Universiteit Utrecht

Aging and Mobility

How future mobility systems can contribute to successful aging; four scenarios for the Netherlands

Internship and Master Thesis (45 ECTS)

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Summary

The Dutch society, as well as other modern societies, is aging. Aging of modern societies is one of the most significant trends within the field of sustainable transport. Mobility is considered to be important for older adults' wellbeing. However, mobility becomes at risk as individuals age. Mobility systems can be described as a combination of the land-use system and the transport system. The wellbeing of older adults can be described as a combination of low risk, high capacity and engagement with life, which together make for successful age.

This research focuses on the question how future mobility systems can contribute to successful aging. The theoretical framework shows that mobility plays a role for engagement, as mobility provides the ability to access social relations, social activities, services and facilities. Moreover, mobility provides the ability to go travel and sightseeing. Furthermore, the theoretical framework shows that all dimensions of successful aging are influenced by the mobility system.

By using the approach of backcasting, interviews are conducted at firms, knowledge institutes, government and interest groups. The data from these interviews is used as the input for a scenario analysis. Based on two key dimensions, four different scenarios are formed (1) concentrated living, multimodal transport, (2) dispersed living, car-dependent transport, (3) concentrated living, car-dependent transport and (4) dispersed living, multimodal transport. The scenarios provide different combinations of contributions from the mobility system to successful aging.

The first and second scenario are contrasting in terms of contributions to successful aging (the third scenario is a combination, the fourth scenario is not considered to be feasible). A proportion of the future older adults can be expected to live concentrated. However, another proportion can be expected to live dispersed. Consequently, depending on the dwelling situation, contributions from both the first and second scenario can be considered as possible improvements for the design of the mobility system. By doing so, mobility systems can be designed in such a manner that they contribute successful aging.

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1 Introduction

1.1 Problem description

As well as other modern societies, the Dutch society is aging. This means that the proportion of the Dutch population that consists of older adults, is increasing. As a result, the average age of the Dutch population is rising. CPB (2000) shows that from 1970 to 2000, two main factors are identified that contribute to this development. These are declining fertility rates and increasing life expectancy. In 1990, the life expectancies for Dutch males and females were respectively 73 and 80 year. Currently these numbers are 78 and 82 year (Raad voor Verkeer en Waterstaat, 2010). The ageing of the Dutch population will continue, as the post-war generation, the so-called 'baby-boomers', are currently becoming older adults. As a result of this trend, 20% of the Dutch population will be 65 years or older in 2020 (Jorritsma & Olde Kalter, 2008).

Whereas environmental aspects initially led to the characterization of the transport system as being not sustainable, currently other factors are recognized as well, such as the social dimension of sustainable mobility. Rates of fatalities and injuries caused by crashes in the transport system are an example of the social dimension of the (non-)sustainability of mobility (Black & Nijkamp, 2002). According to Rudinger et al. (2004), aging of modern society is one of the most significant trends within the field of sustainable transport. The amount of older adults that are licensed to drive is rising. The mobility behaviour of this group is currently at interest. Personal mobility is essential for functioning in society. However, mobility becomes at risk as individuals age.

Rudinger et al. (2004) describe the importance of mobility for older adults for their quality of life. This is illustrated by, for example, reduction of personal isolation and maintenance of intellectual stimulation. Rudinger et al. (2004) argue that social cohesion is a part of the social dimension of sustainable mobility. Public transport services should be adapted to better fit the needs of older adults. In addition, the current transport system should be modified for older adults that continue driving. Bottom line of Rudinger et al. (2004) is that the mobility patterns, attitudes and needs of older adults should be known in order to secure mobility of older adults. The group of older adults with physical dysfunctions deserves special attention.

Increasing the mobility of older adults should be done by combining transport policies with socio-political measures and planning. Alternatives to the car and traditional public transport should be developed with a focus on older adults. Moreover, neighbourhoods should be designed with a similar focus on older adults (Rudinger et al., 2004). This is underlined by OECD that stresses that aging of modern societies will influence almost all aspects of life (OECD, 2001) and that one of these aspects is mobility. OECD (2001) stresses that mobility of older adults should be secured by well thought-out planning. This is also in line with current state of scientific research on older adults and mobility that indicates that a focus should be on the development and evaluation of interventions, in order to improve safety of older drivers. By doing so, auto mobility, as part of the quality of life of older adults should be secured (Owsley, 2002). Older adults that can no longer drive have to cope with other problems. These should be, and currently are, addressed as well (Mollenkopf et al., 2004).

The process of aging of individuals is addressed by the scientific field of gerontology. Within this field, Rowe & Kahn (1997) postulate the distinction between usual aging and successful aging. Moreover, Rowe & Kahn propose a model that defines the concept of successful aging

as a combination of three dimensions: *"low probability of disease and disease-related disability, high cognitive and functional capacity, and active engagement with life"* (Rowe & Kahn, 1997: 433). Successful aging of older adults can be influenced by adapting factors underlying the three dimensions. Intervention studies should concentrate on strategies that increase the share of older adults aging successfully (Rowe & Kahn, 1997). The distinction between usual and successful aging can be used to indicate direction for interventions that lead to successful aging (Rowe & Kahn (1997). In this context, interventions to secure the mobility of older adults can be given direction with use of the concept of successful aging.

Within the field of gerontology, the concept of mobility can be defined as *"…a person's purposeful movement through the environment from one place to another"* (Owsley, 2002: 220). The rationale for this movement is usually to accomplish a certain task or achieve a certain goal. Although the concept of mobility gives insight in a person's physical and psychological wellbeing (Owsley, 2002), aspects of the physical environment are not addressed, at least not directly. In order to include these aspects, one should include elements from transport theory. Geurs and Van Wee (2004) postulate that four (interrelated) components of the mobility system influence the accessibility of places. These are a land-use component, a transport component, a temporal component and an individual component. The first two components relate to the design of the mobility system, and will be used throughout this research.

1.2 Research Question

The problem description shows that the current Dutch mobility system can be improved, in order to increase the share of older adults aging successfully. The aim of this research is to identify how a future mobility system can facilitate the successful aging of older adults. Moreover, it is studied what can be learned from the different future scenarios. The main question that this research addresses is:

"How can mobility systems contribute to successful aging and what can be learned from different future scenarios?"

This question cannot be answered directly, given its complexity. In order to answer the main research question, different sub-questions have to be answered first. These three sub-questions are:

1. *"What is the role of mobility in successful aging?"*
2. *"How do mobility systems influence successful aging?"*
3. *"How can different future scenarios of the mobility system be described?*"

It has to be noted explicitly that this research is delineated to the Netherlands. Reason for this delineation is that the government is primarily involved in the mobility system by laws and policy on the national level, or lower. Furthermore, it has to be noted that only the systems that are relevant for travel on the ground will be studied throughout this research. Travelling by plane is not included in this research, as it is assumed to be not relevant for travel within the Netherlands.

1.3 Outline

In the second section of this thesis, the theory and demarcation are described. Transport theory is combined with gerontology, in order to form a suitable theoretical framework. The third section describes the research design, consisting of a description of the backcasting

approach, as well as data collection and scenario analysis. In the fourth section, the results are presented in terms of four different future scenarios. The fifth section of this thesis is contains the conclusions of this research, as the research questions are answered. In the sixth section, a discussion of this research is presented. Limitations of the research are indicated.

2. Theory and demarcation

2.1 Introduction

In this section of the thesis, the theoretical background of the research is presented, based on both transport theory and gerontology. As indicated in the introduction, the mobility system includes a land-use component and a transport component. These components are discussed extensively, in order to obtain insight in the design of the mobility system. Hereafter, the concept of successful aging (and its dimensions) discussed, in order to obtain insight in the wellbeing of older adults. Additional theory is discussed that highlights the role of mobility in successful aging of older adults. This section is concluded with a combination of transport theory and gerontology. The resulting comprehensive theoretical framework indicates the role mobility plays in the successful aging. Moreover, the framework indicates how the mobility system influences successful aging.

2.2 Transport theory

The concept of mobility[1] gives insight in movement on the individual level. The rationale for this movement is usually to accomplish a certain task or achieve a certain goal. However, aspects of the environment wherein this movement takes place, are not (at least not explicitly) included within this concept. Closely related to the concept of mobility, is the concept of accessibility to opportunities (from now on referred to as accessibility), which can be defined as *"…the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)"* (Geurs & van Wee, 2004: 128). Contrary to the concept of mobility, this concept includes a focus on aspects of the environment.

Geurs and Van Wee (2004) propose that accessibility is influenced by four (interrelated) components of the mobility system[2]. These are a land-use component, a transport component, a temporal component and an individual component, as presented in figure A. As the first two components relate to the physical design of the mobility system, they are used to define the mobility system throughout this research.

[1] As defined within the field of gerontology, for example by *"…a person's purposeful movement through the environment from one place to another"* (Owsley, 2002: 220).

[2] Geurs & van Wee (2004) use the model to analyze accessibility in evaluations of land-use and transport strategies. Although this research does not evaluate these strategies, the model is suitable to obtain insight in the concept of accessibility.

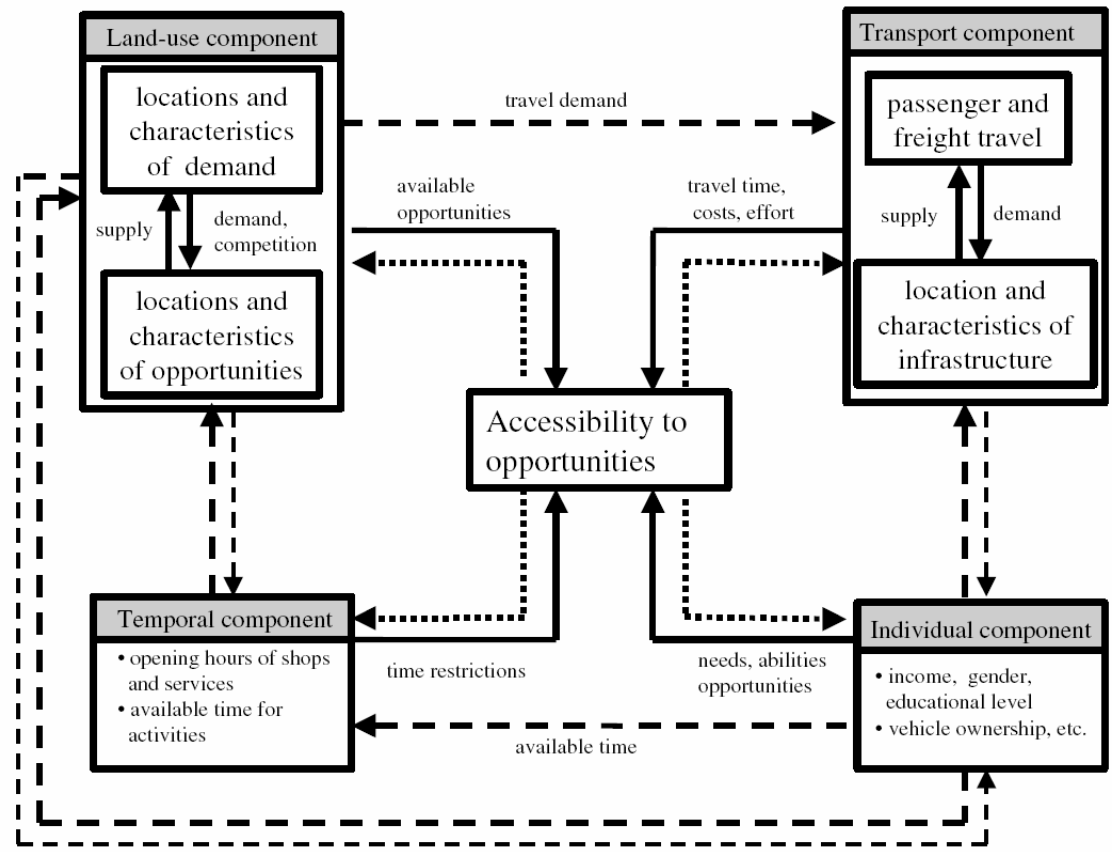

Figure A: Relationships between components of accessibility (Geurs & van Wee, 2004: 129)

Figure A shows that the temporal component includes the opening hours of possible opportunities and available time for activities. Since this research focuses on the physical design of the mobility system, the temporal component is considered to be less important and is not included in this research. The individual component indicates the needs, capacities and possibilities of individuals. This component is not primarily focused on in this research, since it provides insight on the individual level. Although characteristics of specific individuals will not be studied throughout this paper, more general characteristics of older adults are relevant. These general characteristics of future older adults provide a background that indeed should be taken into account when studying future mobility systems.

The land-use component consists of the land-use system. The land-use system is defined by three elements. These elements are *"the amount, quality and spatial distribution opportunities supplied at each destination"*, *"the demand for these opportunities at origin locations"* and *"the confrontation of supply of and demand for opportunities"* (Geurs & van Wee, 2004: 128). Other authors (van Acker & Witlox, 2005; Geurs & Ritsema van Eck, 2001) define the land-use system with three similar elements. Since this research focuses on the physical design of the mobility system, the first element is relevant here.

The influence of the first element of land-use system on mobility can be further specified. Van Wee (2002) identifies several characteristics of land-use that significantly influence mobility. The most important characteristics are *"densities, the level of mixed land use, neighbourhood design and distance to railway connections" (van Wee, 2002: 261).* For this research, the last characteristic is broadened to 'distance to transport connections', since there

are more possibilities for transport than railway connections[3]. Reason for this is that other transport connections are possibly relevant for this research, that are designed specially for older adults and therefore not public.

The characteristic density relates to the amount of opportunities within a certain area. Possible opportunities are dwellings, shops or hospitals. Density affects mobility since a higher density can provide an environment wherein individuals have to travel less to reach opportunities. It has to be noted that this influence on mobility is only relevant for relatively large areas. In smaller areas this influence will be less relevant, because a greater part of opportunities will be outside of the dense area. The level of mixed land-use relates to the mixing of different opportunities within a certain area. Again, a higher level of mixed land-use can provide an environment wherein individuals have to travel less to reach opportunities (van Wee, 2002).

Neighbourhood design is relates to the lowest scale of land use, for instance the dwelling and its direct vicinity. Although this characteristic is studied less in the literature, it is significant for mobility. For instance, the availability of cycling lanes and sidewalks can provide an environment wherein individuals can use slow modes. In addition to infrastructure and opportunities, architecture can provide an attractive environment. Distance to public transport connections obviously affects mobility. A lower distance to public transport connections can provide an environment wherein individuals can more easily make use of public transport (van Wee, 2002).

The transport component consists of the transport system. The transport system allows individuals to reach the opportunities they choose to participate in. Comparable to the land-use system, the transport system is defined by three elements, which are *"the disutility for an individual to cover the distance between an origin and a destination", "supply of infrastructure" and "demand for infrastructure"* (Geurs & van Wee, 2004: 128). Again, other authors (van Acker & Witlox, 2005; Geurs & Ritsema van Eck, 2001) define the land-use system with three similar elements. As with the land-use system, the element relating to supply is relevant for this research, given the focus on the physical design of the mobility system.

The influence of the element relating to supply can be further specified. Geurs & Ritsema van Eck (2001) propose three basic components of the transport system that influence accessibility. These components are time, cost and effort. The component time includes pre-transport time, transport time (including congestion time, parking time) and post-transport time. The component costs includes fixed costs, operational costs (for instance fuel, parking, road-pricing) and maintenance costs. The component effort includes issues as level of comfort, physical effort, reliability, stress, accident risk, social safety, information and status (Geurs & Ritsema van Eck, 2001).

Together, the three components indicate the resistance individuals face when travelling between an origin and destination. Understandably, these three components are perceived differently on the individual level. For every mode of transport, the three components differ. Geurs & Ritsema van Eck (2001) make a distinction between car, public transport, and bicycle and walking. Obviously, these three components can also be used for other modes of

[3] The characteristic 'distance to railway connections' is broadened to 'distance to public transport connections' in the work of van Wee (2002).

transport. Thus, for every mode of transport, the three components can be filled in distinctively[4].

Concluding, the physical design of the mobility system can be defined by a combination of the land-use system and the transport system. For the land-use system, density, mixed land-use, neighbourhood design and distance to transport connections are relevant for accessibility. For the transport system, the components time, cost and effort are relevant for accessibility.

2.3 Gerontology

The scientific field of gerontology is concerned with the process of aging of individuals. In this section, theory from the field of gerontology is discussed in order to obtain insight in the process of individual aging. Moreover, the theory of successful aging is discussed in order to obtain insight in the wellbeing of older adults.

Baltes & Smith (2003) propose that aging of human beings is marked by two periods; the so-called third and fourth age. Two ways to define third and fourth age are recognized. These are the population-based and person-based definition. The first definition focuses on birth cohorts. It creates a distinction between the third and fourth age, based on the chronological age at which only half of the birth cohort is still alive. The second definition focuses on individuals and creates a distinction between the ages, based on terminal decline connected with death and dying. This last definition is currently used most. Given the definitions of the third and fourth age, no specific age ranges can be connected to these periods.[5]

Baltes & Smith (2003) argue that the third age is characterized by demonstrations of gains. Evidence shows that older adults can be more valuable in effective and productive terms than current society allows for. In order to improve this, science and policy should address opportunities from different disciplines. Contrary to the third age, the fourth age is characterized by demonstrations of losses. Evidence shows that the group of older adults in the fourth age, often suffer from dysfunction. Improving functions is possible in this age, though the chances to do so decline. Moreover, psychological decline sets in. Therefore, question is whether the prolonging of life in the fourth age actually contributes to the dignity of older adults. This should also be considered when allocating resources to different age groups in society (Baltes & Smith, 2003).

