Deliverable D5.4

Phase I - Design Phase: Selection of the two winning teams for Phase II

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Glossary of Terms

ECHORD++: The European Coordination Hub for Open Robotics Development (E++ for short)

1 Introduction

The current deliverable is connected to Phase 1 of the Public end-user Driven Technological Innovation (PDTI) focusing on the two application areas Healthcare (Comprehensive Geriatric Assessment) and Urban Robotics (Sewer Inspection). In the previous deliverable (D5.3), phase 0 of the PDTI process was described in detail. D5.4 now gives an overview over the proceedings in Phase 1 and the evaluation and selection of the two winning teams that will continue in Phase II.

Phase 1 of the PDTI Challenge is focused on the solution and system design. Three consortia per application scenario were chosen to compete in Phase I, which lasted 6 months. Even though Phase II will focus on developing a reliable prototype for the solution, the consortia already had to show a working prototype at the end of Phase I. Two consortia per scenario have been chosen to compete in Phase II. In the final phase III, the same consortia as in phase II will perform small-scale test series with their prototypes to improve them and prepare them and prepare them for commercialization.

Each phase of PDTI framework can be compared to the Technology Readiness Levels (TRL) used by Horizon 2020. Therefore, Phase I is associated with TRL level 4, where technological components are built together in order to test if they would work together. It is also a phase of design and technology implementation through laboratory testing (Horizon2020, 2014). Phase II is based on TRL level 6, where the technology has to be tested in a relevant environment. Here, the process demonstration should be carried in a real life scenario. The final Phase is then associated with TRL level 7 where the prototype of the system has to be demonstrated in an operational environment. The aim here is to minimize the manufacturing risks. If all the tests run well, this phase could go up to level 8 of the TRL where the system has to be complete, which can represent the end of the actual system development.

2 PDTI Urban: Overview of the Process

Phase I - Solution Design and first prototype – started on January 1st, 2016 and finished on June 30th, 2016. During these six months the RTD consortia designed and developed a first prototype to be tested at the end of this phase in a real environment.

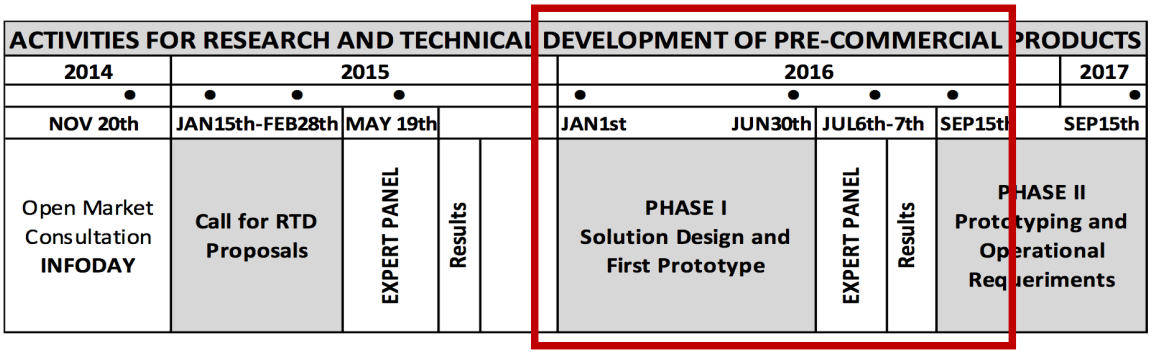


Figure 1: PDTI Urban Phases

During these six months the UPC Team has had continuous contacts with the consortia, answering technical questions. Several visits to the Barcelona sewer infrastructure have been done by the consortia in order to test the prototypes. The public entity managed all these visits giving support to the operational performance. The document "PDTI Sewer: Evaluation Criteria Phase I", elaborated between the public entity, BCASA and the UPC Team, technological coordinator of the process, was presented and discussed at the kick-off meeting programed on February, 17th, 2016. Also, a FQA document (Annex 1) was collected during the previous months and discussed during the meeting. A final document of the "PDTI Sewer. Evaluation Criteria Phase I" was sent on April 14th to all the consortia (Annex 2).

The evaluation of the three technological proposals at the end of phase I has been based on marks according to three basic criteria: Scientific and/or technological excellence, Quality and efficiency of the implementation and the management of the project and potential Impact through the development, dissemination and use of the project. Moreover, the items based on the challenge brief used for the evaluation were:

+ Positive evaluation of the tasks and documentation required during the period (Deliverables, milestones and dissemination milestones)

+ Solution design and the logistics required and operational issues by using the solution

+ Test Series based on the viability of the robotic solution mobility in the sewer network conditions, the communications suitability in underground sewage system network and the autonomy versus mobility of the robotic solution.

+ Economic Viability of the proposal

3 PDTI Urban: Development of Deliverables and Evaluation Criteria for Phase I

The deliverables presented on June 30th, 2016 exposed the solution design of each robotic prototype and the logistics required and operational issues by using the solution. Also, they present the economic viability of the proposal.

ARSI is a Micro Aerial Vehicle (MAV), multi-rotor type, endowed with sensors for its autonomous navigation along the sewer network, collecting data for its inspection. The ARSI platform was designed as a quadrotor platform, meaning that it is propelled by 4 rotors positioned in a square shape. Quadrotors have many advantages over other types of configurations, in particular their stability, maneuverability and efficiency in terms of maximum flight time. In order to minimize the overall platform weight and dimensions while maximizing space for sensors and batteries, SimTech Design decided to use a custom-made carbon body with commercial components from the TBS Discovery platform. The quadrotor arms were repositioned to reduce width of the platform down to 30.95 cm from motor to motor, or 57.2 cm in total when taking propellers and protections into account. The platform is 71 cm long and 39 cm high including landing gear. (See ARSI Deliverables 26.1 and 26.2)

Robodillos Consortia explained the development of the TRL4 solution design for the Robodillos system, an advanced robotic platform for sewer inspection operations that synergistically integrates state-of-the-art wireless communication technologies with autonomous multi-robot systems technologies in a unique, robust, agile, scalable and reliable solution. During phase I, an array of activities including hardware, software and algorithm development were carried out. A detailed solution design has been prepared and a detailed business plan has been developed. Based on the Robodillos solution design and business planning, Robodillos will offer a cost reduction of more than 64% compared with current practice, with an inspection cost of less than 0,27 € / lineal meter and a performance up to 1.335.360 lineal meters per year. (See ROBODILLOS Deliverable D27.1)

The SIAR Consortium started their studies and evaluation of the sensors, actuators and processing system, based on the existing IDMs RaposaNG. After the kick-off meeting and after an evaluation of scenario based on the collected videos and images, it became clear to the team that a tracked solution based on RaposaNG would have many difficulties to adapt to the different sewer configurations encountered in Barcelona. Hence, IDM team started the study of other robotic kinematic configurations that could

be more suitable for the proposed sewer scenario. This study took them to a six-wheeled robot configuration, based on six independent motor actuators. A first prototype was built and used to test the locomotion, communication and teleoperation control in the sewers of Barcelona. Two visits to the sewers of Barcelona during phase I allowed the team to have a better understanding of the different issues related with sewer inspection and the requirements of the autonomous system. A new robot was built based on the acquired know-how, with the following key features beyond the state of the art required to properly address the challenge: a robust IP67 robot frame designed to work in the hardest environmental conditions with increased power autonomy and flexible inspection capabilities; an adaptable robot frame that allows to increase/decrease the width of the platform from 460 mm to 666 mm to accommodate to different sewer dimensions; robust and increased communication capabilities; on board autonomous navigation and inspection capabilities; usability and cost effectiveness of the developed solution. (See SIAR Deliverables D28.1 and D28.2).

4 PDTI Urban: On-Site Testing

As mentioned above, during phase I period, the sewer infrastructure was available to the consortia to do open tests. The Final Tests were done on July 6th and 7th, 2016. ARSI prototype performance on July 6th from 10am to 14pm. Robodillos prototype was tested on July 6th, from 15pm to 19pm, and SIAR prototype on July 7th from 10am to 14pm.

Figure 2: Performance at the Sewer Infrastructure of all three RTD consortia

Figure 3: Mobility recovery test of prototypes of all three RTD consortia

5 PDTI Urban: Panel Meeting and Outcome

The Evaluation Panel took place on July 7th at 14pm at UPC. The evaluation was done by two external experts Tjibbe Bouma and Alvaro Iriarte that assisted to all the onsite tests, deliberated and evaluated the three technological proposals and selected the two consortia that pass to the phase II. The expert panel was supported by the public body partner, the City Council of Barcelona / BCASA Team, represented by Javier Varela, Mª José Chesa and Lina Martinez, the technological coordinators, the UPC Team, represented by Alberto Sanfeliu, Josep Casanovas and Ana Puig-Pey and the General Coordinators of E++, represented by Francesco Maurelli from TUM.

The Outcome of the panel meeting - the evaluation and marks elaborated by the two external experts - selected two consortia to continue to phase II: ARSI and SIAR. The evaluation and selection were collected (Annex 3) and communicate to the consortia on August, 8th.

6 PDTI Healthcare: Overview of the Process

The PDTI Healthcare Challenge is focusing on the development of technical solutions to improve Comprehensive Geriatric Assessment (CGA). The public body chosen to assist in achieving this aim is the hospital Sant Antoni Abat in Vilanova i la Geltru. After two open calls three teams were selected to compete in Phase I: ARNICA, ASSESSTRONIC and CLARK. Phase I - Solution Design and first prototype – started on January 1st, 2016 and finished on June 30th ,2016. Phase I was officially kicked-off on February 18th, 2016.

On January, 12th the consortia received an outline of those deliverables that they had to submit at the beginning and at the end of Phase I. They had two weeks to give their feedback and ask initial questions concerning the deliverables. The final, revised version was distributed a few weeks before the kick-off meeting. The consortia had to submit a first deliverable a few days before the kick-off meeting. They had to fill-in an initial document on how they plan to achieve the technological requirements from the Challenge Brief (pp.15) for Phase I. Each consortium received individual feedback from TUM, AQuAS and BOR on their plan in a 30min session during the kick-off meeting. In addition, open questions, which were collected beforehand (Annex 4), concerning the deliverables and administrative tasks were discussed at the kick-off meeting. Finally, the consortia also had a chance to see the rooms that were to be used for the final testing at the end of Phase I.

Each consortium received a private tour by the public body which also allowed them to ask initial questions about the solution requirements.

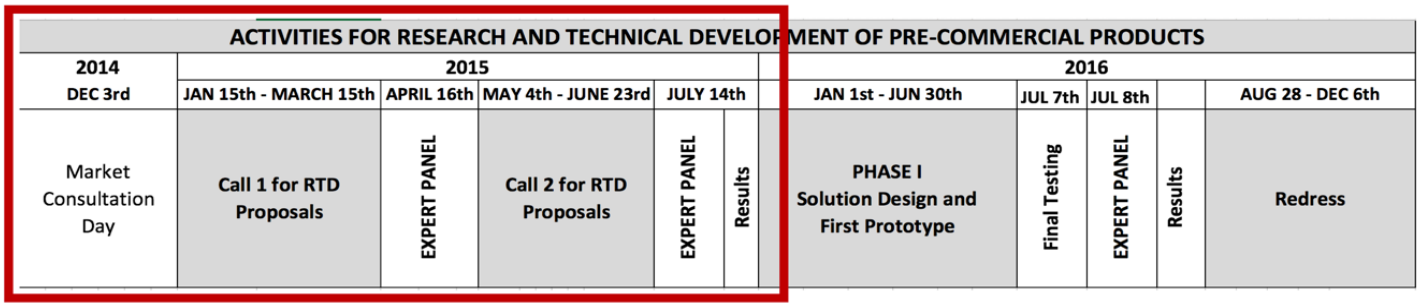


Figure 4: PDTI Healthcare Timeline

During the six months of Phase I, TUM, BOR and ABAT were in ongoing contact with all consortia. Especially the public body answered the consortia's questions during phone calls, conference calls and physically meetings at the hospital. However, the intensity of the contact was dependent on the initiative of the consortia.

On June 7th an evaluation matrix was e-mailed to all consortia, which described the exact criteria per which the reviewers were to evaluate the deliverables and on-site testing performance. The document was edited in the following week based on constructive feedback from all consortia and a final version was sent out to the them. All consortia had to sign a document stating that they agree to accept the outlined criteria. The final testing took place from July 6th to July 8th, 2016 at the hospital Sant Antoni ABAT in Vilanova i la Geltru. The first day was a preparation day for the RTD consortia, the official testing was performed on the second day and the panel meeting without the consortia took place on the third day.

7 PDTI Healthcare: Development of Deliverables and Evaluation Criteria for Phase I

The aim of PDTI Healthcare is the development of solutions which will allow health professionals to perform CGA in an easier and more qualitative way. The expected outcome mentioned in the Challenge Brief at the end of Phase I was to show the first concept solution as well as an initial prototype (Figure 5). The concrete deliverables were specified in more detail by the E++ partners involved in PDTI Healthcare TUM, BOR, AQuAS and ABAT two months before Phase I started and finalized after the Kick-Off Meeting. The final document describing the deliverables is called "Evaluation Criteria" (Annex

5). 1 month before the final evaluation, the RTD consortia received a detailed outline on the ranking of the deliverables in a document called “Evaluation Matrix” (Annex 6).

Stage I (first 6 months)	Stage II (month 7-18)	Stage III (month 19-30)
Concept of whole system First prototype, mainly to assess the look-and-feel, but mock-up functionality	Usable prototype with main functionalities implemented in the first version. First tests with end-users possible, but supported by the developers	Fully functional system ready to be tested in practice with very limited help of the developers.
Mock-up of Barthel [1]and Get-Up and Go tests.	Implementation of Barthel and MMSE test, as well as the Get-Up-and-Go test.	Full implementation of Barthel, Lawton, Pfeiffer, MMSE, Yesavage, as well as Get up and Go, Tinetti Gait, Tinetti Balance tests.

Figure 5: Phases of PDTI Healthcare

The development of the deliverables started in November 2015 and was coordinated by BOR. As the commercial partner, BOR have participated in PCP projects (the UV-Disinfection Robot as most recent example) and have as a company a great focus on developing robotic solutions themselves in their Robi-X program. Thus, they have reasonable knowledge concerning the evaluation of emerging robot solutions and created the deliverables based on their experiences and the descriptions of the Challenge Brief. The public body contributed intensively with a description of the testing site and an outline of the requirements concerning Human-Robot Interaction as well as the workflow and autonomy of the solution. The suggested deliverables were discussed by all partners involved in PDTI Healthcare as well as the reviewers in a few editing rounds.

The document “Evaluation Criteria” does not only focus on the technological development of the solution, but also includes other important aspects that need to be considered when developing a product for the actual market. The advantage of this in comparison to a rather academic demonstration is that the commercial potential of the product is brought into focus. The Evaluation Criteria outline the deliverables and give an initial idea on how the deliverables will be evaluated. This initial description was necessary to give the consortia enough information for phase I as the more detailed Evaluation Matrix was first finalized one month before the submission of the deliverables. Thus, it helped the consortia to focus on the most important aspects required for the evaluation of Phase I. The document also gives a short introduction to the testing area and what kind of tests were to be performed in the final on-site testing. Annex 7 shows an overview of the deliverables and the initially described criteria from the Evaluation Criteria. The consortia had to submit 9 deliverables before the final testing: an idea resume, technical

specifications for Phase I (submitted at the beginning and again at the end of Phase I) as well as Phase II and III, record on their involvement with potential end-users, videos describing their solution design and performance, a report on economic viability and ethical considerations. There are six templates in the appendixes that the consortia are asked to use for their deliverables. Some deliverables do not have a template because they are pure written reports (Economic Viability, Ethics), On-Site Testing or videos. The deadline for these deliverables was January 31st for the development plan of Phase I and June 28th for all remaining deliverables. In general, the evaluation was based on four main criteria:

+ Scientific and/or technological excellence
+ Quality and efficiency of the implementation and the management of the project
+ Involvement of the stakeholders, including the end-users
+ Potential Impact through the development, dissemination and use of the project

Three of these criteria were mentioned in the Guide for Applicants, the involvement of stakeholders, especially end-users, was first added when creating the Evaluation Criteria.

For the final evaluation, a matrix was compiled outlining how the deliverables and the on-site testing would be evaluated in detail and how each area would be ranked. There were several reasons for creating the matrix. First, to have a coherent point of view about the evaluation criteria from E++ partners involved in PDTI Healthcare, especially the public body, as well as the reviewers. Second, to give the consortia an overview on the evaluation that they can expect, especially to give them a more specific description of the evaluated areas and their weighting. Third, all consortia were supposed to be evaluated in the same way by all three reviewers. Fourth, to have the consent of all consortia that they accept the specific evaluation criteria.

The coordination of the matrix development was taken up by BOR because it was based on the content of the Evaluation Criteria. The table from the Challenge Brief on requirements and expected outcome at different stages of PDTI Healthcare was taken as a template and mostly non-technical areas were added for each deliverable. Every partner involved in PDTI Healthcare as well as the reviewers added areas and evaluation criteria based on their expertise in an iterative-editing process. Thus, the public body added for

example criteria on the end-user involvement, Human-Robot Interaction and display of results for each test. TUM added amongst others criteria on the data management, openness of integration with other hospitals, adjustment to future technology and data protection. The reviewers focused on explaining technical requirements and system specifications in more detail as well as expectations for ethical considerations. BOR described the expected outcome for commercialization of the solution and economic viability in more detail. The matrix with all collected input was then finalized and reviewer by everyone.

The final matrix is build on seven main categories: general specifications, the system, evaluation and data management, ethics considerations, the economic viability, configuration and on-site testing evaluation. For each of the categories, specific criteria rate the proposed solutions. In accordance to the focus of Phase I -solution design and first prototype- the success of the solution was based on the feasibility and coherence of the proposed design, outlined development plan and soundness of technical description rather than the status of the core technical development. Finally, the involved E++ partners and the reviewers allocated points to each evaluation criteria to show the weighting of the different categories:

+ Crucial: 10
+ Essential: 8
+ Important: 6
+ Of some significance: 4

Among the evaluation criteria considered crucial, the Human-Robot Interaction came first in the matrix, mostly because this was a very crucial factor for the public body. Here, the focus was on the degree of autonomy of the robot, how the robot identified and interacted with the actors in the specified scenario. When looked at the economic viability, the freedom to operate analysis was also considered crucial, due to the importance of identifying possible restrictions for the product to be further developed. Finally, the criteria for all three on-site tests were considered crucial as well because they would show the actual feasibility and soundness of the design concept.

8 PDTI Healthcare: On-Site Testing

The testing was conducted at the Hospital Sant Antoni ABAT in Vilanova i la Geltru on July 6th and 7th, 2016. The first day was allocated for the consortia to set-up and prepare their solutions for testing. On July 7th, the on-testing for Phase I was conducted. The testing was scheduled in a way that each consortium performed the same test so that the reviewers could compare the solution design of all consortia. After each test sessions, the reviewers had 10 minutes to discuss the performance or ask the consortium questions while the next consortium set-up in front of the room.

Figure 6: ARNICA performing BARTHEL Test, ASSESSTRONIC performing MMSE Test, CLARK performing Get Up and Go Test

The solutions after Phase 1 were not reliable enough to be tested by real end-users. In the case of CGA end-users are not only elderly people, but can also often be cognitively and physically impaired. Thus, it was decided that the person performing the test should be Jean-Patrick Mathieu. As AQuAS is managing PCP projects, they have a considerable knowledge at testing and evaluating solutions. In addition to this, Jean-Patrick could test the solutions in Spanish or Catalan because an English interface was not mandatory at the end of Phase I. More importantly was, however, that Jean-Patrick was not directly involved in the development process in contrast to the public body who tested the solutions throughout Phase 1. Jean-Patrick was therefore the best person to test the solutions as he did not have any pre-knowledge and could test them from a naïve user's point of view. A second test was often performed by one of the reviewers to clarify open questions.

The first test that was performed by all consortia was the BARTHEL Test. Each consortium had 30min to present their solution design related to the BARTHEL Test. The second test was the MMSE Test, which was also performed in 30min. These two tests were performed in a closed room where they also usually take place. The last test was the Get up and Go Test, which was tested in an open room to have enough space for the test per-

son to walk. During a real CGA test, the end-users also use that same open space for patients to perform the gait tests. Each consortium had one hour to perform the test three times and present their concepts to the reviewers. Each test was performed more than three times by different persons imitating physical body postures of elderly people. The test was also performed twice by the same person to test the reliability of the solution and the results. As the tests were performed very quickly, the reviewers had more time to ask final questions to each consortium. The day ended with at around 5:30pm when the last consortium was finished.

9 PDTI Healthcare: Panel Meeting and Outcome

On 8th of July, the panel meeting took place at AQuAS in Barcelona. The three external reviewers Malcom Fisk, Andreas Müller and Philippe Bidaut performed the evaluation based on their individual scores from the Evaluation Matrix. They all have different fields of expertise to evaluate the solution designs from a broad perspective. Thus, not every reviewer could give a score in all areas. Each reviewer only evaluated the areas that he felt comfortable with. The reviewers were supported by E++ partners involved in PDTI Healthcare: Cesar Galvez Barron (ABAT), Jean-Patrick Mathieu (AQuAS), Marie-Luise Neitz (TUM), Franziska Kirstein (BOR). On July 7th, scores from all reviewers were collected in one Excel sheet. At the panel meeting, every reviewer presented their scores based on the submitted deliverables and the on-site testing the day before. Furthermore, they mentioned critical advantages and disadvantages of the solution design of each consortium. After a first score calculation, it was clear that ASSESSTRONIC had received the highest score from each reviewer. They had involved different stakeholders in their design process in Phase 1, especially end-users and presented a concept design that was well thought out and has commercial potential. Especially the public body supported this decision. The subsequent discussion was therefore more focused on the proposed solution designs by CLARK and ARNICA. The first topic of discussion was whether one of their solution showed enough potential to compete with ASSESSTRONIC's solution in Phase 2 at all. Both consortia did not perform as expected, especially because they either did not include the end-user into the development process or failed at translating the needs to a proper design. In this regard, a re-occurring evaluation criteria was the expected market potential of the proposed designs by CLARK and ARNICA, especially how open their platforms are for an iterative re-design in Phase 2 done in

close collaboration with end-users. It was decided that CLARK has a platform, which is more open to technological changes and possible re-design than ARNICA's platform. However, CLARK would need to show more commitment and put a lot of effort into the re-design of their platform in Phase 2 in order to compensate for their wrong development decisions. In addition, their consortium clearly lacked a partner who can translate the end-users' needs into design requirements. Thus, it was decided that CLARK would be chosen for Phase 2 if they committed to re-design parts of their solution and add another partner to their consortium. To conclude, the evaluation panel chose two consortia to advance to Phase II: CLARK and ASSESSTRONIC. The results were communicated on August 15th (Annex 8).

10 PDTI Healthcare: Redress

On August 28th, ARNICA submitted a redress. Conflict of interest (COI)evaluation is even more important for PDTI because the final evaluation was on site and face-to-face evaluation. Guidelines on how to evaluate a potential and disqualifying COI are outlined in the guidelines of the European Commission. The COI issues raised by ARNICA were first evaluated by an internal redress committee and then by the legal office of the European Commission. The latter confirmed that the processes applied in E++ were valid and that there was no ground for a COI. Nevertheless, the entire redress process lasted for three months. During this time, it was not sure whether the RTD consortia needed to be re-evaluated and whether PDTI Healthcare could continue.

11 PDTI Challenge: Lessons Learned

During Phase 0 and Phase I, PDTI handled several challenges successfully and experienced several positive outcomes. The learned lessons from these challenges and experienes could especially be useful for PCP:

+ Deeper development of Phase 0 is required, especially close collaboration of public bodies and technical partners
+ Public entities can use innovative public procurement instruments as PDTI to be more competitive
+ Tailor-made solutions for both scenarios: swift and effective process adaptation to address specific requirements of the different public bodies is needed

+ Qualified, possibly interdisciplinary, team is necessary to converse public body's needs and requirements into technological functions
+ Challenge Brief should have detailed description, if possible including exact knowledge about environment that robotic solution will be
+ Close collaboration with public entities will increase innovative technological challenges (PDTI has received more than 20 innovative technological proposals from public entities)
+ PDTI process gives the link between public entities, industry, researchers and end-users and PCP should incorporate this lesson into the process, especially in Phase 0 because to include the direct opinion and ethical considerations of end-users
+ Phase I should require the development of a first prototype instead of only a solution design
+ Evaluation criteria should be clearly stated and distributed at the beginning of each phase
+ The importance of this interaction is lessons learned from E++ based on a comparison between the approaches between urban and healthcare.

Annex

Annex 1: PDTI Urban. FQA

Annex 2: PDTI Urban Final Report

Annex 3: PDTI Urban Evaluation Criteria Phase I

Annex 4: PDTI Healthcare FQA

Annex 5: PDTI Healthcare Evaluation Criteria Phase I

Annex 6: PDTI Healthcare Evaluation Matrix Phase I

Annex 7: PDTI Healthcare- Deliverable Overview

Annex 8: PDTI Healthcare- Panel report

Public end-user Driven Technological Innovation (PDTI)

UTILITY INFRASTRUCTURES AND CONDITION MONITORING FOR SEWER NETWORK. ROBOTS FOR THE INSPECTION AND THE CLEARANCE OF THE SEWER NETWORK IN CITIES"

QUESTIONS ADDRESSED BY THE CONSORTIA

Updated 29/01/2016

1.- Evaluation between Phase I and Phase II.

The first phase is 6 months long and the continuation depends on the successful milestone review after these six months. Out of the three selected teams, only two will continue for the second phase. The review and the assessment of the competitive teams will be performed by independent experts from different fields. They will evaluate the tasks and documentation required during the period through the document "Evaluation Criteria Phase I".

2.- Tests

We are asking to make a mobility test on the physical robot platform as one of the evaluation criteria. This test is using the platform that you already have, not necessarily with the modifications that are required for doing the inspection task. The public body wants to realize that all the robot platforms have the minimum mobility conditions to navigate inside of the sewer in normal conditions, without obstacles. For this test the platform can be tele-operated and controlled. It is really a validation test on the platform that you already have, not the test of the inspection task.

3.- Test venue

The test demonstration will take place at our partners from the public sector in Barcelona.

4.- Test dates

The delivery of the documentation of the first phase and the tests, detailed in the points 1.1, 1.2, 1.3 and 1.4 of the document "Evaluation Criteria Phase I" should be done before the end of the phase I.

The proposed dates are

June 30th: Delivery of the final documentation

July 5th- 6th- 7th: Open Tests at the sewer infrastructure.

July 8th: PDTI Official TESTS

5.- Will the sewer section type be known for the experiments?

Yes.

6.- Do we need IP65 protection for the experiments?

It is not necessary to use IP65 in this evaluation, but there are always some water on the sewer floor.

7.- Do we have time for setting up the system before and between trials? Will you define this?

Yes. We will give the same slot of time for the three teams during the trial days.

8.- Is there just one test session, or can more than one session be agreed with BCN BCASA?
You can test your system during three days before the final Test.

9.- If just one session, can the test site be accessed before it?

Yes.

10.- Do the three particular tests have to be carried out during the same session?

Yes.

11.- What does “autonomously” mean in this test?

The word autonomously is not the appropriate one in this test, since the robot can be tele-operated, but it has to move without the help of the human operator in case of falling down.

11.1 Fully autonomous robot navigation: localization, planning, navigation and obstacle avoidance without human intervention?

No.

11.2 Autonomous robot navigation with human supervision: Similar to 11.1 but with human supervision for waypoint designation, system checking or tele-operation in critical manoeuvres?

