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I-SUPPORT

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I-Support: ICT-Supported Bath Robots

Deliverable Title:
Progress Report I

Responsible Partner:
ROBOTNIK

Research & Innovation Actions

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Abstract **(for dissemination)**	This document presents the progress report of the first six months of the Horizon2020, RIA project I-SUPPORT. During the period M1 - M6 consortium addressed several tasks and provided results for: user requirements, system requirements, ethics requirements, system's component selection and design, overall system architecture and design, experimental set-up design for data collection experiments for machine learning, theoretical formulation for learning and control of soft-arm robot

	motion. Furthermore the consortium accomplished the tasks related to dissemination of I-SUPPORT early results such as uploading the project website (www.i-support-project.eu), preparing and distributing project brochure, and participating in conference and workshop events. The management, the coordination and the quality control of the project have been conducted without any problems. All tasks are evolving according to the initial plan described in the DoA, Annex I.

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1 Summary of progress for the period M1 – M6

This document presents the progress report of the first six months of the Horizon2020, RIA project I-SUPPORT. During the period M1 - M6 consortium addressed several tasks and provided results for: user requirements, system requirements, ethics requirements, system's component selection and design, overall system architecture and design, experimental set-up design for data collection experiments for machine learning, theoretical formulation for learning and control of soft-arm robot motion. Furthermore the consortium accomplished the tasks related to dissemination of I-SUPPORT early results such as uploading the project website (www.i-support-project.eu), preparing and distributing project brochure, and participating in conference and workshop events. The management, the coordination and the quality control of the project have been conducted successfully. All tasks are evolving according to the initial plan described in the DoA, Annex I. A brief description for every WP follows:

In **WP1**, the user group was defined as home dwelling older persons with beginning ADL deficiencies as primary users. This group is still able to live independently, but is at high risk for adverse events, e.g. falls, and loss of autonomy and experience mild or moderate functional disabilities. Established assessment strategies for major criteria of the I-Support user definition addressing the functional as well as the cognitive status have been described and an outlook for related steps within the project has been agreed. A detailed presentation for the methodological approach and methods for the first user analysis has been conducted. Overall 30 primary users and 15 healthcare professionals were interviewed with interview guidelines. Results and conclusions are drawn for the requirements of the I-Support System. Work has been done for scheduling the ethical approval of I-SUPPORT system. Investigation carried out by the clinical partners indicated there is no need for ethical approval for the interviews but an ethical approval is definitely needed for the pilot studies. The clinical partners defined the time-plan that will be followed and the input needed by all partners for meeting the ethical requirements and attaining ethical approval on time. Safety requirements that are pertinent to the I-SUPORT system have been identified and all designs will comply to these requirements. Partners performed a requirements analysis and developed functional and performance requirements and determined design constraints. High-level use case scenarios were defined and were resolved into flow of events that demonstrate how the system should interact with the user.

In **WP2** higher-level functions were decomposed into lower-level functions to acquire a better understanding of how functions will be technically implemented. Design synthesis was conducted where the partners defined I-SUPPORT technological concepts and components in terms of physical and software elements, which together make up and define the system. The result is referred to as system (hardware and software) architecture where each concept and component meets at least one functional requirement. Technical specifications were derived and all hardware and software components were selected. Adaptations were specified for each components and subsystem. A first design iteration of the overall I-SUPPORT system has been completed. The topology and interfacing of each hardware component within the shower environment has been investigated and different options have been proposed and have been illustrated. The immediate next actions are the selection of the most efficient configuration of the system.

The existing soft robotics technologies have been reviewed in **WP3**. Users' needs, system functionalities, safety and ethics issues pointed out from WP1 have been considered (evaluated) during the first prototyping phase. The most suitable solution for the development of the actuation system has been identified: pneumatic actuators operating in a soft-bodied chamber in combination with cables. We have implemented and tested a preliminary arrangement of the basic actuation units (McKibben-like actuators and cables) in a design of the entire soft arm made of three modules. A first sketch of the motorized chair has been developed in **WP3**. The chair is composed of 2 DOF: one linear horizontal axis to enter and exit to/from the bathing area and a rotational one to move the chair left and right. The inclusion of an extra degree of freedom (vertical axis) on the chair to help the senior in the sitting procedure is under study.

Depth sensor technologies were tested in **WP4**. We selected those who operate using time of flight principle in order to avoid IR interference. These will be used for robot and pose estimation, gesture recognition and environment 3D reconstruction. They will be located inside the shower cabin and will be waterproofed. Force sensor will be embedded into the soft robot arm end-effector. Audio sensors commercially available were investigated and compared. These will be installed in the shower cabin to enable verbal interaction modality. Both vision and audio sensors information will be fused to provide increased success rates for gesture and action recognition. Context awareness sensors will be installed to measure environmental variables. Wearable sensor (Smartwatch) will be used to detect fall and user inactivity. Remote controller has been selected with embedded gyro and accelerometer that can be used by the user in order to tele-control the motion of the robot.

In **WP5** a data collection framework has been developed in order to facilitate the data collection experiments for learning by demonstration, for machine vision and for gesture and action recognition. Data collection experiments have been conducted involving depth sensors, force sensors and audio sensors all integrated in a ROS environment and synchronized using software triggering. Collected data is post-processed, labeled, and uploaded to the KIT Whole Body Motion Database. A motion representation methodology has been designed which will enable the robot to adapt to the user's motion. The basis for a theoretical framework has been developed for learning by demonstration motion primitives of the soft robot arm and for adapting these primitives to users motion and particular characteristics (dimensions, preferences, etc.)

In **WP 7** a detailed dissemination plan has been completed and documented and several dissemination activities have been already conducted. Website has been launch and updated. A brochure has been prepared and published and has been distributed in several events including Researchers Night (In Italy and Greece), IROS2015 workshop, and other conferences. In **WP8** IPR issues have been clarified and agreed by the partners and documented. Quality management plan has been completed and indicates the procedures that should be followed by the partners for the decision-making, the partners' roles, the timely completion of the deliverables and the consortium communication. A kick off meeting was conducted on the first day of the project (March 2, in Rome) and Skype project meetings have been conducted on a monthly basis and more frequent Skype meetings have been scheduled within workgroups (data collection workgroup, hardware design workgroup and user requirements and ethical issues workgroup). The next project meeting is scheduled for 17-19 of September in Athens.

2 Work progress and achievements during the period M1 – M6

2.1 WP1 User requirements, system functionalities, safety and ethics

2.1.1 Objectives for the period

- Definition of the potential user group
- Model of user requirements, based on a clinical model of frequent geriatric impairments and limitations
- Derivation of initial use case scenarios from a clinical perspective
- Model of user abilities and behaviour with regarding to bathing from the user and carer perspective
- Definition of final use case scenarios and I-Support technical implementations
- Sociological, gender and ethical considerations
- Safety requirements

2.1.2 Progress and significant results

- **T 1.1 User definition (Bethanien)**
  - **Progress:** A report was completed in M4. It is part of D 1.1, which is due to submission in M7.
  - **Significant result:** The suggested user definition is purposefully restricted to only two major clinical criteria, which relate directly to the target function of the I-Support device (shower function) and to cognitive status as a main defining criteria for instrumental handling of the shower robot. ***Inclusion criteria*****:** The ADL item “bathing/shower” gives a dichotomous decision between “independent” and “dependent” and will be used as a clear defining criterion for the main functionality of the I-Support project (support in shower activities). The MMSE-Score allows classifying the cognitive status. Category 1 “No cognitive impairment” (MMSE 24-30) and category 2 “Moderate cognitive impairment” (MMSE 18-23) will be included. Selected criteria for cognitive impairment will comprise the majority of patients admitted to geriatric care or nursing homes based on the high prevalence of mild-moderate cognitive impairment in rehab. Persons with advanced cognitive impairment (Category 3; MMSE <18) were excluded us such persons may be overtaxed to manage the assistance by I-Support bath robot or may need a far more complex handling support.
  - **Milestones:** User definition (M4). The user definition was spread among project partner at M4 by Bethanien partners to allow inclusion of definition for other project tasks (e.g. interview of potential users, risk evaluation, definition of functionalities) and will be included in the first WP1 deliverable (D 1.1).

- **T 1.2 Model of user requirements, based on a clinical model of frequent geriatric impairments and limitations (Bethanien)**
    - **Progress:** A report was completed in M7. It is part of D 1.1, which is due to submission in M7.
    - **Significant result:** Based on the International Classification of Functioning, Disability and Health (ICF) as an internationally established conceptual framework we described a comprehensive model of impairments, limitations and user requirements, which may represent the basis for the definition of use case scenarios from a clinical perspective.
    - **Milestones:** User requirements from a clinical perspective (M7). The clinical model of user requirements was spread around partners; it was reviewed from FRA-UAS and FSL and will be included in the first WP1 deliverable (D 1.1).

