PlatformUptake.eu

ASSESSING THE STATE OF THE ART AND SUPPORTING AN EVIDENCE-BASED UPTAKE AND EVOLUTION OF OPEN SERVICE PLATFORMS IN THE ACTIVE AND HEALTHY AGEING DOMAIN

D4.4

AHA Open Service Platforms Baseline report

PROJECT DESCRIPTION

Acronym: **PlatformUptake.eu**

Title: **Assessing the State of Art and Supporting an Evidence-based Uptake and Evolution of Open Service Platforms in the Active and Healthy Ageing Domain**

Coordinator: SYNYO GmbH

Reference: 875452

Type: CSA

Program: HORIZON 2020

Theme: Healthy ageing, Internet Services & Application

Start: 01. Jan, 2020

Duration: 26 months

Website: www.platformuptake.eu

E-Mail: office@platformuptake.eu

Consortium: **SYNYO GmbH**, Austria (SYNYO), Coordinator

                Institute of science and information technologies, Italy (ISTI)

                Fraunhofer Institute for Computer Graphics Research IGD, Germany (FH-IGD)

                Universidad Politécnica de Madrid, Spain (UPM)

                Institute of Communication and Computer Systems, Greece (ICCS)

                Jožef Stefan Institute, Slovenia (JSI)

                AFEdemy, Academy on Age-Friendly Environments in Europe BV, Netherlands (AFE)

                Cáritas Diocesana de Coimbra, Portugal (CDC)

                Linköping University, Sweden (LIU)

                Universitat de les Iles Balears, Spain (UIB)

                Smart Homes, Netherlands (SMH)

                Etablissementsa Lievens Lanckman, Belgium (LL)

DELIVERABLE DESCRIPTION

Number:	**D4.4**
Title:	**AHA Open Service Platforms Baseline report**
Lead beneficiary:	**LIU**
Work package:	WP4 Analyse: Platform evolution, Uptake and Socioeconomic benefits
Dissemination level:	Public (PU)
Type	Report (R)
Due date:	30.09.2021
Submission date:	13.12.2021

Authors:

Andrea Carboni, ISTI

Dario Russo, ISTI

Davide Moroni, ISTI

Paolo Barsocchi, ISTI

Contributors:

Ad van Berlo, SMH

Christina Samuelsson, LIU

Carlos Juiz, UIB

Bernhard Jäger, SYNYO

Alexander Nikolov, SYNYO

Reviewers:

Efstathios Karanastasis, ICCS

EXECUTIVE SUMMARY

This deliverable presents the outcome of the activities carried out within task T4.4: "Create a baseline report including the main outcomes of the analysis to support the platform improvement and uptake". The goal of this task is to show a general overview of the state-of-art of open platforms, their users, networks, stakeholders, functionalities, outcomes, benefits etc. To achieve this the project consortium analysed all the work which was done in WP2 and in previous tasks in WP4 and carried out further evaluation and refinement of the selected KPIs. To support further development activities in the field the report highlights identified gaps in the ecosystem of open platforms for Active and Healthy Ageing (AHA) and Ambient and Assisted Living (AAL) and makes recommendations to current or future providers of open platforms on how to effectively tackle these challenges.

# TABLE OF CONTENT

TABLE OF FIGURES

TABLE OF TABLES

1. Introduction

The activities in WP4 aim to achieve project Objective 3 "ANALYSE existing platforms based on the created methodology, by assessing the projects and initiatives hosted by them, their further evolution, uptake, sustainability and socioeconomic benefits". The work carried out in this work package has seen the analysis of the outcomes arising from the application of the methodology defined in D2.5 for the measurement of KPIs, together with an accurate analysis aimed at monitoring and evaluating progress that will lead to a large-scale uptake of open platforms. In WP2, the activity carried out led to the identification and definition of four groups of KPIs, one for each of the four stakeholder groups defined at that time, namely Primary end Users, End User Customers, Technology Providers and Government. We will see in the course of this document how, over the months, the study, research and analysis process carried out by the subsequent WPs, with particular reference to WP4 and WP5, has brought to light information that allowed us to refine what was then defined. In particular, in WP5, the stakeholder groups have been redefined, which has also partly affected the KPIs established previously, as they refer to the old definitions. In WP4, on the other hand, with particular reference to the interviews and the application of the methodology for compiling the KPIs, we saw a further refinement step of the KPIs list, which was based on the validity and type of information collected by the various users and professionals who took part in the testing phase.

1.1.   Work package methodology

The object of this deliverable is the outcome of T4.4 "Create a baseline report including the main outcomes of the analysis to support the platform improvement and uptake". The goal (Figure 1) is to review all the results of WP2 and those related to deliverables D4.1, D4.2 and D4.3 for the creation of a baseline report which shows a general overview of the state-of-art of open platforms, their users, networks, stakeholder, functionalities, outcomes, benefits etc. In this document the work carried out in WP2 and WP4 will be briefly described and the main information being useful for the creation of the baseline report will be extracted. Based on this first part of the work, the KPIs already defined in WP2 will be analyzed and reorganized and new ones will be defined, on the one hand to cover aspects that emerged later and not initially covered, on the other to limit the selection only to the KPIs that are functional. Hence, the baseline report will provide an accurate description of the selected KPIs and the methodologies for collecting and analyzing them for each user group according to the corresponding domain. Next, an outline of main capability gaps in terms of platforms' uptake by their end user groups will be presented. This knowledge will be later made available on the Open Information Hub for all interested organization to support their development activities in the field. This will be accompanied by a section containing recommendations, always divided by user group, which emerged mainly during the interview phase of managers, end users and developers of the various analyzed platforms. The baseline report that will be presented here therefore has the dual function of being a guide to the correct evaluation of uptake, success factors and hindrance factors both in the construction phases of a platform and in its ongoing evaluation, but also that of showing a general overview of the state-of-art of open platforms, their users, networks, stakeholders, functionalities, outcomes, benefits, etc.

The baseline report may be used to find success and hindrance factors of open platforms which have already come to the market, and which should be considered when constructing a new platform. Moreover, the report will also be very useful when purchasing an open platform from market parties, who claim to be open.
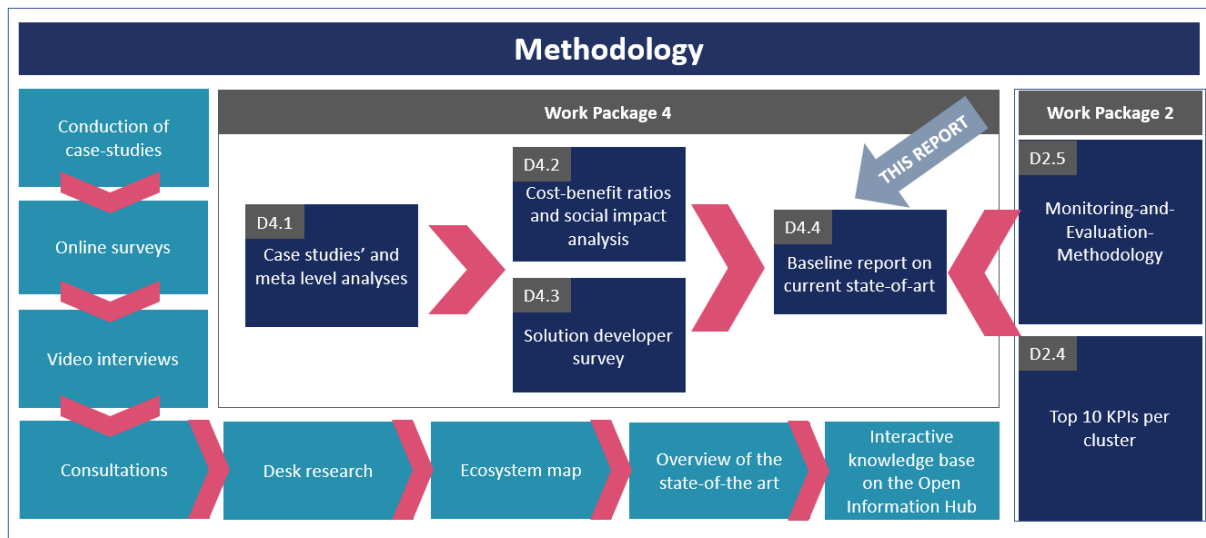
Figure 1: WP4 Methodology

The structure of the deliverable is organised along the following sections:

In **Section 2** and **Section 3**, respectively, the main phases of the work carried out in WP2 and in tasks T4.1, T4.2, T4.3 of WP4 will be retraced.

Section 4 contains a detailed analysis of users, networks, stakeholders, functionalities, outcomes, benefits of open platforms and of how our research has developed over the months. Great importance will be given to the selection of KPIs, which are fundamental for the methodology defined in WP2.

Section 5 will review all the selected KPIs, thus seeking to provide their exhaustive description.

Section 6 highlights identified capability gaps in the ecosystem of open platforms for AHA and AAL from the points of view of their end user groups. Hence, the report provides a basis for further development activities which will ultimately boost the uptake of open platforms in the field.

In Section 7, the document outlines recommendations for a more targeted and effective collection of open platforms. In addition to this, a state of the art of all the open platforms that have been assessed during our research in both WP2 and WP4 is presented.

The report concludes with **Section 8,** which summarizes the findings in the report and provides an outlook of planned actions.

2. Recurring terminology

The definition of some terms which are used recurrently within the PlatformUptake.eu project is considered useful for the continuation of reading, namely: uptake, open platform, success factor and hindrance factor.

Uptake: In AHA/AAL platforms, level of making use or taking up a platform. Level of knowledge or market absorption of the platform by any stakeholder domain.

Open platform: In AHA and AAL domains, an open platform is a software system that allows the many-to-many substitutability between applications, services and devices from multiple vendors via common APIs for the benefit of an individual user whatever her/his role is (older person, carer, social worker, care worker, governmental representative, technology developer etc.). It is an open digital ecosystem that connects the individual users to health or social care provisions, to lifestyle and prevention applications and home technology to support their independent living, healthy lifestyles and participation in society. An open platform tries to maximize adherence to the principles of: Open Source, Open Standards Based, Federatable, Shared Common Information Models, Vendor and Technology Neutral, Support Open Data, Provide Open APIs, Open Usage and Open Adaptation.

Specifically, these criteria have been defined as follows:

- Open Standard Based: The implementation should be based on agile open standards. Any willing party should be able to use these standards without charge to build an independent, compliant instance of the complete platform. [9]
- Open source: Open Source refers to the availability of the source code of a piece of software in a given programming language with a license in which the copyright holders provide the rights to study, change, and distribute the software to anyone and for any purpose. An open platform does not necessarily mean it is open source [10]
- Federatable: It should be possible to connect any implementation of the open platform to all others that were independently developed, in a federated structure, to allow the sharing of appropriate information and workflows between them. [9]
- Shared Common Information Models: There should be a set of common information models in use by all instances of the open platform, independent of any given technical implementation. [10]
- Vendor and Technology Neutral: The standards should not depend on particular technologies or require components from particular vendors. Anyone building an implementation of the open platform may elect to use any available technology and may choose to include or exclude proprietary components. [9]
- Supports Open Data: Data should be exposed as needed (subject to good information governance practice) in an open, shareable, computable format in near to real-time. Implementors may choose to use this format natively in their persistence (storage) layer of the open platform itself or meet this requirement by using mappings and transformations from some other open or proprietary format. [9]
- Provides Open APIs: The full specification of the APIs (how applications are connected to the platform) should be freely available. [9]
- Open Usage (adoptability): Adoptability refers to enabling others to use the open platform while bypassing specific business development negotiations. This does not necessarily mean

that the usage must be royalty-free; it is rather about published, clear, and generally applicable (non-discriminatory) terms and conditions, usually known as the license. [10]

- Open Adaption: Assuming that the specifications are publicly available, adaptability of an open platform refers to the possibility of changing existing functionality of the platform itself as opposed to adding new functionality. [10]

Success factor: In AHA/AAL open platforms, any factor considered by any stakeholder domain to increase its activity with/on the platform, including but not limited to the use of applications or solution and their development. Success factors are the ones that increases platforms' uptake in any sense.

Hindrance factor: In AHA/AAL open plaforms, any hindering factor considered by any stakeholder domain that impedes platforms' uptake, including but not limited to, weak support to the open platform principles.

It is necessary to underline that, for the purposes of the PlatformUptake.eu project, the terms uptake, success factor, hindrance actor, should be measurable with concrete values to try to give both a measure of the effective uptake of each platform, and to recognize which factors that can be evaluated as success or hindrance factors. In our analysis, the measurement process takes place through the analysis of the KPI values together with an interview phase that ensures their understanding, therefore it is precisely from the values of the KPIs that we can try to measure the uptake and what factors are to be considered of success or hindrance. However, it must be emphasized that the uptake level is by definition a very complex measure, dependent on countless factors that go beyond those considered in the KPIs and is more to be considered as a metadata that derives in part from intrinsic aspects related to the KPIs, and on the other to aspects such as sales data and actual use also in relation to time and other competing or consequent platforms, as we will see later.