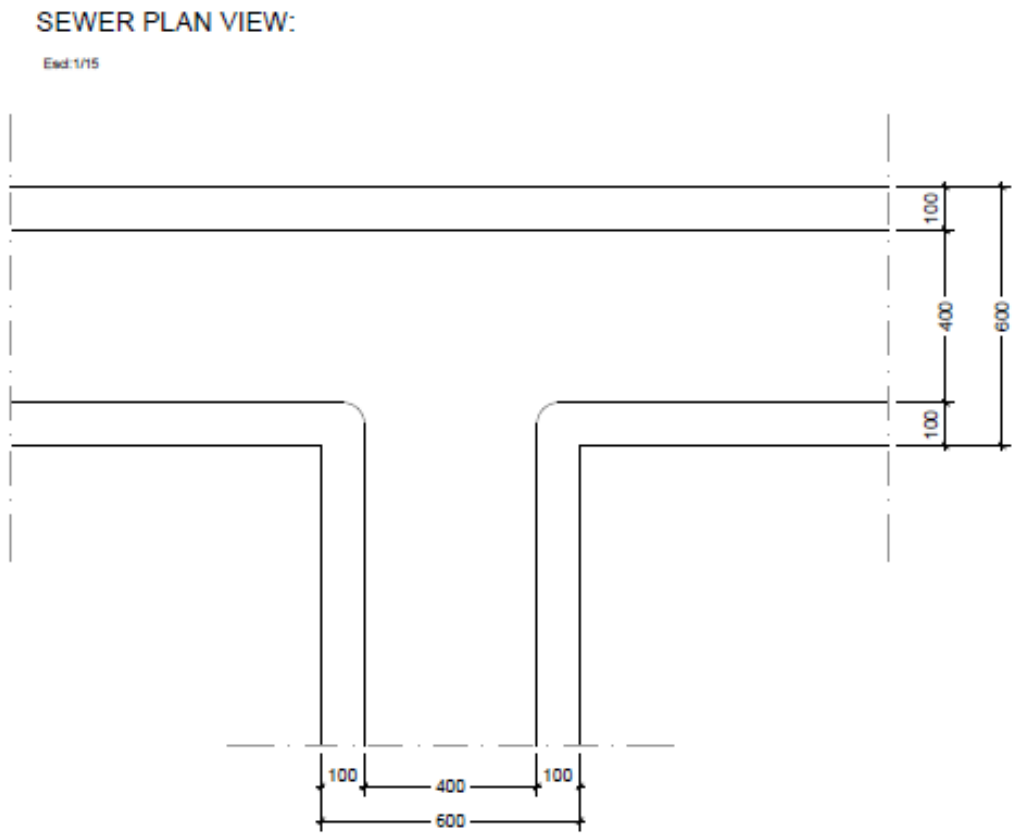
No.

11.3.- Fully tele-operation from the distance: being able to tele-operate the robot from the distance using a control station.

Yes.

12.- Is Fig 4 depicting the type of sewer for these mobility tests? The numbers in the sewer plan view (Fig 4) are barely readable, can you send us a better picture?

Yes. We include a new Fig.4.



13.- How will the communication quality be measured? Will this be a common test for all the teams through a specific software?

To be defined.

14.- Can the robot deploy radio repeaters automatically to extend/improve the communications?

Yes, but you will have to explain how you will manage these repeaters, because the human operators cannot recover them.

15.- What does the radius mean in the conditions table?

See new Fig. 4.

16.- How mobility will be evaluated? Which aspect in particular?

Motion and fall down recovery.

17.- Do not understand why the illumination conditions are considered into this test, is the robot expected to stream images for monitoring during the test?

The sewer doesn't have illumination in almost all the infrastructure. The final test will be done with and without light.

Public end-user Driven Technological Innovation (PDTI)

"UTILITY INFRASTRUCTURES AND CONDITION MONITORING FOR SEWER NETWORK. ROBOTS FOR THE INSPECTION AND THE CLEARANCE OF THE SEWER NETWORK IN CITIES"

EVALUATION CRITERIA PHASE I

FINAL EVALUATION AND SELECTION

June 30th: Delivery of the final documentation

July 5th- 6th -7 th.Open Tests at the sewer infrastructure.

July 7th-8th: PDTI Official TESTS

Updated March 29 th, 2016

1 Evaluation criteria for Phase I

The technology development of the PDTI will take place in three phases:

1. System design (duration 6 months, 3 R&D consortia per scenario)
2. Prototyping (duration 12 months, 2 R&D consortia per scenario)
3. Small-scale test series (duration 12 months, 2 R&D consortia per scenario)

For the first phase, three consortia per scenario are selected, and two out of them will be selected for the remaining phases based on the outcome of the system design after the first 6 months of system design work. The timeline is illustrated below.

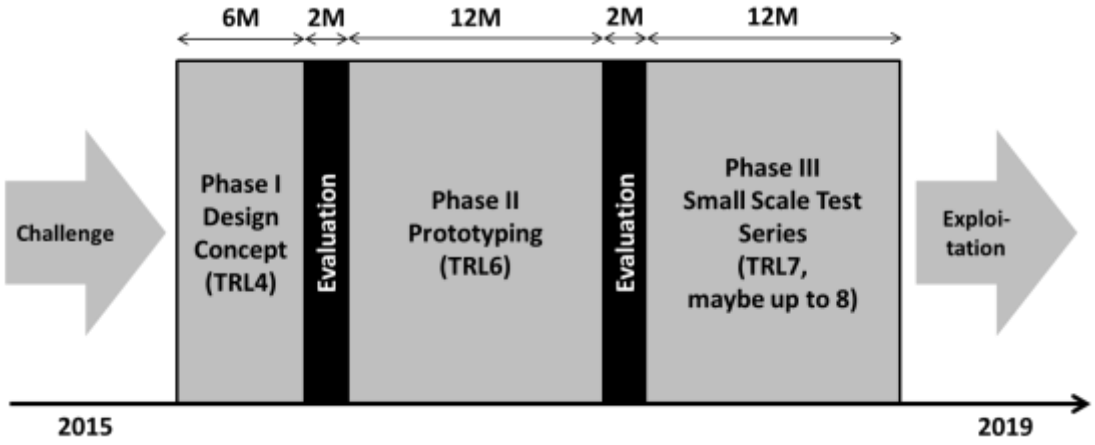


Fig. 1. Activities for research and technical development of Pre Commercial products

The Phase I of the PDTI stablishes the design of the technological solution and has to show how the robotic solution will perform the different tasks assigned in the Challenge Brief specifications.

The evaluation of the three technological proposals at the end of the Phase I will be based on marks given according to three basic criteria:

- Scientific and/or technological excellence
- Quality and efficiency of the implementation and the management of the project
- Potential Impact through the development, dissemination and use of the project

The main issues proposed to evaluate the Phase I are:

1.1 Positive evaluation of the tasks and documentation required during the period

Deliverables and Milestones

Dissemination Milestones

Technical KPI milestones

Impact KPI milestones

1.2 Solution design

Detailed explanation of the solution design

Logistics required and operational issues by using the solution

1.3 Test Series

Viability of the robotic solution mobility in the sewer network conditions

Communications suitability in underground sewage system network

Autonomy versus mobility of the robotic solution

1.4 Economic Viability of the proposal

2 Test Series

2.1 Viability of the robotic solution mobility in the sewer network conditions

The mobility under the conditions of the sewers is one of the main challenges to be solved.

Fig. 2. Sewer Network Conditions

Sections that make up the Barcelona sewage network are widely varied. Nowadays, there are up to 2.076 types of sections from which the most common are the T111 and T130.

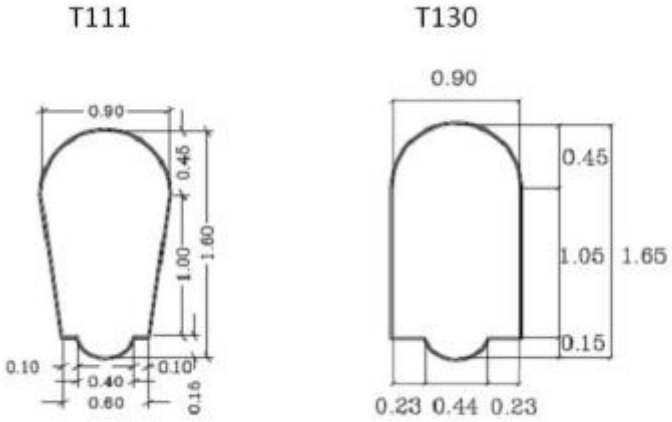


Fig. 3. Examples of sewer sections

It is necessary during Phase I that the robot mobility can be evaluated under the conditions of the accessible sewers. It is expected that the robot has a maximum speed but also a minimum speed in order the scans, monitoring, sampling and other functionality has been done properly. We are asking to make a mobility test on the physical robot platform as one of the evaluation criteria. This test is using the platform that you already have, not necessarily with the modifications that are required for doing the inspection task. The public body wants to realize that all the robot platforms have the minimum mobility conditions to navigate inside of the sewer in normal conditions, without obstacles. For this test the platform can be tele-operated and controlled. It is really a validation test on the platform that you already have, not the test of the inspection task. To test the performance, the following mobility test will be used at least:

MOBILITY TEST

<table>
<tr><th>Description and conditions</th><th>Evaluation</th></tr>
<tr><td>Robot motion:

100 meters (autonomously) The word autonomously is not the appropriate one in this test, since the robot can be tele-operated, but it has to move without the help of the human operator in case of falling down.</td><td rowspan="2">1) The maximum and minimum speed will be evaluated. 60 minutes is the maximum time to cover 100 meters
2) Recovery test: The evaluators will place the robot in the ground of the sewer at different inclinations. The robot has to recover from these positions</td></tr>
<tr><td>Conditions:

• The robot has to include the equivalent weight of the sensors and electronic drivers
• One trial in straight line and another one with a 90º curve.
• The trial will be done in Barcelona

• The trial will be done at different illumination conditions</td></tr>
</table>

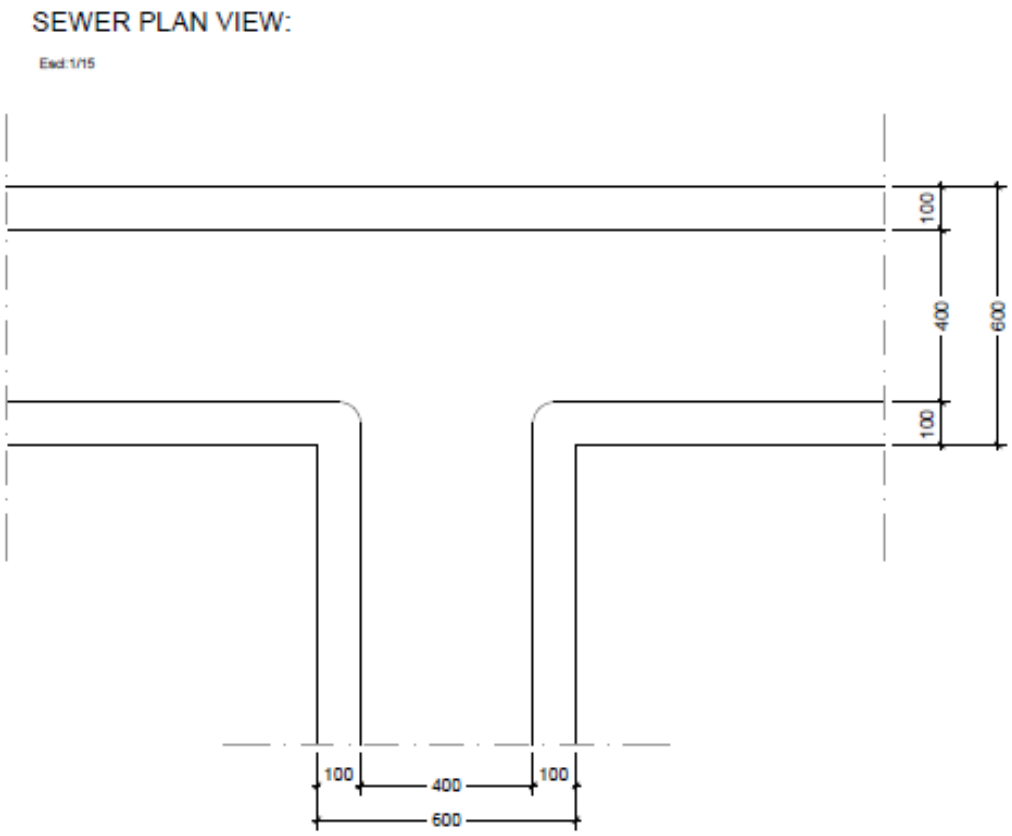


Fig. 4. Sewer network conditions

2.2 Communication suitability in underground sewage system network

Communications in the sewer conditions, as an underground infrastructure, are also one of the aspects to be solved in this project. It is proposed to perform a test to check the suitability of the communications technology proposed by each robotic solution, using the following description and conditions:

COMMUNICATIONS TEST

<table>
<tr><th>Description and conditions</th><th>Evaluation</th></tr>
<tr><td>Send information from one point to another at different distances (100m, 200m, 300m). The robot can be without movement to make the test.</td><td rowspan="2">1.- Communication bandwidth
2.- Signal/Noise rate
3.- Delay to send the information
Note: The coordinators will provide to the Consortia the software that will be used for the evaluation.</td></tr>
<tr><td>Conditions:
Trials in straight line and curve specifying the maximum transmission speed (Baudrate).
100m straight line
200m straight line with one curve (90º). Radius
300m straight line with two curves (90º +90º). Radius</td></tr>
</table>

2.3 Autonomy test of the robotic solution

The autonomy is an important factor that has to be assessed, since this property depends on the performance of the functions to be done by the robotic solution. It is proposed a test using the following description and conditions:

AUTONOMY TEST

<table>
<tr><th>Description and conditions</th><th>Evaluation</th></tr>
<tr><td>Demonstration that in 8 hours the robotic solution can arrive to 1 km away. The batteries can be charged or changed automatically or manually several times during the trial. Proposers have to specify the real autonomy and to indicate how the recharge will be done if it is the case.</td><td rowspan="2">The platforms should cover a distance of 400m with the equivalent weight of the sensors and electronic drivers and the velocity should be the adequate to perform the required inspection functions. The energy consumption could be measure. And the batteries could be changed "in situ".</td></tr>
<tr><td>Conditions:
The results of the above test will be extrapolated considering the energy consumption in each case, and the performance in 8 hours will be forecasted.
The robot has to include the equivalent weight of the sensors and their electronic drivers
The trial will be done at different illumination conditions</td></tr>
</table>

Fig. 5. Sewer network conditions

3 Economic viability

The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre commercial product.

The proposal should develop the economic viability for the future companies and institutions involved: the robotic SME, the logistic services company and the public entity. This study has to be for a period from 2015 to 2023 and as specific as possible.

For the robotic SME, R&D consortia have to make a budget of the costs and revenues, specifying as detailed as possible the cost of the technological equipment – platform, sensors, communication system, licenses, batteries–; the cost of the support equipment and remote stations; the cost of maintenance; and the cost of the R+D involved. The price of the technological equipment and a prevision of units sold will allow computing the revenues of the robot plus remote station's sales, the maintenance and the licenses. Specify whether an additional investment will be required.

For the Services Company, R&D consortia have to make a budget of the cost of the task brigades and other costs related to the operational tasks. Moreover, the energy cost has be specified.

For the Public Entity, the economic proposal of the new public tender as well as the reduction of the public cost service has to be specified

Finally, R&D consortia have to provide the cost per meter of sewer serviceability inspection (considering 1.000.000 meters); the cost per meter of structural defect inspection (considering 1.000.000 meters) and the cost per sampling (50 samples / year) if it is the case.

ECHORD++

Public end-user Driven Technological Innovation (PDTI)

"UTILITY INFRASTRUCTURES AND CONDITION MONITORING FOR SEWER NETWORK. ROBOTS FOR THE INSPECTION AND THE CLEARANCE OF THE SEWER NETWORK IN CITIES"

FINAL EVALUATION AND SELECTION PHASE I

July 27, 2016

1 Evaluation criteria for Phase I

In the Phase I of the PDTI Sewer, the objective is to design a first version of the robotic solution to inspect sewers and test the robot in a real-life sewer environment in Barcelona.

For the evaluation three documents have been used. The first one explains the general objectives of the PDTI Sewer, and the document is:

[1] "Utility infrastructures and condition monitoring for sewer network. Robots for the inspection and the clearance of the sewer network in cities. Challenge brief – related to ECHORD++ call for R&D proposals". ECHORD++ document, 2015.

The second one describes the criteria that will be used to evaluate the performance of the robots of the three consortia in Phase I. The document is:

[2] "Utility infrastructures and condition monitoring for sewer network. Robots for the inspection and the clearance of the sewer network in cities. Evaluation Criteria Phase I". ECHORD++ document, 2016.

The third document includes the questions addressed by the consortia and the answers given by the ECHORD++ PDTI Sewer coordination team. This document is:

[3] "Utility infrastructures and condition monitoring for sewer network. Robots for the inspection and the clearance of the sewer network in cities. Questions addressed by the consortia". ECHORD++ technical report, 2016.

In document [2] is described how the evaluation has to be done, and the evaluation criteria that will be used. With respect to the marking for the evaluation the document specifies:

> *"The evaluation of the three technological proposals at the end of the Phase I have been based on marks given according to three basic criteria:*
>
> - *Scientific and/or technological excellence*
> - *Quality and efficiency of the implementation and the management of the project*
> - *Potential Impact through the development, dissemination and use of the project"*

Moreover, document [2] also includes the items that will be used for the evaluation:

"The main issues proposed to evaluate the Phase I, are:

1.1 Positive evaluation of the tasks and documentation required during the period

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1.3 Test Series

Viability of the robotic solution mobility in the sewer network conditions

Communications suitability in underground sewage system network

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1.4 Economic Viability of the proposal*"*

In order to make the evaluation, the three consortia were invited to prepare their equipment for the evaluation. During the Phase I period, 6 months, the sewer infrastructure was available to the consortia to do open tests with the help of BSCASA (the public body partner). Two of the consortia, SIAR and ARSI made tests during this period.

On July 6th and 7th the official tests were done in Barcelona in the sewer infrastructure. The evaluation panel took place on July 7th at 14h in the UPC. The evaluation was done by two external experts Tjibbe Bouma and Alvaro Iriarte, that deliberated and evaluated the three technological proposals and selected the two consortia that pass to the Phase II. The expert panel were supported by the public body partner, City Council of Barcelona / BCASA team, represented by Javier Varela, Mª José Chesa and Lina Martinez, and the technological coordinators, the UPC team, represented by Alberto Sanfeliu, Josep Casanovas and Ana Puig-Pey.

2 Final Evaluation and Marks of the PDTI Sewer Phase I

In this section we include the evaluation and marks elaborated by the two external experts, Tjibbe Bouma and Alvaro Iriarte after the panel, on July 7th. These marks follow the criteria established in the document [2]. The results from the experts are the following:

Acronym: ARSI

Scientific and / or technological excellence (relevant to the topics addressed by the call)	**Score:** **4.0**
The ARSI Consortium has delivered very detailed and thorough reporting on Deliveries 2.1 (Operation requirements and system design) and 2.2 (First results). The consortium has systematically identified key topics to be addressed and has worked through them methodically. The consortium has made good use of the expertise available at different consortium partners and has reached a commendable level of integration given the limitations of budget and time in phase 1 of the project. In particular, the proposed integration with the DRACMA system for operational planning and execution is impressive and shows that the consortium is in close communication with the potential end user of the solution. The choice of an aerial solution has clear advantages in a sewer environment, which contains many different obstacles and geometries. The tests have demonstrated that semi-autonomous flight is a must for a viable operational solution. Robust tele-operated flight will not be possible without it so it is critical for the success of the solution. The consortium has indicated several methods to improve control and positioning of the UAV, but none of these have been implemented yet. The consortium is encouraged to explore the 3D reconstruction from the visual data, which is mentioned as a theoretical option (page 31). It is the reviewers' opinion that there is too much reliance in the proposed solution on the 2D laser system for obstacle avoidance and navigation. Some obstacles may/will be missed by the laser scanner (e.g. horizontal bars, steps) potentially resulting in collisions. The camera set-up chosen by the consortium seems satisfactory for the main purpose of the inspection (serviceability of the sewer), whether it can also serve for structural integrity inspection will have to be further investigated in the next phases. Another point of concern is the robustness of the UAV. The consortium seems to focus on high tech (software, sensors) solutions for obstacle avoidance. However,	

given the complex and confined environment collisions will be probably unavoidable from time to time. The AUV needs to be able to withstand and/or recover from such collisions. The current collision protection is inadequate (rotor protection bends upon collision interfering with the rotors) and the landing beams are not sufficient to withstand uncontrolled or marginally controlled landings in various sewer geometries. It is recommended to redesign the airframe from a perspective of unavoidable collisions and passive safety, rather than solely relying on avoiding obstacles to keep the UAV safe. Confined space indoor flying requires protection against impact from all sides, in particular from above.

Regarding to the autonomy, the analysis and flight tests carried out in Phase 1 of this project suggest that an autonomy between 15 and 20 minutes. Given an estimated battery life of 10 minutes and an inspection speed of 0.5 m/s, we obtain an inspection range of 300 meters. This would give an estimated inspection rate of **300 meters per hour**, or 2.4 km per 8h day what exceeding the challenge brief minimum requirement of 1000m/day for robots, or even 1500m/day currently achieved by current inspection protocols. However, in case of a critical point detected where a detailed inspection may be required, the autonomy of the battery could be a problem if the mission requires extra time. The consortium should investigate a way to allow this type of extra time mission for critical points inspection.

A further area of attention is the humid environment in the sewer system. The UAV needs to be able to operate in this environment for prolonged periods of time and would have to be enough protected against water (IP67) both for operational use and for cleaning maintenance.

The consortium has indicated that part replacements will be part of the operating procedures, however it is likely that the high humidity environment will significantly affect the operating time of critical components, which may need to be shielded more adequately from the environment for a commercially viable solution.

Robust communication with the UAV is mission critical. The consortium has done interesting experiments and theoretical background investigations on the waveguide properties of sewer tunnels, which demonstrate that the wireless communication range is very significantly extended in tunnels. The consortium even provides some evidence that the wave guiding properties might enable operation beyond line of sight, making use of smooth bends inherent to the sewer system design. Based on the tests during the field trials witnessed, the reviewers remain unconvinced that the phenomenon is strong enough to allow robust operations beyond line of sight. In combination with the limited flight time of the UAV (another area of attention), it seems prudent concentrate on line of sight deployment only (possibly in combination with repeaters) for operational purposes. In this way, the implementation of these repeaters must be studied deeply in order

to not depend in the manual implementation by the sewer inspection brigades. The reviewers are confident that all necessary scientific and technological skills are present in the consortium and the results to date show that these have been used in a systematic approach to problem solving. As a conclusion the reviewers are confident that the consortium has the ability to overcome the highlighted areas of concern in the next phase of the project.	

Quality and Efficiency of the implementation and the management The consortium has a balanced composition. A big plus is that there is a large practical experience in sewer inspection, which improves the likelihood of success. In particular the close interaction with FCC about the integration of the robotic inspection in current work practices and tools is commendable. Based on the documentation received and the trials witnessed, the consortium is well balanced and well managed with a clear division of roles and a high level of complementarity of skills. The consortium was well prepared for the trials and shows a good awareness of the challenges that need to be resolved in the next phase of the project. The crucial risks are well addressed and the proposed mitigation is satisfactory. The management plan is well proposed with a structured breakdown of tasks.	**Score: 5**

Potential Impact through the development, dissemination and use of Project results The potential impact of the proposed concept is promising. The consortium has presented a business case for each member of the value chain, which looks highly plausible. A viable business case for the entire value chain is a must for successful market introduction of the solution. In view of the proposed integration of the solution with the proprietary DRACMA system it will be interesting to know how the consortium intends the deliver the solution to other service providers, who don't have access to this system and how this affects the business case. In addition the costs of consumables is probably understated (more items will have to be replaced more regularly in these hostile environments), but it doesn't significantly affect the business case, which hinges	**Score: 4**

critically on reduced manpower need. The goal of the total cost per meter using ARSI system is also previewed been around 0.471 €/m, below of the targeted threshold of 0,50 €/m. In that light an area that needs more investigation is how to deal with the data analysis, reporting and storage. Experience shows that this potentially takes significantly additional time and resources, which need to be taken into account for the business case. Dissemination activities to date have been satisfactory but will have to be increased during phase II and III to ensure sufficient exposure to potential customers in the run up to a market launch.	

Acronym: ROBODILLOS

Scientific and / or technological excellence (relevant to the topics addressed by the call) The consortium has submitted a concise report regarding progress to date. It has more or less achieved the objectives it set itself for Phase 1. However, there are two significant issues with the solutions that the consortium has chosen: 1) The design solution for the Robodillos system is based on the Atum Rover, an existing solution. The Robodillos design solution retains key elements of the Atum Rover design, specifically regarding the axle/drive system. The tests in the sewer have demonstrated that this design with a fixed axle and fixed width will not be able to cope robustly with the various geometries and obstacles encountered in the sewer system. The potential of the platform to get stuck by axles touching the ground and/or fall two wheels in the gutter and/or encountering steps, gutters and others obstacles that can not be overcome is very high. The recovery tests performed during the trials have shown that there are a number of situations from which the platform cannot recover. To resolve these issues a substantial redesign of the platform will be necessary. The consortium does not indicate that they are aware of these shortcomings, nor does the concept design presented address these experimental findings. The current conceptual design is highly unlikely to produce a robust solution that will be operable in the sewers. In fact, if the proposed solution is quite difficult to operate in a manual mode, when the mission requires operating in semi-autonomous mode it would be even more difficult to overcome the obstacles increasing the risk of failure. 2) A strong point for the consortium, at least in principle, has been the effort	**Score: 2.5**

it has put into the communication system and the method of deployment with multiple robot platforms to relay the signal. However, the Silvus system selected did not perform significantly better than conventional Wifi systems during the trial. Like conventional Wifi systems the communication needs line of sight and the consortium did not demonstrate improved bandwidth, error rates, or latency compared to conventional Wifi systems. The necessity to maneuver multiple robotic platforms through the system seems a risk, given the mechanical design limitations of the platform chosen by the consortium. The conceptual solutions proposed for the sensor system, sampling and inspection is satisfactory. The range of Robodillos platform demonstrated during the autonomy trials is satisfactory. In conclusion the current mechanical design of the platform and concept design presented offers little hope of a robust working remotely operated or semi-autonomous solution. The consortium would have benefitted from more direct interaction with an end user, early trials in the actual sewer and/or having an end user in the consortium.	

Quality and Efficiency of the implementation and the management The crucial problems related to the platform are not well solved in a successful way. The consortium has put significant thought into the concept solution and the requirements in sewers. This has led to a concept solution, which addresses most of the issues associated with operation in sewers, such as the localization, sensing, sampling. The consortium offers a conceptual solution to deal with the line of sight requirement of the communication. However, the most critical part of the design: how to actually reach the locations that need to be inspected and retrieve the robot from such locations has been severely underestimated. This has led to critical shortcomings in the mechanical design of the proposed solution. The consortium should have taken more note of the actual topology in the sewer, which would have led to earlier realization of the basic design issues. The consortium would have benefitted from more direct interaction with an end-user more familiar with the sewer's operating environment. Timeline and budget requested seem realistic. Consideration is given in the risk analysis regarding the environmental challenges, but experience in the consorti-	**Score: 3**

um with the specific sewer environment is lacking. The management plan is well proposed with the tasks deeply described	

Potential Impact through the development, dissemination and use of Project results The consortium presents a business case in which a projected 0.27 Euro per lineal meter is assumed. This cost critically depends on achieving the 1.5 kilometer per 8 hours. Given the design limitations of the proposed solutions it is highly questionable whether such productivity is actually achievable. In addition, the total cost reduction of 64% stated in the business case depends also on the total length of sewer which is addressable by the proposed solution. It is likely that only a small portion of the sewer system will be practically addressable with the currently proposed solution, which severely limits the potential impact. The consortium offers the business case for the utility and the technology manufacturer. However, it is unclear how the service provider who will operate the robot will benefit from the new solution. To make the solution viable in the market place, there needs to be a positive business case for all parties involved. The dissemination activities reported are satisfactory for this stage of the project.	**Score 2**

Acronym: SIAR

Scientific and / or technological excellence (relevant to the topics addressed by the call) The SIAR consortium has submitted detailed and clear reports on their project to date. The consortium has made radical design changes compared to their initially proposed solution in order to accommodate the real world environment in the sewer. Their proposed tracked solution has been replaced by a 6-wheel crawler and further changes to the 6 wheeled design are proposed to accommodate the various widths of the gutters in the sewer system. It is laudable that the consortium has very quickly realized and has acted upon the realization that their tracked solution was not going to work. However, precious time and resources have been spent to arrive at this point, which might have been preventable if the consortium would have taken earlier advise from subject experts on sewers. The proposed new design with variable width (not demonstrated during the trial)	**Score: 4.0**

will likely provide further performance improvements to the current design, however, at the expense of more complex design and operating procedures. Based on the trial results and the design specification offered it is still likely that the design will have operational limitations, e.g. when it comes to traversing wide gutters or negotiating steps.

