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Project acronym: EASY LINE+

Project title: LOW COST ADVANCED WHITE GOODS FOR A LONGER INDEPENDENT LIFE OF ELDERLY PEOPLE

Instrument: Specific Targeted Research Project

Thematic Priority: Information Society Technologies (2002-2006)

Easy Line+ Project Final Report

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document History

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Authors: Roberto Casas, Armando Roy, Alba Jiménez, Rubén Blasco

Contributors: All project consortium

Abstract: The present document is a publishable summary of the final activity report. It summarises the main achievements of sixth framework programme project EASY LINE+, which started January 2007 and finished in April 2010

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1. THE EASY LINE+ PROJECT

It is a reality that the number of elderly people is increasing significantly in Europe, in fact, the number of people 80+ will rise by 180% by 2050. Therefore, families will not be able to solve the matter of caring for elderly people on their own. There is the risk that the elderly people will have to stay at to nursing homes due to the difficulty of carrying out independent life activities or due to the danger of household accidents. Nevertheless, there is a European policy to improve and increase the independent life of elderly people.

Old age affects functioning of sense organs, information processing capacity, reduces speed and increases variance in the timing when doing precise movements, increases "thinking time" necessary to interpret complex display scenarios, makes it difficult to do two things at once, reduces maintenance of attention over long periods of time, etc.. Consequently, domestic appliances that usually have been a big help while people had an independent daily life, owing to their new functional limitations, become a barrier to overcome.

The elderly people suffer some disabilities that get worse over the years. These disabilities will difficult the tasks to carry out an independent life. It is a reality that the main disabilities (42%) prevent to carry out home tasks and that, about a fourth of household accidents are produced in the kitchen, where the "white goods" are key elements.

1.1 Project objectives

The general objective of the project is to develop prototypes near to market of advanced white goods, in order to support elders with or without disabilities to carry out a longer independent life, which will compensate their loss of physical and/or cognitive abilities.

In order to achieve this general objective, the following **specific objectives** have been identified and described in DoW:

1. To develop new prototypes of white goods:

   - REFRIGERATOR

     Refrigerator will comment on what goes in and out

Refrigerator will comment on expired goods

Refrigerator will advise on goods when cooling has been interrupted (thermal TR)

- OVEN-MICROWAVES

  Development of intelligent systems which aid in the programming of the appliance

- WASHING MACHINE

  Investigate current industrial laundry solutions for domestic applications, i. e. sorting aids to see whether modification is appropriate.

  Development of intelligent systems which aid in the loading of washing machines

  Development of intelligent systems which aid in the programming of the appliance

- STAND-ALONE READER

  Identify tagged products that will come into the kitchen after shopping

  Identify the packs in the garbage when dropping it.

2. The principal characteristics of the advanced white goods are to be:
   - Secure, the reliability must be 100% because they provide functionalities linked to the elderly people's health.
   - Intelligent: because they act considering variables and learnfrom their environment.
   - Establish communications with other at home devices and external devices (like mobile phone),interact with the end user through user-friendly interfaces and incorporate domotic sensors for collecting data.
3. To provide intelligence to the white goods:

   To develop a White Good control system, called "e-servant" based on context awareness and the habits of the user that can configure any appliance with or without user cooperation

   To develop a "learning system" in the "e-servant" that detects the loss of abilities of the user and tries to compensate them.

To develop a quality of life evaluation tool that informs the user's carer about relevant information.

4. To develop new more robust and interoperable RFID sensors
5. To introduce the following new technologies in white goods

   RFID sensors

   Wireless communications like Zigbee between, domotic sensors, "e-servant" systems and white goods

   PLC Communications between white goods,"e-servant" and domotic sensors

   Voice synthesis messages with familiar pre-recorded voices employed as instructions, help in emergency situations, and any other recommendations that increase user's autonomous quality living
6. To develop suitable Human Machine Interfaces (HMI) for interaction between elderly people and white goods through the "e-servant" system.
7. To provide external communication: to the e-servant system with emergency services and family members.
8. To validate the white goods with all the new functionalities included in real scenarios with real end users among elderly people with different physical and cognitive characteristics.
9. To prepare an exploitation plan for the introduction of the project results on the market.

1.1.1 Services provided

Objectives defined in DoW are too much related to technology, WP1 analyzed user requirements in order to define services to be offered by the technology developed:

a) Facilitate the use of the household appliances adapted to the disabilities or preferences of the user and include accessible interfaces. Thanks to the influence of having a multidisciplinary design of the system implemented by social and health workers, we decided not to change system's functioning automatically, to avoid user's disorientation. Specifically the functions provided are the following:

- **FRIGDE / FREEZER**
  - i. Display status
    1. On / Off / Problem / Disconnected
    2. Temperature
    3. Door open / closed
    4. Contents
  - ii. Configure. The user can set the device
    1. Target temperature
- **WASHING MACHINE**
  - i. Display status
    1. On / Off / Problem / Disconnected
    2. Door open / closed
    3. Time to finish
    4. Contents
  - ii. Configure. The user can set the device
    1. Switch On / Off
    2. Set program
- **HOB**
  - i. Display status
    1. On / Off / Problem / Disconnected
  - ii. Configure
    1. Switch Off
- **OVEN**
  - i. Display status
    1. On / Off / Problem / Disconnected
    2. Temperature
    3. Door open / closed
    4. Time to finish
  - ii. Configure
    1. Switch On / Off
    2. Set the target temperature
    3. Set cooking time (start time / period in minutes)

b) Provide useful information and warnings about the use of the household appliances. Specifically the following:

- **FRIGDE / FREEZER**
  i. Advise if the door is left open
  ii. Advise if food is past its use-by date
  iii. Advise if food is approaching its use-by date
- **WASHING MACHINE**
  i. Advise of wrong fabric mix (e.g. white and coloureds)
  ii. Advise of unsuitable fabrics (e.g. dry clean only)
  iii. Advise if machine loaded but not yet on (forgotten to switch it on?)
  iv. Advise if cycle interrupted
  v. Advise if unload incomplete (clothes left in?)
  vi. Advise when machine is on final spin
  vii. Advise when cycle finished
- **HOB**
  i. Advise if hob is left on with no pan
- **OVEN**
  i. Advise when food is ready

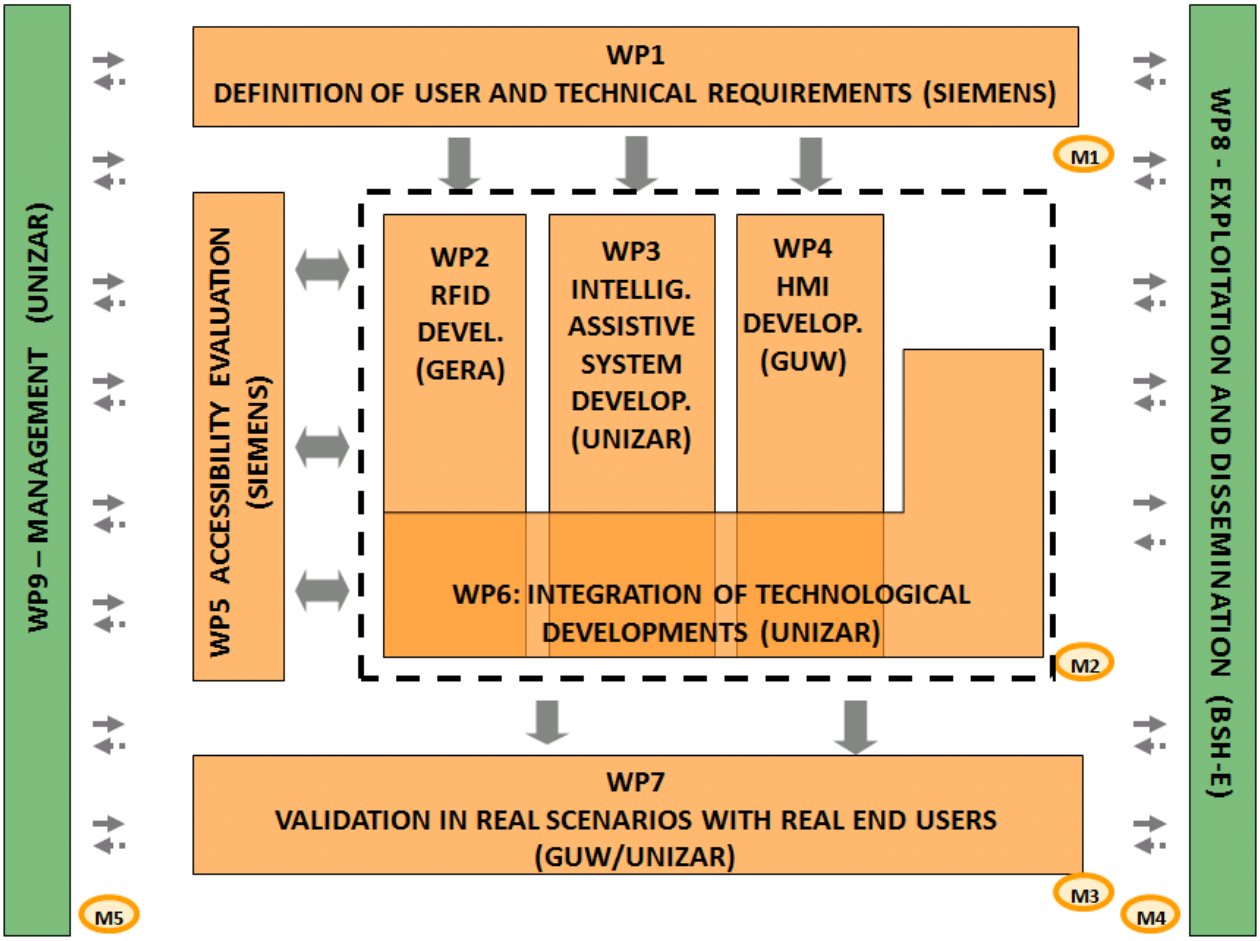
c) Detect emergency situation and automatically take some actions: warn the user, switch off some appliances (e.g. the hob and oven in case of fire or the washing machine if there are water leaks detected).

- Advise about a "Fire detected" emergency
- Advise about a "Smoke detected" emergency
- Advise about a "Water leaks detected" emergency

d) Analyze all the data gathered to extract relevant information that could be useful for user's carer and/or relatives in order to evaluate the person's quality of life. It is able to detect behaviour changes, loss of abilities (memory problems, oblivions, etc.) of the user. For example, it seems clear that changes in HMI's navigation skill, opening the fridge too many times (without picking anything) or loss of skill of programming the washing machine might have relationship with loss of cognitive capacity or disorientation.

1.2 Project Work Plan Achievements

The next diagram is a graphical presentation of the WPs, showing their interdependencies and the leading partners, in parentheses.