- **T 1.3 Initial use cases (Bethanien)**
    - **Progress:** A report was completed in M7. It is part of D 1.1, which is due to M7. The preliminary use case scenarios will be amended by the identification of user behaviours and attitudes from a qualitative perspective as identified by qualitative interviews and quantitative data collection (Frankfurt University of Applied Sciences). Final use cases will be described in cooperation with technical partners including their technical perspective and identification of functionalities.
    - **Significant result:** Within the development process of the I-Support bath robot system, we have identified a hierarchy of system processes, representing core functionalities and additional support or optional functionalities to be integrated in use case scenarios of the I-Support project. The ***core process*** of the I-Support project is represented by the entire shower process. For the shower process we defined four use case scenarios for different body parts, based on various user requirements (especially motor impairments and limitations), with a range from assisting (use case scenario core region shower process) to fully automatized functionalities (use case scenarios distal, back and posterior region shower process). Each shower process is starting in a sitting position within the shower area to facilitate the validation of sub-processes. Because bathrooms have been identified as a hazardous location with a high prevalence of fall-related injuries, we suggest to integrate the transfer and transition use case scenarios to the core process. The ***support processes*** comprise functionalities for the overall operation, control and modification of the I-Support bath robot system with respect to cognitive, sensorial, and motor impairments of the potential user group (see Chapter 2 of D 1.1). They still need to be specified by technical partners. The ***optional process*** describes two valuable functionalities for skin care.
    - **Milestones:** Initial use case scenarios have been suggested partners by Bethanien (M5), and will be discussed at a project meeting in Athens September 2015. System functionalities (M5) have been suggested (M5) and will be discussed at the same meeting. A final list of functionalities is still to be developed.

- **T 1.4 Model of user abilities and behaviour with regard to bathing from the user and carer perspective (FRA-UAS)**
  - **Progress:** Till the end of August 25 of 30 interviews with primary users (elderly and frail person) and 12 of 15 interviews with secondary users (professionals in the health and social care sector) have been undertaken. Additionally, several discussions with experts in the healthcare sector, stakeholders and industry were carried out.
  - **Significant result:** Sensitive areas and not reachable areas could be identified from the users´ and experts´ perspective. A detailed description will follow in D 1.1.

    Publication for IROS 2015 was handed in: B. Klein; S. Kortekamp; R. Roßberg: The role of culture and gender in the robotic design process. In: IEEE/RSJ International Conference on Intelligent Robots and Systems. IROS´2015 Full day Workshop. Cognitive Mobility Assistance Robots: Scientific Advances and Perspectives. C. Tzafestas, P. Maragos; A. Peer; K. Hauer (Organizers). Proceedings, 2015; pp.3-4 (http://robotics.ntua.gr/IROS2015-Workshop-Cognitive-Mobility-Assistance/proceedings.htm).
  - **Milestones:** not required.

- **T 1.5 Definition of final use case scenarios and I-Support technical implementations (Bethanien + Omega + ICCS + SSSA)**
  - **Progress:** The initial use case scenarios will be discussed during a project meeting in Athens September 2015. A final report, which is part of D1.1 (M7) is currently in preparation.
  - **Significant result:** The preliminary use case scenarios will be amended by the identification of user behaviours and attitudes from a qualitative perspective as identified by qualitative interviews and quantitative data collection (Frankfurt University of Applied Sciences).
    OMEGA has contributed in D1.1 to the overall conceptualization of I-SUPPORT services and also contributed to T1.4 by conducting detailed analysis of the “final use cases”, i.e. those use cases that will be executed during the Pilot Studies. To this end the following steps were accomplished:
    - ➢ OMEGA contributed (along with other partners) to the conceptualization and description of the overall I-SUPPORT system and to its service requirements, based on which BETHANIEN derived the use cases.
    - ➢ OMEGA, (together with SSSA and ICCS) resolved each final use-case scenario into flow of events that demonstrate the steps of interaction between the user and the I-SUPPORT subsystems. Their description is represented at a low-level of abstraction using standard formulas that unroll a detailed flow of events for each use case. The analyzed use cases are briefly listed below, and are described in detail in D1.1.
    - ➢ Use cases analyzed by OMEGA:
      - Stand-to-sit and transfer

  - Sit-to-stand
  - Rinsing the back of the user
  - Scrubbing the back of the user
  - Rinsing the distal region (legs)
  - Scrubbing the distal region
  - Rinsing the bottom region
- ➢ Use cases analyzed by SSSA:
  - Fall detection - Under development.
  - Assistance request (Implemented and successfully tested)
  - Environmental monitoring (The selected devices are to be purchased)
  - Dead man detection (Implemented and successfully tested)
  - User identification (Implemented and successfully tested)
- ➢ Use cases analyzed by ICCS:
  - Gesture recognition
  - Audio commands
- ➢ OMEGA translated each of the above use case events to functional requirements, and subsequently resolved the functional requirements into technical requirements. The complete chain of use-case events, functionalities and technical requirements has been described in detail and is depicted graphically in D1.1.

  This analysis articulated the "What the system should do" (use cases and event flow) with the "How the system does it" (functional and technical requirements). The set of functional and technical requirements will be used in WP2 for selection of components, for the design of concepts and for the design of the hardware and software architecture of the I-Support system.

- **Milestones:** Scheduled milestone in M5: MS2 Initial use cases. In relation to the wearable sensing and environmental control, a set of five use cases and their associated system functionalities have been investigated and defined (SSSA).

- **T 1.6 Sociological, gender and ethical considerations (FRA-UAS)**
  - **Progress:** Till the end of August 25 of 30 interviews with primary users (elderly and frail person) and 12 of 15 interviews with secondary users (professionals in the health and social care sector) have been undertaken. Additionally, several discussions with experts in the healthcare sector, stakeholders and industry were carried out. Data analysis with respect to sociological, gender, cultural and ethical considerations will follow on basis of D 1.2.
  - **Significant result:** Although the showering process is a very individual procedure, it can be divided into 3 major steps: preparation for showering, the showering process and the follow-up phase. The whole process is very much influenced by architecture and the setting of the bathroom. In Germany, only a very small percentage of bathrooms have an accessible design. This might be one of the key features to be taken into account when developing the I-Support system.

Detailed description in D 1.2

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- **Milestones:** not required.

- **T 1.7 Safety requirements (Robotnik)**
  - **Progress:** In order to derive safety requirements from international safety standards a deep research on international regulation has been performed. Three generic safety standards were found interesting (IEC 60335-1, IEC 61010-1, 2006/95/EC) while up to 14 robotic standards including safety issues were listed and studied.
  - **Significant result:** After the analysis of the international safety standards and regulations, one concrete standard was found as the most relevant for the I-Support robotic system, namely the ISO/FDIS 13482: Robots and robotic devices -- Safety requirements for personal care robots. This international standard specifies requirements and guidelines for the inherently safe design, protective measures and information for use of personal care robots, in particular mobile servant robots, physical assistant robots and person carrier robots. The I-support robotic solution can be considered as a physical assistant robot, so this ISO 13482 will be the safety guideline that will be followed throughout the project development.
  - **Milestones:** Safety requirements (M5). A list of robotic standards was spread around partners and will be included in D 1.3 (M12).

2.1.3 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.1.4 Deviations from work plan

- None

2.1.5 Corrective actions

- No need for corrective Action.

2.1.6 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

2.2 WP2 Service robotics system architecture & integration

2.2.1 Objectives for the period

- Partition system into discrete reusable h/w and s/w modules consisting of isolated, self-contained functional elements with well-defined modular interface.
- Create system architecture design: (i) selection of blocks and modular components based on functionality specification of WP1, (ii) definition of interoperability standards; (iii) definition of communication protocols. Add value to the system by integrating and interconnecting the subsystems to yield an overarching functionality.
- Create a safety design ensuring that safety standards are met by all system components and by the overall system.
- Define technical performance metrics as well as module metrics that will be measured through WP6 activities.

2.2.2 Progress and significant results

- **Task 2.1I-SUPPORT overall system software and hardware architecture**
    - **Progress**

During the first two months of WP2 (started on M4) the consortium defined a complete version of the hardware architecture and a preliminary version of the software architecture, both of which will be presented in detail in Deliverable D2.1 (scheduled for M8).Priority was given on the definition of the hardware architecture because this is a prerequisite for the definition of software architecture, since most of the software in this project is meant to drive and control the hardware components of the system. A summary of progress towards the Task 2.1 objectives follows next.

Hardware architecture

Partners SSSA, ROBOTNIK, ICCS and OMEGA specified the hardware components and the devices used by I-SUPPORT. The consortium derived the system architecture that employ these components and which successfully implement the use cases and functionalities specified in D1.1.These devices, components and concepts are summarised below.

- Partner ROBOTNIK has produced the preliminary design of a motorized chair equipped with 2 degrees of freedom, which allows safely transferring the user from the exterior to the interior of the shower cabin. The design permits easy and modular installation of the motorized chair. ROBOTNIK has provided preliminary designs on the integration of this subsystem to the shower environment.
- Partner SSSA has provided the design of two soft robot arms and a translational base onto which the two arms are connected. The translation base is mounted on the wall and moves along the vertical axis so that the workspace of the robotic device can encompass the entire body of the user. The arms are equipped with pneumatic and cable driven actuators for strength and accuracy. The interfaces of the arms are designed so that they have a degree of modularity and can be replaced easily. One arm provides washing functionalities

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(into which a channel for water flow is embedded) while the other provides scrubbing functionalities. The base could also be designed to accommodate only one soft robot arm.

