



**Project no.:** INFSO-IST-045515

**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)

## D7.2. Report with the results of the end users' test

**Due date of deliverable:** 31/03/2010

**Actual submission date:** 30/06/2010

**Start date of project:** 01/01/2007

**Duration:** 40 months

| Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006) |   |   |
|---|---|---|
| Dissemination Level   |   |   |
| <b>PU</b>   | Public  | X |
| <b>PP</b>   | Restricted to other programme participants (including the Commission Services)        |   |
| <b>RE</b>   | Restricted to a group specified by the consortium (including the Commission Services) |   |
| <b>CO</b>   | Confidential, only for members of the consortium (including the Commission Services)  |   |

---

**Document History**

| Version     | Status               | Date       |
|-------------|----------------------|------------|
| Version 1.0 | Deliverable produced | 30/06/2010 |
|             |                      |            |
|             |                      |            |
|             |                      |            |
|             |                      |            |
|             |                      |            |

**Author/s:** Rubén Blasco, Roberto Casas, Jorge Falcó, Vic Grout, Richard Picking

**Keywords:** Evaluation, usability testing, validation, real users

**Abstract:** This deliverable reports the results of the end user's testing of Easy Line Plus system.

# TABLE OF CONTENTS

|  |           |
|--|-----------|
| <b>1. Introduction .....</b>   | <b>4</b>  |
| <b>2. Description of evaluation procedure.....</b>   | <b>5</b>  |
| 2.1 Functional description of the technology evaluated .....   | 6         |
| 2.2 User participation .....   | 10        |
| 2.2.1 Background information from users .....  | 11        |
| 2.2.2 Recruitment of users.....  | 12        |
| 2.3 Pilots description .....   | 15        |
| 2.3.1 University of Zaragoza.....  | 15        |
| 2.3.2 Glyndŵr University .....   | 16        |
| 2.4 Conclusions from previous user evaluation .....  | 17        |
| 2.5 Evaluation methodology.....  | 23        |
| 2.5.1 Accessibility, usability, functionality, performance and user satisfaction with beneficiary..... | 23        |
| 2.5.2 Longer independent life evaluation and functionality with carer .....                            | 29        |
| <b>3. Evaluation results .....</b>   | <b>34</b> |
| 3.1. Users participating in evaluation.....  | 34        |
| 3.2. Evaluation of Easy Line+ system.....  | 39        |
| 3.2.1. Accessibility results.....  | 39        |
| 3.2.2. Usability, performance and user satisfaction results .....                                      | 46        |
| 3.2.3. Evaluation of functionality .....   | 47        |
| 3.2.4. Longer independent life evaluation.....   | 48        |
| 3.3. Evaluation of the e-servant system.....   | 51        |
| 3.3.1. Evaluation of functionality .....   | 51        |
| 3.1.1. Longer independent life evaluation.....   | 52        |
| <b>4. Enhancements of the system after user evaluation .....</b>                                       | <b>54</b> |
| 4.1 User Interface and Intelligence .....  | 54        |
| 4.1.1. Technical problems.....   | 54        |
| 4.1.2. Users' requirements.....  | 59        |
| 4.2. Context awareness and intelligence .....  | 60        |
| 4.2.1. Technical problems.....   | 60        |
| <b>5. Conclusions .....</b>  | <b>62</b> |
| <b>Annex I. Evaluation user reports .....</b>  | <b>64</b> |

# 1. INTRODUCTION

---

WP7 General objective is to validate the prototype of advanced “white goods” obtained in the WP6 in real environments with real end users. Testing involves real users performing tasks with the system being evaluated and observing them in a controlled environment in order to spot any accessibility, usability, performance, etc. issues. Running such a test implies an in-depth planning in order to take the most appropriate measures and actions required without disregarding the ethical issues involved.

We aim at achieving the following goals of the evaluation:

- Assess the overall effectiveness of the Easy Line Plus system.
- Evaluate accessibility, usability, functionality, performance and user satisfaction of the system.
- Evaluate how the system provides longer independent life for the users using it.
- Help designers to enhance the system and rectify deficiencies.

Section 2 of this document summarizes the evaluation procedure that is described in detail in D7.1. Section 3 presents the evaluation results according with the methodologies presented in previous section. Section 4 outlines the enhancements of the system after user evaluation. These enhancements have been done to improve stability of the system, to add new functionalities and to improve the end user interaction. Finally, section 5 concludes the paper.

## 2. DESCRIPTION OF EVALUATION PROCEDURE

---

In the evaluation process of the Easy Line+ system many issues have been considered. The system evaluated is technologically complex and a careful evaluation plan has been put into place in two different locations: Spain and UK.

First question we need to answer is: what are we trying to assess in the evaluation process? There are several answers to this question, and each answer leads us to different actions in the evaluation process.

Easy Line+ is an e-inclusion project and thus it is oriented to a clear target of users. Thus our evaluation objectives are to obtain an evidence of performance of the developed system and its goals regarding its main e-inclusion driving targets: improvement of life quality of elderly people and improving their autonomy to allow longer stances at home even when capacities of the individual start to mildly deteriorate.

Of course it is mandatory to fulfil these objectives to assess accessibility and usability of the resulting system to people with special needs. Also, as any other system that might go into the market, assessment of functionality, performance and user satisfaction is also mandatory.

Before presenting the results of the evaluation procedure, it is necessary to present the “ecosystem” created. This includes:

- a functional description of the systems evaluated,
- description of the users participating in the procedure, its selection criteria and the relationships with the end user entities,
- description of the pilots set up in each country,
- description of the methodology followed

## 2.1 Functional description of the technology evaluated

Main objective of the project is to develop prototypes near to market of advanced white goods in order to support elderly persons with or without disabilities to carry out a longer independent life compensating their loss of physical and/or cognitive abilities.

Under this objective and considering end user requirements, we have developed a system covering most of the ICT functionalities detected; what we call **Easy Line+ system**. In following figure we can see how all the parts of the system interact among them.

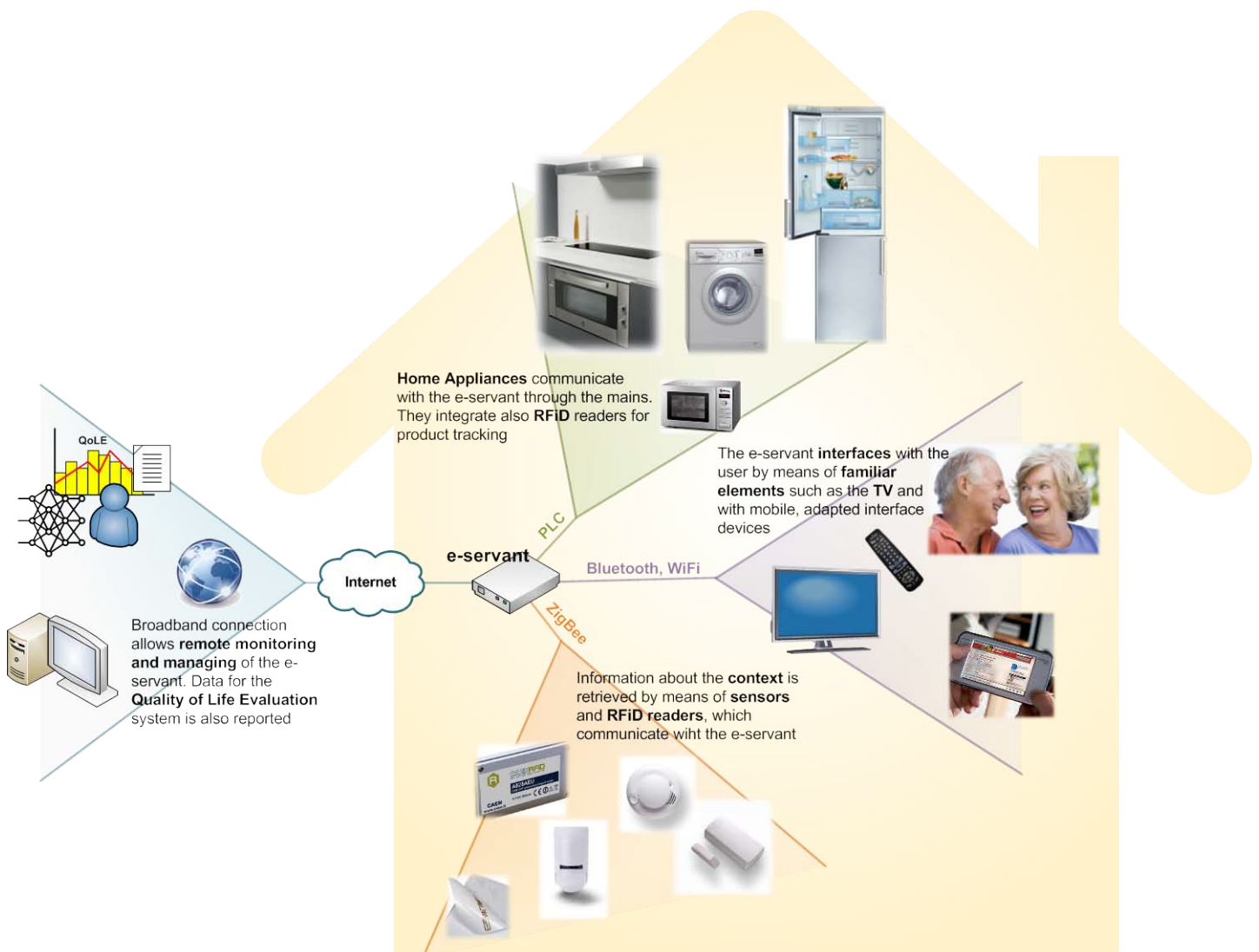


Figure 1. Block diagram of the new kitchen concept.

Due to the maturity of the RFID technology, it is not feasible to put such a system into the market in the short term. Thus there is a reduced version of the system that doesn't use RFID enabled white goods; what we call **e-servant system**. These systems are made up by:

- One e-servant software + hardware
- One wireless set of monitoring and security sensors
- One RFID stand alone reader
- White goods with PLC and RFID technology. In case of e-servant system, white goods do not include RFID technology.
- RFID tags (washable and normal tags)
- One or various Human-Machine Interfaces (Could be the current TV of the user, Touch screen, etc.)

The functionalities of both versions of the system are the following:

|   | Easy Line+<br>system | e-servant<br>system |
|---|----------------------|---------------------|
| <b>Facilitate the use of the household appliances adapting to the disabilities or preferences of the user and using adapted interfaces.</b> |                      |                     |
| Indication of fridge/freezer status:<br>On/Off/Problem/Disconnected, door open or closed, current temperature                               | Yes                  | Yes                 |
| Display of fridge/freezer contents  | Yes                  | No                  |
| Support for configuration of fridge/freezer settings:<br>Set target temperature   | Yes                  | Yes                 |
| Indication of washing machine status:<br>On/Off/Problem/Disconnected, door open or closed, time to finish                                   | Yes                  | Yes                 |
| Display of washing machine contents   | Yes                  | No                  |
| Support for configuration of washing machine settings:<br>Set washing program, switch on/off  | Yes                  | Partially           |

|   |     |   |
|---|-----|---|
| Indication of hob status:<br>On/Off/Problem/Disconnected  | Yes | Yes                                     |
| Support for configuration of hob settings:<br>Switch off  | Yes | Yes                                     |
| Indication of oven status:<br>On/Off/Problem/Disconnected, time to finish, temperature  | Yes | Yes                                     |
| Support for configuration of oven settings:<br>Set target temperature, switch on/off, set starting cooking time, set duration | Yes | Yes                                     |
| <b>Provide useful information and warnings about the use of the household appliances</b>                                      |     |   |
| Advise if the fridge/freezer door is left open  | Yes | Yes                                     |
| Advise if food is past its use-by date  | Yes | Partially<br>(using stand alone reader) |
| Advise if food is approaching its use-by date   | Yes | Partially<br>(using stand alone reader) |
| Warning about fridge/freezer breakdown  | Yes | Yes                                     |
| Advise of wrong mix of clothes (e.g. mix of white and coloured clothes)   | Yes | No                                      |
| Advise of unsuitable fabrics (e.g. dry clean only)  | Yes | Partially<br>(using stand alone reader) |
| Advise if machine loaded but not yet on   | Yes | No                                      |
| Advise if cycle interrupted   | Yes | Yes                                     |
| Advise if unload incomplete   | Yes | No                                      |

|  |     |                                |
|--|-----|--------------------------------|
| Advise when machine is on final spin   | Yes | Yes                            |
| Advise when cycle finished   | Yes | Yes                            |
| Warning about washing machine breakdown  | Yes | Yes                            |
| Advise if hob is left on with no pan   | Yes | Yes                            |
| Warning about hob breakdown  | Yes | Yes                            |
| Advise when food in the oven is ready  | Yes | Yes                            |
| Warning about oven breakdown   | Yes | Yes                            |
| Inform how a cloth should be washed, its colour, etc.  | Yes | Yes (using stand alone reader) |
| Inform how food should be cooked, its expiration date, etc.  | Yes | Yes (using stand alone reader) |
| <b>Detect emergency situation and automatically take some actions</b>                                      |     |                                |
| Advise "Fire detected" emergency   | Yes | Yes                            |
| Advise "Smoke detected" emergency  | Yes | Yes                            |
| Advise "Water detected" emergency  | Yes | Yes                            |
| <b>Detect routine changes in the kitchen</b>   |     |                                |
| Inform whenever there are changes in conduct patterns that can identify any loss of abilities in the user. | Yes | Yes                            |
| Adapt system's functionality to the user (supervised by the caretaker)                                     | Yes | Yes                            |

Table 1: Functionality of Easy Line+ and e-servant systems

## 2.2 User participation

Users have been present in most of the different steps of the project. In next diagram we show this involvement and specifically it has been put into place in the final evaluation of the system.

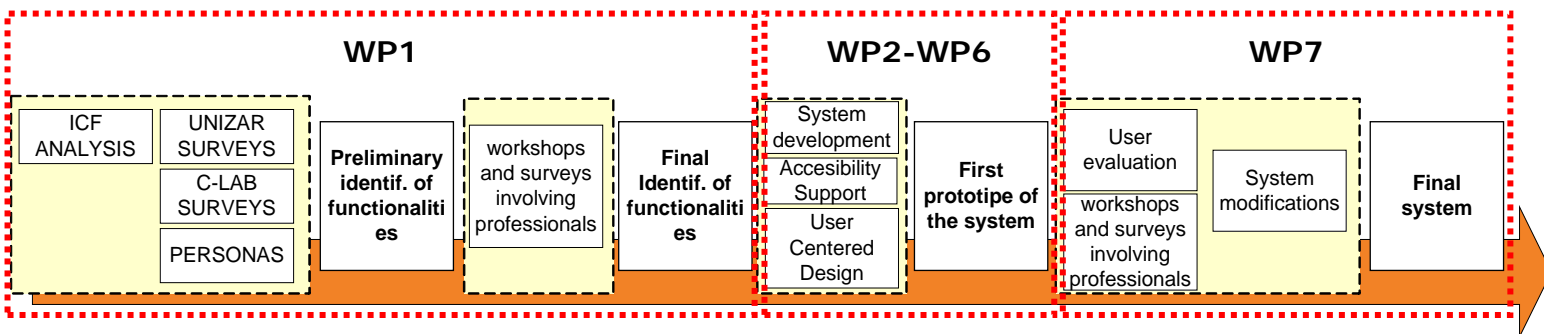


Figure 2. Easy Line+ project methodology for user involvement.

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 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 evaluation activities have been:

- end user evaluation of technology in the pilots from the point of view of accessibility, functionality, usability, performance and user satisfaction
- 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.

Ideally, large amount of users would be needed testing the system in real life conditions. Nevertheless, as Easy Line Plus has its frame in ICT program evaluation has to be done with ten's of users (further evidences with larger amount of users would be appropriate for other European programs, such as CIP). Due to this frame, we are aiming for: evidences of performances regarding the main objectives, as much statistical significance possible, quantify each result

as much as possible and classification of results in the areas considered relevant for each outcome (i.e. capacities of the individual are relevant for accessibility assessment).

