

2. CORE OF THE REPORT FOR THE PERIOD: PROJECT OBJECTIVES, WORK PROGRESS AND ACHIEVEMENTS, PROJECT MANAGEMENT

2.1 Project objectives for the period

The project objectives achieved in the period are reported below and extensively described at WP level in section 2.3.

- a) Definition of Active Ageing Lifestyle protocol
- b) Selection of the complete set of parameters needed to be monitored according to the:
 - Selection of the most appropriate group of sensors and devices
 - Specifications of the activity recognition models, developed by WP4, based on WP2 requirements
 - Definition of the high level and logical architecture for module identification, dependencies and data flow hypothesis.
- c) Development of the auto configuration system and the integration of sensors in WSN environment (WP3).
- d) Generation of data for physical activity, balance assessment and indoor socialization recognition and its integration in reasoning system (activity of WP4 in close collaboration with WP2 and WP3)
- e) Development of cognitive, social and exergames with the scientific partners (result of interaction between WP2 and WP5)
- f) Development of competitive analysis for market positioning of DOREMI products during WP7 activities.

2.2 Summary of recommendations from previous reviews (if any)

The first review meeting took place on 9th December 2014. Recommendations concerning future work included:

R1 - Development of the wristband should be speed up and the project team should provide a clearer understanding of the smart environment, sensor network and data generation to engage elderly in their lifestyle management and especially social inclusion in “normal life” circumstances.

R2 - Some criteria have to be reviewed such as “nursing home” residents, which do not fit with project objective of having people autonomous with their food.

R3 - Consortium should demonstrate how DOREMI user group with all the selection criteria and the conditioned pilot environment would represent a significant and profitable market.

R4 - Baseline period is heavy in terms of tests. Older people are easily tired and stressed because of tests especially for the elderly with mild cognitive impairment. A baseline period protocol should be set in order to avoid any error in assessment in D2.2.

R5 - Rewarding system for gamified environment should be designed in order to motivate elderly without referring to school marks or such type of evaluation.

R6 - Gamified interface has to be designed in order to adapt to elderly to needs in term of accessibility (contrast, size of letters...).

R7 - Consortium should consider different targets and differentiate end users (older people), payers (older people, social security, insurance, residence home...), it should as well evaluate different B2B,

B2B2C or B2C approaches to build exploitation plan.

R8 - Consortium should reconsider involving third parties especially when considering entering French and German markets from which none of the consortium member is native.

R9 - Consortium should evaluate future cost of the system and potential price per user for future exploitation. This will help identify payers' target.

R10 - For future implementation, the exploitation plan should consider the elaboration of a simplified concept based on the selection of key data and key sensors deriving from experimentation results. Process should prove the benefit of each sensor and data to project objective.

R11 - We recommend that a project review be organised quickly after resubmission of the deliverables D3.1 and D4.1 and before the start of the pilot phase to demonstrate that all necessary devices and software (wristband, WSN and games) are operating according to DOW.

R12 - Clearly define the added value of the DOREMI concept based on a proper benchmark of existing or emerging solutions.

The Consortium took into account and addressed all recommendations. In particular:

R1 - In order to improve the availability of the intermediate results of the development in wristband, one preliminary release of the wristband hardware was introduced with due date in January 2015. Besides, the collaboration with the main internal client of the wristband results, the WP4 was significantly improved, providing punctual updates in data models, data simulations and several data acquisition campaigns in order enable the work in parallel and reducing the development time. As a result of these collaborations, the initial requirements for the wristband and other WP3 devices were refined and the available data is more meaningful for the WP4 objectives. Socialization data acquisition campaigns have been performed in collaboration with WP4 in order to iteratively improve the response of the socialization assessment and foresee more and more complex situations in the daily life of users.

R2 and R4 – See WP2 section.

R3 - As explained in D7.3.2, the target user group for the exploitation of DOREMI will be the elderly in general, not only the ones with the selection conditions applied in the pilots. Most partners indicate that their products are aimed at the elderly in general and DOREMI is useful for all aged people (not only for the ones with malnutrition, sedentariness and mild cognitive decline), since it can contribute to the prevention and early detection of these conditions.

Due to the increase of life expectancy and the aging of the European population, the elderly market represents a very promising market.

R5 – It is confirmed that the gamified system doesn't refer to school marks.

R6 - To design the interface, international guidelines (presented in D5.1) were followed; then, through the User Centred Design approach (presented both in D5.1 and D5.2) usability of the interface was tested with users with the same inclusion criteria of the DOREMI user group.

R7 - D7.3.2 established that DOREMI will target the whole elderly population but the exploitation actions will take into account the age group of the elderly, if they live in nursing homes or alone at home, their economic background and their ICT skills. In D7.3.2 some actors were mentioned as potential payers (nursing homes, social care providers, health care specialists/GPs, hospitals, insurance companies, public authorities, carers, the elderly, and advertisers). How they should be involved will be further explored during the following year.

R8 - As explained in D7.3.2, the exploitation strategy will first focus on UK, Spain and Italy, in which the Consortium has members. If the exploitation in these countries proves successful DOREMI will be expanded to the other EU countries. For this the Consortium will analyse whether the involvement of third parties is necessary.

R9 - This has not been addressed because the costs of the whole system are not available yet.

R10 - During the pilots, key data will be collected which will allow the benefits of DOREMI to be assessed. D7.4 (Impact assessment) will use these data to predict the impacts of DOREMI on the whole European population and the health systems. This will help to determine the exploitation potential of DOREMI.

R11 – After resubmission of D3.1 and D4.1 and a further round of explanations concerning appropriateness of the participants' autonomy at the validation sites, the 3 external reviewers saw significant improvements in the resubmitted deliverables and expressed their satisfaction with the information provided. During next review meeting that will take place mid December 2015, the consortium will be able to show that all devices and software are operating according to DoW.

R12 - D7.3.2 expanded the competitive analysis conducted in D7.3.1 for each DOREMI component. This competitive analysis discussed the advantages and drawbacks of DOREMI compared to the main competitors. The added value of DOREMI is that it is tailored to elderly needs, more clinically-oriented, and that links different components (activity tracker, balance board, serious games, etc.).

2.3 Work progress and achievements during the period

In the section below a detailed description of work progress and achievements by work package is provided.

2.3.1 WP1 Project Coordination and Management

Please see section 2.4

2.3.2 WP2 End user profile and Active Ageing Lifestyle protocol development

The main activities of WP2 Period 2 were:

- Elaboration of Active Aging Lifestyle protocols focused on nutrition, physical activity and cognitive stimulation;
- Identification of expected improvement levels for each impairment after DOREMI treatment;
- Identification of key performance indicators (clinical, social and technical) for Active Aging Lifestyle Protocol;
- Elaboration of final Validation Plan (D2.3) in collaboration with medical and technical partners;
- Contribution to the definition of the evaluation protocol reports to be approved by the UK and Italian local committees.

■ Objectives

- Select the complete set of parameters needed to be monitored according to the Active Ageing Lifestyle protocol
- Define the protocol rules needed for the development of the reasoning system (Task 4.4)
- Develop a validation plan including four sub-set specifically designed for the clinical validation plan of the services, the technical validation plan of the platform, the usability plan of the platform as guideline for the validation to be performed in WP6 and the statistical approach for the evaluation of DOREMI platform effectiveness
- Contribute to the definition of the evaluation reports to be approved by the UK and Italian local committees

■ Summary of progress towards objectives and details for each task

Task 2.1 Target users definition, literature analysis and survey for scenarios of use (CNR-IFC) – M1-M6

Completed

Task 2.2 Active Ageing Lifestyle protocol development (CNR) – M2-M8

Completed

Task 2.3 Validation Plan (UOC) – M9-12 (Submission of D2.3 extended until M17)

UOC is the task leader. CNR IFC, SI4LIFE, DMU, Extra and Accord are the main partners involved in this task.

Activities of Task 2.3 are focused on the elaboration of Deliverable 2.3 (D2.3), sent in a draft version to European Commission during 2014 (November 25th 2014, M13). Deliverable D2.3 has reorganized and systematized all the tests and procedures described in the previous deliverables produced under WP2 activities, has designed the whole validation process of DOREMI solution, and has prepared all documents necessary for study protocol submission to the local Ethics Committees in UK and IT.

UOC has organized and coordinated the efforts of all the Task 2.3 participants to achieve an integrated and agreed detailed description of the activities that would be carried out in each step of the validation process. To this end, various contributors have provided their expertise and capabilities to finalize the deliverable. In particular:

- SI4LIFE and DMU have designed all the tests and protocols related to the evaluation of the cognitive ability of the participants to the validation process of DOREMI solution. SI4LIFE and DMU have also submitted the entire documentation to local ethical committees receiving their approval.
- CNR IFC has designed all the tests and protocols related to the evaluation of the eating behavior and the physical activity of the participants to the validation process of DOREMI solution.
- CNR IFC has worked on the development of exergame with IMA (part of the gamified environment of DOREMI solution), designed to provide a detailed description of physical exercises. Moreover, in collaboration with IMA, it has defined the training protocol for using METADIETA software as well as the daily routine of the trial participants in respect to the monitoring of their eating behavior.
- UOC has designed all the tests and protocols related to the evaluation of the social inclusion of the participants to the validation process of DOREMI solution.

■ Significant results

Definition of Final version of Active Aging Lifestyle Protocol in Task 2.3

■ Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)

At the time of submission of D2.3 in draft form, three essential points for Ethics Committees application were not yet solved:

1. The choice of the most accurate test for measurement of Mild Cognitive Impairment (MCI).
2. The criteria and technical tools to be used to quantify Social Interaction through the DOREMI Gamified environment.
3. The design of the statistical evaluation process that will be applied on the collected data.

In particular:

1. Initially, MMSE test was identified as the main selection and evaluation criteria for MCI. After a first set of tests performed by UK partners, it appeared that this test does not show

a high sensitivity in identifying mild levels of cognitive decline. DMU performed a series of test on a population with characteristics similar to those of the DOREMI users to compare differences between the MMSE and the Montreal Cognitive Assessment (MoCA) tests. This latter showed a higher sensitivity for the recognition of MCI in our population.

2. Monitoring and quantification of social interaction activities that will be monitored registering logs files of the daily activity done by the individual virtually interacting with the other trial participants through the gamified environment focusing on: the daily persons virtually encountered; the amount of time spent in virtual socialization.
3. For the Validation process DOREMI partners will perform a transparent and robust statistical multivariate analysis. In this regard we will use several data analysis techniques including multiple regression analysis, discriminant analysis and conjoint analysis.

Active Ageing Lifestyle Protocol and its Validation plan were key points of DOREMI project and Deliverable D2.3, which collected them, required a deep discussion and analysis. However, this delay in D2.3 submission, also is necessary, didn't impact on other tasks, in particular on the beginning of Validation activity (T6.4), as also on resources and other planned activities.

- Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)

The delay in finalizing D2.3 did not affect the development of the other activities linked to Task 2.3 as also has not a negative impact on resources. At the same time, DOREMI partners were stimulated to anticipate discussion on technical solutions to be applied during trial in UK and Italy.

- Explain deviations (if any) between actual and planned person-months (per beneficiary)
- Please see section 2.4
- Corrective actions

Corrective actions are already described above in the plan and they are related to the activities for completing the D2.3. In particular:

1. Choice of MoCA test instead of MMSE: MoCA presents a higher sensitivity respect to MMSE.
2. Definition of statistical elaboration process for DOREMI solution.
3. Definition of specifications and presentation of documentation for Local Ethics Committee.