The prototype used in the trial was optimized for the specific "test track" made available by BCASA and with the exception of the steps and traversing the wide gutter in the main channel performed appropriately during the mobility test in manual control mode, although clearly the robot was at the limits of its operating envelope in some instances (gutter traverse, width of the vehicle). It is unlikely that the current design would have been able to perform the test in remote control or semi-autonomous mode (not yet implemented).

The autonomy test was satisfactory and it is likely that the final design will have sufficient range (in terms of power) to operate under practical conditions.

Communications rely on line of sight. As long as this line of sight is maintained the range and performance is satisfactory. The consortium intends to use repeaters to maintain communication beyond line of sight. It is recommended that the consortium evaluates the practicalities of deployment and retrieval of the repeaters in more detail as they may become a major impediment to practical application.

Based on the limited recovery test performed during the trial, it is likely that both the current prototype as well as the proposed variable width solution may end up in unrecoverable situations, which would make human interference or other means of recovery necessary. This is an area of concern, which needs further attention.

The implementation of the sensors for 3D mapping, navigation, air sampling and inspection is commendable and worked well during the demonstration. Further attention may be needed to implement the right lighting conditions for visual inspection.

The reviewers further recommend to pay particular attention to the following elements during further development:

- Robot weight and size. Labor laws restrict the maximum weight that can be carried by personnel (typically max 25 kg). Also the way this weight is distributed matters for ergonomic reasons. The current target weight of the robot would require either modular assembly in the sewer or special aids for deployment of the robot. In addition the robot needs to be able to be deployed through 60 cm manholes, some of which may be further restricted due to the presence of steps/stairs in the manhole.
- Robustness and water protection. It is recognized that the current model was a prototype, but the production prototype must be extremely well protected to avoid water ingress and damage during operations and cleaning maintenance (IP67).

- Tele-operation/autonomy: It is imperative that the robot can be easily operated in tele-operation or semi-autonomous mode. It is unclear if the proposed solution will be able to achieve that and it should be tested in an early stage of further development to avoid design complications at a later stage. In conclusion: Very significant technical challenges remain. It is unclear at this point in time whether the consortium will be able to resolve them to a sufficient extend to produce a commercially viable solution. However, the progress the consortium has made from the initial proposal is impressive and the design team has shown themselves agile, creative and non-dogmatic in the adoption of different solutions than initially proposed which is laudable. The consortium is encouraged to keep improving the designs and implementations in line with these work practices.	

Quality and Efficiency of the implementation and the management The consortium appears to be cooperating well and is well managed. The team is highly motivated, agile and focused. The improvements made on the design and concept during phase I are impressive, but many more will be called for to arrive at a satisfactory and viable solution. It is the view of the reviewers that many improvements implemented during phase I would not have been necessary if a subject matter expert on sewers and/or sewer inspection would have been consulted more closely. This would have led to a better initial design of the solution and would have saved time and resources. This will still be true for many of the design choices and tests that lay ahead. The consortium would benefit substantially from closer contact with sewer experts (utility or service providers). It is therefore recommended that the consortium seeks ways to structurally establishes a relation with a relevant organization with deep experience in inspection or exploitation of sewers facilities. This will give benefits during the development phase, but may also lower the threshold for market introduction. The potential collaboration with Vodafone will be also a plus if they can offer special solutions for underground wireless communications.	**Score: 4.5**

Potential Impact through the development, dissemination and use of Project results The consortium has made impressive progress towards a deployable solution. However, big hurdles remain and it is too early to judge whether the consortium will be successful in overcoming them to a sufficient extend to arrive at a commercially viable solution. The sewer system is simply an extremely challenging environment for terrestrial solutions. In addition, it is recommended that the consortium pays further attention to the planning process and operational deployment aspects to allow incorporation in current work practices. Seamless integration in current work practices will significantly reduce the time-to-market and overall potential of the solution. The consortium assessment of the sewer inspection cost reduction to 0,51 Euro per meter seems realistic. The potential optimum of 0.20 Euro per meter seems far away, if ever achievable. Whether such cost savings are sufficient for utilities to warrant the investment depends on the addressable fraction of the total sewer system and thus on the versatility of the final product. In practice the end user of the robot will be a service provider. The consortium has not elaborated on the viability of the business case for the service provider (nor for the fact that the utility will have to share the benefit in cost reduction with the service provider). Finally the sales forecast of 80 units by 2024 is unsubstantiated and appears to be rather optimistic given the currently remaining design hurdles. The business case needs to be further improved incorporate these changes. Dissemination activities to date have been satisfactory but will have to be increased during phase II and III to ensure sufficient exposure to potential customers in the run up to a market launch	**Score: 3**

3 Main issues used for evaluation

As it is described in document [2], Evaluation criteria, the main issues that were considered in the evaluation were:

Positive evaluation of the tasks and documentation required during the period

Deliverables and Milestones

Dissemination Milestones

Technical KPI milestones

Impact KPI milestones

Solution design

Detailed explanation of the solution design

Logistics required and operational issues by using the solution

Test Series

Viability of the robotic solution mobility in the sewer network conditions

Communications suitability in underground sewage system network

Autonomy versus mobility of the robotic solution

Economic Viability of the proposal

3.1 Positive evaluation of the tasks and documentation required during the period

Deliverables and Milestones

Dissemination Milestones

Technical KPI milestones

Impact KPI milestones

On June 30th, all the consortiums send by email the required documents:

ARSI

D2.1 Operation requirements and System Design

D2.2 Towards Automatic Sewer Inspection. First Results

ROBODILLOS

D3.1 Robodillos Phase I Report

SIAR

D1.1 Detailed Robot Design

Progress Report

Multimedia Report

Economic Viability of the proposal

Milestone Phase I

Full system design; demonstration of major features critical for the technology development including risk analysis; timeline for the entire project (Phase II and III).

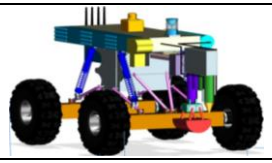
The documents have been sent to the reviewers on June 30th.

3.2 Solution design

Detailed explanation of the solution design

Logistics required and operational issues by using the solution

In order to facilitate the evaluation task, a comparative document was prepared by BCASA.

PDTI SEWER PHASE I ECHORD++					
Proposal number			**1**	**2**	**3**
Acronym			**ARSI**	**ROBODILLOS**	**SIAR**
Project full name			**Aerial Robots for Sewer Inspection**	**A Networked Mobile Robotic Platform for Shared Autonomy Sewer Inspection Operations**	**Sewer Inspection Autonomous Robot**
Consortium	**1**	**Participant name**	**Fomento de Construcciones i Contratas (FCC)**	**Cyprus University of Technology**	**Universidad de Sevilla**
		Department	Environment Barcelona	Mechanical Engineering and Materials Science and Engineering	Ingeniería de Sistemas y Automática
		City - country	Barcelona - Spain	Limassol, Cyprus	Sevilla, Spain
	2	**Participant name**	**EURECAT**	**Helikas Robotics, LTD**	**IDMIND**
		Department	R&D	Technical	R&D
		City - country	Barcelona - Spain	Nicosia, Cyprus	Lisboa, Portugal
	3	**Participant name**	**Simtech Design S.L.**		**Universidad Pablo de Olavide**
		Department	-		Systems Engineering and Automation
		City - country	Barcelona - Spain		Sevilla, Spain
	4	**Participant name**	**IBAK Helmut hunger GmbH & Co. KG**		
		Department	-		
		City - country	Kiel - Germany		
	5	**Participant name**			
		Department			
		City - country			
	Knowledge characteristics		Robotics + image processing + sewer inspection	Robotics + image processing	Robotics + image processing
Type of robot			Micro aerial vehicle (MAV) multi rotor platform	Wheeled vehicle	Wheeled vehicle
Image					
General especifications	**Movement**		Aerial	Terrestrial	Terrestrial
	Suitable for visitable sections		Yes	Yes	Yes
	Diameter of sewer		From less than 1 m to all types of visitable sewers	From less than 1 m to all types of visitable sewers	From less than 1 m to all types of visitable sewers
	Robot size, weigth & other dimension characteristics		Quadrotor platform with 4 T-Motor MT3110 KV780 Weigth: 2,7 kg Payload: 0,6 kg Height: 0,17 m Length: 0,71 m Width: 0,57 m Ground clearance: variable	Four wheeled vehicle Weigth: 21,6 kg Payload: 2,5 kg Height: 0,51 m Length: 0,75 m Width: 0,58 m Ground clearance: 0,22 m	Six wheeled vehicle Weigth: 50 kg Payload: not specified Height: 0,60 m Length: 0,80 m Width: 0,46-0,67 m automatic adaptation of platform width Ground clearance: not specified
	Water/humidity protection (IP)		Some parts	Waterproof	IP67
	Robot cost		13.656 €	34.985 €	15.350 €
Functions	**Mapping**		No	Yes	Yes
	Structural inspection		Yes	Yes	Yes
	Sediment inspection		No	Yes	Yes
	Air inspection		Yes	Yes	Yes
	Water inspection		No	Yes	Yes
	Sampling (air, water or sediment)		Only air	Yes: sediment (300 ml), water (400 ml), air (530 mg of active carbon)	Yes
Operativity	**1.Teleoperated**		Yes	Yes	Yes
	2.Semi-autonomous		Yes	Yes	Yes
	3.Full autonomous		No	Yes	Yes
	Energy		Electricity (Battery: Gens Ace 6000mAh 4S 35C)	Electricity Locomotion: 6-cell Lithium Polymer battery 22.2 VDC 20Ah Computing, communications, sensing and manipulation: three 3-cell Lithium Polymer batteries 11.1 VDC 6.2Ah	Electricity Two batteries LiFePO4 12V 20AH
	Type of light		LED, two types: CREE XLamp 1590 lm and VOLO LEDs	LED Sensor imaging: three low-light high-resolution digital cameras	Two LED 6W MR16 GU5.3 lamp 6000K projectors
	Hours of autonomy		0,17	4	5
	How it works mobility and autonomy		Flying, hovering, 10 minutes of autonomy with full payload	Land displacement, sampling, 240 minutes of autonomy with full payload	Land displacement, automatic adaptation width, sampling, 300 minutes of autonomy with full payload

Operativity	**Speed**	0,5 m/s	0,9 m/s	0,75 m/s
	Inspection cost	0,471 €/m	0,27 €/m	0,51 €/m
Specific devices and sensors	**Wireless technology**	Radio and Wi-Fi	Radio	Wi-Fi
	Comunication	Radio Control for piloting Wi-Fi for data	Mobile ad hoc network Utilizing a COFDM, MN-MIMO, MANET/mesh based wireless networking solution Enforcing a network connectivity and performance maintenance predicate within its GNC3 architecture.	The robot and base station will be equipped with a long range WiFi router Microhard nVIP-2400 in order to provide the different computers onboard of the robot and the comms package with a high baudrate (up to 54 Mbps) WiFi connectivity.
	On-board data processing	Yes	Yes	Yes
	Off-line data processing	Yes	Yes	Yes
Specific devices and sensors				
	Localization algorithms	Yes	Yes	Yes
	Navigation algorithms	Yes	Yes	Yes
	Mapping algorithms	No	Yes	Yes
Summary of devices incorporated and relevant features	**Structural inspection algorithms**	Yes	Yes	Yes
	Sediment inspection algorithms	No	Yes	Yes
	Integration to GIS	Geotagged and timestamped	Yes	Yes
	Data collected	Images in 360º, 2D map, air monitoring	Images in 360º, 3D map, air monitoring, water monitoring, sediments sampling	RGB-D 3D mapping, air monitoring, water monitoring, air sampling, water sampling, sediments sampling
	Location and navigation devices	Inertial Navigation System, 3DR Pixhawk A 3-axis gyroscope (pitch, roll and yaw) for attitude control A 3-axis accelerometer: for velocity control and position estimation A magnetometer for heading estimation A high-resolution MEMS pressure sensor for altitude control Laser scanner, Hokuyo UST-20LX	Inertial Navigation System, VN-100 Rugged A 3-axis gyroscope for attitude control A 3-axis accelerometer A 3-axis magnetometer A pressure sensor for altitude control Suite of sensors to use the technic SLAM Camera 180 degrees Panoramic optics with camera Laser scanner with mechanism	Inertial sensor IMU: Arduimu v3 A 3-axis gyroscope A 3-axis accelerometer 5 x RGBD cameras: 2 Orbbec's Astra RGBD sensor (8 m. range) and 3 Orbbec's Astra S RGBD sensor (6 m range)
	Inspection devices	Laser scanner, Hokuyo UST-20LX Video cameras Two grayscale VGA cameras (640x480) cameras are mounted on each side of the platform, to record close-range video of the sewer walls where structural defects are often found. Two HD (1200x800) cameras are mounted at the front and rear of the platform, providing wide-angle views of the vehicle surroundings, including the sewer ground and ceiling.	Manipulator with camera Camera 180 degrees Panoramic optics with camera Laser scanner with mechanism Sediments sampling mechanism	5 x RGBD cameras: 2 Orbbec's Astra RGBD sensor (8 m. range) and 3 Orbbec's Astra S RGBD sensor (6 m range) Water Sampling. It will transport a system able to collect water from the sewer and store it in 300 ml reservoirs Peristaltic pump to collect water from the sewer and using up to 8 water solenoid electric valves redirect the water to small 300 ml reservoirs equipped with a level sensor to determine if the reservoir is full. Air Sampling. It will carry commercial air capsules that will be used to collect samples from the air Sediments sampling. It will carry a device able to collect samples from the sediments
	Air quality sensors	Custom air sensor, Envira SL able to monitor temperature, humidity, Carbon Monoxide (CO), Hydrogen Sulphide (H2S)	Air temperature sensor Relative Humidity sensor Gastight syringe Hydrogen sulphide sensor Carbon monoxide sensor Oxygen sensor pH sensor	Libelium Gas PRO board Temperature (ºC) sensor MCP9700A Relative Humidity (%RH) sensor 808H5V5 Carbon Monoxide (CO) sensor TGS2442 Hydrogen sulphide (H2S) sensor TGS2602 Methane (CH4) sensor TGS2611 Oxygen (O2) sensor SK-25 Lower explosive limit (LEL) Volatile organic carbons (VOCs) sensor MiCS-5524

Summary of devices incorporated and relevant features	Infrared camera	No	No	No
	Ultrasonic sensor	No	No	No
	Sonar sensor	No	No	No
	Electromagnetic sensor	Yes	Yes	No
	3D representation	Yes	Yes, with SLAM	Yes
	Camera 3D (stereo camera)	No	No	No
	Laser sensor	Yes	Yes	No
	Lighting	Yes	Yes	Yes
	Images in 360º	4 wide angle cameras with overlap	Panoramic optics with camera	No, uses 3D mapping
	Lidar or Ladar	Yes	No, uses SLAM	No, uses RGB-D
	VI-sensor (Visual-Inertial Sensor)	No	No	Yes, with RGB-D
	3D mapping	No	Yes	Yes
Abstract		The sewer network is one of the essential infrastructures of a city. Given its characteristics: a very wide underground network of pipelines, which are frequently small, that was built several decades ago, and due to the presence of big amounts of waste along its length, the network becomes a hostile environment, making the automatic collection of data a complex task. In many points of the sewer network the terrain is highly irregular and with obstacles. The presence of significant levels of liquid waste and litter, produced by the collection of residual and pluvial waters, limit the operability of terrestrial vehicles and frequently, a cleaning of the sewer is necessary previous to an inspection with one such vehicle (see state of the art). The ARSI consortium plans to tackle the pipelines and galleries inspection using an **micro aerial vehicle (MAV)**, multi-rotor type, endowed with sensors for its autonomous navigation along the network, collecting data for its inspection. The aerial option avoids the mobility constraints that suffer the vehicles that should advance along paths having steps, steep drops and even objects like the own domestic waste or elements dragged by pluvial waters. A MAV solution has to overcome the strong constraints of size, weight and energy necessary in every situation. Since the vehicle should move autonomously on small size environments (diameters less than 100 cm), its size, and therefore the weight it can carry, are strongly limited. Thus, one of the challenges is to adapt the autonomous guidance and inspection systems to low weight and low consumption sensors and hardware. These limitations impose the use of low performance sensors, which limitations will be tackled by the software with the aim to offer an operability level that justifies the use of this technology in front of the current manual inspection, or that implemented by terrestrial vehicles.	Robodillos presents an advanced robotic platform for sewer inspection operations that synergistically integrates state-of-the-art wireless communication technologies with autonomous multi-robot systems technologies in a unique, robust, agile, scalable and reliable solution. The system economics and per-formance, scale with the multi-robot team's size, where bigger teams result in lower inspection costs and better inspection performance. For the minimal Robodillos team of 2 robots and a base station, a cost reduction of 76,8% is anticipated, with an inspection cost of 0.174 € / lineal meter and a performance of 3400 meters in 8 hours. For a Robodillos team of 5 robots and a base station, a cost reduc-tion of 85,2% is anticipated, with an inspection cost of 0.111 € / lineal meter and a performance of 5360 meters in 8 hours. Robodillos provides a shared autonomy solution featuring seamless transition from mixed-initiative control to fully autonomous operation ensuring safe, effective and responsive operation. In the mixedinitiative control case, human operator(s) are provided with remote operation capability filtered through performance guards to enable safe, effective and fool-proof teleoperation where the human operator only focuses on the task at hand without having at the same time to deal with low-level issues like collision avoidance, tip-over stability, network connectivity and quality-of-service maintenance – these are automatically and transparently been handled by dedicated control systems. Fully autonomous operation automatically takes over as soon as the human operator ceases to interact with the system, which then autonomously performs according to high-level task specifications provided during inspection initiation.	The SIAR project will develop a fully autonomous ground robot able to autonomously navigate and inspect the sewage system with a minimal human intervention, and with the possibility of manually controlling the vehicle or the sensor payload when required. The project uses as starting point the platform RaposaNG from one of the partners. A new robot will be built based on this know-how, with the following 3 key steps beyond the state of the art required to properly address the challenge: • An IP67 tracked robot frame will be designed to work in the hardest environmental conditions, able to navigate over a wide range of floors and small obstacles, including stairs and slopes. Key platform features like 5 hours autonomy, more than 3 Km per battery charge, adjustable body width and a flexible payload system will definitely ease the system setup in sewers, adapting the robot to a wide spectrum of galleries and tasks. • Communication cables will be removed in order to improve robot usability and autonomy, by integrating a communication system able to automatically deploy or recover wireless repeaters along the robot path, enabling long distance communications without cables. • The cost of such systems will be reduced by employing low-cost sensors, such as RGBD cameras, for robot localization, safe autonomous navigation and automatic sewer structural defects evaluation with minimal human intervention. A simple and intuitive GUI will also help decision taking and commanding the robot. The Consortium is composed of a SME called IDMind (IDM) and two Universities, Universidad de Sevilla (USE) and Universidad Pablo de Olavide (UPO). The project is coordinated by IDM, which also leads the commercial exploitation of the SIAR system.
Observations				

3.3 Tests Series

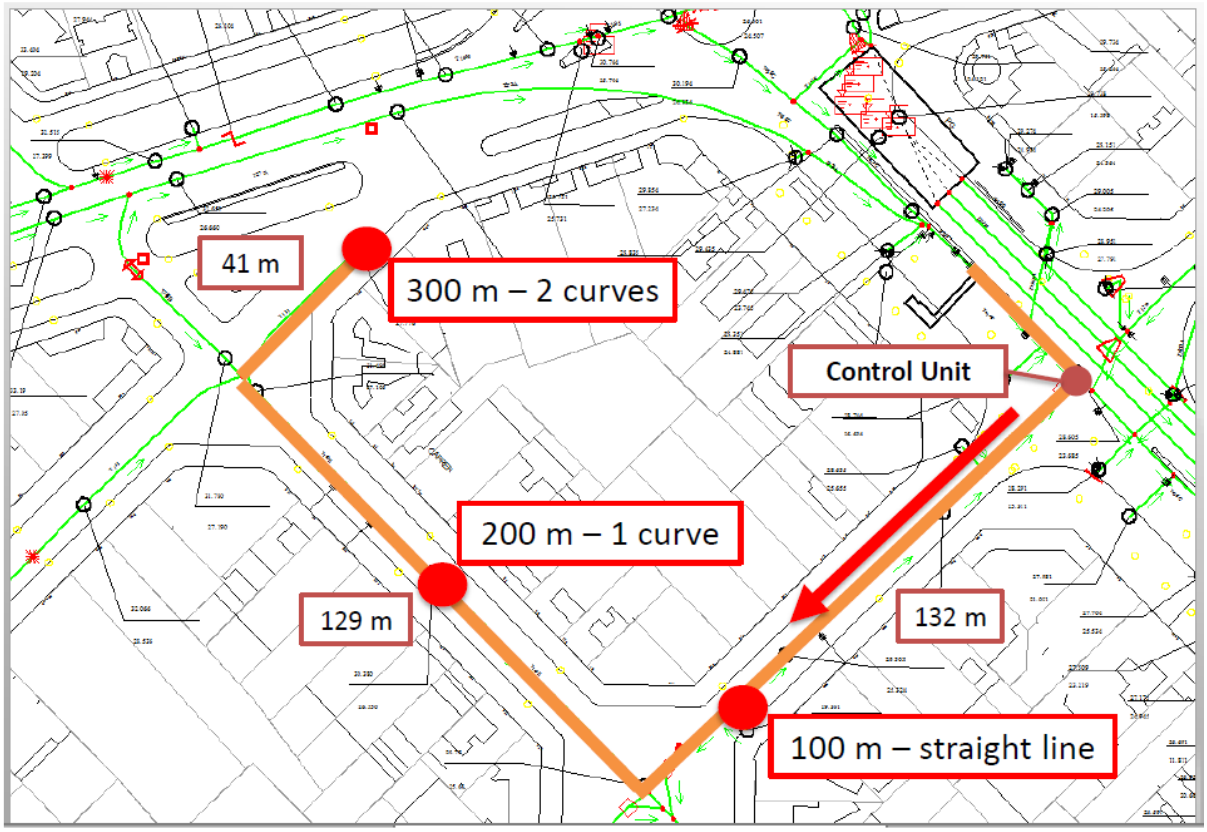
As proposed in the document [2], Final Evaluation Criteria, the three final tests to be done are:

Viability of the robotic solution mobility in the sewer network conditions

Description and conditions	Evaluation
Robot motion: 100 meters (autonomously) The word autonomously is not the appropriate one in this test, since the robot can be tele-operated, but it has to move without the help of the human operator in case of falling down, recover and continue moving.	**1) The maximum and minimum speed will be evaluated. 60 minutes is the maximum time to cover 100 meters.** **The minimum speed is specify by the precision to detect the defects, and has to be justified in the deliverable.** **This minimum speed has to be used in the trials.** 2) **Recovery test: The evaluators will place the robot in the ground of the sewer at different inclinations. The robot has to recover from these positions**.
Conditions: • The robot has to include the equivalent weight of the sensors and electronic drivers • One trial in straight line and another one with a 90º curve. • The trial will be done in Barcelona • The trial will be done at different illumination conditions: with illumination and complete darkness.	

Communications suitability in underground sewage system network

Description and conditions	Evaluation
Send information (video and data) from one point to another at different distances (100m, 200m, 300m). The robot can be without movement to make the test. The robot should carry the same sensors used for mobility and autonomy tests.	**1.- Communication bandwidth** **2.- Signal/Noise rate** **3.- Delay to send the information** **Note: The coordinators will provide to the Consortia the software that will be used for the evaluation.**
Conditions: Trials in straight line and curve specifying the maximum transmission speed (Baudrate). 100m straight line 200m straight line with one curve (90º). Radius 300m straight line with two curves (90º +90º). Radius	



Autonomy versus mobility of the robotic solution

Description and conditions	Evaluation
Demonstration that in 8 hours the robotic solution can arrive to 1 km away. The batteries can be charged or changed automatically or manually several times during the trial. Proposers have to specify the real autonomy and to indicate how the recharge will be done if it is the case.	**The platforms should cover a distance of 400m with the equivalent weight of the sensors and electronic drivers and the velocity should be the adequate to perform the required inspection functions. The energy consumption could be measure. And the batteries could be changed "in situ".**
Conditions: • The results of the above test will be extrapolated considering the energy consumption in each case, and the performance in 8 hours will be forecasted. • The robot has to include the equivalent weight of the sensors and their electronic drivers • The trial will be done at different illumination conditions: with illumination and complete darkness.	

The consortia prototypes arrived to the Barcelona sewer location on July 4th. During two days, July 4th and 5th, the three consortia did open tests.

A slot of 3 and half hours for each consortium were given for the final tests.

The final tests starts on July 6th. ARSI prototype starts on July 6th from 10:00 to 13:30; Robodillos continued from 15:00 to 18:30 and SIAR made its test on July 7th, from 10:00 to 13:30. Each consortium gave a presentation of the solution design and they followed with the mobility test, the autonomy one and finally the communication test.

The reviewers were at the sewer during the test performance with the BCASA and UPC team. A group of four BCASA workers joint the tests and facilitate the tests in the sewer. A professional video was done during the three slots in order to recover all the information about the results. The video is available.

ARSI TESTS

ROBODILLOS TESTS

SIAR TESTS

3.4 Economic Viability

All the consortia explained the economic viability of the proposal. The study and business plan have been done not only for the Robotic SMS, that built the robot but also for the Robotic Service SME, that provides the inspection service to the public body; and finally for the Public Body, in our case BCASA, looking to improve the public service and reduce the cost of the Sewer Inspection and Maintenance of the sewer infrastructure.

4 Final results and selection

The final results of the evaluation of Phase I are the following:

PDTI SEWER Evaluation PHASE I	ARSI	ROBODILLOS	SIAR
Scientific and / or technological excellence (relevant to the topics addressed by the call)	4.0	2.5	4.0
Quality and Efficiency of the implementation and the management	5.0	3.0	4.5
Potential Impact through the development, dissemination and use of Project results	4.0	2.0	3.0
	13.0	**7.5**	**11.5**

PDTI SEWER Selection

Finally, the result is that the two consortium that pass to Phase II are:

ARSI consortium with a rate of 13.0 points and

SIAR consortium with a rate of 11.5 points

FQA

- Is the hospital offering a storage area for ID patients in their internal servers?
- Is the hospital offering an internet connection during the evaluation ?
- Is it possible to have some recorded Barthel assessment for our lab tests?
- For UP and GO tests, is it possible to have some reference model for the different behaviors you are mentioning in this tests ie: normal, very slightly abnormal, .. ?
- The rooms where movement analysis is to be done (Up and GO, and Tinetti tests), have stable illumination conditions?
- Do these rooms have changing furniture, or is it rather fixed?
- In a same patient visit to the hospital, is a movement test done only once or rather several times?
- It is possible to have access to anonymous examples of tests in order to train our system?

Questions for patients
- General
- General satisfaction about having the CGA carried on by a robot
- What kind of robot they imagine and they would like to have as CGA assistant?
- Should the robot replace or assist the doctor/nurses?
- Questionnaire-based tests
- Do they like the idea to can communicate with the robot both via touch screen and voice?
- Do they prefer standard tests or something more interactive such as games?
- Data management
- Are they concerned by the fact that their personal data are stored somewhere and accessible by the doctors (especially recorded videos)?

Questions for families' patients
- General
- General satisfaction about having the CGA carried on by a robot
- What kind of robot they imagine acceptable as CGA assistant?
- Should the robot replace or assist the doctor/nurses?
- Questionnaire-based tests
- Do they think that interactive exercises such as games could be more interesting, stimulating and effective for patients?
- Data management
- Are they concerned by the fact that personal data of their relative are stored somewhere and accessible by the doctors (especially recorded videos)?

