



The European Coordination Hub for Open Robotics Development



**ECHORD++ Review Meeting
WP5 Reporting Period 4**

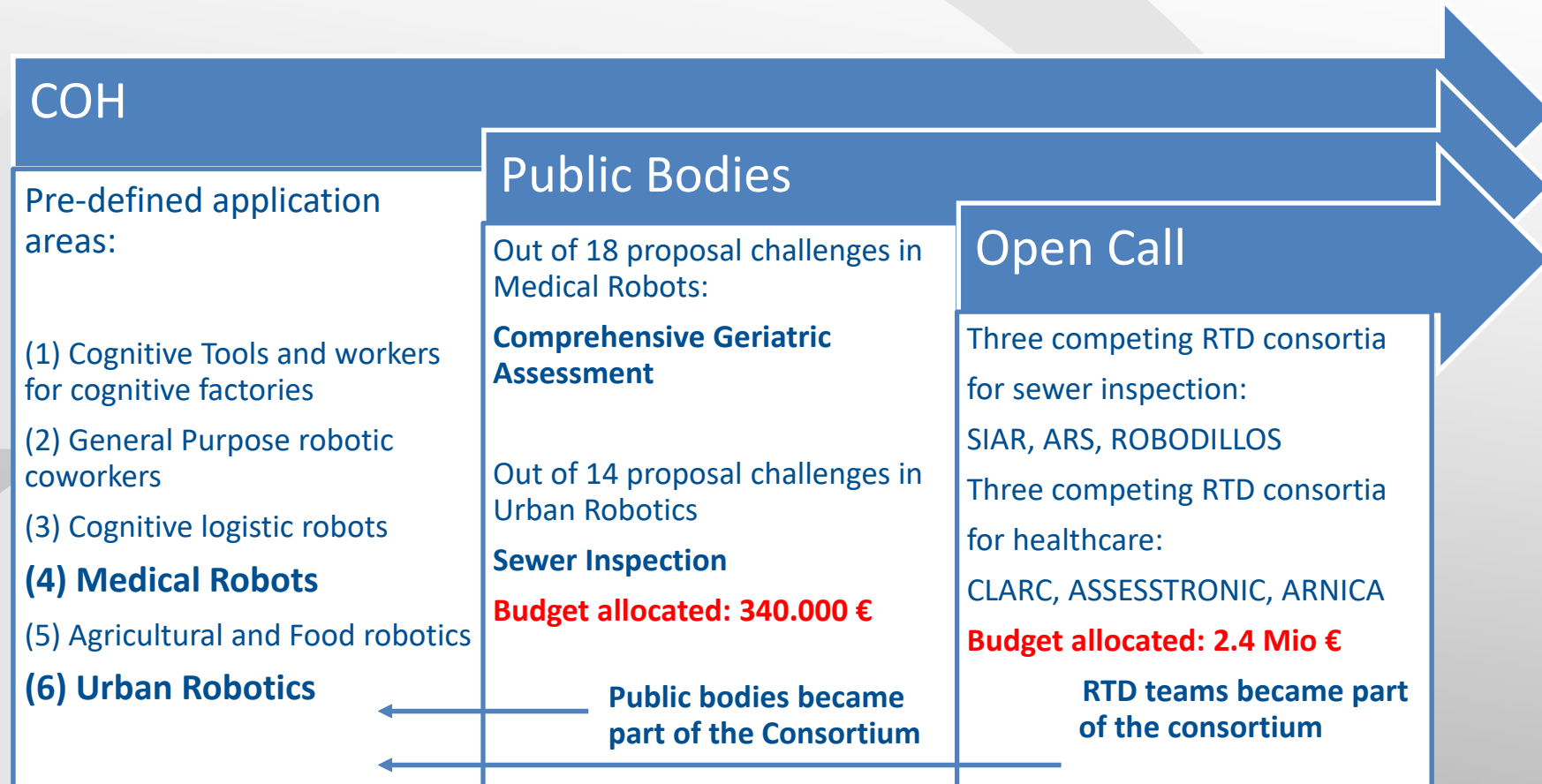
Marie-Luise Neitz, TUM

Franziska Kirstein, BOR

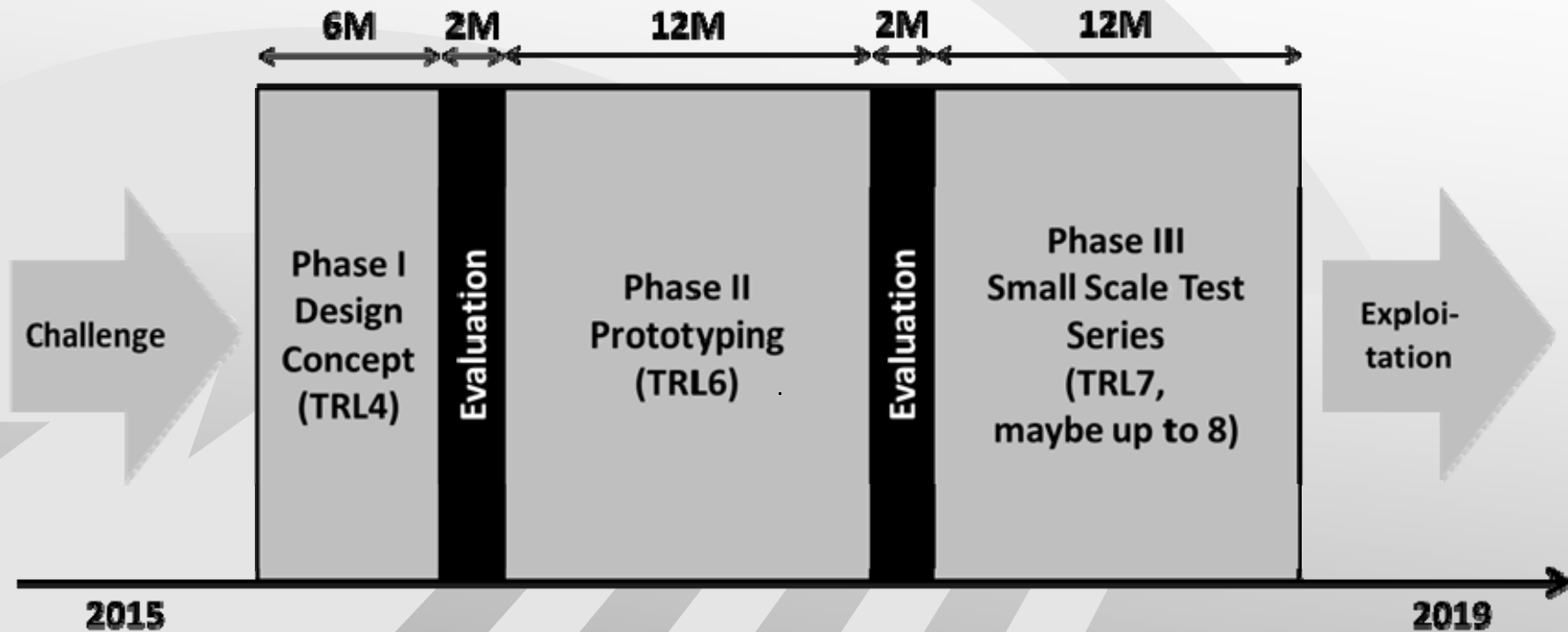
Prof. Alberto Sanfeliu, UPC

Luxembourg, February 22th 2018

PDTI process in a nutshell - stakeholders



PDTI process in a nutshell - monitoring



Strength of PDTI over PCP:

Academic teams and public bodies monitoring the technology development teams to tell them what is required and feasible