Recommendations of Reviewers and their reply.

R2 - Some criteria have to be reviewed such as “nursing home” residents, which do not fit with project objective of having people autonomous with their food.

Reply: potential users were selected considering their living situation (people living alone in the identified residential retirement communities and private houses) and their capability to have autonomous control on their diet. In the retirement communities, users have access to a private kitchen or to a refectory, where it is offered a wide variety of foods to be chosen.

R4 - Baseline period is heavy in terms of tests. Older people are easily tired and stressed because of tests especially for the elderly with mild cognitive impairment. A baseline period protocol should be set in order to avoid any error in assessment in D2.2.

Reply: After a discussion with DMU, SI4LIFE and CNR IFC, tests and their required effort were reduced to users as much as possible during the baseline phase to avoid an overload of activity and stress conditions. Furthermore, during baseline period, Extra, ACCORD and SI4LIFE personnel will continuously support users with the direct assistance of CNR-IFC physicians.

2.3.3 WP3 Development of WSN environment and auto configuration system

The second year of execution of the project has concentrated the biggest workload for this WP in terms of software and hardware releases, device testing and integration activities.

Specifically, during this year, three hardware versions (including the final) of the wristband have been released, one of the indoor location network (final version), the final release of the smart carpet, the final integration of the environmental sensors, three versions of the DOREMI gateway (including a merged version of the main beacon and the DOREMI gateway in the final release) and several software revisions for the middleware and auto-configuration system and firmware updates for the hardware components.

For the end of this period, two milestones of the project scheduled in the DoW have been accomplished: *MS4 Preliminary version for the WSN environment, smart environment for context awareness and gamified environment* and *MS5 Developed Sensors prototypes ready for the validation activities, WSN environment and auto configuration system*.

The main outputs of this WP have been the following:

- DOREMI wristband: an unsupervised and unattended (no user intervention needed) device which provides indoor location, step counter, full access to 3-axis accelerometer data and heart rate measurement. The use of these sensors makes possible important features of the DOREMI protocol as the caloric consumption assessment, the activity recognition or the pattern detection.
- Smart carpet: a device that provides easy and precise measurement of weight and balance, enabling an automatic way to get the BERG scale assessment.
- Environmental sensor network: a set of presence detector and door contact sensors installed to effectively assess the socialization aspects of the user when is at home. These data is processed in WP4 developed modules and gives an accurate assessment of the social situations.
- Indoor location network: a set of reception devices that enables precise indoor location and a communication infrastructure for the DOREMI wristband. Thus, this network is a key element for calculating user's location but also for receiving a huge amount of data without losses. The elements are specially designed for private houses, so that they do not need special communication infrastructure (such as an Ethernet network) and they are unobtrusive avoiding light emissions or beeps.
- DOREMI gateway: a central element to concentrate all the data coming from user's house and forwarding it to remote DOREMI servers.
- DOREMI middleware and integration layers: a software tool to connect all the data sources to a common communication platform and make available these data to all the DOREMI subsystems. Each hardware component has its own integration layer.
- Auto configuration system: An effective system to manage several DOREMI system working and the same time and a way to declare all the published data and make it accessible by other applications.

The deliverable D3.2 (April 30th of 2015) reports about the preliminary release of the WSN and the integration middleware. This version was part of the MS4, the preliminary version of the DOREMI environment. The deliverable D3.3 reports about the final version of the WSN, middleware, integration layers and auto-configuration system. This includes a guide for configuration, installation and troubleshooting, as an input to the WP6 installation tasks.

The execution of the tasks planned for this period is satisfactory and no significant deviations have been detected. The testing of the first version of the wearable wristband was slightly delayed due to components and manufacturing providers. Specifically, there was a lack of HR sensor components not correctly notified to MYSPHERA and also a delay caused by the manufacturing provider. This circumstance has been solved by coordinating and collaborating with WP4 to minimize this impact, new dates for data acquisition and integration testing were arranged with virtually no impact in the final results. However, this required a partial re-organization of the work of WP4 and a deeper integration of WP3 and WP4 to speed up the development of the heart rate signal processing firmware of the wristband.

In month 24 the work of WP3 officially ended with the delivery of the WSN system, which is going to be installed in month 26 in a collaborative work between WP3 and WP6 partners. The pending task that affect the work done by WP3: troubleshooting, maintenance, bug report/fix are task that will be done within the effort envisaged in WP6, where the development partners of WP3 (MYSPHERA, CNR-ISTI and AIT) have resources to perform that activities.

The main goal of WP3 is to develop the WSN environment and auto configuration system by a set of coordinated tasks.

■ Objectives

- Selecting the most appropriate group of sensors and devices that will be distributed in the preferred environment of the elderly person. These sensors and devices will be both off-the-shelf or prototype developed by the partners.
- Design and development of the devices and sensors that will be developed in the project (e.g. bracelet/wristwatch) or integrated by the use of commercially available sensor or devices (as in the case of the smart carpet).
- Perform a data collecting and retrieval layer that will support the data processing and the interoperability with the smart environment developed in WP4.
- Design and develop an auto configuration system.
- Integration of the full set of sensors into the WSN monitoring environment.

■ Summary of progress towards objectives and details for each task

Task 3.1 Requirements, parameters and sensor selection (MYSPHERA) – M3-M9

Completed

Task 3.2 Sensors development and production (MYSPHERA) – M6-M24

This period has covered all the WP3 releases foreseen in the DoW, summarized below.

A first laboratory version of the wearable wristband was developed by the end of January (month 15). This prototype, henceforth called *lab prototype* is composed by the union of all hardware development modules of each component, integrated in a single device able to send the data gathered from sensors to a main beacon prototype. The components and boards have been integrated in a standard box to allow the mobility of the *lab prototype*. This device has standard micro-USB power connector and it has a finger-clip heart rate sensor (given that it is the sensor provided by the SoC manufacturer to hardware development and, in practise, it is impossible to fit the lab prototype to a wrist).

In the period between February and the end of April 2015 it was developed a second prototype of the wristband, meeting the schedule planned in the DoW and the milestones. The second prototype is a wearable wristband including the full set of sensors planned for the final release.

By the end of June 2015 the signal processing firmware of the wristband was ready for the first data acquisition campaign (conducted in WP6, see details in the report of task 6.1), which was executed from the beginning of July up to the end of August. These tests and the analysis of the results, performed in cooperation by MYSPHERA, CNR-IFC, CNR-ISTI and UNIFI, allowed the identification of some bugs in the firmware.

A second improved version of the wristband, which also included an improvement of its size and battery life, was delivered in October 2015 and tested in a second data acquisition campaign conducted by the end of October (again by WP6, see details in the report of task 6.1). The analysis of the results of this campaign, conducted in cooperation with MYSPHERA, CNR-IFC, CNR-ISTI and UNIFI, showed a significant improvement of the wristband but it also allowed the identification of some further aspects to improve in the signal processing firmware. For this reason, a third (and final) version of the wristband was released by the middle of November. This version is being tested in a third data acquisition campaign at the end of November/beginning of December 2015 conducted by WP6 (see the report of task 6.1 for details).

Besides the development and integration of the electronic components, a provisional casing was designed and produced with 3-D printing to enable the preliminary tests and data collection. This device presented some problems in the PCB design that made virtually impossible to obtain HR data in a stable, proper way. This forced to increase the collaboration mainly with WP4 members to meet the deadlines and milestones as agreed.

The final release of the DOREMI wristband hardware was thus made available by mid November 2015. This prototype has reduced its size in nearly the 25%, improved the battery life about 100% (reaching two days without charging), improving the contact surface of the HR sensor with the user skin, the overall performance and including wireless charging. Several case designs have been tested with these electronics as well as strap models. The prototype is 100% integrated with the DOREMI smart environment and provides all data needed for the DOREMI Lifestyle Protocol.

The DOREMI Gateway has been developed during this period. Initially it was split in two different elements, one for the communication with balance board (based on Bluetooth 3.0) and one for the indoor location and wristband (Bluetooth Low Energy). However, MYSPHERA and CNR-ISTI finally decided merge them on a new device, making easier the installation and troubleshooting and also implying lower costs. The device is 100% functional and bug safe.

In addition to the DOREMI gateway, an advanced 100% functional prototype of the RTLS beacon has been released. This element, which was not initially indicated in the DoW, has been developed to fit the pilot sites requirement of having as less wiring as possible and the impossibility of wiring with Ethernet the user's apartments. This version of location beacons communicate between themselves and with the wristband using exclusively Bluetooth Low Energy (BLE), so that no data wiring is required and the beacon can be located near a power socket minimizing the visible wires in the user's house. Development status is 100%.

MYSPHERA, together with ACCORD and EXTRACARE, performed an in-site analysis for UK pilots: further details are described in T6.1 (WP6).

During this period, several software components and tools were developed to support data acquisition campaigns: socialization, physical activity and smart carpet. All of them were performed in collaboration of MYSPHERA, CNR-ISTI and UNIFI.

CNR IFC with CNR ISTI and UNIPI have organized, during this period, 3 meetings to coordinate WP3 work (Pisa, 04/11/2014, 09/01 and 25/02/2015) to discuss the last review comments and the revision of deliverables.

MYSPHERA organized a technical meeting on 22nd-26th of June to evaluate the preliminary version of WSN and other aspects not directly concerning this task.

CNR IFC has developed the user scenario of use for balance board, has defined its requirements and, together with CNR ISTI and UNIPI, during several sessions (Viareggio 28/11/2014, Pisa, 18/03/2015, 27/03/2015, 24/04/2015), this balance was tested on a user population similar (23 users) to those of the DOREMI trial. In particular, three items of BERG balance scale (nr. 6, 7 and 10) were replicated with the use of balance board and data obtained were correlated with the individual BERG balance score, feeding the reasoning system (WP4).

CNR IFC organized during May 2015 and October 2015, in collaboration with CNR ISTI, UNIPI and MYSPHERA, a series of tests to collect data (heart rate, blood pressure, blood oxygen saturation, accelerometer data, energy expenditure by metabolimeter) for activity recognition of Physical Activity exercises, foreseen during the DOREMI intervention.

MYSPHERA organized several data acquisition campaigns for the socialization activity recognition.

Task 3.3 Sensor Integration and Middleware (CNR-ISTI) – M6-M20

CNR-ISTI continued the development of Sensor Weaver Middleware reaching version 2.0 in December 2014. The software was later refined to fix bugs and add minor improvements that facilitate the management of the platform. Documentation of the Java API, a brief description of the architecture and a guide for developers and administrators was released along with the software artifacts and made available to partners through public sites (SVN code repository, maven nexus repository, wiki for documentation).

CNR-ISTI developed, over the reporting year, the integration layer for the smart carpet and tools for acquiring data for T6.1. A tool was also developed in order to analyze data characteristics in relation to the transmitter-receiver distance. Several improvements were also made to the device driver in order to improve Gateway hardware resource usage and the balance board data sample rate.

During the last month of the reporting period, CNR-ISTI started to collaborate with MYSPHERA on the integration of Z-Wave environmental sensors. CNR-ISTI and MYSPHERA jointly developed a solution for gathering data from Z-Wave environmental sensors using the Vera-Lite Z-Wave Gateway and a software integration layer running on the DOREMI Gateway.

During the reporting period, MYSPHERA also developed the sensor integration layer for the indoor localization system, the smartphone (GPS data) and the wristband generated data. The set of sensors integration layers has been made ready for the integration event in Valencia (M25). Several tools were also developed by Mysphera in order to allow wristband data gathering for T6.1 (physical activity and socialization). Several Android and Java applications were developed to this end.

