smartwork

D2.3 - DATA COLLECTION PROTOCOL

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0.2	23.04.2019	RRD	Revised Table of Contents based on feedback from partners
0.3	10.05.2019	RRD, CDC, CAT, UPAT, IPN, SPARKS	Input provided to the several sections of the deliverable
0.4	17.05.2019	RRD	Revised version of the deliverable after input from all partners
0.5	28.05.2019	RRD, CDC, UPAT, IPN, SPARKS	Revised version of the deliverable after second round of input from all partners
0.6	30.05.2019	RRD	Internal review of the deliverable
0.7	20.06.2019	RRD	Final version after revision from partners
0.8	24.06.2019	RRD	Submitted to the Coordinator for final review and upload
1.0	30.06.2019	BYTE	**Final review, additions and submission to the EC**

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GLOSSARY

ABBREVIATION	DESCRIPTION
AI	Artificial Intelligence
CAPI	Computer Aided Personal Interviewing
ELSA	English Longitudinal Study of Ageing
ICPSR	Interuniversity Consortium for Political and Social Research
ISSDA	Irish Social Science Data Archive
PAPI	Paper and Pencil Interviewing
PEBL	Psychology Experiment Building Language
PIAAC	Programme for the International Assessment of Adult Competencies
PUB	Public Use Files
SHARE	Survey of Health, Ageing and Retirement in Europe
TILDA	The Irish Longitudinal Study on Ageing

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1. Executive Summary

The SmartWork project builds a Worker-Centric AI System for work ability sustainability, which integrates unobtrusive sensing and modelling of the worker state with a suite of novel services for context and worker-aware adaptive work support. This deliverable is the main outcome of **Task 2.3 Design of the Data Collection protocol** and its aim is to establish a preliminary protocol for the data collection phases within the life cycle of the project. In this document we define the timing, content, and methods related to the collection of data, based on the information available at the current stage of the project (M1-M6). In the later stages of the project, this preliminary Data Collection Protocol established in Task 2.3 will be integrated, and regularly updated based on project advancements, as part of the Data Management Plan in WP9.

There are three data collection tracks foreseen within the SmartWork project: (1) Co-creation with end-users, (2) Technical optimization, and (3) Final evaluation. These three tracks guide the structure of the present document.

In Chapter 3 we describe the data collection needed for requirements elicitation and the preliminary results. During the requirements phase, a pan-European survey was developed to assess the needs of older office workers in the several European countries, with a special focus on the two pilot sites: Portugal and Denmark. Furthermore, caregivers and managers were interviewed to elicit the requirements mostly connected to the *iCare* and *digiTeam* services, respectively. The requirements elicitation process and respective results are further described in D2.2 – First version of the Co-design methodology, user requirements and use cases.

Chapter 4 describes the data collection needed for technical optimization of the SmartWork system. One of the challenges of the SmartWork project is to combine unobtrusive sensing and state-of-the-art modelling techniques to support work ability. This means that data will be collected from existing large data registries. The initial plans for data collection for this purpose are described in Section 4.1, while the development of the functional, cognitive and work ability models will be described in deliverables D4.1, D4.2 and D4.3 respectively. Furthermore, technical integration requires that the technology is regularly tested, initially in a lab settings, then moving to more real-life settings. This data collection needed for testing SmartWork functionalities is described in Section 4.2.

After the technical tests are performed, the system is ready to be tested with end-users. Chapter 5 is dedicated to the description of the two moments planned for testing with end-users: a first trial in semi-controlled environments (Portugal) aiming at usability testing and a final evaluation in two pilot sites (Portugal and Denmark) aiming at obtaining preliminary evidence of effectiveness of the SmartWork system in maintaining work ability of older office workers. The full evaluation plan will be described in deliverable D8.1 – Pilots planning and evaluation framework (M22).

To sum up, within the life cycle of the SmartWork project, the first year (2019) is dedicated to the requirements elicitation, the second year (2020) is dedicated to data collection for technical

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optimization ending with the usability testing with 12 end-users, and the final evaluation occurs in the third year (2021).

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2. Introduction

The SmartWork project builds a Worker-Centric AI System for work ability sustainability, which integrates unobtrusive sensing and modelling of the worker state with a suite of novel services for context and worker-aware adaptive work support. The unobtrusive and pervasive monitoring of health, behaviour, cognitive and emotional status of the worker enables the functional and cognitive decline risk assessment. The holistic approach for work ability modelling captures the attitudes and abilities of the ageing worker and enables decision support for personalized interventions for maintenance/improvement of the work ability. The evolving work requirements are translated into required abilities and capabilities (work ability model), and the adaptive work environment supports the older office worker with optimized services for on-the-fly work flexibility coordination, seamless transfer of the work environment between different devices and different environments (e.g. at home, at the office, or on the move), and on-demand personalized training. The SmartWork services and modules for on-the-fly work flexibility also empower the employer (manager) with AI decision support tools for efficient task completion and work team optimization through flexible work practices. Formal/informal carers are enabled to continuously monitor the overall health status, behavioural attitudes and risks for the people they care for, and adapt interventions to the evolving workers status, thus providing full support to the older office workers for sustainable, active and healthy ageing. Figure 1 illustrates the high-level conceptual overview of components and services of SmartWork.

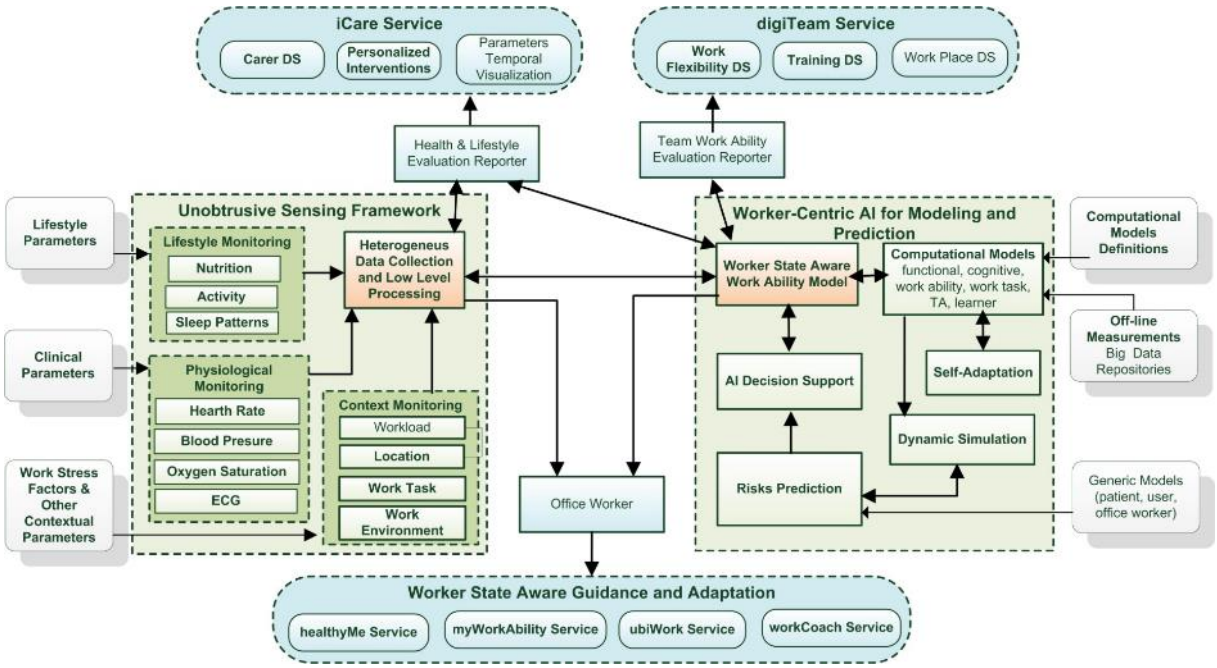

FIGURE 1 – SMARTWORK HIGH-LEVEL CONCEPTUAL OVERVIEW OF COMPONENTS AND SERVICES.

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The aim of this deliverable is to establish a preliminary protocol for the process of data collection in the several phases of the life cycle of the SmartWork project. In this document we define the timing, content, and methods related to the collection of data, taking into account the information available at the current, early stage of the project, in the task that is running from M1 to M6. Evidently, although the Document of Action sets out the context and outlines of the services to be developed in the SmartWork project, the implementation and design details of the SmartWork system are evolving with the ongoing requirements gathering tasks (see Section 2.2, outlining the relationship between this deliverable and other project deliverables).

2.1. Structure of this deliverable

From a high-level perspective, we identify three tracks of data collection foreseen in the life cycle of the SmartWork project, each one corresponding to a section of this document.

- **SmartWork Co-creation with end users**: following a user-centric approach, the SmartWork system is developed in an iterative collaboration with the end users. This means that the needs and preferences of primary users – the older office workers – as well as secondary and tertiary users – managers and informal carers – are listen to and considered in all phases of the design, development and evaluation of the system. The requirements specification with end users is planned to take place in the first year of the project (2019) as described in Section 3. The full activities within co-creation are described in D2.2 and D2.7, corresponding respectively to the first and final versions of the Co-design methodology, user requirements and use cases.
- **Technical optimization of the SmartWork System**: The SmartWork system advances current state of the art of work ability modelling, by capturing the attitudes and abilities of the ageing worker. The technical optimization of the SmartWork system will be done with big data registries and with real data acquisition in in-lab. Open big data registries will be used for idea/hypothesis generation and validation, and for the implementation of the modelling, simulation, prediction and decision support tools with a more generic character (e.g. capturing groups of users). The detailed use of data from big registries for optimization of the SmartWork system is described in deliverables D4.1, D4.2, D4.3 and D4.4. Secondly, before testing with end-users, the sensing and reasoning algorithms need to be tested and validated in-lab, meaning that these tests occur in controlled conditions. Section 4 describes the data collection for technical optimization in detail.
- **SmartWork evaluation**: Once the first prototype is finalized and has successfully undergone the in-lab testing and validation, the SmartWork system will be evaluated with end-users. There are 2 specific evaluation phases planned within the life cycle of SmartWork. The first, between M19 and M28, is the trial in semi-controlled environments. For two months period, end users will test the SmartWork system with the aim of identifying the easiness of use of the system. This trial will result in a list of improvement points for the technical partners and in another round of

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development. In the third year of the project (2021), the field trials will take place in Portugal and in Denmark, where end users will use the system for 6 months. The aim of this study is to obtain preliminary evidence on the effectiveness of the SmartWork system in maintaining or increasing Work Ability of older office workers. The preliminary planning of the data collection is described in Section 5. The full evaluation plan will be described in D8.1 and the results of the trial in semi-controlled environments and the field trials will be described in deliverables D8.2 and D8.5, respectively.

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2.2. Dependencies on other deliverables in the project

The work described in this deliverable has several connections to other deliverables in the project. Below we list the most relevant related deliverables and shortly describe how those documents relate to the current deliverable D2.3.

- **D1.2 – First version of Ethics and Safety Manual (M6)**
  This deliverable defines the first version of ethical and safety management issues regarding, among other aspects, the data collection within the life cycle of SmartWork.

- **D2.1 – SOA review and benchmarking of best practices (M3)**
  This deliverable has generated a list of sensors that could potentially be used within the SmartWork platform to automatically collect data about the SmartWork users. Data collection through the use of such sensors is described here in Section 5.1.2.

- **D2.2 – First and Final versions of the Co-design methodology, user requirements and use cases (M6)**
  The initial results of the co-design methodology, written and produced simultaneously with the current task has generated input for the Data Collection Protocol described here, specifically in Section 3.1.

- **D4.1 – First version of the Functional Modelling Framework (M15), Final version D4.5 (M24)**
- **D4.2 – First version of the Cognitive Modelling Framework (M15), Final version D4.6 (M24)**
- **D4.3 – First version of the Work Ability Modelling Framework (M18), Final version D4.7 (M28)**
- **D4.4 – First version of the Predictive Models and Decision Support Tools (M18), Final version D4.8 (M28)**
  The deliverables related to the Functional-, Cognitive-, and Work Ability Modelling, as well as the related deliverables D4.4 and D4.8 related to Decision Support Tools will use the data collection protocols as defined in this Deliverable, specifically in Section 4.1.

- **D3.2 – First version of the Unobtrusive Sensor Network (M12), final version D3.5 (M22)**
  Section 4, and specifically Section 4.2 of the current document serve as input to the design of the SmartWork sensing framework that starts after the release of the current document and will be described in D3.2.

- **D8.1 – Pilots planning and evaluation framework (M22)**

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The deliverable on pilots planning (D8.1) will take into account the data collection procedures described in this deliverable, specifically in Section 5

- **D8.2 – Small-scale evaluation report (M28)**
  Section 5.1 of the current document describes the initial data collection protocols for the trials to be held in semi-controlled environments; these will be further specified in D8.2.

- **D8.3 – First version of the Field trials reports (M30), final version D8.5 (M36)**
  Section 5.2 of the current document describes the initial data collection protocols for the field trials, to be further refined in D8.3 in preparation for the field trials.

- **D9.13 – Data Management plan (M12 – first version)**
  The Data Management Plan will provide further details on all the data collection procedures described in this document, especially focusing on privacy-, security- and data access policies.