### 2.2.1 Background information from users

In order to optimise the obtained results from the evaluation and to get the most meaningful information impartial test persons were selected. The people that evaluated the system have been classified using the same variables described. In order to do that, all the people evaluating the system fulfilled a background interview with the following fields:

#### *I. Participant Information*

- Gender and age
- Last degree studied and main work
- Residence

#### *II. Household activities experience*

- Use of household appliances: Washing machine, fridge, oven, hob, microwave, dishwasher, etc.
- Autonomy in household tasks: Do the laundry, do the shopping, hang out the clothes, prepare a meal, etc.

#### *III. Capacities*

- If any, type of sensory, physical and cognitive disabilities.

#### *IV. Technology Experience*

- Experience with IT technologies: computer, mobile phones, PDAs, etc.
- Skill in computer use: hours a day of use, typical use, etc.

To classify results we first need to relate each individual to some standard capacities or lacking of such capacities. Categorization of capacities of the individuals can be done in different levels of depth, and due to the frame of qualified evidence the project looks for, it has been estimated to take this information relying on individuals expression on their own capacities.

As a result, each individual participating in the test to validate the full system would have a vector of characterization in which their elements would be the

variables already defined (age, gender, visual capacity, aural capacity and so on). Each specific value in the variables a priori will influence how the interaction of the user with the system is. People with the same impairment may have completely different ways to cope with their daily tasks or upcoming situations. This depends on individual criteria like education, experience, training, etc. For example, users with less technology experience will probably find more difficult to use the system. Similar might happen with people with higher degree of disabilities, less experience using household appliances, etc.

The background information gathered from the carers is the same but answering about the cared person instead of answering about themselves.

## **2.2.2 Recruitment of users**

The involvement of end-users and its associations is the key in the evaluation process of the system. The recruitment process needs to be executed carefully as we need to recruit people that match the targeted audience's profiles. In each pilot site a different recruitment methodology adapted to its specific particularities will be adopted.

Regarding the recruitment of carers, we focused in formal caregivers and informal caregivers of people that need assistance in carrying out their activities of daily living.

### **2.2.2.1 University of Zaragoza**

Tecnodiscap group is a research group of the University of Zaragoza which main aim is to improve quality of life of the elderly and people with disabilities. This is done not only by developing new technology resulting from research; we also aim to ensure a real transference to the society after any project ending. Thus, we find necessary to involve other additional actors in every action of the group.

For these reasons, as a group policy, we are establishing formal relations with many actors through institutional collaboration agreements:

Local and Regional Administrations:

- Collaboration agreement with the City Council for the temporary cession of two flats for evaluation with end users.

- 
- Collaboration agreement with the Social Services Department of the Regional Government and the Research and Development Department of the Regional Government to finance the transference of assistive technology to the society.

The group has several collaboration agreements with different user associations (three different groups of people and entities have been identified to work with our research team):

- Cognitive disabled: ATADES, ATECEA, ATADI, Fundación Virgen del Pueyo, Alborada School.
- Physically disabled (including elderly): DFA, AIDIMO, ATECEA, Discapacitados sin fronteras, Cerbuna.
- Elderly Entities: Fundación Rey Ardid, ATADES (cognitive+elderly)

Specifically, ATADES and Fundación Rey Ardid shown their interest on participating in the validation phase, providing end-users and their experience to carry out the validation.

As first step, we already started the contacts during May'09 with people responsible of the Entities and the Elder Section Director of the Social Services of the City Hall to present the exact project outcome and specific needs of the project and preselect the user candidates.

First week of June, there will be an information meeting with preselected candidates. There, after explaining the project outcome and the activities to be performed, the Informed Consent of those interested will be signed and personal data will be registered to individually arrange the testing agenda.

Finally, the users selected in June evaluated the system in the Spanish pilot from mid July to end of September.

Recruitment of carers for the assessment of the system has also needed from planning. In Unizar we contacted with different entities and groups of carers:

- Social company "Más manos" that professionally dedicates to help users at home.
- Associations of families of Alzheimer's and Parkinson's patients in Aragon also collaborated with us. On one hand, professionals from the socio-sanitary field working there: social workers, occupational therapists and social educators. On the other hand, informal carers currently caring familiars with these diseases.

- 
- Various professionals assisting to a master in Social Gerontology already with large experience working with elderly people.

The initial approach was similar to that in prior testing with final users. First we contacted the persons responsible of the associations to explain what is the Easy Line + project about and seek their cooperation to participate in it.

Afterwards, with those interested in participating (the ones described above), we set a date and venue to explain the project to the specific professionals and family members and invite them to cooperate.

Finally, we set the specific meetings with the formal and informal carers where they to read and sign informed consent and complete the questionnaires. This work was done during November'09.

### **2.2.2.2 Glyndŵr University**

Glyndŵr University has relationships with a number of Elderly associations, their contribution to the evaluation of technology is listed below:

- Outside/In (Wrexham Social Services Service User Group). This is the primary contact group, which acts as a communication and publicity channel to other associations. This association comprises service users, their carers, academics and professionals from Wrexham Social Services. The service users' profiles include people with severe physical disabilities (e.g. cerebral palsy, limb deformities), diseases of the central nervous system (e.g. Parkinson's disease), and age-related conditions (e.g. failing hearing, failing sight). All of these people live in their own homes, sometimes with their carers (typically husbands/wives), and sometimes alone. Their ages range from 40s to 80s. The Outside/In group has worked with Social Work training organizations, and helps to interview potential Social Work students at the University, from a service users perspective.
- The Wrexham Access Group (WAG) is an umbrella for a network of local organizations and groups, which specializes in supporting people with accessibility issues. We have an agreement with WAG to provide us with a wide range of potential users.
- Pendine Park is a local residential complex, which specializes in dementia patients in particular. The University has a formal 'memorandum of understanding' with this organization, and they have agreed to provide us

with potential users with mild forms of dementia, and general elderly conditions. They work with both residential and home-based clients.

- Age Concern North East Wales and by Plas Madoc Communities First (over 50s group). This group has close relationships with Glyndwr University, and has agreed to provide as many participants as we require.

There have been several meetings with the organizations in June to establish a clearer plan of action and to identify specific dates for the testing to be carried out. Finally, all organizations contacted have agreed to provide users and carers for the evaluation from July to November.

## 2.3 Pilots description

### 2.3.1 University of Zaragoza

In Zaragoza (Spain), the testing environment includes two separate flats owned by the University of Zaragoza. The flats are located in a residential area called Valdespartera, a brand new neighbourhood constructed only few years ago. Both flats are fully furnished and provide with all necessary facilities required to fulfil any normal activities in the everyday life.



Figure 3. Living lab kitchen

The testing environment is exclusively situated at the main entrance of the flats as both living room and kitchen are the first accessible rooms after entering the

main corridor from the outside, users will only have to cross the corridor to change from one room to another. The Living rooms are spacious and bright; they contain a dinner table, chairs, a sofa, a small table with shelves and a bigger one where the TV stands. Each flat comprises a medium-sized, fully equipped kitchen with hob, oven, microwave, washing machine, fridge/freezer and dishwasher; the fridge, microwave and the washing machine have RFID readers which will acquire relevant information from the RFID tags in the clothes and the food items. Fridge, washing machine and freezer include sensors at the doors to verify if they are closed. All rooms in the flat have a video camera and smoke/fire sensors.

During the testing, users control the system by means of a portable remote controller with four coloured buttons. The controller will communicate with an infra-red receptor situated below the TV. The TV will be the main UI display of the system while the testing takes place, principally due to its size and because is the predominant choice of the users; the TV is connected to a computer located by its side where the system is installed. In addition there will be another portable device able to control the system remotely as a secondary option in case the user is watching TV or in case he/she simply prefers so. There is also a touchscreen PC in the kitchen to facilitate user interaction in place.

### 2.3.2 Glyndŵr University

At Glyndŵr University (Wales), the study will take place in the CAIR usability laboratory to conduct the sessions. There is a testing room with a one-way mirror to an observation room. The room is furnished with two armchairs, a coffee table with a digital picture frame, a corner table with a television, a bookshelves and a nest of tables. Participants will use a TV screen and a TV remote control as their main tool for interaction. They also have at their disposal a Nokia Internet tablet which is a small touch screen device which can display the interfaces as well. The TV screen is connected to a laptop (which is linked to the "e-Servant simulator" on a different computer in the control room) that runs the user client; so in order to be able to use the remote control with the interfaces, there is a infra-red located close to the TV that will detect the user's responses.

Cameras have been placed in the room and will capture the participant's face, body and environment; the *GeoVision Multicam* software will record what's

happening on the screen (and will collect other data). There are also few microphones set up in the room to create a set of audio recordings for backup.



Figure 4. Usability lab at Glyndŵr University

The kitchen part of the room consists of a washing machine, an oven, a cooker hob and a fridge. A set of two sensors are positioned in order to track the door status (open or closed) of the fridge and the washing machine and another sensor is used to trace the fridge temperature (in degree Celsius). The kitchen appliances are connected to the power line and are equipped with a serve@home System Interface card. A small ZigBee receiver is connected to the e-servant computer and communicates wirelessly with each of the kitchen appliances. This serve@home management system is used to monitor and control the kitchen appliances from the observation room via a secured wireless network created.

## 2.4 Conclusions from previous user evaluation

The evaluation methodology has been derived from and improved following the usability testing exercises undertaken in deliverable 4.2.

We decided to conduct the evaluation in question in the relatively controlled setting of a usability laboratory in order to give us assurance and confidence that later studies (in a home environment) would not be compromised by usability or reliability problems. This environment also helped us to identify potential ethical issues.

In the context of the project development as a whole, a fundamental criterion for the methodology we followed was that it should be practical. Heavily participative methods can be time-consuming and costly, so we were relatively economical in our reliance on the user population in the project's development. Following initial

user engagement, we decided to formulate personas<sup>1</sup> to reduce the reliance on significant user consultation. Also, as our user population is vulnerable, to involve them in a more intensive participatory design approach may have caused ethical and practical problems. Such issues have been highlighted in the past, particularly by Newell and Gregor<sup>2</sup>. One alternative solution has been successful, where trained performers role-play elderly adults<sup>3</sup>. However, a recognized drawback of this approach is that this too can be expensive.

The full set of results of the usability evaluation studies is reported in deliverable 4.2. A summary is shown in Table 2. We conducted between-groups laboratory-based usability studies with heterogeneous groups of users, including elderly and disabled users, people with learning difficulties, as well as with 'healthy' adults. We were interested in evaluating the latter group for two reasons. Firstly, it has been documented that elderly and vulnerable participants in usability studies may react differently than they normally would, for example by being over-positive due to their involvement in the study<sup>4</sup>. Comparing their results with what might be termed a control group would potentially identify issues of this nature. Secondly, our earlier evaluations suggested that the product might be suitable for time-impooverished people (for example, stressed parents with babies in the home), not just elderly and disabled people.

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

---

<sup>1</sup> Cooper, A.: *The Inmates are Running the Asylum: Why High Tech Products Drive us Crazy and How to Restore the Sanity*. Sams Publishing, USA (2006)

<sup>2</sup> A. F. Newell and P. Gregor: "User sensitive inclusive design in search of a new paradigm", CUU 2000 First ACM Conference on Universal Usability (2000) (Eds. J. Scholtz and J. Thomas), pp.39-44. USA. ISBN: 1-58113-314-6

<sup>3</sup> A. F. Newell, P. Gregor and N. Alm, CHI : "HCI for older and disabled people in the Queen Mother Research Centre at Dundee University, Scotland", 2006 (2006), pp.299-303. Montreal, Quebec, Canada, 22-27 April.

<sup>4</sup> Eisma, R., Dickinson, A., Goodman, J., Syme, A., Tiwari, L., Newell, A.F., 2004. Early user involvement in the development of information technology related products for older people. *Universal Access in the Information Society* 3 (2), 131–140.

kitchen appliances and the user interface, which for this study was provided on a television screen and mobile device. Participants' activities were recorded in the laboratory, and were subsequently analyzed. They were also asked to complete a questionnaire comprising 20 semantically-rated questions, which were categorized according to usability, design and layout, functionality, user satisfaction, and expected future use.

The aggregated results for every category and for all groups indicated a positive outcome for the usability experience questionnaire. An Analysis of Variance (ANOVA) revealed that there were no significant differences in the responses provided by the three groups ( $F = 1.52$ ;  $p < 0.05$ ), apart from one question which asked whether they felt embarrassment at using the system - some members of the learning difficulties group were uncomfortable with it from this point of view. The control group performed expectedly better in general, and the only observed usability issues involved elderly users' difficulty in using a standard remote control handset and the small-screened mobile device, both of which were easily rectified by selecting alternative input and output devices.

|                    | <b>Overall Average</b> | <b>Control Average</b> | <b>Elderly Average</b> | <b>Learning Average</b> |
|--------------------|------------------------|------------------------|------------------------|-------------------------|
| Usability          | 2.87                   | 3.22                   | 2.79                   | 2.56                    |
| Design and Layout  | 2.71                   | 2.90                   | 2.71                   | 2.54                    |
| Functionality      | 2.67                   | 2.89                   | 2.74                   | 2.44                    |
| Satisfaction       | 3.00                   | 3.33                   | 3.08                   | 2.48                    |
| Future use/outcome | 2.55                   | 2.67                   | 2.78                   | 2.01                    |

Table 2. Mean results by questionnaire category (scale 0-4)

**In conclusion, our earlier studies re-assured us that evaluating usability with elderly and disabled participants could effectively be undertaken in the environment of a laboratory, and in other controlled environments.** Indeed these guidelines are being disseminated as generic principles in several

international conferences and journals<sup>5 6 7</sup>. We found that evaluation of usability 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:

- *Settle the participants – make them 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 into what might seem a strange environment. 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.
1. *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. Sometimes things need to be read out twice or more, or

---

<sup>5</sup> 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 (Aml'09)*, November 18-21 2009, Salzburg, Austria

<sup>6</sup> 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.

<sup>7</sup> 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.

explained in simpler terms. The diverse age ranges of our participants also required sensitivity, as terminology is familiar for some people and not for 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 universally-used household terms, especially where elderly people are concerned. 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.

2. *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 into the environment. In our evaluation, we demonstrated a situation which did not use any scenarios used in the test itself to avoid obvious bias.
3. *Don't put vulnerable people on their own unless absolutely necessary.* In our pilot studies, 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 our observational analysis, as participants' 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 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).
4. *Keep it short.* It is important that participants are given time to settle into the environment. However, the usability test itself should be relatively short for vulnerable people who may get tired, may have attention span problems, and may become uncomfortable in a laboratory setting. We recommend that from

---

start to finish (that is, from participants entering the laboratory to leaving it) should last no longer than about one hour, if possible.

5. *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.
6. *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.
7. *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.
8. *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 Glynor 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.
9. *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.

10. *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.

## 2.5 Evaluation methodology

Detailed description of the evaluation methodology can be found in D7.1: End Users Evaluation Protocol. We have done an evaluation procedure in three different dimensions in order to assess the objectives presented at the beginning of current section:

- Evaluation of accessibility of the system with end users
- Evaluation of usability, functionality, performance and user satisfaction again with end users
- Evaluation with carers to what extent the system can extend end user's independent life

The procedure is all based in different questionnaires passed in two activities, one with the end users and other with the carers. Following we present both activities.

### 2.5.1 Accessibility, usability, functionality, performance and user satisfaction with beneficiary

First activity is done in the pilots with end users trying the prototype of the system in various situations.

### 2.5.1.1 Design of test procedure

In order to evaluate the e-servant system in several aspects, four situations have been defined in order to test all of the system functionalities. Evaluating all system's functionalities requires a very long time. Since elderly people in particular grow tired of lengthy testing, each session should last an hour and a half maximum. So, we decided to only test functionalities that are similar to one or more appliances.

The situations created for testing purpose are the following:

- Situation 1: "Coming home from shopping": the participant comes home from shopping and s/he is required to store all the items from the shopping bag into the fridge, freezer or cupboards.
- Situation 2: "Making dinner": the participant is asked to show a frozen pizza to the standalone reader so the interface identifies the item and asks the user if s/he wants to cook it. If yes it goes to the set\_oven\_configuration with the needed parameters (parameters can be hardcoded in the scenario if not implemented). The participant is in the living room (maybe watching TV) when the food in the oven is finally done cooking.
- Situation 3: "Doing my laundry": the participant is asked to do a laundry (maybe just the spinning program if no water) using different clothing items.
- Situation 4: "My house is on fire": the participant is resting and watching TV while the hob is on. The smoke detector is triggered; even if there is actual fire, we can pretend.

