Deliverable D5.3

Open Call and Selection of the RTD consortia

____

Franziska Kirstein (BOR)
Ana Puig Pey (UPC)
Marie-Luise Neitz (TUM)

Version 1

Delivery date: 30.09.2015

CONTENTS

Glossary of Terms

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

1 Overview of the process

ECHORD++ focuses on research and development (R&D) with relevance to industrial applications and high market potential. The **Public end-user Driven Technological Innovation (PDTI)** scheme offers R&D consortia the possibility to develop robotics technology according to the needs of public bodies. Public bodies often have specific requirements for the products they use. E++ offers to both, the technology developers and the public authorities, the chance to closely interact and interface with each other during the conception and development of the solution. This is to make sure that the product meets the requirements of the target group, technically and price-wise.

Two application areas have been identified: **Healthcare** and **Urban Robotics**. Various public bodies have submitted different challenges (technology needs) and out of this pool a panel of experts has selected one challenge for each scenario: **Robotics for Comprehensive Geriatric Assessment (CGA)** in the Healthcare scenario and **Robots for the Inspection and Clearance of the Sewer Network in Cities** in the Urban Robotics Scenario.

E++'s PDTI is inspired by Pre-Commercial Public Procurement instruments, but with a different focus. While PCP is centered around the procurement and entails a procurement obligation for the public body, PDTI is a grant inspired by the experiments in ECHORD and focused on the interaction between public bodies and robotics RTD consortia which are closely monitored in phases II and III to make sure that the requirements of the public bodies are adequately addressed in the technology development process. Furthermore, in contrast to usual PCP projects, PDTI includes a much more intensive iteration process with the public bodies in preparation of the selection of the challenge (Phase 0). This deliverable describes the start of the Activities for research and technical development of pre-commercial products and the development of its Phase I (Figure 1).

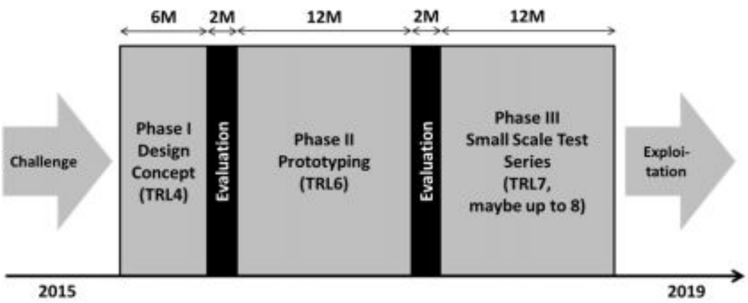


Figure 1: PDTI Phases

1.1 PDTI Urban

The specific timeline for **PDTI Urban** is exposed in Figure 2. The Open Market Consultation – INFODAY was celebrated on November 20th, 2014. The Call for RTD proposals was upload to the website of E++ from January 15th to February 28th. On May 19th, the expert panel for the evaluation and selection of the RTD proposals took place in Barcelona, jointly with the Public Entity and the UPC partner as coordinator and technology support of all the process.

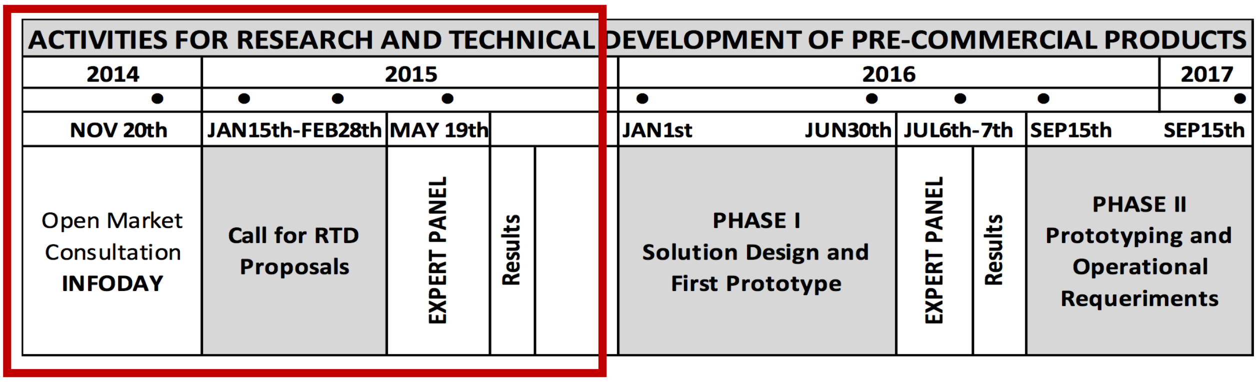


Figure 2: PDTI Urban Timeline

1.2 PDTI Healthcare

A timeline of the process for **PDTI Healthcare** can be seen in Figure 3. After familiarizing public bodies and technologicy development organizations about the Open Call at dissemination events like the Open Market Consultation day, the *Call for E++ PDTI R&D Proposals in Healthcare Robotics* opened on 15th of January 2015. It ended on 14th of March 2015. The expert panel met on April 16, 2015 in Munich and decided that none of the submitted proposals was strong enough to receive funding. Thus, a second call was opened on May, 4th until June, 23rd and more focused dissemination was performed to receiv more strong and interdisciplinary proposals. The second panel meeting took place on July 14th where three RTD consortia were selected for Phase II.

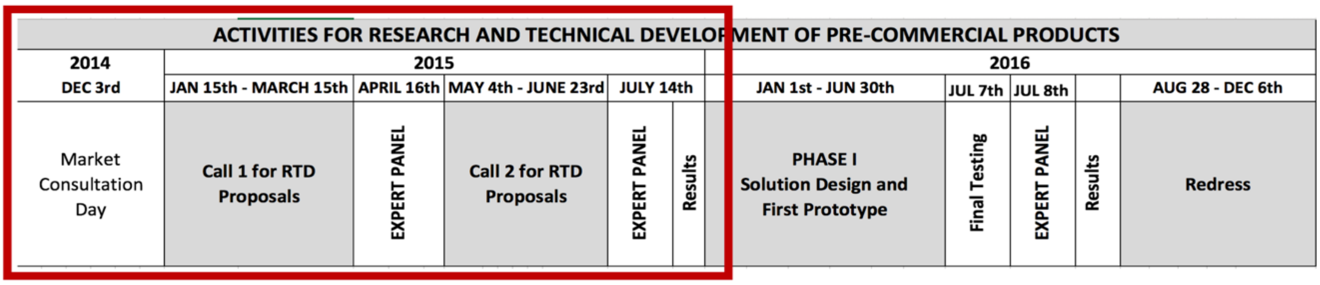


Figure 3: PDTI Healthcare Timeline

2 Open Market Consultation Day

Taking advantage of the Smart City World Congress and Expo, celebrated in Barcelona on November 17th to 19th, 2015, E++ participated with a stand and a PDTI presentation and organized an **Open Market Consultation for PDTI Urban** on November 20th.

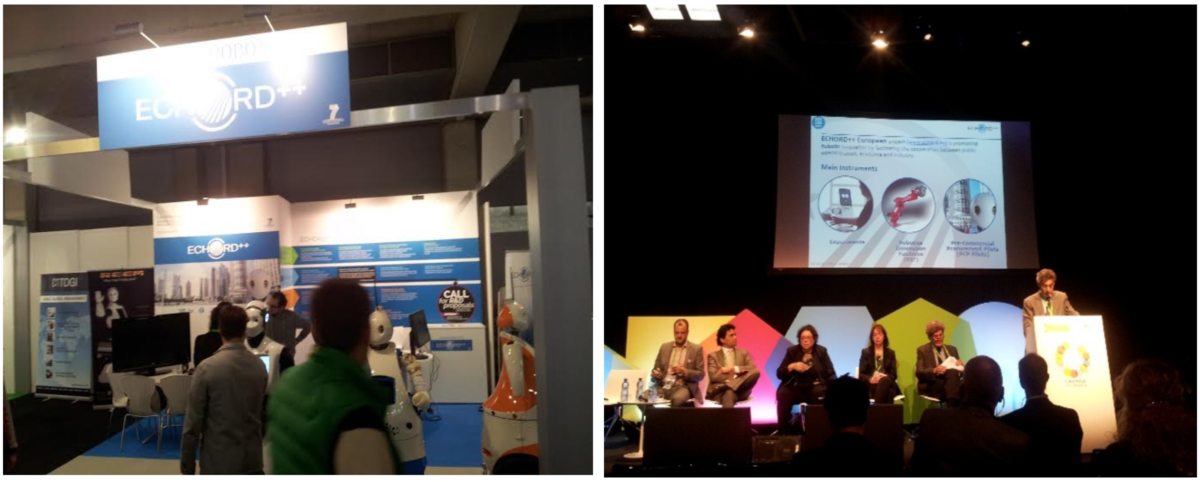


Figure 4: E++ booth at Smart City World Congress and opening of Open Market Consultation Infoday

The presentations of E++ Project and the PDTI instrument have been done by the public entity and the core partners of E++ from UPC and TUM. The main one was based in the Challenge Brief document where the requirements and functionalities of the new robotic technology were developed. The evaluation criteria for the selection and the advantages for SMEs have been also described. And we finish with a presentation of the opportunities that E ++ and its instruments would give to SMEs. A number of 16 companies represented by 24 participants attended the Open Market Consultation. The last part of the Infoday was a visit to the sewer infrastructure managed by the public entity offering to the participants a realistic environment for their futures proposals

Figure 5: Presentation of Sewer visit during Open Market Consultation Infoday: E++ booth at Smart City World Congress and opening of Open Market Consultation Infoday

The **Market Consultation for PDTI Healthcare** took place on 3rd December 2014 in Munich. At this event, hosted at TUM's university hospital "Klinikum rechts der Isar", both researchers and the public bodies, AQuAS – Agència de Qualitat i Avaluació Sanitàries de Catalunya, a public entity of the Catalan Department of Health, Fundació Privada Sant Antoni Abat, a non-profit private foundation managing and developing innovation and research in healthcare, gained insight into the process, timeline and funding of PDTI.

The following presentations were given at the event:

+ ECHORD++ project presentation
+ Funding and administration of PDTI
+ The selection of the challenge and the public bodies
+ The PDTI challenge in urban robotics
+ Improving the Comprehensive Geriatric Assessment (CGA) with robotics
+ State of the art in medical robotics
+ Robotics Innovation Facilities (RIFs)

3 Call Documents

The call documents for **PDTI Urban** were developed by a team formed by four UPC robotics researchers and four people of the city council who were directly involved in the performance of the public service. During eight rounds the requirements of the new technology were discussed and possible and optimal public service functions were presented. The discussion finalized in a document, the Challenge Brief (Annex 1), where the functions were described with the inputs of the robotic team, looking to facilitate the innovation on one hand and answering the real needs of the public service on the other hand that would give rise to a pre-commercial product.

The partners developing the Challenge Brief for **PDTI Healthcare** were TUM and BOR from the Core Consortium, ABAT as public body and AQUAS as representative for the public body. The principal document elaborated for the Call for RTD proposals was the Challenge Brief (Annex 2). The Challenge Brief is a document with a clear explanation of the public service and with enough information about the functions to be developed by the new technology. It is important to address that this Challenge Brief is not a common procurement document, but an innovative one, and has to be written taking in mind its functionalities instead of the specific requirements that could narrow the innovation field. The translation of the needs into functional requirements requires a team of people with highly developed competences. Particularly in PDTI Healthcare this team needs to be highly interdisciplinary. The Challenge Brief for PDTI Healthcare is very detailed in its technological requirements and focuses very much on the user requirements and technological development during each phase. Furthermore, a description of the CGA problem was described including information on what CGA is, the process and the benefits and the tests which need to be performed. In addition, an assessment of the benefits that robotic solutions could add to the procedure of CGA was included in the Challenge Brief. Based on this, the main requirements for the final solutions were decided and are concerning:

+ General requirements (Overall system, weight, power supply, language interface, touch-screen interaction, motion tracking)
+ Configuration (Patient-specific configuration, integration of new tests, their integration based on motion analysis, calibration)
+ Actual testing (Dialogue, Tests based on motion analysis, audio/video recording)
+ Evaluation and data management (Patient-specific view, analysis of results, Integration into clinical data management, Data protection)

In the revised version of the Challenge Brief for Call 2 (Annex 3), the description of CGA was kept, but the content of the document was revised and improved. The Functional requirements and technical specification section was even more thoroughly described and the expected outcome was divided into mandatory and desirable properties and non-technical requirements. The categories were kept the same, but a more specific explanation of the outcomes was given. Furthermore, the telecommunication aspect was included in the Challenge Brief and it was explicitly stated that a consortium partner of the RTD consortia needs to have expertise within this field.

For both PDTI Urban and Healthcare, the same set of application documents was used: The Guide for Applicants (Annex 4) and a Proposal Template (Annex 5).

4 Call Statistics

The PDTI Urban Call received 6 RTD proposals. The RTD consortia were composed by 20 universities and companies, mostly SMEs, from five different European Countries and they proposed different technologies to give an answer to the urban challenge proposed. A comparative table was developed by the public entity that exposed the different approaches of the proposals (Annex 6). It remarked not only the robotic technology to develop but also the operative performance to answer the real need of the public service and how would it arrive to a commercial product.

For the first PDTI Call in Healthcare a total of 11 proposals were received. The remote evaluation showed weak results and after carefully analyzing all submissions during the panel meeting. The panel decided that none of the proposals met the thresholds. Detailed information about the proposals, their evaluation and the ranking can be seen in the panel report for Call 1 (Annex 8). Thus, the call was re-launched. In the second call, 15 eligible proposals from 11 countries were submitted. The panel decided that 7 proposal were below and 8 above the thresholds. The composition of consortia, country distribution and ranking of proposals can be seen in the panel report for Call 2 (Annex 9).

5 Panel Meeting and selected proposals

On May 19th, 2015, the expert panel for PDTI Urban took place in Barcelona to evaluate the RTD proposals. Two technological experts from SMEs, Tjibbe Bouma and Alvaro Iriarte, were to evaluate and select the three better proposals to start the RTD process. The UPC Team - Alberto Sanfeliu, Ana Puig Pey, Josep Casanovas - and the Public Body team – Javier Varela, Mª José Chesa, Silvia Burdons -, were assisting the evaluators and answering the questions addressed about the process, the consortia and the functions required by the public service. The evaluation has been based in the Scientific and Technological Excellence, Quality and efficiency of the implementation and the management proposed, and Potential impact through the development, dissemination and use of project results.

Three RTD proposals have selected: ARSI, Aerial Robots for Sewer Inspection; ROBODILLOS, Sewer Intelligent Robotics System and SIAR, Sewer Inspection Autonomous Robot.

On April 16, 2015, the panel meeting for the first call of PDTI Healthcare took place in Munich after an initial remote evaluation conducted by two independent experts for each proposal. Three external reviewers were chosen to evaluate the submitted proposals. The three experts shared expertise from different fields: Andreas Müller and Philippe Bidaud (robotics technology development) and Malcom Fisk (telemedicine, end-users focus and ethical considerations). The reviewers were supported by TUM, BOR, AQuAS and ABAT. Just like for PDTI Urban, the evaluation was based on the scientific and technological excellence (focusing on the system requirements outlined in the Challenge Brief on pp. 15), quality and efficiency of the implementation and proposed management as well as potential impact through the development, dissemination and use of project results.The panel meeting witnessed a very intensive and serious discussion on the quality of the proposals. The panelists finally concluded that they could not identify a proposal strong enough to justify funding. One of the main reasons was that telemedical competence- a fundamental part of the required cross-sectional operation- was completely absent. This was also because this requirement was not adequately addressed in the Challenge Brief. The final decision was to not select any of the proposals and to relaunch the call. Thus, the second call opened from 4th of May 2015 until 23rd of June 2015. The time before the re-launch was actively deployed to contacting experts from the field of telemedicine to receive stronger proposals with more interdisciplinary teams in Call 2.

The second panel meeting took place on July 13-14, 2015 in Barcelona with the same participants and evaluation criteria as in the first panel meeting. After carefully evaluating the submission, the first three proposals with higher score were selected for Phase 1: CLARK, ASSESSTRONIC and ARNICA.

Annex 1: Challenge Brief PDTI Urban: "UTILITIES INFRASTRUCTURES AND CONDITION MONITORING FOR SEWER NETWORK. ROBOTS FOR THE INSPECTION AND THE CLEARANCE OF THE SEWER NETWORK IN CITIES"

Annex 2: Challenge Brief 1 PDTI Healthcare: "Robotics for Comprehensive Geriatric Assessment (CGA) Challenge"

Annex 3: Challenge Brief 2 PDTI Healthcare: "Robotics for the Comprehensive Geriatric Assessment (CGA) Challenge"

Annex 4: Guide for Applicants PDTI Challenge

Annex 5: Proposal template PDTI Challenge

Annex 6: PDTI Urban- Comparative Table

Annex 7: PDTI Urban- Panel Report

Annex 8: PDTI Healthcare- Panel Report Call 1

Annex 9: PDTI Healthcare- Panel Report Call 2

Ajuntament de Barcelona

Barcelona Cicle de l'Aigua SA

Medi Ambient i Serveis Urbans – Hàbitat Urbà
Barcelona Cicle de l'Aigua, SA

Acer, 16
08038 - Barcelona
Telèfon 932 896 800
www.bcasa.cat

SEVENTH FRAMEWORK PROGRAMME

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

CHALLENGE BRIEF –CALL FOR PROPOSALS

Project acronym: **ECHORD ++**

Project full title:

European Clearing House for Open Robotics Development Plus Plus

INDEX

1. SUMMARY

THE CHALLENGE IN URBAN ROBOTICS: Robots for the inspection and the clearance of the sewer network in cities

Sewer inspections require many people to work in risky and unhealthy conditions.

Introducing a robotic solution in this process aims at reducing the labour risks, improving the precision of sewer inspections and optimizing sewer cleaning resources of the city.

This system should be able to determine the state of the sewer in order to identify sewer segments where its functionality has been reduced either by sediments or by structural defects. Other functionalities required are sewer monitoring and water, air and sediment sampling.

To well carry out these tasks, some general functions are desirable like remote operation, video and images capture, scanning and map building, among others.

2. DESCRIPTION OF THE CURRENT SITUATION

2.1. INTRODUCTION

The current need of the City of Barcelona is to mechanize sewer inspections in order to reduce the labour risks, objectify sewer inspections and optimize sewer cleaning expenses of the city.

The sewer network of Barcelona is 1532 km long, from which approximately 50% is accessible, which means that the pipe is at least 1.5 m high and workers are allowed to go inside it.

In order to determine the state of the network, visual inspections are done with different frequencies depending on the slope and other characteristics of the sewer. Workers walk all along the pipe, in some sections even four times a year, and decide where it is necessary to clean.

Moreover, sewers are classified as confined spaces which require special health and safety measures, in addition to other risks like slippery sections, obstacles or biological risks from the eventual contact with wastewater.

These features made the process of sewer inspection a risky and expensive process that requires improvements urgently.

Sanitation worker controlling a home drain

Sewer inspection is a service included in the public management of the sewers of Barcelona. Nowadays, sewer inspections are done by people performing visual inspections and collecting information about the state of the sewage like sediment level and type, pipe obstructions, etc.

Because of the sewer risks, the performance of the inspections is about 1.5 km of sewer every 6 hours.

This methodology requires approximately 1 million Euros per year in staffing expenses only, excluding equipment, machinery, health and safety measures, or other expenses.

The requirements for the new technology are given by the inherent sewer characteristics, namely:

- different ranges of pipe sizes
- possible high concentration of, not explosive, but toxic gases as hydrogen sulphide
- slippery areas
- obstacles
- atmosphere with 100 % humidity
- water temperature 16 °C
- no telecommunication coverage in the sewer

There is no regulation that applies to this public service except for the prevention of occupational hazards and, in particular, the regulation of access to confined spaces.

The city is willing to amend the legislation of its jurisdiction for introducing this new technology.

Barcelona sewage system network has a wide variety of sewers. As previously stated, the sewer network of Barcelona is 1532 km long, from which approximately 50% is accessible. This percentage is higher than other similar cities where it is normally less than 30%

This enables us to test the technology in various sewer sizes and facilitates the transfer of the technology to other cities.

This urban challenge is expected to:

- improve sewer workers health and safety measures
- improve the public service given since it optimizes the sewer cleaning resources
- improve the quality of life of citizens since it will improve the sewer performance

2.2. BARCELONA SEWAGE DATA

2.2.1. Characterization of sewers according to their visitability

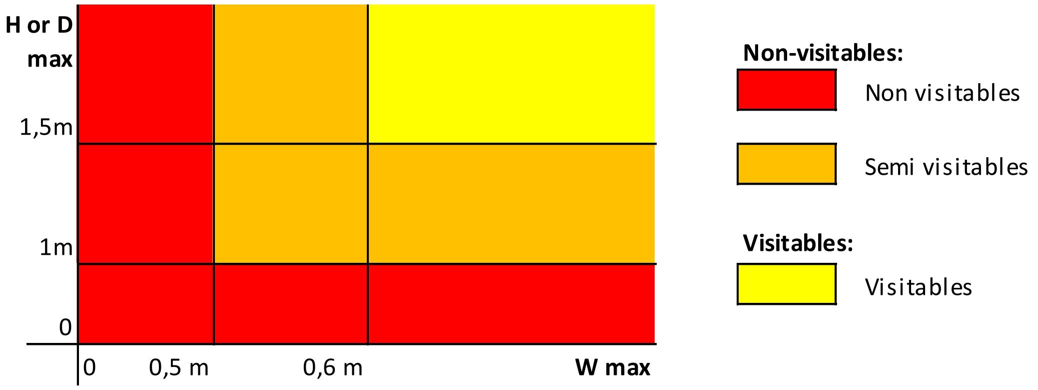
According to the characteristics of sewer sections, there are three possible situations according to their height (H) and width (W). In the case of tubular sewers, diameter (D) is equivalent to height (H).

a) If H or D ≥ 150 cm and W ≥ 60 cm: Visitable sewer, except sewers without curb (in this case it is considered as semi visitable sewer).
b) If H or D ≥ 100 cm and W ≥ 50 cm: semi visitable sewer.
c) If H or D < 100 cm or W < 50 cm: non visitable sewer.

Visitable sewers: these stretches are feasible due to their size and allow staff access to its interior.

Non visitable sewers: due to its dimension or morphology, these stretches do not allow staff access to its interior.

Semi visitable sewers: due to its characteristics, the access to these stretches is restricted to the application of additional measures, to be defined for each type of task.



Note: in tubular sections, visitability is conditioned by the size criteria (D) and the existence of curb. In case that the sewer fulfils size conditions but do not have curb, it will be considered as semi visitable.

2.2.2. Sewer network data

The following table states the length of the sewer network, in lineal meters, according to their visitability.

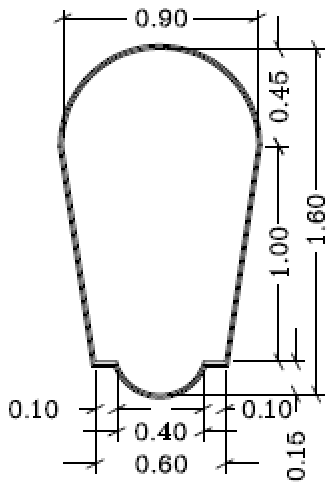
TYPE OF SEWER	LENGTH (m)	PERCENTAGE
Non visitable sewers	541.000	35%
Semi visitable sewers	148.000	10%
Visitable sewers	843.000	55%
TOTAL	**1.532.000**	**100%**

Total length of sewers is classified into the following ranges of heights. Notice that sewers heights below 1m are considered non visitable, and sewer heights between 1m and 1.5m are considered semi visitable.

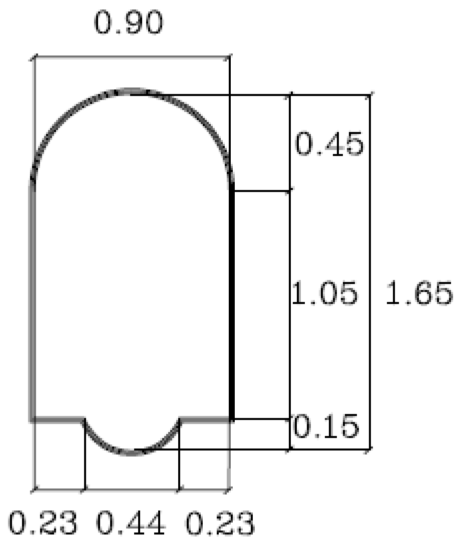
<table>
<tr><th rowspan="2">MAXIMUM HEIGHT</th><th>NO TUBULAR</th><th>TUBULAR</th></tr>
<tr><th>LENGTH (Km)</th><th>LENGTH (Km)</th></tr>
<tr><td>< 1m</td><td>30</td><td>511</td></tr>
<tr><td>1m <= x < 1.5m</td><td>114</td><td>34</td></tr>
<tr><td>1.5m <= x < 2.0m</td><td>668</td><td>6</td></tr>
<tr><td>2.0m <= x < 2.5m</td><td>91</td><td>4</td></tr>
<tr><td>2.5m <= x < 3.0m</td><td>44</td><td>1</td></tr>
<tr><td>3.0m <= x</td><td>27</td><td>2</td></tr>
<tr><td rowspan="2">TOTAL</td><td>974</td><td>558</td></tr>
<tr><td colspan="2">1.532</td></tr>
</table>

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.

T111



T130



Finally, the following table states the number of existing inlets and manholes in the sewer network.

ELEMENT	NUMBER
Manholes	42.425
Inlets	62.397
Grates	3.564

3. CURRENT TECHNOLOGY FOR KNOWLEDGE AND MANAGEMENT OF SEWER SYSTEM

3.1. INSPECTION VEHICLES

Currently inspection tasks can be supplemented by inspection vehicles equipped with different types of sensors according to the level of detail and autonomy required.

The current market has been analyzed and here there is a list of solutions that currently exist to inspect the sewer.

More or less, there are common features in all devices that are:

- Rolling ground displacement devices.
- Ultrasonic sensors.
- Sonar sensor used usually for detection and inspection underwater not for navigation.
- Laser for 3D reports of de sewer.
- Pan-Tilt-Zoom cameras with several degrees of freedom.
- Own lighting, based on LEDs.
- Electromagnetic sensors to evaluate structural integrity.
- External control units equipped by a cable reel that supplies energy to the unit and transmit the control.
- Set of different bodies and wheels to adapt the inspection unit to the sewer that has to be inspected mainly with two criteria, the diameter and deterioration or condition of the sewer surface.

These inspection vehicles can do mainly the following functions:

- Follow the commands from the operator console.
- Move in one direction.
- Adapt the vehicle to the sewer dimensions before the access, in a range that goes from 100 mm to 2000 mm approximately.
- Move along the sewer as much distance as cable length is available in the cable reel.
- Illuminate the sewer by them-selves.
- Record video in several degrees of freedom and also with one articulated arm with a camera at the end of it, record some meters of bifurcation sewers that are smaller than the vehicle like for example inlet sewers.
- Generate 3D models of the sewer.
- Support for reports of the state of the sewer
- Support to evaluate the structural integrity of the sewer

3.2. INSPECTION ROBOTS

In addition to the inspection vehicles described, that are difficult to consider them as robots, there are other types of sewer inspection devices that are self-propelled. This kind of devices that could be considered as robots have the following features:

- They are able to move themselves in one direction by sewer and record video in 360º to register the state of the sewer.
- It is also possible to analyze the sewer by zooming and navigating in 360º by the video images.
- These robots are able to access into the sewer system at one point and being recuperated in other point in an autonomous way.
- They can be equipped with cameras, LASER, *Lidar* and INS** technology*, Sonar sensor (for underwater detection if there is some stream of water) and hydrogen sulphide sensor.
- With all data collected by the sensors, it is possible to generate a model of the interior of the sewer and identify the possible impairments.

