SRS

Multi-Role Shadow Robotic System for Independent Living

Small or medium scale focused research project (STREP)

DELIVERABLE D1.4.1

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

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3	Facal, D.	20/01/2012	Factor analysis & privacy
4	García, A.	10/02/2012	Prioritization based on ethnological study
5	Facal, A.	10/02/2012	Brief report of results from the Manipulation and Visualization trials
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SUMMARY

Task 1.6 address elderly people differences in their needs, their performance and how their physical and mental states change when they are getting older. Therefore, it is necessary that the SRS system can be dynamically adapted according to the specific needs and to the change of needs, by modularity and customizable designs. Privacy, safety and environmental peculiarities must also be taken into account. All this considerations should be relevant for the primary users on their own and it should be also relevant for other local users or the remote operators.

This 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. The aim is to specify general requirements for future remotely control service robots in the process of aging in place and also being an open consultation guide in topic related EC projects. At the end of this task, a proposal of requirements in assistive robotics for frail older adults is going to be included.

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1 INTRODUCTION

Since development of ICT for new users covering 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 frailty older adults living independently. Apart from supporting detailed design and development, user involvement are usually performed when developing and / or validating requirement specifications (Rashid, Wiesenberger, Meder, & Baumann, 2009).

Several studies are being 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 Section 2, 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 6 (ethnographical study, scenario validation study, manipulation and visualization tests, and so on). In Section 3, a user requirement prioritization will be conducted. 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 included in section 2. In section 4, a deeper analysis of responses about privacy is conducted, in order to ensure the coverage of privacy needs reported. In section 5, updated information about safety will be included, applying the methodology for "safe HRI" outlined in SRS deliverable D2.3. In section 6, a preliminary analysis of the results collected in Manipulation and Visualization trails conducted in San Sebastian are included. As a result from this process, in section 7 it is going to be included a first approach to the proposal of general user requirements in assistive robotics for frail older adults living independently.

2 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.

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.

2.1 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 1. 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.

2.2 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).

2.3 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 2. 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.

3 USER REQUIREMENT PRIORIZATION

3.1 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).

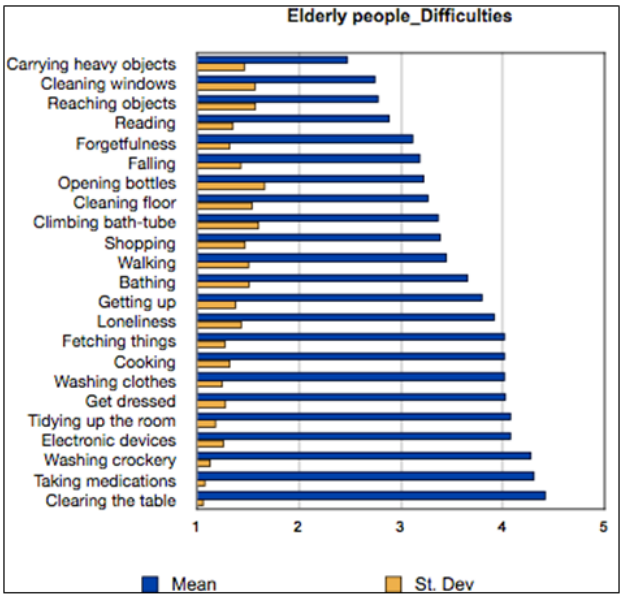


FIGURE 1. EXAMPLE OF GRAPH FROM THE USER REQUIREMENT STUDY

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).

3.2 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.