Rowe & Kahn (1997) argue that in gerontology, it has been a trend to only stress the distinction between older people with diseases or disabilities, and older people without any of these. Gerontologists refer to them as pathologic and non-pathologic. Rowe & Kahn (1997) propose another distinction within the non-pathological group; the distinction between usual and successful aging. Moreover, they propose a conceptual model for the concept of successful aging. Successful aging is defined as a combination of three dimensions: *"low probability of disease and disease-related disability, high cognitive and functional capacity, and active engagement with life"* (Rowe & Kahn, 1997: 433). Separately, these three

[4] For instance, van Wee & Annema (2009) argue that for public transport, the effort component includes *comfort, physical strain, reliability, information, social safety, image and accessibility for disabled people*. For walking, the effort component includes *comfort, physical strain, social safety and weather influences*.

[5] Consequently, no specific age ranges will be used throughout this research. However, to give an idea of age ranges, (for developed countries) the third age can be suggested to start a couple of years before retirement, thus at approximately 60 years. The fourth age can be suggest to start at approximately 80 years (Baltes & Smith, 2003).

dimensions are all important for older adults. However, true successful aging consists of a combination of these three dimensions, as presented in figure B.

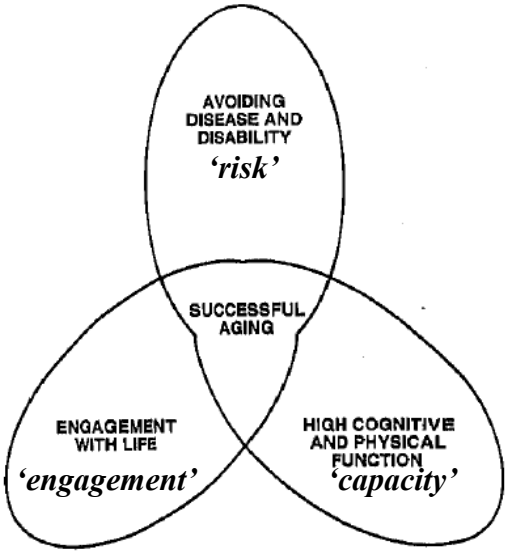

Figure B: Model of successful aging (adapted from Rowe & Kahn, 1997: 434)

The first dimension of successful aging, *'low probability of disease and disease-related disability'*, hereafter referred to as *risk*, addresses the risk individuals face for disease and disability in later life. This dimension includes intrinsic factors, extrinsic factors and intra-individual variability[6]. Rowe & Kahn (1997) relate the proportion of the population affected by risk (followed by disease, disability and death) to the age of individuals in aging societies.

Studies on risk show equal results. Risk in advancing age is determined by both intrinsic and extrinsic factors. This means that apart from genetically determined factors, factors relating to lifestyle are of great significance for risk of emergence of disease. Moreover, as age advances, the influence of these extrinsic factors increases, and the influence of intrinsic factors decreases. In addition, even characteristics of usual aging can be influenced. The rationale for reducing these risks is prolonging the period individuals are healthy, or *"aging successfully with respect to risk of emergence of disease"* (Rowe & Kahn, 1997: 434). Rowe & Kahn (1997) argue that behaviour of individuals, as well as the environment, is important for this dimension. Moreover, a healthy life-style can facilitate this dimension.

The second dimension of successful aging, *'high cognitive and functional capacity'*, hereafter referred to as *capacity*, addresses capacity of older adults, in both cognitive and functional terms. This dimension includes cognitive capacity, physical capacity and behaviour. This dimension is related to the previously mentioned one, as both cognitive and functional capacity can be influenced by the risk of disease or disability. Rowe & Kahn (1997) indicate that cognitive functions (as learning and short-term memory) are important for successful aging. Furthermore, several other factors are relevant, such as education, physically demanding activities and self-efficacy. These three factors can be influenced externally. Exercise can possibly enhance cognitive functions. Physical functions are important as well. Factors relevant for physical functions are (for instance) body mass, blood pressure and cognitive performance. As indicated, behaviour is significant for this dimension of successful

[6] Intra-individual variability concerns short-term variability in individual functions, such as speed and balance. Intra-individual variability is a determinant for (increased) risk. However, this is not considered to be relevant for this research.

aging. Relevant factors are physically demanding leisure and exercise activities and emotional support.

The third dimension of successful aging, *'active engagement with life'*, hereafter referred to as *engagement*, addresses the relations of older adults with other people. Included are social relations and productive activities. Similar to the previous dimension, this dimension is related to the previous one, as the cognitive and functional capacity influence the ability to be actively engaged with life. Rowe & Kahn (1997) state that social relations are significant for active engagement with life. Relevant factors are social ties, appropriate socio-emotional support and appropriate instrumental support. As indicated, productive activities are important for this dimension as well. Productive activities are all contributions in terms of paid and volunteer work, as well as unofficial support. Relevant factors are functional capacity and self-efficacy.

Given the relations between the three dimensions, it is argued that the dimensions are hierarchical, at least to a certain extent. This means that low risk is partly a condition for capacity. Subsequently, capacity is partly a condition for engagement (Rowe & Kahn, 1997). Rowe & Kahn (1997) argue that several of the factors underlying the three dimensions can be adapted. This adaptation can be done by individuals themselves, or by the environment they live in. By adapting the three dimensions, successful aging of older adults can be influenced. Therefore, intervention studies should concentrate on strategies that increase the share of older adults aging successfully. Baltes & Smith (2003) indicate that third age older adults have the potential to become more valuable than current society allows for. The concept of successful aging, as described by Rowe & Kahn (1997), can evidently be connected to this potential. Rowe & Kahn (1997) explain that aging is not only a biomedical process, by indication other dimensions of successful aging as well. These dimensions relate to the lifestyles of older adults, which are facilitated by the environment older adults live in. Thus, the theory of successful aging explains how the potential described by Baltes & Smith (2003) can be achieved.

The concept of successful aging provides insight in the wellbeing of older adults. Rowe & Kahn (1997) provide three general domains relevant for successful aging and as they indicate themselves, present *"some pathways or mechanisms that make for successful old age"* (Rowe & Kahn, 1997: 433). As Strawbridge et al. (1996) argue, indicating an objective measurement for successful aging is problematic. Reason for this is that individual older adults perceive criteria for successful aging differently, which makes them rather subjective. Thus, when studying the role mobility plays in successful aging, one should consider that there can only be indicated *how* mobility can contribute to successful old age. On the individual level, in the end, the value of mobility for successful aging will is subjective, as it depends on the individual attributes of older adults. Consequently, no objective measurement for the actual degree of successful aging can be provided.

Next, the role mobility plays in every dimension of successful aging is discussed, with use of additional literature that highlights the significance of mobility in the wellbeing of older adults. A clear distinction should be made between the role mobility plays in successful aging, and influences from the mobility system on successful aging. The role mobility plays in successful aging indicates *why* mobility is specifically relevant for the different dimensions of successful aging. Influences from the mobility system indicate *how* the mobility system has influence on the different dimensions of successful aging.

The role mobility plays in the first dimension of successful aging, risk, can be discussed shortly here. With use of the literature, no specific role of mobility can be identified in this dimension. Thus, in itself, mobility is not important for this dimension. However, this does not imply that this dimension is not influenced by the mobility system. For example, safety issues, influence this dimension. A higher degree of safety of the mobility system can be expected to decrease the probability of disease and disability. As stated, this influence will be discussed later on.

The role mobility plays in the second dimension of successful aging, capacity, can also be discussed shortly here. Again, with use of the literature, no specific role of mobility can be identified in this dimension. Hence, mobility systems are unlikely to contribute directly to the capacity of older adults. However, this dimension can be expected to be influenced by the mobility system. The degree to which a mobility systems challenges the capacity of older adults, influences the individually perceived capacity of the older adult. Thus, for this dimension, the perceived degree of successful aging can be influenced by designing less demanding mobility systems, on both the cognitive and functional level. Compensating for generally weak characteristics influences this dimension of successful aging. Again, this influence will be discussed later on.

The role mobility plays in the third dimension, engagement, deserves a more elaborate discussion here. In accordance with Rowe & Kahn (1997), Mollenkopf et al. (2004) argue that social relations and activities are essential elements of successful aging. Mobility is a condition for sustaining these social relations and activities. However, the precise role mobility plays in social relations is rather complicated (Mollenkopf, 1997). This role will be studied here with use of a framework proposed by Metz (1999). As in this research, Metz (1999) depicts that before considering interventions aimed at improving older adults' mobility, the contribution of mobility to older adults' life has to be clarified. Metz (1999) argues that the relation between mobility and quality of life is not clear[7], because there is lack of an operational concept of mobility. Therefore, Metz (1999) proposes a framework that includes elements of mobility that are related to older adults' experience. Five different elements are described by Metz (1999).

1. *"Travel to achieve access to desired people and places";*
2. *"Psychological benefits of movement – of "getting out and about"";*
3. *"Exercise benefits";*
4. *"Involvement in the local community";*
5. *"Potential travel"* (Metz, 1999: 149)

The third element proposed by Metz (1999) has no significance for engagement. This element refers to reversing declining strength of muscles and bones, which cannot be considered as a characteristic of active engagement with life. However, exercise can be perceived as an influence on mobility, since different modes of transport will be more physically demanding than others. This is a similar influence as for the dimension capacity, as described above. As indicated, this influence will be presented later on.

Except for the third element, the elements described by Metz (1999) can be argued to display the role of mobility in this dimension of successful aging. The first element is rather clear in

[7] After the work of Metz (1999), Webber et al. (2010) proposed a framework consisting of five key determinants of mobility of older adults (cognitive, psychosocial, physical, environmental and financial). However, these determinants are rather abstract and therefore not explicitly used throughout this research.

terms of active engagement with life. It refers to the ability to access desired people (the older adults' social relations) and places of interest, which is traditionally perceived as the demand for mobility. Evidently, the fourth element is closely related to the first one, since Metz (1999) states that involvement in the local community is significant for access to social activities. This is in accordance with Rowe & Kahn (1997), that describe social relations and activities as the major elements of active engagement with life. Consequently, the first two characteristics of successful aging and mobility for engagement can be defined as: **The ability to access social relations** and **the ability to participate in social activities**. Notably, social relations can provide direct instrumental support. Moreover, socio-emotional support can be provided, such as discouragement of possible risky behaviour (which in fact influences the dimension risk), as well as encouragement of more effective medical support (Strawbridge et al., 1996).

The first element proposed by Metz (1999) includes more than solely the access to social relations, since desired places are included as well. As indicated, access to desired places is part of the traditional demand for mobility. When specifying to older adults, access to services and facilities that is relevant for (this dimension of) successful aging. Particularly relevant for older adults, are for instance grocery stores, drugstores and hospitals (AARP, 2005). Thus, **the ability to access services and facilities** should be included here as a characteristic of engagement as well.

The second element, 'psychological benefits of movement – of "getting out and about", consists of the type of benefits older adults derive from sightseeing (Metz, 2000). The fifth element is closely related to the second one, as it refers to older adults' consciousness that they have the ability to travel. It has to be noted that this does not imply that older adults actually travel (Metz, 2000). Although Rowe & Kahn (1997) do not literally describe travel and sightseeing, it can be considered as part of engagement. As a result, a fourth role of mobility in engagement can be defined: **The ability to travel and go sightseeing**.

2.4 Comprehensive framework

Current literature on older adults and mobility is mainly focused on countermeasures for physical decline (impairments) and traffic participation of older adults. Although studies on countermeasures for physical decline specify how living with reduced cognitive and functional capacity can be supported, it does not indicate how the land-use and transport system can contribute to true capacity of older adults. Studies on traffic participation portray an indicator for active engagement with life. However, these studies also do not explain how the land-use and transport system contribute to active engagement with life. Thus, although related, the approach of this research is different from other studies, since it indicates how future mobility systems can contribute to the entire concept of successful aging.

As indicated, this research is concerned with the actual design of the mobility system. This part of the mobility system consists of the land-use system and the transport system, as described above. The wellbeing of older adults is described by the theory of successful aging, consisting of three interrelated dimensions. Moreover, this theory stresses that the factors underlying these dimensions can be adapted, in order to improve the wellbeing of older adults. To a certain extent, this can be done by external influences, such as the mobility system.

The role mobility plays in successful aging is schematically presented in figure C. As argued above, mobility does not play a primary role in the first and second dimension of successful

aging. However, as indicated, mobility does play a role in the third dimensions of successful aging. As pointed out in the theoretical framework, the dimensions of successful aging are all related to each other. These relations are presented arrows A,B,C and D in figure C. Arrow A and B refer to the extent to which the first dimension is a condition for the second dimension, and the second dimension for the third dimension, as argued in the theoretical framework. Arrow C and D present the influence from the third to the second dimension, and from the second to the first dimension. Since mobility plays a role in the third dimension, it can be expected to (positively) influence the second dimension. The second dimension can on its turn be expected to (positively) influence the first dimension. The pronounced influences on successful aging from the mobility system are included in figure C as well, in order to present a complete overview of the discussion above.

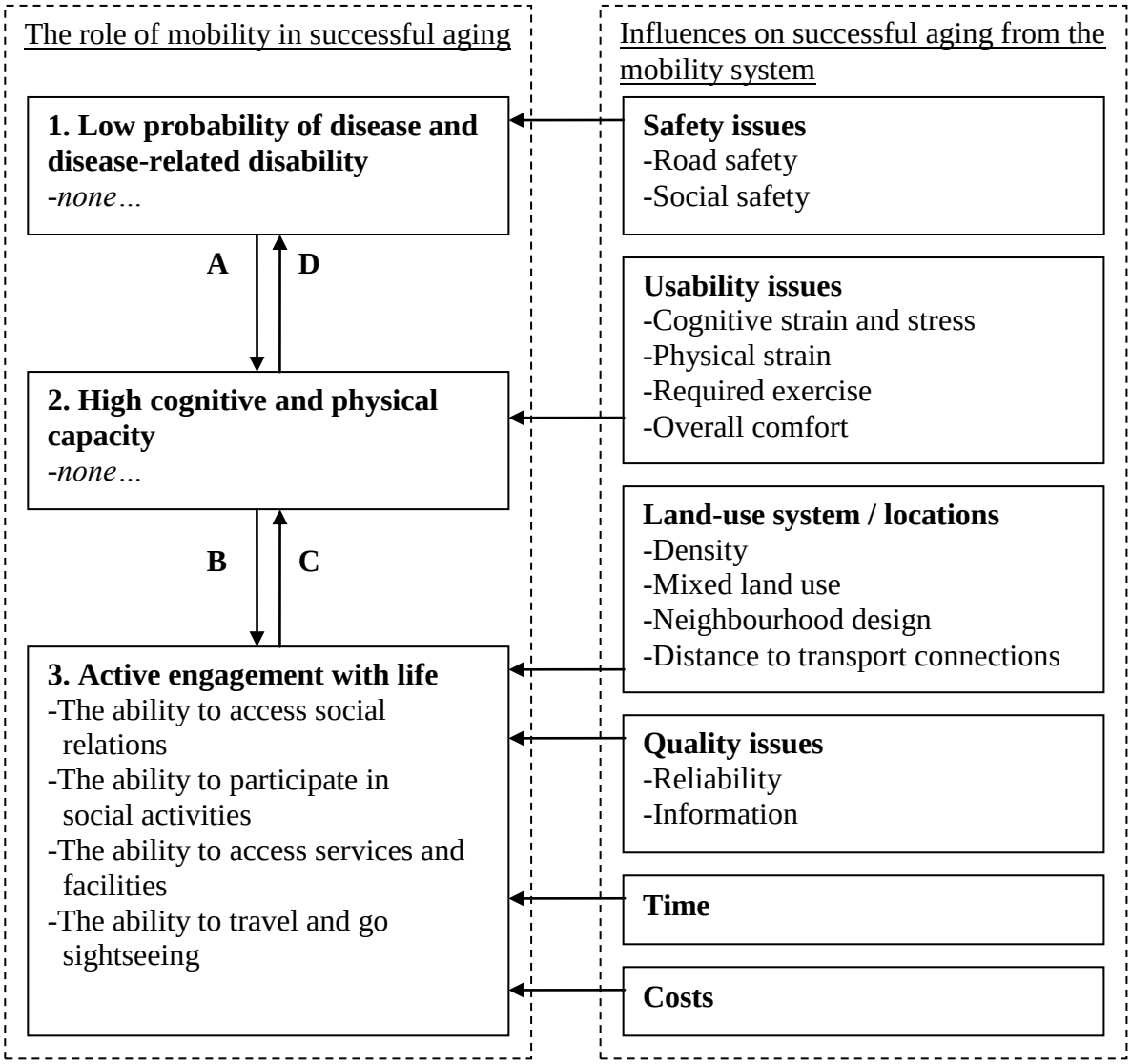

Figure C: Characteristics of, and influences on successful aging and mobility (note that already, some influences are included, these will be completed later on)

Several influences of the mobility system on successful aging are already pronounced. Next, the influences of the mobility system are studied more elaborately. As pronounced, the first dimension of successful aging, risk, is influenced by safety issues, as it includes the risk of disease and disability. Safety issues are covered by the effort component from the transport

system. Two types of safety issues can be distinguished, road safety and social safety (Van Wee & Annema, 2009). Apart from these two types of safety issues, there are no influences on this dimension.

