SRS

Multi-Role Shadow Robotic System for Independent Living

Small or medium scale focused research project (STREP)

DELIVERABLE D1.4.2

Requirement specification of future remotely control service robot for home care (final)

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16	García, A.	18/05/2013	Final version

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1. SUMMARY

SRS Task 1.6 “Requirement of future remotely control service robot in home care” address elderly people differences in their needs, their performance and how their physical and mental states change when they are getting older. The present deliverable is based in a wider assessment and more specification on the user needs and difficulties collected in WP1, and also with feedback from data collected in WP6. Different considerations are included about users’ perceptions and expectations, including factor analysis, prioritization of user requirements, privacy and safety considerations, and interaction with a robotic arm.

As developed, the iterative process of requirements definition has shown a huge amount of data related to user requirements and needs, house distribution, ethical constraints, etc. Results have been structured by means of prioritization procedures to make possible selecting the most important requirements the system should meet.

In such a constructive bottom up process (gathering the specific requirements and prioritizing, selecting, organizing in factors of common responses…) the final aim is to offer a comprehensive and traceable list of requirements that any researcher in the field can use to direct his efforts. To achieve the aim, the project went through different phases in which information is collected, and the prioritization procedure was applied. Based on this work, the user requirements specification for future remotely controlled service robots in the process of aging is in place. It is intended to be an open consultation guide for related projects. At the end of this task, a proposal of requirements about assistive robotics for frail older adults is listed.

The users’ requirements study in SRS point out that the Robotic Assistive Technologies need to be adaptive and personal based on the need of specific users. It should come with modular and customizable designs. Privacy, safety and environmental peculiarities must also be taken into account. All this considerations should be relevant for technical developers who aim to provide with technological solutions for frail older people.

2. SCOPE

The document provides the method of prioritizing and the requirements list linked to technical requirements which show the most relevant requirements for Supporting Robots for elderly people with frailty.

3. INTRODUCTION

The development of ICT for new users, which normally bring in new needs, is challenging. It is crucial to get valid information about the intended, future users and represent that information in a proper way (Biihler, 1996; Björndal, Rissanen, & Murphy, 2011, Kujala, Jauppinen, Lehtola, & Kojo, 2005). User requirements research on assistive technology is one of the main issues in the ICT challenges for the development of new technological devices adapted to the users’ needs and capabilities. Starting with user-based analysis, the direct involvement of users is a

driving force in the development and use of new technologies for people with daily-living difficulties, including frail older adults living independently. Apart from supporting detailed design and development, user involvement is usually performed when developing and / or validating requirement specifications (Rashid, Wiesenberger, Meder, & Baumann, 2009).

Several studies have been carried out within the FP7 programs to define and specify what are the user's desires, interests and needs regarding technology and specifically in Healthcare Robotics. As the robotic field is getting shaped as an affordable strategy to cope with the needs of an increasingly ageing population, the need for establishing unified users' requirements is clear.

Task 1.6 comprises a wider assessment and more specification on the user needs regarding difficulties, environment, safety and privacy in order to the build an open consultation guide in topic related EC projects. An identification of the variety of needs to be expected will be made based on results of previous tasks in WP 1 and feedback from WP6.

In the Section 4 we present the SRS Requirements development model. This is the User Centred Design approach followed through the project, which aims to set up the comprehensive description of the procedures compilation for establishing a general working framework for Assistive Technologies developers regarding user and technical requirements. In Section 6 we will conduct different analysis in order to: a) optimize the knowledge obtained from the data collected in the user requirement study; and b) link this knowledge with the results of other studies conducted with users within the project in WP1 and WP6. In Sections 7 and 8 a deeper analysis of responses about privacy is conducted, in order to ensure the coverage of privacy needs reported. Also updated information about safety will be included, applying the methodology for "safe HRI" outlined in SRS deliverable D2.3. In Section 9, requirements prioritization is conducted according to the results obtained in the ethnographic research. The aim is to achieve an organized and systematic set of requirements from users through a systematic process, by the assignment of relative importance to each requirement. This process was started in D1.1b; in this document, we include a more detailed description of the methodology followed and a new prioritization based in the complete analysis is included. In section 10, the final step on prioritizing requirements is carried out. This produced a final requirements checklist, a first approach to the proposal of general user requirements in assistive robotics for frail older adults living independently.

4. SRS REQUIREMENTS DEVELOPMENT MODEL.

There are several models to gather requirements in the literature. Usually, these models are basically lists of procedures extracted from the social sciences to understand what the users' difficulties are, what they would like to have and how they would like to use it. In ICT projects, these can be reinterpreted as requirements: targeted users' comprehensive needs and interests that an envisaged system should aim to provide support.

Even when the basic guidelines of gathering requirements are clear, projects development tend to present deviations from the original plan, the use of different methodologies not always easily comparable (depending of the dynamic needs of the project) and unexpected situations regarding data manipulation prevents the studies to be easily handled.

Throughout this project, the users' interests and needs have been gathered, reformulated into user requirements that in connection to the technical developers have been translated into system requirements to make the final solution functional, usable, accessible and acceptable. This has been achieved by means of several iterations. One of the aims of the deliverable was to present a unified pack of scaled requirements to be used as a basic guide in similar projects which aim was supporting older people with medium to severe motor impairment. These requirements have been organized stepwise in the different levels of analysis, depending on the structuration degree, on whether they were technical or user related, and in the gathering phase. Additionally taking into account that several requirements have been found repeated, this point far to be a problem is another indicator of the importance of the requirements, so the final list have been also organized based in these findings prioritization. In the following section a specific gathering needs model is shown based in the work carried out in SRS project.

4.1. FINDING A PROBLEM WITH A TENTATIVE SOLUTION

To this end, which is previous to the project idea establishment, a creative process is involved, but also a focusing moment should take place in order not to exceed the reasonable balance of costs/benefits that depends on the project scale and funding. Probably a good starting point is to find what kind of problem we want to address, what are our possibilities in relation with the state of the art and what relation this problem has with other similar problems that a smart initiative could help to solve due to the synergetic possibilities of our envisaged solution. To this point we can take a look at the basic needs of the older people:

TABLE 1 - GENERAL REQUIREMENTS OF ELDERLY

General requirements (GR)	
GR1	Motor Domain
GR2	Sensation and Perception Ability
GR3	Cognition Domain
GR4	Social Relations

These General Requirements have seen addressed previously, but the relations between the users needs should be interpreted not as a static cluster but as a probable co-occurring list. In the following figure we can establish what kind of problems we would like to offer a solution.

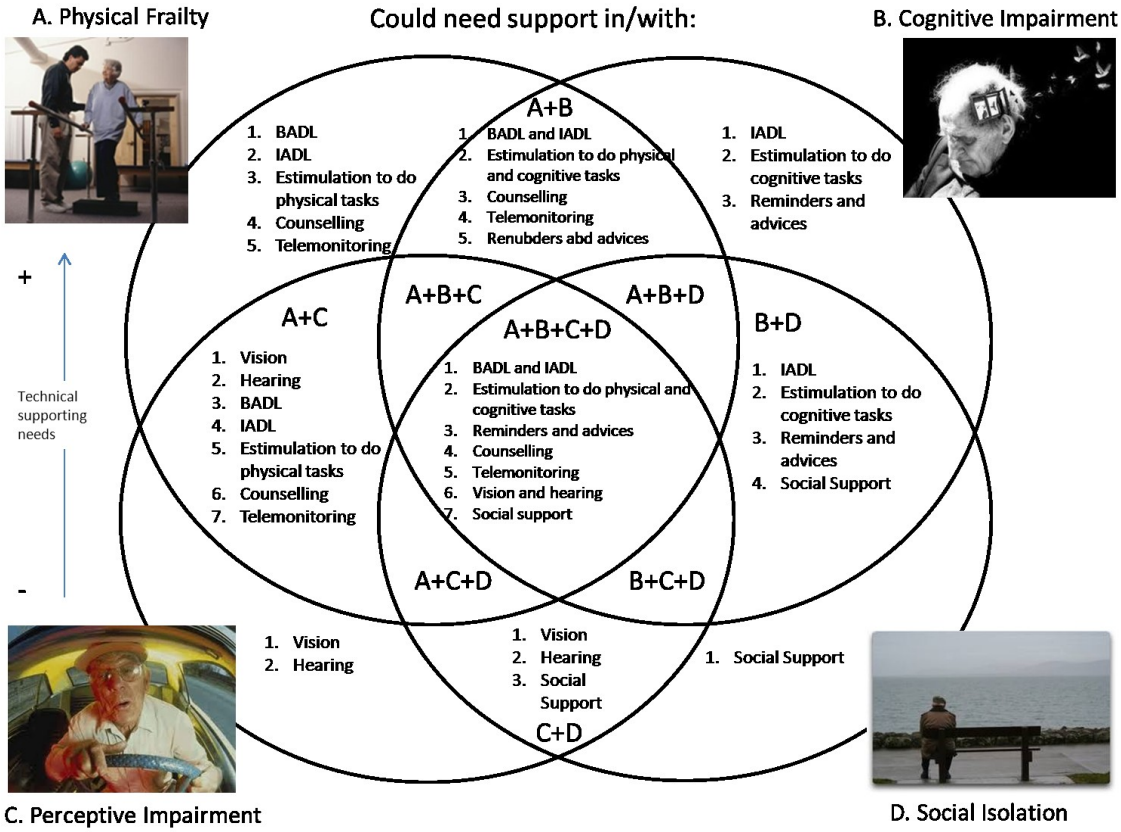


FIGURE 1 - RELATION BETWEEN PATIENTS' NEEDS WITH GENERAL REQUIREMENTS

The main aim of SRS is to develop a system that could give support with some of the problems related to the GR1 (A. in the picture) motor domain. Our targeted users are older people with a frailty status. Some of the needs could be related to: Basic Activities of Daily Living (BADL), Instrumental Activities of Daily Living (IADL), and could be useful to give the users stimulation, rehabilitation, counselling or telemonitoring. The envisaged solution will be focused in supporting BADL and IADL. To this end a very technical assistive technology will be developed: a semiautonomous robot with a robotic arm. Focusing in these needs does not involve avoiding other related needs but consider them as nice to have features apart from the main objective.

4.2. ANALYSIS OF THE LITERATURE FOR SPECIFIC FINDINGS

A creative idea and the literature search should give an interesting insight about the possible solutions. In our case we found a list of 9 BADL and 10 IADL user requirements. The level of analysis of the requirements is still very broad: bathing, grooming, shaving, housework, etc. The requirements at this point could be general definitions, enumerations or constructs related to the objective. If the targeted group has not already studied with the aim of the project, still there is no need to go deep into operative and systematic definitions of the needs.

Further study in the users needs should take this finding into account. In order to check:

a) Do the requirements found in the literature exist in our sample?
b) Are there any other related requirements to be taken into account?
c) What other related requirements and problems we should take into account for developing a solution?

4.3. SOCIAL RESEARCH BASED INFORMATION GATHERING PROCEDURE

In this point further information is needed. We started with focus groups. At this stage, the information obtained could not be specific enough for the technical development yet, but it helps on defining the scenarios of use, the availability and the appropriateness of the envisaged solution. To be more specific, the research restricts the approach by focusing in one person at a time. A research protocol should be developed taking into account the different possibilities of the social sciences: interviews, scales and questionnaires or an ethnographic approach based in observation and even in participation in the user's life could be used.

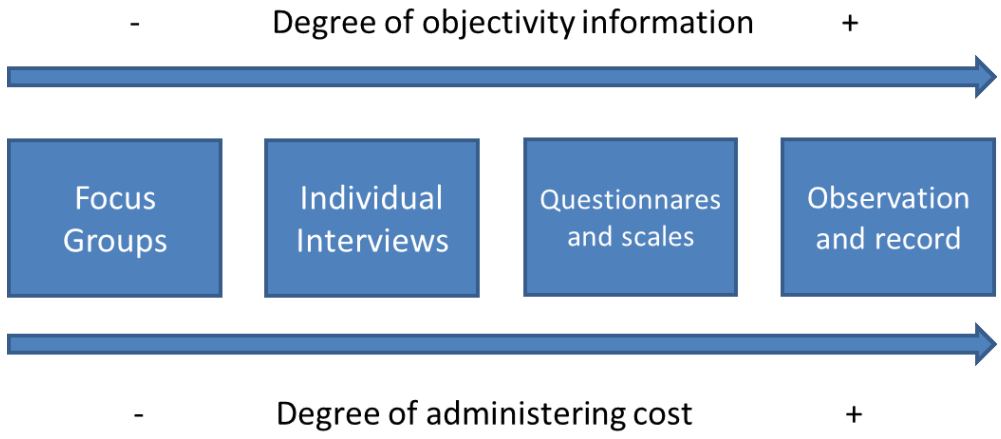


FIGURE 2 - SCALE OF POSSIBLE METHODS FOR COLLECTING REQUIREMENTS

We found the following requirements depending on the procedure:

1. Focus Groups: 9 user requirements. Still too general, but the main point of the focus group is not to gather specific requirements but to get a first view of the problem and the solutions involving the users. These user requirements were elaborated and prepared in a questionnaire involving frequency and impact in the Individual interviews and questionnaire phase.
2. Individual interviews: 33 user requirements with a higher specificity degree based in several fields elaborated from the FG were found:
    - Robot environment: 4
    - ADL support: 6
    - Emergency: 4
    - Housekeeping: 1
    - Memory and activity support: 2
    - Social Support: 1
    - Privacy and Safety: 15

These requirements went through a process of prioritization to know which of them should be (within scope) addressed by SRS.

	Germany		Italy		Spain	
	Agree	Dis agree	Agree	Dis agree	Agree	Dis agree
C2-Privacy intrusions	53,5	21,4	52,7	36,8	29,4	47,1
C3-Safety risks	42,9	25	68,5	15,8	47,1	23,5
C4-Trustfulness	25	17,8	47,3	26,3	58,8	0
C5-Promoting independency	32,2	28,6	63,2	31,6	70,6	0
C6-Overcontrol	35,7	32,1	47,4	42,1	17,6	41,2
C7-Family relax	64,3	10,7	68,4	26,3	88,2	5,9
C8-Social life enjoyment	28,5	25	47,4	36,8	76,5	0
C9-Housing difficulties	21,4	42,8	47,4	26,3	47,1	5,9

Country 1	Country 2	Country 3	Prioritization
M	M	M	M
M	M	L	M
L	L	M	L
L	L	L	L

Privacy issues	Priority
C7-Family relax	H
C5-Promoting independency	H
C3-Safety risks	H
C8-Social life enjoyment	H
C2-Privacy intrusions	M
C4-Trustfulness	M
C6-Overcontrol Disagreement	M
C9-Housing difficulties	M

FIGURE 3 - EXAMPLE OF PRIORITIZATION CARRIED OUT

3. Ethnographic approach: 6 user requirements with a higher specificity degree and naturalistic description were developed. This helped to build the scenarios with a realistic approach based in the experience of the user in his context.
4. Scenarios: 25 requirements with specific tasks were gathered by means of the scenarios (i.e: The robot should help to climb bathtub or shower, robot should does laundry, hangs, folds, puts away clothes, etc.)

4.4. TRANSFERRING KNOWLEDGE FROM THE USERS TO THE TECHNICAL SIDE

The user requirements have to be translated to requirements which a system should have. Once the user problems are identified and specified in an operative way, a new procedure of problem specification must be carried out under the collaboration between users' oriented partners (the ones that directly gathered the requirements) and the technically oriented partners (the ones that should develop the system). The ideal both sides should be involved from beginning until the end. The approach can be costly as a duplicate of the manpower is required.