Instead, for the dynamic recognition of the success or failure factors, the proposal is to identify a threshold value for each KPI, above or below which the KPI under consideration is considered a success or hindrance factor.

The deliverable continues with the description of the workflows related to WP2 and WP4. Subsequently, the phase of creating the baseline report will begin, first with an accurate analysis and reprocessing of the KPIs and then provide a set of guidelines and recommendations useful for their correct measurement and observation.

3. WP2 workflow

WP2 objective sought to provide an overview of the ecosystem of open platforms in the AHA and AAL domains [1].

We can divide the WP in two main steps (Figure 2):

- **collect and observe existing platforms,** identifying their functionalities, complementarity, and interactions
- **define KPIs and other parameters** for tracking their success and evolution and define a methodology for evaluating the successful uptake of existing platforms, focusing on universAAL and FIWARE.
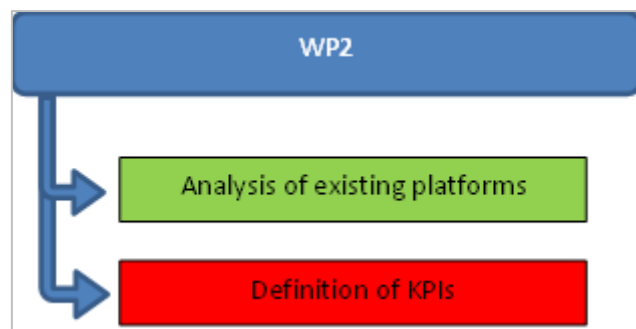

Figure 2: WP2 Workflow

The first step concerned the identification of EU funded platforms which have been the most representative in AAL/AHA research in the last ten years. We identified 48 research projects that covered the field of interest. From this first group, we selected, according to some criteria such as the impact on research in the AAL / AHA sectors and the European coverage, 18 platforms to be part of the ecosystem map: ACTIVAGE [2], AMIGO [3], AmIVITAL [4], BeyondSilos [5], EkoSMART [6], FIWARE [7], GIRAFFplus [8], inLIFE [9], InterIoT [10], m-power [11], OASIS [12], PERSONA [13], REACH2020 [14], ReAAL [15], SOPRANO [16], UNCAP [17], universAAL [18], VAALID [19].

The ecosystem map consists of a set of views belonging to four different domains (Figure 3):

- geographic: an EU geographic map where each country shows a list of projects where it is involved;

- relationship: the main dependencies between the examined platforms. For example, a platform uses a previous platform as the basis for its creation; a platform allows inter-platform interoperability; a platform inherits the design and implementation of a specific layer of another platform;

- application: application domains to which the platforms refer (general-purpose, AAL and AHA);

- temporal: starting and ending years of platform projects.
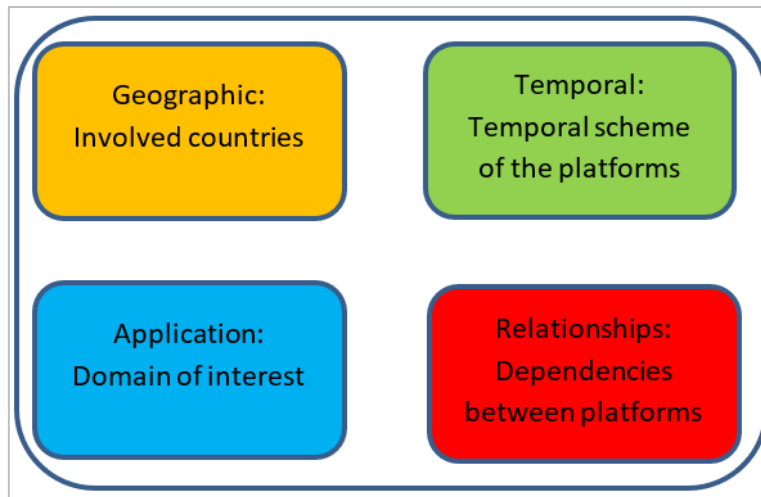
Figure 3: WP2 ecosystem map domains

The created ecosystem map permitted us to filter the list of platforms for the in-depth analysis phase again, according to the development timeline and current status of the platforms and their final scope and outputs. The in-depth analysis finally included: UniversAAL IoT, Activage_AIOTES, Ekosmart, Reach2020, Sensinact [20], UNCAP, FiWare, Onesait [21]. The analysis consisted of three correlated aspects (Figure 4):

- technical analysis of the platforms, including the description of the features, functionalities and services provided by each of them;
- contextual analysis that includes legal, ethical and data concerning information;
- business analysis concerning financial and exploitation aspects.
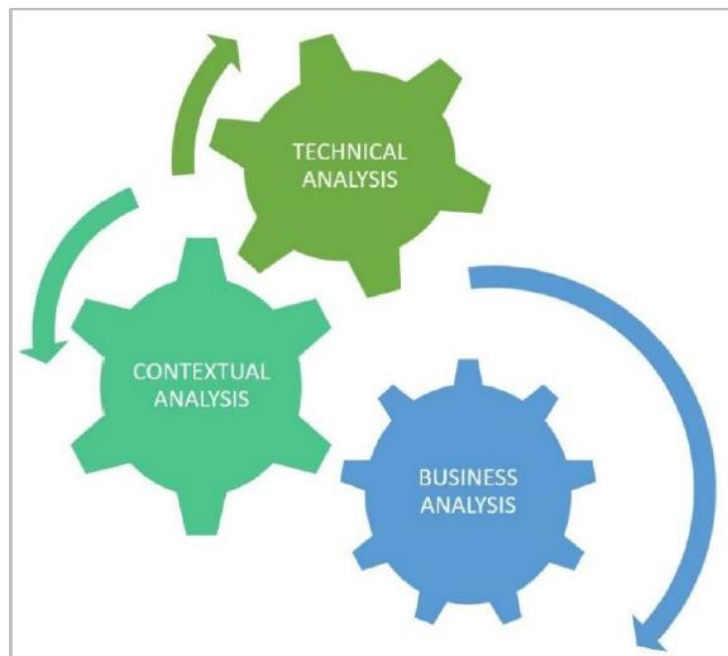
Figure 4: Three aspects for the in-deepen analysis

On these grounds, a three-layered investigation permitted a better understanding of possible success and hindrance factors based on their characteristics, existing networks, and stakeholders.

The analysis started using the information recovered by official project documentation. To cover all aspects of the analysis, we organized a set of questionnaires covering both technical and business aspects of projects filled by the respective representative participants.

The second step concerned the definition of KPIs. According to aims of PlatformUptake.eu project, we started with an adaptation of the International Consortium for Health Outcomes Measurement (ICHOM) [22] (Figure 5).
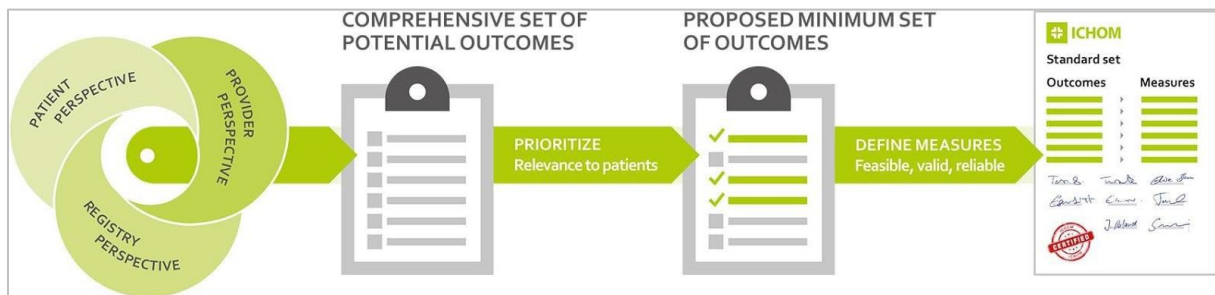
Figure 5: ICHOM methodology (Source: ICHOM website, https://www.ichom.org/)

The first activity was to define perspectives (or clusters), collecting the future identified KPIs. These were:

- Primary end Users (i.e. older people –assisted persons, caregivers);
- Technology Providers (including platform developers, third-party developers, etc.);
- End-User Customers (healthcare providers, social and wellbeing organizations, etc.);
- Government (Authorities / Policy Makers).

The first KPI list included a wide of potential KPIs related to the uptake and success of platforms, coming from different sources as literature (scientific literature); other projects/platforms (related research project or service platform already developed); own experience (expertise of partners); methodologies (benchmarking, and methodologies like MAST [23], MAFEIP [24], OPEA, GLOCAL [25]). According to the partner's expertise, the KPIs belonging to this wide list were then filtered by selecting and proposing them as a priority of importance. Selected KPIs were rephrased whenever needed, according to the different defined clusters and results of assessment work.

After that followed a second analysis of KPIs assessing the work done. KPIs were divided per cluster according to corresponding target stakeholders. Calculating the average priority rate and the standard deviation we selected the top 10 KPIs per cluster to provide a holistic assessment of a platform represented by the most critical factors regarding each of the four perspectives.

Defined clusters for KPIs

Primary End-users: older people, assisted persons

Technology providers: platform and third-party

End-User Customer: caregivers, social

Government: Authorities, policy makers

Source to collect data for KPIs

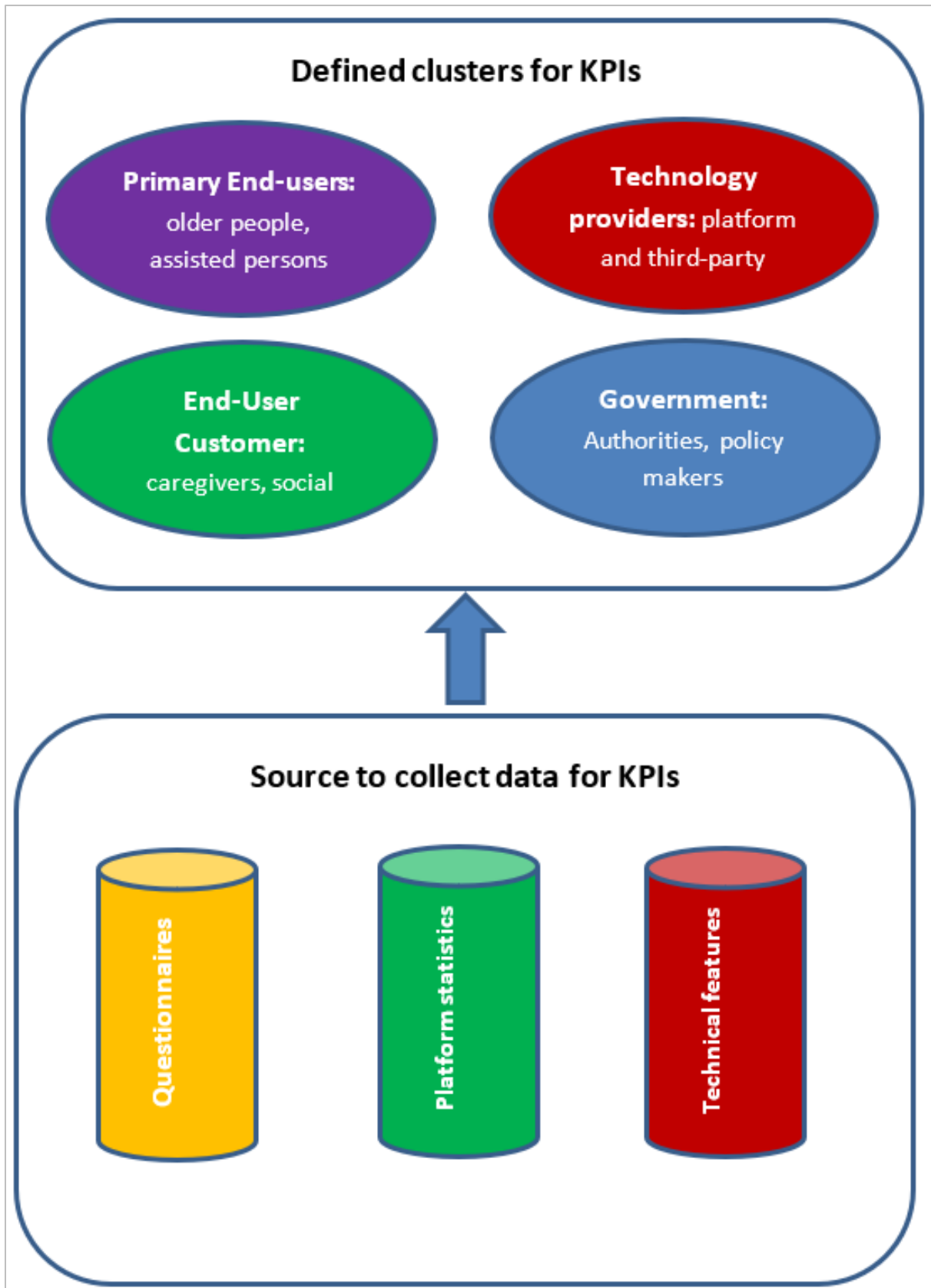Questionnaires

Platform statistics

Technical features

Figure 6: KPIs evaluation for clusters

The defined list of KPIs, divided per cluster, requires the creation of a practical methodology for monitoring and evaluating existing platforms' uptake and other success indicators.