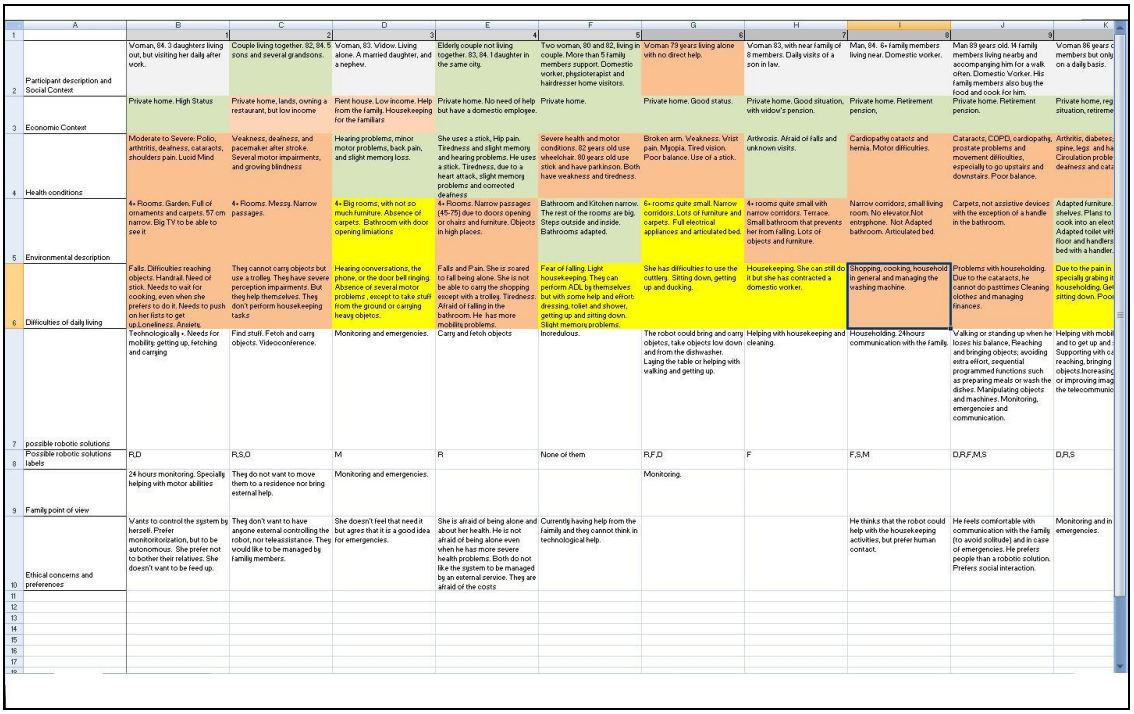
Users desired possible robotic solutions:

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).



	A	B	C	D	E	F	G	H	I	J	K
1		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. 6 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 familiars	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 parkinson. 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.	Cardiopathy cataacts and hernia. Motor difficulties.	Cataracts, COPD, cardiopathy, prostate problems and movement difficulties, especially to go up stairs 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 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.	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 wit 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 lists 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 housekolding. Due to the cataracts, he cannot do pastimes Cleaning clothes and managing finances.	Due to the pain in specially grabing th 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 telecommuni
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 monitorization, 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 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 2. 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 to 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.

4 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.

5 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. As this project phase is “work-in-progress”, this interim version D1.4.1 only describes the starting point of the safety analysis – final report then will be included to D1.4.2.
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.

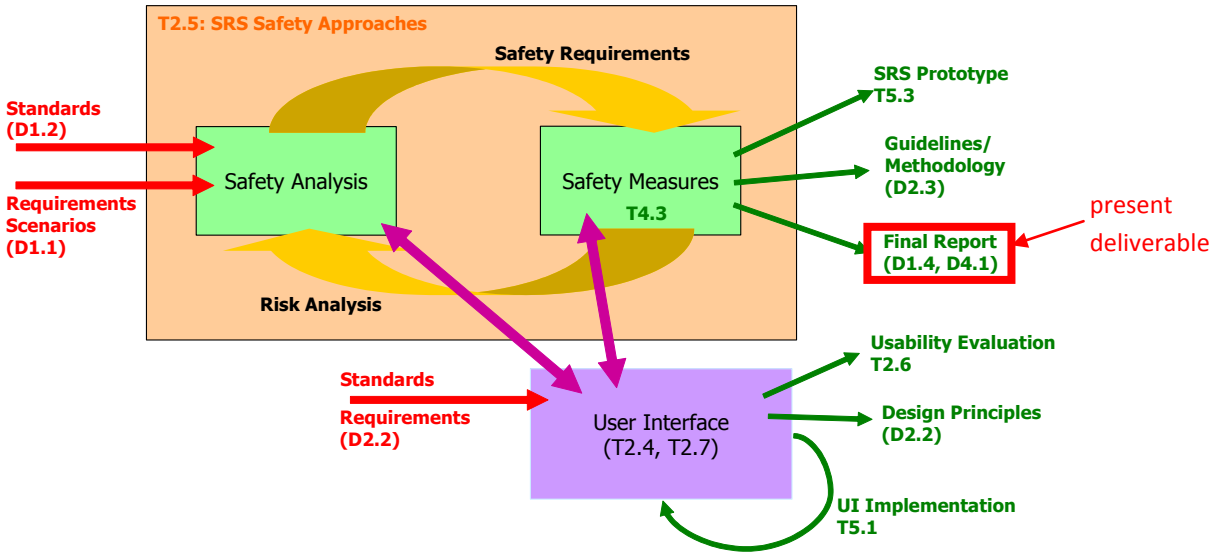


FIGURE 3. "SAFETY" IN SRS PROJECT (figure adapted from deliverable D2.3)

