# D1.1 Literature review of the older adults' mobility needs and services for mobility

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The Happy Walker Consortium consists of the following partners:










# Contents

# Figures and tables

## Figures

**No table of figures entries found.**

## Tables

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# 1. Introduction

## 1.1 The literature review

The Happy Walker project is summarised in this introduction to place the required perspective of the literature that was surveyed to complement this project. The purpose of this literature review is as follows:

- Characteristics of the older adults with no or mild (widely spread) functional and cognitive and mobility limitations will be identified. The characteristics form a person's profile and include aspects such as health status, physical condition; one owns preferences, and motivation.
- Existing services and technologies used by the older groups with regard to their mobility will be identified.
- Also the review of potential competitors in the market and the state of the art (technology assessment) and IPRs will be performed.
- The literature review is a deliverable of the first work package of the Happy Walker project
- The gathered literature and the information within the literature review will be used as a precursor for the following deliverables within the first work package of this project: co-design sessions; scenarios and user requirements; user interface concepts and specifications of a set of services; user evaluations.

There are three main sections to the literature review:

- A first review will provide a description about the targeted groups namely the elderly with no or mild functional and cognitive mobility limitations. Profiles of the targeted groups will be made to specify the needs and preferences with regards to their mobility.
- A second review will be an inventory of the mobility services that the targeted groups are currently using. The mobility services will be matched with the profiles we made about the targeted groups.
- The third review will report about the current technologies available on the market for the mobility of the elderly.

The reviews will take a European perspective, taking into account the existing technologies and services for the mobility of the elderly available in different European countries
The results for the reviews will be used as input for the preparation of the co-design sessions, and help to identify which participants to invite in the sessions.

## 1.2 The Happy Walker project summary

The mobility of the older adults and its maintenance is seen as a fundamental prerequisite for an autonomous, active and healthy ageing, resulting in a better quality of life. As people

grow older, the likelihood that physical and cognitive problems will appear will grow. Physical problems will be associated with reduced mobility, e.g. due to difficulties in understanding the complex time schedules in public transportation, to make the appropriate choices, or to find the shortest way by bike or walking to the bus or train station, Moreover, due to cognitive impairments, they might get lost. As a consequence, older adults suffering from these problems will lose confidence and mobility. The current technological solutions on the market, that have been developed to enhance mobility, like navigation systems or dedicated websites, have a number of drawbacks for use and acceptance by older adults. They are not designed with and tailored to the older adults who possibly experience (multiple) physical and mental problems due to the ageing process. In addition they are not integrated with the typical objects of daily use such as a walker or a watch. Our challenge will be to develop an ICT-based solution, specifically targeted to the older adults, that sustains the ability of the older adults to use different types of transportation and stimulates active lifestyle.

*Target group*

The targeted group of this project is the older adults from 60 years onwards, living independently at home, with mild or more severe (widely spread) functional and cognitive mobility limitations.

*Innovative idea of the proposal*

The innovation in this project consists of the development of an easily accessible and affordable platform facilitating a consistent, intuitive, personalized, and contextualized set of mobility enhancement services for older adults. Personalization refers to both (current) characteristics of the user (profiling), e.g. physical condition, preferences, motivation, previous knowledge and experience regarding mobility and (current) characteristics of the direct surroundings, e.g. living accommodation, neighborhood and further range of aims and actions of the user such as visiting family, using public transport. Services include stimulating an active life style, enhancing the outdoor safety (features such as for example drop-off detection and finding an accessible and friendly walking/driving route), emergency alarming and localization, providing travel planning and support over heterogeneous transportation means, taking into account the direct surrounding neighborhood, life-style and self-management. The services can be combined with preparation and supervision functions for involved formal and informal caregivers. These services will be optimized for user-friendliness and usefulness by filtering out useful information provided in an unobtrusive way. The services will be integrated in or attached to typically used assistive technology, and/or other objects, which are daily used by the older adult (i.e. wrist watches, walkers or bikes).

*Lead to novel, effective and coherent solution, based on a sound concept and a proven rationale.*

The project develops a solution helping the older adults to prolong their mobility for as long as possible by various means of transport, and by enhancing the levels of autonomy and perceived safety. The developed solution "Happy Walker" (H☺W) is based on the profile, wishes and needs of the older adults and their caregivers (if relevant). The solution of

mobility-maintenance includes a set of core characteristics for the whole group of older adults (60+): it is user-friendly, adaptable and personalized to the person's life style and customs, affordable technology and with a set of integrated services. The H☺W platform will be based on recent trends in (mobile) services, and the previous developments by the involved project partners, already tested in other application domains.

*By stimulating active lifestyle, the Happy Walker* (H☺W) *will increase the joy of life and keep older adults longer away from the institutional care.*

*Affect the end-users*

This project will contribute substantially to the goal of the European Innovative Partnership on Active and Healthy Ageing to increase *healthy* life expectancy of European citizens with two years by 2020. It does so by lowering barriers for ageing people to independently move about outdoors and to take part in society. In turn, enabling older people to be able to continue such activities, stimulates physical and mental activity - driving forces for maintaining and enhancing healthy functioning.

*Testing*

To optimally meet the needs of the older adults, their profiles, wishes and needs will be analyzed and services will be developed in an iterative co-creation process. Two rounds of trials with potential end-users will take place in two countries (Spain and the Netherlands) to allow for diversity. The trial persons will use a mix of the developed services.

*Effort and period to bring idea to market*

After finishing the project, a prototype platform coupled to 2-3 services will be ready for further development and market introduction by the project partners, and a business plan will be available. Market introduction will take another 2-3 years.

# 2. Literature Review

## 2.1 Creating an inventory of target group profiles for the project

Being able to identify the profiles of the people that the project is aimed at helps to be able to plan efficient and successful co-design sessions; helps to understand the people that the project is designed for and allows focus to be placed correctly throughout the project.