- ROBOTNIK provided 3D CAD design of the overall architecture. Two architectures were presented and studied. The first mounts both motorized chair and 2-arm robot on the same wall of the shower cabin. The second mounts themotorized chair and the 2-arm robot on different walls. The second option was preferred because the workspace is larger and the positioning of the user with respect to the robot more flexible.
- ICCS, INRIA and ROBOTNIK provided specifications for the vision components that will be used for 3D reconstruction of the user, the robot and the environment. The partners opted for two KINECT V2 sensors. INRIA conducted experiments and demonstrated that KINECT V2 technology does not suffer from interference problems when more than two sensors are combined (because the principle of operation is time of flight and not structured light). Experiments conducted by INRIA also indicated that the sensors cannot be placed behind glasses because reflections distort the vision information. Therefore the consortium decided that sensors should be place inside the shower cabin and be waterproofed.
- ROBOTNIK provided waterproof casing designs for the vision sensors.
- Audio sensors were studied by the ICCS and three options were presented. The criteria for the final selection will be the ease of waterproofing their flexible integration and easy installation in the shower environment.
- Force sensors will also be integrated in the soft robot arm end-effector to measure contact forces and the profile of forces imparted on the user during scrubbing. No force sensor has been selected yet.
- OMEGA after doing a market research for remote sensor handles equipped with inertial sensors opted for the Wii remote sensor handle because it is readily available, it is low cost, it reminds a common TV remote controller and the inertial sensors can be read easily. This device is equipped with a gyro and a linear accelerometer. OMEGA integrated this device with the ROS environment and verified that the (linear) acceleration and gyro signals are acquired real-time using ROS functions.In order to develop a remote controller that is simple and can be easily operated by the seniors, OMEGA deactivated most of the buttons and kept active one button on the top surface of the remote controller and the mechanical trigger at the underside of the device.
- SSSA has provided solutions for context awareness and has demonstrated how these can be integrated with the rest of the system. The first solution is a wearable IMU sensor (wrist watch) manufactured by Samsung, which offers functionalities of fall-detection, dead-man identification (detecting inactivity), transmission/reception of alert/acknowledge messages either via telephone or via the Internet (which could be used for transmitting user ID and personal info to the I-SUPPORT central computer such as height, weight, medical condition). The second solution comprises two poly-sensors: Cubesensor and Amphiro. The first is a commercial air smart sensor measuring temperature, humidity, noise, pressure, light, air quality, manufactured by CUBESENSORS the second is a commercial

water smart sensor manufactured by Amphiro. The environmental monitoring sensors and the wearable sensor are connected in order to operate according to the IoT paradigm.

- OMEGA coordinated the gathering of the description of the hardware subsystems reviewed their specifications, verified their interfacing and contributed to the design of the overall architecture (locations of each component in the shower environment, use case analysis, etc.) and put together everything into deliverable D2.1.

Two significant functionalities have not been defined yet: These are the drying procedure and the automatic tool exchanger with quick release mechanism. Their definition will be completed during the second semester of the project.

Software architecture

Overall architecture: The past two months a preliminary study was conducted on the software architecture and the candidate software modules. ICCS, KIT and OMEGA have identified so far the following software modules: Low-level controller, Hybrid controller (motion/interaction), Sensor listener and sensor fusion module, Robot pose estimation, human pose estimation, gesture, action, intention recognition, motion primitives library, inverse kinematics and inverse dynamics module. However, the derivation of the architecture is currently at an early stage because emphasis was put on the derivation and completion of the hardware architecture. No significant results of the overall architecture can be presented so far apart from the data collection framework that will be used to train robot’s motion primitives, machine vision, gesture recognition and control parameters. This is described in the following paragraphs:

Data collection framework: During the first six months work has been carried out by KIT for the data collection framework which is described in WP 5 Task 5.4. KIT implemented distributed sensor components in order to standardize the access to the various sensors. The components are based on robot development environment ArmarX which realize distributed processing of various software components. The communication between the software components is accomplished by using Internet Communications Engine (Ice) which enables the communication between components which can run on different platforms (e.g. Linux, Windows) or are implemented using different programming languages (e.g. Python, C++, C#, Java).

Each sensor component encapsulates the basic functionalities of the sensor-specific API and implements a common Ice interface specification which defines methods which can be called remotely and data types which are sent and received by the component. Thus, each component implements methods like startRecording and stopRecording for the synchronized collection of sensor data. So far, we implemented following sensor components:

- ViconRemoteComponent implemented in C++. The communication between the Vicon program Nexus is done via XML messaging and enables remote triggering and stopping of the recording process and the manipulation of filenames. The integrated ViconDataStream SDK enables the sensor component to capture the motion data stream sent from Nexus and provides the sensor data as topic in ArmarX,

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- The ATIFTRemoteComponent implemented in C++. The communication to the FT sensor board is accomplished via UDP messaging. UDP packages received from the sensor are translated into forces and can be either stored in a local data file or streamed,
- KinectRemoteComponentV1 implemented in C++ and integrates the freenect library to obtain depth data, registered point cloud data and RGB images from the Kinect V1 sensor,
- KinectRemoteComponentV2 implemented in C++ and integrates the freenect2 library to obtain depth data, registered point cloud data and RGB images from the Kinect V2 sensor,
- KinectWinRemoteComponentV2 implemented in C# and integrates Kinect for Windows SDK to obtain skeleton data.

The sensor components can be accessed by the MasterMotionCaptureComponent and a corresponding GUI implemented with Qt. The user interface allows a user to select the sensors which are involved in the data collection process, to check on the status of the sensors, to set a common prefix for the filenames of the data recordings and to start and stop a the data collection process.

Furthermore, KIT has conducted experiments in order to investigate possible cross interferences and the optimal placing of the sensors. As a result the Kinect cameras and the Vicon system can be used in a combined setup with minor constraints. The sensor data of Kinect V1 becomes more noisy when using with the Vicon system. For the Kinect V2, this is not the case. Since both sensor systems, Kinect and Vicon, rely on the emission and reflection of IR light, Vicon markers are not visible in the point cloud data. Furthermore, we figured out that a minimal number of three PCs are needed for the data collection experiments, one Vicon PC and two PCs with, each for a Kinect V2 sensor. Due to low computational costs the MasterMotionCaptureComponent as well as the ATIFTRemoteComponent can run on one of the Kinect PCs.

- Deliverables

No WP2 deliverable are planned for the first six months of the project.

- Milestones

No WP2 milestones are planned for the first six months of the project.

- **Task 2.5 Define system performance metrics**
  - Progress

  No progress has been made so far in the accomplishment of this task. Although according to the DoW it has started on month 4, we decided to obtain first a clear picture of the system architecture and the detailed use cases before we proceed to the definition of system performance metrics. It is expected that performance metrics will be specified with the next 3 months, i.e. by month 9.

  - Significant result

  No significant results have been produced for this task so far.

  - Deliverables

No WP2 deliverable are planned for the first six months of the project.

- Milestones

No WP2 milestones are planned for the first six months of the project.

2.2.3 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.2.4 Deviations from work plan

- None

2.2.5 Corrective actions

- No need for corrective Action.

2.2.6 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

2.3 WP 3: Robotic devices and other h/w integration

2.3.1 Objectives for the period

Among the objectives set within WP3, in the first 6 months of the project, new results have achieved in:

- **Objective 1:** Employ soft robotic devices (arms) and other required accompanying h/w (e.g. potentially a rigid robotic base) to support the bathing activities of senior users, ensuring safe human-robot physical interaction. Define what the necessary adaptations to existing prototypes are and adapt correspondingly. Target modularity and reusability /re-configurability.

Start of the adaptation process. The technologies already used in previous developed manipulators have been analysed together with other suitable actuation principles derived from the state of the art of soft robotics in manipulation.

- **Objective 2:** Employ industrial design to methods to accommodate the technology into aesthetic concepts that can optimize acceptability by senior users.

Gather feedbacks from potential users (through interviews and questionnaires) about external features and functionalities with the aim of increasing the acceptability of the system.

- **Objective 3:** Employ a motorized chair inside the shower to assist the older adults during sit-to-stand and stand-to-sit tasks.

This chair will be a modular component that must allow the integration of processing units, sensors, signal conditioners and wireless transmission units if needed (and depending on the needs of the user). For controlled and safe operation the following variables will be measured: motor speed, joint angles, chair elevation and presence of a seat occupant.

- **Objective 4**: Perform all necessary sensorisation of the I-SUPPORT h/w devices/components, to enable system intelligence and context awareness.

The wearable and environmental sensor network has been designed.

- **Objective 5**: Integrate commercial wireless handle/sensor technology to enable tele-manipulation of the soft robotic arms and handling of the motorized chair.

- **Objective 6**: Perform sensor and other h/w waterproofing.

The waterproofing requirements and capabilities for some of the sensors envisaged for the I-support robotic system have been checked.

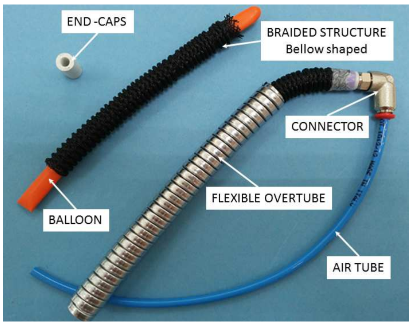
2.3.2 Progress and significant results

- **Task 3.1. Adaptation, low level control and industrial design of soft robotic arm**
  - **Progress**

This project has received funding from the European Union'sHorizon 2020 Research and Innovation Framework Programme, Societal Challenge 1 (DG CONNECT/H) under grant agreement No 643666, Activity PHC-19-2014, ICT-Supported Bath Robots.
www.i-support-project.eu.