Monitoring comprises a regular collection and analysis of information undertaken while the project is ongoing. Monitoring can help the project's team identify and solve problems and keep track of project inputs and outputs such as activities, reporting and documentation, finances and budgets, supplies and equipment.

The proposed methodology for monitoring and evaluating the various open platforms consists of the interaction between the five stakeholder clusters (Platform Providers, Primary end-user, Technology Providers, End-user Customers, Government) and the data collected with different instruments (Questionnaires, Platform statistics, Technical features). Depending on the data needed for monitoring or evaluation, the selected instruments will be performed/measured with different frequencies (Figure 6).

Considering the proposed monitoring and evaluation methodology, the various stakeholders' information were divided into three dimensions: technical, business, and contextual. Regarding this, the consortium made the correspondence between the type of KPI and these three dimensions, counting the type of collected information.

The frequency definition is critical to assess because we have to consider the return of investment (time and money spent to perform the monitoring activity) and if it is possible to perform the monitoring during the defined times. We decided to monitor the technical and business dimension KPIs twice a year regarding the type of open platform data and the number of involved stakeholders to provide information. Since platform statistics can be easily monitored, we decided to monitor them monthly.

We also defined nine central values that can be easily extracted, for example, from Google analytics. To do this, we considered the websites and web platforms monitoring good practices concerns, aiming at regular monitoring of statistical and analytical data. They are Total page views, Total unique visitors, Bounce rate, Number of users, Number of new users, Number of sessions, Number of sessions per user, Page views and Number of pages per session.

Technical dimension monitoring comprises an in-depth platform analysis of the solution structure and implementation of the physical, service, application, semantic and interoperability layer, as well as device management, integration/interoperability, information security, types of protocols, data analytics and support for visualization.

Business dimension monitoring comprises the Business Model Canvas questionnaire. It involved key partners, activities, resources, platform value proposition, customer segment, channels, customer relationship, costs, and revenue streams.

Contextual dimension comprises the analysis of the Regulatory Framework, ethics and privacy, data sharing governance and Intellectual Property Rights.

4. WP4 workflow

WP4 seeks to deepen the analysis of open platforms in the AHA and AAL domains with regards to their uptake by user groups, expansion of their communities' subnetworks and socio-economic impacts. The analysis will be performed by applying the defined methodology and measuring the KPIs already set as part of WP2 and additional research activities involving end users.

WP4 workflow can be divided in four main steps (Figure 7):

- **monitor and evaluate the progress towards a large-scale uptake of open platforms**: this is done by collecting feedback from their communities, and describing overall users and selected case-studies;
- **assess the socioeconomic impact**: the impact of platforms on their communities;
- **understand end-users' perspectives**: verify if KPIs show real values and stakeholders made good use of the platforms;
- **provide a knowledge base**: summing up all findings.

Figure 7: WP4 workflow

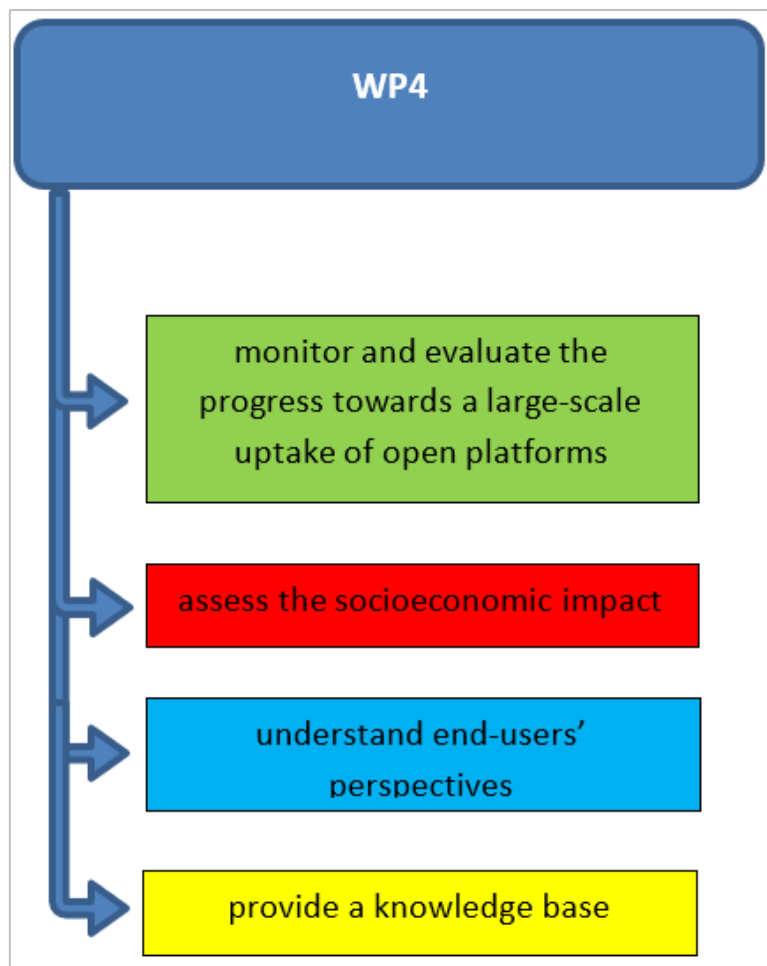The first step takes as input the KPIs and user groups defined in WP2. The monitor activity is based on the collection of KPI results related to the technical, business, and contextual dimensions of each platform, or platform statistics collected during their working. The evaluation activity checks if a project is achieving its goals or not and if it is of impact for the community. Evaluation aims to

understand how the platform's uptake is going, and why. We identified five criteria for a project evaluation: Relevance, Effectiveness, Efficiency, Impact and Sustainability. To monitor and evaluate platforms, we created a survey to measure mostly defined KPIs addressed to the four defined user groups (Figure 8), we used platform statistics and analyzed technical features of platforms.
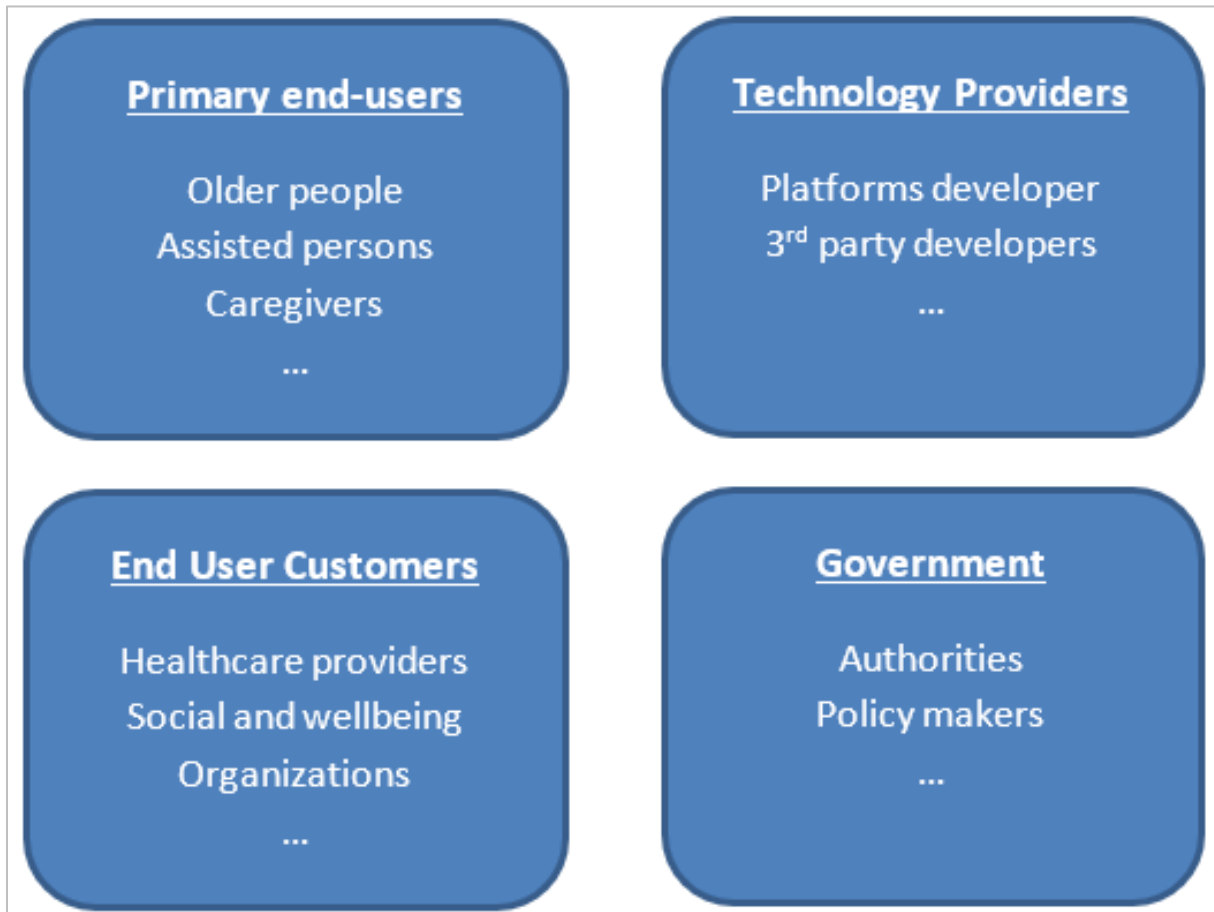
Figure 8: WP2 defined user groups

We created questionnaires to implement the survey in a way to assign values to KPIs. Project partners located in Austria, Belgium, Germany, Greece, Netherlands, Portugal, Slovenia, and Spain translated into German, Slovenian, Spanish, Portuguese, and Dutch languages and distributed them using personal contacts and networks (Figure 9) to proper platform stakeholders. We covered the top 10 KPIs for each user group with questionnaires, since measuring all the 84 KPIs would be too much for being covered by the questionnaires.

Using the collected information, we conducted case studies on three platforms: AIOTES-ACTIVAGE, WoQuaZ [25] (Use of universAAL IoT) and EKOSMART to exemplify a comparison between platforms and extend the created knowledge base that will be made available at the end of the WP4.

Figure 9: Personal contacts and network

We complete this step by creating a final state of the art of open platforms in the AHA and AAL domains in Europe, presenting a basis for comparison and further elaboration on the factors for the successful uptake of open platforms in the field. We collected the needed information to obtain a complete overview of the domain of interest, collecting data related to:

- EU funded projects, and in particular GATEKEEPER, Shapes, Pharaon, SmartBear, MedGUIDE, vINCI, ACCESS, ACESO, Brain@Home, BREATHE and CordonGris);
- open platforms resulting from EU projects, and in particular MiBida, Carelife, CuraVesta and ACTIVAGE – AIOTES;
- commercial platforms, in particular IoTool, PharosN, Medixine, Observia Patient Cloud, and Comarch IoT.

Since the survey collected information proved to not be sufficient for our aim, we conduct an interview study with representatives of a subset of the selected platforms. We selected eight open platforms: AIOTES-ACTIVAGE, FIWARE, universAAL IoT, eVida, MiBida, Oscar Senior, Openremote and Pharos Navigator IoT. Some of them are EU funded, and some of them are commercial. To conduct interviews, we invited the stakeholders of those platforms to gain a deeper understanding of the perceived uptake of the platforms and success factors and hindrance aspects regarding their employment by the user groups.
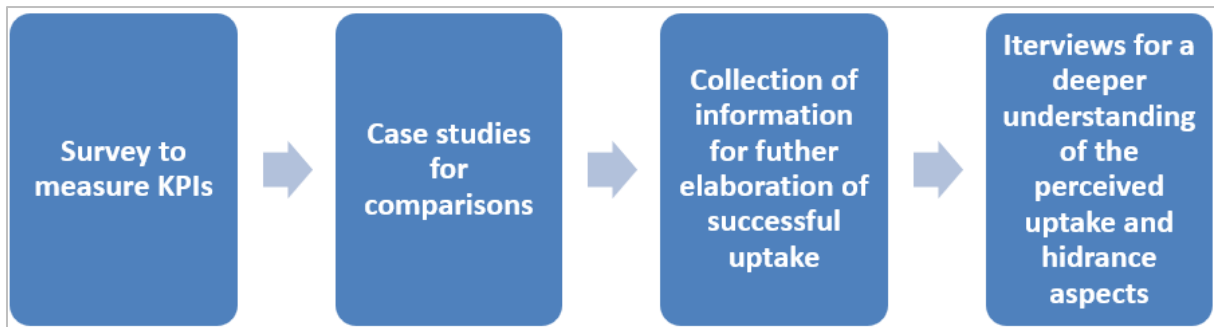
Figure 10: WP4 first step workflow

The assessment of the socio-economic impact step of WP4 (Figure 10) aims to analyze the business, market and cost-related aspects of platforms.