Questions for caregivers
- General
- General satisfaction about having the CGA carried on by a robot
- What kind of robot they imagine and they would like to have as CGA assistant?
- Should the robot replace them or just assist them during CGA?
- Do they think that such kind of platform could be more useful for CGA in care centers, in patients' home or both equally? Why?
- Questionnaire-based tests

• Their opinion about voice interface. Do they think that the patients are able to carry on a vocal communication with a machine or this is to complicate for them? The patients will accept the robot limited capability of understanding or they will give up on the interaction because of the feeling that it is not going to work.
• Do they think that standard tests are more or less interesting, effective and motivating than something more interactive such as games?

Questions for caregivers
• Physical activity-based tests
• What kind of information they expect from the machine? Macro analysis such as time spent in a task and number of steps or something more detailed such as joints movements and body balance? What kind of accuracy is acceptable in a clinical point of view?

Appendix 2: Actual Testing/ Audio & Video Requirement
"Proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide suitable point and field of view for the tests." We understand that this statement means that the robot, manually located in an adequate place, should be able to correctly record the test. Is that correct, or does the robot need also to automatically identify if the location is adequate or not to record the test?
Answer: We do not require that the robot would be able to check if the location is adequate. It should be equipped with sensors of adequate field of view in order to properly record the scene.

Appendix 2: Configuration/ Integration of new tests based on motion/video Analysis "Description of concept. This type of new assessments need the help of system experts, but the specified system should have the possibility to add such things." We don't understand the specification related to the Integration of new tests based on motion/video analysis. Could you indicate an example? What do the clinicians want with this requirement? Answer: The software should be modular enough to allow the integration of (a) different test(s). This means decoupling the video acquisition from the analysis of the data, and allow a clear protocol for receiving the images, so that a new module for data analysis could be easily integrated at a future stage.

Data Management
"The requirement indicates that system will create data/information which be made available to different systems. The system has the possibility of open publication of the data acquired. We don't understand this scenario. Could you provide an example?" Answer: The format of the data generated need to be readable by freely available software (best if non-proprietary). We want to avoid that data are stored in a proprietary format which is readable only with one system (and in the worst case, only by paying license fees). For example the data should be saved for example in XML or CSV format if textual data. We do not want the data to be saved in a binary file data. MYSYS readable only by proprietary software. This article will show you a concrete example of the importance of this requirement:
- the data acquired should be made available for other research purposes (of

course with the needed "anonymisation"). EU is putting more and more efforts on open data. This document can give you some more information about the various aspects to consider in data management.
- Note that you are not required at this stage to follow all the specifications of this document, but it is important to have a clear plan to make the data available (in a "readable" format, as explained in the previous point).

Users
• How many users? End-users? Medical staff or patients?
Answer: Will be specified
• Catalan/Spanish speakers? Can we do the first demo in English?
Answer: Appendix 2: Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated.
• Age? Degree of cognitive/physical impairment? (if users are patients)
Answer: Will be specified

ARNICA

Is the hospital offering a storage area for ID patients in their internal servers?
César: All medical information is stored in our servers and each patient has a specific electronic record in our medical software. Currently only very few tests are stored in paper format but even them are scanned and stored into computers**.** Patients have not access to our medical software.

Is the hospital offering an internet connection during the evaluation?

César: We have restricted access to internet from hospital´s computers. For instance we have not access to skype, youtube and so on. In the other hand we have access to medical webs, web of general information, so on. WiFi is available but getting access may be very complicated. Please, tell us if your need some specific petition in relation to that for the evaluation session.

Is it possible to have some recorded Barthel assessment for our lab tests?

César: I will send links to video demostrators.

For UP and GO tests, is it possible to have some reference model for the different behaviors you are mentioning in this tests ie: normal, very slightly abnormal, .. ?
César: This point is important, during the face to face session I spoke to you about time recorded during the test. I have reviewed both tests (timed up and go, and get up and go) and I have talked to our physiotherapist. We concluded get up and go is the most useful for us. I will send you some demonstrative information.

The rooms where movement analysis is to be done (Up and GO, and Tinetti tests), have stable illumination conditions?

César: Now you know the room!

Do these rooms have changing furniture, or is it rather fixed?
César: Yes, furniture is constantly moved (but no so much) in according to our needs.

In a same patient visit to the hospital, is a movement test done only once or rather several times?

César: Usually the movement test is done once per visit but sometimes exceptions arise when the health professional ask to other one for a second opinion. Availability for repeating test during the same session is advisable.

It is possible to have access to anonymous examples of tests in order to train our system?

César: Yes it is possible. Please, let me know what test you need.

Is the MMSE test implementation to be considered in the first phase?
Answer (KoM): Yes (p.10 PDTI Healthcare Phase 1- Evaluation Criteria

In the mock-up demonstration, will the system interact with the patient alone or also with his relatives? if with his relatives, do we need to identify who answered to Barthel questions ?
Answer (César): For mock-up demonstration I think the identification is not needed but for final version the system have to specify who answer the test, in brief I imagine the option by which the health professional during selection test phase can introduce who will answer the test.

Do we need to provide video and data obtained from video (movement parameters) in real-time? Or can we provide these data with a reasonable delay?
Answer (KoM): With a reasonable delay is ok. **César comment:** Data have to be available during the medical session, that's why delay muss not be exceed very few minutes

Movement analysis for patients involve medical staff to help patient move? If this is the case, how close to the patient is the health professional? Would it be possible to provide the health professional with a shirt of a specific color?
Answer (César):
First question is answered below in ASSESSTRONIC section.
Second question **(César)**: Yes, it is possible but wearing it has to be very fast and easy.

<u>CLARK</u>

Appendix 2: General Requirements/ Motion Tracking:
"Concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test and the Tinetti Balance and Gait tests."

Answer (KoM): Only Get up and Go test
Note: not Time up and Go test

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We understand that this statement means that the robot, manually located in an adequate place, should be able to correctly record the test. Is that correct, or does the robot need also to automatically identify if the location is adequate or not to record the test?
Answer: (KoM) We do not require that the robot would be able to check if the location is adequate. It should be equipped with sensors of adequate field of view in order to properly record the scene.

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Answer: (KoM) The software should be modular enough to allow the integration of (a) different test(s). This means decoupling the video acquisition from the analysis of the data, and allow a clear protocol for receiving the images, so that a new module for data analysis could be easily integrated at a future stage.

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Note that you are not required at this stage to follow all the specifications of this document, but it is important to have a clear plan to make the data available (in a "readable" format, as explained in the previous point).

ASSESSTRONIC

Users
How many users? End-users? Medical staff or patients?
Answer:

Catalan/Spanish speakers? Can we do the first demo in English?

Answer (KoM): Appendix 2: Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated.

Age? Degree of cognitive/physical impairment? (if users are patients)
Answer (César): There are no limits for age. For patients with cognitive impairment we usually consider valid the test applied to patient's relatives.
In case of physical impairment, the gait/balance tests are performed only if the patient has enough physical performance to do that. For our case:
Get Up and Go test: only technical aids for the patients (like stick) are allowed during the test (help from other person like health professional is not allowed).
Tinnetti: presence of other person is mandatory.

Evaluation setup
Where? At the hospital?
Answer: First part of kick-off meeting
Specific setup? (room, how many meters, other details such as illumination conditions)
Answer: First part of kick-off meeting
What is the time frame?
Answer (César): From hospital's side, we expect be available during one day (8:15-16:00h).

Technical aspects to be evaluated
Are we free to show up our demos/prototype following the order we wish or do we have to follow a specific evaluation protocol (e.g. unit tests)?
Answer (César): From our side for demo session the order may be free. You have to consider for final solution that we usually perform the tests in a sequential way:
1: functional, 2: mental, and 3: gait test.

Public end-user Driven Technological Innovation (PDTI)

"Robotics for the Comprehensive Geriatric Assessment (CGA) Challenge"

EVALUATION CRITERIA PHASE I

1 Introduction

The technology development of the PDTI will take place in three phases:

1. System design (duration 6 months, 3 R&D consortia per scenario)
2. Prototyping (duration 12 months, 2 R&D consortia per scenario)
3. Small-scale test series (duration 12 months, 2 R&D consortia per scenario)

For the first phase, three consortia per scenario are selected, and two out of them will be selected for the remaining phases based on the outcome of the system design after the first 6 months of system design work. The timeline is illustrated below.

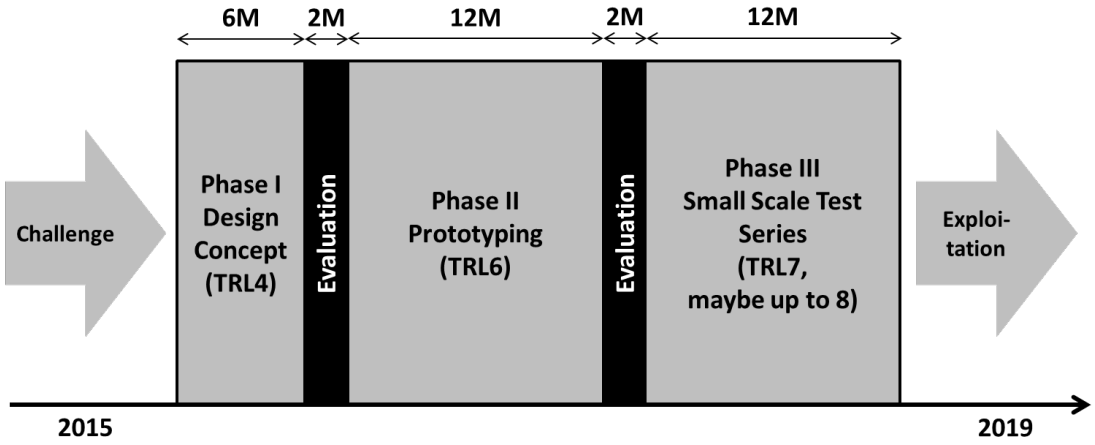

Fig. 1. Activities for research and technical development of Pre Commercial products

The Phase I of the PDTI stablishes the design of the technological solution and has to show how the robotic solution will perform the different tasks assigned in the Challenge Brief specifications.

The evaluation of the three technological proposals at the end of Phase I will be based on marks given according to three basic criteria:

- Scientific and/or technological excellence
- Quality and efficiency of the implementation and the management of the project
- Involvement of the stakeholders, including the end-users
- Potential Impact through the development, dissemination and use of the project

After six months the technological solutions will be demonstrated. The assessment will take place in the hospital in Barcelona where experts in different fields will evaluate the results after Phase I. The consortia are expected to travel to Barcelona and also bring the hardware required for demonstration (mock-up systems).

After six months you will be expected to deliver:

1. The **interface** with the patient and the medical professionals for the Barthel and MMSE test (mock-up to be evaluated by experts in different fields on the spot in Barcelona;
2. The **motion tracking system**: The technical concept and first prototype of the tracking system demonstrating the sensing modality(ies) and the movement analysis (algorithms, interpretation of motion data, visualization, etc.). Assuming that the same patient will see the hospital for tests e.g. every six months, the system you provide shall help the medical professionals to assess differences in behavior and motion patterns (the Time Up and Go test will be used as a basis for this). *Note, that the mobility of the platform should not be the main concern of the R&D consortia in the first phase and not drive costs in Phase I. Instead, the focus of the development should be on the interface, motion tracking system and data management. However, for the final testing of Phase I, all sensors should at least be embedded on a robotics mobile platform in order to show the innovative part of the solution as a*n autonomous mobile platform allows to consider an alternative way to the usual one.
3. **Data management**: Here we would like to assess how the created data/information will be made available to different systems, for direct use and for storage and integration in the established workflows (e.g. also considering electronic patient files). A statement on conformity with established standards and data security regulations is also required. It is important that the data are recorded in an open format to allow for access by non-proprietary systems, i.e. readable without the need of purchasing/using proprietary software. Please also comment on the possibility of open publication of the data acquired paying attention to the required anonymization and ethical approval.
4.

The tests to be performed as well as the documentation to be submitted are detailed out in the following chapters of these specifications.

2 Solution Specifications

2.1 Idea Resume

The Idea Resume serves to give a short overview over the project's state after the first six months. You can find detailed descriptions in the appendix. **To be submitted on: 31.06.2016.**

Solution name:		Coordinator:	
Solution Description	**Key Features and Functions**	**Feasibility Assessment**	
Critical Uncertainties	**Economic Viability**	**Potential Impact**	
Challenges Phase I	**End-User Involvement**	**Idea Sketch**	

Fig. 2. Idea Resume Phase I

2.2 Explanation of the technical specifications

This part is based on the technical specifications described in the challenge brief and serves as a short overview and update of the work conducted in Phase I. In specific, the R&D consortia should describe the technical specifications of their solution. If these specifications differ from the description given in the application before Phase I, please specify both. In case the prototype after Phase I does not comply with the solution description yet, please describe the technical specifications of the prototype. Furthermore, the R&D consortia should justify why they decided to specify the solution the way they did (e.g. because of end-user or stakeholder preferences, technical challenges or information from desktop research).

To be submitted by 31.01.2016: *"Appendix 2: Specifications after 1 months":* Table specifying in detail how the system will tackle the technical requirements detailed out in the table after six months. The different approaches will be checked by the public bodies as well as by the members of ECHORD++ core consortium and the R&D consortia will get feedback by 15.02.2016 so that corrections can be implemented where necessary.

To be submitted by 31.06.2016: *Appendix 3: "Specifications after 6 months", Appendix 4: "Phase 2", Appendix 5 "Phase 3*: A detailed description of how the systems address the different requirements in the table after six months plus a detailed outlook on how the system configuration will be adjusted during Phase II and Phase III in order to fully meet the requirements of the public bodies.

The evaluation criteria after Phase I will be:

- The validity of the technical approach to the solution and handling technical challenges
- The extent to which the R&D consortia have demonstrate and/or are likely to have allocated the necessary skills and resources for performing the work (knowledge, equipment, technology, etc.).

2.3 End-User Involvement

The R&D consortia are encouraged to involve end-users (patients, relatives and health professionals) regularly in their development process in order to receive feedback from a clinical perspective, this also includes information retrieved from desktop research, reports from public bodies or direct communication/ field research with end-users. We encourage the R&D consortia to record their communications with end-users or stakeholders briefly in the knowledge collection (Appendix 6). **To be submitted on: 31.06.2016.**

The evaluation criteria will be:

- The extent to which the R&D consortia included the end-user in the design process
- The extent to what the R&D consortia handled and processed the input of the end-users
- The extent to which the proposed solution meets the challenge as described in need description, including the extent to which the minimum requirements specified outperform, extent, the solution meets the stated requirements.
- The extent to which the solution is practically feasible from a clinical perspective, including the handling of ethical challenges

Check List Solution Specifications

Deliverable	**Form of Deliverable**	**Appendix**
Idea Resume	Word Table	Appendix 1
Specifications after 1 month (to be delivered by January 31,2016)	Word Table	Appendix 2
Specifications after 6 months	Word Table	Appendix 3
Specifications Phase II	Word Table	Appendix 4
Specifications Phase III	Word Table	Appendix 5
End-User Involvement	Knowledge Collection	Appendix 6

3 Video Deliverable

The R&D consortia have to submit a video about their solution. The video serves as an introduction for the test series in Barcelona and should just shortly explain the most important and innovative features of the solution as well as the interaction of the solution with the end-user. The video is only a minor part in the whole evaluation process. Note that the simulation will be evaluated according to the quality of the content and not the quality of the animations/ pictures.

3.1 Explanation of Solution Design

The introduction of the video should visualize and describe the solution and its features in detail, this can be done in form of a series of pictures, videos of the prototype or technical drawings. The introduction part should max. be 2 min long.

The evaluation criteria will be:

- The extent to which the proposed solution meets the challenge as described in the need description in the challenge brief
- The extent to which the solution is practically feasible
- The simulation will be evaluated according to the quality of the content and not the quality of the video

3.2 Explanation of Solution Performance

All in all, this part of the video has to illustrate the **level of autonomy** of the solution**, and indicate the specific tasks for which** the robotic solution **will be able to discharge the clinician** and **tasks for which a person's assistance will be needed,** and **general operational issues that could arise by using the solution.** It should max. be 3 min long and can be done in form of a series of pictures, videos of the prototype or technical drawings.

4.1.1 Functional specifications summary table

Functional specifications summary table	Doing test autonomously	Accompanied by Health Professional during tests
Selection, by health professionals, tests to be performed	X	X
Verbal interaction with patient/relative	X	
Ability to perform tests queries collecting information by autonomous interaction with patients/relatives (speech and touch screen)	X	
Ability to interpret and codify tests answers	X	X
Identification of test items the Health Professional is performing with patient/relatives		X
Coding test scores according to guidelines / configuration of the system	X	X
The Health Professionals must be allowed to modify tests scores	X	X
User-friendly interface to display tests results in a clear and understandable way (Dashboard-style with access to details)	X	X
Audio/video-recording and storage of raw and processed data during gait and balance tests	X	X
Audio/video-recording and storage of raw and processed data during other tests, like mental tests	X	

Fig. 3. Table functional specification summary

The simulation has to give a realistic impression on the robotic solution's performance, especially on **autonomy** and **human-robot interaction**. In that sense, the following issues should be included:

First stage- Preparation

- How the robotic solution assists the clinician to prepare the visit and how s/he will be able to configure / review the tests to be performed.
- The medical doctor could be interested in revising previous recordings, or previous results of the patient.
- How the doctor can introduce/configure a new test in the robotic solution.

Second stage: The CGA process

- How the assessment can be performed
- How the solution will interact with the different actors (doctor, other healthcare professionals, patient and patient's relatives).
- How the solution identifies each of the actors when interacting with them.
- How the robot moves (or is transported) around the hospital's settings.
- To show which activities (CGA's tests) can be done in parallel. For instance: Barthel test being applied by robot to patient in a specific room and, at the same time in another room, Barthel test being applied by health professional to patient's relative.

Third stage: Result Revision

- How the robot displays the test results
- How the clinician can compare those results with previous results
- How the results can be transferred to other hospital's systems

The evaluation criteria will be:

- The extent to which the proposed solution meets the challenge as described in the challenge brief
- The extent to which the solution is practically feasible, including ethical issues
- The extent to which the R&D consortia have identified the key challenges regarding Human-Robot Interaction, autonomy of the robot and how they have tackled these challenges
- The extent to which the R&D consortia have involved the end-user to tackle these challenges
- The simulation will be evaluated according to the quality of the content and not the quality of the video

Check List Simulation Requirements

Deliverable	**Form of Deliverable**	**Appendix**
Explanation of Solution Design	Movie, max. 2 min	**/**
Explanation of Solution Performance	Movie, max. 3 min	**/**

4 Test Series

The physical demonstration of the mock-up system in Barcelona will be done based on three standard tests for Comprehensive Geriatric Assessment. You will be expected to produce mock-up systems to illustrate:

1. The **interface** with the patient and the medical professionals for the Barthel and MMSE test (mock-up to be evaluated by experts in different fields on the spot in Barcelona;
2. The **motion tracking system**: The technical concept and first prototype of the tracking system demonstrating the sensing modality(ies) and the movement analysis (algorithms, interpretation of motion data, visualization, etc.). Assuming that the same patient will see the hospital for tests e.g. every six months, the system you provide shall help the medical professionals to assess differences in behavior and motion patterns (the Time Up and Go test will be used as a basis for this). *Note, that the mobility of the platform should not be the main concern of the R&D consortia in the first phase and not drive costs in Phase I. Instead, the focus of the development should be on the interface, motion tracking system and data management. However, for the final testing of Phase I, all sensors should at least be embedded on a robotics mobile platform in order to show the innovative part of the solution as an autonomous mobile platform allows to consider an alternative way to the usual one.*
3. **Data management**: Here we would like to assess how the created data/information will be made available to different systems, for direct use and for storage and integration in the established workflows (e.g. also considering electronic patient files). A statement on conformity with established standards and data security regulations is also required. It is important that the data are in open format, i.e. readable without the need of purchasing/using proprietary software. Please also comment on the possibility of open publication of the data acquired, with the needed anonymization and ethical approval.

4.1 Test Set-Up

The test-set up will include a real hospital's setting distribution including Ambulatory Care and Day Hospital Units, and healthcare professionals to be considered. Thus, the conditions will be standard hospital conditions. The test set-up is described in more detail in the following:

Rooms 1, 2 and 3: offices which are usually utilized by medical doctors to meet patients and their relatives (rooms 1 and 2 in Ambulatory Care, and 3 in Day Hospital Unit). Furthermore, room 3 is usually considered for multidisciplinary sessions.

Nursing office: office which is used by nurses to develop some evaluations or medical procedures: blood tests, weight measuring, blood pressure tests, intravenous treatments, so on.

Common area: this space is used for group activities (cognitive stimulation, psychomotor exercises) or to perform some tests like gait and balance tests.

Patients who need some specific physiotherapeutic treatment are transferred to Gym area.

Human resources:

Ambulatory care:

- Medical doctors

Day Hospital:

- 1 medical doctor
- 1 nurse. She also supports to medical doctor in ambulatory care unit.
- 1 physiotherapist (partial time)
- 1 occupational therapist (partial time)
- 1 social worker (partial time)
- Psychologists (partial time)

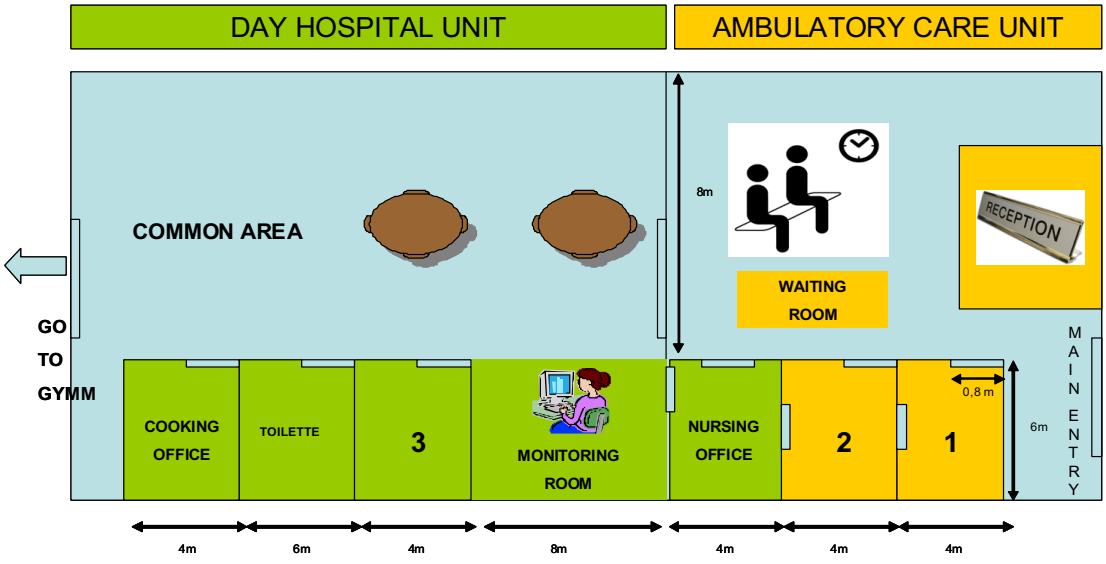

Fig. 2. Test Set-Up Evaluation Phase 1

4.2 Test: Functional Assessment

BARTHEL TEST

Description and Evaluation	Condition
Description: Barthel test, face-to-face interview as described in the challenge brief	Time: 10min Setting: Set-up described in 5.1 or similar Participants: doctors/clinicians (taking the role of the patients during testing)
Evaluation: • Ability to interact by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers and with multi-language support. Alternative mode of interaction like touch screen tool may be considered. • Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or correct tests scores; • Ability to display information and results in a user-friendly way (dashboard style). Note: Professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepen when needed.	

4.3 Test: Gait

TIME UP AND GO TEST

Description and Evaluation	Condition
Description: 1. Time up and go test as described in challenge brief. *Note that all sensors should at least be embedded on a robotics mobile platform.*	Time: 20 min Setting: Set-up described in 5.1 or similar Participants: Participants: doctors /clinicians (taking the role of the patients during testing)
Evaluation: • Ability to evaluate patients' performance • Ability to record the patient's performance, using standard components for motion analysis to the extent possible. • Ability to maintain sufficient visibility for the video and audio recording of patients during the tests. • Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or correct tests scores; • Ability to display information and results in a user-friendly way (dashboard style). Note: Professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepen when needed.	

• Platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. • How the platform addresses human locomotion/ postural parameters/ spatio-temporal gait parameters/ kinematic and dynamic parameters • Innovation and creativity regarding information registering. Usually, clinical information is registered only in text format into clinical records. However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video may be useful to compare patients' performance at the beginning and at the end of a rehabilitation process.	

4.4 Test: Mental Assessment

MMSE TEST

Description and Evaluation	Condition
Description: MMSE Test, face-to-face interview as described in the challenge brief	Time: 10 min Setting: Set-up described in 5.1 or similar Participants: Participants: doctors /clinicians(taking the role of the patients during testing)
Evaluation: • Ability to interact by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers and with multi-language support. Alternative mode of interaction like touch screen tool may be considered. • Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or correct tests scores; • Ability to display information and results in a user-friendly way (dashboard style).	

Check List Test Series

Deliverable	Form of Deliverable	Appendix
Barthel Test	Test on site, 10min	/
Time Up and Go Test	Test on site, 20min	/
MMSE test	Test on site, 10min	/

5 Economic Viability

The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre-commercial product. The proposal should develop the economic viability for the future companies and institutions involved.

The R&D consortia should describe the following points as detailed as possible in a report (max. 2500 words). It can be an advantage to be in close communication with possible manufacturers, integrators, business partners or investors. Please refer to useful literature at the end of the report (in addition to the 2500 words).

1. **Costs for the Public Entity**

- Summarized cost of the technological equipment – platform, sensors, communication system, licenses, batteries
- Life expectancy of the solution
- Production costs
- Installation costs
- Operating and maintenance costs, including labor costs for manual processes
- Energy consumption
- Costs for disposal
- Production price
- Estimated sales price

2. **Assessment of Market Potential**

	Total number of beds	**Robots per. 100 patients**	**Number of devices**	**Price per robot**	**Turnover**	**Profit**
Europe						
Spain						
USA						
China						
UEA						
Japan						
Russia						
Brazil						
Chile						
Argentina						
Total						

3. **Freedom to operate (FTO) analysis**

- Relevant Patents

4. **Business Case**

- including a cost benefit analysis estimation focusing on the Public Entity's situation
- including a go-to-market strategy, investment analysis, tech roadmap
- dialogues with manufacturers, integrators, investors or business partners
- description of possible supplier network

5. **Logistics & Planning**

- the logistics, planning and dissemination activities for the subsequent phases, including the transition phase from R&D to the market

6. **Repayment Period**
7. **Existing Solutions**
8. **Advantages of Consortia's solution**

The evaluation criteria will be:

- The extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution
- The extent to which the solution is estimated to have commercial potential, also in relation to existing solutions market
- The extent to which stakeholders have been involved in the calculation of the economic viabilities
- The extent to which the solution contains a clear plan for development of a viable solution, including whether there is a realistic schedule for completion of the work for the next phases.
- The extent to which the R&D consortia have identified the key risks (technical, commercial and other) in relation to the security of and demonstrates the success of the project to be able to deal with these effectively.
- The extent to which the R&D consortia have involved the public body

Check List Economic Viability

Deliverable	**Form of Deliverable**	**Appendix**
Report	Word Document max. 2500 words, excl. literature	/

6 Ethics

The ethical issues in field of research and development of medical devices are regulated by legal requirements made by health agencies. Therefore, the R&D consortia should review all published ethical and legal guidelines and requirements specified by health agencies regarding development and research of medical devices. At the end of Phase I, the R&D consortia need to deliver a document that lists the applying requirements for their solution and a description of how the R&D consortia fulfill the respective legal and ethical requirements.

In addition, we advice the R&D consortia to take the collected input from the end-user's (especially elderly people) into account. The R&D consortia are welcome to add a creative section (video, document, etc.) about the end-user's needs and opinion on their solution.