The improvements in the existing technology that this project seeks for are

- To facilitate real-time decision making
- Innovation that make inspection devices more autonomous
- To have more degrees of freedom to move around the network
- The possibility to intensify the checking of a zone where impairment has been detected.

** The Lidar technology (acronym of Light Detection and Ranging) is used in robotics for the perception of the environment and classification of objects. With this technology is possible to make three-dimensional elevation maps of the terrain and take levels with high accuracy among other things.*

*** The INS technology (acronym of Inertial Navigation System) is used in robotics for navigation calculating via dead reckoning the position, orientation, and velocity (direction and speed of movement) of a moving object without the need for external references. This technology uses motion sensors (accelerometers) and rotation sensors (gyroscopes).*

4. FUNCTIONS AND CONDITIONS OF THE NEW TECHNOLOGY

The objective of developing this new technology is to mechanize sewer inspections in order to reduce the labour risks, objectify sewer inspections and optimize sewer cleaning expenses of the city.

Visitable sewers (under normal conditions, there is no light inside sewers)

4.1. ASSESSMENT CRITERIA AND WEIGHTING

The selection of the proposals will be based on the following four sections (in parenthesis the weighting relative to the total score):

1. Scientific and technological excellence (60%)
2. Quality and efficiency of the implementation and the management (10%)
3. Potential impact trough the development, dissemination and use of the project (10%) and economic impact (20%)

This brief challenge is expected to explain the **Scientific and technological excellence criteria** applied to the proposals' evaluation and the **Economic impact assessment**.

4.1.1. Scientific and technological excellence criteria

The **Scientific and technological excellence** part in turn is divided into the three following parts:

<u>How well the proposed technology addresses the challenge as detailed in the Challenge Brief document?</u>
The functions summarized in the following table are what the new device has to be able to do and are fully explained beneath. Within the weighting of this question, the weighting of each of these functions is the following:

<table>
<tr><th colspan="3">FUNCTIONS</th><th colspan="2">WEIGHT</th></tr>
<tr><td rowspan="5">Sewer serviceability inspection</td><td colspan="2">Sewer performance (at least 1000 lineal meter/labour day)</td><td>10%</td><td rowspan="5">80%</td></tr>
<tr><td colspan="2">Images (Video)</td><td>40%</td></tr>
<tr><td colspan="2">Geometric analysis (scanning)</td><td>20%</td></tr>
<tr><td rowspan="2">Monitoring</td><td>Air</td><td>9%</td></tr>
<tr><td>Water</td><td>1%</td></tr>
<tr><td colspan="3">Structural defect inspection</td><td colspan="2">15%</td></tr>
<tr><td colspan="3">Sampling</td><td colspan="2">5%</td></tr>
</table>

<u>How well does the proposed technology integrate the required functionalities?</u>

- *How intuitive is the technology for the end users?* This means for example the ease for operations and recharges achieved by the technology or the autonomy for self-resolving the operator orders.

- *How easy can the technology be integrated in the environment?* By this question it is expected to evaluate the minimum dependency from the environment conditions. For instance, the score for this question could be associated to:
  - Wireless technologies
  - Flying devices
  - A high operational speed in order to reduce the affectation to public roads by the opened manholes covers.
  - Maximum reliability with the minimum incidents (for recovering a robotic system, some staff has to be mobilised)

- *How robust is the technology?* Minimum maintenance expenditures and high components' reliability and simplicity will be assessed.

- *Does it solve specific technological challenges (Mobility, Communication, etc)?* In order to assess this question, the following abilities will be evaluated:
  - The level of motion capability
  - The level of communication achieved and the interaction capability
  - The expected autonomy (in terms of batteries or available energy)
  - The decisional autonomy
  - The degree of transferability
  - The scalability of the technology
  - The adaptability
  - The cognitive ability

- The configurability
- The dependability,
- The flexibility
- The manipulation ability
- The perception ability

And finally, to what extent shows the proposal a clear plan for the development of a working solution?

4.1.2. Economic impact assessment

The economic impact expected to be reached trough the implementation of this technology is fully explained in the subheadings 4.2.2.1. Economic performance and 5.1. Economic impact.
The price of the solution for total cost independent of the business model determines the points awarded. In between a linear scale will be used to one decimal point.

4.2. GENERAL FUNCTIONS AND CONDITIONS

4.2.1. Environment conditions

The general requirements for the new technology are given by the inherent sewer characteristics that restrict the staff access in plenty of cases:

- Possible high concentration of, not explosive, but toxic gases as hydrogen sulphide or carbon monoxide
- Slippery areas
- Obstacles
- Atmosphere with 100 % relative humidity
- Water temperature around 16 °C
- No telecommunication coverage in the sewer

In particular, for the robot size design, it is important to take into account the pipe size and the manhole diameter. In the case of sewers with diameter below 0.8 m the inspection problems are solved with the existent technology. Because of that, the future technology has to be focused in pipes with diameter over 0.8 m.

In addition, although the standard manhole diameter in the city of Barcelona is 0.70 m, it is suggested to consider a diameter ≤0.60 m since it could be reduced by the manhole stairs and other singularities.

4.2.2. General services

The following are the general services required for well developing the specific functions exposed beneath.

4.2.2.1. Economic performance

Developers should consider that the public administration is interested in obtaining the full service of inspection and not just the robot. That is why the cost of the complete inspection brigade for working in visitable sewers (with all its elements like inlets, manholes, siphons, slope changes, etc.) should be less than 0.50 € / lineal meter. This price includes the necessary and sufficient staff, the previous works required for the inspection, signage, elements of protection and security staff, ventilation, the equipment, tools, materials, assistance needed, reporting, editing, filming, etc. The current economic data for the sewer inspection service in Barcelona is fully developed in the subheading 5.1. Economic impact.

4.2.2.2. Robotic system performance

Since current inspection performance is about 1500 meters every 8 hours because of sewer conditions, the developed robot is expected to significantly enhance it. Thus the robotic system performance should be at least 1000 meters in 8 hours, and from this minimum inspection performance, the higher length inspection performance the higher score will be obtained by the bidders.

4.2.2.3. Remote operation

The robotic system must be able to receive instructions by an on-site operator located outside the sewer. The receiver has to be able to see images sent by the robot in real time.
In addition, the robotic system can navigate autonomously in order to move through the environment avoiding obstacles and sensing the sewer depending on the chosen functionality.

4.2.2.4. Digital images and video

The robotic system has to be able to send video images to the operator in real time at VGA standard at least. The images can be obtained with any kind of imagery sensor (CCD, IR, UV, X-ray….).

In addition to video sending, the robotic system has to have the ability of in-site recording snapshots at higher resolution and to make videos at WVGA-30fps system. Also, the robotic system has to be able to record video sequences at HD standard under demand.

4.2.2.5. Scanning

The robotic system has to be able to perform a 3D scan of the sewer under demand, relaxing the robot performance in 4.2.2.2.

The planned uses for the scanning are:

- To compare the obtained data with the available information of the sewers (mainly type and section) and identify where the sewer serviceability has been reduced or where there is a structure defect.

- To precisely identify the sewer structure on the areas where reduction or widening of the sewer's section happens.

4.2.2.6. *Sewer elements location and mapping*

Sewer management, like any issue tightly linked to the territory, must be based on the reliable knowledge of the location and characteristics of the environment. This basic principle in network management services, traditionally solved using paper maps, now has dramatically improved with the use of geographic information systems (GIS).

Knowing the location of all sewerage lines and identifying its basic elements, such as connections, street inlets and home drains, enables a more effective sewerage management, as in most networks sewer operation is closely linked to terrain topography.

The service provider obtains significant benefits by adding geo-referenced information to their systems, for reasons not only technical but also strategic:

- It supplies precise knowledge about an important company's asset: the current infrastructure.
- This information is used to strengthen hydraulic models, which provide insight into the network hydraulic characteristics and thus allowing accurate strategic decision making and efficient operation, planning and development of new infrastructure.
- Provides greater flexibility in the distribution of information both inside the corporation and externally.
- Maintenance and rehabilitation of sewers require reliable knowledge about the network and the territory it drains.

Into the sewer there are a number of structures and connections that heavily modify network's behaviour and because of that it is needed to know their nature and location. Thus, this project should assist on the mapping of sewers and the localization of its elements:

<u>Sewer map building</u>

The mapping of sewers must be made taking as a starting point the location of the manhole covers. Each manhole cover should be referenced to the cartography base (sidewalks, buildings, road axis ...).
It is also necessary to map the typology of the path between the elements of the sewer (straight or curved), since these data are decisive for making the map and necessary in order to calculate the hydraulic parameters of the sewage system.

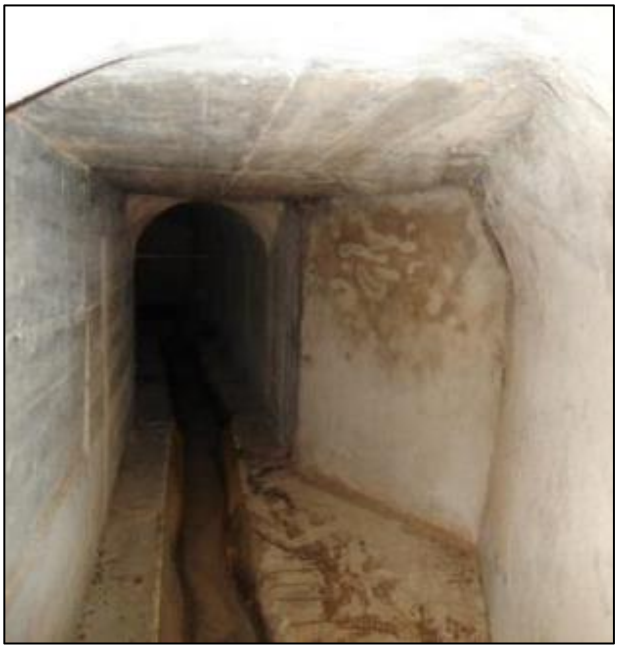
<u>Sewer elements location</u>

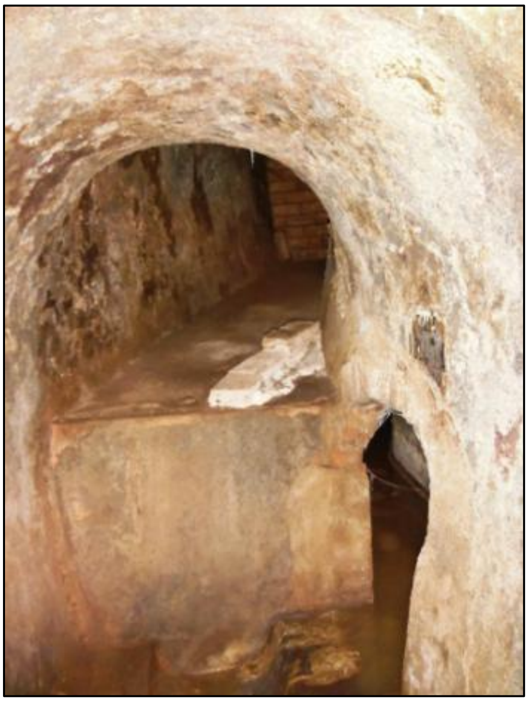
The distance between manholes and other elements inside the sewer should be measured as the robot moves forward through the sewer.
The angular position of each element from True North must be provided.
On the areas where reduction or widening of the sewer's section happens, a 3D scan must be done in order to precisely identify the structure.

The elements that have to be located at least:

- Manholes


- Home drains inlets	- Street drains inlets
	

- Points where two or more sewer lines cross at the same level and connect	- Points where a noticeable reduction or broadening occur
	

- Points with sudden slope changes	
	

4.3. SPECIFIC FUNCTIONALITIES

The specific functions that the new technology must address are the main challenges in the sewer inspection:

1) Determining the sewer serviceability
2) Identify critical structural defects
3) Sewer monitoring
4) Water, air and sediment sampling

4.3.1. Sewer serviceability inspection

4.3.1.1. Serviceability reduction alarm

On the basis of the scanning or the video made, the robot has to compare the obtained data with the available information of the sewers (mainly type and section) and identify where the sewer serviceability has been reduced.

The operator should receive a "pop-up" alarm that indicates the location of the obstruction and helps to decide if the robot has to make an extra specific snapshot or video.

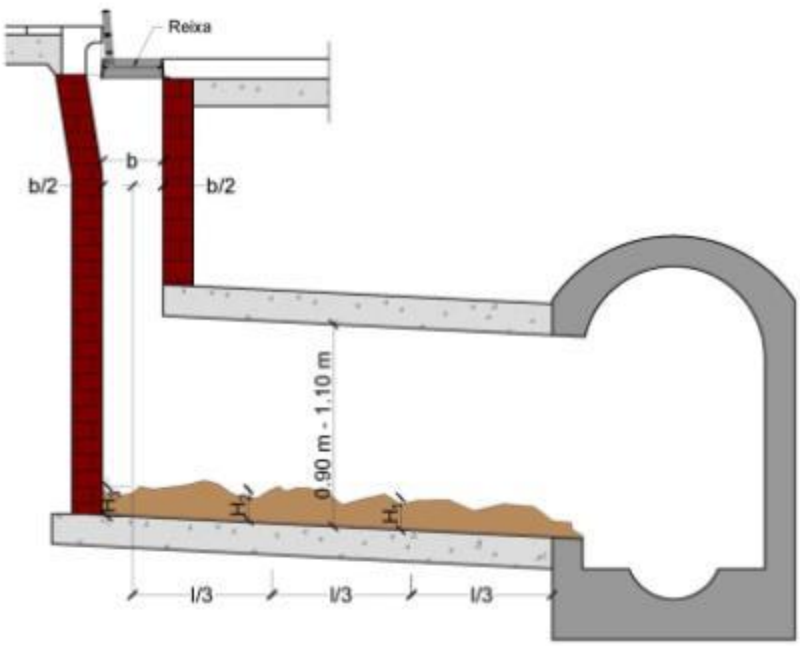
4.3.1.2. Criteria for serviceability reduction alarm

The following table shows the minimum standards of serviceability for the various items to be inspected by the prototype, which determine no need to be cleaned. Those elements that exceed the defined values will be collected on a proposal of sewer stretches that need to be cleaned in order to ensure the optimal operation of the sewer.

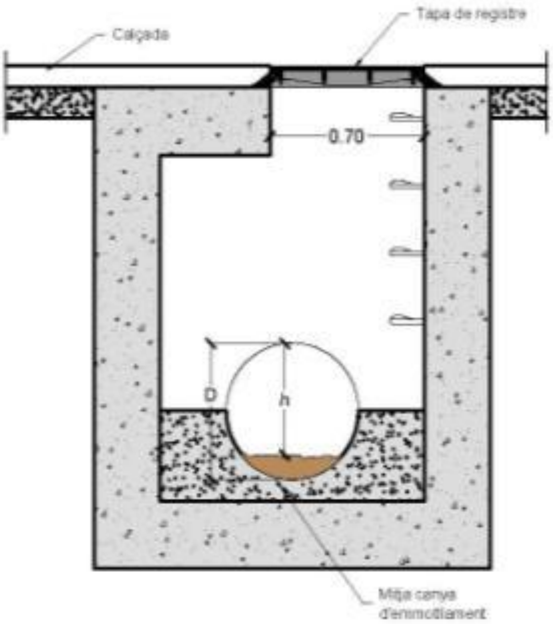
<table>
<tr><th>PARAMETER</th><th>VALUE</th></tr>
<tr><td>GUTTERS or INLETS</td><td></td></tr>
<tr><td>

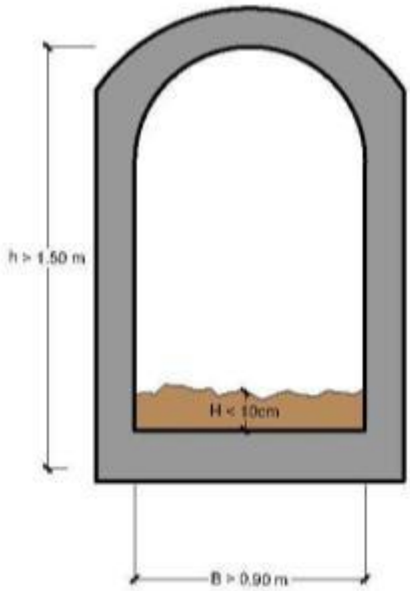
Level of waste at Gutter Tunnel: Thickness of the waste accumulated in the tunnel gutter.

The level of waste will be measured in three equidistant points distributed along the axis of the gutter tunnel considering the first measurement point located in the centre of the gutter manhole. The maximum height of the waste should not exceed 10 cm in two of the three measured points. The existence of bulky waste (stones greater than 10 cm in diameter, construction debris, wood or sticks, etc.) will imply cleaning the entire tunnel regardless of the measurement values obtained.



</td><td>< 10 cm</td></tr>
</table>

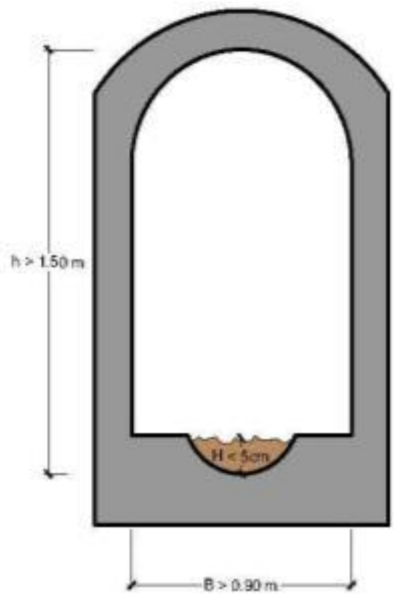
<table>
<tr><th>PARAMETER</th><th>VALUE</th></tr>
<tr><td>TUBULAR VISITABLE SEWER</td><td></td></tr>
<tr><td> Free section: section of the tubular sewer free from waste.
If the waste is deposited uniformly throughout the sewer, or part thereof, with circulation of wastewater without causing obstructions or odours, the height free of wastes will be measured at the manhole.
If the waste is accumulated at one or more points distributed along the tubular sewer producing obstructions and odours, the sewer stretch will be proposed to be cleaned regardless of the measurement values obtained.

</td><td>> 90%</td></tr>
</table>

PARAMETER	VALUE
VISITABLE SEWER	
With flat sill: waste height deposited on the sill. If the waste is deposited uniformly throughout the section, or part thereof, with circulation of wastewater without causing obstructions or odours, the height of wastes will be measured at the point where the greatest volume of sediment is perceived. If the waste is deposited at one or more points distributed along the sewer producing obstructions and odours, the sewer stretch will be proposed to be cleaned regardless of the measurement values obtained. 	< 5 cm

<table>
<tr><th>PARAMETER</th><th>VALUE</th></tr>
<tr><td>VISITABLE SEWER</td><td></td></tr>
<tr><td>With bucket: waste height deposited in the bucket

The waste height will be measured in the centre of the basin at the manhole.

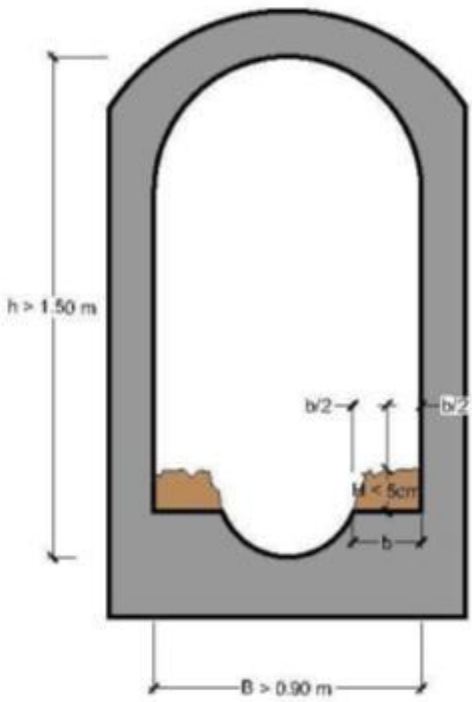
If the waste is deposited at one or more points distributed along the sewer producing obstructions and odours, the sewer stretch will be proposed to be cleaned regardless of the measurement values obtained.


</td><td>< 5 cm</td></tr>
</table>

<table>
<tr><th>PARAMETER</th><th>VALUE</th></tr>
<tr><td>VISITABLE SEWER</td><td></td></tr>
<tr><td>With Curb: waste height deposited at the curb.

The waste height will be measured in the centre of the curb at the point where the greatest volume of sediment is perceived.

If the waste is deposited at one or more points distributed along the sewer curb producing obstructions and odours, the sewer stretch will be proposed to be cleaned regardless of the measurement values obtained.


</td><td>< 5 cm</td></tr>
</table>

4.3.2. Structural defects inspection

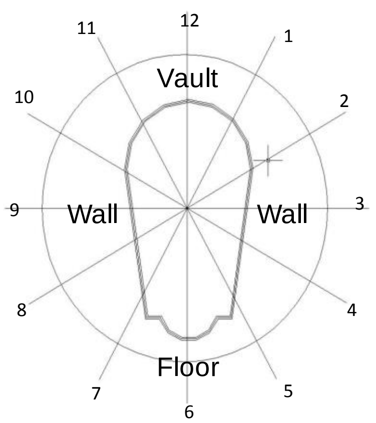
The prototype should locate and identify critical damage inside the sewers, whether it is located on floor (sewer's bottom), vault (sewer's roof) or walls.

Identification of critical defects should be done according to the table below:

NAME	UNE-EN13508-2 CODE	DESCRIPTION	EXAMPLES
Crack	BABB	Crack lines can be seen on the sewer's walls, floor or vault. Fragments are still in place.	
Fracture	BABC	Noticeably open cracks on the sewer's walls, floor or vault. Fragments are still in place.	
Break	BACA	Fragments of sewer wall, floor or vault visibly displaced, but not lost.	
Break with loss	BACB	Missing fragments on sewer walls, floor or vault.	

NAME	UNE-EN13508-2 CODE	DESCRIPTION	EXAMPLES
Collapse	BACC	Structural integrity completely lost.	

Defects location should be stated giving the following measurements:



Circular location following a clock-face pattern

- Distance from the nearest manhole to the defect: nodes (manholes and inlets) are codified in the GIS.
- Circular location following clock-face pattern (12-above, 3-right hand, 6-below, 9-left hand).

4.3.3. Sewer monitoring

The objective of sewer monitoring is to approximate the robot to the maximum level of sensitivity which will allow the sewer manager to make decisions without exposing to risky locations. Among other reasons, sewer monitoring is extremely useful:

- To avoid access to sewers at risk situations
- To decide safety and health measures for staff
- To locate and follow spills or leaks, normally illegal, in order to protect sewer infrastructures from abrasion, rust and aggressive spills
- To determine tendencies in compounds (seasonal, daily, etc.)
- As a tool for environmental research in sewers

It would be highly recommendable to incorporate to the robot the following functions:

<u>Air Sensors</u>

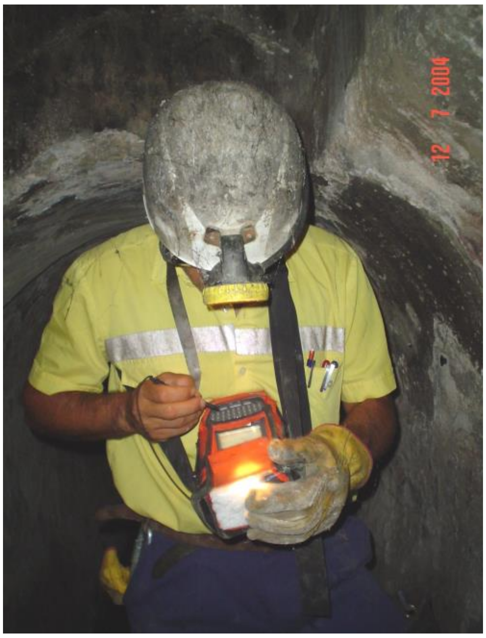
Knowing the environmental quality of the sewers is very important to determine both safety parameters and odours occurrence. Improvements in the former could help to reduce risk situations and optimize human resources. Besides, the last is a very important issue for managers due to the increasing citizen's sensitiveness.

- Temperature (T)
- Relative Humidity (%RH)
- Carbon Monoxide (CO)
- Hydrogen sulphide (SH_2)
- Methane (CH_4)
- Oxygen (O_2)
- Lower explosive limit (LEL)
- Volatile organic carbons (VOCs)

<u>Water sensors</u>

The knowledge of the water quality with real time monitoring is interesting for detecting tendencies in compounds (seasonal, daily, etc.) that flow along sewers. Complementing this functionality, punctual changes detected in water quality can alert about spills.

- Temperature (T)
- pH
- Conductivity
- Turbidity



Example of sewer monitoring

4.3.4. Sampling system

Sampling objectives are the very same of monitoring systems. Furthermore, sampling systems in sewer networks, as a second step or as a complement after monitoring, is greatly important in order to obtain valid and traceable information which could be used afterwards to determine environmental legislation and policies.

Examples of spills

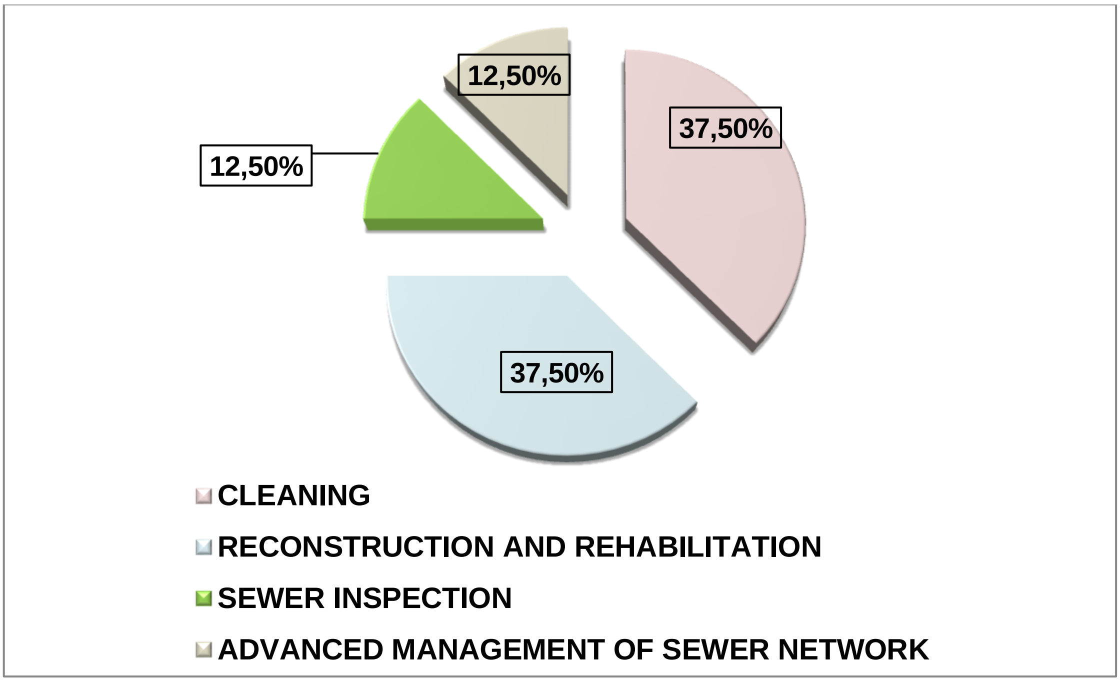
It is difficult to establish a minimum volume required per sample, as this depends on the parameters to be analyzed. However, at least the minimum following volumes would be necessary:

- Water sampling: 300 ml (higher volumes will have greater value)
- Air sampling:
  - Passive sampling system like active carbon filters (for instance, 530 mg of active carbon)
  - Active sampling system like air capsules
- Sediments sampling: 300 ml

5. EXPECTED IMPACTS

5.1. ECONOMIC IMPACT

The sewer inspection cost in Barcelona is about 1 million € per year what represents 12.5 % of the total cost of sewers management as it is shown in the following figure.



