CE 1581 niCE-life

CUSTOMISED MONITORING SOFTWARE
(Deliverable DT.2.3.3)

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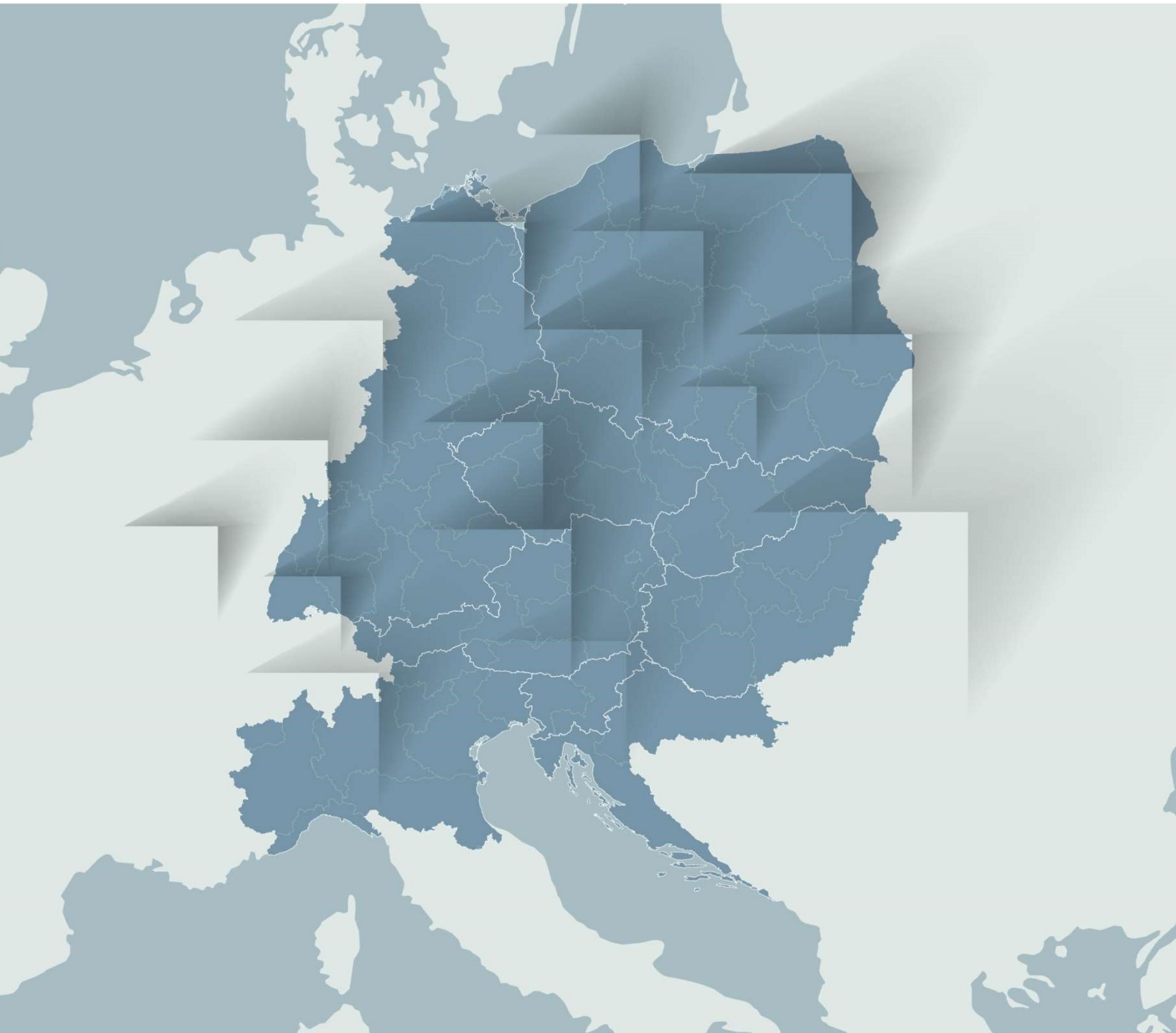
(version 1)



CUSTOMISED MONITORING SOFTWARE (DT.2.3.3)

1. Introduction

In this deliverable, we describe the software for the caregivers, which integrates GPS tool with intelligent monitoring platform. The tool is based on a commercial software identified on the market following a specific analysis carried out in the framework of previous deliverables (D.T1.3.1) and further research. This software was further extended by additional developed parts that were programmed to extend the functionality of the current platform.