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3. SmartWork Co-creation with end users

3.1. Requirements specification with end-users

As part of the co-creation process of SmartWork, the requirements elicitation is done in strong collaboration with end-users. The elicitation of ideas and concepts contributes to the mapping of the needs of the target group of SmartWork and in terms of specifying the functional requirements for the system services. Moreover, it provides a clearer scope of the SmartWork system and it sets boundaries to which data needs to be collected in order to achieve improvement of the work ability in ageing workers.

The elicitation of requirements and following creation of scenarios is developed within Task 2.2, and reported in *D2.2 – First Version of Co-design methodology, user requirements and use cases*. The methodology of elicitation consisted of questionnaires, interviews, group sessions and a literature study to gather information holistically and in a structured, semi-structured and unrestricted manner. The first round of requirement elicitation took place in all different user groups (employees, employers and caregivers) to disclose a multi-sided point-view. The input received was processed into several use scenarios to clarify requirements in an understandable language.

As requirements are known to be volatile, they will be revised and refined. Feedback will be included from the co-design of the sensing network (T3.1) and accessible interfaces (T5.1), along with the results of the first prototype deployments in the pre-trial (T8.2).

A questionnaire entitled "Expectations, needs and requirements in older workers" was distributed among 200 (older) employees from several countries. The questionnaire was distributed with EUSurvey (an application developed by the Commission of the European Union which is committed to user privacy). The questionnaire was divided into five main sections: (1) Demographics and general information on personal habits, needs and workplace preferences, (2) Health status, (3) System functionalities, (4) System interface and wearables, and (5) Privacy. The aim of this questionnaire was to gather preferences and ideas from the employees' point of view and assess privacy concerns regarding collection and storing of their personal data. But also assess main use information (e.g. how often do you want to assess your health?). A thorough analysis of the data acquired, enables the identification of specific needs in sub-groups of the main target group, based for example on the demographics or health status.

Next to the questionnaire for employees, employers were interviewed and interviews or group sessions were held with caregivers. The aim of the interview with employers was to define the functional specification of the services that the SmartWork system will provide to employers, the *digiTeam Service*: a service for smart and flexible management of the workforce from the side of the employers (e.g. manager, supervisor) to increase efficiency and productivity of teams working on specific tasks, and to optimize training and knowledge management activities. Ten (10) Danish and ten (10) Portuguese managers were interviewed, with a focus on their view towards older workers

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(e.g. which attributes have your younger and older workers for your organization? Does your organization have a (health prevention) policy for workers?).

The focus groups were held with informal caregivers of older office workers to assess their view on the role that the SmartWork system can play for them and the older workers they care for. The interviews and group sessions followed the ORCS method (Open questions, Reflect, Confirm and Summarize) to assess the complete view of the participants on topics related to effect of chronic health conditions, the amount of care needed, the (missing) support on the work floor, system requirements and device interaction.

To complete the requirement list, scientific articles about older workers, chronic diseases and work were searched and stored in the SmartWork Zotero reference manager.

Use case scenarios:

From the requirements, a set of 5-7 scenarios, with associated personas and use cases were developed, that bring user-context to life in detailed realistic examples of how older adults will carry out their daily life both at work and in their personal life. Next to the user perspective view, with two different personas, one persona for the caregivers and one persona representing the managers were created. The results will serve as an aid to understanding and clarifying user requirements and expectations of the system functionality and to provide a basis for the definition of the system service features. Knowing these specific features, provides a clear view on which data needs to be collected and therefore lay the basis for the data collection protocol.

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4. Technical optimization of the SmartWork system

4.1. Technical optimization with big data registries

The implementation of the data-driven modeling, prediction and decision support tools in WP4, in addition to their co-design with the end users and technical optimization with in-lab data collection during the project lifetime, will also be grounded on technical optimization by using existing big data registries. More specifically, within WP4 a personalized virtual user model will be created based on user specific data and on generic models computed by analyzing existing relevant data registries. The following datasets will be considered, based on the analysis performed so far:

- The English Longitudinal Study of Ageing (ELSA)[1];
- The Irish Longitudinal Study on Ageing (TILDA)[2];
- The Survey of Health, Ageing and Retirement in Europe (SHARE)[3];
- Programme for the International Assessment of Adult Competencies (PIAAC)[4].

Further details on the dataset characteristics, conditions of use, and potential usage in SmartWork are provided in the following subsections.

4.1.1. ELSA Data Registry

The English Longitudinal Study of Ageing (ELSA) is a rich resource of information on the dynamics of health, social wellbeing and economic circumstances in the English population aged 50 and older. The current sample contains data from up to eight waves of data collection covering a period of 15 years, and the survey data are designed to be used for the investigation of a broad set of topics relevant to understanding the ageing process.

4.1.1.1. *Dataset Characteristics*

The dataset contains both objective and subjective data relating to health and disability, biological markers of disease, economic circumstance, social participation, networks and well-being. Currently, the aim is to extend the dataset to 18 years of study, providing potential for longitudinal analyses to examine causal processes. The high-quality multidisciplinary data are relevant for:

- Health trajectories, disability and healthy life expectancy;

[1] English Longitudinal Study of Ageing (ELSA): https://www.elsa-project.ac.uk/
[2] The Irish Longitudinal Study on Ageing (TILDA): https://tilda.tcd.ie/
[3] Survey of Health, Ageing and Retirement in Europe (SHARE): http://www.share-project.org/home0.html
[4] http://piaacgateway.com/what-is-piaacupdated/

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- The determinants of economic position in older age;
- The links between economic position, physical health, cognition and mental health;
- The nature and timing of retirement and post-retirement labour market activity;
- Household and family structure, social networks and social supports;
- Patterns, determinants and consequences of social, civic and cultural participation;
- Predictors of well-being.

Sample members are drawn from respondents to the Health Survey for England (HSE), and they have a face-to-face interview every two years of the study and a nurse assessment every four years. The nurse assessment involves measurements of physical function, anthropometric measurements and collection of blood samples for extraction of biomarkers and DNA. The last wave (began in July 2018) data collection also includes an online dietary questionnaire.

4.1.1.2. *Conditions of use and Access*

Access to the ELSA dataset is given through the UK Data Service, which implements a generic, three tier access policy:

1. **Open** – data licensed for use with an "open license", which are not personal and have relatively few restrictions to use, and neither login nor registration is required to access these data collections;
2. **Safeguarded** – data licensed for use in this category are not personal, but the data owner considers there to be a risk of disclosure resulting from linkage to other data, such as private databases, and such data may have additional conditions attached (e.g. special agreements, depositor permission, limited to non-commercial or academic users, data destruction clauses, specific forms of citation) and registration/authentication is required;
3. **Controlled** – data which may be identifiable and thus potentially disclosive, are only available to users who have been accredited and their data usage has been approved by the relevant Data Access Committee and required registration/authentication.

Most of the data in the ELSA database are under the second tier, and registration/authentication is required in order to access and use the data. Certain parts of the data set (e.g. DNA) which are under the controlled tier are not relevant for the SmartWork project and will not be used, thus no application/approval procedure is necessary.

Important conditions related to the use of the ELSA dataset are related to:

- Confidentiality, to ensure that no links or attempts are made to identify participants or their geographic location;
- The obligation to feed back to the UK Data Service and new datasets derived from the original ELSA dataset;
- The obligation to not use the dataset for commercial purposes;
- Acknowledgement of original data creators, copyright and intellectual property rights.

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4.1.1.3. *SmartWork Use of the ELSA data registry*

In the SmartWork project, the ELSA dataset will be used in WP4 to establish virtual user models with a highly generic character, such as older person with chronic conditions, male and female older persons, employed person and retired person.

4.1.2. TILDA Data Registry

The Irish Longitudinal Study on Ageing (TILDA) collects information on all aspects of health, economic and social circumstances from adults aged 50 years and over resident in Ireland. Waves of data collection take place every two years.

4.1.2.1. *Dataset Characteristics*

The TILDA dataset provides a comprehensive and accurate picture of the characteristics, needs and contributions of older persons in Ireland to inform and support improvements in policy and practice, advancements in technology and innovation, tailored education and training through an enhanced ageing research infrastructure, harmonization with leading international research to ensure adoption of best policy and practice and comparability of results. The main topics covered by the dataset are:

- Ageing
- Cognitive processes
- Economic conditions
- Health
- Health status
- Income
- Lifestyle and health
- Mental health
- Retirement
- Social participation

The population of the dataset is a nationally representative sample of community-dwelling adults aged 50 years and over, resident in Ireland. Methods of data collection included self-completed Paper and Pencil Interviewing (PAPI) and Computer Aided Personal Interviewing (CAPI).

4.1.2.2. *Conditions of Use and Access*

The TILDA dataset provides anonymised publicly accessible dataset files for research use, which are hosted by the Irish Social Science Data Archive (ISSDA) based at the University College Dublin and the Interuniversity Consortium for Political and Social Research (ICPSR) based in the University of Michigan. Researchers wishing to access the data must complete a request form, available on one of these two organizations website.

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The important conditions of use refer to:

- Confidentiality, as the data should not be used to attempt to obtain or derive information relating specifically to an identifiable individual or household;
- To acknowledge, in any work based in whole or part on resources provided by the ISSDA, the original data creators and the specific copyright and intellectual property rights as requested (www.ucd.ie/issda).

4.1.2.3. *SmartWork Use of the TILDA data registry*

In the SmartWork project the TILDA dataset, similarly to the ELSA dataset, will be used in WP4 to establish virtual user models with a highly generic character, such as: older person with chronic conditions, male and female older persons, employed person, retired person, etc.

4.1.3. SHARE Data Registry

The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks of about 140,000 individuals aged 50 or older, covering 27 European countries and Israel.

4.1.3.1. *Dataset Characteristics*

The main research areas targeted by the SHARE dataset are:

- Health on various dimensions, such as physical health, behavioural risks, cognitive function, mental health, with certain medical tests being performed in all waves (e.g. grip strength, walking speed) and other measurements being performed only in some of the waves (e.g. blood sample was taken only in Wave 6, expiratory peak flow was measured in Waves 2, 4 and 6);
- Health Care;
- Work and Retirement, including employment, pensions, and expectations;
- Social Networks, including social support and activities;
- Financial aspects, including household income, assets, and financial transfers;
- Other daily life aspects, including housing, consumption, and computer use.

Data collection employed CAPI for the main interview and paper and pencil for drop-offs. The first data collection wave took place in 2004, Wave 7 main data collection took place in 2017 and Wave 8 is scheduled for Autumn of 2019.

4.1.3.2. *Conditions of Use and Access*

The SHARE dataset is available at the SHARE Research Data Center to the entire research community free of charge on the basis of a release policy that gives quick and convenient access to all scientific users world-wide after individual registration. SHARE data may be used for scientific research, subject

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to European Union and national data protection laws and the specific SHARE Conditions of Use[5]. Any other uses, such as a commercial use of the data, are excluded. In accordance with the legal requirements and ethical commitments related to the SHARE data collection, applicants have to acknowledge and agree that they will use the SHARE data only for scientific purposes. The individual registration/authorization procedure and the access to the data is immediate.

4.1.3.3. *SmartWork Use of the SHARE data registry*

In the SmartWork project the SHARE dataset, similar to the ELSA and TILDA datasets, will be used in WP4 to establish virtual user models with a highly generic character, such as: older person with chronic conditions, male and female older persons, employed person, retired person, etc.

4.1.4. PIAAC Data Registry

The Programme for the International Assessment of Adult Competencies (PIAAC), also known as the Survey of Adult Skills, is a large-scale international household study that assesses the key cognitive and workplace skills that adults need to participate successfully in the 21st century society and the global economy. The survey measures adults' proficiency in key information-processing skills (see section 4.1.4.1) and gather information and data on how adults use their skills at home, at work and in the wider community. The survey was conducted in over 40 countries.

4.1.4.1. *Dataset Characteristics*

The PIAAC is designed to asses a broad range of abilities and competencies, covering the following domains:

- Literacy;
- Reading;
- Numeracy;
- Problem solving in technology-rich environments.

4.1.4.2. *Conditions of Use and Access*

Public Use Files (PUB) containing individual unit record data in SAS, SPSS and CSV format are available for downloading for each of the countries participating in the survey, with the exception of the Australian, German and USA datasets, for which specific conditions are applied. In SmartWork the freely available PUB data from European countries will be used, thus no application/approval procedure is necessary. No registration/authorization procedure is required, and the access to the data is instant.

[5] http://www.share-project.org/data-access/share-conditions-of-use.html

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4.1.4.3. *SmartWork Use of the PIAAC data registry*

In the SmartWork project the PIAAC dataset will be used in WP4 to enrich generic virtual user models with features related to competencies and skills relevant for the functional and cognitive modelling of older persons.