One example of this requirement step by step translation could be like this:

1) General requirement (user related): The user has motor impairment in his arms.
2) Broad requirement (user-context related): The user needs support with his daily tasks.
3) Specific requirement (user-context related): The user needs help with: carrying heavy bags.
4) Usage context requirement (scenario related): The user needs help with moving from the sofa (getting up by himself with help of the cane), going to the door, opening the door to the home delivery service from the supermarket, paying with one hand while he need the other to hold himself, and especially to bend over, catch the food bags and take them back to the fridge.
5) Technical requirement (technical solution related): The user could use the tablet to ask the telecare service to open the door, take the bags, and take them to the

kitchen to put the groceries in the fridge. These should be breakdown in the technical tasks such as (programming, the system, establishing communication by videoconference, mobility of the robot, mapping the room, etc.)

4.5. TESTING THE SOLUTION

Once the requirements have been established and the technical solution has been developed, taking into account that the system functions correctly in functional trials and it is safe to be used with a user the first prototype is tested, the system is confronted to the user to be tested in controlled environments. The aim of the trials is to test the solution by means, not only of functionality but in terms of usability, acceptance and accessibility. Besides, it is a good opportunity to register new use cases, user requirements and technical requirements (as areas of improvement). As the testing situation is always a new situation, new circumstances can arise that have not been foreseen. A broad number of requirements were obtained from testing the system. The most of them related to the technical development, but also on user needs regarding the new established situation (privacy concerns, safety, etc.)

1. First trials: 41 technical requirements were obtained in the first trials.
2. Advanced trials: 27 technical requirements were identified in the second trials.

After having tested the solution, the procedure should be iterated: the information has to be structured, prioritized and translated into feedback for the technical developers. And then, the testing cycle should start again. The logic tells us the much iteration the procedure makes, the most adapted the system will be, however costs involved should make possible a good costs/benefits balance.

4.6. CHECKING THE REQUIREMENTS FULFILLMENT

As we stated previously, cooperation between technically oriented and user oriented partners is a main issue in requirements elicitation, but it is also important in the self evaluation stage of the project. User requirements and technical requirements should be covered, as much as possible and within the scope of the project, to ensure the achievement of the objectives planned. The requirements achieved through the project should be listed and checked by the partners involved in each section of development. From this point on, the requirements have been established and they could be used in further studies in which the targeted user or the envisaged solution was similar too, as a part of the study of the literature step. The need for obtaining more information directly related to the users is still a step needed, but with the support of the previous studies the effort to spend should decrease.

5. MODEL DEVELOPMENT CONCLUSIONS

A requirements gathering model has been developed based in the findings of the SRS project users studies. A more specific guide of prioritization and decision making could be found in the

D1.1.a to which the present deliverable provides additional elaboration. The data shown in the present DV should be helpful for further studies and development in the field of supporting robotics for older people with motor impairment. Despite the fact of the sample size and that it was composed by Italians, Spanish and Austrian people, and a broad sample could bring specific insights on the study of requirements, the work carried out in SRS probably could be generalized to some extent to the western Europe users due to the specific nature of the problem. Some issues should be studied in deep such as the needs perceived by societies with differences in family support or differences in the experience with the technology.

6. IN-DEPTH ANALYSIS

Data obtained in the SRS Project have been gathered throughout several phases including different procedures, such as qualitative and quantitative methods, to ensure an integrated point of view of the users' context and needs. The following sections describe an in-deep analysis of the data gathered in the previous steps of the project. These additional analysis have provided results which have been included in the requirements

Several data analyses have been carried out to complete the information in the D1.1. Hypothesis were developed and tested. Elderly people would show different needs than the other groups about the elderly people needs. This asseveration points to the better knowledge of the elderly people about their own abilities and impairments. With this aim these research questions have been splitted into the following hypotheses:

Elderly people's difficulties:

a) To study differences between elderly people needs and needs observed by other groups (family members vs formal caregivers vs health professionals vs elderly people). To test this hypothesis, statistical differences have been searched between the groups involved, taking into account that not all the groups have been interviewed in the three countries.
b) To obtain differences between Germany and Spain, Italy and Germany, Italy and Spain.
c) To prioritize the user needs as obtained by the different groups following the prioritization procedure.

Envisaged use of the robot:

a) To study differences between elderly people needs and needs observed by other groups
b) To obtain differences between Germany and Spain, Italy and Germany, Italy and Spain.
c) To prioritize the user needs as obtained by the different groups following the prioritization procedure.

6.1. DIFFERENCES IN PERCEIVED DIFFICULTIES

Do family members, formal caregivers and health professionals perceive the same difficulties in elderly people´s activities? (despite country differences)

In order to make this comparison, the individual scores in section A “difficulties”, were added up. Once these individual scores were obtained, means were calculated for each group of subjects in order to compare them. We can appreciate that, in general, elderly people have obtained significantly different global scores comparing to family members, formal caregivers and health professionals. Alternatively; family members, formal caregivers and health professionals obtained similar global scores.

In Italy, statistically significant differences were found in the added score in difficulties perceived between elderly people and the rest of the groups. Several differences were found between groups in several items. There were no item in which differences were found between caregivers and health professionals.

In Germany, statistically significant differences were found in the added score in difficulties perceived between elderly people and the rest of the groups (family members and formal caregivers). Several differences were found between groups in several items. There were no item in which differences were found between caregivers and health professionals.

In Spain, statistically significant differences were found in the added score in difficulties perceived between elderly people and the rest of the groups (family members and health professionals). Several differences were found between groups in several items. There were no item in which differences were found between caregivers and health professionals.

Is there any concrete item in which these perceptions differ between groups?

In order to answer this question, means were calculated for the different groups in each question. When the means were compared, we could see that there were several items in which the perceptions differed. Elderly people differed significantly with the other three groups in “fetching things”, “shopping”, “cleaning windows”, “cooking”, “washing crockery”, “cleaning the table”, “washing clothes”, ”dressing”, “bathing”, “electronic devices” and “taking medications”.

They differed from family members and formal caregivers in “cleaning floor” and “tidying up the room”.

Elderly people also differed from formal caregivers and health professionals in “getting up”, “climbing bathtub”, “falling”, “forgetfulness” and “loneliness”.

Finally, elderly people differ from their family members in the “opening bottles” item.

In general, we can appreciate that elderly people´s perception of their own difficulties differ significantly from the perception of groups. Elderly people reported less difficulty than the other groups reported about them. That could be related to the lack of knowledge of the real problems in the elderly people daily activities or it could be related to the elderly people underestimation of their own difficulties, or social desirability. This finding should be taken into

account when gathering information of these groups related to the frailty topic. It is interesting that no other groups differed significantly from any other group in other items, which means that they have quite a similar opinion.

Is there any difference between groups from each country in perceived difficulties?

Differences between elderly persons' difficulties were also analyzed between country and category. The comparison was made within the country to observe if there were differences between the assessed profiles (Table 1).

TABLE 2.USER REQUIREMENT STUDY, GROUPS ANALYZED IN EACH COUNTRY

Italy	Elderly people		Health professional	Formal Caregiver
Germany	Elderly people	Family member		Formal Caregiver
Spain	Elderly people	Family member	Health professional	

No difference in the perceived difficulties mean composed score of the three countries was found, but several differences were found in specific items:

1. Spanish elderly people differ to German in walking and climbing the bathtub.
2. Italian and German elderly people only differ in the reading item.

6.2. ROBOT ENVISAGED USEFULNESS

Are there any group differences in the perception of usefulness of the robot within each country?

In "carrying heavy objects", elderly people differed significantly with formal caregivers and family members also differed significantly with formal caregivers. Results shown that elderly people and their family members stated that the system could be less useful to carry heavy objects than the formal caregivers thought

Regarding the perception of the usefulness of the robot a mean comparison was carried out to obtain the differences in each country between the professionals interviewed and the elderly people.

In Italy, significant differences were found in the mean value between elderly people and formal caregivers about the perceived usefulness of the robot in several items. Elderly people

reported less perceived usefulness about the system supporting them in their daily living than stated by the formal caregivers.
In Germany, there was no difference found between groups (elderly people, family member and formal caregiver) in the mean composed score but significant differences were found in a few items: technological support for getting up, electronic devices, taking medications and fetching things were reported by elderly people as less useful than the formal caregivers reported.
In Spain, there were no significant differences found between groups in Spain. Statistically significant differences were found in the following items: Reaching objects by a remote operator (differences between elderly and health professional), cleaning the floor by a remote operator (elderly and family member) and preference for remote control (differences between elderly and the rest of the groups).

6.3. FACTORIAL ANALYSIS

In the part B of the questionnaire applied within the user requirement study elderly people, family caregivers, professional caregivers and health professional, we asked them about their opinions regarding a machine that can move around the apartment of an older person, with an arm to grab and the possibility to call somebody in order to take control of the machine for complex tasks. With the aim of making the results of this part of the questionnaire easier to use and discuss, we have conducted a factor analysis with the data collected in this part of the questionnaire. Factor analysis is a statistical method that allows explaining a large set of measurements, such as the measurements collected in the user requirement study, in terms of a smaller number of unobservable factors, by providing insight into the structure of the dataset and reducing its dimensionality (Todman & Dugard, 2007). Factor analysis also allows transform scores from different items in a single, factorial score.

Because of sample size requirements, factor analysis has been conducted here with the full sample, including the data from elderly participants, family caregivers, professional caregivers and health professionals. Because of the difficulties found responding those questions about the use of the remote control function, we have restricted this analysis to those general items about the use of this technology for helping with each difficulty.

Four factors were extracted from the analysis (Table 1): Factor 1 has been labeled “Simple home tasks”, since it includes perceptions about the help of technology with cooking, washing crockery, clearing the table, tidying up the room, washing clothes, dressing and bathing. Factor 2, labeled “Social tasks”, includes those items at the end of the questionnaire, such as use of electronic devices, medicine taking, reading, memory aids and help with loneliness. Factor 3, labeled “Mobility”, includes items about help with walking, getting up, carrying heavy objects, climbing bathtub, fetching things, reaching objects and avoiding fallings. When compared with Factor 3, activities in Factor 1 involve more precise movements and are more related to the Fetch and carry scenarios. Factor 4, labeled “Complex home tasks”, included help with

shopping, cleaning windows, cleaning floor and opening bottles. Factor 1 explained the 17.424% of the variance; Factor 2 explained the 16.929% of the variance; Factor 3 the 16.894% of the variance; and Factor 4 the 14% of the variance. The total variance explained was 65,245%, which can be considered a high percentage (Todman & Dugard, 2007); the percentage of variance explained by each factor is also high and uniformly distributed between factors.

TABLE 3. ROTATED FACTOR MATRIX, INCLUDING CORRESPONDING FACTORIAL LOADING FOR EACH ITEM.

	Factor 1 Simple home tasks	Factor 2 Social tasks	Factor 3 Mobility	Factor 4 Complex home t.
Walking			0.749	
Getting up			0.839	
Carrying heavy objects			0.816	
Climbing bathtub			0.539	
Fetching things			0.734	
Reaching objects			0.598	
Avoiding fallings			0.411	
Shopping				0.702
Cleaning windows				0.791
Cleaning floor				0.700
Opening bottles				0.472
Cooking	0.697			
Washing crockery	0.499			
Clearing the table	0.690			
Tidying up the room	0.615			
Washing clothes	0.499			
Dressing	0.795			
Bathing	0.775			
Electronic devices		0.686		
Taking medication		0.632		
Reading		0.740		
Forgetfulness – a		0.650		
Forgetfulness – b		0.751		
Loneliness – a		0.707		
Loneliness – a		0.482		

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Mornalization

Comparing means from the different subgroups in the whole sample, significant differences were found in factorial scores for Social tasks $F(3, 127) = 5.245$; $p<0.01$ and Mobility $F(3, 127) = 2.719$; $p < 0,05$. Post – hoc analysis (Bonferroni tests) showed significant differences in Social tasks scores between elderly people (mean score = 0.328) and both family members (mean score = -0.405) and professional caregivers (mean score = -0.384), pointing to a higher agreement of the caregivers with the social component of the robot when compared with elderly people.

Comparing means from the different countries, we have analyzed factorial scores for elderly people, since this group was studied in the three countries. In this sample, significant difference were found for Simple home tasks $F(2, 63) = 6,671$; $p < 0.01$. Post – hoc analysis (Bonferroni tests) showed significant differences in Simple home tasks scores between elderly people from

Italy and from Spain. These differences point to a higher agreement of the Elderly people from Spain about the help that they can receive from a system like the proposed one in activities such as clearing the table.

Regarding the three scenarios selected, differences in Factor 1 point to country specificities with Fetch and carry scenario, whereas differences in Factor 3 point to group specificities with Situation monitoring scenario.

7. PRIVACY

One of the aims of user involvement is to improve to address ethical principles in human-technology interaction. In this regard, privacy issues must be taken into consideration in order to ensure that user rights are upheld, and also that requirements for user confidence and acceptance are covered (Kujala et al., 2005).

In D1.1.a, it was concluded that, concerning acceptance of the remote control function, elderly people seemed to put needs fulfillment before any privacy concerns, whereas caregivers and health professionals seemed to worry more about potential privacy problems than elderly users. Taking into consideration the essential role of privacy issues in a project based on remote operation, we have conducted some complementary analysis in this task to better understand differences.

The basic idea behind multiple regressions is that the criterion variable can be expressed as a linear function of one or more predictors, allowing us to calculate the accuracy of the function and the relative contribution of each predictor. As potential predictor of the privacy composite score, we have selected: country (Italy, Germany, Spain), category (elderly, family caregiver, professional caregiver, health professional), age, gender (female, male), educative level (none, low, level, high); factor scores for simple home tasks, social tasks, mobility and complex home tasks; and frequency of positive and negative responses in different dimensions measures with the Survey of Technology Use (SoTU) (Scherer, 2007), including experiences with technology, perceptions on technologies, activities, and personal and psychological matters.

Using stepwise regression, five predictors entered in the model: Factor 2 (Social tasks), Factor 3 (Mobility), Frequency of positive responses for perceptions on technology, Country and Frequency of positive responses on personal and psychological matters. The final model is significant $F(5, 115) = 14.954$; $p < 0.01$, and it explains the 40% of the variance ($r^2=0.405$).

The perceptions of the participants about the role of technology in their social and mobility needs and, in general, about their positives perceptions about technologies should be taken into account when analyzing issues related to privacy perception. The psychological state of the participants and the country where they come from also play a role in predicting these results.

According to these results, the privacy concerns would be related to their knowledge of the technology, making possible to develop educative and informative programs about assistive technolgies to facilitate the acceptance of technological support for the elderly people.

8. SAFETY

Safety of a system like SRS is of paramount importance for the acceptance of this kind of assistive technology and also is one of the main requirements, furthermore stipulated by related directives (e.g. “Directive on Machinery” -- 2006/42/EG) and standards.

A robot like SRS inherently has the potential to damage goods or - even worse - harm humans. In particular in the environment of elderly people, who are possibly unable to cope properly with critical situations, the highest safety standards have to be fulfilled. In SRS, a detailed safety review is being performed, considering the specific conditions of the robots in the environment of elderly people during operation. The result of this task will be a set of safety requirements and/or measurements, which have to be considered in the system architecture and design and which finally have to be verified in the appropriate life cycle phases.