Highlights – major achievements during the reporting period

Healthcare: Comprehensive Geriatric Assessment

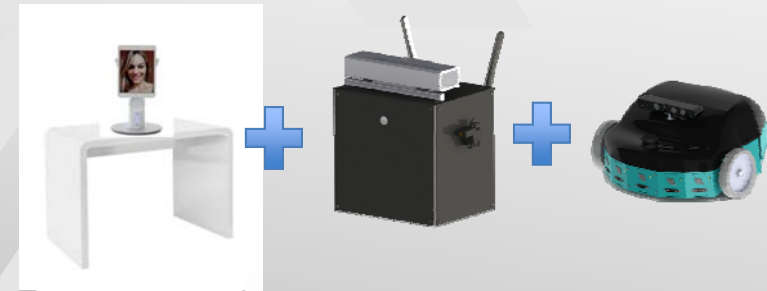
CLARK



PHASE II



ASSESSTRONIC



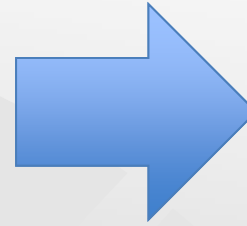
- Prototyping Phase still under way (delayed start due to redress from Arnica)
- Proof of merits of end-user focus and iterative design approach to CLARK
- Phase II on-site review directly after review meeting: 2 fully functional prototypes (1 for each team) at TRL 6
- Business training done for both teams by Blue Ocean Robotics