MYSPHERA and CNR-ISTI also collaborated on creating technical solutions regarding the ease of WSN installation, system remote management and privacy concerns, responding to requirements posed by pilot partners during 2015.

CNR-ISTI developed a web dashboard that allows to easily monitoring the status of DOREMI Gateways and sensors availability. Several software tools were also developed by CNR-ISTI to easily check the status of the data acquisition on the sensor DB and the status of sensors integration layers running on the DOREMI Gateways.

In order to respond to the constraints posed by pilot partners regarding internet connectivity, CNR-ISTI and MYSPHERA devised a solution that allows to either use local ADSL internet connection or wireless broadband internet connectivity, with subscription and SIM cards provided by the pilot partners, without sacrificing remote control capabilities. MYSPHERA provided a solution for bundling all the computing and networking devices of the WSN (DOREMI Gateway, router, Z-Wave Gateway) in a small box (called DOREMI Box), responding to a specific requirement posed by pilot partners during 2015.

CNR-ISTI and MYSPHERA collaborated in the latter months of the reporting period to overcome concerns raised by pilot partners regarding privacy and usability issues derived from the usage of tablets and smartphones.

Task 3.4 Auto configuration system and calibration (AIT) - M9-M24

AIT's HOMER (Home Event Recognition System) was chosen to play the role of the auto configuration system within DOREMI. HOMER is developed in JAVA and based on the OSGI framework KARAF. This allows HOMER to be configured individually in terms of adding or removing functionality by adding or removing so-called bundles, which are modular, and capsuled pieces of software.

HOMER supports the configuration of smart environments via a graphical user interface, the storage of sensor data and has standardized interfaces for third parties to retrieve current status or the configuration of the environment.

A virtual machine (VM) was setup at AIT premises to run the auto configuration (and probably other) system as part of the DOREMI installation. The VM runs an UBUNTU server, which is made accessible from remote via secured connection (SSH).

HOMER was screened for further improvements to fulfil the DOREMI requirements and necessary adoptions have been made. This are enhanced graphical configuration possibilities, enhanced third party interfaces (REST, Websocket, RabbitMQ) and enhancing the reliability.

In the current period the focus was on improving the internal messaging processes and enhancing the internal database modelling. Also a couple of issues related to the graphical configuration interface have been solved.

In detail, these were:

- implementation of an automated database upgrade feature
- implementation of an authentication procedure for websocket connections
- enhanced hierarchical item view panel
- updated to the new karaf framework
- fixing bugs concerning the graphical flat representation

■ Significant results

- DOREMI wristband final version (3 releases).
- Final version of de Wireless Sensor Environment including; custom wristband, environmental sensors, RTLS location system with wireless communication beacons, DOREMI gateway and smart carpet.
- Final version of smartphone application available in Google Play Store as a closed beta (v1.0).

- Integration of RTLS back end and DOREMI Middleware.
- Middleware 2.0 available for the pilot, developers and administrators documentation available.
- Sensor integration layers developed, tested and ready for the final integration tests.
- Virtual machine at AIT premises running the auto configuration system.
- HOMER finally developed and set up for being ready for the trials.
- Setup of 3 virtual server environments for running the trials.
- Developed T6.1 tools for data collection: physical activity balance assessment, socialization.
- Devised definitive setup for WSN, responding to pilot partners requirements.

■ **Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)**

There had been a deviation in the development and testing of the firmware of the wristband, to react to the late delivery of the hardware and to the anticipation of the pilots of one month.

The intermediate lab prototype was released one week after the internally agreed date, but that didn't have consequences since its use was not requested.

The first working release of the wristband arrived nearly three months late, so that a good coordination with WP2-WP4-WP6 partners was needed to limit the effect the tasks depending on this milestone.

■ **Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)**

Not applicable.

■ **Explain deviations (if any) between actual and planned person-months (per beneficiary)**

See Section 2.4 "Project management during the period"

■ **Corrective actions**

The corrective actions consisted in a deeper coordination of the activities of WP3, WP4 and WP6, and in a partial re-organization of the work of WP4. Specifically, the data acquisition campaigns (in WP6) and had been scheduled to meet the delivery of the intermediate versions of the wristband, and WP4 re-organized its work to provide timely feedbacks about the functional tests of the wristband, to allow WP3 to speed up the procedure of bug fixing and of improvement of the signal processing firmware.

2.3.4 WP4 Development of a Smart Environment for Context Awareness

The main goal of WP4 is to define and implement the DOREMI Context Awareness and Activity Recognition system.

During Year 2, WP4 partners have collaborated to design, implement, integrate and test a Smart Environment for Context Awareness system to be used in pilot sites deployment, developing a set of solutions and functionalities based on data analysis, machine learning and reasoning methods tailored to the DOREMI goals, including:

- preprocessing, cleaning and segmentation of noisy streams of environmental and personal sensors within DOREMI middleware integration (T4.2);
- exploratory data analysis to identify patterns of user habits from traces of indoor mobility, allowing to detect alterations and anomalies in the user daily behavior, and other aggregated and statistical values of the DOREMI lifestyle protocol (T4.2);
- supervised short-term human activity recognition/estimation from available temporal streams of sensor data, allowing automatic, un-obtrusive and population-targeted estimation of relevant user parameters, such as calorimetric expenditures, balance skills and patterns of social indoor visits, as part of the DOREMI lifestyle protocol (T4.3);
- aggregation and reasoning over activity recognition and games data across different time-scales to automatically assess compliance of the users with the DOREMI lifestyle protocol and to implement its progression (T4.4);
- visualization of the user parameters of interest for the DOREMI lifestyle protocol to the general practitioner through the Dashboard component (T4.4).

A refinement of the requirements and specifications for the functionalities and methods developed within WP4 has also been produced as part of T4.1 yielding to the final definition of the system functionalities, interfaces and implementation-level specifications.

The activities of the WP4 coordination team have continued as planned, with monthly physical and virtual meetings with the project management (CNR-IFC), the clinical stakeholders and representatives of the other WPs.

■ Objectives

This WP investigates statistical analysis based solutions for explorative data analysis tasks (Task 4.2) and machine-learning solutions for predictive data analysis (Task 4.3). Explorative approaches typically rely on unsupervised learning models and are useful both as a preliminary pre-processing step, e.g. to filter, segment and cluster relevant sensor data, as well to discover some informative grouping of the sensor data, when little supervised expert information exists. Predictive approaches, on the other hand, usually rely on supervised learning models, and are tailored to acquire robust predictive models of a process for which there is insufficient background knowledge to set up a procedural algorithmic solution, but a sufficient set of real-life supervised example data is available. These latter models will be used, in Task 4.3, to learn a short term activity recognition/classification system from expert labelled data that will support a higher level reasoning service on long-term user data in Task 4.4.

- Summary of progress towards objectives and details for each task

Task 4.1: Data preparation and models assessment specification (UNIFI) – M1-M8/M20-M30

The second part of Task 4.1 (M20-M30) has progressed as planned in the last months of Y2: its outcomes will be documented in D4.2 and D4.3 after task completion (at M30 and M33). In the reference period, the Task 4.1 activities dealt with the revision of the requirements and the specification of the “Smart Environment for Context Awareness” system, following changes in the clinical and technical requirements of the DOREMI pilot studies. Further, Task 4.1 dealt with the design and coordination of the process for selecting the most appropriate computational learning methodologies/configurations to implement the DOREMI Activity Recognition components through validation on experimental data collected by WP6.

The key outcomes of Task 4.1 during the period of interest are

- A revision of the requirements and specifications for the functionalities developed within WP4; many computational tasks have been further focused on the specific needs of the DOREMI environment setting and protocols.
- The identification of most suitable computational methodologies/configurations to be deployed on the DOREMI pilots based on an experimental validation exploiting WP6 data.
- A revision of the data format and interfaces between WP4 and WP3 components for the final DOREMI software integration.

UNIFI has lead Task 4.1 activities, coordinating requirements revision and refinement of the WP4 system design. UNIFI has also identified the most suitable machine learning solutions to address the activity recognitions tasks and that have been experimentally assessed on WP6 data. Further, UNIFI has participated to the design of the experimental data collection protocols for WP6 activities, providing requirements in terms of data quality and sampling as well as scientific and technical advisory for the implementation of the collection campaign for data used to train the predictive Activity Recognition models in Task 4.3. During the considered period CNR-ISTI coordinated the technical activities in order to integrate the developed WP4 components in the DOREMI middleware system developed in the WP3 used as data integration framework. In this regard, CNR ISTI has performed the setup of the backend for storing sensor data (MongoDB database) and the organization of data in different data collections in order to guarantee the integrity of raw data and features data.

The coordinator partner CNR-IFC has organized 2 meetings related to the activities of Task 4.1, mainly to gather WP4 requirements on the experimental campaign in WP6 and to design and finalize the protocols and scripts for training data collection.

Task 4.2: Activity recognition: explorative data analysis (CNR ISTI) – M6-M33

During the reference period, CNR-ISTI implemented the data preparation layer for the predictive activity recognition tasks by building on the state-of-the-art on exploratory data analysis techniques produced in the first year. After a first prototyping version written in Matlab, it has been realized as a set of filtering utilities by means of OSGi modules integrated in the middleware developed in the WP3. The layer gathers sensory data by means of the middleware utilities, splits the data into epochs, applies mean, standard deviation, kurtosis and skewness on it, and populates the relative collections of the raw data MongoDB instance. Thus, once raw data are available, the filtered data and the features extracted from them will be ready to be used by the predictive machine learning tasks. The layer has been functionally tested on data collected by the smart carpet designed by UNIFI and CNR ISTI, and on data received from the bracelet designed by MYSHERA. As part of the Task activities, it has been also designed, developed, and integrated techniques to produce aggregated data from environmental

sensors and the GPS embedded in the smartphone used in the outdoor scenario. These modules produce aggregated and statistical values for:

- daily weight evaluation;
- daily heartrate statistics (min, max, average per hour);
- daily indoor time statistics (time spent indoor, time spent in each room);
- daily steps counter statistics per hour;
- daily outdoor time spent and covered distance walking;
- daily outdoor DOREMI socialization levels.

another activity involved in Task 4.2 is represented by the application of unsupervised approaches to long-term user behaviour discovery by means of environmental sensors activations. In order to be ready for the actual deployment of the module in the real test sites, an indoor mobility model is under development to simulate indoor mobility traces and the time series related to the environmental sensor activations. An unsupervised model to be applied on these synthetic traces has been developed and preliminary results based on the “stigmergic” approach have been reported in the revised version of the deliverable D4.1. The model has been also validated on real traces collected in ad hoc campaigns and the results have been published in [1].

Furthermore, in order to test the validity of the stigmergic approach dealing with indoor localization information, a technique that exploits the Bluetooth Low Energy beacons (also present in the DOREMI test sites) has been developed producing more accurate indoor positioning information. This work has been presented to an international conference [2].

The possibility to exploit the information coming from the activations of environmental sensors deployed in the DOREMI test sites to increase the localization accuracy has been analysed. A technique has been developed and tested on publicly available datasets and it has been described together with its results in a journal paper [3]. This kind of approaches can be very useful in order to deal with possible failures of the DOREMI indoor localization system, increasing its robustness.