As pronounced as well, the second dimension of successful aging, capacity, is influenced by the degree to which a mobility system challenges the cognitive and functional capacity of older adults. Again, this can be related to the effort component from the transport system. Several issues are relevant for this dimension of successful aging. These are the level of cognitive strain, physical strain, stress, required exercise and overall comfort (Van Wee & Annema, 2009). Together, these issues are summarized to usability issues. Apart from these usability issues, there are no influences on this dimension.

The third dimension of successful aging, engagement, is influenced by the effort component from the transport system as well. Relevant issues here are reliability and information (Van Wee & Annema, 2009). Although these issues do not influence the first two dimensions of successful aging, the degree to which these issues are suitable influences the engagement with life of older adults. These issues are summarized to quality issues, as presented in figure C. Apart from these issues related to effort, the component time and cost are both relevant here. Time and cost obviously influence the degree to which an individual older adult can be mobile. The land-use system influences this dimension of successful aging. Obviously, the land-use system presents a resistance to engagement, by the distances between opportunities that results from this system. It has to be noted that the first and second dimension of successful aging are not influenced by the land-use system[8].

3. Research design

3.1 Introduction

In this section of the thesis, the research design is described. First, the theoretical background of the methodology used throughout this research is described. This includes the background of the approach of backcasting, interviews and scenario development. Second, the practical steps taken throughout this research are described. Again, this includes backcasting, interviews and scenario development.

3.2 Theoretical background methodology

3.2.1 Backcasting

The first, and perhaps main methodological issue of this research is that it does not focus on historical development, but on future development. Within the field of future studies, the two main approaches can be identified. These are forecasting and backcasting. Where forecasting focuses on the most likely future, backcasting focuses on the most desirable future. Two general motives for the use of backcasting are identified (Robinson, 2003). First, people only have very limited capabilities to predict the future. Second, the most likely future does not have to be the most desirable future. This second motive illustrates the main difference between forecasting and backcasting perspectives.

[8] Although neighbourhood design can be argued to influence the first and second dimension, because people (for instance) walk within this area, this is already included in the transport system, as it comprises all possible modes of transport.

Backcasting can be considered as an approach, valuable in terms of exploration (Dreborg, 1996). The approach of backcasting is *"…not intended to reveal what the future will likely be, but to indicate the relative feasibility and implications of different policy goals"* (Robinson, 2003: 842). Since the future is partly dependent on the implementation of policy resulting from backcasting, nothing can be said about the most likely future. Hence, the main goal of backcasting is to *"…providing policy maker and an interested general public with images of the future as a background for opinion forming and decisions"* (Dreborg, 1996: 813).

Backcasting is a suitable perspective to study societal problems (Robinson, 2003). Studying societal problems demands that the functioning of underlying systems is described. The approach of backcasting is mostly used for long-term, complex societal problems. Moreover, backcasting is suitable if the problem is complex, demands major change, is dependent on dominant trends, relates to externalities, and allows for intervention (Dreborg, 1996).

Since the introduction of backcasting, the approach has known various developments. The most recent development in backcasting is towards stakeholder participation (Quist & Vergragt, 2006). Different stakeholders are included in the process of backcasting, in order to form a robust vision of a desired future state. Moreover, a begin can be made to ponder how this desired future state can be achieved, by considering different means. Backcasting has a link with Constructive Technology Assessment (CTA), as concerns of a broad set of stakeholders are considered. Five stages of backcasting are defined (Quist & Vergragt, 2006):

1. *"Strategic problem orientation";*
2. *"Construction of sustainable future visions or scenarios";*
3. *"Backcasting";*
4. *"Elaborating, analysis and defining follow-up and (action) agenda";*
5. *"Embedding of results and generating follow-up and implementation"* (Quist & Vertraght, 2006: 1033)

Quist & Vergragt (2006) argue that *"…each stage of the backcasting approach generally requires tools and methods"* (Quist & Vergragt, 2006: 1034). Furthermore, Quist & Vergragt (2006) state that the first stage if formed by *"…setting the normative assumptions and goals…"* (Quist & Vergragt, 2006: 1033). These normative assumptions are typically defined by the involved stakeholders. Four different societal groups relevant for backcasting are indicated. These groups are firms, research institutes, government, and interest groups (Quist & Vergragt, 2006).

The method of backcasting implies that a relatively long period is used to study future development. "*In order to permit time for futures significantly different from the present tom come about, end-points are usually chosen for a time 25-50 years into the future"* (Robinson, 2003: 842).

3.2.2 Interviews

Data can be collected with use of several methodologies. One of these methodologies is conducting interviews. Conducting interviews in order to collect data has two main advantages. Interviews are a targeted method of data collection, as interviews can be used to directly aim at the subject. Thus, conducting interviews is an effective method of collecting data. Moreover, interviews are an insightful method of data collection (Yin, 2003).

However, collecting data with use of interviews has several drawbacks. A weakness is that interviews can be recalled inaccurately by the researcher. Two other weaknesses of interviews are biases due to poorly designed interview questions and reflexivity, as interviewees potentially react on questions by giving answers which are desired by the researcher (Yin, 2003).

Interviews can be open-ended, focused or a survey. In open-ended interviews, interviewees can be asked about facts and opinions (Yin, 2003). A specific method for interviewing and creating future scenarios, is to propose interrelated aspects (technological, socio-cultural, political, and economic) (van Merkerk, 2007). These aspects, as well as the relations between them, are questioned several times to interviewees, in order to create a coherent scenario. Moreover, the interviewees are asked to indicate the aspects as fact, hampering factor, or supporting factor for the scenario (van Merkerk, 2007).

3.2.3 Scenario development

A methodology to construct scenarios is to derive scenarios from data by reducing complexity (Hofmann et al., 2007). This methodology of scenario development is schematically presented in figure D. At the lowest aggregation level, the *base*, *drivers* and *trend*, are distinguished. Drivers are important influences on structural change. These influences are typically difficult to predict in terms of future development. Trends are important influences on structural change as well. However, these influences are typically more easy to predict in terms of future development.

At the first aggregation level, *dynamics* and *trend-like dynamics* are distinguished. Dynamics are aggregations of drivers, that are considered to be correlated (in terms of future development). Like drivers, dynamics are typically difficult to predict. Trend-like dynamics are aggregations of trends, that are considered to be correlated. Like trends, trend-like dynamics are typically more easy to predict (Hofmann et al., 2007).

At the second aggregation level, different *scenarios* are distinguished. The scenarios are formed by a combination of dynamics. As the interaction between dynamics is considered, scenarios are coherent images of the future. Other dynamics, which can logically be related to the scenarios, are added in order to create coherent images of future mobility systems. Dynamics that cannot be added to the scenarios, as they cannot be logically related the scenarios, are so-called *wild cards*. Wild card are left out of the scenarios.

The scenarios are distinguished by two *core dynamics*. The core dynamics are the two dynamics (i.e. the dynamics, not the trend-like dynamics) that can be expected to have the strongest influence on structural change of the mobility system. Thus, the key dynamics are the key dimensions (arrows in figure D) by which four scenarios are distinguished (Hofmann et al., 2007).

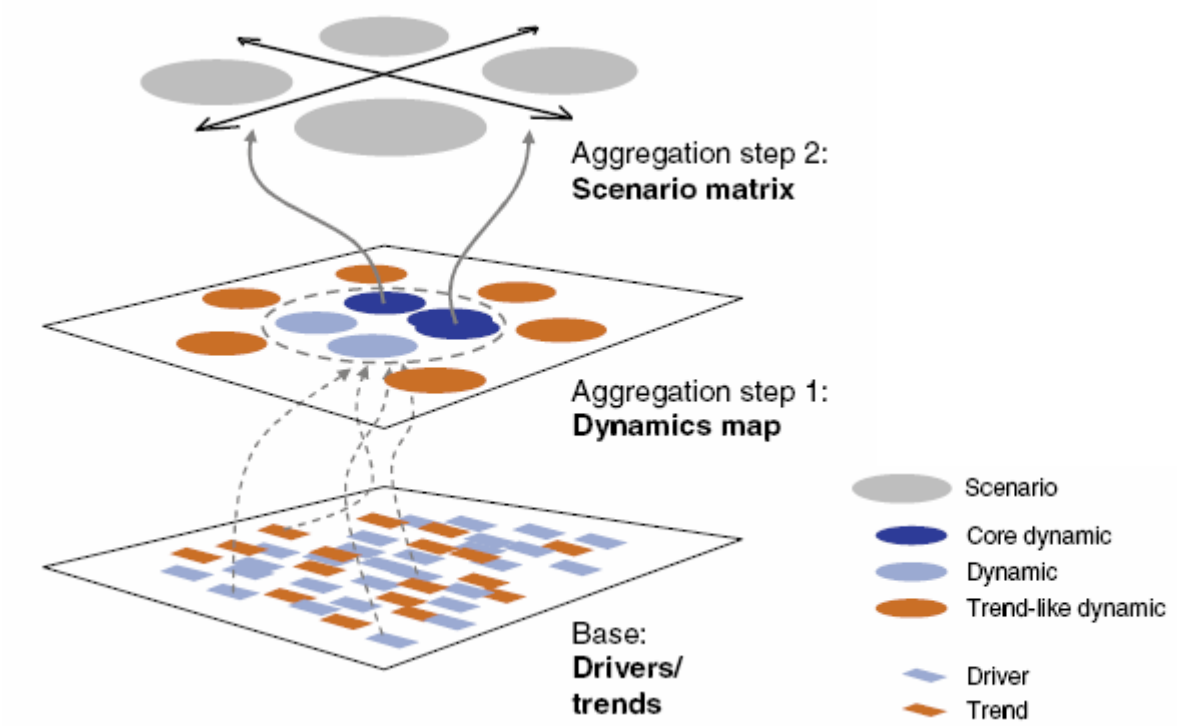

Figure D: Development of scenarios by two aggregation steps (Hofmann et al., 2007: 6)

3.3 Methodology

3.3.1 Backcasting

As described, backcasting is suitable for complex problems that demand major change, are dependent on trends and allow for intervention. Obviously, as outlined in the problem definition, the subject of this research -aging and mobility- is a complex problem, that is dependent on trends. Moreover, the demand for changes by active intervention is indicated. As described, backcasting provides an approach to explore desirable future images, in order to provide a background for opinion forming and decisions. Indeed, this research aims to provide insightful future images (i.e. scenarios). Therefore, backcasting is considered to be a suitable approach for this research.

Five stages are described for backcasting. For this research, it is considered to be infeasible to execute all stages of the backcasting process. Stage one, two and three are the most important stages that are executed throughout this research. Thus, this research includes strategic problem orientation, scenario construction and backcasting. For this research, the end-point is chosen to be 25 years into the future, thus 2035. Accordingly, this time span allows to observe clearly visible structural changes. At the same time, these changes are connected to the current situation as much as possible, as the minimum time period is used.

3.3.2 Interviews

As described, the first stage of backcasting, strategic problem orientation, implies that normative assumptions are defined by stakeholders (firms, research institutes, government, and interest groups). Throughout this research, strategic problem orientation is executed by interviewing stakeholders. As interviewing is a targeted and insightful method of data collection, it is considered to be a suitable method here, given the limited time for this research. The interviews provide insight in the normative options for (desired) future contributions from the mobility system on the wellbeing of older adults.

For backcasting, four societal groups relevant. These groups are firms, research institutes, government, and interest groups. Accordingly, interviews are conducted at these four groups. The interviewees are all individuals from organizations that already have some kind of experience with the subject aging and mobility. Given the scope of this research, the interviews are only conducted at Dutch organizations. As much individuals are interviewed as possible, taking the limited time for this research into account. Moreover, the amount of interviews is limited by the fact that not all organizations were able to cooperate with this research. Throughout the interviews, the interviewees are questioned at which other organizations data relating to aging and mobility can be gathered as well, as suggested by Yin (2003).

Insight form firms is gathered at commercial consultancy organizations that already have experience with aging and mobility, as they have performed projects relating to the subject of aging and mobility. Insight from research institutes is gathered at organizations that already have created or collected knowledge relating to this subject. In total, ten individuals from six different research institutes are interviewed. Insight from the government is gathered at two different levels. At the national level, information is gathered at the most important ministry for this subject, as well as its realizing organization. Two individuals are interviewed. At the regional level, information is gathered at provinces where aging already has visible effects on mobility. In total, four individuals from two different provinces are interviewed. Insight from interest groups is gathered from organizations that are connected to the Dutch program 'Blijf Veilig Mobiel'. This program is concerned with the mobility of older adults. The aim of this program is to improve safety of older adults in traffic, considering the demographic development of aging. Five individuals from five different interest groups are interviewed. For each group, the total number of organizations, interviews and interviewees is presented in figure E.

Group	**Number of organizations**	**Number of interviews**	**Number of interviewees**
Firms	**2**	**2**	**2**
Knowledge institutes	**6**	**8**	**10**
Government	**4**	**4**	**6**
Interest groups	**4**	**4**	**4**

Figure E: Interviews

However, as indicated, collecting data with use of interviews has several drawbacks. A weakness is that interviews can be recalled inaccurately by the researcher. In order to prevent this, notes are made throughout the interviews. With use of these notes, the most important findings of the interviews are reported (in a written form). Hereafter, these reports are presented to the interviewees in order to check the validity of the findings. When interviewees indicate that findings are recalled wrong or inaccurately, the reports are corrected before further analysis. Two other weaknesses of interviews are biases due to poorly designed interview questions and reflexivity, as interviewees potentially react on questions by giving answers which are desired by the researcher (Yin, 2003). In order to cope with these two weaknesses, interviewees are questioned with use of a specific interview technique, as outlined later on.

As indicated, the aim of the interviews is to provide insight in the normative options for (desired) future contributions from the mobility system on the wellbeing of older adults. Given the method of backcasting, the interviews have an explorative (open-ended) character. Although the interviews have an explorative character, some structure is necessary in order to obtain similar data and cope with the described weaknesses of the method of interviewing. The interview technique is based on the methodology described by van Merkerk (2007). In order to create a coherent view of (a part of) the desired future mobility system, four similar aspects are applied in the interview technique of this research. These aspects are desired future mobility system, successful aging, policy, and resources. The last aspect, resources, relates to financial resources, as well as knowledge. The first and second aspect relate directly to the theoretical framework. Moreover, different sorts of resources will be needed. A graphical overview of this interview tool is presented in figure F. The third and fourth aspect relate to the method of backcasting, which implies that so-called 'driving factors' (van Merkerk, 2007) are included in the analysis. As indicated, policy has a significant influence on the future mobility system.

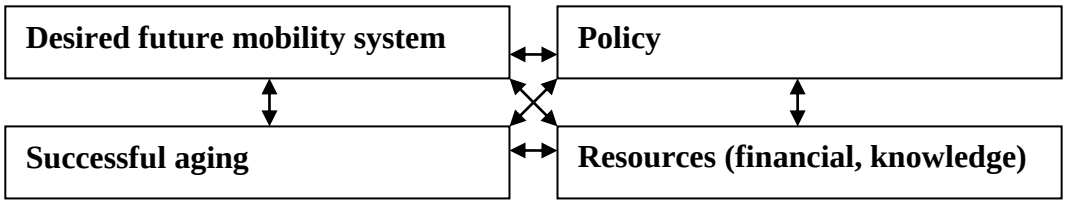

Figure F: Interview tool

The interviews are started by presenting the interviewee an overview of the research. In order to give the interviewee an idea of the concepts this research (and the interview) is concerned with, the concepts of the mobility system and successful aging is described shortly. The goal and the method of the interview, including the interview tool itself, is presented. The interviewees are initially questioned how they see the desired future mobility system. Following questions address the three related aspects. Moreover, questions are asked in order to obtain insight in the specific relations between the four aspects. By doing so, a coherent view of a future scenario is established.

3.3.3 Scenario development

The second stage in backcasting is the construction of scenarios. The most important findings from the interviews are reported and checked by the interviewees, as described. The reports form the actual data used as input for scenario development. The reports are analyzed by means of computer assisted qualitative data analysis. With use of the software package 'Atlas.ti', one single dataset is created, containing the data from all separate interviews.

All text passages are selected that contain relevant information for the subject of aging and mobility. These passages are the so-called *quotations*. Obviously, the quotations contain information different subjects. These subjects are linked to the quotations by assigning different *codes*. Thus the codes itself indicate the subject that the text passage refers to. The assigned codes are typically dimensions from the theoretical framework. Additionally, Atlas.ti provides the option to create a network of codes, by linking them, indicating theoretical relationships. Second, all quotations that are linked to a certain code are further analyzed, by writing parts of text, so-called *memos*, which contain corresponding findings from the interviews. Thus, the memo's consist of opinions with regard to a desired state of different parts of the future mobility system. With use of these memos, concepts are identified. The concepts are the input for the scenario analysis.