Challenges Phase III: Solid Business planning and scalability for CLARK solution to make up for costly platform

Highlights — major achievements during the reporting period

Urban Robotics: Sewer inspection

SIAR



PHASE II



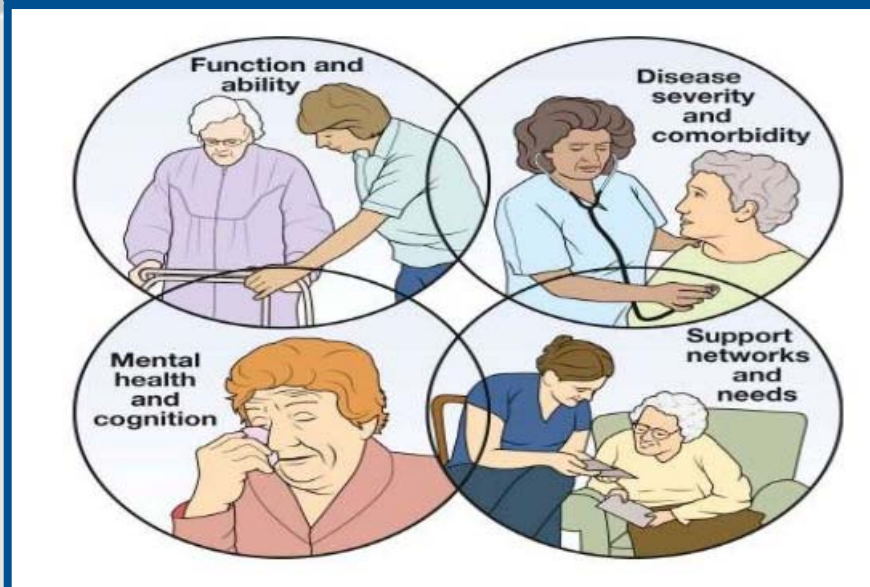
ARSI



- Successful completion of functional prototyping (Phase II)
- 2 fully functional prototypes (1 per team) at TRL 6 >> TRL7
- End-user interested in both solutions, challenge perfectly tackled by a combination of both systems
- Scalability potential beyond original challenge for those solutions

Major challenges Phase III: Robustness and performance – route for navigation

PDTI Healthcare Comprehensive Geriatric Assessment



Expected Outcome

Phase I

- Concept of whole system
- First prototype, mainly to assess the look-and-feel, but mock-up functionality of cognitive and ability test.

Phase II

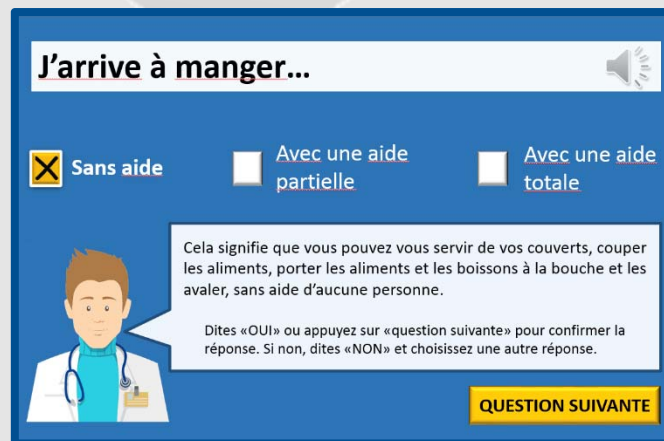
- Usable prototype with main functionalities
- First tests with end-users possible, but supported by the developers
- Implementation of cognitive test, as well as the ability test.