Task 4.3: Activity recognition: predictive machine learning approach (UNIPi) – M6-M33

The key activities in Task 4.3 across Y2 have focused on the implementation, testing and validation of the predictive Human Activity Recognition (HAR) system and on its integration within the DOREMI platform. During the reference period, UNIPi has developed a Java API (package `doremi.har`) that implements the activity recognition software system described in Section 7.3.2 of D4.1 and that will ultimately perform the supervised activity recognition tasks (in Section 6.1.3 of D4.1) for the DOREMI pilot sites. The developed system includes the following functionalities

- system auto-configuration mechanisms interfacing with the DOREMI Homer DB;
- data interfaces for patient and daily pilot data retrieval from DOREMI Raw DB;
- data interfaces for uploading daily activity recognition predictions to the DOREMI Kiola DB;
- HAR system management and journaling mechanism;
- activity recognition components trained and validated on WP6 data.

The single HAR system components were tested in isolation between M19 and M22 also availing of data from WP6 to validate the performance of the activity recognition components, progressively made with the available partial sets of annotated data. A complete integration testing of the developed HAR system has been performed at M23-M24, including extensive testing of the full data processing chain from sensor data acquisition (WP3), to pre-processing (T4.2), to production of the activity recognition

predictions and their forwarding to the reasoning system (T4.4). The HAR system is currently ready for deployment in Pilot studies: the doremi.har API and the associated documentation will be released as part of D4.2.

In addition to HAR system development, Task 4.3 has undertaken extensive data analysis and model assessment activities to identify the best performing learning model/configuration for each of the activity recognition tasks (progressively along with the availability of the data). To this end, UNIFI has developed a number of software components implementing different computational learning models suitable for the activity recognition tasks and identified through the background analysis in Task 4.1, which include reservoir computing models as well as different forms of time-delay/recurrent neural networks (e.g. Elman, IDNN, etc.). In addition to that, UNIFI has developed procedures for training, validation and testing of such learning models on DOREMI activity recognition tasks using real-world data progressively available from WP6 (considering the specificity of each task). A comparative experimental analysis of the different learning models have been performed to identify the most suitable approaches/configuration for pilot deployment: the details of this analysis will be released, together with the post-hoc analysis of the data from the DOREMI pilots, as part of D4.3.

Members of the UNIFI team contributed, with CNR IFC and ISTI, to the design and realization of a measurement campaign targeted at collecting balance-related data from the Wii smart carpet, in relation to the “Balance Assessment” computational learning task. In this respect, UNIFI has also developed and progressively refined a Graphical User Interface (GUI) that facilitates the process of data gathering and annotation. The balance-related gathering process has been developed in successive stages during M11-M19, with several measurement campaigns at ISTI CNR, involving healthy DOREMI staff, as well as at ISI “Piaggia” (Viareggio) and ASL5 in Pisa, under CNR-IFC coordination, involving elders with various degrees of physical impairments. As part of Task 4.3 activities, UNIFI has conducted incremental experimental analyses on such data, which have contributed to a progressive refinement of the protocol adopted for the measurements. Such cooperative and incremental approach, involving both data experts and clinical staff, has allowed the identification of a compact subset of patient-safe and information-rich exercises from the Berg Balance Scale tests that are well suited for automatically computing the Berg Balance Scale from smart carpet measurements.

UNIFI collaborated with CNR-ISTI and MYSPHERA to the entire process of design, refinement, and data gathering concerning the supervised activity recognition task “Person meeting the user at home”. The measurement campaign pertaining to this task has been carried out in successive stages from M12 to M24, actively involving members of UNIFI also in the phases of refinement of the scripts for the data collection protocol, of the logging system and of the data format. These activities also took advantage of the experimental assessment and analysis carried out by UNIFI on the progressively available data on this task. UNIFI, in cooperation with members of CNR-ISTI and CNR-IFC, participated to the design and realization of measurement campaign pertaining to the supervised activity recognition task “Physical Activity Level”, performed in several stages during the period M21-M24. Moreover, UNIFI contributed to the progressive refinement of the protocol for data acquisition through the analysis of the heart rate and caloric consumption-related data, collected using different devices in different experimental settings. In particular, according to the project needs, a focus have been made on the analysis of the exercise phase of users activities

During the reference period, it has been held monthly meetings of WP4 coordination team with CNR IFC and ISTI, which have served, among the others, to design the experimental campaign for AR training data collection, to define the hardware and software setup of DOREMI pilot sites as well as to discuss the preliminary results and findings of activity recognition analysis on the experimental training data. Two coordination meetings occurred in Valencia in June 22nd, 2015 and in Leicester in September 23rd, 2015 with all WP4 partners. One skype-call meeting has taken place on the 26/02/2015, including members of CNR ISTI, CNR IFC, UNIFI and AIT to discuss the physical deployment of the DOREMI raw and high-level databases and server for computation (which will be hosted by AIT), as

well as the details of the deployment of the software components of the Context Awareness and Activity Recognition system, together with the associated computational, interfacing and communication requirements. Another skype-call meeting has taken place on the 06/10/2015, including members of UNIPI and AIT, to finalize the interface and interactions between the activity recognition modules and the DOREMI Reasoner. Members of the WP4 technical team have participated to the first integration meeting, held at MYSPHERA Living Lab in Valencia, which has produced the first integration between the WP4 and WP3 components of the system. Integration of the full Smart Environment for Context Awareness system has been successfully completed at M25 during the second integration meeting, also held at MYSPHERA Living Lab.

Task 4.4: Reasoning system and Personalization (AIT) – M10-M33

During the period of interest the data model, reasoning system and dashboard have been gradually refined. 131 different data items are now collected in the medical, cognitive and social domain and visualized on the dashboard.

Integration with HOMER, Metadieta and the activity recognition modules has been completed.

The reasoning system provides decision support for clinical experts and psychologists in the area of exercise progression, cognitive game progression, detecting missing data and exercise compliance based on both: rule-based and statistical approaches. The reasoning system can be personalized by clinical experts (using the dashboard) through setting individual parameters. (e.g. maximum heart rate during exercising).

■ Significant results of WP4

WP4 has contributed to meeting the following project milestone

- Milestone MS4 at M18, by contributing to the implementation level specification of the DOREMI system (including definition of software component interfaces and exported functionalities), as well as by developing a preliminary version of the HAR system and DOREMI dashboard

WP4 has developed, integrated and tested a Smart Environment for Context Awareness system that is ready for pilot sites deployment. The developed system includes the *functionalities* described in the above WP4 *summary section*. Further details are described in the following for selected specific results.

As part of Task 4.3, UNIPI has developed and experimentally validated a number of supervised models for user activity recognition which have led to potentially impacting applications with respect to automated and un-obtrusive assessment and monitoring specifically targeted to the elderly population. In this concern, it has been developed an automatic system for *balance assessment* in elderly people. This work represents the first attempt in *literature* to estimate the overall Berg Balance Scale (BBS) score by analyzing temporal data generated by a smart carpet (implemented through a Nintendo Wii balance board) during the execution of one simple BBS exercise using neural networks for time-series (directly exploiting the richness of the signal dynamics). The system allows a time-saving and autonomous monitoring of balance stability, using only one out of 14 BBS items. In particular, experimental analyses on this task also resulted in the selection of the BBS exercise #10 (i.e. “turn to look behind”) as part of the protocol for balance assessment for the DOREMI users. Reservoir Computing (RC) networks achieved very good performance on such balance estimation task, with a (person out) generalization error below the score range of a single BBS exercise and the tolerance for clinical significance, considering also the issue of a human assigned ground truth, its variability and the input signal noise. Such results compare favourably with those achieved using other neural network models for temporal data. Moreover, the proposed approach is more effective and less intrusive than the approaches

currently in literature. The experimental analysis of RC on balance assessment has been presented at the 1st International Workshop on Advanced Analytics and Learning on Temporal Data, co-located with ECML-PKDD and held in Porto on 7-11 September 2015 [6].

The experimental analysis carried out on the socialization-related data led to the development of an automatic system for detecting the events of visitors entering and leaving the user's house from streams of data generated by presence sensors and door contacts. Different experimental settings were considered in this regard, in order to take into account the possibility of environments with different configurations. In general, results show a good predictive performance, with high generalization accuracy, and increasingly better performance when larger sets of environmental sensors are available.

The analysis on the physical-activity related data took into consideration different approaches and experimental settings, corresponding to different sources of heart rate information, patient personal parameters and different frequencies of operation of the activity recognition component. In general, results pointed out a very good predictive performance (on the available set of data from WP6, by Garmin) achieved using models for time-series, as the RC learning models, which allow an accurate step-by-step estimation of the calories consumption series during the DOREMI physical activity protocol from heart rate data streams. The approximation of the proposed estimation (in terms of error in Kcals) compares well with literature approaches as well as with a reference caloric estimation by Mio Alpha 2 commercial smart-watch, that has been considered for comparison during the measurement campaign for its state-of-the-art performance among the commercial products currently on the market.

As part of Task 4.4, AIT has achieved the following goals:

- data synchronisation with output from activity recognition modules and KIOLA platform has been completed.
- data synchronisation with output from tablet application (cognitive games) and the diet application has been completed.
- interactive visualisation of output for specialists on a web-based dashboard completed.
- personalized reasoning system in the area of cognitive games, diet, physical exercise, reminders and social activity has been completed.

The preliminary results obtained in the application of semi-supervised stigmergic-based techniques on testing datasets have been described in a paper published on the Pervasive and Mobile Computing journal by Elsevier [1].

The stigmergic approach applied to Bluetooth Low Energy beacons aiming at providing indoor localization information has been published in the conference proceedings of the 12th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS) [2].

The technique aimed at improving the accuracy of the DOREMI indoor localization system exploiting the information coming from the environmental sensors activations has been described in a paper published on the Journal of Ambient Intelligence and Smart Environments by IOS Press [3].

An experimental assessment of the learning models, including a comparison between different neural network architectures, using benchmark human activity recognition data, has been described in a paper accepted for journal publication [4].

The key features of the HAR software system, developed as part of WP4 activities, have been presented at the third Italian Workshop on Machine Learning and Data Mining (MLDM) during the XIII AI*IA Symposium on Artificial Intelligence, held in Pisa on 10-11 December 2014. Moreover, the overall architecture of the data acquisition and human activity recognition systems of DOREMI has been presented at the CINI Annual Workshop on ICT for Smart Cities and Communities (I-CiTies 2015), Palermo, October 29-30, 2015.

A paper [5] describing WP4 system architecture and discussing the exploitation of human activity recognition and reasoning to monitor the elderly and to empower them to follow a lifestyle protocol

for active aging, has been presented at the XVII Portuguese Conference on Artificial Intelligence (EPIA2015), thematic track on “Artificial Intelligence in Medicine”.