4.2. Technical optimization with SmartWork real test data

The SmartWork Data Collection infrastructure allows for sensor orchestration, data acquisition, storage and manipulation, together with advanced analytics on the available information and obtained datasets. For properly defining the models and interventions to be computed and generated by the platform, a preliminary evaluation phase is required in order to test our work with real data prior to reaching out to trial end-users. The scope of this phase is no other than obtain a basic idea of the prototype per se in a bottom-up approach, starting from the necessary modules that will compose the final sensor network and all auxiliary services, the underlying algorithms that will facilitate data handling and analytics, the communication protocols that will be used, and most importantly, the overall behavior of the SmartWork platform, its role and how it can be efficiently exploited for deploying a robust, near production-ready prototype.

The roadmap for implementing a working prototype of the SmartWork platform involves:

- Selecting the necessary metrics that will be monitored via specialized sensors (e.g. physiological parameters);
- Selecting the necessary metrics that will be collected using offline methods from the end users (e.g., questionnaires or manual inputs);
- Training and testing the machine learning and AI modules of the platform against existing open datasets that are available for similar scenarios, where applicable;
- Performing an initial in-lab data collection cycle that will provide datasets for the developers involved in the implementation of the SmartWork platform and validate the data collection mechanism for its completeness and robustness;
- Testing and validating all implemented software components that interact with the collected data for their completeness and robustness;
- Integration of all components and verification of end-to-end functionality of the SmartWork platform.

This evaluation phase allows developers to get solid evidence of potential system flaws and liabilities, therefore efficiently tackle all rising issues, prior becoming a real threat for the field trials. After each of the numerous production phases, a revision process is scheduled, primarily for fine-tuning purposes, leading to a system that can be deployed and tested under real conditions.

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Since the available spectrum of choices for each sensor and hardware component was considerably wide (please refer to deliverable D2.1 Analysis of Current Practices), it is expected that before defining a conclusive prototype architecture, all different options to be evaluated with the most appropriate to prevail. The choice will be made in distinct cycles involving specification analysis, development, integration testing, and field evaluation and reporting, and this is the fundamental reason that renders this evaluation phase of paramount importance.

This evaluation phase is designed to take place before any final user interaction of our platform. It will be conducted mainly by the developers of the system in controlled environments as there is a high probability that a few issues will be identified and will need to be ironed out in that process. Placing this period before the interaction with end-users will also help us gather the required baseline data that can be internally used to better train and fine-tune higher-level systems.

4.2.1. Cross-validation

Cross-Validation is a statistical method used for evaluating and comparing the learning capabilities of algorithms by dividing data into two parts: one group is used to learn or train a model, while the other group is used to validate the algorithm. In most approaches of cross-validation, the training and validation datasets must be switched over in successive iterations, to allow each data point to be validated.

One of the basic forms of performing cross validation is also known as k-fold cross-validation. However, there are other procedures to evaluate algorithms, consisting in particular cases of k-fold cross-validation or involving repeated rounds of k-fold cross-validation, depending on the available information and the desired results.

To perform a k-fold data cross validation, the first task to do is dividing the dataset that will be used to test the developed algorithm, into equal or almost equal *k* parts/folds. After that, there will be performed *k* iterations of training/validation procedures, each one realized with a different fold for validation while the remaining *k-1* parts will be used for learning. In each iteration, the training and validation datasets change, as shown in Figure 2.

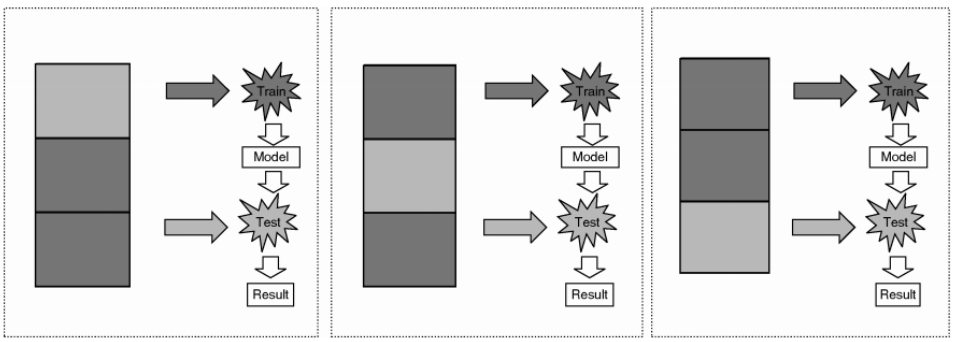

FIGURE 2 – PROCEDURE OF THREE-FOLD CROSS-VALIDATION. IMAGE FROM (IMAGE RETRIEVED FROM REFAEILZADEH ET AL., 2008).

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This approach is widely used in several applications, like machine learning and data mining, where cross-validation with 10 different folds/bins is the most common.

The cross-validation process is performed at each iteration where, one or more learning algorithms use k-1 folds of data to learn one or more models. The generated models will then be used to make predictions relatively to the data in the validation bin, and the performance of the algorithm can be evaluated used some of the pre-existing performance metrics, like accuracy, for example. At the end of the cross-validation process it is expected to have *k* samples of performance data, which can lead to a conclusion by performing an averaging methodology or be integrated in statistical hypothesis test to evaluate, side by side, the performance of different algorithms [1].

In the SmartWork context, the above approach can be very useful to test and evaluate the performance of the different algorithms that will be developed, by the partners, during the execution of the project. However, the algorithm train/validation approach cannot be deployed if there are not any available datasets. One possible approach to solve the data issue is to use pre-existing and tested data sources. Nevertheless, as SmartWork is an innovative All-In-One (AIO) solution that packs different sensors and measure different parameters, it is more difficult to find datasets that contain the information needed to evaluate the algorithms.

4.2.2. Creation of a proprietary dataset

In order to pack all needed data to test and evaluate tools/procedures, a proprietary dataset will be crated during the project lifetime. This data collection should be made using the same conditions and approaches, to ensure that the information is coherent and consistent, despite the type of data gathered. One way to perform the data acquisition is by performing test from the Psychology Experiment Building Language (PEBL) Test Battery.

PEBL experiments are a good procedure to collect data. The experiments normally are executed by a software launcher that permits users to select characteristics of how the test is conducted (monitor resolution, participant code, etc.) and also permits "experiment chains" – tests that can be run in order. PEBL has a library of functions for general computing as well as functions dedicated to the project of experiments. These contain an extensive collection of purposes for randomization, sampling, and counterbalancing; data treatment and statistics; typical experimental idioms (e.g. built-in functions for messages, multiple choice questions and various methods of commonly used graphic stimuli), and both restricted set (e.g. press one of several keyboard buttons) and multidimensional response collection [2]. The PEBL software provides one of the largest collections of open-source test battery available, meaning that various users not ever have necessity to produce their own new tests, but somewhat usage or adapt existing ones [3].

Even though PEBL enables the acquisition of data, nothing is mentioned in relation to validity and reliability of the gathered data, which is an important parameter. Validity describes the evidence that an assessment tool measures what it is supposed to measure and reliability refers to whether the

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scores are reproducible, is the degree to which an assessment tool produces stable and consistent results and it is obtained through internal consistency and also from the test-retest reliability [4].

Having that question in mind, IPN, has performed a study dedicated to evaluate and validate test data gathered by conducting tests in PEBL, where were used several scales like Epworth Sleepiness Scale [5], Stanford Sleepiness Scale [6] and NASA Task Load Index [7] to enable the test and comparison. The study was done in an office environment, having submitted some of the workers to specific situations in order to analyse and validate the information collected, obtained very positive results. In this study, the PEBL was the adopted software to create and run the tests with custom characteristics with the objective of creating a compilation of data, used to test and validate the developed software in the scope of the project. This experience in creating and running PEBL test that IPN has, could be used in the context of the SmartWork project to develop a customized dataset if in the further development stages, the partners verify that a custom dataset will be important to validate the SmartWork Software suite.

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5. SmartWork evaluation

This section describes the two periods planned for evaluation with end-users: the trial in semi-controlled environments (Section 5.1) and the field trials with end-users (Section 5.2) aiming at testing the usability and preliminary effectiveness of the SmartWork system, respectively. A detailed description of the evaluation protocol will be provided in *D8.1 – Pilots planning and evaluation framework*, to be released in M22. Furthermore, the ethical, privacy, legal and safety considerations regarding the collection of data within the life cycle of the SmartWork system are reported in *D1.2 – First Version of Ethics and Safety Manual* (M6).

Although the details of the evaluations (both in semi-controlled environments, and for the field-trials) are not yet defined, we make here some assumptions on the way they will be set up. We have divided each one of the evaluation periods in three phases:

1. **Baseline:** screening and baseline assessment
2. **Monitoring:** Ongoing measurements during the trial
3. **Closing interview:** Qualitative research – interview with participants and other relevant people involved in the trial

In defining the data collection procedures in Sections 5.1 and 5.2 below, we have taken these three phases into account in describing the types of data that will be collected at which point in time.

Below, we first describe the functional and technical evaluation in semi-controlled environments in Section 5.1. Where necessary, assumptions on the trial's design are clarified. For the first trial phase all relevant foreseen data collection (Section 5.1.2) and processing (Section 5.1.3) needs are described. Then, in Section 5.2 we describe the initial setups of the trials in Portugal and Denmark and discuss any differences in data collection procedures between those final field trials and the trials in semi-controlled environments described before.

5.1. Trial operation in semi-controlled environments

The aim of the trial operation in semi-controlled environments is to test the **ease of use** of the SmartWork system and Smart Services Suite and identify any practical difficulties the end users may

Outcome: each trial will be concluded with a report describing the functionality and technical issues encountered

Timing of the trials: M19-M28 (July 2020 – April 2021)

Trial duration: 2 months

Participants: 12 older office workers, 2 managers and 2 carers

Trial Location: Portugal (CDC)

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experience. The SmartWork system and Smart Services Suite will be improved based on the results of this trial before the execution of the field trial with end users.

Each participant will use the SmartWork system for 8 weeks, being the first week dedicated to training, in close connection with the research and technical team. At week 3, a mid-term interview will be performed to make an evaluation of the status of the trial (Figure 3).

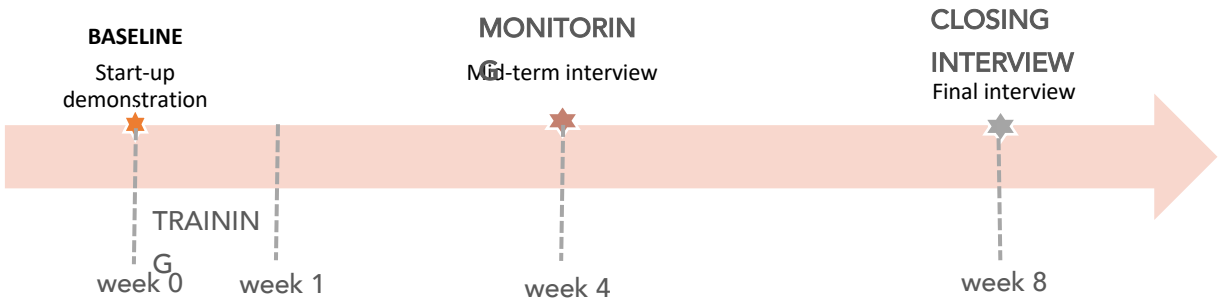

FIGURE 3 – TIMELINE OF THE TRIAL OPERATION IN SEMI-CONTROLLED ENVIRONMENTS.

5.1.1. Trial Description

The aim of the semi-controlled trial is to carefully investigate and highlight any potential issues that may impede implementation of the SmartWork. The first release version of the SmartWork system will be evaluated carefully with 12 older office workers, 2 managers and 2 carers, recruited from employees and relatives at CDC pilot site centre. The office workers will undergo a start-up demonstration, followed by full training of use of each unobtrusive monitoring device and Smart Service and will be monitored in all environments (work, home, on-the-move) for 2 continuous months of testing, with close support provided from the research and technical team. The managers and the carers will also participate in the trial operation in semi-controlled environments, in parallel with the workers. The aim is to test the ease of use of the SmartWork system and Smart Services Suite and identify any practical difficulties the end users may experience. At the end of each trial operation a report will be issued describing functionality and technical issues encountered. This will allow us to improve the SmartWork system and services before starting the second phase of the evaluation.

5.1.2. Data collection

We provide here the current view on the data to be collected during the trial. The table presented below (Table 1) provides a preliminary version of the data that will be collected during the trials as well as its context. The parameters listed were selected to cover the six services of the SmartWork system: *healthyMe*, *myWorkAbility*, *ubiWork*, *workCoach*, *digiTeam* and *iCareService*. These services

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and their connections to the various SmartWork system components are depicted in Figure 1 (Section 2).

The table of data collection types within the trial is intended to be exhaustive on the one hand (there is no guarantee that all described data types will be collected), but indicative on the other (there may be additional sensors or data types added as new requirements are generated).