We studied strategies to find common indicators for analyzing the economical parameters of open platforms to evaluate their cost-effectiveness. Cost-effectiveness analysis or cost-utility analysis is a research method that characterizes the costs of interventions relative to the amount of benefit they yield. It is a way to examine both the costs and health outcomes of one or more interventions in an associated manner. We considered general health cost-effectiveness resources and the monitoring and assessment actions put in practice in various European projects such as MAST, MAFEIP and OPEA. However, to analyze the socio-economic aspect of an intervention or solution, the most proposed and used instrument is the ICER (Incremental Cost-Effectiveness Ratio) [26]. ICER (Figure 11) permits a comparison between a health care setup with and without the open platforms-based solutions in terms of costs and Quality-of-Life variation.
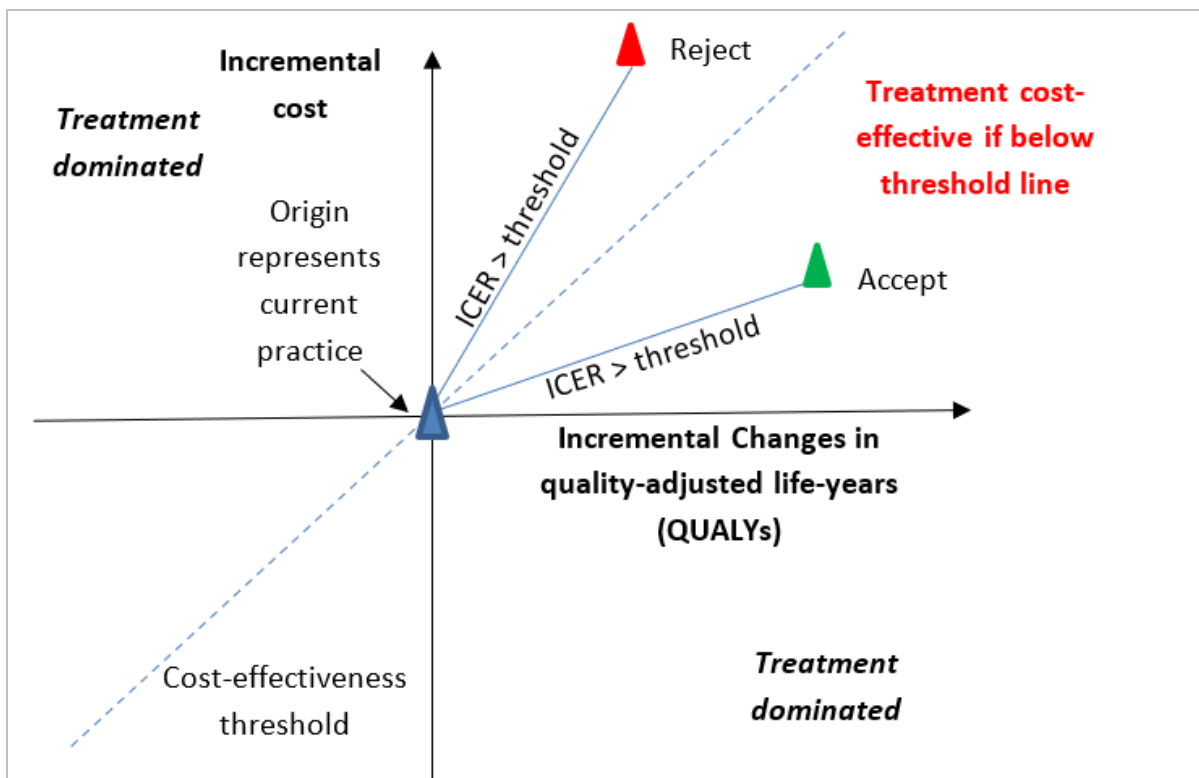

Figure 11: Incremental cost-effectiveness ratio

To calculate the total costs related to the deployment and usage of the platforms and their services, both the minimum fixed costs and the variable/ functional costs per year should be collected. The minimum fixed cost consists of the IoT infrastructure, initial development, installation, and training costs. The cost per year includes all annual variable costs required for the proper functioning of the platform and the provision of the services, such as any personnel costs and any other recurring costs needed. A relevant questionnaire (EuroQol [27], EQ-5D [28], HRQoL [29], etc.) can be used to assess the quality of life and its changes.

The business context analysis peered the results obtained in the WP2 "*Stakeholder Interviews Report*" about the eight considered platforms: ActivAge- AIOTES, Ekosmart, Fiware, Reach2020, SensiNact, Onesait, universal and Uncap. However, Uncap was not included in the analysis because specifically required information was not available.

The analysis of the business context of open platforms follows two main aspects:

- cost-related: cost of platform setup, maintenance, cost acceptability, fees per services and subscriptions, etc.;
- market related: market growth rate of users, memberships, apps, healthcare improvement of end-users, platform revenue, etc.

To measure platforms' economic and business aspects (Figure 12), we selected KPIs defined in WP2 to address our aim. We identify, for each KPI, the more appropriate user group (Primary end-users, Secondary end-users, Technology Providers, Government) to which we were able to assign a value.

We also analyzed the economic and business aspects according to a use case driven approach to deepen specific businesses of selected open platform main services. The analysis started using questionnaires created in the first WP4 step to show the overall situation throughout the open platform market.

In order to gain thorough insight, we also organized additional short discussions, which were held with the participants of interviews. The questions of the discussions targeted a general overview of the business, market and cost aspects. Finally, the outcomes of discussions were combined with the outcomes of questionnaires.

To complete the analysis of the demonstrated use-cases, related to MiBida, OpenRemote, Oscar Senior platforms, we identified which criteria the solutions under consideration adhere to for an open platform. The set of criteria was based on the collected insights from the development and deployment of representative cases in the field, and their contribution to creating an open market for digital solutions for AHA.
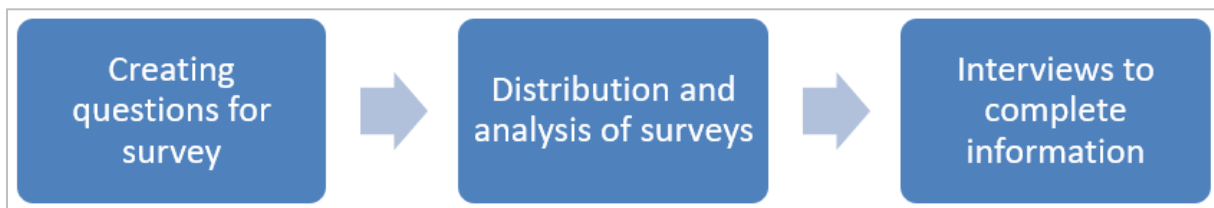

Figure 12: WP4 second step workflow

To understand end-users' perspectives, in the third WP4 step (Figure 13), we conducted an online survey to analyse the functionalities and operability of platforms, in order to understand users'

experiences and insights. The survey aims to check whether the defined KPIs show real values and that the identified stakeholders used the platforms to roll out successful solutions for the field. Survey questions were formulated taking into account previous surveys. Questions were further discussed and updated in several iterations. However, additional questions were introduced because previous surveys did not cover deep topics related to the business plan and market analysis. The survey was widely distributed among representatives of personal and professional networks of the consortium members to third parties/organizations, developers and individual users that responded according to their visions and needs.

Additionally to the survey, we conducted a series of interviews to complete information with the parties which we have contacted and responded to our requests.

Figure 13: WP4 third step workflow

The key messages retrieved from the interviews are:

- The available market is very big and not yet covered. Latent markets can be still identified
- Close contact to customers such as Healthcare providers is needed to ensure some confidence, since they are often personally responsible for providing the right care
- Building up the business, developing the solution based on the platform can take time (about 6 years in two of the cases)
- One must prepare for setbacks and unforeseeable regulations in the different regions and markets

These key messages are confirmed in the research regarding the European AAL, Telecare and Digital Therapeutics market. COVID-19 pandemic has accelerated digital convergence in the healthcare industry, making health management faster, smarter, more personalized and efficient. Thus, large healthcare organizations are increasingly forging partnership with retail, ICT, medical technology, and insurance companies.

5. KPI analysis

This chapter will describe the phases that led to the improvement of the first draft of the KPIs set which was established in WP2. The analysis carried out in PlatformUptake.eu is very complex and covers a set of domains (technical, contextual, business) that have taken shape more and more clearly with the passage of the time and through our continues work. In fact, we will see how clusters have changed over time and how this change has affected the top 10 lists of KPIs defined in D2.4. In addition to this, the outcomes of the previous tasks T4.1, T4.2 and T4.3 were also fundamental, with particular reference to the surveys for compiling the KPIs and the interviews, which allowed us to understand how they were perceived by the various clusters. We will now see this process in detail, first recalling the definitions already seen in WP2 and then comparing them with the new ones defined in WP5. Subsequently, a new list of KPIs will be presented, resulting from the processing of all the inputs collected in the previous tasks.

5.1. WP2 clusters

The four clusters initially defined in the early stages of the project, within the activities of WP2 are the following:

- Primary end users
- End user customers
- Technology provider
- Government

Each of these clusters can pertain to the three domains Technical, Contextual and Business, an aspect that is consequently mapped in the definition of each KPI to make the methodology defined in D2.5 applicable. The Government group was defined at a later stage to bring together all those involved at a regional, national, or European level who contribute to the development and introduction of AHA/AAL platforms within their respective realities.

5.1.1. Primary end-users

In the AAL/AHA domains it is the single individual intended as the main beneficiary of a service or a set of services provided by the considered platform. The Primary end-user directly benefits from these services with an increase of his quality of life. This group also contains formal or informal caregivers and family members who give help and support in using applications or services provided by the platform.

Table 1: TOP 10 KPI List Primary end-users

	KPI Title	KPI definition
1	Easy-to-use	The platform is easy-to-use. The platform hides the system's complexity from the user, and provides a smooth, natural, intuitive, and comfortable user experience.
2	Reaching user goals, needs and preferences	The platform meets the user's needs, expectations, and preferences.
3	Safety	The platform is safe to use

4	Trustability	The user trusts on the platform and its solutions
5	Quality of Life	Impact of the platform services on the Quality of Life (QoL)
6	Learnability	The platform and its functions are easy to learn by end-users
7	Accessibility	The platform is accessible for older adults and people with different functional abilities.
8	Services/applications offered	Number of services and applications offered by the platform
9	Privacy and data governance	The platform provides information on data collection, access, usage, control, sharing and benefit to the user. It provides an adequate privacy statement and policy, and explains what data are collected, and how they are going to be used. It also explains how the user can control their (data) privacy settings in a usable way and how this benefits the users. The user provides consent of collection and usage.
10	Autonomy	End-users can use the platform themselves without help from others

5.1.2. End User Customers

This group contains care organisation or institutions who contribute to organise, pay or enable applications and services provided by the platform, like healthcare providers, social and wellbeing organisations, etc.

Table 2: 10 KPI List End User Customers

	KPI Title	KPI definition
1	Customer satisfaction	The platform meets the customer's needs and expectations
2	Management flexibility	The platform is flexible to allow the adaptation to the company's needs and strategies
3	Cost per year	The costs to maintain the platform active
4	Cost per user	The mean costs for each end-user (i.e. Primary end-user)
5	Scalability	The platform is scalable and can be adapted according to the number of services needed and/or users
6	Initial investment	The costs related to the setup of the platform (e.g. hardware, software royalties, installation and configuration)
7	Compliance/ Adherence to standards	Number of standards that the platform adheres to. These would make the platform directly compatible with hardware (e.g. medical or other IoT devices), software (e.g. services or tools, data) or other kinds of protocols (e.g. compliance to legal/ethics/security requirements via standards), easier to integrate and more sustainable

8	Platform support services	How good are the provided support services (e.g. phone/email/chat support/user communities) for the platform
9	Healthcare costs	Impact of the platform on the cost of healthcare services (e.g. hospitalizations) provided to end-users
10	Services/applications offered	Number of services and applications offered by the platform

5.1.3. Technology providers

This refers to the group of individuals that follow and implement the entire life cycle of the applications, or more generally, of the products, deriving from a given platform. This group includes platform developers, who create and maintain the platform's product services and applications, and third-party developers, those who develop standalone applications or products using available APIs and SDK made available by the platform.

