SRS

Multi-Role Shadow Robotic System for Independent Living

Small or medium scale focused research project (STREP)

DELIVERABLE D6.3

SRS Ethical and Cost-effectiveness

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EXECUTIVE SUMMARY

The overall goal of the SRS project is the development and the prototyping of remotely-controlled, semi-autonomous robotic solutions in domestic environments to support elderly people.

The aim of this deliverable is to analyse the SRS cost-effectiveness, its socio-economic Implications and the ethical issues related to the project and to the use of SRS system.

Chapter 1 of this document focuses on the prospective cost-effectiveness assessment of SRS system. This is based on the application of validated cost-outcome assessment tools to purposely-defined use scenarios. Characteristics of effectiveness have been evaluated in the intensive user testing activity already performed. To complete effectiveness assessment, an answer was needed to the question: “Is the outcome worth the investment?“, answering this question means to evaluate the cost of the intervention, taking into consideration not only the financial aspect of a product developed for assisting people but also its social costs, the sum of costs incurred by all players. Starting from the estimated market price (identified in task 7.1 and reported in Deliverable D7.1) the social cost of the SRS system has been calculated, which considers also the service model, the maintenance cost, the assistance needed, etc.. The long term effectiveness of the SRS solution have been then examined in comparison with other assistive solutions, with the objective to assess effectiveness of a semi-autonomous robot assisting frail elderly persons to live independently in their houses, versus different traditional care situations including nursery home, family and / or professional caregiving at home and the use of Assistive Technology (AT) products like SRS system or other commercial alternative

products. The costs of assistance and of commercial products alternative to the SRS system were investigated by project partners in some European countries. The social cost of a non-intervention solution – the retirement in an assisted living facility – has been analyzed too. On this basis SRS Investment cost, maintenance cost and cost of services, were calculated for SRS to have an acceptable cost compared to the alternative solutions considered, commercial alternative products and retirement in an assisted living facility.

Chapter 2 analyses the ethical issues arisen during the project which have been divided in two main topics: whether the project has been conducted with proper attention to ethical issues and which strategies should be adopted to deal with ethical issues possibly raised by the use of the robot. In D1.1a we defined ethics as "all these issues that concern questions about life (and death), about revealing personal data, revealing diagnosis, about daily care and guidance, or about the application of protective or liberty-restraining measures". Research with vulnerable subjects implicates specific ethical challenges and involves additional measures that are needed for such research to be ethical (European Commission, 2010). We adopted four well known principles regarding this topic: non maleficence, beneficence, justice and respect for autonomy. Regarding strategies to deal with ethical issues possibly raised by the use of the robot the following topics were analyzed: data protection and privacy, Safety/accountability, Human welfare, Autonomy.

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1.1 INTRODUCTION

Effectiveness is a term used by research methodologists when referring to the attributes of a new health care intervention which, if lacking, may result in its rejection despite its efficacy and efficiency [1]. Effectiveness evaluation of an intervention helps to understand if it responds to the initial objectives which caused it. Due to the pressure to economize, increased consumerism and concerns about quality in relation to costs, the assessment of the outcome of assistive technologies has been given increasing attention. Care providers and consumers increasingly require evidence to ensure that a proposed new product not only works (efficiency) but is practical (effective). Making a deep analysis of the outcome of an Assistive Technology (AT) provided has the purpose to enhance the outcome itself. It seems to be a great challenge to demonstrate the efficacy of the application of new technology, to establish the effectiveness of assistive technology over time, to steer the development of new assistive technology [2] and also to perform well-designed studies that can deliver evidence in terms of effectiveness in the assistive technology field [3].

The increasing demand for evidence of the cost-effectiveness of AT products generated several research activities in this area [9],[10],[11],[12],[13]. The need for cost-effectiveness evidence comes not only from policy makers and financing agencies, who need such information to properly allocate resources and to control how efficiently they are used, but also from health care professionals who are expected – today more so than in the past – to be accountable for the economic implications of their decisions or prescriptions. Indeed, rehabilitation professionals need to know whether their AT choices have proved effective within the rehabilitation programme, whether they have been useful for the customer and have made efficient use of resources [14]. Studies on this issue began to appear in the literature only recently. Andrich et al. (1998) [15] depicted a conceptual framework for AT cost-effectiveness analysis.

Effectiveness on societal level is often considered in relation to costs, such as cost-effectiveness. Then effectiveness is regarded as the whole set of benefits potentially resulting from the introduction of any intervention. Common effectiveness qualities that might be considered in the formal evaluation of new rehabilitation devices and equipment are cost, convenience to the user ('user-friendliness'), and compliance with the local standards [3]. According to Gelderblom & de Witte (2002) [2], benefits can be expressed in financial units, utility measures or outcomes. On the other hand, costs are expressed in both financial and other terms, all following from the availability of the intervention. The cost-effectiveness of the intervention is then established by weighing the benefits against the costs.

When the benefits of the intervention can be expressed in financial units, obtaining a cost-benefit ratio is easy. Nevertheless, in the assistive technology field, decisions on the application of interventions are not so simple, because of the complexity of assistive technology outcomes originated from a) the diversity in contributing variables, b) outcome being a multidimensional concept, c) the embedding of an AT device, and d) the goals to be reached with an assistive device. The outcome of AT is made by a balanced positive effect on various dimensions: facilitation of activities of daily living, change in functional independence, user satisfaction, societal and individual gains, effects on participation, employment and social roles. Therefore, establishing the effect of AT may require more than one instrument depending on the type of question underlying the assessment [2].

Cost-effectiveness assessments have been conducted to study lower-limb prosthesis intervention [3], day care for people with severe mental disorders [4], dementia care [5] or tele-assistance integrated care for people with amyotrophic lateral sclerosis [6], showing cost-effective impact of assistive technologies in the daily life of their users. Lansley et al. (2004) [7] also showed that home environmental interventions and assistive technologies can substitute for and supplement formal care in frail older adults, and that in most cases the initial investment in assistive technologies is recouped through subsequently lower care costs within the average life expectancy of a user.

Mann et al. (1999) [8] evaluated a system of assistive technology and environmental intervention (AT-EI) service provision designed to promote independence and reduce health care costs for physically frail elderly persons through a randomized controlled trial with a total of 104 home-based frail older adults assigned to 1 of 2 groups (52 treatment, 52 control). All participants underwent a comprehensive functional assessment and evaluation of their home environment. Health care costs included costs of AT-EIs; in-home personnel, including nurses, occupational therapists, physical therapists, speech-language pathologists, case managers, and personal care aides; and institutional costs, including hospitalization and nursing home stays. For AT-EIs, they included both the equipment cost and personnel costs associated with assessment, training, and follow-up. As a result the treatment group expended more than the control group for AT and EIs, the control group required significantly more expenditures for institutional care. Results indicate rate of decline can be slowed, institutional and certain in-home personnel costs reduced, through a systematic approach to providing AT and EIs. Authors concluded that assistive technology and EIs offer the promise of more integrated services, including those that are preventive and support maintenance of independence at the lowest level of care.

1.2 COST-EFFECTIVENESS EVALUATION

The objective is to assess effectiveness of a semi-autonomous robot assisting frail elderly persons to live independently in their houses, versus different traditional care situations including nursery home, family and / or professional caregiving at home, the use of AT products, and the absence of intervention. We are fully aware that our review presents significant challenges because it focuses on how a specific intervention could affect the daily life of its users [3]. Furthermore, in a chronic sample in risk of dependency, the evidence for clinical effectiveness is not reasonable for improvements in physical health but limited to prolonging the time staying independently at their own home, as well as indirect benefits derived from staying of the frail old adult in his or her own place.

Because of that, we propose an analysis based on :

- a clinical approach: considering chronic complications of the elderly persons' difficulties for independent living (mild but constant, non-recoverable diseases), beyond interventions for concrete diseases, SRS looks for a wider solution based on a multi-role remote-controlled approach, providing solutions to the diversity of needs of a frail elderly person living alone at his or her home;

- a financial approach: financial analyses must be included, since costs vary longitudinally, current expenses and expenses expected in 5 years are different, and ignoring it would make our analysis unrealistic;

- a social approach: the role assigned to family members as potential remote-operators, because of that, not only paid professionals but also family caregivers have been included in the analysis.

