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SOULMATE - Secure Old people's Ultimate Lifestyle Mobility by offering Augmented reality Training Experiences

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Abstract

With ageing, travel becomes more and more complex. Physical and cognitive abilities may decline, and thus, elderly people may experience several problems that hinder them from travelling independently. One of the most difficult issues when addressing the problem of age-related travel restrictions is the heterogeneity of the ageing population. SOULMATE offers a non-intrusive and personalized mobility package that evolves with the end-user across his/her different life stages to ensure him/her to make secure trips. SOULMATE aggregates three types of mobility support: Indoor virtual training of a route, active routing during trips and monitoring by a coach at a distance during trips. For each individual, the desired or necessary functionalities can be chosen, based on his/her specific abilities and travel needs. The SOULMATE solution will be developed iteratively, in co-creation with end-users and stakeholders, and the package will be tested intensively, and evaluated in three countries (Belgium, The Netherlands and Austria) based on usability, technical and business aspects.

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1. Introduction

Elderly people (still) have the desire to travel to satisfy their personal needs. They like to go outside, to participate in an active social life, to visit familiar locations or to explore new places across the globe; for functional or for more leisure-related functions. Travel behaviour, or mobility, refers to the making of (physical) trips from one place to another, in order to participate in professional, social and economic life. Mobility has a range of positive outcomes, not only for individuals themselves (health benefits, reduced isolation, increased well-being and improved quality of life through new experiences and memory-building); but also for the wider community and economy [1] (e.g., more consumption, reduce healthcare costs).

But with ageing, travel seems to become more and more complex. As society continuously gets busier, traffic gets more complicated, dangerous or confusing. In addition, the shift to the digital era leaves many individuals confused and helpless with regard to modern society and its functionalities. These barriers cause a lot of travel restrictions in the life of aging individuals. Physical and cognitive abilities may decline with increasing age, and elderly people may experience several problems, like feelings of insecurity or sudden moments of being lost, that hinder them from travelling independently in society [2]. A recent study by GfK [3] that collected data from 22.000 internet users in 17 countries, pointed out that increased restriction of mobility was one of the top five worries people had in relation to ageing. So there is a huge potential to offer better assistance, reassurance, and simple solutions to optimise the transport opportunities for individuals as they age.

One of the most difficult issues when addressing this problem of age-related travel restrictions is the heterogeneity of the ageing population. While the group is merely defined by age, it includes a wide range of different characteristics, comprising highly dissimilar elderly profiles [4]. Biological age explains only to a limited extent the (im)possibilities in transportation that older people experience. Cognitive, psychosocial, physical, environmental, and financial factors determining (loss of) transportation vary to a large extent between older adults and do not necessarily correlate with biological age [5]. From a technical perspective however, this heterogeneity offers significant challenges:

- Although universal design offers strategies and possibilities to develop solutions that have sufficient usability for all (“one size fits all” solutions), personal customization is desirable to (continuously) adapt the solution to one’s (changing) personal needs;
- Solutions should not be stigmatizing, as this would likely cause user rejection;
- Solutions should be able to grow and evolve with the user, to counterbalance the loss of independence through the ageing process.

Therefore, in the European AAL project “SOULMATE (Secure Old people’s Ultimate Lifestyle Mobility by offering Augmented reality Training Experiences)”, we address the diverse travel wishes and needs of older adults (aged 65+) in order to engage in (and to ensure) an active, healthy and independent living in a secure way through active mobility and physical activity. In this way, the need for homecare will be lowered and the rehousing to institutionalized care will be postponed. Therefore, the SOULMATE solution will offer a personalised, customizable smartphone-based mobility solution that will evolve with the end-user’s needs across the different life stages and can be used for different elderly profiles. SOULMATE will maximize the capacities (i.e., the abilities to successfully carry out a specific task) of the user, without stigmatizing any restrictions they may face.