Table 3: Top 10 KPI List for Technology Providers

	KPI Title	KPI definition
1	Compliance/ Adherence to standards	Number of standards that the platform adheres to. These would make the platform directly compatible with hardware (e.g. medical or other IoT devices), software (e.g. services or tools, data) or other kind of protocols (e.g. compliance to legal/ethics/security requirements via standards), easier to integrate and more sustainable.
2	Integration level	How easy the platform permits to integrate different hardware and/or software from third parties through the platform's developing tools (API, SDK, etc.)
3	Number of users / adopters	Number of users (i.e. beneficiaries) of the platform (e.g., number of existing adopters/users, number of members of associated communities) to measure the wideness of its adoption
4	Platform support services	How good are the provided support services (e.g. phone/email/chat support/user communities) for the platform
5	Robustness	Robustness represents the elapsed time between failures of a platform, during normal system operation
6	Minimal fixed cost	Initial cost for development on the platform according to the minimum set of requirements (in terms of hardware, software, licenses, etc.)
7	Platform support documentation	How good are the platform installation, configuration and development support documentation
8	Scalability	The platform is scalable and can be adapted according to the number of services needed and/or users
9	Modularity	The platform separates the frontend from the backend. It allows the technology providers to extend the solution by adding additional modules, if needed.

10	Platform configuration	How difficult is to configure the different tools/components of the platform

5.1.4. Government

This group includes the public sector service organizers, public authorities, social security systems, insurance companies, municipalities, and policy makers.

Table 4: 10 KPI List for Government

	KPI Title	KPI definition
1	Healthcare costs	Impact of the platform on the cost of healthcare services (e.g. hospitalizations) provided to end-users
2	Cost per year	The costs to maintain the platform active
3	Cost per user	The mean costs for each end user (i.e. Primary end-user)
4	Cost-effectiveness	The platform is cost-effective
5	Initial investment	The costs related the setup of the platform (e.g. hardware, software royalties, installation and configuration)
6	Platform support services	How good are the provided support services (e.g. phone/email/chat support/user communities) for the platform
7	Scalability	The platform is scalable and can be adapted according to the number of services needed and/or users
8	Openness	The platform is open source
9	Affordability of long-term social care	Impact of the platform on the affordability of long-term home care and/or institutional care
10	Services / applications offered	Number of services and applications offered by the platform

5.2. WP5 clusters

At the beginning of the work carried out in WP5, during the preparation of the workshops, the stakeholders of open platforms identified in WP2 were further explored. During this process it became clear that the earlier defined stakeholder groups were not quite clear yet. Therefore, the consortium decided to create one uniform definition of the projects' stakeholders, that is aligned with the AHA/AAL definitions and can be conveyed in the communication and dissemination activities. Five main groups were identified, as can be seen in Table 5.

Table 5: Clusters of Stakeholders

	Cluster Name	Stakeholders
1	Primary end-user	Older person
2	Secondary end-user	Healthcare organization Home care / community support Residential care home Professional caregiver Informal caregiver Volunteer
3	Authorities and facilitators	Public authorities Social security system Insurance companies Policy makers
4	AAL/AHA solution developer/provider	Hardware manufacturer Software/app developer
5	Open platform provider	EU funded platform Commercial open platform

The refinement carried out in WP5 led to the transition from four to five clusters, the new cluster identified and isolated is that of the "Open platform provider", strongly connected to cluster 4 "AAL/AHA solution developer/providers". This addition was motivated by the fact that the interest of PlatformUptake.eu is mainly oriented to the evaluation of the open platforms in terms of how they can be used for the creation of new services starting from APIs and SDKs eventually made available or how effectively the services and applications offered from the point of view of the various clusters can be evaluated. Therefore, the main point of view of interest is "external" to the platform providers, and this applies to all the previous four clusters. For an accurate evaluation and analysis, some "platform-insider" information is useful and necessary, therefore some of the KPIs may also refer to the "internal" aspects of the platform in question, which we will see in detail in the next paragraph and therefore are related to cluster 5 "Open platform provider". The other difference to note, compared to the initial classification carried out in WP2, was the shift of caregivers from the first to the second cluster, which affected their respective KPIs as we will see in the next paragraph.

5.2.1. Analysis, redefinition, and reorganization of the KPIs

In this paragraph, in the light of the activities carried out in tasks T4.1, T4.2, T4.3, the KPIs of each cluster will be analyzed again and for each of them a new list will be drawn up taking into consideration the new inputs that have been collected over the months. Among the various changes that will be described in the respective sections, the first to mention was the abandonment of the wording "Top 10", the new groups of KPIs, in fact, vary in number and have been identified as those necessary for the purposes of our research. In Section 6, with the definition of the Baseline Report and the drafting of the "recommendations", these KPIs will be described comprehensively, also with reference to the possible subgroups of users for each cluster, to cover all possible variables and use cases.

Primary end-users

This cluster now contains only the older people, that is the final beneficiaries of the services or applications offered by one or more platforms or developed through them. These people can typically benefit from these services directly, for example by purchasing them from an Open platform provider (typically commercial) or through a Secondary end-user (typically a healthcare facility or similar). This last scenario is quite typical for EU funded projects, especially during the test phases, where the Secondary end-users are also project partners and take care of the selection of the Primary end-users that will test the prototype of the system financed by the project. The analysis carried out in the previous WP4 tasks led to the selection of only the KPIs that proved to be actually useful following the testing phase of the methodology (for example, they showed that they were well understood, and the answers obtained were consistent with the questions asked) and from the study of use cases and interviews.

Therefore, the KPIs that we have decided to maintain with respect to the first draft are the following:

- Easy-to-use
- Reaching user goals, needs and preferences
- Safety and Trustability
- Quality of life

Safety and *Trustability* were initially two different KPIs, but as they are closely connected, it was difficult for Primary end-users to understand the differences; therefore, they have been merged into a single KPI.

The KPIs removed were the following:

- Autonomy
- Learnability
- Services/Applications offered
- Accessibility
- Privacy and data Governance

The *Autonomy* and *Learnability* KPIs were found to be part of the *Easy-to-use* KPI and were therefore removed. It is important to remember that, although the final value associated with each KPI is an integer, the evaluation of this number takes place in various methods, in this case a questionnaire, which must therefore be expanded to cover these two new aspects as well. As for the KPI *Services Application* offered, the answers obtained proved extremely inconsistent with respect to reality, demonstrating that the question is too technical to be posed to a Primary end-user. As we will see, we will find this KPI both in the Secondary end-user's cluster and in the AAL/AHA solution developer/provider's cluster. For the same reasons, the KPIs *Accessibility* and *Privacy and Data Governance* were also moved to the Secondary end-user cluster. The first, since in *Easy-to-Use* there is already an assessment linked to the autonomy of the individual, in the new cluster it acquires its true meaning as, for example, it is the Health Care Facilities that can evaluate how effectively a service offered by a platform can be used independently by people with different types of disabilities. The same example applies to the second, since, referring for example to the privacy statements, the distribution, collection, and verification of the same is centralized at the Secondary end-user level.

Finally, two new KPIs were added to the four selected KPIs:

- Attractiveness and enjoyment
- Costs

The first one was added based on the fact that the success of a service was also related to the actual interest it aroused in the Primary end-user, typically in proportion to the quality of the same. The KPI *Costs*, on the other hand, was inserted to cover broader scenarios where the user pays for the service received, either to a Secondary end-user, or directly to an Open platform provider, and is useful for estimating the final cost level for users of the platform.

The final list of KPIs for Primary end-users is presented in Table 6.

Table 6: KPIs for Primary end-users

	KPI Title	KPI definition
1	Easy to use	Measures the easy in the use of the platform by Primary end-users
2	Reaching user goals, needs and preferences	Measures the platform's ability to satisfy users' expectations
3	Safety and Trustability	Measures the users' awareness about processes of treatment of personal data and the level of confidence
4	Quality of Life	Measures the degree to which the platform contributes to improving individual health, comfortability, and ability to participate in or enjoy life events
5	Attractiveness/Interest and enjoyment	Measures the pleasure and users' emotional responses of using the application
6	Costs	How much, and if, the Primary end-user pays to use the platform

Secondary end-users

As mentioned previously, the various types of caregivers are now also included in this cluster, this has led to the presence of two subgroups of stakeholders, one represented by the caregivers family and that of the care organizations, also from a management point of view. This means that in the definition of KPIs, some will be destined for one group and others for another. An important part of the methodology is to always refer as accurately as possible to the correct groups of stakeholders. In fact, during the distribution of the questionnaires it often happened, submitting the surveys to the people belonging to the macro-categories defined by the individual clusters, that many answers were inaccurate or left empty because the target stakeholder did not exactly match the correct subgroup. In this document we will try to clarify these aspects as well.

In the KPI analysis of this stakeholder cluster, the KPIs that have been confirmed by a good response rate and useful KPI values are the following:

- Customer satisfaction (+ Management flexibility)
- Cost per year
- Cost per user

- Initial Investment
- Platform support services
- Healthcare costs
- Services/Applications used

The KPI *Management flexibility* has now been merged with *Customer satisfaction* and added to its definition, while the KPI previously defined as *Services/Application offered* has become *Services/Applications used,* as typically Secondary end-users choose which services or applications of the platform to use to fulfill their purposes, selecting only a subset of those offered by the platform in question.

The KPIs discarded were instead:

- Scalability
- Compliance/Adherence to standards

Both KPIs were considered too technical and difficult to understand by the group of stakeholders considered, therefore their reformulation at a higher level is now part of the KPI Customers satisfaction.

The following were then added to the seven selected KPIs:

- Accessibility
- Privacy and data governance
- Churn Rate

The first two, as already explained in the previous paragraph, have been moved from the Primary end-user cluster as they find a more coherent location in this cluster. *Churn rate*, on the other hand, was considered an important evaluation factor to determine the acceptance level of a platform and therefore was included in the list.

The final list of KPIs for Secondary end-users (Table 7) was then rearranged by separating the economic and management aspects, aimed only at the Care organizations management subgroup (light blue in the table), from the others, linked more to Primary end-users operational aspects.

Table 7: KPIs for Secondary end-users, the KPIs in light blue are for care organisations management only

	KPI Title	KPI definition
1	Customer satisfaction	Measures how much the platform services can be integrated and are able to satisfy the needs of Secondary end-users
2	Platform support services	Measures the quality of provided support services provided by the Platform providers in order to support Secondary end-users
3	Services/applications used	Measures the number of platform services acquired by Secondary end-users
4	Churn rate	Measures the percentage of lost users in relation to the total number of active customers

5	Accessibility	Measures the general level of platform accessibility for Primary end-users in relation with their different functional abilities
6	Privacy and data governance	Measures if the platform provides information on data collection, access, usage, control, sharing and benefit to the user.
7	Initial investment	Measure of the costs related to the setup of the platform (e.g. hardware, software royalties, installation and configuration)
8	Cost per year	Measure of the mean costs to maintain the platform active for a year
9	Cost per user	Measure of the mean costs for each end user (1 year timeslot)
10	Healthcare costs	Measures the impact of the platform on the cost of healthcare services

AHA/AAL Solutions developers/providers and Open platform providers

The two new clusters AHA/AAL Solutions developer/provider and Open platform provider are now considered in a single cluster from the point of view of defining the KPIs. This choice was also sprung from the feedback received during the interviews and case studies, which made it possible to better understand the complexity of this cluster, but also to better focus on one of the objectives of the PlatformUptake.eu project. The complexity we are talking about derives mainly from the fact that although our analysis focuses mainly on EU Funded platforms, also commercial platforms have always been considered important in this analysis, remembering however that the aim of the project is to measure uptake, success and hindrance factor of the platforms from a point of view of their usage. Having said that, the role of the developer in an EU funded platform, compared to a commercial one, is typically very different. In the case of an EU funded platform, most of the people involved from a scientific and technical point of view are researchers and are an active part of the consortium that submitted the project application to the European community and therefore are aware, even if not always to in-depth level, of most of the aspects relating to the platform, including economic or managerial ones. When we talk about commercial realities, developers are typically employees and often, also for security reasons, they are only aware of the specifics of the sub-projects they work for. We wanted to bring out this difference clearly by inserting the new cluster Open platform providers, clearly distinguishing the two different types of stakeholders. As for the AHA/AAL Solutions Developer/Provider, the point of view of our analysis is that of the third-party developers who use, for fee or not, the services (applications, APIs, SDKs, etc.) made available from a platform, to create new AHA services and applications.

The KPIs that have been maintained with respect to the previous list are the following:

- Compliance/Adherence to standards
- Integration level
- Number of users/adopters
- Robustness
- Minimal fixed costs
- Platform Support Documentation
- Platform Support Services

The KPIs *Platform Support Documentation* and *Platform Support Services* are aimed at third party developers and therefore to the AAL/AHA Solution Provider/Developer subcluster.