In order to develop coherent future scenarios of the entire mobility system, another step is made throughout the analysis. Thus, the qualitative data analysis results in concepts. These concept are the building blocks (or input) for the scenario analysis. This methodology for this step, the development of scenarios, is based on the work of Hofmann et al. (2007). It has to be noted that this method for the development of scenarios has originally been designed for forecasting, aimed at identifying probable future visions. Since this research is based on backcasting, aimed at identifying the most desirable future, some modifications have been made to fit the method with this research. The elements from the scenario analysis are modified in order to fit this research. The elements are schematically described in figure G. As indicated, the identified concepts are the input for the scenario analysis. More precisely, the concepts present the trends and drivers of the scenario analysis.

Elements of scenario analysis	**Description**
Trends	-Concepts that <u>are not</u> subject to policy, given the scope of this research -Important factors of influence on future structural change -Development is considered to be constant
Drivers	-Concepts that <u>are</u> subject to policy, given the scope of this research -Important factors of influence on future structural change -Development is typically inconstant as it is subject to policy
Trend-like dynamics	-Aggregations of trends, which are thematically related to each other -Future development of these trends is correlated -<u>Cannot be influenced</u> in this research -Provide background / context wherein the scenarios exist
Dynamics	-Aggregations of drivers, which are thematically related to each other -Future development of these drivers is correlated -<u>Can be influenced</u> in this research -Provide the building blocks / elements of specific scenarios
Core dynamics	-The two dynamics that have the biggest impact on structural change of the mobility system -The key dimensions of the scenarios -With use of these key dimensions four different scenarios are identified, as presented in the scenario matrix
Scenarios	-A consistent image of the future -The different scenarios are based on the core dynamics -Specific scenarios ther dynamics are added, that can be logically related
Wild cards	-Concepts that <u>are not</u> subject to policy, given the scope of this research -Important factor of influence on future structural change -Development is considered to be inconstant

Figure G: Elements of the scenario analysis

The construction of scenario itself is executed by the same method, described in the theoretical background of the methodology. The concepts from the qualitative data analysis (which are all important factors of influence on structural change) are the trends and drivers that form the starting point of the scenario analysis. Concepts that cannot be influenced (as they are not the subject of policy here, give the scope of this research), are the trends. These trends are considered to be constant developments. The concepts from the qualitative data

analysis that can be influenced are the drivers. These drivers are considered to be inconstant, as they are the subject of policy.

Trends that are thematically related to each other in terms of future development are bundled into trend-like dynamics. Logically these trend-like dynamics cannot be influenced in this research. Therefore, the trend-like dynamics provide the background wherein the different scenarios exist. Drivers that are thematically related to each other in terms of future development are bundled as well, into dynamics. In contradiction to trend-like dynamics, dynamics can be influenced in this research. The dynamics provide the building blocks for the scenarios.

The two dynamics that have the biggest impact on structural change of the mobility system, are the core dynamics. The core dynamics present the key dimensions of the scenarios. With use of these key dimensions, four scenarios are identified, as presented in the scenario matrix (figure H). To the core dynamics (i.e. key dimensions), specific for a scenario, other – logically related- dynamics are added, in order to create consistent images of the future. However, not all dynamics can be logically related to the scenarios. These dynamics are so-called wild cards, which are presented separately.

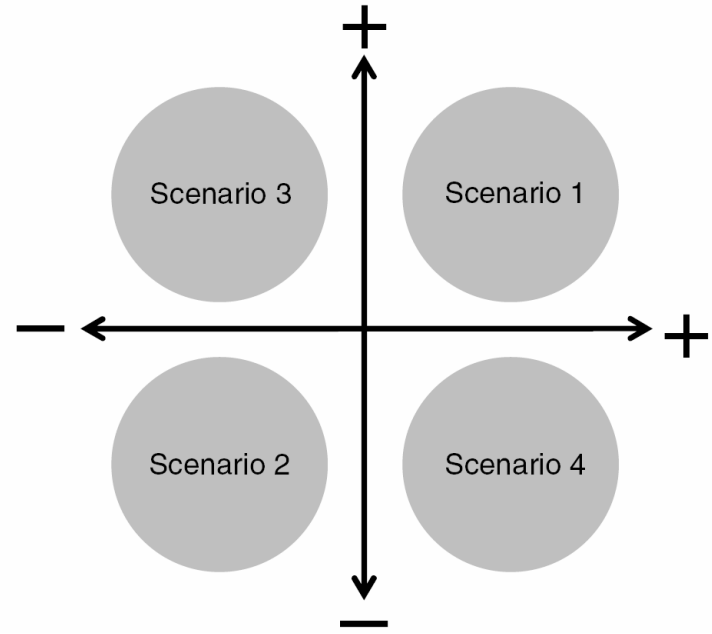

Figure H: Scenario matrix (adapted from Hofmann et al., 2007: 5)

It has to be noted here that the core dynamics are identified, based on the findings from the interviews. The findings from the interviews are (subjective) opinions of different interviewees. However, the creation of the scenarios is not subjective, as a clear method is used as described above. As indicated by Bryman (2004),a strict method is necessary for social research, in order to cope with interpretivism. The method described above allows to account for differences between individuals in terms of their subjective meaning.

4 Results and analysis

4.1 Introduction

In the previous section, the methodology of this research is presented. By following the steps described in the methodology, several results are produced (i.e. trend-like dynamics, core

dynamics, dynamics and wild cards). To start with, the trend-like dynamics are presented. As argued earlier, the trend-like dynamics cannot be influenced in this research, given the scope. Hereafter, the core dynamics are presented. The core dynamics are the key dimensions for the design of mobility systems. With use of the two core dynamics, four different scenarios are identified, that are presented in the scenario matrix.

Hereafter, every scenario is presented separately. First, a description of the scenario, consisting of core dynamics and (logically related) dynamics, is presented. Second, the scenario specific results for every dimension of successful aging are presented, by relating the dynamics to the theoretical framework. Concluding, the scenario specific dynamics and results for the dimensions of successful aging are presented schematically.

A wild card is presented as well. Given the scope of this research, the wild card is not subject to policy. The wild card is an important factor of influence on future structural change. However, its future development is considered to be inconstant. Henceforth, the results are analyzed, by relating them to the current situation. By doing so, insight is provided in what is necessary in order to contribute to successful aging.

4.2 Trend-like dynamics

In this section, the trend-like dynamics are presented. As indicated earlier, the trend-like dynamics are aggregations of trends (i.e. concepts that are not subject to policy, given the scope of this research), which are thematically related to each other. Since the trend-like dynamics cannot be influenced in this research, they present the background (or context) wherein all scenarios exist.

The first trend-like dynamic is formed by the **general characteristics of older adults**. In 2035, several characteristics of older adults have changed. On average, future older adults have a higher level of education. Older adults are expected to be less willing to compromise. This also holds for their demand for mobility. On average, older adults are used to a higher level of mobility. Thus, as these people age, they are expected to demand to maintain this level of mobility. Differences in financial status of older adults will have been increased. The group of older adults that has a good financial status, travels over longer distances, as they are already used to this. The spatial environment wherein older adults will travel will has been increased, as older adults will travel further (to other countries, etc.).

Furthermore, in 2035, older adults who share interests tend to visit or meet each other. However, this does not imply that future older adults who share interests per definition live near each other. Moreover, the children of older adults probably live increasingly further away. Thus, in order to access their children, older adults have to travel over a longer distance. A reason to access social relations is personal care to social relations. A part of the group of older adults has children that give care to them. However, (third age) older adults themselves give a significant amount of care to other social relations. An increasing share of the future older adults gives care to their own parents. Moreover, some older adults babysit their grandchildren.

Another issues here is the older adults' assessment of their individual capacities. A group of older adults performs relatively well at assessing their own capacities. When participating in traffic, this group of older adults tries to compensate for possible disabilities in both cognitive and physical terms. However, another group of older adults performs less well at assessing their own capacities. Perhaps, as individuals age, the capability to assess their capacity

decreases. Within this group, most older adults tend to overestimate their own capacities. These older adults logically do not compensate for possible disabilities. Often, after being involved in an accident, the perception of the own capabilities changes, resulting in a change in traffic behavior. On average, older adults feel younger than they are and they do not want to be confronted with their actual age. However, in general, older adults remain in good health for an increasing period. On the other hand, there is a group of older adults, who's cognitive and physical capabilities is affected by chronic illnesses, which can already start at an age of approximately 55. As individuals age, they can be expected to have an increasing demand for more specialized medical aid. Because this specialized medical aid will be offered at medical facilities that are less widely available, older adults will have to travel further as they age.

The second trend-like dynamic is formed by the **spatial characteristics of the Netherlands**. In 2035, the spatial characteristics of the Netherlands have changed. In general, the Netherlands is densely populated. However, the distribution of the population has changed. A distinction should be considered between urban areas and rural areas. In several provinces of the Netherlands, the population of urban and rural areas has increased. However, within several provinces, the population of the rural areas has decreased. Finally, there are several provinces wherein the population in both the urban and rural areas have been decreased (for instance the province Limburg).

4.3 Core dynamics and dynamics

In this section, the core dynamics are presented. As indicated earlier, the core dynamics are the two dynamics that have the biggest impact on structural change of the mobility system. Consequently, the core dynamics present the two key dimensions for future mobility systems. With use of the key dimensions, four different scenarios are identified. The scenarios are schematically presented a scenario matrix.

The first core-dynamic relates to the design of the future land-use system, or more specifically, the **dwelling situation of future older adults**. The dwelling situation of future older adults is expected to have a strong influence on the whole structure of the future land-use system (and therefore on the entire mobility system). Whereas one group of interviewees argued that future older adults ideally live concentrated (i.e. concentrated living with older adults), another group of interviewees argued that future older adults ideally live dispersed.

The second core-dynamic relates to the design of the future transport system, or more specifically, the **different modes of transport** within the future transport system. The different modes of transport is expected to have a strong influence on the structure of the whole structure of the future transport system (and therefore, as above, on the entire mobility system). Whereas one group of interviewees argued that within the future transport system, there is only place for the car, another group of interviewees argued that ideally, more different modes of transport are included in the transport system.

It has to be noted that the development of the core dynamics is typically inconstant, as they are subject to policy measures. As described, the core dynamics provide the two key dimensions in which the future mobility system can differ. Subsequently, the scenario matrix (i.e. the highest aggregation level) is sketched. The scenario matrix is presented in figure I.

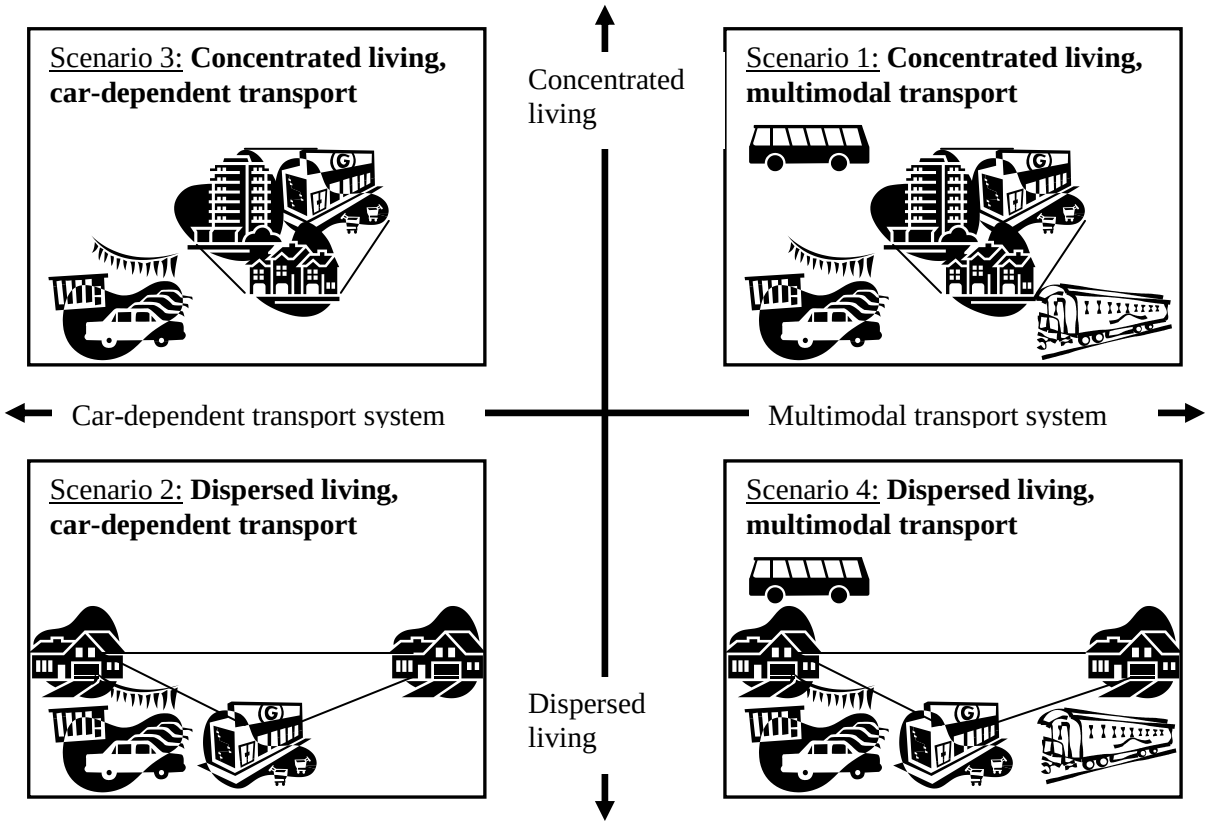

Figure I: Scenario matrix (illustrating the distribution of dwellings and nature of the transport system)

Based on the two key dimensions (the core dynamics), four different scenarios are distinguished, as presented in the scenario matrix. Every scenarios represents another image of the future mobility system. As descried, in addition to the core dynamics, other dynamics can be logically related to the specific scenarios. By adding these dynamics, coherent images of future mobility systems are constructed.

4.4 Scenario 1 – Concentrated living, multimodal transport

4.4.1 Scenario description

As indicated, the core dynamics for this scenario are concentrated living and multimodal transport. These core dynamics are described next. Hereafter, other dynamics that are described, that can logically be related to this scenario (as a combination of core dynamics).

The first core dynamic is **concentrated living**. In 2035, older adults prefer to live concentrated. In both urban and rural areas, older adults live near each other. The areas wherein older adults live differs in scale. Typically, these concentrations are relatively small in rural areas. In urban areas, these concentrations are relatively large. The early development of older adults living in the same neighbourhood, such as in the Dutch city Doorn, has continued, resulting in concentrations of dwellings as large as cities. These cities are the largest scale of areas with dwellings for older adults, and are similar to the cities of older adults in the United States, that have already be present for a long time. The smallest scale of concentrations of dwellings are dwelling centres dedicated to older adults. Within these dwelling centres, older adults that are similarly minded live together. There is a difference in dwelling centres for relatively wealthy and poor older adults. Relatively wealthy older adults can afford to live concentrated, in luxury dwelling centres, as these older adults make high

demands on their dwelling. However, relatively poor older adults cannot afford to live in these luxury dwelling centres. Instead, these older adults live in less luxury dwelling centres.

Older adults are well informed on the consequences their dwelling situation has. For instance, older adults realize that they should live at a location, where care is easily accessible. When choosing a specific dwelling, older adults take the available services and facilities into account. Older adults are aware that as they age, the demand for services and facilities can be expected to increase. Subsequently, the last time older adults move house, this is typically towards a concentrated area, where more services and facilities for older adults available. In several cases, older adults' dwelling and care is combined into residential care centres. These centres are placed near green spaces (as well as schools). In spatial planning, the demands of older adults partly cover the demands of the youth. Both groups are vulnerable and reaction times are relatively low (for the youth because they are easily distracted). Placing residential care centres near schools anticipates on this, for instance by creating streets without cars in this neighbourhood.

The second core dynamic is **multimodal transport**. In 2035, multiple modes of transport that are available for older adults, resulting in a multimodal transport system. These include both private and public modes of transport. Typically, private transport plays the most important role in mobility in the direct neighbourhood of older adults (relatively short distances). Public transport plays the most important role in mobility outside the neighbourhood of older adults (relatively long distances). In 2035, the mobility of older adults is facilitated, by considering the whole chain of mobility. The links in the mobility chain are formed by different modes of transport. Ideally, all different public transport links present a complete mobility chain on itself. A distinction is made between public transport in rural areas and public transport in urban areas. In rural areas, the public transport system is less dense. For older adults, buses are provided as a first link in the mobility chain. Especially for travelling over longer distances, public transport is a link in the mobility chain that older adults are willing to use.