### 2.1.1 General target group profiles

In this regard, literature was searched for in similar fields and projects to assess how and why certain profiles are made for this target group. A very large and thorough profiling of the elderly was performed in a collaborative project, "GOAL Growing Older, staying mobile: Transport needs for an ageing society" (1). This was a Seventh Framework Programme project and TNO was involved in this study. TNO, also being one of the partners in the Happy Walker consortium could also make direct contact with the parties involved in the GOAL project, if required. Reference is often made to the SHARE database (http://www.share-project.org). The ICF (International Classification of Functioning, Disability and Health) standards are also mentioned as a means for classifying different profiles

Interesting tables and figures that appear in this study.

| Fully mobile Seniors | Slightly physically impaired seniors | Highly physically impaired seniors |
|---|---|---|
| • Mostly still working<br>• Mostly younger than 70 years old<br>• Highest proportion of car drivers<br>• Assess their possibilities to leave home and drive a car better than the other groups<br>• Highest proportion of seniors living in multiperson households<br>• Leave their home more frequently, than the other groups. | • Mostly already retired<br>• Mostly in the older age groups<br>• High contentment with health state<br>• Hardly suffer from physical impairments<br>• Prefer walking and cycling<br>• More than half of the seniors in this group<br>• live in multi-person households. | • Mostly over 70 years old<br>• Mostly dissatisfied with the own state of health<br>• Highest proportion of seniors, who suffer from motor impairments<br>• Highest proportion of seniors who prefer public transportation and special transport<br>• Leave their home less frequently, than the other groups<br>• Highest proportion of seniors, who live in single-person Households |

*Table 2-5: Types of mobility based on health aspects, household structure and employment status (Szenamo 2010).*

| | Literature | SHARE Database |
|---|---|---|
| **physical health** | Ability to hear, see, walk properly (wheelchair user, walking disability, blind, visually impaired, deaf, impaired hearing,...) | Health in general |
| | | Parkinson |
| | | Hearing |
| | | Eyesight |
| | | Pain in back, knees, hips and other joints |
| | | Fatigue |
| | | Difficulties in mobility: walking 100m, sitting 2 hours, getting up from chair, climbing stairs, stooping/kneeling/crouching, reaching arms above shoulder, pulling/pushing large objects, lifting/carrying weights over 5 kilos, walking across room, getting out of bed |
| | | Usage of aid: cane or walking stick, walker, wheelchair, scooter |
| **mental health** | depression<br>emotional barriers<br><br>fears: darkness, assault, crime, accident, ruthless people | depression |
| | | hopes for the future |
| | | interest in things |
| **cognitive skills** | Ability to read signs, maps, travel alone, use technologies,... | Self-related reading skills |
| | | using map in a strange place |

*Table 3-1: Variables describing physical and mental characteristics of older people (comparison: literature, SHARE-database).*

(1)

Five profiles were created according to the data and the requirements of the GOAL project. They were named with descriptive and verbal labels. The table on the next page (figure 5-3) explains these profiles in more detail and scores various variables according to each profile.

Proposed additions to this table are for physical health: incontinence, when you have continence problems you can feel very uneasy to travel because you need to be able to access a toilet quickly. For mental health: loneliness and also the grief of losing close friends or family that pass away, self confidence and the (lack of) feeling of living a meaningful life and being able to be meaningful to other people.

Mollenkopf (2) describes keeping the elderly mobile and focuses on the social relationships of elderly people. Of the data is extracted from surveys performed in Germany and Italy. The importance of particular social relationships (Table 1) are explored and transport modes and activities are discussed.

| | | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 |
|---|---|---|---|---|---|---|
| | | Fit as a Fiddle | an Oldie but a Goodie | Hole in the Heart | The Care-Full | Happily Connected |
| Demographics | main age group | 50-59 | 80-90 | 50-75 | 85-100 | 60-75 |
| | gender | more male | more female | o | more female | o |
| | financial resources | + + + | + | - - - | - - | + + |
| | still employed | + + + | - - | - - | - | + |
| | household information | married or in partnership | single | O | single | married or in partnership |
| Health | general health | + + + | + | - - | - - - | + + |
| | eyesight and hearing | + + + | - - | O | - - - | + + |
| | limitation in activities | - - - | + | + + | + + + | - |
| | suffer from pain | - - - | - | + + | + + + | - - |
| | Dementia / Alzheimer's | - - - | + | - - | + + + | - - |
| | drugs needed | - - - | + | + + + | + + + | - |
| | aid needed | - - - | + + + | O | + + + | - |
| Transport | importance of driving | + + + | - - - | + + + | - | + + |
| | importance of public transport | - - | + + + | - - | - | + |
| | importance of walking | - | + + + | O | + | + + |
| | assistance needed | - - - | + | + + | + + + | - - |
| | number and length of trips | + + + | - - | - - | - - - | + |
| | purpose of trips | work, leisure, socializing | socializing, religious services shopping | medical facilities | medical facilities, religious services | recreation, sport, family, socializing |
| Environ-ment | problems with infrastructure barriers | - - - | + + | + + | + + + | - |
| | afraid of crime | - - - | + | + + | + + | - |
| Life Satisfaction | satisfaction and mental health | + + + | + + | - - - | - - - | + + + |
| | social networks | + + | + + | - (family only) | - - (family only) | + + + |
| | activities | + + + | + | - - | - - - | + + |
| | Technology usage | + | - - | - | - - - | + |

*Figure 5-3: Draft Profiles comparison*

*+++ above average; - - - below average; o not clear*

(1)

Table 1
Important persons for elderly people (across 2 countries: in %)

| | Germany (Mannheim/Chemnitz) | Italy (Ancona) |
|---|---|---|
| Son | 58* | 49* |
| Daughter | 56* | 48* |
| Grandchild | 63 | 56 |
| Good friends | 49* | 34* |
| Neighbours | 50* | 20* |
| Church/priest | 14 | 10 |
| Co-worker | 11 | 4* |
| Brother/sister | 38 | 38 |
| Other relatives | 37* | 15* |
| Mother | 5 | 6 |
| Father | 1.5 | 2 |
| Household helper | 5 | 2 |
| Paid helper | 2 | 0.5 |

*P<0.01.
Question: Which persons are important for you'?
(2)