Recommendations from Phase I

PHASE I

ASSESSTRONIC

- User-centred approach for concept development
- Mock-up tested with users

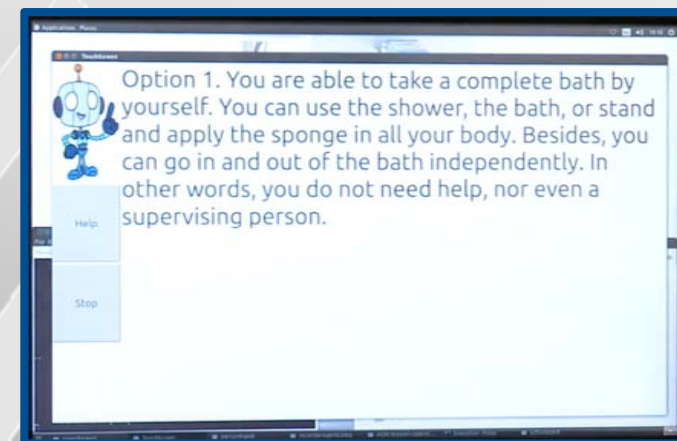


PHASE II

- develop HMI mock-up into prototype
- User test prototype

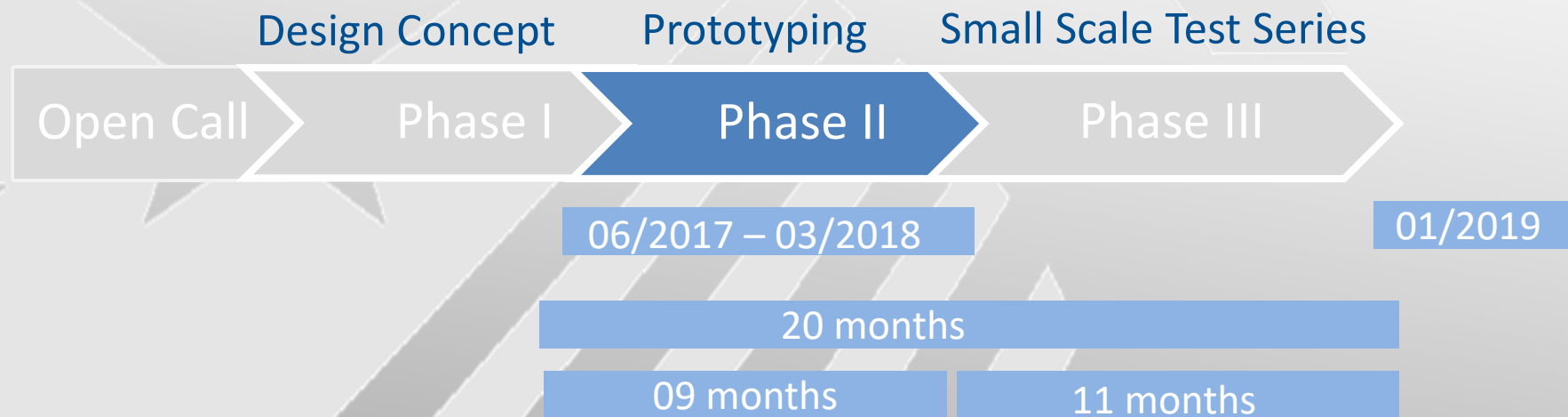
CLARK

- Focus on platform & algorithm development
- Testing with wrong end-users



- intensive user testing
- re-design of HMI prototype

Phase II context and timing of activities



Phase II context and timing of activities



- **KPIs** were set together with RTD consortia and in alignment with public body and reviewers
- **Monitoring** took place continuously; including reviewers and involvement of public body
- **Final evaluation preparation:** both RTD consortia and reviewers to discuss procedures and open issues
- **Final evaluation**
 - Reviewers with different backgrounds/expertise: healthcare, robotics, technology development, user-testing of medical products for elderly, ethics
 - Testing with elderly people

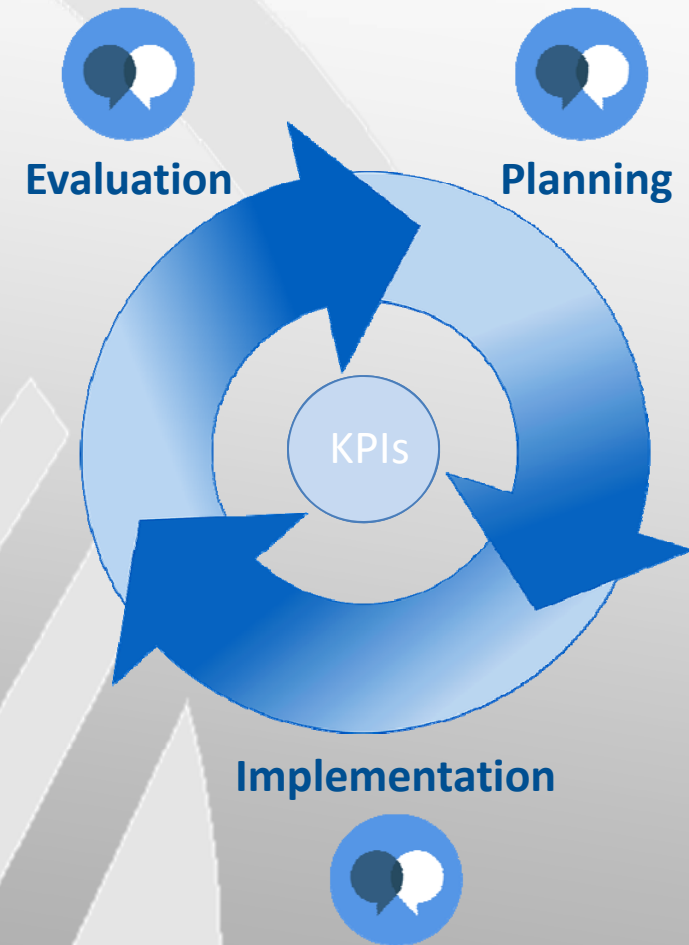
Active Interaction in Phase II

Phase I: no active interaction (deliberate decision)