The supply of public transport and the demand for demand responsive transport relate to each other. By supplying public transport options that are suitable for older adults as well, the trend of increasing use of demand responsive transport has come to an end. Although most older adults are able to use public transport in 2035, not all older adults can. It is not considered to be feasible to create public transport that can be used by everybody. Reason is that when designing public transport for one group specifically, other groups of users are affected as well. Therefore, demand responsive transport remains an important link in the mobility chain as well.

The bicycle is a link in the mobility chain as well. Older adults mainly use the bicycle in their own neighbourhoods. However, near more distant destinations, the bicycle presents a link in the mobility chain as well, when it is used for instance as a public transport bicycle. Though, a proportion of the older adults perceives the bicycle more as an alternative transport option that can be used when the weather is nice, or only for recreation. Naturally, also the car is a link in the mobility chain. In 2035, the proportion of older adults that are able to drive a car has increased. Beside the rather traditional modes of transport, the transport system includes other, new modes of transport. These modes of transport are formed by vehicles that are relatively small and mostly electrically driven. An example is the Segway. Perhaps, more modes of transport between a golf cart and a traditional car exist. Condition is that the place of these modes of transport is clear (including the interaction with the infrastructure).

The first dynamic is **reconsideration of the place of modalities in the transport system**. In the past, driving a microcar was rather confusing, as the place in the transport system was by no means clear. Furthermore, it was not required to perform a driving test in order to drive a microcar. In 2035, the place of the microcar has been reconsidered. As a result, the microcar has a unambiguous place in the transport system. Moreover, a driving test specific for microcars has been developed. Thus, older adults are required to perform a driving test, in order to examine whether individual older adults are capable to drive a microcar. Similar to the microcar, the place of mobility scooters in the transport system was not clear in the past. This resulted in all sorts of (in some cases undesired) traffic behaviour and situations. Therefore, in 2035, the status of the mobility scooter in the transport system is reconsidered. The rules for the use of mobility scooters are described clearly. Last, the education necessary to use a mobility scooter has been clarified.

The second dynamic is **separation of traffic flows**. In 2035, the infrastructure is improved, as non-conflicting traffic flows are created. This improvement is specifically aimed at vulnerable age groups (such as individuals aged 75 years and older), modes of transport (such as bicycles) and problematic situations (in particular situations where priority and passing through[9] play a role). In terms of safety, situations of priority and passing through were specifically indicated as problematic for older adults (as well as other traffic participants). Examples of non-conflicting traffic flows are underpasses and separately placed bicycle lanes. This also holds for infrastructure for pedestrians, which present a vulnerable group in the mobility system.

Ideally, instead of the concept of shared space, the concept of sustainable safety[10] has been used in 2035 in order to improve infrastructural design and separate traffic flows. In the past, when the concept of sustainable safety was implemented, concessions were made. However, in 2035, this has come to an end. When implementing this concept, it is followed strictly, in order to create uniform infrastructure.

The concept of 'shared space' deserves to be mentioned explicitly here. This concept is based on the most vulnerable participant in traffic. In some cases (mainly depending on traffic intensity), the implementation of this concept results in a higher objective safety, contributing to the first dimension of successful aging. The perception of safety obviously differs for individual older adults. However, in general, older adults do not feel safe in shared space situations. Ultimately, older adults may avoid these situations. Thus, although objective safety may be improved in some situations with the implementation of shared space, subjective safety may deteriorate, potentially affecting the dimension active engagement with life of older adults

The third dynamic is **examination of abilities and support**. In 2035, it is still important to emphasize which (dis)abilities are considered to be acceptable for participating in traffic, and which are not. Therefore, older adults still have to perform a test, in order to prolong their driving license. Possible effects of the use of medicines are taken into account as well. Perhaps, another institution than the CBR[11] has become responsible for these tests. This

[9] In Dutch: "Voorrang doorgang situaties"
[10] In Dutch: "Duurzaam veilig"
[11] In the past, the 'Centraal Bureau Rijvaardigheidsbewijzen' (CBR) has been responsible for examining the driving abilities of older adults of 70 years and older. Medical issues were taken into account as well, as a doctor has to provide a statement on this. Concluding, the CBR decided whether the driving license was prolonged for a period of 5 years. After this period, the driving abilities was examined again.

institution has the ability to withdraw driving licences of older adults that are no longer able to drive, in order to secure their road safety (as well as the road safety of other traffic participants). However, the responsible institution has a broader function than only testing whether an older adults is able to drive or not. When an older adult is no longer able to drive, the institution supports the mobility of the older adult, by suggesting and advising the use of other modes of transport.

The fourth dynamic is **protection of neighbourhoods**. In 2035, social safety of older adults is enhanced by both the land-use system and the transport system. Within the land-use system, social safety is an issue in the neighbourhood older adults live in. As older adults live concentrated in this scenario, their neighbourhoods can be designed specifically designed for them. In these neighbourhoods, social safety is ideally improved by using appropriate lighting, as social safety is especially an issue when it is dark. Furthermore, the presence of surveillance contributes to social safety. Relatively wealthy older adults probably arrange surveillance themselves. As less wealthy older adults are dependent on surveillance provided by the government, appropriate surveillance is ideally provided by municipalities.

The fifth dynamic is **supervision in public transport**. In 2035, for older adults (as well as other traffic participants), social safety is secured throughout the whole mobility chain. Again, proper lighting improves social safety. Social safety is particularly an important issue for public transport. Social safety is further improved by encouraging that individuals are not alone, but travel together, including waiting involved. In public transport, social safety has been enhanced. As social safety cannot be enhanced by providing solely camera surveillance, personal surveillance is present in public transport as well. Furthermore, shelters for bicycles, mobile scooters and other modes of transport should are protected with a security systems as well.

The sixth dynamic is **differentiation of reference for infrastructural design**. In 2035, older adults remain in good health in cognitive terms, for a longer time than in the past. However, as older adults age, their cognitive and physical capacities still diminish (including, for instance, assessing capabilities). In the past, the young autochthon male was (argued to be) the reference for design of the transport system. However, in 2035, this standard has been differentiated. As older adults live concentrated in this scenario, the reference for infrastructural design can be differentiated. Thus, in the neighbourhoods older adults live in, older adults themselves are taken as the reference for infrastructural design.

In 2035, human factors are considered throughout the infrastructural design. Three characteristics prove to be important for older adults. These are recognisability, complexity and workload. In the neighbourhood older adults live in, all (different sorts of) information have to be recognizable and uncomplicated, resulting in a minimal mental workload (obviously, these subjects are closely related). Obviously, traffic signs and route signing play an important role here, as part of the infrastructural design.

Concluding, as older adults live concentrated, they can be taken as a reference for design in their neighbourhoods. As a result, their neighbourhoods are designed specifically for them. As a result, ideally, the cognitive and physical capacities of older adults do not have to be high, in order use the mobility system.

The seventh dynamic is **physical accessibility of the mobility chain**. In 2035, the transport system is designed in such a way that it is easily accessible in physical terms. Physical accessibility plays a role for older adults that walk. For these older adults, ideally, infrastructure is designed in such a manner, that there are no difference in ground levels. In the neighbourhood older adults live in, even kerbstones are possibly removed. As a result, older adults can easily use rollators, mobility scooters and other assistive devices for walking. Furthermore, the reduced walking speed of older adults has been taken into account. Traffic lights provide enough time for older adults to cross a street. Possibly, this is done by new technologies that are able to detect whether an individual has crossed the street. The traffic light responds on this situation, resulting in enough time for an individual to cross the street, while other road users do not have to wait longer than necessary. Furthermore, ideally, public transport has become better accessible. The concept of 'seamless travel' is used as a starting point for the design of public transport. This concept implies that all transfers (including transfers that involve trams, etc.) are at the same height. Older adults (as well as other individuals) can therefore easily access public transport. Moreover, older adults are able to use rollators or other assistive devices in public transport.

The eighth dynamic is **education of the mobility chain**. In 2035, education is provided one the use of different links in the mobility chain. Thus, when older adults purchase a mobility scooter, an appropriate instruction is provided on how the mobility scooter should be used. The supplier of the mobility scooter is responsible for this instruction, whether this is a municipality or another supplier. This instruction is be obligatory, but a self-evident part of the distribution of the mobility scooter. The same holds for other links of the mobility chain and assistive devices, such as electrical bicycles. When older adults purchase such a bicycle, an appropriate instruction is provided on how the electric bicycle should be used in traffic.

The ninth dynamic is **concentration of services and facilities**. For the availability of services and facilities, a distinction is considered between services and facilities in rural and urban areas here. In urban areas, there are relatively many services and facilities available. In rural areas however, there are typically relatively few services and facilities available. A trade-off exists between the dwelling location and the availability of services and facilities. As older adults live concentrated, services and locations dedicated to these older adults can be provided near the concentrations of dwellings of older adults (or even be part of the concentration). Simultaneously, older adults will prefer to live near services and facilities, as older adults take the availability of services and facilities into account when choosing their dwelling location. Hence, services and facilities, and dwellings of older adults are located near each other. As a result, older adults have to travel over shorter distances in order to reach services and facilities.

However, a distinction has to be considered here, between services and facilities that play a role in the daily life of older adults and services and facilities that are visited less frequently. Services and facilities that play a role in daily life are for instance grocery stores, restaurants and markets. These services and facilities are typically broadly available and located within the direct neighbourhood of older adults. Services and facilities that are visited less frequently are for instance specialized medical facilities. These services and facilities are typically less available. Depending on the distribution of different concentrations of dwelling of older adults, the less frequently visited services and facilities are located strategically, as described in textbox 1.

*A specific option for the location of dwellings and services and facilities, is that a network of **satellites** is created. These satellites are formed by cores of dwellings and cores of services and facilities. The cores of services and facilities include health centres, swimming pools and other recreational facilities. The services and facilities situated in this core do not only aim for older adults, but also other groups of people. The core of services and facilities is located at the centre of the network. Around this core, several cores of dwellings are located. Additional cores are formed by schools, as they will also make use of the core of services and facilities.*

Moreover, as described, the demands of the youth and older adults overlap, as both groups are vulnerable. This is anticipated on, by creating streets without cars. In addition, as both groups desire to have green space located nearby, green space is provided near the cores.

Advantage of a core with services and facilities surrounded by cores of dwellings for older adults, is that mobility between these concentrated areas can be organized well. Consequently, cores are connected to each other by transport options, such as light-rail connections. Naturally, other transport solutions are provided as well, such as carpooling. Older adults that are still able to drive a car take other older adults that are not able to drive a car with them. Another example is car-sharing.

Textbox 1: Satellites as a specific option for the land-use system

The tenth dynamic is **optimization of neighbourhood design**. As older adults age, the size of the area wherein older adults perform their daily activities typically decreases. As the size of older adults' living environment decreases, the neighbourhood becomes increasingly important as older adults age. Since older adults live concentrated in 2035, their neighbourhoods are designed specifically for them. Throughout the design of these neighbourhoods, municipalities collaborated with all inhabitants of the neighbourhood. Consequently, older adults themselves have been involved in the design of their neighbourhood. Also in neighbourhoods that are revitalized, the demands of older adults are taken into account.

In 2035, the neighbourhoods older adults live in are optimized to meet their specific demands. Within the neighbourhoods of older adults, there are enough green spaces. As green spaces are specifically invested in, the value of the real estate within the neighbourhoods is relatively high. Project developers have taken responsibility for the development of the neighbourhood surrounding their real estate. As a result, project developers have risen the quality of the neighbourhood to a high level. Municipalities play a role in this process, as they secure the quality of the neighbourhoods by providing minimal conditions on the design of it. The neighbourhoods older adults live in, helps them to remain mobile and vital. The neighbourhood stimulates older adults to remain vital as opportunities to physically exercise are provided. These opportunities are for instance formed by the supply of appropriate sidewalks (especially around dwelling centres and residential care homes). Moreover, parks are provided in the neighbourhoods of older adults as well. In these parks, older adults can physically exercise. Older adults' physical exercise is further supported by social internships from schools. This means that the youth accompanies older adults in walking. As older adults remain in contact with the youth by this, active engagement with life is positively affected.

The eleventh dynamic is **supply of dedicated transport options**. As older adults (and other people) live more concentrated, dedicated transport options can be provided. This holds in particular for collective forms of transport, such as carpooling. Older adults that are still able to drive a car (and want to do this), drive a car and take other older adults from the same neighbourhood with them. Ideally, these designated drivers are provided a special education. Other variants of carpooling are present as well, such as car lending. Cars are provided by residential care homes, insurance companies or local services and facilities, which have interest in the mobility of older adults.

In 2035, as public transport is designed well, it is has become a relaxed way of transportation. There are be more transport options available in urban areas than in rural areas. In shrinking areas, where the proportion of younger people has decreased, traditional public transport perhaps has disappeared. Instead of traditional public transport, there are smaller buses available as well. All different groups of people make use of these buses. These buses also ride outside normal routes. Consequently, older adults can depart from other places than the fixed bus stops. Within urban areas, the public transport system is more dense. Within and around cities, public transport is widely available. Thus, although the form of public transport differs for different areas, public transport is available everywhere for older adults, in order to allow them to be actively engaged with life outside their neighbourhood.

A specific possibility is that designated spots are created to transfer from one mode of transport to another. Older adults typically use private transport to reach these spots. From there on, older adults can choose different sorts of public transport in order to travel further, for instance to a certain urban area. As these spots are located near smaller cities and rural areas, these locations are connected to urban areas.

The twelfth dynamic is **comfort of the mobility chain**. In 2035, the transport system is designed in such a manner, that it is comfortable for future older adults (this concerns public transport especially). The reason for this is that older adults are already used to a high level of comfort. Possible disabilities should are taken into account throughout the design of the entire transport system. With regard to comfort, several issues have to be mentioned. For older adults, it is important to be able to travel from ‘door to door’. Therefore, the number of transfers is decreased as much as possible in public transport. The mobility chain is further strengthened and expanded. As the number of links of the mobility chain is increased, older adults have more options for mobility. As stated, the comfort that is known from using a car is taken as a benchmark here. Moreover, the transfers itself are as comfortable as possible.

The thirteenth dynamic is **reliability of the mobility chain**. In 2035, the reliability of the entire transport chain has been improved. In general, in order to secure the reliability of the transport system, the fail factors of the mobility chain are clarified. When a certain link in the mobility chain breaks down, it is known how it can be anticipated on. This holds for the whole mobility chain, including the planning and undertaking of a trip. Furthermore, ideally, individual links in the mobility chain are as reliable as possible, in particular in terms of time. Thus, the times at which public transport departs and arrives are as reliable as possible.

The fourteenth dynamic is **maximization of flexibility in terms of time**. For time, a distinction should be made for the different modes of transport included in this scenario. Ideally, all links of the mobility chain would be available at all times, as it gives older adults maximum flexibility. For instance, for public transport, which is part of the mobility chain

here as well, time is a relevant issue. Ideally, the times at which public transport departs and arrives are reliable. Furthermore, in the past, in some situations, even healthy adults did not have enough time for a transfer. For older adults, transfers can be even harder. Ideally, the times for transfers, both intra- and intermodal, are improved. Last, public transport departs with high frequencies. As a result, the flexibility in terms of time when using public transport is increased, positively influencing active engagement with life.

The fifteenth dynamic is **maximization of flexibility in terms of** costs. Obviously, costs differ for different modes of transport. Ideally, all transport options are affordable for older adults, as this minimizes the resistance for older adults to be actively engaged with life. In 2035, a part of these financial resources required for public transport is provided by the government. Another part of these resources is provided by public transport companies. Last, a part of these resources is provided by older adults themselves, as they use public transport. Possibly, this is linked to the financial status of older adults, perhaps resulting in free public transport for certain older adults. As in the past, older adults pay less for travelling with public transport. However, in contrast with earlier, ideally, older adults have the ability to travel with a discount before 9:00 as well. Furthermore, when travelling with public transport, taxi's are an important link in the mobility chain for older adults. Therefore, municipalities secure the affordability of the use of a taxi, specifically for older adults. A specific option for costs is presented in textbox 2.

> *A specific option for the transport system, is that **mobility providers** supply mobility for older adults. In 2035, individuals no longer purchase a certain vehicle to meet their mobility demands. Instead, older adults purchase a number of kilometres at a mobility provider. The mobility provider provides a specific vehicle (or ticket for public transport), for a specific movement.*

Textbox 2: Mobility providers as a specific option for the transport system

4.4.2 Implications for successful aging

In this section, the implications of the described scenario for successful aging are discussed. In order to do so, the described dynamics are related to the theoretical framework. As described, older adults live concentrated in this scenario. In the theoretical framework, density is indicated as a characteristic of the land-use system. The land-use system influences engagement with life of older adults. More precisely, concentrated living contributes to the ability to access social relations, as a part of the social relations of older adults (other older adults) can be expected to live in the same neighbourhood. The same holds for social activities. As older adults live concentrated, a part of their social activities can be expected to be located in the same neighbourhood. Consequently, by facilitating concentrated living for older adults, they are not dependent on the transport system for a part of their engagement with life. As indicated, the transport system comprises multiple modalities in this scenario. Consequently, the mobility of older adults is facilitated by a well designed mobility chain. The multimodal transport system does not directly influence successful aging. However, obviously, the dynamics that refer to the transport system in this scenario are all based on the fact that the transport system comprises multiple modalities.