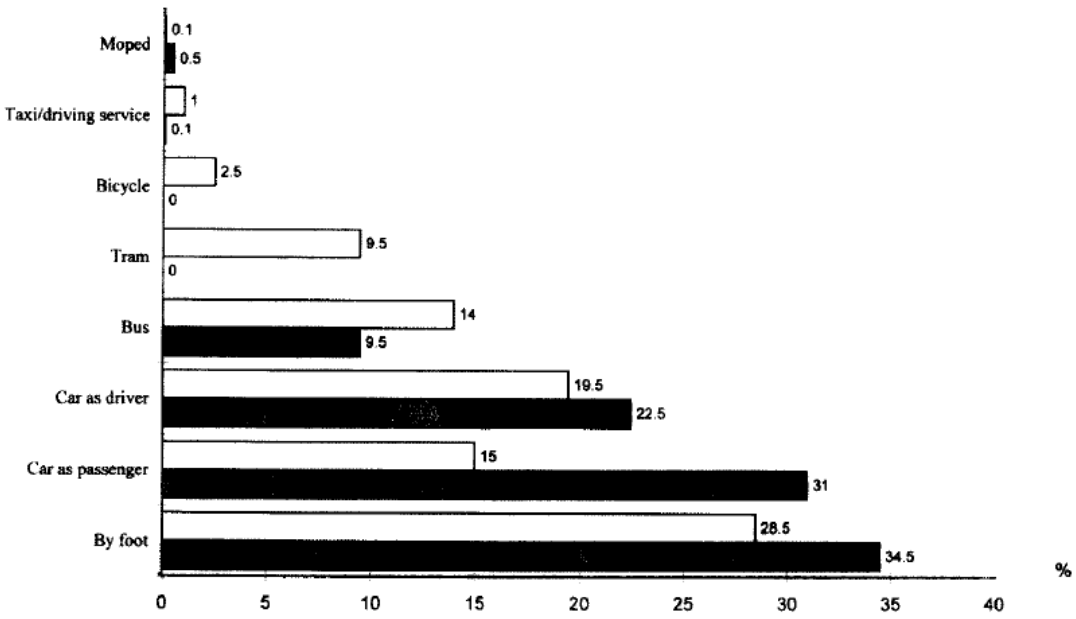


Fig. 1. Transport mode when visiting important people. □ Germany (Mannheim/Chemnitz); ■ Italy (Ancona).

(2)

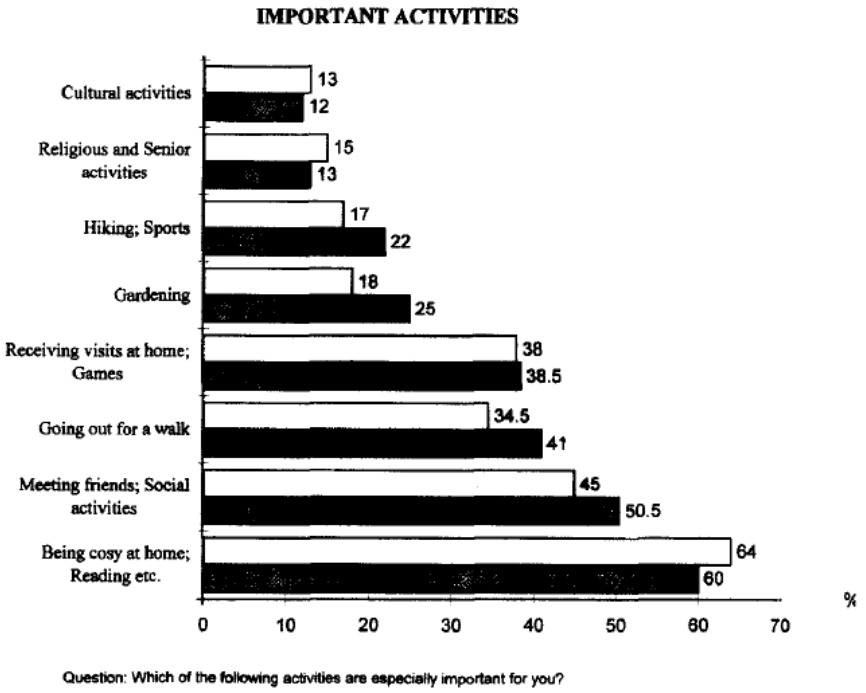


Fig. 2. Elderly people in Germany (Mannheim/Chemnitz): important activities. □ No children; ■ children.

(2)

Wilkie (3) describes outside mobility of elderly people, but specifically those fitting a profile of mild mobility issues, namely knee pain.

A proposed addition to this table is the activity of going to get groceries. In the Netherlands, half of the walks with a rollator are made to go to the grocery store and also a big part of the use of a scootermobile is for fetching groceries. (4), (5)

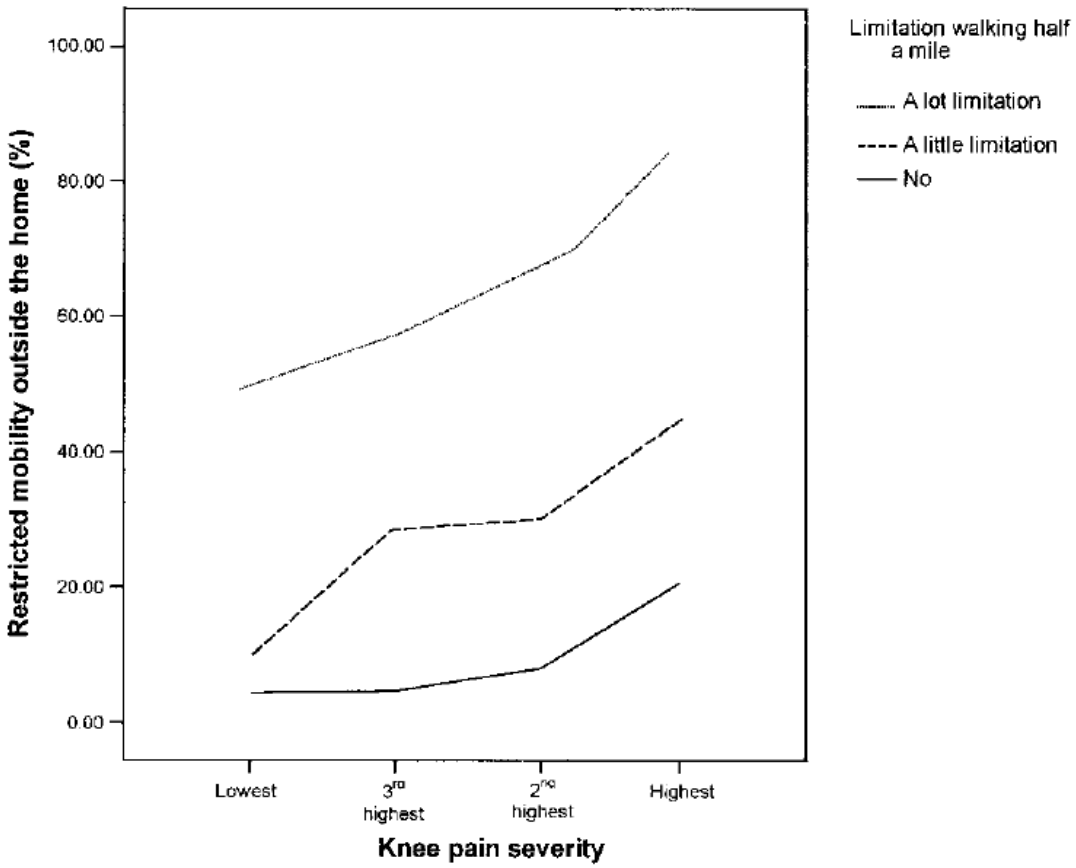


**Figure 1.** The proportion of responders with knee pain who had no walking limitation, a little limitation walking half a mile, and a lot of limitation walking half a mile, stratified by knee pain severity and restricted mobility outside the home.