The proposed system automatically monitors the health conditions and activities of persons with Mild cognitive impairment or suffering from dementia. It also analyses the received data about behaviour patterns of persons and provides added insight to caregivers about their status according. Finally, we talk also about integration with intelligent monitoring platform.

2. Purpose of the monitoring platform

The objectives related to the implementation of a monitoring platform are many, but the ultimate goal is certainly to ensure a good quality of life for the elderly person, starting first of all from a crucial element, security. However, not only that, the impact of the platform can have a significant role in several aspects, respectively:

- First of all, the monitoring platform can provide older people with a higher level of security when dealing with everyday activities. People with Mild cognitive impairment or who are at risk of developing forms of cognitive impairment can benefit greatly from the knowledge that even if they experience disorientation, there will always be someone who can identify and support them. This platform will also allow a higher degree of freedom and independence in daily life;
- The relatives of the elderly will have significant benefits in terms of reducing what is called the "caregiver's burden" in the literature. Through an application they can easily identify the position of their loved ones and be supportive in case of need;
- The information that will be collected by the platform through the wearables and a series of sensors will not only be information related to the position. Through the monitoring of other variables such as heartbeat and sleep quality, it will be possible to develop, together with the project partners, a model supported by machine learninig that will be able to predict the evolution over time of the health status of the people involved in the project. The latter objective represents the added value of the project compared to other experiments carried out in European projects. It concerns not only an improvement in the capabilities of the hardware, but also an improvement that could be predicted given the speed of development of these technologies. Above all, it concerns an evolution in terms of the system and the exploitation of the data that can be obtained.

3. Starting point of the project: SPES

The testing envisaged by the niCE-life project, in particular the specific focus on GPS technology in support of the elderly, is based on the numerous projects that have been developed in recent years that have dealt with this specific topic (see for a specific excursus the deliverable dt2.3.2). Among the various initiatives, the SPES project (http://www.spes-project.eu/index.php?pilots&id=2) was particularly relevant, particularly with regard to the experimentation carried out by that project in the Vienna pilot site. In that experience, the objective was to identify and provide useful technologies for people with dementia that contribute to enhancing their quality of life. The objective of the SPES project was then concretely expressed in 5 main test areas, respectively: Orientation support, Preventing dangerous situations, Talking key; Finding things again; Brain stimulation. Among the five areas indicated, the work carried out in the first two are relevant for the current implementation of GPS tracking in the niCE-life project. Starting from orientation support, as can be seen in the image below the hardware differs significantly.

Figure 1: Spes device

Figure 2: niCE-life device

The niCE-life project introduces a tool capable of integrating multiple functions into a single device, unlike the SPES project. This is due to the strong innovative drive that has countersigned these technologies in the last 5 years. The miniaturisation process has a strong impact on usability itself. In fact, the elderly people who will participate in the pilot site will have an endowment composed only by the smart-band and some inexpensive sensors.
A further important innovation concerns the type of functionalities and data that will be integrated into the monitoring platform. In the experimentation of the niCE-life project, the elements to guarantee security, i.e. GPS tracking and geofencing, will be preserved, but a series of additional functionalities will be introduced to maximise the improvement of the well-being and quality of life of the elderly person.

Moreover, the characteristics of the platform will also be an evolution of what was done in the SPES project.