As shown in the following summary, the current cost associated to the inspection of visitable sewers with the objective of determining the serviceability level (not structural defects) is about **0.75 €/lineal meter**. This cost includes a complete inspection brigade for working in visitable sewers (inspecting all its elements like inlets, manholes, siphons, slope changes, etc.), the previous works required for the inspection, signage, elements of protection and security staff, ventilation, the equipment, tools, materials, assistance needed, reporting, editing, filming, etc.

<u>Summary of the principal cost data for the visitalbe sewer inspection service in Barcelona:</u>

- An inspection brigade is composed by 2 skilled officers, 1 pawn and a driver equipped with a van (leasing) and costs **110 €/h**.
- Nowadays there are 4 brigades available. That means: 4 brigades * 110€/h * 8 h * 214 labour days = **753.280 €/year** for the inspection service
- These 4 brigades inspect the 1.000.000 m of visitable sewers at least once a year. Thus, we obtain that 1.000.000 m / (214*4) = 1168 lineal m/(day*brigade) which means that a brigade can approximately inspect **1168 lineal meters per day**.
- Finally, as stated before, the unitary cost is 753.280 € /1.000.000 m = **0,75 €/ lineal meter**

Thereby, in case the new technology developed reduces the cost to 0.50€ /lineal meter, as it is required in the subheading 4.2.2.1. Economic performance, the saving would be about 30%.

Improving the efficiency of sewer inspections in general is expected to reduce not only the expenditure in sewer inspection tasks but the cleaning, reconstruction and rehabilitation expenditures as well. Savings done could revert in more investments for improving and innovating in sewage integral management.

5.2. ENVIRONMENTAL IMPACT

The impacts expected in environment are varied. For instance, by facilitating the inspection tasks, the new technology would help to enhance the sewer performance and in turn it would prevent overflows both to the city and to the environment.

Through early detection of defects in the sewer, it would be feasible to prevent waste water leaks to the underground that could finally get into underground water.

And, monitoring and sampling into the sewers would provide with deeper knowledge of the sewage tendencies. This would help to tackle and design measures to reduce odours from sewers and environmental policies would be directly addressed to the current specific circumstances of the city of Barcelona.

5.3. SOCIAL AND CULTURAL IMPACT

As stated before, the citizens' quality of life would improve since a better sewer performance would prevent overflows and odour problems.

Additionally, a sewer inspection made with a robot could minimize affectation to public roads as there would be no need to open all the manhole covers along the inspected segment for ventilating the confined space. In this way, roads that nowadays are inspected at night could probably be inspected in working hours thereby reducing its costs.

And last but not least, the new technology is expected to improve sewer workers health and safety since they will not have to enter into dangerous locations classified as confined spaces.

5.4. INNOVATION IMPACT

Access to confined spaces has always been a problem to deal with. Because of that, Barcelona city has developed a very specialized staff in entering into this kind of infrastructures, but the need of improving this method, making it more affordable and available, has been detected in other municipalities of the Barcelona Metropolitan Area and abroad in Spain. In these cases, where the public administration could not afford this service, visitable sewers were simply not inspected.

Thus, the new technology is expected to really improve the current inspection methodology by reducing the healthy risks for workers and making it affordable to public administrations.

5.5. ABILITY TO EXECUTE

Finally, the new technology is expected to be really feasible and affordable to implement and include in the current inspection services.

6. USES CASES

6.1. BARCELONA CITY

In order to better understand the current inspection difficulties, please visualize the presentation and the video presented during the Infoday Market Consultation that took place on the 20th November 2014 at Barcelona:

http://www.echord.eu/public-procurement/market-consultation-urban-robotics/

6.1.1. Affectation to public roads

The inspection methodology for confined spaces implies that all the manholes' covers along the sewer to be inspected have to be opened for previously ventilating the toxic gases. This means that the traffic has to be cut or reduced for doing the inspection. In the case of sewers under big and busy roads, inspections are done at night in order to reduce the affectation to the car traffic.

A sewer inspection made with a robot could minimize affectation to public roads as there would be no need to open all the manhole covers along the inspected segment for ventilating the confined space. In this way, roads that nowadays are inspected at night could probably be inspected in working hours thereby reducing its costs.

6.1.2. Toxic gases detection

In some points into the sewer network, high concentrations of hydrogen sulphide have been detected, probably due to an entry of waste water from a private pumping. In these cases, the access into the sewer is not possible or has to be done with extra safety measures as air masks. The application of the new technology could help to do a previous inspection in order to identify the source of the hydrogen sulphide.

7. OTHER EXAMPLES

7.1. BARCELONA METROPOLITAN AREA AND SPAIN

Although in lesser extent, other municipalities from Barcelona Metropolitan Area also have visitable sewers. As well as Barcelona City, they have to deal with the strict safety measures related to confined spaces and suffer from lack of specialised staff. Consequently, visitable sewers could sometimes not be inspected at all.

Some examples of cities with this kind of problem in Spain are Sevilla, Valladolid, San Sebastián, Saragossa or Palma de Mallorca, and cities where Barcelona sewage staff has done technical assessment are the following:

SITGES	LENGTH (Km.)	PERCENTAGE
Visitable	7.1	5.9%
No visitable	113.7	94.1%
TOTAL	**120.8**	**100%**

SANT ADRIÀ DE BESÒS	LENGTH (Km.)	PERCENTAGE
Visitable	9	13.6%
No visitable	57	86.4%
TOTAL	**66**	**100%**

SANTA COLOMA DE GRAMENET	LENGTH (Km.)	PERCENTAGE
Visitable	18.3	22.3%
Semivisitable	15.7	19.2%
No visitable	48.0	58.5%
TOTAL	**82.0**	**100%**

BADALONA	LENGTH (Km.)	PERCENTAGE
Visitable	50.3	15.8%
Semivisitable	33.3	10.5%
No visitable	234.8	73.7%
TOTAL	**318.4**	**100%**

7.2. CITY OF PARIS

The Paris sewage is more than 2.400 km length and has three basic characteristics: it is a combined sewer network, works by gravity and is almost completely visitable.
The network has the following types of sewers from the smaller to the highest:

TYPE OF SEWER	HEIGHT (m)	BUCKET (m)
Elemental sewers	1.3	-
Secondary collectors	3	1.2
Principal collectors	5 to 6	3.5
Emissaries (tubulars, no visitable)	2.5 to 6	-

The network is managed through an IT system named TIGRE (Traitement informatisé de la gestion du réseau des égouts) that stores the information about the sewers. This information is collected on site by the sewage staff that inspects the sewer network twice a year.

Public end-user Driven Technological Innovation (PDTI)

Robotics for Comprehensive Geriatric Assessment (CGA) Challenge

CHALLENGE BRIEF – RELATED TO THE ECHORD++ CALL FOR R&D PROPOSALS

Version 25.1.2015

Table of contents

1 Introduction

The profile of aging in the world is changing dramatically since the second half of the 20th century and will continue changing in the future. The average life expectancy at birth has increased from 47 years in 1900 to over 78 years in 2008. By 2030, the percentage of the population over 65 years of age will exceed 20 %, or over 70 million people.

Definitions of health and well-being in late life have changed with the increase in life expectancy. Heart disease, cancer, and stroke have become the leading "killers" among older adults, while deaths due to infection have decreased. Adults surviving into late life suffer from high rates of chronic illness; 80 % have at least one and 50 % have at least two chronic conditions. There is a strong association between the presence of geriatric syndromes (cognitive impairment, falls, incontinence, vision or hearing impairment, low body mass index, dizziness) and dependency in activities of daily living.

Decline in function and loss of independence are NOT an inevitable consequence of aging. Given the high prevalence and impact of chronic health problems among older patients, evidence-based interventions to address these problems have become increasingly important to maximize both the quantity and quality of life for older adults. In this context health services for older persons are becoming increasingly important, and Comprehensive Geriatric Assessment (CGA) is a clinical management strategy, used around the world, that gives a framework for the delivery of interventions which address relevant and appropriate issues related to an individual frail older patient.

CGA determines an elderly person's medical, psychosocial, functional, and environmental resources and problems linked with an overall plan for treatment and follow-up.

The expected results of the work are systems which have to manage specific tasks of the CGA processes to allow Health Professionals to perform CGA in an easier way and with more quality. There is no need to have mobile platforms. The main requirements are:

- Ability to do autonomously some functional or mental tests instead of the health professional, discharging and enabling him/her to focus in other issues of the CGA process.
- Accompanying the Health Professionals during clinical interviews recording or displaying information avoiding communication barriers (desk, screens, computers, etc.). That shall allow Health Professionals be focused on the patient and relatives, maintaining visual contact during interview.
- Gather patient's data in different formats: video of gait, audio of voice during tests, etc.

1.1 Healthcare burden of elder population

United Nations (2013)[1] reports that population ageing, which entails an increasing share of older persons in the population, is a major global demographic trend which will intensify during the twenty-first century.

Ageing has profound consequences on a broad range of economic, political and social processes. First and foremost is the increasing priority to promoting the well-being of the growing number and proportion of older persons in most countries of the world.

[1] Health population ageing 2013. United Nations. Department of Economic and Social Affairs

Ageing is also partly the result of the trend toward longer and generally healthier lives of individuals, but because chronic and degenerative diseases are more common at older ages, they result in an increased prevalence of non-communicable diseases at the population level. Last but not least, as societies' age, they also bring about changes in the living arrangements of older people vis-à-vis younger family members, and in the private and public systems of economic support for older persons.

The world is in the middle of a transition toward significantly older populations

The world's population is changing in both size and age composition. There are approximately 810 million persons aged 60 years or over in the world in 2012 and this number is projected to grow to more than 2 billion by 2050.

Population ageing and development[2]

Number of persons aged 60 years or over: will grow dramatically from approximately 810 million persons in 2012 to more than 2 billion by 2050. At that point, older persons will outnumber the population of children (0-14 years) for the first time in human history. Asia has more than half (55 per cent) of the world's older persons, followed by Europe, which accounts for 21 per cent of the total.

Proportion of the total population aged 60 years or over: in 2012, one out of every nine persons in the world is aged 60 years or over. By 2050, one out of every five persons is projected to be in that age group. The proportion of the total population that is 60 years or older is much higher in the more developed regions than in the less developed regions: one in five persons in Europe; one in nine persons in Asia and Latin America and the Caribbean; and one in 16 persons in Africa. Although ageing is evolving fast in the more developed regions, the less developed regions will experience faster ageing over a much shorter period of time.

Share of persons aged 80 years or over: the older population is itself ageing. Currently, the oldest old population (aged 80 years or over) accounts for 14 per cent of the population aged 60 years or over. The oldest old is the fastest growing age segment of the older population. By 2050, 20 per cent of the older population will be aged 80 years or over. The number of centenarians (aged 100 years or over) is growing even faster, and is projected to increase tenfold, from approximately 343,000 in 2012 to 3.2 million by 2050.

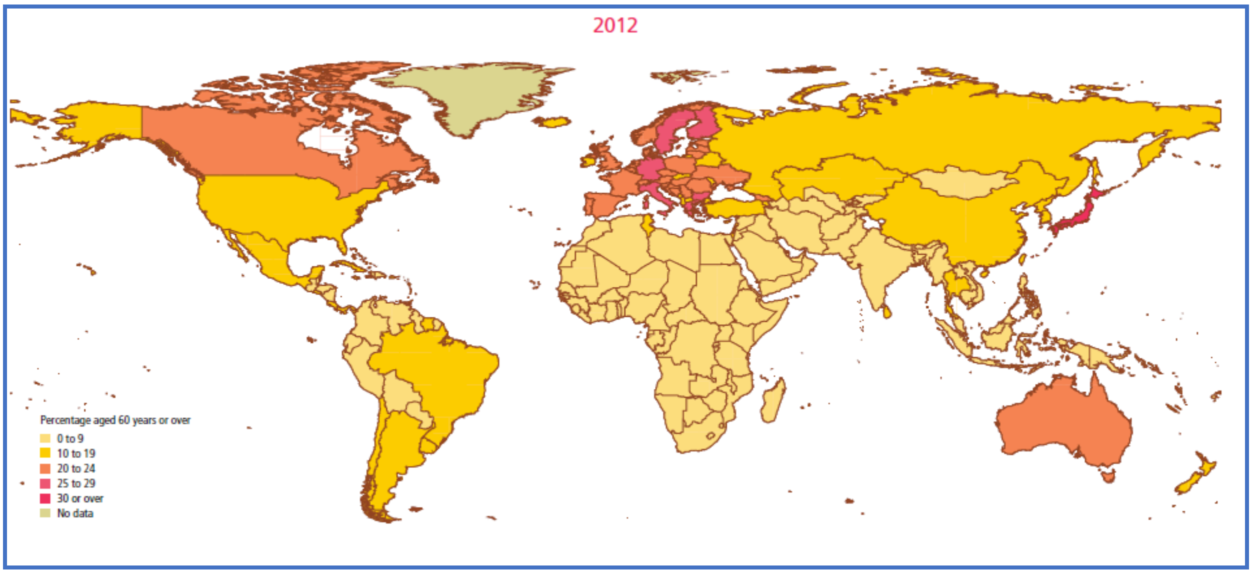
Life expectancy at age 60: the world has experienced large improvements in longevity, while the gap across development regions has narrowed.

Life expectancy at birth	1950	2010-2015	2045-2050
More developed countries	65	78	83
Less developed countries	42	68	75

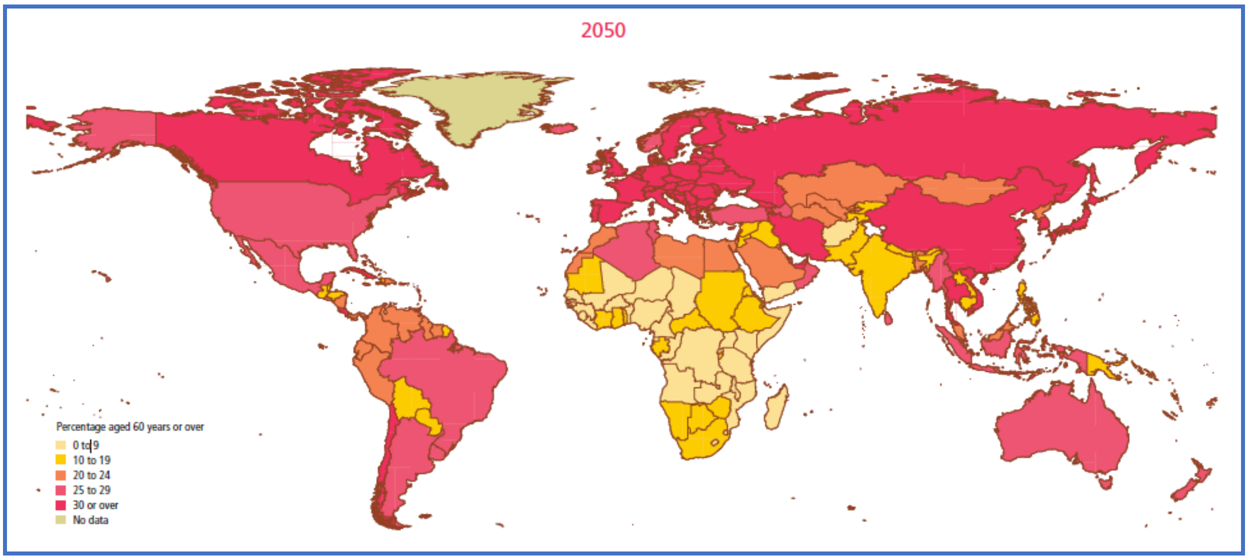
Proportion of older persons who are living independently: living independently, that is, either living alone or only with one's spouse or husband, is rare among older persons in developing countries, but is the dominant living arrangement in developed countries. An estimated 40 per cent of the world's older persons live independently, with no discernible difference by sex. The gap in the proportion living independently between the more developed regions and the rest of the world is remarkable.

[2] Population ageing and development 2012. Department of Economics and Social Affairs of United Nations. www.unpopulation.org

Almost three quarters of all older persons in the more developed regions either live alone or only with their spouse compared with only a quarter in the less developed regions, and just over 10 per cent in the least developed countries. The predominance of independent living among older persons is likely to increase as the world's population continues to age.



..



2 The Comprehensive Geriatric Assessment (CGA)

In Echord++ the Public end-user Driven Technological Innovation (PDTI) in Healthcare is challenging the robotics industry to develop **robotic health solutions** to improve the Comprehensive Geriatric Assessment (CGA).

2.1 What is Comprehensive Geriatric Assessment (CGA)?

CGA is more than an assessment process of an individual; it is an intensive interdisciplinary process to assess functional status of elder. It is widely used and during the last 20 years, has become a standard clinical tool for healthcare professionals of around the world to identify medical, psychosocial, and functional limitations of frail elder people; it is used to develop a coordinated plan to maximize their overall health. The CGA process is performed by a number of specialist of many disciplines in older people's health; it involves an holistic, multidimensional (not only medical diagnoses, but also functional impairments and the environmental and social issues which affect patient wellbeing), interdisciplinary (with inputs from doctors, nurses and other allied health professionals) assessment which has been demonstrated to be associated with improved outcomes in a variety of settings.

CGA typically results in the formulation of a list of needs and issues to tackle, and develop an individualised goal-driven care and support plan, tailored to the patient's needs, wants and priorities that, ultimately, provides and coordinates an integrated plan for treatment, rehabilitation, support and long-term care.

2.2 Which are the benefits of CGA?

As shown in figure 1 below, CGA has demonstrated benefits in different areas of health and social care processes:

- improving the **diagnostic plan** by appropriate selection of diagnostic tests to be performed or, to be avoided;
- giving **right and proportional therapeutic decisions** to patient's expectations and clinical status (avoiding over or insufficient treatment). It also reduces complications during hospitalization (like delirium and intrahospitalary infections) and less mortality;
- **increasing** patient's **functional autonomy at hospital discharge** and reducing need for income in nursing homes;
- selecting of **the most adequate level of care for the patient** (hospitalization in acute or sub-acute care units, day hospital care, or ambulatory care).

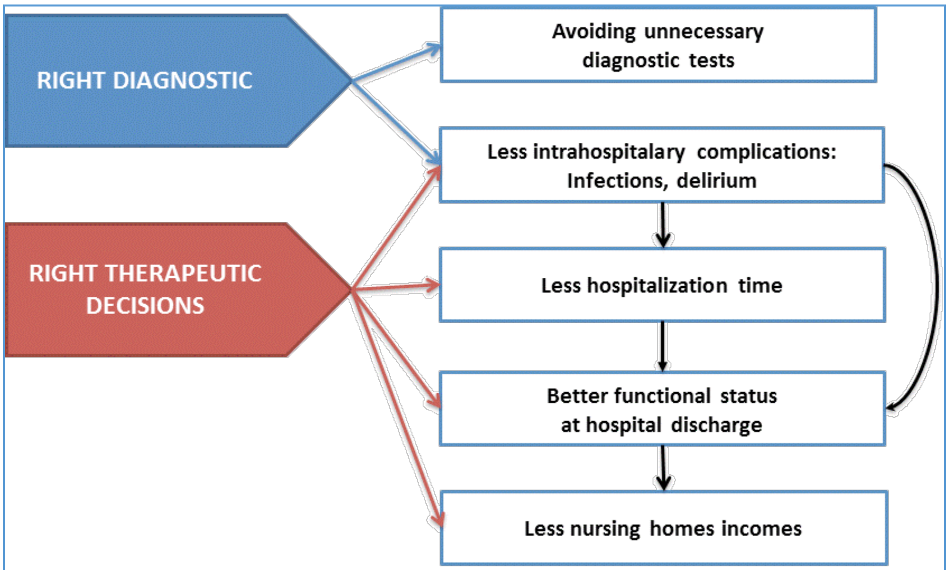


Figure 1: Benefits of CGA

Economic impact on costs from the above benefits are obvious and all them have been reported at the different settings where CGA has been evaluated: ambulatory care services, hospitalization units, and urgency services.

2.3 What is the process?

Below, there is a brief description of the most important issues to be considered during the CGA process.

2.3.1 Patient's issues to be evaluated

CGA implies the evaluation of all the relevant issues related with patient status which have to be considered to perform a successful care plan for an elderly or old-age patient for any health or social intervention; it comprises functional, mental, social, and clinical assessment (including nutritional status). Thus, CGA is individualized and needs to be updated periodically (usually every 6 moths).

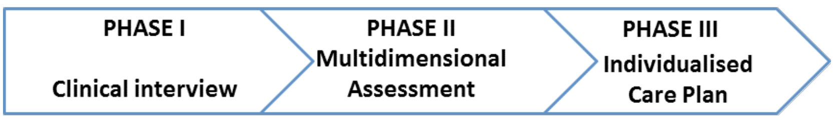
2.3.2 Hospital settings where CGA is performed

Hospital settings are the usual scenarios where the CGA assessments are performed:

- Hospitalization Units for income patients;
- Day Care Hospital;
- Ambulatory Care Units for ambulatory patients

2.3.3 Phases of CGA process

The CGA process involves three main groups of activities to reach the objectives: the clinical interview, the assessment and the care plan.



Phase 1: Clinical interview

The clinical interview is the initial phase of the process where patients and relatives meet the healthcare professionals and discus the main problems and worries concerning the elder while overviewing his personal health issues (allergies, diseases, surgeries and medications).

Phase 2: Multidimensional Assessments

During this phase multidimensional assessment tests are performed to assess the functional, mental and social status of the elderly person.

Tests used in a CGA process are described in more detail in section 2.3.4.

Phase 3: Individualised care plan

This is the most important phase of the CGA process where healthcare professionals evaluate patient's information gathered during the previous phases and devise a personalized care plan adequate to patient and relatives' profile.

The individualized care plan includes: additional diagnostic tests, therapeutic recommendations (medications, rehabilitation treatment, cognitive stimulation, etc.) and the more suitable setting for the patient to execute the care plan (ambulatory care unit, day care hospital, or hospitalization units).

Since patient and relatives perceptions about the patient's performance on functional or daily basic activities like cooking or medications control may differ (especially in cases of cognitive problems where the patient is not aware about its limitation), in Phase 1 and Phase 2 activities the health professionals need gather information from both patients and relatives and, with patient's consent, some interviews or tests may be performed separately. **In that sense, doing tests in a parallel way (patient and relative in separated rooms) might be very useful because we can reduce the total time for the process and we can avoid the waiting time for patient and relatives.**

2.3.4 CGA tests

The wide range of issues to assess in CGA in order to evaluate functional and mental status of a frail elder, requires an organized process to get and organize information. In this sense, at present, existing formal tests are the most objective and valuable tools used by health professionals to objectively evaluate the status of patients.

CGA tests gather quantitative information that can be, easily, shared with other Health Professionals. This information must be updated periodically to follow patient's evolution from a quantitative point of view. Both subjective assessments and quantitative information have to be considered during CGA process to allow Health Professionals to perform a successful CGA.

To evaluate patient's potential for improvement and his evolution during the care process the tests are applied in different moments to analyze different status:

- **Basal status**: how was the patient when he or she was stable (for example 6 months before the date when the medical interview is performed).
- **Current status**: how is the patient at the moment of medical interview. His interview is repeated in regular intervals, e.g. every 6 months, to allow assessment of the development.

From the time of the first clinical interview on, the tests are repeated during the care process to evaluate the patient's improvement or deterioration. Therefore, all data related to the individual tests and results over time are recorded and an analysis of the development over time has to be performed by the system. The resulting information can be used to estimate the further development and to adapt the care plan and therapeutic recommendations.

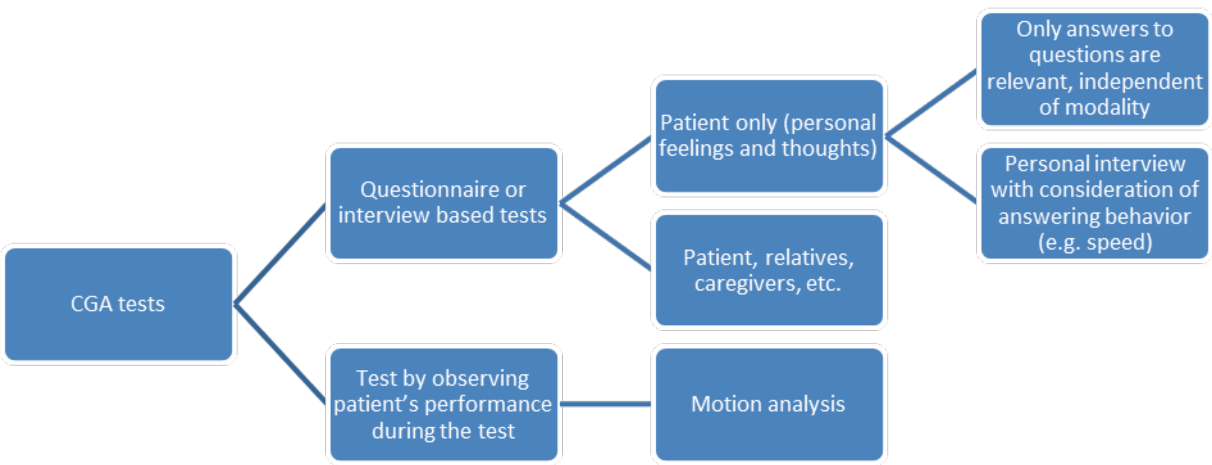
There are a lot of tests available to perform the assessment in Phase 2 of CGA process. Table 1 illustrates the main characteristics of the most common tests.

Table1: Main characteristics of GCA tests

TEST TYPE	ASSESSMENT	HOW IS DONE	HEALTH PROFESSIONALS INVOLVED (1*)	RANGE OF SCORES	HOSPITAL SETTING (2*)	DURATION
FUNCTIONAL ASSESSMENT						
Barthel Index	Performance on basic activities	Face to face	MD, N, OT	from 0 to 100	ACU, DCH, HU	10-15 min
Lawton Index	Performance on instrumental activities (more complex than basic activities)	Face to face	MD, N, OT	from 0 to 8 (Female), from 0 to 5 (Male)	ACU, DCH, HU	10-15 min
Time Up and Go test	Gait and balance	Visual observation	MD, P	Time (seconds)	DCH	5 min
Tinetti test Gait	Gait	Visual observation	MD, P	from 0 to 9	DCH	10 min
Tinetti test Balance	Balance	Visual observation	MD, P	from 0 to 26	DCH	10 min
MENTAL ASSESSMENT						
Pfeiffer test	Screening test for dementia	Face to face	MD, N	fro 0 to 10	ACU, DCH, HU	5 min
MMSE test	Screening test for dementia	Face to face	MD, N, Psyc	from 0 to 30	ACU, DCH, HU	15 min
Yesavage test	Screening test for depresion	Face to face	MD, N, Psyc	from 0 to 15	ACU, DCH, HU	10 min
SOCIAL ASSESSMENT						
Zarit test	Caregiver's emotional burden	Face to face	MD, SW	from 0 to 88	ACU, DCH	40 min
CLINICAL ASSESSMENT						
Face Pain Scale	Pain intensity	Face to face	MD, N	from 0 to 6	ACU, DCH, HU	5 min
Analogic Visual Scale	Pain intensity	Face to face	MD, N	from 0 to 100	ACU, DCH, HU	5 min

(1) MD: medical doctor; N: nurse; OT: occupational therapist; P: physiotherapist; Psyc: neuropshycologist; SW: social worker.*
(2) ACU: ambulatory care unit; DCH: day care hospital; HU: hospitalization unit*

The tests can be classified according to the following scheme:



The questionnaire-based tests require advanced interfacing modalities and advanced technical cognition (artificial intelligence) because the test's questions are usually open and there is a need to interpret and codify the patient or relative's answers. However, an useful alternative may be to change the questions in closed ones with pre-defined answers where patient or relatives may select an specific option through interaction with a device like a touch screen. Behavioral analysis during cognitive test may be interesting.