The table below details, for each situation, which of the system's functionalities are being tested.

|  | Situations |    |    |    |
|--|------------|----|----|----|
| Advanced functionalities of prototypes   | S1         | S2 | S3 | S4 |
| Facilitate the use of the household appliances adapting to the disabilities or preferences of the user and using adapted interfaces. |            |    |    |    |

|   |   |   |   |   |
|---|---|---|---|---|
| Indication of fridge/freezer status:<br>On/Off/Problem/Disconnected, door open or closed, current temperature                 | X |   |   |   |
| Display of fridge/freezer contents  | X |   |   |   |
| Support for configuration of fridge/freezer settings:<br>Set target temperature   |   |   |   |   |
| Indication of washing machine status:<br>On/Off/Problem/Disconnected, door open or closed, time to finish                     |   |   | X |   |
| Display of washing machine contents   |   |   | X |   |
| Support for configuration of washing machine settings:<br>Set washing program, switch on/off                                  |   |   | X |   |
| Indication of hob status:<br>On/Off/Problem/Disconnected  |   |   |   | X |
| Support for configuration of hob settings:<br>Switch off  |   |   |   | X |
| Indication of oven status:<br>On/Off/Problem/Disconnected, time to finish, temperature  |   | X |   | X |
| Support for configuration of oven settings:<br>Set target temperature, switch on/off, set starting cooking time, set duration |   | X |   | X |
| <b>Provide useful information and warnings about the use of the household appliances</b>                                      |   |   |   |   |
| Advise if the fridge/freezer door is left open  | X |   |   |   |
| Advise if food is past its use-by date  | X |   |   |   |
| Advise if food is approaching its use-by date   | X |   |   |   |
| Warning about fridge/freezer breakdown  | X |   |   |   |

|  |  |   |   |   |
|--|--|---|---|---|
| Advise of wrong mix of clothes (e.g. mix of white and coloured clothes)                                    |  |   | X |   |
| Advise of unsuitable fabrics (e.g. dry clean only)   |  |   | X |   |
| Advise if machine loaded but not yet on  |  |   | X |   |
| Advise if cycle interrupted  |  |   | X |   |
| Advise if unload incomplete  |  |   | X |   |
| Advise when machine is on final spin   |  |   | X |   |
| Advise when cycle finished   |  |   | X |   |
| Warning about washing machine breakdown  |  |   | X |   |
| Advise if hob is left on with no pan   |  |   |   |   |
| Warning about hob breakdown  |  |   |   |   |
| Advise when food in the oven is ready  |  | X |   |   |
| Warning about oven breakdown   |  | X |   |   |
| Inform how a cloth should be washed, its colour, etc.  |  |   |   |   |
| Inform how food should be cooked, its expiration date, etc.  |  | X |   |   |
| <b>Detect emergency situation and automatically take some actions</b>                                      |  |   |   |   |
| Advise "Fire detected" emergency   |  |   |   | X |
| Advise "Smoke detected" emergency  |  |   |   | X |
| Advise "Water detected" emergency  |  |   |   |   |
| <b>Detect routine changes in the kitchen</b>   |  |   |   |   |
| Inform whenever there are changes in conduct patterns that can identify any loss of abilities in the user. |  |   |   |   |
| Adapt system's functionality to the user (supervised by the caretaker)                                     |  |   |   |   |

Table 3. Functionalities &amp; Situations

### 2.5.1.2 Evaluation tool

Main objective of this procedure is to extract the relevant data in order to evaluate the usability, accessibility, functionality and reliability of the system as well as the user satisfaction and future use/outcome.

So, the tool has divided in four sections:

- Background interview questionnaire (BIQ): The BIQ objective is to find and measure the relevant information about the person in order to extract the user variables. These variables will define to the person in the evaluation.
- Situation questionnaires (SQX): During the evaluation process the user interacts with the system in four 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 forgets by the users.
- User questionnaire (UQ): The objective of the UQ is 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 broad questions to collect preferences and other quantitative data and also follow up on any particular problems that came up for the participants. The questions are divided in several categories: usability, accessibility, functionality, satisfaction and future use/outcome.

In the UQ the participants have the opportunity to share their remarks and criticisms about the system; but most of all to assist the designers in identifying the issues and improving the system afterwards.

- Observation form (OF): When the test is ended, while the user and the moderator are filling the UQ, the observer does the same with the OF. In this form s/he puts his/her impression about the user. The parameters evaluates in the OF are directly related with some questions in the UQ. So it is possible to contrasts the information "objective" from the OF with the "subjective" from the UQ.

### 2.5.1.3 Roles

We can identify the following roles of people participating in this procedure:

- User: person who will evaluate the technology.

- Test observer: person who is watching the different situations evaluated without contact with the user, taking notes about the participants' performance and reactions. The observation notes will be considered "objectives" because they are not influenced by the user. Also, the observer will take note about any fail of the system.
- Test moderator: S/He leads the usability sessions. S/He is in charge of interacting with the participants and observing them during the testing. The moderator will introduce the session to the participants and realize several short interviews between the different situations tested. Because this study is somewhat exploratory, s/he may ask unscripted follow-up questions to clarify participants' behaviour and expectations. During the test s/he should be neutral. However, s/he can decide when to help and how much to help. Of course, if the test moderator takes part in the test, this situation will be logged.

#### 2.5.1.4 Schedule of test procedure

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 on the same issues throughout the study.

It is important that this test plan is acknowledged and understood by all the pilots. Major changes to the participant characteristics and the session tasks and activities after the test moderator creates the session script could result in questionable data and findings.

A default user profile has been set up for the e-servant since it has been successfully received by previous participants. The user interface has been customised to have big text font and audio feedback for notification messages and warnings.

Following table shows the schedule for a typical testing session:

|   |
|---|
| Introduction and system training (10 mins)  |
| User background interview + consent form (10 mins)  |
| <b>Situation 1: "Coming home from shopping" (10 mins)</b>   |
| <ul style="list-style-type: none"> <li>• Explain situation</li> <li>• Run scenarios</li> <li>• Fill up questionnaire</li> </ul> |
| <b>Situation 2: "Making dinner" (10 mins)</b>   |
| <ul style="list-style-type: none"> <li>• Explain situation</li> <li>• Run scenarios</li> <li>• Fill up questionnaire</li> </ul> |

|   |
|---|
| Snacks and drinks (from the making dinner scenario)   |
| Situation 3: "Doing my laundry" (10 mins)   |
| <ul style="list-style-type: none"> <li>• Explain situation</li> <li>• Run scenarios</li> <li>• Fill up questionnaire</li> </ul> |
| Situation 4: "My house is on fire" (5 mins)   |
| <ul style="list-style-type: none"> <li>• Explain situation</li> <li>• Run scenarios</li> <li>• Fill up questionnaire</li> </ul> |
| Questionnaire of User Satisfaction (15 mins)  |
| User observation (10 mins)  |

Table 4: Evaluation Schedule

## 2.5.2 Longer independent life evaluation and functionality with carer

The main objective of the project is to build a system that can support user independence. Evaluation of this is more complicated than assessing accessibility, usability, etc. as statistical evidence would require a long term testing with tens of users in an unsupervised manner; i.e. a CIP project. As this is not feasible within the current project framework, we can just have carers and experts' opinions as indicators that evidence longer independent life and functionality. In the next points we describe the methodology followed to make this assessment.

### 2.5.2.1 Design of test procedure

When a person cannot or has difficulties to perform ADLs s/he becomes more dependent and consequently loses her/his independent life. The system developed in Easy Line+ project tries to support and reduce dependency of the person by facilitating his/her daily tasks and, as a result, to improve his/her independence. The system helps the user handling the appliances with easier and more accessible interfaces, improving the safety at home, early detecting if there are relevant changes in the user's habits which could mean that the user is losing capacities, etc.

In order to evaluate how the system can empower independent life, parameters that related to user independence have been crossed with the functionalities of the system; thus the following matrix is produced:

| SYSTEM FUNCTIONALITIES  | ACTIVITIES OF DAILY LIVING | Health maintenance  |                                   | Carry out domestic tasks |             |                    | Make decisions |
|---|----------------------------|---------------------|-----------------------------------|--------------------------|-------------|--------------------|----------------|
|   |                            | Avoid risks at home | Ask for help in case of emergency | Prepare a meal           | Do Shopping | Do laundry/ironing | Domestic Tasks |
| <b>F1</b> - Show appliance status through the adapted interfaces  |                            | X                   |                                   | X                        | X           | X                  | X              |
| <b>F2</b> - Show fridge contents and trigger a warning if any food items are expired or about to expire   |                            | X                   |                                   | X                        | X           |                    | X              |
| <b>F3</b> - Show washing machine contents to know the type of clothes   |                            |                     |                                   |                          |             | X                  | X              |
| <b>F4</b> - Trigger a warning if there is a wrong mix of clothes or unsuitable fabric.  |                            |                     |                                   |                          |             | X                  | X              |
| <b>F5</b> - Program appliance status through the adapted interfaces   |                            |                     |                                   | X                        | X           | X                  | X              |
| <b>F6</b> - Program suggestions when using the oven or the washing machine  |                            |                     |                                   | X                        |             | X                  | X              |
| <b>F7</b> - Trigger warnings and reminders when the appliances require attendance (Door left open, Laundry finished, etc)   |                            | X                   |                                   | X                        |             | X                  | X              |
| <b>F8</b> - Trigger emergency warnings (fire, smoke, flood) and act in case there is no response (for example, turn off appliances automatically if there is smoke) |                            | X                   | X                                 |                          |             |                    |                |
| <b>F9</b> - 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.     |                            | X                   |                                   |                          |             |                    |                |
| <b>F10</b> - Detect routine changes in the kitchen to adapt system's functionality to the user (supervised by the caretaker)  |                            | X                   | X                                 | X                        | X           | X                  | X              |

Table 5. System functionalities &amp; activities of daily living

The evaluation tool we developed registers the carer opinion on every mark in the previous table. This gets how each functionality of the system supports one or more essential activities for the autonomy of the person. Therefore, if the system makes these activities easier and helps people to do these activities for themselves, it will be reducing their dependency level and consequently increasing the time they can remain independent.

### **2.5.2.2 Evaluation tool**

The main objective of this tool is to extract relevant data in order to evaluate how the system can extend the independent life of a person. The tool is divided in three sections:

- Background Carer Questionnaire (BCQ): The BCQ objective is to find and measure the relevant information about the carer and (if it's the case, of the person cared for).
- Carer Questionnaire (CQ): The objective of the CQ is to find the opinion of the carer about the system, its features and its capacity to extend the time a person can remain independent. The questions are divided in several categories:
  - General questions about usability and functionality of the system.
  - Questions about the capacity of the system to extend users independence in general and support user's activities of daily living
  - Questions about future use/outcome of the system
  - Open question for further suggestion/Improvements
- User situation questionnaires (SQx): These questionnaires have already been described in section 2.5.1.2. They are used to evaluate the functionalities tried by the user in each situation. In this way we know the user's point of view contrasted with the expert's opinion.

### **2.5.2.3 Roles**

There are two roles involved in the longer independent life evaluation:

- Carer: person who (informally or professionally) cares for elderly person/persons with or without disabilities. S/He is going to evaluate if, in

her/his opinion of expert, the system could increase the time the cared persons can live independently.

- Test moderator: S/He leads the evaluation sessions. S/He is in charge of interacting with the carers and observing them during the testing. The moderator will introduce the session to the participants and make several short interviews between the different situations tested. During the test s/he should be neutral.

#### **2.5.2.4 Design and schedule of the test procedure**

This evaluation has been designed so carers can understand the new functionalities provided by the system and how it works. The following process has been followed:

- Description of the system and interface: The moderator introduces the system and its functionalities. Also, s/he shows a tactile screen with the interface to illustrate how it works, carers can try it.
- Carer Background Questionnaire: The moderator explains the questionnaire to the carers and helps them to complete it.
- Watching Video examples: The moderator illustrates the functionalities of the system displaying some videos of the situations which have been evaluated by the users.
- Examples of detection of routine changes: Moderator shows several examples of reports from the e-servant. These reports show how the habits of the user are logged by the e-servant and how these habits are displayed for carer evaluation.
- Carer questionnaire: Once the carers know the functionalities of the system, the moderator introduces the CQ which is then answered.
- Debate and coffee/tea: Finally the moderator invites the carers to a coffee/tea and starts a debate about the system and how it can be improved. The conclusion of this debate is written by the moderator.

Next table summarizes the schedule of this procedure.

|  |
|--|
| Description of the system and interface demo (10 mins) |
| Carer Background Questionnaire (5 mins)                |
| Watching Video examples (20 min)                       |

|   |
|---|
| Explain situation and play video <ul style="list-style-type: none"><li>• Video of Situation 1: "Coming home from shopping"</li><li>• Video of Situation 2: "Making dinner"</li><li>• Video of Situation 3: "Doing my laundry"</li><li>• Video of Situation 4: "My house is on fire"</li></ul> |
| Show examples of detection of routine changes and explain report for the carer (10 min)   |
| Carer Questionnaire (10 mins)   |
| Debate and coffee/Tea about the e-servant and the improvement of the system (10 min)  |

Table 6. Schedule of the procedure

### 3. EVALUATION RESULTS

This point presents the results of the final evaluation of the system with end users and experts related with handicap and elderly people following the process described in the point 2. This information can be completed with the user's reports added in the annex 1 that shows the evaluation of the system for each user. Evaluation process has considered the whole system and the sub-set (e-servant system). So, results have been presented in separated sections.

#### 3.1. Users participating in evaluation

Sixty-three beneficiaries have participated in the evaluation of the system. Disabled people younger than 59 years old have been recruited because, although they are not representatives of the elderly, they increase the ratio of people with disabilities. Beneficiaries recruited are shown in following table.

| Characteristics               | Recruited participants |
|-------------------------------|------------------------|
| <b>Impairments/Disability</b> |                        |
| - none                        | 26                     |
| - visual impairment           | 13                     |
| - hearing impairment          | 13                     |
| - cognitive impairment        | 12                     |
| - motor impairment            | 23                     |
| <b>Age</b>                    |                        |
| - <59                         | 11 (8 female)          |
| - 65–79                       | 46 (28 female)         |
| - 80+                         | 7 (4 female)           |
| <b>Gender</b>                 |                        |
| - female                      | 40                     |
| - male                        | 23                     |
| <b>Total</b>                  | 63                     |

Table 7: Recruited participants' characteristics

A relevant limitation that hinders us to obtain conclusions about the ability of the system to cope with specific disabilities is that the users usually have more than one disability being very difficult to isolate the effects of each one over the system use.