1.2.1 Main Tasks per WP

EASY LINE+ major achievements are the following:

Within WP1:

- Identification of the specific needs that the elderly persons have in the use of "white goods", considering the different existent levels of physical and cognitive disabilities in the elderly people.
- Definition of the exact functionalities of the system and the services it will offer at each technological level.

- Definition of what are the main technological developments (RFID, HMI and intelligence) to answer the identified needs of elderly people in using "white goods".
- Definition of the global system architecture, the communications between the different parts and software architecture.

Within WP2-WP3-WP4-WP6 (Technical WPs):

- Development of new applications for the RFID developments in domestic white goods:
    - refrigerator (to read the information about the food inside);
    - microwaves (to read the information of the food about to be cooked);
    - washing machine (to read the information about the garments inside);
    - stand-alone reader (to read the information about the tagged products that will come into the kitchen after shopping and to identify the packs in the garbage when dropping it)
- Definition of the EPC data information for food and garments in RFID tags.
- Development and testing of different RFID tag prototypes.
- Development of a context awareness environment for the kitchen (ZigBee sensors prototypes and white goods connected to PLC).
- Development of the e-servant intelligence that coordinates communication with all other systems:
    - facilitates the use of the appliances, adapting the systems to the disabilities or preferences of the user;
    - analyzes all the data gathered to extract relevant information that could be useful for user's carer and/or relatives to evaluate the person's quality of life;
    - in case of conflict or emergency it can send a warning message to the user and automatically take corrective actions.
- Development of (modular) user-friendly interfaces flexible enough to adapt to target all members of the public (in particular the ageing society) in order to fit user's individual preferences or needs (cognitive or physical).

- Integration and testing of all the developments to create the smart kitchen system, fulfilling the user requirements and to be evaluated by end users.

Within WP5:

- Support to technical WPs ensuring that the design complies with the requirements of accessibility by means of workshops, surveys, work with end users and their associations, experts, etc.
- Definition of testing procedure for the whole system considering different levels of physical, sensory and mild cognitive disabilities of elderly people.

Within WP7:

- Ethical guidelines, a code of conduct and legal documentation for technology evaluation with users is been addressed in NEWI and UNIZAR.
- Formal relationship with end user associations has been established in NEWI, UNIZAR and C-LAB for requirement collection and testing activities.
- Definition of a common methodology for evaluating accessibility, functionality, usability of the system with the end users.
- Evaluation of the full system has been done in Wresham and Zaragoza.
- Refinement of technological developments considering feedback from users

Within WP8:

- Definition and execution of a common dissemination plan in industrial, scientific, standardization and end user areas.
- Design, development and update of the Project Web Site – www.easylineplus.com
- Synergies with other projects have been promoted in order to collaborate in ICT technologies for ageing society issues
- Development of a exploitation plan for the system developed including foresight analysis on mass manufacturing of the developments
- Intellectual Property Rights have been considered, agreements between partners signed, and specific patents filed at national (Spain and Germany) and European levels.

- Study about new applications and further R&D developments derived from the project

1.2.2 Deliverables and milestones achieved

Workpackage achievements are mainly measured by accepted deliverables and reached milestones. The status of the deliverables is as follows:

Del no.	Deliverable name	WP no.	Nature [1]	Dissemination Level	Status
1.1	Report that collects information about the: Interview definition, Sample for the interview, Matrix with the detected needs classified and selection of the most important ones and technological developments defined in RFID, HMI and Neuronal Networks for answering the selected needs	1	R	Public	Accepted
2.1	RFID system for integration in domestic refrigerators for the elderly	2	OTH	Restricted	Accepted
2.2	RFID system for integration in domestic microwave for the elderly	2	OTH	Restricted	Accepted
2.3	RFID system for integration in domestic washing machines for the elderly	2	OTH	Restricted	Accepted
2.4	Standalone RFID system for integration in kitchen for the elderly	2	OTH	Restricted	Accepted
2.5	Report of the RFID developments and results	2	R	Restricted	Accepted
3.1	"e-Servant" system validated at laboratory level	3	OTH	Restricted	Accepted
3.2	Report with the design, architecture and development of e-servant system and the results of the tests carried out	3	R	Restricted	Accepted
4.1	Suitable HMI for white goods management by elderly people with different cognitive and physical disabilities.	4	OTH	Restricted	Accepted
4.2	Report with the description of the HMI design, developments and test results.	4	R	Restricted	Accepted
5.1	Report with a description of the support giving in the WP2 and the description of the tests carried out and their results obtained.	5	R	Public	Rejected
5.2	Report with a description of the support giving in the WP3 and the description of the tests carried out and their results obtained	5	R	Public	Rejected

[1] Indicates the nature of the deliverable using one of the following codes: **R** = Report; **P** = Prototype; **D** = Demonstrator; **O** = Other.

Del no.	Deliverable name	WP no.	Nature [1]	Dissemination Level	Status
5.3	Report with a description of the support giving in the WP4 and the description of the tests carried out and their results obtained.	5	R	Public	Accepted
5.4	Report with a description of the workshops carried out and definition of tests for WP7	5	R	Restricted	Accepted
6.1	Prototype of the advanced "white goods": e-servant + household appliances + interfaces	6	OTH	Restricted	Accepted
6.2	Report with the defined test, the methodology for testing and the test results.	6	R	Restricted	Accepted
7.1	Report with the definition of the validation test and the results of the test - Preliminary	7	R	Restricted	Second version of deliverable submitted in M40
7.2	Report with the results of the test	7	R	Public	Deliverable submitted in M40
7.3	Prototypes near to market of advanced white goods able to support elderly persons with or without disabilities to carry out a longer independent life which will compensate their loss of physical and/or cognitive abilities	7	R	Public	Deliverable submitted in M40
8.1	Project Web Site	8	OTH	Public	Accepted
8.2	Compilation of articles, panels…etc created by partners for project results diffusion	8	OTH	Public	Deliverable submitted in M40
8.3	Draft of the Exploitation Plan	8	R	Restricted	Accepted
8.4	Exploitation plan	8	R	Restricted	Deliverable submitted in M40
8.5	Studies, papers and process of patenting/protecting.	8	R	Restricted	Deliverable submitted in M40
8.6	Studies of new markets and new researching paths.	8	R	Restricted	Deliverable submitted in M40
9.1	First 6-monthly Interim Activity report	9	R	Restricted	Accepted
9.2	First Technical Progress Report & First annual financial report	9	R	Restricted	Accepted
9.3	Second Interim Activity report	9	R	Restricted	Accepted
9.4	Second Technical Progress Report & Second annual financial report	9	R	Restricted	Accepted
9.5	Final Progress Report and Final Financial Report	9	R	Restricted	Deliverable submitted in M40

All milestones have been finalized among all the deliverables but the last one - Milestone 5: EC approval of technical and financial reports- because the final review meeting with EC has not taken place yet. The following Milestones have been reached:

- Milestone 1 (Month 6): End users and technical requirements have been defined,
- Milestone 2 (month 24): The advanced white goods functionality, robustness, security and interoperability have been validated at laboratory level: e-servant interacting with the dedicated household appliances and interfaces.
- Milestone 3 (month 38): Prototypes near to market of advanced white goods have been validated in real scenarios with real end users.
- Milestone 4 (month 40): Exploitation plan at large scale has been defined

1.2.3 Project Deviations

The Easy Line+ project has had important deviations from the initial Description of Work. These deviations have not affected the final outcome of the project that is considered successful; however they have influenced the total time needed (10 months more than expected) to complete the project, and the responsibilities of the partners involved (coordinator and consortium composition has changed). The corresponding deviations and issues that appeared during the project are chronologically described in the following paragraphs.

At the end of the first year, the coordinator of the project, Mr. Victor Calvín (BSHE-E) retired. In order to achieve a smooth transition for the benefit of the project, Dr. Armando Roy (UNIZAR) took on its coordination. This issue altogether with other minor administrative (Legal name of C-LAB changed to Siemens) and financial (budget amendment required to cover the responsibilities and work shifting between entering and exiting coordinators) aspects had their corresponding amendments already presented.

This amendment was applied at the same time as the first year's financial report, which provoked the postponement in the payment of the first period. This unusual situation had an important impact in the consortium because some of

the industrial partners could not dedicate the expected effort to the project from month 18th till month 26th.

Another management issue that caused a big impact in the project was the withdrawal of Siemens from the project in month 27th. As a result the accessibility evaluation (WP5) changed its scope to adapt to this new situation. In addition some partners (Universities of Zaragoza and Glyndwr) ended up having a greater implication in some aspects of the project. In particular Glyndwr and the university of Zaragoza became much more involved in user validation, they together developed a common testing methodology and build a usability lab (GLYNDWR) and a flat (UNIZAR) including fully equipped kitchens to be tested by the users.

Motive Technology UK Limited, for the purposes of Easy Line+ contract, has taken over the rights and obligations of A D SOFTWARE SOLUTIONS LIMITED as of month 26th. The resolution of this issue also lasted some months and prevented the fulfilment of some technical work from Motive till month 34th.

Other minor administrative issues happened: North East Wales Institute of Higher Education changed its legal name into Glyndwr University and Gera-Gera GmbH changed its legal name to GIS Gera Ident - Systeme GmbH.

Furhtermore two amendments were done to extend ten additional months the duration of the project with the purpose of compensating the delays occurred, adjusting the efforts spent by some partners and regularizing the administrative situation of the partners.

Summarizing, three contract amendments have been produced to overcome the issues above described and project duration has been extended from 30 to 40 months in order to complete all the objectives in the contract.

2. METHODOLOGIES

Easy Line+ has followed an iterative implementation plan considering the end user perspective in many stages of the project; following figure illustrates this.