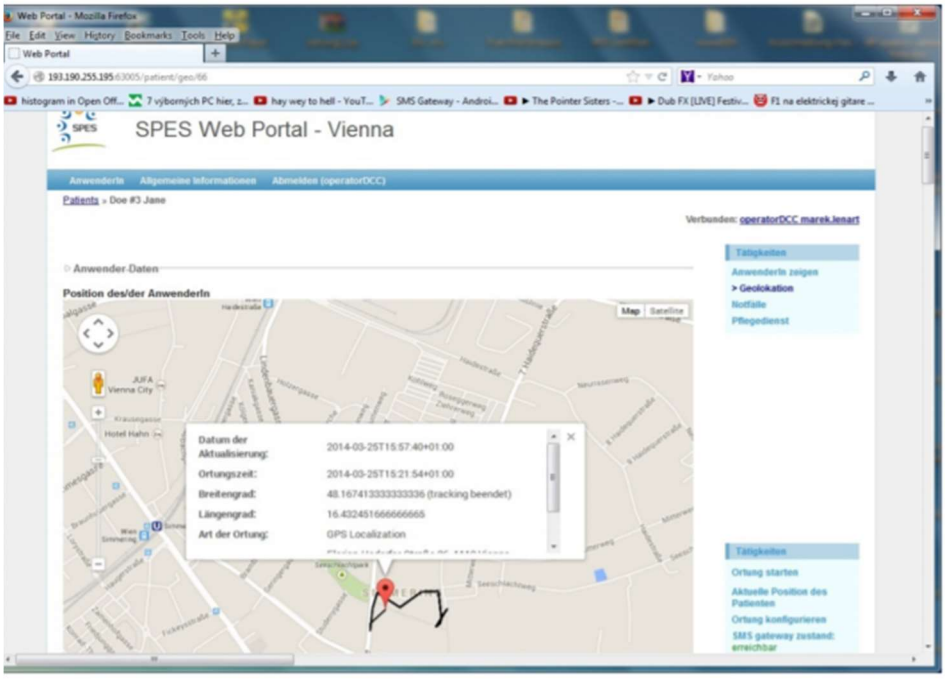


Figure 3: SPES platform

The niCE-life project monitoring portal will be accessible not only through an online portal, but also through a mobile application. The motivation for this choice has to be the desire to include informal caregivers in the project. They are in fact an inseparable resource for the support of the elderly and their role, if adequately supported by technology, can be even more decisive in terms of the overall sustainability of the system. Moreover, as already pointed out above, the monitoring platform will not only include data related to the safety of the person (gps tracking, geofencing) but also numerous parameters related to the well-being of the elderly.
Finally, the greatest element of innovation that fully represents the step forward made by niCE-life compared to previous experiences, is the use of data and the enormous potential they have, supported by machine learning, in predicting the evolution of people's health. The data collected by the platform will therefore be available to the Brno University of Technology that, together with partners, will develop models which, in a recursive approach, may also lead to changes in the overall care model.

4. The actors of the platform

The platform that will be implemented in the nicelife project will play a crucial role as a connector of the actors involved in the pilot site activity. It will have to provide a clear and secure path for the information that will also be reflected in the organisational model of the

platform management. Through this tool the responsibilities and the role of each actor in the system are defined. The three main users of the service will be

1. care providers (formal caregivers)
2. the elderly person
3. Relatives (informal caregivers in general)

Each of these actors will have clearly defined responsibilities and the possibility to act on the platform as defined below:

1. The care provider will have the overall management of the platform. Through a specific monitoring portal it will be able, through the specific work of a care manager, to carry out different types of activities. First of all, the organisation will be able to receive alerts from the devices worn by the elderly person. The alerts will be triggered following events defined ex ante, such as the use of the SOS button or the exceeding of health thresholds defined specifically for the user. Through remote monitoring the care provider will be able to verify the position of the subject and this will be particularly useful in cases where specific parameters are defined and an alert is automatically triggered within the platform. The care provider will also have the task of extracting data from the platform so that they can be used by partners to develop predictive models of health status through the analysis of data patterns.