The KPIs removed are the following:

- Scalability
- Modularity
- Platform Configuration

These three KPIs have been grouped into the new KPI *Technical Efficiency*, as they contain technical specifications belonging to the same family. The new KPIs added were therefore:

- Openness
- Number of services provided
- Technical Efficiency

Except for the KPI *Openness*, aimed only at the subgroup of Open platform roviders, all the other KPIs are aimed at both the subclusters described above, in this way the analysis can effectively cover both the EU funded platforms and commercial ones, and internal/third parties developers. The final list of KPIs for this cluster is presented in Table 8.

Table 8: KPIs for AHA/AAL Solutions Providers/Developer and Open Platform Providers

	KPI Title	KPI definition
1	Openness	Measures if the platform is open or not according to the given definition
2	Number of services provided/developed	Total number of services/applications provided by the platform
3	Number of users / adopters	Number of users (i.e. beneficiaries) of the platform (e.g., number of existing adopters/users, number of members of associated communities, number of Secondary end-users) to measure the wideness of its adoption
4	Compliance/ Adherence to standards	Number of standards that the platform adheres to.
5	Technical efficiency	Measurement of the technical efficiency of the services/applications made available by the platform, taking into account the ease of configuration according to the number of installation instances and the possibility of expanding their functionality through plug and play modules.
6	Platform support documentation	Quality measurement of documentation related to installation, configuration and development support for the platform
7	Platform support services	Quality measurement of the provided support services (e.g. phone/email/chat support/user communities)
8	Integration level	Quality measurement of how easy the platform permits to integrate different hardware and/or software from third parties through the platform's developing tools (API, SDK, etc.)

9	Robustness	Measure of the elapsed time between failures of a platform, during normal system operation
10	Minimal fixed cost	Measure of the initial cost for development on the platform according to the minimum set of requirements (in terms of hardware, software, licenses, etc.)

Authorities and facilitators

This cluster is unique and during our analysis we encountered significant difficulties in obtaining input for the methodology test. In general, it can be seen as a larger scale version (regional, national, or international) of the Secondary end-users (Healthcare facilities subgroup) cluster. The KPIs therefore remain unchanged compared to the initial draft, even if, as we will see later in the recommendations, the type of problems involved are very complex aspects also linked to laws, infrastructures, or aspects such as readiness or the impact they have on a large scale, a subject that we managed to deal with during the interviews and which will be exposed in Section 5. Compared to the initial list, in this analysis the *Openness* and *Scalability* KPIs have been discarded as they belong to the technical domain. The list of KPIs is shown in Table 9.

Table 9: KPIs for Authorities and facilitators

	KPI Title	KPI definition
1	Healthcare costs	Measures the impact of the platform on the cost of healthcare services (e.g. hospitalizations)
2	Cost per year	Measure of the costs to maintain the platform active
3	Cost per user	Measure of the mean costs for each Primary end-user
4	Cost-effectiveness	Measure the economic value of the introduction of Platform services, compared with the actual solution or an alternative one (ICER)
5	Initial investment	Measure of the costs related to the setup of the platform (e.g. hardware, software royalties, installation and configuration)
6	Platform support services	Quality measurement of the provided support services (e.g. phone/email/chat support/user communities)
7	Affordability of long-term social care	Measure of the impact of the platform on the affordability of long-term home care and/or institutional care
8	Services / applications used	Measures the number of platform services/applications acquired by Authorities and Facilitators for their purposes

6. End-user insights and gaps

Based on the analysis of the ecosystem of open platforms in the AHA and AAL domains and insights collected through virtual consultations and events with relevant stakeholders, it was established that in general open platforms allow for the easy integration of software or hardware of third parties on low costs. This and the provided interoperability with other systems help AAL / AHA solution developers / providers (Hardware manufacturer, Software/app developer) expand their market positions internationally and build new revenue streams. Perceived broadly as facilitators of open market for digital solutions for active and healthy ageing, the platforms support the development of technology (apps, wearables, sensors etc.) which can be easily learned by Primary end-users (older people) to tackle their everyday needs. In similar manner, Secondary end-users (Healthcare organization, Home care / community support, Residential care home etc.) claim that the platforms which they use meet their expectations. They do so by providing the management staff of the care organisations with one single point of contact for their inquiries, the flexibility to extend and co-create their services regardless of available hardware infrastructure and transparency of ongoing costs. The latter is particularly important for Secondary end-users to plan future investments and upgrade of facilities' infrastructure.

The abovementioned benefits are mainly possible due to the openness of the platforms which includes among others the presence of open standards, open code, open APIs as well as a good scalability. Another aspect which is important for the platforms' efficient use, according to the interviewed stakeholders, are their communication and integration systems. The integration of hardware or software from third parties into open platforms is perceived also as easy due to the available platforms' developing tools. Finally the heterogeneity of the available platforms is seen as positive because of their ability to alleviate the restrain of interoperability and vendor lock-in.

However, despite the technological advancement which has been achieved in the field through the creation of open platforms, there are capability gaps which need to be tackled urgently to ensure the their successful uptake. The following part of the document will outline gaps that have been identified through the knowledge collection and assessment work that were conducted in WP4.

As open platforms bring greater opportunities such as costs effectiveness, ability to scale digital solutions for older people globally and entire new services to enrich the daily lives of the end users, accountability, low level of trust towards insecure autonomous systems and technology in general appear to be major concerns among the Primary end-users. Safety for example is an issue among older persons who to only some extent agree that they feel safe when using digital services. To address these challenges affectively and allow for older people to benefit from the digital solutions which are built upon the open platforms, more inclusive approach during their development needs to be applied. This in particular concerns the accessibility, design, trust and data equality of the developed solutions and needs of older people.

Authorities and facilitators (Public authorities, Social security systems, Insurance companies, Insurance companies) are defined by the project is one of the open platforms' end user groups who potentially can benefit through the platforms' role as facilitators of a market of accessible and affordable digital solutions. However, it was established that it is difficult for government representatives to assess the economic aspects and provide a monetary valuation of a platform that has been used in the context of research and innovation projects. This is due to the lack of information on existing platforms and

costs which generally occur during their installation and maintance. For example AIOTES is not yet in the market but still in the process of being launched as a commercial solution through ACTIVAGE.ORG. Other EU-funded platforms have not managed to enter the market and remained only as a result of research projects. On the other side, as reported by the interviewees during the "AHA experts' voices" series of interviews, government officials in general are reluctant to accept the change which is embodied by the digital technology. The reason for this resistance lies in the lack of understanding among the public authorities of the impact of open platforms on their daily activities and wellbeing of the population as a whole. Budgets are always seen by the Authorities and facilitators as an obstacle when it comes to implementation of technology which actually can help them decrease resources. This is where, providers of open platforms need to communicate actively the role of their solutions as engines of digital transformation and the core of their business cases lies.

It became also clear that open platforms are not created only with technical challenges, but also barriers related to the business models can be just as critical to solve. Based on the conducted survey and interviews with AAL / AHA solution developers / providers (Hardware manufacturer, Software/app developer) it was established in this context that lack of capability to meet the end users' objective as well as internal innovation processes of the company represents a major hurdle on the path towards the broader applicability of the open platforms' services. Moreover, it is of utmost importance for future platforms to have a comprehensive communication strategy paired with consistent execution, to ensure that their unique value proposition addresses the needs of their end users as closely as possible. The creators of open platforms need also to ensure that the process is transparent and clearly communicated to its end users, including available training and support, information on security and privacy issues, ease of use and understandability of the system setup documentation. The latter in particular was stated to be a main issues due to the fact that most of the documentation regarding the platform setup, configuration and usage is not available to third parties. This is the case to most of the proprietary platforms. Another challenge which the hardware manufacturers and software/app developers are confronted with is that some of the platforms on the market have outdated architectures or are too complex and inflexible to integrate their niche solutions. This consequently results in failures in the connection to the existing infrastructure and higher development costs. At the end of the day, as mentioned by interviewed companies, scaling down a complex platform is also connected to a lot of efforts.

Overall the Secondary end-users consider the technology of open platforms as beneficial for the provision of quality care and assistance to older people in their facilities. It is common understanding that secure digital systems and connectivity can improve risk identification and management. However, clear communication combined with close contact to the managers of the care facilities, patient centered care and protecting data security were identified as issues that need to be clearly tackled by existing and future providers of open platforms to ensure the successful uptake of their services by the members of this stakeholder group. It was further established that on national level, there is a lack of knowledge on existing open platforms in the AHA and AAL domains and their benefits, where success stories can be reported on a regional level. This can be explained due to the fact, that small regional companies know their end users, communicate with the them in understandable language and are flexible to adapt their services according to their end-users' needs and requirements.

The previous part of the document presented an outline of the capability gaps in the field from the points of view of the different end user groups of open platforms' services. In the following the consortium will seek to highlight challenges which are related to the context of projects funded by the

EU. Hence, PlatformUptake.eu will present factors which affect the successful uptake of the platforms which are developed by the projects' consortiums.

During the work which was conducted for the creation of KPIs and Monitoring and Evaluation methodology, the project concluded that little is known about the hindering and success factors that affect platforms' launch and broad application. For example most of the projects which are funded by the EU focus on general strategies for launching an open platform, including the organization of pilots and exploitation of results through the project consortium network. However, the development of open platforms does not include only the tackling of technical challenges, but also the planning of the platform's commercialization. The latter was claimed to be as rather difficult due to the two-sided market of the platforms, in which the needs of AAL / AHA solution developers / providers and Secondary end-users need to be met. Some of the successfully implemented commercial platforms in the field, as demonstrated through the interviews with their founders and CEOs, act as intermediaries between two or more end-users groups, which have independent needs and requirements. The successful entry in such two-sided market depends largely on the provision of services and products which can increase the attractiveness of the platform to its end users. An open platform in the field which is able to provide valuable services to the Secondary end-users is reliant on its ability to attract a sufficient number of AAL / AHA solution developers / providers which in turn are more likely to use the platform's services with already established demand from care and health care organisations. Therefore, the entry strategy of future platforms should not only revolve around the complete development of their technical infrastructure and services, but also include the rapid establishment of a large network of end-users. This is because, the larger the platform's network becomes the bigger its value for all end-users in the network is. Last but not least, it was found that creating a platform is time and costs consuming process which additionally can be slowed down by the presence of various preferences for the end product's design and services. Therefore, it is recommendable that future EU-funded projects in the field imply strong vision for the platforms to be developed, which is based on knowing and understanding the real needs of their future end users.

Moreover, during our analysis of all the projects and connected platforms we have also established, that with some of them a comprehensive communication strategy with strong value proposition towards potential end users was partially addressed or not sufficiently implemented. Which otherwise would increase the visibility of the platform and promote its benefits to the end users and attract attention of potential investors. This will present an effective solution to the lack of funding once the project is completed. Further, it is also imperative for the projects' teams to keep the internal as well external stakeholders of the platforms engaged beyond the funding period, and thus ensure their continuous commitment and contribution to the platform success. This however is not the case with most of the projects which were assessed by PlatformUptake.eu and needs to be considered by future initiatives.

Security and privacy issues, including less flexible and cumbersome legislation across Europe are brought to the fore by most of the interviewees as a gap but also in relation to future needs. This is related to the need for communication between systems and interoperability, and one of the main problems that remains to be solved is the regulation around data protection in order not to make data trapped in silos. Siloed data, according to interviewed stakeholders, can prevent open platform providers but also developers of technology for active and healthy ageing from growing and up-scaling their processes and solutions. As a result an inconsistent information is used to make decisions and facilitate personalized customer experience. This means also that organisations will hardly be able to

integrate end-users' experiences across all channels. To close the gap between the data and who needs to use it, a balance between free flow data and a protection of personal data needs to be established. This will consequently encourage innovation and support the uptake of open platforms in the field.

In terms of development activities in the field there is little evidence on best-practices and lessons learned from the actual application of the platforms' services. Additionally there is no sufficient research on current success and hindrance factors for the uptake of open platforms in AHA/AAL domains. For example, only general numbers regarding users and applications were provided by the approached EU-funded platforms. This points out that the market aspects of the platforms are not handled efficiently. The same holds for the platform impact related to the decrease of hospitalizations/improvements related to healthcare. Most of the platforms did not provide data regarding revenue while two of them declared that they are not business oriented and thus they do not expect any revenue. This can be explained due to the fact that some of the analysed platforms have not accomplished the transition to the market yet or have not used the potential of their networks to promote effectively their solutions.

7. Recommendations

In the previous four chapters all the main findings and outcomes of tasks T4.1, T4.2, T4.3, together with those of WP2, were brought to light to compose the baseline report. In this chapter we will refine the work done on the selected KPIs trying to enrich their description, and where necessary add recommendations for their correct measurement. To complete the general overview of the state-of-art of open platforms, their users, networks, stakeholders, functionalities, outcomes, benefits, etc., we will review all the platforms that have been examined in the research carried out in WP2 and WP4 thus completing the desired general scenario.