A simulation has been developed in order to assess these assumptions about the effectiveness of a semi-autonomous robot assisting frail elderly persons. In this direction, the first thing to do in this task has been to explain the different possibilities of home or institutional care for an elderly person with difficulties for independent living, taking into account the different actors involved in the general context of the project explained in D1.1. Since the life expectancy of a frail, elderly person is limited, we have taken a time reference of 5 years, instead of a longer period. The different care options considered are based on the preliminary scenario included in the SRS Document of Work. Although more concrete situations have been developed within the project, scenarios included in DoW represent a wider and more market-based view. In our simulation, the user would be a frail elderly person living alone in her home. She is about 77 years old (or older). Since she needs some kind of help because of the increase in her difficulties in daily living, decision has to be taken between several options in order to promote her independent living and quality of life. Persons involved in this situation would be the elderly person, family caregivers, and traditional care providers (professional caregivers).

Some characteristics of effectiveness have already been evaluated in the intensive user testing activity already performed; now, to have a more complete effectiveness assessment, an answer is needed to the question: “Is the outcome worth the investment?“. Answering this question means to evaluate the cost of the intervention, taking into consideration not only the financial aspect of a product developed for assisting people but also its social costs, the sum of costs incurred by all players. The purchase price is not a meaningful indicator of the social cost. The social cost depends to a large extent on how the Assistive Device is used and on the environment, as well as on the role of the device within the whole assistive program. The triad person / activity / environment, as well as determining the criteria for choosing a particular Assistive Solution, influences the overall social cost.

The most appropriate indicator of the cost of an intervention should take into account that:

- The costs are distributed among several actors: social cost could be seen as the sum of costs incurred by all players,
- Some costs have to be considered as fixed (independent from the specific solution chosen), some other costs instead are marginal (depending on the specific system selected for care),
- The cost of the intervention has to be compared with the cost of "non-intervention" : what matters is the additional cost occurring in this case.

SCAI (SIVA Cost Analysis Instrument)[16] is a specific instrument for social cost analysis designed to help clinicians estimate the economic aspects of providing individual users with assistive technology solutions. It is an informative instrument that, used during clinical assessment, makes clinicians and users aware of the economic consequences of their decisions. It is designed to help in the estimation of the cost of selecting a particular solution for autonomy (aid, personal care, environmental adaptations ...) and to economically compare the various alternative options.

The SCAI analysis doesn’t consider inflation or discounting because – on the one hand – it would make the analysis dramatically complicate; on the other hand SCAI focuses on the comparison between the costs of different solutions rather than on the absolute cost figures related to each solution. Indeed inflation and discounting calculation would affect only the absolute cost figures while their relative ratio (which is the actual focus of the analysis) would stay unchanged.

The SCAI “social cost” approach is not usual in public Service Delivery Systems. They usually look just at the purchase price of the assistive device, which would seem at a first glance the most logical indicator to describe whether an AT solution is cheap or expensive: unfortunately this perspective often leads to severe distortions in the cost-outcome analysis.

Conversely, SCAI estimates the additional social cost generated by the chosen solution over a certain period of time. This basically includes four cost categories:

- Investment: cost of purchasing the equipment and having it installed, personalized and ready-to-use. This also includes the provision of adequate training for the customer.
- Maintenance: running costs of technical maintenance; depending on the case, this may include repairs, insurance, power supply, etc.
- Services: other services that may be needed in relation to the chosen AT solution (e.g. a bulky powered wheelchair might require specialized minibus transport instead of a cheaper ordinary bus).
- Assistance: the amount of human assistance needed in relation to the device (e.g. a pushchair works only if a personal assistant is there to push), independently of whether that manpower is paid for, or offered for free by relatives or friends or volunteers.

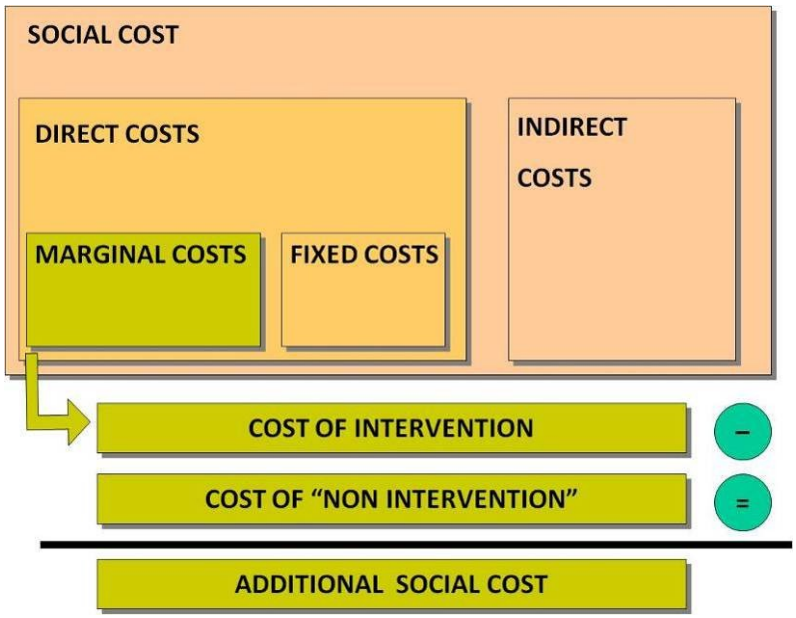

FIGURE 1: Types of costs considered in the SCAI analysis.

In order to better explain the way in which SCAI instrument analyzes social costs, some definitions are needed:

- Social Cost: The set of all resources used in a certain period of time by all actors involved (e.g. family, National health system facilities, City, volunteering, etc. ..) ,
- Direct Social Costs: The total costs that can be recognized as directly related to the choice of that particular solution,
- Indirect costs: The total costs that can be recognized not directly related to the choice of that particular solution, which indeed are present whatever solution is chosen,
- Fixed costs: The costs which are related to the particular solution but which are present in the same amount whatever the solution is,
- Additional Social Cost: Cost Difference between the social cost of intervention, and that in the absence of intervention. This difference can be>0 (investment), zero (moving resources) or <0 (savings),
- Expenditure: The actual outlay of money by the different "co-financing" actors,
- Time horizon: For how many years the costs need to be accounted for:
    - Clinical duration: Within the time horizon, how many years that type of AT will be useful to the user,
    - Technical duration: lifespan of the system.

The most intriguing issue is about what scenario should be considered as "non-intervention". With respect to SRS, various options can be considered;

- simply no help at home (which implies loss of autonomy and the related ethical consequences);
- a human caregiver at home (which however may imply loss of privacy)
- moving to an assisted living facility.

The SRS, in conjunction with other actors, could represent an interesting alternative.

In the following chapters, a cost comparison between the introduction of SRS and the use of currently available tele-alarm, tele-monitoring and tele-presence systems will be provided. Indeed these systems currently represent the most comparable and widespread technological alternatives to the innovative solution proposed by the SRS system.

1.2.1 PRODUCT DEFINITION

Before starting with SCAI analysis, the main features of SRS Product are reported.

SRS is a service robot able to provide frail elderly people with the assistance they need to prolong independent living at their own home. The robot can find and bring objects that are placed in different places at home to elderly people with mobility difficulties due, for example, to arthritis, Parkinson's or other common diseases of old age. The robot can also help the elderly to initiate a video call with a healthcare professional, or family members, to allow them to remotely monitor health conditions of the elderly during an emergency. The robot also offers help to authorized healthcare/homecare providers and family members to 'virtually' enter an elderly persons home, checking around the house and carrying out a 'natural visit' as if they were actually present in the house.

1.2.1.1 USERS

The categories of people which interact with SRS system follow:

- Elderly people living in their original private home or in assisted living facilities such as sheltered accommodation and retirement complex with the focus on independent living: having difficulties with instrumental activities of daily living, prone to falling or if there is the occurrence of other emergency situations,
- Informal caregivers (family, friends) caring for an elderly person, as specified above, and potential caregivers who are willing to provide care but have so far been unable due to geographical distance (in Europe, the nearest child of adults above 70 lives more than 1km away for the 51% of them and more than 25km away for the 16%) [17],
- Professional tele-assistants, available 24 hours a day in a service center (can be current employees of home tele-assistance centers for elderly people having received training for robot remote assistance).