2. The elderly people who will participate in the project will be the most important actor and the target identified by the project proposal. Participants will be selected on the basis of their compliance with the parameters defined by ISRAA and the state of need, for which the technology could have a significant impact. The target includes older people aged 65 or more, with MCI living in cohousing alone or with an informal caregiver and older people that live in nursing home with formal caregivers assistance. Mild cognitive impairment (MCI) is defined as cognitive decline greater than expected for an individual's age and education level, which does not interfere affect basic activities of daily living. The activities required of the elderly person will therefore be minimal, precisely because of the need to minimise the complexity and skills that the elderly person must have in order to use the proposed solution. Therefore, the elderly person will have to wear the smartwatch all day long and periodically recharge the battery of the device through probably a magnetic base. The elderly person will be able to use the sos button to ask for support from family members or the care provider. In addition, if the participant still has sufficient cognitive skills, he or she will be able to access the dedicated app and assess his or her health over time, orienting his or her behaviour towards improving his or her condition. Finally, the elderly will participate in a short training before the start of the training. Through little and clear information, they will be able to make the best use of the proposed technology.

3. Finally, a valuable role in terms of guaranteeing and sustainability of the intervention will be ensured by the participation of family members, who are often the main caregivers in our society for people who are ageing. The specific actions that family members will be able to carry out with regard to the platform are many. First of all, they will be able to access a dedicated app which will provide the position of their relative, as well as parameters indicating the evolution of their state of health. The informal caregiver will also be included in the alarm chain that will be triggered if the elderly person presses the SOS button or if

thresholds established through the technology platform are exceeded. Therefore, through the implementation of these technologies it will be possible to alleviate the caregiver's anxiety level, who will be able to live his or her daily life better with a tool capable of reducing the potential dangerous situations that the elderly person might encounter.

5. The functionality of the platform and connected devicese

The general architecture of the platform follows the approach defined in the Deliverable D.T2.3.2 - Design and development of the GPS tool

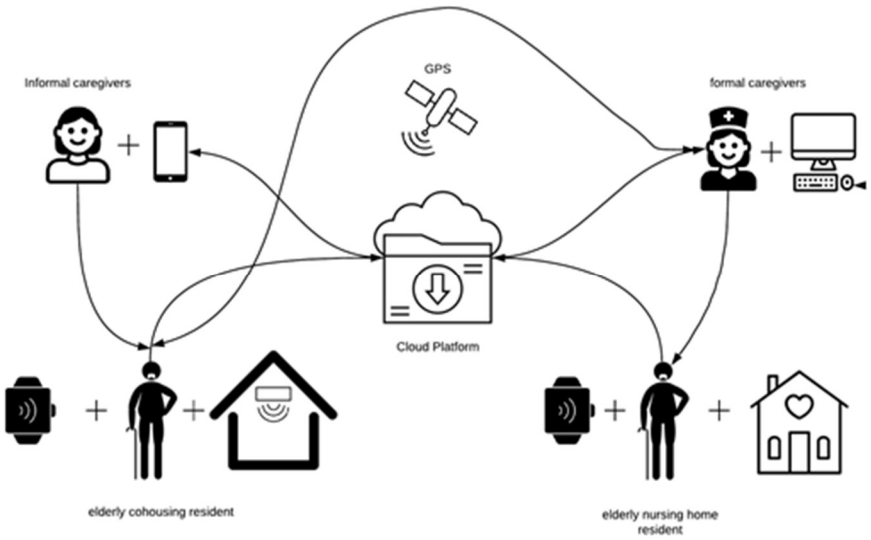


Figure 4: An architecture for a GPS tracking solution

The monitoring platform is the centre of the system because it allows to connect the actors foreseen by the project, i.e. the elderly person, informal caregivers (i.e. mainly family members) and formal caregivers (i.e. the care provider's employees). But not only that, the platform will have the important task of aggregating the data coming from the sensors that will be present in the wearable devices and in the elderly person's living environment.