5.1.1 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

Compilation of the “Hazard Matrix” is work-in-progress -- documentation of the completed matrix will be included in deliverable D4.1.2 (PrM 36).

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

Risk

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).

6 PRELIMINARY RESULTS OF THE VISUALIZATION AND MANIPULATION TRIALS

Manipulation and visualization tests in San Sebastian were conducted in January 2012 with the aim of address the main peculiarities of the robotic arm with real users. In this section, we are presenting a preview of the data with special focus in user acceptance, and discussing the similarities and differences compared with results of our previous studies. A complete report of results collected in these trials is going to be included in D6.2.

6.1 MANIPULATION TRIALS

In the manipulation trials, we collected data about frail elderly users' subjective perception on the robotic arm on tasks based on grasping movements. We recruited 14 patients of the Rehabilitation Service of Birmingham Hospital - Matia Foundation (mean age = 79,14, d.t. = 9,607). All of them presented mobility problems in lower limbs, and some of them also in upper limbs. Some could present mild cognitive impairments, although only one presented suspicious of possible dementia (Mini-Mental State Examination < 23).

Although none of the participants are institutionalized, 50% of them report some degree of dependency and 64.3% of them declare been concerned their health.

For the trials, according to mobility problems of the participants, the Rehabilitation Service facilities were prepared for on-site testing. In concrete, we used one of the extensive exercise rehabilitation gymnasiums of the Hospital.

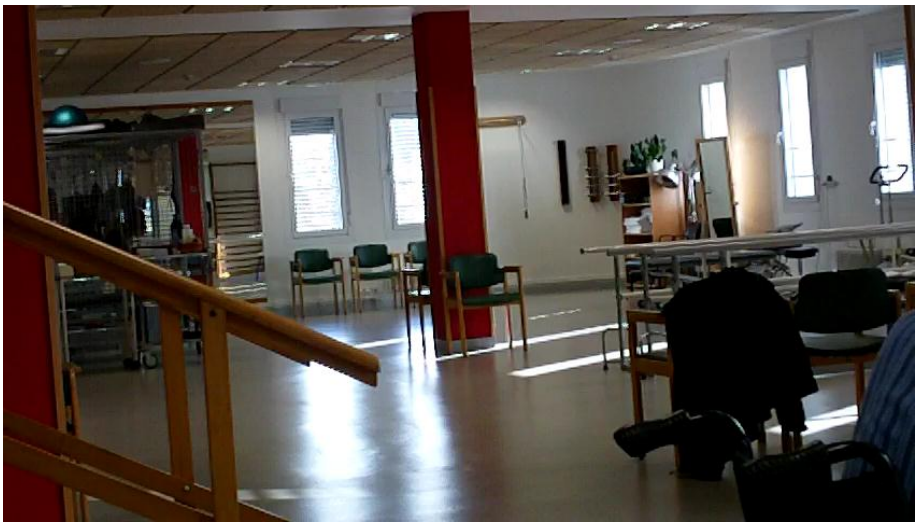


FIGURE 4. MATIA HOSPITAL'S REHABILITATION GYMNASIUM

The rehabilitation gymnasium is oriented at the physiotherapy and rehabilitation of patients of early injured elderly people. This service aims to provide support and professional training to patients that have underwent stroke, ictus, hip fracture, lower and upper limbs fracture, traumatic injuries, etc.

In these trials, we have combined ad-hoc questions with a validated test, the AttrakDiff (Laugwitz, Held, & Schrepp, 2008), selected to measure user experience in a simple and immediate manner (details about protocol development can be consulted in D6.1). 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. Users do not seem afraid of the system and their behavior shows that they think that the system is safe.

TABLE 3 – FREQUENCY OF FRAIL OLDER ADULTS' RESPONSES IN THE ATTRAKDIFF FOR THE MANIPULATION TEST.