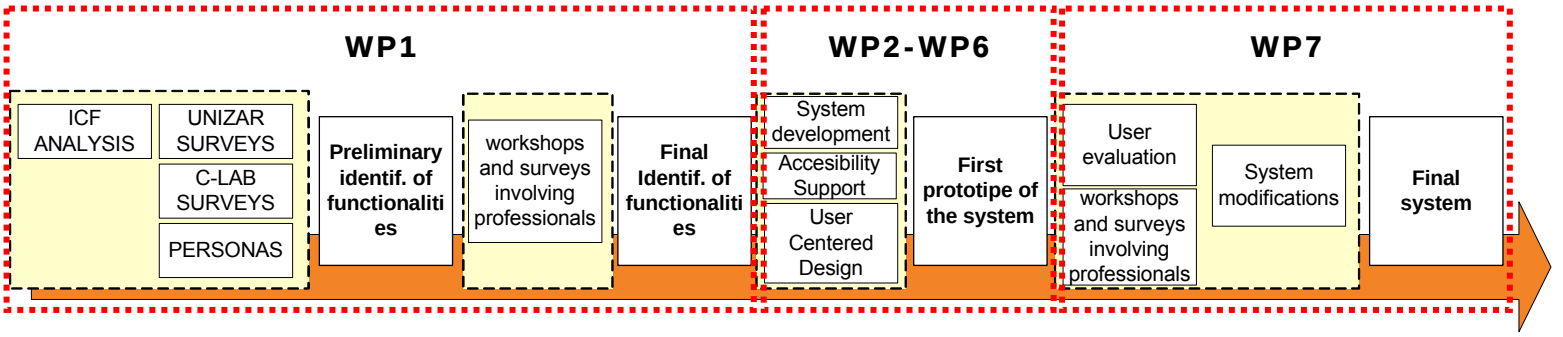


Figure x. Easy Line+ project methodology for user involvement

2.1 Definition of end users and technical requirements

Identification of functionalities of the final system was done inside WP1 using a multidisciplinary and iterative approach. In a first stage a **Persona methodology was used** to understand the current situation of the elderly in Europe and to provide the developers with valuable insights and an efficient way of keeping the stakeholders in mind throughout the system design with the aim of making and simplifying design decisions.

The definition also included a systematic analysis to determine how a person with disabilities (physical, sensory and cognitive) faces each of the tasks done in the kitchen. Then the required capacities are analized to execute each task according to **WHO's ICF (International Classification of Functioning)**. Finally, the physical, cognitive and sensory aspects of elderly people affecting the execution of the task and corresponding appliance requirements are pointed out.

After the results of the Persona and ICF analysis, two **surveys were designed** to objectivise and quantify the findings with the intention of identifying the necessary technical developments which will fit with the original requirements. The planned surveys aimed to confirm the main problems and needs that the elderly and people with disabilities have when interacting with white goods. There was the need to identify the issues that would jeopardize mobility,

accessibility, usability and safety inside the kitchen, in order to overcome disabilities -whether they are sensory, motor or cognitive- achieving greater independence and quality of life. There was a special focus in four different areas related to different activities in the kitchen: food storage, cooking, washing the dishes and doing the laundry.

First survey is very much detailed focusing in the tasks to be performed in the kitchen when interacting with white goods. Second survey was more generic and oriented to all white goods. This survey also included an -interview to ask the user about his/her needs and preferences.

Based in the analysis of all this material and our own expertise, the consortium came up with a preliminary identification of functionalities that the technology should provide.

At this point any further functionalities were defined and contrasted with end users associations and health and social care professionals. This phase of work was **workshop with a multidisciplinary group of professionals** with large experience working with elderly people.

We used a collaborative methodology, in order to contrast the results with the participant's opinion by means of surveys and recordings. Firstly there was an introduction to the project objectives and a description of the system functionalities right afterwards. After this presentation, there were several multidisciplinary groups created to work on the proposed features and to generate other improvements that might be useful to help elderly people in their houses. They also focused in the selection of the parameters whichare important to assess the person's capacities and identify if they are able to live by themselves. The collaborative work was then concluded with a discussion of the results were each individual talked about how the system should help the user and about the utility that checks the evolution the capacities of the user. Finally, all the participants filled a survey to evaluate the results obtained from the workshop and to weight the importance of the parameters used to assess the person's capacities.

At the end of this process we finally identified the functionalities of the system as described in section 1.1.1.

2.2 System design and development

Different technological developments have been tackled in the project within WP2-WP6: RFID technology, sensors and communications, system intelligence,user interfaces, etc. All the development process is based on **User-Centred Design (UCD) principles** that helped us to improve the quality of the findings at every stage and to design for achieving maximum accessibility and usability. This approach allowed us to find out what users want, create it, refine it, and finally, make it the most reliable/secure possible which, overall, is the main focus of the HMI. The main aim obviously has been to meet users' expectations of the final product.

Nevertheless, in some aspects of development, end user perspective cannot be taken into account due to the technology intrinsic nature. For example, communication protocols or the algorithms used in artificial intelligence are not influenced by any accessibility or usability implication (the same as the electronics inside of a computer). On the other side, user interface has the largest influence by end user perspective.

2.2.1 Accessibility

Accessibility requirements were considered in many forms during the whole cycle of the system's design and development. WP5 has supported technical WPs in ensuring that the design will comply with the requirements of accessibility.

Technology developers have used an **accessibility guideline** based on the practical knowledge of Siemens accessibility experts , on the users' requirement specifications and on international accessibility standards. It provides recommendations to improve the accessibility of ICT equipment and services. Equipment and services following this guideline will have wider accessibility for use in home environments. This guideline covers issues associated with design of equipment and services for people with a wide range of sensory, physical and mild-cognitive abilities, including the elderly people.

The guideline is complemented by a specific **developer checklist** that acts as measuring instrument for the verification of the implemented accessibility features of the user interface. The checklist outlines implemented accessibility

features of the user's interface that meet the needs of the target group considering their sensory, physical and mild-cognitive limited abilities.

Finally, **accessibility workshops** were performed to gather specific information concerning accessibility of the prototypes. Both workshops proved to be very useful in terms of meaningful user feedback. Potential obstacles were disclosed and accomplished achievements were carefully examined. A lot of important information was gathered to further the development of prototypes as well as the practical course of the accessibility tests.

2.2.2 User interaction

Building HMI (Human Machine Interfaces) requires constant feedback from the users; the point is to keep the project focused on delivering value and to keep clear and open lines of communication. We used **RAD (Rapid Application Development) methodology** because it relies on extensive user involvement, Joint Application Design sessions, prototyping, integrated CASE tools (UML), and code generators.

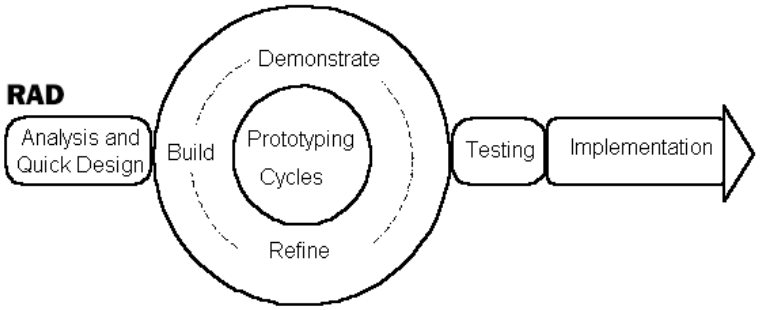


Figure x. X RAD Cycle

RAD methodology has been implemented by means of workshops, open days and demonstrations that gathered group of experts from different related fields (telecare, smart home technologies etc.) and end users that have informally assessed the usability of the Easy Line+ interface.

Also 'Personas' have been used to help technology designers to have a clearer view about the target users and their capacities without burdening the end users who might be in a vulnerable situation.

Finally, a usability lab for the purpose of testing user interfaces with potential users has been created. The laboratory consists of a control room and an observation room, separated by a one-way mirror. We conducted specific pilot

testing of the Easy Line+ user interface in the laboratory where participants were observed and recorded, and their reactions and interaction with the system were analyzed. They were also given a post-session questionnaire, where their opinions of the usability of the interface were solicited.

2.3 User Validation

Evaluation of the system has to give the information needed to determine if the objectives of the project are fulfilled. In order to assess these evidences, different methodologies and types of users have participated in the evaluation process: beneficiaries directly using the system, informal and formal caregivers of those beneficiaries and professionals of the social and healthcare sector.

Main activities have been: **end user evaluation of technology in the pilots**; **evaluation of the system with formal and informal carers** from the point of view of accessibility, functionality, usability, performance and user satisfaction as well as longer independent life evaluation, and **workshops done in the University of the Zaragoza with professionals** of the social and healthcare sector discussing the capacities of the system to improve the quality of life of the elderly people.

3. THE EASY LINE+ PROTOTYPES

Main objective of the system proposed is to increase the elderly and people with disability autonomy in their everyday activities allowing them to carry out an independent live for a longer period of time. Following picture shows the final prototypes.

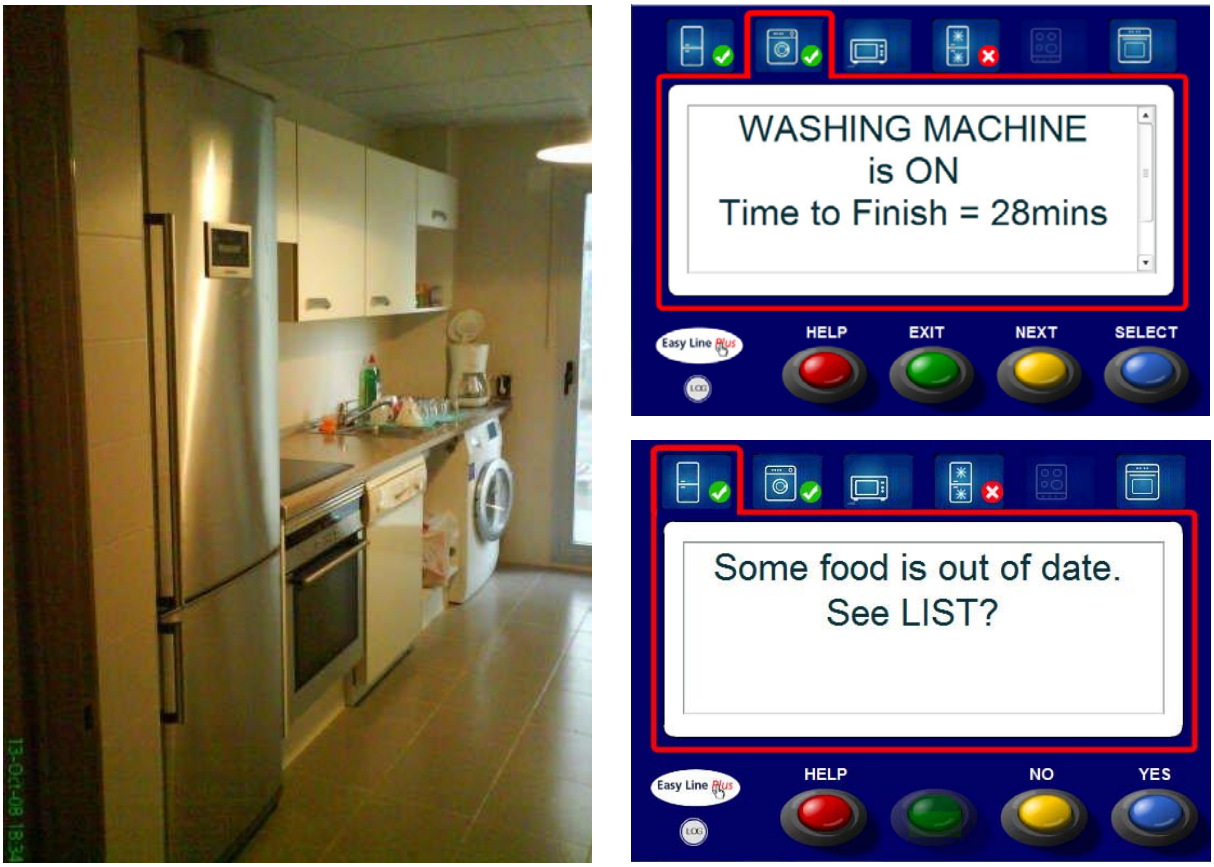


Figure 1. Fnal Easy Line+ prototypes (kitchen environment, user interface)

