3. **Strategies to improve the older driver’s safe mobility**

Increases in the number of people aged 75 years and above, in the driving licence rates for older people, and in the mobility per older driver will increase the future number of fatalities among older drivers. The latter increase will, however, probably be toned down by reduced fatality rates due to future older drivers being more vital and experienced than those of today. Road safety measures can further reduce the fatality rate of older drivers in the future. In the following chapters of this thesis, the focus will be on two of those measures: adjustments to road design which reduce the complexity of traffic situations, and in-car driver assistance systems which compensate for the relative weaknesses of the older driver.

3.1. **Introduction**

The aim of this chapter is to look into the future and give a rough estimate of how the safety of older drivers will develop (Section 3.2). In addition, measures are described which may reduce future crash and injury rates for older drivers (Section 3.3). Out of the wide range of available measures, two types are selected for further research: adjustments to road design and in-car driver assistance systems. These measures will be studied in detail in the following chapters.

3.2. **Factors which may influence future risks**

The results of the analyses described in Chapter 1 showed that the current fatality rate and fatal crash rate for drivers aged 75 and above is the largest of all drivers. Future crash and injury rates will not necessarily be the same. Various factors can lead to future increases or decreases of the presented rates. Examples are the age distribution of the population of the country in question, the number of people who own a driving licence, and their driving experience. If these factors change in the course of time, they will influence the future number of fatalities among older drivers. In Section 3.2.1, the developments in the past 20 years are used to predict future changes. Subsequently, in Section 3.2.2, an attempt is made to estimate the future share of older drivers in the total number of fatalities among drivers.
3.2.1. Past developments

Developments in the past twenty years in the mobility and safety of older drivers, coupled with the expected growth of the number of inhabitants aged 75 and above may provide some insight in future crash and injury rates. These developments are summarized in Table 3.1 and described in the paragraphs below.

<table>
<thead>
<tr>
<th>Index (1985=100)</th>
<th>People aged 75 and above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Inhabitants</td>
<td>149</td>
</tr>
<tr>
<td>Driving licences</td>
<td>270</td>
</tr>
<tr>
<td>Driver kilometres</td>
<td>204</td>
</tr>
<tr>
<td>Seriously injured</td>
<td>119</td>
</tr>
<tr>
<td>Injury rate¹</td>
<td>58</td>
</tr>
</tbody>
</table>

¹ Because of large fluctuations, 3-year periods were used (1985-1987 vs 2004-2006).

Table 3.1. Developments in the past 20 years (1985 versus 2006).

Age distribution of the population

For a long time now, the group of those aged 65 and above has gradually grown. In the Netherlands, the size of this group increased from 1.7 million people in 1985 to 2.2 million in 2006. Prognoses of Statistics Netherlands show that this growth will continue for another 30 years. In 2040, 4.3 million people will be aged 65 or more (Statistics Netherlands, 2006). In comparison with the total size of the population, the share of those aged 65 and above will increase from 14.3% in 2006 to 25.0% in 2040. A substantial part of this group will be much older than 65. At this moment in time, approximately 1.1 million people are older than 74. Statistics Netherlands (2006) expects that this number will have doubled by 2040, resulting in 2.2 million people aged 75 and above. The percentage of people having difficulties in traffic due to functional limitations is clearly larger in this older group than it is in the group of people aged between 65 and 74.

Driving licences

The number of older adults that have a driving licence has increased substantially during the last two decennia. Within a period of twenty-one years, the number of driving licence holders among those aged 75 and above increased from 128,000 in 1985 to 420,000 in 2006. A comparison of the
possession of driving licences among men and women teaches that the increase of the number of driving licences among older adults was clearly and mainly a case of the women catching up. For men aged 75 and above the number of driving licences increased by ‘only’ 270% (from 97,000 in 1985 to 262,000 in 2006), whereas for women aged 75 and above it increased by 510% (from 31,000 in 1985 to 158,000 in 2006). The group of older drivers has, thus, not only grown in numbers, but also changed in composition.

**Mobility**

The kilometres travelled by older drivers also increased substantially during the past twenty years. This growth has been the largest among those aged between 60 and 74 (from 4.7 billion driver kilometres in 1985 to 11.5 billion in 2006), followed by those aged 50-59 and those aged 75 and above. The development in the kilometres travelled by the 18-24 year olds deviated from that of the other age groups. The distances travelled by this age group strongly decreased, from 8.5 billion in 1985 to 4.9 billion in 2006. Again, trends between men and women differed. The largest increase in kilometres travelled is found among women aged 75 and above (from 0.1 billion driver kilometres in 1985 to 0.4 billion in 2006). By way of comparison, the increase among men of the same age group was from 0.7 billion driver kilometres in 1985 to 1.2 billion in 2006.