Regarding the cognitive assessment there are two type of evaluation:

- **brief** tests (screening test) for dementia, lasting between 5 and 15 minutes, are performed either by medical doctors or nurses; only this type of tests is done by the expected robotic system
- **extensive** neuropsychological evaluation, lasting between 45 and 90 minutes is performed by trained neuropsychologist. This evaluation is necessary when the brief test and clinical impression healthcare professionals are not enough to determine if the patient is affected by dementia. This type of tests is not required to be implemented on the system.

Table 2 contents a list of links to videos of tests used in CGA. Examples of questionnaires used for the tests can be found in annex I.

Table2: Where to found more information related with tests

Test	Evaluated issue	Current way of assessment	HP	Score's range	Hospital's setting
Functional tests					
Barthel Index	Performance on basic activities	Face to face inter-view	MD, N, OT	0-100	ACU, DCH, HU
Lawton Index	Performance on instrumental activities (more complex than basic activities)	Face to face inter-view	MD, N, OT	0-8 (F), 0-5 (M)	ACU, DCH, HU
Time Up and Go test	Gait and balance	Visual ob-servation	MD, P	Time (se-conds)	DCH
Tinetti test Gait	Gait	Visual ob-servation	MD, P	0-9	DCH
Tinetti test Balance	Balance	Visual ob-servation	MD, P	0-26	DCH
Mental tests					
Pfeiffer test	Screening test for dementia	Face to face inter-view	MD, N	0-10	ACU, DCH, HU
MMSE test	Screening test for dementia	Face to face inter-view	MD, N, Psyc	0-30	ACU, DCH, HU
Yesavage test	Screening test for depresion	Face to face inter-view	MD, N, Psyc	0-15	ACU, DCH, HU
Social test					

Zarit test	Caregiver's emotional burden	Face to face inter-view	MD, SW	0-88	ACU, DCH
Clinical test					
Face Pain Scale	Pain intensity	Face to face inter-view	MD, N	0-6	ACU, DCH, HU
Analogic Visual Sca-le	Pain intensity	Face to face inter-view	MD, N	0-10	ACU, DCH, HU
MD: medical doctor; N: nurse; OT: occupational therapist; P: physiotherapist; Psyc: neuropshycolo-gist; SW: social worker					
ACU: ambulatory care unit; DCH: day care hospital; HU: hospitalization unit					

3 Business model

3.1.1 Problem description

The ageing population across the EU is placing relentless pressure on increasingly scarce health and social care resources. More people live with multiple co-morbidities, and there are fewer people to care for them. The demographic dynamics and the economic crisis require urgent actions to make the delivery of health and social services to the elderly more sustainable and to increase independent living at home for older people.

The research and development in the Robotic for Comprehensive Geriatric Assessment Challenge will focus on frail older people aged over 80 with the idea that a robotics solution introduced should help to improve the overall status of patients.

The target users of robotics for CGA solutions will be the Health Professionals, patients and their relatives during the CGA process.

3.2 Problems during CGA process and potential benefits of a robotic solution

3.2.1 Time spending

CGA process duration depends on the setting where it is performed. On average, between 2 and 3 hours per patient are needed to complete the assessment.

Most of time is consumed to gather information in Phase 1 and Phase 2 (see 2.3.3. Phases of GCA) and, usually, the Healthcare professional lacks of enough remaining time to evaluate results and draw up the personalised care plan for the patient.

For instance, when CGA in performed in Ambulatory Care Units the process lasts only 60 minutes. In this settings time is a handicap and the health professional needs to hurry in Phase 1 and Phase 2 in order to complete the process; but many times the CGA process is not completed in one session and has to be continued in further sessions also in other hospital setting (usually Day Care Hospital Unit). All in all, in ambulatory care units the health professional has a lack of time to perform the process; especially for the final and most important phase, where the personalised care plan is organised.

On average, the execution of tests in the Multidimensional assessment (Phase 2) takes over 50% of the total time of the process while the individualised care (Phase 3) plan phase only lasts 11 % of the time.

A robotic device should be able to manage autonomously the execution of some tests and assist the Health Professionals during Phase 2, discharging and freeing up time for them to focus on more important activities of Phase 1 or Phase 3. Furthermore, discharge also should decrease health professionals' tiredness or fatigue perception as consequence of doing tests.

It should be expected a discharge of 20 - 30% of Health Professional's time by using a robotic solution.

3.2.2 Patient – professional interaction

Usually, the process requires professionals' to use supporting devices (frequently a computer).

These devices, sometimes difficult interaction between Health Professionals and patients/relatives:

- Health Professionals need to pay attention at patients/relatives but also have to introduce and manage information in the supporting devices loosing visual contact; that interrupts communication and, many times, patients feel that health professionals spend more attention in computer than in them.
- Screen, tables and other furniture are barriers and impact adversely in visual contact during interviews.
- CGA process is not continuous and there are interruptions due to the special characteristics of tests. For instance, some tests (especially balance and gait tests) have to be performed in specific settings outside the office where interaction patient-professional is being performed.
- Cognitive tests performed by professionals may cause anxiety in patients; they know that they are being evaluated and results will affect important issues as his autonomy and ability to stay at home. In that sense, a robot is felt neutral by patients so they should be considered an alternative in cognitive tests.

If the Health Professionals reduce the time spending with supporting devices and focus their attention on patients and their relatives during the CGA's process, the patient - professional interaction will improve considerably and more accurate information may be obtained.

3.2.3 Clinical information registration

Usually, clinical information is registered in text format into clinical records. Health Professionals would like to see patients' performance when walking; for instance, a video should be useful to compare patients' performance at the beginning and at the end of a rehabilitation process. Availability of patient's facial expression or voice before and after an antidepressant treatment may be another issue to be considered by Health Professionals to evaluate effectiveness of treatments.

3.2.4 What are the costs today?

CGA it is not a rapid process. The initial assessment and care planning for a full CGA is likely to take at least 1.5 hours of professional time, plus the necessary time for care plan negotiation and documentation; that represents a total of 2.5 hours. But as on-going review are needed periodically, at least twice a year, hospitals need to increase efficiency of CGA process to be able to attend more patients and absorb the increasing demand.

Some actual costs in Catalonia are:

- The public health insurer (CatSalut) pays hospitals per CGA process performed:

Type of assessment	2012	2013
Mental Assessment	207,81 €	198,25 €
CGA – Not Mental Assessment	147,45 €	140,76 €

- Each Assessment unit may attend 5 patients per day and there are waiting lists of 2 or 3 months.

3.2.5 Track the improvement

Extensive research has shown that CGA in hospital increases independence (individuals are more likely to go home after this process compared to standard medical care) and reduces mortality. A recent Cochrane[3] review showed that those who underwent CGA on a ward had a 30% higher chance (Odd Ratio 1.31 Confidence Interval 1.15 – 1.49) of being alive and being in their own home at 6 months.

Existing studies state that it is highly likely that CGA in any setting will be an effective intervention for an older person identified as having frailty. In the community there may need to be local flexibility in terms of what constitutes an interdisciplinary team and how the medical input is provided – nevertheless, the principle stands. The resulting individualised care and support plan must include information for older people and their carers about how and when to seek further advice and possibly information which defines advance planning for end of life care.

3.2.6 Health insurances and customers interest

To attend the increasing demand, health insurers and hospitals need to improve efficiency of CGA processes and, additionally, they have to increase elder population service portfolio.

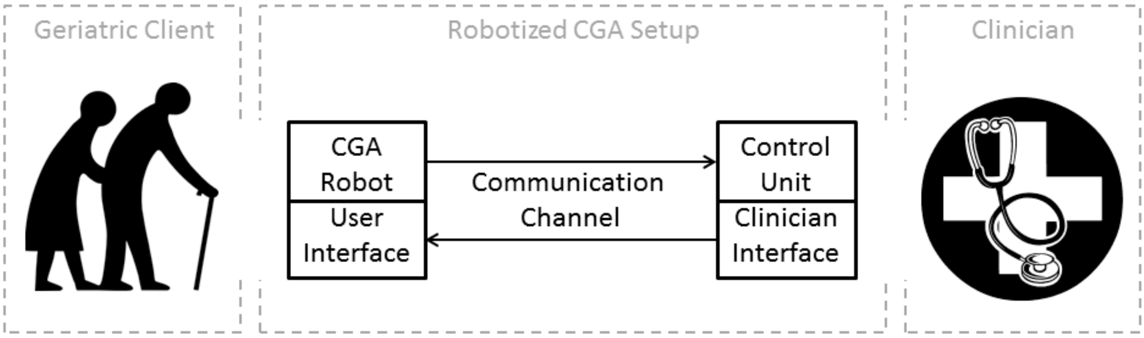
Improving cost efficiency in patient treatments is, and will be in the future, a big challenge. Robotics integrated in health service delivery may be part of the required solutions.

3.3 State of the art analysis for "Robotized comprehensive geriatric assessment"

[3] Comprehensive geriatric assessment for older adults admitted to hospital (Review); Ellis G, Whitehead MA, O'Neill D, Langhorne P, Robinson D

3.3.1 Robotization

Mainly, tests included in CGA could be performed by a robotic solution. The main objective is not to replace human professionals but enable them to have more time to be spent for care planning decisions itself (the analytic and comprehensive final step of CGA) instead to spend very valuable time for just doing tests.



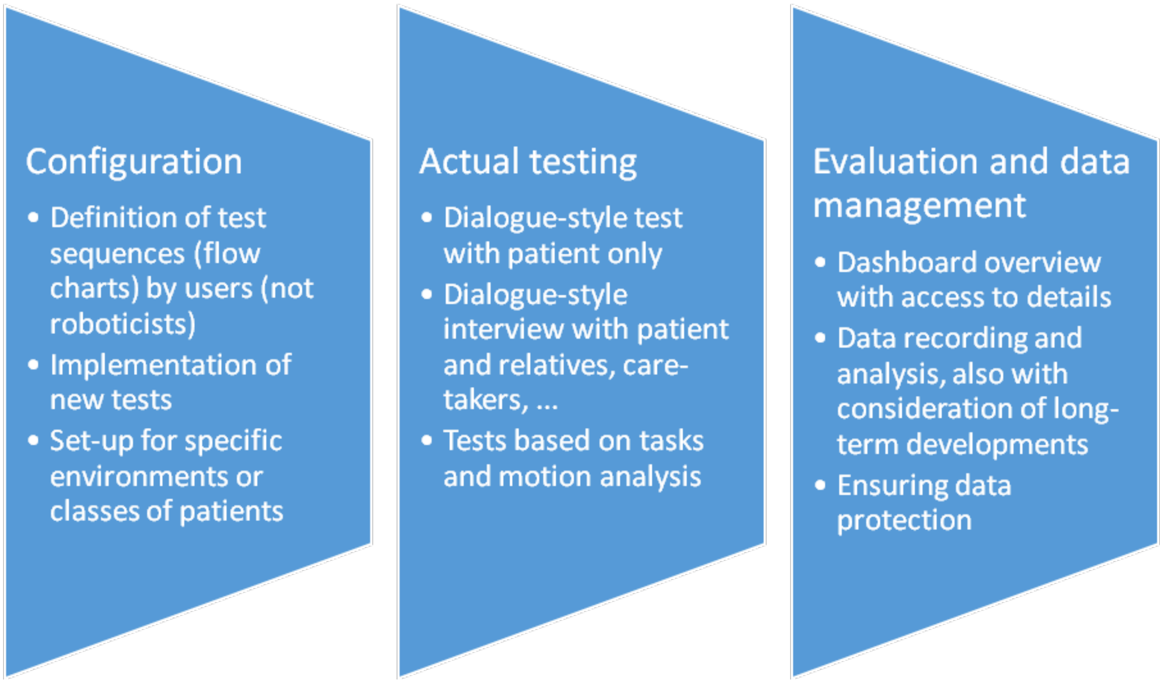
3.3.2 State of the art

Currently there is no robot known in the market which assists clinicians in taking CGA. Few specific software architectures have been introduced for online application of clinical tests. However, they usually require the direct collaboration of patient and online availability of the health professional. Functional tests like Tinetti or Berg test cannot be performed through these platforms because the evaluator needs to move beside the patient to get a successful assessment.

4 Functional & technical specifications (requirements)

4.1 Functional Requirements

Functions can be grouped by different types of use according to the following diagram



4.1.1 PDTI R&D stages and expected outcome:

Although the main activities a robot in CGA may perform autonomously are in Phase 2, there should also help to improve the process in other Phases. All the identified problems of CGA described in section 3.2, may be considered targets for improvements.

The new solution to the CGA challenge must help the staff at the geriatric department to decrease the amount of time spent on the clinical interviews and on the geriatrics tests in order to have more time with the patient and relatives to decide on an individualized care plan (that is the final and most important phase of CGA's process). Furthermore, the new solution should assist the staff in order for them to be able to focus more on the patients directly. (Rather than focusing on typing e.g.).
Hence, the desired functionalities/technical specifications for the robotic solution for CGA are:

- The design of the system must inspire trust both with the staff and with the patients and relatives. Patients have mentioned that the robotic systems should not seem dominant, e.g. by operating with humanoid/android hands.

- The solution should assist in clinical interviews, helping the staff to focus directly on the patient by having eye contact rather than looking into a computer screen. Also, the solution should help reduce the time spent on the clinical interviews, but still ensuring the quality and the proper data collection.
- The solution should assist when making the geriatric tests (see section 1.3.4 and AnnexI). All data must be stored safely. The robotic solution should assist health professionals offering the possibility of relegating some tests, so that professionals shall be more focused on the other phases or tests improving the outputs of CGA's process.
- The solution must be able to evaluate patients' performance during walking tests (like gait and balance tests): recording the patient's performance, using standard components for motion analysis to the extent possible.
- The solution must be portable in order to be moved around at the clinic
- The solution must be modular and scalable in order to ensure as big an international deployment as possible.
- The solution can build on already existing technologies as long as the RTD consortium has a legal agreement on further development of the existing technology. The consortium may also develop new technology for the CGA challenge.

The main requirements for the final systems are:

- Easy configuration and development / implementation of new tests with minimal (ideally no) need for assistance by robotics or computer science experts
- Selection by professionals of tests to include in an individual CGA. A predetermined flow chart for test sequence may be considered[4];
- 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;
- Ability to ask patients/relatives questions of selected tests;
- Ability to interpret and codify patients/relatives answers in spoken language and by touch screen input of selected 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). 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] Adapting the tests for the use of closed questions and pre-specified answers will be considered.

Requirements and expected outcome at the different stages of the development according to the stages defined in the Guide for applicants[5]

	Stage I (first 6 months)	Stage II (month 7-18)	Stage III (month 19-30)
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.	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	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	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.	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.	Prototypes meeting the specification, the portability has to be demonstrated.
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 an critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated	The stage II prototype can be powered by cable.	The prototypes must be able to be operated both in battery mode and plugged as specified.
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), but the capability for multi-language support has to be demonstrated.	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), but the capability for multi-language	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

[5] See http://www.echord.eu/fileadmin/user_upload/Services/PDTI-call/Guide-for-applicants-2014-12-22.pdf

		support has to be demonstrated	and other supporting staff.
Touch-screen interaction	Mock-up of touch-screen based interaction for all sorts of dialogues, for tests, configura-tion, and evaluation/data management. Each prototype needs to be able to handle 2 of these touch-screen interfaces in parallel (e.g. one for patient, one for relative). 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.	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	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 lan-guage(s) will be done with the help of the public bodies and other supporting staff.
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	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go	Full implementation of the motion track-ing component with analysis software and the dashboard for this functionality for Get up and Go, Tinetti Gait, Tinetti Balance
Configuration			
Patient- specific configuration	Mock-up of system dialogues for selection of tests and definition of test sequences in form of flow charts[6], handling of patient data	System dialogues for selection of tests, handling of patient data	Final version of system dialogues for selection of tests, handling of patient data
Integration of new/additional tests	Mock-up of a functionality to develop a new questionnaire-type tests.	Functionality of adding a new question-naire. This should be doable by medical staff with help of system engineers.	Functionality of adding a new question-naire. This should be doable by medical staff only.
Integration of new tests based on motion/video analysis	Description of concept. This type of new as-sessments need the help of system experts, but the specified system should have the possibility to add such things.	Proof-of concept in context with the prototype	Actual demonstration of adding a new analysis in context of the final evaluation

[6] An example of such a test sequence is given in Annex I.

Calibration	Mention, if there is a need to calibrate the motion detection component	If calibration is needed, a first version of the calibration functionality (operated by system engineers) needs to be shown	If calibration is needed, the calibration functionality (operated by clinical staff) needs to be shown
Actual testing			
Dialogue (questionnaire)-based tests	Mock-up of the dialogue-based Barthel test	Implementation of the dialogue-based Barthel and MMSE tests.	Implementation of the following dialogue-based tests Functional tests: Barthel and Lawton tests. Mental tests: Pfeiffer test, MMSE test, and Yesavage test.
Tests based on motion analysis	Mock-up of the Get Up and Go test.	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go	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	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.	Full recording capability to be demonstrated	Full recording capability integrated
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 visualisation of the motion analysis.	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 other visualisation of the motion analysis	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 visualisation 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	Demonstration of functions to interpret and codify patients/relatives answers of selected 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. Ability to calculate test scores based on codified information. The Health Professional has to be able to modify or correct tests scores	Integration of these function in the prototypes
Integration into clinical data management	Possibility to interface with clinical data systems in the overall concept	This version does not need to be able to be integrated into the overall clinical data management system	Prototypes able to be integrated into the overall clinical data management system
Data protection	Description of data protection concept and fulfilment of standards	Refined concept for data protection concept and fulfilment of standards and its integration into clinical data management systems	Proof of concept for integration into clinical data management systems including data protection and fulfilment of standards

4.1.2 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
Video-recording and storage during gait and balance tests	X	X
Video-recording and storage during other tests; like mental tests	X	

5 Use Case Scenario

Dr Fernández, geriatrist, receives a request from Doctor Bonilla for cognitive assessment of Mister Charles Balot, an 85 year old male patient living alone who has three offspring living far from him. During the last three months M. Balot's offspring have detected memory problems and changes in his behaviour like including irritability and verbal aggressiveness along with careless handling at home (neglected toilet, expired food, etc.). M. Balot does not recognize memory deficits neither his needs for support and goes to the visit almost exclusively because of the insistence of the family and Doctor Bonilla. His daughter, Marie, accompanies him. The scheduled time for the assessment is of 60 minutes.

Dr Fernández thinks that, due to the different point of view between the elder and his relatives, in this case, it is important to gather information separately from both the patient and his relatives. Then he plans the CGA process as follows:

1. Clinical assessment with patient and daughter.
2. Functional evaluation: tests Barthel and Lawton separately to patient and daughter.
3. Mental evaluation (cognitive and behaviour): subjective assessment with the patient, test MMSE and test Yesavage.
4. Social evaluation: direct interview with both patient and relative.

At the beginning of the assessment the doctor receives Mr. Balot and Marie. After the initial review of Mr Balot's health status, Doctor Fernández proposes Marie to go with the assistant robot to perform the Barthel and Lawton tests while he stays with Mr Balot asking him questions to build up a subjective impression on Mr Balot's awareness of his limitations.

Mr Balot and Marie agree with the proposal of Dr Fernández. During the interview Mr Balot denies having problems for self-care and behaviour changes affecting his personal relations. At the end, Dr Fernández asks Mr Balot's consent to interview Marie to get her impression on her father's behaviour and memory and invites Mr Balot to go with the robot to perform the MMSE, Barthel and Lawton tests.

Finally, the three of them reunite again to complete the social assessment.

Mr Balot's results are:

Type of Assessment	**Participants**	**Test**		**Total Score**	**Interpretation**
Functional Assessment	Patient-Robot	Barthel	Barthel 6 months ago	100	Autonomy for basic activities
			Barthel at present	100	
		Lawton	Lawton 6 months ago	4	Autonomy for instrumental activities except transport
			Lawton at present	4	
	Relative-Robot	Barthel	Barthel 6 months ago	100	Patients' independence to perform basic activities
			Barthel at present	100	
		Lawton	Lawton 6 months ago	4	Patient's impairment for public transport use. But Patient's capability to phone and manage money, medication and shopping.
			Lawton at present	1	

Mental Assessment	Patient-Robot	MMSE		16	Probable cognitive impairment
	Patient-Robot	Yesavage		6	Probable mood disorder

After reviewing these results Dr Fernández explains to Mr Balot and Marie that probably he is having a cognitive problem. He recommends to perform additional tests (laboratory, neuroimaging and extension of cognitive tests) to have a better diagnose and to start treatment for the behaviour symptoms identified. In this stage, some subjects are discussed as the need for monitoring Mr Balot’s special relationship with medication and money management. Dr Fernández answers also some doubts of Mr Balot and Marie and a new appointment is scheduled to complete the assessment with the additional tests.

Which are the benefits of using a robotic solution?

Dr Fernández was partially discharged by the robotic solution during the 25 minutes needed to perform the 8 functional tests and had more time to attend cognitive and behaviour assessments of Mr Balot.

- While Marie was doing functional tests with the robot, the Dr Fernández was able to maintain direct contact with Mr Balot and got an initial subjective impression of the patient's condition.
- While Mr Balot was doing functional tests with the robot, the Dr Fernández was interviewing Marie about his father’s health status; including changes in behaviour and cognitive deficits.

Dr Fernández and the robot were attending Marie and her father in parallel. So, interviews were held separately shortening the total length of the process. By this mean, Dr Fenández got also better information by about Mr Balot’s cognitive deficits and behaviour alterations; when the interviews are held jointly, relatives are cautious and avoid to comment serious behaviour disturbances to avoid later adverse reactions from the patient.

Interacting with the robot, instead of with a healthcare professional, for cognitive tests, MMSE and Yesavage, Mr Balot felt more confident during tests. Interaction with healthcare professionals caused him to feel examined and more nervous about the consequences the results would have on his autonomy. Furthermore, the assessment of aspects such as personal performance in the toilet, shower, shopping and money management is easier for Dr Fernández with the robot than with a computer.

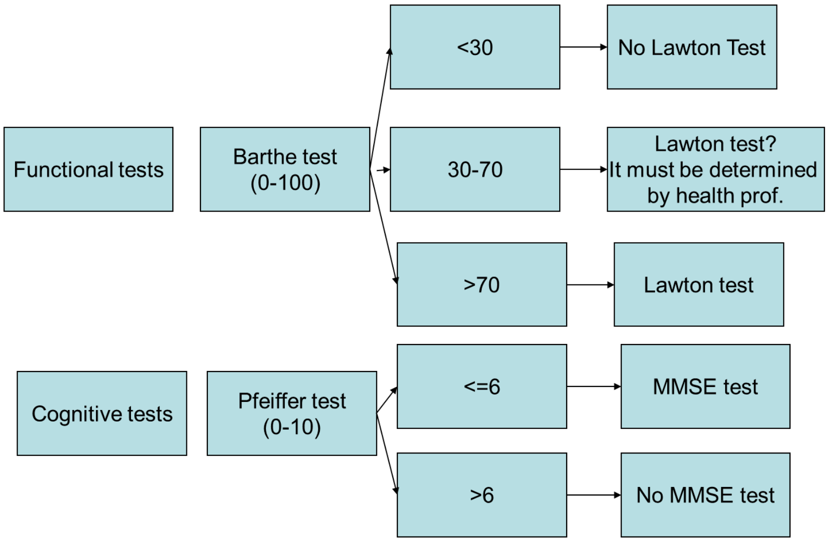
The time reduction by using a robot during CGA gave Dr Fernández more time to devise and agree with Mr Balot and Marie, the most adequate care plan for him which included: complementary tests, supervision of medicines, etc. This additional time, will improve the adherence of the patient and his relatives to treatment.

ANNEX I: EXAMPLES OF CGA TESTS AND TEST SEQUENCES

The most relevant tests are given in the following table in form of web links to documents and videos, and examples for currently used test sheets are given on the subsequent pages.

Tests	**Link**
Barthel Index	https://www.youtube.com/watch?v=03IsiYJSk0o
Lawton Index	http://downloads.lww.com/wolterskluwer_vitalstream_com/AJN/TRYTHIS_EP13_CH1_FINAL.wmv
Time Up and Go Test	https://www.youtube.com/watch?v=j77QUMPTnE0
MMSE test	http://videos.med.wisc.edu/videos/15378
Yesavage test (short form)	http://consultgerirn.org/resources/media/?vid_id=4200933#player_container
Other tests	http://consultgerirn.org/resources

Example of a test sequence as a flow chart:


Functional tests
Barthe test
(0-100)
<30
No Lawton Test
30-70
Lawton test?
It must be determined
by health prof.
>70
Lawton test
Cognitive tests
Pfeiffer test
(0-10)
<=6
MMSE test
>6
No MMSE test

Public end-user Driven Technological Innovation (PDTI)

Robotics for the Comprehensive Geriatric Assessment (CGA) Challenge

CHALLENGE BRIEF – RELATED TO THE ECHORD++ CALL FOR R&D PROPOSALS IN HEALTHCARE

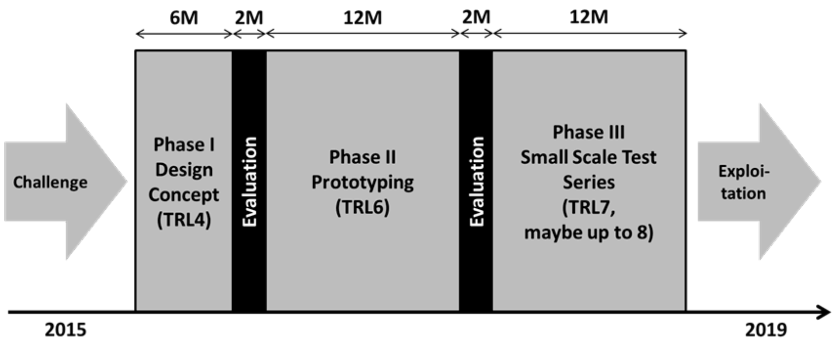
Version 4.5.2015

Table of contents

1 Summary

In Echord++ the Public end-user Driven Technological Innovation (PDTI) in Healthcare is seeking for technical solutions to improve the Comprehensive Geriatric Assessment (CGA).

The PDTI scheme is structured in 3 phases: 6 months for the first phase and 12 months for the second and third one. The main parameters and the timeline is shown in the diagram and the table below.