3.1 Architecture

As we are talking about the kitchen, appliances, of course, are the most important elements no matter if they are intelligent or not. It is evident that new "intelligence" and interfaces have to be introduced in the whole system; nevertheless, this doesn't mean that white goods have to be more intelligent or incorporate new adapted interfaces. This would increase their unitary price, harden their installation (adapt the functioning to the user particular case requires configuration) and consequently hinder the market penetration. Thus, instead of having new smart appliances with accessible interfaces, we envision a

central intelligence aware of the status of all the white goods, able to control them and also able to interact with the user. That is to say, we just add the appliances the capacity to communicate. This, besides lowering the price of the appliances, also eases their development and perdurability; appliances don´t change their current way of functioning, just add a new feature: manage communication hardware to inform about their status and execute actions. In following figure we can see the blocks diagram including all the technology involved in the new kitchen concept

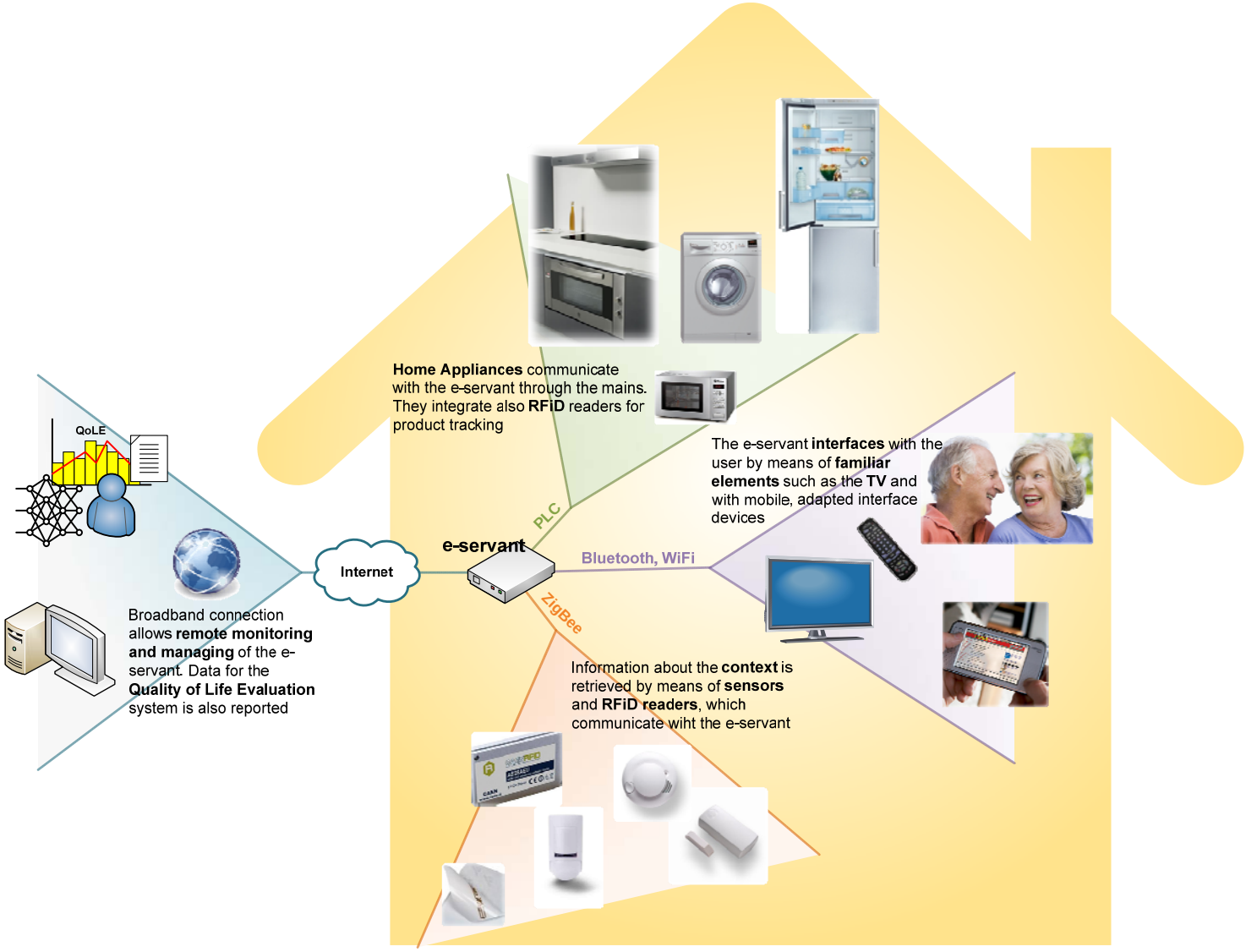


Figure 2. Block diagram of the new kitchen concept

3.2 Physical context

All the devices within the green and orange frames would be the **physical context**.

- Obviously the appliances form one basic block in the kitchen; their contribution to the context will be informing about their status (for example, temperature in the case of the fridge, washing program in the washing machine, etc.) and execute actions (for example, change temperature reference, stop operation, etc.).
- Diverse sensors are usually used for context awareness tasks; specific selection depends on the AmI application. We propose some sensors already usual inside the kitchen (temperature, fire, smoke, flooding) and other not so used in this scenario:
    - door sensors for detecting when the user opens/closes a cupboard or drawer
    - illumination sensor to detect when the user forgets the light on
    - presence sensor to detect when the user enters the kitchen

  We have also considered RFID readers for identifying clothes and food. The use of RFID and EPC can provide useful information about what is in the washing machine or fridge, what does the user want to eat or have just bought, etc. Food information is useful to inform the user about the food that is missing, which food is going to go out of date, which food the user may eat, etc. Cloth information is helpful to determine which washing programme fits best with clothes the user has introduced in the washing machine. An RFID reader in the microwaves oven is also of interest to advice the user the program needed to cook the food about to be introduced.

  Food is not only stored in the fridge, for that reason we found useful to have a stand-alone reader able to detect all the items in a bag. This way when the user enters the kitchen after doing the shopping, the system can register the items bought; check if those that need refrigeration are promptly introduced in the fridge. And the same could be done with the garbage bags.

- It's important to highlight that the context architecture proposed is not restricted to the devices so far presented. Any other sensor or appliance could be added to the system in order to enhance its capabilities.

All this information harvested from the context, besides being used to help the user managing the kitchen, is of valuable help for determining his/her quality of life level. For example if the person is losing cooking, washing or shopping abilities, or if he/she is getting more frequently disoriented, etc.

3.3 User interaction

The purple frame is the human-machine interface (HMI) that manages **user interaction**. HMI devices must be easy of use and must be available for any kind of user, having the capability of change the interface according with the user profiles. They must have good communications interface, but they do not need a powerful processing neither storage capacity.

There are many different types of clients that can be used to managing the system: the mobile devices (PDAs, smart phones, wearable devices, ultra-mobile PCs, touch screens, etc.) which means the user can carry them around the house and be able to monitor the house appliances wherever he or she is; the fixed devices (computer or digital TV) will be used as a centralized control and finally the embedded devices which can be control panels implanted in each of the actual appliances. After a study of the state-of-art in the actual market about the technical specifications of potential clients, it was decided that suitable user controls for the system will be:

- Digital TV plus remote controller (elderly people accept it and know how to use basic functions). Central intelligence could send "HMI output" through a S-video or digital signal and receive "User information" through an infrared remote control.
- As a portable device, there are many devices of this type but thinking in low cost and enough process and storage capacities, the best option could be a touch screen device with a dock, middle way between a tablet PC and a PDA; something similar to Nokia N800.
- Digital photo frames are also considered because they are having a big market penetration, and because besides pictures they can reproduce audio

and video, even some models have wireless communication (Bluetooth or WiFi) and they are simple and cheap. These issues make them a good choice to show information ubiquitously in the home.

3.4 Intelligence

In the middle of the figure we have the **intelligence** of the system; what is been called e-servant. E-servant is the coordinator with whom all the other systems communicate. In order to have an invisible system for the user, different blocks use the most appropriate way of communication, and e-servant has to implement them all:

- We use power line communication (PLC) over the main wires to get the status of appliances and to control them; orange frame. PLC is the best option for white goods because all have to be main powered and there are European standards being promoted on this matter. Consequently there are no extra configurations needed to install a new appliance.
- We use wireless sensor networks to enrol all the sensors in the kitchen and also to get RFID data from the readers; green frame. Many protocols exist on these fields, so far we are using ZigBee because it is becoming a de-facto standard in home environments.
- Communication with the interfaces is used through standard communication protocols such as Bluetooth or WiFi; purple frame. The main reason for this is that the communication established can be considered between computers that already include this kind of communication ability.

Finally, communication with the outside world (information to the social services or families about the user's quality of life, information about possible technical alarms, information about maintenance needed, etc.) is also done using standard protocols such as DSL or WiFi. This is showed in figure 1 inside the blue frame.

4. USER VALIDATION

Final assessment of the system is of great importance and the consortium spent a considerable amount of effort in this task. In this process we aimed the following goals:

- Assess the overall effectiveness of the Easy Line Plus system and the subset suitable for exploitation.
- Evaluate accessibility, usability, functionality, performance and user satisfaction of the system and the subset suitable for exploitation
- Evaluate if the system (and the subset suitable for exploitation) can extend the time end users can be living independent
- Provide feedback to designers in order to enhance the system and rectify deficiencies

It is profusely documented in deliverables 7.1 (End Users Evaluation Protocol) and 7.2 (Report with the results of the end users' test).

4.1 Ethical and Legal Issues Considered

Ethical and legal issues have been considered in both places where the technology has been evaluated: University of Zaragoza and Glyndwr. Full information is available in section 3.1 and annexes I and II in Deliverable 7.1.

Summarizing, in the Spanish case:

- a Civil Responsibility Insurance was contracted for the evaluation of the facilities
- An Informed Consent and Protection of User Personal Data was redacted and used.
- The Local Ethical Committee of Aragón approved the testings done in the project

In the British case:

- As the testing took place inside the University no insurance has been needed.