The main functionalities that will characterise the platform are the following:

1) GPS Tracking
2) Geofencing
3) Indoor tracking

4) SOS button

5) Fall Alarm

6) Heartbeat

7) Sleep monitoring

Below each functionality will be described in detail:

1) GPS tracking. This functionality constitutes the central element of the experimentation, consistently with what is defined in the application form. GPS technology allows both formal caregivers and relatives to know the position of the elderly person wearing the bracelet. Probably, the frequency will be measured at most every five minutes.

Formal and informal caregivers will be able to know the position of the person wearing the bracelet through the monitoring platform. It will be accessible through two channels. The first one is the web console, which allows following all participants in the project activities at the same time. It is mainly designed for formal caregivers and allows quick access not only to the position of the person but also to health data.

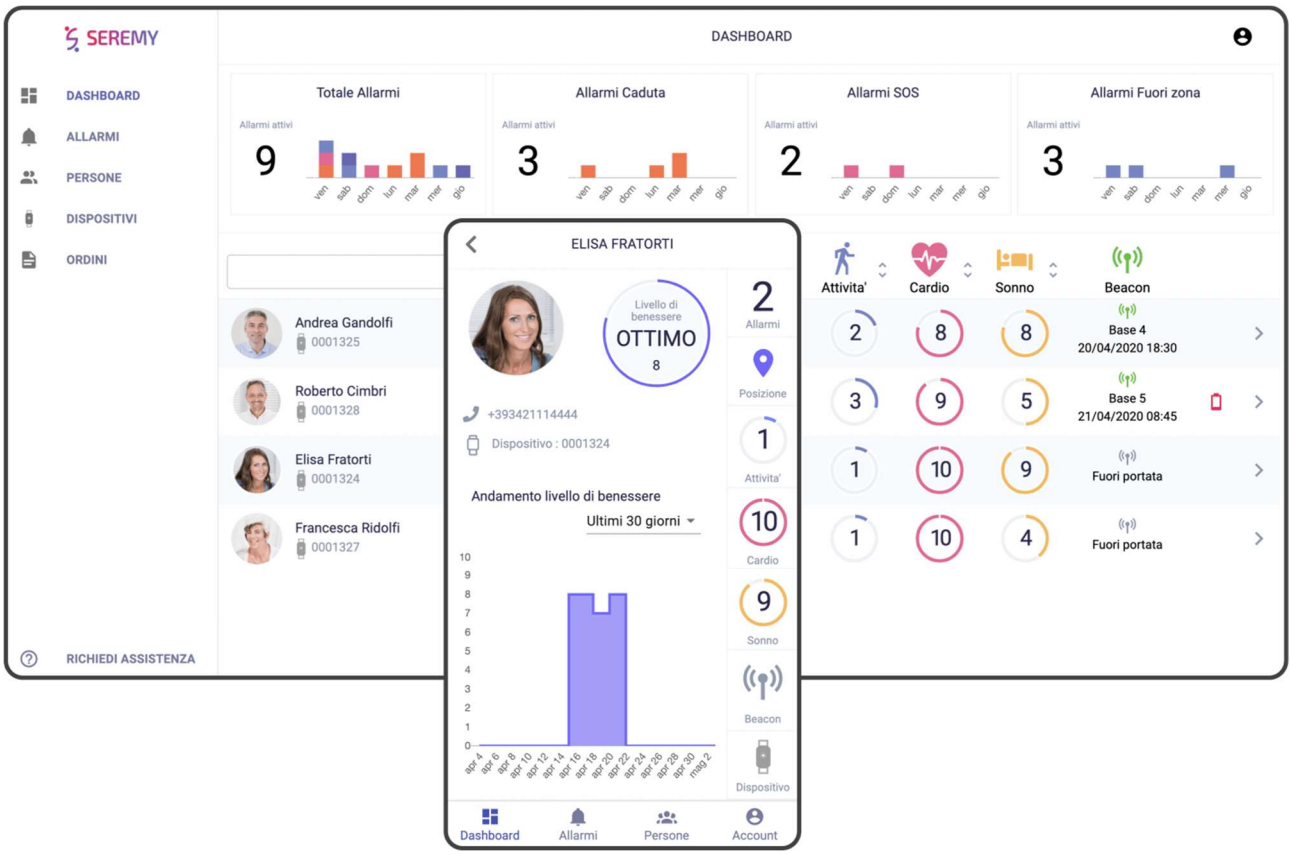


Figure 5: Console web and dedicated application

The second channel that allows login to the monitoring platform is a mobile application accessible via smartphone and tablet. It is designed primarily for informal caregivers who can easily access their loved one's location via the application. The choice of the application is due to the need to facilitate access to the platform for informal caregivers, who often have low digital skills. Nevertheless, access to the platform via an app can also be a useful tool for care managers if they need to move away from their workplace.

Finally, it is necessary to underline that information about the position of the elderly person will be transmitted through a specific device connected to the platform. It will have some functional features that will guarantee a high level of usability by the target group of the project.

In particular, the wearable device, will be characterised by some crucial requirements such as:

- to be autonomous as far as the internet connection is concerned. Through an integrated sim it will be able to transfer data to the cloud without having to connect to wi-fi networks;
- have a long battery life. This is a crucial aspect considering the target group of the project. People who are developing symptoms of dementia risk forgetting to recharge their device if this has to be done too frequently;
- With regard to charging the device, wireless solutions, such as magnetic bases, will be preferred in order to maximise the usability characteristics of the device.