In the SOULMATE project, the three service solution partners of the existing mobility support modules (i.e., Activ84Health, ABEONAconsult BVBA and FH Joanneum) are accompanied by a research partner with expertise in mobility and activity patterns (TU/e), a business partner with expertise in co-creation approaches (RRD), and two business partners with technical expertise in the development of services for elderly (c.c.com Moser GmbH and FRAISS). The consortium team will be completed by three end-user organizations that will intensively test and evaluate the integrated solution from a user (primary, secondary and tertiary), technical and business perspective (Slimmer Leven, Happy Aging and GEFAS STEIERMARK).

This paper describes the scientific and technical research outline of the SOULMATE project. Section 2 gives an overview of the technology methodology, including the state of the art of the individual mobility support types as well as a description of the integrated mobility solution; while section 3 describes the co-creation process more in detail. The paper concludes with expected outcomes of SOULMATE for the different types of end-users.

2. Technology methodology

2.1. State of the art of the individual mobility support modules

The SOULMATE project builds an integrated solution consisting of different types of mobility support: training of the route, security during the trips and routing during the trips. SOULMATE will integrate these three service solutions, improve their functionalities towards the transport needs of the end-user, and combine them in a mobility solution to fit the diverse and varying mobility needs of elderly. This section briefly presents each of the individual mobility solutions.

Training of a route (Memoride): Memoride is an indoor cycling solution developed by Activ84Health that enables users to practice routes in a fun, motivating and safe virtual training environment with Google Street View images projected on a large screen (www.memoride.eu). The training can be performed on stationary bikes, on a treadmill, cross-trainer, or in a sitting position for sedentary persons. Routes are practiced within the safety and comfort of an indoor setting in order to build confidence, memorize visual cues for route finding, building confidence and self-reliance. Routes can both be practiced before performing them in real-life outdoors, as well as training of difficult sections after they have performed outdoor routes. Memoride has a very simple and flexible hardware setup (touchscreen tablet - tablet holder - cadence sensor) which fits virtually on any fitness device. This hardware is commercially available off-the-shelf and ascertains that the user is offered an interactive experience in which physical activity and virtual experience are integrated. The core of Memoride actually is in the software. Memoride makes use of Google Street View images, which opens up a whole world of possibilities. As long as 360° pictures are available for a location, Memoride can take the user there. Through this ubiquitous availability of Google Street View images, users can explore any street and planned routes. It offers the unique opportunity to safely train any route without restriction, and to find alternative routes in case difficulties or unforeseen circumstances (e.g., road works) appear. Navigation through the world is done through arrows that display route options at each intersection. The user simply has to tap on the arrow of the desired direction, and can continue his/her journey along the path chosen. The software is stored in a cloud-environment, so users do not need to go through installation or update procedures.

Security during trips (Viamigo): Viamigo offers passive monitoring of trips by a remote coach (www.viamigo.be). Elderly are taught an individual route, which they can accomplish independently afterwards, while non-intrusively being monitored by a personal coach (caregiver, family member or friend), who takes care of this individual while making the trip. Viamigo determines the location of the user by GPS and compares this in time and space within a predetermined range, so that deviations from the planned route, an incorrect speed, entering a dangerous zone, among others, can be detected. In case Viamigo detects an anomaly, it automatically sends a signal to the coach and the exact location of the user can be identified in real-time. Besides this 'on route' functionality, Viamigo also allows to create geofences around destinations (to monitor if the user stays within a predefined zone) and to start emergency tracking (to detect the location of the user in real time). Viamigo was initially developed for persons with intellectual disabilities, in order to both support their independent outdoor mobility (e.g. increase their use of public transport) as well as to reduce their caregivers' burden [6]. It is expected that Viamigo can also support and improve the social participation of elderly who may suffer from spatial disorientation and have difficulties in interpreting and navigating the environment, elderly with physical disabilities building up new endurance skills, or other elderly profiles.