It may be expected that the future women of 75 years and above will drive an even larger number of kilometres. After all, those women that are now responsible for the strong increase in the number of driver kilometres in the younger age groups will eventually enter the age group of those aged 75 and above. It is not expected that they will give up the freedom given to them by their car.

The expectations expressed in this paragraph about the future developments in the kilometres travelled are based exclusively on the trends in the available data for the past twenty years. Any changes in the mobility patterns of older people as a result of, for example, an increase in e-commerce, have not been taken into account. Another factor that may influence the future number of fatalities among older drivers could be the transition of older drivers from a minority group with special needs and habits to one of the largest subgroups of drivers. This transition will probably affect the dynamics of the total traffic system, including the behaviour of other road users. The increasing probability of having to interact with an older driver may elicit profound changes in the behaviour of all drivers, as well as in
patterns of interaction among the participants in the traffic system. As a result, the increasing participation of older drivers in traffic may lower the crash rates for older drivers (OECD, 2001).

3.2.2. **Expectations about future crash and injury rates**

A rough but nevertheless informative way of estimating future crash and injury rates is one in which the current share of older drivers is multiplied by the expected increase in its share in the population. Using this technique, Sivak et al. (1995) estimated that the share of older drivers (65 years and above) in the total number of U.S. drivers involved in fatal crashes in 2030 will be 19%, compared to 11% in 1990. For the Netherlands, the same calculation results in a share 14% of all drivers involved in severe crashes in 2030, compared to 9% in 1998 (see Table 3.2). If the same calculations are made for the number of fatalities among drivers, it turns out that in 2030 25% of all fatalities among drivers will be aged 65 or above, compared to 16% in 1998. These calculations assume that the shares of driving licence holders, kilometres travelled, crash rates, and fatality rates would remain the same between 1998 and 2030. However, the previous paragraphs taught that these assumptions are incorrect; the number of kilometres travelled by those aged 65 and above will increase faster than they will for younger people. As a result, the prognoses in Table 3.2 may be used as a minimum for the expected shares of older drivers in the total number of drivers involved in severe crashes and in the total numbers of severely or fatally injured drivers.

<table>
<thead>
<tr>
<th>Age</th>
<th>1996-1998</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-24</td>
<td>18.7</td>
<td>18.7</td>
<td>15.7</td>
<td>18.1</td>
</tr>
<tr>
<td>25-29</td>
<td>17.9</td>
<td>17.6</td>
<td>16.5</td>
<td>13.3</td>
</tr>
<tr>
<td>30-39</td>
<td>20.0</td>
<td>23.6</td>
<td>24.5</td>
<td>16.2</td>
</tr>
<tr>
<td>40-49</td>
<td>13.5</td>
<td>14.3</td>
<td>15.9</td>
<td>14.2</td>
</tr>
<tr>
<td>50-59</td>
<td>9.8</td>
<td>10.4</td>
<td>11.2</td>
<td>11.1</td>
</tr>
<tr>
<td>60-64</td>
<td>3.9</td>
<td>3.7</td>
<td>3.5</td>
<td>5.5</td>
</tr>
<tr>
<td>65-74</td>
<td>8.6</td>
<td>6.6</td>
<td>5.6</td>
<td>9.2</td>
</tr>
<tr>
<td>75+</td>
<td>7.7</td>
<td>5.2</td>
<td>3.4</td>
<td>8.6</td>
</tr>
<tr>
<td>65+</td>
<td>16.3</td>
<td>11.8</td>
<td>9.0</td>
<td>17.8</td>
</tr>
</tbody>
</table>

*Table 3.2. Prognosis of the shares of the various age groups in a) the total number of driver fatalities, b) the number of severely injured, and c) the total number of drivers involved in severe crashes, in 2010, 2020, and 2030.*
3.2.3. Conclusions regarding future crash and injury rates

Increases in the number of people aged 75 years and above, in the driving licence rates for older people, and in the mobility per older driver will increase the future number of fatalities among older drivers. The latter increase will, however, probably be toned down by reduced fatality rates due to future older drivers being more vital and experienced than those of today. Road safety measures can further reduce the fatality rate of older drivers in the future.

3.3. Measures for a safer future: overview of remaining chapters

Future crash and injury rates, such as those estimated in Section 3.2, are not conclusive. They can still be influenced in various ways (see e.g., Langford & Oxley, 2006; Maycock, 1997; OECD, 2001). Measures that may lower future crash and injury rates for older drivers can be distinguished according to the way in which they influence these rates; either by reducing exposure to risk, by reducing crash involvement, or by reducing injury severity. Exposure to risk can be reduced by making sure that people do not drive in situations in which crash risks are elevated. Crash involvement can be reduced either by making the driving task easier or by improving the driver. Injury severity can be reduced by improved crashworthiness of vehicles and further development of safety devices. Having made a distinction between the various types of measures available does not imply that one type of measure has to be chosen. In fact the opposite is true; it is desirable to influence all components of crash and injury rates simultaneously.