2) Geofencing, a virtual perimeter associated to a real world geographical area (Geolocation Data And New Global Markets, on royalholloway.stream, 10 October 2017), is another essential functionality, closely linked to GPS technology and able to support the monitoring activity through the platform. Within the niCE-life project, geofencing will allow formal and informal caregivers to receive an alarm if the person wearing the bracelet leaves a predetermined area. This can ensure a good level of security for those people who are developing early forms of dementia who will then be able to move more freely, knowing that this technology is there to support them.

3) Indoor tracking. This functionality is largely underestimated, as it can play a decisive role in protecting the health of the elderly person. In fact, safety must be guaranteed not only outside the home but also inside, where classic GPS tracking technology addresses numerous problems.

In addition, indoor tracking can also be particularly interesting for care providers who can monitor the position of their caregivers within their own facilities, whether they are in old people's homes or cohousing or alternative forms of residential care. Specifically, indoor tracking allows the identification of the person's presence in internal areas, be they rooms, gardens or any other area.

Figure 6: indoor tracking

From a technical point of view monitoring will be possible thanks to the use of BLE proximity TAGs. The 100% wireless BLE (Bluetooth Low Energy) sensors are easy to install thanks to the standardised, non-proprietary protocol. The intelligent battery management is essential, as the BLE tags consume twice less energy than classic Bluetooth, reducing power consumption while providing a wide range of coverage. In addition, these sensors are now accessible at a low cost, thus allowing a wider range of coverage. Finally, thanks to BLE technology, the sensors can be interfaced with any device with Bluetooth connectivity, making it easy for the platform to acquire data.

4) The sos button is one of the other features that integrate with the platform with the aim of maximising the level of security of the elderly person. This functionality will be extremely easy to use by the person wearing the bracelet, in fact, it will be sufficient to press the button to trigger a previously configured chain of alarms. From the side of the platform, the alarm will come via a notification that will trigger a loud siren-like sound so that the emergency situation is suddenly taken over. The notification of the emergency situation will reach both the dedicated application and the web console. This will also allow informal caregivers to be the first to come to the rescue of their relative in need. In any case, the alarm chain will be configured specifically for each participant in the project.