	Phase I Design concept	**Phase II** Prototyping	**Phase III** Small scale test Series
No. of R&D consortia	3	2	2
Funding per consort.	50.580 €	174.360 €	350.100 €
Duration	6 months	12 months	12 months

The expected results of the work are systems which have to manage specific tasks of the CGA processes to allow Health Professionals to perform CGA in an easier way and with more quality. The expected systems have the following main characteristics:

- Ability to do autonomously some functional or mental tests instead of the health professional, discharging and enabling him/her to focus in other issues of the CGA process.
- Accompanying the Health Professionals during clinical interviews recording or displaying information avoiding communication barriers (desk, screens, computers, etc.). That shall allow Health Professionals to be focused on the patient and relatives, maintaining visual contact.
- Gather patient's data in different formats: video of gait, audio of voice during tests, etc.
- Record the data in an open format to interoperate with other systems

The expected outcome of the three phases is summarized in the following table.

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.

To achieve the different functionalities, the consortia should cover the following complementary skills and competences: Multi-modal human-robot interaction, dialogue-based systems, health care expertise, etc. Additional competence in teleconsultation/telesurveillance/collaborative platforms might strengthen the consortium.

[1] For the definition of these tests, please refer to the annex.

2 Introduction

The profile of aging in the world is changing dramatically since the second half of the 20th century and will continue changing in the future. The average life expectancy at birth has increased from 47 years in 1900 to over 78 years in 2008. There are approximately 810 million persons aged 60 years or over in the world in 2012 and this number is projected to grow to more than 2 billions by 2050.

There is a strong association between the presence of geriatric syndromes (cognitive impairment, falls, incontinence, vision or hearing impairment, low body mass index, dizziness) and dependency in activities of daily living. However, decline in function and loss of independence is NOT an inevitable consequence of aging. Given the high prevalence and impact of chronic health problems among older patients, evidence-based interventions to address these problems have become increasingly important to maximize both the quantity and quality of life for older adults. In this context health services for older persons are becoming increasingly important, and Comprehensive Geriatric Assessment (CGA) is a clinical management strategy, used around the world, that gives a framework for the delivery of interventions which address relevant and appropriate issues related to an individual frail older patient.

CGA determines an elderly person's medical, psychosocial, functional, and environmental resources and problems linked with an overall plan for treatment and follow-up.

2.1 Healthcare burden of elder population

Ageing has profound consequences on a broad range of economic, political and social processes. First and foremost is the increasing priority to promoting the well-being of the growing number and proportion of older persons in most countries of the world.

Ageing is also partly the result of the trend toward longer and generally healthier lives of individuals, but because chronic and degenerative diseases are more common at older ages, they result in an increased prevalence of non-communicable diseases at the population level. Last but not least, as societies' age, they also bring about changes in the living arrangements of older people vis-à-vis younger family members, and in the private and public systems of economic support for older persons.

Population ageing and development[2]

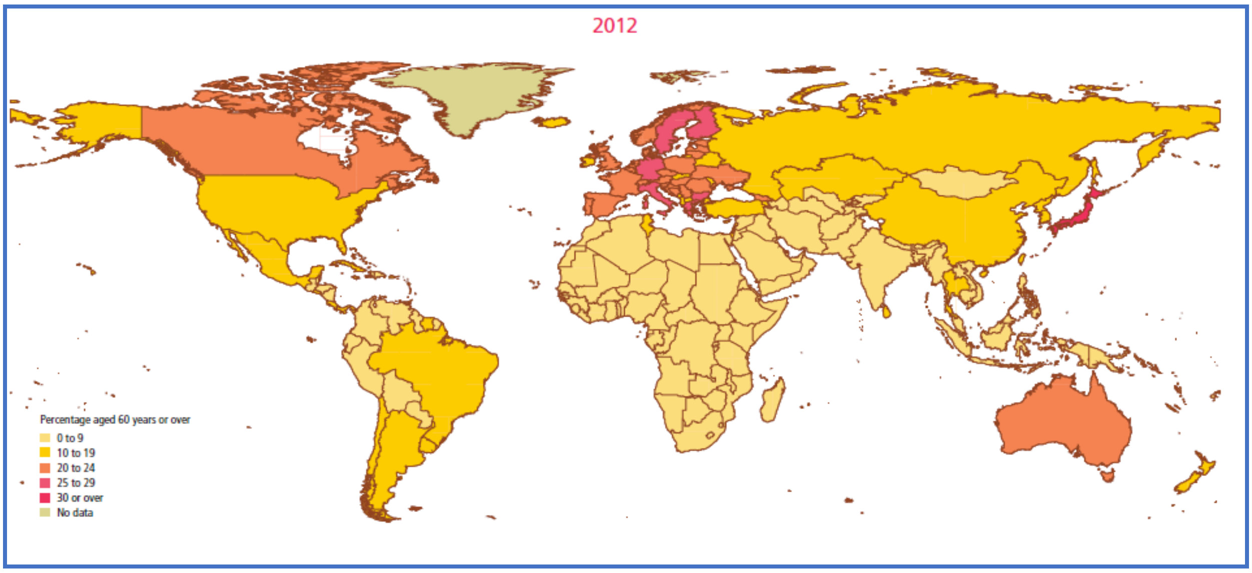
Proportion of the total population aged 60 years or over: in 2012, one out of every nine persons in the world was aged 60 years or over. By 2050, one out of every five persons is projected to be in that age group. The proportion of the total population that is 60 years or older is much higher in the more developed regions than in the less developed regions: one in five persons in Europe; one in nine persons in Asia and Latin America and the Caribbean; and one in 16 persons in Africa.

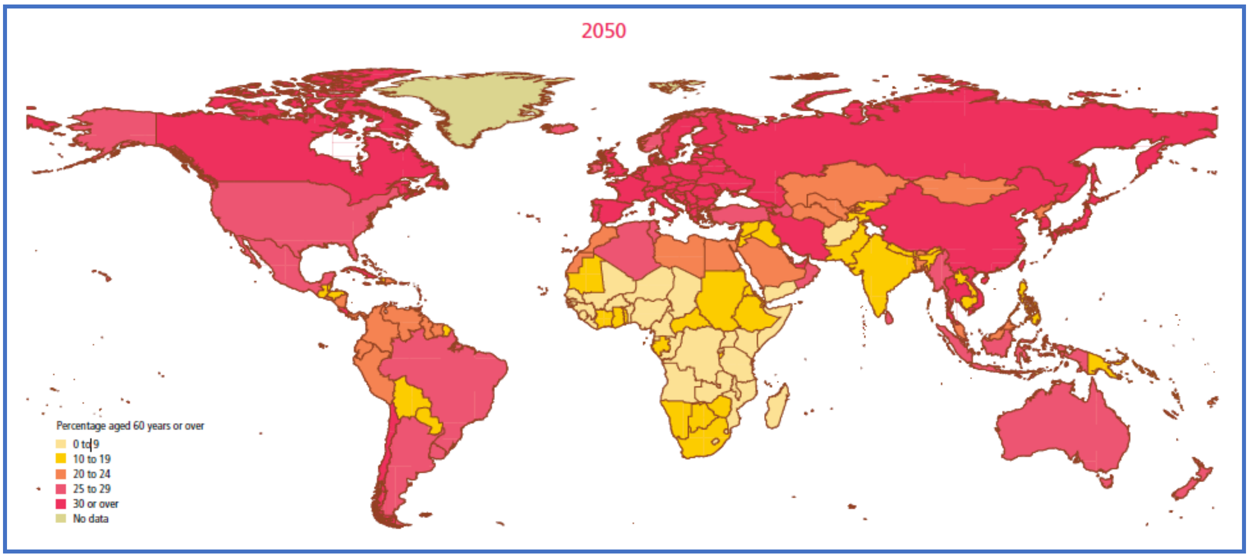
Share of persons aged 80 years or over: the older population is itself ageing. Currently, the oldest old population (aged 80 years or over) accounts for 14 per cent of the population aged 60 years or over. The oldest old is the fastest growing age segment of the older population. By 2050, 20 per cent of the older population will be aged 80 years or over.

Proportion of older persons who are living independently: living independently, that is, either living alone or only with one's spouse or husband, is rare among older persons in developing countries, but is the dominant living arrangement in developed countries. An estimated 40 per cent of the world's older persons live independently, with no discernible difference by sex. The gap in the proportion liv-

[2] Population ageing and development 2012. Department of Economics and Social Affairs of United Nations. www.unpopulation.org

ing independently between the more developed regions and the rest of the world is remarkable. Almost three quarters of all older persons in the more developed regions either live alone or only with their spouse compared with only a quarter in the less developed regions, and just over 10 per cent in the least developed countries. The predominance of independent living among older persons is likely to increase as the world's population continues to age.





2.2 Which are the benefits of CGA?

As shown in figure 1 below, CGA has demonstrated benefits in different areas of health and social care processes:

- improving the **diagnostic plan** by appropriate selection of diagnostic tests to be performed or, to be avoided;
- giving **right and proportional therapeutic decisions** to patient's expectations and clinical status (avoiding over or insufficient treatment). It also reduces complications during hospitalization (like delirium and intrahospitalary infections) and less mortality;
- **increasing** patient's **functional autonomy at hospital discharge** and reducing need for income in nursing homes;

- selecting of **the most adequate level of care for the patient** (hospitalization in acute or sub-acute care units, day hospital care, or ambulatory care).

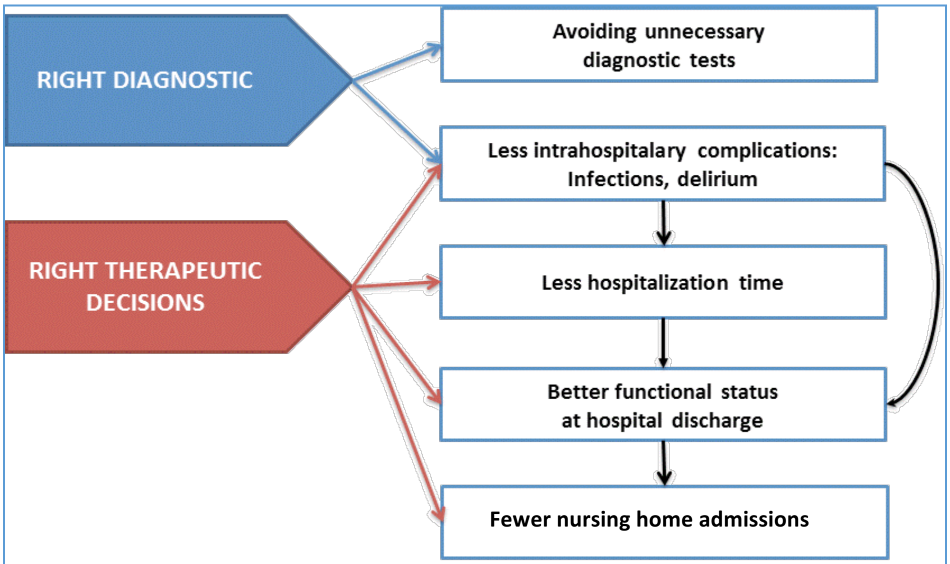


Figure 1: Benefits of CGA

Economic impact on costs from the above benefits are obvious and all of them have been reported at the different settings where CGA has been evaluated: ambulatory care services, hospitalization units, and urgency services.

Usually, the process requires professionals' to use supporting devices (frequently a computer). These devices sometimes impede the interaction between Health Professionals and patients/relatives: Health Professionals need to pay attention at patients/relatives but also have to introduce and manage information in the supporting devices loosing visual contact; that interrupts communication and, many times, patients feel that health professionals pay more attention to the computer than to them. Screen, tables and other furniture are barriers and impact adversely in visual contact during interviews.

Cognitive tests performed by professionals may cause anxiety in patients; they know that they are being evaluated and results will affect important issues as his autonomy and ability to stay at home. In that sense, a robotic system is felt neutral by patients so they should be considered an alternative in cognitive tests.

3 Comprehensive Geriatric Assessment (CGA) – State of the art

3.1 What is Comprehensive Geriatric Assessment (CGA)?

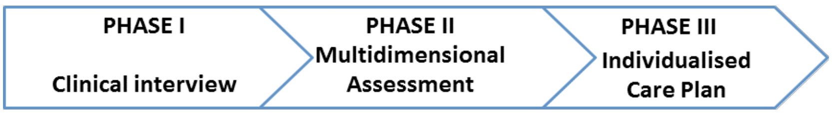
CGA is more than an assessment process of an individual; it is an intensive interdisciplinary process to assess functional status of elderly including medical, psychosocial, and functional limitations of frail elderly people; it is used to develop a coordinated plan to maximize their overall health.

CGA implies the evaluation of all the relevant issues related to patient status which have to be considered to perform a successful care plan for an elderly or old-age patient for any health or social intervention; it comprises functional, mental, social, and clinical assessment (including nutritional status). Thus, CGA is individualized and needs to be updated periodically (usually every 6 moths). Since patient and relatives perceptions about the patient's performance on functional or daily basic activities like cooking or medications control may differ (especially in cases of cognitive problems where the patient is not aware about its limitation), in Phase 1 and Phase 2 activities the health professionals need to gather information from both patients and relatives and, with patient's consent, some interviews or tests may be performed separately. Therefore, doing tests in a parallel way (patient and relative in separated rooms) is very useful because the total time for the process waiting time for patient and relatives are minimized. CGA typically results in the formulation of a list of needs and issues to tackle, and develop an individualised goal-driven care and support plan, tailored to the patient's needs, wants and priorities that, ultimately, provides and coordinates an integrated plan for treatment, rehabilitation, support and long-term care.

3.2 What is the process?

Phases of CGA process

The CGA process involves three main groups of activities to reach the objectives: the clinical interview, the assessment and the care plan.



Phase 1: Clinical interview

The clinical interview is the initial phase of the process where patients and relatives meet the healthcare professionals and discuss the main problems and worries concerning the elder while overviewing his personal health issues (allergies, diseases, surgeries and medications).

Phase 2: Multidimensional Assessments

During this phase multidimensional assessment tests are performed to assess the functional, mental and social status of the elderly person. The usual scenarios where the CGA assessments are performed: are hospital settings: Hospitalization Units for income patients, Day Care Hospital, or Ambulatory Care Units for ambulatory patients. This is the main functionality of the envisaged technical solution.

A detailed description of the functionality can be found in section 4.

Phase 3: Individualised care plan

This is the most important phase of the CGA process where healthcare professionals evaluate patient's information gathered during the previous phases and devise a personalized care plan adequate to patient and relatives' profile.

The individualized care plan includes: additional diagnostic tests, therapeutic recommendations (medications, rehabilitation treatment, cognitive stimulation, etc.) and the more suitable setting for the patient to execute the care plan (ambulatory care unit, day care hospital, or hospitalization units).

3.2.1 CGA tests

The wide range of issues to assess in CGA in order to evaluate functional and mental status of a frail elder requires an organized process to get and organize information. In this sense, at present, existing formal tests are the most objective and valuable tools used by health professionals to objectively evaluate the status of patients.

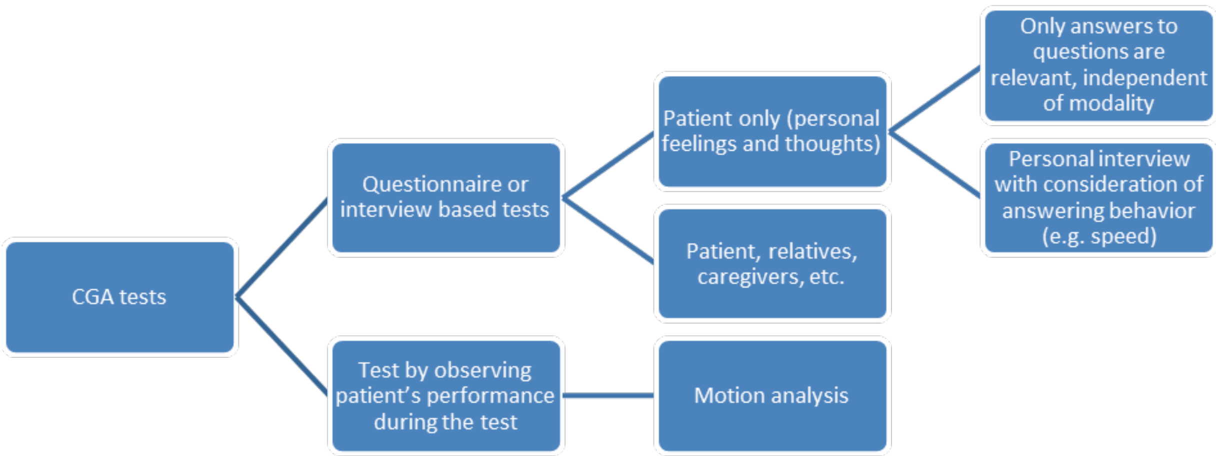
CGA tests gather quantitative information that can be easily shared with other Health Professionals. This information must be updated periodically to follow patient's evolution from a quantitative point of view. Both subjective assessments and quantitative information have to be considered during CGA process to allow Health Professionals to perform a successful CGA.

To evaluate patient's potential for improvement and his evolution during the care process, the tests are applied in different moments to analyze different status:

- **Basal status**: how the patient was when he or she was stable (for example 6 months before the date when the medical interview is performed).
- **Current status**: how the patient is at the moment of medical interview. His interview is repeated in regular intervals, e.g. every 6 months, to allow assessment of the development.

From the time of the first clinical interview on, the tests are repeated during the care process to evaluate the patient's improvement or deterioration. Therefore, all data related to the individual tests and results over time are recorded and an analysis of the development over time has to be performed by the system. The resulting information can be used to estimate the further development and to adapt the care plan and therapeutic recommendations.

The tests can be classified according to the following scheme:



Regarding the cognitive assessment, **brief** tests (screening test) for dementia, lasting between 5 and 15 minutes, are performed either by medical doctors or nurses and need to be done by the expected robotic system .These tests require advanced interfacing modalities and advanced technical cognition (artificial intelligence) because the test's questions are usually open and there is a need to interpret and codify the patient or relative's answers. However, a useful alternative may be to change the questions in closed ones with pre-defined answers where patient or relatives may select a specific option through interaction with a device like a touch screen. Behavioral analysis during cognitive test may be interesting.

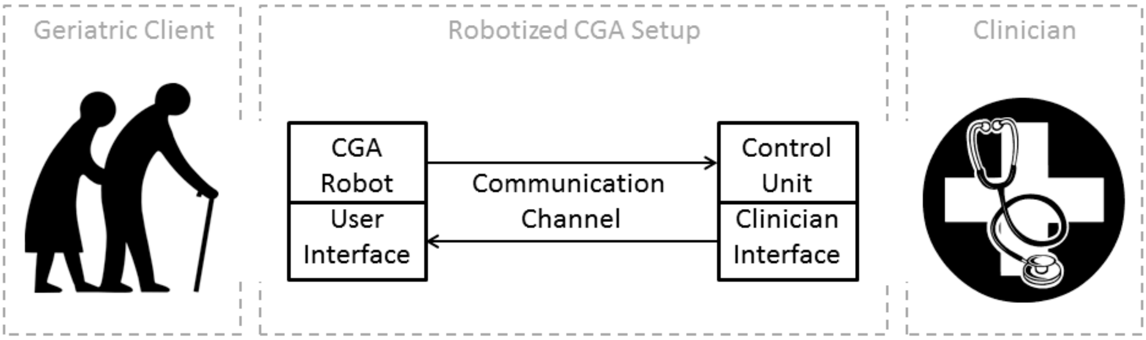
There are a lot of tests available to perform the assessment in Phase 2 of CGA process. Table 1 illustrates the main characteristics of the most common tests, detailed can be found in the annex.

Table1: Main characteristics of GCA tests

Test	Evaluated issue	Current way of assessment	HP	Score's range	Hospital's setting
Functional tests					
Barthel Index	Performance on basic activities	Face to face interview	MD, N, OT	0-100	ACU, DCH, HU
Lawton Index	Performance on instrumental activities (more complex than basic activities)	Face to face interview	MD, N, OT	0-8 (F), 0-5 (M)	ACU, DCH, HU
Time Up and Go test	Gait and balance	Visual observation	MD, P	Time (seconds)	DCH
Tinetti test Gait	Gait	Visual observation	MD, P	0-9	DCH
Tinetti test Balance	Balance	Visual observation	MD, P	0-26	DCH
Mental tests					
Pfeiffer test	Screening test for dementia	Face to face interview	MD, N	0-10	ACU, DCH, HU
MMSE test	Screening test for dementia	Face to face interview	MD, N, Psyc	0-30	ACU, DCH, HU
Yesavage test	Screening test for depresion	Face to face interview	MD, N, Psyc	0-15	ACU, DCH, HU
Social test					
Zarit test	Caregiver's emotional burden	Face to face interview	MD, SW	0-88	ACU, DCH
Clinical tests					
Face Pain Scale	Pain intensity	Face to face interview	MD, N	0-6	ACU, DCH, HU
Analogic Visual Scale	Pain intensity	Face to face interview	MD, N	0-10	ACU, DCH, HU

MD: medical doctor; N: nurse; OT: occupational therapist; P: physiotherapist; Psyc: neuropshycologist; SW: social worker
ACU: ambulatory care unit; DCH: day care hospital; HU: hospitalization unit

3.3 State of the art analysis for "Robotized comprehensive geriatric assessment"



Currently there is no robotic system known in the market which assists clinicians in taking CGA. Few specific software architectures have been introduced [3]for online application of clinical tests. However, they usually require the direct collaboration of patient and online availability of the health professional. Functional tests like Tinetti or Berg tests cannot be performed through these platforms because the evaluator needs to move beside the patient to get a successful assessment.

[3] Rocha A, Martins A, Freire Junior JC, Kamel Boulos MN, Vicente ME, Feld R, et al. Innovations in health care services: the CAALYX system. Int J Med Inform. 2013 nov;82(11):e307–320

4 Functional & technical specifications (requirements)

4.1 Functional Requirements

Although the main activities a robotic system in CGA may perform autonomously are in Phase 2 (Multidimensional Assessment) of the CGA process, the system should also help to improve the process in other phases. All the problems of CGA described in section 3.2 may be considered targets for improvements.

The new solution to the CGA challenge must help the staff at the geriatric department to decrease the amount of time spent on the clinical interviews and on the geriatrics tests in order to have more time with the patient and relatives to decide on an individualized care plan (that is the final and most important phase of CGA's process). Furthermore, the new robotic solution should assist the staff in order for them to be able to focus more on the patients directly (e.g., rather than focusing on typing). CGA process is not continuous and there are interruptions due to the special characteristics of tests. For instance, some tests (especially balance and gait tests) have to be performed in specific settings outside the office where interaction patient-professional is being performed.

To achieve this in an intuitive and socially acceptable way of interacting with the elderly, the patient's position and orientation during the tests should not be constraint too much by technical requirements. This can lead to the need for adaptation to the situation which would exploit mobility capabilities of the system to make gestures, body language, facial expressions, synchronization with stimulation, verbal expression, breath, etc. better observable. This will be also recorded for later comparison with the current state of a patient. The extraction of such multimodal signals may be required for patients with mild cognitive impairment such as attention deficit disorder, apathy, etc. to capture emotions and gestures, posture, etc. or chronic disease or mild disease (minor injuries). This information will be used by the health professional during the cognitive assessment. The sensor system in this way would become less invasive and would place the tests within a framework of more natural activity. The ability to position the system in a specific way also helps increasing the quality (signal / noise ratio) and would also simplify the image and/or audio processing for specific tests. In addition, new test types could be supported, e.g. exercises to find a particular place or a chain of activities (turn in place and return Mr. X's office). Furthermore, mobility can also be a component of stimulation to the patient as part of cognitive exercises.

Hence, the functionalities and system properties for the robotic solution for CGA are:

Technical requirements:

- A robotic device should be 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 like phase 3 of the process. Furthermore, discharge also should decrease health professionals' tiredness or fatigue perception as consequence of doing tests in a repetitive and mechanical way.
- Ability to ask patients/relatives questions of selected tests;
- Selection of tests by professionals to include in an individual CGA. A predetermined flow chart for test sequence may be considered, including the option to skip some tests[4];

[4] Adapting the tests for the use of closed questions and pre-specified answers will be considered.

- Easy configuration and development / implementation of new tests with minimal (ideally no) need for assistance by robotics or computer science experts
- Doing tests in a parallel way (patient and relative in separated rooms) might be very useful because the total time for the process can be reduced and the waiting time for patient and relatives can be avoided (see section 5 Use Cases)
- 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 interpret and codify patients/relatives answers in spoken language and by touch screen input of selected 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). 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.
- 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. Availability of patient's facial expression or voice before and after an antidepressant treatment may be another issue to be considered by Health Professionals to evaluate effectiveness of prescribed treatments.
- The solution must be able to evaluate patients' performance during walking tests (like gait and balance tests): recording the patient's performance, using standard components for motion analysis to the extent possible. A mobile platform may be deemed helpful to maintain sufficient visibility for the video and audio recording of patients during the tests.
- The solution must be portable in order to be moved around at the clinic
- All data must be stored safely and in an open format.

Overall system - Properties and non-technical requirements:

Mandatory:

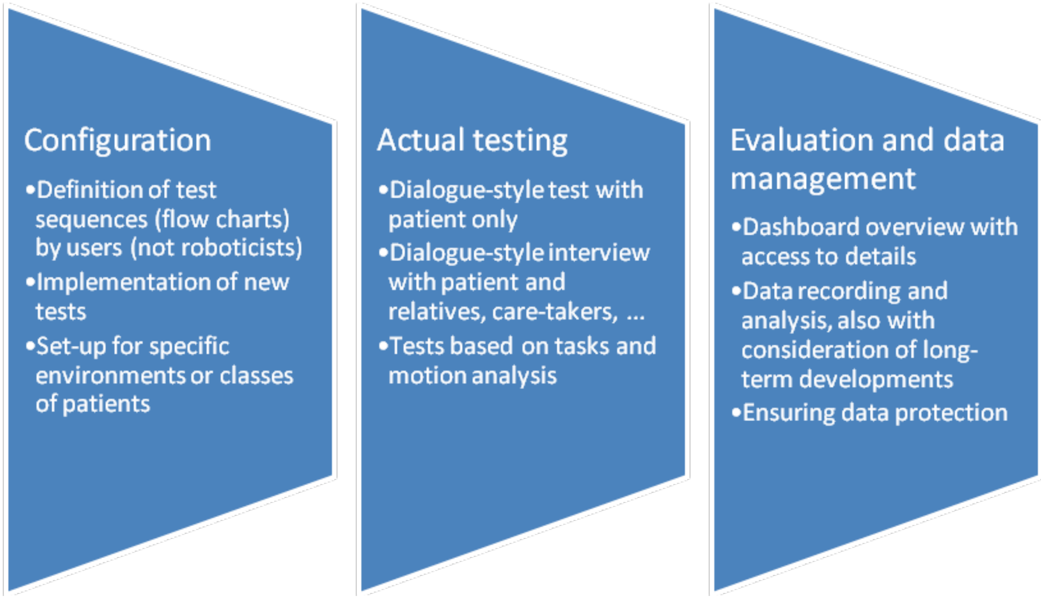
- The robotic solution should assist health professionals offering the possibility of relegating some tests, so that professionals shall be more focused on the other phases or tests improving the outputs of CGA's process.
- The design of the system must inspire trust both with the staff and with the patients and relatives. Patients have mentioned that the robotic systems should not seem dominant, e.g. by operating with humanoid/android hands.