The soft robotic arm design and development have been investigated taking into account the major requirements for a service robotics system. The existing soft robotics technologies have been reviewed focusing on the definition of suitable dimensions, applied forces and design for the target I-SUPPORT application. Moreover, users' needs, system functionalities, safety and ethics issues pointed out from WP1 have been considered (evaluated) during the first prototyping phase. Industrial design methods are used in this first developmental phase with the purpose to accommodate the technology into aesthetic concepts mainly focused on acceptability by end users. This process has been conducted in combination with the FRA-UAS partner, by involving potential end-users in interviews about technical/aesthetic issues and physical interaction with a mock version of the soft arm (not functional but with geometry, dimension, weight and external aspect very close to a possible embodiment). This phase is fundamental to set the basic design principles to guarantee a suitable level of acceptability, thus having an early feedback from the users is crucial. Combining users' needs and a few concepts for the aesthetics of the robot arms, a mock-up and an evaluation kit have been prepared and used in the interviews. Questionnaire outcomes are currently under examination for the steering of the soft arm design process.

In parallel, some technological concepts have been evaluated. After a preliminary analysis of the state of the art on existing soft arms, according to the final application of the system, we referred to OCTOPUS and STIFF-FLOP projects as they represent a valid starting point for the soft robotic shower/wiping arms. With the major requirements of the soft arm in mind, the most suitable solution for the development of the actuation system has been identified: pneumatic actuators operating in a soft bodied chamber in combination with cables. With this combination the robotic shower will present elongation, shortening, omnidirectional bending and stiffening capabilities. Moreover, we can count on their high mechanical flexibility to perform complex movements, their lightness and very low manufacturing costs. We developed McKibben-like actuators (Figure 1), made of an external braided structure with a bellow shape, in order to optimize their performance during the actuation phase by exploiting design features.



Figure

Figure 1. Main components for the development of a McKibben-like actuator.

Moreover, we also implemented and tested a preliminary arrangement of the basic actuation units (McKibben-like actuators and cables) in a design of the entire soft arm made of three modules. Figure 2 shows our technological concept of the soft robotic arm composed of 3 modules each one based on three McKibben-like actuators and cables.

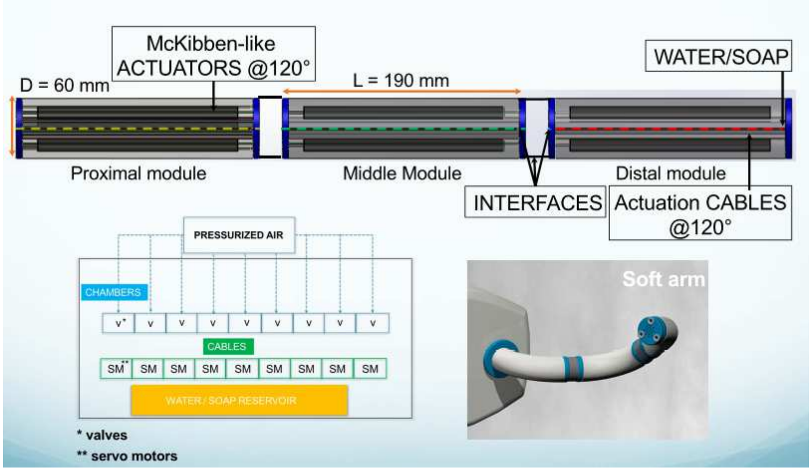


Figure 2. A CAD model representing the technological concept for the entire soft arm.

- **Significant result**

Before starting with the module characterization, we tested the McKibben-like actuator in order to define the maximum allowed pressure during the active phase. An actuator with 10 mm in diameter and 150 mm in length is able to achieve an elongation until 70% of its initial length (Figure 3)

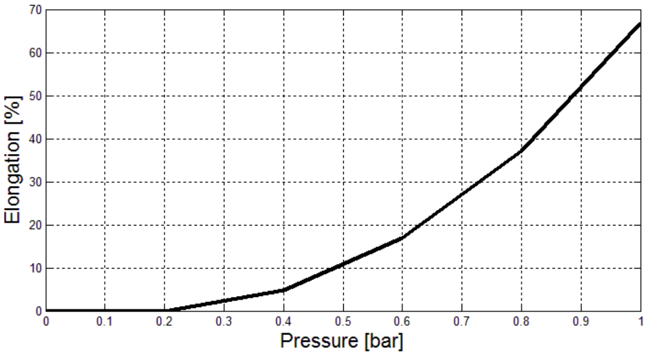
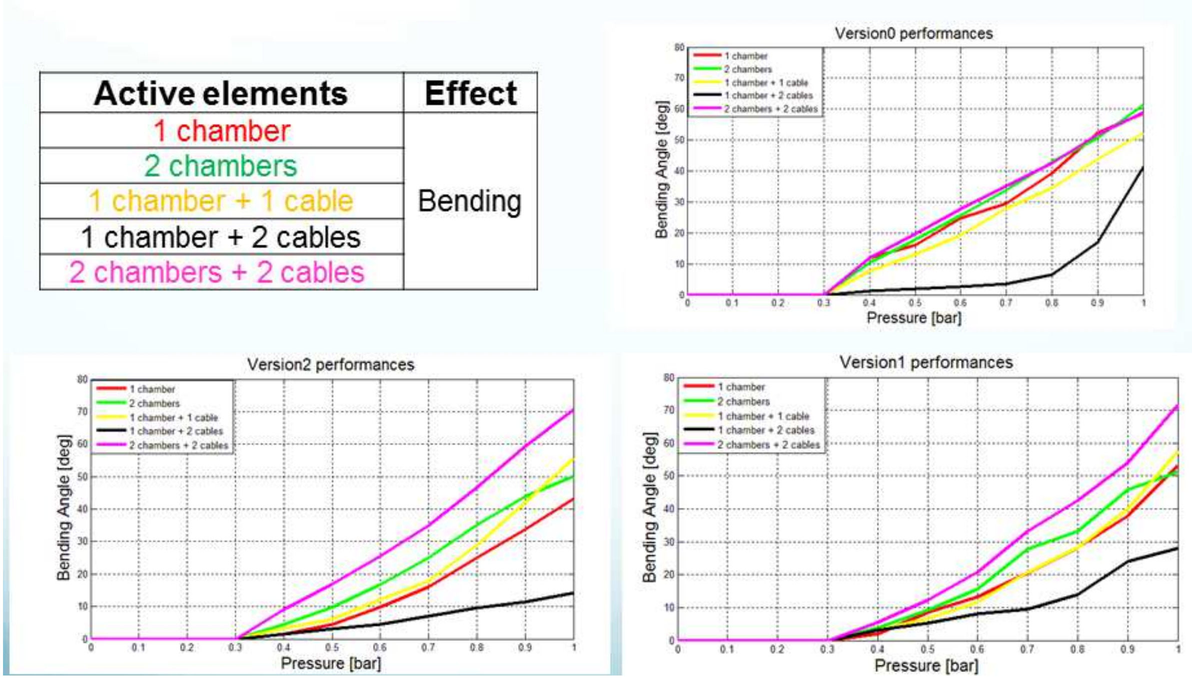


Figure 3 Elongation of the fluidic actuator at increasing pressure from 0 to 1 bar.

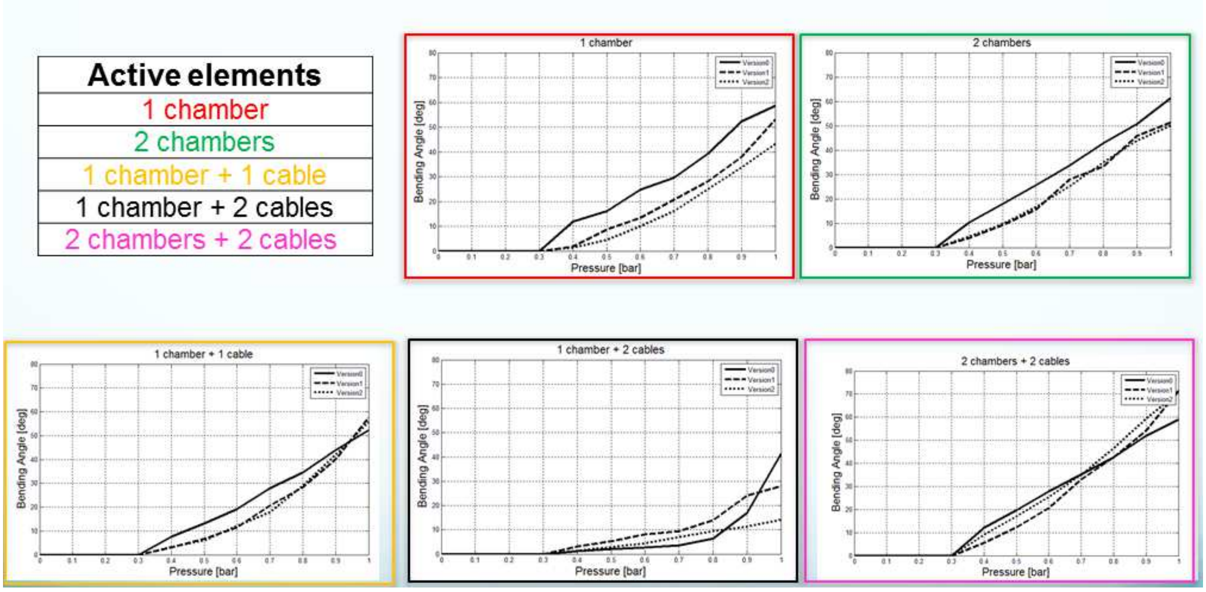
Module performances have been evaluated in terms of elongation, shortening and bending capabilities with three different models (configuration) of the module.

Figure 4 and Figure 5 summarize which are the bending performances both for the same model in different actiavation configurations and for the three different models at the same working configuration respectively.