- An Informed Consent and Protection of User Personal Data was redacted and used.
- The testing followed the research about the code of practice from Glyndŵr Research Ethics Committee regarding ethical standards for research involving human subjects.

4.2 Field Tests

System has been validated in several situations using different methodologies. As described in following sections, 90 beneficiaries and 31 formal and informal carers participated in the system's evaluation. The Public deliverable D7.2 can be accessed for further details.

4.2.1 Usability testing

During the development phase we conducted an evaluation in a relatively controlled testing envinronment in order to give us assurance and confidence that later studies (in a home environment) would not be compromised by usability or reliability problems.

We selected a total of **27 participants for this evaluation exercise**, comprising nine elderly users, nine with learning difficulties, and nine from the 'control' group. Each group was given a set of scenarios to follow (for example loading the refrigerator, baking food and doing laundry), which involved interaction with the kitchen appliances and the user interface. The selected interfaces for this study were the television, a touch screen in the kitchen and a mobile device. The testings were recorded in the laboratoryand subsequently analyzed. The users were also asked to complete a questionnaire comprising semantically-rated questions, which were categorized according to usability, design and layout, system functionalities, user satisfaction and oppionion about any expected future uses.

4.2.2 Final System testing with beneficiaries

Field tests have been done in two different sites: Universities of Zaragoza and Glyndwr. In total, **63 beneficiaries participated in the testing**, following table shows specific distribution of the people grouped per age and disability.

Characteristics	Recruited participants
Impairments / Disability[2]	
- none	26
- visual impairment	13
- hearing impairment	13
- cognitive impairment	12
- motor impairment	23
Age	
- <59	11 (8 female)
-65–79	45 (28 female)
- 80+	8 (4 female)
Gender	
- female	40
- male	23
Total	63

Both testing places put into place the same evaluation methodology in order to get mergeable outcomes during the evaluation of the usability, accessibility, functionality and reliability of the system as well as the user satisfaction and future uses..

A session script is created for the test moderator to use during the sessions. This ensures that all of the participants receive the same instructions and that the test moderator gathers data concerning to the same issues throughout the study. We used the following methods:

- Background interview questionnaire to find and measure the relevant information about the person in order to extract user's variables.
- Situation questionnaires: During the evaluation process the user interacts with the system in different situations of everyday life. The objective of this test is to collect the information quickly after every situation in order to prevent mistakes and before the user forgets any relevant data.
- User questionnaire: to know the opinion of the user about their experience using the system in order to evaluate several parameters. This debriefing interview is about asking general questions to collect preferences and other quantitative data and also follow up on any particular problems that came up for the participants. In this questionnaire the participants have the opportunity to share their remarks and criticisms about the system;

[2] These disabilities are not mutually exclusive i.e a person can have visual and cognitive impairments.

but most of all to assist the designers in identifying the issues and improving the system afterwards.

- Observation form is where the observer puts his/her impression about the user.

4.2.3 Final System testing with carers

Added to the direct beneficiaries of the technology, **31 formal and informal carers and have participated in the assessment of the system**. The Main objective of this experience was to extract relevant data in order to evaluate how the system can extend the independent life of a person. It has been designed to allow carers to understand the functionalities provided by the system and how it works. We used the following methods:

- Background Carer Questionnaire to find and measure the relevant information about the carer and (if it's the case, of the person cared for).
- Carer Questionnaire to find the opinion of the carer about the system, its features and its capacity to extend the time a person can remain independent.
- Life situation questionnaire already described in previous section
- Coffee/tea breaks to discuss about the system and potential improvements. The conclusions of this discussion are written by the moderator.

4.3 Evaluation conclusions

Evaluation with end users provided conclusions in different ambits. In one side we have proposed a set of guidelines for evaluating systems with vulnerable users under 'laboratory' conditions. These guidelines are being disseminated as generic principles in several international conferences and journals [3] [4] [5]. These

[3] Picking, R., Grout, V., Crisp, J. & Grout, H., "Simplicity, consistency, universality and familiarity: applying 'SCUF' principles to technology for assisted living", *First International Workshop on Designing Ambient Interactions for Older Users* (*DAI'09*), [part of the *third European Conference on Ambient Intelligence* (*AmI'09*), November 18-21 2009, Salzburg, Austria

[4] Grout, V., Picking, R., McGinn, J., Robinet, A. & Roy Delgado, A., "Interface Design for the Elderly, Disabled and Cognitively Impaired: Experiences from the EU FP6 ICT 'EASY LINE+' Project" (abstract), *Proceedings of*

guidelines were based on the fact that a usability evaluation with elderly and disabled participants could effectively be undertaken in the environment of a laboratory, and in other controlled environments; following we summarize the guidelines proposed:

- *Make participants comfortable*. This is a generic principle, but we seek to emphasize the need to make vulnerable participants *particularly* comfortable. Provide refreshments if possible. Give the participants time to settle down into what might seem as a strange environment at first. Stay in the lab with participants until they are happy to proceed with the tests. Cameras and two-way mirrors may be particularly intimidating, so reassure the participants of their anonymity and emphasize the professionalism of the researchers involved. The participants in our study with learning difficulties seemed especially conscious that their identities should be protected.

- *The orientation script needs a degree of flexibility.* Use an orientation script for the purposes of reliable testing, but don't expect it to work when read word-for-word prior to each session. We used an orientation script, but it became clear very early in our pilot studies that a degree of flexibility would be required to account for the diversity of participants involved. Sensory difficulties such as partial deafness and cognitive difficulties must be accounted for. For some users things need to be read out twice or more, or explained in simpler terms. The diverse age ranges of our participants also required a sensible approach, as several terminologies are familiar for some people and not for some others. The use of any jargon should be avoided, but in today's hi-tech world, that is not as straightforward as it may seem. Words such as 'internet' and even 'computer' are still not universal household terms, especially concerning elderly people. Consequently, adaptation of the orientation script on the fly is a recommendation. This requires the application of interpersonal communication skills which should be practised during the pilot study.

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the First Institution of Engineering and Technology (IET) Conference on Assisted Living (AL 2009), London, UK, 24-25 March 2009.

[5] Picking, R., Grout, V., McGinn, J., Crisp, J. & Grout, H., "Simplicity, consistency, universality, flexibility and familiarity: the SCUFF principles for developing user interfaces for ambient computer systems", *International Journal of Ambient Computing and Intelligence* (to appear), 2010.

- *Always demonstrate the product prior to the test.* The orientation script states that a short demonstration of the product should be given prior to the usability evaluation test. This reassures potentially reticent participants and helps them to relax in the unfamiliar environment. In our evaluation, we demonstrated a situation which did not use any scenarios used in the test itself to avoid obvious bias.

- *Don't put vulnerable people on their own unless it is absolutely necessary.* In our pilot testings, it was immediately apparent that participants felt particularly uncomfortable when faced with the prospect of being tested alone. Our experimental design placed participants in groups of three in a 'co-discovery' situation. This proved very valuable for the observational analysis, as participant's conversations about the product were recorded and analyzed. On more than one occasion when the nature of the usability study was explained prior to the test, participants expressed relief that they wouldn't have to conduct the tests in isolation. Bias within a co-discovery group may be a negative factor with this approach. It is therefore important to be prepared for this situation in subsequent analysis. We experienced this in one co-discovery group, but the fact that there was an issue actually highlighted a usability problem that was experienced by other groups in the evaluation (the 'alarming' auditory warning which frightened some of the participants with learning difficulties).

- *Keep it short.* It is important that participants are given time to get familiar with the environment. However, the usability test itself should be relatively short for vulnerable people who may get tired, have attention span problems, and may become uncomfortable in laboratory environments. It is recomended that the testing (that is, from participants entering the laboratory to leaving it) should last no longer than about one hour, if possible.

- *Provide a realistic, familiar layout where possible.* This is another generically applicable principle, but is especially important for vulnerable participants. Distracting participants and keeping them occupied with familiar artefacts can help to alleviate concerns over cameras, microphones and two-way mirrors. We used books, newspapers, magazines, and the television set which was

conveniently central to the study in question. A reassuring hot drink was also provided.

- *Ensure the laboratory is accessible and flexible.* Elderly and disabled participants may have a range of disabilities, and the laboratory should be able to accommodate for them wherever possible. Wheelchair users in particular should have adequate access. The laboratory layout should be flexible enough to enable fixtures to be easily moved out if necessary, and for extra facilities to be moved in.

- *Use realistic and familiar scenarios.* Make sure that participants are testing the product, and not learning a new scenario or situation, as this will adversely affect the test. Include questions in the user profile questionnaire that elicit the participants' experience of the scenarios to ensure this. We asked about familiarity with kitchen appliances and domestic activities prior to initiation of the evaluation.

- *Prioritize ethical and legal issues.* Working with vulnerable people in any way requires ethical and legal procedures to be followed. For the testing, we are bound by Glyndŵr University's own strict codes of ethical conduct (for example, non-malificence, beneficence, confidentiality, informed consent, trust, honesty and integrity). Similar codes of practice have been applied in the University of Zaragoza.

- *Prioritize health and safety issues.* Any usability laboratory environment should conform to health and safety policies. Where vulnerable people are involved, their exposure to potentially hazardous situations must be avoided. Consequently, there may be a requirement for intervention by the usability evaluators to facilitate a test. In our case, the test moderator was responsible for controlling and interacting with the kitchen appliances. The participants were unfamiliar with the appliance controls, and training them in these was considered unnecessary and may have introduced confusion with respect to learning the user interface being tested, regardless of the obvious hazards of using an unfamiliar oven, for example.

- *Don't rely purely on laboratory-based studies.* The laboratory-based evaluation is a very useful tool amongst many. The results have provided us with confidence to move to more situated evaluation (the apartment in

Zaragoza). Earlier participative methods (e.g. focus groups and workshops) have also been useful to us on the Easy Line+ project, although from a practical point of view these can be time-consuming and expensive when relied on too heavily. We recommend using a range of evaluative tools in the process of developing products for diverse user populations. Whichever tools are used, the Hawthorne effect must be carefully considered. Our use of a control group in the laboratory-based evaluation helped us overcome concern over this factor.

Regarding the validation of the system's prototype in real environments with real end users we have extracted the following conclusions.

From the accessibility point of view, 90% of the users can perceive and understand at least one input channel (tactile screen, remote control or voice) and output channel (visual or aural) and 70% have the opinion that the system is accessible. Usability of the system has been evaluated with a 3.85 over 5. Therefore we can conclude that the system has good usability and physical, sensory and cognitive accessibility. In any case, several suggestions from the users have been taken in account to improve the accessibility and functionality of the system

About the functionalities of the system, we observed that both for beneficiaries and carers, the highest rated function of the system is to bestow security at home: "Trigger emergency warnings (fire, smoke and flood) and act in case there is no response". For the carers, this functionality is closely followed by "Detect routine changes in the kitchen to inform whenever there are changes in conduct patterns that can identify any loss of abilities in the user" as it can strongly improve the tools that they have to monitor the evolution of the elderly and disabled people.