As described in section 2.2.1, each user fulfils a background questionnaire that allows us to parameterize him/her. These parameters (except sex and age) have been ranged between 5 and 0 to be graphically represented. Thus, the user's profile can be presented as following:

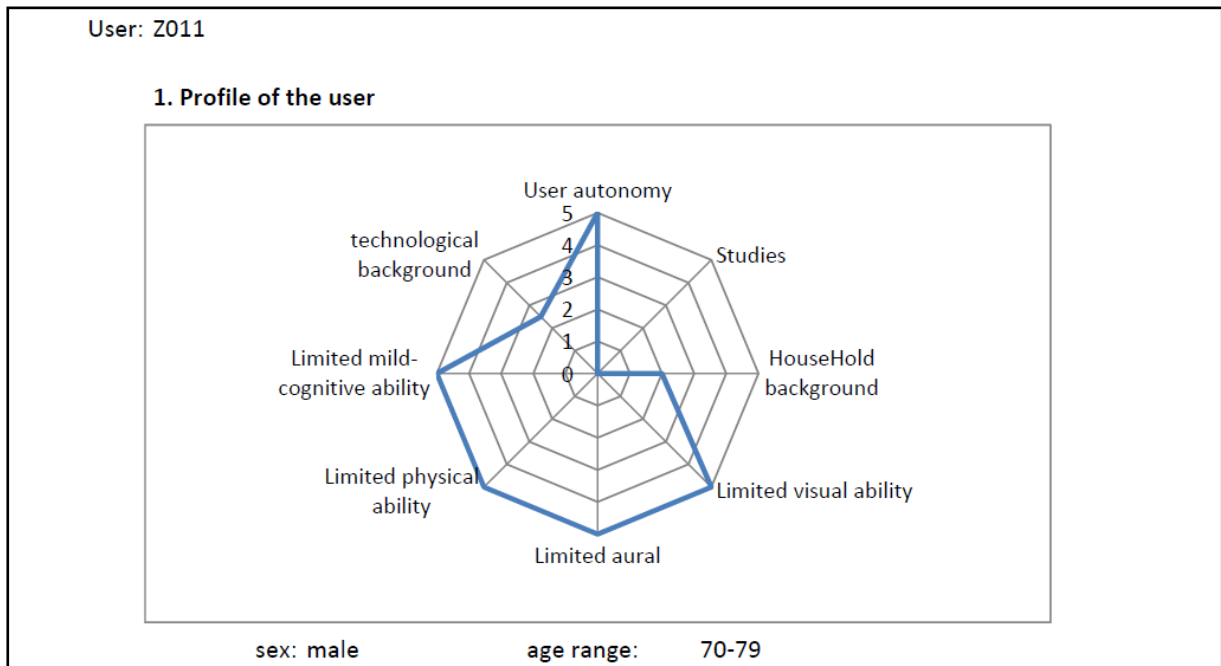


Figure 5 User's profile

Rationale of this graphic is very simple: Full heptagon means that the person has all the parameters analyzed with the best values. In this example, user Z011 has a full autonomy, not any kind of disabilities, no studies, medium-low technological background and medium-low household activities' background.

The following graphs show how all the beneficiaries are distributed according to the parameters that complete the user's profile:

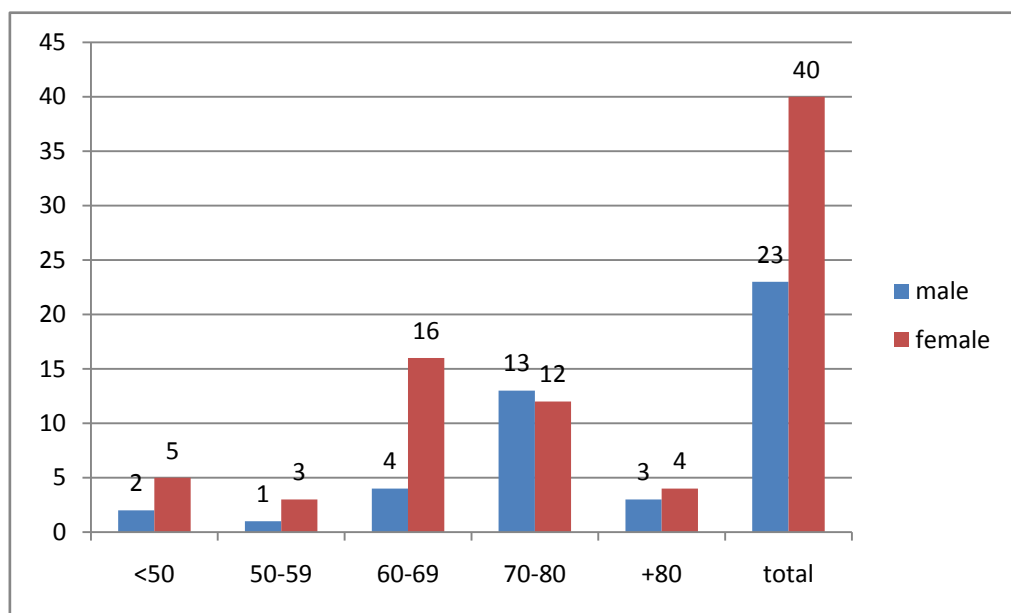


Figure 6: Users by age and sex

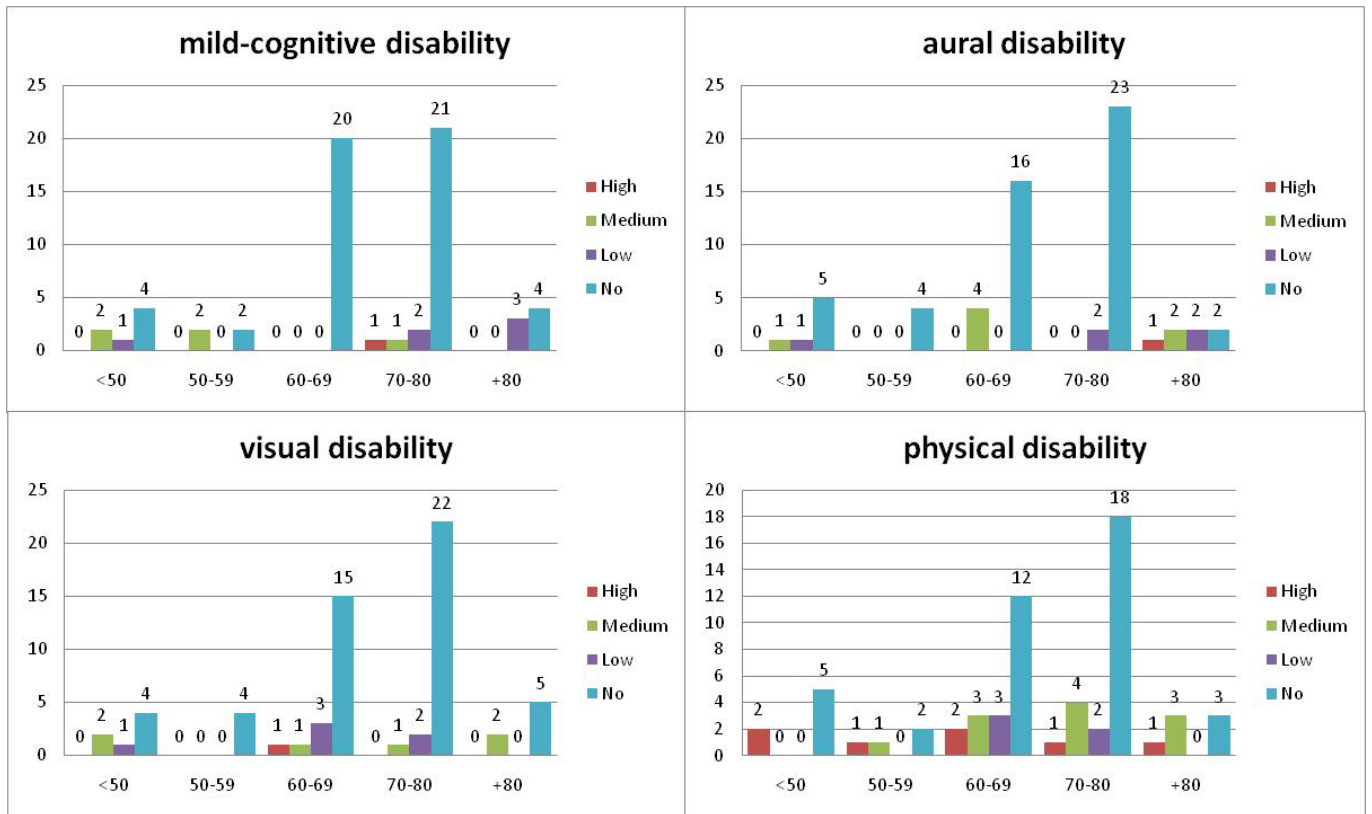


Figure 7: Users' disabilities by age

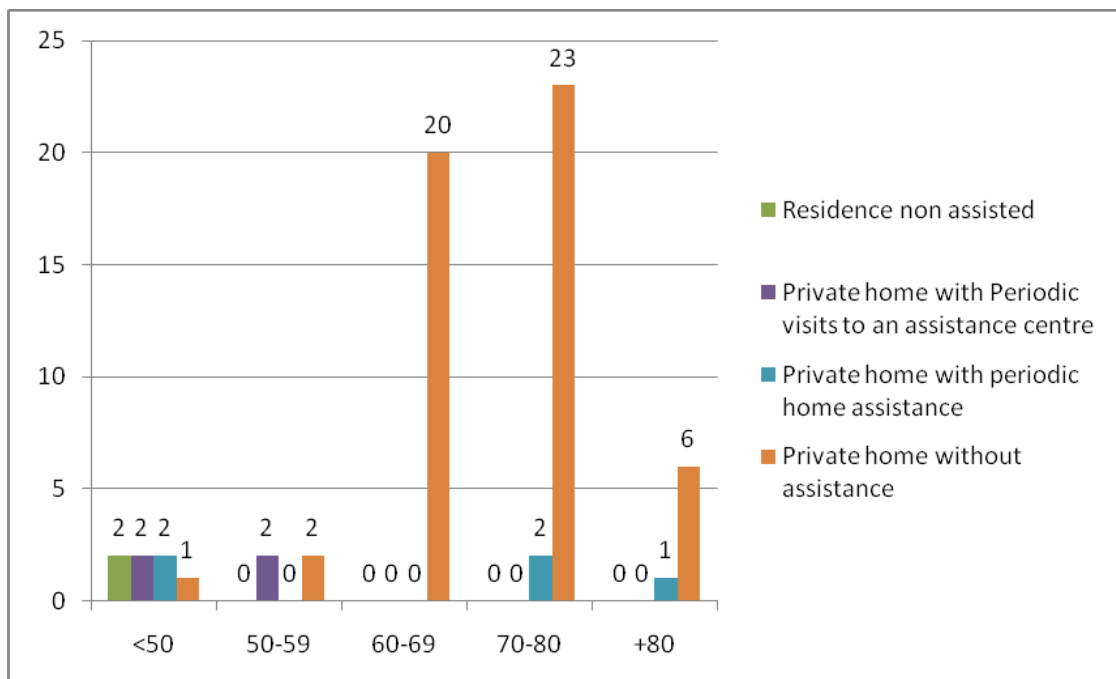


Figure 8. Users' autonomy by age

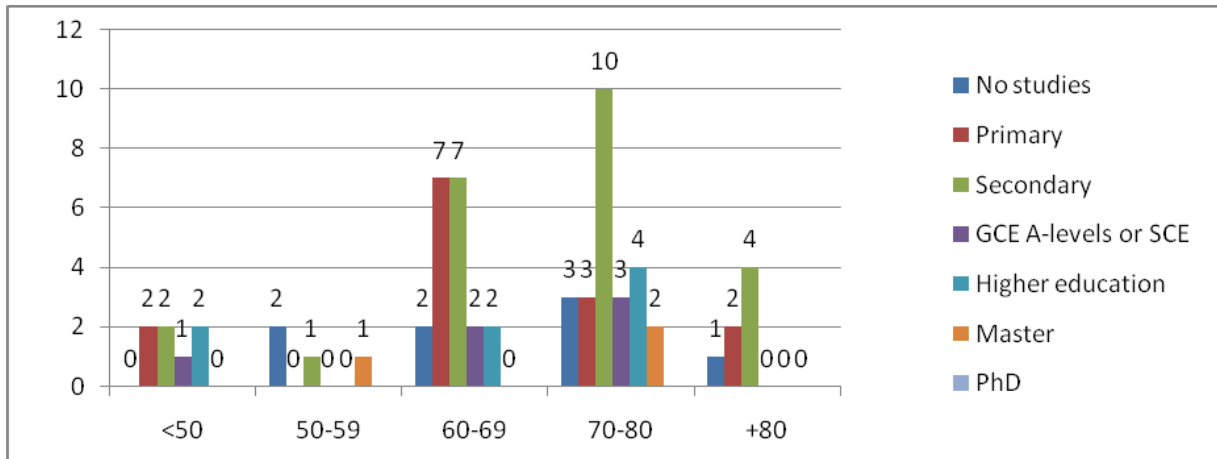


Figure 9. Level of education of users by age

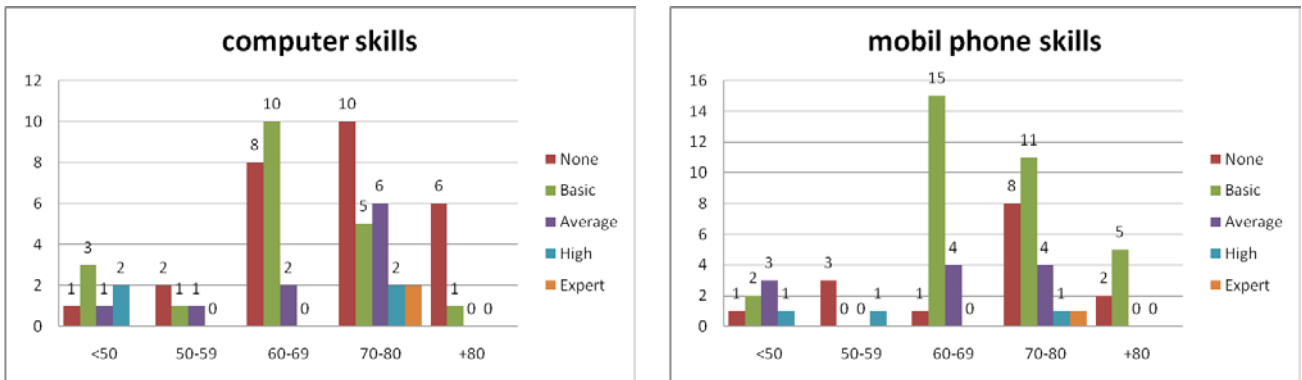


Figure 10. Technological background

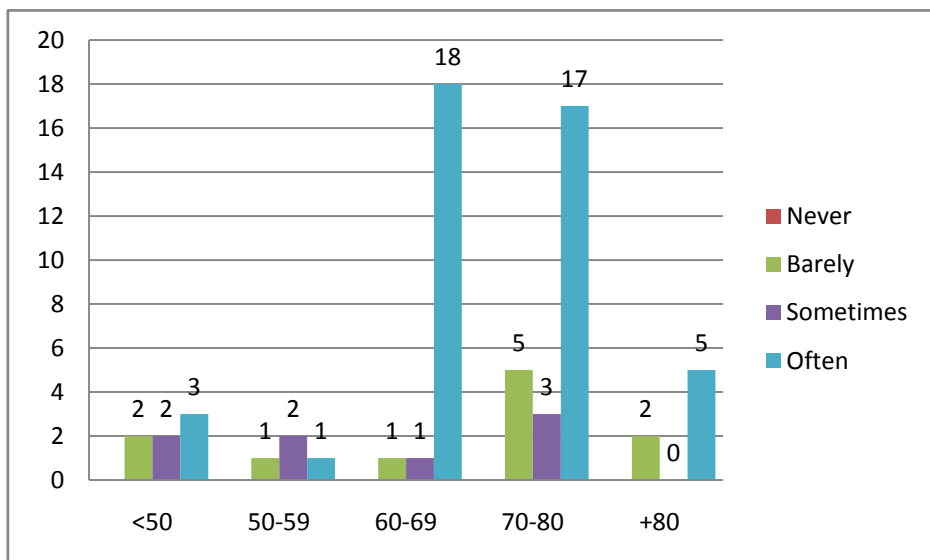


Figure 11. Frequency doing household activities

Added to the direct beneficiaries of the technology, formal and informal carers and have participated in the assessment. A total of 31 carers have contributed to the evaluation of the system. Following figure illustrates their relationship with the beneficiary cared and their background