In order to be able to perform pilot trials at the end-user's side, they will request the R&D consortia to fill out documents for the application process. This might involve some effort from the R&D consortia during Phase I and the R&D consortia are asked to work closely with the end-user on this issue.

Check List Ethics

Deliverable	**Form of Deliverable**	**Appendix**
Report	Word Document, table	/

Idea Resume

Solution name:		Coordinator:	

Solution Description	Key Features and Functions	Feasibility Assessment
Critical Uncertainties	**Economic Viability**	**Potential Impact**
Challenges Phase I	**End-User Involvement**	**Idea Sketch**

Specifications after 1 month

	Description of requirements after Phase I	Description of implementation plan for Phase I (to be delivered after 1 month – by January 31, 2016)
General requirements		
Overall system	Specification of overall system setup with geometric parameters, weight of the system, description of interaction modalities. One single prototype mainly with mock-up functionalities, see below.	
Weight	The specified system must be portable by a normal human, the first prototype can be bigger/ heavier, but needs to give an impression of the final one at the end of stage III.	
Power supply	The specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated	
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated.	
Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if the natural language interface is not suitable, e.g. when a patient is not or only hardly able to speak. Also here, the multi-language issues apply in the same form as described above.	

Motion tracking	Concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test and the Tinetti Balance and Gait tests	
Mobility		
Platform's ability in terms of person following, face tracking, and similar advanced features	Implementation of patient motion tracking functions on sensors used for activity analysis.	
Actual testing		
Dialogue (questionnaire)-based tests	Mock-up of the dialogue-based Barthel test.	
Tests based on motion analysis	Mock-up of the Get Up and Go test.	
Audio/Video recording	Proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide suitable point and field of view for the tests.	
Evaluation and data management		
Patient-specific view	Mock-up of the dashboard for one patient's data including his development in test results, and access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores	

Integration into clinical data management	Possibility to interface with clinical data systems in the overall concept	
Data protection	Description of data protection concept and fulfilment of standards	
Configuration		
Patient- specific configuration	Mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts6, handling of patient data	
Integration of new/additional tests	Mock-up of a functionality to develop a new questionnaire-type tests.	
Integration of new tests based on motion/video analysis	Description of concept. This type of new assessments need the help of system experts, but the specified system should have the possibility to add such things.	
Calibration	Mention, if there is a need to calibrate the motion detection component	

Specifications after 6 month

	Description of requirements after Phase I *(see also Evaluation Matrix for important factors to mention and how your description will be evaluated)*	Description of how the different aspects are addressed in detail after 6 months (Phase I) as preparation of the on the spot evaluation in Barcelona (July 2016)
General requirements		
Overall system	Specification of overall system setup with geometric parameters, weight of the system, description of interaction modalities. One single prototype mainly with mock-up functionalities, see below.	
Weight	Describe all specifications concerning the weight of the solution. The specified system must be portable by a normal human, the first prototype can be bigger/ heavier, but needs to give an impression of the final one at the end of stage III.	
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform's ability in terms of person following, face tracking, and similar advanced features.	
Power supply	The specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated	
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated.	
GUI design Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if the natural language interface is not suitable, e.g. when a patient is not or only	

	hardly able to speak. Also here, the multi-language issues apply in the same form as described above.	
Motion tracking	Concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test and the Tinetti Balance and Gait tests	
Evaluation and data management		
Patient-specific view	Mock-up of the dashboard for one patient's data including his development in test results, and access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores	
Integration into clinical data management	Outline of the possibility to interface with clinical data systems in the overall concept.	
Data protection	Description of data protection concept and fulfilment of standards.	
Configuration		
Patient- specific configuration	Description of mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts, handling of patient data.	
Integration of new/additional tests	Description of mock-up of possibilities to develop a new questionnaire-type tests.	
Calibration	Mention, if there is a need to calibrate the motion detection component and if yes, describe the necessary steps.	
On-site testing		

BARTHEL and MMSE Test BARTHEL: 2 tests à 15 min MMSE: 2 tests à 15 min	The proposed solution will be evaluated during the BARTHEL/ MMSE test based on its ability to interact with humans by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers with multi-language support. An alternative mode of interaction like a touch screen tool may be considered to solve speech recognition issues. Describe possible explanations or Human-Robot Interactions here.	
Get up and Go Test 3 tests à 20 min	The Get up and Go Test will be evaluated based on the proposed solution's ability to evaluate and record the patients' performance using standard components for motion analysis to the extent possible, to maintain sufficient visibility for the video and audio recording of patients during the tests and the platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. Describe possible explanations or Human-Robot Interactions here.	
Ethics	Please note that there are also ethical requirements to be described in a separate deliverable report.	
Economic Viability	Please note that you also need to include considerations concerning economic viability in a separate deliverable report.	

Specifications Phase II

	Description of requirements after 18 months (Phase II)	Description of implementation plan for Phase II (deliverable Phase I)
General requirements		
Overall system	Overall system prototype fulfilling the requirements described in Stage I, with all foreseen interaction modalities, even if not in final shape, but advanced enough to do a first evaluation with doctors, nurses, etc. as test users.	
Weight	The specified system must be portable by a normal human, the stage II prototype can be a bit bigger/heavier, but needs to give an impression of the final one at the end of stage III.	
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform's ability in terms of person following, face tracking, and similar advanced features.	
Power supply	The stage II prototype can be powered by cable.	
Language interface	Fully functional Robust Natural language interface, ability to interact by speaking and natural language processing (even in case of slightly slurred speech). The demonstration can be done using any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated.	
Touch-screen interaction	Demonstration of touch-screen based interaction for all sorts of dialogues in the prototype resulting from stage II, capability for multi-language support has to be demonstrated.	

Motion tracking	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go test.	
Evaluation and data management		
Patient-specific view	First prototype of a dashboard for one patient's data including his development in test results, and access to raw data, such as answers given in a specific test or videos and visualization of an analysis.	
Analysis of results	Demonstration of functions to interpret and codify patients/relatives answers of selected tests; Ability to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores. For the mental and functional tests, the analysis and coding of the answers need to be shown, even if not in the final form. For the motion-related tests, the parameters extracted are gait speed, time spending during the tests, and so on. Here, state-of the art motion analysis tools should be used to start from.	
Integration into clinical data management	This version does not need to be able to be integrated into the overall clinical data management system.	
Data protection	Refined concept for data protection concept and fulfilment of standards and its integration into clinical data management systems.	
Configuration		
Patient- specific configuration	System dialogues for selection of tests, handling of patient data.	

Integration of new/additional tests	Functionality of adding a new questionnaire. This should be doable by medical staff with help of system engineers.	
Integration of new tests based on motion/video analysis	Proof-of concept in context with the prototype.	
Calibration	If calibration is needed, a first version of the calibration functionality (operated by system engineers) needs to be shown.	
Actual testing *(please note that the specifications for the actual testing will be define after Phase I, please only describe whether you will be able to achieve the below mentioned criteria and how)*		
Dialogue (questionnaire)-based tests	Implementation of the dialogue-based Barthel and MMSE tests.	
Tests based on motion analysis	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go test.	
Audio/Video recording	Full recording capability to be demonstrated.	
Ethics	Please note that you should also consider to describe ethical requirements after Phase II in your separate report.	
Economic Viability	Please note that you should also consider economic viability factors in your separate deliverable report.	

Specifications Phase III

	Description of requirements after 30 months (Phase III)	Description of implementation plan for Phase III (deliverable Phase I)
General requirements		
Overall system	Small-scale test series (4 systems, to be used in the main hospital scenarios: ambulatory care units, day care hospital and hospitalization units. 1 additional system as backup and for tests) with all foreseen interaction modalities, actually being evaluated at the public bodies sites in an 28 days evaluation trial.	
Weight	Prototypes meeting the specification, the portability has to be demonstrated.	
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform's ability in terms of person following, face tracking, and similar advanced features.	
Power supply	The prototypes must be able to be operated both in battery mode and plugged as specified.	
Language interface	Fully functional Robust Natural language interface, ability to interact by speaking and natural language processing (even in case of slightly slurred speech). The actual tests will be in Catalan and/or Spanish, the addition of these language(s) will be done with the help of the public bodies and other supporting staff.	
Touch-screen interaction	Full implementation of all dialogues which use the touch-screen mode, The actual dialogues will be in Catalan and/or Spanish, the addition of these language(s) will be done with the help of the public bodies and other supporting staff.	

Motion tracking	Full implementation of the motion tracking component with analysis software and the dashboard for this functionality for Get up and Go, Tinetti Gait, Tinetti Balance.	
Evaluation and data management		
Patient-specific view	Dashboard for one patient's data including his development in test results, and access to raw data, such as answers given in a specific test or videos and visualization of the motion analysis.	
Analysis of results	Integration of these functions in the prototypes.	
Integration into clinical data management	Prototypes able to be integrated into the overall clinical data management system.	
Data protection	Proof of concept for integration into clinical data management systems including data protection and fulfilment of standards.	
Configuration		
Patient- specific configuration	Final version of system dialogues for selection of tests, handling of patient data.	
Integration of new/additional tests	Functionality of adding a new questionnaire. This should be doable by medical staff only.	

Integration of new tests based on motion/video analysis	Actual demonstration of adding a new analysis in context of the final evaluation.	
Calibration	If calibration is needed, the calibration functionality (operated by clinical staff) needs to be shown.	
Actual testing *(please note that the specifications for the actual testing will be define after Phase II, please only describe whether you will be able to achieve the below mentioned criteria and how)*		
Dialogue (questionnaire)-based tests	Implementation of the following dialogue- based tests. Ideally: Functional tests: Barthel and Lawton tests. Mental tests: Pfeiffer test, MMSE test, and Yesavage test.	
Tests based on motion analysis	Full implementation of the motion tracking component with analysis software and the dashboard for this functionality for Get up and Go, Tinetti Gait, Tinetti Balance.	
Audio/Video recording	Full recording capability integrated.	
Ethics	Please note that you should also consider to describe ethical requirements after Phase III in your separate report.	
Economic Viability	Please note that you should also consider economic viability factors in your separate deliverable report.	

Knowledge Collection

Date	Activity	Source	Main Outcome
27/01/16	**Name:** Introduction meeting **Purpose:** Presentation of solution and questions for end-user about technical specifications	Name of contact person, company or institution	Short description of main outcome, e.g. important findings, feedback

Evaluation Matrix

June, 7th, 2016

This evaluation Matrix describes the evaluation criteria and allocated points for each criterion of the PDTI Healthcare projects after Phase 1. The reviewers will evaluate the proposed solutions with this matrix based on the 11 deliverables that the consortia will hand in until **June, 20 2016** and the on-site testing taking place on **July, 7th ,** at the hospital Sant Antoni Abat. Detailed information about the expected content to be described in the deliverables can be found in the document "PDTI Healthcare Phase 1 Evaluation Criteria". Detailed information about the on-site testing can be found in the same document in section "4. Test-Series". The success of the proposed solution will largely be base on the feasibility of the solution rather than the technical means by which this is achieved. See a detailed description below.

Point:
Crucial: 10
Essential: 8
Important: 6
Of some significance: 4

Evaluation Criteria	Description of evaluation criteria after Phase I	Points	Comments from reviewers
General The following is a description of the overall evaluation criteria, which will be evaluated in the sections detail below. These criteria are interconnected and need to be fulfilled in order for the proposed solution to be a success.			
Overall system	Audit based evaluation of the design/requirement capture, methodology and general specifications in the context of medical devices and equipment. The score will take into account the level of understanding of the services requested, completeness and clarity of the specification, methodology for ensuring quality control, and life cycle of the product. Special attention will be payed to the level of integration, installation/storage modalities, ICT connectivity, interfaces, ergonomics.	Important	
Human-Robot Interaction	The evaluation of Human-Robot Interaction will focus on the robot's level of autonomy. This includes an evaluation of the interaction design, meaning how the solution will identify each of the actors and interact them with them (doctor, other healthcare professionals, patient and patient's relatives) e.g. when in the interaction	Crucial	

	the robot is autonomous, where can it discharge the healthcare professional, which tasks/ interactions with the patient are reserved for the healthcare professional, where does the robot need assistance and from which person (clinician, nurse, etc.). It will also be evaluated how the robotic solution assists the healthcare professional to prepare the visit, how the healthcare professional will be able to configure / review the tests to be performed and how the solution analyzes and displays test results in the most appropriate and innovative way. It is also important that the robot gets the right information from the patients and can evaluate the importance of the information. The evaluation will also include a more general view on the workflow- how the daily workflow in the hospital takes place without the robot solution and which tasks change when the robot is introduced. It will be looked at whether the tasks allocated to the robot fit into the workflow of the hospital and add value to the healthcare professional's work. For this, it is important to show which activities (CGA's tests) can be done in parallel. For instance: Barthel test being applied by robot to patient in a specific room and, at the same time in another room, Barthel test being applied by health professional to patient's relative.		
End-User Involvement	The R&D consortia are encouraged to apply an end-user driven design approach and involve end-users (patients, relatives and health professionals) regularly in their development process in order to receive feedback from a clinical perspective. The evaluation will include the extent to which the R&D consortia included the end-user in the design process, how they handled and processed the input of the end-users, whether the proposed solution meets the challenge as described in need description, including the extent to which the minimum requirements specified outperform, extent, the solution meets the stated requirements. Furthermore, the evaluation will focus on whether and how the solution is practically feasible from a clinical perspective, including possible ethical challenges.	Essential	
Economic Viability	The evaluation for each of the following categories will be based on the extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution, the estimated commercial potential, the extent to which stakeholders and the public body have been involved in the calculation of the economic viabilities, in how far the solution contains a clear plan for development of a viable solution. It will also be evaluated in how far the R&D consortia have identified	Important	

	the key risks (technical, commercial and other) and demonstrated that they are be able to deal with these effectively.		
Integration with other hospitals	This criterion is closely connected to the economic viability described above. The evaluation will include the extend to how the proposed solution can be used by other hospitals. This is divided into two parts. On the one hand, this includes the possibility to integrate the proposed solution into other systems from a technical perspective (IT-platforms, data managements systems, etc.). On the other hand, this includes the possibility for other hospitals to use the proposed solution from an ethical perspective, including regulations and legal requirements on medical devices in other hospitals or countries.	Important	
Adjustments to future tests or technology	In general, the innovative thinking of the consortia and how adaptable the proposed solution is to future usage and development of technology will be evaluated. Additional features that the consortia described as relevant and how they would integrate them will be taken into consideration.	Of some significance	
System			
Weight	The description of the future concept (after Phase 2 and 3) will be evaluated in terms of how the robot moves (or is transported) around the hospital's settings and whether the solution is portable by average hospital personnel. This does not necessarily mean that a human has to carry the solution, but rather that it can be easily transported from one setting to another. The first prototype shown during the testing can be bigger/ heavier than the described concept, but needs to give an impression of the final concept anticipated at the end of stage III. The evaluation will also include a review on whether the described final concept matches can be achieved based on the achieved development work after Phase 1. If the solution is to be carried by humans, the weight and the manual transportation conditions must comply with the risk prevention rules. Also, solutions with wheels need to comply with security and risk prevention rules.	Essential	
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform’s ability in terms of person following, face tracking, and similar advanced features. The evaluation of mobility includes the implementation (prototype as well as future concept) of patient motion tracking functions on sensors used for activity analysis. It will also be evaluated whether the solution has	Of some significance	

	the autonomous mobility to support the sensors and whether possible embedded computers will be used to increase the performances e.g. relax constraints on patient position by sensor based tracking (face, sound source, posture), reduce the invasiveness of the exam, parameters extraction for the tests) or increase functionalities. The rating will be based on an audit of the methods they will implement and the capabilities of the platform to support these advanced features (verbal fluency, stress, interaction engagement, dynamic postural parameters, etc.)		
Power supply	The evaluation of power supply will be based on the battery autonomy time, battery changing/recharging time and ease, security protection. The magnetic compatibility will be another evaluation criterion. The rating will include the degree of compliance with general rules and guidelines. Compliance and reference to regulations and guidance from the countries of the R&D consortia will be positively evaluated. Basic requirements for power supply are that the specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated.	Essential	
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated. The evaluation will include the multi-language user interface (to setup the system), the dialog manager (speech recognition and vocal synthesis) and sound analysis modules. Multi-language adaptation needs to be easy. Particularly the performance will be evaluated regarding the following three criteria: 1) Speech recognition rate (based on specified dictionary and grammar). The teams have to demonstrate this function, and must describe the applied benchmark. 2) Robustness of the voice recognition and vocal synthesis with respect to the level of surrounding noise in the environment. That is, how sensitive is the voice recognition w.r.t. to environmental conditions? It is allowed to use a tailored sound capture system as ling as it is simple to use and practically feasible.	Essential	

	3) Robustness of the vocal synthesis with respect to the level of surrounding noise in the environment. That is, how easy can the generated speech be understood by the patient? 4) Adaptability to others languages.		
GUI design Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if the natural language interface is not suitable, e.g. when a patient is not or only hardly able to speak. Also here, the multi-language issues apply in the same form as described above. The GUI design will be graded based on an audit of the development method (50%) and of the usability of the GUI tested in the on-site testing (50%), where the user will be observed how s/he navigates and uses the system to perform the test tasks.	Important	
Motion tracking	The evaluation includes the concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test. The evaluation will be based on the number of parameters successfully extracted, the expected precision robustness to environmental perturbations (light, relative position of the sensor with respect to the patient), calibration time, the associated performance analysis tools.	Important	
Evaluation and data management			
Patient-specific view	Mock-up of the dashboard that the patient will be using and example for how the robot displays results that show the patient's development in test results after several visits as well as access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	Of some significance	
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores and compared results with previous sessions.	Important	
Integration into clinical data management	This evaluation includes the solution's possibility to interface with clinical data systems in the overall concept and how the collected data results can be transferred to other hospital's systems. It will be evaluated how the created data/information will be made available to different systems, for direct use and for storage and integration in the established workflows (e.g. also considering electronic patient files). It is important that the data are recorded in an open format to allow for access by non-proprietary systems, i.e. readable without the need of purchasing/using proprietary software. It will also be evaluated whether there is the	Important	

	possibility for open publication of the data acquired, paying attention to the required anonymization and ethical approval.		
Data protection	The description of data protection concept will be evaluated and checked whether it fulfills the standards.	Important	
Ethics			
Legal and ethical regulations	The ethical issues in the field of research and development of medical devices are regulated by legal requirements made by health agencies. Therefore, the R&D consortia should review all published ethical and legal guidelines and requirements specified by health agencies regarding development and research of medical devices. A description of how the R&D consortia fulfill the respective legal and ethical requirements will be evaluated.	Important	
Development and production of medical devices	When developing medical devices, there are several regulations to pay attention to. Thus, the evaluation will include the ability of the R&D consortia to identify the necessary compliances and analyze as well as argue for the degree of compliance of their solution with general rules and guidelines. As the end-user is located in Catalunya, it is necessary for the solution to comply with Spanish regulations by the regulatory institution "Agencia Española del Medicamento y Productos Sanitarios". The requirements to guarantee safety of the device are clearly outlined by the above mentioned regulatory agency. The evaluation will include the R&D consortia's ability to analyze the regulations and describe the degree of compliance of their solution with these regulations. In addition, it will be evaluated how the R&D consortia analyze and comply with regulations from other countries. Here, it is especially important to • Identify the countries with the highest scalability of the solution suggested • Argue and defend this selection • Identify the regulations which are valid in these countries		

	• outline how other regulations differ from the Spanish requirements, whether the R&D consortia also comply with these regulations and if not, how they will achieve compliance with these other regulations • And outline the adjustments of the technological solution which will be necessary to meet the legal and ethical requirement of these countries (including the impact on costs and prices) • Outline market barriers in these countries geared to the technology proposed At the end of the PDTI challenge, the solution is not only supposed to be sold in Spain, but in as many other countries as possible. Thus, it will be evaluated how the R&D consortia will show a possible scalability of the product and ensure flexibility towards international regulations and EC markings that will be requested by future customers.		
End-User Perspective	This evaluation includes the considerations and decisions that the R&D consortia have made to include the end-user's, especially elderly people, perspectives, opinions and fears.	Important	
Analysis of ethical issues	We encourage the R&D consortia to point out ethical issues that they experience in Phase 1 or foresee for the subsequent phases and present possible solutions in their ethics report.	Of some significance	
Economic Viability			
Costs for the Public Entity	The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre-commercial product. The proposal should develop the economic viability for the future companies and institutions involved. The evaluation will include the cost of the technological equipment (platform, sensors, communication system, licenses, batteries), life expectancy of the solution, production and installation costs, operating and maintenance costs, including labor costs for manual processes, energy consumption, costs for disposal and the estimated sales price.	Important	
Assessment of Market Potential	The aim of this PDTI is not only to develop a solution that can be used at hospital Sant Antoni Abat, but in as many other hospitals as possible to make it a good business case. The R&D consortia's assessments of the market potential and the sales potential of their proposed solution will be evaluated.	Essential	

Freedom to operate (FTO) analysis	An analysis of possible patents and other restrictions that could prevent the development, sales or production of the proposed solution will be evaluated.	Crucial	
Business Case	The evaluation includes a description of different parameters for a business case including, but not limited to, a cost benefit analysis with estimations focusing on the Public Entity's situation, a go-to-market strategy, investment analysis, tech roadmap, dialogues with manufacturers, integrators, investors or possible business partners and a description of a possible supplier network.	Important	
Logistics & Planning	It is important that the R&D consortia have a realistic schedule for the completion of their development work for the following phases. Therefore, this evaluation includes the extent to which the R&D consortia's have shown and described their ability to plan and execute dissemination and commercial activities for the subsequent phases, including the transition phase from R&D to the market.	Important	
Repayment Period	The evaluation includes a calculation of the repayment period.	Important	
Existing Solutions	The evaluation includes a market analysis of existing solutions that could partially or fully take over the tasks that the proposed solution is to perform.	Important	
Core advantages of Consortia's solution	The R&D consortia might have pointed out challenges of their proposed solution in the aforementioned categories. Here, their solution's core advantage in regards to economic viability and in comparison to existing solutions will be evaluated.	Essential	
Configuration			
Patient- specific configuration	This includes the evaluation of a mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts and handling of patient data.	Important	
Integration of new/additional tests	The functionality to develop new questionnaire-type tests and the connected mock-ups for this functionality will be evaluated. This evaluation also includes the possibility for integration of new tests based on motion/video analysis. This type of new assessments probably needs the help of system experts; it will be evaluated how this issue is solved.	Of some significance	

Calibration	This evaluation will include the type of calibration that is needed for the components, e.g. the motion detection component.	Essential	
On-Site testing; test-dependent evaluation			
General criteria for all 3 tests	The evaluation of all three on-site tests will be based on the information described by each consortium in the deliverables. It will include the methodology that is used to conduct the test as well as to analyze, calculate and display the test results based on codified information. Note, that the healthcare professional has to be able to modify or correct tests scores in a modification mode. The aforementioned methodology is chosen by the consortia based on the data they received from the end-users (data can be described in the "Knowledge Collection"; Appendix 6 of document "PDTI Healthcare Phase 1 Evaluation Criteria"). Furthermore, the autonomy of the robot in the interaction and the way how it interacts with the patient and the healthcare professional will be evaluated. It is expected that the prototype shows a proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide a suitable point and field of view for the tests. It is important that the proposed solution displays information and results in a user-friendly way (dashboard style). Healthcare professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepened when needed. The results will also be evaluated from a healthcare professional's view, his usual analysis and how the analysis of the proposed solution adds value to the healthcare professional's work and his/her evaluation of the patient. It will also be evaluated how the solution and calculated results can be connected and transferred to existing data storage and electronic health record systems and how data can be exploited for diagnosis. While the on-site testing is a very crucial factor in the evaluation, it is important to notice that the overall development process will be evaluated. In case a R&D consortia is not able to deliver the expected test demonstration because of unexpected issues, we will still be able to evaluate the prototypes and the descriptions (submitted deliverables).	Crucial	
BARTHEL and MMSE Test BARTHEL: 2 tests à 15 min MMSE: 2 tests à 15 min	The proposed solution will be evaluated during the BARTHEL/ MMSE test based on its ability to interact with humans by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-	Crucial	

	defined answers with multi-language support. An alternative mode of interaction like a touch screen tool may be considered to solve speech recognition issues. **<u>Test-Scenario</u>** The BARTHEL/ MMSE test will be performed in a closed room with one healthcare professional from Sant Antoni Abat. The test will be performed according to the structure, questions and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during the first phase. End-users will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to one patient, in this case the healthcare professional. The test is usually performed with one person, while the other person (relative or patient) is being interviewed in another room. Thus, the testing of the MMSE/BARTHEL tests will only involve one interviewee. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Each of both tests will be tested during 15 min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		
Get up and Go Test 3 tests à 20 min	The Get up and Go Test will be evaluated based on the proposed solution's ability to evaluate and record the patients' performance using standard components for motion analysis to the extent possible, to maintain sufficient visibility for the video and audio recording of patients during the tests and the platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. Evaluation will also focus on how the platform addresses human locomotion, robustness to perturbations, variance, the number of extracted parameters, postural parameters, spatio-temporal gait parameters, kinematic and dynamic parameters. In terms of result analysis and how results are displayed after a Get up and Go Test, the evaluation will include the innovative thinking of the consortia and how the data that was received from the end-user was translated into a concept and included in the proposed solution. Usually, clinical information is registered only in text format.	Crucial	

	However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video/animation may be useful to compare patients' performance at the beginning and at the end of a rehabilitation process. **<u>Test-Scenario</u>** The Get up and Go test will be performed in an open area (see document "PDTI Healthcare Phase 1 Evaluation Criteria" for an outline), which the R&D consortia were able to see during the Kick-Off Meeting. The test will be performed according to the structure and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during Phase 1. An End-user will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to the patient, in this case the healthcare professional. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Afterwards, a third person will perform the test while being supported by a healthcare professional during some time of the test. All in all, the same test-activity will be performed three times by three different persons (while the last person while receive help); markers are used in terms of locomotion. A T-Shirt might be used for identification issues after Phase 1. Each test will be tested during 20min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		

Deliverable	Description	Summary of evaluation criteria	Form	Date
Solution Specification				
Idea Resume	Overview of development progress phase I.		Word Table	31.06.2016
Technical Specifications *after 1 month (for Phase I)	Overview of technological development phase I. Table taken from Challenge Brief and edited by partners and reviewers.	+ The validity of the technical approach to the solution and handling technical challenges + The extent to which the R&D consortia have demonstrate and/or are likely to have allocated the necessary skills and resources for performing the work.	Word Table	31.01.2016
Technical Specifications *after 6 months (for Phase I)	Overview of technological development and more specific description of current development stage at the end of phase I. Table taken from Challenge Brief and edited by partners and reviewers.		Word Table	31.06.2016
Technical Specifications *after 6 months (for Phase II and III)	Overview of development plan for phase II and III. Table taken from Challenge Brief and edited by partners and reviewers.			