From the point of view of the beneficiaries security functions are followed by the reminder services "Trigger warnings and reminders when the appliances require attendance".

It has been evidenced that the functionalities of the system can support the user in several areas of the Activities of Daily Living (ADLs), reduce the dependence level of the person and consequently increase his/her time of independent life. Carers and beneficiaries agree, the system support the user in the ADLs' areas of

carrying out domestic tasks (prepare a meal, do the shopping and do laundry/ironing) and making decisions (about domestic tasks).

Furthermore, the system has been positively evaluated in health maintenance area (avoid risks at home, ask for help in case of emergency). Already in the health maintenance area, the system is considered very useful to detect routine changes in the kitchen and to inform whenever there are changes in conduct patterns. This would allow early intervention of the carers when loss of abilities of the user is identified. Early intervention is basic to reduce and retard effects of the diseases (Alzheimer, senile dementia, etc.) and thus prolongue the time the users can remain independent.

Early detection of changes in routines would also help to monitor quality of life of the user in some aspects. For example, it can be detected if the person is washing less often, which might indicate that he/she is wearing dirty clothes.

5. DISSEMINATION AND USE

5.1 Publications

The Easy Line+ project has been very successful in publishing its results, attracting national media coverage in Spain, UK and Germany (more than 60 for the general public in press, TV, radio, seminars, etc.). The consortium followed a systematic plan for disseminating its results, as described in D8.2.

30 articles have been published in scientific journals (16), chapters of books (4) and international conference proceedings (10). The most scientifically remarkable contributions are outlined as follows:

- **Health and Social Considerations in Ambient Intelligence Design - 2007**

  Main contribution – New approach about how health and social workers can contribute to AmI systems design and specifically to the design of Easy Line Plus system.

  Reference – A. Ibarz, R. Casas, A. Marco, Y. Garrido, JL. Falcó, A. Roy. Health and Social Considerations in Ambient Intelligence Design, Ubiquitous Computing & Ambient Intelligence, UCAmI 2007, ISBN: 84-9732-442-0, Zaragoza, 10 sept. 2007.

- **Step by Step Framework for Evaluation of Information Technology Benefit in Social Scenarios - 2008**

  Main contribution – New multidisciplinary framework used in Easy Line+ for IT evaluation in social scenarios.

  Reference – E. Vaquerizo, Y. Garrido, J. Falcó, T. Skenhan, A. Jimenez, R. Casas, Step by Step Framework for Evaluation of Information Technology Benefit in Social Scenarios, Communications in Computer and Information Science 1865-0937, Vol: 19, Pp: 19-23, ISSN: 1865-0929, 2008

- **User Modelling in Ambient Intelligence for Elderly and Disabled People - 2008**

  Main contribution – New user modelling concept developed in Easy Line+ to be used in Ambient Intelligence for Elderly and Disabled People

Reference – R. Casas, R. Blasco, A. Robinet, A.S. Roy, A. Roy, J. McGinn, R. Picking, V. Grout, User Modelling in Ambient Intelligence for Elderly and Disabled People, Lecture Notes In Computer Science. Computers Helping People With Special Needs. Vol 5105, pp 114-122, ISSN: 0302-9743; 2008

- **Design and Evaluation of a Sound Based Water Flow Measurement System - 2008**

  Main contribution – New method for measuring water flow in sinks based in Bluetooth and audio processing. Developed inside the frame of Easy Line+ and Monami projects.

  Reference – A. Ibarz, G. Bauer, R. Casas, A. Marco, P. Lukowicz. Design and Evaluation of a Sound Based Water Flow Measurement System, LNCS: Smart Sensing and Context, Vol: 5279, pp 41 - 54, ISSN: 0302-9743; 2008.

- **Common OSGi Interface for Ambient Assisted Living Scenarios, Behaviour Monitoring and Interpretation - 2009**

  Main contribution – New proposal for a Common OSGi Interface for devices and services in AAL related scenarios. Developed inside the frame of Easy Line+ and Monami projects.

  Reference – A. Marco, R. Casas, G. Bauer, R. Blasco, A. Asensio, B. Jean-Bart, M. Ibáñez. Common OSGi Interface for Ambient Assisted Living Scenarios, Behaviour Monitoring and Interpretation, Ambient Intelligence and Smart Environments Vol 3, pp 336-257, IOS Press, ISBN: 978-1-60750-048-3, 2009.

- **Accessible Gaming Through Mainstreaming Kinetic Controller - 2009**

  Main contribution – Innovative work to reuse kinetic controllers as accessible user interfaces inside Easy Line+.

  Reference – Y. Garrido, A. Marco, J. Segura, T. Blanco, R. Casas. Accessible Gaming Through Mainstreaming Kinetic Controller, LNICST: Intelligent Technologies for Interactive Entertainment Vol 9, pp 68-77, ISSN: 1867-8211, 2009.

- **Connectivity for Healthcare and Well-Being Management: Examples from Six European Projects - 2009**

Main contribution – Present the global outcome of Easy Line+ and its architecture compared with other European projects' approaches.

Reference – M.N. Kamel Boulos, R.C. Lou, A. Anastasiou, C.D. Nugent, J. Alexandersson, G. Zimmermann, U. Cortes, R. Casas, Connectivity for Healthcare and Well-Being Management: Examples from Six European Projects. Int. J. Environ. Res. Public Health 2009, 6, 1947-1971, ISSN 1660-4601

- **A case study using a methodological approach to developing user interfaces for elderly and disabled people - 2009**

Main contribution – Innovative methodological approach defined inside the frame of Easy Line+ for developing user interfaces for elderly and disabled people.

Reference – Picking, R., Robinet, A., Grout, V., McGinn, J., Roy, A., Ellis, S. & Oram, D., "A case study using a methodological approach to developing user interfaces for elderly and disabled people", The Computer Journal, 2009.

- **Quality of Life Evaluation of Elderly and Disabled People by Using Self-Organizing Maps - 2009**

Main contribution – Innovative method developed inside the frame of Easy Line+ to objectively assess quality of life of elderly and disabled people

Reference – Antonio Bono-Nuez, Bonifacio Martín-Del-Brío, Rubén Blasco-Marín, Roberto Casas-Nebra, Armando Roy-Yarza, Proceeding IWANN '09 Proceedings of the 10th International Work-Conference on Artificial Neural Networks: Part II: Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living, 2009.

- **Design Principles for Assisted Living Interfaces – 2009/2010**

Main contributions – A description of techniques defined inside the frame of Easy Line+ for designing interfaces for assisted living (three papers)

Reference 1 – Picking, R., Grout, V., Crisp, J. & Grout, H., "Simplicity, consistency, universality and familiarity: applying 'SCUF' principles to technology for assisted living", *First International Workshop on Designing Ambient Interactions for Older Users* (*DAI'09*), [part of the *third European Conference on Ambient Intelligence* (*AmI'09*), November 18-21 2009, Salzburg, Austria.

Reference 2 – Grout, V., Picking, R., McGinn, J., Robinet, A. & Roy Delgado, A., "Interface Design for the Elderly, Disabled and Cognitively Impaired: Experiences from the EU FP6 ICT 'EASY LINE+' Project" (abstract), *Proceedings of the First Institution of Engineering and Technology (IET) Conference on Assisted Living* (*AL 2009*), London, UK, 24-25 March 2009.

Reference 3 – Picking, R., Grout, V., McGinn, J., Crisp, J. & Grout, H., "Simplicity, consistency, universality, flexibility and familiarity: the SCUFF principles for developing user interfaces for ambient computer systems", *International Journal of Ambient Computing and Intelligence* (to appear), 2010.

- **Agent-Based AmI System case study: the Easy Line+ Project - Accepted**

  Main contribution – Innovative agent-based software architecture developed inside Easy Line+

  Reference – 8th International Conference on Practical Applications of Agents and Multi-Agent Systems, 2010

After the project´s conclusion, more publications and presentations at prestigious conferences are planned. www.easylineplus.com will continue to be updated with important events in the after-life of the Easy Line+ project. See public deliverable D8.2 and Final Plan for Using and Disseminating the Knowledge for a complete list of Easy Line+ publications.

5.2 External Collaborations and Clustering

Easy Line+ participated in an eInclusion project cluster organized by Cogknow project for joint dissemination and specific project cooperation. The cluster is participated by 6 European projects: COGKNOW, MonAMi, EasyLine+, i2home, Share-IT and Caalyx. Besides joint dissemination activities, Easy Line+ collaborated with Monami in specific technical work such as the design and Evaluation of a Sound Based Water Flow Measurement System and the definition of the Common OSGi Interface for Ambient Assisted Living Scenarios.

The **ICT+Ageing project**, a study undertaken for the European Commission, DG Information Society and Media, has the goal to identify and understand the market barriers which currently hinder uptake of ICT for independent living and

active ageing in Europe. One important element of the study is to bring together currently active EU research projects in order to build a platform for mutual exchange of knowledge and experience concerning market related aspects; Easy Line+ has participated in various activities organized inside this forum.

6. EXPLOITATION AND IMPACT

Easy Line+ partners are working to make the developed system available as a product. The detailed exploitation plan (D8.4) is project-internal.

Nevertheless there are important issues that hinder market introduction of the system as it has been developed in the project.

The complexity of the system is very high; as it can be seen in the following figure, besides a computer has specific hardware devices like: RFID readers, sensors and networked white goods. Multiple Human Machine Interfaces as tablet PCs, Digital Photo Frame, mobile devices and TV plus remote controller. Several communication protocols: Power Line, cabled Ethernet, WiFi, USB, Infrared and ZigBee. Software package interfacing hardware, managing scenarios for user interaction, analyzing data, etc.