(3)

### 2.1.2 Project specific target group profiles

Derived from the general target group profiles, the following more project specific target group profiles can be derived. These are, amongst others, used for targeting specific groups of elderly in the recruitment for the co-design sessions in Spain and The Netherlands (see D1.2).

| **Target group** | **More specific explanation (to be evaluated in co design sessions)** |
|---|---|
| **1.** Elderly people **living independently at home, without real** physical problems, but having **trouble** | Using public transport can be a problem for elderly people when they |

| | |
|---|---|
| **using public transport** | are having trouble handling the complex information that you need to understand and process when you use public transport. Also finding out where the train/busstops are and where you can find a place to sit and wait can be a problem when you cannot walk very far/stand very long (all this described is also named "mental accessibility"). |
| **2.** Elderly people living at home that are vulnerable and **go outside very little because of physical problems and lack of confidence.** | These physical problems could be for exemple: rheumatoid arthritis, loss of strength, energetic restrictions, sight problems or balance problems. Not getting out can cause their health getting worse and they can get isolated.<br><br>These people can be aware of their need for assistive technology themselves or can be stimulated to use assistive technology to go outside by family carers or professional caregivers. |
| **3. Elderly people with mild cognitive problems** that sometimes causes them to be disorientated, to forget the way home or forget what their home of home environment looks like. | Sometimes the person with mild cognitive problems feels insecure himself, but sometimes the person with mild dementia does not realize that this could be dangerous to him. In these case it is mainly the family carers that are very worried for the safety of their loved ones. |
| **4. Elderly people that do not go outside much but have no particular mobility problem** that restricts them | These people might be helped by a tool that makes it fun to go outside / stimulates them. |

## 2.2 Creating an inventory of mobility services used by elderly people

### 2.2.1 Demand responsive transport

Demand Responsive Transport or Demand-Responsive Transit (DRT) or Demand Responsive Service (6) or Dial-a-ride or Flexible Transport Services (7) is "an advanced, user-oriented form of public transport characterised by flexible routing and scheduling of small/medium vehicles operating in shared-ride mode between pick-up and drop-off locations according to passengers needs" (8). In many areas DRT is instead known as DART, or Dial-a-Ride Transit. (9) (10)

DRT systems provide a public transport service in rural areas or areas of low passenger demand, (11) (12) where a regular bus service may not be as viable. As such, DRT schemes for may be fully or partially funded by the local transit authority, as providers of socially necessary transport. As such, operators of DRT schemes may be selected by public tendering. Other schemes may be partially or fully self-funded as community centred not for profit social enterprises (such as a Community interest company in the UK).

DRT schemes may also be provided by private companies for commercial reasons; some conventional bus operating companies have set up DRT-style airport bus services, which compete with larger private hire airport shuttle companies.

**Differences from other modes of transport**

- Regular transit bus routes: DRT employs flexible routes and schedules (13)
- Shuttle bus services: DRT departure and arrival points are not necessarily fixed (13)
- Deviated Fixed Route Service: Transit service that operates along a fixed alignment or path at generally fixed times, but may deviate from the route alignment to collect or drop off passengers who have requested the deviation (6)
- Paratransit: DRT is available to the general public, whereas paratransit is available to pre-qualified user bases, especially for people with disabilities and the elderly. In the Netherlands people whith mobility problems that cannot use normal public transport have a right to use DRT for free. The vehicles that are used for DRT in the netherlands are mostly multy purpose Vans for the transport of 8 people and can be instantly adjusted into a vehicle for safe transport of wheelchair occupants if one of the rides occurs to be for a person/persons in a wheelchair.
- Taxicabs: DRT generally carries more people, and passengers may have less control over their journey on the principle of DRT being a shared (11) system as opposed to an exclusive vehicle for hire. Additionally, journeys may divert en-route for new bookings (13)

**Mode of operation**

A DRT service will be restricted to a defined operating zone, within which journeys must start and finish. Journeys may be completely free form, or accommodated onto skeleton routes and schedules, (12) varied as required. As such, users will be given a specified pick-up point and a time window for collection. (12) Some DRT systems may have defined termini, at one or both ends of a route, such as an urban centre, airport or transport interchange, for onward connections.

DRT systems require passengers to request a journey by booking with a central dispatcher (12) (13) who determines the journey options available given the users' location and destination.
DRT systems take advantage of fleet telematics technology in the form of vehicle location systems, scheduling and dispatching software and hand-held/in vehicle computing. (11) (12) (14)
Vehicles used for DRT services will usually be small minibuses, reflecting the low ridership, but also allowing the service to provided as near a door to door service as practical, by being able to use residential streets (12). In some cases Taxicabs are hired by the DRT provider to serve their routes on request.

**Simulations of health and environmental effects**

For a model of a hypothetical large-scale demand-responsive public transport system for the Helsinki metropolitan area, simulation results published in 2005 demonstrated that "in an urban area with one million inhabitants, trip aggregation could reduce the health, environmental, and other detrimental impacts of car traffic typically by 50–70%, and if implemented could attract about half of the car passengers, and within a broad operational range would require no public subsidies". (15)

**Licensing**

DRT schemes may require new or amended legislation, or special dispensation, to operate, as they do not meet the traditional licensing model of authorised bus transport providers or licensed taxicab operators. The status has caused controversy between bus and taxi operators when the DRT service picks up passengers without pre-booking, due to the licensing issues. (16) (17) Issues may also arise surrounding tax and fuel subsidy for DRT services.