5) Fall alarm. Falls are among the traumatic events that can have the greatest impact on the health and quality of life of the elderly person. The problem of falls in the elderly is particularly relevant not only in terms of the frequency and severity of the results in the case of fractures, but also in terms of the consequences on the psychophysical well-being of the person, because even the insecurity linked to the fear of falling can considerably limit the performance of everyday activities. The data on falls are explanatory of the severity of the problem. In fact, at European level, it is estimated that an average of 35.848 older adults (65

and above) are reported to have died from falls on an annual basis. Moreover, Falls are also the predominant cause (58%) of injury-related emergency department attendances for older people within the EU (https://www.eurosafe.eu.com/key-actions/older-people/reports). Cognitive impairment is recognised as a risk factor by the Higher Institute of Health (https://www.epicentro.iss.it/incidenti-domestici/rischi-cadute-anziani#fattori). Therefore, our project seeks to offer a solution that guarantees a higher degree of safety for older people at risk of falling through a wearable band. From the point of view of the monitoring platform, the fall will be automatically signalled through the generation of automatic alarms. The chain for taking charge of the fallen person will be customisable and therefore defined from time to time, together with informal caregivers. Finally, the benefit of using this technology must also be linked to a better-perceived level of security, directly linked to the stress levels of the participants.

6) Heartbeat. This element is one of the platform indicators that focus more on the well-being of the elderly than on safety. The importance of monitoring this data is also indicated in the scientific literature (https://www.jacc.org/), which considers heartbeat monitoring to be a useful tool to prevent possible problems related to arrhythmias and heart attacks, often widespread among the elderly population. As far as the monitoring activity through the platform is concerned, it will be possible to define specific thresholds for each participant in the project which, if exceeded, will generate a specific alarm. Moreover, the monitoring series of this parameter will constitute one of the types of data that will feed the forecasting capacity of machine learning.

7) Sleep monitoring. This indicator is an extremely useful tool especially for the target group of the Treviso pilot, i.e. people at risk or suffering from cognitive impairment. In fact, sleep plays an important role in maintaining brain health and lowers the risk of age-related cognitive decline. Findings indicate that poor sleep is a risk factor for cognitive decline and the development of Alzheimer's disease [1]. So, constant monitoring will certainly be a valuable resource. In fact, the platform will be able to analyse the quality of sleep of the participant. This will make it easier to change behaviour in order to improve this indicator and consequently, the health status of the elderly person.

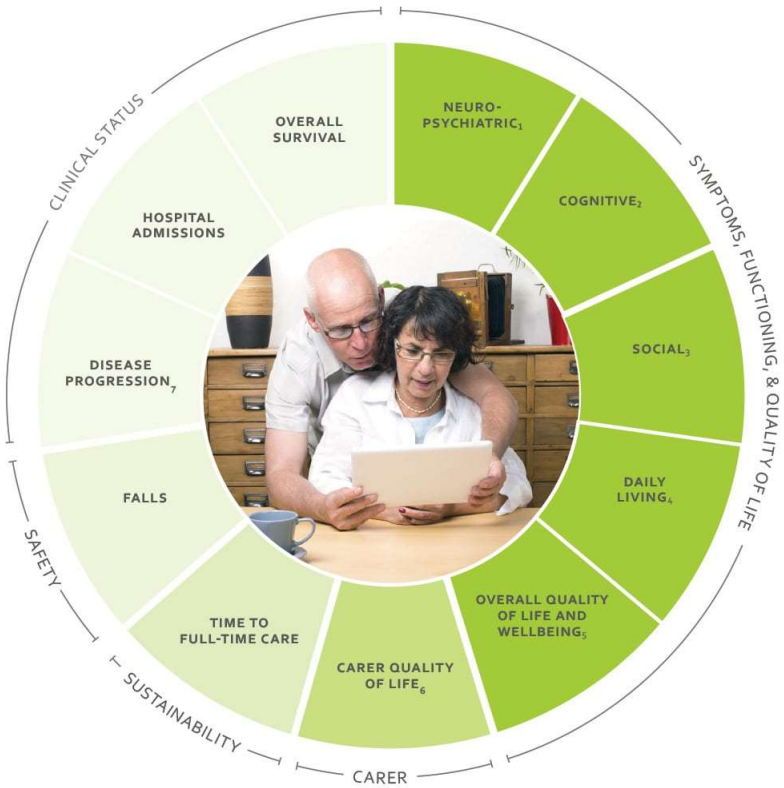
[1] Yue Jirong, Huang Changquan, Wu Hongmei, and Dong Bi-Rongcorresponding author. Association of sleep quality and dementia among long-lived Chinese older adults.Published online 2012 Jun 6. doi: 10.1007/s11357-012-9432-8P https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3705112/

