AAL AMBIENT ASSISTED LIVING	**Project Acronym: ExCITE** **Project Title: Enabling Social Interaction through Embodiment** **Starting date: 1st July 2010** **Ending date: 31st December 2013**

ExCITE

D2.2 Yearly technical recommendation report M36

WP related to the Deliverable:	WP2
Nature:	Report
Dissemination Level :	P
Version:	V2.0
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Contractual Date of Delivery:	30 June 2013
Actual Date of Delivery:	30 June 2013

Deliverable Summary

This deliverable extends the technical recommendations document delivered for the second year. In addition to the recommendations elicited after the evaluation activities of the second year, some further comments have been considered on the basis of the new evidences collected during the third year of the ExCITE project.

The present document also identifies a set of relevant design features for mobile telepresence systems that should be enhanced in order to improve their use in real contexts of life. Following such a telepresence platform design perspective, a careful analysis of the feedback gathered from end users has been performed. Specifically, the results from both short term evaluation sessions and long term experiences in setting up and running the ExCITE test sites have been critically analyzed and translated into a set of technical recommendations for the refinement of the Giraff prototype.

In this respect, this document illustrates (a) a set of relevant design features for mobile telepresence systems that have been identified as particularly critical during evaluation and especially with respect to the involvement of elderly people; (b) a set of elicited technical recommendations that has been proposed for the third year of the project (many of which still remain open) to improve the prototype. Accordingly with the identified design features, the technical issues/recommendations have been grouped into six main categories: *video features*, *autonomous navigation*, *pilot user interface*, *Giraff system functionalities, robot hardware*, *Giraff software*. For each category, the document provides the justification for its consideration as well as an associated priority.

A final critical analysis has been performed aiming at producing a final technical reference document for supporting further technological enhancements of the Giraff telepresence platform.
Also, many technical actions have been implemented after the list of recommendations elicited at M24. These technical improvements allowed fixing more than 50% of the technical issues identified during the first two years of the project. Almost 30% of them are partially fixed while less than 15% are still remains open.

This document illustrates in details this situation.

Table of Contents

List of Figures

1 Introduction

1.1 Scope of the document

The main objective of the ExCITE project is to evaluate user requirements of social interaction that enables embodiment through a robotic telepresence system, called Giraff. An existing prototype has been deployed to the targeted end-users, and has been continuously refined by tightly involving the users in the development cycle. Figure 1 provides a brief sketch of the whole project idea: several Giraff prototypes have been deployed for long periods of time (at least three months, and possibly 1 year) in three different countries (Italy, Spain and Sweden) in real contexts of use. Feedback obtained from the users (both older users having the robot at home and the clients, that is people connecting to and visiting the older users) has been used to technically improve the robot.

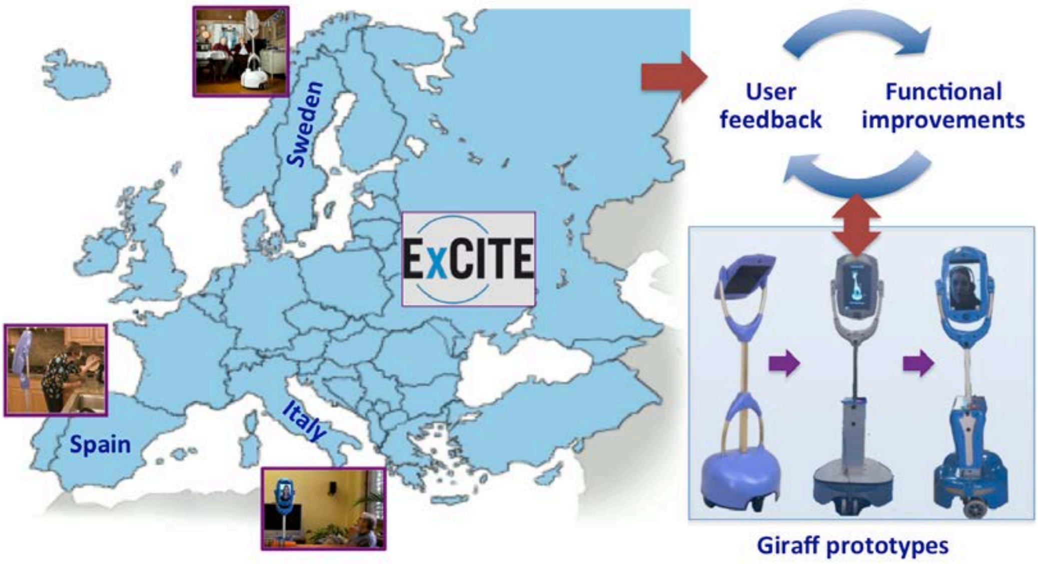

Figure 1 The ExCITE approach.

This deliverable describes the technical recommendations elicited after the evaluation activities of the last year of the ExCITE project as an updated version of the same document delivered at M24. The new feedback and comments derived from the last year analysis are highlighted in green in the rest of the document.

The approach followed to derive the Technical recommendations has been to critically analyze and discuss the various results emerged from the evaluation sessions with real users and described in Deliverable D2.3 M24 User-technical cycle (see Figure 2).

This document contains some further comments elicited after the third year of the project. In particular such comments have been synthesized on the basis of new evidences collected during the last period of the ExCITE project. Specifically, the last version of D2.2 document has been enriched in a twofold way: i) the set of implemented actions deployed after the intermediate version of the D2.2 are reported. For each issue, if present, technical solutions addressing open issues are described; b) a refinement of the critical analysis has been performed aiming at enriching the set of technical issues or at providing further evidences of the *issues already reported. Those additional contributions allow producing a final technical reference document for the Giraff telepresence platform.*

In the rest of the document, third year contributions are highlighted as Green Text Boxes (like the present one).

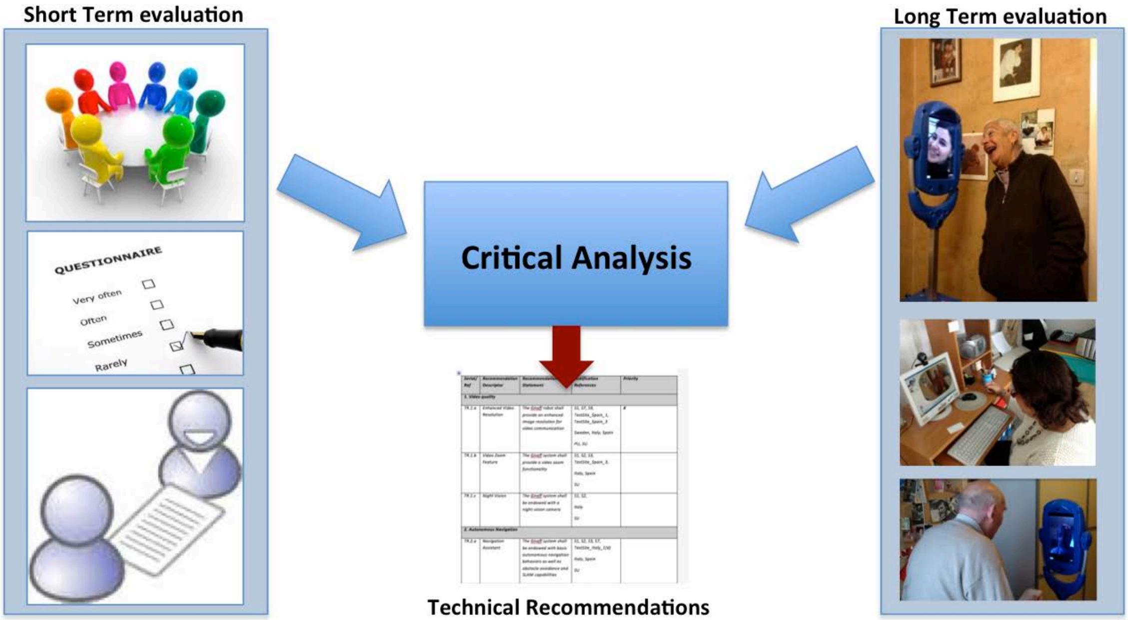

Figure 2 Method used to derive the technical recommendations

In particular, two sources of feedback have been considered: a) the short-term evaluation sessions carried out in the three countries and b) the experiences emerged from the long-term test sites activated and managed during the first two years of the project. The analysis has then translated into a set of detailed technical recommendation that have been also assigned a level of priority.
This report presents the result of this effort. Specifically it illustrates the analysis performed that allowed identifying a set of relevant design features for mobile telepresence system to be improved as well as a set of associated technical recommendations that can be followed for the prototype refinement.

1.2 Deliverable Structure

The rest of the document is organized as follows: Section 2 describes in details the analysis of the results obtained both from the short term evaluations in the three countries and the systematic feedback gathered during the long term tests sites activated during the first *three* years of the project; Section 3 provides the detailed list of Technical Recommendations that can contribute to enhance the effectiveness of the Giraff robot in real contexts of use with elderly people. Section 4 provides some conclusive remarks.

2 Analysis of users feedback and test sites experience

The ExCITE project aims at assessing the robustness and validity of the Giraff telepresence robot as a means to support elderly and to foster their social interaction and participation. The project embraces the user centered product refinement principle while deploying robots in user tests outside research laboratories to investigate how people interact with robots over long periods of time. In this regard, a remarkable effort has been spent to gather relevant feedback from the User Experience with Giraff in a systematic and reliable way. As already described in Deliverable D2.3 User-technical cycle two types of user evaluations have been considered: a short-term evaluation effort has been performed in order to identify immediate comments/feedbacks from users while using the telepresence robot; a long-term evaluation effort is aiming at collecting a set of comments raising from the daily use of the Giraff in real living environments rather than a single and not-fully-realistic experience.

The document “D2.3 User-technical cycle” describes the evaluation activities of the project and provides a first complete report on the results generated after the analysis of short-term evaluation sessions. Moreover, some results of the long-term evaluation have been presented and discussed particularly referring to both the ongoing and already ended test sites.

Starting from those results we here describe our analysis of the users’ feedback to derive the technical recommendations.

2.1.1.1 Third Year Addition.

During the third year of the project, additional evaluation activities have been performed. Two further short-term evaluation sessions have been held in Sweden and four additional test sites have been included in Italy and Sweden.

Evaluation sessions. *Two new evaluation sessions have been performed in Sweden and Spain. Here follows a short description of them:*

- ***Session 11****: In June 2012, an assessment on how different spatial configurations (Kendon F-formations or not) were perceived by and affects elderly. The study was conducted in the Ängen Research and Innovation Apartment in Örebro, Sweden. 10 persons were involved (3 males and 7 females).*
  - *Additional Comments: The ten elderly were guided around the apartment by a researcher who either interacted in natural F-formations or not. The sessions were recorded by video and during retrospective interviews, the elderly were asked to comment on the interaction. It was clear that it was important for the elderly to be able to see who of them interacted with. Further, when analyzing the videos, it was clear that they moved towards a face-to-face interaction when the researcher oriented the robot such that an F-formation was not created.*
- ***Session 12****: In June 2013, a side-by-side comparison of Giraff Pilot 1.3 and different beta versions of Pilot 2.0 (for further details, the reader may refer to D4.2 M36) has been performed. 23 persons have been involved (17 males and 6 females).*
  - *Additional Evidence: Later versions of the pilot led to better performance as there were a number of on-screen commands and graphical tools which helped the drivers to better estimate distance to obstacles.*

Test Sites status updates. *Two new test sites have been started in Italy and two in Sweden. Here, follows a short description of them:*

- ***TestSite_Italy_4.*** *A private residence in Rome where an old woman, with depressive attitude, lives alone. A social assistant is considered as the remote user.*
  - *Status: Ongoing.*
  - *Additional Comments: The Giraff robot has been used as a support in usual assistance activities. The social assistant uses the robot as an alternative to phone calls. The robot was presented several technical problems: it was stuck with black screen and BIOS reset was needed; for some time, the robot presented a false positive status due to bad network, i.e., it was not reachable even though it seems on line on the pilot interface; sometime, the robot turned out to be with low battery even though properly docked.*
- ***TestSite_Italy_5.*** *A private residence in Ancona where an old man, with mild Alzheimer, lives with his wife. The son is considered as the remote user.*
  - *Status: Ongoing.*
  - *Additional Comments: Since the first days, the end-user and his wife reported to be disturbed by the noise of the robot during the night, as well as by the wires and the additional router in the house. For a long period of time, bad quality Internet connection prevented to have regular calls. Then, also this robot was affected by a software bug providing false positive status on the pilot interface. Finally, given the distance between CNR and the test site (about 300 km), a local engineer provided his availability to perform interventions on site. Nevertheless, this entailed many*

interactions between CNR researchers and Giraff technical staff, and then, between CNR researchers and the engineer, creating an additional dimension for technology testing.