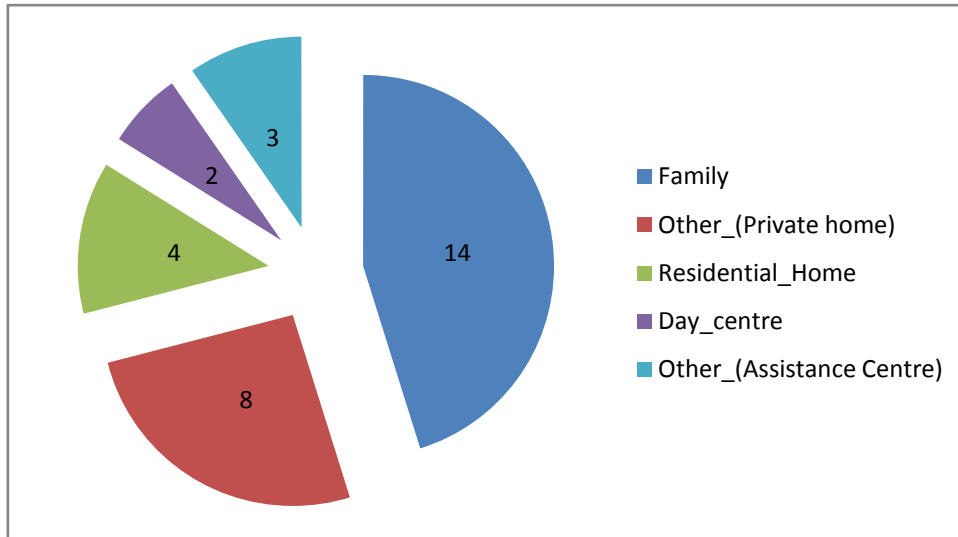


Figure 12. Relationship between the carer and the beneficiary cared

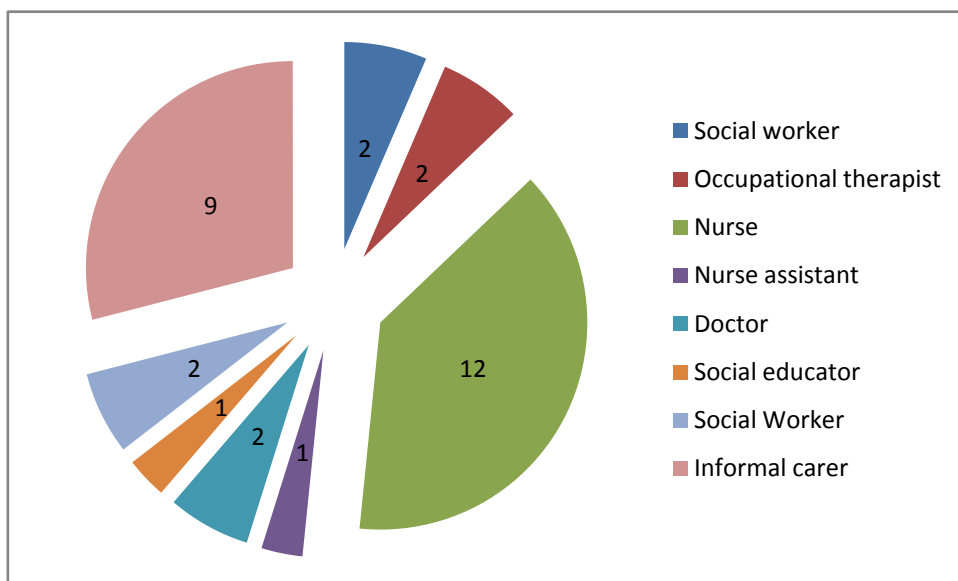


Figure 13. Background of the carers

Also 38 professionals working with the end users from the social or health area have participated in a workshop organized in the University of Zaragoza. Following graphic shows their background:

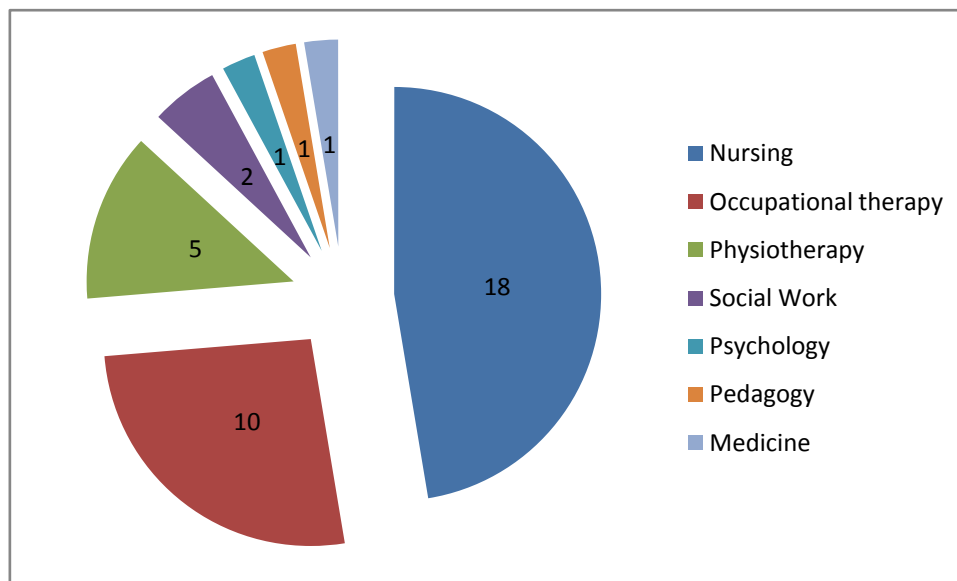


Figure 14. Workshop participant background

## 3.2. Evaluation of Easy Line+ system

### 3.2.1. Accessibility results

In order to evaluate the accessibility of the system, we have selected the relevant indicators to the case of a person interacting with his/her environment. To ensure a proper communication process (and fulfilment of objectives) it is necessary that the person:

- is able to perceive stimuli and information from the environment in an adequate way. This means appropriate correspondence between the output channel of the environment and input channel to the person. As we are evaluating the system and not the person, we call this **perception of output channel** (from the system point of view). Sensorial (aural, visual, tactile) capacities of the person determine the accessibility of this item.
- is able to comprehend the information coming from the environment. As an example, if the user interface uses a language than person cannot understand or the content is too complicated to understand, communication becomes extremely difficult. We call this **comprehension of the output channel**. Cognitive capacities of the person determine the accessibility of this item.
- is able to properly actuate over the environment (to command the system, express desires, etc.). This means appropriate correspondence between the input channel to the environment and output channel from the person. As an

example, if a blind person has to input information in a tactile screen, communication becomes extremely difficult. We call this **handling of input channel** (from the system point of view). Sensorial (aural, visual, tactile) and physical (dexterity, mobility, vocalization, etc.) capacities of the person determine the accessibility of this item.

- is able to understand which, how, where, in which format, etc. has to input information to the environment. As an example, if a person knows what to do so many options appear in the user interface that person doesn't know how to do it, communication becomes extremely difficult. We call this **comprehension of the input channel**. Cognitive capacities of the person determine the accessibility of this item
- is able to perform the cognitive process necessary to decide, once comprehended the information from the system, what to do. We call this **functional cognitive process**. Cognitive capacities of the person determine the accessibility of this item

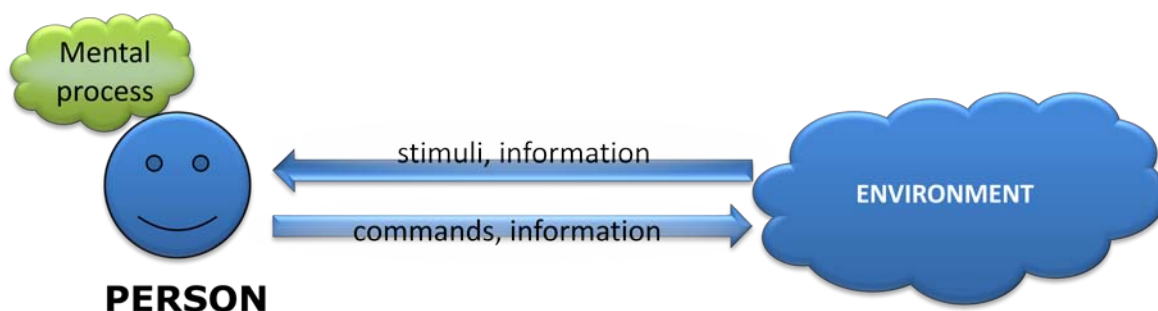


Figure 15 Communication process

Following these criteria, global accessibility evaluation (GAE) has been defined of the next way:

*“A system is accessible for a person if s/he can fully interact with it being able to access all the functionalities, independently of the communication channel used. This interaction implicates the perception and comprehension of the information exchanged.”*

The system offers different input and output channels. All users always have visual and aural output, nevertheless the can choose the input method that best

suits them. Following figure shows the amount of users using each input channel (some used various methods)

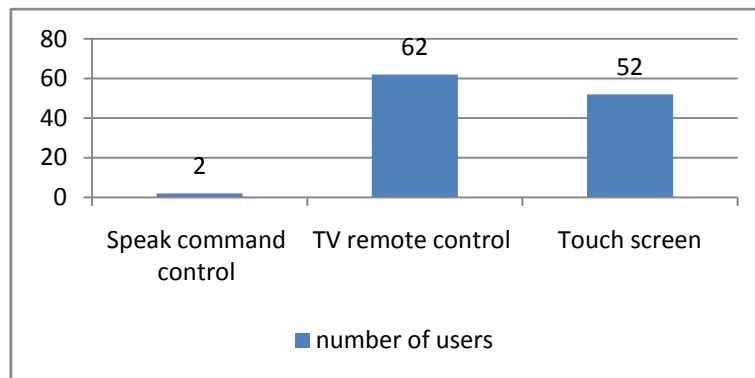


Figure 16 Number of users that have tested an input channel

Next graphics show the perception and comprehension of every channel from two points of view, from the user (perceived perspective) and from the observer (observed perspective). Data displayed are the average of the users' scores with a confidence interval of a 95%. These parameters have been scored between five and zero. A channel is considered accessible for a user if its score is equal or greater than 3.

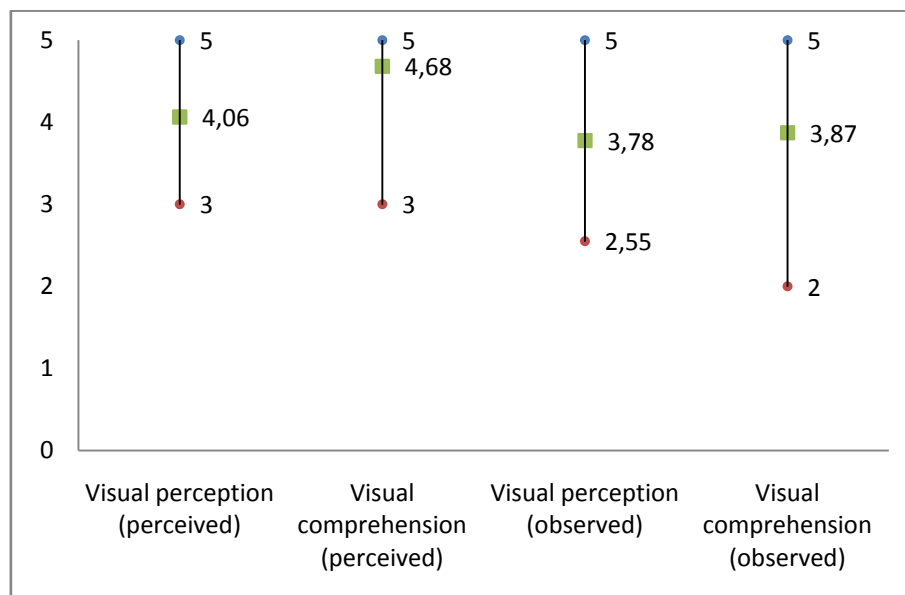


Figure 17. Visual output channel

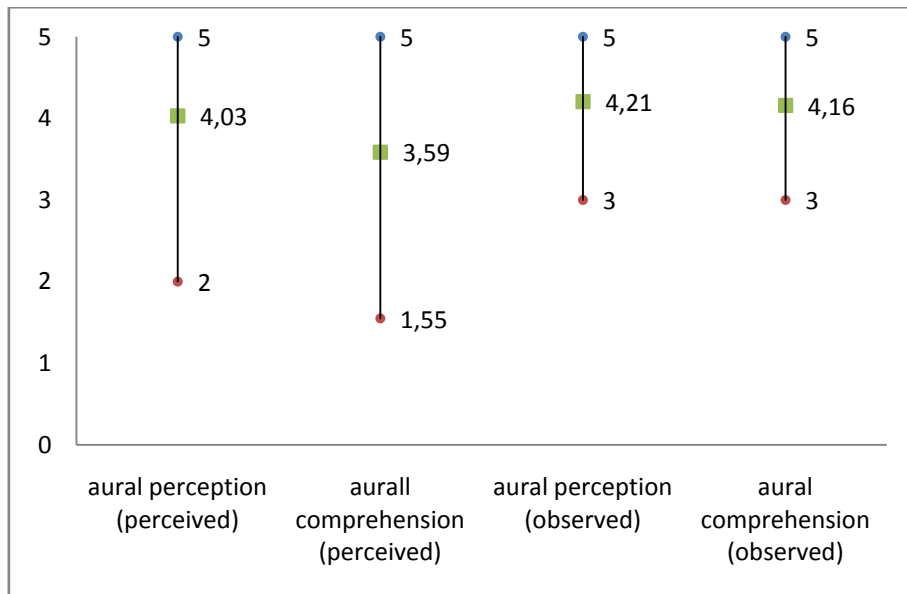


Figure 18. Aural output channel

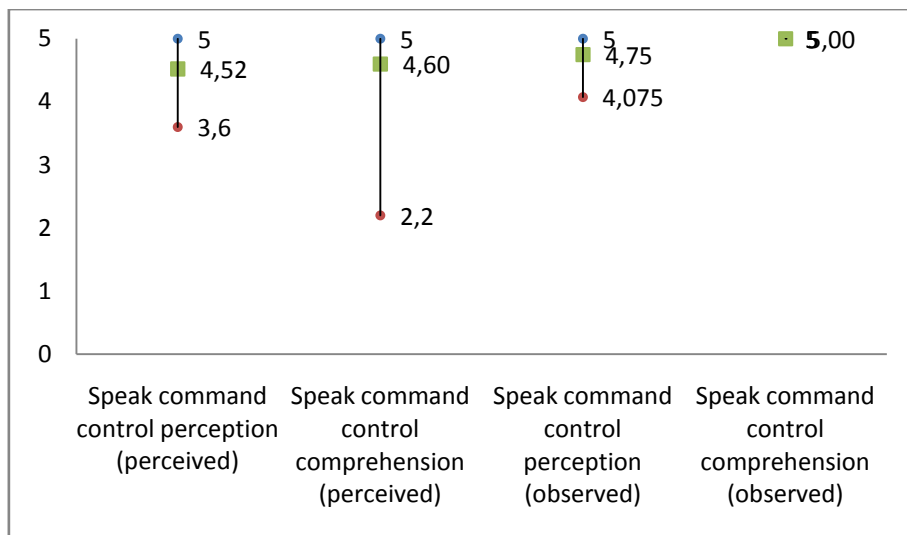


Figure 19. Speak input channel

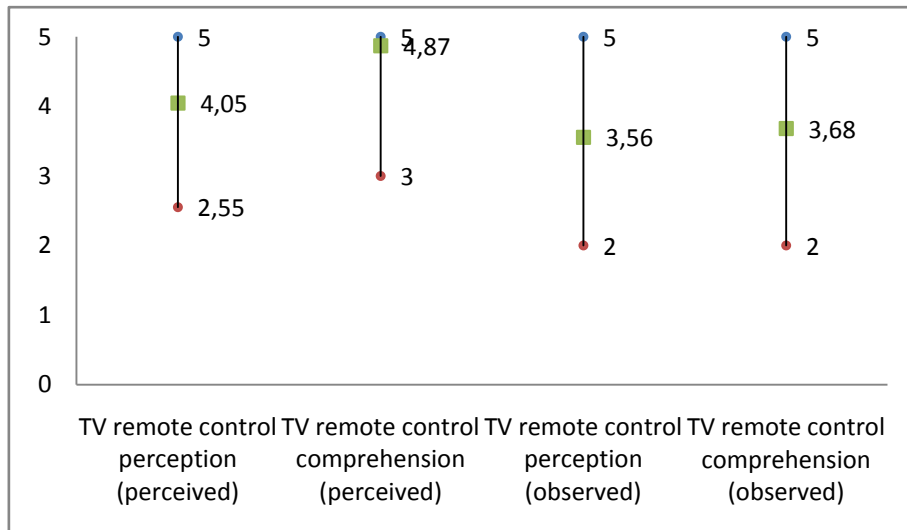


Figure 20. TV remote control input channel

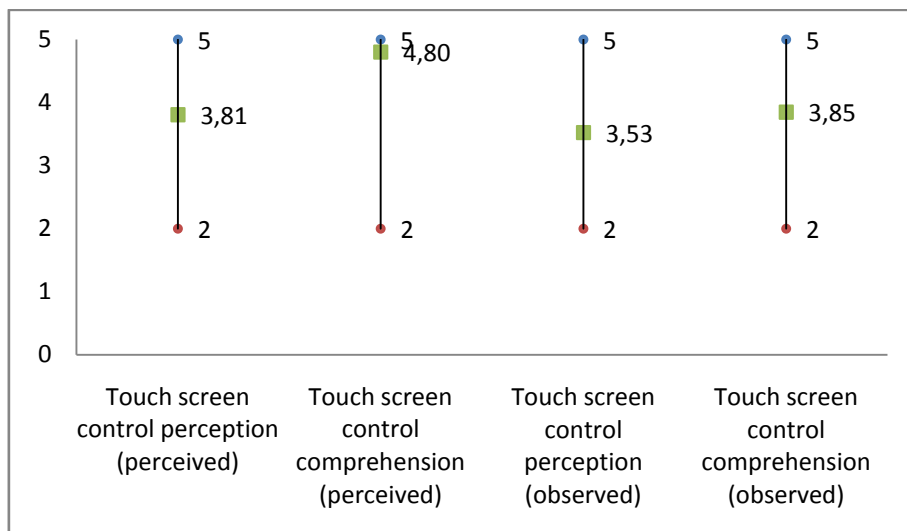


Figure 21. Touch screen control input channel

Analyzing the results and considering that a channel is accesible for a user if its score is equal or greater than 3, we can observe that for the 98,6% of users at least one output channel (visual or aural) is accesible. Doing the same with the input channels (tactile, TV remote, spoken), we can conclude that for 92% of users find at least one input channel accesible.