**DRT by country**

| Country | Description | References |
|---|---|---|
| USA | The large majority from 1,500 rural systems in the US provides demand-response service; there are also about 400 urban DRT systems. | (10), (13), (18), (19) |
| Germany and Austria | In German-speaking countries many isolated systems exist under the following names: Anruflinienfahrt (ALF), Anruf-Linien-Dienst (ALD), Anruflinienbus, Anruflinientaxi (ALT, alita), Anrufbus, Rufbus, „Ruf-mich-Bus", Linienbedarfstaxi(LBT), „Taxibus", „Linientaxi", „Bedarfsbus", Anruftaxi, RuftaxiAnruf-Buslinien und –Sammeltaxis. | |
| Switzerland | In sparse populated areas (unter 100 p/km2) since 1995 PostBus Switzerland Ltd (national post company) operates a DRT service called PubliCar. CasaCar is a DRT service operated by PostBus region of Graubünden | |

| | | |
|---|---|---|
| UK | Under the existing UK bus operating regulations of 1986, some DRT schemes were operating, allowed by the fact they had a core start and finish point, and a published schedule. For England and Wales in 2004, the regulations concerning bus service registration and application of bus operating grants were amended, to allow registration of fully flexible pre-booked DRT services. | (6), (7), (20), (21), (22), (23) |
| Australia | Multiple services available | (8), (24), (25), (26), (27) |
| Canada | Dial-a-Ride Transit, Winnipeg Transit, replaces regular fixed transit route service in three neighbourhoods during low-use hours and provides door-to-door transit service in one inner-city neighbourhood during daytime hours. | (9) |
| Italy | Following some pioneering DRT schemes implemented in the eighties, in Italy a new generation of applications have been launched and are in operation starting from mid nineties. | (28), (29) |
| Poland | The first ever demand responsive transport scheme in Poland - called Tele-Bus - is operated since 2007 in Krakow by MPK, the local public transport company | |
| Czech Republic | There is recognized only one public city DRT system - Radiobus - and one rural DRT system - operated by DHD - in the Czech Republic. | (30) |

### 2.2.2 OV Buddy

Eljakim, one of the partners of the Happy Walker consortium is involved in a project called OV Buddy (31), which is focused on making public transport more accessible. This type of service is interesting to the Happy Walker project.

### 2.2.3 Redzaam ouder

Redzaam ouder (older and coping) (32) is an initiative by the RVZ to improve the lifestyle of the elderly, especially when they have suffered from degradation in their mobility or cognitive ability.

## 2.3 Creating an inventory of mobility technologies used by elderly people

### 2.3.1 Fall alarms

Fall alarms have proven to reduce falls at home or in nursing homes and hospitals. Fall alarms serve as an "early warning system" as the alarm sound alerts the nursing staff when a

patient is engaging in activities that are likely to result in a fall. Fall alarms can play a vital role in helping staff to prevent a serious injury as a result of a fall.

Fall alarms are not a restraint. As such they do not prevent a patient from getting up nor are they designed to prevent a patient from falling. Fall alarms are designed to alert staff to a potentially hazardous fall event via a high decibel level auditory sound. Fall alarms have proven to reduce the critical response time of staff members to a fall risk situation. It is not the fall alarm itself but rather the timely response of staff members to the alarm sound that can potentially prevent a fall from occurring.

All types of fall alarms function in a similar manner. They allow patients to maintain a free movement zone or an area of normal activity. If the patient exceeds the free movement zone the alarm sound will alert staff members to a potentially dangerous fall situation. The alarm may be set to sound in the patient's room and/or at the nurse's station, in a hallway or on a staff member's pager.

The standard fall alarm system (FAS-1) consists of a fall detector, worn like a pager by the user and a telephone auto dialler. The fall detector has a belt clip for attachment to a belt or clothing and is equipped with a simple on-off switch. When the detector is switched on, any sudden movement or tilt from a vertical to a horizontal position will result in a pre-alarm tone that will sound for 30 seconds prior to transmitting the emergency control signal to activate the telephone dialler. This provides sufficient time for the user to cancel the alarm to avoid false dialling to the recipients on the call list.

The telephone dialler can store up to six of your own emergency contact telephone numbers. When the dialler receives a signal from the fall alarm, the automatic dialling sequence begins. The first number will be called. If the call is answered the dialler will announce emergency then speak your home telephone number. If the first call recipient can attend to the emergency, they can use their telephone keypad to cancel all further calls on the call list. If they are unable to deal with the incident, they can simply hang up leaving the dialler to call the next number on the call list and so on until calls are cancelled by disarming the dialler using the keypad or by a call recipient telephone. If the call is answered by a mobile telephone voicemail, or a land line answer machine, the message will be left. The dialler will then go on to dial the remaining numbers on your call list.

Verhaert, one of the partners in the Happy Walker consortium, has developed a fall detector and is also developing further generations of fall detectors (33). These new types are compact and easily worn, are visually appealing and offer more features than previously conceived. The detectors can utilize Bluetooth and GSM networks to get in contact with emergency services or caregivers quickly. These detectors are based on complex algorithms to ensure correct detection of a fall and neglect false positives, such as sitting down quickly. These algorithms have been explored extensively for this and other applications. (34) (35)

In another AAL project a fall alarm is developed based on ambient intelligence for which the user does not have to wear technology itself. It is called the UAS system, unattended autonomous surveillance. More information can be found on the website www.aal-rosetta.eu

### 2.3.2 Hip protectors

A hip protector is a specialized form of pants or underwear containing pads (either hard or soft) along the outside of each hip/leg, designed to prevent hip fractures following a fall. (36) They are most commonly used in elderly individuals who have a high risk of falls and hip fractures (for example, due to history of a previous fall and underlying osteoporosis).

Most hip fractures follow an impact due to a lateral fall. The pads are located over the trochanters, the bony extrusions of the hip region.

Hip protectors are either of the "crash helmet type" or "energy-absorbing type". The "crash helmet type" distributes impacts into the surrounding soft tissue, while the "energy-absorbing type" is made of a compressible material and diminishes the force of impact. Both of these systems aim to reduce the focused force beneath an estimated fracture threshold.

Several different commercially available hip protectors exist, such as the Safehip (Tytex A/S, Ikast, Denmark), the AHIP Protector (Astrotech, Vienna, Austria) and the KPH hip protector (HRA Pharma, Paris, France). The former has been used in most clinical trials. Hip protectors have the advantage of having no important adverse effects.