Desirable:

- The solution should assist in clinical interviews, helping the staff to focus directly on the patient by having eye contact rather than looking into a computer screen. Also, the solution should help reduce the time spent on the clinical interviews, but still ensuring the quality and the proper data collection.
- The solution must be modular and scalable in order to ensure as big an international deployment to the extent possible.

- The solution can be built on already existing technologies as long as the RTD consortium has a legal agreement on further development of the existing technology. The consortium may also develop new technology for the CGA challenge.

Another way of grouping the required functionalities is shown in the following diagram: Functions can be grouped by different types of use.



Requirements and expected outcome at the different stages of the development according to the stages defined in the Guide for applicants[5]

	Stage I (first 6 months)	Stage II (month 7-18)	Stage III (month 19-30)
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.	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-	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	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.	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.	Prototypes meeting the specification, the portability has to be demonstrated.
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 an critical problem because the device will be used in patient's rooms or small places where plugging may be very complicated	The stage II prototype can be powered by cable.	The prototypes must be able to be operated both in battery mode and plugged as specified.
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.	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	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	Mock-up of touch-screen based interaction for	Demonstration of touch-screen based	Full implementation of all dialogues

[5] See http://www.echord.eu/fileadmin/user_upload/Services/PDTI-call/Guide-for-applicants-2014-12-22.pdf

	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.	interaction for all sorts of dialogues in the prototype resulting from stage II, capability for multi-language support has to be demonstrated	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	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	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go test	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
Actual testing			
Dialogue (questionnaire)-based tests	Mock-up of the dialogue-based Barthel test	Implementation of the dialogue-based Barthel and MMSE 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	Mock-up of the Get Up and Go test.	Implementation of the motion tracking component and prototype of the analysis software and the dashboard for this functionality, get up and go test	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	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.	Full recording capability to be demonstrated	Full recording capability integrated
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 visualisation of the motion analysis.	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 visualisation of an analysis	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 visualisation 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	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 of these functions in the prototypes
Integration into clinical data management	Possibility to interface with clinical data systems in the overall concept	This version does not need to be able to be integrated into the overall clinical data management system	Prototypes able to be integrated into the overall clinical data management system
Data protection	Description of data protection concept and fulfilment of standards	Refined concept for data protection concept and fulfilment of standards and its integration into clinical data management systems	Proof of concept for integration into clinical data management systems including data protection 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	System dialogues for selection of tests, handling of patient data	Final version of system dialogues for selection of tests, handling of patient data
Integration of new/additional tests	Mock-up of a functionality to develop a new questionnaire-type tests.	Functionality of adding a new questionnaire. This should be doable by medical staff with help of system engineers.	Functionality of adding a new questionnaire. This should be doable by medical staff only.
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.	Proof-of concept in context with the prototype	Actual demonstration of adding a new analysis in context of the final evaluation
Calibration	Mention, if there is a need to calibrate the motion detection component	If calibration is needed, a first version of the calibration functionality (operated by system engineers) needs to be shown	If calibration is needed, the calibration functionality (operated by clinical staff) needs to be shown

[6] An example of such a test sequence is given in Annex I.

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	

5 Use cases and expected demonstrable outcome

This use case will be a typical example of a test to be performed when evaluating the prototypes at the different phases of the development process.

Dr Fernández, geriatrist, receives a request from Doctor Bonilla for cognitive assessment of Mister Charles Balot, an 85 year old male patient living alone who has three children living far away from him. During the last three months they have detected memory problems and changes in Mr Balot's behaviour like including irritability and verbal aggressiveness along with careless handling at home (neglected toilet, expired food, etc.). Mr Balot does not recognize memory deficits neither his needs for support and goes to the visit almost exclusively because of the insistence of the family and Doctor Bonilla. His daughter, Marie, accompanies him. The scheduled time for the assessment is 60 minutes.

Dr Fernández thinks that, due to the different point of view between the elderly and his relatives, it is important to gather information separately from both the patient and his relatives. Therefore, he plans the CGA process as follows:

1. Clinical assessment with patient and his daughter.
2. Functional evaluation: Barthel and Lawton tests separately answered by patient and daughter.

3. Mental evaluation (cognitive and behaviour): subjective assessment of the patient, MMSE and Yesavage tests.
4. Social evaluation: direct interview with both, patient and relative.

At the beginning of the assessment the doctor receives Mr. Balot and Marie. After the initial review of Mr Balot’s health status, Doctor Fernández proposes Marie to go with the assistant robot to perform the Barthel and Lawton tests while he stays with Mr Balot asking him questions to build up a subjective impression on Mr Balot's awareness of his limitations.

Mr Balot and Marie agree with the proposal of Dr Fernández. During the interview Mr Balot denies having problems for self-care and behaviour changes affecting his personal relations. At the end, Dr Fernández asks Mr Balot’s consent to interview Marie to get her impression on her father’s behaviour and memory and invites Mr Balot to go with the robot to perform the MMSE, Barthel and Lawton tests. In addition, the Tinetti Gait and Balance tests are performed to get a full overview of the patient’s status.

Finally, the three of them meet again to complete the social assessment.

Mr Balot’s results are:

Type of Assessment	Participants	Test		Total Score	Interpretation
Functional Assessment	Patient-Robot	Barthel	Barthel 6 months ago	100	Autonomy for basic activities
			Barthel at present	100	
		Lawton	Lawton 6 months ago	4	Autonomy for instrumental activities except transport
			Lawton at present	4	
	Relative-Robot	Barthel	Barthel 6 months ago	100	Patients' independence to perform basic activities
			Barthel at present	100	
		Lawton	Lawton 6 months ago	4	Patient's impairment for public transport use. But Patient's capability to phone and manage money, medication and shopping.
			Lawton at present	1	
Mental Assessment	Patient-Robot	MMSE		16	Probable cognitive impairment
	Patient-Robot	Yesavage		6	Probable mood disorder

After reviewing these results, Dr Fernández explains that Mr Balot has probably a cognitive problem. He recommends to perform additional tests (laboratory, neuroimaging and extended cognitive tests) to have a better diagnosis and to start treatment for the behaviour symptoms identified. At this stage, some issues are discussed such as the need for monitoring Mr Balot’s medication and money management. Dr Fernández answers also to some questions of Mr Balot and Marie and a new appointment is scheduled to complete the assessment with the additional tests.

What are the benefits of using a technical solution?

Dr Fernández is partially relieved by the robotic solution during the 25 minutes needed to perform the 8 functional tests and has more time to focus on cognitive and behaviour assessments of Mr Balot.

- While Marie is doing functional tests with the robot, the Dr Fernández is able to maintain direct contact with Mr Balot to get an initial subjective impression of the patient's condition.
- While Mr Balot is doing functional tests with the robot, the Dr Fernández interviews Marie about his father’s health status; including changes in behaviour and cognitive deficits.

So, interviews held separately shorten the total length of the process. By this means, Dr Fenández gets also better information by about Mr Balot's cognitive deficits and behaviour alterations; when the interviews are held jointly, relatives are cautious and are hesitant to comment serious behaviour disturbances to avoid later adverse reactions from the patient.

Interacting with the robot instead of a healthcare professional during the cognitive tests (MMSE and Yesavage), Mr Balot feels more confident during tests. Interaction with healthcare professionals causes him to feel examined and more nervous, anticipating the consequences the results could have on his autonomy.

The time reduction by using a robot during CGA gives Dr Fernández more time to devise the most adequate care plan including complementary tests, supervision of medicines, etc. This additional time will improve the adherence of the patient and his relatives to treatment. This plan is finally agreed with Mr Balot and Marie.

6 Business model

The demographic dynamics and the economic crisis require urgent actions to make the delivery of health and social services to the elderly more sustainable and to increase independent living at home for older people.

The research and development in the Robotics for Comprehensive Geriatric Assessment Challenge will focus on frail older people aged over 80 with the idea that a robotics solution introduced should help to improve the overall status of patients.

The target users of robotics technology for CGA solutions will be the Health Professionals, patients and their relatives during the CGA process.

6.1 Expected benefits of a robotic solution

6.1.1 Parallelization and time saving during the CGA process

CGA process duration depends on the setting where it is performed. On average, between 2 and 3 hours per patient are needed to complete the assessment.

Most of time is consumed to gather information in Phase 1 and Phase 2 (see 2.3.3. Phases of GCA) and, usually, the Healthcare professional lacks of enough remaining time to evaluate results and draw up the personalised care plan for the patient.

For instance, when CGA in performed in Ambulatory Care Units the process lasts only 60 minutes. In this settings time is a handicap and the health professional needs to hurry in Phase 1 and Phase 2 in order to complete the process; but many times the CGA process is not completed in one session and has to be continued in further sessions also in other hospital setting (usually Day Care Hospital Unit). All in all, in ambulatory care units the health professional has a lack of time to perform the process; especially for the final and most important phase, where the personalised care plan is organised.

On average, the execution of tests in the Multidimensional assessment (Phase 2) takes over 50% of the total time of the process while the individualised care (Phase 3) plan phase only lasts 11 % of the time.

A robotic device should be able to manage autonomously the execution of some tests and assist the Health Professionals during Phase 2, freeing up time for them to focus on more important activities of Phase 1 or Phase 3. Furthermore, this should also decrease health professionals' tiredness or fatigue perception as consequence of doing tests.

It should be expected a reduction of more than 30% of Health Professional's time to perform tests by using a robotic solution.

If the Health Professionals reduce the time spending with supporting devices and focus their attention on patients and their relatives during the CGA's process, and enable them to have more time to be spent for care planning decisions itself (the analytic and comprehensive final step of CGA) instead to spend very valuable time for just doing tests.

6.1.2 What are the costs today?

CGA it is not a rapid process. The initial assessment and care planning for a full CGA is likely to take at least 1.5 hours of professional time, plus the necessary time for care plan negotiation and documentation; that represents a total of 2.5 hours. But as on-going review are needed periodically, at least twice a year, hospitals need to increase efficiency of CGA process to be able to attend more patients and absorb the increasing demand.

Some actual costs in Catalonia are:

- The public health insurer (CatSalut) pays hospitals per CGA process performed:

Type of assessment	2012	2013
Mental Assessment	207,81 €	198,25 €
CGA – Not Mental Assessment	147,45 €	140,76 €

- Each Assessment unit may attend 5 patients per day and there are waiting lists of 2 or 3 months.

6.1.3 Track the improvement

Extensive research has shown that CGA in hospital increases independence (individuals are more likely to go home after this process compared to standard medical care) and reduces mortality. A recent Cochrane[7] review showed that those who underwent CGA on a ward had a 30% higher chance (Odd Ratio 1.31 Confidence Interval 1.15 – 1.49) of being alive and being in their own home at 6 months.

Existing studies state that it is highly likely that CGA in any setting will be an effective intervention for an elderly person identified as having frailty. In the community there may need to be local flexibility in terms of what constitutes an interdisciplinary team and how the medical input is provided – nevertheless, the principle stands. The resulting individualised care and support plan must include information for older people and their carers about how and when to seek further advice and possibly information which defines advance planning for end of life care.

6.1.4 Health insurances and customers interest

To attend the increasing demand, health insurers and hospitals need to improve efficiency of CGA processes and, additionally, they have to increase elder population service portfolio.

Improving cost efficiency in patient treatments is, and will be in the future, a big challenge. Robotics integrated in health service delivery may be part of the required solutions.

[7] Comprehensive geriatric assessment for older adults admitted to hospital (Review); Ellis G, Whitehead MA, O'Neill D, Langhorne P, Robinson D

6.2 Business opportunities for the R&D consortia

The successful applicants will have the opportunity to develop a detailed concept and a first prototype within the first 6 months. After this first stage of the PDTI R&D work, 2 out of the initially 3 selected consortia are selected to further develop the system during the remaining phases.

The main opportunities of the scheme are to develop a system with close interaction with the end users, to get known not only in a local environment to a single user, but also to show close-to-market prototypes on a European level to potential customers at the end of the activities. Potential business models include selling and maintaining the systems, specific services such as the implementation of more complex and clinic-specific tests, etc.

ANNEX I: EXAMPLES OF CGA TESTS AND TEST SEQUENCES

The most relevant tests are given in the following table in form of web links to documents and videos, and examples for currently used test sheets are given on the subsequent pages.

Tests	Link
Barthel Index	https://www.youtube.com/watch?v=03IsiYJSk0o
Lawton Index	http://downloads.lww.com/wolterskluwer_vitalstream_com/AJN/TRYTHIS_EP13_CH1_FINAL.wmv
Time Up and Go Test	https://www.youtube.com/watch?v=j77QUMPTnE0
MMSE test	http://videos.med.wisc.edu/videos/15378
Yesavage test (short form)	http://consultgerirn.org/resources/media/?vid_id=4200933#player_container
Other tests	http://consultgerirn.org/resources

GUIDE FOR APPLICANTS

ECHORD++ PDTI activities

This guide, and all other information related to ECHORD++ Calls for Public end-user Driven Technological Innovation (PDTI) activities.
The call text and other documents needed to prepare the proposals can be downloaded from the following web-site: http://www.echord.eu

Open Call for Public end-user Driven Technological Innovation (PDTI) proposals within ECHORD++

The FP7 project ECHORD++ (European Clearing House for Open Robotics Development, Grant Agreement Number 601116, www.echord.eu) aims at strengthening the co-operation between scientific research and industry in robotics, as a follow-up to ECHORD (2009 – 2013).

ECHORD++ focuses on research and development with relevance to industrial applications and high market potential. For the technology development within the PDTI scheme, two application areas have been identified, Healthcare and Urban Robotics.

Different public bodies have submitted different challenges (technology needs) and out of this pool, a panel of experts has selected one challenge for each scenario: Robotics for Comprehensive Geriatric Assessment in the Healthcare scenario and Utilities Infrastructures and Condition Monitoring for Sewer Network. Robots for the Inspection and Clearance of the Sewer Network in Cities in the Urban Robotics Scenario.

Now, after the secelction of the challenges, R&D consortia have the opportunity to address these challenges by submitting proposals for both scenarios. Three proosals will be selected for each scenario to provide a system design within the first 6 months, then two of the three consortia will continue developing prototypes which are finally tested at the public bodies' sites in form of small-scale test series.

TABLE OF CONTENTS

Glossary of Terms

ECHORD++: European Clearing House for Open Robotics Development Plus Plus (E++ for short)

PDTI: Public end-user Driven Technological Innovation

SME: Small and Medium-sized enterprises form a specific target group for the experiments and the RIFs in E++. The term is used in exactly the same way as defined by the EC (http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm)

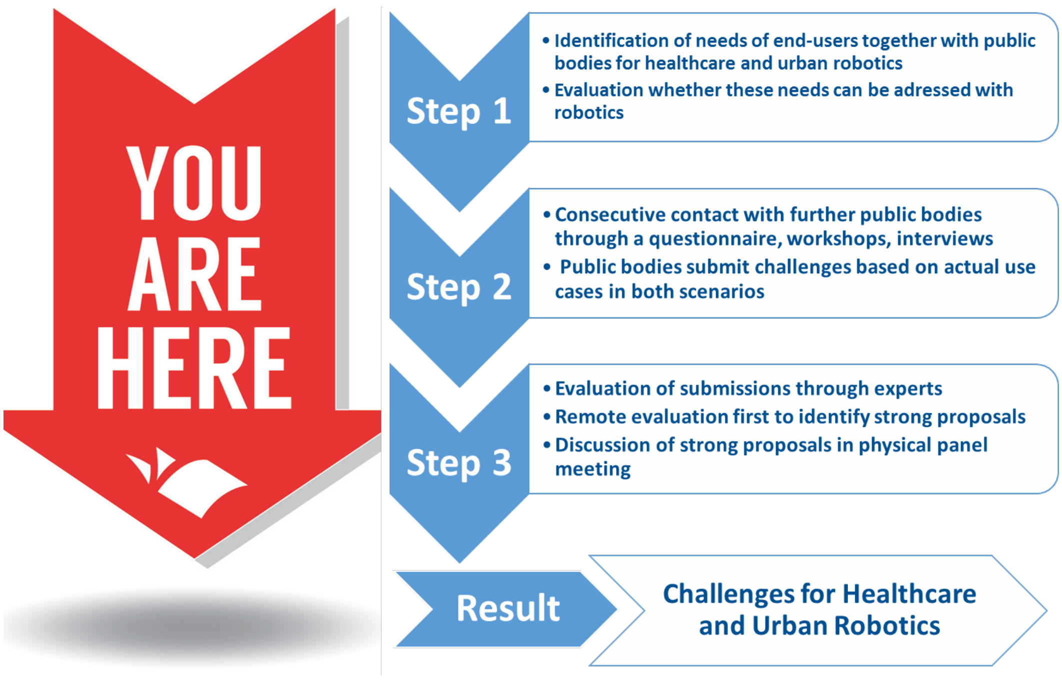
Scenarios: represent the expected use of state-of-the-art robot technologies in the near future, in case of PDTI Healthcare and Urban Robotics have been selected.

1 General Information

This guide is related to the FP7 project ECHORD++ (European Clearing House for Open Robotics Development, Grant Agreement Number 601116, www.echord.eu). ECHORD++ is a 5 year project, which aims at strengthening the cooperation between scientific research and industry in robotics, following the path developed by ECHORD (2009 – 2013, www.echord.info.

ECHORD++ focuses on research and development with relevance to industrial applications and high market potential. For the technology development within the PDTI scheme, two application areas have been identified, Healthcare and Urban Robotics.

Different public bodies have submitted different challenges (technology needs) and out of this pool, a panel of experts has selected one challenge for each scenario: Robotics for Comprehensive Geriatric Assessment in the Healthcare scenario and Utilities Infrastructures and Condition Monitoring for Sewer Network. Robots for the Inspection and



Clearance of the Sewer Network in Cities in the Urban Robotics Scenario. The process for the challenge selection is shown below.

2 Scenarios and challenges for PDTI activities

2.1 The challenge in Healthcare: Robotized Comprehensive Geriatric Assessment

The Comprehensive Geriatric Assessment (CGA) is a diagnostic instrument designed to collect data on the resources and problems of elderly patients. CGA is performed by many medical professionals. The goal of utilizing a robot to control and to conduct the geriatric tests is to reduce the amount of time medical professionals spend on taking tests and thereby enable them to invest this time on care planning decisions

2.2 The challenge in Urban Robotics: Robots for the inspection and the clearance of the sewer network in cities

Sewer inspections require many humans to work in risky and unhealthy conditions. Introducing a robotic solution in this process aims at reducing the labour risks, improving the precision of sewer inspections and optimizing sewer cleaning resources of the city. The robot should determine the quantity of sediments in the sewer by detecting abnormal levels of water or obstructions in pipes.

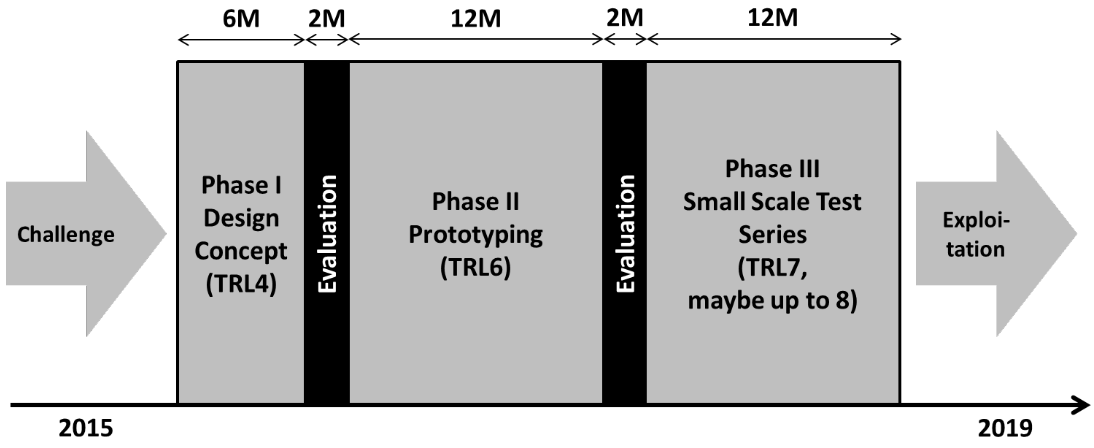
The individual challenge descriptions can be downloaded from www.echord.eu/???

3 Phases of the R&D development within PDTI

The technology development will take place in three phases:

1. System design (duration 6 months, 3 R&D consortia per scenario)
2. Prototyping (12 months, 2 R&D consortia per scenario)
3. Small-scale test series (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 development work.The timeline is illustrated below.



In both scenarios, ECHORD++ expects an increase in the Technological readiness level (TRL)[1] as shown.

4 Activities and reimbursement

The activities to be carried out in the context of PDTI activities may only cover Research and Technological Development activities (RTD), aimed at a significant advance beyond the established state of the art. Thus, RTD is the only activity type which is eligible for experiments within ECHORD++. Other types of expenses are not eligible for funding. The costs of the certificates for the financial statements (audits), if needed, are the only costs eligible under Management (subcontracting).

For the three phases, the following indicative budget is foreseen:

Phase 1: The total indicative funding for all 6 (3 per scenario) envisaged R&D consortia is 303 480 €, this means 50 580 € per R&D consortium for the first 6 months.

Phases 2+3: For the 4 R&D consortia (2 per scenario) selected after phase 1, the total indicative budget is 697 440 € for phase 2 (164 360 € per consortium) and 1 400 400 € for phase 3 (350 100 € per consortium).

Reimbursements will be based on eligible costs as defined in Article II.14 of the FP7 model grant agreement. Direct and indirect costs are to be identified in accordance with

[1]For a definition of TRLs in contect of robotics, see Multi-annual roadmap of euRobotics http://www.eu-robotics.net/cms/upload/PDF/Multi-Annual_Roadmap_2020_Call_1_Initial_Release.pdf, p. 117 ff.

Article II.15 of the FP7 model grant agreement. Maximum reimbursement rates of eligible costs for Research and Technological Development (RTD), in accordance with Article II.16(1) of the FP7 model grant agreement, are either 50% or 75% (the 75% rate applies to participants that are non-profit, public bodies, secondary and higher education establishments, research organisations and small and medium-sized enterprises (SMEs).

For hardware purchases (durable equipment and consumables) in the experiments, the maximum reimbursement is capped at 100% of the net acquisition cost. Depreciation rules may apply; proposers are encouraged to check this issue early with their organisation before finalizing their budget for the proposal.

The R&D consortia will receive a payment from the coordinator TUM at the beginning of their PDTI activities. This pre-financing will cover equipment costs (see above) and also part of the personnel costs. All other costs will be paid after the reporting period has ended, based on cost claims, and in accordance with the provisions of the Grant Agreement.

5 Ethical issues

Research activities in FP7 should respect fundamental ethical principles, including those reflected in the Charter of Fundamental Rights of the European Union. Therefore, questions about ethical issues are to be addressed in the proposal text. If ethical issues apply to an experiment, proposers must take appropriate measures before and during the run time of the experiment, including approval by the relevant commitees in cooperation with the public bodies which defined the challenge.

6 Submission of proposals

Proposal submission is web-based. The proposal must be submitted electronically via http://www.echord.eu before the given deadline. Call deadlines are absolute and strictly enforced. It is the proposers' responsibility to ensure the timely submission of proposals. The complete proposal consists of (i) completed and uploaded proposal template, (ii) completed web forms.

Shortly after the effective submission of the proposal, an acknowledgement of receipt thereof will be sent to the e-mail address of the proposal coordinator named in the submitted proposal. The sending of an acknowledgement of receipt does not imply that a proposal has been accepted as eligible for evaluation. For any given proposal, the R&D consortium coordinator acts as the main point of contact between the experiment partners and ECHORD++.

Upon receipt by ECHORD++, proposals will be registered and their contents entered into a database to support the evaluation process. Eligibility criteria for each proposal will also be checked by ECHORD++ before the evaluation begins. Proposals that do not fulfill these criteria will not be included in the evaluation. A proposal will only be considered eligible if it meets all of the following conditions: (i) it is received before the deadline given in the call text, (ii) template and web forms (all sections!) have been completed. The proposal must be submitted by legal entities which have been established in one of the member states of the EU or in an associated country. For a list of associated countries, see

ftp://ftp.cordis.europa.eu/pub/fp7/docs/third_country_agreements_en.pdf

Each proposal will be evaluated by at least two external experts (evaluators) who are independent of ECHORD++ and of the proposers, and where no conflict of interest exists. They will maintain strict confidentiality with respect to the entire evaluation process. Experts perform evaluations in their private capacity, not as representatives of their employer, their country or any other entity. Experts are to maintain strict confidentiality with respect to the whole evaluation process. Under no circumstance may an expert attempt to contact an applicant directly, either during the evaluation or afterwards.

7 Evaluation criteria

The evaluation of RTD PDTI proposals will be based on marks given according to three basic criteria:

1. **Scientific and/or technological excellence**

- How well the proposed technology addresses the challenge as detailed in the respective challenge description.
- How well does the proposed technology integrate the required functionalities? How intuitive is the technology for the end users? How easy can the technology

be integrated in the environment? How robust is the technology? Does it solve specific technological challenges (Mobility, Communication, etc.)?

- To what extent shows the proposal a clear plan for the development of a working solution.

2. **Quality and efficiency of the implementation and the management**

- How effectively will the project be managed?
- To what extent appears the consortium to have dedicated the resources (e.g. Human capital, equipment, man hours, etc.) necessary to perform the scope of the proposal
- To what extent the crucial risks (technical, commercial and other) to project success appear to have been identified and how effectively will these be managed

3. **Potential Impact through the development, dissemination and use of project**

- Does the project clearly identify a partner (as part of the consortium) who will bring the technology to the market?
- Does the project include a commitment to the commercialization of the technology?
- To what extent has the proposal the potential to address future / wider challenges in the area
- Return on Investment: Time span required to have the break even with the purchase of the device
- Time to commercialization
- Marketablity
- The price of the solution (including installation, training, maintenance,...) for totel cost - independent of the business model (sale or leasing).

For each criterion, (excellence, implementation and impact), a 0-to-5 mark will be given; the experiment proposal will be above threshold, if each mark is equal to or above 3 and the sum of the three marks is not less than 10. Half points can be used.

8 Selection of proposals

The selection will be based on the evaluation reports written by the external experts (evaluators). The final selection of R&D consortia to be funded will be made based on the outcome of a ranking of the proposals and the indicative budget planned for the call.

Based on this information, the European Commission will approve the final list of selected R&D consortia. The funding decisions and the evaluation summary reports will be sent to the proposers. The reports and evaluation panel minutes will be forwarded to the European Commission by ECHORD++. After the R&D consortium has been selected for funding, the partners involved in the consortium join the E++ Grant Agreement via an official amendment. They will also accede to ECHORD++'s consortium agreement.

During its run time, each R&D consortium selected for funding will be subject to a bimonthy scientific monitoring (remote via the ECHORD++ website), as well as to a final review, in certain cases also to a mid-term review by independent experts.

Template

For ECHORD++ PDTI[1] Proposals

- This template is for the ECHORD++ PDTI proposals "only for technology providers"
- Call open 15th January 2015
- This form may be submitted electronically any time before the 28th February 2015, 17:00 Brussels time, to the electronic submission facility at the ECHORD++-homepage at http://www.echord.eu

Text in red represents comments and should be deleted in your submission. Page limits refer to this text style in word: Times New Roman 11 pt font, Line spacing 1.15 lines, 6pt after, Standard A4 page size and margins

[1] Public end-user Driven Technological Innovation

Table of contents

Summary (limit: 1/3 Page)

This proposal addresses the challenge[2] in

☐ Healthcare

☐ Urban robotics

Please insert a summary of our proposal here. This summary should be a "Mission Statement" rather than a scientific abstract: The mission shall include a statement on the technology developed (how do you address the challenge); the step beyond the state of the art (can also be "system integration"!), the starting point and the impact. Make it short and crispy!