End-User Involvement	Proof for end-user involvement and record of design decisions based on end-user feedback.	+ Involvement of the end-user in the design process. + The handling and processing of the input from the end-users. + The proposed solution meets the challenge as described in need description. + The solution is practically feasible from a clinical perspective, including the handling of ethical challenges	Knowledge Collection	31.06.2016
Video Deliverable				
Solution Design	Visualization of product.	+ The proposed solution meets the challenge as described in the challenge brief + The solution is practically feasible + The quality of the content and not the quality of the video	Movie, Max. 2 min	
Solution Performance	Visualization of product development in phase I and integration of robot into workplace, including the level of autonomy and HRI within the robot's workflow.	+ The proposed solution meets the challenge as described in the challenge brief + The solution is practically feasible, including ethical issues + The identified key challenges regarding Human-Robot Interaction,	Movie, Max. 3 min	

		autonomy of the robot and and a way to have tackled these challenges + Involvement of the end-user to tackle these challenges + The quality of the content and not the quality of the video		
Test Series				
Barthel Test	Real environment test within area: function assessment.	+ Ability to interact by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers and with multi-language support. Alternative mode of interaction like touch screen tool may be considered. + Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or + correct tests scores + Ability to display information and results in a user-friendly way (dashboard style). Note: Professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepen when needed.	Test on Site, 10 min	
Time up and Go test	Real environment test within area: gait assessment.	+ Ability to evaluate patients' performance + Ability to record the patient's performance, using standard components for motion analysis to the extent possible. + Ability to maintain sufficient visibility for the video and audio recording of patients during the tests. + Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or + correct tests scores;	Test on Site, 20 min	

		+ Ability to display information and results in a user-friendly way (dashboard style). Note: Professionals usually do not + need to see all detailed scores of tests; they would like to have a global vision of total scores and deepen when needed. + Platform's potential in terms of person following, face tracking, + and other advanced features that will be implemented in the subsequent phases. + How the platform addresses human locomotion/ postural parameters/ spatio-temporal gait parameters/ kinematic and dynamic parameters + Innovation and creativity regarding information registering. Usually, clinical information is registered only in text format into clinical records. However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video may be useful to compare patients' performance at the beginning and at the end of a rehabilitation process.		
MMSE Test	Real environment test within area: mental assessment.	+ Ability to interact by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers and with multi-language support. Alternative mode of interaction like touch screen tool may be considered. + Ability to calculate tests scores based on codified information. The Health Professional has to be able to modify or + correct tests scores; + Ability to display information and results in a user-friendly way (dashboard style).	Test on Site, 30 min	
Economic Viability				

Economic Viability Report	Overview of market potential, cost price and other involved costs for customer, business case, repayment period, other existing solution (and advantage of consortia's solution), freedom to operate.	+ The extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution + Estimation for commercial potential, also in relation to existing solutions on the market + Stakeholders' involvement in the calculation of the economic viabilities + The clearness of the plan for development of a viable solution, including whether there is a realistic schedule for completion of the work for the next phases. + Identification of the key risks (technical, commercial and other) in relation to the security of and demonstrates the success of the project to be able to deal with these effectively. + Involvement of the public body.	Word Document, Max. 2500 words, without literature	
Ethics				
Ethics Report	Overview on ethical and legal guidelines when developing medical devices, and considerations suggested by end-users	+ Ability to evaluate endu-users' thoughts and general ethical issues	Word Document, Table	

ECHORD++ - PDTI Phase I, healthcare

EVALUATION REPORT

Version July 23, 2016

1. Introduction and methodology

This report covers the assessment of *PHASE I (Design Phase) of PDTI in healthcare.* The process and governance of PDTI is outlined in Annex I of ECHORD++, verison dated 22/12/2015. The purpose of this assessment (PDTI milestone review) on 8th July 2016 in Barcelona is to a) decide if two out of the three experiments selected for Phase I justify funding under Phase II (PROTOTYPING) of PDTI and b) if so, to identify the two approaches which should be continued with clear recommendations from the extermal reviewers.

During the panel meeting in Barcelona on 13th July 2015, the following three experiments were selected out of 15 eligible proposals received and invited to design within 6 months (01/01/2016 – 30/06/2016) the different technological approaches to successfully tackle the challenge on Robotized Comprehesive Geriatric Assessment (CGA) in PDTI healthcare. The different approaches of these three experiments can be summarized as follows:

ARNICA: Kompaï Robot for Robotized Comprehensive Geriatric Assessment
Partners: Robosoft S.A., INLOC Robotics SLU, Danish Technological Institute, Assistance Publique Hôpitaux de Paris - Hôpital Broca

ARNICA proposes a robotic device able to help with Comprehensive Geriatric Assessment. This robot is able to manage autonomously the execution of some tests and assist the Health Professionals, discharging and freeing up time for them to focus on more important activities. Furthermore, discharge also should decrease health professionals' tiredness or fatigue perception as consequence of doing tests. The proposal is coordinated by Robosoft, producer of the Kompai robot and involved in some previews projects focalized on assistance at home for elderly peoples. The proposal brings together the well-known Kompai platform and commercial footprint of ROBOSOFT, INLOC offers a secondary line of work solving automatic control problems, including control algorithms (low or high level control problems) and related electronics and DTI with their competences in engineering, design, Human Robot Interaction (HRI), health care and education will develop and implement functionalities related to the Configuration, actual testing and Data management and evaluation functions comprising: System dialogues for selection of tests, handling of patient data, implementation of the dialogue-based Barthel and MMSE tests, implementation and calibration of balance and gait analysis. The impact centres on deep progress toward EU scientific and market leadership in a user driven solution for this major challenge. The path to market deployment by bringing ARNICA solutions to end users is clearly developed.

ASSESSTRONIC: ASSESSTRONIC
Partners: Accel, Université Pierre et Marie Curie-Paris 6 (UPMC)

Nowadays CGA exams are done under very limited and time consuming protocols. ASSESSTRONIC ambitions to take benefit of robotic technologies to make the execution of these tests easier, faster and more traceable, and to provide added-valued outputs in different, more objective and subtle dimensions. A robotic platform for CGA will be developed with the following key objectives: - Increase the user experience for both the doctor and end-user by performing CGA tests through natural interfaces, such as voice (natural language), tactile or gestural interfaces. Thanks to them, of the tests will be carried out autonomously by the robot. - Explore multimodal signal analysis for fine diagnosis. The platform will extract and analyze behavioral parameters, much finer than those now offered by conventional tests, based on indices of non-verbal (i.e. facial expressions, gestures, gaze, etc.) and paraverbal communication (i.e. voice volume, pitch, speech, intonation, breathing, fillers and so on). - Automatic physical assessment. The mobility of the platform relative to the person will allow performing tests to autonomously analyze and quantify motor, psychomotor and sensory-motor activity on the basis of physical activities. - Health data storage and management. The data related to each patient GCA process will be collected, treated and stored in a safe and efficient way. To avoid distribution barriers due to costly solutions, our approach will leverage existing low-cost technologies (such as cameras, Kinect systems, standards computers and devices). ASSESSTRONIC project will adapt, study the suitability for CGA and integrate state of the art methods and algorithms previously developed (completely or mostly) by the members of the consortium. The participants will use their know-how and experience in the different fields to transfer the technologies and results obtained in laboratory condition to the final product ready for the market.

CLARK: smart CLinic Assistant Robot for CGA
Partners: Servicio Andaluz de Salud, METRALABS GmbH, Universidad de Málaga, UNIVERSIDAD CARLOS III DE MADRID (UC3M)
This proposal focuses on the development of CLARK, a mobile robot able to receive the patient and his family, accompany them to the medical consulting room and, once there, help the physician to capture and manage their data during Comprehensive Geriatric Assessment (CGA) procedures. The hardware structure of CLARK will be based on the robotic platform from METRALABS. The software architecture of the platform will be enhanced incorporating a deeply tested framework for interactive robots. This framework will encode the whole CGA session using Automated Planning, being able to autonomously plan, drive, monitor and evaluate the session. It will also ease robot navigation and data acquisition. The sequence of tests used by the task-based planner will not be fixed, but will adapt to the user. Likewise, the internal parameters of these tests will be adjusted on-the-fly. CLARK will incorporate a RGB-D sensor, a touch panel, and a shotgun microphone. These sensors will allow the robot to collect additional data automatically, using non-invasive procedures, during the CGA interactive session. CLARK will work autonomously and will not impose any constraint to the user. The healthcare professional could use it to automatically collect data while he/she addresses other tasks such as personal interviewing, data evaluation or care planning. The monitoring abilities of the software architecture will allow CLARK to ask for

help to the medical expert if needed. This will significantly reduce total times for CGA sessions increasing the quality and quantity of the data collected while maintaining safety and personalized care.

The requrements towards the three experiments – defined from a user's perspective in very tight collaboration with the public body as a potential lead buyer of the technology – ABAT - were summarized in the document "Public end-user Driven Technological Innovation (PDTI) - "Robotics for the Comprehensive Geriatric Assessment (CGA) Challenge" - EVALUATION CRITERIA PHASE I" dated 26/11/2015. For the sake of comparability these specifications determine the following identifcal deliverables for all three experiments.

Deliverable	**Name**	**Submission date**
1)	Specifications after 1 month (Appendix 2)	January 2016
2)	Specifications after 6 months (Appendix 3)	24/06/2016
3)	Idea Resume (Appendix 1)	28/06/2016
4)	Specifications Phase II (Appendix 4)	28/06/2016
5)	Specifications Phase III (Appendix 5)	28/06/2016
6)	Video deliverable (2 movies)	28/06/2016
7)	Economic Viability	28/06/2016
8)	Ethics	28/06/2016
9)	Knowledge collection & EndUser Involvement (Appendix 6)	28/06/2016

The on-site testing took place on 7th July 2016 following the agenda below, while on 6th July 2016 the test site was open for the three teams to prepare and try out on their own, while ABAT was present and available all the time to cross-check again the requirements of the public body and to interface intensively with the doctors.

After submission by the three different experiments, the above devlierables were forwarded to the following three independent external experts, who provide an ideal knowledge matrix of market intelligence, expertise in robotics and competence in geriatric assessment which is required to fully appreciate all required aspects of the technology:

- Prof. Andreas Müler, head of the institute of robotics at the Johannes Kepler university Linz, Austria. Working on dynamics modelling and optimal control of robotic systems (lightweight, mobile platforms, humanoids, mechatronic systems) with application to automation, human machine interaction, biomechanics and ergonomics, UAVs.
- Prof. Philippe Bidaud [Currently Scientific Director at ONERA and Professor et University Paris 6. Committed for over 30 years in robotics research but also in technology transfert. His areas of expertise are dynamic systems and human/systems interactions.

- Dr Malcolm Fisk, Senior Research Fellow at the Centre for Computing and Social Responsibility, De Montfort University (Leicester UK) – with expertise relating to older and disabled people as users of assistive technologies in the context of health and social care services.

Deliverable no 2, "Specifications after 6 months" (Appendinx 3), builds on the public end-user driven requirements which were outlined in the Challenge Brief on Robotized Comprehensive Geriatric Assessment (CGA) which was already part of the Open Call for RTD proposals. Starting from this list of requirements, the evaluation template for the external evaluators was developed. Each individual requiremnet was weighted according to their relevance (from the users' perspective) for the final technology.

Requirements which are considered **Crucial** by the end user weigh **10 times**
Requiements which are rated **Essentia**l by the end user weigh **8 times**
Requirements which are **Important** fort he end user weigh **6 times**
If requrements are of **Of some significance**, they will weigh **4 times**

The evaluation matrix was shared with the three different teams and confirmations of their acceptance of these evaluation crieteria / matrix and the assessment based on them was collected prior to the panel meeting.

For each criterion / requirement, a score from 1 (lowest) to 5 (highest) was possible, half points were not allowed.

Excellent	5
Very good	4
good	3
Average	2
below average	1

There was no threshold for possible funding, but non of the requirements considered crucial may fall below average (minimum score 2).

The outlined approach, which provides a very tight link between the Challenge Breif, the deliverables sumitted by the three experiments and the evaluation matrix used by the independent experts, guarantees that the public end-user driven requirement form a stringent and coherent link throughout all phases of PDTI on healthcare.

The evaluation process was divided into three phases:

(i) Submission of the deliverables, particularly deliverable no 2 (Appendix 3) by the three competing experiments, analysis of these deliverables by the independent experts to prepare for the on-site testing

(ii) Three individual *evaluation reports* were written by three independent experts (*evaluators*) during the on-site testing. While Andreas Müller and Philippe Bidaud assessed all criteria / requirements, Malcolm Fisk (expert on geriatric assessment but without in-depth knowledge of opportunities and limitations of robotics technology) concentrated on those requirements more directly relating service approaches, ethics and the end-

user experience. Thus, he skipped the requirements / criteria which are directly related to the assessment of the technical aspects.

(iii) A *panel meeting* was held with these 3 independent experts. In that meeting, the scores of the three indiependent evaluation reports plus the evaluation report of ABAT (end-user perspective) were calibrated and a ranking of the experiments was established. The scores of the three independent experts were summed up and then miliplied with the "weight" (from excellent to below average) of the individual criterion to give the total scores for each individual requirement. The rating of ABAT was taken to reflect the pub-lic ender user view and to make sure that it is taken into account, but the scores were not counted.

As the panellists could not come to a conclusion during a one-day physical meeting held on 8th July, 2016, the final discussions were done via e-mail exange after the physical meeting.

3. Proposal prioritizing

After the discussion, ranking and prioritization (Annex 1), 2 experiments – ASSESSTRONIC and CLARK - were suggested for continuation to PHASE II of PDTI

Overall scores by independent experts:

ARNICA: 1.520 scores

ASSESSTRONIC: 2.178 scores

CLARK:1.557 scores

In order to make sure that the end user perspectice is adequately taken account of in the selection process, the **medical doctor from ABAT** also rated the three experiments, focusing on those criteria which are highly relevant from the end-user perspective.

		Points	ARNICA	Cecar	Assesstronic	Cesar	CLARK	Cesar
Overall system	Important	6	2	12	4	24	2	12
Human-Robot Interaction	Crucial	10	3	30	5	50	3	30
End-User Involvement	Essential	8	3	24	5	40	2	16
Economic Viability	Important	6						
Integration with other hospitals	Important	6						
Adjustments to future tests or technology	Of some significance							
				66		**114**		**58**
Weight	Essential	8						
Mobility	Of some significance	4						
Power supply	Essential	8						
Language interface	Essential	8						
GUI design Touch-screen interaction	Important	6	3	18	5	30	3	18
Motion tracking	Important	6	3	18	5	30	3	18
				36		**60**		**36**
Patient-specific view	Of some significance	4	3	12	5	20	3	12
Analysis of results	Important	6	3	18	4	24	2	12
Integration into clinical data management	Important	6						
Data protection	Important	6						
				30		**44**		**24**
Legal and ethical regulations	Important	6						
velopment and production of medical devices								
End-User Perspective	Important	6						
Analysis of ethical issues	Of some significance	4						
Costs for the Public Entity	Imporant	6						
Assessment of Market Potential	Essential	8						
Freedom to operate (FTO) analysis	Crcucial	10						
Business Case	Imporant	6						
Logistics & Planning	Imporant	6						
Repayment Period	Imporant	6						
Existing Solutions	Imporant	6						
Core advantages of Consortia's solution	Essential	8						
Patient- specific configuration	Important	6	2	12	5	30	2	12
Integration of new/additional tests	Of some significance	4	2	8	4	16	2	8
Calibration	Essential	8	3	24	5	40	4	32
				44		**86**		**52**
General criteria for all 3 tests	Crucial	10	3	30	5	50	3	30
Barthel and MMSE test		10	2	20	4	40	3	30
BARTHEL: 2 tests à 15 min		10	3	30	5	50	3	30
MMSE: 2 tests à 15 min		10	1	10	4	40	3	30
Get up and Go Test; 3 tests à 20 minutes	Crucial	10	3	30	5	50	2	20
				120		**230**		**140**
	Total			296		534		310

ASSESSTRONIC

The experimentl **ASSESSTRONIC** gets the strongest rating from all external experts as well as from the public body ABAT. In the preparation of the on-site review ASSESSTRONIC had the most intensive interface with the public body to collect the requirements, but also integrated additional exter-

nal expertise from [Prof. Dantoine research group in Limoges Hospital to substantiate the requirements from the geriatric point of view and to design a user-friendly interface. ASSESTRONIC is the only experiment coming up with a modular system which is scalable concerning functionalities and costs. The mobile solution having the additional benefit of "robotizing" hospital carriers which increases the economic impact by tackling another interesting market for the ASSESSTRONIC technology. Summary : The proposed system is designed in a modular way. Expected services have been clearly identified. The hardware and software integration of all components still remain to be finalized as well as voice interfaces. The devices shows several interesting innovations in particular with regards to the avatar based communication and human behavior analysis modules as well as clues to the analysis of locomotor activities.

CLARK

Compared to ARNICA, CLARK is slightly better rated in terms of the genral criteria, test-dependent evaluation, the configuration and the data management. It receives higher scores from the medical doctors than ARNICA (end-user perspective) and is leading in all criteria which are considered "crucial". CLARK has shortcomings with regard to end-user involvement, basic technical features of the system and economic viability. But the technology presented and the consortium have the potential to address these points efficiently and effectively. At the moment there is **limited involvement of health professional in the design of the system**. This must be improved in the second phase. It is important that in the second phase the relevance and the features of the robotic system are clearly reflected upon the requirements of CGA. This will be important to define the essential functions of robotic systems in its context of use. The **price** of the proposed device is particularly high. A version with reduced complexity (and therefore also reduced performances) of the device has to be designed in order to reduce its costs. This has to be done through a further precise functional analysis from the uses and operating context the device. As the robot manufacturer is part of the consortium, the panel trusts that it will **be possible to adjust the system** to the requirements. Concenring data evaluation and management, CLARK works with the same system as ASSESSTRONIC, which impressed the medical doctors who did not relaize the full potential of the motion tracking system for the comparability of the results over time. Motion capture technique for the implementation of locomotor abilities exploit articulated mannequin of the kinect SDK. It provides time sequence of the position of joint locations and some gait data. The calibration methd of this model is required and should be clarified.
The methods that will be used to access information on postural balance remain to be defined. Data processing also needs to be enhanced to provide a richer and more complete examination basis by exploring e.g. motor coordination or locomotion trajectory, etc.

ARNICA

The major disadvantages of ARNICA compared to CLARK is the use of outdated technology with a Comai-Robot which has inherent technical limitations that prebvent the system from being adjustable. On eo fthe limitations of the system is data collection and motion tracking. The test is carried out on the basis of classification methods based on the data from the RGB -D sensors. The extracted data are at the image level of a deformable body rather than the motion data of a kinematic model. The kinematics of the multibody system is not extracted and the analysis of the motor activity of the patient remains limited and the postural balance information will be difficult to obtain. Hence the current solution makes no use of motion capture features that are readily available on the market. In colcusion, in comparison to CLARK, the ARNICA experiment has displayed shortcomings which canot be addressed within the runtime of ECORD++.

Next steps

ASSESSTRONIC will be funded throughout PHASE II of E++ PDTI with some recommendations and a regular remote monotring via the E++ monitoring platform until the next on-site milestone review at the end of PHASE II.

CLARK will be funded for another six months at first with the following additional obligations :

- Extension fo the consortium with a partner to contribute the lacking geriatric expertise to the consortium, mainly with regard to the design of the interfaces and the integration of patient's needs in the technology development. The E++ core consortium will suggest sone potential candidates. The selection of a partner from theis list or from outside is the decision of the consortium. But the extension has to be done – without increasing the level of funding !
- monthly remote moniutorings by members of the E++ core team plus Malcolm Fisk as the external expert most familiar with the integration of patients's requriements into the technology development. The monitoring will be based on a roadmap which will be presented to the CLARK cosortium by the E++ core team. Thus, CLARK will be asked to balance the shortcomings of the system which they should have addressed during Phase I already. They will be expected to do so without additoonal funding.
- After six months CLARK will have to go again through another additional on-site milestones review whcih will decide about their further funding.

ARNICA will not be continued through Phase II.

Annex

Annex 1 : Evaluation Matrix Arnica
Annex 2 : Evaluation Matrix Assesstronic
Annex 3 : Evaluation Matrix CLARK

Evaluation Matrix: Arnica

Evaluation Criteria	Description of evaluation criteria after Phase I	Weight	Comments from reviewers
General The following is a description of the overall evaluation criteria, which will be evaluated in the sections detail below. These criteria are interconnected and need to be fulfilled in order for the proposed solution to be a success.			
Overall system	Audit based evaluation of the design/requirement capture, methodology and general specifications in the context of medical devices and equipment. The score will take into account the level of understanding of the services requested, completeness and clarity of the specification, methodology for ensuring quality control, and life cycle of the product. Special attention will be payed to the level of integration, installation/storage modalities, ICT connectivity, interfaces, ergonomics.	Important	**Score: 36 / 90** The whole system is based on the robotic platform Kompaï which is a product developed by the Robosoft company. The development of this platform will in future be pursued by a spin-off of Robosoft. The major contribution of the ARNICA project in Phase 1 is a set of software modules for physical and cognitive tests for geriatric assessment. Those modules are integrated into the Kompaï platform. This platform was initially developed for personal assistance. The current design solution should better address the specific functionalities required for CGA. It is not clear how the proposed solution can achieve the required degree of mobility necessary for patient tracking. The method used for capturing the end-users' requirements in the system development is not adequately demonstrated. The

			process that has been presented does not show how the end users have been involved in the development phase."
Human-Robot Interaction	The evaluation of Human-Robot Interaction will focus on the robot's level of autonomy. This includes an evaluation of the interaction design, meaning how the solution will identify each of the actors and interact them with them (doctor, other healthcare professionals, patient and patient's relatives) e.g. when in the interaction the robot is autonomous, where can it discharge the healthcare professional, which tasks/ interactions with the patient are reserved for the healthcare professional, where does the robot need assistance and from which person (clinician, nurse, etc.). It will also be evaluated how the robotic solution assists the healthcare professional to prepare the visit, how the healthcare professional will be able to configure / review the tests to be performed and how the solution analyzes and displays test results in the most appropriate and innovative way. It is also important that the robot gets the right information from the patients and can evaluate the importance of the information. The evaluation will also include a more general view on the workflow- how the daily workflow in the hospital takes place without the robot solution and which tasks change when the robot is introduced. It will be looked at whether the tasks allocated to the robot fit into the workflow of the hospital and add value to the healthcare professional's work. For this, it is important to show which activities (CGA's tests) can be done in parallel. For instance: Barthel test being applied by robot to patient in a specific room and, at the same time in another room, Barthel test being applied by health professional to patient's relative.	Crucial	**Score: 80 / 150** The level of autonomy of the platform is low at this point. Tests were held in a sequential way. Variability in their implementation is limited. At this stage, the tests cannot be parallelized because they use an integrated system of robotics sensors (including the Kinect) but also the touch screen interface which also serves for the motion control of the robot. In its current form the motion capture system requires calibration, and is sensitive to changes in the environment.
End-User Involvement	The R&D consortia are encouraged to apply an end-user driven design approach and intensify the regular involvement of end-users (patients, relatives and health professionals) in their development process in order to receive feedback from a clinical perspective. The evaluation will include the extent to which the R&D consortia included the end-user in the design process, how they handled and processed the input of the end-users, whether the proposed solution meets the challenge as	Essential	**Score: 56 / 120** The consortium includes a group of geriatricians who participated in several previous projects with Robosoft. The system has potential for application as personal assistant, cognitive stimulation as

	described in need description, including the extent to which the minimum requirements specified outperform, extent, the solution meets the stated requirements. Furthermore, the evaluation will focus on whether and how the solution is practically feasible from a clinical perspective, including possible ethical challenges.		well as for geriatric risk assessment.
Economic Viability	The evaluation for each of the following categories will be based on the extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution, the estimated commercial potential, the extent to which stakeholders and the public body have been involved in the calculation of the economic viabilities, in how far the solution contains a clear plan for development of a viable solution. It will also be evaluated in how far the R&D consortia have identified the key risks (technical, commercial and other) and demonstrated that they are be able to deal with these effectively.	Important	**Score: 36 / 90** The economic viability of the project is questionable. Indeed, the platform has yet to undergo significant changes from both hardware (upper part rotation) and software point of view (particularly for the low - level control of the robot).
Integration with other hospitals	This criterion is closely connected to the economic viability described above. The evaluation will include the extend to how the proposed solution can be used by other hospitals. This is divided into two parts. On the one hand, this includes the possibility to integrate the proposed solution into other systems from a technical perspective (IT-platforms, data managements systems, etc.). On the other hand, this includes the possibility for other hospitals to use the proposed solution from an ethical perspective, including regulations and legal requirements on medical devices in other hospitals or countries.	Important	**Score: 72 / 90** The robot itself has already been used in several projects aiming to explore the benefits of robotics systems in assisted living of elderly people. Ethical issues have been considered within these previous projects.
Adjustments to future tests or technology	In general, the innovative thinking of the consortia and how adaptable the proposed solution is to future usage and development of technology will be evaluated. Additional features that the consortia described as relevant and how they would integrate them will be taken into consideration.	Of some significance	**Score: 30 / 60** Adaptation of the platform to other uses is possible. Hardware evolutions are planned in particular to have a rotational mobility of the upper part of the robot. Software upgrades are also envisaged for the low-level control of the robot. The evolution of the CGA package that would be integrated into the robot poses no

			particular difficulty to the extent that it is completely controlled by the consortium.
System			
Weight	The description of the future concept (after Phase 2 and 3) will be evaluated in terms of how the robot moves (or is transported) around the hospital's settings and whether the solution is portable by average hospital personnel. This does not necessarily mean that a human has to carry the solution, but rather that it can be easily transported from one setting to another. The first prototype shown during the testing can be bigger/ heavier than the described concept, but needs to give an impression of the final concept anticipated at the end of stage III. The evaluation will also include a review on whether the described final concept matches can be achieved based on the achieved development work after Phase 1. If the solution is to be carried by humans, the weight and the manual transportation conditions must comply with the risk prevention rules. Also, solutions with wheels need to comply with security and risk prevention rules.	Essential	**Score: 48 / 120** The weight of the device does not allow to carry it manually. It can be moved by pushing it or through a remote control joystick.
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform's ability in terms of person following, face tracking, and similar advanced features. The evaluation of mobility includes the implementation (prototype as well as future concept) of patient motion tracking functions on sensors used for activity analysis. It will also be evaluated whether the solution has the autonomous mobility to support the sensors and whether possible embedded computers will be used to increase the performances e.g. relax constraints on patient position by sensor based tracking (face, sound source, posture), reduce the invasiveness of the exam, parameters extraction for the tests) or increase functionalities. The rating will be based on an audit of the methods they will implement and the capabilities of the platform to support these advanced features (verbal fluency, stress, interaction engagement, dynamic postural parameters, etc.)	Of some significance	**Score: 36 / 60** The autonomous mobility of the platform is obtained by a system of SLAM 2D (Karto software). Obstacles at height can be detected in the frontal plane of the device by a laser scan sensor. Mobility with obstacle avoidance has not been demonstrated. The methods enabling the implementation of a local mobility for the tracking of the person are not defined at this stage.
Power supply	The evaluation of power supply will be based on the battery autonomy time, battery changing/recharging time and ease, security protection. The magnetic compatibility will be another evaluation criterion. The rating will include the degree of compliance with general	Essential	**Score: 84 / 120** The device has a range of autonomy which is about 8 hours.

	rules and guidelines. Compliance and reference to regulations and guidance from the countries of the R&D consortia will be positively evaluated. Basic requirements for power supply are that the specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated.		
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated. The evaluation will include the multi-language user interface (to setup the system), the dialog manager (speech recognition and vocal synthesis) and sound analysis modules. Multi-language adaptation needs to be easy. Particularly the performance will be evaluated regarding the following three criteria: 1) Speech recognition rate (based on specified dictionary and grammar). The teams have to demonstrate this function, and must describe the applied benchmark. 2) Robustness of the voice recognition and vocal synthesis with respect to the level of surrounding noise in the environment. That is, how sensitive is the voice recognition w.r.t. to environmental conditions? It is allowed to use a tailored sound capture system as ling as it is simple to use and practically feasible. 3) Robustness of the vocal synthesis with respect to the level of surrounding noise in the environment. That is, how easy can the generated speech be understood by the patient? 4) Adaptability to others languages.	Essential	**Score: 72 / 120** Several languages for verbal communication are implemented (Catalan , Spanish and English).
GUI design Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if	Important	**Score: 54 / 90** The implemented GUI allows for different graphical dialogs to be displayed.

	the natural language interface is not suitable, e.g. when a patient is not or only hardly able to speak. Also here, the multi-language issues apply in the same form as described above. The GUI design will be graded based on an audit of the development method (50%) and of the usability of the GUI tested in the on-site testing (50%), where the user will be observed how s/he navigates and uses the system to perform the test tasks.		
Motion tracking	The evaluation includes the concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test. The evaluation will be based on the number of parameters successfully extracted, the expected precision robustness to environmental perturbations (light, relative position of the sensor with respect to the patient), calibration time, the associated performance analysis tools.	Important	**Score: 36 / 90** The patient motion capture is realized using a RGB-D camera. The algorithms do not make use of the Kinect SDK and are in this sense independent from the sensor technology. At this stage, the extraction of relevant features for the classification of the global posture, feet ground contact detection is implemented. The implemented algorithms basically serve for tracking rather than motion capturing. The latter would have provided accurate information on human motion in a multi-segmental form.
Evaluation and data management			
Patient-specific view	Mock-up of the dashboard that the patient will be using and example for how the robot displays results that show the patient's development in test results after several visits as well as access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	Of some significance	**Score: 32 / 60** The basic information data will be stored and displayed. The functionality for accessing, evaluation, and comparing different tests is to be further developed.
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be	Important	**Score: 48 / 90** Data exploitation methods are not developed enough, for

	able to modify or correct tests scores and compared results with previous sessions.		example with regard to patient history over a long period of time and examination skills which are at the core of clinical practice.
Integration into clinical data management	This evaluation includes the solution's possibility to interface with clinical data systems in the overall concept and how the collected data results can be transferred to other hospital's systems. It will be evaluated how the created data/information will be made available to different systems, for direct use and for storage and integration in the established workflows (e.g. also considering electronic patient files). It is important that the data are recorded in an open format to allow for access by non-proprietary systems, i.e. readable without the need of purchasing/using proprietary software. It will also be evaluated whether there is the possibility for open publication of the data acquired, paying attention to the required anonymization and ethical approval.	Important	**Score: 54 / 90** The clinical trial management system considered the use of secure cloud environments for the operational data. Examination results are summarized in an XML file that will be adapted to the local medical record system.
Data protection	The description of data protection concept will be evaluated and checked whether it fulfils the standards.	Important	**Score: 36 / 90** The consortium considers secure cloud services as data storage offering new dimensions to store, access and process medical data. The protection of data which will be collected by the device resulting from the Arnica project will comply with the directive 93/42/EEC Article 1.2.
Ethics			
Legal and ethical regulations	The ethical issues in the field of research and development of medical devices are regulated by legal requirements made by health agencies. Therefore, the R&D consortia should review all published ethical and legal guidelines and requirements specified by health agencies regarding development and research of medical devices. A description of how the R&D consortia fulfil the respective legal and ethical requirements will be evaluated.	Important	**Score: 42 / 90** The consortium is aware of the legal issues related to medical devices development.