For the given project, safety related issues are distributed to several work-packages and tasks. Task T2.5 deals with formulation of a methodology for a safe system design, in particular considering different aspects of Human-Robot-Interaction (reported in SRS deliverable D2.3 “Methodology of safe HRI”). Relevant international standards - domain-specific ones as well as generic ones - have been analyzed with respect to their applicability for SRS. Based on the research in T2.5, selected safety-related directives and requirements have been compiled into a set of design guidelines. The resulting methodology finally is being applied to the SRS robot system – first results (i.e. formulation of an “Intended Use” for the SRS robot system as well as analysis of “Essential Requirements”) are summarized in deliverable D2.3.
The present deliverable is completing the report on safety analysis by outlining the results of the SRS risk analysis process. Resulting from the safety analysis, critical risks are being identified and appropriate counter-measures are being analyzed. A selection of these mitigation measures is being implemented for the SRS system – a detailed description of the measures as well as their verification (according to the guidelines set in D2.3) will be finally included in deliverable D4.1 (“Integrated report about SRS control programme and safety assurance”).

The following picture describes the basic “safety loop” and shows the links to different tasks in SRS.

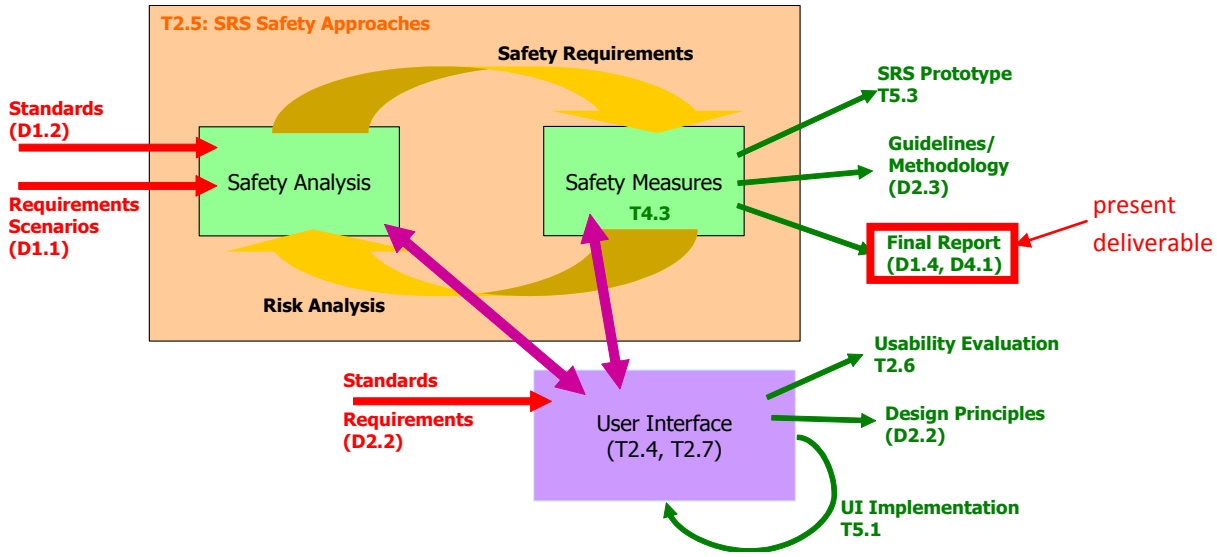


FIGURE 4. "SAFETY" IN SRS PROJECT (FIGURE ADAPTED FROM DELIVERABLE D2.3)

8.1.1. SRS SAFETY ANALYSIS

As described in D2.3 the manufacturer of a service robot system must ensure that a risk assessment is carried out in order to determine the health and safety requirements which apply to the robot. The robot must then be designed and constructed taking into account the results of the risk assessment. By the iterative process of risk assessment and risk reduction referred to above, the developer of such a system shall:

- determine the limits of the robot system, which include the intended use and any reasonably foreseeable misuse thereof,
- identify the hazards that can be generated by the robot and the associated hazardous situations,
- estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence,
- evaluate the risks, with a view to determining whether risk reduction is required,
- eliminate the hazards or reduce the risks associated with these hazards by application of protective measures.

The methodology designed for SRS starts with analysis of potential hazards and mapping these hazards to the desired system functionality and/or key components. A list of potential hazards is outlined in D2.3 – a dedicated "Hazard Matrix" helps to systemize the process.

The idea behind the matrix is to list the potential hazards in the horizontal axis and the planned/required system functions as well as relevant components in the vertical axis. Each combination between a particular hazard and a particular (sub-) function/component is being analyzed for its relevance – if applicable a more detailed description of this combination is being added.

For the sake of completeness, the "Potential Hazards" for the SRS robot system are outlined below (taken from deliverable D2.3).

Mechanical Hazards

- Overturning/tilting due to movement (caused by dynamic effects)
- Overturning/tilting due to external forces (putting load to the robot, collisions, etc)
- Collision due to movement of mobile platform
- Collision due to movement of manipulator
- Clamping/Crushing (e.g. due to openings or gaps with varying size)
- Sharp edges
- Falling objects
- Rotating elements (e.g. power transmission elements)

Electrical Hazards

- Short circuit
- Electrostatic hazards
- Live parts, terminals of battery
- Overload, overheating
- Insufficient power supply
- Loss of power

Hazards from Operational Environment

- Ingress of moisture or liquid
- Disturbance by electro-magnetic noise
- Heat source
- Pets
- Hazards from limited traversability (steps, slippage, etc)
- Conditions causing sensor errors (e.g. strong sunlight)

Hazards from User Interaction, Ergonomics

- Over-complicated operating instructions
- Wrong design or location of indicators and visual displays units
- Mental/cognitive overload of the user (wrong input, wrong interpretation of situation)
- Limited visibility (especially regarding remote-control)
- Change of control mode
- Handing over a wrong (hazardous) object
- Overload during object manipulation
- Allergenicity/irritancy

Hazards due to Emissions

- Sound (including ultra-sound)
- Light (including IR, laser)

Vibrations
Electro-magnetic noise

Hazards caused by Malfunction of Control System

Unintended movement
Wrong decision making
Loss of communication (especially regarding mobile controls)
Wrong data transmission
Wrong sensor reading and/or interpretation
Over-speed, runaway

Relevant functions, actions and components of the SRS robot are as follows (adapted from deliverable D1.3 “SRS Initial Knowledge-base and SRS hardware, software communication, and intelligence specification” and deliverable D2.2 “Conceptual HRI Design, Usability Testing, HRI Interaction Patterns, and HRI Principles for Remotely Controlled Service Robots”):

Functions/Actions

Selection and starting service
Get sub-task list from knowledge base
Switch to remote operator
Alter sub-task list from remote interface
Show platform position and sensor data in UI_PRI
Show platform position and sensor data in UI_PRO
Show manipulator arm position and sensor data in UI_PRI
Show manipulator arm position and sensor data in UI_PRO
Plan trajectory for mobile base
Move mobile base in automatic mode
Move mobile base in RC mode – sensor-based (=semi-autonomous)
Move mobile base in RC mode – without sensor support
Detect obstacle for mobile base
Self-localization of mobile platform
Manual update of localization of mobile platform via UI_PRO
Build 3D map of environment
Update 3D map of environment
Plan trajectory for manipulator arm
Move manipulator arm in automatic mode
Fold manipulator arm in automatic mode
Unfold manipulator arm in automatic mode
Move manipulator arm in RC mode – sensor-based (=semi-autonomous)
Move manipulator arm in RC mode – without sensor support
Open gripper
Close gripper

Locate object
Object recognition
Select target object
Teach new object
Calculate grasp configuration
Over-rule grasp configuration via UI_PRO
Move tray to up position
Move tray to folded position

Key components

UI_LOC
UI_PRI
UI_PRO – screen
UI_PRO – input device for RC movement mobile base
UI_PRO – input device for RC movement manipulator arm
Mobile base
Robot base structure
Manipulator arm
Gripper
Foldable tray
Sensor head
Sensor obstacle detection mobile base
SRS Decision Making
SRS Object Database

As described in deliverable D2.3 a FMEA process is finalizing the safety analysis. For each identified combination of hazard and function/component, a list of failure causes is being identified and analyzed regarding its “Severity” and “Probability”. The “Risk Priority Number” (=RPN) is then calculated by: *Risk = Severity x Probability*.
For all “critical” failures – i.e. failures with RPN higher than a pre-defined threshold and/or high number for “Severity” (for concrete numbers see below) – appropriate counter-measures (“mitigation measures”) are being identified and described.

A "single fault philosophy" is being used in the risk analysis process. It means that within a limited period of time only single points of failure are considered. This first failure shall not lead to a hazard. If it is not a hazard and not detected (i.e. a “passive failure”), an additional failure has to be assumed after a certain time has elapsed. Also this second failure shall not lead to a hazard. Three independent failures are usually not assumed during the life time of a medical device. The time after which an independent second failure has to be assumed depends on the type of device and is sometimes defined by a standard. For SRS, this time is defined as “one complete use cycle” (e.g. one complete fetch&carry task).

The following categories for “Severity” and “Probability” are defined for SRS:

For each applicable hazard the severity is being estimated in cooperation with representatives of the user groups. The severity is being assigned in a semi-quantitative way by means of categories. The following four severity levels are defined:

Severity	**Value**	**Effect on User**
Negligible	1	little or no potential of injury
Marginal	2	potential of injury
Critical	3	potential of serious injury
Catastrophic	4	potential of death

For each of the identified failures the probability of occurrence is being estimated as well. The following sources of information usually can be used:

-- experience with similar products,
-- agreed rules of technology,
-- life tests,
-- the best engineering guess of the risk analysis team.

The result of the probability estimation is being assigned as semi-quantitative categories. The following five categories are defined:

Category	**Value**	**Frequency**
Improbable	1	May occur once in the life time of the system
Remote	2	May occur once in 100 service cycles
Occasional	3	May occur once in 10 service cycles
Probable	4	May occur once in a service cycle
Frequent	5	May occur several times in a service cycle

(REMARK: “service cycle” is one full set of actions for one robot service, e.g. one fetch&carry task)

Risks are considered as “critical risks” if the **RPN is higher than 6** and/or if the **“Severity” is higher than 3**. This finally leads to the following “Risk Management Table”:

Severity (Se)	**Probability (Pr)**	**Risk**

1 = Negligible	1 = Improbable
2 = Marginal	2 = Remote
3 = Critical	3 = Occasional
4 = Catastrophic	4 = Probable
	5 = Frequent

P\S	1	2	3	4
5	ALARP	NAC	NAC	NAC
4	ALARP	NAC	NAC	NAC
3	AC	ALARP	NAC	NAC
2	AC	AC	ALARP	NAC
1	AC	AC	ALARP	NAC

(REMARK: “AC” = acceptable, “NAC” = not acceptable, ALARP = As Low As Reasonably Practicable)

The FMEA for the SRS system is work-in-progress -- documentation of the completed matrix will be included in deliverable D4.1.2 (PrM 36).

8.2. IMPLICATION FOR USER REQUIREMENTS

The UI-PRO has been iteratively improved in the SRS project based on the user acceptance and usability study. Improvement related to remote control interface, aesthetics and grasping and bringing performance is be based on the recommendations specified in SRS D6.2. With the modification, the final SRS trials showed that the user acceptance of the interaction with the robotic arm is medium to high.

9. ETHNOGRAPHIC APPROACH USER REQUIREMENTS’ PRIORIZATION

9.1. USER REQUIREMENT PRIORITIZATION METHODS

Prioritization procedures should be developed aiming to cover the most relevant targets of the research projects, due to the usual project constraints in money and time regarding research and development. A comprehensive analysis should take place after the tests phase. Just presenting results could be unbearable to the reader due to the huge amount of data that an in-deep study can generate. Especially, when several gathering information procedures have been developed to cover most part of the interaction events between the users and the systems/or by confronting them to the concept.

In this scenario, establishing the inferred acceptability of the system based on the requirements needs should be organized in hierarchy for a better understanding. In this case we will assign grade levels to the requirements stated by the target users, instead of doing so for the usability lacks. The following criteria for prioritizing the results could be adapted from Dumas and Redish (1994) of usability prioritization.

High

- The finding is extreme. If it is not accomplished the product will fail.
- Frequent and re-occurring.
- It is broad and will have interdependences with other requirements.

Medium

- The finding will be difficult for some participants.
- Not to cope with this finding can cause frustration or confusion in the majority of the users.
- The requirement might affect other tasks.

Low

- A few participants might experience frustration and confusion.
- It is isolated.

Since it is difficult to balance the importance of even a single item of the scale (representing a possible user requirement) due to the different outcomes that every item could bring: frequency of the answer by the users (the number of users stating the same scale answer), intensity in terms of preference (A little, much) or temporal frequency (never, sometimes, always...). To this end, in every case, the same criteria to establish a requirements prioritization have been applied: transforming frequency and intensity in its different output values into an easy to understand 3 level priority scale. High, Medium and Low would make possible for us to catch easily the otherwise difficult to understand great amounts of data. This would lead us to a manageable results structure that makes us possible to choose and evaluate every single requirement.

To a comprehensive prioritization procedure:

1. Data internal matrix.

Once you have collected all the users data in a spreadsheet, the second step is to analyze the data extracting descriptive information of the sample. In this way we can obtain a picture of what are the users stating about their needs and desires. These users' requirements will become the requirements of the system.

2. Graphs, tables and visual observation.

From the previously gathered and organized data, visual support will be given to the numeric results (i.e. Figure 1).

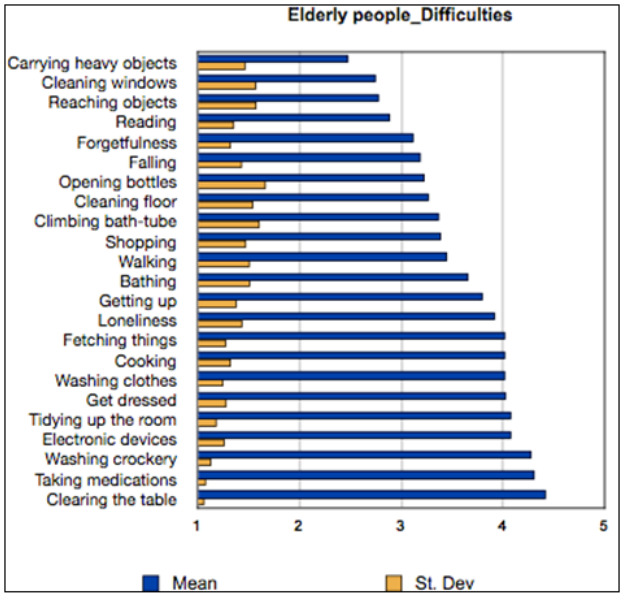


FIGURE 5. EXAMPLE OF GRAPH FROM THE USER REQUIREMENT STUDY

This information while valuable for his raw informative potential can be not enough informative if lacks a criterion to choose the limits of the data. These lacks could be within the same construct: (i.e. “What are the most important Elderly people difficulties?” or “Where we can establish a threshold between the important and the nice to have issues”) or between the whole information gathered in in-deep quantitative studies (i.e what is more important? users’ stated requirements, caregivers’ stated requirements, agreement about control remote or inferred help the system could bring?).

To address these issues, a first prioritization needs to be done in terms of the criteria evaluation of the user needs (impact and number). Impact refers to the subjective judgment about consequences of the requirement and the event frequency, whereas number refers to the frequency of users that address the requirement. The outcome transformation of the user needs in high, medium or low impact came from the establishment of a threshold in the frequency of the answers.

1. High: More than 60% of the users stated the need / the mean reported is pointing to a more than average difficult.
2. Medium: Between 40% and 60% of the users stated the need/ the mean reported is average difficult.
3. Low: Less than 40% of the users stated the need /the mean reported points to a little difficulty on the item, but a difficulty on carrying an activity.