The typical methodology for collecting the information necessary to evaluate the KPIs for each cluster is the creation of a targeted questionnaire to extrapolate the necessary values. Depending on the type of KPI, for example the more complex ones or those intended for subjective measurements (e.g. Easy-to-use, Quality of life, etc), the questionnaire should consist of a greater number of questions. In these cases, it is always suggested, where possible, to enrich the information collected with targeted interviews. The interview, especially with regard to non-technological aspects, therefore mainly for Secondary End-users and Open Platform Providers, represents in most cases the best way to obtain information, given the complexity of the topics covered and possible issues related to privacy or NDA which could make the use of questionnaires useless.

Finally, the presented KPIs constitute an instrument that can be utilized by current and future providers of open platforms who seek to tackle the gaps which were elaborated in Section 6. Hence, these KPIs represent the starting point for the design and development of an open platform in the AHA and AAL domains. They enable also the collection of valuable insights into the performance of the platform and applied strategy for the uptake by its end-user groups.

7.1. Primary end-users

Easy-to-use: measures the ease in the use of the platform for the Primary end-user. The platform has to be intuitive in its use, exploiting all its functionalities hiding the system's complexity. It must be usable, and accessible, also according to possible disabilities, for a smooth, natural, and comfortable user experience. Ease of use is very much depending on the interfaces of the applications and services and, in addition, the platform itself should be usable and accessible.

Reaching user goals, needs and preferences: measures the platform ability to satisfy users' expectations, helping them deal with their problems according to their own needs and lifestyle.

Safety and Trustability: measures the users' awareness about processes of treatment of personal data and the level of confidence. Particular attention should be paid to personal health data. They are sensitive, and they should not have been shared in any way but elaborated in anonymous mode. To work, only authorized systems/people can match people with data.

Quality of Life: measure the degree to which the platform contributes to improving individual health, comfortability, and ability to participate in or enjoy life events. The quality of life includes wealth, employment, the environment, physical and mental health, education, recreation and leisure time, social belonging, religious beliefs, safety, security, and freedom.

Authonomy: measures the users' autonomy to use the platform without the help of other people, permitting the right and power of a self-governing in its use, according to their own decisions.

Attractiveness/Interest and enjoyment: measures the pleasure and users' emotional responses of using the application. The attractiveness and desirability of a software are very important in the initial phases of interaction with a product because they are, with other factors, main reasons for a user to stay or leave the platform.

Costs: measure of the costs (if any) related to the use of the platform that the Primary end-users have to sustain. The costs can be in hardware (e.g. sensors, actuators, process data units) or software (e.g. licences for the use of the platform).

7.2. Secondary end-users

Customer satisfaction: measures the degree of satisfaction in using the platform regarding initial expectations and desired goals. This satisfaction index is also linked to aspects of ease of management and smooth integration.

Platform support services: measures the quality and how to receive support for the platform. Support services are generally technical support or break/fix services. These services include revenue derived from long-term technical-support contracts or pay-as-you-go, incident-based support. Software support services typically include remote troubleshooting capabilities, installation assistance and basic usability assistance. Remote troubleshooting capabilities may be delivered via telephone and online communication media or without human assistance through automated means that reside on the customer's device or are available on the Web. Support services may include new product installation services, installation of product updates, migrations for major releases of software, other types of proactive or reactive on-site services, and support for custom application or infrastructure software. Services may be delivered by a product vendor, a consulting firm or third-party software maintainers.

Services/applications used: measures the number of platform services acquired by Secondary end-users for their own purposes, which will then be part of the services offered to Primary end-users. This question is primarily intended for healthcare facility managers.

Chun rate: metric used to measure the percentage of lost users in relation to the total number of active customers. A constant Churn Rate measurement is important to realize if the end-user is satisfied with the use of the platform and/or offered services. If not, the secondary end-user can plan to act changes (in the platform or its services). This question is primarily intended for healthcare facility managers.

Accessibility: Measures the general level of platform accessibility for Primary end-users in relation to their different functional abilities. Many older people have age-related impairments, such as: declining vision — including reduced contrast sensitivity, color perception, and near-focus, making it difficult to read web pages; physical ability — including reduced dexterity and fine motor control, making it difficult to use a mouse and click small targets; hearing — including difficulty hearing higher-pitched sounds and separating sounds, making it difficult to hear podcasts and other audio, especially when there is background music; cognitive ability — including reduced short-term memory, difficulty concentrating, and being easily distracted, making it difficult to follow navigation and complete online tasks.

Privacy and data governance: The platform provides information on data collection, access, usage, control, sharing and benefit to the user. It provides an adequate privacy statement and policy, and explains what data are collected, and how they are going to be used. It also explains how the user can control their (data) privacy settings in a usable way and how this benefits the users. The user provides consent of collection and usage.

Initial investment: Measure of the costs related to the setup of the platform (e.g. hardware, software royalties, installation and configuration in money and man time). This question is primarily intended for healthcare facility managers.

Cost per year: Measure of the mean costs to maintain the platform active for a year. It includes software royalties, activation of third-party paid services to make the system work. Platforms, applications and third-party services can be billed according to different factors: consumption-based pricing ties the subscription fee depends on the actual use; size-based pricing ties: the subscription fee depends on the size of the secondary user's organization. User-based pricing ties fee changes according to how many people have using the software. This question is primarily intended for healthcare facility managers.

Cost per user: The mean costs per each end user i.e. in hardware (like sensors, actuators), software licences. This question is primarily intended for healthcare facility managers.

Healthcare costs: measures the impact of the platform on the cost of healthcare services. In particular, they refer to the final consumption of health care goods and services (i.e. current health expenditure) including personal health care (curative care, rehabilitative care, long-term care, auxiliary services and medical goods) and collective services (prevention and public health services as well as health administration, e.g. hospitalizations). This question is primarily intended for healthcare facility managers.

7.3. AAL / AHA solution developers / providers

Openness: measures if the platform is open or not according to the given definition

Number of services provided/developed: Total number of services provided by the platform (not considering API or SDK). It indicates the number of potential solutions for end users that the platform can provide.

Number of users / adopters: number of users (i.e. beneficiaries) of the platform (e.g., number of existing adopters/users, number of members of associated communities, number of Secondary end-users) to measure the wideness of its adoption. It can potentially indicate the approval for the platform.

Compliance/ Adherence to standards: Number of standards that the platform adheres to. These would make the platform directly compatible with hardware (e.g. medical or other IoT devices), software (e.g. services or tools, data) or other kinds of protocols (e.g. compliance to legal/ethics/security requirements via standards), easier to integrate and more sustainable. Moreover, standards help protect consumers from all sorts of harm, including identity theft and personal injury. They can cover every part of software development and deployment, from variable naming conventions to incident response protocols. Software that complies with software standards, it is less likely to contain bugs,

security weaknesses, and design flaws. And if it's free of bugs, weaknesses, and flaws, it is more likely to comply with a software standard.

Technical efficiency: Measurement of the technical efficiency of the services/applications made available by the platform, taking into account the ease of configuration according to the number of installation instances and the possibility of expanding their functionality through plug and play modules. A modular approach and the separation of the frontend from the backend can improve significantly efficiency.

Platform support services: Software documentation is a part of any software. Good documentation practices are important for the success of the software. Documentation must comprise an interactive user experience, Information architecture, and a good understanding of the audience. In general, documentation solves issues encountered by the developer during the development process, and it helps the end-user understand the product. It assists customers and the support team in finding the information. Documentation can be: How-to guides – Guides the user to complete a task or a predetermined goal; Tutorials – Learns a concept by following a series of steps concept; Reference docs – Describes the technical detail of the product (Software requirement specification, software design documents and so on); Administration Guide: Enables the administrator to refer to this after installing an application; Configuration Guide: Allows the administrator to refer to this document for configuration parameters. This question is primarily intended for third party developers.

Integration level: How easily the platform permits to integrate different hardware and/or software from third parties through the platform's developing tools (API, SDK, etc.). It permits understanding the degree of expandability of the platform versus other platforms, devices and so on. This question is primarily intended for third party developers.

Robustness: Robustness represents the elapsed time between failures of a platform, during normal system operation. Software is robust if it can tolerate problems such as unanticipated events, invalid inputs, corrupted internally stored data, improper uses by system operators, unavailable databases, stress overloads and so on. Systems that include both hardware and software are robust if they can tolerate physical problems such as equipment damage loss of power software crashes and equipment damage, loss of power, software crashes and so on. Robustness testing tries to make a system fail, so we can observe what happens and whether it recovers. This question is primarily intended for third party developers.

Minimal fixed cost: Initial cost for development on the platform according to the minimum set of requirements (in terms of hardware, software, licenses, etc.). This question is primarily intended for third party developers.

7.4. Authorities and facilitators

As previously written, the KPIs for the cluster Authorities and Facilitators is unique and during our analysis we encountered significant difficulties in obtaining input for the methodology test. In general, it can be seen as a larger scale version (regional, national, or international) of the Secondary end-users (Healthcare facilities subgroup) cluster. The type of problems involved are very complex aspects also linked to laws, infrastructures, or aspects such as readiness or the impact they have on a large scale, a subject that we managed to deal with during recent interviews with Sonja Hansen, European Project Officer at the Municipality of Aarhus, Denmark and Robert Thijssen, Innovation manager for digital

care and responsible for the SIGRA Innovation Lab, The Netherlands. The information collected represents a first step in the right direction and is an excellent indicator of the relationship between municipalities and AAL / AHA platforms. The main goal is to help citizens to allow them to live an independent life for as long as possible therefore the interest and research of AHA / AAL oriented platforms is constant and of great importance. To achieve this, the first task is the collaboration between the various Health and Care departments and external partners, with the aim of researching, developing, testing and implementing AHA / AAL solutions. This is to provide citizens with increased self-reliability and independent living, which consequently can improve working conditions, increase efficiency and improve the economy for the municipality. Companies play an important role in all this and therefore it is important that they are supported by the state with funds for innovation but also other activities such as periodic exhibits in order to give visibility to even the smallest companies.
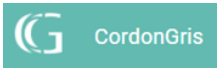
About the needs and requirements for digital technology, the two main aspects were how to relate and how to connect. How to relate implies a work that makes municipalities ready for each type of platform. Here the main aspects are: the understanding on policies and policy coordination, collaboration on care processes, without which the whole system becomes unstable, information must be understood and defined in its structure and content, while on the application side it is important to connect the systems, infrastructures, in compliance with laws and safety standards. How to connect is more about values and the right of citizens to have a say in the decision making process.

7.5. Platform analysis - state of the art summary
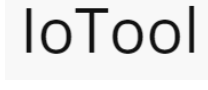
In this paragraph we will summarize the state of the art of all the AHA/AAL platforms, including even those only partially oriented to these domains, which have been examined during the work carried out in WP2 and WP4. The table contains also the specification of the type of financing and a reference to the various activities carried out on them divided by WP.

Table 10: State of the art of AHA/AAL platforms

Platform's Name	Logo	Funding	References
ACCESS	ACCESS	EU	WP4: • State-of-the-art of open platforms in Europe
ACESO	ACESO	EU	WP4: • State-of-the-art of open platforms in Europe
Activage AIOTES	ACTIVAGE PROJECT	EU	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis WP4:

			• Case study
			• State-of-the-art of open platforms in Europe
			• Interview study
			• Setup costs overview
			• Maintenance costs overview
			• Affordability of platform costs overview
			• Platform pricing overview
			• Number of platform users overview
			• Number of developed apps per platform overview
			• Healthcare improvement overview
			• Platform revenue overview
Brain@Home		EU	WP4: • State-of-the-art of open platforms in Europe
BREATHE		EU	WP4: • State-of-the-art of open platforms in Europe
Carelife		EU	WP4: • State-of-the-art of open platforms in Europe
Comarch IoT platform		Commercial	WP4: • State-of-the-art of open platforms in Europe
CordonGris		EU	WP4: • State-of-the-art of open platforms in Europe
CuraVesta		EU	WP4: • State-of-the-art of open platforms in Europe
DM4ALL		EU	WP4: • End-user survey

eVida		Instituto Pedro Nunes, Portugal	WP4: • Interview study • End-user survey
Ekosmart		Slovenijan Ministrstry for Education, Science and Sport	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis WP4: • Case study • Setup costs overview • overview • Maintenance costs overview • Affordability of platform costs • Platform pricing overview • Number of platform users overview • Number of developed apps per platform overview • Healthcare improvement overview • Platform revenue overview
FiWare		EU	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis WP4: • Case study • Interview study • Setup costs overview • Maintenance costs overview • Affordability of platform costs • Platform pricing overview • Number of platform users overview • Number of developed apps per platform overview