- [1] P. Barsocchi, Mario G.C.A. Cimino, E. Ferro, A. Lazzeri, F. Palumbo, and G. Vaglini. "Monitoring elderly behavior via indoor position-based stigmergy". *Pervasive and Mobile Computing*, Volume 23, October 2015, Pages 26-42, Elsevier.
- [2] F. Palumbo, P. Barsocchi, S. Chessa, J.C. Augusto. "A stigmergic approach to indoor localization using Bluetooth Low Energy beacons". *Advanced Video and Signal Based Surveillance (AVSS)*, 2015 12th IEEE International Conference on, August 2015, Pages 1-6, IEEE.
- [3] F. Potortì, F. Palumbo. “CEO: A context event only indoor localization technique for AAL”. *Journal of Ambient Intelligence and Smart Environments*, Volume 7, No. 6, November 2015, Pages 745-760, IOS Press.
- [4] F. Palumbo, C. Gallicchio, R. Pucci, A. Micheli, "Human Activity Recognition using Multisensor Data Fusion based on Reservoir Computing", *Journal of Ambient Intelligence and Smart Environments*, IOS Press, ISSN 1876-1364, 2015, (In Press).
- [5] D. Bacciu , S. Chessa, C. Gallicchio, A. Micheli, E. Ferro, L. Fortunati, F. Palumbo, O. Parodi, F. Vozzi, S. Hanke, J. Kropf, K. Kreiner, “Smart environments and context-awareness for lifestyle management in a healthy active ageing framework”, *Proc. of EPIA 2015 - Seventeenth Portuguese Conference on Artificial Intelligence*, Coimbra, 8-11 September 2015, *Progress in Artificial Intelligence*, LNCS, Vol. 9273, pp. 54-66, Springer, 2015.
- [6] C. Gallicchio, A. Micheli, L. Pedrelli, F. Vozzi, O. Parodi, "Preliminary Experimental Analysis of Reservoir Computing Approach for Balance Assessment", *Proceedings of the 1st International Workshop on Advanced Analytics and Learning on Temporal Data co-located with The European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML PKDD 2015)*, Porto, Portugal, September 11, 2015, *CEUR Workshop Proceedings*, vol. 1425, pages. 57-62, 2015.

- **Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)**

WP4 partly re-organized its work due to the need of providing timely feedbacks to WP3 concerning the results of the tests of the intermediate versions of the wristband. This partly affected the work of tasks 4.2 and 4.3. In particular, it delayed the process of validation and model comparison of the activity recognition module of the Physical Activity Energy Expenditure Prediction.

- **Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)**

The deviation is not critical and impacts only a few objectives of WP4.

- **Explain deviations (if any) between actual and planned person-months (per beneficiary)**

See Section 2.4 “Project management during the period”.

For timing deviations see D1.2.2 – Annual Periodic Report Period 1.

- **Corrective actions**

The activity recognition module responsible for the prediction of the physical activity energy expenditure is made basing on the first rounds of data acquisition.

A further refinement of the process of validation and model comparison of the activity recognition module for the physical activity energy expenditure estimation (from wristband heart rate data) can continue in the next period.

2.3.5 WP5 Development of Social and gamified environment

Work package 5 is dedicated to the design and development of the overall gamified active ageing support environment to the different impairment of users involved.

The definition of the gamified active ageing protocol that is the main objective of the T5.1 was conducted together with WP2 during Year 1. In D5.1 the gamification of the medical protocols important inputs for the game environment design and development was presented.

To design and develop the game-based active ageing environment (T5.2), the user-centered design activities went on with older people, with the aim to validate the gamified protocols step by step and to obtain an app with good standard regarding usability and acceptance. The whole methodological approach, first results and the activity plan have been presented in D5.2.

The same methodological approach was used to complete T5.3, T5.4 and T5.5, three twin tasks, aimed to design and develop the three main areas and functionalities of the game environment: the exercise area (T5.3), the social area (T5.4) and the cognitive area (T5.5), where the three clinical protocols are proposed. During Year 2 a great effort was spent to produce these areas and to integrate them to the whole gamified environment. The main result of WP5 is the prototype of the DOREMI app that is the main tool used in the project to engage users and to motivate them to complete the proposed daily activities according to the 'Active Ageing' lifestyle protocols (prepared in WP2).

Several meetings (mainly virtual) were organized between WP5 partners to design the DOREMI app and, in particular, to define the gamified techniques and to test them with users. Furthermore, several meetings were also organised between WP4 and WP5 with the aim to describe data formats and attributes as input to reasoning system, as described in D5.2, D5.3, D5.4 and D5.5.

Starting from the first prototypes, designed for each of the three main areas and starting from the first gamified environment mock up (presented in D5.2) and from feedback collected during the user centered design activities in UK and in Italy, the final version of the prototype has been designed and developed.

For the end of this period, one milestone of the project scheduled in the DoW has been accomplished: *MS7 Development of the social and gamified environment ready to be integrated in DOREMI system.*

■ Objectives

- The generation of multi-parametric flexible serious games both for physical and cognitive stimulation and motivation
- Dynamic aggregation all the components and services that need to be presented to users, offering elderly people with a coherent and consistent virtual/augmented highly-interactive environment that can be used to access all the available features, providing a guide to both the DOREMI solution usage and the active ageing gamified environment (including training on daily life aspects) also by means of an intelligent virtual companion
- Promote the development of social communities addressing the areas of engagement proposed in DOREMI (e.g. diet, physical activity, leisure etc.) aiming at stimulating real life social interaction through a proper use of selected and developed game-based/networking/communication services.
- Integrate the game platform with the Web 2.0 services developed in task 7.4 and animated by the involvement of ageing communities

- Summary of progress towards objectives and details for each task

Task 5.1 Gamified active ageing protocol definition (DMU) – M3-M8

Completed

Task 5.2 Game-based active ageing environment (IMA) – M6-M14

Game-based active ageing environment should be closed on M14, but as explained in D5.2, according to the methodological approach that we chose and according to the key role of this environment in WP5, the task couldn't be considered definitively closed by M14.

In fact, user centered design activities went on, collecting feedback with users, in UK and in Italy, and modifying and improving different prototypes, to collect new feedback. For this methodological reason, this task continued in parallel with T5.3, T5.4 and T5.5, until M24. Furthermore, there is also a design reason for this: in fact, to obtain a well-integrated and working application (both from a look and feel and a usability perspective), it was necessary to design and develop the environment at the same time of the three main areas of the application.

As designed for the first mock up (presented in D5.2), in the gamified environment each user has to walk the dog around a path (where each path represents a level), based upon aggregate scores from all areas. Each path represents a European city. For example, the user could walk the dog around Paris, as they reach milestones along the path, they unlock a postcard reward "e.g. the picture of the Eiffel Tower".



Figure 1: The DOREMI game environment, final version. The user has to walk the dog around Paris, thanks to activities completed in the main areas of the application (on the right of the screen: cognitive area; exercise area and social area). Along the path, they can collect achievements: here the Eiffel Tower was achieved (the picture is coloured) while next aim is the Sacre Coeur (the picture is in back and white).

All the areas of the application (described below) are now integrated in a unique environment. This game environment will be used to motivate, engage and support users in their ‘new’ health behaviours and lifestyle, suggested by the DOREMI protocols, regarding cognitive training, physical and social activities and nutrition.

Task 5.3 - Exergames development (IMA) - (M13–M24)

IMA worked together with CNR IFC and DMU with the aim to develop a specific area of the DOREMI app (Exercise Area) considering both the clinical requests and the motivational aspects to engage users. Several meetings were organized to design this area, starting from the first iOS DOREMI PA app, in-house developed by CNR IFC and to connect this section to the main DOREMI app.

The user interface, user interaction modalities and type of data to be collected were defined and developed (they are described in D5.3).

IMA designed and developed, first of all, an Android standalone application, ready to be tested with users during the same test sessions organized for PA activity recognition (WP3 and WP4).

All the videos recorded by CNR IFC (representing the 21 validated exercises included in the clinical protocol plus the chair sit to stand test - CSST) were used and integrated in the application.

Finally, this standalone application was integrated in the whole gamified environment, representing the ‘Exercise Area’, connected to the ‘dog path’ through different rules used by the KIOLA reasoning system (WP4).

Task 5.4 - Social games development (UOC) - (M13–M24)

IMA worked together with UOC and DMU with the aim to develop a specific area of the DOREMI app (Social Area) and some other social features of the app, considering both the clinical requests and the motivational aspects to engage users. Several meetings were organized to study and design the best way to present the DOREMI social activities within the application.

Different ideas and prototypes have been proposed and discussed with users during user centered design activities, both in UK and in Italy (also with Si4life, Extracare and Accord help in recruiting participants), with the aim of collecting feedback and decide which are the most effective, usable and engaging techniques.

Finally, all the social features were decided (as described in D5.4) and the Social Area was designed and developed, directly integrated with the game environment as a previous standalone application wouldn’t have had any sense: all the social features are related to other activities within the application (i.e. share an achievement or challenge someone else in a specific cognitive game).

The ‘Social Area’ is connected to the ‘dog path’ through different rules used by the KIOLA reasoning system (WP4).

Task 5.5 - Cognitive games development (IMA) - (M13–M24)

IMA worked together with Si4life and DMU with the aim to develop a specific area of the DOREMI app (Cognitive Area), considering both the clinical requests and the motivational aspects to engage users. Several meetings were organized to design each game and to test it within the user centered design approach. As presented during the first EU project review, beginning of T5.5 was anticipated at M10, starting to collect feedback about the first prototype, following this methodological approach.

SI4Life provided an in-depth description of each game's characteristics and scenarios needed to train and improve the older person's functionalities in some outlined domains (memory, language, attention, calculation, visual-spatial functioning and praxis). Starting from the collected feedback, a first set of cognitive games about some of these impairments was designed and developed, and retested several times, till they were completely accepted (also from a usability point of view) by users.

According to SI4Life suggestion, the four cognitive games were developed in a unique version (and not in three different versions, according to the degree of the impairment).

Every game is developed with nine different difficulty levels that were tested with users, using the first version of the prototype, a standalone application.

Finally, this standalone application was integrated in the whole gamified environment, representing the 'Cognitive Area', connected to the 'dog path' through different rules used by the KIOLA reasoning system (WP4). The reasoning system manages also the progress through the levels, based on results obtained in each game.

■ Significant results

D5.3, D5.4 and D5.5 were delivered. The three main areas of the DOREMI application were delivered as a unique prototype, integrated with the gamified environment, as everything was ready at the deadline of these deliverables (M24).

The DOREMI App is optimized for Nexus 9 tablet (device chosen by the project consortium) but it will be available also for other tablets with different screen sizes thanks to the responsive design of the App. The DOREMI App is available for Android 4.4 or later versions (the suggestion is to update devices at the last version available). The app includes an 'Exercise Area', a 'Cognitive Area' and a 'Social Area'. Furthermore, it is provided of a 'setting' menu, an 'achievement section' and a 'statistics area'. Everything is connected to the Kiola Server and works according to the reasoning results.

Some other features will be implemented or fixed in the context of WP6 activities, according to feedback collected with users.

■ Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)

T5.2, as described above, was officially closed in M14. Nevertheless, several activities in Year 2 included design and development of the gamified environment. This decision was taken due to the close connection of the environment (that could be considered the main container of the app) and all the different areas (that could be considered the contents of the environment). The main impact of this expedient is to have a more integrated prototype, both from the usability, look&feel and from the general way to work point of view.

■ Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)

Not applicable

■ Explain deviations (if any) between actual and planned person-months (per beneficiary)

See Section 2.4 "Project management during the period"

- Corrective actions

Not applicable

2.3.6 WP6 Validation driven system integration at lab and pilot site

WP6 has the main aim to validate the driven system integration both at lab and pilot site. The activities will permit a progressive integration and validation of the sensors developed in WP3, the serious games in WP5 and components developed in WP4. The data collected have been annotated using data base/datasets during the lab activities according to the ground truth.

T6.1 (M14-27) includes two sections of activities: (1) collection of data regarding the activities of interest of elderly target groups. according to the requirements for activity recognition tasks developed in WP4 and by exploiting serious games in WP5 and the sensors developed in WP3 (2) pilot studies preparation activities conducted by pilot partners in UK and Italy.