1.2.1.2 SPECIFIC FEATURES OF THE SYSTEM

SRS system features follow:

- Mobile platform: Care-o-bot 3-Omni-directional: Base size approx. 600 mm, overall height is around 1500 mm, four driven wheels, Li-ion battery pack, laser scanners, and a PC for navigation tasks;
- Robotic arm: Schunk LWA3 modular 7-DOF (120 mm max extension), connected to three finger gripper with tactile sensors;
- Retractable tray for carrying objects;
- Motorized sensor head containing high-resolution fire-wire (IEEE 1394) stereo-vision cameras and 3-D time of flight cameras, enabling the robot to identify, to locate and to track objects and people in 3-D. These sensors are mounted on a 4 DOF positioning unit allowing the robot to direct its sensors to any area of interest;
- Touch screen integrated in the tray, microphones, speakers, and colored LEDs;

- Navigation system allowing the robot to find its way to locations in the home, avoiding humans and obstacles;
- Image processing abilities allowing the robot to learn and later recognize and localize objects like bottles or cups;
- Ability to detect geometric environment features such as planes in order to identify tables or walls;
- Ability to identify grasp configurations and plan arm movements to grasp objects autonomously.
- Supposed Technical duration: 5 years

1.2.1.3 HUMAN ROBOT INTERACTION DEVICES

Each user group has a different device for interacting with the robot. The devices and their user interfaces scale in their portability and capabilities:

- UI-LOC: smartphone-sized touchscreen device for local elderly user, portable but with only easy-to-use basic functions focusing on autonomous robot services;
- UI-PRI: tablet computer for remote caregivers, portable and always connected but larger, making some semi-autonomous navigation and grasping functions as well as tele-operated navigation is possible;
- UI-PRO: PC with 3D interaction devices for professional tele-assistants, desk-based with the widest range of possible interventions including tele-operated grasping.

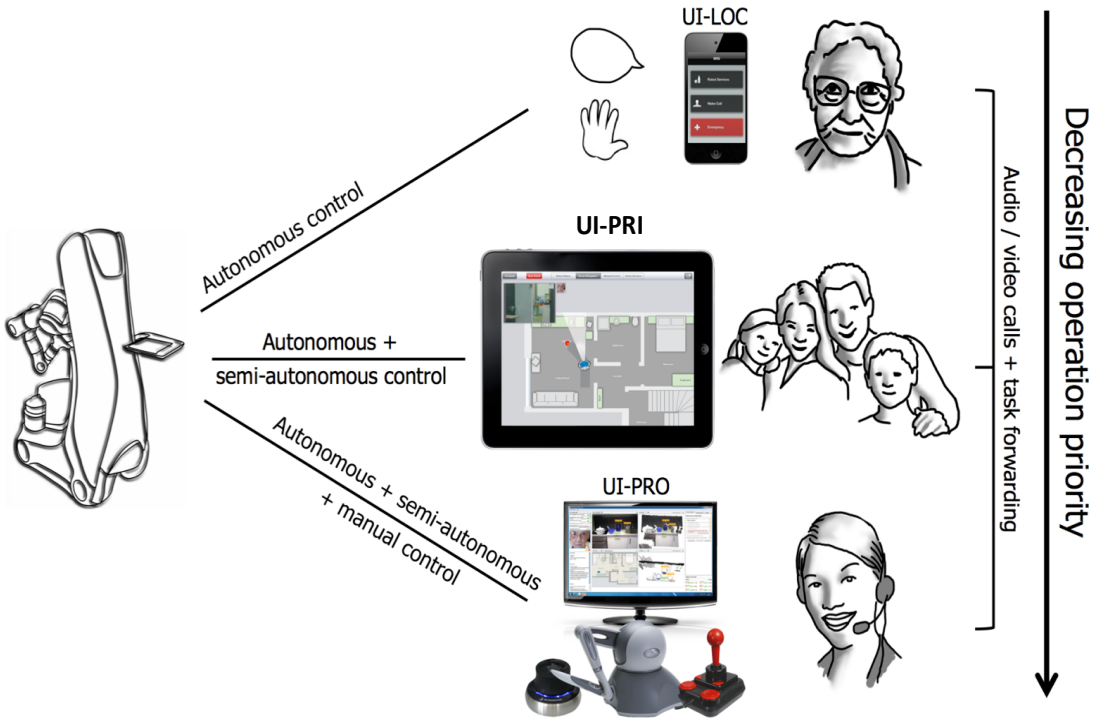

FIGURE 2: SRS human robot interaction devices

1.2.1.4 ROBOT SERVICES

Fetch, carry and manipulation: Grasping objects and delivering them to a different location, opening doors or pressing buttons, these are basic required functions of a manipulating robot and key to achieving a large number of other, more specialized applications (e.g. objects low on the ground and high up are often difficult to reach, also heavy objects can be problematic).

Emergency assistance: The elderly person places an emergency call (e.g., in case of a fall). A remote operator moves the robot to the emergency location and assesses the health status or type of injury through the robot's cameras. The operator can also use fetch-carry, e.g. to bring medicine, or open the apartment door for the ambulance.

To continue living at own home, frail elderly people often need for some help, that of course varies according to the specific difficulties of the person. However, comparing needs of elderly people with difficulties that can now be solved by some daily help offered by family or professional caregivers and security devices, the SRS system could represent a good solution to give the elderly more independence lowering at the meanwhile the time dedicated by family or other caregivers in assisting the elderly.

However the SRS robot and other commercial product considered could not help with all activities of daily living considered difficult for the elderly (e.g. helping people with personal hygiene, accompany the elderly to take a walk, make grocery shopping and prepare a full meal). For this reason the proposed alternative solutions will take into account the complementary presence of a family member or a professional operator for some hours per day, the number of hours depends on the services the AT solution considered can provide.

1.2.2 SCAI ANALYSIS

A comparison between different possible assistive alternative solutions has been made with the help of the SCAI worksheet: some of them involve the SRS system with different personal assistance settings, provided either by relatives or professional caregiver; others involve currently available commercial solutions for remote assistance by means of monitoring, tele-alarms and remote communication. Each commercial system needs a different amount of assistance to allow the elderly to live autonomously and safely in their home.

Finally, the retirement to an assisted living facility has also been considered as a possible alternative solution – or rather a non-intervention.

Tele-alarm systems are systems which allow the elderly to press a button on a wearable remote control in case of emergency thus to contact a tele-assistance service available around the clock. The SOS Center identifies the origin of the call and activates the emergency services required, providing them with all the information and putting also in hands-free contact the emergency services and end users.

As these systems provide only partially the possibilities of SRS, their use still require a higher level of assistance from family members or professional caregivers.

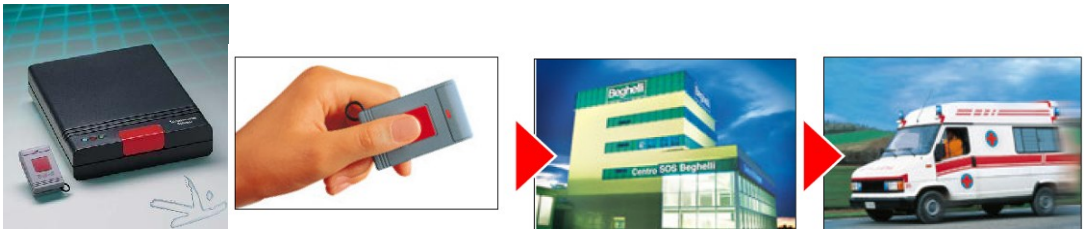

FIGURE 3: An example of commercial Italian tele-alarm system

TELE-SALVALAVITA (manufacturer BEGHELLI S.p.A.)

FIGURE 4: An example of commercial British tele-alarm system

KOMPANION YELLOW PACKAGE (manufacturer Seniorlink Eldercare LLP)

FIGURE 5: A Spanish SOS center

Monitoring systems usually monitor the person and his/her living environment, can operate even if the person is unconscious, detect his/her movements, his/her localization (even when the person is exiting a security area), environmental data, the systems can memorize data collected and/or send SMS, the elderly can also triger an alarm.

This kind of systems don't give any assistance to the elderly for daily activities (i.e. catching objects not reachable or heavy), but by monitoring his/her movements and localization it implies that less hours of surveillance would be necessary.