Clinical studies of their effectiveness have shown conflicting results. A systematic review from 2006 found that that hip protectors are only marginally effective for preventing hip fracture among nursing home residents, and not effective among community dwelling elderly individuals. A recent randomized trial was discontinued because it failed to demonstrate any benefit. A Bayesian meta-analysis showed a decreased risk of hip fractures in elderly nursing home residents.

However, acceptance and long-term compliance towards them is quite low, mainly because of discomfort, dislike of their appearance by the person wearing it, and disagreement about fracture risk. A recent study showed that hip protectors' design and mechanical properties vary drastically among commercially available hip protectors.

### 2.3.3 Technology to promote safe mobility in the elderly

New technologies designed to help prevent adverse events related to the mobility of geriatric patients (i.e., patient falls, bed-rail entrapment, patient handling, and wandering) are described.

Technology offers the potential to eliminate or mitigate preventable adverse events that interfere with treatment, delay rehabilitation, potentiate impairment, and compromise patient safety.

Unchecked, these adverse events can have a negative impact on patient health, functional status, and quality of life. It is not surprising that the elderly constitute the population at highest risk for adverse events, based on poor health, chronic conditions, long hospitalizations, and institutional care. Patient falls are a high-risk, high-volume, and high-cost adverse event.

Key technologies to prevent falls and fall-related injuries include hip protectors, wheelchair/scooter safety features, intelligent walkers, fall alarms, and environmental aids.

Bed-rail entrapment is a serious adverse event, which includes patients being trapped, entangled, or strangled in beds. New technologies to prevent bed-rail entrapment include new hospital bed designs, height-adjustable low beds, devices to close gaps in legacy beds, and bed exit alarms.

Patients with mobility impairments necessitate physical assistance in transfers and other patient-handling tasks, which increases risk for the caregiver and the patient.

Featured technologies to prevent patient handling injuries include innovations in floor-based lifts, new ceiling-mounted patient lifts, and improvements in powered standing lifts, new friction-reducing devices, and new patient transport technology.

Wandering affects 39% of cognitively impaired nursing home residents and up to 70% of community-residing elderly persons with cognitive impairments. New technologies to prevent adverse events associated with wandering include door alarms and signal-transmitting devices.

Nurses in geriatric settings would benefit from exposure to technologies that could improve patient and caregiver safety. To maximize the benefits of technology, it is critical that front-line nursing staff be involved in the testing and selection of devices that will be used in their practice. Further, to reap the full benefits of technology, a careful plan for implementation needs to be developed that would include integrating the new technology with existing infrastructure. Training needs to be provided for all staff who will be using the technology, and efforts to ensure competency over time is needed.

A major barrier to widespread use of new technology is cost. Further research is needed to demonstrate the cost effectiveness of these devices. Results from these studies will help to build a business case, demonstrating that initial capital investments will result in cost savings, improved quality of care, and other benefits. (37)

### 2.3.4 Electric mobility scooters

**A mobility scooter is a mobility aid similar to a wheelchair but configured like a motorscooter. It is often referred to as a power-operated vehicle/scooter or electric scooter.** (38)

A mobility scooter has a seat over two rear wheels, a flat area for the feet, and handlebars in front to turn one or two steerable wheels. The seat may swivel to allow access when the front is blocked by the handlebars. Mobility scooters are usually battery powered. A battery or two is stored on board the scooter and is charged via an onboard or separate battery charger unit from standard electric power. Gasoline-powered scooters are also available, though they are rapidly being replaced by electric models.

Assistive and small sit-down motor scooters provide important advantages to people with mobility problems throughout the world. A scooter is useful for persons without the stamina or arm/shoulder flexibility necessary to use a manual wheelchair and also for people that want to take something with them, wich is not very easy in a wheelchair.. A mobility scooter is very helpful for persons with systemic or whole-body disabling conditions (coronary or lung issues, some forms of arthritis, obesity, etc.) who are still able to stand and walk a few steps, sit upright without torso support, and control the steering tiller. In the Netherlands it is often used as an alternative to cycling and walking at the same time. In the Netherlands, that cannot walk or stand very long anymore well enough to use public transport can receive a mobility scooter provided by the municipality. (39)

What the disabled scooter is going to be used for, and how often it is going to be used, will help to determine which model will be best. For example, somebody purchasing a mobility scooter which will be used daily to replace a car has different needs to someone purchasing a mobility scooter that will be carried in the car and used primarily at weekends for travelling short distances. There are different sizes of mobility scooters, from robust ones for use on the streets and with battery power for long journeys (up to 15 km.h. with 45 km distance per battery charge) to very small ones that are foldable for transport in the trunk of a car and are only stable enough to be used on flat surfaces like a shopping mall or museum.

Mobility scooter batteries are rechargeable and depending on the model of scooter, and will allow the mobility scooter to travel in excess of 30 miles. The smaller boot scooters have a range of around 10-15 miles depending on the model. The batteries can sometimes be upgraded to provide better performance, or an additional battery pack can be carried on the scooter to effectively double the range of the electric scooter. (40)

The speed of the mobility scooter is determined by the amount of pressure put on the forward / reverse lever. The overall speed of the disabled scooter is governed by the speed dial on the control panel. When getting used to the electric scooter, it may be better to use a lower speed setting. On the road legal mobility scooters, there is usually a switch which lowers the maximum speed from 8mph to 4mph, which then allows the scooter to be used legally on a pavement.

In order to slow down, the user just needs to release the forward or reverse lever which then brings the mobility scooter to a stop. Disabled scooters have regenerative brakes fitted, which mean that the scooter can be left on a slope with out fear of it rolling away. An emergency bicycle style brake is fitted to some models for additional safety and security.

Class 3, 8mph mobility scooters are road legal, and so can travel on the street. By law, these have to be fitted with full lights and indicators. This type of electric scooter is larger and more luxurious than those designed to be dismantled and transported in a car boot.

These disabled scooters are often purchased for being mobile on the streets by people that cannot use a bicycle or drive a car anymore, and so are much more powerful, and more rugged than a boot scooter. These disabled scooters usually have an adjustable and removable seat. The more luxurious seats recline and slide and some even have a headrest, like a car seat. They have good suspention and are especially suitable for heavy weight people or people with back problems. Depending on the model of electric scooter, the seat may be upgraded to a larger, more comfortable more supportive seat.