The criteria chosen based in percentages is related to the aimed statistic validity of the user statements within the sample. The criteria can be changed to address the importance of different statements. For example we could want to define what could be the most important requirement that is stated by 100% of the sample, but probably this highly specific percentage

can bring us one obvious statement (100% of the sample with hip fracture stated that they have problems with the hips and legs movement) or even not any statement because the sample is still heterogeneous in their responses, specially when the sample is broad. The criteria should be defined and specified by the researchers based on the scope of the research.

Depending on the item and its score format, the output can be very different, and thus the prioritization model should be adapted to this output in order to generate comprehensive knowledge about the data.

Direct estimation methods (Likert scales, Visual analogic scales or semantic differentials) on one hand and on the other hand, quantitative estimation scales (Guttman and Thurstone scales) have different response ways meaning that the numeric adscription to the concepts developed in the scale should be different.

In SRS the previous scales and questionnaires have been used, including semantic differential scales. The Likert format of answer implies that the score went from 1 (I can do this on my own without any difficulty) to 5 (I have substantial difficulties with this). Results of Section A were normalized in order to align them with B and C: 1 is the maximum difficulty and 5 is the minimum value of the scale. This could lead us to the following transformation based on the % from 1 (80%+ difficulty) to 5 (0% difficulty). In this case it was considered as High priority level mean 2 or less, then Medium priority between 3 and 2, a Low priority more than 3. The across country prioritization was done following this requirement overestimating criteria. If a country consider the requirement as mandatory, the whole value of the requirement was mandatory.

According to all these criteria, the following priorities were included in D1.1b:

- Four difficulties emerge as medium priority according to the impact criteria: carrying heavy objects, cleaning windows, reaching objects and reading. According to the transformation criteria, four difficulties emerge as high priority (getting up, walking, climbing bathtub, opening bottles) and two as medium priority (cleaning floor and reading).
- Use of the robot prioritization according to the impact criteria point to high priority uses (getting up, tidying up the room, washing clothes, get dressed and taking medications) and one medium priority use (loneliness).
- Use of the remote control prioritization according to the impact criteria points to one use with high priority (falling) and eleven uses with medium priority (reaching objects, reading, getting things, shopping, carrying heavy objects, cleaning windows, taking medications, electronic devices, cleaning the floor, washing clothes, getting up).
- Use of the remote control prioritization according to the impact criteria point to high priority requirements (a closer controller when possible, feedback about the actions of the system, and authorization to take the control of the machine) and medium priority use (such as the preference for a professional operator instead a not professional).

9.2. NEW PRIORITIZATION BASED IN COMPLETE ANALYSIS

In order to go in this topic in deep and complete results published in D1.1a, in this deliverable the prioritization about ethnographic information collected is included in this section, and prioritization with data from user trials are going to be included in the Final Report.

The following categories were used to comprise the user requirements in the qualitative ethnographic approach/concept validation study. Data will be categorized under labels in order to make us able to prioritize the users' requirements and needs regarding the use of the robot.

Participant description and Social Context: In this category, age was reported and also social support related to the activities of daily living.

1. Mean age.
2. Living alone, poor social support (colour scheme: light red): In the case the participant don't receive social support or with the ADL from the family, caregivers or domestic workers.
3. Living alone, good social support (colour scheme: light blue): In the case the participant does not receive support from the family on a daily basis.
4. Living together, poor social support: A couple living together without family or professional help. (*In our sample, no couple with poor social support participated*).
5. Living together, High social support (colour scheme: light green): A couple with family or professional support.

Health conditions: Depending on a subjective evaluation of their capabilities related to motor impairment, regardless other personal impairments that even being important (fear to falls, anxiety, pain) are not preventing the participants to perform activities of daily living.

1. Severe motor impairment (colour scheme: light red): People have pain, broken bones, gait instability or any other motor circumstances that prevent people to carry out housekeeping and activities of daily living without help from third parties.
2. Moderate impairment (colour scheme: yellow): Having problems, pain or health circumstances that make the activities of daily living performance difficult but still being able to do it.

Environmental description:

1. Messy and with narrow spaces (colour scheme: light red): Lots of furniture and carpets, not having adaptations yet or planned.
2. Partially adapted (colour scheme: yellow): With minimal non structural adaptations such as having carpets or furniture removed, or having installed handles or other devices but still having narrow corridors, lots of furniture or narrow spaces.
3. Adapted (colour scheme: light green): Handles or other devices installed that implies moderate structural modifications in a way that allow the participant to keep on with their daily routine, such as handles installed or bathtub removed, non slipping floor, etc.

Difficulties of daily living:

1. Moderate difficulties (colour scheme: yellow): Pain, weakness and tiredness that make difficult for the person to keep on with their daily activities.

2. Severe difficulties (colour scheme: light red): Motor impaired capabilities that prevent the person to perform their activities of daily living, making them dependent of the other peoples' help.

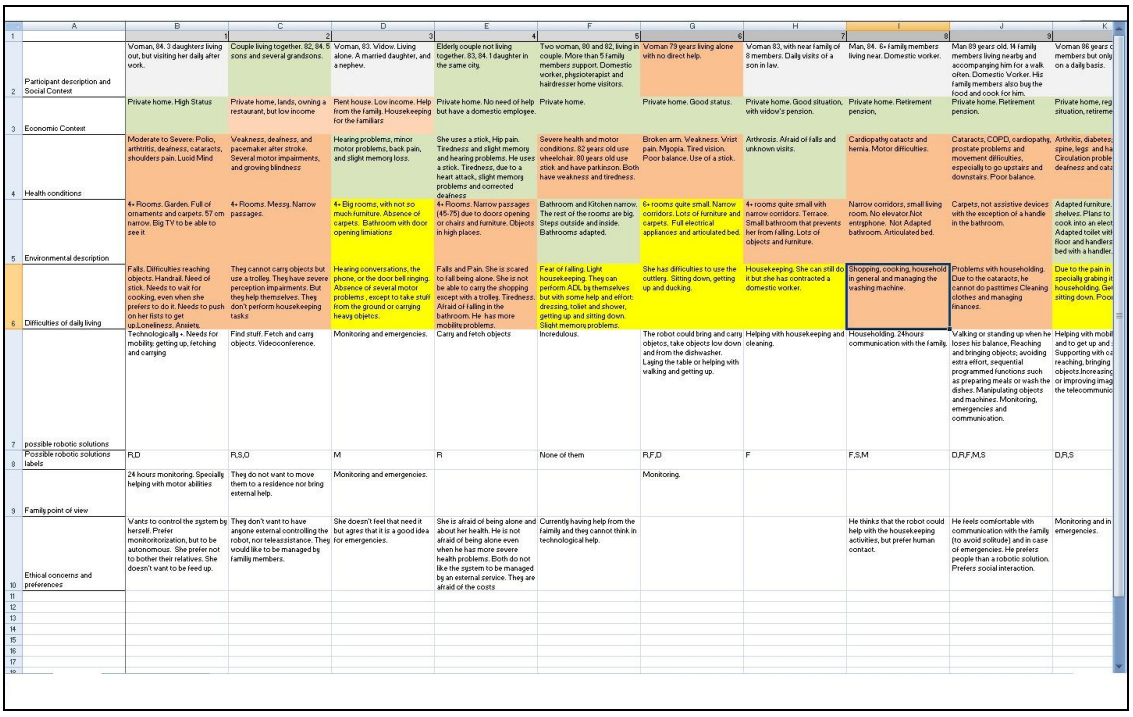
Users desired possible robotic solutions:

1. Rough tasks (R): Such as reach, carry and bring objects to the users.
2. Fine sequential tasks (F): Probably not yet available tasks, such as: cooking, supporting with hanging the laundry, washing dishes, general householding.
3. Direct help tasks (D): Tasks not already allowed due to the risks, such as: helping getting up, sitting down, walking support, etc.
4. Monitorization and emergency (M): Passive tasks related to
5. Social interaction and communications (S): Telecommunications functionalities which make the user more able to interact with their families and healthcare systems due to the increased usable features: Big screens, adapted and usable interfaces, better sound and image quality, avatars, etc.

Ethical concerns and preferences: The users' particular opinion about possible ethical risks such as violation of privacy, independency, autonomy, confidentiality, confidence in the system, and preferences in general.

The family point of view was assessed in general and was not possible through all the interviews, so we just will point out the most relevant information obtained in the ethnographic phase.

The interviews performed and reported in the corresponding Internal Document were organized in tables according to the categories established above (see Appendix). The previously stated color scheme labeling was applied to the tables letting us observe easily and quickly what were the most relevant and frequently stated and observed characteristics of the users and of the envisaged uses of the robot (see Figure).



		1	2	3	4	5	6	7	8	9	
2	Participant description and Social Context	Woman, 84. 3 daughters living out, but visiting her daily after work.	Couple living together. 82, 84. 5 sons and several grandsons.	Woman, 83. Widow. Living alone. A married daughter, and a nephew.	Elderly couple not living together. 83, 84. 1 daughter in the same city.	Two woman, 80 and 82, living in couple. More than 5 family members support. Domestic worker, physioterapist and hairdresser home visitors.	Woman 79 years living alone with no direct help.	Woman 83, with near family of 8 members. Daily visits of a son in law.	Man, 84. 6+ family members living near. Domestic worker.	Man 89 years old. 14 family members living nearby and accompanying him for a walk often. Domestic Worker. His family members also buy the food and cook for him.	Woman 86 years c members but only on a daily basis.
3	Economic Context	Private home. High Status	Private home, lands, owning a restaurant, but low income	Rent house. Low income. Help from the family. Housekeeping for the familiarz	Private home. No need of help but have a domestic employee.	Private home.	Private home. Good status.	Private home. Good situation, with widow's pension.	Private home. Retirement pension,	Private home. Retirement pension.	Private home, reg situation, retireme
4	Health conditions	Moderate to Severe: Polio, arthritis, deafness, cataracts, shoulders pain. Lucid Mind	Weakness, deafness, and pacemaker after stroke. Several motor impairments, and growing blindness	Hearing problems, minor motor problems, back pain, and slight memory loss.	She uses a stick, Hip pain. Tiredness and slight memory and hearing problems. He uses a stick. Tiredness, due to a heart attack, slight memory problems and corrected deafness	Severe health and motor conditions. 82 years old use wheelchair. 80 years old use stick and have parkinzon. Both have weakness and tiredness.	Broken arm. Weakness. Wrist pain. Myopia. Tired vision. Poor balance. Use of a stick.	Arthrosis. Afraid of falls and unknown visits.	Cardiopatiy catacts and hernia. Motor difficulties.	Cataracts, COPD, cardiopathy, prostate problems and movement difficulties, especially to go upstairs and downstairs. Poor balance.	Arthritis, diabetes, spine, legs' and ha Circulation proble deafness and cata
5	Environmental description	4+ Rooms. Garden. Full of ornaments and carpets. 57 cm narrow. Big TV to be able to see it	4+ Rooms. Messy. Narrow passages.	4+ Big rooms, with not so much furniture. Absence of carpets. Bathroom with door opening limitations	4+ Rooms. Narrow passages (45-75) due to doors opening or chairs and furniture. Objects in high places.	Bathroom and Kitchen narrow. The rest of the rooms are big. Steps outside and inside. Bathrooms adapted.	6+ rooms quite small. Narrow corridors. Lots of furniture and carpets. Full electrical appliances and articulated bed.	4+ rooms quite small with narrow corridors. Terrace. Small bathroom that prevents her from falling. Lots of objects and furniture.	Narrow corridors, small living room. No elevator. Not entryphone. Not Adapted bathroom. Articulated bed.	Carpets, not assistive devices with the exception of a handle in the bathroom.	Adapted furniture, shelves. Plans to cook into an elect Adapted toilet with floor and handlers bed with a handler.
6	Difficulties of daily living	Falls. Difficulties reaching objects. Handrail. Need of stick. Needs to wait for cooking, even when she prefers to do it. Needs to push on her fists to get up.Loneliness. Anxiety.	They cannot carry objects but use a trolley. They have severe perception impairments. But they help themselves. They don't perform housekeeping tasks	Hearing conversations, the phone, or the door bell ringing. Absence of several motor problems , except to take stuff from the ground or carrying heavy objects.	Falls and Pain. She is scared to fall being alone. She is not be able to carry the shopping except with a trolley. Tiredness. Afraid of falling in the bathroom. He has more mobility problems.	Fear of falling. Light housekeeping. They can perform ADL by themselves but with some help and effort: dressing, toilet and shower, getting up and sitting down. Slight memory problems.	She has difficulties to use the cutlery. Sitting down, getting up and ducking.	Housekeeping. She can still do it but she has contracted a domestic worker.	Shopping, cooking, household in general and managing the washing machine.	Problems with householding. Due to the cataracts, he cannot do pasttimes Cleaning clothes and managing finances.	Due to the pain in specially grabing it householding. Get sitting down. Poor
7	possible robotic solutions	Technologically + Needs for mobility: getting up, fetching and carrying	Find stuff. Fetch and carry objects. Videoconference.	Monitoring and emergencies.	Carry and fetch objects	Incredulous.	The robot could bring and carry objects, take objects low down and from the dishwasher. Laying the table or helping with walking and getting up.	Helping with housekeeping and cleaning.	Householding. 24hours communication with the family.	Walking or standing up when he loses his balance, Reaching and bringing objects; avoiding extra effort, sequential programmed functions such as preparing meals or wash the dishes. Manipulating objects and machines. Monitoring, emergencies and communication.	Helping with mobil and to get up and Supporting with ca reaching, bringing objects Increasing or improving imag the telecommunic
8	Possible robotic solutions labels	R,D	R,S,O	M	R	None of them	R,F,D	F	F,S,M	D,R,F,M,S	D,R,S
9	Family point of view	24 hours monitoring. Specially helping with motor abilities	They do not want to move them to a residence nor bring external help.	Monitoring and emergencies.			Monitoring.				
10	Ethical concerns and preferences	Wants to control the system by herself. Prefer monitorionization, but to be autonomous. She prefer not to bother their relatives. She doesn't want to be feed up.	They don't want to have anyone external controlling the robot, nor release assistance. They would like to be managed by family members.	She doesn't feel that need it but agree that it is a good idea for emergencies.	She is afraid of being alone and about her health. He is not afraid of being alone even when he has more severe health problems. Both do not like the system to be managed by an external service. They are afraid of the costs	Currently having help from the family and they cannot think in technological help.			He thinks that the robot could help with the housekeeping activities, but prefer human contact.	He feels comfortable with communication with the family (to avoid solitude) and in case of emergencies. He prefers people than a robotic solution. Prefers social interaction.	Monitoring and in emergencies.
11											
12											
13											
14											
15											
16											
17											

FIGURE 6. EXAMPLE OF TABLES WITH ETNOGRAPHIC INFORMATION WITH COLOR SCHEME LABELING

According to the table the most relevant information is:

Participant description and Social Context: The participants were 84.7 years old of average. 60% of the people in the sample were living alone with good social support, meanwhile just 20% were living alone with poor social support. 20% of the sample was living in couple also with good social support. We should take into account that even when most part of the sample that are living alone has good social support, the group that lives alone with no social support is the one which needs more the technological system support.

Health conditions: 80% of the sample has severe motor impairment: developing pain related to arthrosis, broken bones, gait instability or any other motor circumstances that prevent them to carry out housekeeping and activities of daily living without help from third parties. The most relevant and frequent characteristic were motor impairment, pain, weakness, tiredness and gait instability. Apart from the deafness and visual perception impairment, the difficulties experienced by these people lead them to dependence or force them to neglect housekeeping or even their own health related aspects (such as feeding, hygiene, etc.).

Environmental description: Near to 53% of the visited houses were unadapted full of furniture and/or with carpets neither removal intentions. Most of them have narrow corridors or spaces were the envisaged robot could not perform movements. There were little adaptations at home in most of the cases, and in few cases there were handles installed in the bathroom to avoid falls. Just 2 out of 15 users had the home adapted to their needs. These cases also had important social support.