- Evaluate pro-activeness of RTD consortia

Phase II: open dialogue between **all stakeholders** (monitoring team + RTD consortia)

- Ensuring end-user's needs (**public body**) are considered
- Consideration for **RTD consortia's** input
- Clarity of Phase II goals
 - **RTD consortia** can continuously evaluate whether they fulfil expectations
 - **Reviewers** were actively involved to give recommendations before end of Phase II



Evaluation Criteria

Technical KPIs

- Reliability of machine-to-patient communication
- Reliability of patient-to-machine communication
- Data management
- Power, autonomy, system, mobility
- Technology Readiness Level (TRL)

Impact KPIs

- Reliability test-delivery-speed
- Test-support efficacy
- Quality of clinical information
- Data presentation
- Patient acceptability
- Ease of operation and flexibility
- Quality of business plan

Involvement of public body:

- ensuring KPIs provide fair reflection of user's need
- additional tests and metrics were included to measure quality of data during final evaluation



Progress of RTD Consortia: CLARK

Additional partner selection

- Matrix of potential partners
- Evaluation criteria set with monitoring team
- Final partner: ActivAging Living Lab, UTT
 - Expertise: interface-testing with older adults



Additional partner

User Test & Re-Design

Phase II

12/16-01/17

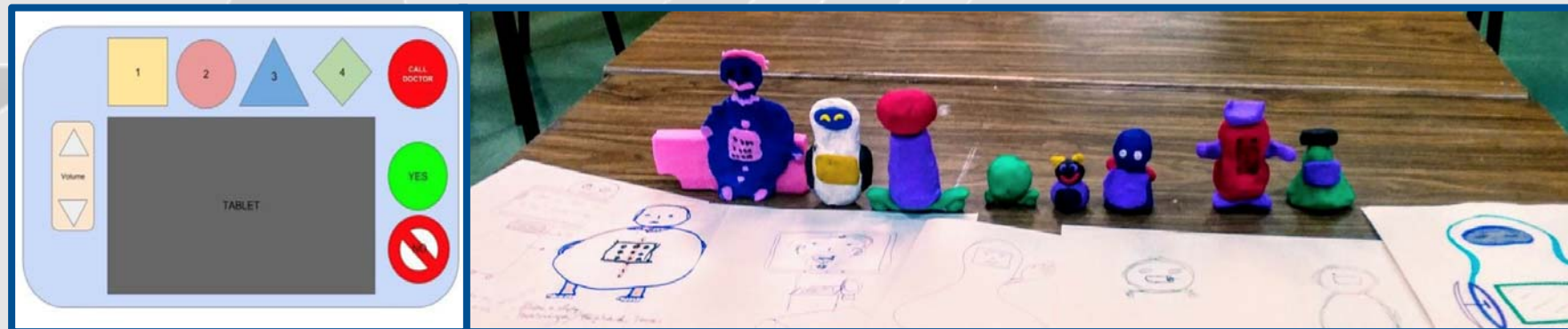
03/17 – 06/17

06/17 – 03/18

Progress of RTD Consortia: CLARK

User Tests & Re-Design:

- Retirement home in Seville
 - Demonstration of robot
 - Test trials with older adults (well-functioning)
 - Focus groups: engineers, physiotherapist, geriatricians, nurse, psychologist, elderly patient with caretaker, retiree



Additional partner

User Test & Re-Design

Phase II

12/16-01/17

03/17 – 06/17

06/17 – 03/18

Progress of RTD Consortia: CLARK



Phase II

- CLARK pro-active team
- Re-design improved interface
- Focus: ability of patients to interact with new technology
- Testing with prototype: 11/2017
- PDTI process assisted team in structuring their workflow and manage priorities
- Long-distance coaching & monitoring can be a challenge
- Crucial next step: preparing for commercialization