While a mobility scooter eliminates much of the manual strength problems of an un-powered wheelchair, its tiller steering mechanism still requires upright posture, shoulder and hand strength, and some upper-body mobility and strength. Other drawbacks of mobility scooters are their longer length, which limits their turning radius and ability to use some lifts or wheelchair-designed access technologies such as kneeling bus lifts. Specially adjusted seats cannot be made very well on a mobility scooter, people who need such a seat normally use an electric wheelchair.

Mobility scooters are very easy to use, and shouldn't be daunting. Despite all the various models and types to choose from, they all work in similar ways. The main differences are the number of wheels (three or four), the maximum speed, the battery life, the suspension and the size of the disabled scooter.

Mobility scooters normally require a key to start them and are immobile without the key. This allows the electric scooter can be left outside a shop or house safely and securely, and prevents unauthorized use. Disabled scooters have a freewheel mode, which allows the scooter to be moved, without the scooter being turned on. This makes storing and transporting your electric scooter easier, and can assist when the batteries are charging and it needs moving.

Disabled scooters are steered using the tiller which is similar to a bicycle or motorbike handlebar. The tiller is usually adjustable, depending on the model, and can often be dropped down for transportation. Mobility scooters are driven using the thumb or fingers pushing or pulling a lever. This control is called a "wig wag" and works on the "see saw" principle. If the forward lever is pushed, it is the same as pulling on the reverse lever, and vice versa. Some models are driven by pushing the lever with the thumb, whilst others are driven by pulling the lever with the fingers, like a bicycle brake. A Delta handlebar means that both forward and reverse can be controlled using the same hand. This is fitted as standard on some disabled scooter models and available as an optional extra on others. In all cases good hand function is needed to operate the mobility scooter. Some 4 wheeled scooters can be adjusted with a foot pedal.

2 wheel electric scooters, also known as Electric Bicycles or Mopeds, are a great, low-noise, zero-emissions form of transportation that are also suitable for persons with limited mobility. The electric scooter or moped is classified as a power-assisted bicycle, thus in most states (depending on motor size) you do not need a driver's license to ride the bike on the street, nor does it have to be registered, plated, or insured.

3 wheel electric scooters - Ideal for using indoors, especially in the home or in a shop, as they have a smaller turning circle than the equivalent four wheel model, which makes them easy to maneuver. Four wheel disabled scooters were previously perceived to be more stable but, due to technological advances, there is very little difference in stability between three and four wheel scooters these days. Most mobility scooter manufacturers offer three and four wheel versions of the same model.

4 Wheel Mobility Scooters - A 4-wheel mobility scooter offers the most stability of the three scooter categories. Two back wheels and two front wheels make the risk of toppling over extremely slim. If you have any balance problems, then a 4-wheel medical scooter is an excellent choice. While the double wheels in the front are not as maneuverable as their 3-wheel and compact cousins, 4-wheel scooters make up for the lack in rugged durability.

Compact scooters - Sometimes called boot or trunk scooters - Very popular and are designed to be transported, and can be taken apart in a matter of seconds. The seat and battery pack are easy to remove, and sometimes the scooter chassis will separate into two parts. Depending on the model of mobility scooter, the components may have handles incorporated into them to make putting them into a car boot even easier. Some models of small disabled scooter separate without the need to disconnect plugs or cables which makes transporting the electric scooter even easier.

These smaller mobility scooters, or boot scooters, are usually less luxurious than the larger electric scooters, and often do not have the same sort of features such as pneumatic tires, full suspension or a highly adjustable seat. The maximum range that the scooter can travel is usually less, as is the weight capacity.

**Pavement mobility scooter** - A compromise between the boot scooter and the road legal scooter. These models of disabled scooter usually have some of the features of the larger scooters, such as lights and indicators, suspension, and a comfier seat than a boot scooter, but can usually still be dismantled for transportation. Some models have a top speed of 6mph, rather than the usual boot scooter top speed of 4mph.

Currently in the United States, Medicare will not approve a power wheelchair for persons who do not need to use the chair "inside their own home", even if their medical needs restrict the use of a mobility scooter. For example, a person with severe arthritis of both shoulders and hands may not be the best candidate for a scooter, but because they can walk a few steps in their own home, such persons are not seen as approved candidates for a power wheelchair either. Various disability rights groups are campaigning for Medicare to change this policy.

A mobility scooter can bring back, or help to maintain independence, and allow long and short journeys to be enjoyed in both comfort and style.

### 2.3.5 Walkers and Rollators

Walkers

A walker or walking frame is a tool for disabled or elderly people who need additional support to maintain balance or stability while walking. (41)

Design

The basic design consists of a frame that is about waist high, approximately 12 inches (30 cm) deep and slightly wider than the user. Walkers are also available in other sizes such as pediatric (for children) or bariatric (for obese persons). Modern walkers are height adjustable and should be set at a height that is comfortable for the user, but will allow the user to maintain a slight bend in their arms. This bend is needed to make people walk straight and allow for proper blood circulation through the arms as the walker is used. The front two legs of the walker may or may not have wheels attached, depending on the strength and abilities of the person using it. It is also common to see caster wheels at the front or glides on the back legs of a walker with wheels on the front.

Use

The person walks with the frame surrounding their front and sides and their hands provide additional support by holding on to the top of the sides of the frame. Traditionally, a walker is picked up and placed a short distance ahead of the user. The user then walks to it and repeats the process. With the use of wheels and glides, the user may push the walker ahead as opposed to picking it up. This makes for easier use of the walker, as it does not require the user to use their arms to lift the walker. This is beneficial for those with little arm strength.

A walker is a good tool for those who are recuperating from leg or back injuries. It is also commonly used by persons having problems with walking or with mild balance problems.

Also related is a hemi-walker, a walker about half the size of a traditional walker which is intended for use by persons whose dexterity is limited or non-existent in one hand or arm. These walkers are more stable than a quad cane (a cane with four points that touch the ground, as opposed to one), but are not recommended as highly as a traditional walker for those who can use it.

Walker Cane Hybrid

A walker cane hybrid was introduced in 2012 designed to bridge the gap between an assistive cane and a walker. The hybrid has two legs which provide lateral (side-to-side) support which a cane does not. It can be used with two hands in front of the user, similar to a walker, and provides an increased level of support compared with a cane. It can be adjusted for use with either one or two hands, at the front and at the side, as well as a stair climbing assistant. The hybrid is not designed to replace a walker which normally has four legs and provides 4-way support using both hands.