FIGURE 6: An example of commercial Italian monitoring system

CONTEXTA-CARE (manufacturer: Contexta Network Solutions)

FIGURE 7: An example of commercial British monitoring system

KOMPANION (manufacturer: Seniorlink Eldercare LLP)

Remote communication systems allow family members and caregivers to put a call to check the elderly and his/her home status, the elderly can also make calls if assistance is required. The system can move around the home (maybe controlled remotely) and allow interaction with the resident there via videoconferencing.

This kind of systems don't give any assistance to the elderly for daily activities (i.e. catching objects not reachable or heavy), but by monitoring his/her status through a video call it implies that less hours of surveillance would be necessary.

FIGURE 8: An example of commercial remote communication system

GIRAFF (manufacturer: Giraff Technologies AB)

1.2.2.1 DESCRIPTION OF DIFFERENT ASSISTIVE SOLUTIONS

The assistive solution can be obtained combining different assistive devices and personal assistance in various quantities, the alternative solution of the elderly person retiring in an assisted living facility is also considered. The progressive numbers associated to the different solutions will be reported in the cost analysis simulation using SCAI worksheet reported in par. 1.2.2.2.

1.2.2.1.1 SOLUTION 1: SRS + FAMILY

Elderly at home:

- SRS system purchase/rent,
- 24 hour tele-assistance service adoption,
- family assisting for specific activities 2 hours 30 minutes per day at home and 30 minutes as remote operator.

An example of daily routine:

Actors:

Elderly person: Mrs. Rosa , 77 years old;

Daughter of Mrs. Rosa: living in the same city of the mother, helping her in the daily routine;

Son of Mrs. Rosa: living in another city, helping his mother acting as SRS remote operator;

Professional tele-operator: tele-operator of the 24h service, helping Rosa remotely with emergencies or other tasks not involving family.

Early morning: The daughter of Mrs. Rosa (before going to work) goes to her mother's house, checks her health status, helps her with her main difficulties while toileting, prepares medicines she has to take during the day and prepares the lunch so that Rosa will need only to heat it.

Late morning: To check if everything is alright at Rosa's home, the son initiates from his workplace a request for a remote session with SRS during a pause. Rosa accepts the request on the portable communication device and the video communication is established. Rosa states that today she is not feeling well, unable to get up to reach some

water for taking medicines for her needs. The son sends the robot to the kitchen, makes it bring the medicine, a glass and a bottle of water to her mum. Rosa and her son greet each other and agree to contact each other later.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf but she doesn't want to disturb a relative for this task, knowing that they are all at work, so Rosa calls directly for a professional remote operator. A remote operator answers the call, Rosa explains that she was not able to fetch the desired book. The remote operator uses the professional manual mode to make the robot grasp the book and bring it to Rosa. They greet each other and the call ends.

Late afternoon: The daughter comes back to her mother house; they go outside for a short walk and to buy something for the dinner.

Evening: The daughter, reached by the rest of her family in Rosa's home, prepares dinner and they eat all together. Finally she checks that everything is ok for the night, says goodnight to Rosa and goes home with her family.

Night: Rosa needs to go to the bathroom but feels bad on the way. She falls, and unable to get up again. With the device she always carries around her neck, she calls "emergency". Right away, a call is placed to the 24-hour tele-assistance center. The 24-hour center first accepts the call, then following Rosa direction, sends the robot near her. Because Rosa can no longer move the legs due to strong pain, the two decide to call an ambulance and the family. The remote operator keeps monitoring and talking to Rosa until someone arrives at home. The daughter was warned in the meanwhile, she joins the remote session just to reassure her mum that she is already coming in person.

1.2.2.1.2 SOLUTION 2: SRS + PROFESSIONAL CAREGIVER

Elderly at home:

- SRS system purchase/rent,
- 24 hour tele-assistance service adoption,
- professional caregiver assisting for specific activities 2 hours 30 minutes per day at home,
- family assisting 30 minute per day as remote operator or during visits helping in daily activities.

An example of daily routine:

Actors:

Elderly person: Mrs. Rosa , 77 years old;

Francesca: Professional caregiver, helping her in the daily routine;

Son of Mrs. Rosa: living in another city, helping his mother acting as SRS remote operator;

Professional tele-operator: operator of the 24h service, helping remotely Rosa with emergencies or other tasks not involving family;

Daughter of Mrs. Rosa: living in the same city of the mother, going to visit the mother twice a week.

Early morning: Mrs. Rosa gets up, prepares and takes her breakfast, and seats on the sofa to watch TV.

Morning: To check if everything is alright at Rosa's home, the son initiates from his workplace a request for a remote session with SRS during a break. Rosa accepts the request on the portable communication device and the video communication is established. Rosa states that today she is not feeling well, unable to get up to fetch drinks , and cannot take medicines which she needs. The son sends the robot to the kitchen, makes it bring the medicines, a glass and a bottle of water for her. They greet each other and agree to contact each other later.

Late morning: Francesca arrives, checks Rosa health status, helps her with her main difficulties while toileting. Francesca and Rosa go outside for a short walk and to buy something. Back home Francesca cooks lunch. Before going away she prepares the dinner (so that Rosa will need only to heat it up), and prepares the medicines Rosa will have to take in the next 24 hours.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf but she doesn't want to disturb a relative for this task, knowing that they are all at work, so Rosa calls directly for a professional remote operator. A remote operator answers the call, and she explains that she was not able to fetch the desired book. The remote operator uses the professional manual mode to make the robot grasp the book and bring it to her. They greet each other and the call ends.

Evening: The daughter has a late shift and it is too late to visit the mother; so she just makes her a phone call after dinner.

Night: Rosa needs to go to the bathroom but feels bad on the way, falling unable to get up again. With the device she always carries around her neck, she calls "emergency". Right away, a call is placed to the 24-hour tele-assistance center. The 24-hour center first accepts the call, then following Rosa direction sends the robot near her. Because Rosa can no longer move the legs due to strong pain, the two decide to call an ambulance and the family. The remote operator keeps monitoring and talking to Rosa until someone arrives at home. The son, warned in the meanwhile, joins the remote session to verify what happens. The doctor arrives, verifies that she is feeling better and decides that it is not necessary to take her to the hospital. Rosa goes to bed and talks a little more with her son through the remote session, they greet each other and the call ends.

1.2.2.1.3 SOLUTION 3: TELE-ALARM + PROFESSIONAL CAREGIVER

Elderly at home:

- Tele-alarm system for rent, plus service,
- professional caregiver for specific activities 5 hours 30 minutes per day at home,
- family helping in daily activities 2 hours twice a week.

An example of daily routine :

Actors:

Elderly person: Mrs. Rosa , 87 years old;

Francesca: Professional caregiver, helping her in the daily routine;

Professional tele-operator: operator of the 24h service, helping remotely Rosa with emergencies;

Daughter of Mrs. Rosa: living in the same city of the mother, going to visit the mother twice a week.

Morning: Mrs. Rosa gets up, prepares and takes her breakfast, and seats on the sofa to watch TV.

Late morning: Francesca arrives, checks Rosa health status, helps her with her main difficulties while toileting. Francesca and Rosa go outside for a short walk and to buy something. Back home Francesca cooks lunch.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf and asks Francesca to do it for her. Before going away Francesca prepares the dinner (so that Rosa will need only to heat it up), and the medicines she will have to take in the next 24 hours.

Late afternoon: Left alone Rosa is not feeling well, with the device she always carries around her neck, pressing its button, she calls "emergency". Right away, a call is placed to the 24-hour tele-assistance center. The SOS Center identifies the origin of the call and activates an hands-free call to check the situation, Rosa is not close to the hands-

free calling device but can talk to each other with the operator tells how she feels. The operator checks the medicine list Rosa has to take during the day and talking to Rosa. The operator realizes that she did not take one of the key medicines, hence recommends Rosa to take it now and to make another call if she will not feel better.

Evening: The daughter has a late shift and it is too late to visit the mother; so she just makes her a phone call after dinner, Rosa tells her about the alarm call she made in the afternoon but says that now, after having taken the medicine, she is feeling better.