Difficulties of daily living: Near to 53% of the users have severe difficulties to perform the activities of daily living. 7 out of 8 participants that had severe difficulties were also categorized in the severe motor impairment category the remaining one was a male impaired to do their activities of daily living due to prevention of heart attack, pain and not being familiarized to the housekeeping tasks. 46% of the participants had difficulties to carry out the daily activities tasks due to pain, gait instability, or moderate motor

Users desired possible robotic solutions: The most required solution was support to rough tasks (73%) followed by: fine sequential tasks (53%), social interaction and communications (46%), monitoring and emergencies (46%) and direct help tasks (40%). Participants not only stated this helps separately but they prefer support in packs. i.e.: 4 participants stated that they prefer to have all the robot functionalities support (D,R,F,M,S) and 5 participants stated that they would want support in rough tasks, fine sequential tasks and monitoring (R,F,M).

Ethical concerns and preferences: The main concern about the robot help was that people prefer human beings that robot and they do not like robots to substitute human contact: “a robot will never be like a person who you can touch or talk to”. Others do not want other people to remotely control the robot and would prefer to control it themselves. Others think that having a robot at home would be difficult to accept or prefer to keep on their personal stuff even when it is more complicated for them to perform their daily living activities.

The family point of view. The main help asked by the family members was monitoring and emergencies.

In the light of these results, a first prioritization of the requirements, desires and needs, and the envisaged robotic solutions could be based in the frequency for two different profiles: people living alone with good social support and people living alone with low social support, but taking into account that 80% of the sample has severe motor impairment.

High importance:

- Give direct support to people that have severe motor impairment and low social support.
- The most relevant health characteristics that make the people need technologic support are: motor impairment, reaching the things, not being able to walk, getting up and sitting down.
- Take into account that people do not have broad spaces at home and they do not want to have the furniture and carpets removed.
- Users want support in rough tasks (carrying things, reaching and bringing things) and fine sequential tasks (cooking, cleaning, housekeeping).
- People prefer human contact than robotic contact.
- People prefer not having an external staff taking controlling the robot.

Medium importance:

- Give support to people that have moderate motor impairment.
- Give support to people that have severe motor impairment but also have good social support.

- Give support with augmented communication to people with perceptual impairment.
- Users need support in social interaction and communications, monitorization and emergencies and direct help tasks.

9.3. CASE STUDY ANALYSIS

The main objectives of this case study were:

- To properly describe the environment were elderly people lives, focusing on were relevant objects are placed.
- To complete information about activities of daily living in context, especially those related with fetching and bringing things.

This research is focused on object manipulation in real context and aims to support fetch and bring scenario by collecting information about objects relevant for daily life activities and about where these objects are placed. The study is based on observation in the home of the frail older adults and on a non-structured interview. Complementary research methods (Picture-taking home visit, daily-life capture task) are also used. The procedure was as follows:

1. Project presentation (description)
2. Informed consent
3. Personal information + Frailty (Barber test)
4. Picture-taking home visit: In the picture-taking home visit, the researcher and the elderly person walked through the house and the researcher takes picture of anything considered worthwhile to capture, with objects placed inside the home and that could be moved because of daily life activities of the frail older adult.
5. Semi-structured interview.

The possible questions for the interview were:

1. How many rooms does your house have?
2. Which kind of facilities are there (handless, seat for the bathtub…)?
3. What are the most important considerations for living alone/at home for you?
4. What does wellbeing mean to you?
5. Could you describe a typical daily routine to me? (Beginning with waking up in the morning, going to the bathroom, preparing your breakfast…)
6. Do you have any activity rituals during the day/week? (A ritual is considered to be an activity that you look forward to, that you enjoy)
7. What are your most favourite activities during the day?
8. Which activities cause the most difficulties during your daily routine?
9. Are you (still) doing all housekeeping activities by yourself? (Which not and why…)
10. What are you doing when you cannot cope with a situation at home? (Do you seek for help, tray to do them by yourself,…)?
11. Are there any situations during your daily procedure which are frightening you?

12. Can you think of situations where you'd appreciate assistance/help?
13. Are there any activities for which you need the help of your caregiver? (if so, which)

Three women of 63, 60, 67 years old with a frailty status took part in the study at their homes.

9.3.1. CASE 1: WOMAN IN CITY ENVIRONMENT

TABLE 4 - 1ST PARTICIPANT DESCRIPTION

Participant description	Woman, 67 years old. Problems in the knee that prevents her to walking without the support of a walking crane.
Environment description	She lives alone at a home financially supported by the social services due to her health status and income. She has support by the social services. Has home assistance 1 hour a week. (Note: at the last moment, the participant contacted us to state that due to legal reasons related to the social services support to the home, she was not able to let the pictures to be published. Thus the information will be just published in text).
Qualitative questions	
Regarding wellbeing	"To live independently, meanwhile I can make do by myself"
Activity	Her favourite activity is to paint, got to the gym and o out with her friends.
Difficulties during the day	She does the housework almost with problems and if she has any problem. She would contact her neighbours or family. She is afraid of using stairs or ladders if she is alone.
Objects that could be manipulated by SRS	Mobile phone, remote control, doors (to be opened), clothes, a blanket, a cushion, magazines and books. Not to be manipulated by the robot would be dishes and glasses or slippery items. "the objects should be placed in the same place"

A normal day in her life

TABLE 5 - 1ST PARTICIPANT AGENDA

8:00	She gets up.
9:00	Breakfast and morning hygiene.
9:30	Houseworks and cooking.
11:00	She gets out: • goes groceries. • goes to the library. • goes walking. • she performs the daily and office tasks.
13:00	Comes back home.
14:00	Has lunch.
15:00	• sews • reads • paints • irons • swipes
18:00	She gets out for a walk with her daughter.
21:00	Has dinner
22:00	she reads and watches TV until she goes to bed.

Regarding the system:

- She disagrees about purchasing or using the system not considering usable for her.

Furniture configuration.

- The home is minimalistic and very oriented to be useful and pragmatic.
- There are not many ornaments.
- She has a shelf with a dozen of books, which is accessible.
- The cutlery is accessible and she only uses the minimum necessary.
- The food is organized easily.
- The wardrobe is organized and not very broad.

9.3.2. CASE 2: WOMAN IN CITY ENVIRONMENT

TABLE 6 - 2ND PARTICIPANT DESCRIPTION

Participant description	Woman, 63 years old. Housewife. Diagnosed of osteoporosis six years ago with a bone loss of 25%. Light impairment in arms with pain

	associated.
Environment description	City environment. New built home but with no adaptations. She lives with her son.
Qualitative questions	
Regarding wellbeing	Wellbeing is related with the health of the family and to have money enough to be good and not to be worried for the future.
Activity	She likes to sew, to rest and to be with her grandson.
Difficulties during the day	Housekeeping: to clean and to cook, specially. To go shopping she uses a cart so she does not need to make sever effort carrying heavy stuff.
Objects that could be manipulated by SRS	The bags of the shopping: Milk bricks and beverages packs, potatoes sacks… hang the curtains and clean de windows.

A normal day in her life

TABLE 7 - 2ND PARTICIPANT AGENDA

9:00	Goes to her daughter home to take care of her grandson.
9:30	Takes the grandson to the school.
10:00	Goes to the groceries.
11:00	Comes back home and starts housekeeping tasks.
12:00	
13:00	
14:00	Cooks.
15:00	Eats and watch TV.
16:00	Goes to have a nap.
17:00	Gets up and has a coffee while watches TV.
18:00	Goes to have a snack with her family and finalizes shopping.
19:00	Comes back home and sews while watches TV.
20:00	Prepares dinner.

21:00	Dinning with her son.
22:00-24:00	She watches TV until she goes to sleep

Regarding the system:

- She would not use nor buy this system when it becomes available. “I hope not to have to use it because it’s very big and fearsome. Anyway it will not fit in the house.”
- She would not use the system, “Probably it becomes better with time, still is too big”.

Furniture configuration.

- The kitchen is very narrow and there is not space enough for two people to go along it.
- The cupboards are a little bit high for her and sometimes have to use a little stepladder to reach some of the dishes and food pantry.
- The rest of the cookware and cutlery are easily reachable in handy drawers.
- Food is organized in the cupboard and fridge, but not in the cupboard, where food is overloaded and unreachable in the upper ladders.
- The most used stuff and kind of food are placed in reachable places.
- The shelves with books and personal stuff are overloaded and covered with family pictures, making them not very accessible.

FIGURE 7. BOOK SHELVES IN THE LIVING ROOM

FIGURE 8 - KITCHEN FURNITURE AND DISHES

9.3.3. CASE 3: WOMAN IN RURAL ENVIRONMENT

TABLE 8 - 3RD PARTICIPANT DESCRIPTION

Participant description	A 60 years old woman from country environment. She has osteoporosis principle, with pain in the arms, neck, shoulders and the back. She lives with her husband, and one child of 35, but two other children come to have dinner at night. She did not end the primary studies and started working very young.
Environment description	Rural environment. Rural home with 6 rooms on the upper floor, 4 rooms in the lower floor and two courtyards. Recently they have adapted the upper floor and have an adapted toilet. Even when the rooms are spacious, corridors and spaces are narrow due to the furniture.
Qualitative questions	
Regarding wellbeing	Wellbeing is having good health, over everything the family is well in every aspect, health but also economically. Not to be overburden.
Activity	With the exception of the housekeeping, she does not have any activity that enjoys particularly. Her favourite activity is to be with the grandchildren “when they are good”.
Difficulties during the day	Pain while doing the tasks, and tiredness. but she do not consider any task to be frightening. If there is an activity that gives her problems (such as

	painting the walls), she leaves it to her husband.
Objects that could be manipulated by SRS	"The system should clean, so: dishes, glasses... but specially it should clean and vacuum

A normal day in her life

TABLE 9 - 3RD PARTICIPANT AGENDA

9:00	She got up at 9:00, does the hygiene.
9:30	has breakfast
10:00	Starts with housework, tidyng the room, making the beds.
11:00	Housework.
12:00	Goes shopping
13:00	Starts cooking
14:00	Eating
15:00	Starts to cook again for her older son
16:00	Cleans up the kitchen
17:00	The nephews come from school, and she sits down to watch TV
18:00	She gives the afternoon snack to their nephews.
18:30	The daughter comes home to take their children.
19:00	She starts to cook dinner
20:00	If she have some spare moment, she sits down and watch TV
21:00	She has dinner with their children, once at time when we came back from work.
24:00	She rests while watch TV and then goes to sleep.

Regarding the system:

- She would not use nor buy this system when it becomes available. "If I had money I would have a maid".
- She would not use the system, "to have more stuff at home that I am not using. I would use it If I was alone and at bed".

Furniture configuration.

- The kitchen used to be very organized with not so much stuff over the place in order to make cooking accessible and easy.
- The cupboards are at good height not being difficult to reach the most used things, however, the upper shelf is not as accessible as the lower one. Glasses are easier to reach than dishes that are piled.
- The rest of the cookware and cutlery are easily reachable in handy drawers.
- Food is organized in the cupboard and fridge, but not easily reachable. Having to take out some things in order to access others.
- The shelves with books and personal stuff are overloaded and covered with family pictures.
- The toilet has been adapted and is accessible.

FIGURE 9 - KITCHEN

FIGURE 10 - CUPBOARD, SHELVE IN THE LIVING ROOM AND ADAPTED BATHROOM

9.3.4. CONCLUSIONS:

The three woman were in state of frailty but not impaired. They live independently at home with some difficulties related to some tasks, tiredness or pain. They do not feel that they need to use the system at least at the moment of the tests, and even when they do not dismiss to use a system such as SRS in the future, they understand that the system, to be usable, should be smaller, nicer and faster. In this case, we can observe that they wanted to make do by themselves while they can, so the system is not desirable at this moment. Probably the system could be better accepted if they would have a higher degree of impairment or if the functionalities were related to housework. They would also use the system if it would support the housework tasks such as cleaning and carrying heavy bags. The objects the users would like to be manipulated with the system would be objects that cannot be broken such as: books and cleaning objects: cloths, dish towels or sponges to clean the floor and surfaces. Any system developed with the aim of helping people with motor impairment or frailty should take into account that the houses are not naturally prepared for big systems, the furniture is organized for the fine manipulation of the human hand, and it would be difficult to access to books, dishes, glasses, food, etc. without adapting the placement for the robot to access it.

10. METHODOLOGY FOR GATHERING AND PRIORITIZING REQUIREMENTS

Several studies have been carried out through the project following different methodologies depending on the kind of information aimed to be gathered and the analysis level. All the studies can be framed into the more comprehensive User Centred Design methodology. Regarding the user requirements, several iterations have been carried out to gather the relevant information needed by the technical developers to design the most adapted system for the user: quantitative information has been gathered by the use of ad hoc developed

questionnaires; qualitative information was gathered by means of an ethnographic approach and finally both quantitative and qualitative information was gathered from the different field trials carried out with the prototypes when they were functionally ready to be tested by the users.

The following steps have been carried out through the project to achieve the final requirements list:

1. Literature analysis
2. Focus groups (elderly people, family caregivers, professional caregivers and health professionals).
3. Individual interviews.
4. Scenario development.
5. First prioritization of requirements.
6. Ethnographic studies.
7. Interface trials (manipulation and visualization trials).
8. Field tests.
9. Second iteration of interface trials and field tests.
10. Case studies
11. Final prioritization of requirements.

Going through these steps in the project, several requirements have been developed. In all the iterations, intermediate requirements prioritization procedures have been carried out for choosing the most important requirements. In the next section a more comprehensive ad hoc procedural model has been developed to elicit/gather/prioritize the user requirements obtained during the SRS project.

10.1. LITERATURE ANALYSIS

From the literature analysis we can find the general requirements based in the changes that older people experience during the different biological, social and psychological processes in ageing. (D1.1. Detailed user requirements, environment definition, general guidelines on ethical concerns and SRS scenario report). These changes could prevent to perform several tasks, thus arising requirements and needs that should be coped.

The older people general requirements gathered are the following and help defining the user objective.

TABLE 10 - OLDER PEOPLE GENERAL DIFFICULTIES AND THEIR ASSOCIATED REQUIREMENTS

Difficulties	Cause	Requirements
Motor domain. As people age, their movement control performance deteriorate [Motl and McAuley, 2010]. Movement	Degenerative Joint Disease Rheumatoid Arthritis	Support with physical tasks that involve motor broad and fine movement: walking, running, going up and downs stairs,

speed and accuracy decrease, and motor strategies approaching tasks change.	Arthrosis Hip Fracture Osteoporosis Parkinson's disease Other similar causes.	instrumental activities of daily living and basic activities. Pain management.
Sensation and Perception		
Seeing Vision difficulties increases with age, and most of them start when individuals are over age 45. Very often, visual factors seem to be associated with difficulties in performing certain daily activities.	Cataract Glaucoma Macular degeneration Presbyopia Other ethiologies or ageing related impairment.	Support with tasks in which vision performance is involved such as: manipulate and use coins, pay bills, use the telephone, and take the medicine correctly [Ishihara et al., 2004]. Support with physical activities related to the motor domain.
Hearing Auditory problems are quite common for people over age 65 and especially in older men [Fisk et al., 2009]. Auditory loss	Tinnitus Presbicusis Chronic sinusitis Ear wax Neurological associated hearing loss	Support with communication in order to keep involved in the information society and social interactions.
Cognition Cognition related changes. one of the main and most frequent complaints in older adults is about age-related changes in cognition	Age normal decline and pathological processes (Parkinson's, Alzheimer's disease, etc.) that include impairment in: Episodic memory Working Memory Language Speed of Processing	Support with the following functions: memory, mental functions of language, recognizing and using signs and symbols, consciousness, intellectual, orientation, energy and drive, organization, sleep functions and engagement.