Active elements	Effect
1 chamber	Bending
2 chambers	
1 chamber + 1 cable	
1 chamber + 2 cables	
2 chambers + 2 cables	

Figure 4 Bending performances have been evaluated and summarized in a single plot for each version.



Active elements
1 chamber
2 chambers
1 chamber + 1 cable
1 chamber + 2 cables
2 chambers + 2 cables

Figure 5. All the modules are compared respect to a specific configuration of cables and chambers.

- Deliverables

No deliverables were scheduled in the first 6 months.

- Milestones

No milestones were scheduled in the first 6 months.

- **Task 3.2. Adaptation, instrumentation & low-level control of motorized chair**

The goal and main functionality of the motorized chair is to allow the senior to smoothly access to the bathing zone, and to support him/her during the showering in a sit position. A first sketch of the motorized chair has been developed, so the chair is composed of 2 DOF: one linear horizontal axis to enter and exit to/from the bathing area and a rotational one to move the chair 90º left and right. The size of the seat will be about 40x40 cm. The inclusion of an extra degree of freedom (vertical axis) on the chair to help the senior in the sitting procedure is under study.

- **Significant result**

The CAD model of the first prototype has been designed and shared with the rest of the partners (see Figure 6).

Figure 6. The CAD model of the first prototype of the motorized chair.

- Deliverables

No deliverables were scheduled in the first 6 months.

- Milestones

No milestones were scheduled in the first 6 months.

- **Task 3.3. Wireless sensor handle adaptation and integration (Leader: OMEGA)**
  - **Progress**

This project has received funding from the European Union'sHorizon 2020 Research and Innovation Framework Programme, Societal Challenge 1 (DG CONNECT/H) under grant agreement No 643666, Activity PHC-19-2014, ICT-Supported Bath Robots. www.i-support-project.eu.

OMEGA conducted a market search for commercially available, low cost, remote controllers with embedded inertial sensors. The goal of this device in the context of I-SUPPORT project is to enable limited tele-manipulation of the soft robot arm, to enhance the gesture recognition capabilities of the I-SUPPORT perception system and to increase the sense of safety to the senior. Technical requirements are:

(a) The sensor bar functions as a joystick to provide 3D remote control of the soft robot arm. The sensor bar contains gyros and linear accelerometers and can sense and track 6DOF motion (3DOF translational and 3DOF rotational). The controller in the central I-SUPPORT computer will receive (wirelessly) the 6DOF feedback values and transform them into soft robot motion according to a tele-manipulation control algorithm.

(b) The 6DOF information transmitted to the central computer will be fused real-time with the KINECT data to provide more accurate positioning of the human arm and improve the gesture recognition results.

(c) Buttons for start/stop functionality and panic button functionality.

(d) Low cost device (less than 200euros) so that can be integrated to the rest of the system without significantly augmenting the cost.

- Significant results

(1) Our market research led us to the conclusion that Wii Remote by Nintendo fulfills the criteria of embedded inertial sensors, low cost and that of appearance. The Wii Remote is equipped with several buttons. Most of them will be inactive so that the senior user is not confused by the array of small buttons. We will keep activated one or two buttons that will function as panic button and start-stop button. Details and technical specifications of the Wii Remote operation can be found at Deliverable D2.1, at the hardware architecture section.

(2) We employ the Robotic Operating System (ROS) as middleware for passing the messages between the WiiRemote and the central computer, for configuring the Wii remote and for processing the signals. Both gyro and accelerometer signals were successfully recorded.

- Deliverables

No deliverables were scheduled in the first 6 months.

- Milestones

No milestones were scheduled in the first 6 months.

- **Task 3.4. Sensor integration and sensor waterproofing on the I-SUPPORT system**

Robotnik has been checking the waterproofing requirements and capabilities for some of the sensors envisaged for the I-support robotic system. In the meantime SSSA has designed the wearable and environmental sensor network as summarized in Figure 7, involving a wrist worn sensing unit, air monitoring and water monitoring. The middleware of the proposed solution supporting the IoTpardigm has been developed and it is being tested in its components:

a) the SmartDeviceISupportProvider, an AndroidService;

b) the HTTP_ISupport_Server an Android App.

The SmartDeviceISupportProvider is an Android Service dedicated to:

a) the routing of data between the Smartwatch (via Bluetooth by using a Samsung proprietary protocol) and the HTTP_ISupport_Server;

b) the transmission/reception of alert/aknowledge messages (related to Fall detection/Dead man detection) either via telephone or via Internet.

The HTTP_ISupport_Server is an Android app whose main function is to expose all resources related to the Smartwatch (and from the other IoT nodes included in the monitoring system) activity as web resources. The HTTP_ISupport_Server will allow to setup the Smartwatch or to collect any data produced by it by using an HTTP client (e.g. a web browser) from a remote workstation.

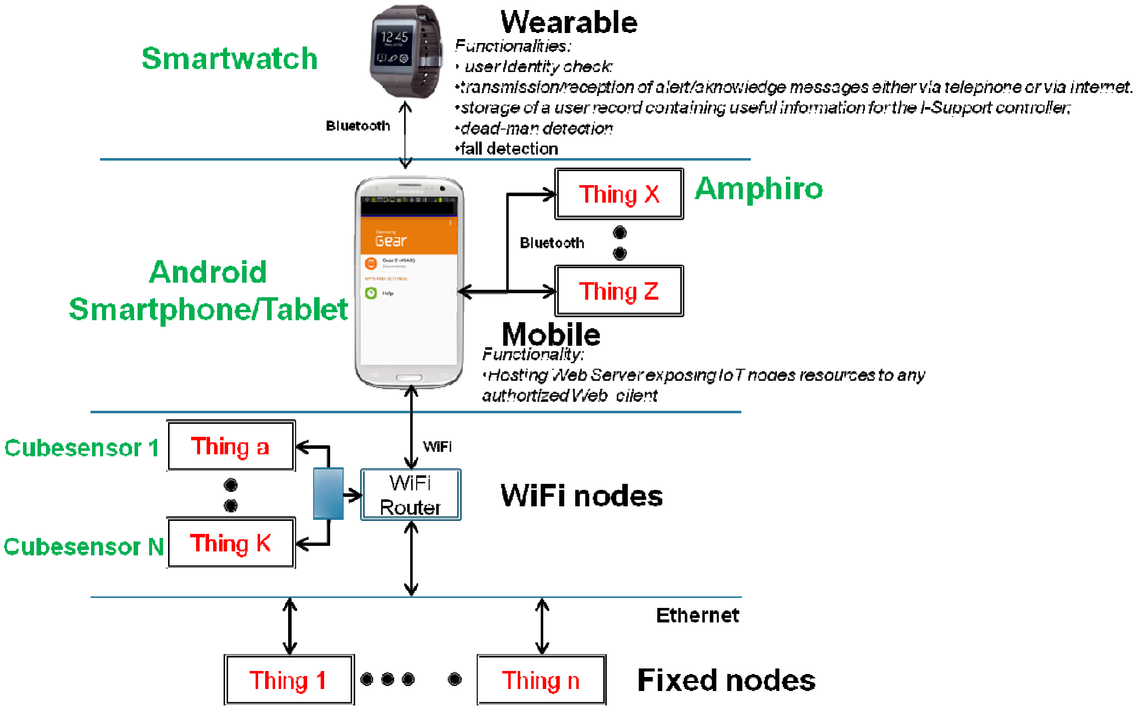


Figure 7. SSSA has designed the wearable and environmental sensor network.

Both the Cubesensor and the Amphiro will be integrated in the IoT sensor network. The middleware component for environmental sensing is the same application used by the wearable system.

- **Significant result**

- The Xtion sensor showed good performance behind windows, but difficult to waterproof due to its inherent design. Finally, the Kinect V2 sensor was found easier to waterproof and its corresponding enclosure has been designed (see Figure 8).

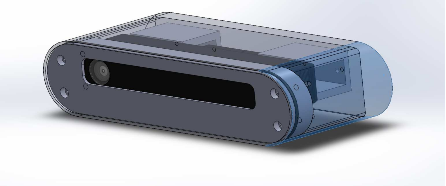


Figure 8. KINECT V2 waterproof enclosure CAD design.

- The middleware for wearable sensing devices has been developed successfully, granting access to sensor data, processing results and device setup through web browsing. Data consistency tests were executed successfully over prolonged period of time.

- Deliverables:

No deliverables were scheduled in the first 6 months.

- Milestones

No milestones were scheduled in the first 6 months.

2.3.3 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.3.4 Deviations from work plan

- None

2.3.5 Corrective actions

- No Corrective Actions needed

2.3.6 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

2.4 WP4 Control system design and implementation

2.4.1 Objectives for the period

During the first 6 months of the project, work has focused on progressing specific tasks towards achieving the following objectives, in line to the workplan as set within WP4:

- Tracking human posture, movements and actions in the considered application (shower) environment.
- Designing a multi-layered architecture that will cope with the multiple levels of the control problem, including position, shape, and stiffness control.
- Researching methods to achieve efficient shared control in soft-art telemanipulation.

2.4.2 Progress and significant results

Tasks 4.1 and 4.2 have started on month 4, while the start of tasks 4.3 to 4.5 is planned for month 7. In the sequel, we briefly summarise the progress achieved and the first results obtained in these tasks during the first six months of the project.

- **Task 4.1. Human pose estimation (Leader: INRIA, M4–M35):**

  We started by exploring the potential of deformable part models for the task of articulated human pose estimation, focusing in particular on exploiting the potential of Depth-based features for object detection. For this we developed ‘Histogram-of-Depth’ features, as well as higher-performing variants that rely on Sparse Coding to encode the depth field in the vicinity of a putative object part.