Rollators

A different approach to the walker is the rollator, also called wheeled walker, invented by the Swede Aina Wifalk in 1978, herself a polio sufferer. Although originally a brand name, "rollator" has become a genericized trademark for wheeled walkers in many countries, and is also the most common type of walker in several European countries.

The rollator consists of a frame with three or four large wheels, handlebars and a built-in seat, which allows the user to stop and rest when needed. Rollators are also often equipped with a shopping basket. Rollators are typically more sophisticated than conventional walkers with wheels. They are adjustable in height and are light-weight, yet sturdier than conventional walkers. The handlebars are equipped with hand brakes that can be lifted or pushed downward to instantly stop the rollator. The brakes can also be used in manoeuvring the rollator; by braking one side while turning the rollator towards that side a much tighter turning radius can be achieved. (39)

## 2.4 Research on a specific service for people with mild dementia or mild cognitive impairment

### 2.4.1 Introduction

Products on the market for people with dementia for supporting mobility outside have at this moment as main functionality to locate the person with dementia by another person (informal or formal carers) when the person with dementia has lost his way (wandering). These products are mainly based on GPS-localisation, optionally with for instance GSM-localisation.
An example of this type product is the Keruve from Vision, although this product is quite different comparing to the others products on the market and better equipped for the scenarios for localization of people with dementia.
The underlying problem is that during the dementia process of 7 years already in the beginning of the process – the so-called mild dementia stage or Mild Cognitive Impairment (MCI) – the risk can be that a person with dementia cannot find the way back home anymore. Often these people are still relative active. The dementia hinders them not in their mobility. They still want to go out by themselves.
Moreover: research has given evidence that outdoor activities have a positive effect on the cognitive decline.

Especially for people in the mild dementia stage the general idea has been proposed of providing oudoor navigation support. Goal: to find the way back home when outdoors by themselves. So that that the carers don't need to track the lost person with dementia.

The research history of this functionality is:

### 2.4.2 Preliminary study direct navigation

Publication, Netherlands: *Ondersteuning voor licht dementerende ouderen in hun dagelijks leven*, van den Berg et al., 2008 (47) -> support of people with mild dementia in their daily life.

Research design: Interviews with 23 people and tests with 2 people.

Screenshots of evaluated variants:

Variant 1.


Variant 2


Variant 3


Conclusions:

- Navigation on mobile is desired.
- The variant 2 with photos is preferred -> remark: application of Google Streetview for the Happy Walker device?
- It is useable by people with mild dementia
- Additional functionality: reached destination.

### 2.4.3 Audio study

Publication: *Auditory navigation for persons with mild dementia*, de Boer, 2008 (48)

Goal: which voice and which sounds works best?

Research design: Four people with mild dementia walked the same four routes.

Results:

- The voice of the own informal carer has the preference
- A sound for each voice prompt has no effect.

### 2.4.4 Safety study for FP6-project COGKNOW

Publication: University of Applied Sciences Windesheim (Marike Hettinga), Novay and others, 2008: Navigation for People with Mild Dementia, study for the FP 6 Cogknow project (see next) (49).

Goal: How much attention goes to the device and how much to the traffic?

Research design: In a small scale exploratory research with the target group people with mild dementia the effects of two different types of audio instructions were studied and assessment of the pedestrian safety while operating the device.
Observation of 13,3 km of walking with a navigation device by three people with mild dementia including video analysis.

Most important conclusions:
- Navigation support on a mobile device can be used by people with dementia.
- Navigation instructions spoken by a familiar voice seemed to have a positive impact on the effectiveness of the navigation system, while the use of warning sounds seemed to have the opposite effect.
-No evidence was found of unsafe walking behavior with navigation support. The persons crossed the streets safe and were not distracted by the device.
Also there was no higher risk of falling.
-Remarkable in the results is that the use of warning sounds almost always results in worse achievements of the participants than when no warning sounds are used.
-Future studies should also look into navigation systems that may prevent unsafe situations. For example by means of technology such as an **active attention management system which prevents the GPS-device from creating participant interruptions during the higher-risk activity of crossing a street.**
-The follow-up research was focused on so-called social navigation: people with dementia press an emergency button when they get lost and the informal carer or call center sees the location of the person on a map and through a phone connection can guide the person home. The safety benefit of this application can be that the informal carer can instruct and warn the person with dementia for any unsafe traffic behavior. This as an alternative for the before mentioned active attention management system. See below: the project Talk Me Home.

### 2.4.5 European FP-6 project COGKNOW

This project was conducted in the period 2006 – 2009. Amongst others by Novay. A small part were – limited - tests with navigation when outdoors; Take me Home, only in the third and last test round.

Social navigation (Talk Me Home) was only a mockup/simulated version for the workshops.

No results found in the available documents.

Information and video's: http://www.cogknow.eu/1/FP6_COGKNOW/overview.html (50)

Remark: from this project a commercial organisation has emerged. This organisation suggests on their website that they bring amongst others the mild dementia navigation on the market in 2012: see www.cogknow.eu.

### 2.4.6 Social navigation project Talk Me Home

Period: 2010 - 2011
Publication: *Guiding People with Early Dementia Home with the TalkMeHome Service,* Nauta et al. 2012 (51)

Project of Novay, University of Applied Sciences Windesheim, care organisation Carint-Reggeland, companies Verklizan and Findwhere.

Goal: Can the direct navigation be replaced by a person? In case of this project direct navigation from a call center for personal alarming.

Research design: four persons with dementia. Testing of several technical solutions.

Website: www.talkmehome.nl

Video: http://www.youtube.com/watch?v=hPqnxMSX8-E&feature=mfu_in_order&list=UL (52)

Most important conclusions:

- All participants were guided home
- Communication between call center employee and the person with dementia went well
- Participants were at ease with their mobile device
- The task of the call center employee was tedious
- **Also: the call center employee cannot see on the screen in which direction the person with dementia looks. There was no orientation information.**
  **Remark: this is also important for the direct navigation variant.**

### 2.4.7 Current situation of this research line

The described research line has now the focus on the social navigation variant with a manned call center in the chain. The main reason for this is the safety of the person with dementia, as mentioned: The safety benefit of this application can be that the informal carer or call center can instruct and warn the person with dementia for any unsafe traffic behavior.

# 3. Concluding Remarks

Within the elderly group:

- we are dealing with different elderly profiles
- regarding the mobility of the elderly several transport services are available (e.g. for bus and cabs)
- there are limited mobility technologies for and used by the elderly group

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