Night: Rosa needs to go to the bathroom but feels bad on the way. Shee falls and unable to get up again. With the device she always carries around her neck, pressing its button, she calls "emergency". Right away, a call is placed to the 24-hour tele-assistance center. The SOS Center identifies the origin of the call and activates a hands-free call to check the situation; Rosa is not close to the hands-free calling device but can talk to each other with the operator. Because Rosa can no longer move the legs due to strong pain, the two decide to call an ambulance and the family. The remote operator provides the emergency service with all the information and keeps talking to Rosa until someone arrives at home. The daughter, warned in the meanwhile, comes over and waits for emergency service with her mother.

1.2.2.1.4 Solution 4: Smart home monitoring system + Professional caregiver

Elderly at home:

- Tele-monitoring system purchase,
- professional caregiver for specific activities 3 hours 30 minutes per day at home,
- family assisting 1 hour 30 minutes per day in presence or from remote.

An example of daily routine:

Actors:

Elderly person: Mrs. Rosa , 77 years old;

Daughter of Mrs. Rosa: living in the same city of the mother, helping her in the daily routine;

Son of Mrs. Rosa: living in another city, assisting his mother from remote;

Francesca: Professional caregiver, helping her in the daily routine.

Early Morning: Mrs. Rosa, wearing monitoring system sensors, gets up, prepares and takes her breakfast, seats on the sofa to watch TV. The daughter receives messages from the monitoring system reporting that her mother is not feeling well, the daughter phones Rosa and realizes that Rosa forgets to take her medicines, recommends her to take them, greet each other and agree to hear each other later.

Late morning: Francesca arrives and helps Rosa with her main difficulties while toileting. Francesca and Rosa go outside for a short walk and to buy something. Back home Francesca cooks lunch.

Lunch: Rosa's son, who received in the morning messages from the monitoring system, too, had been reassured by his sister that their mother took medicines already and felt better; he calls home to check if everything is alright, Francesca and Rosa confirm him that the mother is feeling better now.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf and asks Francesca to do it for her. Before going away Francesca prepares the dinner (so that Rosa will need only to heat it up), and the medicines she will have to take in the next 24 hours.

Evening: Rosa's son did not receive any more messages from the monitoring system, he makes a phone call to his mother, and confirmed everything is alright.

Night: Rosa needs to go to the bathroom but feels bad on the way, falling unable to get up again. Through the sensors she always wears the monitoring system detects a dangerous situation and sends an automatic alarm to the sons indicating the room where Rosa is laying on the floor. The daughter reaches Rosa, she can no longer move the legs due to strong pain, the two decide to call an ambulance.

1.2.2.1.5 SOLUTION 5: REMOTE COMMUNICATION SYSTEM + PROFESSIONAL CAREGIVER

Elderly at home:

- Remote communication system,
- professional caregiver for specific activities 4 hours 30 minutes per day at home,
- family communicating 1 hour per day from remote.

An example of daily routine:

Actors:

Elderly person: Mrs. Rosa , 77 years old;

Son of Mrs. Rosa: living in another city, communicating his mother from remote;

Francesca: Professional caregiver, helping her in the daily routine.

Early Morning: Mrs. Rosa gets up, prepares and takes her breakfast, and seats on the sofa to watch TV.

Morning: To check if everything is alright at Rosa's home, the son initiates from his workplace a request for a remote communication during a pause. Rosa accepts the request, the device reaches her and the video communication is established. Rosa states that today is not feeling well, he asks her if she took her medicines this morning and realizes she didn't, he recommends her to take them, they greet each other and agree to contact each other later.

Late morning: Francesca arrives, checks Rosa health status, she is feeling better now, helps her with her main difficulties while toileting. Francesca and Rosa go outside for a short walk and to buy something. Back home Francesca cooks lunch.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf and asks Francesca to do it for her. Before going away Francesca prepares the dinner, so that Rosa will need only to heat it, and the medicines she will have to take in the next 24 hours.

Evening: Rosa's son initiates from his house a request for a remote communication. Rosa accepts the request, the device reaches her and the video communication is established, everything is alright.

Night: Rosa needs to go to the bathroom but feels bad on the way, falling unable to get up again. Through the remote control she always carries the system sends a request for a visit to her son. The son accepts the request, the device reaches Rosa, the son communicates with her telling her that he will call an ambulance. The doctor arrives, verifies that she is feeling better and decides that it is not necessary to take her to the hospital. Rosa goes to bed and talks a little more with her son through the remote session, they greet each other and the call ends.

1.2.2.1.6 SOLUTION 6: TELE-ALARM + SMART HOME MONITORING SYSTEM + PROFESSIONAL CAREGIVER

Elderly at home:

- Smart home monitoring system,
- tele-alarm system for rent plus service,

- professional caregiver for specific activities 3 hours per day at home,
- family assisting 1 hour 30 minutes per day in presence or from remote.

An example of daily routine :

Actors:

Elderly person: Mrs. Rosa , 77 years old;

Daughter of Mrs. Rosa: living in the same city of the mother, helping her in the daily routine;

Son of Mrs. Rosa: living in another city, assisting his mother from remote;

Francesca: Professional caregiver, helping her in the daily routine.

Early Morning: Mrs. Rosa, wearing monitoring system sensors, gets up, prepares and takes her breakfast, seats on the sofa to watch TV. The daughter receives messages from the monitoring system reporting that her mother is not feeling well, phones her and realizes that she did not remember to take her medicines, recommends her to take them, greet each other and agree to hear each other later.

Late morning: Francesca arrives and helps Rosa with her main difficulties while toileting. Francesca and Rosa go outside for a short walk and to buy something. Back home Francesca cooks lunch. Rosa's son, who received in the morning messages from the monitoring system, too, had been reassured by his sister that their mother took medicines and felt better, he calls home to check if everything is alright, Francesca and Rosa confirm him that the mother is feeling better now.

Afternoon: Rosa does not feel safe climbing a ladder. She wants to fetch a book on a shelf and asks Francesca to do it for her. Before going away Francesca prepares the dinner (so that Rosa will need only to heat it up), and the medicines she will have to take in the next 24 hours.

Evening: Rosa's son, did not receive any more message from the monitoring system, and makes a phone call to his mother, everything is alright.

Night: Rosa needs to go to the bathroom but feels bad on the way, falling unable to get up again. Through the sensors she always wears the monitoring system detects a dangerous situation and sends an automatic alarm to her sons indicating the room where Rosa is laying on the floor, in the meantime with the device she always carries around her neck, pressing its button, she calls "emergency". Right away, a call is placed to the 24-hour tele-assistance center. The SOS Center identifies the origin of the call and activates a hands-free call to check the situation; Rosa is not close to the hands-free calling device but can talk to each other with the operator. Because Rosa can no longer move the legs due to strong pain, the two decide to call an ambulance. The remote operator provides the emergency service with all the information and keeps talking to Rosa until someone arrives at home. The daughter, who is warned in the meanwhile, calls her mother and decides to come over and wait for emergency service with her mother.

1.2.2.1.7 SOLUTION 7: RETIRING IN ASSISTED LIVING FACILITY

The last possible solution considered is the retirement of the elderly person in an assisted living facility. In fact, even if the frail elderly is autonomous in many activities, he or she would find assistance in an assisted living facility. They can not be left alone for difficult activates in case of fall or faint.

1.2.2.2 SCAI WORKSHEET: FROM A SPECIFIC EXAMPLE TO A GENERAL COST HYPOTHESIS

The SCAI worksheet is composed by different sections. In the first one, reported in Table 1, analyzing the situation of the typical SRS user, the case and the objectives to be reached are described.

Clinical background
Frail elderly person having difficulties with instrumental activities of daily living, prone to falling or there is the occurrence of other emergency situations
Personal and social background
Elderly person living in original private home. He/she keeps living at home despite needing assistance from family members and/or professional caregivers for some hour every day.
Objectives of the programme
Autonomy and safety at home.
Expected developments in case no intervention is carried out
Moving to assisted living facilities.
Expected results in relation to individual expectations
For elderly people: Keep living at home, increasing autonomy in activities of daily living, increasing safety.
Expected results in relation to family (or primary network) expectations
For the family members: Monitoring and better managing emergency situations, giving assistance around the clock.
Expected results in relation to expectations of the caring professionals
Decreased need to resort to assisted living facilities.
Expected results in relation to expectations of the community
Optimization of the community home care network.