Social and affective needs Ageing is a process that may bring to a period of multiple losses [Baltes and Mayer, 1999], loneliness [Pratt and Norris, 1994] and decreased abilities. Social losses often come along with changes in cognitive, sensory and motor functioning as those described above.	Cognitive, emotional and physical changes. Mobility changes of the family network	Support to keep the social network.

According with this elaboration we would have the first list of general requirements to point at when developing a ICT project for supporting elderly people. Several of the fields are related, so supporting older people in one field could support a different range of impaired abilities (i.e. supporting hearing impairment could help to improve the social relations).

TABLE 11 - GENERAL REQUIREMENTS CLUSTERS

General requirements (GR)	
GR1	Motor Domain
GR2	Sensation and Perception Ability
GR3	Cognition Domain
GR4	Social Relations

Within the scope of SRS project, the first domain of requirements (GR1, Motor Domain) have been chosen to be studied for developing technological solutions adapted to the users' needs and requests. The main aim in SRS is to give support to older people with motor impairment, thus from now on we will focus in those specific requirements more related to the Motor Domain.

10.1.1. SPECIFIC REQUIREMENTS FOUND IN THE LITERATURE.

Taking into account this broad domains in which the user could experience different kind and range of impairment, specific tasks can be compromised and could be object of support.

In Gerontology and Geriatrics researches are constantly developing scales to assess the ability degree of the person with descriptive, predictive and controlling objectives. Related to the

scope of SRS, the most used scales in the field have been taking into account as a possible requirement elicitators: Activities of Daily Living (ADL) [Katz, 1963] and Instrumental Activities of Daily Living (IADL) [Lawton & Brody, 1969]. There are six basic categories of ADLs: a) hygiene (bathing, grooming, shaving and oral care); b) continence, c) dressing, d) eating (the ability to feed oneself), e) toilet (the ability to use a restroom), f) transferring (actions such as going from a seated to standing position and getting in and out of bed); and IADLs are more nuanced and complex social activities than ADLs and typically include but are not limited to: finding and using resources (looking up phone numbers, using a telephone, arranging and keeping doctor appointments); driving or arranging travel (either by public transportation or private car); preparing meals (opening containers, using kitchen equipment); shopping (getting to stores and purchasing necessities like food or clothing); doing housework (doing laundry, cleaning up spills and maintaining a clean living space); managing medication (taking prescribed dosages at correct times and keeping track of medications); managing finances (basic budgeting, paying bills and writing checks).

According to the requests made by the older users gathered in studies which targeted similar population (analyzed in D1.1. Lex, 2008; Dudgeon et al., 2008), the difficulties most frequently mentioned were related to: heavy housework, walking, shopping, money management, light housework, bathing, toileting, handling practices, accompaniment outside home, companionship and socialization, shopping and preparing meals, economic contribution, housekeeping, transport, personal hygiene, other home services, minor repairs.

So taking into account the main requirements in the literature:

TABLE 12 - REQUIREMENTS OBTAINED FROM THE LITERATURE STUDY

Requirements in the literature (LR)	
BADL (B)	
(LR/B1)	Bathing
(LR/B2)	Grooming
(LR/B3)	Shaving
(LR/B4)	Oral Care
(LR/B5)	Continence
(LR/B6)	Dressing
(LR/B7)	Eating
(LR/B8)	Toilet

(LR/B9)	Transferring
(LR/B10)	Walking
IADL (I)	
(LR/I1)	Using phone
(LR/I2)	Arranging appointments
(LR/I3)	Driving
(LR/I4)	Arranging travel
(LR/I5)	Preparing meals
(LR/I6)	Shopping
(LR/I7)	Heavy housework
(LR/I8)	Light Housework
(LR/I9)	Taking Medication
(LR/I10)	Minor repairs

Cognitive and social specifically related activities have not been taken into account due to getting out of the scope of the project: money management, accompaniment outside home, companionship and socialization.

Once we had established a base with the requirements gathered in the literature and taking into account that our envisaged solution involves a Human Machine Interaction (HMI) solution, specifically a social service robot for supporting people with motor impairment, we need to go deep in the requirements and needs study for specifying the solution. This involves also create scenarios, analyze the foreseen solution acceptance and set up the main concept in collaboration with the final users.

10.2. USER REQUIREMENT ELICITATION: QUALITATIVE AND QUANTITATIVE APPROACHES.

In this section the main social research methods are presented, applied to the study of the SRS requirements. Focus groups, Interviews and questionnaires, scenarios and ethnographic procedures are briefly described, as it has been described more in depth in previous deliverables. The aim of the section is to present the main requirements obtained in each evaluation step.

10.2.1. FOCUS GROUPS

With the goal to provide SRS designers with useful guidelines for further innovation and to ensure the validity of the information gathered, four different groups took part in the focus groups: 1) elderly people, 2) informal caregivers, 3) formal caregivers, 4) health professionals who directly work with elderly adults. The aim of the focus groups was to gather new requirements, prioritize the problems and the solutions, evaluate the scenarios, and envisage the difficulties.

The main findings were clustered in: Activities of Daily Living and Instrumental ADLs, Assistive Technology, Human-robot interaction, and Privacy issues related to the Remote Control function.

In this case, the focus groups bring out requirements based in the privacy management, assistive technology and human robot interaction. Specific situations in which the envisaged solution need to be carefully managed, that is to say: new requirements for the solution development.

The meaning of Robot Features items listed in Table 4 is the following.

- Size: worries concerning the robot size;
- Voice/speech: the robot should have a voice and being able either to speak and understand verbal instructions;
- Control: proposed ways to control the robot;
- Mobility: the robot helping in case of mobility difficulties;
- Preparing meals: the robot helping during the preparation of meals;
- Housekeeping: the robot helping to keep the house clean;
- Cognitive/psychological help: the robot being more a social robot or helping to train memory and cognitive functions;
- Emergency: the robot helping in emergency cases, such as falls;

TABLE 13 - REQUIREMENTS ELABORATION FROM THE FOCUS GROUPS

Requirements in the Focus Groups (FG)	
Robot Features (RF)	
(FG/RF1)	Correct Size
(FG/RF2)	Understandable voice/speech
(FG/RF3)	Control related requirements

(FG/RF4)	Mobility Support
(FG/RF5)	Meals Support
(FG/RF6)	Housekeeping Support
(FG/RF7)	Cog/psychological Support
(FG/RF8)	Emergency/security
Remote Control Features (RC)	
(FG/RC1)	Keep Privacy
(FG/RC2)	Usable user control
(FG/RC3)	Family members control (not increasing the burden)
(FG/RC4)	Usable Physician control

In this case, there are specific requirements that begin to be repeated: mobility support, meals support and housekeeping support. Some of them are the same than some others found in the literature. This will be taken into account further on as an indicator of the importance of the requirement.

10.2.2. INDIVIDUAL INTERVIEWS

In this second stage of the user requirements assessment, our research approach was to combine the gathering of quantitative and qualitative data. Considering the themes elicited through the Focus Groups, an ad hoc questionnaire was developed for data collection. The questionnaire consisted of three main sections measuring a) the most difficult activities to carry out at home for elderly people, b) participant feelings and perception of the robot usability and remote control options and c) perceived advantages/disadvantages and privacy issues related to the use of a remote control function as a distal control mode of the robot. To assess users' experience with technology, the Survey Of Technology Use (SOTU) [Scherer and Craddock, 2002] was employed in the initial section of the questionnaire.

The results obtained and described in the deliverable D1.1 were selected and prioritized in a further version of the same deliverable: D1.1a Detailed user requirements, environment definition, general guidelines on ethical concerns and SRS scenario report. In this document the prioritization procedure based on impact and frequency is established. 36 technical requirements were established and clustered. In the following table some of these requirements have been reassigned to other categories after further analysis.

TABLE 14 - REQUIREMENTS FROM THE INTERVIEWS

Techincal requirements based in the Individual Interviews (II)	
Robot-Environment (RE)	
(II/RE1)	The system should maneuver in narrow spaces
(II/RE2)	The system should recognize the user position
(II/RE3)	The system should recognize different rooms
(II/RE4)	The system should avoid obstacles
ADL Support (AS)	
(II/AS1)	The system should recognize shapes, colours or codes
(II/AS2)	The system should reach objects
(II/AS3)	The system should be able to grasp objects with different shapes
(II/AS4)	The system should be able to handle up to 3kg objects with different shapes
(II/AS5)	The system should carry out heavy objects
(II/AS6)	The system should be able to manage objects with care
Emergency (E)	
(II/E1)	The system should cope with falling or other emergencies
(II/E2)	The system should monitor activities
(II/E3)	The system should alert a remote operator
(II/E4)	The system should support in getting up
Housekeeping (H)	
(II/H1)	The system should storage and display task information
Memory and Activity support (MA)	
(II/M1)	The system should remind tasks to the user
(II/M2)	The system should be able to be programmed to develop tasks during the day by itself
Social Support (SS)	
(II/M1)	The system should allow direct communication between

	user and remote operator
Privacy (P)	
(II/P1)	Only authorized persons should access the remote operator system
(II/P2)	Authentication procedure is required
(II/P3)	Robust security system should be developed to avoid malignant external use
(II/P4)	If the remote operator changes the user must be informed
(II/P5)	The user should be able to allow or not the remote control
(II/P6)	Personal information storage have to be done in safe restricted databases
(II/P7)	Personal information gathering should be restricted to the useful information
(II/P8)	The system should have an on/off system customizable and accessible for the specific user needs
Privacy/Safety (PS)	
(II/PS1)	The user should verify plans of action before the system starts acting.
(II/PS2)	The system should communicate the task performance on real time.
Safety (S)	
(II/S1)	The system should bring objects to the user avoiding contact with potential dangerous parts
(II/S2)	No robot movement should happen without initial confirmation by the user
(II/S3)	There should be a clear indication on the robot side if the robot is in autonomous mode or in remote controlled operation

10.2.3. SCENARIO BASED REQUIREMENTS ELICITATION

On the following table, requirements in the form of possible SRS application scenarios are listed. Information in the table considers the extensive list of scenarios that emerged from the SRS focus groups and were subsequently rated for usefulness in the SRS survey.

TABLE 15 - REQUIREMENTS ESTABLISHED IN THE SCENARIOS

Requirements from the scenarios (RS)	
(RS1)	The system should assist in case of falling
(RS2)	The system should remind of appointments
(RS3)	The Robot should remind to take medication
(RS4)	The Robot should wipe and vacuums floor
(RS5)	Robot reads aloud small letters on food packages, medicine leaflets, books, etc.
(RS6)	Robot opens containers like food cans, bottles
(RS7)	Robot fetches objects difficult to reach (e.g. high on shelf or on the floor)
(RS8)	Robot helps operating electronic devices like TV
(RS9)	Robot cleans windows.
(RS10)	"Purchases": delivery service brings shopped food; robot opens door, accepts, opens box, places purchases on shelf, fridge, etc.
(RS11)	Robot does laundry, hangs, folds, puts away clothes
(RS12)	The robot should fetch and carry
(RS13)	Ths system should allow videoconference
(RS14)	The robot should support get up
(RS15)	Tidy up. The robot should take the objects back to its place
(RS16)	The robot should carry heavy objects
(RS17)	The robot should load and unload the dishwasher
(RS18)	The robot should help to climb bathtub or shower
(RS19)	Robot clears away things on the table
(RS20)	The robot should be able to play board games
(RS21)	The robot should help with bathing
(RS22)	The robot should help with cooking
(RS23)	The robot should help with dressing

(RS24)	The robot should assist with walking
(RS25)	The robot should talk and provide companionship

At this point, the first prioritization of requirements was carried out, previously to the first tests. From now on, the requirements become more technical and more specific.

10.2.4. REQUIREMENTS EXTRACTED FROM THE ETHNOGRAPHIC APPROACH.

The ethnographic study performed to increase the knowledge of the users in their own environment brought qualitative information on these topics: participant description and social context, health conditions, environmental description, difficulties of daily living, user-desired possible robotic solutions, ethical concerns and preferences, the family point of view. Taking into account that the sample was composed by: older people with severe motor impairment: developing pain related to arthrosis, broken bones, gait instability or any other motor circumstances that prevent them to carry out housekeeping and activities of daily living without help from third parties, at the end of this section we summarize the prioritization about ethnographic information collected.

TABLE 16 - REQUIREMENTS FROM THE ETHNOGRAPHIC APPROACH

Requirements from the Ethnographic approach (EA)	
(EA1)	Give direct support to people that have severe motor impairment and low social support
(EA2)	The system should be developed to respect furniture and carpets
(EA3)	The system should give support to rough tasks (carry objects)
(EA4)	The system should give support to sequential tasks (cooking, cleaning and housekeeping)
(EA5)	Taking into account that people prefer human contact, if there is a robot it should be automatic or directly manipulated by the user.
(EA6)	The system should have augmented communication for people with communication diversity

Even when they cannot specifically be identified as requirements, several insights arose from the ethnographic study that could mediate in the requirements expression and priority.

High importance:

- The most relevant health characteristics that make the people need technologic support are: motor impairment, having problems to reach the things, not being able to walk, getting up and sitting down, and not having social support.
- Users want support in rough tasks (carrying things, reaching and bringing things) and fine sequential tasks (cooking, cleaning, and housekeeping).
- People prefer human contact than robotic contact.
- People prefer not having an external staff taking controlling the robot.

Medium importance:

- Give support to people that have moderate motor impairment but also have good social support.
- Give support with augmented communication to people with perceptual impairment.
- Users need support in social interaction and communications, monitorization and emergencies and direct help tasks.

10.2.5. NEW REQUIREMENTS OBTAINED FROM THE FIRST PROTOTYPE TRIALS.

10.2.5.1. Requirements obtained in the manipulation and visualization trials

In D1.4.1. Requirement specification of future remotely control service robot for home care, as interim document, several analyses were made in order to keep on with the iterative development-testing process. Data about usability, accessibility and acceptability was gathered in a in depth analysis. Differences in perceived difficulties, robot envisaged usefulness, factorial analysis of the requirements, privacy and safety, preliminary results of the trials and a new prioritization based on the recent results were carried out and analyzed in the document.

This data should serve as a new input to complete the final requirements document. The methodology to include the new data as requirements is a constructive procedure adding on the outcome to the previously detailed requirements list.

Requirements extracted from the robotic arm manipulation trials.

Manipulation and visualization tests in San Sebastian were conducted in January 2012 with the aim of addressing the main peculiarities of the robotic arm with real users (D6.2.).

The users were confronted to the robotic arm with the aim of analyzing the acceptability and use intention from the users perspective. From the acceptability point of view, we gathered the following requirements:

TABLE 17 - REQUIREMENTS FROM THE MANIPULATION TRIALS

Requirements from First Manipulation trials (1MT)	
Nr.	Requirement
(1MT1)	The system should bring the stuff near. The users want the system to minimize their mobility if they need to use the robotic arm.
(1MT2)	It is not usable by people with dementia. The usability should be high, probably by voice recognition.
(1MT3)	The system should be faster and more accurate or being used only by people with motor impairment who live alone.
(1MT4)	The system should be used just when the user cannot perform the task by himself.
(1MT5)	The system should be cheaper, increase its functionalities or being partially funded by the social services.
(1MT6)	The system should be able to be used directly by the user, and in second hand used by someone out of the home.
(1MT7)	The system should not only bring the objects but to carry them away to the original place.
(1MT8)	The system should be smaller.

Requirements extracted from the UI-PRO visualization trials.