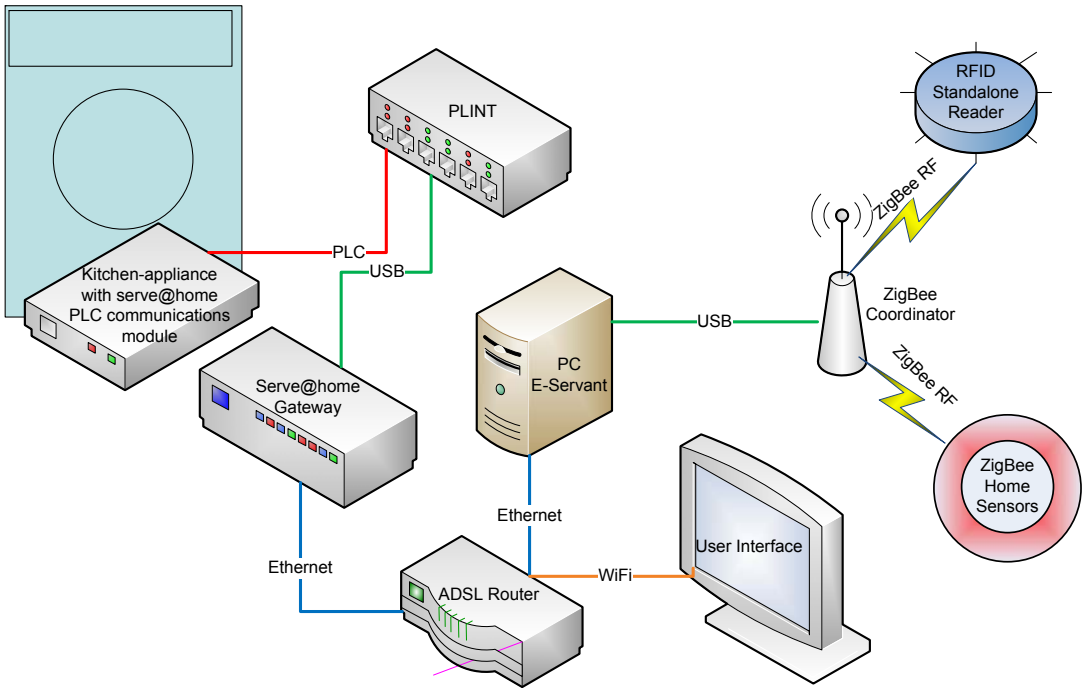


Figure 3. E-servant network scheme

The prototype is functional; nevertheless, it is not mature enough to become a commercial product. If it was installed in end user's homes as it is now, specialized technical support would be needed too often (because of the installation, set up and maintenance) making it economically unsustainable. In order to overcome this issue we are planning a second phase of the project to

create a common software package that facilitates fast deployment, provide management and monitoring of its current operational status remotely and capable of recovering from critical errors autonomously. A Specific plan to convert the prototype into a commercial product has been designed and actors involved are actively looking for the resources needed.

From a market strategy point of view, the system requires several actors involved in the exploitation: On one hand there are technology providers; all of them partners of the consortium. On the other hand there are the target clients which due to the particularities of the system are identified as the user associations that prescribe to the final user the kitchen solution with his/her needs. Between those actors we find a local system integrator that gathers inputs from technology providers (BSH, IDENT, MOTIVE and already existing devices from the open market in order to fulfil the requirements for the user) and install as well as provide system maintenance to the user. The main line of this exploitation plan is to use the following scheme for market implantation:

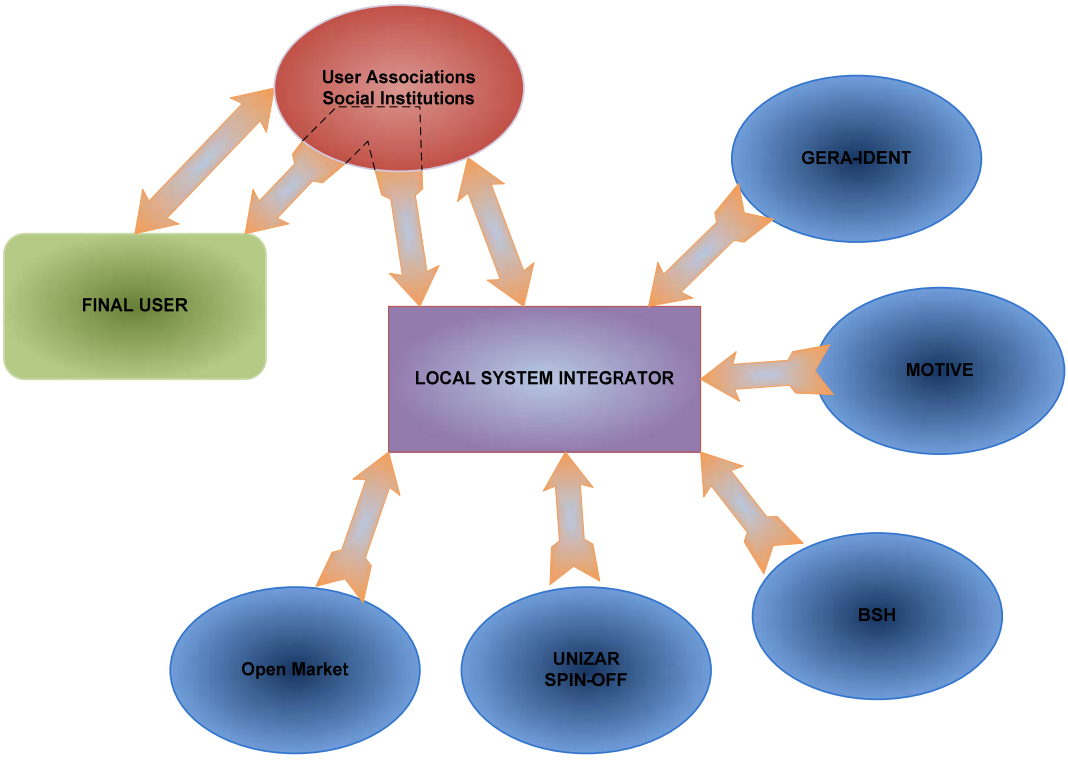


Figure 4. Agents scheme

Local system integrator is a key figure with a quite specialized profile: it has to have considerable and multidisciplinary technical knowledge, close contact with end user's stakeholders, etc. Its enrolment in the project exploitation is a must in

each place the system is deployed and it can only happen after developing a commercial product.

A grade of maturity of the system has been reached and some technologies developed by partners in the project are already exploitable products in the market. Those intermediate results permit in the Easy Line+ to choose among different technologies to be evaluated prior to their final implantation and integration. It also permits a modularization of the system that will later enhance scalability possibilities in the architecture so the user needs are covered and cost has no increment with unused parts.

IDENT has developed an RFID reader resulting in a final market product that is already available for the final user from the final quarter of 2009. IDENT is also RFID tag provider while the use of RFID tags is not extended.

A spin-off of the University of Zaragoza has been created to commercialize ZigBee based devices. Electrical safety, electromagnetic compatibility and EC certification tests are being performed now. Once these tests are completed, the sensors and actuator devices will get into production process, being available for the final customers in the last quarter of 2010.

7. FINAL PROJECT CONCLUSIONS

Easy Line Plus is an EU FP6 project that has been developed between January'07 to April'10. During this time a very challenging work plan involving interaction with end users, technical development, business perspective, dissemination activities, etc. has been put into place. The main conclusion of the project is that we have developed and user-validated a smart environment that supports independent living in the kitchen providing the following services:

- To facilitate the use of the household appliances adapted to the disabilities or preferences of the user and provide adapted human-machine interfaces.
- Provide useful information and warnings about the use of household appliances.
- Detect emergency situations and automatically take palliative actions: warn the user, switch off some appliances (e.g. the hob and oven in case of fire or the washing machine if water detected).
- Detect routine changes in the kitchen informing whenever there are changes in conduct patterns that can identify any loss of abilities in the user.

Throughout the entire project, users have been very much considered in Easy Line+. Besides all the user oriented methodologies used and the contributions to methodological advances regarding involvement of end users in research projects, we can consider that the amount of end users, carers, and healthcare and social professionals involved have been very large: 113 people surveyed to define project requirements, 138 took part in different workshops and 90 beneficiaries and 31 formal and informal carers121 evaluated the system.

The evaluation confirmed that the system has the right functionalities and user interface physically, sensory and cognitively accessible and usable for elderly and disabled. We have found evidences that the system developed would prolong the time elderly and disabled people could remain independent in their own homes positively impacting their quality of life. Nevertheless, longer studies with larger user groups would be needed to confirm this.

An exploitation plan has been developed and started to be put into place: developments of the project are already commercial products, a university spin-off has been created and specific actions to turn the prototype into commercial

product are being tackled. It has also become clear that complementary business partners are needed for commercialization, in particular local integrators and care solutions providers.

The project has used a multi-disciplinary methodology. From the human factors perspective, the focus was on accessibility, usability, usefulness and efficacy. The technology perspective focused on advancing the state-of-the art within RFID technology, wireless sensor networks, artificial intelligence, ubiquitous computing for ambient assisted living, user interaction and distributed software.

There is also need for further technical research within RFID technology, natural user interfacing and profiling, context reasoning and prediction.

Diverse methodologies have been put into place in Easy Line+; some of them are profusely used in the scientific community, while others have been developed inside the project. The following lessons have been extracted and are worthy to be mentioned:

- Short duration testing just provides evidences about the real impact of the system in user's quality of life and in empowerment of independent living. Long duration tests would are mandatory to have scientific proofs.
- Evaluation methods based in questionnaires are not always reliable specially when fulfilled by elderly or people with special needs. This methods need to be completed by observation and interview procedures.
- The project consortium have created and maintained a strong local relationship with local end user associations and other stakeholders. This is absolutely key to have proper user feedback into the project.
- Defining research questions (from user, technical and business perspective) in advance of the field test gives a systematic structure to the evaluation process. It also makes possible to add any needed logging instrumentation to the prototype or preparing other data collection methods.
- Five partners developed different technical parts of the system. Integration plan and software engineering best-practice should be studied and adapted to the project at an early stage. It is also very convenient to define a technology testing plan that ensures system reliability and stability with qualitative and quantitative measures prior to proceed with user testing.

- Technical work it is more efficient to have short cycles of design-development-testing where the system is progressively built and evaluated by the end users. This also allows final outcome closer to end user needs.
- Business strategy has to be tackled from the beginning of the project as it can greatly influence technical development. In our case we have a working prototype however thesoftware needs to be rebuilt to become a commercial product.

In addition to the results of the user's validation, there are important evidences about the quality of the work done in the project. Large amount of scientific publications have been produced by the project consortium; 16 referred journals, 4 chapters of books, 10 international conference proceedings.

Six patents (4 European, 1 German and 1 Spanish) have been already filed protecting different parts of the system developed.

Local and national impact through different mass media has been also promoted; To date the project has been presented or referenced at least 34 times in press and other broadcasting media.

Updated information on Easy Line+ is available on the project website www.easylineplus.com.