Development and production of medical devices	When developing medical devices, there are several regulations to pay attention to. Thus, the evaluation will include the ability of the R&D consortia to identify the necessary compliances and analyze as well as argue for the degree of compliance of their solution with general rules and guidelines. As the end-user is located in Catalunya, it is necessary for the solution to comply with Spanish regulations by the regulatory institution "Agencia Española del Medicamento y Productos Sanitarios". The requirements to guarantee safety of the device are clearly outlined by the above mentioned regulatory agency. The evaluation will include the R&D consortia's ability to analyze the regulations and describe the degree of compliance of their solution with these regulations. In addition, it will be evaluated how the R&D consortia analyze and comply with regulations from other countries. Here, it is especially important to • Identify the countries with the highest scalability of the solution suggested • Argue and defend this selection • Identify the regulations which are valid in these countries • outline how other regulations differ from the Spanish requirements, whether the R&D consortia also comply with these regulations and if not, how they will achieve compliance with these other regulations • And outline the adjustments of the technological solution which will be necessary to meet the legal and ethical requirement of these countries (including the impact on costs and prices) • Outline market barriers in these countries geared to the technology proposed At the end of the PDTI challenge, the solution is not only supposed to be sold in Spain, but in as many other countries as possible. Thus, it will be evaluated how the R&D consortia will show a possible scalability of the product and ensure flexibility towards international regulations and EC markings that will be requested by future customers.	Weight was not defined	**Score: 36 / 90** In the next stages of the apparatus development, particular attention should be paid to the regulations relevant for eHealth devices and mobile applications to deploy the medical services and collect the medical data.

End-User Perspective	This evaluation includes the considerations and decisions that the R&D consortia have made to include the end-user's, especially elderly people, perspectives, opinions and fears.	Important	**Score: 42 / 90** A number of interactions between the consortium and the end-users took place during the first phase as well as during the previous projects that led to the design of the Kompaï robot. Nevertheless, the usability must be improved.
Analysis of ethical issues	We encourage the R&D consortia to point out ethical issues that they experience in Phase 1 or foresee for the subsequent phases and present possible solutions in their ethics report.	Of some significance	**Score: 36 / 60** Ethical issues have been addressed. Recommendations for use of robotized CGA have been gathered. It will be important to pay attention to these within the implementation.
Economic Viability			
Costs for the Public Entity	The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre-commercial product. The proposal should develop the economic viability for the future companies and institutions involved. The evaluation will include the cost of the technological equipment (platform, sensors, communication system, licenses, batteries), life expectancy of the solution, production and installation costs, operating and maintenance costs, including labour costs for manual processes, energy consumption, costs for disposal and the estimated sales price.	Important	**Score: 36 / 90** The final sale price of the unit seems a bit optimistic (reduction by a factor of 5 of the cost from the current version to the final version).
Assessment of Market Potential	The aim of this PDTI is not only to develop a solution that can be used at hospital Sant Antoni Abat, but in as many other hospitals as possible to make it a good business case. The R&D consortia's assessments of the market potential and the sales potential of their proposed solution will be evaluated.	Essential	**Score: 36 / 120** Marketing of the system is envisaged by a Robosoft spin-off. The Kompaï robot seems not to have penetrated the market as anticipated. Sustainable future development of the system seems somehow critical since the Kompaï

			robot itself would need a major overhaul.
Freedom to operate (FTO) analysis	An analysis of possible patents and other restrictions that could prevent the development, sales or production of the proposed solution will be evaluated.	Crucial	**Score: 90 / 150**. The patents referenced in the documents cover more specifically CGA software, and are not a property of the Robosoft company but of Inlog. The CGA Package will therefore be subject to an agreement between the project partners.
Business Case	The evaluation includes a description of different parameters for a business case including, but not limited to, a cost benefit analysis with estimations focusing on the Public Entity's situation, a go-to-market strategy, investment analysis, tech roadmap, dialogues with manufacturers, integrators, investors or possible business partners and a description of a possible supplier network.	Important	**Score: 45 / 90** Since the marketing of the CGA system will depend on the marketing of the Kompaï robot the business case contains some uncertainties.
Logistics & Planning	It is important that the R&D consortia have a realistic schedule for the completion of their development work for the following phases. Therefore, this evaluation includes the extent to which the R&D consortia's have shown and described their ability to plan and execute dissemination and commercial activities for the subsequent phases, including the transition phase from R&D to the market.	Important	**Score: 36 / 90** The development plan covers the mobile robot by itself but the nature of future software developments that constitutes the bulk of the added value is not sufficiently evident.
Repayment Period	The evaluation includes a calculation of the repayment period.	Important	**Score: 45 / 90** The return on investment description is plausible in general. More evidence would be needed, however.
Existing Solutions	The evaluation includes a market analysis of existing solutions that could partially or fully take over the tasks that the proposed solution is to perform.	Important	**Score: 45 / 90** No precise evaluation of existing solutions and the potential offered by the state of the art. Only searches by the key word CGA was performed on a basic public patents database.

Core advantages of Consortia's solution	The R&D consortia might have pointed out challenges of their proposed solution in the aforementioned categories. Here, their solution's core advantage in regards to economic viability and in comparison to existing solutions will be evaluated.	Essential	**Score: 60 / 120** Potential competitors' products for cognitive and physical assessment in the CGA are insufficiently evaluated by the consortium.
Configuration			
Patient- specific configuration	This includes the evaluation of a mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts and handling of patient data.	Important	**Score: 45 / 90** The system is open to allow for specific features. At the moment there is no systematic and seamless way for achieving this.
Integration of new/additional tests	The functionality to develop new questionnaire-type tests and the connected mock-ups for this functionality will be evaluated. This evaluation also includes the possibility for integration of new tests based on motion/video analysis. This type of new assessments probably needs the help of system experts; it will be evaluated how this issue is solved.	Of some significance	**Score: 30 / 60** The system seems open to implementing new capabilities that allow for further developments. At the moment this must be done in an ad hoc manner without a systematic approach.
Calibration	This evaluation will include the type of calibration that is needed for the components, e.g. the motion detection component.	Essential	**Score: 60 / 120** Prior acquisition of the 3D environment is necessary to scale the images captured by the RGB-D sensor. The capture of the movement can only be done when the camera is fixed.
On-Site testing; test-dependent evaluation			
General criteria for all 3 tests	The evaluation of all three on-site tests will be based on the information described by each consortium in the deliverables. It will include the methodology that is used to conduct the test as well as to analyze, calculate and display the test results based on codified information. Note, that the healthcare professional has to be able to modify or correct tests scores in a modification mode. The aforementioned methodology is chosen by the consortia based on the data they received from the end-users (data can be described in the "Knowledge Collection"; Appendix 6 of document "PDTI Healthcare Phase 1 Evaluation Criteria").	Crucial	**Score: 80 / 150** The system seems to work well in all relevant aspects. The weak points are the user interfaces and to some extent the motion capture system.

	Furthermore, the autonomy of the robot in the interaction and the way how it interacts with the patient and the healthcare professional will be evaluated. It is expected that the prototype shows a proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide a suitable point and field of view for the tests. It is important that the proposed solution displays information and results in a user-friendly way (dashboard style). Healthcare professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepened when needed. The results will also be evaluated from a healthcare professional's view, his usual analysis and how the analysis of the proposed solution adds value to the healthcare professional's work and his/her evaluation of the patient. It will also be evaluated how the solution and calculated results can be connected and transferred to existing data storage and electronic health record systems and how data can be exploited for diagnosis. While the on-site testing is a very crucial factor in the evaluation, it is important to notice that the overall development process will be evaluated. In case a R&D consortia is not able to deliver the expected test demonstration because of unexpected issues, we will still be able to evaluate the prototypes and the descriptions (submitted deliverables).		
BARTHEL and MMSE Test (1) BARTHEL: 2 tests à 15 min (2) MMSE: 2 tests à 15 min (3)	The proposed solution will be evaluated during the BARTHEL/ MMSE test based on its ability to interact with humans by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers with multi-language support. An alternative mode of interaction like a touch screen tool may be considered to solve speech recognition issues. **<u>Test-Scenario</u>** The BARTHEL/ MMSE test will be performed in a closed room with one healthcare professional from Sant Antoni Abat. The test will be performed according to the structure, questions and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the	Crucial	**Score: 80 / 150 (1)** **Score: 70 / 150 (2)** **Score: 60 / 150 (3)** Barthel test is implemented in its standard form by exploiting Microsoft speech recognition software. Speech recognition suffers at this stage from problems related to external noise interference. Regarding the MMS test, presence of the practitioner when the testing is carried out

	challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during the first phase. End-users will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to one patient, in this case the healthcare professional. The test is usually performed with one person, while the other person (relative or patient) is being interviewed in another room. Thus, the testing of the MMSE/BARTHEL tests will only involve one interviewee. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Each of both tests will be tested during 15 min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		is required for a number of reasons. The level of autonomy of the testing is consequently low.
Get up and Go Test 3 tests à 20 min	The Get up and Go Test will be evaluated based on the proposed solution's ability to evaluate and record the patients' performance using standard components for motion analysis to the extent possible, to maintain sufficient visibility for the video and audio recording of patients during the tests and the platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. Evaluation will also focus on how the platform addresses human locomotion, robustness to perturbations, variance, the number of extracted parameters, postural parameters, spatio-temporal gait parameters, kinematic and dynamic parameters. In terms of result analysis and how results are displayed after a Get up and Go Test, the evaluation will include the innovative thinking of the consortia and how the data that was received from the end-user was translated into a concept and included in the proposed solution. Usually, clinical information is registered only in text format. However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video/animation may be useful to compare	Crucial	**Score: 80 / 150** The test is carried out on the basis of classification methods based on the data from the RGB -D sensors. The extracted data are at the image level of a deformable body. The kinematics of the multi-body system is not extracted and the analysis of the motor activity of the patient remains limited and the postural balance information will be difficult to obtain.

	patients' performance at the beginning and at the end of a rehabilitation process. **<u>Test-Scenario</u>** The Get up and Go test will be performed in an open area (see document "PDTI Healthcare Phase 1 Evaluation Criteria" for an outline), which the R&D consortia were able to see during the Kick-Off Meeting. The test will be performed according to the structure and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during Phase 1. An End-user will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to the patient, in this case the healthcare professional. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Afterwards, a third person will perform the test while being supported by a healthcare professional during some time of the test. All in all, the same test-activity will be performed three times by three different persons (while the last person while receive help); markers are used in terms of locomotion. A T-Shirt might be used for identification issues after Phase 1. Each test will be tested during 20min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		

Evaluation Matrix: Assesstronic

Evaluation Criteria	Description of evaluation criteria after Phase I	Weight	Comments from reviewers
General The following is a description of the overall evaluation criteria, which will be evaluated in the sections detail below. These criteria are interconnected and need to be fulfilled in order for the proposed solution to be a success.			
Overall system	Audit based evaluation of the design/requirement capture, methodology and general specifications in the context of medical devices and equipment. The score will take into account the level of understanding of the services requested, completeness and clarity of the specification, methodology for ensuring quality control, and life cycle of the product. Special attention will be payed to the level of integration, installation/storage modalities, ICT connectivity, interfaces, ergonomics.	Important	**Score: 72 / 90** The proposed system is designed in a modular way. Expected services have been clearly identified. The hardware and software integration of all components still remains to be finalized, as well as speech interfaces. The devices show several interesting innovations in particular with regards to the avatar based communication and human behaviour analysis modules as well as clues to the analysis of locomotor activities.
Human-Robot Interaction	The evaluation of Human-Robot Interaction will focus on the robot's level of autonomy. This includes an evaluation of the interaction design, meaning how the solution will identify each of the actors and interact them with them (doctor, other healthcare professionals, patient and patient's relatives) e.g. when in the interaction the robot is autonomous, where can it discharge the healthcare professional, which tasks/ interactions with the patient are reserved for the healthcare professional, where does the robot need assistance and from which person (clinician, nurse, etc.). It will also be evaluated how the robotic solution assists the healthcare professional to prepare the visit, how the healthcare professional will be able to configure / review the tests to be performed and how the solution	Crucial	**Score: 110 / 150** The parallelization of the testing is possible due to the simplicity of the developed system and its costs. The level of autonomy in the realization of the tests remains to be improved in particular by exploiting a mean for planning / supervision (under uncertainties) of the elementary actions.

	analyzes and displays test results in the most appropriate and innovative way. It is also important that the robot gets the right information from the patients and can evaluate the importance of the information. The evaluation will also include a more general view on the workflow- how the daily workflow in the hospital takes place without the robot solution and which tasks change when the robot is introduced. It will be looked at whether the tasks allocated to the robot fit into the workflow of the hospital and add value to the healthcare professional's work. For this, it is important to show which activities (CGA's tests) can be done in parallel. For instance: Barthel test being applied by robot to patient in a specific room and, at the same time in another room, Barthel test being applied by health professional to patient's relative.		
End-User Involvement	The R&D consortia are encouraged to apply an end-user driven design approach and involve end-users (patients, relatives and health professionals) regularly in their development process in order to receive feedback from a clinical perspective. The evaluation will include the extent to which the R&D consortia included the end-user in the design process, how they handled and processed the input of the end-users, whether the proposed solution meets the challenge as described in need description, including the extent to which the minimum requirements specified outperform, extent, the solution meets the stated requirements. Furthermore, the evaluation will focus on whether and how the solution is practically feasible from a clinical perspective, including possible ethical challenges.	Essential	**Score: 96 / 120** The design of all the tests was made from significant interactions with geriatrics and cognitive science specialists.
Economic Viability	The evaluation for each of the following categories will be based on the extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution, the estimated commercial potential, the extent to which stakeholders and the public body have been involved in the calculation of the economic viabilities, in how far the solution contains a clear plan for development of a viable solution. It will also be evaluated in how far the R&D consortia have identified the key risks (technical, commercial and other) and demonstrated that they are be able to deal with these effectively.	Important	**Score: 72 / 90** The economic conditions of the project realization and furthermore the distribution of product that will result from the project were discussed specifically by Accelis. The company seems able to carry out its objectives.

Integration with other hospitals	This criterion is closely connected to the economic viability described above. The evaluation will include the extend to how the proposed solution can be used by other hospitals. This is divided into two parts. On the one hand, this includes the possibility to integrate the proposed solution into other systems from a technical perspective (IT-platforms, data managements systems, etc.). On the other hand, this includes the possibility for other hospitals to use the proposed solution from an ethical perspective, including regulations and legal requirements on medical devices in other hospitals or countries.	Important	**Score: 72 / 90** Several other hospitals are participating or will participate in the development of the product.
Adjustments to future tests or technology	In general, the innovative thinking of the consortia and how adaptable the proposed solution is to future usage and development of technology will be evaluated. Additional features that the consortia described as relevant and how they would integrate them will be taken into consideration.	Of some significance	**Score: 36 / 60** The proposed solution is technically completely controlled by Accellis company and its partner. Evolution opportunities will be possible and are largely considered.
System			
Weight	The description of the future concept (after Phase 2 and 3) will be evaluated in terms of how the robot moves (or is transported) around the hospital's settings and whether the solution is portable by average hospital personnel. This does not necessarily mean that a human has to carry the solution, but rather that it can be easily transported from one setting to another. The first prototype shown during the testing can be bigger/ heavier than the described concept, but needs to give an impression of the final concept anticipated at the end of stage III. The evaluation will also include a review on whether the described final concept matches can be achieved based on the achieved development work after Phase 1. If the solution is to be carried by humans, the weight and the manual transportation conditions must comply with the risk prevention rules. Also, solutions with wheels need to comply with security and risk prevention rules.	Essential	**Score: 108 / 120** The solutions proposed are particularly light and the devices are portable
Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform’s ability in terms of person following, face tracking, and similar advanced features. The evaluation of mobility includes the implementation (prototype as well as future concept) of patient motion tracking	Of some significance	**Score: 36 / 60** The potential of the robotics system used to support the mobility of the testing platform is not demonstrated at

	functions on sensors used for activity analysis. It will also be evaluated whether the solution has the autonomous mobility to support the sensors and whether possible embedded computers will be used to increase the performances e.g. relax constraints on patient position by sensor based tracking (face, sound source, posture), reduce the invasiveness of the exam, parameters extraction for the tests) or increase functionalities. The rating will be based on an audit of the methods they will implement and the capabilities of the platform to support these advanced features (verbal fluency, stress, interaction engagement, dynamic postural parameters, etc.)		this stage. The prototype and the design of the mobility system has further evolved. The proposed principle is to make mobile existing medical cart. The focus on the patient for the feature extraction remains to be implemented.
Power supply	The evaluation of power supply will be based on the battery autonomy time, battery changing/recharging time and ease, security protection. The magnetic compatibility will be another evaluation criterion. The rating will include the degree of compliance with general rules and guidelines. Compliance and reference to regulations and guidance from the countries of the R&D consortia will be positively evaluated. Basic requirements for power supply are that the specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated.	Essential	**Score: 84 / 120** The device power requirement is low. Only the device for mobility requires energy management. The target duration range is 4 hours of continuous use. Nothing is said about the system's ability to automatically recharge in case of more autonomous large displacements.
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated. The evaluation will include the multi-language user interface (to setup the system), the dialog manager (speech recognition and vocal synthesis) and sound analysis modules. Multi-language adaptation needs to be easy. Particularly the performance will be evaluated regarding the following three criteria: 1) Speech recognition rate (based on specified dictionary and grammar). The teams have to demonstrate this function, and must describe the applied benchmark.	Essential	**Score: 80 / 120** Speech interfaces exploit the synthesis and recognition software for Microsoft Windows. Alternative solutions should be considered in the perspective of the commercial product development as well as to overcome certain limitations and more generally to get a full control of this key element if the natural language dialog is

	2) Robustness of the voice recognition and vocal synthesis with respect to the level of surrounding noise in the environment. That is, how sensitive is the voice recognition w.r.t. to environmental conditions? It is allowed to use a tailored sound capture system as long as it is simple to use and practically feasible. 3) Robustness of the vocal synthesis with respect to the level of surrounding noise in the environment. That is, how easy can the generated speech be understood by the patient? 4) Adaptability to others languages.		required for the patient interaction. Using an avatar synchronized with the voice synthesis is likely to enhance the understanding of queries.
GUI design Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if the natural language interface is not suitable, e.g. when a patient is not or only hardly able to speak. Also here, the multi-language issues apply in the same form as described above. The GUI design will be graded based on an audit of the development method (50%) and of the usability of the GUI tested in the on-site testing (50%), where the user will be observed how s/he navigates and uses the system to perform the test tasks.	Important	**Score: 78 / 90** The GUI has been carefully designed with the help of specialists. Its articulation with the dialogue remains a part to consolidate for reaching a robust and efficient operation.
Motion tracking	The evaluation includes the concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test. The evaluation will be based on the number of parameters successfully extracted, the expected precision robustness to environmental perturbations (light, relative position of the sensor with respect to the patient), calibration time, the associated performance analysis tools.	Important	**Score: 60 / 90** The capture of the movement is achieved by the use of a kinematic model of the person which exploits the manikin implemented in the Kinect SDK. “An analysis of the locomotion activity is proposed. The performances of the motion capture are to be established by correlation with market based MOCAP systems which can be considered as a baseline.
Evaluation and data management			

Patient-specific view	Mock-up of the dashboard that the patient will be using and example for how the robot displays results that show the patient's development in test results after several visits as well as access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	Of some significance	**Score: 44 / 60** The system incorporates a mean to store and access both raw and processed video data.
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores and compared results with previous sessions.	Important	**Score: 66 / 90** A methodology and tools for adjusting and exploiting data have been defined and implemented. This is one of the most developed parts of the current prototype.
Integration into clinical data management	This evaluation includes the solution's possibility to interface with clinical data systems in the overall concept and how the collected data results can be transferred to other hospital's systems. It will be evaluated how the created data/information will be made available to different systems, for direct use and for storage and integration in the established workflows (e.g. also considering electronic patient files). It is important that the data are recorded in an open format to allow for access by non-proprietary systems, i.e. readable without the need of purchasing/using proprietary software. It will also be evaluated whether there is the possibility for open publication of the data acquired, paying attention to the required anonymization and ethical approval.	Important	**Score: 63 / 90** The system allows for integration of heterogeneous data, according to the nature of the information systems where the system would be deployed.
Data protection	The description of data protection concept will be evaluated and checked whether it fulfils the standards.	Important	**Score: 60 / 90** The CGA platform meets the HIPAA (US) and EC requirements including the French laws for Health Data Hosting.]
Ethics			
Legal and ethical regulations	The ethical issues in the field of research and development of medical devices are regulated by legal requirements made by health agencies. Therefore, the R&D consortia should review all published ethical and legal guidelines and requirements specified by health agencies regarding development and research of medical devices. A description of how the R&D consortia fulfil the respective legal and ethical requirements will be evaluated.	Important	**Score: 48 / 90** The consortium is aware of the particular constraints that govern the development of medical devices.

Development and production of medical devices	When developing medical devices, there are several regulations to pay attention to. Thus, the evaluation will include the ability of the R&D consortia to identify the necessary compliances and analyze as well as argue for the degree of compliance of their solution with general rules and guidelines. As the end-user is located in Catalunya, it is necessary for the solution to comply with Spanish regulations by the regulatory institution "Agencia Española del Medicamento y Productos Sanitarios". The requirements to guarantee safety of the device are clearly outlined by the above mentioned regulatory agency. The evaluation will include the R&D consortia's ability to analyze the regulations and describe the degree of compliance of their solution with these regulations. In addition, it will be evaluated how the R&D consortia analyze and comply with regulations from other countries. Here, it is especially important to Identify the countries with the highest scalability of the solution suggested Argue and defend this selection Identify the regulations which are valid in these countries outline how other regulations differ from the Spanish requirements, whether the R&D consortia also comply with these regulations and if not, how they will achieve compliance with these other regulations And outline the adjustments of the technological solution which will be necessary to meet the legal and ethical requirement of these countries (including the impact on costs and prices) Outline market barriers in these countries geared to the technology proposed At the end of the PDTI challenge, the solution is not only supposed to be sold in Spain, but in as many other countries as possible. Thus, it will be evaluated how the R&D consortia will show a possible scalability of the product and ensure flexibility towards international regulations and EC markings that will be requested by future customers.	Weight not defined	**Score: 90 / 90** As medical devices supplier, Accelis is aware of the regulatory constraints.
End-User Perspective	This evaluation includes the considerations and decisions that the R&D consortia have made to include the end-user's, especially elderly people, perspectives, opinions and fears.	Important	**Score: 84 / 90** The development has been carried out in closed relationship with end-users.

Analysis of ethical issues	We encourage the R&D consortia to point out ethical issues that they experience in Phase 1 or foresee for the subsequent phases and present possible solutions in their ethics report.	Of some significance	**Score: 36 / 60**
Economic Viability			
Costs for the Public Entity	The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre-commercial product. The proposal should develop the economic viability for the future companies and institutions involved. The evaluation will include the cost of the technological equipment (platform, sensors, communication system, licenses, batteries), life expectancy of the solution, production and installation costs, operating and maintenance costs, including labour costs for manual processes, energy consumption, costs for disposal and the estimated sales price.	Important	**Score: 81 / 90** Device prices are scaled according to different versions and are quite well related to the potential market.
Assessment of Market Potential	The aim of this PDTI is not only to develop a solution that can be used at hospital Sant Antoni Abat, but in as many other hospitals as possible to make it a good business case. The R&D consortia's assessments of the market potential and the sales potential of their proposed solution will be evaluated.	Essential	**Scores 108 / 120** The market has been thoroughly investigated, and shows a convincingly high potential. As for the potential of the system for the global market the figures seems to be slightly too optimistic.
Freedom to operate (FTO) analysis	An analysis of possible patents and other restrictions that could prevent the development, sales or production of the proposed solution will be evaluated.	Crucial	**Score: 105 / 150** Several developments are based on commercial technologies and the product development should ensure their future availability (including Kinect and speech synthesis). The issues of intellectual property components that would be integrated in the product and their protection should also be considered.