- ***TestSite_Sweden_6.*** *A private residence in Örebro where an old woman, who had several strokes, lives alone. A sister, a daughter and a granddaughter have been considered as remote users.*
  - *Status: Prematurely Ended.*
  - *Additional Comments: The robot presented a software bug showing false positive status on the pilot interface. A daughter tried to connect but did not succeed. After some months, the resident asked for the removal of the robot and it has been removed.*
- ***TestSite_Sweden_7.*** *A private residence in Örebro where an old man, with impaired function in his legs and a shoulder aches lives alone. Some friends and a son-in-law are considered as remote users.*
  - *Status: Ongoing.*
  - *Additional Comments: The resident was not able to hear the "incoming call" sound so the emergency call setting is used as the usual way to connect. A new "incoming call" sound has been installed on the robot. The remote users have difficulties while docking the robot, so a sign with a big arrow has been attached on the wall to point out the docking station position.*

Table 1 briefly summarizes the evaluation situation. The table is the one reported in D2.3 (updated after the new sessions and test sites implemented during the third year) and it is here replicated so as to have an easy reference for the elicited technical issues. For more details, the reader can refer to D2.3.

Reference session	Country	Participants/Types
Session 1	Italy	44 nurses
Session 2	Italy	44 nurses
Session 3	Italy	10 care operators
Session 4	Sweden	21 alarm operators and 11 health care professionals
Session 5	Italy	4 high school students and 1 Electronics teacher
Session 6	Sweden	150 participants (22 nursing teachers, 13 health subjects teachers, 79 nursing students, 25 occupational therapy students and 11 audiology students)
Session 7	Spain	15 people with a high technological profile
Session 8	Sweden	38 participants
Session 9	Sweden	10 participants
Session 10	Italy	2 medical doctors, 1 psychologist and 1 engineer

Session 11	Sweden	3 males, 7 females
Session 12	Sweden	17 males 6 females
TestSite_Sweden_1(a)	Sweden	Private Residence
TestSite_Sweden_1(b)	Sweden	Rehabilitation Center
TestSite_Sweden_2	Sweden	Elderly residential home
TestSite_Sweden_2PersonA	Sweden	Elderly residential home
TestSite_Sweden_3	Sweden	Rehabilitation Center
TestSite_Sweden_4	Sweden	Private Residence
TestSite_Sweden_5	Sweden	Private Residence
TestSite_Sweden_6	Sweden	Private Residence
TestSite_Sweden_7	Sweden	Private Residence
TestSite_Spain_1	Spain	Private Residence
TestSite_Spain_2	Spain	Private Residence
TestSite_Spain_3	Spain	Private Residence
TestSite_Spain_4	Spain	Private Residence
TestSite_Italy_1(a)	Italy	Private Residence
TestSite_Italy_1(b)	Italy	Private Residence
TestSite_Italy_1(c)	Italy	Private Residence
TestSite_Italy_1(d)	Italy	Private Residence
TestSite_Italy_2	Italy	Health care organization
TestSite_Italy_3	Italy	Private Residence
TestSite_Italy_4	Italy	Private Residence
TestSite_Italy_5	Italy	Private Residence

Table 1 Reference sessions

In order to classify the various technical problems emerged during the evaluations we also looked at previous research work. Many research efforts have been carried out in order to identify relevant design features for mobile telepresence system (e.g., [8]), and in particular, some of them put a major attention on the use of telepresence robot with people with special needs (e.g., [7]) such as elderly people. Looking at the literature some features have been identified as particularly important when designing a telepresence robotic platform, which inspired our classifications of technical problems and design features. Among others we here highlight the following: *video*, *audio*, *autonomous navigation*, *user interface* and *hardware robot features*.

Following this classification we examined the various input provided by the mentioned evaluation sessions and classified it according to these categories. In this regard, while audio issues have not been recognized for the Giraff system, several problems have been identified related to the general Giraff software (both on server and client side) reliability.

Therefore, a set of technical issues has been identified which are grouped according to the following categories:

- ***Video features***, that mainly concerns the need to enhance the video quality and to consider some additional functionalities;
- ***Autonomous navigation***, related to the need to enable a more effective and safe navigation of the environment with the Giraff robot;
- ***Pilot user interface***, to get a more natural and easy interaction with the pilot UI as well as to facilitate the control by the user of the Giraff system;
- ***Additional Giraff system functionalities***, to increase the overall Giraff system capabilities for both primary and secondary users;
- ***Robot hardware***, to enhance the overall quality of the Giraff robotic platform;
- ***Giraff software***, to enhance the quality of the Giraff software services.

In the following subsections, we discuss in detail the identified issues proposing a set of suitable technical solutions to address them. Specifically, for each category we provide the following information:

Technical Issue: that is the specific problem encountered either during an evaluation session or reported by a test site;

Explanation: that is a detailed explanation of the problem with a reference to the short-term evaluations or the test site where the issue has been raised;

Recommendation: that is the technical solution proposed for the refinement of the Giraff prototype.

Further Evidence*: that is a description of the additional evidences collected in the evaluation sessions and/or test sites of the third year of the project.*

Implemented Action(s)*: that is the set of technological solutions deployed after the recommendation discussed in the previous version of the present document (M24 version) to address the related issue.*

In Section 3, the results of this work have been further critically analyzed resulting in a list of detailed Technical Recommendations with an associated priority.

2.2 Video Enhancements

Some improvements related to the video features of the Giraff system have been recognized as crucial by a large part of the end-users involved in the ExCITE evaluation sessions. The most relevant desired enhancements are (i) the *enhancement of the video quality* (i.e., video resolution), (ii) the *introduction of a video zoom functionality* and (iii) the possibility to have a (sort-of) *night vision feature*.

2.2.1 Video quality

Technical issue: The video quality has been considered not completely satisfactory both by primary and secondary users.

Explanation: During session S1, the video quality has been detected as sufficient to allow for general navigation in the environment but it was considered not entirely satisfactory while performing specific visual inspections such as reading a text or recognizing the state of some specific objects within the remote environment. The secondary users involved in session S7 have perceived the camera image quality as to hamper the visitor to be aware of obstacles in the surroundings while steering the robot as well as to limit some maneuvers like the docking operation. Finally, during the tests of Session S9, the involved pilot users had difficulties in recognizing task requests presented as text written on paper by pen or pencil and, the experimenters had to use more contrast black marker and large font in order to make the task visible.

In addition, secondary users involved in TestSite_Spain_1 and TestSite_Spain_3 have considered the video quality as not adequate. In particular, secondary users argue that they were not able to distinguish, for example, the meal on the plate of the primary user or that it is difficult to perceive states of mind or emotional states of the primary user through visual inspection. Figure 3 shows examples of the scarce quality of video. The picture has been taken from running test sites.

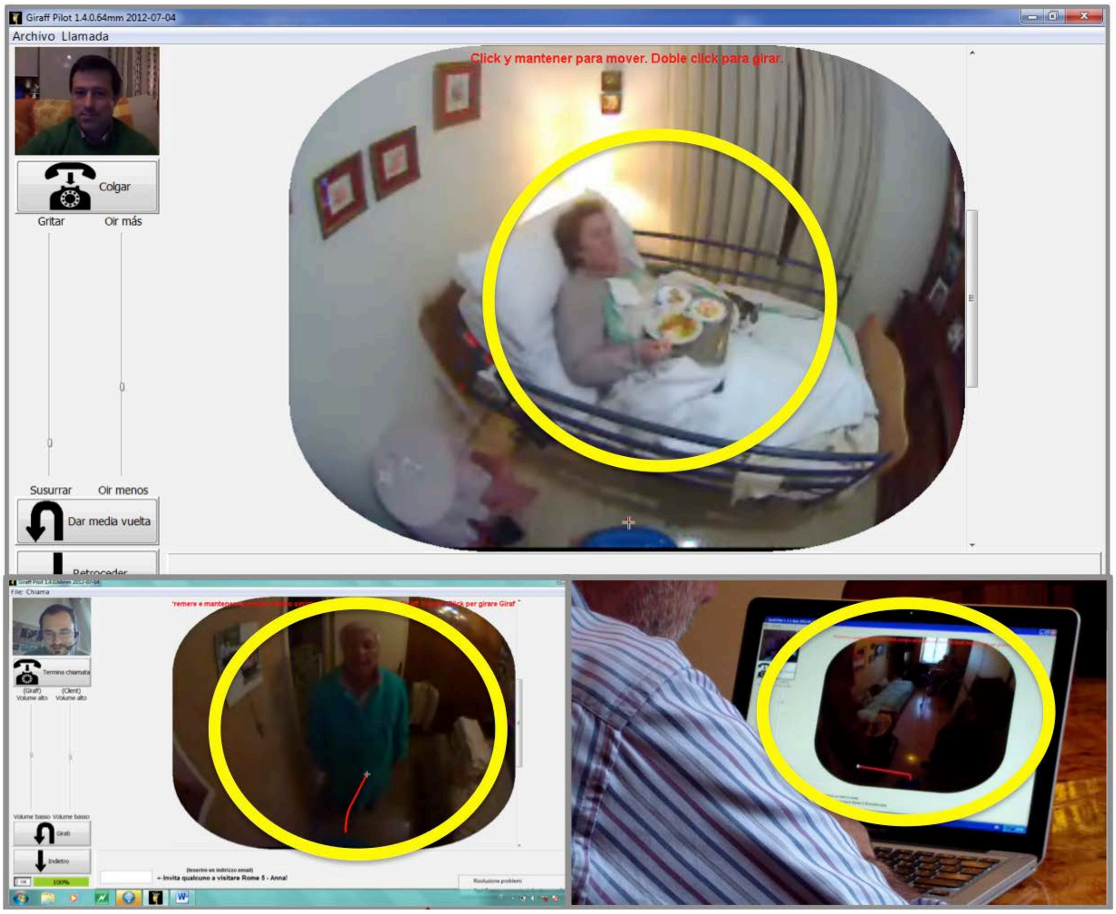

Figure 3 Example of scarce quality of video in low light condition

Recommendation: The suggested technical recommendation is to increase the image resolution used for the video communication rather than improving the quality of the video camera mounted on the robot (thus, not affecting the overall cost of the robotic platform). In fact, the video resolution is usually limited in order to avoid Internet bandwidth saturation and this is also the case of the Giraff platform. But, given the current Giraff system configuration and its specific use in this particular domain, a more suitable trade-off is needed.

Implemented action(s): A new high performance camera and matching lens (see Figure 4) have been added to the robot providing the opportunity to get 720p resolution in the call. The greatly improved video resolution will help the pilot users to see enough details.

Figure 4 Sentech STC-MCA5MUSB3 camera.

2.2.2 Video Zoom

Technical issue: The absence of video zoom capability for pilot users.

Explanation: During three different evaluations sessions, a group of nurses (sessions S1 and S2) and homecare operators (session S3) have clearly requested an additional improvement related to the video functionality, i.e., to provide the Giraff system with a video zoom feature. In particular, home care operators suggested the zooming functionality as a very useful feature of the camera in order to better observe details of the remote environment. Also the secondary users involved in TestSite_Spain_3 required the possibility to zoom in or out in order to highlight a region of interest. In Italy test sites highlighted similar problems. Figure 5 shows a clear example where the zoom functionality, in combination with an improved video quality, would increase the quality and utility of communication.