The table contains the following elements:

- **Action**: This column specifies the action stage in which the data is collected. There are three stages of actions: baseline (*at the beginning of the trial*), monitoring (*during the trial*) and closing evaluation (*at the end of the trial*).
- **Partner**: Specifies the partner responsible for decisions regarding data collection.
- **Category**: Specifies the category of the data collected. Following Figure 1, in the monitoring stage there are 3 categories: *lifestyle*, *physiological* and *context*.
- **Parameter**: This is the core column of the table as it specifies the parameter that will be monitored.
- **Output**: The detailed output of the parameter described in column "Parameter".
- **Device**: The device(s) with which a parameter will be monitored.
- **Frequency of monitoring**: The frequency of monitoring of the given parameter.
- **Local**: Specifies the local where the data will be collected. Three options are expected: *home*, *work* and *on-the-move*.
- **Storage replication**: All types of data described in Table 1 are expected to be stored in the SmartWork Unobtrusive Sensing Framework (see T3.1). This column "Storage replication" lists any other places where the data may be stored, either intermediary or permanently.

TABLE 1 – DETAILED DESCRIPTION OF THE DATA COLLECTED WITHIN THE TRIAL OPERATION IN SEMI-CONTROLLED ENVIRONMENTS.

Action	Partner responsible	Category	Parameter	Outcome	Device/ questionnaire	Frequency of monitoring	Local of monitoring	Storage replication
Baseline	CDC	Baseline parameters	Quality of life	Quality of life	WHOQOL-OLD	One-time assessment	Research facilities	NA
	CDC	Baseline parameters	Quality of life	Quality of life	Work Ability Index questionnaire	One-time assessment	Research facilities	NA

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	CDC	...	To be defined in D8.1					
Monitoring	RRD	Lifestyle	Physical Activity	Steps / minute Minutes in physical activity intensity	Fitbit Alta or Charge	Continuous	Work & Home & On-the-move	Fitbit database
					MOX2			NA
					Withings Move			Withings database
					Smartphone			NA
	RRD	Lifestyle	Nutrition	Weight	Withings Body & Smart Scale	Event-based	Home	Withings database
				Food diary	Diary on a smartphone	Event-based	Work & Home & On-the-move	NA
	RRD	Lifestyle	Sleep	Time asleep Time awake Sleep stages	Fitbit Alta or Charge	Continuous during the night	Home	Fitbit database
					Withings Sleep Tracking Mat			Withings database
	RRD	Lifestyle	Mental load	Cognitive Fatigue Emotional wellbeing	Experience sampling on smartphone	Time-triggered ESM	Work	NA
	IPN	Physiological	Tiredness / Vigilance	Mouse Movements Mouse Click Stream	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	IPN	Physiological	Stress Level	Galvanic Skin Response (GSR) Grip Strength	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	IPN	Physiological	Anxiety Level	Hand Trembling Heart-Rate	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	IPN	Physiological	Hand Temperature	Mouse Temperature	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	IPN	Physiological	Cardiological Health	Heart-Rate Oxymetry Blood Pressure	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	IPN	Physiological	Skin Parameters	Skin Response Hand Sweat	SensIN Intelligent Mouse	Continuous	Work	RMQ message queue
	SPARKS	Physiological	ECG	Heartrate RR interval Beat Classification	SPARKS ECG	On Demand	Home/ Work/ On the move	SPARKS API
	SPARKS	Context	Location	Coarse Location (e.g., at work)	Smartphone Geo-fence	Event-Based	Home/Work/On the move	SPARKS API
	SPARKS	Physiological	Glucose	Blood Glucose	Offline Meter	On Demand /	Home / Work/ On the move	SPARKS API

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					MySignal Glucometer FreeStyle Libre Sensor	Continuous		
	SPARKS	Physiological	Respiration	Breaths Per Minute	Offline Meter	On Demand / Continuous	Home / Work/ On the move	SPARKS API
	SPARKS	Context	Work environment	Temperature Humidity Luminosity Noise VOC Particles	SPARKS custom Device	Continuous	Home/Work	SPARKS API
Closing evaluation	CDC	To be defined in D8.1						

5.1.3. Data pre-processing

5.1.3.1. *System use & User interaction logging*

To realize the trials, several test sites will be deployed with the different components of SmartWork worker-centric AI system that will produce large amounts of test data and logs that need to be stored and sorted, in order to enable the additional data processing by the partners. Despite that, the system that will store raw and specific data must be cloud-based since the trials can be deployed at different test sites and the gathered information should be available at any moment, despite the location.

Based on that, the solution will be based on a web server that should meet the following requirements:

- OS Environment: Debian 6.0
- RAM: 2 GB
- CPU: Intel® Xeon® or similar
- Storage: 100 GB
- Monthly Bandwidth: 200 GB
- Average Monthly Users: 100

The web-server requirements were calculated based on the premise of a test trial with 60 users, for which the system will generate a diary log of 50MB. This leads to an average generated data of about 3GB if we talk on a daily basis. Considering a monthly timetable, it is expected to have a database of about 100GB that will conduct to a used bandwidth of 200GB, consisting in an upload process of data from the trial machine to web-server and the respective download to the corresponding partners.

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However, if the web-server is also used as a data repository during the total execution period of the trials, the storage capacity must be updated accordingly.

Having the web-server as a cloud-based and always-on storage point, the user interaction and logging function will be provided by the Elastic Stack (former ELK Stack), which consists in three part open-source solution composed by Logstash, Elasticsearch and Kibana (Figure 4).

FIGURE 4 – ELASTIC STACK AND ITS MAIN FUNCTIONALITIES REPRESENTATION.

Logstash is a plugin-based data collection and processing engine, packing a wide variety of plugins that can be used to collect, process and forward data independent of the chosen architecture (Figure 5). The processing part is divided into one or more pipelines, and in each one can be configured one or more input plugins to receive or collect data, and place it on an internal queue. Then, the information stored in the queue is read by a processing thread in micro-batches and processed through any configured filter plugins. Once processed, the thread sends the data to the appropriate output plugin, which are responsible for formatting and sending data onwards, for example, to Elasticsearch. Both input and output plugins can also have a codec plugin embedded, which allows the data to be formatted and parsed before sending it to the next plugin.

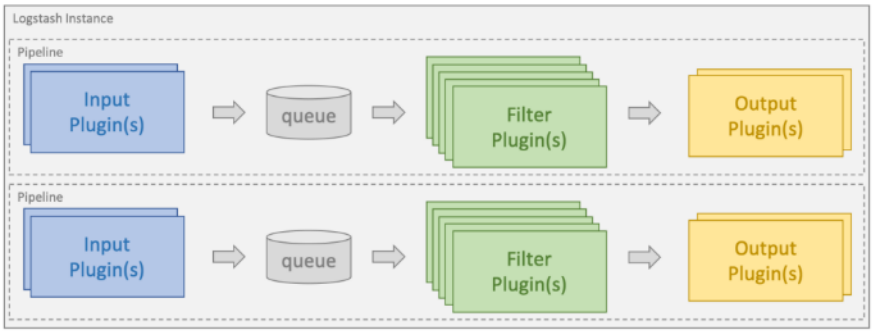

FIGURE 5 – CONCEPTUAL ARCHITECTURE OF LOGSTASH.

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This part of the solution will be implemented by installing a daemon/service which is locally configured to be listening for changes in log files of each client machine, sending the changes to a specific address, what, in this case, is the web-server.

Once the log data is stored, it is necessary to have a search engine capable of deal with the amount of data generated during the 6-month trials. Due to the easiness of integration with Logstash and powerful capabilities, Elasticsearch is the best choice when it comes to search engine.

Elasticsearch is an open source, RESTful search engine built on top of Apache Lucene tailored for work with large amounts of data without compromising the performance. Due to the inverted index search it is possible to search information almost in real time. It also has the advantage of being multi-platform and highly scalable, enabling the indexing of information of one or more simultaneous servers, giving some flexibility to system architecture. This search engine, when combined with Logstash, provides a complete, fast and reliable mechanism to store and search data that will be generated during SmartWork trials.

The last component of this solution is responsible for creating a visual interaction between the stored data and the user. Kibana is an open source platform, designed interact with Elasticsearch, enabling the search, view, and interaction with data stored in Elasticsearch indices (Figure 6). It is possible to perform advanced data analysis and display the data in a variety of charts, tables, and maps, making it easy to understand large volumes of data due to its simple and browser-based interface. It enables all the partners to access the gathered data of different parts of the SmartWork system, and sort it in the most adequate way to use it in different reports.

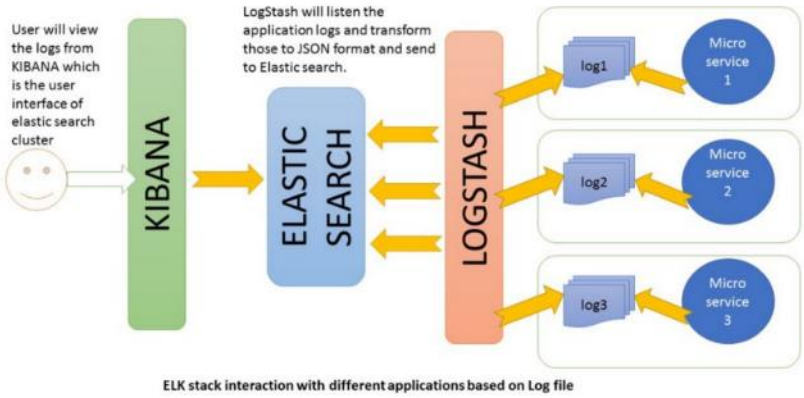

FIGURE 6 – ALL-IN-ONE SOLUTION FOR STORE AND MANAGE LOG DATA.

Like shown above, this stack is a powerful tool that covers a lot of different scenarios and possibilities, and for that reason, the configurations can have lots of variations. However, the standard format of Logstach configuration have a predefined structure, which can be seen in Figure 7.

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```
# This is a comment. You should use comments to describe
# parts of your configuration.
input {
  ...
}

filter {
  ...
}

output {
  ...
}
```

FIGURE 7 – STANDARD FORMAT OF LOGSTACH CONFIGURATION

This structure can be filled with any one of the available plugins that met the requirements for input, filter or output functions. Figure 8 shows a list of the most used plugins for each one of the sections. The complete list can be consulted on https://www.elastic.co/guide/en/logstash/current/index.html.

inputs	codecs	filters	outputs
amqp	dots	advisor	amqp
drupal_dblog	json	alter	boundary
elasticsearch	json_spooler	anonymize	circonus
eventlog	line	checksum	cloudwatch
exec	msgpack	cidr	datadog
file	multiline	cipher	datadog_metrics
ganglia	netflow	clone	elasticsearch
gelf	noop	csv	elasticsearch_http
gemfire	oldlogstashjson	date	elasticsearch_river
generator	plain	dns	email
graphite	rubydebug	drop	exec
heroku	spool	environment	file
imap		extractnumbers	ganglia
irc		gelfify	gelf
log4j		geoip	gemfire
lumberjack		grep	google_cloud_storage
pipe		grok	graphite
rabbitmq		grokdiscovery	graphtastic
redis		json	hipchat
relp		json_encode	http
s3		kv	irc
snmptrap		metaevent	jira
sqlite		metrics	juggernaut
sqs		multiline	librato
stdin		mutate	loggly
stomp		noop	lumberjack
syslog		prune	metriccatcher
tcp		railsparallelrequest	mongodb
twitter		range	nagios
udp		ruby	nagios_nsca
unix		sleep	null
varnishlog		split	opentsdb
websocket		syslog_pri	pagerduty
wmi		translate	pipe
xmpp		urldecode	rabbitmq
zenoss		useragent	redis

FIGURE 8 – MOST USED PLUGINS FOR LOGSTASH.

If we consider the basic plugins for the input, filter and output sections, the generated configuration file should be similar to the one presented below:

- Input Section
    - Amqp – interacts directly with RabbitMQ message queues (Figure 9).

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```
input {
  amqp {
    ack => ... # boolean (optional), default: true
    add_field => ... # hash (optional), default: {}
    arguments => ... # array (optional), default: {}
    auto_delete => ... # boolean (optional), default: true
    codec => ... # codec (optional), default: "plain"
    debug => ... # boolean (optional), default: false
    durable => ... # boolean (optional), default: false
    exchange => ... # string (optional)
    exclusive => ... # boolean (optional), default: true
    host => ... # string (required)
    key => ... # string (optional), default: "logstash"
    passive => ... # boolean (optional), default: false
    password => ... # password (optional), default: "guest"
    port => ... # number (optional), default: 5672
    prefetch_count => ... # number (optional), default: 256
    queue => ... # string (optional), default: ""
    ssl => ... # boolean (optional), default: false
    tags => ... # array (optional)
    threads => ... # number (optional), default: 1
    type => ... # string (optional)
    user => ... # string (optional), default: "guest"
    verify_ssl => ... # boolean (optional), default: false
    vhost => ... # string (optional), default: "/"
  }

}
```

FIGURE 9 – EXAMPLE OF AMQP PLUGIN CONFIGURATION.

- Syslog - reads syslog messages as events over the network (Figure 10).

```
input {
  syslog {
    add_field => ... # hash (optional), default: {}
    codec => ... # codec (optional), default: "plain"
    debug => ... # boolean (optional), default: false
    facility_labels => ... # array (optional), default: ["kernel", "user-level", "mail", "system",
    host => ... # string (optional), default: "0.0.0.0"
    port => ... # number (optional), default: 514
    severity_labels => ... # array (optional), default: ["Emergency", "Alert", "Critical", "Error
    tags => ... # array (optional)
    type => ... # string (optional)
    use_labels => ... # boolean (optional), default: true
  }

}
```

FIGURE 10 – SYSLOG CONFIGURATION PARAMETERS.