Time span of the analysis	5 years	*Time considered long enough for a social cost analysis*
Clinical duration	5 years	*Time indicated to consider stable health condition of an elderly people*

TABLE 1 – FIRST PART OF THE SCAI WORKSHEET: INDRODUCTORY INFORMATION

An analysis made by project partners brought to the values, reported in Table 2, of costs of assistance in Italy (IT), Spain (ES) and Great Britain (GB). The costs for assistance by relatives, which don't involve any disburse of money (expenditure), have been valuated with the same hourly cost of professional caregiver.

Valuation of personal assistance costs	Hourly cost	Hourly expenditure
Family-IT	10 euro	
Professional caregiver-IT[1]	10 euro	10 euro
Family-ES	10,6 euro	

[1] Costs of human assistance are based on Italian current values and are based on national contract of home professional caregivers and data furnished by service companies

Professional caregiver-ES[2]	10,6 euro	10,6 euro
Family-GB	16 euro	
Professional caregiver-GB[3]	16 euro	16 euro

TABLE 2 – VALUATION OF COST ASSISTANCE IN ITALY, SPAIN AND GREAT BRITAIN

The analysis made in the exploitation plan, whose results are reported in D7.1, led to an estimated SRS purchase price of 250.000€ at 2013. The possible cost of SRS annual costs for maintenance (power supply + technical assistance) and services (availability of a remote professional operator 24h) are 1.000 € and 2.000€ respectively; the SRS technical duration has been set to 5 years because it has been presumed that after that period technological obsolescence would cause the need to purchase a next release of the product.

As the time span of our analysis overlaps perfectly with the SRS technical duration, no residual value for the product would be present at the end of the period.

Based on these assumptions, a social cost analysis has been carried out with the help of the SCAI worksheet, as reported in Table 3 and Table 4.

The scenarios analyzed in Table 3 involve ***the use of the SRS system***: the social costs of the two solutions described in Paragraphs 1.2.2.1.1 and 1.2.2.1.2 have been evaluated for the three countries considered. The amount of personal assistance needed by the elderly person can be provided totally by the family (solution 1) or by the family plus professional caregivers (solution 2). The cost analysis reveals that – if the total amount of hours of personal assistance is the same, as one may reasonably expect, independently of who is providing it – the social cost doesn't change even if the expenditure is different (the time spent by the family must be considered in the economic analysis, even if it has no financial impact).

The row "valuation of assistance" in Table 3 also reveals that - within the countries considered - the average value of personal assistance needed in conjunction with SRS accounts to 66.000€.

[2] "Perspectivas de futuro de los servicios de atención a la dependencia. El Servicio de Atención a Domicilio (SAD)", Martínez Meseguer, José Luís (2008), n.p. Deloitte page: 41-59

[3] Laing & Buisson, Domiciliary Care UK Market Report 2011

	Solution 1	Solution 2	Solution 1	Solution 2	Solution 1	Solution 2
	SRS + family(IT)	SRS + prof.careg. at home(IT)	SRS + family(ES)	SRS + prof.careg. at home(ES)	SRS + family(GB)	SRS + prof.careg. at home(GB)
Parameters						
Technical duration years	*5*	*5*	*5*	*5*	*5*	*5*
Recyclable ? (1>YES 0>NO)	*1*	*1*	*1*	*1*	*1*	*1*
Reusable ? (1>YES 0>NO)	*1*	*1*	*1*	*1*	*1*	*1*
Investment						
Overall cost	€ 250.000	€ 250.000	€ 250.000	€ 250.000	€ 250.000	€ 250.000
Maintenance						
Yearly cost	€ 1.000	€ 1.000	€ 1.000	€ 1.000	€ 1.000	€ 1.000
Services						
Yearly cost	€ 2.000	€ 2.000	€ 2.000	€ 2.000	€ 2.000	€ 2.000
Assistance family-IT						
actions/month	*30*	*30*				
minutes/action (+ waiting)	*180*	*30*				
Assistance prof-IT						
actions/month		*30*				
minutes/action (+ waiting)		*150*				
Assistance family-ES						
actions/month			*30*	*30*		
minutes/action (+ waiting)			*180*	*30*		
Assistance prof-ES						
actions/month				*30*		
minutes/action (+ waiting)				*150*		
Assistance family-GB						
actions/month					*30*	*30*
minutes/action (+ waiting)					*180*	*30*
Assistance prof-GB						
actions/month						*30*
minutes/action (+ waiting)						*150*
Investment cost	*€ 250.000*	*€ 250.000*	*€ 250.000*	*€ 250.000*	*€ 250.000*	*€ 250.000*
- Residual value						
+ Maintenance cost	*€ 5.000*	*€ 5.000*	*€ 5.000*	*€ 5.000*	*€ 5.000*	*€ 5.000*
+ Cost of services	*€ 10.000*	*€ 10.000*	*€ 10.000*	*€ 10.000*	*€ 10.000*	*€ 10.000*
+ Valuation of Assistance	*€ 54.000*	*€ 54.000*	*€ 57.240*	*€ 57.240*	*€ 86.400*	*€ 86.400*
= Social Cost	**€ 319.000**	**€ 319.000**	**€ 322.240**	**€ 322.240**	**€ 351.400**	**€ 351.400**
Expenditure	*€ 265.000*	*€ 310.000*	*€ 265.000*	*€ 310.000*	*€ 265.000*	*€ 310.000*

TABLE 3 – SCAI WORKSHEET USED TO CALCULATE SOCIAL COST OF SRS SYSTEM ADOPTION IN THE THREE COUNTRIES TAKEN IN EXAM

Table 4 shows the results of the SCAI analysis applied to various other commercially available solutions for remote home care, as described in Paragraphs 1.2.2.1.3, 1.2.2.1.4, 1.2.2.1.5, 1.2.2.1.6. Possible alternatives have been analysed in different countries (Italy, Spain, Great Britain) along with the related costs for home assistance by the family and by professional caregivers.

Table 4 reveals that - within the countries considered - the average value of social costs of commercial solutions alternative to SRS accounts to 110.000 €.

	Solution 3	Solution 3	Solution 4	Solution 5	Solution 6	Solution 6
	TeleAlarm + prof.careg. at home(IT)	TeleAlarm + prof.careg. at home(ES)	TeleMonitor + prof.careg. At home(IT)	Remote comm. + prof.careg. at home(IT)	Tele(alarm+monit) + prof.careg. at home(ES)	Tele(alarm+monit) + prof.careg. at home(GB)
Parameters						
Technical duration years	*5*	*5*	*7*	*5*	*5*	*5*
Recyclable ? (1>YES 0>NO)	*1*	*1*	*1*	*1*	*1*	*1*
Reusable ? (1>YES 0>NO)	*1*	*1*	*1*	*1*	*1*	*1*
Investment						
Overall cost			€ 7.500	€ 7.000		€ 100
Maintenance						
Yearly cost			€ 1.000	€ 600		
Services						
Yearly cost	€ 100	€ 300			€ 900	€ 246
Assistance family-IT						
actions/month	*8*		*30*	*30*		
minutes/action (+ waiting)	*120*		*90*	*60*		
Assistance prof-IT						
actions/month	*30*		*30*	*30*		
minutes/action (+ waiting)	*330*		*210*	*270*		
Assistance family-ES						
actions/month		*8*			*30*	
minutes/action (+ waiting)		*120*			*90*	
Assistance prof-ES						
actions/month		*30*			*30*	
minutes/action (+ waiting)		*330*			*180*	
Assistance family-GB						
actions/month						*30*
minutes/action (+ waiting)						*90*
Assistance prof-GB						
actions/month						*30*
minutes/action (+ waiting)						*180*
Investment cost			*€ 7.500*	*€ 7.000*		*€ 100*
- Residual value			*-€ 2.143*			
+ Maintenance cost			*€ 5.000*	*€ 3.000*		
+ Cost of services	*€ 500*	*€ 1.500*			*€ 4.500*	*€ 1.230*
+ Valuation of Assistance	*€ 108.600*	*€ 115.116*	*€ 90.000*	*€ 99.000*	*€ 85.860*	*€ 129.600*
= Social Cost	**€ 109.100**	**€ 116.616**	**€ 100.357**	**€ 109.000**	**€ 90.360**	**€ 130.930**
Expenditure	*€ 99.500*	*€ 106.440*	*€ 75.500*	*€ 91.000*	*€ 61.740*	*€ 87.730*

TABLE 4 - SCAI WORKSHEET USED TO CALCULATE SOCIAL COST OF COMMERCIAL PRODUCT ALTERNATIVE TO SRS

As mentioned above, the social cost of a non-intervention solution – the retirement in an assisted living facility – has to be analyzed too. A survey made in Italy, Spain and Great Britain led to the values of cost per year for assisted living facilities reported in Table 5. Table 6 shows the calculation of social costs, on the considered time horizon.