TABLE 18 - REQUIREMENTS FROM THE 1ST VISUALIZATION TRIALS

Nr.	Requirement
V1	Controlling the robot should be easier and more intuitive. The environment simulation screen should give more detailed spatial information. If not automatic movement can be developed, the robot should provide subjective point of view to improve the intuitive control.

V2	The system should give clear instructions to start the actions, and feedback about the procedure. -Task checklists or onscreen messages could support the users performance.
V3	The screen should be customizable: the user should be able to change the point of view, size of the screen, and angle.
V4	The system should be more automatic. i.e. press double click on the item to be taken and the robot performs all the subtasks automatically.
V5	The system should have a stop-safety button in order to stop the system whenever something is going wrong.
V6	The system should have a self stop system when the arm is getting near to something with the hand closed, making possible to open it again.
V7	To avoid splitting attention, the minimum commands and just one screen should be viewed in the same monitor. One screen to avoid divided attention/simplify multiple-screen solution.
V8	The movement should be easier and smoother. A possible solution could be having mixed control. The user points the place and the robot goes autonomously instead of the user has to move the robot. Develop collision-avoidance systems. If not automatic collision-avoidance system can be develop should be direct feedback about the position of the robot to the user (sound, speedometer, light or colours schemes…).
V9	There should be the minimum number of buttons in the screen. Just keep the functional ones. If several buttons were needed to perform another actions than moving and grasping should be out of sight in advanced menus.

V10	People have established patterns of searching information in the screen. The functional and more important buttons should be in a place that can be directly addressed, and the secondary out of the screen in menus, etc.
V11	The stop button should be easier to find, probably bigger than other buttons and near to the control pad.
V12	There should not be intermediate interfaces, the robot should be moved by just one physical interface (mouse, joystick, keys, buttons…), not by a virtual one (that needs to be controlled by the physical one stated before).
V13	Develop lateral movement.
V14	The speed to take the things should be the same as the human.

10.2.5.2. New Requirements from the whole system pre-test in real homes.

The main objectives of this test were to identify technical problems when operating the robot in a real home environment and to get a first feedback from elderly users on their perception of the robot in their home. From this feedback and the observation of the professionals, new requirements will be integrated in the previous requirements lists. For more information the reader can check the Interim document *DELIVERABLE D6.2-DRAFT SRS user validation – results.*

TABLE 19 - REQUIREMENTS FROM THE FIELD TRIALS

Requirements from the real home trials (HT)	
Nr	Requirement
Requirements of Movement (M)	
(HT/M1)	The UI-PRI should facilitate position estimation and distance of the robot. A possible solution could rely on the labeling of the items that could make possible for the user just to point it in order to activate the robot's automatic mode.
(HT/M2)	The navigation system of the robot should be improved in order to make the system able to pass between rooms. Probably having a smaller robot could be an

	advantage in houses with narrow passages.
(HT/M3)	The robot need to be smaller in order to maneuver easily in the home, or if the current size and shape is needed, new movement patterns should be researched.
Requirements for grasping (G)	
(HT/G1)	The system should recognize automatically the objects at home. The training procedure need to be easy to use or must be accomplished by a professional in the customization installation phases.
(HT/G2)	The system must be safe for the user and his goods. It is important that the system has a safety system that prevents it from harm or shatter the user's items.
(HT/G3)	The robot should be able to recognize objects in every environment (lighting, , appearance, position, shape, etc.). Other possibility is to develop architectural solutions and minimize the number of items the system can recognize and grab.
Other requirements related to Performance (P)	
(HT/P1)	The system should start an auto charging routine when the batteries are running off.
(HT/P2)	Better mapping functionalities should be developed. On the other hand, The manual of the system should warn the user of the requisite to make slight/temporarily changes at home.
Appearance and Acceptability Requirements (AA)	
(HT/AA1)	The robot should be friendly. No emotional cues should be needed (avatars, face, etc.). Technology must be hidden but appearance as furniture or standard electronic devices could be a good option.
(HT/AA2)	The robot size is a matter of appearance and functionality. It should be between 100 and 120cm. Bigger size could be not only unusable

	at home but also less acceptable.
(HT/AA3)	The system should be quiet.
(HT/AA4)	The system should have smooth movements to ensure acceptability.
(HT/AA5)	The system should be wheeled, or probably with caterpillar tracks to avoid obstacles. Balance with acceptability and functionality should be studied.
(HT/AA6)	The participants should feel safe (not only be). The robot should perform correctly in every moment.

10.2.6. NEW REQUIREMENTS FROM THE ADVANCED SRS PROTOTYPE TESTS

During the last part of the project, the final prototypes were tested in order to assess the evolution of the system and whether the system has achieved the usability, accessibility and acceptance goals.

The UI-PRO was improved since the first test based on the findings related to usability and accessibility. The final tests pointed out new requirements, based in the new user-system interaction. The complete tests results can be checked in the D6.2.

TABLE 20 - REQUIREMENTS FROM THE 2ND VISUALIZATION TRIALS

Requirements from the UI-PRO 2nd Visualization trials (2V)	
Nr.	Requirements
Screen Appearance (SA)	
(2V/SA1)	The interface should only display information concerning to the user. The interface could display tooltips to ease the use.
(2V/SA2)	More real vision is encouraged.
	The user should be allowed to place an axis starting point from which start the camera movement
(2V/SA3)	If real vision could not be developed. Labels by code of colours and names should be generated.
(2V/SA4)	There should be feedback on the robot task performance. An “uploading” kind bar, percentages or similar indications should be displayed.

(2V/SA5)	The display menu should be easier, with less steps, avoiding intermediate functional steps.
(2V/SA6)	Rviz y gazebo should be integrated.
(2V/SA7)	Minimize the number of steps needed from the user.
(2V/SA8)	The step and the options needed to perform the task should be done automatically. If not higher formation could be needed.
(2V/SA9)	The simulation could need more development.
(2V/SA10)	The interface should be in the language of the country.
(2V/SA11)	Make possible to see the room.
(2V/SA12)	Display the options in not complementary colors for the blind impaired.
Movement of the robot (MR)	
(2V/MR1)	-Develop automatic grasping based on labels that could be detected by the robot sensors. -Make the camera mobile making possible for the user to aim to the more difficult situations.
(2V/MR2)	Develop faster response systems. If it is not possible. Give option to an emergency external protocol (ambulance, etc.)
(2V/MR3)	Develop faster response systems. If it is not possible, minimize the user interaction in order to the user can perform other tasks while the system is working. In this case the user could be notified when actions were required.
(2V/MR4)	The system should give feedback about the movement. Some possibilities could be a risk notification (changing % of hit chance, measured by the sensors in real time), notifications when the robot is stopped by an unexpected event.
(2V/MR5)	The ideal thing should be to click in some point of the map and the robot went there.
(2V/MR6)	Integrated camera and map could solve the issue.

	Automatic obstacle recognition should be improved.
(2V/MR7)	Make possible to perform the whole movement. There should be buttons with predetermined turning options (45º, 90º, 180º)
Grasping functionality (GF)	
(2V/GF1)	It could be a grabbing notification in a "loading bar" way, something that could give feedback about the process is still working and that didn't get blocked".
(2V/GF2)	There should be an alarm notification with some instructions of problem solving if it is the case.
(2V/GF3)	The task performance should be faster or not require the whole user attention during the task.
(2V/GF4)	Select the most important tools and place in a highly visible place (center-up), develop intuitive icons.
(2V/GF5)	Letting the two options for maneuver could be useful. The system should be customizable, allowing the user to choose his interface depending on his abilities.
(2V/GF6)	Minimize the display to the minimum options. Develop a point and click manipulation could be helpful.
(2V/GF7)	Develop more detailed explanations.
(2V/GF8)	Display all information in one window and different tabs for the actions that require it.

10.3. CHECKLISTS AND TRACEABILITY OF TECHNICAL REQUIREMENTS

Based on the previous work, specific technical requirements have been found and described. In the present section we can observe which are the technical requirements that probably all the systems that aim to support older people with motor impairment should aim to cope, what kind of procedures have been used in SRS to support the requirements gathering, whether the SRS project have fulfilled this requirements and to which extent.

The information was structured in the following tables by:

- Description of the requirement: specification of the requirement and needs extracted from the SRS studies.
- Area of influence: requirements are grouped in areas such as: basic activities of daily living, privacy, safety, and emergency management.
- What kind of empirical support the requirement has: The requirement studies in SRS have been of two nature: qualitative and quantitative, both giving complementary information about the main issues.
- To which extent the requirement has been accomplished in SRS project: in this column we can check if the project has achieved the aim and what would the future developments need to do to achieve it.

Technical Requirements for an ADL-supporting robot	Area	Has SRS accomplished it?
The system should help elderly people with mobility issues such as reaching objects.	BADL	SRS achieved fairly well this requirement for 'known objects'. Unknown objects require assisted grasping which presents some issues in particular cases related to the position or shape of the object.
The system recognizes and identifies objects (shapes, colors, letters on food boxes, numbers on microwave display).	BADL	The system work well with recognition of 'known objects', even if external environmental factors, such as light conditions and colors, can impact the functionality.
The system is able to grasp objects (i.e. bottle, books).	BADL	The system grasping ability has been improved to increase its accuracy but again it depends on the object and the surrounding environment.

Technical Requirements for Emergency	Area	Has SRS accomplished it?
The system should help with coping with unexpected, emergency situations such as falling.	Emergency	The system can't detect an emergency situation by itself. Anyway can help in communication with the operator that will be able to call for assistance.
The system monitors activities and recognizes the user position, and the time spent in the same position.	Emergency	Not achieved.
The system alerts a remote operator when an emergency has occurred by sending a	Emergency	This works only if the call is initiated by the elderly person through the UI-LOC.

high priority call to the relative or to the service operator.		
The system could support the weight of a man in a getting up task.	Emergency	No.

Technical Requirements for Privacy	Area	Has SRS accomplished it?
Only authorized persons to have access to the remote control of the system	Privacy	Yes during normal operation the elderly person must authorize the remote operator for controlling the robot. In emergency situations this does not apply.
Authentication procedure as a protection of the access to be included for both family caregivers and professionals.	Privacy	Same as above.
Possibility of external and non authorized intruders to be avoided by a robustness security system	Privacy	The selected scenarios did not cover this situation.
Avoid possibility of access to the system without explicit consent of the elderly, including non authorized access of authorized remote operators	Privacy	The selected scenarios did not cover this situation.
If remote operator changes within one session, the elderly user must be informed	Privacy	The selected scenarios did not cover this situation, but as the communication with the operator is vocal, a change in operator can be detected by the elderly.
Unintentional, not authorized disclosure of information related to the life of the users has to be prevented by restricting access to the information stored in the system.	Privacy	The system does not store information related to the life of the users. So there is no risk of disclosure.
Storage and management of personal information related to behaviors and preferences	Privacy	The system does not store information related to the life of the users. So there is no risk of

of the users have to be done in safe, restricted databases		disclosure.
Storage of personal information related to behaviors and preferences of the users will be limited to that information relevant for the functionalities of the system. Non relevant information processed if not necessary.	Privacy	The system does not store information related to the life of the users. So there is no risk of disclosure.
Unintentional, not authorized disclosure of information related to the life of the users to be prevented by including agreements of confidentiality for authorized users.	Privacy	Confidentiality agreement is not part of the system but will be handled off line between the interested parties (family and operators).
An “on/off” mode to be implemented in order to protect privacy in very personal moments. The access to the “on/off” mode could be adaptable attending to the specific frailty of the elderly user.	Privacy	The elderly has full control and then he can decide when to call for any intervention.
Verification of the plans of action by asking the elderly user before it starts acting.	Privacy	Yes the system check the planned action with the elderly person before executing it.
Communication of action outcomes during performance of the robot, in order to maximize the awareness of the elderly user. Communication as continuous as possible.	Privacy	Yes, the user interfaces provides feedbacks about the performed actions.

Technical Requirements for Safety	Area	Has SRS accomplished it?
Communication of action outcomes during performance of the robot, in order to maximize the awareness of the elderly user. Communication as continuous as possible.	Safety	Yes, the user interfaces provides feedbacks about the performed actions.

No robot movement should happen without initial confirmation by the user who is in direct physical contact with the robot.	Safety	No physical contact is planned during the operations of the robot. If there is a collision between the robot and an object it stops immediately and when a human person is too close.
There should be a clear indication on the robot side if the robot is in autonomous mode or in remote controlled operation	Safety	A part from through the UI there is no mechanism to inform the user if it's in autonomous mode or in remote controlled operation.

11. MOST IMPORTANT REQUIREMENTS DECALOGUE

Taking into account all the requirements gathered in the SRS studies, we have composed a "top ten" kind of checklist to approach the user and technical requirements in the SRS or related projects. Taking into account that we have defined our targeted user as older people with motor impairment and a low social support, and that our specific field is robotic support, in the following sections we point out the main user requirements (the most frequently stated and the ones considered as the most important, but also the ones that have relation with other requirements) and the main technical requirements. The requirements are established from the general to the specific.

11.1. TOP TEN USER REQUIREMENTS

1. The users have (by user specification) motor impairment. So they require broad support with physical tasks.
2. The users require support with Instrumental Activities of Daily Living, specially with sequential tasks and housework.
    - cleaning windows
    - cleaning floor
    - opening bottles
    - carrying heavy objects
    - cooking
3. The users require support with Basic Activities of Daily Living.
    - not being able to walk
    - getting up
    - sitting down
    - reaching the things
    - climbing bathtub

4. The users require Cognitive Support.
    - arranging and reminding appointments.
    - reminding tasks.
    - reminding medicines intake.
5. The users require Monitorization in case of Emergencies.
6. The users require Social interaction.
    - communication with others (preferring human to robotic).
7. Leisure.
    - reading.
    - playing games.
8. The users want their Privacy to be respected, but each user has different privacy interests.
9. The users want Safety in their caring process.
10. Customization and adaptation: the users needs are dynamic and can change.

11.2. MOST IMPORTANT TECHNICAL REQUIREMENTS DECALOGUE

Top ten technical aims for giving support to the elderly people with motor impairment.

1. The system should be prepared to provide technological support to the motor impairment, specially for the high priority difficulties. The most required solutions were rough tasks (i.e. carry out objects) and sequential tasks (i.e. preparing meals, washing dishes)
    - cleaning windows
    - cleaning floor
    - opening bottles
    - carrying heavy objects
    - cooking
2. When accomplished the high priority difficulties, ir would be “nice to have” support on:
    - not being able to walk
    - getting up
    - sitting down
    - reaching the things
    - climbing bathtub
3. Social interaction: As the users do not want to substitute social interaction with robotic interaction, the system should not create psychological, environmental or sociological barriers for human interaction, but create opportunities so establish and keep social relationships.

4. Privacy: The users do not like to have a system remotely controlled at home. As far as possible, the system should be autonomous or with limited remote control if not adapted to the users own control.
5. Accessibility: Several users' houses are not accessible both for the acquired or developed impairment and for having a big mobile robot platform at home. The system should adapt to the users homes, narrow corridors, carpets, furniture and narrow doors. Also to the relevant ornaments such as carpets or pictures that could prevent some systems to work correctly.
6. Privacy/Security: The system should be customizable for any users' privacy constraints. Each user can have a different position in the balance of support instead of privacy. The personal opinion is more important than the objective needs at least within the law and legal rights and responsibilities.
7. The system should respect both the ethical issues, legal constraints and users' opinion in equilibrium and avoid neglecting any of these fields.
8. Safety: Users are concerned about other people controlling the robot. They prefer to control themselves but they are afraid that it must be difficult to learn how to operate the system.
9. Adaptability: as the users' needs are dynamic and could change, the system should be scalable and modular in order to adapt to the evolving needs of the users.
10. Customization and adaptation: the system should be adapted to the dynamic needs of the user.