T6.2 (M18-25) activities have the aim to integrate WSN and Context aware system and validate in the CIAMI living lab in Spain. The activities have been divided and conducted following a three-phased plan, including (1) integration and delivering of the WP3 components and deliver the WSN system (2) integration and testing of WP5 components, and part of WP4 components (Activity Recognition data pre-processing, Exploratory Data Analysis and Activity Recognition components) (3) the integration and testing of the reasoner and the dashboard components developed under WP4 and the final validation of the system according to the DOREMI use cases.

T6.3 (M20-30) activities include the conduction of three experimental studies to validate the Social and Gamified environment developed in the WP5. The experiments will involve aging population monitoring behaviors and engagement of participants. During these experiments information about the behavior style will be collected. A multiregressive model will be build, based on data obtained during these experiments to measure the impact of independent variable observed during the experiments on behaviors. These data will permit to identify the condition that makes effective the gaming intervention.

During T6.4 starting at M27, the validation of the integrated system will take place and refined by means of a multicentre longitudinal case control study. In the three enrolling centres (SI4life, Extracare and Accord) 40 subjects will be involved according to the inclusion and exclusion criteria defined in D2.3. All the collected data will be organized in a database suitable for statistical analysis. Parameters correlated with cardiovascular performance, cognitive abilities, social functioning, nutrition and physical activities will be collected.

■ Objectives

- The collection of annotated data base/datasets during the lab activities needed by WP4 to sustain and improve the quality level of the activity recognition and behavioral analysis system development.
- Perform lab validation of the WSN and smart environment enabling their integration and preparing to include the data provided by the validated serious games
- A virtual lab validation of the serious games performed by exploiting the community of users involved though the dissemination activities
- Set up the pilot site in Italy and UK for proof the concept of the fully integrated system in a real scenario of use

- Summary of progress towards objectives and details for each task

Task 6.1 Data Collection and pilot site preparation (CNR IFC) – M14-M27

The task is focused on the collection linked with DOREMI intervention areas, including physical activity (PA), dietary support and cognitive training. These data, obtained by means of different campaigns of tests and focus groups are reported in accordance with requirements of sensors developed in WP3, of activity recognition system in WP4 and gamified environment in WP5.

CNR IFC has dedicated its effort in this task to the Physical Activity (PA) data collection. This task was focused on two main items: balance board tests and PA environment. The work on balance board has foreseen a strong integration and collaboration with UNIPI and CNR ISTI. CNR IFC has worked with CNR ISTI on balance board development and modification in accordance with requirements of DOREMI protocol. CNR-ISTI collaborated with UNIPI on the development of a software tool to facilitate the process of data gathering and annotation. During the reference period, UNIPI has participated to the preparation of the data collection process, with the aim of guiding the phases of data gathering and annotation, through a progressive refinement of the scripts concerning the computational learning tasks “Person Meeting the user at home” and “Balance Assessment”. In this work UNIPI was also involved for activities on human activity recognition and CNR IFC has collaborated to define the user scenario.

These components are already employed in the context of the preliminary data collection concerning the balance evaluation. CNR-ISTI developed tools that allow curation and extraction of smart carpet data from the database and CNR IFC has collaborated to define the physiological meaning of the tests performed over the balance board. These activities produce datasets according to WP4 requirements in terms of annotated data and data format. Pilot sites partners expressed safety concerns regarding the placement of the smart carpet at the side of the bed. The resulting discussion brought to a change in the smart carpet usage scenario for the pilot. Partners decided to discard the sitting-to-standing scenario and adopt a new one where the user steps on the device, while standing, to perform some BERG test exercises. Preliminary data collection scripts were modified accordingly.

During this reference period tests with balance board were focused on the evaluation of a series of items derived from Berg balance scale test. CNR IFC has selected 25 potential users presenting an age between 65 and 80 and with Berg value between 31 and 56 (the class between 1 and 30 was a priori excluded falling in the exclusion criteria of DOREMI; see D2.3, Annex F), already following the Inclusion and Exclusion criteria defined in D2.2. These users were visited by a CNR IFC clinician and were evaluated through the 14 items of Berg scale: at the end a score distribution table was obtained. In 4 different sessions between November 2014 (M13) and May 2015 (M19), after data analysis of score distribution, the selected users were subjected to Balance board tests, replicating items 6, 7 and 10 of Berg scale (see D2.2, §11.5): these three items were selected because of its wide spread score among the studied population, allowing to investigate accuracy of HAR analysis in a large range of test's response. Furthermore, these three items proved to be safe and feasible in all participants. Data analysis of balance assessment was presented in D6.1. The data were collected by CNR ISTI to test the hardware and by UNIPI to feed the DOREMI reasoning system: this system, once in pilot sites, will perform the daily users' evaluation of balance assessment.

CNR IFC has focused also its work on PA environment. CNR IFC has defined the entire PA protocol and its clinical performance indicators, presenting also the entire documentation to CNR Bioethics Committee to obtain approval for experimentation in humans, which was released on 16/02/2015. Furthermore, CNR IFC has recorded PA exercises videos necessary to show, via app, the entire protocol to users and has developed an alpha in-house version (iOS version) of app. CNR IFC has organized a meeting (03/02/2015, Milan) to work with IMA on the PA app, which will be integrated in DOREMI environment (Android version). In this meeting the user interface, user interaction

modalities and type of data to be collected were discussed. CNR IFC supported the development version testing the app during PA test sessions (M19), jointly organized for project activities of WP3 and WP4. In these sessions, users have performed the entire PA protocol collecting their data (heart rate, blood pressure, oxygen consumption, energy expenditure in terms of Kcalories, accelerometer data) and testing app user interface usability and interaction. For point 2, the DOREMI PA protocol was developed during T2.2 (WP2). This is composed by 21 exercises, which have been devised following the World Health Organization guidelines. In addition, the Chair Sit to Stand Test (CSST) will be performed, as Autotest, at the end of the physical activity protocol. Data pertaining to Physical Activity assessment has been collected following the specification of the computational task “Physical Activity Level” in D4.1, whose aim is to quantify the levels of physical activity, in terms of caloric consumption, during the execution of the DOREMI physical activity protocol and develop the PA activity recognition system for PA. In particular, caloric consumption was strictly related to heart rate evaluated through bracelets, both commercial and MYSPHERA one. Ground-truth data consist, for metabolic rate, in a series of measurements (calories per minute) over the execution of each exercise collected using a professional metabolic measurement system (Cosmed K5); for heart rate, a GARMIN chest band was used as gold standard. For annotation of start and the end of each exercise a custom made applications were developed by CNR-ISTI.

The schedule of the data collection rounds was adapted to support the partners of WP3 in the development of the wristband. In particular, the development of the wristband suffered from some initial delay due to hardware production, which required a reshaping of the internal timing of development. WP6 thus scheduled the data collection rounds right after the delivery of the various intermediate versions of the wristband in order to provide tests essential for the identification of bugs and improvements of the signal processing firmware.

Specifically, three different data collection round were performed: one in July-August (M21-22) by CNR-IFC, one in October (M24) by CNR-IFC, and a third in November (M25) performed by CNR, MYSPHERA and UNIPI, for a total of 25 users. CNR-IFC followed Inclusion and Exclusion criteria defined in D2.2 for user selection. Cardiologists collected biometric data, a brief anamnesis and information about pharmacological treatment as also blood pressure and oxygen saturation, heart rate data. Users were invited to perform physical exercises: 21 exercises + CSST test (as described in §3.3.2 D6.1). During the first round, for heart rate assessment, LG G Watch Urbane (commercial device) and DOREMI bracelet (1st version) were tested, while in the second round, Mio Alpha 2 (commercial device) and DOREMI bracelet (2nd version) were used. In the third round, the final version of the DOREMI bracelet is being used. Data analysis was presented in D6.1 and D6.2.

DMU, IMA, ACCORD, EXTRACARE and SI4life have performed testing sessions of the games prototypes and the gamified environment. To test them 4 focus group data collection has been conducted, 2 in Italy and 2 in UK involving people aged 65-80 that comply with the inclusion/exclusion criteria described in D2.3. Based on data collected and feedback from users, several modifications have been implemented in the refinement of the games. SI4life and IMA have worked on data recording and visualization for the users. At the end of the testing sessions, this process permitted to increase the usability and accessibility of the WP5 components. CNR-IFC was involved in the development of the UK version of food database to be integrated in METADIETA app. This work was in collaboration with METEDA and the Dept. of Food, Environmental and Nutritional Sciences of Milan University. CNR-IFC have worked at definition and refinement of UK foods as also at the integration of some Italian foods useful to support the Mediterranean diet guidelines for healthy diet, according to the NU-AGE project and the developed diet pyramid over 65.

The second part of task is dedicated to the pilot site preparation, the preliminary activities of recruitment and enrolment of participants.

Maps, blueprints and pilot sites information have been gathered in order to perform a preliminary design of the installations in the different pilot sites. The distribution of devices was agreed between WP3, WP4 and WP6 teams to optimize the data availability and the user acceptance.

There was a physical meeting in UK between MYSPHERA and the partners responsible for the UK pilots (Accord and Extra), where details about the site preparation were discussed, an in-site analysis of the user routines and needs was performed, and the technical details of the installation of the devices were also assessed. All these activities have been conveniently documented in minutes and reported to the involved partners. The results of the information obtained from the partners in charge of pilots have been processed and discussed in several WP3 and WP4 meetings. Conclusions of this work have been written down in the deliverable D3.1 resubmitted on February 2015.

DMU have been involved in meetings with ExtraCare and Accord to plan recruitment activities for the UK trial. Awareness raising activities began at M20 and involved: presentations at meetings; posters; letters; and one to one targeted recruitment of suitable participants. Actual recruitment started at M24 and involves a dedicated staff member at each site

SI4life has conducted internal meeting to plan the activities to prepare the pilot sites and the recruitment of subjects. Si4life have designed the Case Report Form (CRF) and eCRF to permit uniformity in the pilot sites studies data collection. DMU, Accord, Extracare, CNR IFC have refined the design of the training phase, based on user requirements collected by pilot sites partners. CNR IFC is tuned with the other clinical partners in designing the material that will be used during the training phase, including written guidances on physical activity and correct dietary habit. Furthermore, during baseline and training phase of trial in the UK sites, CNR-IFC will carry out: tests to measure metabolic parameter and body mass composition with BIVA system, training the local staff in its use; dynamic tests such as 6MWT to collect in DOREMI participants physiological parameters (blood pressure, oxygen saturation and heart rate); tests to evaluate user functional exercise capacity, by 6MWT, and balance assessment by BERG test; collection of user dietary habits, with support of METADIETA app, and generation of Users' Personalized Dietary Plan. SI4life with technical partners started working on the user manual that will be left to the users during the intervention phase. The user manual has been reviewed to be accessible and usable for the DOREMI target users. A skills analysis has been conducted by Si4life to map the competencies in administering tests that will be conducted during the Sample selection, Baseline and intervention Phase of the pilot studies on the pilot site staff. Training activities for the pilot partner's staff have been planned, to fill the gap. The training for the pilot partner's technical staff has been planned by the WP leader to conduct the installation phase in autonomy.

Task 6.2 Living lab validation and integration of WSN and Context aware system (CNR ISTI) – M18-M25

During the reporting year, the effort has been spent mainly in two tasks: integration of components developed by different partners under WP3-WP4-WP5 and the validation of the context-awareness system.