As described, the role of modalities in the transport system has been reconsidered. As a result, the road safety of older adults (as well as other traffic participants, such as older adults walking on sidewalks) has been enhanced. Consequently, a contribution is made to the first dimension of successful aging, risk. Moreover, reconsidering the place of modalities in the transport system improves the usability of these modalities as well. Consequently, a contribution is made to the second dimension of successful aging, the perception of capacity.

Traffic flows are separated in this scenario. As a result, the road safety is improved. In the theoretical framework, road safety is indicated as part of safety issues, influencing the first dimension of successful aging, risk. This, separation of traffic flows contributes to the risk dimension. As this first dimension is a condition for the other dimensions of successful aging, capacity and engagement, these dimensions are positively affected as well.

As described, older adults have to perform tests in order to prolong their driving license. When they do not pass this test, the use of other modes of transport is supported. By doing so, the road safety of older adults is enhanced. Consequently, a contribution is made to the dimension risk. However, simultaneously, the dimension engagement is negatively affected. Clearly, a tension exists between these two dimensions of successful aging. Although engagement is hampered when older adults are no longer allowed to drive, this is compensated by offering support and advice for the use of other modes of transport.

In older adults' neighbourhoods, social safety has been enhanced. In the theoretical framework, social safety is indicated as part of safety issues. Safety issues influence the first dimension of successful aging, risk. Thus, by providing protection in the older adults' neighbourhoods, a contribution is made to the dimension risk.

As described, supervision is provided in public transport to enhance social safety. As argued before, changes in the mobility system that improve social safety, present contributions to the first dimension of successful aging, risk.

The reference for design is reconsidered in this scenario. As older adults live concentrated in this scenario, their neighbourhoods are designed specifically for them. By doing so, both cognitive and physical strain are reduced. As cognitive strain and stress and physical strain are parts of usability issues, a contribution to the second dimension of successful aging is made.

As described, the physical accessibility of the mobility chain is enhanced in this scenario. By doing so, physical strain is reduced. Physical strain is indicated in the theoretical framework as part of usability issues, influencing the second dimension of successful aging, the perception of capacity.

Education on the use of different links in the mobility chain is provided for older adults in this scenario. Education can be related to required exercise, as indicated as part of usability issues in the theoretical framework. As usability issues influence capacity, education of traffic rules contributes to the older adults' perception of capacity. However, a contribution to this dimension of successful aging positively affects the first dimension (risk) and third dimension (engagement) of successful aging as well.

As described, older adults live concentrated in this scenario. As a result, the frequently used services and facilities are located in the older adults' neighbourhoods. The theoretical framework indicates density and mixed land-use as characteristics of the land-use system, that influence older adults' engagement. Obviously, locating frequently used services and facilities in older adults' neighbourhoods contributes to the ability to access services and facilities. Again, older adults are not dependent on the transport system in order to access these services and facilities. By concentrating the less frequently used services and facilities at strategic locations, it is possible to provide several transport options, including public transport.

Neighbourhood design is optimized in this scenario. Neighbourhood design is indicated as part of the land-use system in the theoretical framework, influencing the third dimension of successful aging, engagement. It has to be noted that by providing suitable neighbourhoods for older adults' engagement, the second dimension of successful aging is positively affected as well.

As described, as older adults live concentrated, dedicated transport options can be provided in their neighbourhoods. The distance to transport options is indicated in the theoretical framework as part of the land-use system, influencing engagement. Obviously, providing dedicated transport options for older adults contributes to engagement. It has to be noted that this concerns engagement outside the neighbourhoods of older adults.

The comfort of the mobility chain has been enhanced in 2035. Comfort has been indicated as part of usability issues. Usability issues influence the perception of the second dimension of successful aging, capacity. Thus, by improving comfort of the mobility chain, a contribution can be made to the perception of the older adults' capacity.

As described, in this scenario, the reliability of the mobility chain has been improved in 2035. In the theoretical framework, reliability is indicated as part of quality issues of the transport system. Quality issues influence the third dimension of successful aging, engagement. Thus, by increasing the reliability of the transport system a contribution is made to engagement of older adults, as resistance to be mobile is decreased.

In this scenario, flexibility in terms of time is maximized. Time is indicated in the theoretical framework as an influence on engagement with life. Thus, by maximizing the flexibility in terms of time, a contribution is made to older adults' active engagement with life.

As described, in this scenario, flexibility in terms of costs is maximized. Costs are indicated in the theoretical framework as an influence on engagement with life. Thus, by maximizing the flexibility in terms of costs, a contribution is made to older adults' active engagement with life.

Concluding, in a mobility system based on concentrated living and multimodal transport, several contributions can be made to successful aging. Separation of traffic flows, reconsideration of the place of modalities, examination of abilities and support, protection of neighbourhoods and supervision in public transport contribute to the first dimension of successful aging, risk. Differentiation of reference for infrastructural design, physical accessibility of the mobility chain and education of the mobility chain contribute to the second dimension of successful aging, the perception of capacity. Concentration of services and facilities, optimization of neighbourhood design, dedicated transport options, comfort of the mobility chain, reliability of the mobility chain, maximization of flexibility in terms of time and maximization of flexibility in terms of costs contribute to the third dimension of successful aging, engagement.

Thus, overall, when older adults live concentrated, engagement with life becomes partly possible in the neighbourhood older adults live in. older adults have the ability to easily access a part of their social relations and participate in social activities (i.e. other older adults that live in the same neighbourhood and social activities that are arranged in their neighbourhood). Moreover, services and facilities that are used frequently are located near the

dwelling of older adults. Since older adults live concentrated, their neighbourhoods can be designed specifically for them. As a result, Also, older adults have the ability to easily access frequently used services and facilities. Last, older adults have the ability to go sightseeing in their neighbourhood. Consequently, the land-use system facilitates older adults to be actively engaged with life within their own neighbourhood. The transport system is considered to be less important for active engagement with life within older adults' neighbourhood, as older adults can easily walk (possibly with an assistive device). As a result, older adults are less dependent on the transport system for engagement. However, for engagement with life outside the neighbourhood, several transport options are provided for older adults.

4.5 Scenario 2 – Dispersed living, car-dependent transport

4.5.1 Scenario description

The first core dynamic is **dispersed living**. In the year 2035, older adults prefer to live dispersed, for several reasons. The dwelling situation of third age older adults is classically determined by other factors than age-related factors. Consequently, there are no concentrations of individuals that belong to the same age group. Moreover, older adults typically prefer to live dispersed, as they prefer to live among other people than only older adults. Sub-cultures are important for older adults, which implies that similarly minded individuals will meet each other. However, this does not imply that similarly minded individuals will live together. Thus, a part of the social relations of future older adults does not live within the same neighbourhood. Consequently, individuals will travel over longer distances in order to meet the people they are interested in (i.e. their social relations).

Another reason for living dispersed is that older adults do not like to move, as they are connected to the area they live in (and have lived in, in earlier phases of their lives). Especially older adults that already live a longer period in rural areas, dislike to move towards other areas, in particular to more urban areas. As older adults do not like to move, all dwellings are designed in such a manner, that they are suitable for people of all ages. By doing so, the dwellings remain suitable for individuals, as they age.

The last reason for older adults to live dispersed is actually related to age. A proportion of the group of (generally wealthy) third age older adults deliberately moved to live dispersed in shrinking areas[12], in order to enjoy their retirement[13]. Moreover, these shrinking areas attract older adults to enjoy calm holidays.

The second core dynamic is **car-dependent transport**. In 2035, only the car is available for mobility, resulting in car-dependent transport. The trend of increasing car use by older adults has continued. As a result more older adults drive a car than before. An important reason to use a car instead of other modes of transport is that the car provides individual mobility. Older adults are more used to travelling with the car and have the wish to continue this as they age. The fixed costs of driving a car have decreased. When older adults are no longer able to drive a car themselves, they turn to taxi's or private chauffeurs.

As a result, older adults are less dependent on public transport. Public transport therefore does not play a role in the transport system. Another reason is that in order to make use of public transport, individuals should have used this form of transport earlier in their lives. As a large proportion of older adults never used public transport in their lives, they will not turn to

[12] In the Netherlands known as 'krimpgebieden'
[13] So-called 'Drenthenieren'

public transport for their mobility. Thus, even if public transport was provided, older adults would perhaps not chose to use this.

The first dynamic is **optimization of distributor roads**. In 2035, older adults perhaps still perceive driving on a highway (mostly 120 km) as relatively risky. As provincial roads (mostly 80 km) are perceived as less risky, older adults possibly avoid these highways and prefer to drive on provincial roads instead. However, in the past, on average, the actual road safety on highways was significantly higher than on provincial roads. Ideally, in 2035, provinces have improved the objective road safety on the provincial roads.

The second dynamic is **examination of driving abilities**. In this scenario, older adults are enabled to drive as long as possible, as it is their only (independent) transport option. As in the first scenario, it is important to emphasize which (dis)abilities are considered to be acceptable for participating in traffic, and which are not. Again, older adults have to perform a test in order to examine their driving capabilities. Obviously, possible effects of the use of medicines is considered as well. Prolonging the time older adults are allowed to drive is done by distinguishing different driving licenses for cars. Several other options are possible here. Older adults can for instance be given the opportunity to remain driving a car, but solely in and around their dwelling, which is familiar. Another option is to give older adults the possibility to remain driving, but solely during daylight.

The third dynamic is **reconsideration of reference for infrastructural design**. In this scenario, older adults live dispersed. As a result the reference for infrastructural design cannot be differentiated (as described in the first scenario). However, in this scenario, a contribution is made as the reference for design is reconsidered. In 2035, human factors are considered throughout the design of the transport system. In the past, the young autochthon male was (argued to be) the reference for design of the transport system. However, this standard has been reconsidered. Ideally, for successful aging of older adults, the entire transport system is designed in such a way that literally all individuals are able to use it. However, all human beings (including older adults) differ. Certain aspects of the design of the mobility system can present a benefit for a specific group of individuals, while these aspects present a cost for another group of individuals. Thus, the question is which individuals (or better; which range of individuals) are be used as the reference for the design of the mobility system. In this scenario, the reference for design is no longer the autochthons young male, but more an average human being.

A good reason to take account the abilities of older adults, is that in general, the aspects of the design of the mobility system that present benefits for older adults, do present benefits for other groups of individuals (for instance youth) as well. As the transport system is designed in such a way that it is suitable for older adults, other groups such as children are also able to use it. From this point of view, the cognitive capacities of older adults can be used as a benchmark throughout the design of the transport system. By doing so, a part of the consequences of aging of modern society are taken into account. As argued before, recognisability, complexity and workload are considered to be the most important aspects of infrastructural design.

However, it has to be noted here that there will always be a group of individuals (possibly including older adults) that are not able to use the regular transport system. These individuals are typically dependent on other people, or demand responsive transport.

The fourth dynamic is **implementation of ADAS technologies**. In 2035, several new technological developments are used in order to contribute to the road safety of older adults. The technologies are typically known as Advanced Driving Assistance Systems (ADAS)[14]. With regard to driving, there is a variety of new technologies that intervene when the physical impairments of older adults pose problems. Possible technologies are lane-departure systems, systems that take over when individuals become unwell, systems that warn help when an accident occurs and systems that guard the distance with the next road user. The driving function has been taken over as much as possible by these new technologies. However, it remains possible to overrule these systems. As a result of the implementation of these new technologies, traffic participants have an increasing monitoring function, and a decreasing driving function.

Perhaps, a part of the existing road signs can disappear, as information is provided by in-car technologies. However, not all road sings have disappeared, since the most crucial signs remain present as a backup when technological systems fail. This kind of technological development is desirable, as long as it decreased the mental strain on older adults. One solution here is to present information in the direction of (for instance) the danger. Thus, when danger approaches from the left, information is presented on the left.

Older adults typically have a positive attitude towards new technologies (such as technologies that are able to park a car independently), as long as new technologies do not make older adults nervous. Market parties, such as car manufacturers and transport organizations for instance, have been aware of aging of the society for a long time. Consequently, in 2035, market parties anticipated independently on this development. Ideally, costs for the development of assistive technologies are paid by the market. As new technologies are applied on a large scale, the (purchase) price of (for instance) a car does not necessarily have to be increased.

In the past, actual implementation of these new systems was often restricted by national legislation. In 2035, ideally, the national government created a vision on this kind of new technologies. Based on this vision, the government provides guidelines for the direction wherein these technologies are developed. Consequently, the national government plays a role in the development of new technologies, by providing legislation specifically aimed as these technologies. Moreover, the government intervenes when the implementation of new technologies creates unexpected dangerous situations. An example here is the use of a navigation system in a microcar. Navigation systems provide information on routes that are not suitable for microcars. This is not only a problem for comfort, but (more importantly) for safety. On the European level, policy makers have already been aware of the demographical development of aging for a long time. As a result, there are several projects that aim on the development of new technologies. However, in the past, these European projects are very broad and general. These projects should are currently more specific.

The fifth dynamic is **education of traffic rules**. With regard to traffic rules and regulation, in 2035, older adults have the possibility to follow an additional education. By enhancing the understanding of traffic rules and regulation, the traffic behaviour of older adults is improved.

[14] Perhaps, older adults (as well as other individuals) only drive the car themselves in their own neighbourhoods. When older adults reach more busy roads, they lock in to a system that drives the car independently to their destination. Thus, in 2035, there are guiding systems built in the infrastructure. With use of these systems, cars (as well as buses, etc.) can drive independently. These systems are implemented on the main roads, so that 'trains' of vehicles can be formed.

Furthermore, throughout this education, it is emphasized how the mobility system works and how older adults can deliberately use the mobility system.

The sixth dynamic is **dispersion of services and facilities**. As older adults live dispersed in this scenario, services and facilities are located dispersed as well. Again, the distinctions between services and facilities in rural and urban areas should be taken into account here. In urban areas, there are more services and facilities available than in rural areas however. Therefore, the overall availability of services and facilities has decreased. Especially in shrinking areas, the availability of services and facilities has decreased dramatically, as an significant proportion of the populations has moved to urban areas over the last years. Consequently, the average distance that older adults have to travel to services and facilities has increased.

The seventh dynamic is **online services and facilities**. In 2035, a part of the traditional services and facilities is replaced by services and facilities that are not bounded to a certain location. These services and facilities are typically available online. For instance, services and facilities such as grocery stores, have been replaced by delivery services. In a similar way, traditional medical services and facilities have been replaced by online medical services. An example here is an online service for the intake with doctors.

The eighth dynamic is **age resistant neighbourhoods**. As described as a core dynamic, older adults live dispersed in this scenario. Several rationales are proposed for dispersed living, for instance that older adults typically do not like to move and wish to live among other individuals. As described, the neighbourhood older adults live in is an important issue. However, as older adults live dispersed, there are no neighbourhoods where only older adults live in. Consequently, neighbourhoods are not designed specifically for older adults. Therefore, the neighbourhood is not specifically designed for older adults to walk in, or use assistive devices.

However, improvements are made for older adults, as during the design process, it is kept in mind that all inhabitants age and that the composition of the inhabitants can change over time. Therefore, neighbourhoods are designed to be 'age-resistant'. Perhaps, a dynamic neighbourhood design is developed. Dependent on the exact composition of the population of a certain neighbourhood, the design can be adapted to meet the specific demands of the population.

The ninth dynamics is **demand responsive transport**. In this scenario, for independent mobility, older adults are dependent on the ability to use the car. Several improvements aim at prolonging the time that older adults are able to drive a car. However, when older adults are no longer able to drive a car themselves, they become dependent on others. A possibility here is that social relations of older adults drive them around. However, when there are no social relations that are able to help older adults, they become dependent on demand responsive transport. Therefore, in 2035, demand responsive transport is provided. Demand responsive transport is truly available at the times that older adults wish to be mobile, without the need to make reservations. Thus, demand responsive transport provides a safety net for older adults that are no longer able to be mobile independently.

The tenth dynamic is **time restrictions**. In 2035, older adults are encouraged to travel at favourable times. Travelling in peak hours can be problematic for older adults, as this is more demanding than travelling during the rest of the day. As a result, in this scenario, older adults'

active engagement with life is restricted, as travelling during peak hours has become too demanding (at least for a proportion of the group of older adults).

The eleventh dynamic is **cost restrictions**. In 2035, the fixed costs of driving a car are expected to have been decreased. However, the variable costs have increased, as tax is increased by the national government.

4.5.2 Implications for successful aging

In this section, the implications of the described scenario for successful aging are discussed. In order to do so, the described dynamics are related to the theoretical framework. As described, older adults live dispersed in this scenario. In the theoretical framework, density is indicated as a characteristic of the land-use system. The land-use system influences engagement with life of older adults. More precisely, dispersed living does not appear to contribute to the ability to access social relations, as a part of the social relations of older adults (other older adults) do not live in the same neighbourhood. The same holds for social activities. Thus, as older adults live concentrated, no contributions is made to these parts of engagement with life.

In this scenario, the transport system is dependent on the car. The mobility of older adults is facilitated by prolonging the time older adults are able to drive a car. Again, this does not influence successful aging directly. However, the dynamics that refer to the transport system in this scenario are all based on the fact that the transport system does only include the car.