  We have subsequently used Deep Convolutional Neural Networks to phrase the problem of Human Pose Estimation in terms of Semantic Segmentation. During training a set of images containing humans were manually segmented into distinct human parts (head, torso, lower and upper arms, lower and upper legs) which results in a pixel-wise labelling of the image in terms of the distinct object regions. These regions are used in a discriminative training set to provide ground-truth labels: all image pixels are labelled as belonging to either one of these regions, or background

- **Task 4.2. Robot pose estimation (Leader: INRIA, M4–M35):**

  In the absence of ground-truth data for training our algorithms for this task we have had to resort to surrogates from existing datasets. We used the ‘Pascal parts’ dataset that provides ground-truth segmentation of multiple object categories into parts, and trained algorithms similar to the ones outlined above, but now for generic objects. The preliminary results seem promising, and we are currently working on estimating geometric properties, such as surface normal, to complement the region support information.

Formal start of the following tasks (Task 4.3 to Task 4.5) is set for month 7. Nevertheless, during the first six months of the project, specific preparatory phases for the smooth kick-off of these tasks have commenced. Our first problem to solve is the formal statement of the control problem. Towards this goal, we began by identifying and studying the several levels of the control problem focusing both on the differences and similarities for the different control strategies. Some aspects of the control problem are identical in every strategy, others have noticeable differences. Initial work has focused on investigating the various options regarding the design of a multi-layered architecture that will efficiently combine and consolidate the multiple levels of the control functionalities that should be supported by the I-Support platform, including position/motion control, shape control, and interaction/stiffness control.

- **Task 4.3. Motion control (Leader: ICCS, M7–M24):**

  Formal start of this task is month 7. During the first six months of the project, initial studies have commenced, to identify problems related to the free-space motion control of the soft-arms; namely, position control to ensure trajectory tracking for the end-effector, path planning and motion planning with global convergence properties, and collision avoidance. Initial work mainly focused on literature review of state-of-the-art methods regarding these motion planning and control aspects. Collaboration between ICCS and SSSA has also been initiated, to identify low-level control specifications in line with the progress made regarding the development of the soft-arm hardware. In this respect, initial work has also started towards identifying the appropriate kinematic and dynamic models that can be used for simulation and control purposes.

- **Task 4.4. Interaction control (Leader: ICCS M7–M24):**

  Formal start of this task is month 7. During the first six months of the project, initial studies have commenced focusing on literature review of current state-of-the-art and on specifying a research roadmap regarding the development and implementation of control methods to regulate the physical interaction of soft robotic arms with their environment.

- **Task 4.5. Shared control strategies based on human intention (Leader: ICCS, M7-30):**

  For the higher-level control functions, which form the scope of this task, the dissimilarities between the different control modes envisaged are larger. Initial work has begun, aiming to study the feasibility of segmenting the higher-level controller into different subcomponents, combined together within nested-hierarchical feedback loop architecture. The inputs to the system could be based on: a) identifying human intention (derived through interaction between the user and the soft arms) in a semi-autonomous mode; b) decision-making, path-planning and tracking in a fully autonomous operation mode, making use of a library of learned motion primitives; or, c) a suitable combination of both, yet to be determined. The goal is to find the maximum possible common ground of all these different control modalities. Such an integrative approach makes the design and implementation of the control problem much easier and reduces the necessary components to be constructed. We are studying the interconnections of the high-level control modules with the lower-level motion and interaction control to integrate them as inputs to the aforementioned feedback system. The final specifications for the different use-cases (anticipated to be available on month 7) are necessary in order to proceed efficiently with this work.

- Deliverables

  No deliverables were scheduled in the first 6 months.

- Milestones

  No milestones were scheduled in the first 6 months.

2.4.3 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.4.4 Deviations from work plan

- None

2.4.5 Corrective actions

- No Corrective Actions needed

2.4.6 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

2.5 WP5: Context-awareness, perception / cognition for user intention and activity recognition

Summary: The task of WP5 is to provide methods which enable the I-Support system to perceive and to recognize actions, gestures, spoken commands, and the state of a human user. To enhance the perception of the user and the environment, the system relies on the fusion of multimodal sensor data. Furthermore, this work package addresses the learning of robotic skills from the observation of human experts. To accomplish this task, models and methods have to be developed and evaluated which allow the representation of demonstrated washing and drying actions as adaptive skills. Adapted to the user and object specifications, these skills should enable a robot to reproduce these actions in a goal-directed way.

The main results of WP5 in the first six months are:

- Framework for multimodal human motion capture which integrates vision, audio, and haptic sensors
- Initial experiments on training data collection
- Segmentation
- Analysis of representation of washing and drying actions
- Motion primitive designed for the representation of washing and drying actions

2.5.1 Progress and significant results

- **Task 5.1: Action, Gesture and Spoken Command recognition**

Gesture recognition is a visual task that can aid in human-robot interaction and relies on similar visual processing methods as in action classification and pose estimation. Visual action and gesture recognition can be viewed as paradigms of visual activity detection at different scales. In this project we envision a simple role for gesture recognition that will involve the recognition of a relatively small vocabulary of gestures, which will serve the role of visual non-verbal commands. For robustness of the I-Support perception system, and after agreement with the rest of I-Support partners during its kick-off meeting, ICCS intends to supplement gesture recognition with an additional perceptual task of spoken command recognition. The two modalities can work both independently and also in fusion for enhanced performance of human action recognition.

During the first six months of I-Support ICCS evaluated several possible visual sensors in collaboration with other partners for video data acquisition. In addition, audio sensors were studied by the ICCS and several options were presented for the shower environment. In both types of (audio and visual) sensors, the criteria for the final selection will be the ease of waterproofing, their flexible integration and easy installation. Further, ICCS has started designing state-of-the-art computational methods and algorithms for gesture recognition and spoken command recognition both at the feature extraction level, as well as at the detection and classification levels. We have also started performing preliminary experiments on data obtained from application environments similar to I-Support.

- **Task 5.3: Adaptable representation of motion primitives**

One challenge i-Support is to adapt the robot's movement to the movement of the user. For example, the user may move his or her back when the soft robot arm is washing it. The robot must react as soon as possible, after it can correctly sense the user's movement. One way to solve this problem is to learn motion primitives which can be adapted to different situations and according to sensory feedback. However, the resulting large number of different motion primitives may raise the difficulty of designing search strategies.

To address the issue, KIT has designed a representation of a motion primitive which specifically attends the requirements of such a washing action. The developed Coordinate Change Dynamic Movement Primitive (CCDMP) is based on the standard formulation of the Dynamic Movement Primitives (DMP), a representation which uses dynamical systems to encode arbitrary complex trajectories and which is widely used in the context of learning from demonstration. A DMP allows the representation of either a discrete or a periodic motion. To encode adapted washing and wiping actions, a motion primitive is needed which allows the encoding of both in timely-synchronized form. In this case, the discrete part is assumed to be the corrective movement in order to adapt to the user's body part which is accomplished by transforming the local coordinate system of the periodic wiping pattern used to wash that body part. The CCDMP allows the representation of both in a single motion primitive where motion of the local coordinate system and the local washing movement, both encoded using dynamical systems, are synchronized via pose transformation parameter. The integration of the CCDMP allows the generation of global wiping trajectory for a robot which can be adapted to the motion of the user in an online way.

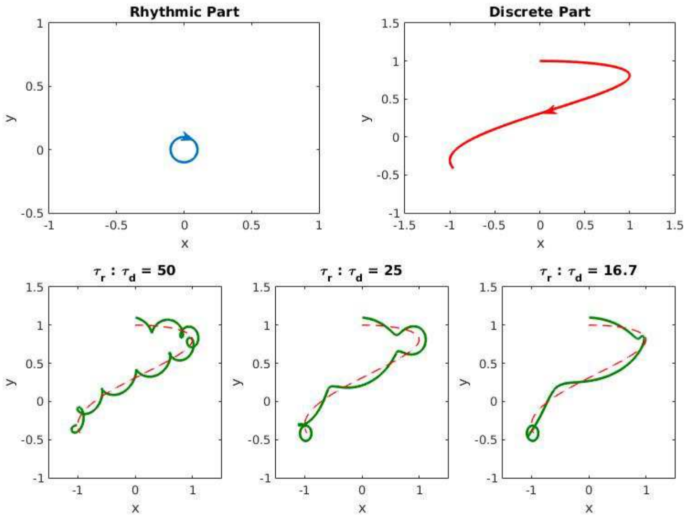


Figure 9: Reproduction of the Coordinate Change Dynamic Movement Primitives with different parameters.

- **Task 5.4: Personalization and adaptation to the user: Learning from Experience and User Feedback**

For the personalization and adaptation of the system to the user, experience models, which encode user-specific information and preferences has to be learnt. In this context, KIT implemented a framework which allows the synchronized collection of human data using vision, haptic, and audio sensors. So far, the framework integrates following sensor systems:

- Vicon system for marker-based human motion capture and motion capture environment which allow recording of multi-subject actions and the normalization of these actions based on a reference model of the human body, the Master Motor Map.
- Force-torque sensor in order to measure the interaction forces acting on the user during washing and drying tasks,
- Two Kinect cameras for the markerless motion capture and the recording of point cloud data, RGB images, and the skeleton data of the integrated markerless human motion capture algorithm
- Videocamera to record video footage of the motion recordings,
- Directed microphone for the recording of the dialogue between washing agent and the user.