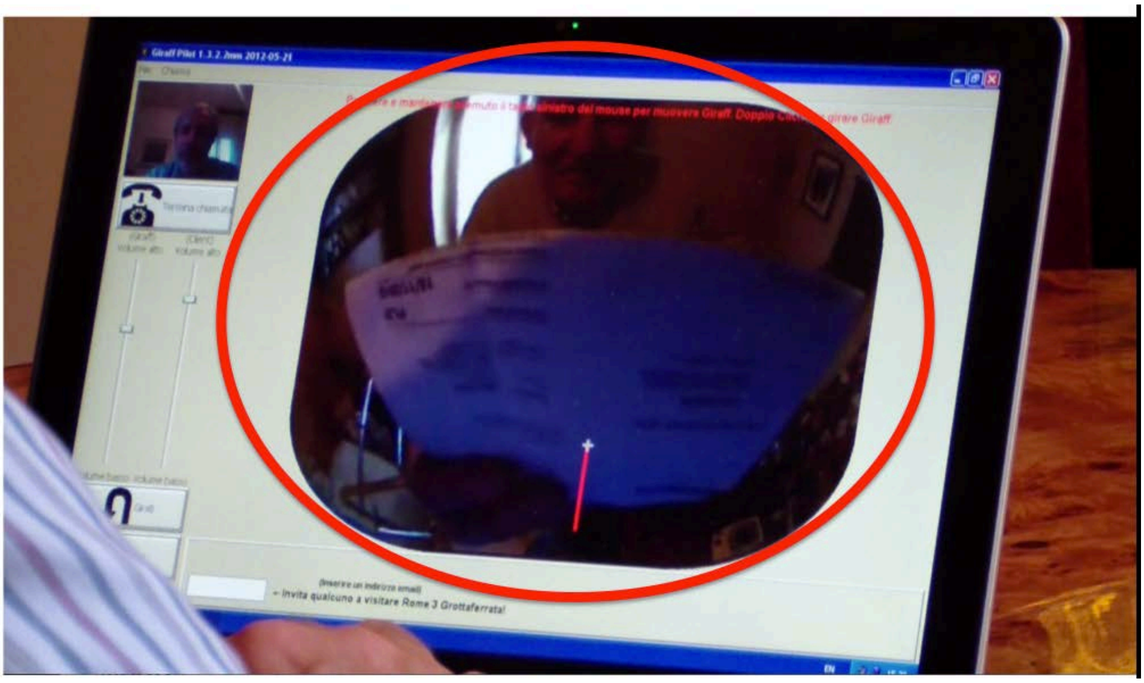

Figure 5 Example from a test site that shows the need for zoom functionality

Recommendation: The suggested technical recommendation is to add digital video zoom functionality for the video camera mounted on top of the robot. The digital zoom is a necessary choice to avoid higher production costs.

Implemented action(s): The addition of the new camera would allow the implementation of zoom capability requested at a later stage. Nevertheless, the issue is still open.

2.2.3 Night vision

Technical issue: The video quality is dramatically affected when a pilot user is controlling the robot in low light conditions (not only during the night, but also when light conditions at home are scarce).

Explanation: During two different evaluation sessions (i.e., sessions S1 and S2), a group of nurses expressed the need of a further video quality improvement: *night vision*. In fact, nurses would appreciate very much the possibility to improve their night surveillance activities in hospital as well as homecare cases. In Figure 6, a clear evidence of how the absence/presence of lights in the room affects the utility and performance of the visit while calling a remote place.

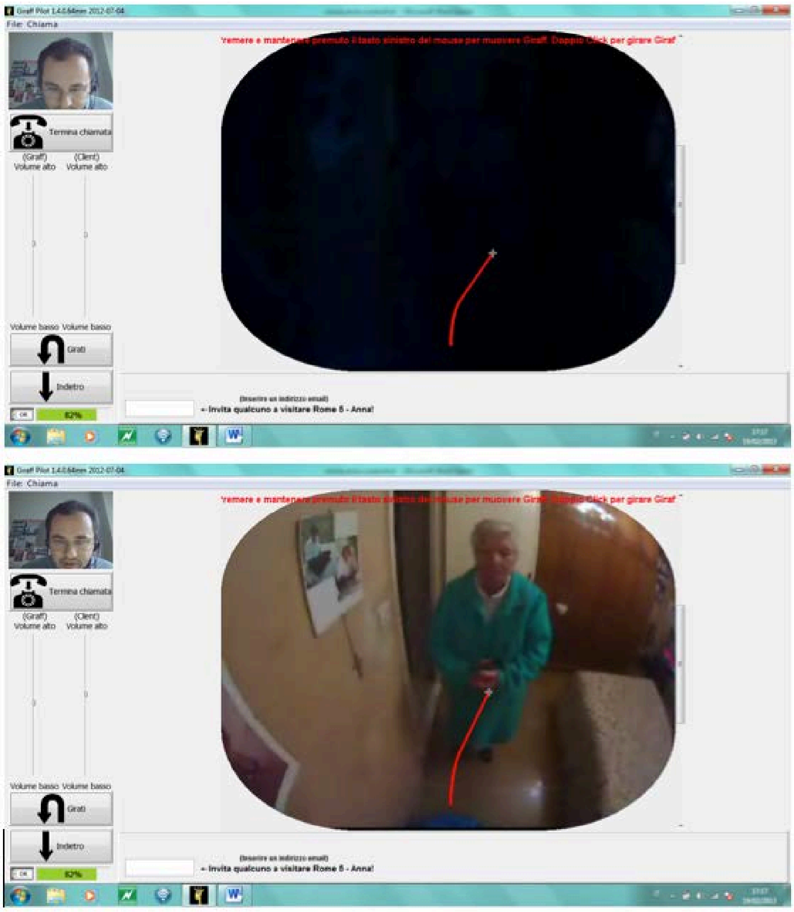

Figure 6 Two pictures of the same scene with lights OFF (upper part) and with lights ON (lower part) in the same remote place.

Recommendation: The suggested technical recommendation is to add the night vision functionality for the camera mounted on top of the robot. Alternatively, adding the possibility to operate in low light conditions (feeble lights) would constitute a desirable requirement.

Implemented actions: The new camera also takes care of the problems that users have had in low light conditions and even at night due to the good low light performance of the camera.

In addition to that, the software night vision mode has been implemented to provide an even better user experience. In this mode, the image becomes grayscale to improve the visual dynamic range.

2.3 Autonomous navigation

It is worth observing that the Giraff robot is a relatively simple system (as most of the currently available telepresence robotic platforms are). It is fully operated by the remote pilot user and, thus, it is not endowed with any autonomous behaviors. However, during many evaluation sessions, an incremental evidence has been gathered showing that situations exist in which technical advancement usually connected with autonomous behavior may enhance the effectiveness (and also the safety) of the robotic system. The enhancements related to autonomous navigation are mainly two (i) the navigation support during the visit of remote environments and (ii) the automatic docking of the robot to the recharging station.

2.3.1 Navigation Assistant

Technical issue: The robot is not able to fully/partially autonomously navigate the remote environment.

Explanation: One of the main worries perceived from end users involved in evaluation sessions (in particular, S1, S2, S3, S7) was related to safer navigation. In particular, in Sessions S1 and S2, some difficulties were encountered when the robot had to move in extremely narrow spaces or with obstacles. And a suggestion from participants regarded the possibility to insert a map and a position indicator of the robot within the environment. Also, some autonomy for helping the remote operator of the robot, when the driving is more critical (e.g., in narrow spaces) could alleviate the workload for the pilot user performing the navigation task. In Session S3, all the operators were particularly worried about the safety issue during navigation and they considered the **obstacles avoidance capability** as a key functionality to be implemented. Finally, the end users involved in an evaluation session in Spain (S7) have identified obstacle detection and warning as a valuable improvement. Similarly, the same issues have been raised by almost all the informal caregivers involved in the Italian test sites. This issue has been raised also in TestSite_Italy_1(d), in which some problems have been experienced with the specific topography of the Italian houses that has created some initial problems due to limited free space, space crowded with objects, etc.

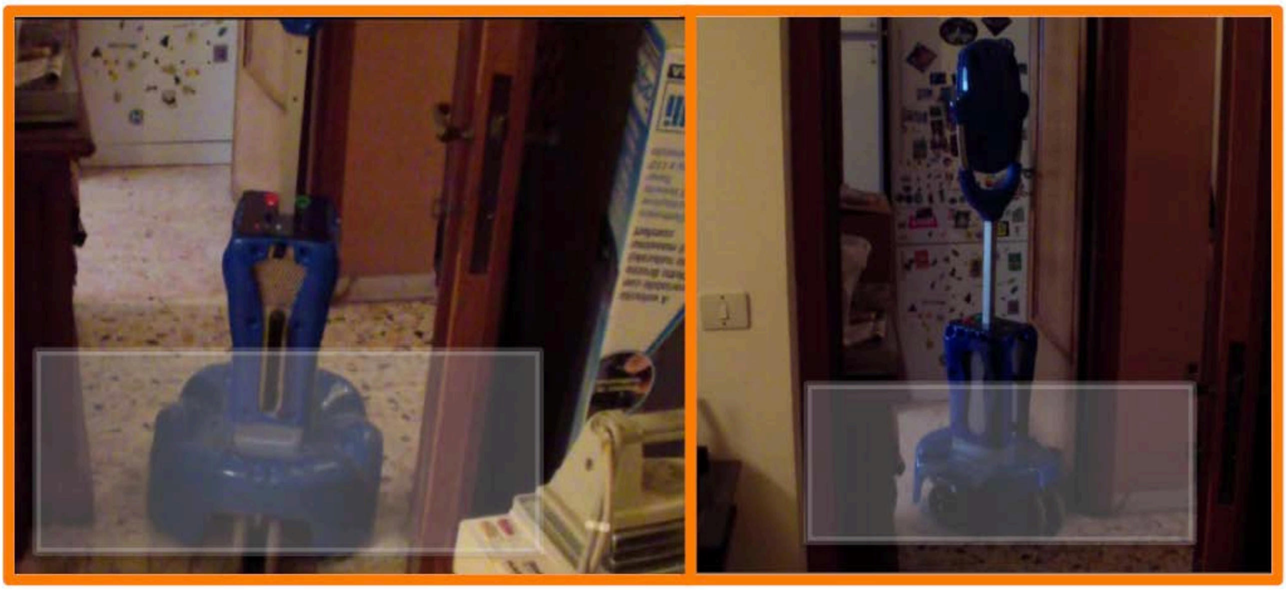

Figure 7 Example where the navigation assistant could help the Giraff driver

Figure 7 shows an example of situation reported from one of the test site where a navigation assistant could help.

Recommendation: As this kind of functionalities is very common in robotics (e.g., [4,5,6]), its implementation would be gracefully integrated in the current Giraff system. In this respect the suggestion is to endow the robot with basic autonomous navigation as well as obstacle avoidance and SLAM capabilities to support the pilot user during the visits. A selection of suitable sensors should be considered as additional devices for the Giraff platform. Obviously, this implies a careful assessment of the choice given the contrasting advantages and disadvantages of the different solutions. The use of laser range finder (LRF) would for instance provide more reliable measures rather than sonars, but LRF would not allow the detection of transparent obstacles (e.g., glass objects). On the contrary, sonars would provide not so accurate measures detecting any kind of obstacles (i.e., both transparent and opaque objects). Other kind of sensors may be also considered. For instance, the Kinect device by Microsoft allows video processing for implementing 3D slam, obstacle detection and also human posture/gesture detection. Selecting one of these devices would depend upon autonomous navigation design choices as well as costs considerations[1].

Moreover, homecare operators suggested during session S3 also to consider the ability of the Giraff robot to automatically search for elderly in the remote environment. Thus, enabling the operators to make an emergency call and, then, to ask the Giraff robot to quickly search for the elderly. Then, an additional recommendation is to endow the Giraff system with automatic people search capability (possibly exploiting a Kinect sensor) to support the pilot user during the visits.

Implemented action(s): A new version of the pilot client interface incorporates the functionalities developed during the project as detailed in other reports (see Figure 8 and D4.2 M36). Concretely, the current version of the pilot:

- Permits the user to identify the docking station on the received image and command an automatic docking operation.
- Visualizes a geometric-schematic map of the elder home where the pose (position and orientation) of the robot is continuously shown. The remote user can remotely construct such a map as well as add distinctive labels to identify different rooms or areas, e.g. “kitchen”. These labels will help the driver to be aware of robot localization within the environment. They can also be used as destinations for the reactive navigation algorithm.
- Includes additional commands to drive the robot using linear and angular velocities consigns. Similarly to the commands in videogames, some users have identified this new navigational mode as an intuitive way for driving the robot.
- The client interface displays the Wi-Fi signal strength from which the driver can react accordingly before the connection is interrupted, i.e. moving towards the router. Moreover, the interface also includes the possibility of activating the Wi-Fi recovery functionality that makes the robot to automatically go back to a previously visited place, with an acceptable Wi-Fi signal quality, in the event of an Internet connection lost.

[1] Indeed, this would affect the cost of the Giraff system as such kind of devices may have not negligible costs: e.g., a Hokuyo LRF costs more than 1000$ while a “Kinect for Windows” sensor costs around 200€. Given their low reliability, sonars are low cost devices.