Additional partner

12/16-01/17

User Test & Re-Design

03/17 – 06/17

Phase II

06/17 – 03/18

Progress of RTD Consortia: ASSESSTRONIC

- Organized approach: focus on product development
- Goal of Phase II: development from mock-up to prototype & testing
- Change of orientation: increased modularity

Phase I



Phase II



- Solution uses technology from robotics areas
- Cost-effective solution that solves end-user's needs

Conclusion PDTI Healthcare Phase II



Next steps

- Final evaluation next week
- Phase III preparation with all stakeholders
 - Focus: commercialization

Take home message Phase II

- RTD consortia have individual expertise and monitoring needs
- Management and monitoring needs to be adaptable
- Collaboration and expertise across WPs useful (WP3)



PDTI Sewer

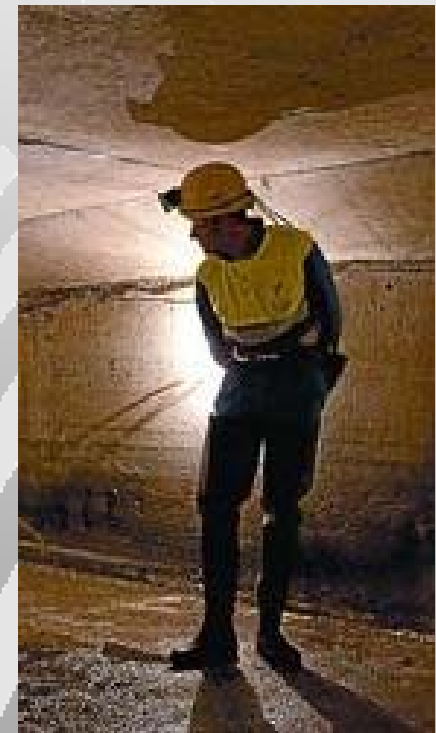
T5.8. Development of prototypes, scientific monitoring, and feasibility studies that match the PDTI Phase II: Prototyping

PDTI							
ACTIVITIES FOR UNDERSTANDING PUBLIC DEMAND				CALL FOR RTD PROPOSALS	ACTIVITIES FOR RESEARCH AND TECHNICAL DEVELOPMENT OF PRE-COMMERCIAL PRODUCTS		
BRAINSTORMING	NARROWING DOWN	RANKING	CHALLENGE DESCRIPTION		SOLUTION DESIGN	PROTOTYPING	SMALL TEST SERIES

PDTI Sewer. Phase II. Context and timing

**PDTI Sewer: Utility infrastructure and condition monitoring for sewer network.
Robots for inspection and clearance of the sewer network in cities**

- **The PDTI's Phase II goal** was to achieve TRL6 level. The prototype system was tested in a relevant sewer area located in the Mercat del Born, Barcelona.
- The suggestions made by the reviewers in Phase I were included in the new prototypes
- **PHASE II period: September, 15th 2016-2017.**
 - Kick Off Meeting: November 15th 2016, linked to the SCWC.**
“
 - Monitoring Process:** Four monitoring periods
 - Phase II final tests and the expert evaluation: October 16th-17th, 2017**



PDTI Sewer. Phase II. Evaluation Criteria

Scientific & Technological Excellence / Implementation / Impact

Positive evaluation of the tasks and documentation required

Deliverables and Milestones, Dissemination Milestones and Solution design

Detailed explanation of the solution design

Solutions to the evaluator's recommendations made in Phase I
Logistics required and operational procedures

Test Series

Achievement level for the specific functionalities included

in the Challenge Brief: Sewer serviceability inspection,
Sewer monitoring, Structural defect inspection and Sampling

Specific issues to be demonstrate: Mobility: remote or semi-autonomous control mode, Repeaters: deploying and recovery, Control station: Data reception and command sending, Serviceability Operational procedure and recovery



Public end-user Driven Technological
Innovation (PDTI)

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

EVALUATION CRITERIA PHASE II

PDTI Sewer. Phase II. Monitoring approach

1st Monitoring Period: 15/09/2016- 15/12/2016.

November 15th, 2016: Kick off Meeting Phase II, Barcelona, Spain

At the kick-off meeting, BCASA, UPC and TUM explained the monitoring process, the evaluation criteria, the dissemination activities and the required deliverables for this phase.

December 15th, 2016: Monitoring TELCO and report of the deliverables D26/28-3.

2nd Monitoring Period: 15/12/2016-15/03/2017.

March 15th, 2017 VISIT to EURECAT LAB, Cerdanyola del Valles, Barcelona.
Autonomy test of the ARSI prototype.