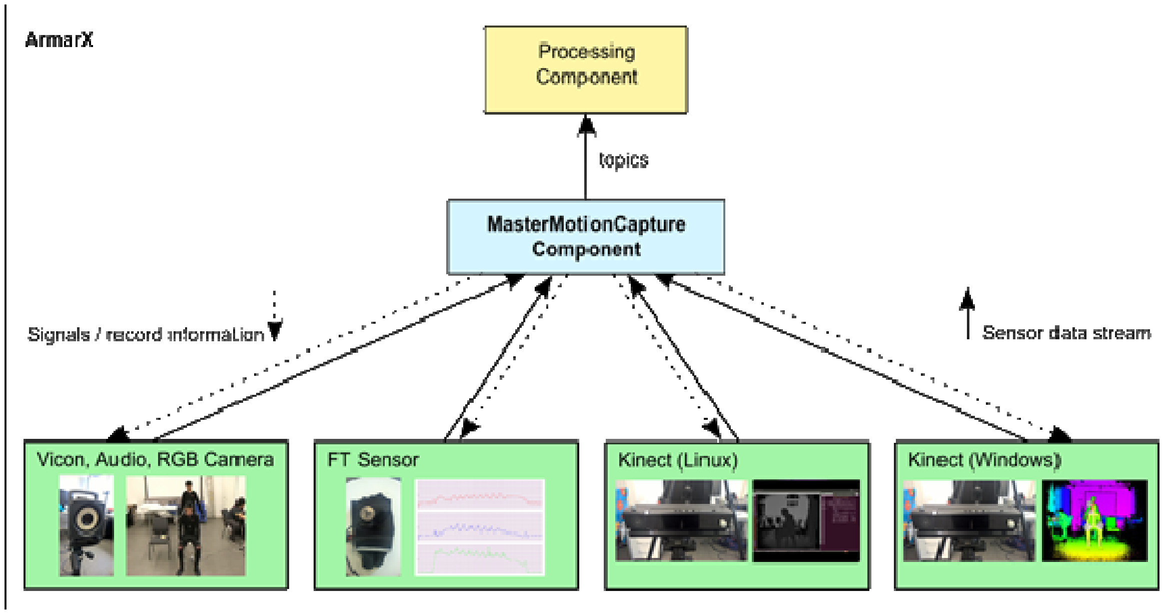


Figure 10: Overview of the i-Support data collection framework.

The i-Support data collection framework is shown in Figure 10. For each sensor, a remote software component is implemented which encapsulates the sensor-specific functionalities and allows remote access and distributed processing of the sensors independent of the programming language of the sensor interfaces or the operating system. To synchronize these remote components, we implemented the MasterMotionCapture component which distributes common signals in the form of UDP packages and administrates recording-specific information (e.g. filename, date, length). This way, we avoid the cumbersome segmentation step to determine start and stop of each sensor recording. Furthermore, the MasterMotionCapture component allows the access to each remote component in order to check the sensor status and to capture a data stream provided by the remote component in order to create sensor data topics which can be accessed by optional processing unit. Technical details of the implementation are given in WP2.

The collected data is post-processed, labelled, and uploaded to the KIT Whole Body Motion Database (Mandery et. al., 2015). To facilitate the exchange and the processing of the collected data by the project partners, using the Master Motor Map, a reference model of the human, captured motion is normalized from the subject-specific properties (such as body height and weight) and represented in a standardized way. Specifically addressing the needs of the I-Support project where we are interested in investigating interaction between multiple subjects, KIT has extended the MMM in order to enable the capturing of multi-subject motion and its mapping onto the MMM model using nonlinear optimization techniques. To enable the observation of object manipulation actions, markers have been attached to common washing tools and corresponding object models have been created.

Figure 11: Visualization of a wash-arm movement mapped onto MMM reference models.

For initial experiments with the data collection framework, a scenario has been developed which feature two subjects a, a washing expert and the potential user. We assume that the user is mildly-constrained, can sit and stand up, and might have problems raising the arms. To obtain user feedback on actions, a spoken dialogue between expert and user has been created by providing the expert a set of questions which are asked to the user during the course of washing and drying. This object, action, and its effect on the user can be evaluated in a personalized way. For a more goal-directed study of washing and drying actions and its effect on specific body parts, recordings of the washing scenario have been segmented. The segments have been analysed in order to identify most common actions in this scenario. Focussing on the upper body, we collected comprehensive data on washing the arms, back and the chest from multiple demonstrations of washing these body parts.

In total, we recorded four iterations of the entire washing scenario, 126 samples of different wiping actions of arms and the torso. The data has been collected from seven different subjects (two female and five male, aged 20-30).

2.5.2 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.5.3 Deviations from work plan

- None

2.5.4 Corrective actions

- No Corrective Actions needed

2.5.5 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

2.6 WP7: Dissemination and exploitation

2.6.1 Progress and significant results

Regarding WP7, the first complete dissemination plan was submitted on Month 6 in “D7.1 Dissemination plan and communication tools” according to the DoW.

2.6.2 Schedule and achievement of critical objectives

- All tasks are on schedule. All critical objectives have been achieved.

2.6.3 Deviations from work plan

- None

2.6.4 Corrective actions

- No Corrective Actions needed

2.6.5 Statement on the use of resources

- Resources have been used as planned with no deviations respect to the declaration stated in Annex 1 of the DoW

3 Project management during the period M1 – M6

- T8.1 Financial administration.

ROBOTNIK is responsible for the financial administration of the I-SUPPORT project including the periodic reporting and maintenance of financial records and preparation of annual cost claims. Financial administration is presented in Section 5 of this report.

- T8.2 Consortium coordination, communication and liaison with the EC (Leader ROBOTNIK M1 – M36)

Consortium coordination

Organizational structure: The selected organizational structure is deliberately simple, enabling the implementation of the work with minimal and precise management. The coordination roles are: The project coordinator is Mr Rafael Lopez (ROBOTNIK). The technical manager is Prof. Costas Tzafestas (ICCS), the Evaluation manager is Dr. Roberta Annicchiarico (FSL) and Ethics manager Prof. Barbara Klein (FRA-UAS). Exploitation manager is Mr Rafael Lopez (ROBOTNIK) and dissemination manager (FRA-UAS). Quality manager is Dr. Panagiotis Vartholomeos (OMEGA).

Decision making structure:

(1) The Plenary Board is the main decision-making body of the consortium about contractual and major implementation issues such as budget and Description of Work revisions, resolution of major conflicts between WPs, reallocation of work, change of partnership or termination of a partner, approval of annual progress reports, outcomes of project reviews, Intellectual Property Rights approaches, etc. The plenary board is led by the Coordinator.

(2) Implementation Committee (IC) and WP leads: The IC is led by the Technical Manager and consists of the Project Coordinator and the WP Leaders, including the Coordination Roles mentioned above, if different from the WP Leaders.

(3) Work package leaders: Are responsible for managing their WP as a self-contained entity. Their responsibilities include, amongst other things, coordinating, monitoring, and assessing the progress of the WP to ensure that objectives, output performance, cost, and timelines are met.

Detailed description of the organizational structure and the decision making structure can be found in Deliverable 8.2 Quality and Risk Management Plan.

The aforementioned organizational structure chaired by the Project Coordinator and the Technical Coordinator ensured during the first six months of the project that:

- The consortium followed the project objectives, its scope, its schedule and the budget;
- Efficient planning, scientific/technical coordination, fostering the flow of information between participants and between work packages;
- Financial and administrative management of the project (including access to grant agreement and keeping records and financial accounts);
- Arrangement and execution of the project KoM. During the KoM various presentations took place from the management, administrative and also the technical sides of the project;

- Planning of the second project meeting, on month 7, in Athens, Greece.
- Project quality management (including templates, deliverables' review etc);
- Communication with EC towards the submission of the periodic deliverables.

Consortium communication:

The Kick-off (2-day) meeting was conducted the first day of the project (02 March 2015) in SSSA, in Pontedera, Italy. The MoM have been documented and are archived in the project's website internal workspace. Plenary Skype-call meetings have been scheduled on a monthly basis for the first six months of the project. All MoM have been documented and are all archived in the project's website internal workspace. In order to achieve more efficient communication and coordination of task execution, three workgroups were formed. The first workgroup, which comprises FRA-UAS, FSL and BETHANIEN, is focusing on the clinical-related tasks of user group definition, user requirements derivation, ethical requirements and ethical approval and use case scenarios. The second workgroup, which comprises SSSA, ROBOTNIK and OMEGA is focusing on hardware development and the third workgroup, which comprises INRIA, ICCS, OMEGA and KIT is focusing on data collection experiments. All three workgroups performed frequent Skype meetings whose MoM have been documented and can be found in the internal workspace of the I-SUPPORT website. The existing workgroups reflect the tasks and needs of the first year. The following two years the workgroup formation might change.

Plenary project meetings:

The second plenary project meeting was conducted on the 17-19 September in Athens, Greece. The third plenary project meeting is scheduled for December of 2015 or January of 2016, in Karlsruhe, Germany.

- T8.3 Scientific and technical management

The Technical Manager (TM) in collaboration with the Quality Manager (QM) provided on-going technical overview and direction for the project. They ensured alignment of the requirements across the work packages, identified the dependencies between the activities and facilitated technical communication between project participantsensuring that each partner acquired the appropriate input from the rest of the partners in a timely manner, so that tasks are completedin the correct order.