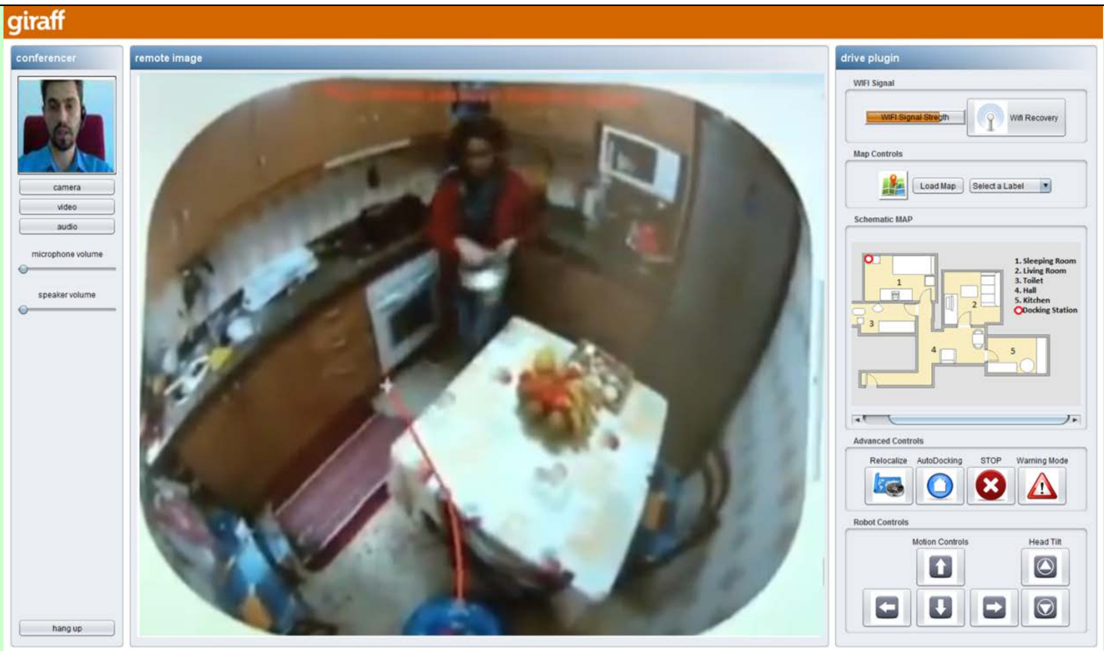

Figure 8 Enhanced version of the pilot interface. A map of the environment and the position of the robot are shown to the driver that can issue a number of predefined commands.

2.3.2 Automatic Docking

Technical issue: The docking task results as the most difficult for mostly all the pilot users.

Explanation: During many evaluation sessions (i.e., sessions S1, S2, S3, S7 and S8), the docking task has been felt as the most critical functionality from the point of view of usability for pilot users. Indeed, large part of the participants in evaluation sessions had difficulties with docking the Giraff robot. Also, in one Italian test site, the involved caregiver was claiming to spend more than half of the time during a call trying to dock the robot at the end of the conversation.
Moreover, in several test sites of all the involved countries (i.e., TestSite_Sweden_1(a), TestSite_Spain_1, TestSite_Italy_1(d)), some problems while docking the Giraff emerged or frequently displacements of the docked robots have been encountered. Also, the docking task is perceived as very complicated and time consuming representing a main problem and leading to cases where the main part of the call is dedicated to docking thus discouraging the call.

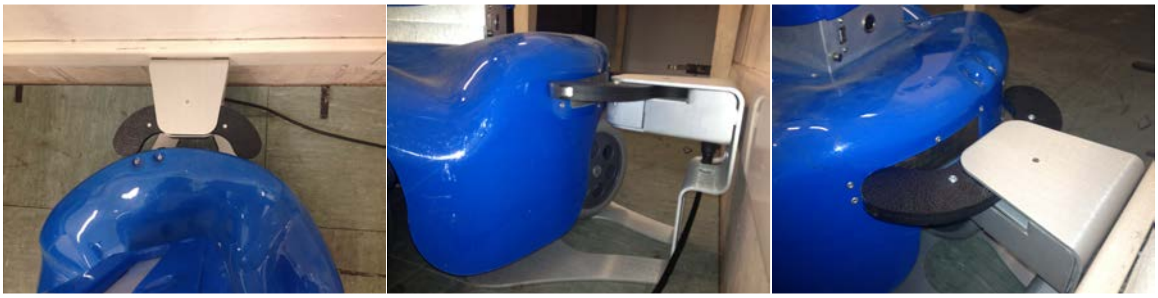

Figure 9 A robot not correctly docked at the recharging station.

This was also complicated by the video quality that makes the docking procedure even more difficult. Figure 10 shows an example in one of our test site that highlights the difficulty also in identifying the docking station.

Figure 10 Evidence of the difficulty in identifying the docking station

Recommendation: Possible suggested solutions to this problem are: the implementation of an automatic docking functionality or, alternatively, providing the docking station with more visible indicators (e.g. colored) and simultaneously put directional indicators in the interface which can "guide" the pilot user during manual docking.
State-of-the-art vision-based process can be exploited (e.g., [1,2,3]) to solve this problem. In this respect the suggested technical recommendation is to enrich the Giraff Pilot software with the automatic docking capability exploiting the image captured through the camera. This would significantly impact on the overall performance of the telepresence experience.

Moreover, as the recharging station is a crucial location for the robot at home, the robot should always be able to reach it. The robot should also be able to detect the status of its battery and, whether below a given threshold, it should automatically reach the docking station.

In this light, an additional technical recommendation is, to endow the pilot software with an automatic search algorithm able of find and reach the docking station.

***Further Evidence**:* In TestSite_Sweden_7, docking the robot has been detected as a tricky task. To help remote users, a sign with a big arrow has been attached to the wall of the resident to point out the docking station position.

Implemented Action(s): An assisted docking solution has been designed and integrated into the pilot software considering a cardboard target attached to the top of the docking station (see D4.2 M36). The current target consists of three concentric circles.

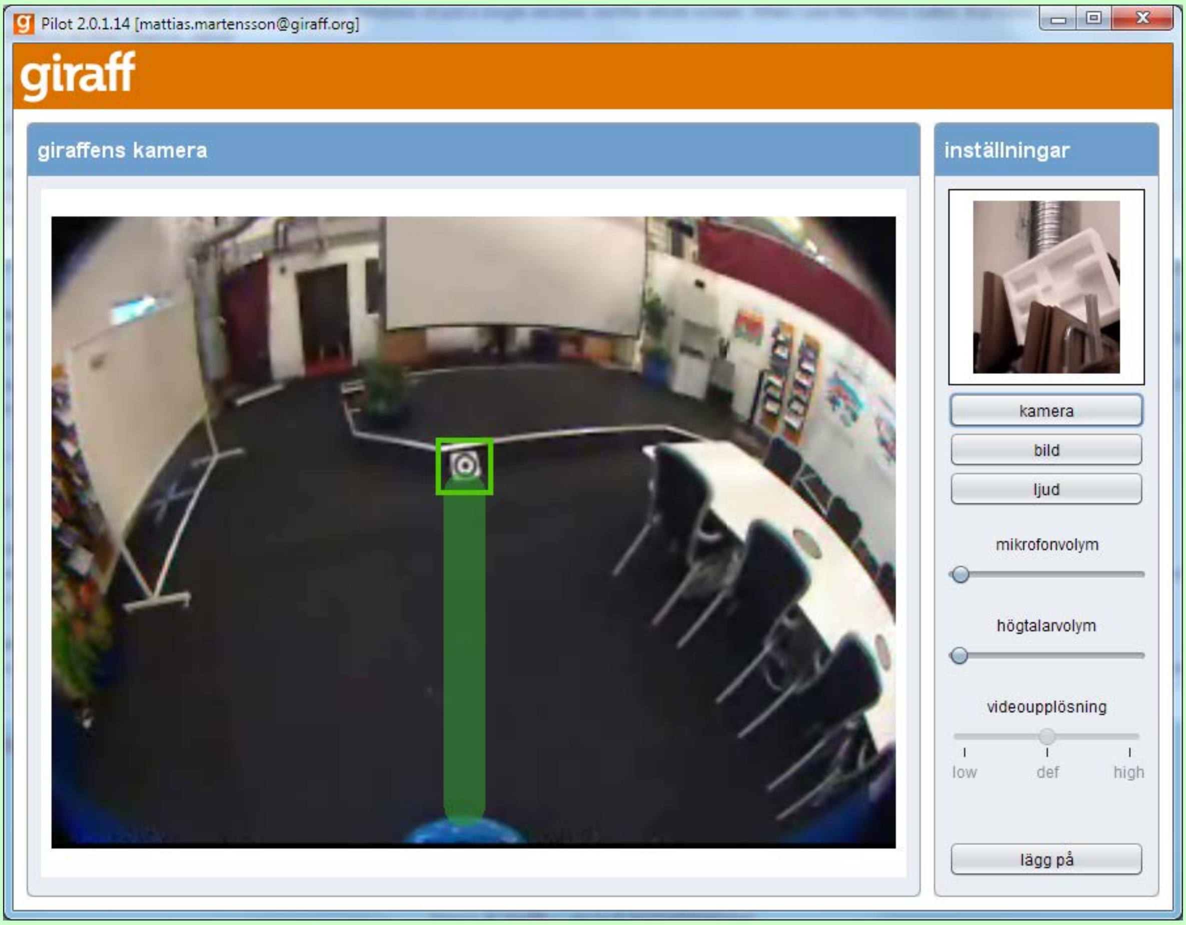

Figure 11 Auto-docking operation. The green rectangle marks the locked target.

The assisted docking software runs in the pilot software as a standard drive plugin. It provides a simple interaction with the user where the best target candidate is searched in the image and marked with a box surrounding it. The user can select the target by double clicking on the box. This action locks/confirms the target. Once a target has been confirmed, the user can press and hold the left mouse button to carry out the automatic docking of the Giraff robot.

2.4 Pilot User Interface

In order to improve the perceived look and feel for the Giraff pilot software interface, usability tests have provided several feedbacks as well as punctual suggestions from end users. In this section, such feedbacks have been used to synthesize the following technical recommendations:

(i) more visible battery level indication, (ii) addition of map and localization indications, (iii) different control over robots behavior, (iv) different volume controls.

2.4.1 Battery level indication

Technical issue: The battery level shown in the pilot user interface is not particularly visible.

Explanation: The battery level indication resulted to be not clearly visible by the pilot UI during sessions S1 and S8. The involved end-users suggested using more visible colors and/or flashing signals as indicator of the robot's battery level. In particular, this would be a really useful capability in order to attract the attention of pilot users while battery is reaching a critical level. Figure 12 shows the Pilot interface highlighting the battery level indicator that should be improved to attract the user attention when a critical level is reached.

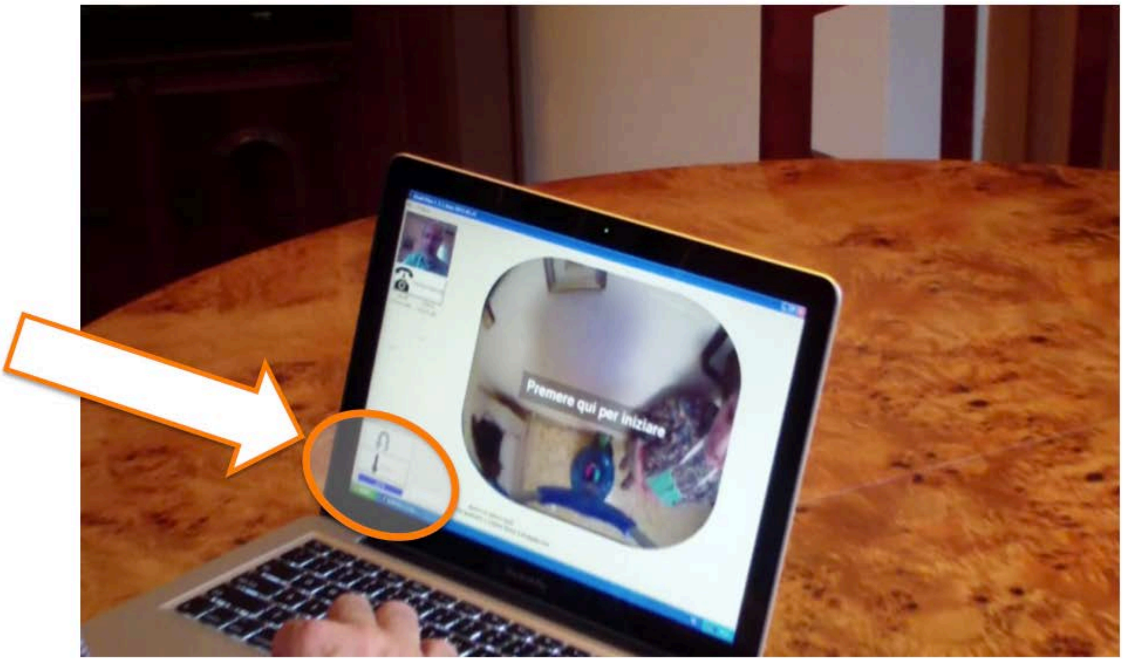

Figure 12 Evidence of the need to improve the battery level indicator

Recommendation: A suggested technical recommendation consists in using more visible colors as indicator of the battery level of charge. Additionally, once a critical level is reached, a flashing signal could also be considered in order to make the criticality more evident.