As described, at distributor roads, road safety is improved in this scenario. This can easily be related to the theoretical framework, as road safety is part of safety issues, influencing the first dimension of successful aging, risk.

Older adults are enabled to drive as long as possible, by distinguishing different driving licenses for cars. By doing so, the road safety of older adults is enhanced. Consequently, a contribution is made to the risk dimension. However, this negatively affects engagement, as no other options for transport are available. In this scenario, no alternatives are available that can compensate for this decrease of engagement, as the car is the only (independent) transport option. Thus, as in the first scenario, a tension between risk and engagement exists. However, in this scenario, no solution is provided for this issue.

As described, the reference for infrastructural design is reconsidered in this scenario. The reference for infrastructural design has become more an average individual. As a result, recognisability, complexity and workload have been reduced. Consequently, traffic participation has become less demanding, in comparison with the past. Obviously, this reduces cognitive strain and stress, which is indicated as part of usability issues in the theoretical framework, influencing the perception of capacity. Thus, the reconsideration of the reference for infrastructural design contributes to the second dimension of successful aging, capacity. The other dimensions of successful aging, risk and engagement, are positively affected as well by this reconsideration. However, it has to be noted that there are restrictions here, since older adults are not taken as the reference for design. Thus, although a contribution is made to usability issues, not all older adults will be able to participate in traffic. Furthermore, as older adults live dispersed in this scenario, the neighbourhoods they live in are not specifically designed for them.

Several ADAS technologies are implemented throughout this scenario. These technologies primarily aim to simplify the driving task. Thus, these technologies decrease the cognitive and physical demands for driving. Cognitive strain and stress and physical strain are indicated in the theoretical framework as part of usability issues, influencing older adults' perception of capacity. Thus, by implementing ADAS technologies, a contribution is made to the second dimension of successful aging. It has to be noted that the contribution of ADAS to capacity affects risk as well, as simplifying the driving task with use of ADAS technologies also contributes to road safety. Furthermore, as capacity is a condition for engagement (presented by arrow b in the theoretical framework), ADAS technologies positively affect engagement as well. As indicated, ADAS technologies should be designed carefully, as they have the potential to present too much signals. In terms of successful aging, ADAS technologies have the potential to negatively affect the perception of capacity, possibly negatively affecting the dimensions risk and engagement.

As described, education on traffic rules is provided for older adults in this scenario. Education can be related to required exercise, as indicated as part of usability issues in the theoretical framework. As usability issues influence capacity, education of traffic rules contributes to the older adults' perception of capacity. However, a contribution to this dimension of successful aging positively affects the first dimension (risk) and third dimension (engagement) of successful aging as well.

Older adults live dispersed in this scenario. In the theoretical framework, density is indicated as a characteristic of the land-use system, influencing engagement with life of older adults. As older adults live dispersed, a part of their social relations (other older adults) will not be located in the direct neighbourhood. The same holds for social activities. Thus, where concentrated living contributes to the ability to access social relations and activities, dispersed living does not do this.

However, it has to be noted that although older adults do not live near each other, this does not mean that they do not live among other people at all. Dependent on the population density (more urban or rural), other social contacts and activities will be available for older adults. Nevertheless, in order to access social contacts and activities outside the neighbourhoods where older adults live, they are dependent on the transport system. As older adults live dispersed, no options can be provided for combined transport. Options that as carpooling and car sharing, as described in the focus scenario are not possible. Older adults are dependent on car for their outdoor mobility.

As described, older adults live dispersed in this scenario. As a result, services and facilities are not located in the neighbourhoods older adults live. Just as the dwelling of older adults, the services and facilities itself are located dispersed. Therefore, the overall availability of services and facilities has decreased. Especially in shrinking areas, the availability of services and facilities has decreased dramatically, as an significant proportion of the populations has moved to urban areas over the last years. Consequently, the average distance that older adults have to travel to services and facilities has increased, negatively affecting the ability to access services and facilities. Obviously, this influences the ability to access services and facilities (as a part of engagement with life) for older adults, as indicated in the theoretical framework. Consequently, older adults are dependent on the transport system in order to access services and facilities. As the transport system is car-dependent in this scenario, older adults are dependent on the use of the car in order to access services and facilities. As long as older

adults are able to drive a car, this is no problem. However, when older adults are no longer able to drive a car, (interpedently) accessing services and facilities becomes problematic.

Online services and facilities are provided in 2035. This dynamic can be related to the theoretical framework, as the ability to access services and facilities is part of the third dimension of successful aging, engagement. In terms of successful aging, these online services positively affect the ability to access services and facilities. However, one can argue that active engagement with life is negatively affected when services become available online, since older adults do not have to leave their dwelling in order to access these services. Perhaps, this increases social isolation. Therefore, although this kind of services is well available, they do not have to be used by older adults at all times. Ideally, these online services can provide a safety net, when older adults temporarily are not able to (or do not want to) leave their dwelling. By using these online services as a safety net, older adults' active engagement with life is optimized, in stead of negatively affected.

As described, older adults live dispersed in this scenario, as they typically do not like to move. In order to facilitate this, neighbourhoods are designed to be age resistant in this scenario. Neighbourhood design is indicated as a characteristic of the land-use system in the theoretical framework, influencing engagement with life of older adults. However, the extent to which neighbourhood design actually facilitates older adults to access social relations, activities and services and facilities is dependent on the availability in the neighbourhood. In urban areas, these will be more widely available. However, in rural areas, these will be less available. Therefore, age resistant neighbourhoods are expected to contribute more to engagement in urban areas than in rural areas. Nevertheless, as age resistant neighbourhoods enable older adults to be have the benefits of physical movement, which is presented by arrow c in the theoretical framework.

In this scenario, demand responsive transport is provided as an appropriate safety net for individuals that are not able to use the regular transport system. The availability of demand responsive transport can be related to the theoretical framework in several ways. Demand responsive transport is a transport option that is available at the dwelling of older adults. Thus, the distance to this transport connection is typically low. Moreover, the availability of demand responsive transport improves the reliability of the transport system. These are all parts of the transport system that contribute to the third dimension of successful aging, engagement. However, there is another side to demand responsive transport. When older adults are dependent on demand responsive transport, their successful aging is negatively affected, as they are no longer able to independently be actively engaged with life.

As described, the transport system is dependent on the car in this scenario. Several improvements are presented which prolong the ability to use a car for older adults. However, as the mobility chain is formed by solely the car, the reliability of the mobility chain is rather low in this scenario. As described, when older adults are not able to use a car (for instance when they are no longer able to do so, or when it breaks down), older adults' ability to be independently use the transport system becomes problematic. In the theoretical framework, reliability is indicated as part of quality issues, influencing engagement with life. Thus, as the reliability of the transport system is totally dependent on the use of the car in this scenario, engagement (outside the neighbourhoods of older adults) can easily become problematic.

Older adults are encouraged to travel at favourable times in 2035. Time is indicated as a resistance of the transport system in the theoretical framework, which influences the third

dimension of successful aging, engagement. As older adults are encouraged to travel at favourable times, their engagement with life is negatively affected.

As described, the fixed costs of driving a car have decreased in 2035. However, the variable costs have increased. Costs are indicated as a resistance of the transport system in the theoretical framework, which influences the third dimension of successful aging, engagement. Since older adults are dependent on the car for their mobility, the financial status of older adults has become extremely important for older adults' engagement in this scenario. In the trend-like dynamics, it has been argued that differences in financial status of older adults will have been increased in 2035. As a result, it can be expected that there is a group of older adults that are not able to afford to drive a car. For this group, engagement becomes almost impossible.

Concluding, in a mobility system based on dispersed living and car-dependent transport, several contributions can be made to successful aging. Optimizing distribution roads and examination of driving abilities contribute to the first dimension of successful aging, risk. However, examination of driving abilities implies that driving licenses of older adults can be withdrawn. As argued, this negatively affects the third dimension of successful aging, engagement. Reconsideration of the reference for infrastructural design, implementation of ADAS technologies, and education of traffic rules contribute to the second dimension of successful aging, capacity. These contributions potentially affect risk and engagement. As argued, dispersed living, dispersion of services and facilities, online services and facilities, age resistant neighbourhoods, time restrictions and cost restrictions influence the third dimension of successful aging, engagement.

However, dispersed living and dispersion of services and facilities partly restricts engagement with life in the neighbourhood of older adults. In rural areas, this is more important than in urban areas. Services and facilities can partly be provided online. However, one can argue that this in fact contributes to social isolation. As a result, older adults are dependent on the use of the transport system for their engagement with life. Since the transport system is based on the car, older adults rely on the use of the car for their independent engagement with life. As argued, improving the usability of the car prolongs the time older adults are able to drive a car. However, when older adults are not (longer) able to use a car, independent engagement becomes problematic. Furthermore, several in terms of time and costs are present in this scenario, which are resistances to the use of the car. Thus, although contributions can be made to the first and second dimension in this scenario, the third dimension (which in fact is the dimension wherein mobility plays a role) is largely dependent on the ability to use a car.

4.6 Scenario 3 – Concentrated living, car-dependent transport

4.6.1 Scenario description

This scenario is based on concentrated living and car-dependent transport. Thus, it is based on a similar land-use system as in the first scenario, and a similar transport system as in the second scenario. Consequently, this scenario includes the dynamics from the first scenario that relate to the design of the land-use system. Furthermore, this scenario includes the dynamics from the second scenario that relate to the design of the transport system. Thus, the dynamics that form describe this scenario are optimization of distributor roads, examination of driving abilities, protection of neighbourhoods, differentiation of reference for infrastructural design, implementation of ADAS technologies, education of traffic rules,

concentration of services and facilities, optimization of neighbourhood design, dedicated transport options, demand responsive transport, time restrictions and cost restrictions.

4.5.2 Implications for successful aging

As argued, this scenario includes dynamics that are described in the first and second scenario. The implications of individual dynamics for successful aging have already been described in the first and second scenario as well. Concluding, optimization of distributor roads, examination of driving abilities and protection of neighbourhoods contribute to the first dimension of successful aging, risk. Again, examination of driving potentially affects engagement negatively. Differentiation of reference for infrastructural design, implementation of ADAS technologies and education of traffic rules contribute to the second dimension of successful aging, the perception of capacity. These contributions all positively affect the risk and engagement dimension. Concentration of services and facilities, optimization of neighbourhood design, dedicated transport options and demand responsive transport contribute to the third dimension of successful aging, engagement. Time restrictions and cost restrictions influence engagement as well.

Thus, as older adults live concentrated, engagement with life is to a certain extent possible in the neighbourhood older adults live in. However, for a part of engagement, it older adults will have to access locations outside their neighbourhood as well. For instance in order to access social contacts and activities that are located outside the neighbourhood, or in order to access services and facilities that are typically visited less frequently. Furthermore, in order to travel and go sightseeing, mobility outside the neighbourhood is required typically. However, in this scenario, older adults are typically dependent on the car, in order to reach these destinations. Thus, when older adults are no longer able to drive a car, independent active engagement with life becomes problematic. As older adults live concentrated, older adults that are still able to drive can perhaps take older adults that are no longer able to drive with them. Hence, older adults that are no longer able to drive are placed in a rather dependent position in this scenario. Furthermore, for older adults that are no longer able to independently drive a car, demand responsive transport provides an opportunity to be engaged with life outside the neighbourhood.

4.7 Scenario 4 – Dispersed living, multimodal transport

4.7.1 Scenario description

This scenario is based on dispersed living and multimodal transport. Thus, it is based on a similar land-use system as in the second scenario, and a similar transport system as in the first scenario. Consequently, as the third scenario, this scenario includes a mix of dynamics presented in the first and second scenario. This scenario includes the dynamics from the second scenario that relate to the design of the land-use system. Furthermore, this scenario includes the dynamics from the first scenario that relate to the design of the transport system. Thus, the dynamics that form describe this scenario are reconsideration of the place of modalities in the transport system, separation of traffic flows, examination of abilities and support, supervision in public transport, reconsideration of reference for infrastructural design, physical accessibility of the mobility chain, education of the mobility chain, dispersion of services and facilities, online services and facilities, age resistant neighbourhoods, comfort of the mobility chain, reliability of the mobility chain, maximization of flexibility in terms of time and maximization of flexibility in terms of costs.

4.7.2 Implications for successful aging

As argued, as in the third scenario, this scenario includes dynamics that are described in the first and second scenario. Again, the implications of individual dynamics for successful aging have already been described in the first and second scenario. Concluding, reconsideration of the place of modalities in the transport system, separation of traffic flows, examination of abilities and support and supervision in public transport contribute to the first dimension of successful aging, risk (and examination potentially affects engagement negatively). Reconsideration of reference for infrastructural design, physical accessibility of the mobility chain and education of the mobility chain contribute to the second dimension of successful aging, the perception of capacity (and positively affect risk and engagement). Dispersion of services and facilities influences the third dimension of successful aging, engagement. Online services and facilities, age resistant neighbourhoods, comfort of the mobility chain, reliability of the mobility chain, maximization of flexibility in terms of time and maximization of flexibility in terms of costs contribute to engagement.

Thus, as older adults live dispersed, engagement with life is facilitated less (in comparison with scenarios wherein older adults live concentrated). In order to access social relations, social activities, services and facilities, and travel and go sightseeing, older adults are dependent on the transport system. However, for engagement with life outside the neighbourhood, several transport options are provided for older adults, as the transport system includes multiple modalities.

4.8 Wild cards

One dynamic cannot be related to the scenarios. This dynamic is a wild card, which is presented here. The wild card is **individualization**. The future development of the social phenomenon of individualization is rather uncertain, based on the findings from the interviews.

Several interviewees argued that the Dutch society is further individualized and ‘hardened’ in 2035. In this case, older adults are more independent and reason from their own point of view. Moreover, older adults will be less interested in costs for other people. The society may even be extremely individualized in 2035. In this case, people have even become afraid of real personal contact. All social contact is digital and groceries are ordered and delivered. Consequently, a large share of society (the middle class) does not leave their homes. Possibly, travelling has become very expensive, so that only the upper class of the society can travel (guarded). However, the lower class of society travels as well, in order to facilitate the individual life of the middle class.

However, several other interviewees argued that the current trend of individualization in the Dutch society has come to an end in 2035. One of the causes for this development is the less important role the government plays in society, resulting in less services and facilities. The government only takes care of a small group of people (only the people who needs it most). Consequently, in this case, older adults will be more dependent on their own social environment, that helps them. The solidarity has increased through this development, resulting in a less individualized society.