In particular within the first six months of the project the technical management focused on fostering communication between the clinical partners and the technical partners for the definition of the use cases, and the system requirements, for the ethical requirements and the safety requirements. The TM fostered communication and the information exchange between the partners in the data collection workgroup (INRIA, ICCS, KIT and OMEGA) and between the partners in the hardware architecture (ROBOTNIK, SSSA and OMEGA).

- T8.4 Quality assurance and Risk management

The QM (Panagiotis Vartholomeos from OMEGA) in collaboration with the rest of the partners determined the project organization, the roles and responsibilities, the quality objectives and quality indicators and the quality monitoring processes that are carried out during the project.

Furthermore, the consortium has identified the critical risks and has proposed solutions for addressing these risks. Accordingly the QM drew an initial risk management plan. All the aforementioned have been documented in detail in deliverable D8.2 “Quality and Risk Management Plan”, which was submitted on Month 7.

3.1 Problems arising (if any) and how they were resolved

No problems have arose during the first six months of the project

3.2 Changes in the consortium composition if any

No changes in the consortium composition.

3.3 Project planning and status

Each workpackage evolves according to the Gantt chart described in the DoA, Annex I. Milestones and deliverables have been delivered on time (including a grace period of one month after the deadline),except deliverable D8.2 Quality and Risk management that was delivered on month 7 instead of month 3. The reason for the delay of D8.2 was that the derivation of an effective risk management plan requires a thorough understanding of the technological and implementation challenges, which was available only after the fifth month of the project when the partners had derived a detailed description of the system’s components and architecture.

An overview of the project execution during the first six months follows:

WP1: All tasks started on month 1. Tasks 1.1, 1.2, 1.4 and 1.5 finished on month 6. Task 1.3 is still on going and is expected to finish on month 12 (in accordance to the DoA). User group, user requirements, system functionalities, use cases, safety and ethics have all been specified and documented. Milestones 1 and 2 have been successfully completed on M7 and M5 and deliverable D1.1 is currently being prepared. A list of robotic safety standards was spread around partners (M5) and will be included in D 1.3 (M12).

WP2: Tasks 2.1, 2.4 and 2.5 started on month 4 and Tasks 2.2 and 2.3 started on month 6. They are evolving according to the DoA. In task 2.1, priority was given firstly on hardware architecture and secondly on software architecture, since the latter depends to a great extend on the former. Within the first six months all hardware components of the system have been defined and most specification requirements have been derived.

WP3: All tasks began on month 4 and are evolving according to the description in DoA. Preliminary designs of the soft-arm robotic system and its actuation and of the motorized chair have been provided and are documented.

WP4: Tasks 4.1 (human pose estimation) and Tasks 4.2 (robot pose estimation) started on month 4, they are evolving according to the DoA. Depth sensors have been selected and experimental set-up for data collection is being prepared. The rest of the tasks are planned to start on month 7 (in accordance to the DoA).

WP5: Task 5.1 started on month 6. Tasks 5.2, 5.3 and 5.4 started on month 4 and are all evolving according to the DoA Gantt chart; at this stage emphasis is put on conducting data collection experiments for learning motion primitives by demonstration. Tasks 5.5 and 5.6 have started on month 3. They are evolving according to the description in DoA; all context awareness sensors have been selected.

WP6: Has not started yet.

WP7: Tasks T7.1 – T73 have started on month 2. All partners have participating in dissemination activities. A preliminary dissemination plan has been developed, documented in D7.1 and submitted on M7. Task 7.4 (exploitation plan) is expected to start on month 20.

WP8: All management tasks have started on month 1. The workpackage evolves according to the DoA. D8.1 was submitted on M3 and D8.2 on M7.

The task execution during the next six months will follow the Gantt chart and the Task description presented in the DoA. The Plenary Board and the Implementation Committee expect no delays or deviations with respect to the Gantt chart by the end of the first year of the project. All partners are in close collaboration and have established strong communication channels for project coordination and timely task execution.

3.4 Impact of possible deviations from the planned milestones and deliverables, if any

Deliverable D8.2 “Quality and Risk Management” was submitted on month 7 instead if month 3. However this deviation had no impact on the smooth execution of the project because significant portion of the report (related to project organization and consortium communication) had been discussed during consortium meetings and documented in internal reports by month three of the project.

4 Deliverables and milestones tables

4.1 Deliverables

Del. No	Del. Name	Version	WP no.	Lead Beneficiary	Type	Dissemination level	Delivery date from Annex I	Actual delivery date	Comments
D7.1	Dissemination Plan and Communication tools	1	7	OMEGA	Report	Public	01/09/15	11/09/2015	-
D8.1	Internal Communication Infrastructure	1	8	ROBOTNIK	Website	Public	01/04/2015	07/09/2015	The website was available on the web in May 2015. On 07/09/15 we uploaded a brief report describing the website features and structure.
D8.2	Quality and Risk Management Plan	0.8	8	OMEGA	Report	Confidential	01/06/2015	14/09/2015	-
D8.3	Progress Report I			ROBOTNIK	Report	Public	01/11/2015		Will be delivered by the end of October. (Progress reports can be completed two months

									after the end of the reporting period.)

4.2 Milestones

Milestone No.	Milestone Name	WP No.	Lead Beneficiary	Delivery date from Annex I dd/mm/yyyy	Achieved Yes/No	Actual achievement date dd/mm/yyyy	Comments
1	User requirements	1	BETHANIEN	01/06/2015	Yes	25/06/2015	A detailed discussion paper on User definitions and user requirements was circulated by BETHANIEN in 25/06 based on which several decisions were made regarding the architecture.
2	Initial use cases	1	BETHANIEN	01/08/2015	YES	10/09/2015	-
3	Safety requirements	1	ROBOTNIK	01/08/2015	YES	28/08/2015	Conclusions to be presented on the next project meeting in Athens

5 Explanation of the use of the resources and financial statements

The next figures show the actual use of resources (personnel):

	M1-M6	Total	Remaining
WP1 User requirements	20,35	43,5	23,15
1.1 End-user and carer requirements	7,40	10,5	3,1
1.2 Models of user abilities and behaviour w.r.t bathing	3,20	10,5	7,3
1.3 Safety requirements	2,04	5,5	3,46
1.4 Definition of use case scenarios and functional specifications	5,51	9,5	3,99
1.5 Sociological, gender and Ethical considerations	2,20	7,5	5,3
WP2 Service robotics system Architecture and Integration	5,05	85	79,95
2.1 Overall system SW and HW architecture	3,65	20	16,35
2.2 Software service robotics system integration and validation	0,20	31	30,8
2.3 HW integration, ergonomic installation and waterproofing	1,20	19	17,8
2.4 safety requirements experimental validations	0,00	8,5	8,5
2.5 Define performance metrics	0,00	6,5	6,5

WP3 Robotic devices and other HW integration	11,37	78	66,63
3.1 Adaptation, low level control and industrial design of soft robotic arm	7,50	46	38,5
3.2 Adaptation, instrumentation & low-level control of motorized chair	2,00	13	11
3.3 Wireless sensor handle adaptation and integration	1,00	7	6
3.4 Sensor integration and sensor waterproofing	0,87	12	11,13
WP4 Contol system design and implementation	2,39	75	72,61
4.1 Human pose estimation	0,20	21	20,8
4.2 Robot pose estimation	0,20	16	15,8
4.3 Motion control	0,80	12	11,2
4.4 Interaction control	0,79	14	13,21
4.5 Shared control strategies based on human intention	0,40	12	11,6
WP5 Context awareness, perception/cognition for user intention and activity recognition	5,51	142	
5.1 Action and gesture recognition	0,11	14	13,89
5.2 Learning motion primitives by demonstration	3,40	30	26,6
5.3 Adaptable representation of motion primitives	0,50	15	14,5
5.4 Personalization and adaptation to the user	1,50	22	20,5
5.5 Context awareness	0,00	42	42

5.6 Fall detection and other alerts	0,00	19	19
WP6 Pilot and evaluation	0	61,5	
6.1 Evaluation Plan	0,00	15	15
6.2 Participants recruitment	0,00	6	6
6.3 Testing activities conduction	0,00	26,5	26,5
6.4 Analysis and synthesis of evaluation results	0,00	14	14
WP7 Pilot and evaluation	2,76	29	
7.1 Dissemination plan and communication tools	1,31	6,5	5,19
7.2 Dissemination events	0,60	11,5	10,9
7.3 Continuous market monitoring	0,65	4	3,35
7.4 Exploitation plan	0,20	7	6,8
WP8 Management	1,74	12,5	
8.1 Financial administration	0,20	2	1,8
8.2 Consortium coordination, communication and liaison with the EC	0,98	9	8,02
8.3 Scientific and Technical management	0,06	0,5	0,44
8.4 Quality assurance and risk management	0,50	1	0,5
TOTAL			
	49,17	526,5	477,33

As we can see from the previous figure, the total amount of PM spent so far (49,17) is the 9,3% of the total amount (526,5), which is a normal figure since the project has just started.

Regarding the budget, next table shows the expenditures from M1-M6

	total project planned	Remaining Total project	M1-M6
Personnel	2439959	2.206.468,99 €	233.490,01 €
Other	406600	392658,87	13.941,13 €
subcontracting	5000	5000	0€
direct costs	2851559	2604127,86	247.431,14 €
Indirect	711639	649781,215	61.857,79 €
total costs	3563198	3253909,075	309.288,93 €

As we can see, the total costs up to M6 (309.288,93€) correspond to the 8,7% of the total budget, which is as well in line with the PM percentage and is again a normal figure taking into consideration that the project has just started.