Implemented action(s): The previous software only supported an alarm to the visitor when the battery was low but did not allow the visitor to monitor time left and plan their visit accordingly. Now the visitor can see how much battery time is left.

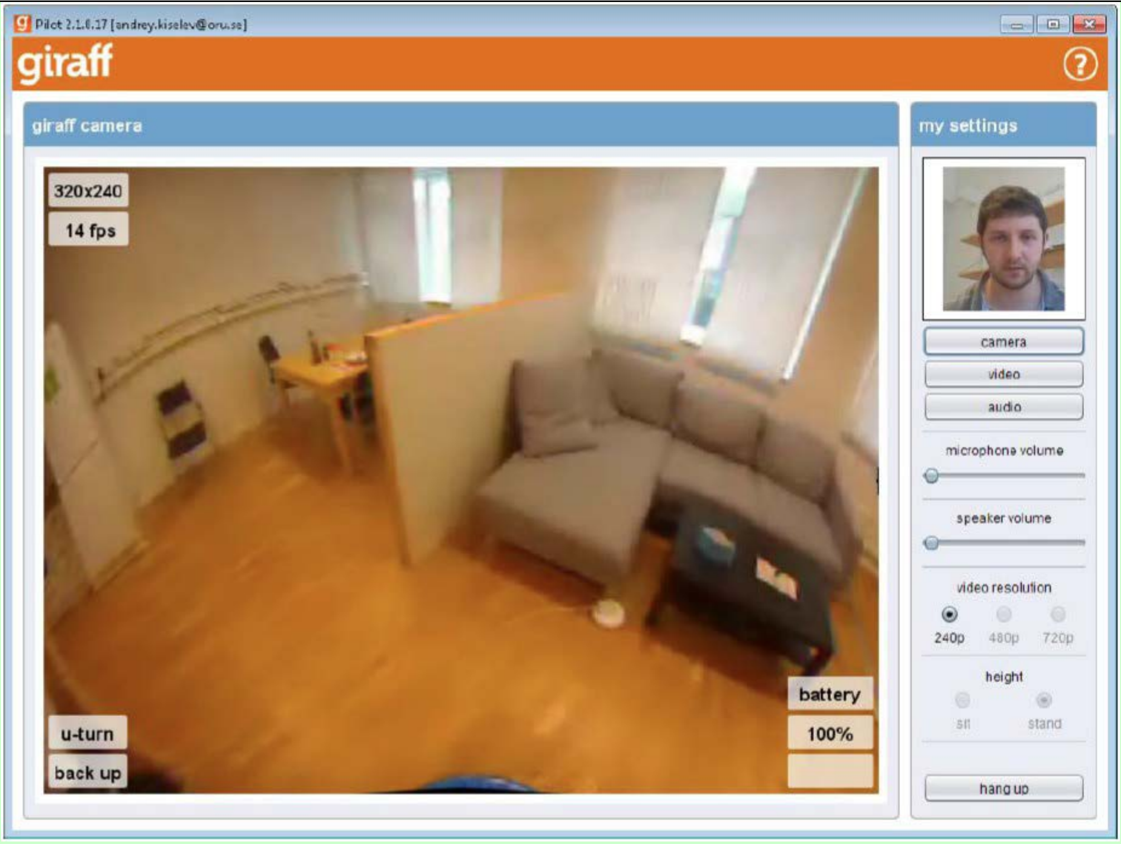

Figure 13 Giraff Pilot version 2.0

More in general, the new Pilot Software 2.0 has been completely redesigned utilizing a Nimbus look and feel to provide modern interface for pilot users.

2.4.2 Map and localization

Technical issue: The pilot user interface does not provide any information on both the map of the remote environment and the position of the robot.

Explanation: The end users involved in the evaluation session S7 suggested enriching the pilot interface with a map of the remote environment and implementing also the capability to show the position of the robot in the remote environment. This functionality is tightly coupled with the SLAM capability discussed above. Moreover, considering robot localization and mapping capabilities would increase the situation awareness of the pilot user with respect to the remote environment: it is very useful when the pilot user is not familiar with the house, for example a caregiver who visits a number of patients every day. In TestSite_Sweden_1(a), alarm operators (who had never visited the homes of the primary Giraff users) asked to have a map to find their way around and to find the docking station.

Recommendation: The proposed technical recommendation is to enrich the pilot graphical user interface with a schematic map of the visited environment where the current position of the robot is continuously showed.

Implemented action(s): Autonomous navigation functionality is available with certain robots equipped with extra sensors. This feature allows users to navigate inside the robot's environment using a map and labels and to see the current position of the robot in the environment. The user interface for autonomous navigation is shown in Figure 14.

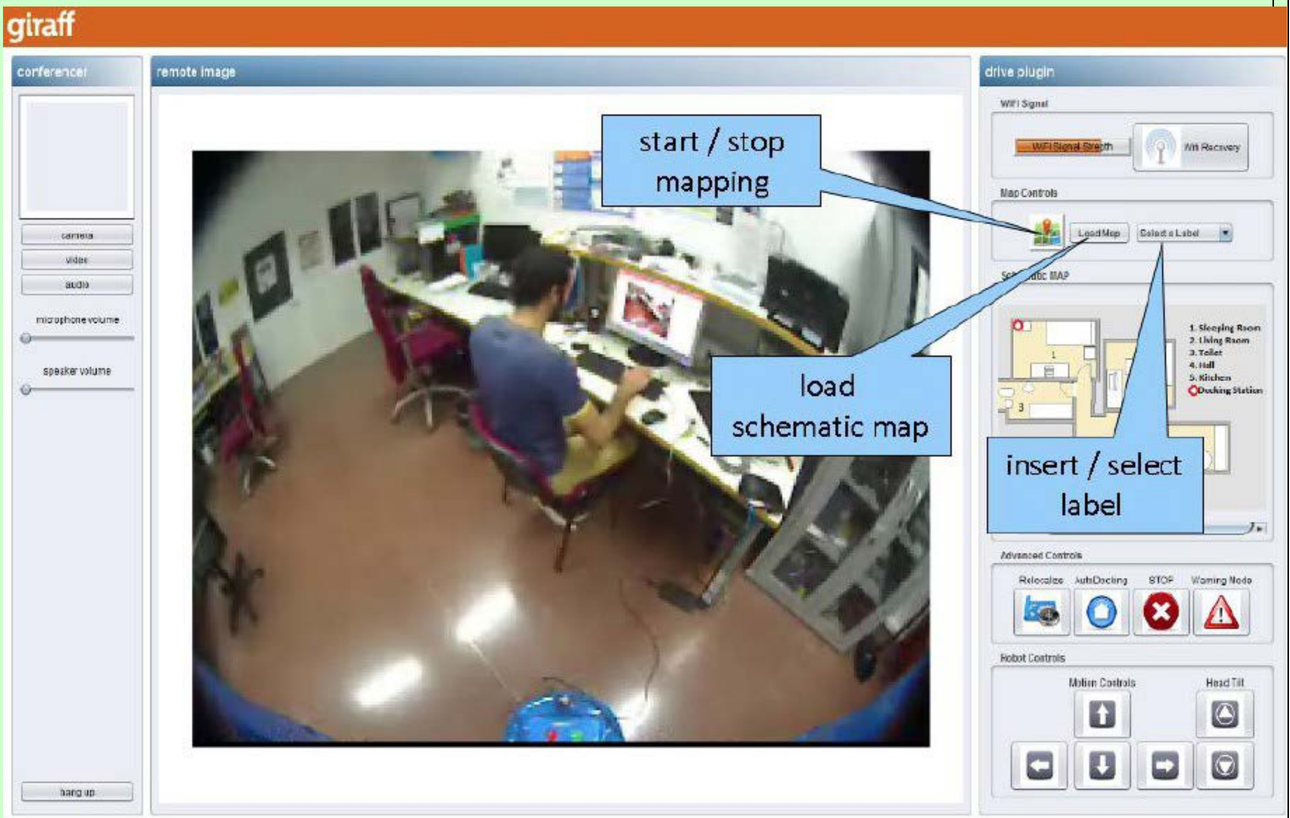

Figure 14 Autonomous Navigation Support for Pilot 2.0

Autonomous navigation also allows user to instruct the robot to reach the docking station in an autonomous manner and to dock it. It also allows the user to see the current position of the robot even when driving in manual mode.

2.4.3 Different control over robot's behaviors

Technical issue: The pilot software does not provide alternative ways, except than using the mouse, for controlling the Giraff robot.

Explanation: The possibility of having more control over robot's behaviors and to use different control interfaces (e.g., keyboard, joystick, etc) seems to be more convenient for some end users (especially those who have experience with computer games) who have attended sessions S1, S2 and S9. This request has been gathered also in one Italian test site where a grandchild, acting as pilot user, asked to control the robot with a sort of gaming interfaces (i.e., a game controller). This suggests that having alternative ways for controlling the Giraff robot could be a beneficial technical improvement. In fact, this improvement could also be also considered as an incentive to motivate the use of the robot by different categories of people.

Moreover, some users experienced some difficulties while performing robot's rotation actions during sessions S4 and S7. In session S9, it was clearly observed that the screen tilt functionality should be implemented in a different way as the use of the mouse to control both robot's and tilt movements was introducing some control interferences sometime. In fact, it resulted that while moving the robot unwanted tilt movement commands were generated.

Recommendation: Enhancing the Giraff robot control interface considering also the use of alternative tangible interfaces, e.g., keyboards or game controllers would facilitate the control of the robot as well as encourage the use of the system by younger secondary users. Moreover, in order to avoid possible command interferences, the control commands available to move the robot and to adjust the tilt position should be different. Still maintaining the same tangible interface (i.e., the mouse), a possible solution is to control robot movements through the click-n-point command while the tilt could be adjusted through the use of the scroll button. This is a reasonable requirement for PC machines where the Giraff pilot software is supposed to run.

Implemented action(s): Giraff Pilot v.2.0 incorporates a plug-in framework which allows third party developers to introduce new functionalities on the Pilot side. This includes full access to video streams and paint overlays and full access to the robot control API which allows developing own robot controlling methods. Additionally, the new Pilot application utilizes pure Java-based rendering for keeping the application cross-platform and resource-efficient.

Thanks to the Giraff plug-in API, it is now possible to implement any driving method by developing a drive plug-in. This allows for implementing, for example, arrow- or WASD-controls in a separate plug-in and using it as an alternative to the original implementation. In other words, is now possible to steer the Giraff using the keyboard and specifically designated controllers or interfaces via the plugin.

2.4.4 Volume controls

Technical issue: Volume controls are not clearly shown on the pilot user interface.

Explanation: Adjusting the pilot and Giraff volume settings resulted as a not so natural action during session S8. In fact, during the training, when asked to adjust the local user's volume, most participants did not notice they had buttons beside the video feed and, generally, they chose first the right slider (adjust pilot volume) and then the right volume slider of the Giraff (left slider). So, the pilot user interface should be enhanced to allow a more natural control of the volume settings for both the pilot and the robot.