- Filter section
  - JSON – Parses the JSON messages that are sent to the message queue (Figure 11).

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```
filter {
  json {
    add_field => ... # hash (optional), default: {}
    add_tag => ... # array (optional), default: []
    remove_field => ... # array (optional), default: []
    remove_tag => ... # array (optional), default: []
    source => ... # string (required)
    target => ... # string (optional)
}

}
```

FIGURE 11 – JSON CONFIGURATION PARAMETERS.

- Output section
    - Elasticsearch_http

```
output {
  elasticsearch_http {
    codec => ... # codec (optional), default: "plain"
    document_id => ... # string (optional), default: nil
    flush_size => ... # number (optional), default: 100
    host => ... # string (optional)
    idle_flush_time => ... # number (optional), default: 1
    index => ... # string (optional), default: "logstash-%{+YYYY.MM.dd}"
    index_type => ... # string (optional)
    port => ... # number (optional), default: 9200
}

}
```

FIGURE 12 – CONFIGURATION OF THE OUTPUT PLUGIN OF LOGSTASH

The examples provided show that Lostash allows for fine tuning in order to find the best fit to the objectives of the SmartWork data collection procedure and the needs and requirements of each one of the partners relatively to interaction with devices and solutions that will be used in the scope of the project.

5.1.3.2. *Ticketing*

The evaluation of usability at early stages of development presents many opportunities to check design, functionality, and user experience before the solution enters in a more definitive stage. This approach enables the developers to reduce requirement uncertainty and refine the design by analyzing the feedback from the participants in the trials. The refinement of usability in an iterative way, throughout the concept to the design process, improves the quality of the final solution because, the more developers focus on retrieving data tickets about usability and user experience, the easier it will be to move towards a robust product/solution that is functional and easy to use to the target group of users, in this case, the older workers.

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Gathering information about usability and user experience can be done in several ways by using a traditional approach like on-site observation of interaction between the participant and the developed solution, questionnaire answering at the end of trial procedure or by creating an environment for participants to report their issues as they interact with the solution, using a specific set of tools, specially developed to track usability issues or bugs.

Developer-oriented ticketing tools

Bugzilla[6] is an open source issue/bug tracking system that provides a vast range of project management and issue tracking features that allows the developers to keep track of system issues/improvements (Figure 13). This free tool is directed for tracking defects, but it also has capabilities to work as a test management tool, as such it can be integrated with other specific test case management tool, like Quality Center, Testlink and others. Bugzilla was developed to enable a direct communication between the developers and the whole development team and the users, creating a common platform to work on bugs and other issues via the app's web interface or even email. This tool does not offer lots of customizations, but in contrast it delivers an optimized database structure that result to improved performance and scalability, thanks to the integration between Pearl and MySQL. It also packs algorithms to protect confidentiality of its users, an advanced query application which records all previous searches, time tracking capabilities, report generation based on inserted information and duplicate issue detection, in case of trying to insert an already existent issue.

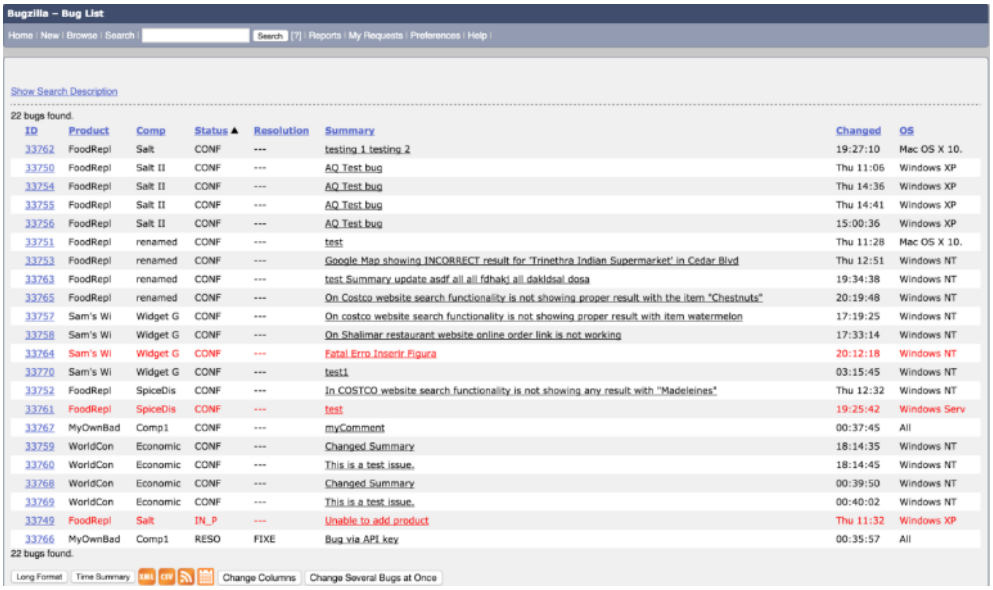


FIGURE 13 – SCREENSHOT OF AN EXAMPLE OF BUGZILLA TICKET LIST.

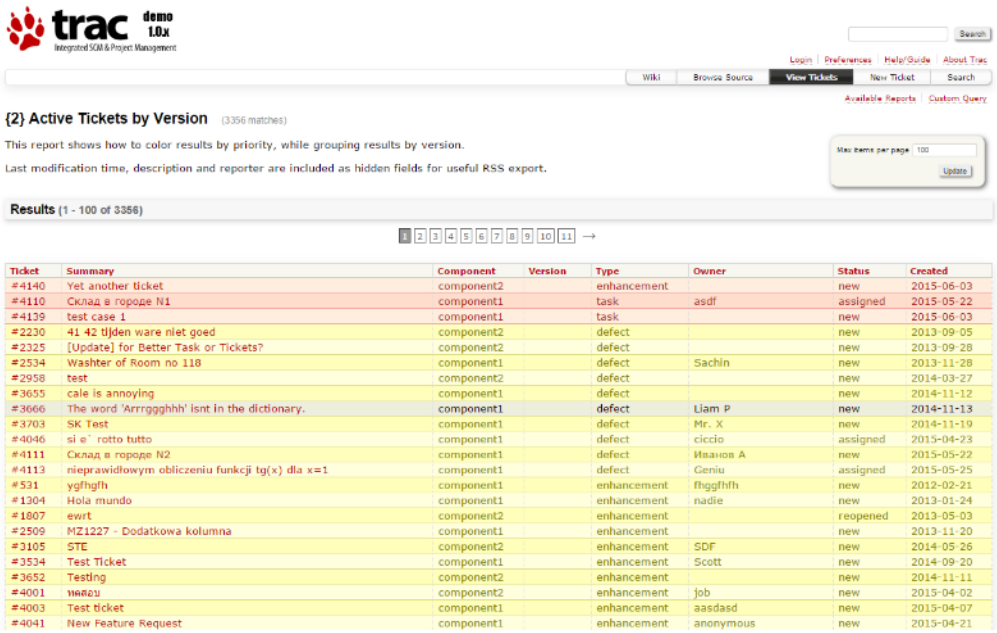
[6] https://www.bugzilla.org/

Trac[7] is another free and open-source tool that is more than a standard bug tracking tool. It is specially designed for project management and issue tracking (Figure 14). It uses a web-based project management approach that is minimalistic and target focused, letting the development teams to establish and use the processes and policies most adequate to issue solving.

Despite the issue tracking capability, Trac also provides an interface to Subversion, Git or other software version control systems, an integrated wiki and enable the generation of various reports which comes handy to graphical visualize the progress of issue solving.

Among other useful features are wiki markup in issue descriptions and commit messages, creating links and seamless references between bugs, tasks, files and wiki pages. The important events are shown in order, in a timeline, making an overview of the project and tracking progress very easy. The roadmap shows the road ahead, listing the upcoming milestones.

Comparatively with Bugzilla, Trac comprises extra features like wiki pages and software versioning, which can be interesting in the SmartWork context, allowing an easy share and organization of information between different partners. The integration capabilities of Trac with other development tools might be an interesting point to keep an eye on before choosing the correct tool.



Ticket	Summary	Component	Version	Type	Owner	Status	Created
#4140	Yet another ticket	component2		enhancement		new	2015-06-03
#4110	Склад в городе N1	component1		task	asdf	assigned	2015-05-22
#4139	test case 1	component1		task		new	2015-06-03
#2230	41 42 tijden ware niet goed	component2		defect		new	2013-09-05
#2325	[Update] for Better Task or Tickets?	component2		defect		new	2013-09-28
#2534	Washter of Room no 118	component1		defect	Sachin	new	2013-11-28
#2958	test	component2		defect		new	2014-03-27
#3655	cale is annoying	component1		defect		new	2014-11-12
#3666	The word 'Arrrggghhh' isnt in the dictionary.	component1		defect	Liam P	new	2014-11-13
#3703	SK Test	component1		defect	Mr. X	new	2014-11-19
#4046	si e` rotto tutto	component1		defect	ciccio	assigned	2015-04-23
#4111	Склад в городе N2	component1		defect	Иванов А	new	2015-05-22
#4113	nieprawidłowym obliczeniu funkcji tg(x) dla x=1	component1		defect	Geniu	assigned	2015-05-25
#531	ygfhgfh	component1		enhancement	fhggfhfh	new	2012-02-21
#1304	Hola mundo	component1		enhancement	nadie	new	2013-01-24
#1807	ewrt	component2		enhancement		reopened	2013-05-03
#2509	MZ1227 - Dodatkowa kolumna	component1		enhancement		new	2013-11-20
#3105	STE	component2		enhancement	SDF	new	2014-05-26
#3534	Test Ticket	component1		enhancement	Scott	new	2014-09-20
#3652	Testing	component2		enhancement		new	2014-11-11
#4001	ывлоы	component2		enhancement	job	new	2015-04-02
#4003	Test ticket	component1		enhancement	aasdasd	new	2015-04-07
#4041	New Feature Request	component1		enhancement	anonymous	new	2015-04-21

FIGURE 14 – SCREENSHOT OF AN EXAMPLE OF A LIST OF ACTIVE TICKETS ON TRAC.

Redmine[8] is designed to manage complex projects (Figure 15). It is an open-source solution, built on Ruby on Rails framework, which is supported by the majority of today's platforms, such as Linux, Unix,

[7] https://trac.edgewall.org/
[8] https://www.redmine.org/

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Mac OS X and Windows. This, combined with the cross-database solution, can be an advantage for teams who work with different development platforms.

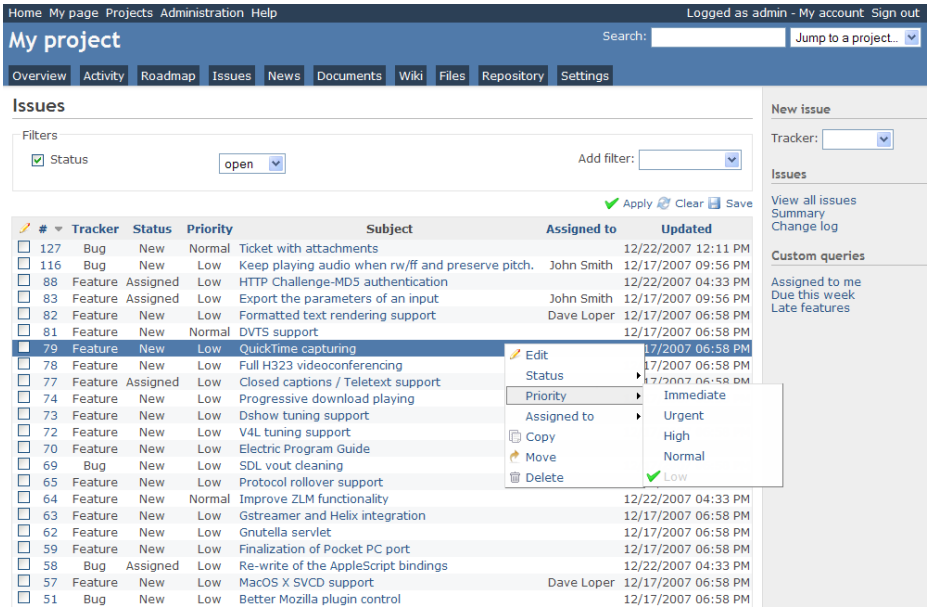

FIGURE 15 – SCRENSHOT OF REDMINE WORKSPACE.

Redmine allows the administrators to allocate each user to different roles, depending on the selected project, which gives flexibility in terms of project management. Relatively to issue tracking and management, the users can define the status of each issue as well as the priority, which becomes relevant to organize the workflow and to direct the workforce to the issues that need to be sorted out first. Other than that, Redmine allows user to communicate with each other via messaging platform and share and work in different documents without need to use external applications by using the document management system. Next to the main characteristics described above, the user also has at disposal Gantt charts, a calendar, a time tracking functionality and feeds with email notifications.

In SmartWork we will develop lots of custom code and software, and for that reason makes sense to have a tool capable not only to track and solve issues, but that also allows merging all lines of code in a specific location, such as Github.

Github[9] is a web platform, more directed to computer code, that offers all of the distributed version control and source code management (SCM) functionalities of Git as well as other important features like bug tracking, feature requests, task management, and wikis for every project (see Figure 16).