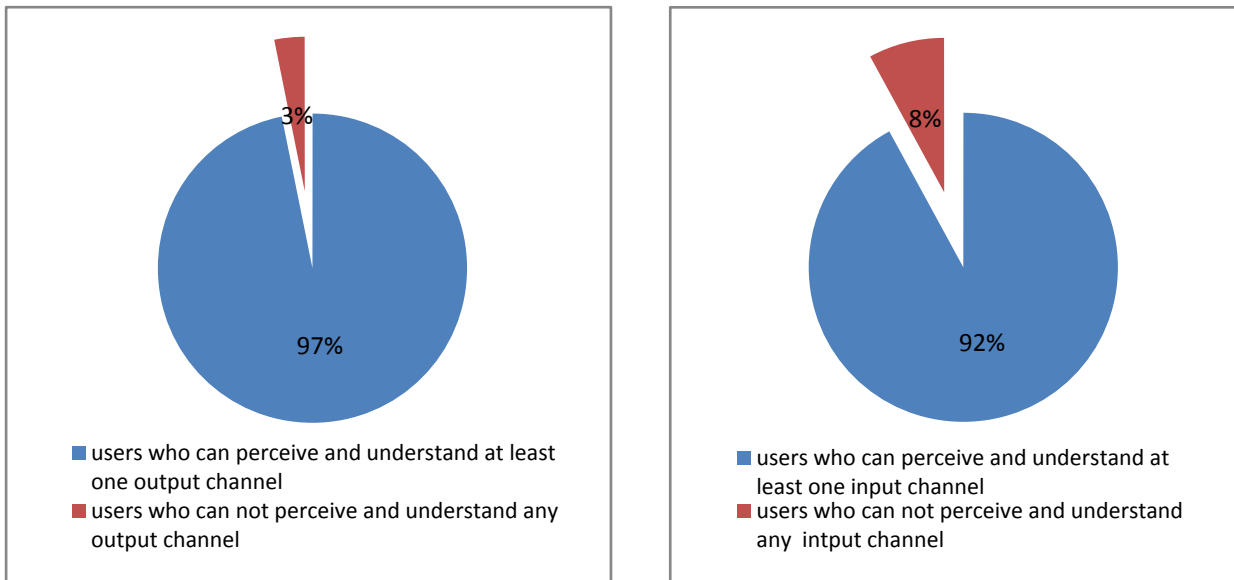


Figure 22. Output and input channel analysis

Therefore, the system is accessible for the people who can perceive and comprehend at least one input channel and one output channel. So, the system is accessible for the 90% of the sample.

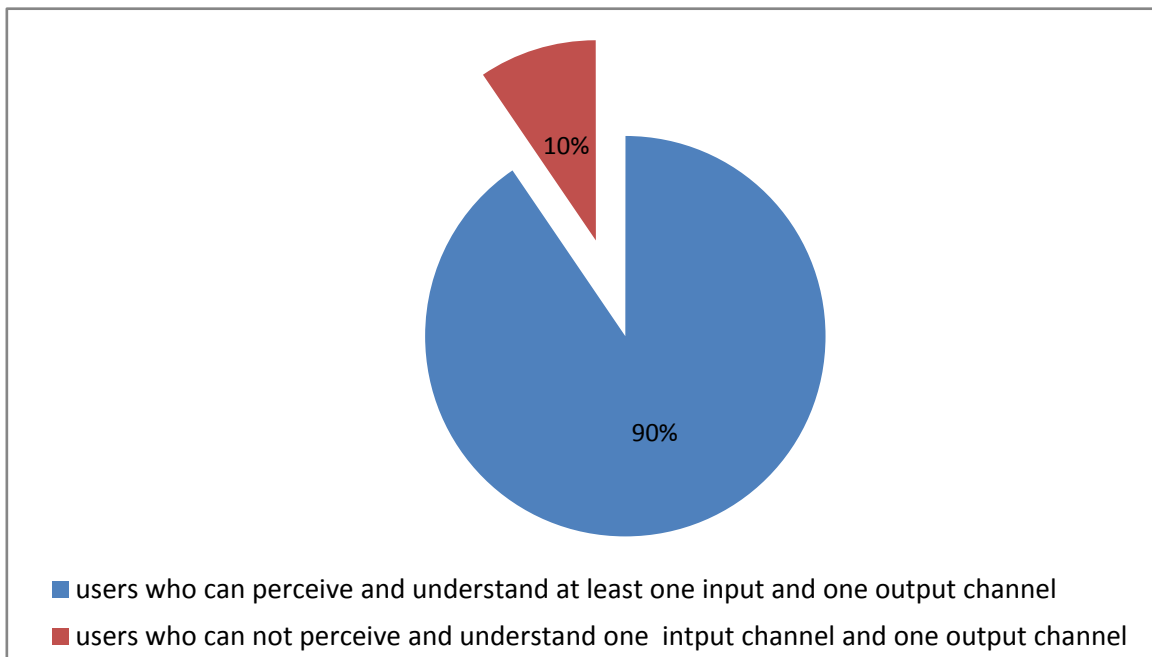


Figure 23. Ratio of the sample finding the system is accessible

Finally, this result has been crossed with the the opinion of the users and the observers about the general comprehension and perception of the whole system. Average and a confidence interval (of a 95%) are displayed.

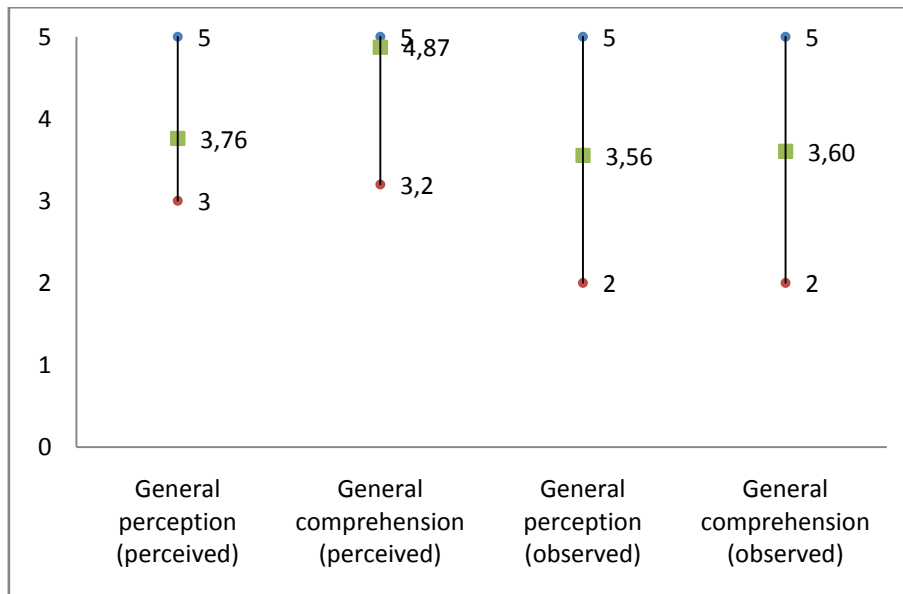


Figure 24. General opinion about the accessibility of the system

Following the Global Accessibility Evaluation (GAE) criteria and considering that accessibility of the system has the number of users that can handler and understand at least one input and one output channel and who think,

To confirm accesibility results, we also get the user and observer opinion about the system accesibility in general. For the users: Do you think that, in general, the product is easy to use? and Do you understand how to use the product?. For the observer: Seems confident using the system and Seems to understand the system. In following figure we can see how answering that generalistic cuestions the success ratio is reduced to 70% of the sample.

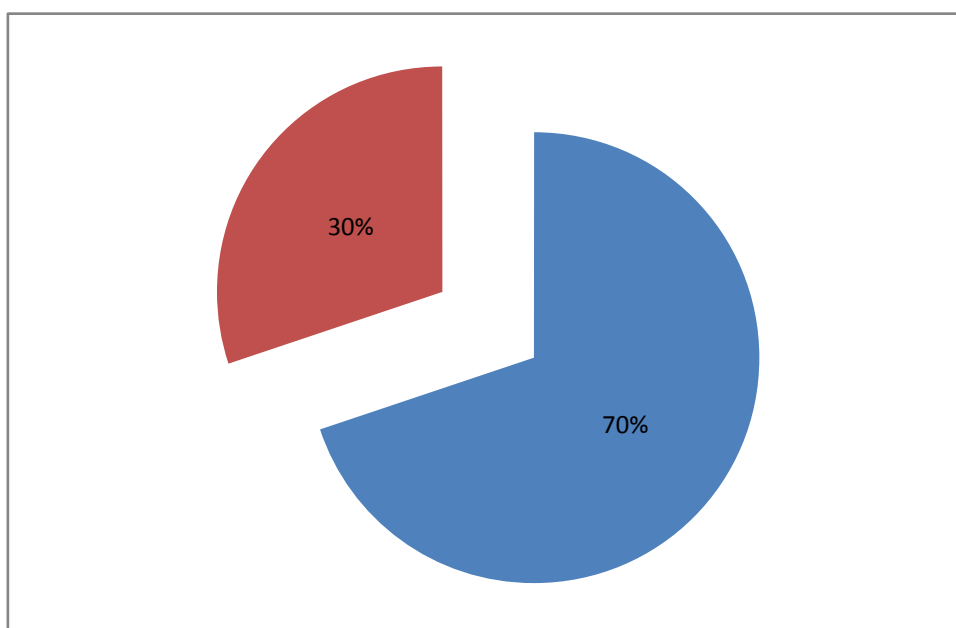


Figure 25. Ratio of users thinking that the system is accessible (70% agrees)

Summarizing, we can observe that the accessibility of the system is good but not perfect; 90% of the sample can perceive and understand at least one input and output channel and 70% have the opinion that the system is accessible. Thus, we have processed suggested improvements regarding accessibility and implemented it. For example, colour and sounds of the client are now configurable, washing machine interaction has been improved, etc. (see section 4 for details.)

### 3.2.2. Usability, performance and user satisfaction results

In order to develop the tool for evaluating the usability, functionality, performance and user satisfaction of the system we found of special relevance the UNIVERSAL DESIGN PRINCIPLES<sup>8</sup> and also the quality standard ISO/IEC 9126-1<sup>9</sup>. Using these data sources we have designed several questions to poll the users in these areas<sup>10</sup>. The result of each area has been translated to a numeric format between zero and five where zero is the worse rating and five the best. Next graphic shows the averaged results with a confidence interval of 95% for each parameter evaluated.

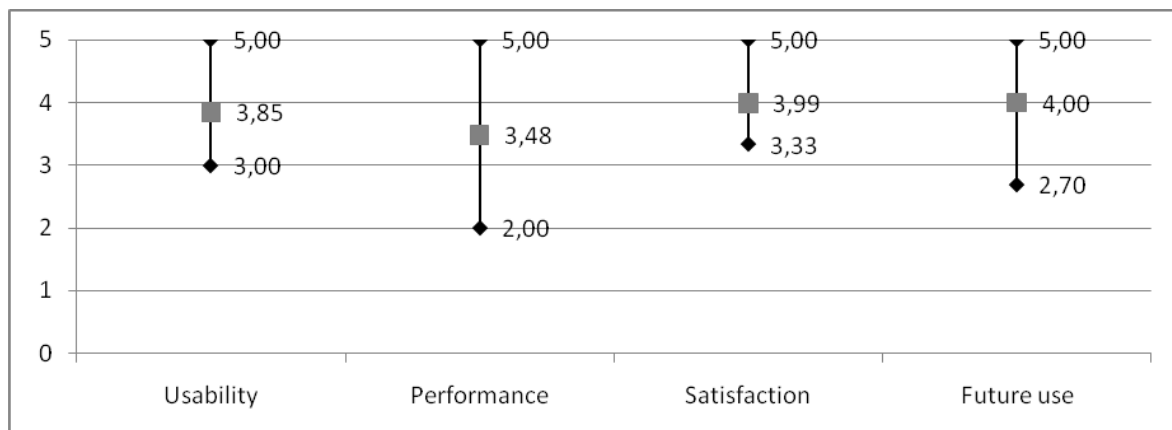


Figure 26. Usability, performance, satisfaction and future use rates

<sup>8</sup> The center for the Universal design. NC State University.

[http://www.design.ncsu.edu/cud/about\\_ud/udprincipleshtmlformat.html#top](http://www.design.ncsu.edu/cud/about_ud/udprincipleshtmlformat.html#top)

<sup>9</sup> International Organization for the Standardization <http://www.iso.org/iso/home.htm>

<sup>10</sup> This information is detailed in the deliverable 7.1

Usability of the system has been evaluated with a 3.85 over 5. Therefore we can conclude that the system has a good usability. Moreover, some changes have been done as suggested from the users to improve this area (see section 4).

Performance of the system has been the parameter with a worst score, 3,48 over 5. This data, firstly we can consider as a good result, has been qualified by the technical people that was supervised the test and several issues has been detected. Due to the system was working continuously for a period longer than a month and with interaction of a lot of people, new problems related with the performance has been appeared. This situation has motivated that technological partners have put some effort to improve the system in this way (see section 4).

User's opinions about the future use of the product as well as about the satisfaction about the use of it are very positive with and score close to 4 over 5.