Routing during trips (Ways4All): Active navigation of individuals themselves by the Ways4All-app, which generates indoor and outdoor route planning by turn-by-turn instructions (www.ways4all.at). Ways4All gives information about the route, like characteristics on the route (e.g., obstacles on the road, or use of elevator instead of stairs) and possible points of interests (POI) along the route (like public toilets or parks). The app takes into account the different preferences and disabilities of the users (shortest route, route without stairs, etc.). The Ways4All user interface can be adapted to accommodate different users groups, like people with visual problems, hearing problems or mobility problems [7]. The user can get help on the route from other people through the app: bus drivers can get the message that entry or exit help is needed (e.g. for people who have problems with walking or sit in a wheelchair) or when the user is lost, the panic button "Request help" calls a preselected person - a personally known or professionally trained helper - via video telephony, which can then give specific navigation instructions based on information gathered through the camera of the smartphone. The current position and the planned route are also transmitted to the helper, for a better orientation.

The Ways4All-app is an application put together for modules developed in preliminary projects for the mobile mass market, which largely works independently of structural conditions and existing infrastructure and can be used internationally. Through a specially developed user interface (also usable by blind people and deaf people), users are able to use public transport vehicles independently and securely and to orient themselves in complex transfer structures. In addition to the real-time communication and the precise positioning and target guidance, the system also offers the possibility of referring specifically to additional navigation aids if required, like real time public transport schedules, communication with busses and trams to find the entrance door or get within the public transport the names of the next stops. An illustration of each of the individual modules is shown in Fig. 1.

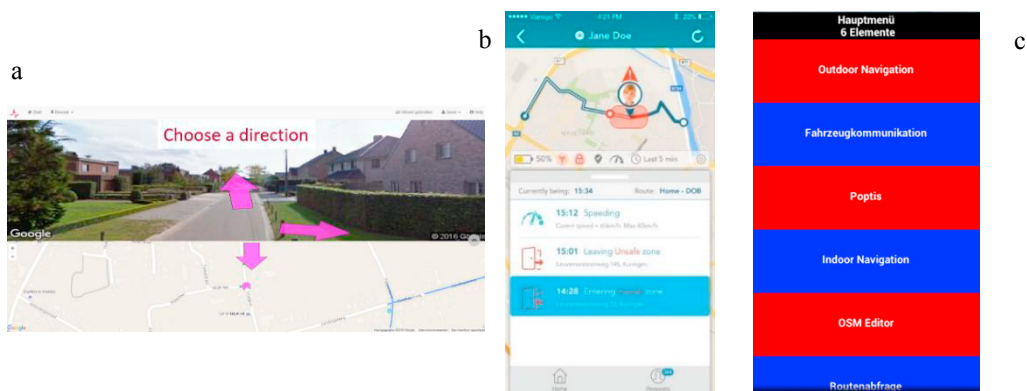


Fig. 1. (a) Training of the route with Google Street View images by Memoride; (b) Passive monitoring by a coach by Viamigo; (3) Active navigation of the individual himself by Ways4All.

2.2. The integrated SOULMATE solution

The SOULMATE solution builds its functionality around three major functionalities: routing, training and monitoring; which come from the expertise and functionalities available in Ways4All, Memoride and Viamigo. The different software components of Soulmate will be integrated in a micro services architecture. A central core delegates responsibilities and takes care of service orchestration. To realize this architecture, we use an agile methodology with industry-standard tools for continuous building, integration and deployment.

By flexibly (dis-)activating and configuring the available functionalities, SOULMATE can cater to elderly users with a wide spectrum of requirements. From the user's perspective, the major advantage SOULMATE has to offer compared to the mere individual tools is that it evolves and adapts to the changing needs of the user. Initially, it can serve as a routing tool, whereas it can evolve towards a monitoring tool to be used during trips into an instrument to train and experience specific trips in a realistic and enjoyable setting. As SOULMATE adapts to the new situation, it remains the familiar instrument, hence lowering the threshold to introduce training and monitoring as it becomes a necessity.

A possible workflow for the use of the SOULMATE solution is illustrated by Fig. 2. As a first step, the elderly (or the personal coach or caregiver) will define the route (1). He/she trains the route in a safe and comfortable environment, thereby memorizing visual cues for the route and building confidence (2). After a learning phase in this virtual training environment, the elderly or his/her coach configures the route characteristics (e.g., the chosen mode of transport – walking, cycling or public transport) - and sets the preferences for instructions for the elderly himself and/or notifications for the coach (3). The trip can be performed in real-life, supported by passive monitoring by a coach, by active navigation turn-by-turn instructions for the elderly, or by both (based on the specific abilities of that individual and his/her travel needs and wishes) (4). Possible pitfalls or confusing situations during the real-life trip can be detected, which can afterwards be trained again in the virtual training environment (5). With SOULMATE, elderly people can choose to use only a limited part of the functionality of the solution (e.g. the outdoor navigation feature) to match their individual needs. Additional features can be added if and when desired by the user, for example, when their physical, cognitive or environmental conditions change.