Italy[4]	Spain[5]	Great Britain[6]
29.548 €	22.489 €	33.706 €

TABLE 5 – COSTS PER YEAR OF ASSISTED LIVING FACILITIES IN ITALY, SPAIN, GREAT BRITAIN

	Solution 7	Solution 7	Solution 7
	Elderly in assisted living facility (IT)	Elderly in assisted living facility (ES)	Elderly in assisted living facility (GB)
Parameters			
Technical duration years			
Recyclable ? (1>YES 0>NO)			
Reusable ? (1>YES 0>NO)			
Investment			
Overall cost			
Maintenance			
Yearly cost			
Services			
Yearly cost	€ 29.548	€ 22.489	€ 33.706
Assistance family-IT			
actions/month			
minutes/action (+ waiting)			
Assistance prof-IT			
actions/month			
minutes/action (+ waiting)			
Assistance family-ES			
actions/month			
minutes/action (+ waiting)			
Assistance prof-ES			
actions/month			
minutes/action (+ waiting)			
Assistance family-GB			
actions/month			
minutes/action (+ waiting)			
Assistance prof-GB			
actions/month			
minutes/action (+ waiting)			
Investment cost			
- Residual value			
+ Maintenance cost			
+ Cost of services	*€ 147.740*	*€ 112.445*	*€ 168.530*
+ Valuation of Assistance			
= Social Cost	**€ 147.740**	**€ 112.445**	**€ 168.530**
Expenditure	*€ 147.740*	*€ 112.445*	*€ 168.530*

TABLE 6 - SCAI WORKSHEET USED TO CALCULATE THE SOCIAL COST OF ASSISTED LIVING FACILITIES IN THE THREE COUNTRIES CONSIDERED

1.2.2.3 SRS ACCEPTABLE SOCIAL COST

[4] cost per year composed by a sanitary quota by Italian NHS, social quota by local administration and elderly person quota

[5] INE, Instituto Nacional de Estadística; Encuesta Imserso 2010; Martínez Meseguer, José Luís (2008). Perspectivas de futuro de los servicios de atención a la dependencia. El Servicio de Atención a Domicilio (SAD)" [Future pespective of the dependence care services: The Home-Care Service]; Martí Vallés, Josep (2008). Estudio inforesidencias.com sobre precios de residencias geriátricas para personas mayores 2008" [Inforesidencias study about prices of nursery-homes for elderly people 2008] Barcelona: Infopenta, S.L, page: 7-8

[6] Laing & Buisson, Care of Elderly People Report 2011

The conclusion of the analysis is summarized in this section. From the SCAI analysis we know that:

- Social cost = Investment cost – Residual value + Maintenance cost + Cost of services + Valuation of Assistance

As the time span of the analysis overlaps perfectly with the SRS technical duration, no residual value for the product is present at the end of the period. Within the countries considered, the average value of personal assistance needed in conjunction with SRS, calculated as the average value of Valuation of Assistance in the three countries reported in Table 3, is **66.000€**.

Based on the figure, the report calculates SRS Investment cost, maintenance cost and cost of services, that give SRS to an acceptable cost compared to the alternative solutions selected.

1.2.2.3.1 COMPARISON WITH AVAILABLE COMMERCIAL PRODUCTS

For SRS to be comparable to commercial products, its Social Cost should be equal in value to the mean value of the social cost of the alternative products considered (**110.000€**). Using the average value of Valuation of Assistance needed with SRS in the three countries (**66.000€**) we can replace some of the variables in the formula:

Social cost = Investment cost – Residual value + Mainteinance cost + Cost of services + Valuation of Assistance

110.000€ = X – 0 + 5*Y + 5*Z + 66.000€

Where

X = SRS Investment cost

Y = SRS Mainteinance cost per year

Z = SRS Cost of services per year

This means:

1. ***in case of SRS for purchase, its cost should be 29.000 € to make it comparable to other commercial products.***

   In fact:

   Y = 1.000€

   Z = 2.000€

   110.000€ = X + 5.000€ + 10.000€ + 66.000€

   Investment cost: X = 110.000€ - 5.000€ - 10.000€ - 66.000€ = 29.000€

2. ***in case of SRS for rent, its yearly rental cost should be 7.800 € to make it comparable to other commercial products.***

   In fact:

   X = 0€

   Y = 1.000€

   110.000€ = 5.000€ + 5*Z + 66.000€

   Cost of services per year: Z = (110.000€ - 5.000€ - 66.000€)/5 = 7.800€

Of course the SRS acceptable purchase price would be double (58.000 €) if it could have a technical duration of 10 years. That's because at the end of the 5-years it would still have a residual value as shown below:

Y = 1.000€

Z = 2.000€

110.000€ = (X – 5/10 * X) + 5.000€ + 10.000€ + 66.000€

Investment cost: X = (110.000€ - 5.000€ - 10.000€ - 66.000€)*2 = 58.000€

1.2.2.3.2 COMPARISON WITH RETIREMENT IN ASSISTED LIVING FACILITIES

The acceptable social cost of SRS could be also evaluated in comparison to the retirement in an assisted living facility. The average value of the annual social cost of assisted living facilities in the countries considered reported in Table 6 is **143.000€**, while the average value, within the same countries, of personal assistance needed in conjunction with SRS is **66.000€**. Let's then replace some of the variables in the formula:

Social cost = Investment cost – Residual value + Mainteinance cost + Cost of services + Valuation of Assistance

143.000€ = X – 0 + 5*Y + 5*Z + 66.000€

Where

X = SRS Investment cost

Y = SRS Mainteinance cost per year

Z = SRS Cost of services per year

This means:

1. ***In case of SRS for purchase, its cost should be 62.000 € to make it comparable to moving to an assisted living facility***

   In fact:

   Y = 1.000€

   Z = 2.000€

   143.000€ = X + 5.000€ + 10.000€ + 66.000€

   Investment cost: X = 143.000€ - 5.000€ - 10.000€ - 66.000€ = 62.000€

2. ***In case of SRS for rent, its yearly rental cost should be 14.400 € to make it comparable to moving to an assisted living facility***

   In fact:

   X = 0€

   Y = 1.000€

   110.000€ = 5.000€ + 5*Z + 66.000€

   Cost of services per year: Z = (143.000€ - 5.000€ - 66.000€)/5 = 14.400€

1.2.2.4 SRS 2.0- PRODUCT DEFINITION-FUTURE VISION

In the long term, a new version of SRS will be developed, with technical features allowing a higher range of functions and covering a broader market.

In synthesis the extended version would present the following features:

- More compact overall size of the robotic platform thus to be compatible with the majority of private homes;
- Low cost platform, which has a similar price to a family car;
- Improved precision and sensibility of the finger gripper to enable fetch & carry functions of wider range of objects;
- UI-LOC application integrated also into the tray of the robot, enabling robot control and video-call also through the robotic platform tray;
- Improved accessibility features of robot interfaces to allow the use of the robot to a wider range of people, for example people with disabilities;
- Increased number of robotic functions, increasing the multitasking peculiarity of the system, such as the standing up assistance function, the reminding function and the reading function.

2 ETHICAL ISSUES

2.1 IS THE PROJECT ETHIC?

In D1.1a we defined ethics as "all these issues that concern questions about life (and death), about revealing personal data, revealing diagnosis, about daily care and guidance, or about the application of protective or liberty-restraining measures". Research with vulnerable subjects implicates specific ethical challenges and involves additional measures that are needed for such research to be ethical (European Commission, 2010). In D1.1 we also adopted four well known principles regarding this topic: non maleficence, beneficence, justice and respect for autonomy.