### 3.2.3. Evaluation of functionality

Functionalities of the system (as described in section 2.5.2.1) have been evaluated by users (Users' point of view, UPV) and carers (Carers' point of view, CPV) that have participated in the test. Their opinion has been ranged between zero and five being 0 useless and 5 very useful. Next results have been obtained:

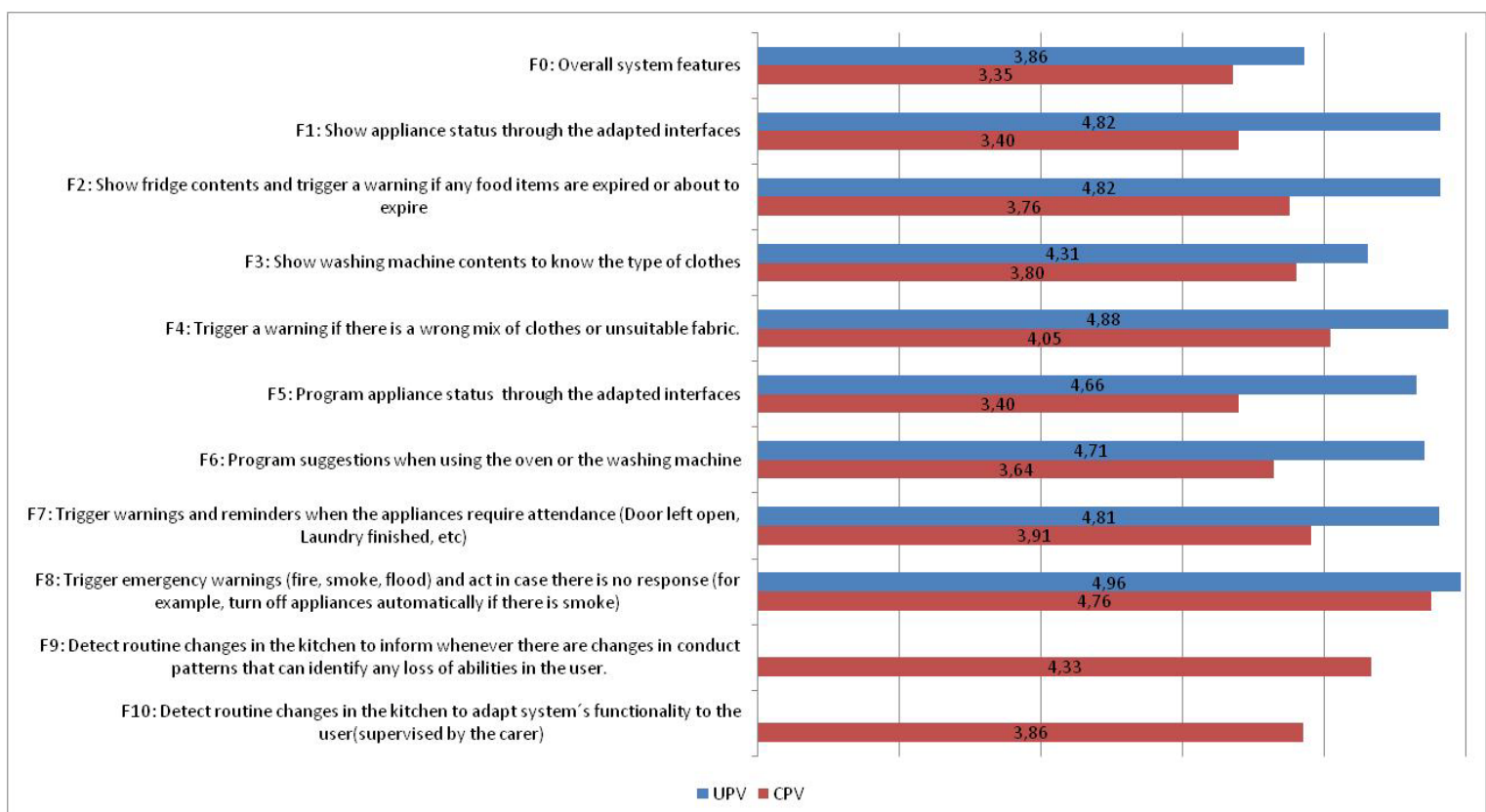


Figure 27. Functionalities of the Easy Line System

Attending to the detailed evaluation of the functionalities of the system, we can observe that, in general, the carers are been more conservatives in the scores assigned. For both, users and carers, "Trigger emergency warnings (fire, smoke, flood) and act in case there is no response" is the functionality rated the highest. For the carers this functionality is 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"

Other functionality with a positive evaluation by the user is "Trigger a warning if there is a wrong mix of clothes or unsuitable fabric."

### **3.2.4. Longer independent life evaluation**

As indicated in point 2.5.2, each functionality of the system is related to one or more essential activities needed for the autonomy of the person. Easing the activities for daily living ADLs and helping people to perform them, we are improving the quality of life of the users and increasing the time they can remain independent.

These functionalities affect to several ADLs how we can see in the matrix in section 2.5.2.1. Using the score of each functionality and calculating the average of the functionalities that affect to an ADL, we can estimate how this ADL could be improved using the system. Next results have been obtained:

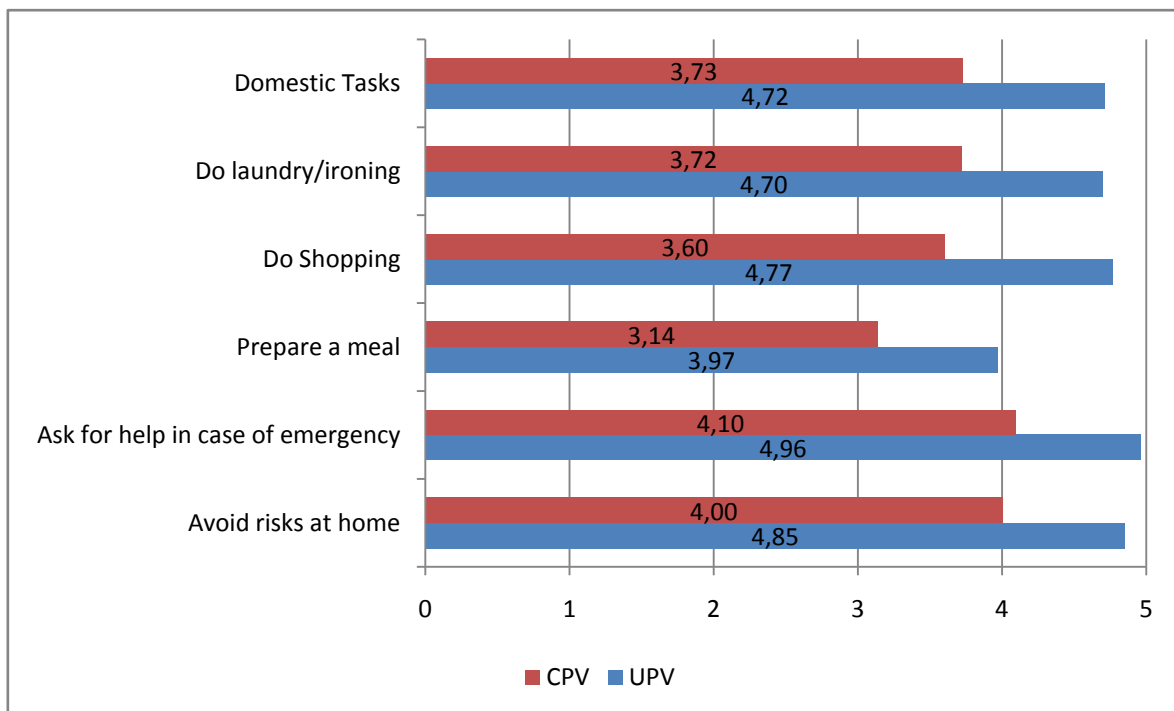


Figure 28. Empowered ADLs using Easy Line Plus System

As we can see, the user perception is always more optimistic than the carer opinion. Anycase, considering the carer feedback we can extract the following conclusions:

- The system is considered quite useful (3,7 out of 5) to help end users with activities of daily living (ADLs): avoid risks at home, ask for help in case of emergency, prepare a meal, do the shopping and do laundry/ironing. Therefore, as the system is able to make these activities easier and help people to do these activities by themselves, we are reducing their dependency level and consequently increasing the time they can remain independent.
- The system is considered very useful (4,1 out of 5) to detect routine changes in the kitchen and to inform whenever there are changes in conduct patterns (see F9 and F10). 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.

### 3.3. Evaluation of the e-servant system

Currently, the market is not ready for the full Easy Line Plus product mainly because of the penetration of RFID technology in the consumer market (food, drink, clothes) and because of the technology maturity. However, a sub-set of the Easy Line Plus product, what have been called e-servant system, could be ready to be exploited. This sub-set includes all the e-servant system except the appliances with RFID capacities.

So far in the evaluation process, we have been talking about the whole system. However, it is necessary to know how the sub-set behaves in terms of accessibility, usability, functionality, performance and capacity to enlarge time people is living independently.

From the point of view of accessibility, there are not changes because the interface is the same than for the whole system; users use the interface best suited to his/her capacities. This is the same cases for usability and performance; if the complete system has a good performance/usability necessarily all its parts have a good performance/usability. **In conclusion, e-servant system has the same rates in accessibility, usability and performance than easy line+ system.**

As described in section 2.1, e-servant system has less functionalities than the complete system. Thus, its functionality and capacity to enlarge time people can live independently must be analyzed.

#### 3.3.1. Evaluation of functionality

E-servant system functionalities (as described in section 2.5.2.1) are been evaluated taking into account the features not available. Next graphic shows the result:

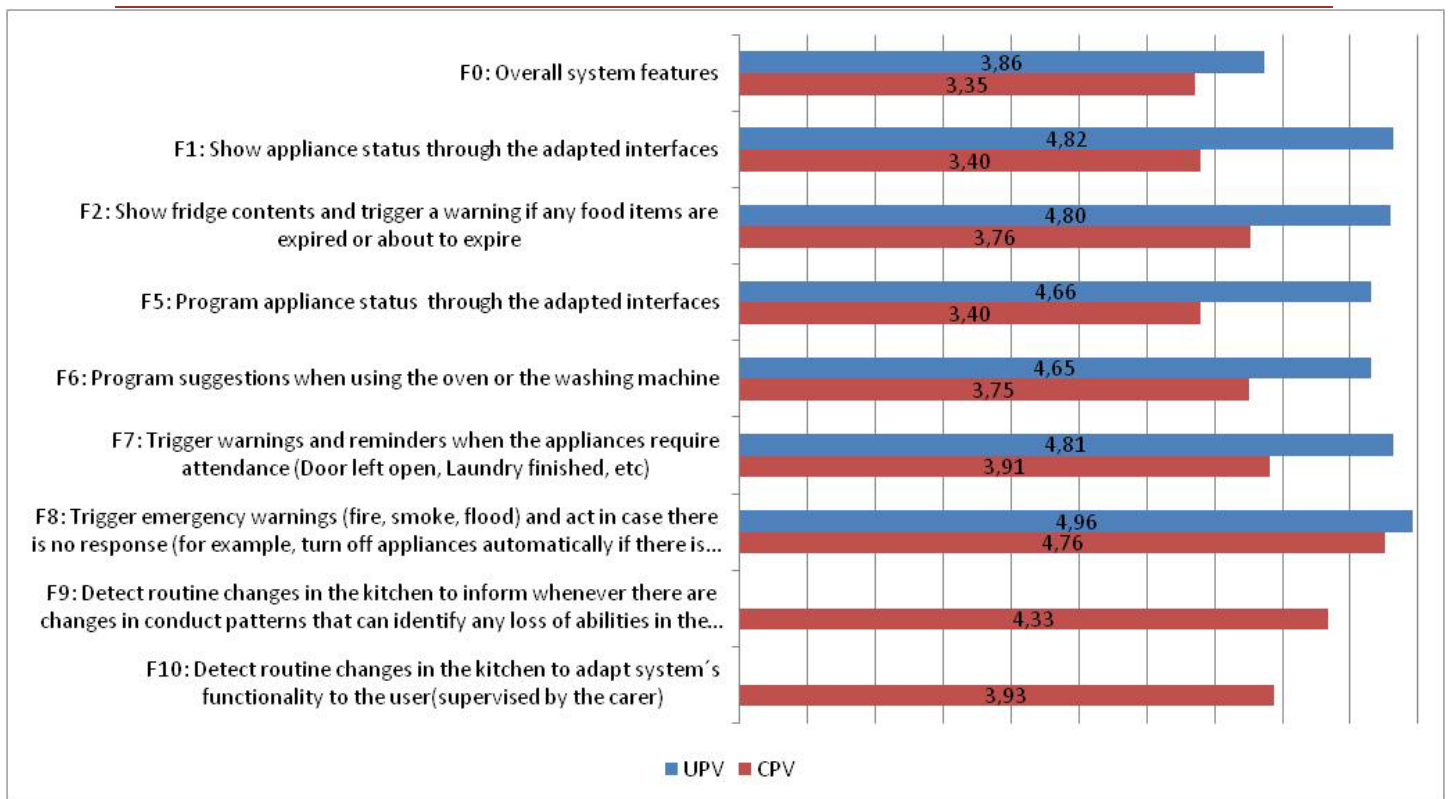


Figure 29. Functionalities of the e-servant system

As in the Easy Line+ system, we can observe that in general, carers are more conservatives in the scores assigned. Functionalities related with the RFID in the white goods (F3 and F4) are not available for the e-servant system.

The functionality highest rated by the users and carers (F8) is common for both easy line+ and in the e-servant systems. We can observe that some functionalities have changed their value respect the easy line plus system. This is due to the fact that each functionality evaluated is calculated by averaging several little functionalities. For example, "F6 - Program suggestions when using the oven or the washing machine" is composed by the score of "program suggestion when using the washing machine" and "program suggestion when using the oven". For the e-servant system case, the program suggestion in the washing machine is not available because the washing machine has not RFID, however, in the oven is enabled because is using the stand alone reader.

### 3.1.1. Longer independent life evaluation

Capacity to enlarge people live independently has been evaluated in the same way that the whole system (see 3.2.4). Attending to the functionalities of the sub-set the result obtain has been the following:

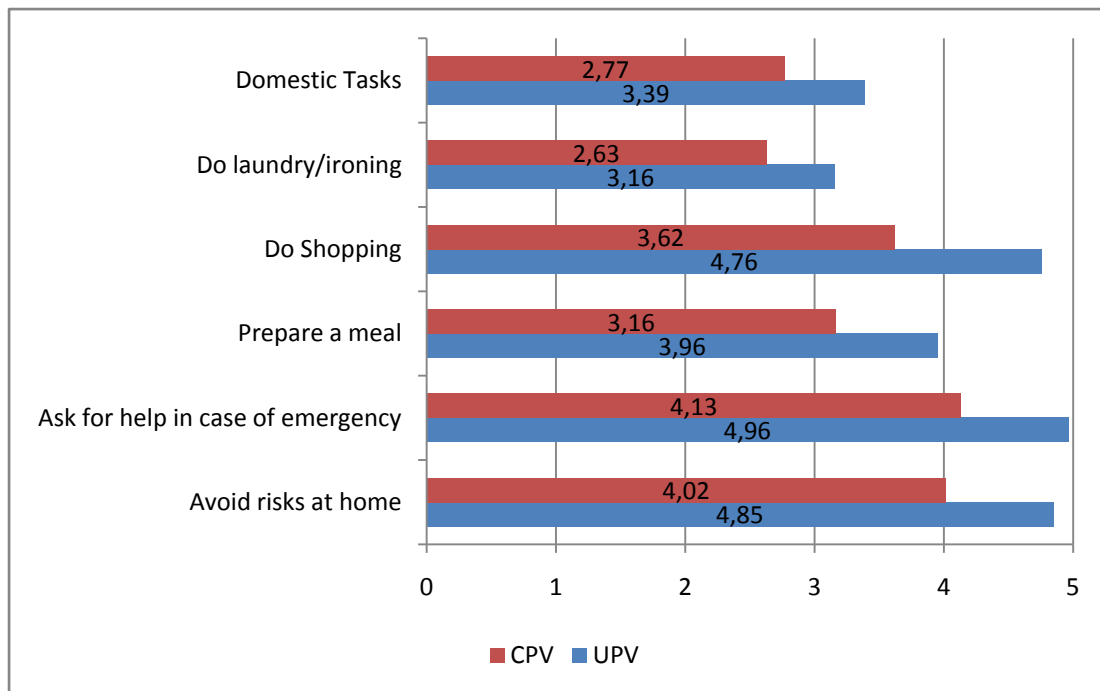


Figure 30. ADL that empowered using e-servant System

We can observe how the "Domestic tasks" and "Do laundry" have been the ADLs more affected by the reduction of functionalities of the sub-set. The influence of the system to improve these areas has decreased around one point over five.

Others ADLs are not significantly affected, thus the considerations for the easy line system are still valid. Also, the system is still considered very useful to detect routine changes in the kitchen and to inform whenever there are changes in conduct patterns.

## 4. ENHANCEMENTS OF THE SYSTEM AFTER USER EVALUATION

---

Users' evaluation has been very usefully to know the strengths and weaknesses of the system. Forms and interviews with users and carers have allowed take a lot of information about the system. Also, that real users handle the system have helped to detect unknown problems.

Next point summarizes the main actuations undertaken to enhance the system after the user testing. They have been divided in two groups. One group related with the User Interface and the Intelligence of the system and the other group related with the context awareness.

### 4.1 User Interface and Intelligence

#### 4.1.1. Technical problems

**Problem 1:** When the controller and clients are working together for around one hour with user's interaction it is usual that the controller hangs.