System integration started at month 18 with a three-phased plan. The first phase consisted in integrating WP3 components and delivers the WSN system. WP3 partners started to discuss aspects regarding the integration and testing of the system, producing a time schedule for the integration of the WP3. Details regarding services hosting and sizing of hardware resources were defined during the first month. CNR-ISTI and MYSPHERA completed the task of integrating environmental and wearable sensors during the first 2 months accounted for the task, producing a preliminary solution for data gathering. The latter was refined many times over the following months, meeting the requirements of WP6 and WP4 partners on data quality, system usability, deployment and maintenance ease.

The final aim of the first phase of the integration was to set up a staging environment in the Living Lab of Valencia, hosted in MYSPHERA premises. An event of one week was scheduled at the end of June 2015 for the final setup of the staging environment, where WP3 and WP4 partners participated. Apart from validation the WP3 system, the Living Lab environment was leveraged, during the same event, in order to collect data and ground truth for the indoor socialization WP4 task.

Second phase started with the early results of the first phase and consisted on the integration and testing of WP5 components, namely the gamified environment and the diet applications, and part of WP4 components (Activity Recognition data pre-processing, Exploratory Data Analysis and Activity Recognition components). Sample data was collected using WP3 systems in order to validate the whole data processing chain. Integration of data processing components with WP3 Sensor database, Kiola database and the auto-configuration system already started in June. It will be completed and validated by M25.

Third phase consisted in the integration and testing of the reasoner and the dashboard components developed under WP4 and the final validation of the system according to the DOREMI users and dashboard users use cases. Validation of reasoner rules has been performed by producing unit tests considering all the possible inputs and expected outputs of the system. Final validation and integration of system components will be performed at M25 with the Living Lab integration event in Valencia, where the availability of a staging environment will allow collecting data and testing all the users related use-cases.

In order to organize the activities in the latter months of the reporting period, T6.2 leader started weekly coordination meetings in September, involving all partners of WP3, WP4 and WP5, and allowing scheduling the final system integration event in Valencia Living Lab at month 25.

Validation of Activity Recognition models was performed by collecting data as part of T6.1 activities by applying standard machine learning validation schemes for training, model selections and performance assessment of the Activity Recognition components (detailed in D4.1 section 8). To this end, many data collection events were scheduled over the second year in order to collect data, using systems developed by WP3 and WP4 partners, along with ground truth, supported by WP2. The data collection events regarded the 3 tasks on which the supervised Activity Recognition solution is focusing on: balance assessment, indoor socialization and calories expenditure estimation. The data collection events are reported by task T6.1 in the deliverables D6.1 and D6.2. Outcome on the validation of HAR model will be detailed in deliverable D4.3 (M33). For this activity, CNR-IFC has collaborated to the validation of activity recognition system focused on: balance assessment, by the use of Wii Balance board and a customized data analysis software useful for its daily unobtrusive evaluation; Physical Activity Level assessment, necessary to quantify the levels of physical activity as caloric consumption (see T6.1); Data analysis of physiological parameters collected (see D6.1 and D6.2).

Task 6.3 - Validation of Social and gamified environment through behavioral analysis (UOC) - (M20–M30)

The duration of the Task 6.3 is from M20 to M30, starting from the definition of the experimental protocol until the conclusion of the experimental sessions, the first part of which using a cross-sectional design through an online panel and the second one longitudinally, through a real-world experiment. The objective of the validation study can be divided in two parts: On one hand, for the online panel study, to test whether the presence of social nudges while playing online cognitive games can increase participants' engagement with them and on the other hand, for the longitudinal part of the study, to test whether a social gamified environment is effective in achieving behavioural shift, in terms of improved performance of the elderly in the online cognitive games.

As regards the specific activities that task leaders and the clinical and technical partners have been carrying out in the last year includes (1) the design of the experimental protocol for the online panel validation study (2) the preparation for the experiment with the online panel has been carried out during and consisted of the following steps: online user community engagement, specification of the recruitment procedure and definition of the on line check-list related to behavioural style of the participants (through self-report questionnaires) (3) adaptation of the social and gamified environment in an online version, definition of the experimental conditions and incorporation of social nudges (mock-up) by the technical partners. In M25, the online panel study is expected to start and it will finish in M26, when the specific experimentation protocol for the second study is going to be defined, also incorporating once feedback from the online panel study. Next, from M27 until M28, the longitudinal experimental study will be carried out. Finally, in M29 the data analysis will be carried out in order to build multiregressive models to measure behavioural shift or different levels of engagement with the online games depending on the various experimental conditions (presence or not of social nudges, type of social nudges) and on the controlling variables.

Task 6.4 - Validation of integrated system and refinement (SI4LIFE) - (M27–M36)

To be started at M27

■ Significant results preparatory to the task

- Developed tools for preliminary data collection for balance analysis
- Preliminary balance data collection
- Data collection and ground truth for the indoor socialization WP4 task
- Usability and accessibility for the cognitive games
- Usability and accessibility for the gamified environment
- Usability and accessibility for the social nudges
- Usability and accessibility for the exergames
- Plan for system integration and validation agreed by the consortium (Valencia, June 2015)
- Defined data model for sensor data on Raw Sensor Database
- Completed integration of WP3 components
- Integration and testing of WP5 components and part of WP4 components
- Defined Kiola data model for data generated by low-level data processing tasks
- Defined list of test cases for the system integration and validation event (Valencia, M25)
- Experimental protocol for the online panel validation study of the social and gamified environment
- On line check-list related to behavioural style of the participants
- Adaptation of the social and gamified environment to the online requirements

- Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)

The Consortium decided some changes of WP6 tasks timelines, already mentioned in the period 1 Project Report, to allow for data collection in parallel with the development phase of the WP3, WP4 and WP5 components, to deliver the validated WSN and Context aware system validated in the living lab within the starting date of the pilot studies (M27), to adapt Social and gamified environment to the online requirements and for conducting studies to validate the social and gamified environment

Summarising:

- Task 6.1 Data collection and pilot site preparation has started with data collection at M14 (instead of M25) and will end at M27
- Task 6.2 Living lab validation and integration of WSN and context aware system has taken up at M18 instead of M20 and will end at M25
- Task 6.4 Validation of the integrated system and refinement has been anticipated at M27 and will end at M36
- Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)

Not applicable

- Explain deviations (if any) between actual and planned person-months (per beneficiary)

Not applicable

- Corrective actions

Not applicable

2.3.7 WP7 Exploitation, Dissemination and IPR

The work package 7 is aimed at upscaling at EU level the results achieved by the project.

In the second year of the project development the WP7 activities were concentrated on the development of the competitive and market analysis of the alternative products to DOREMI and in the understanding of DOREMI component and of the whole solution market positioning. Moreover we have fine-tuned the dissemination and exploitation channels with relevant stakeholders as well as we have worked in defining a dissemination protocol to address the various target audiences that we identified with a more personalized dissemination plan, that is under development during this period. Furthermore, a second questionnaire on exploitation was distributed amongst partners in order to get more detailed information on DOREMI products and services characteristics, on the preferred market segment for exploitation, on potential competitors, on the criteria for establishing IPR and on the individual exploitation activities that partners are conducting for DOREMI.

■ Objectives

- To assess the expected impacts of the project at EU27 level in relation to the emerging trends of the ageing population in EU Member States;
- To disseminate the project outcomes in EU27 at large through social media and targeted actions;
- To design and to set up an exploitation process of the project results in line with the specificity of the DOREMI consortium members and the characteristics of the Ageing Marketplace in EU27.

■ Summary of progress towards objectives and details for each task

This work package includes the dissemination and exploitation activities of the DOREMI project and will be implemented with the contribution of all project partners under the leadership of UOC, while CNR-IFC leads the dissemination task (task 7.4). In this reporting period the partners mainly focused their WP7 activity on conducting dissemination activities, and analysing the competitors and the potential market of DOREMI. They also updated their information provided in the previous year questionnaire on their products, their exploitation interest, their preferred market and their position in it, their opinion on criteria for establishing IPR, etc. Furthermore, they provided extra information on their target user group, their cost structure, potential payers and pricing models and exploitation strategy. In parallel we have fine-tuned the dissemination plan and related activity to support the diffusion of the project's results and their exploitation as well.

A list of dissemination activities carried out by the partners is also provided.

Task 7.1 - Development of exploitation and dissemination plan (UOC) – M3-M5

Completed

Task 7.2 – Market assessment and outline of the business plan (UOC)

(M10-M15; M23-M24; M35-M36)

UOC has coordinated the revision of the D7.3.1 (“Updated Exploitation plan and business plan – IPR rules”). The revision of the Deliverable was aimed at including the “Competitive analysis” of the existing and /or emerging products that other organizations competitors of DOREMI consortium have already on the market or they are planning to launch in the marketplace during the DOREMI project timeframe.

This revision was necessary to reply to the 1st review report item R12 - Clearly define the added value of the DOREMI concept based on a proper benchmark of existing or emerging solutions.

To this end UOC and CNR- IFC in collaboration with the technical partners updated the D7.3.1, by adding an additional chapter (namely “Chapter 7 – Competitive analysis”) where the reviewers’ indications were addressed.

Regarding the item R9 - Consortium should evaluate future cost of the system and potential price per user for future exploitation. This will help identify payers’ target, considering the current stage of the project (prototypes are not ready yet) an accurate price analysis and benchmark with the market available solutions cannot be performed. D.7.3.2 included some prices of DOREMI competitors, however since many costs of DOREMI products are not available; the comparison cannot be performed yet.

The core activities that were deployed to complete the Chapter were: internet search and technical partners interviews to identify a competitors’ list for the different components of DOREMI solution; detailed analysis of the characteristics of the identified products through company websites, phone calls and review of the promotional and technical material; definition of the methodological approach for the evaluation of the products’ performances and their comparison amongst them and with DOREMI solution; definition of the evaluation criteria for the comparison; collection of data from the producers; definition of the “magic quadrant of Gartner” for each group of products in relation with each component of DOREMI solution; analysis and validation of the results; reporting. This analysis was expanded in d7.3.2 by updating the characteristics of the products previously considered and by including new competitors that were later identified.

The exploitation plan previously outlined in d7.2 and 7.3.1 was further developed by distributing a new template to partners so that they could update their information and provide more inputs. This allowed to update the exploitation plan. This exploitation plan specified which end-users, countries, actors and DOREMI components should be given priority during the commercial exploitation. Partners also updated their individual exploitation plan.

Task 7.3 – Impact assessment on Health Care system and on society at large (UOC) - (M10-M15;M23-M24; M35-M36)

UOC has further developed the literature review on the typologies of health care systems existing in EU27 in order to classify impact indicators that are currently used by MS in assessing the performances of their health system. Moreover, these indicators will be used in the impact evaluation framework that will be used to assess the impact of DOREMI solution up-scale on the European health systems.

An extrapolation accounting framework will be used, which will link data from national statistics, DOREMI pilot sites results and DOREMI costs. Available data in national and international databases will be collected regarding the prevalence of the conditions that DOREMI is targeting (malnutrition, sedentariness, and mild cognitive decline) and health costs. Moreover, the results from the pilot sites will be used to estimate the potential effect of DOREMI on decreasing the prevalence of these conditions and thus, on increasing the quality of life of the elderly and diminishing health expenditure. In order to determine the global impact, expected benefits will be compared with the expected annual

costs of DOREMI deployment. For this, we will use information on disease prevalence, DOREMI production costs (to be provided by technical partners) and the potential users.

In addition, CNR-IFC is working, in M23-M24 to prepare a proposal for the regional call for Public Town Planning Intervention (Programma PIU) focused on the development of Smart Social Houses, with particular attention to improve elderly people socialization through exergames and to integrate DOREMI solutions related to diet and physical activity.