March 30th, 2017 VISIT to PABLO OLAVIDE UNIVERSITY, Sevilla.
Autonomy test of the SIAR prototype

3rd Monitoring Period: 15/03/2017-15/06/2017.

June 15th, 2017 TELCO and report of the deliverables D26/28.4-5

4th Monitoring Period: 15/06/2017-15/09/2017 (was postponed to 30/09/2017)

Report of the Final deliverables Phase II D26.6 / D26.7 / D26.8

October 16th-17th 2017 FINAL TESTS Phase II and EXPERT PANEL Evaluation

PDTI Sewer. Phase II. Prototyping

Prototyping.

- Both consortia made new prototypes during Phase II.
- Reviewers proposed some improvements after the evaluations.
- These improvements were implemented in the prototypes.



ARSI PROTOTYPE PHASE II

SIAR PROTOTYPE PHASE II



PDTI Sewer. Operational Procedure

Operational procedure.

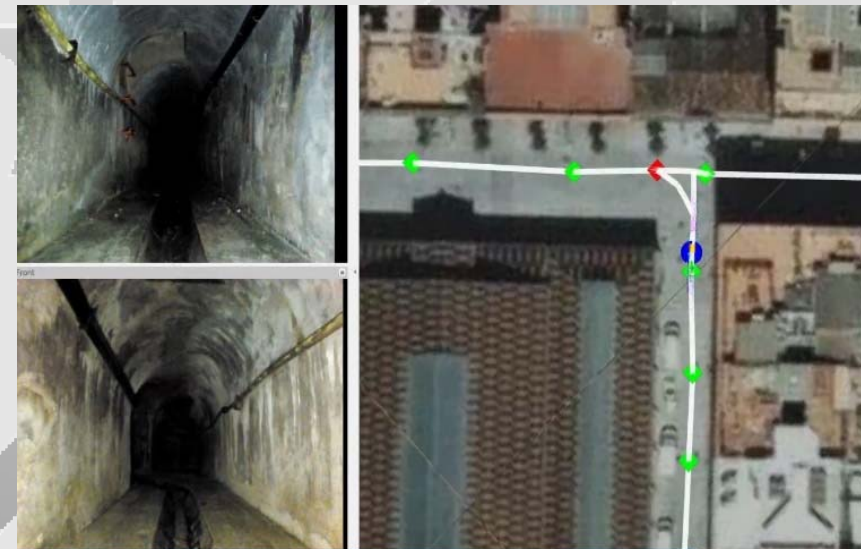
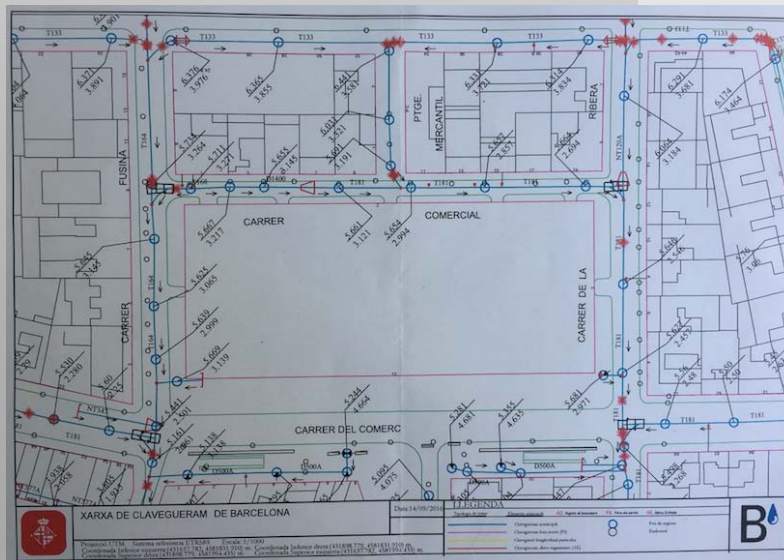
- The public body wanted that the functionality matches the present complete inspection and maintenance of the sewer network.
- The robotic prototype had to accomplish with the operational procedure and the brigade support required. The following table shows the updated functionalities detailed in the Challenge Brief and how well the proposed technology should solve them.

FUNCTIONS			WEIGHT
Sewer serviceability inspection	Sewer performance 1000 lineal meter/labour day)		Essential
	Images (Video)		Essential
	Geometric analysis (scanning)		Essential
	Monitoring	Air	Desirable
		Water	Desirable
Structural defect inspection			Desirable
Sampling			Desirable

BCASA offered during all the period (12 months), open trials for testing the prototypes at the Barcelona sewer network. As it happened in Phase I, both consortia proved their prototypes several times with the human support of the BCASA's brigades required for the sewer operational procedure.