Business Case	The evaluation includes a description of different parameters for a business case including, but not limited to, a cost benefit analysis with estimations focusing on the Public Entity's situation, a go-to-market strategy, investment analysis, tech roadmap, dialogues with manufacturers, integrators, investors or possible business partners and a description of a possible supplier network.	Important	**Score: 72 / 90** A reasonable business model has been presented.
Logistics & Planning	It is important that the R&D consortia have a realistic schedule for the completion of their development work for the following phases. Therefore, this evaluation includes the extent to which the R&D consortia's have shown and described their ability to plan and execute dissemination and commercial activities for the subsequent phases, including the transition phase from R&D to the market.	Important	**Score: 54 / 90** The logistics and planning for future steps are reported and are plausible. But they are not complete.
Repayment Period	The evaluation includes a calculation of the repayment period.	Important	**Score: 45 / 90** The return on investment description is plausible in general. More evidence would be needed, however.
Existing Solutions	The evaluation includes a market analysis of existing solutions that could partially or fully take over the tasks that the proposed solution is to perform.	Important	**Score: 54 / 90** The market positioning of products is envisaged to be deepened.
Core advantages of Consortia's solution	The R&D consortia might have pointed out challenges of their proposed solution in the aforementioned categories. Here, their solution's core advantage in regards to economic viability and in comparison to existing solutions will be evaluated.	Essential	**Score: 72 / 120** The orientations in the development are good but the analysis of market positioning is to be deepened.
Configuration			
Patient- specific configuration	This includes the evaluation of a mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts and handling of patient data.	Important	**Score: 63 / 90** The interfaces for dialogue and operational monitoring of the tests is to be considered in the future phases.
Integration of new/additional tests	The functionality to develop new questionnaire-type tests and the connected mock-ups for this functionality will be evaluated. This evaluation also includes the possibility for integration of new tests based on motion/video analysis. This type of new assessments probably needs the help of system experts; it will be evaluated how this issue is solved.	Of some significance	**Score: 42 / 60** The system is in principle open to other tests. It should be also interesting to explore the implementation of means for data analysis and qualify the

			indexes associated to data from facial expressions as well as those from motion capture for a further step in the development. The joint exploitation the audio-video signal is also to be considered.
Calibration	This evaluation will include the type of calibration that is needed for the components, e.g. the motion detection component.	Essential	**Score: 84 / 120** The motion capture technique comes with the SDK for Kinect.
On-Site testing; test-dependent evaluation			
General criteria for all 3 tests	The evaluation of all three on-site tests will be based on the information described by each consortium in the deliverables. It will include the methodology that is used to conduct the test as well as to analyze, calculate and display the test results based on codified information. Note, that the healthcare professional has to be able to modify or correct tests scores in a modification mode. The aforementioned methodology is chosen by the consortia based on the data they received from the end-users (data can be described in the "Knowledge Collection"; Appendix 6 of document "PDTI Healthcare Phase 1 Evaluation Criteria"). Furthermore, the autonomy of the robot in the interaction and the way how it interacts with the patient and the healthcare professional will be evaluated. It is expected that the prototype shows a proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide a suitable point and field of view for the tests. It is important that the proposed solution displays information and results in a user-friendly way (dashboard style). Healthcare professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepened when needed. The results will also be evaluated from a healthcare professional's view, his usual analysis and how the analysis of the proposed solution adds value to the healthcare professional's work and his/her evaluation of the patient. It will also be evaluated how the solution and calculated results can be connected and	Crucial	**Score: 100 / 150** Particular importance is given to the development of data analysis which is very good. Aids for classification of data are available and need further study.

	transferred to existing data storage and electronic health record systems and how data can be exploited for diagnosis. While the on-site testing is a very crucial factor in the evaluation, it is important to notice that the overall development process will be evaluated. In case a R&D consortia is not able to deliver the expected test demonstration because of unexpected issues, we will still be able to evaluate the prototypes and the descriptions (submitted deliverables).		
BARTHEL and MMSE Test (1) BARTHEL: 2 tests à 15 min (2) MMSE: 2 tests à 15 min (3)	The proposed solution will be evaluated during the BARTHEL/ MMSE test based on its ability to interact with humans by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers with multi-language support. An alternative mode of interaction like a touch screen tool may be considered to solve speech recognition issues. **<u>Test-Scenario</u>** The BARTHEL/ MMSE test will be performed in a closed room with one healthcare professional from Sant Antoni Abat. The test will be performed according to the structure, questions and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during the first phase. End-users will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to one patient, in this case the healthcare professional. The test is usually performed with one person, while the other person (relative or patient) is being interviewed in another room. Thus, the testing of the MMSE/BARTHEL tests will only involve one interviewee. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Each of both tests will be tested during 15 min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual	Crucial	**Score: 110 / 150 (1)** **Score: 110 / 150 (2)** **Score: 110 / 150 (3)** In the demonstrations of the cognitive tests efforts were made to make the patients understand the process, which is very valuable. Work remains to be done to control voice interaction and integration with the GUI.

	testing day.		
Get up and Go Test 3 tests à 20 min	The Get up and Go Test will be evaluated based on the proposed solution's ability to evaluate and record the patients' performance using standard components for motion analysis to the extent possible, to maintain sufficient visibility for the video and audio recording of patients during the tests and the platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. Evaluation will also focus on how the platform addresses human locomotion, robustness to perturbations, variance, the number of extracted parameters, postural parameters, spatio-temporal gait parameters, kinematic and dynamic parameters. In terms of result analysis and how results are displayed after a Get up and Go Test, the evaluation will include the innovative thinking of the consortia and how the data that was received from the end-user was translated into a concept and included in the proposed solution. Usually, clinical information is registered only in text format. However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video/animation may be useful to compare patients' performance at the beginning and at the end of a rehabilitation process. **<u>Test-Scenario</u>** The Get up and Go test will be performed in an open area (see document "PDTI Healthcare Phase 1 Evaluation Criteria" for an outline), which the R&D consortia were able to see during the Kick-Off Meeting. The test will be performed according to the structure and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during Phase 1. An End-user will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce	Crucial	**Score: 120 / 150** The qualification of motion capture data by comparison with data MOCAP (with markers) is important and needs to be done. Integration in the analysis of indexes on motor coordination characteristics is to be considered. Integrating of a dynamics model is also planning to meet the requirements for parameters related to the postural balance.

	the robot to the patient, in this case the healthcare professional. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Afterwards, a third person will perform the test while being supported by a healthcare professional during some time of the test. All in all, the same test-activity will be performed three times by three different persons (while the last person while receive help); markers are used in terms of locomotion. A T-Shirt might be used for identification issues after Phase 1. Each test will be tested during 20min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		

Evaluation Matrix: Clark

Evaluation Criteria	Description of evaluation criteria after Phase I	Weight	Comments from reviewers
General The following is a description of the overall evaluation criteria, which will be evaluated in the sections detail below. These criteria are interconnected and need to be fulfilled in order for the proposed solution to be a success.			
Overall system	Audit based evaluation of the design/requirement capture, methodology and general specifications in the context of medical devices and equipment. The score will take into account the level of understanding of the services requested, completeness and clarity of the specification, methodology for ensuring quality control, and life cycle of the product. Special attention will be payed to the level of integration, installation/storage modalities, ICT connectivity, interfaces, ergonomics.	Important	**Score: 54 / 90** The functional specifications of the whole system to make a system for assessing geriatric risks are not clearly established by the consortium. However, the potential of all of the integrated technologies is quite significant. This statement holds true at the robotic system level for the planning/supervision system and at the level of the management and access to data on the status in real-time of medical exams.
Human-Robot Interaction	The evaluation of Human-Robot Interaction will focus on the robot's level of autonomy. This includes an evaluation of the interaction design, meaning how the solution will identify each of the actors and interact them with them (doctor, other healthcare professionals, patient and patient's relatives) e.g. when in the interaction the robot is autonomous, where can it discharge the healthcare professional, which tasks/ interactions with the patient are reserved for the healthcare professional, where does the robot need assistance and from which person (clinician, nurse, etc.). It will also be evaluated how the robotic solution assists the healthcare professional to prepare the visit, how the healthcare professional will be able to configure / review the tests to be performed and how the solution analyzes and displays test results in the most appropriate and innovative way. It is also important that the robot gets the right	Crucial	**Score: 80 / 150** A high level of autonomy in the examination will potentially be reached thanks to the supervision software architecture implemented that includes an automated planning framework able to plan and control the execution of the planned actions from a deliberative perspective. This framework has been developed previously by the UC3M team and it is based on the standard PDDL language.

	information from the patients and can evaluate the importance of the information. The evaluation will also include a more general view on the workflow- how the daily workflow in the hospital takes place without the robot solution and which tasks change when the robot is introduced. It will be looked at whether the tasks allocated to the robot fit into the workflow of the hospital and add value to the healthcare professional's work. For this, it is important to show which activities (CGA's tests) can be done in parallel. For instance: Barthel test being applied by robot to patient in a specific room and, at the same time in another room, Barthel test being applied by health professional to patient's relative.		
End-User Involvement	The R&D consortia are encouraged to apply an end-user driven design approach and involve end-users (patients, relatives and health professionals) regularly in their development process in order to receive feedback from a clinical perspective. The evaluation will include the extent to which the R&D consortia included the end-user in the design process, how they handled and processed the input of the end-users, whether the proposed solution meets the challenge as described in need description, including the extent to which the minimum requirements specified outperform, extent, the solution meets the stated requirements. Furthermore, the evaluation will focus on whether and how the solution is practically feasible from a clinical perspective, including possible ethical challenges.	Essential	**Score: 48 / 120** At the moment there is limited involvement of health professionals in the design of the system. This must be improved in the second phase. It is important that in the second phase the relevance and the features of the robotic system are clearly reflected upon the requirements of CGA. This will be important to define the essential functions of robotic systems in its context of use.
Economic Viability	The evaluation for each of the following categories will be based on the extent to which the solution is plausible regarding the economic potential relative to the effects of the offered solution, the estimated commercial potential, the extent to which stakeholders and the public body have been involved in the calculation of the economic viabilities, in how far the solution contains a clear plan for development of a viable solution. It will also be evaluated in how far the R&D consortia have identified the key risks (technical, commercial and other) and demonstrated that they are be able to deal with these effectively.	Important	**Score: 42 / 90** The price of the proposed device is particularly high. A version with reduced complexity (and therefore also reduced performances) of the device has to be designed in order to reduce its costs. This has to be done through a further precise functional analysis from the uses and operating context of the device.

Integration with other hospitals	This criterion is closely connected to the economic viability described above. The evaluation will include the extend to how the proposed solution can be used by other hospitals. This is divided into two parts. On the one hand, this includes the possibility to integrate the proposed solution into other systems from a technical perspective (IT-platforms, data managements systems, etc.). On the other hand, this includes the possibility for other hospitals to use the proposed solution from an ethical perspective, including regulations and legal requirements on medical devices in other hospitals or countries.	Important	**Score: 54 / 90** The use of the robot as a medical device has so far not been considered. Meanwhile, the robot platform was designed previously for the purposes of the autonomous living of the elderly people. As so, it can possibly evolve towards the use of a CGA interactive platform.
Adjustments to future tests or technology	In general, the innovative thinking of the consortia and how adaptable the proposed solution is to future usage and development of technology will be evaluated. Additional features that the consortia described as relevant and how they would integrate them will be taken into consideration.	Of some significance	**Score: 42 / 60** The consortium is the developer of the software and the hardware. The consortium includes the developer of the robotic platform. Hence it shall be possible to adapt and extend features needed for other tests. Moreover the software framework supporting the integration will facilitate the implementation.
System			
Weight	The description of the future concept (after Phase 2 and 3) will be evaluated in terms of how the robot moves (or is transported) around the hospital's settings and whether the solution is portable by average hospital personnel. This does not necessarily mean that a human has to carry the solution, but rather that it can be easily transported from one setting to another. The first prototype shown during the testing can be bigger/ heavier than the described concept, but needs to give an impression of the final concept anticipated at the end of stage III. The evaluation will also include a review on whether the described final concept matches can be achieved based on the achieved development work after Phase 1. If the solution is to be carried by humans, the weight and the manual transportation conditions must comply with the risk prevention rules. Also, solutions with wheels need to comply with security and risk prevention rules.	Essential	**Score: 48 / 120** The weight of the device in its current version is much too high. Moreover, no possibility of manual handling is provided which makes its implementation complex and especially inappropriate in the medical context.

Mobility	Mobility is closely connected with the afore described weight criteria of the system and addresses the platform's ability in terms of person following, face tracking, and similar advanced features. The evaluation of mobility includes the implementation (prototype as well as future concept) of patient motion tracking functions on sensors used for activity analysis. It will also be evaluated whether the solution has the autonomous mobility to support the sensors and whether possible embedded computers will be used to increase the performances e.g. relax constraints on patient position by sensor based tracking (face, sound source, posture), reduce the invasiveness of the exam, parameters extraction for the tests) or increase functionalities. The rating will be based on an audit of the methods they will implement and the capabilities of the platform to support these advanced features (verbal fluency, stress, interaction engagement, dynamic postural parameters, etc.)	Of some significance	**Score: 36 / 60** The mobility of the system relies on the SCITOS mobile robotics platform developed by Metralabs. The latter is equipped with a 2D SLAM which exploits a 2D laser scan sensor and trajectory planning system based on a global Probabilistic Roadmap Planner. In this sense the system is mature and up to date.
Power supply	The evaluation of power supply will be based on the battery autonomy time, battery changing/recharging time and ease, security protection. The magnetic compatibility will be another evaluation criterion. The rating will include the degree of compliance with general rules and guidelines. Compliance and reference to regulations and guidance from the countries of the R&D consortia will be positively evaluated. Basic requirements for power supply are that the specified system must be able to be operated both in battery mode for at least 8 hours, as well as in plugged-in mode, the first prototype can be powered by cable. For the final systems, inability to operate in battery mode may be a critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated.	Essential	**Scores 84 / 120** The platform has an autonomous uptime of 8 hours and an automatic recharge can be implemented if the system is equipped with a localization system. All detection functionalities and tracking of people to conceive. The consortium has performed relevant work in the past, but it has not produced a full solution, yet.
Language interface	Technical concept and prototype of a robust natural language interface which allows for multi-language support. Prototypes in stage I and II can use any European language (preferably English, Spanish, or Catalan), but the capability for multi-language support has to be demonstrated. The evaluation will include the multi-language user interface (to setup the system), the dialog manager (speech recognition and vocal synthesis) and sound analysis modules. Multi-	Essential	**Score: 56 / 120** Automatic Speech Recognition (ASR) module (Microsoft Speech Platform SDK) and the Text-to-Speech (TTS) module (Festival or the Microsoft Speech Synthesis API). In Barthel and MMSE, language change is

	language adaptation needs to be easy. Particularly the performance will be evaluated regarding the following three criteria: 1) Speech recognition rate (based on specified dictionary and grammar). The teams have to demonstrate this function, and must describe the applied benchmark. 2) Robustness of the voice recognition and vocal synthesis with respect to the level of surrounding noise in the environment. That is, how sensitive is the voice recognition w.r.t. to environmental conditions? It is allowed to use a tailored sound capture system as long as it is simple to use and practically feasible. 3) Robustness of the vocal synthesis with respect to the level of surrounding noise in the environment. That is, how easy can the generated speech be understood by the patient? 4) Adaptability to others languages.		automatically done for each patient following the information about language preferences stored in the database.
GUI design Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configuration, and evaluation/data management. Other, yet easy to use and robust interaction modalities besides spoken language are also possible for the tests. They need to be able to be used if the natural language interface is not suitable, e.g. when a patient is not or only hardly able to speak. Also here, the multi-language issues apply in the same form as described above. The GUI design will be graded based on an audit of the development method (50%) and of the usability of the GUI tested in the on-site testing (50%), where the user will be observed how s/he navigates and uses the system to perform the test tasks.	Important	**Score: 42 / 90** All tests can be accomplished in different languages (currently Spanish and English languages are available for the tests). At the moment the textual interaction is rudimentary, which must be improved in the next phase.
Motion tracking	The evaluation includes the concept and exact specification of motion tracking system with planned analyses in context of the Get up and Go test. The evaluation will be based on the number of parameters successfully extracted, the expected precision robustness to environmental perturbations (light, relative position of the sensor with respect to the patient), calibration time, the associated performance analysis tools.	Important	**Score: 60 / 90** This feature was implemented using the kinematic model which is in the SDK for Kinect 2. The accuracy of the measurement made is not established at this stage. It will be necessary to qualify the accuracy parameters obtained. This can be done by means of measurement, for instance with a

			motion capture system with markers regarding kinematic variables, a podometer for the gait parameters and - if necessary - a force platform for the postural balance parameters.
Evaluation and data management			
Patient-specific view	Mock-up of the dashboard that the patient will be using and example for how the robot displays results that show the patient's development in test results after several visits as well as access to raw data, such as answers given in a specific test or videos and other visualization of the motion analysis.	Of some significance	**Score: 28 / 60** The system implements a specific interface that allows the physician to access to any session. The physician is also able to online monitor a live session, using a different interface and to compare the videos associated to two previously performed tests. A specific database structure has been designed for this purpose by experts from the UC3M and UMA teams. This framework is connected to the robot through the planning module, HL7 CDA files respecting medical standards and protocols are used for transferring the data. The patient 'dashboard' is only developed to a rudimentary extent.
Analysis of results	Concept to interpret and codify patients/ relatives answers of selected tests and to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores and compared results with previous sessions.	Important	**Score: 42 / 90** The data analysis tools are at very early stage. They should be developed further in the following phases.
Integration into clinical data management	This evaluation includes the solution's possibility to interface with clinical data systems in the overall concept and how the collected data results can be transferred to other hospital's systems. It will be evaluated how the created data/information will be made available to different systems, for direct	Important	**Score: 42 / 90** The interface with the Clinical Data System (CDS) of the Hospital Universitario Virgen del

	use and for storage and integration in the established workflows (e.g. also considering electronic patient files). It is important that the data are recorded in an open format to allow for access by non-proprietary systems, i.e. readable without the need of purchasing/using proprietary software. It will also be evaluated whether there is the possibility for open publication of the data acquired, paying attention to the required anonymization and ethical approval.		Rocio (Seville, SAS) has been defined.
Data protection	The description of data protection concept will be evaluated and checked whether it fulfils the standards.	Important	**Score: 60 / 90** This issue will have to be considered at the next stage.
Ethics			
Legal and ethical regulations	The ethical issues in the field of research and development of medical devices are regulated by legal requirements made by health agencies. Therefore, the R&D consortia should review all published ethical and legal guidelines and requirements specified by health agencies regarding development and research of medical devices. A description of how the R&D consortia fulfil the respective legal and ethical requirements will be evaluated.	Important	**Score: 48 / 90** They were investigated by the consortium. The consortium is generally aware of the legal issues related to medical devices development. Specific necessary steps are not discussed.
Development and production of medical devices	When developing medical devices, there are several regulations to pay attention to. Thus, the evaluation will include the ability of the R&D consortia to identify the necessary compliances and analyze as well as argue for the degree of compliance of their solution with general rules and guidelines. As the end-user is located in Catalunya, it is necessary for the solution to comply with Spanish regulations by the regulatory institution “Agencia Española del Medicamento y Productos Sanitarios“. The requirements to guarantee safety of the device are clearly outlined by the above mentioned regulatory agency. The evaluation will include the R&D consortia’s ability to analyze the regulations and describe the degree of compliance of their solution with these regulations. In addition, it will be evaluated how the R&D consortia analyze and comply with regulations	Weight not defined	**Score: 36 / 90** At this stage, the regulation rules for the development of a product which would be a medical device have not been considered.

	from other countries. Here, it is especially important to • Identify the countries with the highest scalability of the solution suggested • Argue and defend this selection • Identify the regulations which are valid in these countries • outline how other regulations differ from the Spanish requirements, whether the R&D consortia also comply with these regulations and if not, how they will achieve compliance with these other regulations • And outline the adjustments of the technological solution which will be necessary to meet the legal and ethical requirement of these countries (including the impact on costs and prices) • Outline market barriers in these countries geared to the technology proposed At the end of the PDTI challenge, the solution is not only supposed to be sold in Spain, but in as many other countries as possible. Thus, it will be evaluated how the R&D consortia will show a possible scalability of the product and ensure flexibility towards international regulations and EC markings that will be requested by future customers.		
End-User Perspective	This evaluation includes the considerations and decisions that the R&D consortia have made to include the end-user's, especially elderly people, perspectives, opinions and fears.	Important	**Score: 36 / 90** There was limited consideration of the end-user perspective. This will have to be improved.
Analysis of ethical issues	We encourage the R&D consortia to point out ethical issues that they experience in Phase 1 or foresee for the subsequent phases and present possible solutions in their ethics report.	Of some significance	**Score: 28 / 90**
Economic Viability			
Costs for the Public Entity	The aim of a PDTI is to improve the functionalities and /or to reduce the cost of a public service, financing research and development of a pre-commercial product. The proposal should develop the economic viability for the future companies and institutions involved. The evaluation will include the cost of the technological equipment (platform, sensors, communication system, licenses, batteries), life expectancy of the solution, production and installation costs, operating and	Important	**Score: 45 / 90** The cost evaluation which has been made lead to a non-economic viability of the deployment of the actual solution.

	maintenance costs, including labour costs for manual processes, energy consumption, costs for disposal and the estimated sales price.		
Assessment of Market Potential	The aim of this PDTI is not only to develop a solution that can be used at hospital Sant Antoni Abat, but in as many other hospitals as possible to make it a good business case. The R&D consortia's assessments of the market potential and the sales potential of their proposed solution will be evaluated.	Essential	**Score: 48 / 120** The multi-country business which considers a product with a reduced cost has to be developed.
Freedom to operate (FTO) analysis	An analysis of possible patents and other restrictions that could prevent the development, sales or production of the proposed solution will be evaluated.	Crucial	**Score: 105 / 150** The robotics technology will rely on Metralabs IP. The CGA software is exploiting the Microsoft Speech Platform SDK and the Microsoft Kinect 2 SDK. The use of these software in the deployment of the CGA applications and future business operations will have to be considered.
Business Case	The evaluation includes a description of different parameters for a business case including, but not limited to, a cost benefit analysis with estimations focusing on the Public Entity's situation, a go-to-market strategy, investment analysis, tech roadmap, dialogues with manufacturers, integrators, investors or possible business partners and a description of a possible supplier network.	Important	**Score: 36 / 90** The business case needs further clarification.
Logistics & Planning	It is important that the R&D consortia have a realistic schedule for the completion of their development work for the following phases. Therefore, this evaluation includes the extent to which the R&D consortia's have shown and described their ability to plan and execute dissemination and commercial activities for the subsequent phases, including the transition phase from R&D to the market.	Important	**Score: 27 / 90** The logistics and planning for future steps are reported and are plausible. But they are not complete.
Repayment Period	The evaluation includes a calculation of the repayment period.	Important	**Score: 36 / 90** The return on investment description is plausible in general. More evidence would be needed, however.
Existing Solutions	The evaluation includes a market analysis of existing solutions that could partially or fully take over the tasks that the proposed solution is to perform.	Important	**Score: 36 / 90** No precise evaluation of existing solutions and the potential offered by the state of the art.

Core advantages of Consortia's solution	The R&D consortia might have pointed out challenges of their proposed solution in the aforementioned categories. Here, their solution's core advantage in regards to economic viability and in comparison to existing solutions will be evaluated.	Essential	**Score: 48 / 120** Potential competitors' products for cognitive and physical assessment in the CGA are insufficiently evaluated by the consortium.
Configuration			
Patient- specific configuration	This includes the evaluation of a mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts and handling of patient data.	Important	**Score: 36 / 90** A rudimentary version is implemented
Integration of new/additional tests	The functionality to develop new questionnaire-type tests and the connected mock-ups for this functionality will be evaluated. This evaluation also includes the possibility for integration of new tests based on motion/video analysis. This type of new assessments probably needs the help of system experts; it will be evaluated how this issue is solved.	Of some significance	**Score: 24 / 60** The integration of new functionalities can be considered without any particular limitation.
Calibration	This evaluation will include the type of calibration that is needed for the components, e.g. the motion detection component.	Essential	**Score: 84 / 120** The motion capture of the patient exploits the kinematic data extracted from the manikin implementation in the Kinect 2 SDK. This manikin has to be scaled with the patient anthropomorphic data. The way this calibration is done has to be clarified.
On-Site testing; test-dependent evaluation			
General criteria for all 3 tests	The evaluation of all three on-site tests will be based on the information described by each consortium in the deliverables. It will include the methodology that is used to conduct the test as well as to analyze, calculate and display the test results based on codified information. Note, that the healthcare professional has to be able to modify or correct tests scores in a modification mode. The aforementioned methodology is chosen by the consortia based on the data they received from the end-users (data can be described in the "Knowledge Collection"; Appendix 6 of document "PDTI Healthcare Phase 1 Evaluation Criteria"). Furthermore, the autonomy of the robot in the interaction and the way how it interacts with the patient and the healthcare professional will be evaluated.	Crucial	**Score: 80 / 150** The level of autonomy test is still relatively low, however, the operation of the monitoring system should enable it to evolve. A system of registration and operating data has been developed as a sharable database by different devices. The processing paradigms of the data for a deeper cognitive and physical assessment can

	It is expected that the prototype shows a proof of concept of the ability to record patients while they are performing the selected tests. Video recording is especially important for gait or balance tests, and audio and video for mental tests. The system should provide a suitable point and field of view for the tests. It is important that the proposed solution displays information and results in a user-friendly way (dashboard style). Healthcare professionals usually do not need to see all detailed scores of tests; they would have a global vision of total scores and deepened when needed. The results will also be evaluated from a healthcare professional's view, his usual analysis and how the analysis of the proposed solution adds value to the healthcare professional's work and his/her evaluation of the patient. It will also be evaluated how the solution and calculated results can be connected and transferred to existing data storage and electronic health record systems and how data can be exploited for diagnosis. While the on-site testing is a very crucial factor in the evaluation, it is important to notice that the overall development process will be evaluated. In case a R&D consortia is not able to deliver the expected test demonstration because of unexpected issues, we will still be able to evaluate the prototypes and the descriptions (submitted deliverables).		and must still evolve to increase the analysis during clinical examinations.
BARTHEL and MMSE Test (1) BARTHEL: 2 tests à 15 min (2) MMSE: 2 tests à 15 min (3)	The proposed solution will be evaluated during the BARTHEL/ MMSE test based on its ability to interact with humans by speaking and natural language processing (even in case of slightly slurred speech) to limited extend, interpreting a set of standard pre-defined answers with multi-language support. An alternative mode of interaction like a touch screen tool may be considered to solve speech recognition issues. **<u>Test-Scenario</u>** The BARTHEL/ MMSE test will be performed in a closed room with one healthcare professional from Sant Antoni Abat. The test will be performed according to the structure, questions and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during the	Crucial	**Score: 70 / 150(1)** **Score: 70 / 150 (2)** **Score: 80 / 150 (3)** The implementation of cognitive tests is satisfactory. It must however increase its performance in terms of speed and efficiency. Tests must indeed be implemented over limited durations at least for the part that requires the presence of medical staff. Seeking autonomy in the implementation of the tests must meet the criteria of robustness. The extraction of additional data from the audio and

	first phase. End-users will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to one patient, in this case the healthcare professional. The test is usually performed with one person, while the other person (relative or patient) is being interviewed in another room. Thus, the testing of the MMSE/BARTHEL tests will only involve one interviewee. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Each of both tests will be tested during 15 min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		video signals should also be considered to enrich the testing.
Get up and Go Test 3 tests à 20 min	The Get up and Go Test will be evaluated based on the proposed solution's ability to evaluate and record the patients' performance using standard components for motion analysis to the extent possible, to maintain sufficient visibility for the video and audio recording of patients during the tests and the platform's potential in terms of person following, face tracking, and other advanced features that will be implemented in the subsequent phases. Evaluation will also focus on how the platform addresses human locomotion, robustness to perturbations, variance, the number of extracted parameters, postural parameters, spatio-temporal gait parameters, kinematic and dynamic parameters. In terms of result analysis and how results are displayed after a Get up and Go Test, the evaluation will include the innovative thinking of the consortia and how the data that was received from the end-user was translated into a concept and included in the proposed solution. Usually, clinical information is registered only in text format. However, availability of clinical information in other formats may be very valuable. In this sense, Health Professionals would like to see patients' performance when walking; for instance, a video/animation may be useful to compare patients' performance at the beginning and at the end of a rehabilitation process.	Crucial	**Score: 120 / 150** The methods of motion capture for the implementation of tests on locomotor activity exploit the manikin of the kinect2 SDK. It provides access to kinematic data. The calibration method of this model is required and should be clarified. The methods that will be used to access information on postural balance remain to be defined. Data processing also needs to be enhanced to provide a richer and more complete examination base by exploring e.g. motor coordination or locomotion trajectory, etc.

	<u>Test-Scenario</u> The Get up and Go test will be performed in an open area (see document "PDTI Healthcare Phase 1 Evaluation Criteria" for an outline), which the R&D consortia were able to see during the Kick-Off Meeting. The test will be performed according to the structure and features of the original test (or the solution that the R&D consortia propose as appropriate after interfacing with end-users and stakeholders in Phase 1) used by Sant Antoni Abat. Information were included in the challenge call, Sant Antoni Abat has distributed additional information during and after the Kick-Off Meeting and will answer questions from the R&D consortia during Phase 1. An End-user will not be included in the test after Phase 1. A member of the R&D consortium will take the role of the healthcare professional and introduce the robot to the patient, in this case the healthcare professional. Afterwards, the healthcare professional will get the chance to go through the test while doing the test with another available person (other healthcare professional, reviewer, member of the core consortium of Echord++). Afterwards, a third person will perform the test while being supported by a healthcare professional during some time of the test. All in all, the same test-activity will be performed three times by three different persons (while the last person while receive help); markers are used in terms of locomotion. A T-Shirt might be used for identification issues after Phase 1. Each test will be tested during 20min, the R&D consortia will have adequate time to set-up their proposed solution before the testing and will be given a try-out day before the actual testing day.		