			- Healthcare improvement overview - Platform revenue overview - End-user survey
GATEKEEPER		EU	WP4: State-of-the-art of open platforms in Europe
HAPI FHIR		Commercial	WP4: End-user survey
IoTool		Commercial	WP4: State-of-the-art of open platforms in Europe
JHipster		Community	WP4: End-user survey
MedGUIDE		EU	WP4: State-of-the-art of open platforms in Europe
Medixine		Commercial	WP4: State-of-the-art of open platforms in Europe
MiBida			WP4: - State-of-the-art of open platforms in Europe - Interview study - Use case
ModyStudy		Malmö University, Sweden	WP4: Use case
Onesait		EU	WP2: - Technical analysis of the platforms - Analysis of contextual aspects - Analysis of financial aspects and business models - Technical questionnaire and analysis WP4: - Setup costs overview

			Maintenance costs overview • Affordability of platform costs • Platform pricing overview • Number of platform users overview • Number of developed apps per platform overview • Healthcare improvement overview • Platform revenue overview
Oscar Senior	OSCAR SENIOR	Commercial	WP4: • Interview study • Use case
OpenHAB	openHAB	Foundation	WP4: • End-user survey
Openremote	openremote	Commercial	WP4: • Interview study • Use case
OPC digital platform	OPC FOUNDATION	Foundation	WP4: • State-of-the-art of open platforms in Europe
PHArA-ON	pharaon	EU	WP4: • State-of-the-art of open platforms in Europe
PharosN	Pharos Navigator	Commercial	PharosN
Reach2020	REACH 2020	EU	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis WP4: • Setup costs overview • Maintenance costs overview • Affordability of platform costs • Platform pricing overview • Number of platform users overview

			• Number of developed apps per platform overview • Healthcare improvement overview • Platform revenue overview
Sensinact		EU	**WP2:** • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis **WP4:** • Setup costs overview • Maintenance costs overview • Affordability of platform costs • Platform pricing overview • Number of platform users overview • Number of developed apps per platform overview • Healthcare improvement overview • Platform revenue overview
SHAPES		EU	**WP4:** • State-of-the-art of open platforms in Europe
Smart Health Companion		Commercial	**WP4:** • End-user survey
SMARTBEAR		EU	**WP4:** • State-of-the-art of open platforms in Europe
The Care Hub		Commercial	**WP4:** • End-user survey

UNCAP		EU	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis
UniversAAL IoT		EU	WP2: • Technical analysis of the platforms • Analysis of contextual aspects • Analysis of financial aspects and business models • Technical questionnaire and analysis WP4: • Case study • Setup costs overview • Maintenance costs overview • Affordability of platform costs overview • Platform pricing overview • Number of platform users overview • Number of developed apps per platform overview • Healthcare improvement overview • Platform revenue overview • End-user survey
vINCI		EU	WP4: • State-of-the-art of open platforms in Europe

8. Conclusion

This document described the work carried out in T4.4 "Create a baseline report including the main outcomes of the analysis to support the platform improvement and uptake". The goal of this task was to show a general overview of the state-of-art of open platforms, their users, networks, stakeholders, functionalities, outcomes, benefits etc. It is important to remember that the baseline report can be used for the identification of success and hindrance factors of open platforms which are already on the market or should be taken into account when constructing a new platform. In fact, an accurate description of which aspects concern the KPIs has been included.

To support future development activities in the field, the report brought the attention of the reader to main gaps in the ecosystem of open platforms for AHA/AAL. It achieved this by highlighting the outcomes of knowledge exchange activities with relevant end-user groups of the analysed platforms. As a result the consortium established that:

- there is a low level of trust among Primary end-users (older persons) towards insecure autonomous systems and digital technology in general
- based on lack of information government representatives cannot assess economic aspects and provide a monetary valuation of open platforms in the field
- government officials are reluctant to accept the digital transformation and change which are embodied by the platforms
- there is a lack of understanding among public authorities of the impact of open platforms on their daily activities and wellbeing of the population as a whole
- there is no capability to meet the end users' objective as well as internal innovation processes of the end-user organisations
- EU-funded and newly developed commercial platforms experience difficulties with addressing effectively the two-sided market in the AHA/AAL domains
- comprehensive communication strategy with unique value proposition and close contact to potential end-users is missing or insufficiently implemented
- there is a need to involve end-users in the design, development and launch of open platforms
- the lack of technical documentation leads to low level of transparency in the process of setup of platforms' services
- some platforms have outdated or too complex technical infrastructures which causes additional efforts by AAL / AHA solution developer / provider to integrate their solutions
- there is lack of evidence on best practices in the field as well as insufficient research on the hindrance and success factors for the successful uptake of open platforms
- most EU-funded projects and some commercial platform providers do not manage to establish large network of end-users
- the lack of funding after the project is completed puts future development and promotional activities on hold
- less flexible and cumbersome legislation across Europe hinders the uptake of open platforms
- data is trapped in silos (large companies and enterprises) which prevent providers of open platforms as well as developers of technology for active and healthy ageing to upscale their services and solutions

To help providers of open platforms in the field tackle some of these gaps the document outlined recommendations according to clusters, sub-clusters, stakeholder groups and subgroups of stakeholders. From a buyer's point of view, this report can also be used by some stakeholders who are interested in purchasing services or applications related to a platform. The analysis of the various stakeholder groups has revealed even more clearly the complexities that cannot be measured simply with KPIs. This is especially true for the Authorities and facilitators cluster. If we look at EU funded projects, the recognition of the correct stakeholders group becomes more difficult, and therefore fundamental. In these cases, the knowledge of almost all the relevant aspects of the project, under all three contextual, technical and business domains, with the exception of the Primary end-user cluster, is known to all the partners who are part of the project. In this context, accurate identification of stakeholder groups is of fundamental importance so as not to run the risk of acquiring unreliable data. One of PlatformUptake.eu goals is to continue promoting the project's activities with the various stakeholders, to share the importance of these topics, and to further refine the work done so far. The insights which were presented in the baseline report analysis will be integrated into the Open Information Hub as an interactive knowledge source for all project stakeholders.

9. References

[1] Zaidi, A., Gasior, K., Zolyomi, E., Schmidt, A., Rodrigues, R., & Marin, B. (2017). Measuring active and healthy ageing in Europe. Journal of European Social Policy, 27(2), 138-157. https://doi.org/10.1177/0958928716676550]

[2] [Karaberi, C., Dafoulas, G. E., Ballis, A., & Raptis, O. (2018). ACTIVAGE project: European Multi Centric Large Scale Pilot on Smart Living Environments. Case Study of the GLOCAL evaluation framework in Central Greece. Dialogues in Clinical Neuroscience, 1(4), 138-143.]

[3] [Paletta, L., Fellner, M., Schüssler, S., Zuschnegg, J., Steiner, J., Lerch, A., ... & Prodromou, D. (2018, June). AMIGO: Towards social robot based motivation for playful multimodal intervention in dementia. In Proceedings of the 11th PErvasive Technologies Related to Assistive Environments Conference (pp. 421-427).]

[4] [Valero, Z., et al. (2010). AmIVital: Digital personal environment for health and well-being. In International Conference on Wireless Mobile Communication and Healthcare. Berlin/Heidelberg: Springer.]

[5] [Piera-Jiménez, J., Daugbjerg, S., Stafylas, P., Meyer, I., Müller, S., Lewis, L., ... & Lupiáñez-Villanueva, F. (2020). BeyondSilos, a telehealth-enhanced integrated care model in the domiciliary setting for older patients: observational prospective cohort study for effectiveness and cost-effectiveness assessments. JMIR medical informatics, 8(10), e20938.]

[6] [Trilar, J., Zavratnik, V., Čermelj, V., Hrast, B., Kos, A., & Stojmenova Duh, E. (2019). Rethinking Family-Centred Design Approach Towards Creating Digital Products and Services. Sensors, 19(5), 1232.]

[7] [Cirillo, F., Solmaz, G., Berz, E. L., Bauer, M., Cheng, B., & Kovacs, E. (2019). A standard-based open source IoT platform: FIWARE. IEEE Internet of Things Magazine, 2(3), 12-18.]

[8] [Coradeschi, S., Cesta, A., Cortellessa, G., Coraci, L., Gonzalez, J., Karlsson, L., ... & Ötslund, B. (2013, June). Giraffplus: Combining social interaction and long term monitoring for promoting independent living. In 2013 6th international conference on Human System Interactions (HSI) (pp. 578-585). IEEE.]

[9] [Koutsouris, N., Kosmides, P., Demestichas, K., Adamopoulou, E., Giannakopoulou, K., & De Luca, V. (2018, October). InLife: a platform enabling the exploitation of IoT and gamification in healthcare. In 2018 14th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob) (pp. 224-230). IEEE.]

[10] [Fortino, G., Savaglio, C., Palau, C. E., de Puga, J. S., Ganzha, M., Paprzycki, M., ... & Llop, M. (2018). Towards multi-layer interoperability of heterogeneous IoT platforms: The INTER-IoT approach. In Integration, interconnection, and interoperability of IoT systems (pp. 199-232). Springer, Cham.]

[11] [Mikalsen, M., Hanke, S., Fuxreiter, T., Walderhaug, S., & Wienhofen, L. (2009). Interoperability services in the MPOWER Ambient Assisted Living platform. In Medical Informatics in a United and Healthy Europe (pp. 366-370). IOS Press.]

[12] [OASIS, "Open Building Information Exchange (oBIX)." [Online]. Available: https://www.oasisopen.org/committees/tc home.php?wg abbrev=obix]

[13]   [http://www.telemed.no/persona-perceptive-spaces-promoting-independent-aging.541667-247950.html]

[14] [REACH: Responsive Engagement of the Elderly Promoting Activity and Customized Healthcare; project and consortium, website: http://reach2020.eu; 2018.]

[15] [Gambi, E., Montanini, L., Raffaeli, L., Spinsante, S., & Lambrinos, L. (2016, June). Interoperability in IoT infrastructures for enhanced living environments. In 2016 IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom) (pp. 1-5). IEEE.]

[16] [M. Klein, A. Schmidt, and R. Lauer, "Ontology-centred design of an ambient middleware for assisted living: the case of SOPRANO", Proc. of Towards Ambient Intelligence: Methods for Cooperating Ensembles in Ubiquitous Environments (AIM-CU), 30th Annual German Conference on Artificial Intelligence (KI 2007), Osnabrück, 2007.]

[17] [Ubiquitous iNteroperable Care for Ageing People (UNCAP) web page. http://www.uncap.eu.]

[18] [S. Hanke, C. Mayer, O. Hoeftberger, H. Boos, R. Wichert, M.R. Tazari, et al., "universAALan open and consolidated AAL platform", Ambient Assisted Living 4 AAL-Kongress 2011, 2011.]

[19] [http://cordis.europa.eu/project/rcn/86723_en.html]

[20] [sensiNact. https://projects.eclipse.org/proposals/eclipse-sensinact]

[21] [Sophia2/onesait. Accessed: Nov. 14, 2020. [Online]. Available: https://github.com/Sofia2/]

[22] [Kelley, T. A. (2015). International consortium for health outcomes measurement (ICHOM). Trials, 16(3), 1-1.]

[23] [Kidholm K., Ekeland A.G., Jensen L.K., Rasmussen J., Pedersen C.D., Bowes A., Flottorp S.A., Bech M. A model for assessment of telemedicine applications: MAST. Int J Tech-nol Assess Health Care. 2012 Jan;28(1):44–51. doi: 10.1017/S0266462311000638.],

[24][European   Commission,   Joint   Research   Centre   (2009)   MAFEIP. http://is.jrc.ec.europa.eu/pages/TFS/MA-FEIP.html. Accessed 2 Jan 2017 hys.2013.12.014]

[25] [Karaberi, C., Dafoulas, G. E., Ballis, A., & Raptis, O. (2018). ACTIVAGE project: European Multi Centric Large Scale Pilot on Smart Living Environments. Case Study of the GLOCAL evaluation framework in Central Greece. Dialogues in Clinical Neuroscience, 1(4), 138-143.]

[26] [Wichert, R., Tazari, S., Albrecht, A., & Wichert, M. (2021, July). The Value of the User Evaluation Process in the European IoT Large-Scale Pilot for Smart Living. In International Conference on Human-Computer Interaction (pp. 189-209). Springer, Cham.]

[27] [Bang, H., & Zhao, H. (2012). Median-based incremental cost-effectiveness ratio (ICER). Journal of statistical theory and practice, 6(3), 428-442.]

[28] [Group, T. E. (1990). EuroQol-a new facility for the measurement of health-related quality of life. Health policy, 16(3), 199-208.], EQ-5D [Dyer, M. T., Goldsmith, K. A., Sharples, L. S., & Buxton, M. J. (2010). A review of health utilities using the EQ-5D in studies of cardiovascular disease. Health and quality of life outcomes, 8(1), 1-12.]

[29] [Rebollo, P., Ortega, F., Baltar, J. M., Badía, X., Alvarez-Ude, F., Díaz-Corte, C., ... & Alvarez-Grande, J. (2000). Health related quality of life (HRQOL) of kidney transplanted patients: variables that influence it. Clinical transplantation, 14(3), 199-207.]