	1	2	3	4	5	6	7	
annoying	-	-	-	4	1	7	2	**Enjoyable**
not understandable	7	4	-	3	-	-	-	**Understandable**
creative	8	5	1	-	-	-	-	**Dull**
easy to learn	5	5	1	-	1	2	-	**difficult to learn**
valuable	9	1	2	1	-	1	-	**inferior**
boring	1	-	-	2	4	4	3	**exciting**

not interesting	1	-	-	1		5	7	**interesting**
unpredictable	-	2	-	-	3	3	5	**predictable**
fast	4	3	1	5	1	-	-	**slow**
inventive	4	6	1	2	1	-	-	**conventional**
obstructive	-	-	-	4	1	2	7	**supportive**
good	7	4	1	1	-	1	-	**bad**
complicated	-	1	1	2	4	4	2	**easy**
unlikable	-	1	-	5	1	5	2	**pleasing**
usual	-	1	-	1	2	5	5	**leading edge**
pleasant	3	5	-	5	-	1	-	**unpleasant**
secure	6	6	-	2	-	-	-	**not secure**
motivating	3	5	1	2	1	-	1	**demotivating**
meets expectations	5	6	1	1	-	-		**does not meet expects.**
efficient	7	4	3	-	-	-	-	**inefficient**
clear	6	4	3	-	-	-	-	**confusing**
impractical	-	-	-	2	1	5	5	**practical**
organized	4	6	-	2	-	1	-	**cluttered**
attractive	4	8	-	-	5	-	-	**unattractive**
friendly	2	4	2	3	1	-	-	**unfriendly**
conservative	-	1	-	2	-	7	3	**innovative**

Regarding acceptance ad-hoc questions, we obtained:

- A higher percentage of participants with positive responses (Likely and Very likely) in items 1, 2, 3 and 6, showing a majority of positive perceptions about the functionalities of the robotic arm and the intention to use it.

- A higher percentage of participants with negative responses (Very unlikely and Unlikely) in items 4 and 6. Negative responses to item 4 ("Not have to do everything by myself") could reflect the importance of autonomy and sense of independence in this population. Negative responses to item 5 ("I like to use this kind of appliances") seem to points to a lack of relation between acceptance and subjective experience with technology, that it is going to be analyzed in more detail in D6.2.

- An equal percentage of participants with positive and negative responses to item 7 ("I would buy this system when it becomes available"). This result should be taken into account in task 6.4 SRS Cost-effectiveness Assessment & Socio-economic Implications.

TABLE 4 – FREQUENCY OF FRAIL OLDER ADULTS' RESPONSES TO ACCEPTABILITY ISSUES IN THE MANIPULATION TEST.

	Very unlikely	Unlikely	Neutral	Likely	Very likely
1. In general, would you use the functionalities?	3	1	1	5	3
2. The robotic arm can help me to achieve goals in my daily routine	2	-	3	4	5
3. More control over my daily life.	4	-	4		6
4. Not have to do everything by myself	5	2	3	3	1
5. I like to use these kind of appliances	5	2	4	3	-
6. I would use this system when it becomes available	2	1	4	6	1
7. I would buy this system when it becomes available	5	1	2	3	3

Qualitative responses and comments of the participants seem to confirm that they would like to use the system ("I would use it if I would need it", "Everything new is nice. It will be helpful to bear stuff"), although they would like to add more functionalities ("Should bring the stuff nearer", "I would like it to feed me", "But will it clean my arse? No? Then I don't want it", "I would like it to help me to get up, my problem is that I cannot get up from the chair or the floor").

A deeper analysis will be included in D6.2 including different analysis in each dimension of the AttrakDiff.

6.2 VISUALIZATION TRIALS

In the visualization trials, we have collected data from professionals working in areas similar to those involved in SRS. In concrete, we recruited 13 professionals. 7 professionals worked for a tele-assistance company (SaludNova, http://www.saludnova.com/) and 6 for Matia - Ingema professionals. 7 woman and 6 men participated, all of them were medium-aged adults (mean = 31.08 years; d.t. = 5.22). All of them have high educative level (mean =22.09 years of education; d.t. = 3.44) and have a job with responsibilities from medium to high.

Employees from SaludNova were interviewed in the facilities of the company. The rest of the participants were assessed in the rehabilitation gymnasiums of the Hospital where we also conducted the Manipulation trials (see Picture N).

In these trials, we have also combined ad-hoc questions with the AttrakDiff.