ANNEX A. CONTACTS

Project Contact

Further information can be provided by contacting the **EASY LINE+'s** project coordinator:

UNIVERSITY OF ZARAGOZA, TECNODISCAP GROUP

Dr. Armando Roy – armanroy@unizar.es

Alba Jiménez – alba.jimenez@unizar.es

Maria de Luna 1 - Zaragoza, 50018 (SPAIN)

Tel. +34 (976) 76 21 51 Fax. +34 (976) 76 21 11

Or visiting the EASY LINE+'s project public website in:

http://www.easylineplus.com

Project Consortitum

The consortium of this project has been led by University of Zaragoza with large experience coordinating European Projects jointly with:

- BSH-E as European level and third at world level in "White Goods" manufacturing
- R&D experts in new technologies suitable for increase the functionalities of "white goods" like Glyndwr University (Human Machine Interfaces) and University of Zaragoza itself (Neuronal Networks, Zigbee, sensors, etc.)
- Accessibility expert as Siemens (from month 1st to month 27th).
- Important industries in RFID applications (Gera Ident), software/HM (Motive Technology LTD) and domotic implementation (G2V).

Universidad de Zaragoza
Calle Pedro Cerbuna 12
CP 50009 Zaragoza, Spain
http://www.unizar.es
http://tecnodiscap.unizar.es

Motive TechnologyUk Limited
Unit 9, Middlegate, White Lund Industrial Estate
LA33BN Morecambe UK
http://www.motivetechnology.com

BSH Electrodomésticos España, S.A.
Calle Itaroa, 1
31620 Huarte, Spain
http://www.bsh-group.com/laender/es

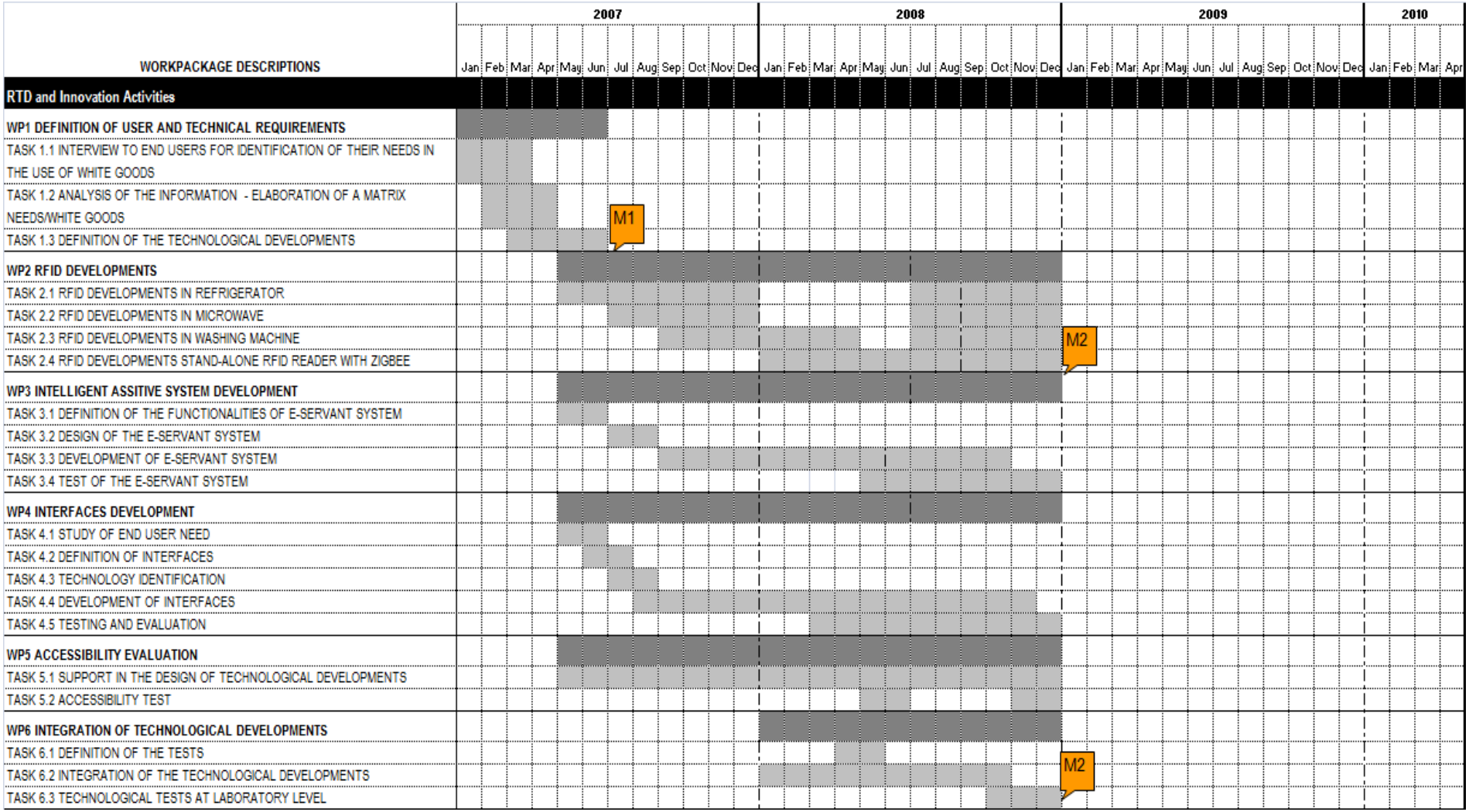
Glyndwr University, Wales
Plas Coch Campus, Mold Road
Ll11 2aw, Wrexham, Uk
http://www.glyndwr.ac.uk

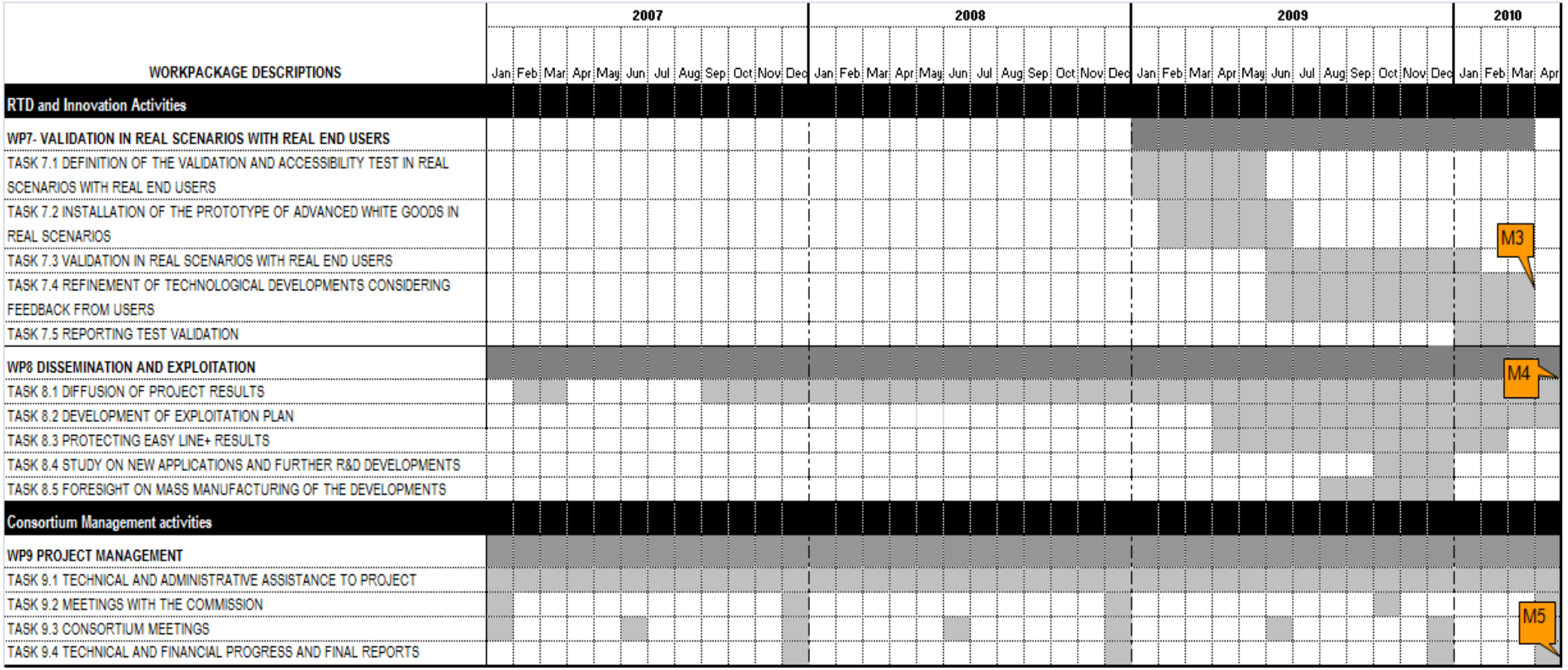
Gis Gera.Ident-Systeme Gmbh
Clara-Zetkin-Strasse, 14
D07545, Gera, Germany
www.gera-ident.com

Siemens Business Services Gmbh And Co. Ohg
Otto-Hahn-Ring 6
81739, Muenchen, Germany
http://www.sbs.siemens.de
http://www.c-lab.de

Isde Aragón, S.L. (Grupo De Empresas G2v)
Santa Inés, 6 Local
50003, Zaragoza, Spain
http://www.g2v.com

ANNEX B. EASY LINE+ TIMELINE




WORKPACKAGE DESCRIPTIONS
2007
2008
2009
2010
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jan Feb Mar Apr
RTD and Innovation Activities
WP7- VALIDATION IN REAL SCENARIOS WITH REAL END USERS
TASK 7.1 DEFINITION OF THE VALIDATION AND ACCESSIBILITY TEST IN REAL SCENARIOS WITH REAL END USERS
TASK 7.2 INSTALLATION OF THE PROTOTYPE OF ADVANCED WHITE GOODS IN REAL SCENARIOS
TASK 7.3 VALIDATION IN REAL SCENARIOS WITH REAL END USERS
TASK 7.4 REFINEMENT OF TECHNOLOGICAL DEVELOPMENTS CONSIDERING FEEDBACK FROM USERS
TASK 7.5 REPORTING TEST VALIDATION
M3
WP8 DISSEMINATION AND EXPLOITATION
TASK 8.1 DIFFUSION OF PROJECT RESULTS
TASK 8.2 DEVELOPMENT OF EXPLOITATION PLAN
TASK 8.3 PROTECTING EASY LINE+ RESULTS
TASK 8.4 STUDY ON NEW APPLICATIONS AND FURTHER R&D DEVELOPMENTS
TASK 8.5 FORESIGHT ON MASS MANUFACTURING OF THE DEVELOPMENTS
M4
Consortium Management activities
WP9 PROJECT MANAGEMENT
TASK 9.1 TECHNICAL AND ADMINISTRATIVE ASSISTANCE TO PROJECT
TASK 9.2 MEETINGS WITH THE COMMISSION
TASK 9.3 CONSORTIUM MEETINGS
TASK 9.4 TECHNICAL AND FINANCIAL PROGRESS AND FINAL REPORTS
M5