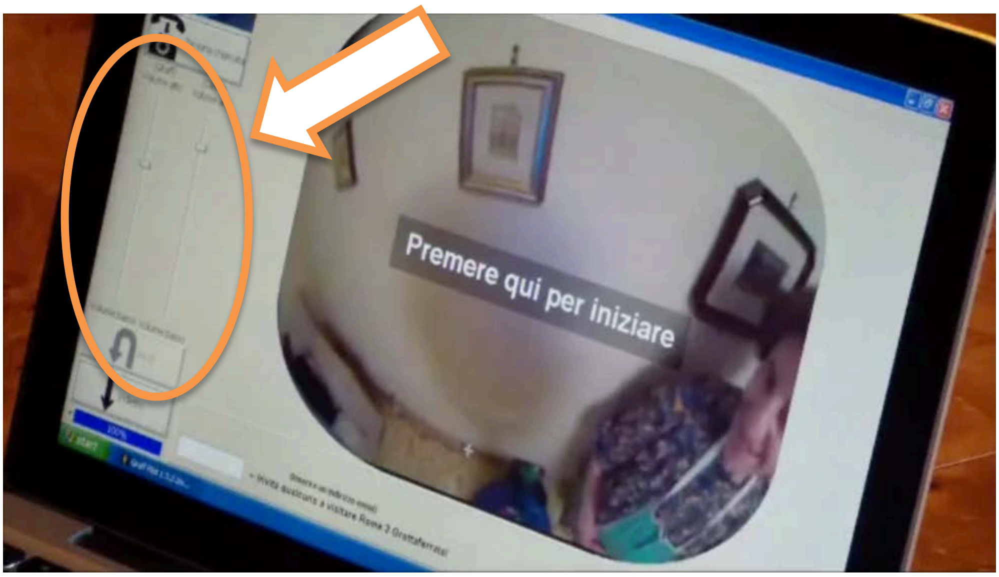

Figure 15 Evidence of the difficulty in distinguishing among Robot and Pilot volume controls

Recommendation: A suggested technical solution is to remove the pilot volume slider. Then, the user will be able to adjust the robot volume through the pilot UI while the local volume will be adjustable through the Windows volume settings control. Alternatively better labels to indicate the different volume controls should be chosen.

Implemented action(s): Everything concerning the driver's own video conferencing equipment is now located next to the drive window to the right. Here, one sees the local image and have access to all the settings one can adjust including selecting the camera during a call and also to adjust speakers and microphone volume.

2.5 Giraff system functionalities

The Giraff robot has been built following a design, which aimed at producing a "simple" but very effective object. Following such design principle has enabled an agile technology development as well as the production of an easy-to-use robotic platform. Nevertheless, in our work of fielding the telepresence robot in real world contexts (i.e., ExCITE test sites), we gathered incremental evidence that situations exist in which additional technical advancements can dramatically affect the effectiveness and usability of the platform when deployed in older people living environments. In this respect some additional functionalities for the Giraff system have been identified: (i) to enrich the call capabilities, (ii) to consider the use of 3G Internet connection rather than the usual ADSL phone line and (iii) to consider the transmission of vital signs of the old people in the house (after having deployed suitable physiological devices in the home).

2.5.1 Call transfer

Technical issue: Currently the Giraff system does not provide alternative solutions when the callout user[2] is not able to react after an emergency call.

[2] A callout user is a secondary user chosen by the elderly person as a reference user. Calls made from the Giraff robot by the older user will contact this person.

Explanation: During session S1, S2 and S3, operators commented that the current implementation of the emergency callout entails that the operator is always in front of a PC. In their specific case, this might not be always guaranteed. To this purpose they judged as extremely useful a service that sends the call also to their cell phone (e.g., through a text message or a pre-recorded message). In addition, it would be also beneficial to enable the call transfer if the client is not connected to the robot via the PC.

Recommendation: The proposed technical solution is to endow the Giraff system with a vocal pre-recorded message to be sent through a mobile gateway to an operator's cellphone. Alternatively, the mobile gateway should be exploited to send a short message to notify the operator that the elder is looking for him/her. There could also be a list of contacts to use for transferring the collouts.

Finally, a suggestion from the same operators was the possibility for the system to transfer the "rights" to make an emergency call. In fact, it may happen that an operator is trying to perform a regular call to the robot in the remote home but there is no answer. Then, the operator could ask an authorized family member to make an emergency call. It could happen though that this person is not in front of a PC (e.g., he/she is driving a car from office to home) but still needs/wants to make the call. The idea would then be to enable the family member to transfer her/his permission to the operator or to another person who usually can only make normal calls. This would allow intervening in the house even when authorized users are not able to perform emergency calls.

Implemented action(s): The administrator can add an email or a phone number to where a notification should be sent if someone tries to do a call out and no one answers on the pilot side.

2.5.2 Contact list

Technical issue: The current design of the Giraff software does not allow the primary user to choose among a contacts list. The old person can only call the single callout user.

Explanation: Another desired option is constituted by the possibility to provide the primary end user with a contact list rather than a single callout user. In fact, having no assistance from a caregiver (e.g., a relatives or an operator), the older person may consider trying a call to some other persons choosing among a personal list of contacts. The persons involved in TestSite_Italy_1(d) and TestSite_Italy_3 have expressed such a request, asking to allow them to interact in a more active way through the robot. In fact, currently, the elderly are thought as totally passive users of the robot: they can only receive calls and perform callout to one predefined user. This resulted as a clear limitation of the Giraff. It is plausible to think that enhancing the system with the possibility to call other persons would contribute to maintain the "active ageing" feeling. The robot could also be a way to let the users feel more secure at home and be connected for example with the police for example if << […] *someone who is not known enter the house or try to do it*>>. So besides the fact that the robot keeps company it clearly emerged the need to have some additional useful and more practical functionalities.

Recommendation: The contact list should be implemented extending the current sentry functionality in order to enable multiple callout users as well as enabling the primary user to choose the desired callout recipient among a predefined list. The old person should be allowed to use the remote controller (provided with the Giraff robot) to navigate the list of contacts and select the desired recipient.

2.5.3 Network requirements

Technical Issue: In general, the Internet connection represents a crucial issue for using the robot in an effective and reliable way. A bad Internet connection negatively affects the performances of the Giraff System.

Explanation: In almost all the test sites, problems with the network connections have been raised. In TestSite_Sweden_1(b), the robot often was “Unavailable” and required frequent restarts. The pilot also experienced latency in the sound compared to the image. In TestSite_Sweden_2, the network range was not sufficient and the use of repeaters has been considered to solve the problem. In TestSite_Sweden_4, there was some delay both in image and sound while using the robot. In TestSite_Spain_1, interruptions of Internet connection and time lags for the communication often occurred. In TestSite_Spain_4, the Internet connection problems emerged in the Health Centre where this man is receiving long term care, limiting the involvement of health professionals as secondary users. In TestSite_Italy_1(a), the main problem was related to the Internet connectivity and bandwidth.

Usually, mobile telepresence robotic platforms come with reference network requirements to provide users with suitable information about the minimal Internet settings and, in some cases, the settings needed in order to have a *best user experience/performance*. For example, the Beam platform by Suitable Technologies Inc. [9] requires 2 Mbps reliable upload and download (4 Mbps for best experience) as well as less than 250 msec reliable latency between pilot and robot location (150 msec for best experience). VGo Communications Inc. [10] claims that the VGo platform operates from about 200kbps up to 850kbps (up and down) even though they recommend at least 1.5Mb (up and down) for best performance.

After an empirical evaluation performed in Italy, the following parameters have been identified as the minimum settings for having the Giraff system running properly: 1.5 Mbps reliable upload and download bandwidth as well as less than 300 msec. reliable latency between pilot and robot location. In any case, a deeper investigation on this aspect is required.

Further Evidence*:* In TestSite_Italy_4, TestSite_Italy_5 and TestSite_Sweden_6, network issues affected the possibility to connect to the robot. For this reason, in TestSite_Sweden_6, a remote user did not succeed in connecting through the robot.

Recommendation: The Giraff AB company should perform a wide evaluation to figure out which are the best internet settings to ensure the use of the Giraff system in a robust and reliable way. Such settings should be properly provided to Giraff users in order to assess the conditions and accordingly setup the remote environment as well as the Giraff pilot workstation.

2.5.4 3G connection

Technical issue: Currently, the deployment of the robot in a test site requires (when not already present) signing a contract with an Internet Service Provider.

Explanation: Usually, elderly people do not have an Internet connection in their homes. This is a very common situation in Italy and Spain. In this respect, within the ExCITE project, one of the main slowing factors in starting a test site (e.g., in TestSite_Italy_1(a)) has been the signature of a contract with the Internet Service Provider (ISP). In fact, in almost every home considered as test site, the signature of the contract with the ISP took a very long time (up to two months). In addition, the National regulation did not allow covering the costs to support this contract thus introducing additional delays to find a solution (in Italy the situation was even more difficult due to the fact that the there is no signed contract yet). Moreover, in some cases (e.g., TestSite_Italy_1(b)), the need to activate the Internet connection has been an important issue to discourage the person. Some concerns connected also to the privacy issue emerged. Specific attention should be given to ensure privacy to the elderly and also the minimization of home modification so as to integrate the technology smoothly.

***Further Evidence**:* In TestSite_Italy_5, the end user and his wife reported to be disturbed by the presence of an additional router in their house. Also having a reliable 3G connection would have prevented network issues in TestSite_Sweden_6, TestSite_Italy_4 and TestSite_Italy_5.

Recommendation: The 3G Internet connections can be considered as an alternative to speed up the activation process of test sites as well as a business opportunity (in Italy also 4G is going to be activated in some of the biggest cities, e.g., Rome). In fact, in the USA, the latest VGO Robot already comes equipped with Verizon LTE adding more flexibility[3]. Indeed, the use of 3G/LTE connection would increase the “ready-to-use” characteristic of the Giraff solution as only electric power supply for the charging station would be needed. This solution would be clearly beneficial for the deployment of the robot.

To summarize, a proposed solution is to endow the robot with a 3G/LTE Internet connection. This would allow connecting to the Internet without being constrained by ISP contract signatures or other administrative issues. It would also impact the Giraff business plan. However, specific test to assess the reliability of this communication technology would be needed.

2.5.5 Transmission of vital signs

Technical issue: The Giraff robot does not allows the transmission of assessments performed through physiological sensors.

Explanation: During sessions S1 and S2, some operators have proposed to consider the installation of some physiological devices on top of the Giraff robotic platform in order to enable the transmission of vital parameters to a doctor. In particular, according to participants, services like

[3] http://blog.ivci.com/2013/01/15/vgo-telepresence-robot-roams-free/

virtual contact, monitoring of medical parameters as well as triggering an alarm when dangerous situations have been detected would constitute important services to detect a life threat.

Recommendation: Actually, this issue can be considered as out of the scope of the ExCITE project. In any case, endowing the robotic platform with some physiological sensors to assess, e.g., blood pressure or glucose level as well as with the capability to gather the measures and communicate them to the a specific pilot user (i.e., a doctor) could be a recommendation for future uses of Giraff.

2.6 Robot requirements

The evaluation sessions allow gathering interesting feedback, identifying relevant issues and synthesizing meaningful technical recommendations. Nevertheless, some issues have been detected only during the setup and management of test sites. In fact, the daily use of the robot allows identifying additional problems that do not emerge during a short period of time and that have been considered as worth being addressed. In particular, some additional robot requirements for the Giraff have been identified: (i) changing the robot display orientation, (ii) visual indication of recharging battery, (iii) adjustable height, (iv) recharging also when switched off and (iii) additional on-board lights.

2.6.1 Changing robot display orientation

Technical issue: End users are not able to see the robot screen to check incoming calls or battery charge information.

Explanation: The current design of the docking station forces the installation of the robot in a position such that the robot screen is placed in front of a wall. Then, the old person in the house is not able to directly see the screen while the robot is docked. For instance, in TestSite_Spain_1, sometimes the Internet connection went down and the primary user did not notice that event.

Also, as incoming calls are reported on the screen, this configuration does not allow seeing who is the caller. Figure 16. shows an example of this problem in TestSite_Italy_1(d). The old woman is receiving an incoming call and, in order to see who is calling, she is forced to lean towards the robot doing a movement, which is not natural. The same problem has been detected in TestSite_Italy_3. This aspect is really crucial as it strongly affects the usability of the Giraff system.

Figure 16 Test site in Italy: Example of problem when answering a call due to the orientation of the robot

Recommendation: A technical recommendation to address the above issue consists in changing the orientation of the display while the robot is docked. In this way, this would avoid having the robot facing the wall and the elderly could be able to check for incoming calls. In addition, the start of the chat between the pilot user and the older user would be more natural.

Implemented action(s): The latest Giraff hardware version (3.4) has been endowed with the possibility to flip the screen 180 degrees when someone calls so the user can see the caller easily.

The issue has been partially addressed as this feature introduces puzzling video effects during the beginning of the call. In fact, on the robot side, the face of the caller on the display is upside down. On the remote side, the pilot application shows disturbing images from the resident's house while the display is flipping.