TABLE 5 – FREQUENCY OF PROFESSIONALS' RESPONSES IN THE ATTRAKDIFF FOR THE MANIPULATION TEST.

	1	2	3	4	5	6	7	
annoying	-	1	2	1	3	4	1	**enjoyable**
not understandable	1	4	-	3	4	-	-	**understandable**
creative	4	3	1	4	-	-	-	**dull**
easy to learn	2	4	2	2	2	-	-	**difficult to learn**
valuable	4	2	2	4	-	-	-	**inferior**
boring	-	-	2	4	-	5	1	**exiting**
not interesting	-	-	-	1	4	5	2	**interesting**
unpredictable	2	1	1	1	5	2	-	**predictable**
fast	1	-	-	3	3	1	3	**slow**
inventive	4	4	1	2	1	-	-	**conventional**
obstructive	1	1	-	3	3	1	3	**supportive**
good	3	3	2	4	-	-	-	**bad**
complicated	-	1	1	2	4	1	3	**easy**
unlikable	-	-	-	3	4	4	1	**pleasing**
usual	-	-	-	-	2	7	3	**leading edge**
pleasant	3	5	3	-	-	-	-	**unpleasant**
secure	1	4	2	2	1	1	1	**not secure**
motivating	3	4	3	1	-	1	-	**demotivating**
meets expectations	3	2	3	1	2	1	-	**does not meet expects.**
efficient	2	2	4	1	3	-	-	**inefficient**
clear	2	5	3	1	1	-	-	**confusing**
impractical	-	-	2	3	2	3	2	**practical**
organized	-	4	4	2	1	-	1	**cluttered**
attractive	2	4	2	2	2	-	-	**unattractive**
friendly	1	2	4	1	3	-	1	**unfriendly**
conservative	-	-	-	-	3	7	2	**innovative**

In this test, responses in the AttrakDiff are more widely distributed, especially in those adjectives more closely related to usability issues. Professionals agree that the technology is inventive and interesting, but also slow and not clearly meeting the expectations of the users. Regarding the acceptance ad-hoc questions, we obtained:

- A higher percentage of participants with positive responses (Likely and Very likely) in items 1, 4, 5, 8, showing that the professionals interviewed consider the robotic arm useful for the frail older adults and interesting for their work. 58% of the participants responded positively to the possibility of using the system when it becomes available, 42% gave neutral responses and no negative responses were collected.

- An equal percentage of participants with positive and negative responses to items 3, 6 and 7. As in the former section, results do not show relations between technology acceptance and system acceptance.

TABLE 6 – FREQUENCY OF PROFESSIONALS' RESPONSES TO ACCEPTABILITY ISSUES IN THE MANIPULATION TEST.

	Very unlikely	Unlikely	Neutral	Likely	Very likely
1. The robotic arm can help to help frail older adults with their daily routines	-	2	-	6	4
2. I perceive the use of the robotic arm can help me to control over the difficulties of the daily users.	3	2	1	4	2
3. This system would make my work easier.	3	1	4	2	2
4. This system would make my work more interesting.	-	1	4	4	3
5. I would use the system because I like to use such appliances.	3	-	3	4	2
6. I would use the system because these appliances are modern.	4	1	2	3	2
7. I would use the system to keep up with the newest technology.	5	-	2	2	3
8. In general, I would like to use this system when it becomes available	-	-	5	1	6

Apart from the ad hoc post-test questionnaires, an observational procedure was developed to take into account primary user-system interaction characteristics. These results will be deeply analyzed in the D6.2. But a brief here we can find an outline of the most relevant:

- There were several problems with the movement interface. The joystick representation present several control problems.

- The users prefer to see what the robot is actually seeing than to have a virtual representation of the environment.
- The participants stated that they need feedback about what it is the robot doing. In their view, the visual representation is not enough to perform correctly the grasping and moving activities.

6.3 IMPLICATION FOR USER REQUIREMENTS

The UI-PRO should be improved in further versions in order to make the software usable and accessible. Improvement related to remote control interface, aesthetics and grasping and bringing performance will be expected based on the recommendations to be specified in D6.2. Apart from usability and accessibility results of the UI-PRO, these trials have showed that the user acceptance of the interaction with the robotic arm is medium to high.

7 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. The iterative process of risk assessment is currently been develop, and a final report will be included in D1.4.2 explicating safety requirement for this type of service robots.

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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APPENDIX

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".