[9] https://github.com/

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The bug tracking feature embedded in GitHub is called Issues, and it is available in every repository. When a user opens an issue, he as to fill some standard fields like title, description, labels, milestones, assignee and comments, which synthesizes the problem detected. This concept is wrapped in a visual and structured interface, with advanced text formatting capabilities, constituting an issue-solving directed approach, valued in a project environment.

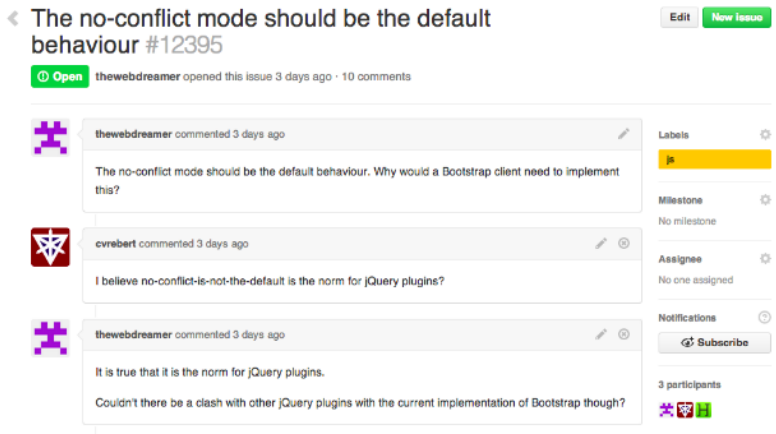

FIGURE 16 – SCREENSHOT OF GITHUB ISSUE TRACKING TOOL.

Milestones are groups of issues that correspond to a project, feature, or time period, and can be helpful to help the software development team to visualize the achievement that the project manager wants to target. This is one of the most important aspects of project planning, because project milestones are the most visible indicators of project progress toward its objectives.

Next to milestones' monitoring, GitHub Issue Tracking system allows a visual and structured organization of ticket issues, which can also be used to filter and select specific issues based on the labels assigned to it.

Other important feature that is allowed in GitHub is the capability of target a specific issue to a specific person, making that person, or assignee responsible for implement a solution for the detected issue. This is particularly important in cases where the development team is vast and spread over several offices, a bit like in SmartWork project.

GitHub Issue Tracker packs also other tools like notifications, mentions and references, which can notify and cross-connect issues and developers in an efficient and flexible way, maximizing the team productivity.

Regardless of being a tool more directed to software development, GitHub concentrates in a single package, lots of important and efficient approaches related with software organization and issue tracking that help maximizing the productivity and the interconnection between different teams, constituting a valid choice for implementation in SmartWork project.

Consumer-oriented ticketing tools

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Zammad[10] is another free open source, fully featured web-based ticketing system for helpdesk or customer support. It ships in with a multitude of features for handling customer communication through various channels such as social networks (Facebook and Twitter), live chat, e-mails as well as telephone (Figure 17). It provides an easy to use API for integrating your telephone system into in and outgoing calls, email services and social networks. It is distributed under version 3 of the GNU AFFERO General Public License (GNU AGPLv3) and available for Linux and Docker as a ready to use and install solution.

Zammad offers features line Automatic ticket assignment, full-text search, individual escalation or setting client solution time limit, various security mechanisms such as device-logging and two-factor-authentication, external authentication via OAuth, Live chat and Internationalization support.

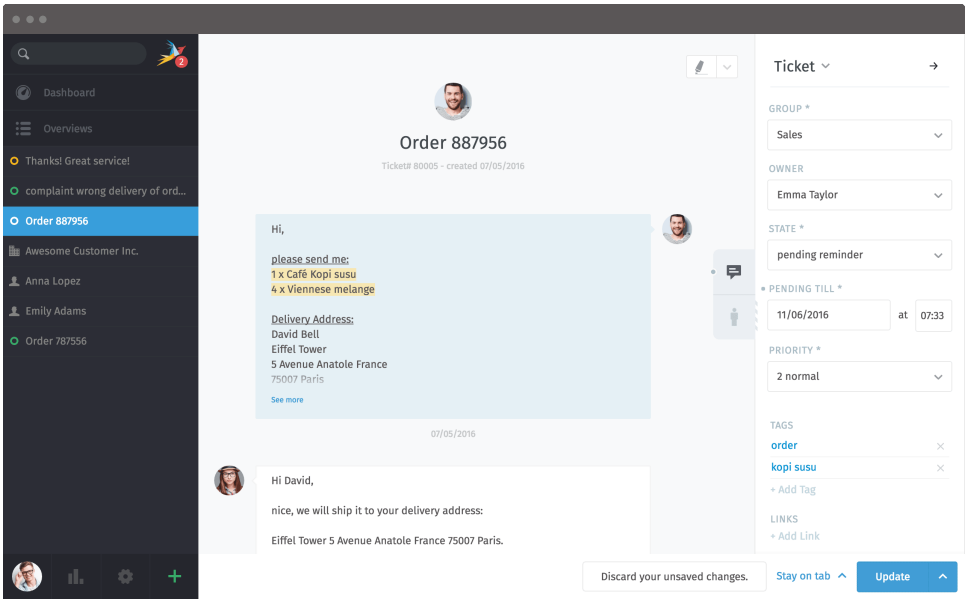

FIGURE 17 – SCREENSHOT WITH AN EXAMPLE OF A TICKET REGISTRATION IN ZAMMAD.

Jira Service Desk[11] is an enterprise-ready helpdesk request tracker (Figure 18). It lets you receive, track, manage and resolve requests from your team's customers. The app comes with a self-service web portal where customers fill out forms to ask for help. Jira Service Desk organizes and prioritizes the requests your customers submit. It keeps your team on track to resolving requests within your team's goals or Service Level Agreements. You can set up alerts and make sure your working on the most important things first. Jira Service Desk is built on the well-established and robust Jira platform provided by Atlassian. Customers submit their help requests to your team through a customer portal or via email. Service desk agents work on customer requests, tracked as issues in a queue. Each team

[10] https://zammad.org/
[11] https://www.atlassian.com/software/jira/service-desk

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works on a project that services requests from a certain area – like IT, HR, legal, or finance. Jira Service Desk is available in a per-agent pricing plan billed on monthly and yearly basis.

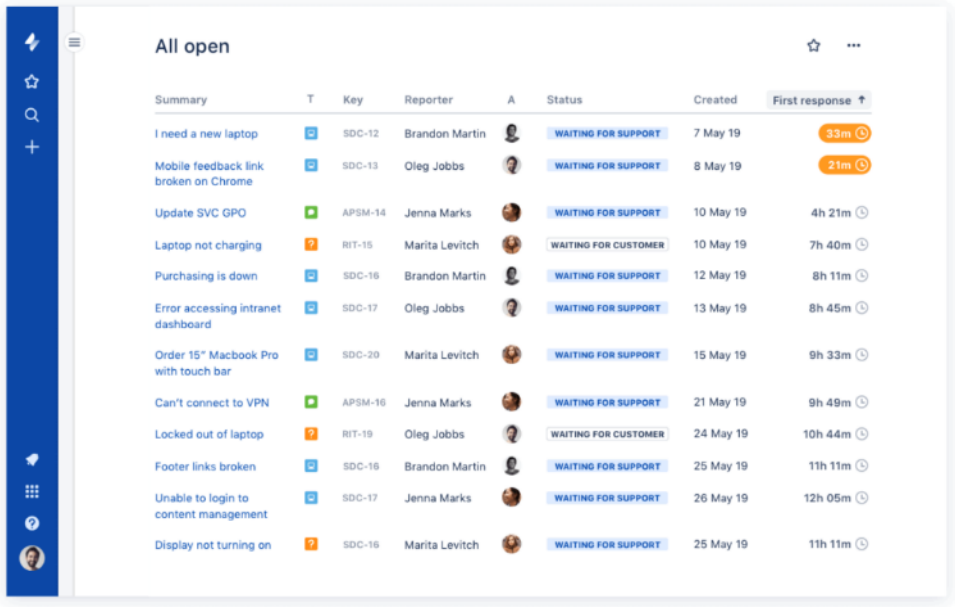

FIGURE 18 – SCREENSHOT OF A LIST OF USER REQUESTS ON JIRA.

Conclusion

SmartWork intends to use a combination of tools from developer- and consumer-oriented solutions to offer the best experience to its end-users and facilitate the needs of its developers. Specifically, we initially plan to use Zammad for the contact with end-users of the trial sites, so that they can report issues or concerns they might have related to the platform. For managing the development tasks and bugs that will pop up during the lifetime of the project we plan to use GitHub. If the task of managing the contact with the end-users seems too trivial to require a separate tool we are also considering the option of merging all communication to Github and reduce the distance between end-users and developers. Using only one tool would mitigate the risk of missing some information that might be split between two tools and also would avoid spending additional effort in managing if both tools are in sync.

5.1.4. Closing evaluation

The main aim of the evaluation of the semi-controlled trial in Portugal is to provide solid ground for the field trials with end-users in Portugal and Denmark. The following items will be evaluated at the start and at the end of the 2-month trial:

1. **Evaluation of the Recruitment of the participants**: The project team and participants evaluate the way the recruitment took place and which lessons can be learned for the field trials;
2. **Evaluation recruitment material**: Participants of the semi-controlled trial will read the information brochure, informed consent forms and receive the oral explanation about the

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trial. Participants will give feedback on the information brochure, informed consent forms and oral explanation in an evaluation form. Based on this feedback, the brochure and oral explanation will be updated and added to addendum for the Ethical Board;

3. **Preparation of the SmartWork system**: the preparatory works of the system will be evaluated by the project team members. The results of the evaluation will be used to update the system;
4. **Test and evaluate the training materials of the SmartWork system**: the training materials will be tested and evaluated by the participants and used to improve the system and materials for the field trials. A short survey (EU Survey) will be used for each participant to evaluate the system and material;
5. **Evaluate the data flow**;
6. **Evaluate the reliability of the data and technologies**;
7. **Evaluation of the usability of the SmartWork system**:
    a. The first use of the system
    b. The continuous logging of everyday problems
    c. Evaluation of use at the end of the semi-controlled trial

The participants and project team members will be provided with templates for recording their experiences during and at the end of the semi-controlled trial. Examples of the templates will become available D8.2 Small-scale evaluation report

After the semi-controlled trial, the larger pilots at CDC and CAT will take place. The evaluation protocols for the semi-controlled trial and the larger pilots will be defined in M16, or even earlier to get the ethical clearance before the start of the testing in M19.

The overview of lessons learned and good practices will become available as input for the field trials with end-users in Portugal and Denmark.

5.1.5. Data reporting

At the end of the SmartWork trial in a semi-controlled environment, it is expected to have large amounts of unprocessed data related with different sections of the system and different developers. However, based on the gathered information, some important topics should be addressed in the report:

- **Overall Performance**: The trials should reveal if the users experienced some type of behaviour that indicates the system performance affects the normal workflow of the user;
- **Issues with hardware or software**: The issues detected during the trials and reported in the issue tracking tool selected will be important to early detect faults and bug in hardware or software and correct them before entering in an advanced development stage;
- **Usability**: The evaluation of solution usability can be done using a System Usability Score;