Actions:

- Motive: Adapt the controller to write logging to file
- UNIZAR: Test and report error
- Motive: Correct the problem

**Problem 2:** Sometimes the client lost the communication with the controller for many reasons. In this case the user is not informed and the interface (the client) seems connected. As a result, the user tries to handle the system without any result.

Actions:

- Motive: Show the status of the connexion in the client.
- Motive: The way in which the client attempts to recover from failed connections has been improved. There are 2 scenarios that we need to cover:

## 1. Connection Unavailable At Start Up

a) When the client starts up, the user needs to select their profile before the connection is made.

If the user presses any of the buttons before the connection has been made, the button click is ignored and the following message is displayed for 4 seconds:

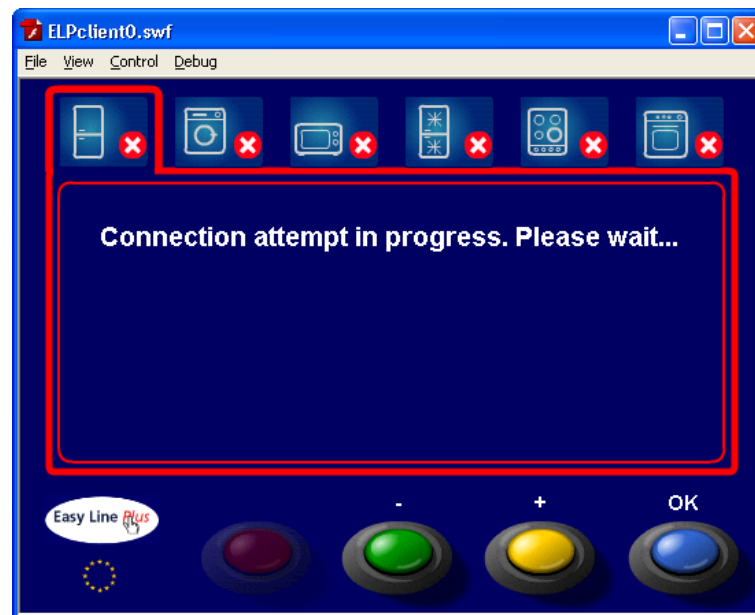


Figure 31. Client capture

b) If the initial connection attempt fails, then the following message is displayed:

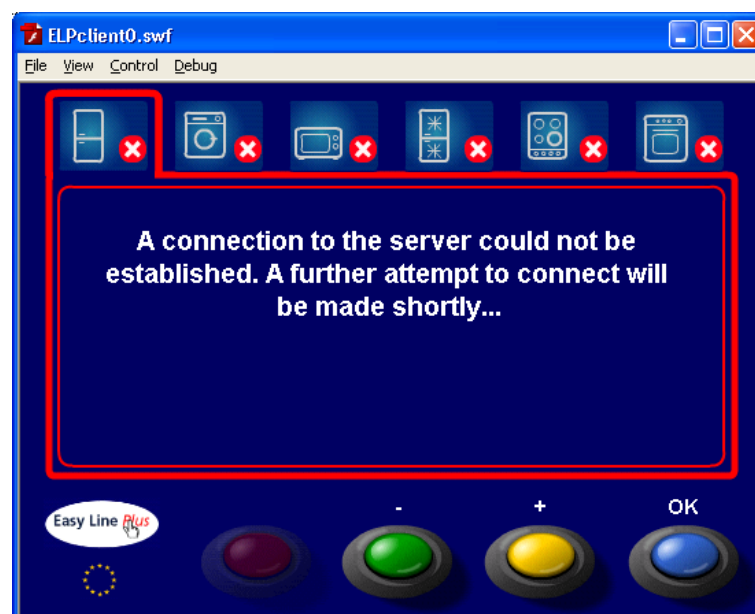


Figure 32. Client capture

A connection attempt is then made in the background every 10 seconds (configurable). If the connection attempt fails, then the above message is shown again to keep the user informed.

d) As soon as the connection becomes available, the following message is displayed for 4 seconds to inform the user. The application then starts as normal and is available for use.

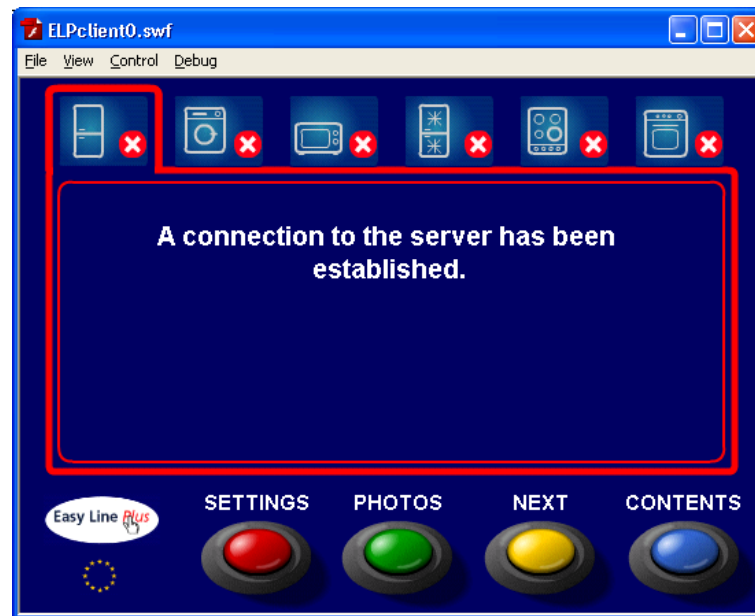


Figure 33. Client capture

## 2. Connection Fails During Use

a) If the connection is lost during usage of the application, the following message is displayed:

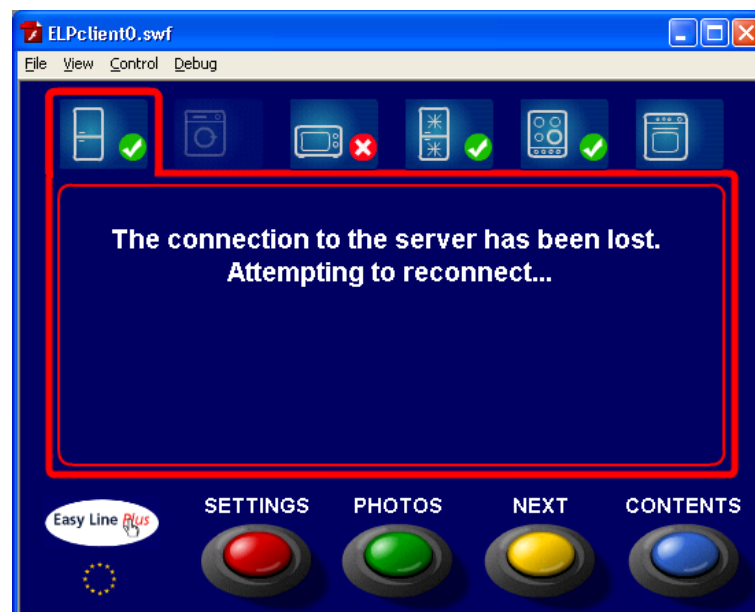


Figure 34. Client capture

b) The client attempts to reconnect every 10 seconds (interval to be configured). The following message is displayed each time an attempt fails:



Figure 35. Client capture

c) If the user presses any of the buttons before the connection has been made, the following message is displayed:

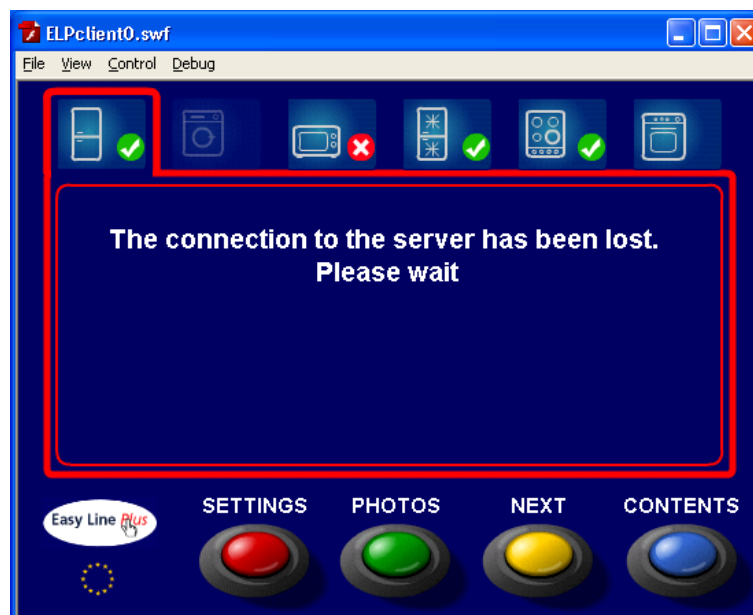


Figure 36. Client capture

This cycle will continue until a connection can be made.

d) Once the connection has been made the following message is displayed and the user can continue to operate the client as normal:

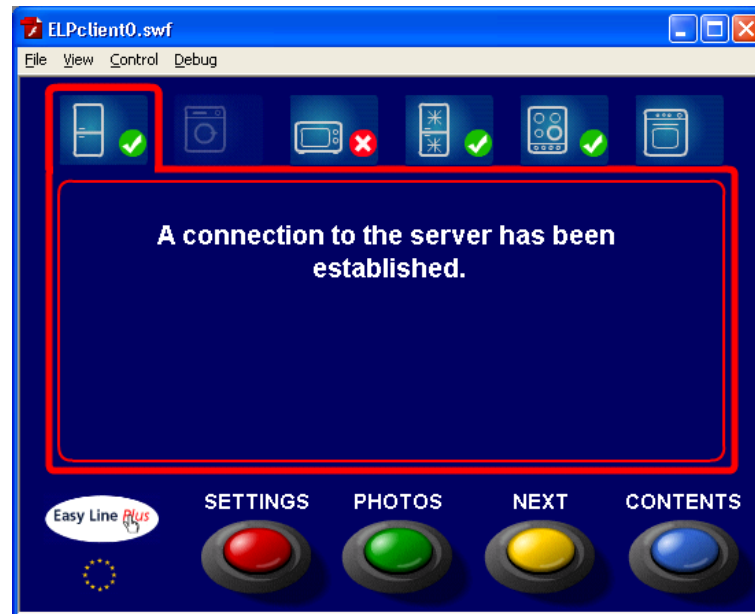


Figure 37. Client capture

Note that the server assigns a new client id when the connection is re-established, effectively starting a new session and the user is returned to the dashboard screen (exiting any scenario that was in progress).

**Problem 3:** If the controller hangs while the intelligence is working, when the controller reloads, it is necessary to clean the database of "null" request scenarios (scenarios launched while the controller is off). Otherwise the controller cannot run correctly (it doesn't launch scenarios, changes variables...).

Actions:

- MOTIVE: added a method in the InterfaceController that removes all rows from the ui\_session\_request table where the SessionId is null.
- UNIZAR: Check the controller

**Problem 4:** when the settings of the controller are changed (IP of the database, password, etc), in some cases, the controller is frozen and finally it falls down. It

seems that the changes are taking effect as they happen and it doesn't wait till all the changes are made.

Actions:

- MOTIVE: The application has been altered so that when the user clicks to open the configuration editor, the InterfaceController is paused and all execution is temporarily halted. When the user clicks on the OK button on the Editor the user is prompted to save any changes they have made and closes. Once the Configuration Editor is closed, it returns a value indicating whether or not to restart the InterfaceController with new settings or simply continue with the old settings.
- UNIZAR: Check the controller

#### 4.1.2. Users' requirements

**Requirement 1:** The user doesn't know if he/she is loading the washing machine and when the item is registered.

Actions:

- Unizar: Update the intelligence of the system to include in the variables "WM\_devicestate" in table "UI\_device\_Input" in database to have more values including ("LOAD MODE") and ("UNLOAD MODE").

0: off, 1: on,... 8: "Loading", 9: "Unloading"

- Motive: Update the client to show the new values in the status field. Also play a voice or sound informing that you are in loading or unloading mode
- Motive: Change the client to play a sound when the list content changes (variable "WM\_content" in table "UI\_device\_Input").
- Motive: Create a separate dictionary for the specifically for the Dashboard, which is loaded into to client at the same time as all the other language files. This new dictionary can now easily be extended to include new items far more easily, without any need for code changes in the client.

**Requirement 2:** Several users are unhappy with the warning sound even, in some cases, the users were scared.

Actions:

- Motive: The client is now looking to the root of Effects and expects to find these two sound files. If a user is not happy with the default sound files, they can select a different one from the contents of the Options > Buzz & Ding folders. Renaming their preferred choice to either Ding or Buzz and overwriting the default sounds in Effects will cause the client to use the new sounds.

**Requirement 3:** Several users are unhappy or have problems with the colour theme of the client.

Actions:

- Motive: Reproduced the clients with three additional colour schemes, there are now four in total and can be selected by changing the numeric value 1 to 4 in the viewconfig.txt file.
- Unizar and Glyndwr: Support to Motive to choose the palette.

**Requirement 5:** when the fridge has many items and its content is displayed, it is very complicated to know which the new products are.

Actions:

- Unizar: Update the intelligence to add a new field in the "fridge content" xml file indicating if the item is new or not
- Motive: Prefixed all items that have are new items with an asterisk.

**Requirement 6:** Provide multimodal information channels in case of emergency

**ACTION:**

- Unizar: Change the intelligence to increase the number of channels to notify carer in case of emergency:
  - o E-mail warnings have been added.
  - o sms warnings have been added.
- A new Zigbee actuator has been added to the system to communicate using any commercial telecare system that provides external alarm input.

## 4.2. Context awareness and intelligence

### 4.2.1. Technical problems

---

**Problem 1:** The firmware of the RFID readers has stability problems working with Zigbee:

- Sometimes the RFID reader in the appliances freezes.
- Sometimes the RFID reader has problems when a high number of labels are in the field.
- Sometimes, when there are several labels, same EPC code is sent several times.
- New commands are needed in the protocol between IDENT and UNIZAR to improve the reliability of the system.

Actions:

- IDENT and UNIZAR: Detect and analyze firmware problems one by one. IDENT provides a solution and UNIZAR tests the improvement in its living labs.
- IDENT and UNIZAR: Check the communication protocol to improve the reliability in the communications. The ACK\_COMMAND is added to have a response in all the messages. STATUS\_COMMAND has been improved to have information about the power level, the reflected power and the firmware version.
- UNIZAR changes the intelligence to follow the new protocol.
- IDENT changes the firmware in the same way.

**Problem 2:** Some EMC problems are detected between the RFID reader and the bridge Zigbee.

Actions:

- Unizar: Change the setup in order to minimize the problem.
- Ident: Support UNIZAR as expert in RFID

**Problem 3:** Stand alone reader has heat problems if it is reading for a long time (i.e. two hours).

Actions:

- Unizar: Add a Zigbee presence sensor (PIR) in the kitchen in order to turn on the reader only when the user is here.
- Ident: Support UNIZAR as expert in RFID.

## 5. CONCLUSIONS

---

The prototype of advanced “white goods” obtained in the WP6 has been evaluated in real environments with real end users and carers in order to spot any accessibility, usability, performance, etc. issues.

Data from the evaluation has been analyzed and correction measures have been taken to improve the system obtained an enhance system.

Next goals have been reached in the evaluation:

- Assess the overall effectiveness of the Easy Line Plus system.
- Evaluate accessibility, usability, functionality, performance and user satisfaction of the system.
- Evaluate how the system provides longer independent life for the users using it.
- Help designers to enhance the system and rectify deficiencies.

Next table summarizes the results of the evaluation:

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. Several suggestions from the users have been taken in account to improve the accessibility and functionality of the system (see point 4).

User’s opinions about the future use (3,98 / 5) of the product as well as about their satisfaction (3,99 / 5) have been also very positive.

During the tests process, several issues that affected to the performance of the system have been detected. This situation has motivated that main effort to improve the system are in this way (see point 4).

About the functionalities of the system, we observed that both for beneficiaries and carers, the highest rated function of the system is security at home: “Trigger emergency warnings (fire, smoke, 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 prolong 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.

## **ANNEX I. EVALUATION USER REPORTS**

---