The connections between the SOULMATE components create added value on different aspects. Routes trained in Memoride can be integrated in the Viamigo and Ways4All applications, hence going from the virtual to the real world. In case real-world situations are more complex than initially foreseen (e.g., a neighbourhood where all the houses look alike), real-life alternatives can be defined and fed back into Memoride for further training these alternatives. When training the route in Memoride, it is possible that the user wants to take another street or direction from the predefined one. The changes in these routes can be sent to the passive navigation module Viamigo or the active navigation module Way4all so that the routes will be adapted. Furthermore, the routes that are created in Viamigo (with annotations for the coach) can be sent to Ways4All, so that the corridor around the route can be used for active navigation/routing. Experienced difficulties during the outdoor trips (e.g., situations where the user takes the wrong road) can be sent to Ways4All for additional navigation support, by which the route will be recalculated according to the new situation to make sure the trip can be completed as planned. The modules can be easily translated into any other language, which means that SOULMATE can be made fully usable for foreign-language users. SOULMATE can be used by people without any disabilities and can grow with the user when they get older and possible disabilities (decrease of sight, hearing, mobility or mental state) occur. This way people get used to the functions and depending on their state of living extra functions can be used without having to learn new applications.

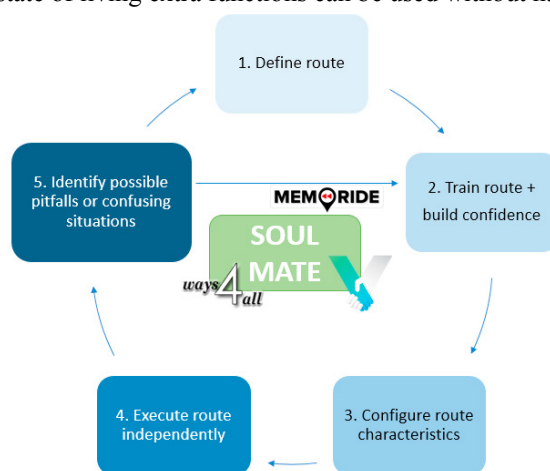


Fig. 2. Illustration of possible workflow using the SOULMATE solution.

SOULMATE configuration revolves around a web-based user management and configuration console. This console allows to manage users, to set up a personalised community around the user, to activate and configure functionalities (e.g. managing the set of routes to train or edit the safe zones for a monitored user), and to add routes for the user. Also, the web interface is one way to obtain real-time information on the status of a monitored user. The SOULMATE user management web interface allows for both managing a single user in a more intimate private setting as well as managing multiple users in an institutional context.

The SOULMATE web interface connects to a set of backend services through a secure API. These services connect to the core SOULMATE database as well as to individual modules. The SOULMATE services serve as the spider in the web, checking the settings in its database and taking appropriate action through secure calls on the APIs of the modules, thus ensuring consistency and propagation of data conform the desires of the user. Every component in the SOULMATE ecosphere can call back to the central services using the API. The SOULMATE user app is a hybrid containing both routing and monitoring functionalities. The robust and secured communication between server and app that was designed in Viamigo will serve as the base platform to build the SOULMATE app. The user experience of the app, which consists of convenient route planning and turn-by-turn instructions will be added based on components and expertise originating from the Ways4All project. While the routing functionality is fully embedded in the user app, the monitoring and the training functionalities provide additional services. The training functionality is based on Memoride and is fed by the SOULMATE services with routes. These routes can be trained before undertaking the real trip, using the Memoride functionalities, which integrate seamlessly with the SOULMATE

overall experience. The routes can be generated by the routing app or through the SOULMATE web interface, where routes to be monitored can be detailed.