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- **Expectations**: The analysis of expectations of users that tested the system in a controlled environment is a benchmark important to assess if the users consider that the SmartWork system can benefit their daily work, improving work productivity;
- **System Improvements**: The compilation of user contributions to improve the system is relevant to approach the developers and end-users and create a product/solution that is targeted to a specific user group, in this case the older workers, and check if the proposed solution have interest among the users and community.

The data reporting will be done by analyzing and reporting on the experiences and results of the trials. Report on the progress and results of the service trails, will include successes, failures, experiences gained as well as a retrospective evaluation of the approach taken in defining, setting up and running the trials and produce an initial deployment report.

The results of the Trial operation in semi-controlled environments will be reported in D8.2 – Small-scale evaluation report (M28).

5.2. Field trials with end users

The aim of the **field trials** with end users is obtain **preliminary evidence of the effectiveness** of the SmartWork system and Smart Services Suite in maintaining/increasing Work Ability of older office workers.

Outcome: report with the results of the trial

Participants: 60 older office workers and managers (30 per pilot site)

Timing of the trials: M25-M36 (January 2021 – December 2021)

Trial duration: 6 months

Trial Location: Portugal (CDC) and Denmark (CAT)

Each participant will use the SmartWork system for 6 months, being the first week dedicated to training, in close connection with the research and technical team. At months 2 and 4, short assessment meetings will perform to make an evaluation of the status of the trial (Figure 19).

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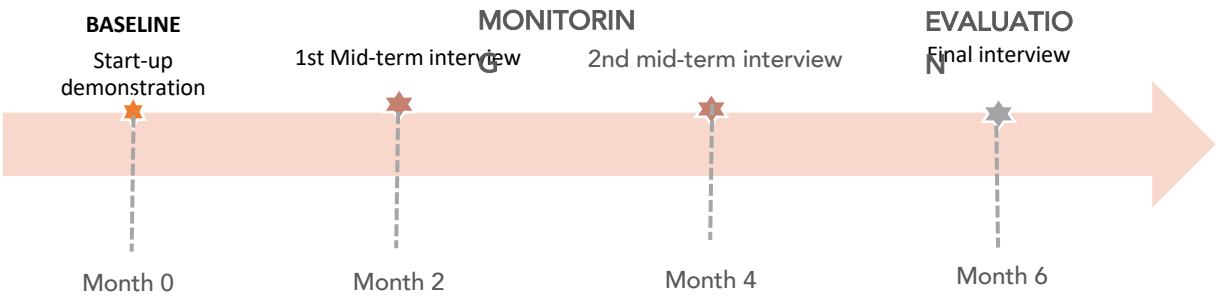

FIGURE 19 – TIMELINE OF THE FIELD TRIALS WITH END USERS.

The sub-section bellow provides a description of the setup and design of the trial, providing details on how Cáritas and Aarhus trial sites are organized, the possible user groups that will participate in the validation and will also describe the work developed by the potential participants groups, as well as the use of technology in their daily work routine.

5.2.1. Trial description in Portugal

Cáritas Coimbra is one of the two pilot sites where the SmartWork evaluations will occur. Cáritas Coimbra is a social non-profit organization that supports people and communities in five districts of the Central Region of Portugal. It has nearly 90 centres (with 129 different responses), 1000 workers and 150 volunteers and supports around 25000 people/year in the following areas; Education; Health; Social Support; Family and Community; Children and Youth at Risk; Elderly; HIV/AIDS; Addiction; Homelessness; Community Intervention; Training; Social Tourism.

The organisation counts with nearly 85 specialized professionals in the health areas (9 doctors/physicians, 43 nurses, 2 therapists, 16 physical therapists, 12 psychologists). In the social field, the organisation has 33 social operators, 178 trainers and teachers and around 450 other staff, such as psychologists, social animators, medical assistants, direct support professionals, auxiliary workers, etc. Besides these, Cáritas also counts with 60 professionals in different support areas, like lawyers, accountants, human resources, etc.

Even though in this phase of the project (M6) the workers who will participate in the trial have not yet been selected, it is possible to predict the scenarios where the trials will occur in Cáritas and describe the work developed in these areas. That way, four different scenarios will be highlighted in this description.

Scenario 1:

Cáritas headquarters are located inside the city of Coimbra and they enclose the administrative services of the whole organization (Figure 20). This building hosts the Board, the main Departments: Financial, HR, Innovation, Secretariat, Purchases and the support teams, such as maintenance, infrastructures, training, legal office, IT, planning and food safety. In this scenario, it is possible to

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highlight two kinds of activities: the administrative work and the work with the public (reception and call centre).

The administrative work consists of duties such as filing, typing, copying, binding, scanning; organising the office documents and coordinating office procedures; monitoring stationary levels and ordering office supplies; processing expenses sheets and invoices; handling sensitive information in a confidential manner. It is a routine job, with procedures repeated frequently or every day. The workers in this area remain most of their time seated and have the need to use the computer (Figure 21).

The receptionist work consists of administrative support to other areas. The work is usually performed in a waiting area such as a lobby or front office desk. The duties of a receptionist include answering visitors and directing them to their destinations, sorting and handing out mail, answering incoming calls on multi-line telephones. This is a desk-based job, so the workers remain most of the time seated and the use of the computer is frequent but not as frequent as in administrative tasks.

FIGURE 20 – CÁRITAS HEADQUARTER PREMISES.

FIGURE 21 – MAIN ENTRANCE OF CÁRITAS HEADQUARTERS AND OFFICE WORKER ON DUTY.

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Scenario 2:

The second scenario will be on workers of services provided to older adults that perform office work. As said before, Cáritas has nearly 90 centres supporting different social areas. Specifically for older adults, Cáritas Coimbra offers 12 day care centres (Figure 22), 18 home care services, 5 nursing homes, 1 chronic disability/impairment home, 2 long term care units, 1 medical and rehabilitation clinic and 1 summer camp for senior citizens – overall Cáritas supports about 3000 older adults in these services. The workers in this field are formal caregivers and their duties combine office work with developing activities for the older users (Figure 23); helping them to take prescribed medication, with mobility around the centres or with personal care and hygiene. It is a job that requires moments of good mobility and the use of computer is required to prepared reports and fulfil information on public platforms. In some Cáritas centres these workers need to share the computer with a colleague (Figure 24).

FIGURE 22 – EXAMPLE OF PREMISES IN A CÁRITAS OLDER CARE CENTRE.

FIGURE 23 – WORKERS AT CÁRITAS OLDER CARE CENTRES SUPPORTING OLDER ADULTS USING TECHNOLOGY.

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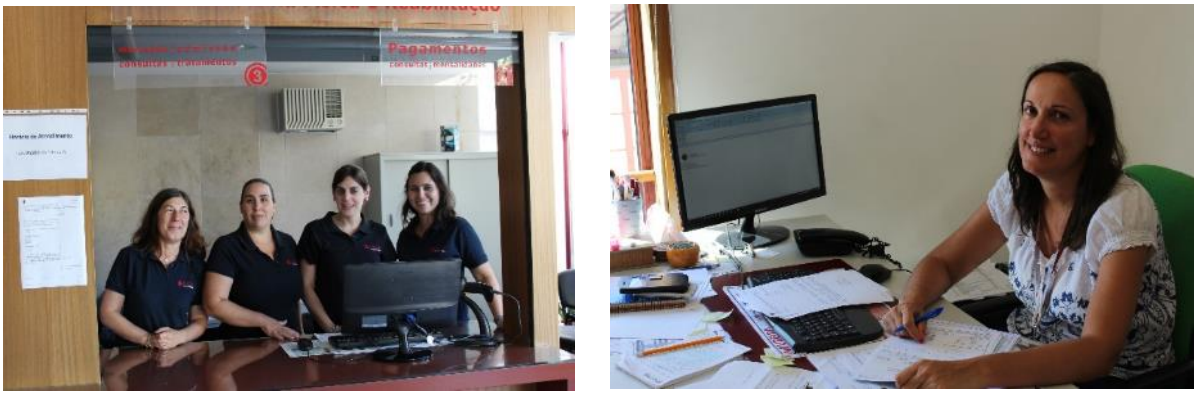

FIGURE 24 – WORKERS AT CÁRITAS OLDER CARE CENTRES IN THEIR DAILY TASKS.

Scenario 3:

The third scenario relates to the educational area, Cáritas Coimbra promotes education and support to children and youngsters since the 1970's, with 5 day care centres, 3 kindergarten, 55 leisure activities centres, 1 youth residential home, 1 children at risk care home, 1 youth summer camp, 1 team for prevention and 25 cross-curricular enrichment activities, involving overall near 11.000 people each year (Figure 25).

The workers in this field provide activities, individual or in group, that benefit the overall development of children and youngsters (Figure 26). It means that is a combined work: one administrative, which is necessary to prepare the activities and insert data in online platforms or provide reports and the other that is in the field, a practical work dealing with the kids.

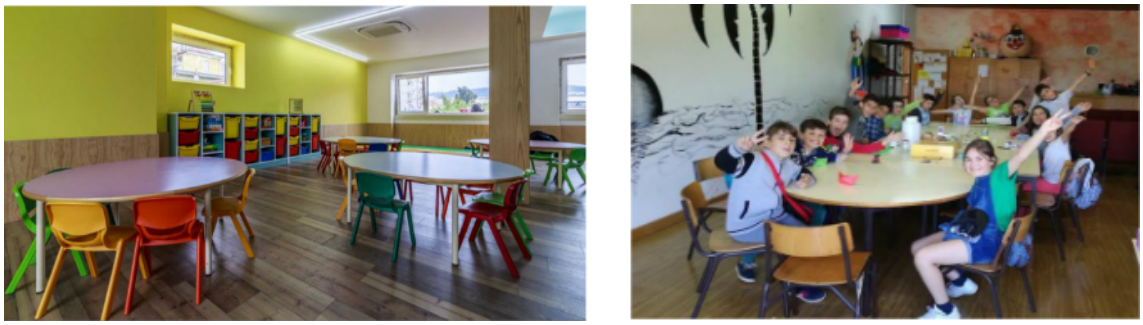

FIGURE 25 – INFRASTRUCTURE AND CHILDREN DOING ACTIVITIES.

DRE

FIGURE 26 – CÁRITAS EDUCATION AND SUPPORT TO CHILDREN AND YOUNGSTERS.

Scenario 4:

The fourth scenario is connected to the support of disadvantaged people for several decades, with 1 social support centre (Figure 27), 1 social income program, 2 social canteens, 1 therapeutic community, 1 day care centre, 2 street teams and a social rehabilitation apartment for people with drug abuse problems, 1 centre for people with HIV, 1 centre for homeless people, 2 community centres, 1 reintegration community for women and 1 team for migrants integration supporting overall 8500 people each year.

The workers involved in this area assure the support and accompaniment to people and families in situation of vulnerability and of social exclusion, as well as of social emergency. The workers in this field provide specialized care, such as psychologists or social services, among others (Figure 28). Besides that, administrative work is required, to articulate and register the data of each user and online reports. It is a job that requires good mobility and the use of computer is required (Figure 29).