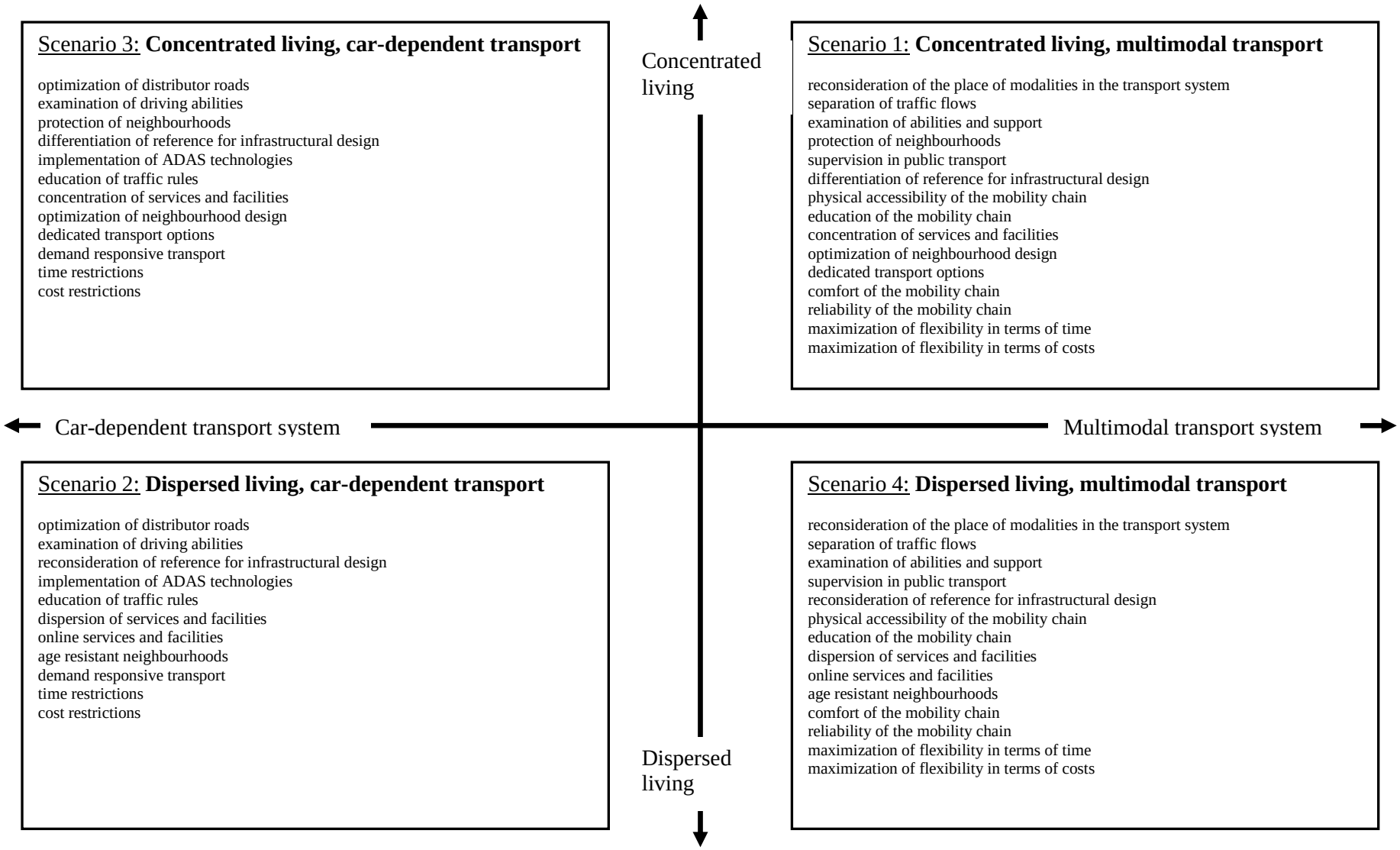

Figure J: Dynamics in scenarios

Scenarios / Dimensions successful aging	**Scenario 1:** **Concentrated living, multimodal transport**	**Scenario 2:** **Dispersed living, car-dependent transport**	**Scenario 3:** **Concentrated living, car-dependent transport**	**Scenario 4:** **Dispersed living, multimodal transport**
Risk	-reconsideration of the place of modalities in the transport system -separation of traffic flows -examination of abilities and support -protection of neighbourhoods -supervision in public transport	-optimization of distributor roads -examination of driving abilities	-optimization of distributor roads -examination of driving abilities -protection of neighbourhoods	-reconsideration of the place of modalities in the transport system -separation of traffic flows -examination of abilities and support -supervision in public transport
Capacity (the individual perception of…)	-differentiation of reference for infrastructural design -physical accessibility of the mobility chain -education of the mobility chain	-reconsideration of reference for infrastructural design -implementation of ADAS technologies -education of traffic rules	-differentiation of reference for infrastructural design -implementation of ADAS technologies -education of traffic rules	-reconsideration of reference for infrastructural design -physical accessibility of the mobility chain -education of the mobility chain
Engagement	-concentration of services and facilities -optimization of neighbourhood design -dedicated transport options -comfort of the mobility chain -reliability of the mobility chain -maximization of flexibility in terms of time -maximization of flexibility in terms of costs	-dispersion of services and facilities -online services and facilities -age resistant neighbourhoods -demand responsive transport -time restrictions -cost restrictions	-concentration of services and facilities -optimization of neighbourhood design -dedicated transport options -demand responsive transport -time restrictions -cost restrictions	-dispersion of services and facilities -online services and facilities -age resistant neighbourhoods -comfort of the mobility chain -reliability of the mobility chain -maximization of flexibility in terms of time -maximization of flexibility in terms of costs

Figure K: Results for successful aging

4.9 Backcasting

In the previous sections, the results of this research are described. Several trend-like dynamics are presented, that cannot be influenced within the scope of this research. Consequently, the trend-like dynamics form the context wherein all scenarios should be seen. Hereafter, based on the two core dynamics, four scenarios are identified. The scenarios are described, by including the dynamics that can be logically related to the specific scenario. These results (scenarios and logically related dynamics) are schematically presented in figure J. Moreover, for every scenario, the results for the dimensions of successful aging are presented in the previous sections, by relating them to the theoretical framework. These results are presented schematically in figure K. In this section, the results from the previous sections are further analyzed. By doing so, insight is provided in what can be undertaken in order to achieve described future mobility systems.

The scenario analysis shows that the core dynamics of the mobility system are the dwelling situation of older adults (as part of the land-use system) and the modalities in the transport system (only the car, or multiple modalities). Furthermore, the scenario analysis shows that different combinations of these most important influences on structural change provide different possibilities to contribute successful aging. Moreover, these scenarios all have other results for successful aging.

Perhaps, from the perspective of successful aging, the first scenario can be indicated as most favourable for successful aging, as engagement is facilitated in the older adults' neighbourhood. Outside the neighbourhood, engagement is facilitated by the mobility chain. Likewise, from the perspective of successful aging, the second scenario can perhaps be indicated as least favourable for successful aging, as engagement can be facilitated less well in older adults' neighbourhoods. Outside the neighbourhood, engagement is facilitated less well, as the transport system is dependent on the use of the car. Henceforth, the third and fourth scenario can be indicated as moderately favourable from the perspective of successful aging.

The scenarios give valuable insight, especially on the dimension 'active engagement with life'. When the four different scenarios are referred to each other, it becomes evident that for successful aging, the influence of land-use system and the transport system cannot be perceived separate from each other. In general, the four scenarios show that successful aging (active engagement) is influenced by both the land-use and the transport system. In the two scenarios based on concentrated living, successful aging is less dependent on the transport system. Likewise, in the two scenarios based on dispersed living, successful aging is more dependent on the transport system. In a similar fashion, in the two scenarios based on car-dependent transport, successful aging is more dependent on the land-use system. In the two scenarios based on a multimodal transport, successful aging is less dependent on the land-use system

It has to be noted again, that these images of the future should not be seen as likely futures. As argued before, the scenarios aim to give policy maker and interested public images of the future. These images provide a background, in order to form opinions and make decisions. Since the future of the mobility system is partly dependent on the implementation of policy, nothing can be said about the most likely future.

As argued, throughout the interviews, it is argued that older adults possibly prefer to live concentrated. However, it is argued as well, that older adults possibly prefer to live dispersed. Logically, it can be expected that the dwelling situation of older adults is an individual choice. It is not considered to be likely that all older adults live concentrated in 2035, or that all older adults live dispersed. Thus, the future mobility system is expected to be a mix of different presented scenarios.

However, throughout the interviews, it is argued that it is not considered to be possible to provide a multimodal transport system for older adults that live dispersed. The financial resources necessary to provide such a transport system are considered to be too high to be feasible. Consequently, the fourth scenario is not considered to be economically feasible. Therefore, this scenario is left out of further analysis. However, this scenario illustrates that older adults that live dispersed, can typically be expected to be dependent on the use of the car for their (independent) mobility, and therefore engagement (as is the case in the second scenario).

On the contrary, when older adults do live concentrated, it is considered to be possible to provide a multimodal transport system, including public transport. Thus, the first scenario is considered to be economically feasible. However, the description of the first scenario indicates that several improvements can, and have to be made in order to provide suitable (public) transport options for older adults. When these improvements are not made, perhaps, older adults will not use other transport options than the car, as is the case in the third scenario.

However, the third scenario presents an image of a future structure of the mobility system that can be considered to be less desirable in terms of successful aging than the first scenario. Indeed, providing more suitable transport options contributes successful aging, in particular the third dimension, engagement. For this reason, it can be argued that a multimodal transport system should be provided (for older adults), where possible. Consequently, the first and second scenario present the most important scenarios to focus on here.

As argued, future older adults are expected to live both concentrated and dispersed. Dependent on the dwelling situation of older adults (concentrated, or dispersed) contributions to the mobility system can be made, in order to facilitate successful aging, as described in the first and second scenario. Throughout the scenario analysis, dynamics are logically related to the specific combination of core dynamics. However, this does not mean that they cannot exist per definition in other scenarios. For instance, dynamics that aim to prolong older adults' ability to drive are presented in the description of the second (and third) scenario. Indeed, these dynamics can be placed in this scenario most logically. However, in a multimodal transport system, the time older adults are able to drive can obviously be prolonged as well. The same holds for the availability of demand responsive transport. Several issues are important for all scenarios (examination / support, reference for infrastructural design, education of mobility chain / traffic rules, and others).

Perhaps, a map could be drawn of the current state of the mobility system in the Netherlands, in terms of the core dynamics that distinguish the four scenarios. Thus, different parts of the Netherlands present opportunities to focus specifically focus on the first or second scenario. For instance, the described shrinking areas present mobility systems wherein older adults typically live dispersed. In these areas, policy measures can focus on the contributions presented in the second scenario. On the other hand, in places described as Doorn, older

adults typically live concentrated. In areas like the city of Doorn (where older adults live concentrated), policy measures can focus on the contributions presented in the first scenario[15].

As indicated in the theoretical framework, the dimensions of successful aging in itself relate to each other. The first dimension is a partly a condition for the second dimension, and the second dimension is partly a condition for the third dimension. The other way around, the third dimension has the potential to reinforce the second dimension, and the second dimension the first dimension. The analysis shows that measures that contribute to the first dimension of successful aging, affect other dimensions as well. As the first dimension is partly a condition for the other dimensions, several measures contributing to the first dimension, contribute to the third dimension of successful aging as well. One important finding from the scenario analysis that deserves to be mentioned here is that there is tension between the first dimension of successful aging (risk) and the third dimension of successful aging (engagement). Dynamics that contribute to the safety of older adults, possible affect engagement negatively. Thus, these contributions should be considered carefully, as older adults' engagement with life is possibly harmed.

5 Conclusions

In this section of the research, the research questions of the research are answered. The main question that this research addresses is: *"How can mobility systems contribute to successful aging and what can be learned from different future scenarios?"* As described, in order to answer the main research question, three sub-questions are used throughout this research: *"What is the role of mobility in successful aging?"*; *"How do mobility systems influence successful aging?"*; *"How can different future scenarios of the mobility system be described*?"

The theoretical framework addresses the first and the second sub-question. Throughout the theoretical framework, it is argued that mobility plays a role in the third dimension of successful aging (active engagement with life). Based on other theories, four different roles of mobility are identified. These are the ability to access social relations, access social activities, access services and facilities, and to travel and go sightseeing.

Furthermore, throughout the theoretical framework, it is argued that the mobility system influences the dimensions of successful aging. The first dimension of successful aging is influenced by safety issues, including both road safety and social safety. The second dimension of successful aging is influenced by usability issues, including cognitive strain and stress, physical strain, required exercise and comfort. It has to be noted that usability issues do not influence the second dimension in absolute terms. However, usability issues influence older adults' perception of the second dimension. The third dimension of successful aging is influenced by the land-use system including the dwelling situation of older adults, the availability of services and facilities, neighbourhood design and transport options. Furthermore, this dimension is influenced by quality issues, including reliability and information. Moreover, time and costs present an influence on this dimension.

[15] When it is failed to provide a multimodal transport system (for instance by inadequate policy measures), the transport system can be expected to be car-dependent, resulting in a mobility system as presented in the third scenario. Successful aging is possible in such a situation. However, based on the theoretical framework, successful aging is less easy as in the first scenario.

With regard to the third sub-question, four different future scenarios are identified during the research, based on two key dimensions (core dynamics). The first key dimension relates to the design of the land-use system. This is the dwelling situation of older adults, which can be concentrated, or dispersed. The second key dimension relates to the design of the transport system. This dimension is formed by the different available modes of transport. A distinction is made between a transport system that is dependent on the car, and a multimodal transport system.

The main research question addresses how future mobility systems can contribute to successful aging and what can be learned from the different future scenarios. By relating the findings from the scenario analysis to the current situation, several things can be learned. The scenario analysis shows that different combinations of these most important influences on structural change provide different possibilities to contribute successful aging. Moreover, these scenarios all have other results for successful aging.

The scenarios give valuable insight, especially on the dimension 'active engagement with life'. The influence of land-use system and the transport system cannot be perceived separate from each other. In general, the four scenarios show that successful aging (and in particular engagement) is influenced by both the land-use and the transport system. For instance, in the two scenarios based on concentrated living, successful aging is less dependent on the transport system. Likewise, in the two scenarios based on dispersed living, successful aging is more dependent on the transport system.

It is not considered to be likely that all older adults live concentrated in 2035, or that all older adults live dispersed. Thus, the future mobility system is expected to be a mix of different presented scenarios. Dependent on the dwelling situation of older adults (concentrated, or dispersed) contributions to the mobility system can be made, in order to facilitate successful aging, as described in the first and second scenario. Several issues prove to be relevant for all scenarios.

Perhaps, a map could be drawn of the current state of the mobility system in the Netherlands, in terms of the core dynamics that distinguish the four scenarios. Thus, different parts of the Netherlands present opportunities to focus specifically focus on the first or second scenario. One last finding from the scenario analysis that deserves to be mentioned here is that there is tension between the first dimension of successful aging (risk) and the third dimension of successful aging (engagement).

6 Discussion

Noticeably, this research has several shortcomings. These shortcomings, mainly concerning the theoretical framework and methodology, are discussed in this section. Throughout this research, the theory of successful aging has been utilized in order to obtain insight in the wellbeing of older adults. This theory has several strong points. The theory of successful aging allows to include physical and cognitive health, as well as aspects relating to behaviour. As argued, the theory of successful aging cannot be used as an objective measurement of the wellbeing of older adults, since older adults perceive criteria for successful aging differently. Nevertheless, the theory of successful aging does provide three general mechanisms that head for successful aging. It would be interesting to use another theory for the wellbeing of older adults, in combination with the transport theory in future research. By doing so, the contributions of the mobility system on the wellbeing of older adults indicated in this

research, can perhaps be validated. Or possibly, other contributions of the mobility system on the wellbeing of older adults can be identified. Thus, by using another theory (or other theories) for the wellbeing of older adults, more comprehensive insight in the contribution of mobility systems on the wellbeing of older adults can be provided. Furthermore, it would be interesting to continuing the methodological steps with another theory of the wellbeing of older adults. This could result in the same, or other future scenarios, respectively underlining this research or providing more insight on important elements (in terms of the wellbeing of older adults) of future mobility systems.

By following the methodology of this research, four different scenarios are created. As argued, these future scenarios are not the most plausible future scenarios. Instead, the scenarios are extreme situations, that provide insight in the (different) contributions of the mobility system to successful aging. Both the focus scenario and the worst-case scenario are coherent stories, that appear to be feasible. Indeed, a proportion of the future older adults can be expected to live concentrated. Likewise, other older adults will live dispersed. Moreover, it certainly is possible that the transport system consists of multiple modalities in the future, as it does currently. However, it is possible as well that the car becomes by far the most important mode of transport (as it is the case in the United States). The scenario based on concentrated living and car-dependent transport is possible future vision as well. However, the scenario based on dispersed living and multimodal transport is considered to be less feasible. In order to provide public transport, it has been argued that concentrations of dwellings are required. When individuals live dispersed, it becomes less feasible to provide public transport.

The issue described above in fact introduces another discussion point. Throughout this research, the difference between urban and rural areas has not been discussed extensively. However, for the availability of services and facilities, as well as transport options, the difference between urban and rural areas is important. Urban areas (concentrations, but not necessarily of older adults) provide a basis for more services and facilities, and transport options. Thus, the density of the area where older adults live in, has influence on their active engagement with life. In concentrated areas, active engagement with life will be more easy, both in the direct neighbourhood, as well as outside the neighbourhood (as more transport options can be provided).

By following the steps that are presented in the methodology, two core dynamics are identified. These core dynamics present the most important dimensions of the (four different) future scenarios. It has to be noted explicitly that these dimensions, as well as all other results, follow from the interviews. Thus, the sample of interviewees has a very high influence on the future scenarios. As indicated, in four different groups, as much interviews were conducted as possible given the limitations. Although the number of interviewees is limited, towards the last interviews, no real new opinions were stated. Consequently, it can be considered that an appropriate degree of saturation of interview results has been achieved. It is not expected that by conducting more interviews, new results are gathered, that change the core dynamics of the scenarios.

An important discussion point refers to one of the core dynamics. Whether older adults live concentrated or dispersed will remain an individual choice. Some older adults will prefer to live concentrated, and others will prefer to live dispersed (alone, or among others). Throughout several interviews, it has been argued that for the wellbeing of older adults, it is important that they live among other, younger people. However, this issue is not included in the theoretical framework (or more precisely, the theory of successful aging) that is used

throughout this research. Although the living situation remains an individual choice, it has consequences for successful aging, and in particular for the degree to which older adults can be actively engaged with life in their own neighbourhood.

Throughout the interviews, several comments are made on the scope of this research. As described, this research focuses on third age older adults. It has been argued that absolute ages are not suitable to identify boundaries for this group of older adults. However, to give an idea of the approximate age boundaries of this age group, ages of 60 and 80 years are mentioned. One of the interviewees argued that the lower boundary should be changed to 55 years, since the first illnesses begin to play a role in the daily life of adults at approximately 55 years old. In fact, this illustrates the statement that absolute ages are not suitable to indicate the group of third age older adults.

One of the interviewees argued that aviation should be included in this research as well, since travelling with an airplane will perhaps become increasingly important in the future. It is argued that in particular for older adults, travelling with an airplane increases the chance of thrombosis (the so-called 'economy class syndrome'). There are multiple cases known of older adults who died after travelling with an airplane as a result of this. However, as described earlier, this research focuses on land-based transportation. Future research could focus on the contribution of aviation to the wellbeing of older adults. In order to study aviation, the theory of successful aging could be utilized again. However, the transport theory used throughout this research does not appear to be suitable, as a lot of modes of transport are mentioned in this theory, except for aviation. Consequently, other transport theory should be used when studying aviation.

7 References

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