The main focus of this thesis is on measures that reduce crash involvement by making the driving task easier. Two types of measures are studied in detail: adjusting road design to reduce the complexity of traffic situations (see Section 3.3.1), and in-car devices that assist the driver (see Section 3.3.2). The question of which assistive devices will be most effective in improving road safety is usually answered by looking at the available devices. In this thesis, however, the above question will be answered by looking at the demands. In order to identify the older driver’s most important needs for support, a theoretical analysis will be conducted of the strengths and weaknesses of the older driver (Chapter 4). Having identified the most important needs for support, in the subsequent chapters the focus is on road design and in-car driver assistance systems as devices which may offer the
desired types of support and improve safety by reducing workload and improving driving behaviour.

3.3.1. Adjusting road design to reduce the complexity of traffic situations

An infrastructure that takes into account the functional limitations that accompany ageing can contribute to a reduction of the crash involvement of older drivers. Taking into account the functional limitations means that the infrastructure provides the driver with enough time to observe, decide and act. Human factors research has provided general knowledge about design aspects that increase workload, and the principles of a sustainable safe traffic system have applied them to road design. However, more knowledge is needed to determine which aspects of the intersection design lead to an increased workload for older drivers, how this workload can be reduced to an acceptable level, and what this acceptable level is. One way of finding out which aspects of the intersection design lead to an increased workload, is by asking older drivers which design elements pose a problem to them. Benekohal, Resende, Shim, Michaels, and Weeks (1992), for example, asked older drivers which driving tasks they considered to become more difficult as they grow older. The tasks that were mentioned the most were (proportion of drivers responding in parentheses):

- reading street signs in towns (27%);
- driving across an intersection (21%);
- finding the beginning of a left-turn lane at an intersection (20%);
- making a left turn at an intersection (19%);
- following pavement markings (17%);
- responding to traffic signals (12%).

In addition, Benekohal et al. asked people to name the highway features that become more important as they age. These were:

- lighting at intersections (62%);
- pavement markings at intersections (57%);
- number of left-turn lanes at an intersection (55%);
- width of travel lanes (51%);
- concrete lane guides for turns at intersections (47%);
- size of traffic signals at intersections (42%).

Mesken (2002) posed similar questions to older drivers in the Netherlands. Manoeuvres which people had to perform in the proximity of intersections that were most often mentioned as being difficult were:
• making a left turn at an intersection without traffic lights;
• driving across an intersection without traffic lights;
• driving on a roundabout that has more than one lane.

The fact that some tasks are more difficult than others does not imply that the former more often result in a crash. Moreover, if younger drivers had answered the same questions, they may have come up with the exact same answers. Nevertheless, several answers correspond to the crash types that are over-represented among older drivers and the manoeuvres that preceded them (i.e., turning left, not yielding). In this thesis, leads for relevant road design elements will be traced by conducting a literature study on road design elements that appear to support the relative weaknesses of older road users as identified in Chapter 4, and by conducting an analysis of the differences between intersections at which many and those at which few crashes occurred involving older drivers (Chapter 5). Subsequently, several types of intersection design will be compared on their effects on driver workload and driver behaviour (Chapter 6).

3.3.2. In-car devices to assist the driver

Advanced Driver Assistance Systems (ADAS) can provide personal assistance in a traffic environment that cannot always take into account the opportunities and limitations of the older driver. Several studies have mentioned ADAS that may be able to provide tailored assistance for older drivers (see for example Bekiaris, 1999; Färber, 2000; Mitchell & Suen, 1997; Shaheen & Niemeier, 2001). Examples are collision avoidance systems, automated lane changing and merging systems, and blind spot and obstacle detection systems. The general opinion is that driver assistance systems have the potential to prolong the safe mobility of car drivers. However, attention must be paid to evaluation research that determines whether specific applications are indeed suitable for older drivers (Caird, Chugh, Wilcox & Dewar, 1998). Knowing which types of ADAS have the most potential to improve the safety of older drivers is not enough to actually improve their safety. Older drivers are more susceptible to the consequences of poorly defined ADAS than younger drivers (Stamatiadis 1994; cited in Regan et al., 2001). They generally need more time to carry out secondary tasks while driving (Green, 2001a). Therefore, the relative weaknesses of older drivers should also be taken into account while designing those types of ADAS that have the most potential to improve the safety of older drivers.
In *Chapter 7*, specific types of in-car driver assistance systems are described that appear to offer the desired types of support as identified in *Chapter 4*. 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.