FIGURE 27 – INFRASTRUCTURE OF CÁRITAS SOCIAL CARE.

FIGURE 28 – WORKERS AND PREMISES OF CÁRITAS SOCIAL CARE.

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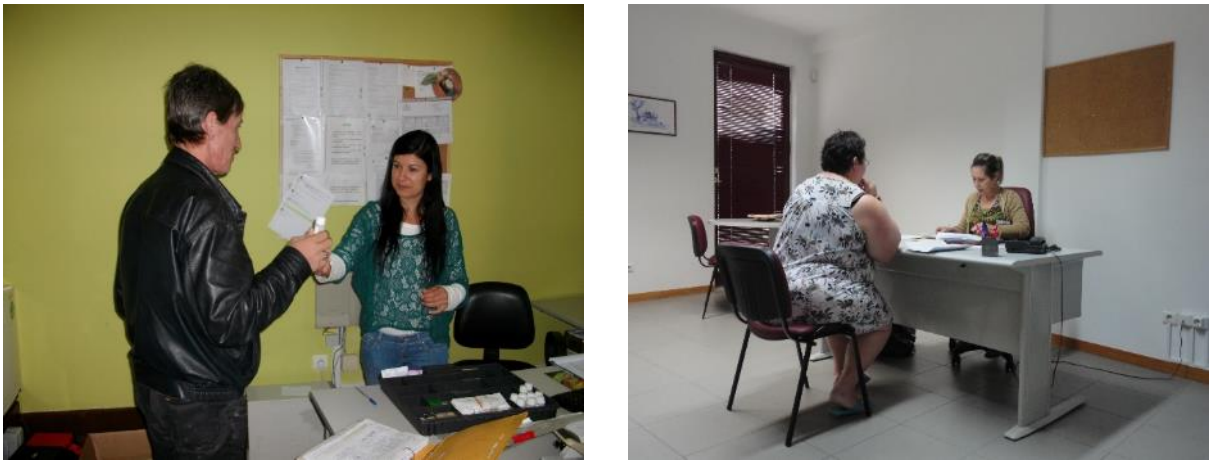

FIGURE 29 – ADMINISTRATIVE WORK AT CÁRITAS SOCIAL CARE.

During the trials, since the first interviews until the completion of the last pilot, Caritas will involve a multidisciplinary team in the process, including technical directors, social workers, social animators, psychologists, nurses and direct helpers, who will support the project team that will accompany the older people. Therefore, all the necessary and appropriate assistance to each stage of the process is guaranteed.

Beyond the project package, Cáritas will provide the necessary equipment to complete the required conditions for the development of the trials in the homes of participants and solve the situations of Internet access in households that do not yet have the service installed, within the approved budget for this purpose.

5.2.2. Data collection

The field trials will be held as the final phase of the SmartWork project. As such, the details about the data collection are very much unknown. At this point in time, we envision the data collection as described for the trial operation in semi-controlled environments to be re-used in the field trials, pending any issues that may have been identified in the meantime.

Instead of repeating the information here, we provide a quick overview of the expected data collection elements during the field trial:

- The data types as describe in Table 1 of Section 5.1.2.
- The data pre-processing methods as described in Section 5.1.3:
    - Capturing and processing of log data
    - Ticketing
- Possible additional questionnaires related to exploitation (e.g. willingness to pay, intended use).

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5.2.3. Trial description in Denmark

The Municipal of Aarhus counts for 340.000 citizens and employs app. 22.000 people in five major areas of operation: Culture and Citizen Services, Techniques and Environment, Social Conditions and Employment, Children and Youth (Schools & Kindergartens), Health and Care.

Health and Care comprise 4.400 employees of which approximately 85% is operational in care jobs organized in seven areas across the city and suburbs. Municipal Health services are often referred to as primary health services, while secondary health services include hospitals, general physicians, psychologists, therapists, dentists and other clinical professionals organized separately in five national regions.

The SmartWork Trial with users will take place at two organizational and geographical separate places:

1. The Health and Care's Main office, across administrative departments (Figure 30):
    - Economy (Building-admin., Controlling, Accounting)
    - Strategy&Development (HR, Communications, Digitization/IT, Executive Secretariat, Assisted Living[12], Management staff)
    - Health (Strategy&Prevention, District offices/Day Care Centers).
2. A number of the 37 "Local-service-centers" in seven different city areas (Figure 31). Local-service-centers are serving the population above 65 years. The centers offers services, at the centers and to the local area citizens in a number areas: Prevention and Health (Ckinics); Training and Rehabilitation; Personal Care Practical help; Food and Meals; Transportation, Assisted Living supplies, Consumer Goods and Interior Design, Housing, Help for people with dementia and their family.

Within the target group of SmartWork participants these two organizations count for approximately 70 individuals at the Main Office premises and 40 at the Local-service-centers. It is envisaged the 30 trial participants are to be selected among the in total 110 employees, who by function and working conditions comprise two groups of 55+ office workers:

1. Ordinary employee office workers, i.e. fulltime academics, consultant etc.
2. Extraordinary employees, less than full time (37 hours/week) Flextime jobs, Senior jobs, etc.

The activities carried out by the two groups is by far administrative case management in a highly digitized and almost paperless environment; hence the activities are focused on IT-applications carried out by laptops, tablets and smartphone Apps.

[12] SmartWork is anchored in Strategy&Development / Center for Assisted Living Technology - CAT

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The setting of the trial at the Head Office is a 12-year-old three-story building where to Health & Care is moving in Spring of 2019. The premises are light open space offices situated app. 6 km. from the city center, Town Hall and Local-service-centers where a considerable amount of corporation with Municipal Health & Care organization takes place.

FIGURE 30 – OFFICE ENVIRONMENT OF AARHUS MUNICIPAL HEALTH & CARE HEAD OFFICE.

Data will initially be collected in databases coming along with the sensor manufactures, one database per sensor-type.

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The setting of the trial will include operational office workers at a number of the 37 local-services-centers representing employees working decentralized, on-the-fly in close contact with citizens. These are heavy users of IT in all documentation, communication and scheduling.

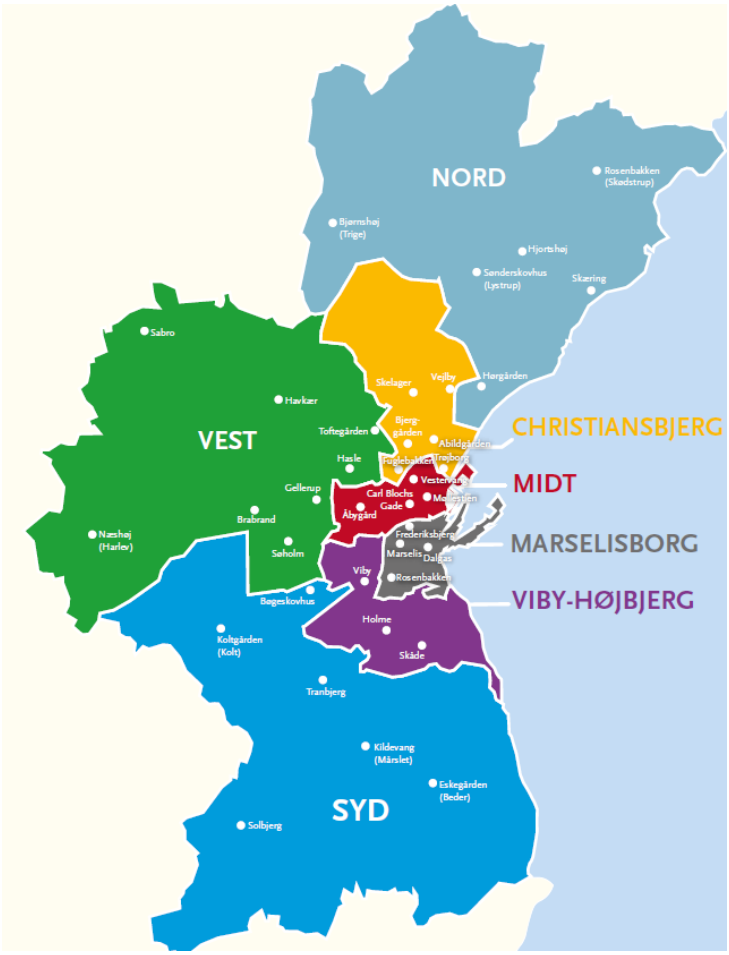

FIGURE 31 – GEOGRAPHICAL LOCATIONS OF LOCAL-SERVICE-CENTERS, AARHUS MUNICIPAL HEALTH & CARE.

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Figure 32 illustrates typical situations and localities for the operational employees.

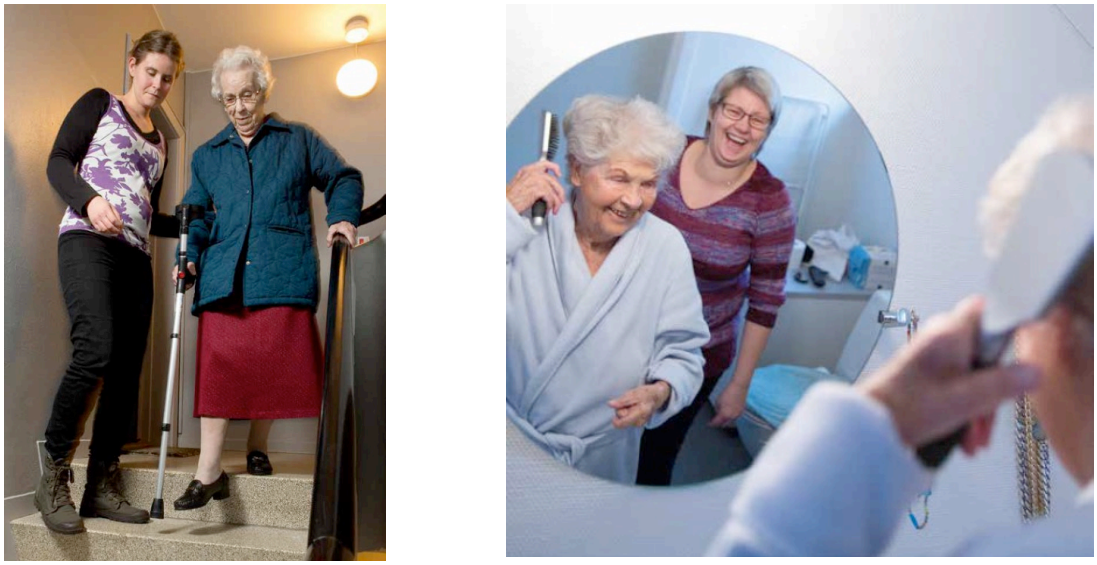

FIGURE 32 – TYPICAL SITUATIONS OF THE OPERATIONAL EMPLOYEES AT HEALTH & CARE.

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6. Conclusion

Within the life cycle of the SmartWork project there are three main tracks of data collection, as defined in Section 2.1.

The first year of the project focuses both on SmartWork co-creation with end-users as well as the technical optimization of the SmartWork system. The emphasis in year one thus lays on the requirement elicitation, the co-design of use cases and on making co-design based decisions for selecting metrics and modelling strategies.

As the project moves into its second year, the technical implementation will be in full swing. The roadmap for implementing a working prototype of the SmartWork platform involves short in-lab data collection and evaluation cycles to improve individual modules and compose the final sensor network and all auxiliary services. Parallel to the technical optimization of the SmartWork real test data, big data registries will be used to optimize machine learning and AI modules in order to create a personalized virtual user model. The second year ends with end-to-end functionality testing in both the lab and semi-controlled environment. Section 5.1 provides all the details currently available on how and when data will be collected, and describes where possible how that data will be processed.

After reporting all issues concerning performance, software, hardware, and usability and identifying potential improvements, the trial preparation of the field trials will start in the third year in Portugal and Denmark, with the aim to obtain preliminary evidence of the effectiveness of the SmartWork system and Smart Services Suite in maintaining/increasing Work Ability of older office workers. The older office workers will be monitored for 6 months. This period will be preceded by a baseline demonstration and concluded with a final evaluation interview. As described in Section 5.2, the current view is that in terms of data collection, these final trials do not diverge much from the trials in semi-controlled environments.

As can be seen in Section 2.2 in the beginning of this document, this deliverable lays the groundwork and serves as input to many different tasks within the project. Wherever details are still lacking in this document, the indicated related deliverables are meant to provide those details, whether it related to trial design or to technical implementation or design of algorithms.

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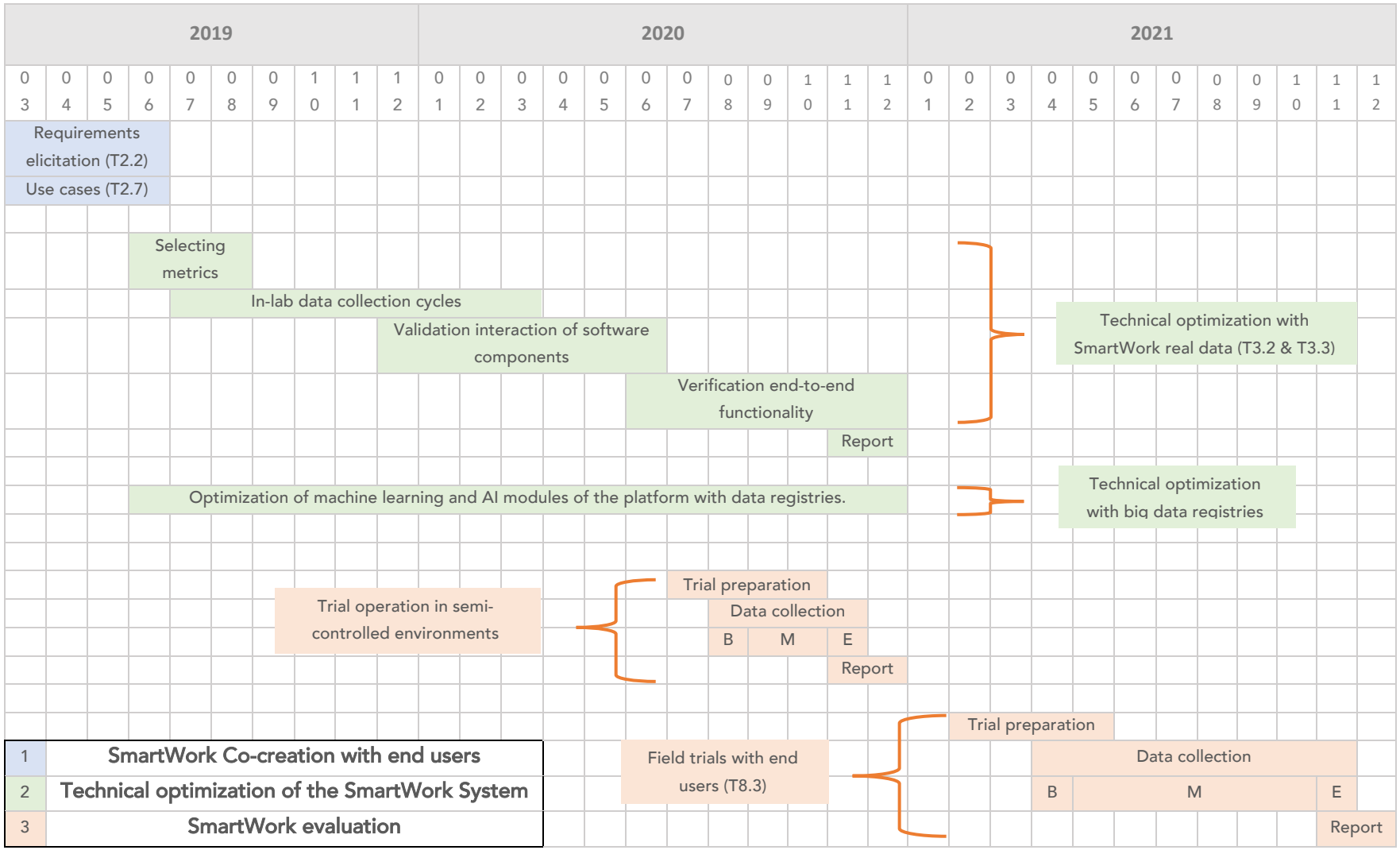

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TABLE 2 - DATA COLLECTION WITHIN THE LIFE CYCLE OF THE SMARTWORK PROJECT, CONSISTING OF THREE DATA COLLECTION TRACKS: (BLUE) SMARTWORK CO-CREATION WITH END USERS, (GREEN) TECHNICAL OPTIMIZATION OF THE SMARTWORK SYSTEM AND (ORANGE) SMARTWORK EVALUATION. THE DATA COLLECTION PERIODS WITHIN THE EVALUATION PERIODS CONSIST OF THREE PHASES: B = BASELINE, M = MONITORING AND E = EVALUATION.

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