1 Scientific and technological quality (limit: 8 Pages)

Your technology should address one of the PDTI challenges, and your work must have the potential to produce/deliver tangible results: at the end of each phase (Phase I: Solution Design, Phase II: Development of Prototypes, Phase III: Small-scale test series). Make sure that there is a robust demonstration at the end of each Phase (Phase I: solution design (TRL: 4-5[3]); Phase II: working prototype (TRL: 6), Phase III: Small-scale test series (TRL 7, maybe 8). Note that there is also an impact section 2 below. The present section should describe the technical approaches in details and justify the technical feasibility, also taking the duration of the different phases as described in the individual challenge descriptions into account.

1.1 Progress beyond the current state of the art

Clearly describe the starting point of your technological development and in which way you intend to advance the state of this technology in order to address the challenge of the PDTI area in an ideal way. Clearly identify HW/SW components, sub-systems, frameworks, middleware, etc that are already available and outline in which parts you will do research/development and where you integrate. When writing this section of your proposal, please answer the following questions:

- What scientific or technological issue does the proposal address: scientific, technological, economic, etc.?
- How will this technology address the corresponding PDTI challenge? What are the specific approaches and why are the proposed solutions promising in the light of existing technology and products (if available, refer to section "Alternative or competing technologies/approaches")?
- How does this technology integrate the required technologies? Which aspects do you include in the technology development in order to make the technology / product intuitive for the different target groups? Outline how your technology will be integrated in the existing environment (clinical set-up or sewer inspection infrastructure). Which aspects are relevant here and how do you want to address them?

Please outline:

[2] For the description of the challences and background information, please refer to the respective challenge description and the guide for applicants, see www.echord.eu/XXX

[3] For the definition of the TRLs, please see http://www.eu-robotics.net/cms/upload/PDF/Multi-Annual_Roadmap_2020_Call_1_Initial_Release.pdf p 117ff

- The added value in terms of (enabling) technology, which the technological solution you propose, will generate. If you capitalize on the research of other projects: name any national or international research and innovation activities which will be linked with the project, especially where the outputs from these will feed into your technology. Please be concrete by giving examples, by referencing authoritative publications, studies, etc. Outline which aspects have prevented a change of the situation up to now and why you are now in a position to do it. Why you? Why like this?
- What will be possible after the completion of your technology that is not possible now? Describe the positioning of the technology, e.g. where it is situated in the pipeline in the three different phases. One way to describe the progress is to use Technological Readiness Levels (TRLs), as described in the current Multi-Annual Roadmap (MAR) of the euRobotics aisbl .
- Why and in which way do these approaches solve the problem and how do you overcome the obstacles that have prevented a problem-solution so far?

1.2 Alternative or competing technologies/approaches

What are the technologies which are available on the market? Which are the advantages of the technologies you will upgrade in your approach compared to the others? What is your advantageous over these competing technologies and what benefits you can get from them? Outline which alternative approaches to tackle the challenge would be possible – and justify why you decided to opt for your way!

1.3 Concept, methodology, and associated work plan

Provide a detailed description of the scientific and technological approach and/or methodology by which you will reach your objectives. Describe a progression of crucial milestones and decision points for your technology development and their expected timing. Make sure that you have tangible results at the end of each of the three Phases. When setting up your work plan, describe the outcome of each phase in a clear measurable way and state what can be demonstrated to both, technical experts and end users.

What would you consider to be a success? What would one learn from failure? Include measures for the overall assessment of progress and results.

Describe the overall strategy of the work plan as follows:

- Provide a work description broken down into tasks (for each of the Phases I-III):
  - Task list (use Table in section 1.3.1);
  - Description of individual tasks (use Table in section 1.3.2);
  - List of deliverables (use Table in section 1.3.3);
  - List of milestones (use Table in section 1.3.5)
- Show the timing of the different tasks and their components (Gantt chart).
- For the first phase, provide a detailed test plan, for the other two phases, outline the test plans.

- Describe any significant risks and associated contingency plans.

1.3.1 Task list

The number of tasks used must be suited to the complexity of the work and the overall value of the proposed technology. The planning should be sufficiently detailed to justify the proposed effort. Furthermore, the role of each partner (in the case of two or more partners) within each task should be clearly stated, including the corresponding forecast effort. Milestones should be sufficiently precise to allow progress monitoring.

Task List: Phase I (Solution Design – duration: 6 months)

Task No.	Task title	Lead Participant (short name)	Start month	End month
T1				
T2				
T3				

Task List: Phase II (Working Prototype – duration: 12 months)

Task No.	Task title	Lead Participant (short name)	Start month	End month
T4				
T5				
T5				

Task List: Phase III (Small-scale test series – duration: 12 months)

Task No.	Task title	Lead Participant (short name)	Start month	End month
T6				
T7				
T8				

1.3.2 Description of individual tasks

Task 1: [name and timing information, i.e. from month to month]		
Participant	Role	Person-months
Objectives:		
Description of work and contribution of individual participants:		

Task 2: [name and timing information, i.e. from month to month]		
Participant	Role	Person-months
Objectives:		
Description of work and contribution of individual participants:		

Add another table for every task that you want to define.

1.3.3 List of Deliverables

There should be at least one deliverable at the end of each phase, in case of major components or integration work done, few(!) additional deliverables should be included. Besides the official deliverables, we need a list of technological features you will concentrate on during the development, starting with Phase II. For each of the features we need an indication of how you will share the results with us to allow us to track the progress properly. Please avoid reports to the extent possible and work the communication of tangible results (illustrated by for instance simulations, videos, statistics, data & measurement etc.).

Del. No.[4]	Deliverable name	Task No.	Nature[5]	Dissemination level[6]	Delivery date[7]
SB	Story Board		O	RE	
MMR	Multi-Media Report		O	PU	
RIF	Report on RIF visit outcome (if RIF use is planned)		R		

[4] Deliverable numbers in order of delivery dates. Please use the numbering convention D<T number>.<number of deliverable within that <T>. For example, Deliverable 4.2 would be the second deliverable from Task 4.
[5] Please indicate the nature of the deliverable using one of the following codes: R = Report, P = Prototype, D = Demonstrator, O = Other
[6] Please indicate the dissemination level using one of the following codes: PU = Public, PP = Restricted to other programme participants (including the Commission Services), RE = Restricted to a group specified by the consortium (including the Commission Services, CO = Confidential, only for members of the consortium (including the Commission Services).
[7] Measured in months from the PDTI R&D project start date (month 1).

D1.1		1			

1.3.4 Summary of technology development effort (in person months, PM)

Please note that the budget you put in the proposal submission tool just covers phase I. Nevertheless, you are asked to distinguish here the PM for all three Phases in order to make sure that you will be able to realize the project within the give time frame and with the indicate budget which is available. The process and the indicative budget standing behind the three phases are outline on the website and in the Challenge Description.

Distribution of PM: Phase I (Design Development – duration: 6 months)

Participant short name	Taskl 1	Task 3	Task 3	...	Total PM

Distribution of PM: Phase II (Prototyping – duration: 12 months)

Participant short name	Taskl 1	Task 3	Task 3	...	Total PM

Distribution of PM: Phase III (Small-scale test series – duration: 12 months)

Participant short name	Taskl 1	Task 3	Task 3	...	Total PM

1.3.5 List of milestones

Milestones (MS) are control points where decisions are needed with regard to the next stage of the technology development. For example, a milestone should be defined when a major result has been achieved, if its successful attainment is required for the next phase of work. Another example would be a point when the consortium must decide which of several technologies to adopt for further development.

Milestones: Phase I, Phase II and Phase III

MS number	Milestone name	Task(s) involved	Expected date[8]	Means of verification[9]
Milestone Phase I	Full system design; demonstration of major features critical for the technology development including risk analysis; timeline for the entire project (Phases II and III)		M06	tbd by applicant

[8] Measured in months from the PDTI R&D project start date (month 1).
[9] Show how it can be checked that the milestone has been attained. Refer to indicators if appropriate.

Milestone Phase II	First Field Trials: Technology demonstration at the site of the public bodies involved. Main functionality is realized at a degree that experts at the public bodies can carry out pre-defined tests, when accompanied by developers.		M20	tbd by applicant
Milestones Phase III	Engineering Prototype Development of prototypes with final technology sub- systems or close analogues in a close to complete form factor. All identified functionality is capable of being demonstrated. Verification trials (independent of developer support) by public bodies possible		M34	tbd by applicant

1.4 Technological risks

What are the risks of the technology development and what is your plan to address these risks? Please make sure that you have identified all the crucial risks (technical, commercial and others) and that you demonstrate how these will be addressed and overcome effectively. Which are potential obstacles to commercialization – and how do you want to address them? The risk assessment should be geared to the three phases (design, prototyping and small-scale test series).

1.5 Intellectual Property and Ethical Issues?

What are your plans to address IP (e.g. patent) issues to protect the technology rights? As exploitation / commercialization is the clear goal of PDTI, it is of utmost importance that you illustrate how you want to handle this issue within the consortium. Hinting to the Consortium Agreement to be signed after the acceptance of the proposal is NOT enough at this point. What is your plan to address Ethical Issues and certification process?

2 Impact (Limit: 4 pages)

2.1 Expected results

Describe the impact generated by your results, e.g., the long-term effects on the robotics community, the market structure, and the economic prospects. Please distinguish between the scientific impact, the technological impact, and the economic impact you expect. The impact should be a) realistic, b) transparent and c) measurable. Please state the indicators by which you would like the impact to be measured and make a distinction between the three phases. Indicators are, for example: creation of new products, revenue, competitive edge, creation of new jobs. Market intelligence to substantiate your information is helpful (trends, graphs, tables). Measures should address the full range of potential users and uses, including research, commercial, social, environmental, contribution to standards, and the commitment of a robot manufacturer to use the work in their future product program. Additional indicators can refer to "networking": joint industry-academia publications, new collaborations, impact of the scientific work of the research done in other institutions, sections or disciplines etc.

Aspects which are crucial to illustrate the impact:

- Please identify clearly the partner within the consortium who will commercialize the product.
- Please illustrate how you will ensure that there is a strong commitment to further develop and commercialize the technology. Please outline the time to commercialization, which efforts will be required after the runtime of E++ in order to do so and how you intend to manage this.
- Please demonstrate the scalability of your technology (which potential has it to address future / wider challenges in the area?
- Please include a business plan and reveal your calculation on "Return on Investment": Only proposals with a binding commitment on exploitation are eligible.
- Which is the target price of your technology to the end user (clinics), how did you calculate this and why do you think that you need this price level in order to be successful with the commercialization of the technology?

2.2 Exploitation plan of project results and management of knowledge and of IP

Try to describe all possible exploitations of the outcome, highlighting any know-how and technology transfer between academia and industry. Examples are: new product generation, founding new companies, creation of patents, etc.

2.3 Dissemination plan of technology development results

The means for dissemination of project results, both to the scientific community and to possible end-users or producers of the technology have to be clearly stated. The dissemination plan should describe measures and target audiences, e.g. presence at trade shows and/or conferences, association meetings, workshops, creation of multi-media material, scientific papers, articles in industrial magazines, etc.

Events/Media	Name of Events/Media	Target-groups relevant to product/technology	Impact of the activity / reason for selecting this one	Time of activity during project run time
Fairs				
Magazines, newspapers, journals, etc.				
Conferences				
Multi-media or web based dissemination				
Other				

3 Implementation (limit: 3 pages)

3.1 Individual participants

For each participant in the proposed technology, provide a description of their organization and their specific role in the project (which competence do they provide?), the main tasks attributed to them, and their previous experience relevant to those tasks. Provide a short profile of the staff members who will be undertaking the work and their commitment expressed as a percentage of the full-time equivalent.

Name of the participant

Description of the legal entity and previous experience relevant to assigned tasks

Profile of the staff members that will undertake the foreseen work in the technology development. These people are also expected to come to meetings.

The coordinating participant has to be indicated.

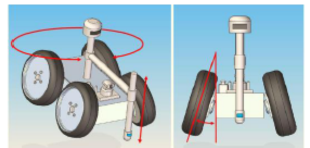
3.2 Description of the consortium (if more than one partner)

Describe briefly the complementary competences within the consortium.

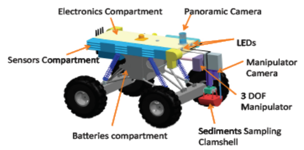
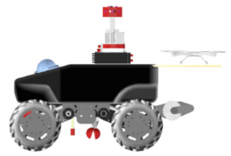
3.3 Overall resources – costs and funding

Justify the budget, e.g., list equipment to be purchased and why it is needed, describe travel expenses, and other major cost items. The overall budget tables are in the budget calculator – no need to repeat this here. Include costs for travel, including to joint events such as workshops, and for dissemination and exploitation events during the run time of the technology development, for the creation of a multimedia report, and etc. Please note that we need a complete planning of resources for all three phases even you will only enter the budget calculation for the first phase in the budget calculator.

Propostes ECHORD++

Proposal number			1	2	3
Acronym			ARSI	ELSIE	ORSON
Project full name			**Aerial Robots for Sewer Inspection**	**Enhanced Large Sewer Inspection**	**Operativr Robotic Sewer Observation Navigator**
Consortium	1	**Participant name**	**Fundació privada ASCAMM**	**Robotnik Automation, SLL**	**Universidad de Málaga**
		Department	Unmanned Systems	R&D	Ingenería de Sistemas y Automática
		City - country	Barcelona - Spain	Valencia, Spain	Málaga, Spain
	2	**Participant name**	**Fomento de Construcciones i Contratas (FCC)**	**INLOC Robotics**	**Joanneum Research**
		Department	Environment Barcelona	-	Digital
		City - country	Barcelona - Spain	Cabrils, Spain	Graz, Austria
	3	**Participant name**	**Simtech Design S.L.**	**Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung E.V**	**Techniche Universitaet Dresden**
		Department	-	IOSB - Institute of Optronics, System Technologies and Image Exploitation	-
		City - country	Barcelona - Spain	Munchen, Germany	Dresden, Germany
	4	**Participant name**	**IBAK Helmut hunger GmbH & Co. KG**	**Hidrotec Sanejament S.L.**	
		Department	-	-	
		City - country	Kiel - Germany	Sant Cugat del Vallès, Spain	
	5	**Participant name**	**Fundació Barcelona Media**		
		Department	Image Research Group		
		City - country	Barcelona - Spain		
	C		Robotics + image processing + sewer inspection	Robotics + image processing + sewer inspection	Robotics + image processing
Type of robot			Micro aerial vehicle (MAV) multi rotor platform	Wheeled vehicle + mini-drone to be defined	Wheeled skid-steer vehicle + maneuverability arm
Image			No image	No image	
General		**Movement**	Aerial	Terrestrial + aerial possibility (to define)	Terrestrial
		Suitable for visitable sections	Yes	Yes	Yes
		Diameter of sewer	From less than 1m to all types of visitable sewers	Above 800 mm	Above 800 mm
		Robot size, weigth & other dimension characteristics	Suitable for less than 1m diameter sewer Multi rotor platform: 55 cm diameter Pay-load: limited to 1 kg	. To asses during the project	Weigth: 60Kg Tread width: 0,4m
		Water/humidity protection (IP)		IP47	
		Robot cost	12K€	50K€ (+6000€ per unit and year) Expected lifetime product: 6 years Addicional cost of an equipped van to provide inspection service: 25K€	
Functions		**Mapping**	Yes	Yes	Yes
		Structural inspection	Yes	Yes	Yes
		Sediment inspection (hydraulic capacity reduction)	Yes	Yes	Yes
		Air inspection	To be valued during the project	Yes	Yes
		Water inspection	No	Yes	Yes
		Sampling (air, water or sediment)	No	Yes	Yes: water and sediment (300ml)
Operativity		**1.Teleoperated**	Yes	Yes (1st mode + teleoperated mini-drone)	No
		2.Semi-autonomous	Yes	Yes (2nd mode)	Yes
		3.Full autonomous	Yes (self-activated when communication is lost)	Yes (3rd mode)	Yes
		Energy	Electricity (Battery)		LFP batteries
		Type of light			
		Hours of autonomy	20 min. Maximum endurance	To asses during the project	12h
		How it works mobility and autonomy	Flying, hovering, 20 minutes of autonomy with full payload	It seems that works like the Summit XL series of comercial robots (http://www.robotnik.eu/mobile-robots/summit-xl/) but with the modifications it is this operativity	electric wheeled skid-steer vehicle with a maneuverability arm
		Speed	(Much higher than the average inspection speed achieved by humans).	3 Km/day (maximum speed: 10 Km/h)	0,5m/s (1800m/h) Real effective inspection per journey: 1000m/day
		Inspection cost (actual cost 0,75€/lineal meter)	0,5€/lineal meter	To asses during the project	0,45€/linear meter
Communication and		**Wireless technology**	Yes	Yes	Yes
		Communication	- areas where an operator has previously deployed a set of repeaters and - areas where the MAV itself will deploy disposable communications nodes to extend the coverage of the network	- Wifi using range extenders in manholes - mono-mode fibre optic motorized roll to tackle any contingency on this subject	Two systems: - low-bandwidth: for robot supervision - high-bandwidth: for transfering full-resolution image data If supported the beacons could also be equipped with repeater functionality to extend antenna ranges within the sewers
		On-board data processing	Yes		yes. real-time processing with a subset of data. Low resolution
		Off-line data processing	Yes	Yes	yes. - Based on the captured images. Full resolution. - provide data for time series
		Localization algorithms	yes	yes	Yes - Odometry - adicional vision sensors used to precised localization

Propostes ECHORD++				
Proposal number		1	2	3
Acronym		ARSI	ELSIE	ORSON
Communication and data processing	Navigation algorithms	Yes. - Path planning for sewer tracking - Autonomous exploration executor	yes. Path planning and plath execution for autonomous navigation capabilities	Guidance: planning, tracking, obstacle avoidance Localization and mapping
	Mapping algorithms	- geometric mapping to enable autonomous navigation based on SLAM	yes. - Implemented to build a metric representation of the environment - a place recognition algorithm	yes. - 3D-mapping. Full resolution map. - labeing wall openings, extracting a topological junction map
	Structural inspection algorithms	Yes. - Visual and range sensors to determine sewer serviceability - image processing techniques, morphological operators and edge detection algorithms to detect cracks and joints	yes. Image processing techniques: - provide sewer serviceability - 3-D scanning of the inner side of the pipes - stuctural defects detection and identification	- use a cylindrical model to map texture and structrure in a regular grid - diferent ways of representing the surface (virtual 3D, unwrapped surface). Allow virtual zooming-in. - advanced automated image interpretation and damage detection algorithms - comparison of measurements at different times (e.g. crack width)
	Sediment inspection algorithms			
	Integration to GIS	Yes		
	Data collected	Geotagged and timestamped		
	Outputs georeferenced	Yes	Yes	NO
	Type of data reception	video, scanned data	video, images, data from air and water sensors	- 3D-model with overlaid texture - 360º panorama every 10 cm of robot travel - status information
	Software features		Software will be ROS based	web based solution for user console
	Other interested features			
Specific	Location and navigation devices	Visual-Inertial Sensor, Ultrasonic sensor, laser range finder, cameras	infrared cameras	càmeras (fisheyes + laser scanning)
	Inspection devices	Camera and laser sensors	digital video, 3D scanning,	càmeras (fisheyes + laser scanning) 3D model
	Air quality sensors	Tª, %RH, CO, H_2S, CH_4, LEL, VOCs	Tª, %RH, CO, H_2S, CH_4, LEL, VOCs	Tª, %RH, CO, H_2S, CH_4, LEL, VOCs, NH_3, O_2
	Water quality sensors	Tª and other environmental sensors	Tª, pH, conductiviy,	pH
Summary of	Infrared camera	Yes	Yes	No
	Ultrasonic sensor	Yes	No	No
	Sonar sensor	No	No	No
	Electromagnetic sensor	No	No	No
	3D representation	No	Yes	Yes
	Camera 3D (stereo camera)	Yes	No	Yes
	Laser sensor	Yes	No	Yes
	Lighting			
	Images in 360º	Yes	No	Yes
	Lidar or Ladar	Yes	Yes	Yes
	VI-sensor (Visual-Inertial Sensor)	Yes	Yes	It seems that yes, because it talks about proprioceptive sensors
	3D mapping	Yes	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.	Sewerage is one of the most important global infrastructures requiring continuous inspection: if damaged or blocked, there is a significant environmental, social and public health risk. Our solution for large sewer inspection builds up on a commercial robot platform, providing a new approach with respect to existing market solutions, targeting sewer mains with diameter >800mm significantly increasing inspection performance. Up to now inspection of big sewers is human based; we offer three robot modes: teleoperated, semi-autonomous and autonomous, including the novelty of a farexploration mode by using a little drone acting the robot platform as mother-ship. We target TRL4 level in Phase I, demonstrating our solution in a similar structural environment to that of sewers; TRL5 and TRL6 levels in Phase II, including localization, mapping, navigation and image based functionalities which will be tested in the real sewers; TRL7 and TRL8 levels in Phase III demonstrating an integrated system fully operational in large sewers providing all the information needed by an infrastructure manager. Our system is designed to be scalable and adaptable to future improvements. We expect a high economic and social impact: over 20.000 municipalities and public entities in Europe contract sewage inspection from SME. Our business model is very clear, as it is the role of each partner during and after the project. It is reasonable to anticipate a market penetration of 5% within 5 years of the project completion, meaning expected sales of 1.000 units for servicing the public sewer networks. Social impact will be regarding the creation of employment, as the 3 SMEs involved in the project are expected to rapidly grow thanks to sales and services offered. Also, scientific impact is expected by contributing with a new integrated system and innovative approaches to concrete challenges as localization, navigation or image based functions.	Our mission is to meet the requirements for developing an intelligent robotic sewer inspection system to identify sediments, structural damages and ambient conditions with the ultimate goals of reducing labor risks and optimizing maintenance and performance of city sewer networks. To this end, we will develop a system that will integrate: i) an easily deployable specialized electric wheeled skid-steer vehicle with a maneuverability arm; ii) an onboard sensor suite consisting of proprioceptive sensors, cameras and optionally a laser scanner for autonomous navigation, on-line inspection, tele-operation, accurate three-dimensional (3D) map building, and ambient monitoring; iii) a removable wireless communication system between the control station and the robotic vehicle in the sewer; and iv) an intuitive operator console by use of non-specialized off-the-shelf hardware with functionalities for sewer inspection and robot control. The major improvements of this robotic system over current sewer inspection support vehicles in contrast to already existing solutions are: autonomous navigation to reachable points of interest (e.g., manholes) in the network, untethered motion with rechargeable LFP batteries, full resolution textured 3D sewer modeling, wireless communication, and advanced web-based console.

4	5	6
ROBODILLOS	**SEWIRIS**	**SIAR**
A Networked Mobile Robotic Platform for Shared Autonomy Sewer Inspection Operations	**Sewer Intelligent Robotics System**	**Sewer Inspection Autonomous Robot**
Cyprus University of Technology	**Robotnik Automation, SLL**	**Universidad de Sevilla**
Mechanical Engineering and Materials Science and Engineering	R&D	Ingeniería de Sistemas y Automática
Limassol, Cyprus	Valencia, Spain	Sevilla, Spain
Helikas Robotics, LTD	**GMV**	**IDMIND**
Technical	-	R&D
Nicosia, Cyprus	Tres Cantos, Spain	Lisboa, Portugal
	Universidad Politécnica de Madrid	**Universidad Pablo de Olavide**
	Center of Automation and Robotics UPM-CSIC	Systems Engineering and Automation
	Madrid, Spain	Sevilla, Spain
	Universidad de Málaga	
	Ingeniería de Sistemas y Automática	
	Málaga, Spain	
Robotics + image processing	Robotics + image processing	Robotics + image processing
Wheeled vehicle	Wheeled vehicle + mini-drone (Parrot Bebop)	Tracked vehicle
		
Terrestrial	Terrestrial + aerial	Terrestrial
Yes	Yes	Yes
Visitable sewer	Above 50 cm width (semi-visitable and visitable sewers)	Non visitable sewers (pipes) to visitabvle sewers (with differents configuration of robot)
Weigth: 18 kg Height: 0,51m Length: 0,75m Width:0,58m Ground clearance: 0,22m	Target weight below 60kg Possibility of tracks instead of wheels	Robot main body with adjustable width (updated with wheels/belts kit with diferents widths easy to assemble in order to adapt on the tipe of sewer).
		IP67
Robodillos basic package (2 robots and a base station): 101.045€ (101K€) - 1 robot: 38.815€ - base station: 23.415€	In 2017 (forecast sales of 5 units): 50K€ In 2020 (forecast sales of 10/15 units): 25K€	50K€ Expected lifetime product: 5 years Annual cost of maintenance of 15% of initial cost Total value for 5 years: 87,500€
Yes - Simultaneous Location and Mapping (SLAM)	Yes	Yes
Yes	Yes	Yes
Yes	Yes	Yes
Yes	Yes	Yes
Yes	Yes	Yes
Yes: sediment (300ml), water (400ml), air (530mg of active carbon)	Yes: water (400ml), sediment (400gr)	No
Yes	Yes (for a 100m length)	Yes
Yes	Yes	No
Yes	Yes	Yes. with the possibility of control from a human operator in case of need
650 Wh (Polymer battery 22,2 VDC 20 Ah)	Battery system	Batteries
Sensor imaging: low-light hight resolution digital cameras	LED lamps (min of 10 LUX)	
4h	8h	5h (more than 3Km per battery charge) The project will study the extension of the autonomy depending on sensors and computational resources onboard
First layer: Motion task planning and control algorithms utilised through the GNC3 architecture **Second layer**: Robodillos mechanical, electrical/electronic and computing systems	It seems that works like the Summit XL series of comercial robots (http://www.robotnik.eu/mobile-robots/summit-xl/) but with some modifications like telescopic mast for long-range inspection and a slave mini-drone as a complementary extension	It seems that works like the RaposaNG series of comercial robots (http://sparc-robotics.eu/raposa-ng-a-search-and-rescue-land-wheeled-robot/) but with modifications to adapt the robot to the sewer
2-3 m/s (top speed: 3,2Km/h) - 2 robots and a base station: 3400m/8h - 5 robots and a base station: 5360m/8h	Maximum speed 2,5-3m/s.	25 to 50 cm/s (0,9 to 1,8 km/h)
- 2 robots and a base station: 0,174€/lineal meter - 5 robots and a base station: 0,111€/lineal meter	0,5€/linear meter	0,51€/linear meter
Yes	Yes. Only the drone	Yes. Since the beginning of the project.
First layer: NLOS (non line of sight) radio technology: - Coded Orthogonal Frequency division (COFDM) - Mobile Networked Multiple Input Multiple Output (MN-MIMO) - Antenna Techniques and Mobile Ad-Hoc Networking (MANET/mesh) **Second layer:** a dedicated communicaton module allocated in the robot enables a high-level definition of network connectivity - The laptop computer communicates through cable with the base station that is submerged in the manhole.	- robot: an umbilical and retractable cable (power and data) with a lenght of 100m - mini-drone: dettachable and optional add-on.- Can be teleoperated by the worker or by the robot itself. Will include sensors to compute and control its relative position and orientation.	- integrates a communication system able to automatically deploy or recover wireless repeaters along the robot path, enabling long distance communications without cables - the project will analize and will make use of COTS equipment available on the market - It will be possible to transmit bidireccional data between robot and operator
Yes real time 3D visualization of the sewer, its elements and the robot localitzation		yes
Yes	Yes	yes
The SLAM module localizes the Robot and the sewer elements including manholes, home drain inlets, street drain inlets	yes. Esitmated from raw measurements and the integrated 3D sensor	- Include a map-based localization system - The global back-end framework will be based on the sewage system map and automatic detection of sewer intersections based on local sensing. This information will be used together with the robot odometry to build a reliable position estimation - Passive radio frequency identification previously deployed in the sewers will be used to reset the robot position - project will explore the use of radio-based time-of-flight (ToF) sensors as global position anchors