3. Co-creation process and involvement of end-users

A heterogeneous group of elderly, aged 65+, from three countries (Belgium, Austria and the Netherlands) will be involved in three phases of the project to co-create the foreseen solution in collaboration with the technical partners and to test the performance and usability of the SOULMATE solution. As previously described in the introduction, aging adults are a heterogeneous group with varying skills, needs and wishes. To ensure the engagement of a diverse group of older adults in the product development, the end-user organizations represented in the project will recruit elderly adults belonging to predefined sub-groups in society. While defining subgroups, we took into consideration environmental, personal and cultural individual differences, that might influence transportation needs and use of digital solutions. Therefore:

- Slimmer Leven 2020 (NL) recruits two groups of older adults that differ on urban density level of their neighborhood (urban versus rural, environmental factor). Low rural population densities make viable public transport more difficult, leading to the fact that people in rural areas typically have a greater need for other (e.g., non-public) transport modes than urban dwellers.
- Happy Aging (BE) recruits two groups of older adults that differ on their level of independent mobility (active without need for assistance versus needs assistance while travelling, personal factor). Persons with an impaired mobility have less flexibility when making their trips, as they may be dependent on others for assistance.
- GEFAS (AUS) recruits two groups of older adults that differ in their region of origin (local Austrian versus (non-western) immigrant, cultural factor). Immigrants may experience information or communication barriers which can make travelling independently more difficult.

These aspects are assumed, based on scientific research [8-9] and on the expertise from the end-user organizations, to hinder or restrict end-users from traveling independently in society. The SOULMATE solution will be developed in correspondence with needs and wishes expressed by end-users and tested on user-friendliness and the willingness / acceptance to use the instrument during the trips. We are interested in usability and user acceptance both during the learning process and after a period of extensive use. Additionally, end-users inputs are considered for the development of a suitable business model. From an academic perspective, the impact on the quality of life of the elderly themselves, the quality of life of their caregivers (secondary end-users), and the way to go to the market, will be evaluated. The end-users must of course be willing to engage in the testing, be able to participate and test the SOULMATE solution (some with help of secondary end-users), and give and discuss their feedback.

First, **co-creation workshops** with heterogeneous groups of end-users will be organized with the aim to gather detailed information on the wishes and needs of the end-users to co-create the SOULMATE solution. In each of the three countries, four workshops (two per predefined subgroup of elderly persons) will be organized. Thematically, workshops will be divided into two categories: service design workshops and feature development workshops. A schematic overview of the organised workshops can be found in Table 1. The elderly, their informal caregivers, the scientific partners and technology developers will, collaboratively, design an integrated set of technologies in the form of a paper prototype. After analysing the paper prototypes, functional specifications of the SOULMATE solution will be deduced.

Table 1. Schematic overview of co-creation workshops.

Workshops	Service design		Feature development	
	Urban	Rural	Urban	Rural
NL total= 4	Urban	Rural	Urban	Rural
BE total = 4	Mobile	Mobility Impaired	Mobile	Mobility Impaired
AUS total = 4	Native	Immigrant	Native	Immigrant

Secondly, in the **initial testing phase** the initial versions of the instrument will be tested by motivated end-users in iterative loops. Per country, five end-users will be involved, again in collaboration with the end-user organizations.

During regular meetings with the end-users (bi- to four-weekly meetings) their use of and experience with the SOULMATE solution will be discussed extensively and topics such as perceived usefulness, integration in everyday life, usability, acceptance, and safety will be addressed. The results will be discussed with the developers to continuously evaluate and improve the instrument until a final version of the instrument is ready.

During the initial testing phase, quantitative indicators, including willingness to pay & acceptance of SOULMATE (presented by an explanation with screenshots), will also be collected by means of a survey, among 100 respondents per country (300 in total). Survey data on quality of life (QoL) indicators will be obtained from this larger group of end-users in all participating countries and used as a benchmark baseline. This will allow testing and quantifying the effects of using SOULMATE by the end-users and will provide information to the developers on how to maximize and personalize the capabilities of the instrument for a variety of end-users. The survey will include a willingness to pay for and acceptance of (WTP&A) experiment for the various components of the SOULMATE solution.