1. Non maleficence. Considering non maleficence as the general operation of the device not harming the participant or put him or her under unacceptable risk, this principle has been covered within the SRS project through the safety analysis conducted during the whole project (deliverables D2.1 and D1.4).
2. Beneficence. Considering beneficence as the benefits obtained by the participants from the operation of the device according to his or her own conception of the good, this principle has been covered within the SRS project using User-Centered Design methodologies through work packages 1, 2 and 6.
3. Justice. Considering justice as the legitimate interests of third parties and no incorporation of any bias based on gender, culture or nationality, this principle has been covered within the SRS project in the analysis conducted in tasks 6.4 SRS Cost-effectiveness Assessment & Socio-economic Implications and 7.1. Exploitation of commercial potential of the developed technology.
4. Respect for autonomy. Considering respect for autonomy as the main support for the capacity for self-determination, the project has taken this principle into account as follows: the participation in the study and the general operation of the device was based upon a process of informed consent and the participants right to control his or her personal information. Participants to user tests and focus groups where informed so that they could understand the topics and the objective, questionnaires were simple and gave the opportunity to collect free expressions, participants could express their opinion in autonomy without being influenced by researchers or other people present, this principle has been covered within the SRS project with the Data Protection Plan and complementary actions explained in D1.1a appendix 7.

No deviation from the SRS Data Protection Plan has been observed. In order to reinsure data protection, Confidentiality Agreement was signed between user partners about sensitive data storage and exchange procedures.

Regarding ethical approval in Spain from the Matia/Ingema/Urkoa Ethics Committee, Ingema Foundation obtained its official approval about tests with users before the starting of the user-requirement study (D1.1a, MS1). In the second year, Ethics Committees were fully informed about experimental protocols, informed consents, authorization for video recording documents, the documentation about sensitive data storage and exchange procedures.

In Italy, the researchers of Don Carlo Gnocchi Foundation at the beginning of the project prepared a complete documentation about the project (including aim, methodology of tests, informed consent, documents for privacy, documents for pictures/video dissemination…) and submitted it to FDCGO Ethical Committee in order to achieve an official approval about tests with users (D1.1a, MS1). Then during the second year, an addition to the first documentation was made including methodology of tests with the robot and new informed consent to obtain approval again.

In Germany, the ethical approval was obtained by Stuttgart Media University (HdM) for SRS related users study at the beginning of the project and covers whole period of the project.

2.2 STRATEGIES TO DEAL WITH ETHICAL ISSUES POSSIBLY RAISED BY THE USE OF THE ROBOT

2.2.1. DATA PROTECTION AND PRIVACY

Data protection and privacy is one of the most important ethical problems to be addressed about assistive technologies: it is important for users to understand the benefits of monitoring technologies since these benefits have to be balanced with concerns about privacy. Assistive technologies could potentially alter the way in which issues related to privacy and technology are perceived, since it is required to store different kinds of personal information (lay-out of a home and its contents, special needs related to disabilities or illnesses, interaction style preferences, individual differences in comfort-spatial zones,…) not stored or used deliberately by currently existing technology [19]. In the EU context, there is an explicit recognition of a right to privacy and this human right is recognized or recalled in various legal instruments specifically dealing with data protection [20].

SRS has been designed to assist the frail older adults through remote human operators, who support the robot on those tasks it cannot handle autonomously. Since the remote control function in SRS can be considered a monitoring function, information about privacy has been extensively collected in the SRS user tests, in particular in project tasks: 1.1 User Requirement assessment, elicitation and specification, 1.6 Requirement of future remotely control service robot in home care, 6.1 User validation on SRS Specification and 6.3 Iterative user evaluations of the SRS.

Information collected in the user requirement study, as the main source of data about privacy and ethics within the project, were analyzed in more detail in Facal, et al. (2012) [21]. As already highlighted in D1.1a, results showed medium to high scores in questions regarding privacy, representing certain concerns about the usage of an assistive technology remotely manipulated in the home of a frail elderly person. It confirms previous findings about services for frail older adults provided by semi-autonomous systems [22] and highlights the need of ensuring the protection of privacy for these potential vulnerable users. Interestingly, these results are independent of socio-demographic and experience-with-technology covariates.

A list of the user requirements about Safeguarding of Privacy and Ethics developed through the User Requirement Study (D1.1a) is reported:

- R23 Only authorized persons have access to the remote control of the system,
- R24 Authentication procedure as a protection of the access to be included for both family and professional caregivers,
- R26 Avoid possibility of access to the system without explicit consent of the elderly, including not authorized access of remote operators,
- R27 If remote operator changes within one session, the elderly user must be informed,
- R28-R29-30-31 Personal information data protection managed in a safe way,
- R32 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,
- R33 Verification of the plans of action by asking the elderly user before it starts acting.

As expressed in D6.1b, methodology selected for the advanced SRS prototype tests allowed to check the fulfillment of these requirements. These tests were performed in an apartment located inside the hospital Santa Maria Nascente of Don Carlo Gnocchi Foundation, focusing on the evaluation of the whole prototype in an advanced stage of development. The evaluation considered the major user requirements determined at the beginning of the project, expressed through real-life scenarios. Results obtained indicate that the prototype developed fulfilled requirements

about privacy and ethics, with the only exception of R32, that had not been implemented at that time but has been implemented later.

2.2.2. SAFETY/ACCOUNTABILITY

There is a need to ensure that robots used by the elderly are safe – and furthermore, in a system in which a robot is responding to the commands of an elderly person, to determine who or what should be held responsible and accountable if something goes wrong, resulting in injury or damage. Responsibility is currently a hot issue in Robotics still to be addressed ethically and legally in society. From our point of view the main aim regarding the user in SRS research is to ensure that no damage will be done to the user and thus restrict the contact between user and robot to obtain the maximum safety possible. To this end, safety procedures have been developed in the trials in D1.4.1 Requirement specification of future remotely control service robot for home care (interim).

2.2.3. HUMAN WELFARE

One ethical risk that may be introduced by the use of robots within elder care is that its presence, reducing the care burden for relatives and care-givers, might reduce as well the amount of human contacts that the elderly have. Indeed, the robot could provide an excuse for the families' neglect, as if it could substitute them in taking care of seniors' physical and emotional needs.

From another point of view, the presence of the robot can be seen as a way for reducing the dependence of the elderly on the people that look after them, allowing at the same time for more frequent virtual visits and calls by family and friends, also whenever they operate the robot through remote control, as the advanced interface enhances frequent checks and video calls.

Another aspect that cannot be underestimated is that the daily help provided by the robot, jointly with the supervision of remote control, allows the old persons to continue living at home, instead of being sometimes obliged to move to nursing homes, with the consequent detachment from their familiar context and social network. In this case, the elderly have the chance to keep living in their own environment, in terms both of physical space they are used to inhabit, as well as social space they are used to interact with, thus enhancing their inclusion and participation in the community, that in this case doesn't need to be reframed from the beginning in a totally new context. This perspective also fulfills the right stated by the UN Convention on the Rights of People with Disability [23], about the need to ensure "the opportunity to choose their place of residence and where and with whom they live on an equal basis with others and are not obliged to live in a particular living arrangement" (art. 19-a "Living independently and being included in the community").

2.2.4. AUTONOMY

Another ethical concern raised by the robot care for the elderly is linked to the restriction of personal liberty implied by the risk of losing control over the robot. Indeed, there is a delicate balance between monitoring the old person, though still preserving his freedom and control over his life. In general, since the users' cognitive and physical abilities cannot be assumed to remain at a particular level, the robot/ remote control operator is in a way responsible for keeping them safe from danger. If it is used insensitively, like becoming an autonomous supervisor, it could increase senior citizens' feeling of objectification and a lack of control over their lives.

Considering the particular case of SRS robot, these concerns are alleviated by the employment of a carefully customized system and the constant consultation of the elderly, who are the primary actors involved in activating the robot: thanks to an easy to use interface assured by usability evaluations, customization and adaptation, the elderly is

able to request for the robot intervention, as well as to choose the functionalities it should perform, according to his/her own capabilities and frailties. Moreover, the user is always in a position to decide and switch off the system.

The only exceptions are represented by 1) monitoring requests by family members, in which case a permission is asked before starting monitoring, and 2) emergency situations, where the remote operator is somehow obliged to force monitoring in order to check the user's conditions and, in case, to provide for assistance. Of course this last scenario is supposed not to be frequent and, moreover, remote control operators are thoroughly trained on a professional procedure to adopt, including practical guidelines about reaction in different situations, psychological approach and expected impact of their intervention.

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