Task 7.4 – Dissemination activities (CNR-IFC) – M3-M36

CNR-IFC together with UOC and AGE platform has improved the dissemination plan of the project with the definition of concrete collaboration protocol amongst the partners to maintain an active presence of the project interim outcomes on the main on-line social network (Facebook and Twitter). Moreover they have worked for the definition of more personalized dissemination activities in relation to the various target audiences that would be interested to DOREMI solutions and achieved results.

In December 2014 DOREMI Newsletter #2 and in July 2015 Newsletter #3 were published.

D7.6 (Dissemination activity report) was submitted in May. The report contains the description of the dissemination activities performed by the Consortium, the revision of the Dissemination Plan and the planned dissemination activities for the rest of the year.

All involved partners contribute to the dissemination of the project results under the coordination of CNR IFC. In the section below “Significant results” the work performed by each partner in the reporting period is described.

▪ Significant results

Dissemination

- Project website publicly available
- Newsletter #2 (December 2014)
- Newsletter #3 (July 2015)
- Submission of dissemination activity report (D7.6) (11/05/2015). Detailed dissemination activities per partner:

CNR IFC

- Participation at European Summit on Innovation for Active & Healthy Ageing, Brussels, March 9-10, 2015. Contact with Partners of Persilaa Project for synergic research activities with DOREMI.
- Newsletter #2 (December 2014)
- Newsletter #3 (July 2015).
- Facebook and Twitter updates.
- Participation at EXPO workshop “An integrated approach to active and healthy living: the possible synergies of the nutritional interventions”, Milan, October 20, 2015.

- Collaboration with PERSSILAA, FP7-ICT funded project: DOREMI will collaborate to develop new solution for frailty screening and prevention.

CNR ISTI

- Paper on preliminary results obtained in the application of semi-supervised stigmergic-based techniques on testing datasets has been published on the Pervasive and Mobile Computing journal by Elsevier [1]: P. Barsocchi, Mario G.C.A. Cimino, E. Ferro, A. Lazzeri, F. Palumbo, and G. Vaglini. "Monitoring elderly behavior via indoor position-based stigmergy". Pervasive and Mobile Computing, Volume 23, October 2015, Pages 26-42, Elsevier.
- Conference proceeding of the 12th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS) on the stigmergic approach applied to Bluetooth Low Energy beacons aiming at providing indoor localization information has been published: F. Palumbo, P. Barsocchi, S. Chessa, J.C. Augusto. "A stigmergic approach to indoor localization using Bluetooth Low Energy beacons". Advanced Video and Signal Based Surveillance (AVSS), 2015 12th IEEE International Conference on, August 2015, Pages 1-6, IEEE.
- Paper on technique aimed at improving the accuracy of the DOREMI indoor localization system exploiting the information coming from the environmental sensors activations has been published on the Journal of Ambient Intelligence and Smart Environments by IOS Press: F. Potorti, F. Palumbo. "CEO: A context event only indoor localization technique for AAL". Journal of Ambient Intelligence and Smart Environments, Volume 7, No. 6, November 2015, Pages 745-760, IOS Press.
- Paper accepted for journal publication on experimental assessment of the learning models, including a comparison between different neural networks architectures, using benchmark human activity recognition data: F. Palumbo, C. Gallicchio, R. Pucci, A. Micheli, "Human Activity Recognition using Multisensor Data Fusion based on Reservoir Computing", Journal of Ambient Intelligence and Smart Environments, IOS Press, ISSN 1876-1364, 2015, (In Press).
- Participation at the XVII Portuguese Conference on Artificial Intelligence (EPIA2015), thematic track on "Artificial Intelligence in Medicine" with a paper describing WP4 system architecture and discussing the exploitation of human activity recognition and reasoning to monitor the elderly and to empower them to follow a lifestyle protocol for active aging: C. Gallicchio, A. Micheli, L. Pedrelli, F. Vozzi, O. Parodi, "Preliminary Experimental Analysis of Reservoir Computing Approach for Balance Assessment", Proceedings of the 1st International Workshop on Advanced Analytics and Learning on Temporal Data co-located with The European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML PKDD 2015), Porto, Portugal, September 11, 2015, CEUR Workshop Proceedings, vol. 1425, pag. 57-62, 2015.

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- O. Parodi, F. Vozzi, E. Ferro, L. Fortunati, A. Micheli, D. Bacciu, C. Gallicchio, S. Chessa, A. Ascolese "Preventing cognitive decline, sedentariness and malnutrition: the DOREMI approach", CINI Annual Workshop on ICT for Smart Cities and Communities (I-CiTies 2015), Palermo, October 29-30, 2015,

AGE

- Presentation of the project in various settings:
- Newsletter #2 (December 2014).
- Newsletter #3 (July 2015).
- Presentation of DOREMI at the "Measuring the specific socio-economic Benefits of a locally connected Gigabit-Society", Brussels (January 2015).
- Presentation of DOREMI at the "DG RTD Public Health Research Workshop", Brussels (January 2015).
- Presentation of DOREMI at the "Policy debate on health literacy hosted by MEP Heinz Becker at the EP", Brussels (January 2015).
- Dissemination of DOREMI at the "JAMToday Fair 2015", (February 2015).
- Dissemination of DOREMI at the "European Summit for Innovation for Active and Healthy Ageing" (March 2015), in collaboration with CNR-IFC.
- Dissemination of DOREMI at the "AAL2Business – Consortium Building Workshop" (March 2015).
- Presentation of DOREMI at the "AGE Council of Administration meeting", Brussels (March 2015).
- Dissemination of DOREMI at the "Health Literacy in Europe. Empowering patients - how can technology contribute to improving health literacy?" (July 2015).

IMA

- Participation at MHCT: "Mobile Health Care and Training", Thessaloniki, Greece, 12-14/11/2014.
- Participation at Segamed 2014, Nice, France, 06/12/2014.
- Participation at CEBIT, Hannover, Germany, 18-20/03/2015.
- Participation at REHAB, Karlsruhe, Germany, 23-25/04/2015.
- Participation at Connected Health, Monaco, France, 10/06/2015.
- Participation at 2nd Italian Digital Health Summit, Milan, Italy, 16/06/2015.
- Participation at Connected Health, Monaco, France, 10/06/2015.

- Participation at Ernst & Young “LIFE SCIENCES EXECUTIVE INFORMATION DINNER: APPLIED INTERACTIVE TECHNOLOGIES”, Frankfurt, Germany, 14/07/2015.
- Participation at Serious Games Conference, Singapore, Singapore, 14-16/08/2015.
- Participation at IED Immersive Education conference, Paris, France, 07-10/09/2015.
- Participation at Rehab@Home Event, Milan, Italy, 15/09/2015.
- Participation at #Sgames 2015 - 5th EAI International Conference on Serious Games, Interaction and Simulation, Novedrate, Italy, 18/09/2015.
- Participation at TeleMediCare 2015. Tele-Medicine & Tele-Care for elderly and disability People, Desio, Italy, 01-02/10/2015.
- Participation at V workshop neuroinformatica Neuroimaging, neurorobotica, neuroriabilitazione, neurogenerazione, Milan, Italy, 30/09/2015.
- Participation at ICT 2015, Lisbon, Portugal, 20-22/10/2015.
- IMA newsletter (February 2015).
- Workshops to presents DOREMI solution and exploit collaboration, Daejeon, South Korea, 08-13/04/2015.
- Article “I giochi che insegnano a vivere meglio” on the main Italian Financial Newspaper “Il Sole 24 Ore”, 27/04/2015.
- Games presentation and NHS test bed, London, UK, 29/07/2015.
- Games presentation and NHS test bed, Manchester, UK, 03/09/2015.
- Drafting of book chapter “Musian, D. & Ascolese, A. (2015). Gamified Cognitive Training to Prevent Cognitive Decline. In D. Novák, B. Tulu, & H. Brendryen (Eds.), Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice. Hershey, PA: IGI Global”.

Exploitation

- Revision of D7.3.1 by including competitive analysis of DOREMI solution’s components and their positioning in the Gartner’s Magic Quadrant.
- Submission of D7.3.2 (04/11/2015) by updating the information included in the previous deliverables, extending the competitive analysis, and expanding the exploitation plan with a focus on commercial exploitation. The plan indicated that the main user target of the commercialisation activities would be the elderly between 60 and 85 years old, but that other relevant actors will also be targeted because they can act as purchasers, payers or providers of DOREMI solution and components. The most relevant actors for DOREMI are hospitals, nursing homes, local and regional authorities and groups of elderly citizens. Moreover, the commercialisation will first take place in Italy, Spain and the UK, countries in which the consortium is better positioned, but with the intention to expand soon to the other EU countries and probably to other regions in the world. Furthermore, the elements to exploit during the first phase will be the components of the monitoring environment and the social and gamified environment and the whole DOREMI solution.
- Presentation of DOREMI balance assessment and Physical Activity protocol to Nintendo Italia for potential collaboration and development of products.

- CNR IFC has reinforced the collaboration with NU-AGE, FP7-KBBE funded project, by skype, email, meeting during EXPO2015 exchange of information on projects' progression between the two coordinating teams. DOREMI and NU-AGE are interacting to find out common goals and link between the results of NU-AGE trial (design a new food pyramid for those over 65 years old to meet the nutritional needs of the elderly; assess the influence of correct diet on inflammation, one factor in the development of age related diseases such as atherosclerosis, type 2 diabetes and neurodegeneration leading to cognitive decline) and DOREMI pilot study that will be conducted at the beginning of 2016 (WP6). DOREMI has received from NU-AGE several suggestions on Mediterranean diet for trial, which will be reported in the diet guidelines distributed to the trial participants. DOREMI will in turn monitor biological and anthropometric parameters of interest for NU-AGE in the trial population.
- On February 2015, CNR IFC, as project coordinator and responsible for nutrition and sedentariness tasks in DOREMI, agreed to open a collaboration with DEDIPAC KH project (Determinants of Diet and Physical Activity Knowledge Hub; www.dedipac.eu, University of Limerick leader), currently developing a compendium of all European datasets and studies focusing on determinants of diet, physical activity and sedentary behaviour. The dataset of DOREMI pilot study has been requested by DEDIPAC coordinating team, to be included in the European compendium.
- By February 2015, the project coordinator made request to the Action Groups of EIP-AHA-A3 Nutrition- to join the Group on Area 1: Screening and assessment of malnutrition as a risk factor for active and healthy aging. CNR IFC committed in the following tasks:
 - ✓ 5.1 Objective: Manage frailty and functional decline through targeted intervention: Develop physical exercise training programs and physical activities tailored to older frail people and with functional decline.
 - ✓ 5.2 Objective: Manage frailty and functional decline through targeted intervention: Develop nutritional and hydration plans, and cognitively, physically and intellectually stimulating social activities to improve independent daily living and mental wellbeing in target populations.
 - ✓ 5.3 Objective: Manage frailty and functional decline through targeted intervention: Software program and ICT devices for feeding and food related tasks. CNR IFC is now engaged in the activities of AG A3, through the nutritional and physical activity protocols developed in DOREMI project.

Specifically, CNR IFC will be involved in the development of an ICT platform able to integrate comorbidities, risk factors, and functional/anthropometric data in elderly people.

- Deviations from Annex I and their impact on other tasks as well as on available resources and planning (if applicable)

Not applicable.

- Reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (if applicable)

Not applicable.

- Explain deviations (if any) between actual and planned person-months (per beneficiary)

Not applicable.

- Corrective actions

Not applicable.