6. Innovative elements of the platform

There are plenty of aspects of how the platform contributes to support and improve elderly people quality of life. The tool provides general features like GPS Tracking, Geofencing, Indoor tracking, SOS button, Fall Alarm, Heartbeat monitoring or Sleep monitoring. These

technologies are already known and available on the market. But in this project's solution all these functionalities are packed into one device. Another innovative element of this deliverable lies in adopting these technologies in the framework of an evaluation model that can provide policy makers and all stakeholders with the evidence to make this solution an integrated part of the services offered to citizens.

Through the tools offered by ICHOM, a solid theoretical framework developed at Harvard Business School by Professors Michael E. Porter and Elizabeth O. Teisberg (https://www.ichom.org/), it will be possible to observe the impact related to specific variables defined ex ante, with a specifi focus on dementia:



The three dimensions that we will consider most, in accordance with the project objectives, are:

- **FALLS**. Through data collection we could determine the number of falls that will occur and the effectiveness of the response.
- **Overall quality of life and wellbeing**. Through the instrument of the Quality of Life questionnaire, it will be possible to determine the evolution of the quality of life of the person participating in the project;
- **Carer quality of life.** Through the Quality of Life tool or through EuroQol-5D, it will be possible to evaluate the increase of the quality of life of the caregivers, in particular the infromal ones.

Finally, two other innovative elements in the implementation of this technology are:

- Sleep patterns analysis and early warning regarding brain diseases risk, such person can be recommended to "Intelligent monitoring tool" for more accurate analysis.
- Heart rate anomaly detection and its relevance to COVID situation (experimental)

7. Integration with Intelligent monitoring platform

Intelligent monitoring tool is integrated using customised software development. This tool is designed mainly for social caregivers that notify people at higher risk. Those people can be notified then and recommended to be monitored from the healthcare perspective by the Intelligent monitoring tool.

Parkinson disease affects 3 % of persons older than 65 years. This disease develops up to 10 years before the first symptoms of the disease. When the symptoms are visible, there are already extensive and irreversible damages of the brain. Unfortunately, the disease still cannot be cured, but treatment is significantly more effective when administered early. Thus our group of tools focus on prolonging active life and improving the quality of life of elderly people.

The integration between intelligent monitoring tool and GPS tracking tool lies in capability to recognize suspicious sleep patterns that are common early state marker for various brain diseases.

8. Privacy and ethics

Due to the participation of vulnerable persons (frail or vulnerable older adults, including those with cognitive impairments) issues regarding ethics and data protection, are of utmost importance. All the activities developed along the project will comply with ethical principles and relevant national, EU and international legislation, for example, the Chapter of Fundamental Rights of the EU and the European Convention on Human Rights. Provisions of Directive 95/46/EC and the General Data Protection Regulation (proposed in (European Commission, 2012)) are shown to be highly relevant to the protection of research participants and service users. NiCE-life will follow the GDPR on data protection. The exploitation of data refers to the re-use of massive data, instead of personal data. However, the use of these data (secondary use) is regulated within the Digital Single Market and also regulated by directives related to consumers' rights, personal data and the GDPR, among others. Since we are dealing with a European project, the exchange of data between partners will be crucial. Nevertheless, the data will be protected by an anonymisation procedure and stored in a cloud based in Europe. The use of the platform will in any case be consistent with the Deliverable D.M.3.7

Data protection manual, developed by the lead partner with the collaboration of the whole consortium.