Before the field trials, we will **baseline measure** the travel behaviour, QoL and physical activity:

- Actual travel behaviour of end-users will be measured by GPS and combined with activity diaries to gather information on their mobility patterns. This includes among others: activity space, number of trips, activity locations and travel party.
- QoL & perceived autonomy score: (QoL-OLD survey) to test for, among others: sensory abilities; autonomy; past, present and future activities; and social participation.
- Activity patterns will be measured by an activity diary & the Groningen Activity Restriction Scale (GARS).
- Social network will be analysed using the social network analysis approach (Van den Berg, 2012) [10].
- Loneliness: The 6-item De Jong Gierveld Loneliness Scale contains items on overall, emotional and social loneliness.
- Physical activity will be assessed by means of collecting physical activity sensor data (which will be subsequently categorized as either sedentary, or low-intensity, moderate intensity, or vigorous activity), which will be provided to the field trial participants for the duration of one week.
- Self-reported health will be assessed by means of the Short Form (36) Health Survey (SF36) [11].
- Patient empowerment will be assessed by means of the Patient Enablement Instrument (PEI).
- Burden on informal caregiver: we will question the end-users' informal caregivers about the burden they experience while taking care of somebody else (12-item version of the Zarit Burden Interview) [12].

In the **field trials** 40 end-users per country will be recruited, with the help of the end-user organizations, to use the SOULMATE solution during their real-life trips. After three months (middle) and after six months (end of field trials), there will be (the same) follow-up measurements of travel behaviour, QoL and physical activity to test for changes compared to the baseline, to test for the effect of using SOULMATE. A multitude of these parameters will be, so we currently hypothesize, positively affected by SOULMATE (e.g. increase of activity space, independency of elderly). Besides the above mentioned measures, the Acceptance and usability of SOULMATE will be measured using the Technology Acceptance Model [13]. These quantitative measurements will be supplemented by interviews with the end-users to explain the findings of the surveys and to gather a deeper understanding of why people (do not) use the technology in certain situations.

4. Conclusion: Expected outcomes for different types of end-users

The SOULMATE solution will be developed iteratively in co-creation with end-users, and the instrument will be intensively tested and evaluated in three countries based on a usability, technical and business aspect. In the end of the project, the three service solution partners will jointly bring the SOULMATE solution to the market. End-users will be involved in the different project phases (co-creation process, initial testing and field trials), and also in the business modelling (e.g. willingness-to-pay and service design). As transportation needs can differ widely among relevant types of end-users, several well-defined homogeneous groups of elderly are defined to intensively test and evaluate the SOULMATE solution. SOULMATE has built-in flexibility (customizable) and therefore an increased attractiveness for the user, since it can be personalized and adapted to their needs, which may change over time. The reminiscence/fun factor and the navigation part appeal primarily to the end user, while the monitoring component strongly appeal to caregivers and/or relatives. The SOULMATE technology is user-friendly and reasonably priced

since no extra devices need to be purchased during the different health stadiums. The SOULMATE solution may also be applied to other types of the population, like persons who have difficulties to move around due to a lack of knowledge, difficulties of understanding the written languages, etc.

Therefore, SOULMATE is expected to have several positive outcomes for different types of end-users:

- **Primary end-users** (elderly themselves): By supporting elderly to execute a rich daily activity pattern in a secure way, it will allow them to live a more healthy, active and meaningful life. In addition, this will allow them to live independently and safely at home for a longer time (increased decision and control of daily activities) with support from their caregivers and community when necessary. Finally, this will provide them more satisfaction and living in dignity, due to reduction of loneliness or isolation by increased social participation.
- **Secondary end-users** (formal and informal coaches): Improving the quality, effectiveness and efficiency of the care they provide reduces stress and leads to a lower care burden, as well as more trust / security as SOULMATE will only intervene as needed.
- **Tertiary end-users** (municipalities, insurance, public transport companies...): due to SOULMATE there will be more participation of elderly within the society / daily life, and more people who can stay at home instead of residential care (which will lead to a reduction of the healthcare costs).

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