4	5	6
ROBODILLOS	**SEWIRIS**	**SIAR**
The navigation sensor suite is designed to provide the necessary robot motion related information to the first layer algorithms. The first layer consists of the Mobility and Autonomy algorithms, comprising the Local Motion Task Planner, the Low Level Locomotion Control and the Low Level Manipulation Control modules in the GNC3 architecture. This module provides collision avoidance, tip-over avoidance and navigation capabilities with the last ranging from mixed initiative tele-operation to fully autonomous operation.	yes. Using the generated maps Use of path planners to find the optimum path to the desired target	- inertial and computer vision methods (based on low-cost RGBD cameras) will be used together with Kalman filtering data fusion techniques to reliably estimate the robot motion with high fidelity - efficient implementations for 3D motion and path planning, considering the perception of the environment
The Simultaneous Localization and Mapping (SLAM) module is responsible for fusing a-priori information about sewer topology and sewer element location with 3D geometric information provided by the laser depth imaging system,with information provided by the navigation sensor suite and with system dynamics information, creates or updates the sewer maps	yes. - combined 3D sensor: integrating ToF cameras and CMOS cameras - near real-time 3D point cloud will be postprocessed to generate 3D, obstacles and roughness maps - From the initial 3D model of the sewer (if existing) and the point cloud measurements the mapping module generates a navigational map - this map will be use to localize sewer elements	3D cameras can metrically reconstruct 3D environment with small errors, interesting for sewer impairment detection
Locate and identify critical structural defects including cracks, fractures, breaks (with or without loss), and collapse.	- Imaging, 3D point cloud processing and machine learning algorithms allow the precise identification and location of sewer elements (manholes, bifurcations) and identify location of structural defects (cracks, breaks, ...) - previous knowledge on tunnel morphologies can be used to make finer decisions	- Development of new techniques for automatic online detection of sewer elements from the 3D scans obtained by RGBD sensors. Geometry-based methods will be considered, by comparison of the reconstructed scans and the previous models of the sewers; along with supervised learning algorithms over the 3D reconstructions of the robot environment - The detection of structural defects will be based on the same ideas. - A multi-sensor map including visual, 3D point-cloud, inertial, temperature and other environmental sampling sensors will be generated offline and used for easy impairment detection and critical structural defects
- First layer algorithms determine the existence and level of bulky waste (stones, construction debris, wood, sticks, etc.) from the surface variations in 3D laser scan data. - Tip guidance is performed through algorithms local to achieve waste height measurement. Timetagged and located. - Quantify the sewer serviceability by parameters: the thickness of the waste accumulated in the tunnel gutter, the waste height deposited on the sill, in the bucket and at the curb. Based on this result the User Interface will be able to appropriately notify the user of the current sewer serviceability state, while producing a "pop-up" alarm in case of serviceability reduction.	- the generate maps will be used to detect the level of waste in gutter tunnels by measuring both cross-section and longitudinal section profiles	- Determining sewer serciceability
		a topological map with metric distant information and sewer connections will be enough
yes. With GPS coordinates !!!		yes. The elements will be geo-referenced into a global frame
digital images, real time video, HD video, real-time streaming, 3D point cloud	drone -> images and short video sequences - stream HD video - 360º inmersive views (imaging, depth point cloud and temperature) - collected measurements, images and data	
high level sewer monitoring and decision support to enable identification of human safety and risk situations, to locate and follow spills and leaks, determination of tendencies and environmental research	- model driven development (refined iteratively) - Use of ROS framework	- Intuive GUI will help decission taking and commanding the robot
	- olfactory systems oriented to localize the source of gases and odors - generate gas distribution maps (from the sparse set of measurements)	- prepared for plug and play connections in ordre to interexchange different sensors - the methodology will be based on iterations over working platforms
Suite of sensors to use the technic SLAM	SLAM technology and 3D mapping	Lidar technology and 3D mapping
càmeras (fisheyes + laser scanning) 3D model, sonar, VI-sensor	Telescopic mast, mini-drone, pulleys for sediments samples	Cameras
Tª, %RH, CO, H2S, CH4, O2, LEL, VOCs	Tª, %RH, CO, H2S, CH4, VOCs, O2 and anemometer	Tª and other environmental sensors
Tª	Tª, pH, conductiviy, turbidity	Tª and other environmental sensors
No	Yes, matrix installed under the robot body to control the pulleys displacement to take sediments samples	
No	Yes, for air sampling it will use an ultrasound anemometer, to gather data about airflows.	No
Yes	No	No
Yes	No	No
Yes, with SLAM	Yes, with SLAM	Yes
Yes	Yes	Yes
Yes	Yes	
	LED lamps (min of 10 LUX)	
Yes	Yes	No
No, uses SLAM	No, uses SLAM	Yes
Yes	Yes	Yes
Yes	Yes	Yes
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.	This proposal presents SEWIRIS, an autonomous robotics system fully compliant with all sewer inspection and monitoring requirements. Our proposed design is based in Summit XL, a mature and robust mobile wheeled-robot from a well-known manufacturer as Robotnik. This robot will be adapted to fit properly within sewer tunnels and to robustly cope with a sewer maintenance scenario. On top of this platform GMV will add its localization, navigation and mapping algo-rithms (IMU, SLAM using 3D laser) derived from a similar GMV led oil&gas robotics system (FOXIRIS, currently participating in the TOTAL Argos Challenge) together with modules related to imaging/video-streaming, sampling and operations in order to reach an autonomous system able to traverse and map hundreds of meters during a typical working journey. A breakthrough compact set of 3D and CMOS camera sensors is proposed over a telescopic mast for long-range inspection while keeping the low power consumption needed in order to ensure endurance of operations. A mini-drone will be added to the mobile robot for complementary extension of short-ranging and fast inspections capabilities by acting as a slave collaborative agent. Academic partners will handle some of the most innovative and complex activities: UPM-CAR (one of the most reputed Robotics Research Centre in Europe) will perform sewer inspection while UMA-MAPIR will contribute with its olfactory system for gas/odors mapping and localiza-tion of sources. Both companies (GMV and Robotnik) share the commitment of commercializ-ing the SEWIRIS robot.	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.

ECHORD++ Call For PDTI R&D Proposals – Urban Robotics Challenge

EVALUATION PANEL REPORT

Version June 10, 2015

1. Introduction and methodology

This report covers *the Call for ECHORD++ PDTI R&D Proposals in Urban Robotics.* The call was opened on 15 January 2015 and closed on 14 March 2015 (deadline was extended, the original plan was to close the call on 28 February 2015). This call targeted the Challenge on "UTILITY INFRASTRUCTURES AND CONDITION MONITORING FOR SEWER NETWORK. ROBOTS FOR THE INSPECTION AND THE CLEARANCE OF THE SEWER NETWORK IN CITIES". General statistics about the proposals which were reviewed in the remote evaluation and in the panel can be found in Table 1.

Echord++ PDTI R&D Call Urban Robotics	**Eligible Proposals**	**Failed threshold(s)**	**Above thresholds**
Number of proposals	6	3	3
Percentage	100%	50%	50%

Table 1. Evaluation overview

One proposal "About the universal mechanical linkage and the formula for the voluntary movement of animal nature“ was completely off-topic (confirmed by the experts in the panel meeting) and therefore no evaluation was performed. Moreover, there were a few incomplete and/or test proposals which were not considered for evaluation.

Given the small number of proposals, only 2 experts were assigned to evaluate all of them, as this was sufficient for a solid evaluation and comparison to finally rank the proposals. The evaluation was performed the following way

(i) Two individual *evaluations* were perfomed by two independent experts (*evaluators*).

(ii) A *panel meeting* was held with both independent experts, where the individual evaluations were discussed and all proposals were compared according to the evaluation criteria, especially closely looking at the fulfilment of the requirements given by the challenge description. In that meeting, the final scores of the proposals were fixed and a ranking of the proposals was established and the consensus report for all proposals was drafted, while the texts of the consensus reports were finalized and communicated by the experts few days after the meeting.

Out of the six proposals received, three were evaluated above thresholds, thence, those three proposals were suggested for possible funding in the fist stage of the PDTI activities with the option to be also funded in the two later phases, as shown in Table 2 below.

Rank	**Proposal-ID**	**Proposal Acronym**	**Partners**
1	1106	ARSI	Fundació Privada ASCAMM (Spain), Fomento de Construcciones y Contratas (Spain), Simtech Design S.L. (Spain), IBAK Helmut Hunger GmbH & Co. KG (Germany), Fundació Barcelona Media (Spain)
2	1120	ROBODILLOS	Cyprus University of Technology, Helikas Robotics Ltd (Cyprus)
3	1127	SIAR	IDMind (Portugal), Universidad de Sevilla (Spain), Universidad Pablo de Olavide (Spain)

Table 2. Proposals suggested for funding

1. Analysis of the proposals

The six proposals received had different technological approaches to achieve the envisaged system prototypes, terrestrial and aereal vehicles and a combination of both. Also the sensing technology varies, but all of the proposals provided an approach to address the given challenge. The country distribution of the successful consortia is given in Fig. 1, whereas the distribution of all eligible proposals is given in Fig. 2.

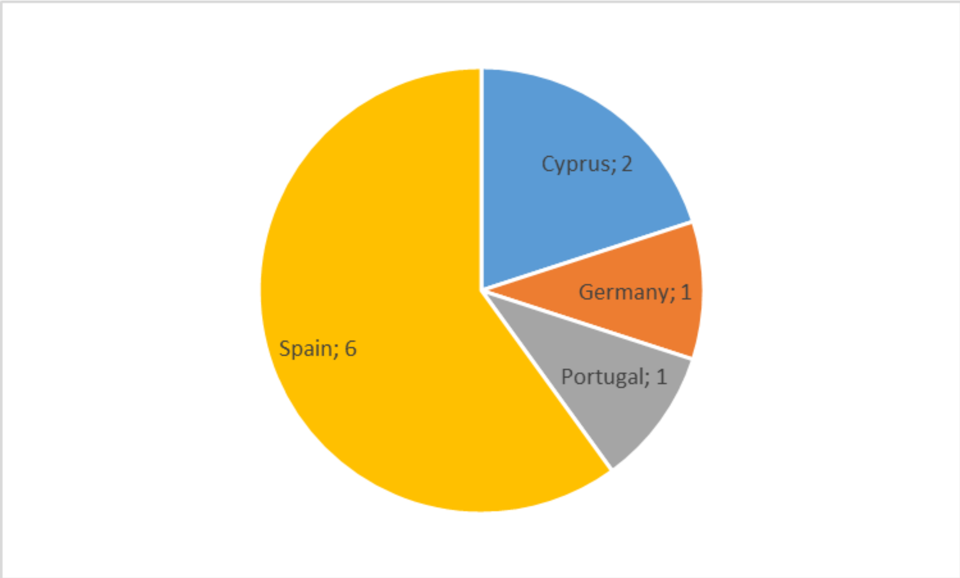


Fig. 1. Country distribution – partners of the selected proposals

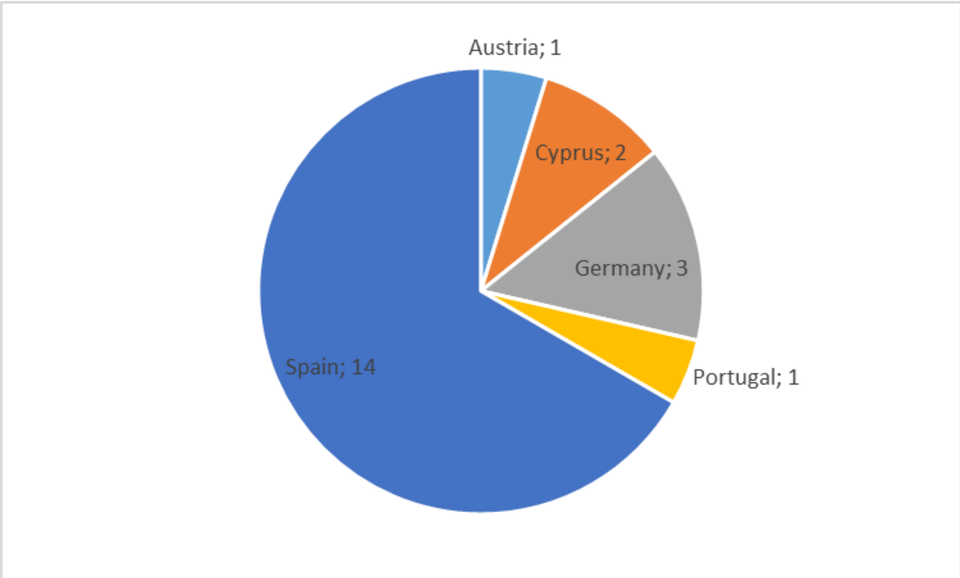


Fig. 2. Country distribution – partners of all proposals

The panel decided to use the following **rules** in the prioritizing procedure of the proposals:

(a) Proposals were ranked by higher total score.

There are different final overall scores for all three proposals above thresholds, hence this rule was sufficient to rank them and the panel recommended to fund all proposals above thresholds (marked green in the table).

Rank	Proposal Acronym	Proposal ID	Criterion 1	Criterion 2	Criterion 3	Total Score
1	ARSI	1106	4	4	4.5	12.5
2	ROBODILLOS	1120	4.5	4	3	11.5
3	SIAR	1127	4	3.5	3	10.5
--	SEWIRIS	1103	2	3	4	9
--	ELSIE	1079	2.5	2.5	3.5	8.5
--	ORSON	1107	2	3.5	2	7.5

Table 3. Proposals and evaluation results

2. Abstracts of proposals above thresholds in the ranking order

1. ARSI -Aerial Robots for Sewer Inspection, ID 1106

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.

2. **ROBODILLOS - A Networked Mobile Robotic Platform for Shared Autonomy Sewer Inspection Operations, ID 1120**

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.

3. **SIAR - Sewer Inspection Autonomous Robot, ID 1127**

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.

ECHORD++ Call For PDTI R&D Proposals – Healthcare Robotics Challenge

EVALUATION PANEL REPORT

Version June 10, 2015

1. Introduction and methodology

This report covers *the Call for ECHORD++ PDTI R&D Proposals in Healthcare Robotics.* The call was opened on 15 January 2015 and closed on 14 March 2015 (deadline was extended, the original plan was to close the call on 28 February 2015). This call targeted the Challenge on “Comprehensive Geriatric Assessment”. General statistics about the proposals which were reviewed in the remote evaluation and in the panel can be found in Table 1.

Echord++ PDTI R&D Call Urban Robotics	**Eligible Proposals**	**Failed threshold(s)**	**Above thresholds**
Number of proposals	11	11	0
Percentage	100%	100%	0%

Table 1. Evaluation overview

The evaluation was performed the following way

(i) Two individual *evaluations* were perfomed by two independent experts per proposal (*evaluators*).

(ii) A *panel meeting* was held with two independent experts physically present and a third one joined the meeting remotely via Skype. The individual evaluations were discussed and all proposals were compared according to the evaluation criteria, especially closely looking at the fulfilment of the requirements given by the challenge description. In that meeting, the final scores of the proposals were fixed and the consensus report for all proposals was drafted, while the texts of the consensus reports were finalized and communicated by the experts few days after the meeting.

1. Analysis of the proposals

Given the narrow focus of the call, there was limited flexibility. However, the proposed technical solutions varied, .e.g. some proposals massively relied on mobile systems, whereas other focused on the human-system (computer, screen) interfaceing part Also the relative importance of motion analysis varied across the proposals.

The country distribution of the partners of all proposals is given in Fig. 1.

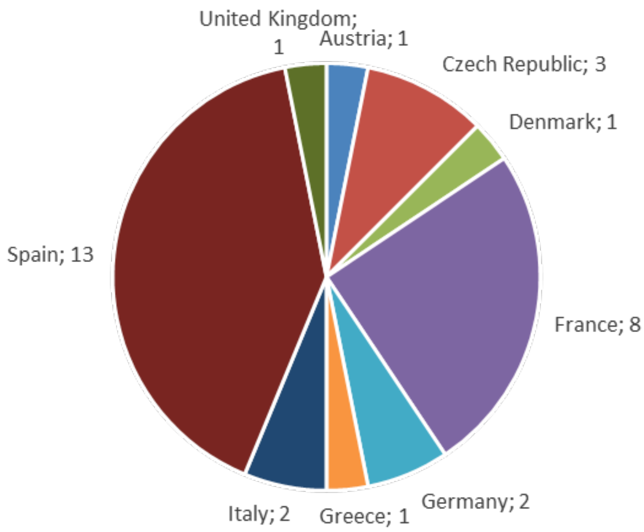


Fig. 1. Country distribution – partners of all proposals

2. Decicion

The panel decided after intensive discussions on the final scores, partly moniofying the initial ones. The result was that none of the proposals met the thresholds, partly in the overall score (not reaching 10 points in total), partly for failing in one or more individual criterion (not reaching 3 points in at least one criterion).

Therefore, the evaluation ended with the result that no proposal of the PDTI call in Healthcare could be selected for funding.

To proceed with the PDTI scheme in the healthcare challenge, the decision was to revise the challenge description and to repeat the call.

ECHORD++ Call For PDTI R&D Proposals – Healthcare Robotics Challenge – second call

EVALUATION PANEL REPORT

Version August 7, 2015

1. Introduction and methodology

This report covers *the Call for ECHORD++ PDTI R&D Proposals in Healthcare Robotics.* The call was opened on 4 May 2015 and closed on 23 June 2015 : This call targeted the Challenge on "Comprehensive Geriatric Assessment". General statistics about the proposals which were reviewed in the remote evaluation and in the panel can be found in Table 1.

Echord++ PDTI R&D Call 2 on Healthcare (CGA)	**Eligible Proposals**	**Failed threshold(s)**	**Above thresholds**
Number of proposals	15	7	8
Percentage	100%	46.67%	53.33%

Table 1. Evaluation overview

The evaluation was performed the following way

(i) Two individual *evaluations* were perfomed by two independent experts per proposal (*evaluators*).

(ii) A *panel meeting* was held with three independent experts. The individual evaluations were discussed and all proposals were compared according to the evaluation criteria, especially closely looking at the fulfilment of the requirements given by the challenge description. In that meeting, the final scores of the proposals were fixed and the consensus report for all proposals was drafted, while the texts of the consensus reports were finalized and communicated by the experts few days after the meeting.

1. Analysis of the proposals

The country distribution of the partners of all proposals is given in Fig. 1, the distribution by coordinating partner in Fig. 2.

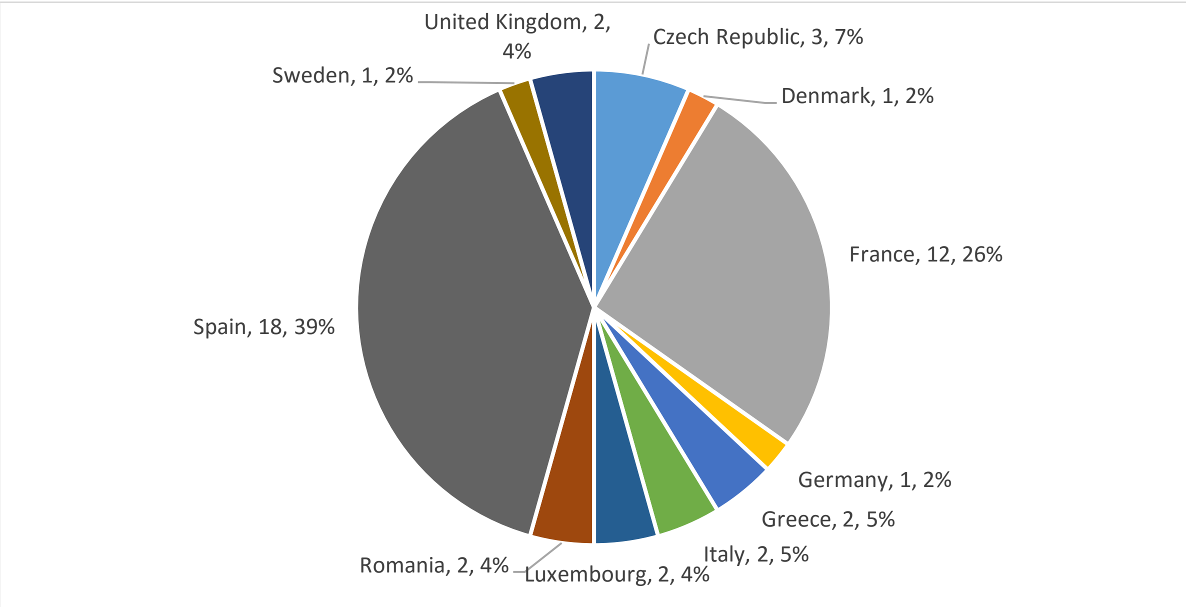


Fig. 1. Country distribution – partners of all proposals

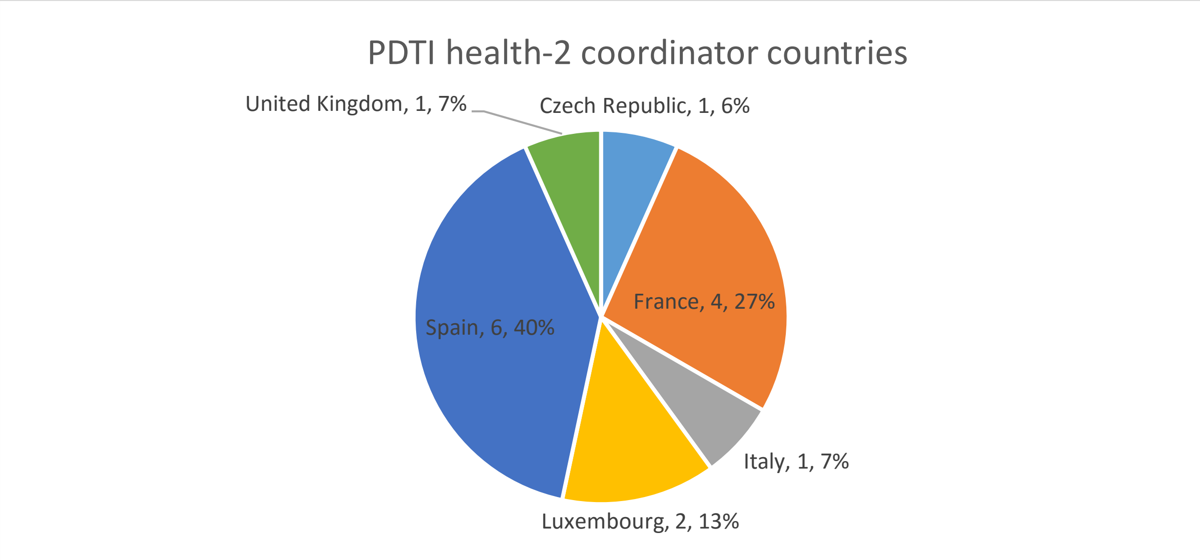


Fig. 2. Country distribution – coordinators of all proposals

2. Selection of R&D consortia

The evaluation outcome is summarized in the table below. The three highest-ranking proposals were selected for possible funding.

Acronym	ID	Score Crit. 1	Score Crit. 2	Score Crit. 3	Total Score	Rank (only if above thresholds)
CLARK	1182	4.5	4.5	4	13	1
ASSESSTRONIC	1315	4	4.5	4	12.5	2
ARNICA	1248	4	4	4	12	3
ROBOGASS-2	1222	4	3.5	4	11.5	4
SERENO	1303	4.5	3	3.5	11	5
MEDIDRONE	1200	3.5	4	3.5	11	6
OPERA	1245	3.5	3	3.5	10	7
VERIDIS	1146	3.5	3.5	3	10	8
CARLA	1149	3	3	3.5	9.5	
GAARER	1288	3	3	3	9	
VASIK	1217	3	3	2.5	8.5	
FAST	1241	2	3	2	7	
FRIGATE	1168	2.5	2	2	6.5	
TMT-GCA	1314	2.5	2	2	6.5	
EXO-GCA	1279	2.5	1.5	1.5	5.5	

Table 1. Final evaluation result

3. Overview of the submitted proposals

The following table shows the eligible proposals received with their partners and countries

Id	Acronym	Coordinator	country	name
1248	ARNICA	1	France	ROBOSOFT SA
		0	Spain	INLOC Robotics SLU
		0	Denmark	Danish Technological Institute
		0	France	Assistance publique – Hôpitaux de Paris
1315	ASSESSTRONIC	1	France	Accel
		0	France	UPMC
1149	CARLA	1	Spain	Adele Robots S.L.
		0	France	Inria
		0	Spain	Universidad de Extremadura
1182	CLARK	1	Spain	Servicio Andaluz de Salud
		0	Sweden	GIRAFF TECHNOLOGIES AB
		0	Spain	Universidad de Malaga
		0	Spain	UNIVERSIDAD CARLOS III DE MADRID (UC3M)
1279	EXO-CGA	1	Spain	Marsi Bionics
		0	Spain	Universidad Politecnica de Madrid
		0	Spain	HOSPITAL UNIVERSITARIO DE GETAFE
1241	FAST	0	France	Université Paris 8 Vincennes Saint-Denis
		1	France	LEME - Univ. Paris Ouest Nanterre La Defense
		0	France	PERCKO
		0	France	COGITOBIO
1168	FRIGATE	1	Luxembourg	ACTIMAGE SA
		0	Spain	New Fundació Hospital Asil de Granollers
		0	France	LIMSI CNRS
		0	Romania	Universitatea Politehnica Timisoara
		0	Romania	Team Tim Dev srld
1288	GAREER	0	Spain	Robotnik Automation, SLL
		1	Spain	Universidad de León
1200	MEDIDRONE	1	United Kingdom	Ortelio Ltd
		0	Greece	Aristotle University of Thessaloniki
		0	United Kingdom	Aston University
		0	Spain	Matia

1245	OPERA	0	France	ROBOSOFT SA
		1	France	Université d'Orléans
		0	Greece	Singular Logic SA
1222	ROBOGASS-2	0	Spain	INLOC Robotics SLU
		1	Spain	TECNALIA Research & Innovation
		0	Germany	MetraLabs GmbH Neue Technologien und Systeme
1303	SERENO	1	Italy	ISTITUTO SUPERIORE MARIO BOELLA SULLE TECNOLOGIE DELL'INFORMAZIONE E DELLE TECNOLOGIE
		0	Spain	PAL ROBOTICS SL
1314	TMT-GCA	1	Luxembourg	Organization of Evangelos PAPADOPOULOS
1217	VAssiC	1	Czech Republic	Ceske vysoke uceni technicke v Praze
		0	Czech Republic	ZAPADOCESKA UNIVERZITA V PLZNI
		0	Czech Republic	CertiCon a.s.
1146	VeRIDiS	0	Italy	RoboTech srl
		0	Spain	Computer Vision Center
		1	Spain	Grupo Elteis,SL

Table 1. Proposals submitted