2.6.2 Visual indication of recharging battery

Technical issue: End users cannot easily check the battery level of the robot.

Explanation: Again, as the display is placed in front of a wall while the robot is docked, another issue is related to the notification of the recharging status of the robot. In fact, sometime the robot undocks (possibly) for some inertial forces in the motors. Then, if the old person is not present or has no possibility to detect the associated notification sound, there is no evidence that the robot is properly docked (and then actually recharging the battery) apart the info reported on the robot screen (not accessible, as stated above).

Further Evidence*: Sometime the robot in TestSite_Italy_4 presented a low battery status even* *though properly docked at the end of the calls.*

Recommendation: A needed improvement concerns the addition of an indicator of the level of charge (not necessarily in the screen but in some visible part of the robot) that could be implemented with a more visible color or through a flashing signal. In particular, the light should also attract the attention of the end user whenever the robot battery is reaching a critical level.

Implemented action(s):LED indicators have been added to be able to see:

- *Charging indicator.* To avoid situation in which is unclear whether the Giraff is charging or not. This is now been taking care of with a status indicator.
- *Battery level indicator.* A battery level indicator has also been added to the outside of the box to easier see the battery level when the Giraff is in its charging station.

Figure 17 LED indicators on the Giraff robot.

2.6.3 Adjustable height

Technical issue: End users cannot adjust the height of the robot according to their needs.

Explanation: The current design of the robot entails a human-height aspect. Even though this characteristic has been designed in order to resemble the presence of a real human, this usually provides elderly people with an uncomfortable feeling while being in front of the robot. In fact, often, old people may be sitting on chairs or even be forced at bed, and the physical presence of the robot causes a sort of awe feeling. In some other cases people is also spending most of the time sitting (e.g., on a wheel chair) or has in general mobility problems. Many of the old persons involved in the evaluation sessions raised this issue and asked to adjust the height of the robot in order to enhance the visual contact with the remote pilot users. And for the specific primary user in TestSite_Italy_1(a), the Giraff size was really a concern. Figure 18 shows an example of such a problem. The old man, who has mobility problems, is forced to stand up to interact with his son through Giraff. The possibility to make to robot resizable would contribute to increase the usability of the system.

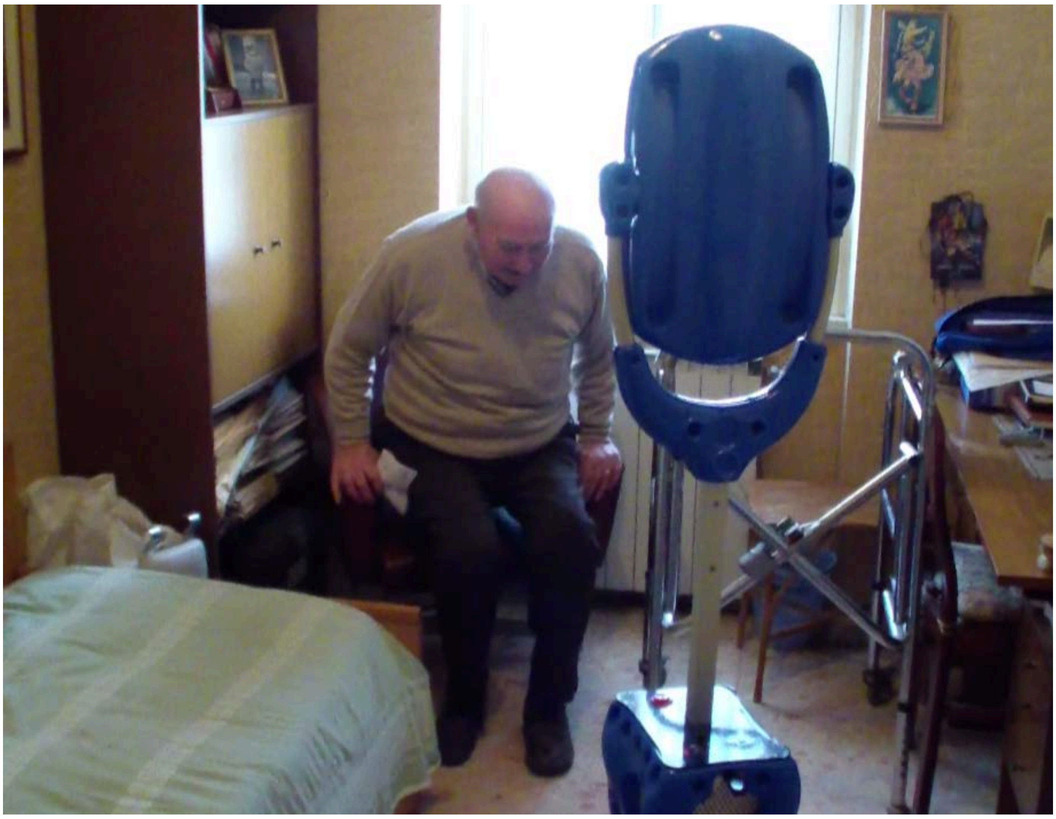

Figure 18 Evidence of the need to make the size of the robot resizable

Recommendation: Having the robot able to adjust its height is an important requirement that should be considered while designing the next generation of Giraff robots. The bar on top of which the screen is posed should allow setting the more proper height of the robot with respect to the user needs.

Implemented action(s): A complete redesign of the mechanics inside the Giraff robot were made to fit the height adjustment feature. This will allow the person driving the Giraff to change the height of the screen (his/her face), to be able to "sit down" at for example a table, remotely. Users have requested this feature to easily be able to have a conversation with the person visiting through the Giraff.

Figure 19 Giraff version 4.0 with screen at two different height settings.

2.6.4 Battery duration

Technical issue: The battery duration is too short.

Explanation: One of the most general user requirement usually discussed with end users is related to the robot's battery duration. Both primary and secondary users consider the current nominal duration as not sufficient.

Moreover, during the run of the TestSite_Sweden_1(a), there were continuous problems of the Giraff being discharged. Although education was given to the elderly and their caregivers as well as to the alarm operators, this was not sufficient to avoid some situations in which the robot was not repositioned in the docking station.

Recommendation: In this regard, the battery duration as well as the recharging modality should be improved. For instance, it would be better having the robot also able to reach autonomously the docking station.

2.6.5 Recharging also while switched off

Technical issue: The battery cannot be recharged while the robot is switched off.

Explanation: The Giraff robot has been designed as a 24-hour service that is to support caregivers during their monitoring activities. Then, the recharging task has been implemented under the hypothesis that the robot is always ready for incoming calls and batteries are not supposed to be charged while the robot is switched off even if it is properly docked.

Recommendation: The robot design should be changed considering also the possibility to allow recharging the battery also with the robot switched off.

Implemented action(s): The Giraff can now be charged when switched off. Status indicators described earlier now indicates when the Giraff is charging and also the battery level even if the Giraff is turned off. The battery can deliver 24V and 4.4Ah and takes about 2 hours to recharge.

2.6.6 Additional on-board lights

Technical issue: The pilot user interface does not provide a proper view of the remote environment in low light conditions.

Explanation: Additionally to video quality (see Section 2.2.1), the robot may be supposed to be controlled in home where light conditions are not the optimal ones. Alternatively, an operator would perform an emergency call during night hours. For instance, secondary users in TestSite_Spain_3 reported as uncomfortable event, the fact that everything was dark when the primary user accepts the call. This happens because the Giraff is docked in a room that usually has the lights off and the primary user accepts the call from another room. Then, the possibility of navigating the environment even with soft (or any at all) light would be a remarkable improvement of the robotic system. In addition, for safety reason, this is a really relevant issue to be addressed. In fact, the ability of allowing a safe navigation of the environment would dramatically affect the overall quality of the Giraff system.

Recommendation: The design of the robot should consider the presence of on-board lights. A first possible design may consider a light source located on the robot head, near the camera. This would also allow controlling the light source through the control of the tilt. An alternative solution is to consider a light source fixed on the robot body to light up the base and the area in front of the robot. Also, the deployment of different artificial lights (e.g., halos lights) should be considered.

Implemented action(s): It is now possible to operate Giraff even in complete dark using only the light from the Giraff's screen. Additionally to that, the software night vision mode has been implemented to provide an even better user experience. In this mode, the image becomes gray-scale to improve the visual dynamic range. So additional on board lights are not necessary anymore.

2.7 Software requirements

Although evaluation sessions have provided an important number of technical issues, fielding the Giraff robots in ExCITE test sites, i.e., real home environment with real primary users, enabled the possibility to collect a notable set of additional technical issues that would require a major attention. In fact, these issues resulted to be subtler than the one identified after the short-term evaluation phase. Actually, the daily use of the Giraff platform is helping to detect the challenges related to the use of the platform in real world scenarios. Then, some additional software requirements have been identified: (i) increasing the robustness of the software update process, (ii) strengthening the automatic Wi-Fi detection functionality, (iii) introducing the possibility to perform some diagnostics as well as fixing action by remote and (iv) enabling a platform independent pilot software deployment.

2.7.1 Robustness of update process

Technical issue: The Giraff software update process is not reliable.

Explanation: During the last year, new Giraff software has been deployed. Namely, the new software updates from version 1.2 to 1.3. In order to update the Giraff software on different remote robots, an automatic procedure has been set up by Giraff AB. Unfortunately, the automatic procedure turned to cause problems in the Italian test sites.

In particular, the automatic procedure did not work properly causing several kinds of damage:

- Older robots present some software settings that have not been considered in the automatic procedure. This situation caused robots to be not correctly updated. Then, a manual intervention has been needed in order to accomplish the software update. The problem has been reported to Giraff AB and the issue has been fixed.
- One of the oldest robots in Rome, even after the manual intervention, was not able to reboot. In addition, during the update, the USB drive has been corrupted and a hard manual recovery procedure was performed to restore the robotic system (i.e., removal, format and restore of the USB drive). The problem has been reported to Giraff AB and the issue has been fixed.
- For some robots, the automatic software update procedure caused an unexpected BIOS reset of the motherboard mounted on the robot (e.g., the main symptom was the robot rebooting but with a blank screen). After restoring the proper BIOS settings, the problem has been fixed. The problem has been reported to Giraff AB. Given that this problem is occurring in a not regular way, it is hard to isolate the causes thus representing still an open issue.

The automatic software update procedure entailed that after the upgrade some robots were not be able to automatically connect to the Wi-Fi network. After restoring the proper Windows OS settings, the problem has been fixed. The problem has been reported to Giraff AB. Also in this case, since the problem is not occurring in a regular way, it is hard to isolate the causes thus representing an open issue.

Recommendation: Given the above issues, the automatic software update procedure should be set up considering all the different versions of robot, thus, avoiding to have some (old) robots not properly managed by the automatic update. Additionally intensive tests should be performed before deploying the updating procedure in order to avoid problems/damages to the robotic systems deployed in the test sites.

2.7.2 Wi-Fi automatic detection

Technical issue: The automatic Wi-Fi connection functionality is not reliable.

Explanation: Very often it happens that robots are not able to automatically detect and connect to the dedicated Wi-Fi network. This entails a clear limitation in the usability of the system as the elderly is not supposed to take care of the management of such software settings and the presence of a robot technician cannot be continuously guaranteed in the house.

In TestSite_Sweden_1(b), a common problem with the Giraff was that it was “Unavailable” which required frequent restarts. The pilot also experienced latencies in the sound compared to the image on the screen. Also the elderly commented on the low synchronization. A possible reason is that the pilot’s computer is connected to the private municipality network while the Giraff is on the public municipality network.

Recommendation: The Giraff software should be permanently configured to remember a Wi-Fi network, and directly connect to it. Another suggestion to make it easier the deployment phase is to provide in addition to the robot also a router already set with a suitable configuration.

Implemented action(s): Robot OS software has been upgraded to Windows 7 embedded to use the latest embedded operation system from Microsoft.

Due to this update, the write protection mechanism present on the Giraff robot software has been removed. So, now users do not have to follow any procedure when adding a new wireless network, adding a 3rd-party application or changing the Windows configuration.

2.7.3 Remote management of the robot

Technical issue: The Giraff system does not allow a remote management of the robot.