12. DISCUSSION AND FUTURE STEPS

In-deep analyses of the user requirement study show that elderly people´s perceptions of their own difficulties differ from other significant groups, reporting less difficulties in daily activities in elderly people. That could be related to underestimation of their own difficulties, or social desirability. Interestingly, no other groups differed significantly from any other group in other items, which means that they have quite a similar opinion. This finding shows us that the opinion and perceived need of the frail older adults must be taken into account, but not exclusively. Data should also be collected from other significant persons involved in the process of aging in place. Complementarily, factor analysis showed us higher agreement of the caregivers with the social component (situation monitoring scenario) of the robot when compared with elderly people, as an example of the different perceptions in the usefulness of the robot in different groups.

Regarding ethnological studies, a prioritization of the requirements, needs and the envisaged robotic solutions have been based in the frequency for two different profiles: people living alone with good social support and people living alone with low social support. This process showed us the importance of giving direct support to people that has severe motor impairment and low social support. It must also be taken into account that old adults do not have broad spaces at home, they do not want to have the furniture and carpets removed and they ask for support in both rough tasks (carrying things, reaching and bringing things) and fine sequential tasks (cooking, cleaning, housekeeping).

About privacy, regression analysis showed that different variables influences the perception of privacy of the potential users, including the role of technology in their social and mobility needs, their perceptions about technologies, their psychological state and their country. One possibility is to take these variables into account in order to develop educative and informative programs promoting the acceptance of assistive technologies.

In Manipulation trials, we have observed that, in spite of the peculiar appearance and technological restrictions of the robotic arm presented, the system did not evoke responses of fear or rejection in the participants, who provided a majority of positive perceptions about the functionalities of the robotic arm and the intention to use it. In Visualization trials, some usability difficulties were reported, to be detailed in D6.2, but professionals also perceived that the technology is inventive and interesting.

Safety of a system like SRS is of vital importance for the acceptance of this kind of assistive robots and also is one of the main requirements, since a robot like SRS inherently has the potential to damage goods or harm humans. A list potential hazards for the SRS robot system is included in section 5.

According to the aim of specifying general requirements for future remotely control service robots in the process of aging in place, the writing process of a general proposal of

requirements in assistive semi-autonomous robotics for frail older adults have started. In this process, we are taking into account data analyzed, prioritized and discussed in this Deliverable, and we will also update the subsequent set of requirements with the results of the user field trials.

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ANNEX 1.

ETNOGRAPHIC INFORMATION WITH COLOR SCHEME LABLING

	Participant #1	Participant #2	Participant #3	Participant #4	Participant #5
Participant description and Social Context	Woman, 84. 3 daughters living out, but visiting her daily after work.	Couple living together. 82, 84. 5 sons and several grandsons.	Woman, 83. Widow. Living alone. A married daughter, and a nephew.	Elderly couple not living together. 83, 84. 1 daughter in the same city.	Two woman, 80 and 82, living in couple. More than 5 family members support. Domestic worker, physioterapist and hairdresser home visitors.
Economic Context	Private home. High Status	Private home, lands, owning a restaurant, but low income	Rent house. Low income. Help from the family. Housekeeping for the familiars	Private home. No need of help but have a domestic employee.	Private home.
Health conditions	Moderate to Severe: Polio, arthtritis, deafness, cataracts, shoulders pain. Lucid Mind	Weakness, deafness, and pacemaker after stroke. Several motor impairments, and growing blindness	Hearing problems, minor motor problems, back pain, and slight memory loss.	She uses a stick, Hip pain. Tiredness and slight memory and hearing problems. He uses a stick. Tiredness, due to a heart attack, slight memory problems and corrected deafness	Severe health and motor conditions. 82 years old use wheelchair. 80 years old use stick and have parkinson. Both have weakness and tiredness.
Environmental description	4+ Rooms. Garden. Full of ornaments and carpets. 57 cm narrow. Big TV to be able to see it	4+ Rooms. Messy. Narrow passages.	4+ Big rooms, with not so much furniture. Absence of carpets. Bathroom with door opening limiations	4+ Rooms. Narrow passages (45-75) due to doors opening or chairs and furniture. Objects in high places.	Bathroom and Kitchen narrow. The rest of the rooms are big. Steps outside and inside. Bathrooms adapted.

Difficulties of daily living	Falls. Difficulties reaching objects. Handrail. Need of stick. Needs to wait for cooking, even when she prefers to do it. Needs to push on her fists to get up.Loneliness. Anxiety.	They cannot carry objects but use a trolley. They have severe perception impairments. But they help themselves. They don't perform housekeeping tasks	Hearing conversations, the phone, or the door bell ringing. Absence of several motor problems , except to take stuff from the ground or carrying heavy objetcs.	Falls and Pain. She is scared to fall being alone. She is not be able to carry the shopping except with a trolley. Tiredness. Afraid of falling in the bathroom. He has more mobility problems.	Fear of falling. Light housekeeping. They can perform ADL by themselves but with some help and effort: dressing, toliet and shower, getting up and sitting down. Slight memory problems.
Possible robotic solutions	Technologically +. Needs for mobility: getting up, fetching and carrying	Find stuff. Fetch and carry objects. Videoconference.	Monitoring and emergencies.	Carry and fetch objects	Incredulous.
Possible robotic solutions labels	R,D	R,S,O	M	R	None of them
Family point of view	24 hours monitoring. Specially helping with motor abilities	They do not want to move them to a residence nor bring external help.	Monitoring and emergencies.		
Ethical concerns and preferences	Wants to control the system by herself. Prefer monitoritorization, but to be autonomous. She prefer not to bother their relatives. She doesn't want to be feed up.	They don't want to have anyone external controlling the robot, nor teleassistance. They would like to be managed by familiy members.	She doesn't feel that need it but agres that it is a good idea for emergencies.	She is afraid of being alone and about her health. He is not afraid of being alone even when he has more severe health problems. Both do not like the system to be managed by an external service. They are afraid of the costs	Currently having help from the faimily and they cannot think in technological help.

	Participant #6	Participant #7	Participant #8	Participant #9	Participant #10
Participant description and Social Context	Woman 79 years living alone with no direct help.	Woman 83, with near family of 8 members. Daily visits of a son in law.	Man, 84. 6+ family members living near. Domestic worker.	Man 89 years old. 14 family members living nearby and accompanying him for a walk often. Domestic Worker. His family members also buy the food and cook for him.	Woman 86 years old. 24 family members but only 2 visitng her on a daily basis.
Economic Context	Private home. Good status.	Private home. Good situation, with widow's pension.	Private home. Retirement pension,	Private home. Retirement pension.	Private home, regular situation, retirements pension.
Health conditions	Broken arm. Weakness. Wrist pain. Myopia. Tired vision. Poor balance. Use of a stick.	Arthrosis. Afraid of falls and unknown visits.	Cardiopathy catacts and hernia. Motor difficulties.	Cataracts, COPD, cardiopathy, prostate problems and movement difficulties, especially to go upstairs and downstairs. Poor balance.	Arthritis, diabetes; shoulder, spine, legs and hands pain. Circulation problems, one ear deafness and cataracts.
Environmental description	6+ rooms quite small. Narrow corridors. Lots of furniture and carpets. Full electrical appliances and articulated bed.	4+ rooms quite small with narrow corridors. Terrace. Small bathroom that prevents her from falling. Lots of objects and furniture.	Narrow corridors, small living room. No elevator.Not entryphone. Not Adapted bathroom. Articulated bed.	Carpets, not assistive devices with the exception of a handle in the bathroom.	Adapted furniture., lowered the shelves. Plans to change gas cook into an electric one. Adapted toilet with non-sliping floor and handlers. Adapted bed with a handler.
Difficulties of daily living	She has difficulties to use the cuttlery. Sitting down, getting up and ducking.	Housekeeping. She can still do it but she has contracted a domestic worker.	Shopping, cooking, household in general and managing the washing machine.	Problems with householding. Due to the cataracts, he cannot do pasttimes Cleaning clothes and managing finances.	Due to the pain in the arms, specially grabing items and householding. Getting up and sitting down. Poor balance.

possible robotic solutions	The robot could bring and carry objetcs, take objects low down and from the dishwasher. Laying the table or helping with walking and getting up.	Helping with housekeeping and cleaning.	Householding. 24hours communication with the family.	Walking or standing up when he loses his balance, Reaching and bringing objects; avoiding extra effort, sequential programmed functions such as preparing meals or wash the dishes. Manipulating objects and machines. Monitoring, emergencies and communication.	Helping with mobility, to walk and to get up and sit down. Supporting with carrying things, reaching, bringing and bearing objects.Increasing the volume or improving image quality in the telecommunications.
Possible robotic solutions labels	R,F,D	F	F,S,M	D,R,F,M,S	D,R,S
Family point of view	Monitoring.				
Ethical concerns and preferences			He thinks that the robot could help with the housekeeping activities, but prefer human contact.	He feels comfortable with communication with the family (to avoid solitude) and in case of emergencies. He prefers people than a robotic solution. Prefers social interaction.	Monitoring and in case of emergencies.

	Participant #11	Participant #12	Participant #13	Participant #14	Participant #15
Participant description and Social Context	Woman, 89 years living alone. 11 family members that visit her weekly but having daily telephonic contact.	Woman, 89 years living alone. 7 family members living far from home. Daily telephonic contact.	Woman 88 years old, living alone. 17 family members, several sons visiting her on a daily basis. Domestic	Woman, 75 years old. Living alone. 9 family members and several visit her on a daily basis. Receives also help from a domestic worker and neighbours.	Woman, 93 years old, living alone. 4 family members that visit her weekly. Also have hired an assistant.

Economic Context	Regular. She is not receiving income. Currently renting her home.	Private home.	Private home. Retirement and widow pension. She uses saved money because pension is not enough.	Regular. Widow pension. She is currently renting this flat	Private home. 5+ rooms.
Health conditions	Operated hands, vertigo and diverticulitis. Back problems.	Arthritis and osteoporosis, Pain in legs and arms. Her knees do not bend and her back is very bent. Slight memory problems.	Hip and pelvis fractures. Surgery in the leg, weakness and tiredness.	Pain in intestines and hips. All motor abilities impaired.	Hyperthension, circulatory problems, meniscus surgery, and pain in her legs. She uses glasses to correct presbyopia and suffers from amblyopia. Reports loss of strenght.
Environmental description	5+ Rooms. Small bathroom.	6+ small rooms with narrow corridors. Messy with a lot of objects in particular places that make her able to reach them. Several carpets. Bathroom not adapted. Gas system in the kitchen.	4+ Rooms.Renewed kitchen, adapted small shower with handles and non silping floor. Have a lot of furniture and personal objects.		Handles in the rooms. Renewed shower with achair and handles. Several carpets in the living rooms and bedrooms. Narrow corridors. Teleassistance devices.
Difficulties of daily living	She does general housekeeping slowly, painfully and with difficulties.	Housekeeping, cleaning the dishes, vacuum, making her bed, sometimes she cannot use one hand to eat. She uses a trolley not to lose the balance.	She uses a stick.	Needs a stick or walker for walking. Help with taking and carrying things as in shopping. Activities such as cooking or having a shower.	Doing houseworks, mopping, ironing, cleaning the curtains, reaching the clothes from the horseclothes and washing dishes.

possible robotic solutions	Fetching and bringing objects, specially reaching higher or lower ones instead using a ladder or having to duck.	Getting up, sitting down, walking, reaching objects, bringing objects and sequential programmed actions such as preparing meals, washing the dishes. Mitigate social communicative aspects that have been reduced due impairments by increasing the volume or improving image quality in the telecomunnications. Medicine and appointment reminders.	Walking or standing up when she loses her balance. Bringing her objects; avoiding extra effort. Reach objects that are too high or low. make sequential programmed functions such as preparing meals or wash the dishes. Standing up from bed or the armchair and can collaborate in the preparation of meals. Emergency situations.	Everything related to motion disabilities. walking or standing up when she loses her balance. Bringing her objects; avoiding extra effort. Reach objects that are too high or low. make sequential programmed functions such as preparing meals or wash the dishes. Standing up from bed or the armchair and can collaborate in the preparation of meals. Emergency situations.	This solution can also reach objects that are too high or low and make other sequential programmed functions such as preparing meals or wash the dishes. Moreover, it could crucial in case of emergencies
Possible robotic solutions labels	R.	D,R,F,M,S	D,R,F,M,S	D,R,F,M,S	R,F,M
Family point of view				She needs help in having a shower and walking to the church. Also, cooking, cleaning the house and standing up from bed.	
Ethical concerns and preferences	a robot will never be like a person who you can touch or talk to. She points the neccessity of human interaction to avoid isolation. States that noone would hire a robot		She has a lot of objects and pictures but she doesn't want to quit them.		to have a robot at home would be a little strange sensation", "It would be something a little bit difficult to accept".

ANNEX. 2

Case study analysis Protocol

Main objectives of this case study are:

- To properly describe the environment were elderly people lives, focusing on **were relevant objects are placed**.
- To complete information about activities of daily living in context, especially **those related with fetching and bringing things**.

This research is focused in object manipulation in real context and aims to support fetch and bring scenario by collecting information about objects relevant for daily life activities and about where this objects are placed. The study is based in observation in the home of the frail older adults and a non-structured interview. Complementary research methods (Picture-taking home visit, daily-life capture task) are also used.

1. Project presentation (description)
2. Informed consent
3. Personal information + Frailty (Barber test)
4. Picture-taking home visit: In the picture-taking home visit, the researcher and the elderly person walked through the house and the researcher **takes picture of anything considered worthwhile to capture, with objects placed inside the home and that could be moved** because of daily life activities of the frail older adult.

5. Non-structured interview. Possible questions:

    - How many rooms does your house have?
    - Which kind of facilities are there (handless, seat for the bathtub…)?
    - What are the most important considerations for living alone/at home for you?
    - What does wellbeing mean to you?
    - Could you describe a typical daily routine to me? *(Beginning with waking up in the morning, going to the bathroom, preparing your breakfast…)*
    - Do you have any activity rituals during the day/week? (*A ritual is considered to be an activity that you look forward to, that you enjoy)*
    - What are your most favourite activities during the day?
    - Which activities cause the most difficulties during your daily routine?
    - Are you (still) doing all housekeeping activities by yourself? (Which not and why…)
    - What are you doing when you cannot cope with a situation at home? (Do you seek for help, tray to do them by yourself,…)?
    - Are there any situations during your daily procedure which are frightening you?
    - Can you think of situations where you'd appreciate assistance/help?
    - Are there any activities for which you need the help of your caregiver? (if so, which)

6. Daily-life capture task
   In this task, the researcher had to fill out a template like the one showed in Figure 1 with the help of the elderly person, asking him or her about his / her daily life activities.

Activities in a typical day
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00

FIGURE 11 - DAILY ACTIVITIES TEMPLATE

7. Project presentation (VIDEOS).
   Which objects in your home would you like being manipulated by the robotic arm? And which object you **would not** like?

8. Project presentation (VIDEOS).

   a. I would **use** this system when it becomes available
      totally disagree ☐ ☐ ☐ ☐ ☐ totally agree
   b. I would **buy** this system when it becomes available?
      totally disagree ☐ ☐ ☐ ☐ ☐ totally agree
   c. I would **use** this system if it becomes available for free from the social services?
      totally disagree ☐ ☐ ☐ ☐ ☐ totally agree
   d. I would **use** this system if it becomes available partially from the social services?
      totally disagree ☐ ☐ ☐ ☐ ☐ totally agree