation restrictions indicate a loss or significant deficiency in a social
role which is normal for a person’s age and social position (Brouwer et al., 2002). Both activity limitations and participation restrictions can be resolved by assistive devices or personal assistance. While neither devices nor personal assistance eliminate the impairments, they may remove limitations on functioning in specific domains (WHO, 2001).

The influence of age-related functional limitations on driver safety can be reduced in several ways. First of all, drivers can compensate for their functional limitations by avoiding difficult driving circumstances such as driving during peak hours, darkness or bad weather conditions. Secondly, the driving task can be made easier by simplifying traffic situations, by personal assistance in the car, or by improving driver performance through education. Thirdly, increased crash rates as a result of functional limitations can be prevented by assessing persons’ fitness to drive. If, from a safety point of view, driving is no longer justified, ex-drivers must be supported in swapping the car for other modes of transport. Although all of the abovementioned compensation strategies reduce the influence that functional limitations have on driver safety, not all of them resolve the activity limitations and participation restrictions to which functional limitations might lead. Some of them might even increase them by restricting driving. Measures that are specifically aimed at removing limitations and restrictions on a person’s functioning as a driver, are those mentioned under the heading of making the driving task easier: simplifying traffic situations, providing personal assistance in the car, and education.

Whereas Withaar (2000) describes ways to improve selection and training procedures as means to compensate for functional limitations, the aim of this thesis is to determine the extent to which road design and in-car driver assistance systems can compensate for functional limitations that affect road safety. Three central research questions can be distinguished. The first question is a general one: how can the safety of older drivers be characterised, and which characteristics of older people may be of influence on their driving performance. The second question is which age-related functional limitations have the greatest influence on driving performance and road safety. The third question is what road design elements and driver assistance systems may compensate for these functional limitations.

In order to answer the first question, various aspects of older drivers are described: their current fatality and injury rates, the types of crashes they are involved in, and their general physical and mental state. The second question
is answered by examining the strengths and weaknesses of older drivers, and the relationship between their weaknesses, the difficulties they encounter in traffic, and their relevance to the occurrence of crashes. To answer the third question, an inventory is made of adjustments to road design and driver assistance systems that may improve the safety of older drivers. In addition, two studies are presented that evaluate the effects of some of those adjustments and driver assistance systems. As the implementation of measures concerning road design, and the development of prototype assistance systems are very expensive, both types of ‘assistive devices’ are evaluated in a simulated environment using a fixed base driving simulator. Measures concerning road design are implemented by bringing variation into the design of the intersections which participants have to pass while driving the simulator car. A driver assistance system is simulated by oral messages that are sent depending on the situation participants’ find themselves in, and on the way they behave in that particular situation.

Analogous to the research questions, this doctoral thesis can be divided into three main sections. Chapters 1 and 2 relate to the first question. In Chapter 1, the safety of older drivers is described based on crash and injury data for the Netherlands. Their current fatality and injury rates are discussed, as well as the underlying factors which determine the level of these rates. Furthermore, the crash types which prevail among older drivers are described. In Chapter 2, the physical and mental qualities of older adults are described, as well as the way in which they can influence driver performance. Chapter 3 closes the first section of this thesis. In this chapter, factors are discussed that may influence future crash and injury rates for older drivers, as well as measures which can be taken to reduce these rates.

Chapter 4 addresses the second question. In this chapter, the physical and mental qualities of older adults are discussed from a theoretical perspective. The aim of this chapter is to identify the relative weaknesses of the older driver, as it is assumed that specific measures will be most capable of reducing the crash involvement of older drivers if they support these weaknesses of the driver. With this aim, the strengths and weaknesses of older drivers are deduced from the literature that originates from several theoretical perspectives on human functioning: Fuller’s task-capability interface model, the human factors approach, cognitive psychology, and game theory. The result is a list of the relative weaknesses of the older driver and the difficulties that older drivers encounter in traffic as a result of these weaknesses. To be able to rate the relevance of these weaknesses to road
safety, the weaknesses are compared with crash data. Those weaknesses that have a substantial influence on road safety, as indicated by the percentage of crashes that could have been avoided if the weakness would not have existed (or would have been compensated for by, for example, ADAS), are considered to indicate a need for support. The result is a shortlist of desired types of support.

In the third section (chapters 5 to 8), the focus is on road design and in-car driver assistance systems as devices which may offer the desired types of support. In the first two chapters of this section, chapters 5 and 6, the focus is on measures concerning road design. To find leads for road design elements that put the older driver to the test, Chapter 5 starts with an analysis of the differences between intersections at which many and those at which few crashes occur involving older drivers. Following on that, adjustments to road design are discussed which take into account the limitations of older drivers, and which for that reason appear to offer the desired types of support mentioned in chapter 4. In Chapter 6, the results are described of a simulator study in which several types of intersection designs were compared on their effects on driver workload and driver behaviour.

In chapters 7 and 8, the focus is on driver assistance systems that may offer the desired types of support. In Chapter 7, specific types of in-car driver assistance systems are described that appear to offer the desired types of support. In addition, it is discussed which conditions assistance systems should meet to actually improve the safety of older drivers. Topics included are user acceptance, design requirements for the human-machine interface, and prevention of negative side-effects. In Chapter 8, the results are described of a simulator study in which one specific driver assistance system was tested for its effects on driver workload and driver behaviour.

Finally, in the last part of this thesis, the main findings are summarized and conclusions are drawn about the role that road design and in-car driver assistance systems can play in compensating for functional limitations.