Explanation: The Giraff AB Company is currently not present in each country, and then manual interventions requested to fix problems/damages on fielded robots are supposed to be performed by not-specialized personnel. In many test sites (e.g., TestSite_Sweden_2, TestSite_Spain_3 and TestSite_Italy_1(d)), malfunctioning of the robots, technical problems and network issues have been managed with difficulties given either the long distance or the absence of a proper technical assistance. In fact, generic technicians have been provided by one of the involved partners in each country. Given the fact that such technicians are not fully familiar with the robotic platform, an increasing risk of introducing additional problems should be considered. In this regard, the possibility to perform at least some software checking/fixing actions via a remote connection to the robot is one option that would allow Giraff AB's personnel to directly (i) check the actual status of the robotic systems, (ii) detect possible causes of problem and, overall, (iii) fix them in a more effective way or (at least) provide more detailed instructions to local technicians.

A strictly related issue concerns the information provided by the Sentry web portal[4]. Currently, a Giraff system administrator cannot gather information about the actual status of the robot through the Sentry system. Then, whenever an error occurs in a remote test site, the robot administrator is not able to perform any remote diagnostics. The sentry does not provide any information about the actual status of the robot (is the robot active? is the robot online? is the robot docked to the charging station? Which is the status of its battery?).

Moreover, it would be very useful to have the possibility to access the robot operating system in order to assess the status of the software application as well as checking the quality of the internet connection and other tests that otherwise can be performed only by physically visiting the remote place and manually accessing the robot system. This is a really crucial issue to enhance the supporting actions needed to run a test site.

Further Evidence: In TestSite_Italy_5, the robot has been deployed in a house at about 300 km from the CNR offices. Thus an engineer living near the resident house has been selected to manage local issues. Unfortunately this entailed many interactions between the CNR researchers, the Giraff technical staff and the local engineer that were not easy to manage. This identifies a different type of weakness in the management model of the final product.

Recommendation: The Sentry system should be enriched with additional functionalities allowing administrators to have access to robot related information (e.g., the status of the robot, the status of its battery, etc.) and also have the possibility to make some maintenance intervention from remote locations (for instance, software updates).

Implemented action(s): The Sentry service has been further extended. Additional and more clear information is available for a robots administrator. Nevertheless, remote interventions are still not possible. Any software setting modification or even simple checks of service status requires a physical intervention in the resident house.

2.7.4 Platform independent Pilot Software

Technical issue: The pilot client software is currently available only for Windows-based machines.

[4] Sentry is the database management system that care organizations and other administrators use to manage Giraffs and Pilot users within their "domain". It allows the administrator to manage several activities from the Sentry web site such as create and edit Giraff "identities", create and edit Pilot "users", manage user permissions to Giraffs, create and manage "approvers" for Pilot users, view "visit logs".

Explanation: A problem highlighted by some test sites was the fact that the software of the pilot side is only running under Windows machines. For instance, in TestSite_Italy_1(a), at least two other client users could have been possible but, these persons had a Macintosh machine and for this reason they could not use the pilot from their machines. Also, in TestSite_Italy_1 (d), a discomfort in using the pilot software has been initially increased by the used computer platform (the main pilot user initially used the client on a Windows machine while he is a native Mac user). Indeed, once he started to use the Giraff client on his Mac, thanks to a new version of Windows emulator (Parallel), the use became more frequent, and its motivation to use the tool with more "regularity" increased.

Naturally, this suggests that having the pilot software capable of running on more OS would be beneficial for the diffusion of the Giraff robot as a major range of pilot users may be able to connect through the robot.

Recommendation: The Giraff Pilot software should be developed also for other OS so as to make it platform independent. Furthermore the wide availability of new platform like tablets or smartphones open up new possibilities of use for the pilot site for professionals that regularly use such kind of portable devices.

3 Detailed List of Technical Recommendations for the Giraff Robot

The results of the work discussed in Section 2 have been further critically analyzed resulting in the following list of detailed Technical Recommendations.

For each recommendation the following information is provided:
Serial/Ref: an identifier of the Technical Recommendation
Capability Descriptor: a brief textual description of the Technical Recommendation
Requirement Statement: a more detailed description of the Technical Recommendation
Justification References: A short reference to the motivations for the Technical Recommendation and specifically the source that inspired it. In particular, the origin of each TR is specified through the specific evaluation session (S1-S10), the country (Italy, Spain and/or Sweden) and the end user category (PU = Primary User, i.e., the old persons, SU = Secondary User, i.e., the pilot users) from which the TR has been addressed.
Priority: the level of importance of the Technical Recommendation in the range of **K**ey, **D**esirable, **O**ptional. Most of the requirements have been assigned a Key priority level since the technical problems associated with them seriously affected the running test sites.
On the contrary, those requirements whose corresponding technical problem was signaled by a limited number of people not causing critical issues, or those whose technical solution was not directly within the scope of the current project, have been assigned either Desirable or Optional.
Status: After the third year, some issues have been addressed while others have been partially fixed and some other issues are still open. An additional column in the table has been added to highlight the status of the issue. Then an issue can be either **Open** or **Partially fixed** or **Fixed.**
The following table summarizes all the technical requirements with the associated information.

Serial/ Ref	***Recommendation Descriptor***	***Recommendation Statement***	***Justification References***	***Status***	***Priority***
		1. Video quality			
TR.1.a	*Enhanced Video Resolution*	*The Giraff robot shall provide an enhanced image resolution for video communication*	*S1, S7, S9, TestSite_Spain_1, TestSite_Spain_3* *Sweden, Italy, Spain* *PU, SU*	***Fixed***	***K***
TR.1.b	*Video Zoom Feature*	*The Giraff system shall provide a video zoom functionality*	*S1, S2, S3, TestSite_Spain_3,* *Italy, Spain* *SU*	***Open***	***D***
TR.1.c	*Night Vision*	*The Giraff system shall be endowed with a night vision camera*	*S1, S2,* *Italy* *SU*	***Fixed***	***K***
		2. Autonomous Navigation			
TR.2.a	*Navigation Assistant*	*The Giraff system shall be endowed with basic autonomous navigation behaviors as well as obstacle avoidance and SLAM capabilities*	*S1, S2, S3, S7, TestSite_Italy_1(d)* *Italy, Spain* *SU*	***Fixed***	***K***
TR.2.b	*Automatic Docking*	*The Giraff system shall be endowed with automatic docking capability*	*S1, S2, S3, S7, S8, S9, TestSite_Sweden_1(a), TestSite_Spain_1, TestSite_Italy_1(d), TestSite_Sweden_7* *Italy, Spain, Sweden* *SU*	***Fixed***	***K***

TR.2.c	*Automatically Reaching the Docking Station*	*The Giraff system shall be able to automatically reach the docking station in the remote environment*	*S1, S2, S3, S7, S8, S9, TestSite_Sweden_1(a), TestSite_Spain_1, TestSite_Italy_1(d), TestSite_Sweden_7* *Italy, Spain, Sweden* *SU*	***Partially Fixed***	***K***
		3. Pilot UI			
TR.3.a	*Battery Level Indication*	*The Giraff system shall be endowed with a Pilot UI with a more visible indicator of the battery level of charge.*	*S1, S8* *Italy, Sweden* *PU*	***Fixed***	***K***
TR.3.b	*Map and Localization*	*The Giraff system shall be endowed with a Pilot UI enriched with a map of the remote environment as well as a clear indication of the position of the robot.*	*S7, TestSite_Sweden_1(a)* *Spain, Sweden* *SU*	***Fixed***	***K***
TR.3.c	*Different Control over Robot's Behavior*	*The Giraff system shall be endowed with alternatives tangible interfaces to control the movements of the robot.*	*S1, S2, S4, S7, S9* *Italy, Spain, Sweden* *SU*	***Fixed***	***D***
TR.3.d	*Volume Controls*	*The Giraff system shall be endowed with a Pilot UI with different volume controls to facilitate their settings.*	*S8* *Sweden* *SU*	***Fixed***	***K***
		4. Giraff System			

TR.4.a	*Call Transfer*	*The Giraff system shall be endowed with a vocal pre-recorded message to be sent to a mobile phone when the callout user is not able to react.*	*S1, S2, S3* *Italy* *SU*	***Partially Fixed***	***K***
TR.4.b	*Contact List*	*The Giraff system shall allow the Primary User to access a Contact list in order to choose a callout user.*	*TestSite_Italy_1(d), TestSite_Italy_3* *Italy* *PU*	***Open***	***K***
TR.4.c	*Network Requirements*	*The Giraff system shall provide a clear statement about the network requirements necessary for best experience.*	*TestSite_Italy_1(a), TestSite_Italy_4, TestSite_Italy_5, TestSite_Spain_1, TestSite_Spain_4, TestSite_Sweden_1(b), TestSite_Sweden_2, TestSite_Sweden_4, TestSite_Sweden_6* *Italy, Spain, Sweden* *PU, SU*	***Open***	***K***
TR.4.c	*3G Connection*	*The Giraff system shall be endowed with the possibility to connect through a 3G (4G/LTE) internet connection.*	*TestSite_Italy_1(a), TestSite_Italy_1(b), TestSite_Italy_4, TestSite_Italy_5, TestSite_Sweden_6* *Italy* *PU*	***Open***	***K***
		5. Giraff Robot			

TR.5.a	*Changing Display Orientation*	*The Giraff system shall be endowed with the capability of changing the orientation of the robot display when it is docked.*	*TestSite_Spain_1, TestSite_Italy_1(d), TestSite_Italy_3* *Spain, Italy* *PU, SU*	***Partially Fixed***	***K***
TR.5.b	*Visual Indication of Recharging Status*	*The Giraff system shall be endowed with a visual indication of the battery level of charge on the robot.*	*TestSite_Italy_1(d), TestSite_Italy_4* *Italy* *PU*	***Fixed***	***K***
TR.5.c	*Adjustable Height*	*The Giraff system shall be endowed with the possibility to adjust the height of the robot.*	*TestSite_Italy_1(a)* *Italy* *PU*	***Fixed***	***K***
TR.5.d	*Battery Duration*	*The Giraff system shall provide battery duration of (at least) 8 hours.*	*S1, S2, TestSite_Sweden_1(a)* *Italy, Sweden* *SU, PU*	***Open***	***K***
TR.5.e	*Recharging also While Switched Off*	*The Giraff system shall be able to recharge even if it is switched off*	*TestSite_Italy_1(d)*	***Fixed***	***K***
TR.5.f	*Additional On-Board Lights*	*The Giraff system should be endowed with some onboard light*	*TestSite_Spain_3* *Spain* *SU*	***Fixed***	***K***
		6. Giraff Software			
TR.6.a	*Robust Software Update Process*	*The update process of the Giraff system should be robust enough to avoid any kind of problems in the test site*	*TestSite_Italy_1(d)* *Italy* *SU, PU*	***Open***	***K***

TR.6.b	*Wi-Fi Automatic Detection*	*The Giraff software should be permanently configured to remember a Wi-Fi network, and directly connect to it*	*TestSite_Sweden_1(b)* *Sweden* *SU*	***Fixed***	***K***
TR.6.c	*Remote Management of the Robot Software*	*The Sentry system should be enriched with additional functionalities allowing administrators to have access to robot related information as well as to make some maintenance intervention from remote locations.*	*TestSite_Italy_1(d), TestSite_Spain_3, TestSite_Sweden_2, TestSite_Italy_5,* *Italy, Spain, Sweden* *SU*	***Partially Fixed***	***K***
TR.7.c	*Pilot Software Platform Independent*	*The Giraff Pilot software should be developed also for other OS so as to make it platform independent.*	*TestSite_Italy_1(a), TestSite_Italy_1(d)* *Italy* *SU*	***Open***	***D***

4 Final considerations

This deliverable illustrated the work done to derive the technical requirements for the Giraff system after the three years of assessment. Specifically, starting from the results of the evaluation with real users both in laboratory sessions and in the running test sites, a careful analysis of user feedback has been performed and translated into technical requirements for the robot refinement. It is worth highlighting that the twofold approach of the evaluation methodology, which is structured into short term and long term assessment, led to a distinction also in the identification of the technical recommendation. Indeed, while the short term sessions allowed to highlights many problems related to the interaction with the robot, video and audio issue, as well as usability aspects, the experience with the long term test sites have been crucial to assess many technical issue connected with robustness, stability and safety of the system that could have only be noticed after real usage for long periods of time.
The combination of this analysis has led to the definition of a set of technical recommendations that have been used in the last year of the project to implement suitable technical improvements of the telepresence platform, thus supporting the user-drive approach peculiar of the ExCITE

project. As a final result, 24 technical recommendations have been stated at M24. Many actions have been implemented and more than 50% of the technical issues have been fixed. Almost 30% of them are partially fixed while less than 15% are still open.

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