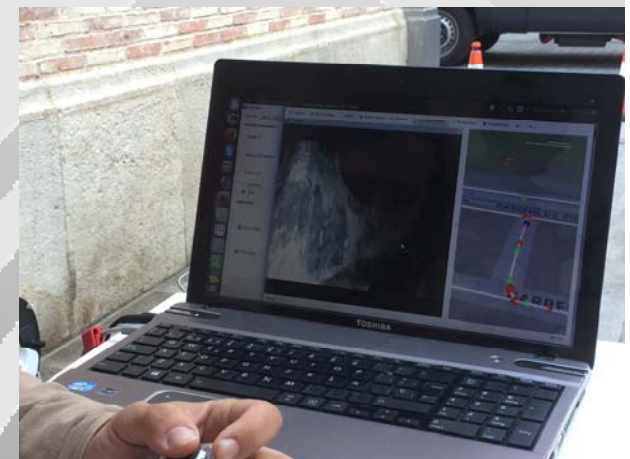
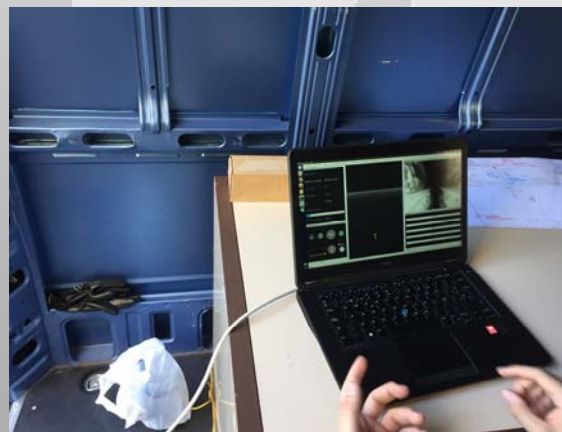
PDTI Sewer. Final tests

- The tests were organized in order that both consortia could decide the most efficient way allowed by their robotic solution.
- The time to inspect the entire track including setup and disassemble (640 lineal meters approximately) was limited to 8 h.
- The location for Phase II tests was the surroundings of the Cultural Centre of Mercat del Born.
- Six different sewer sections typologies and permanent obstacles (singularities) were included in the GIS information.
- Non permanent obstacles as sediments on the floor or tubes at the top of the sewer were included in the last part of the final tests.



PDTI Sewer. Final tests

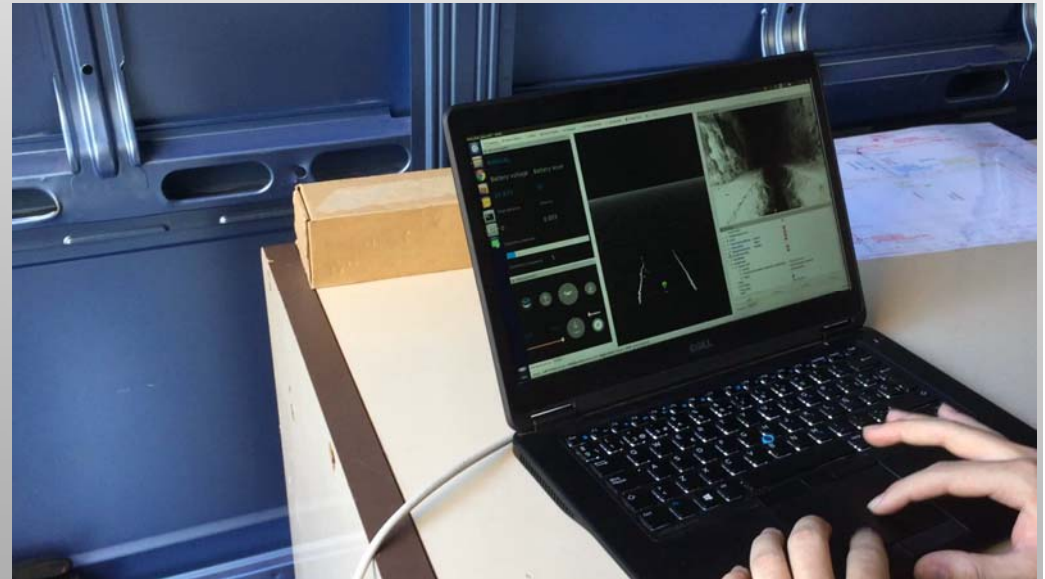
Final tests in the Mercat del Born (Barcelona)



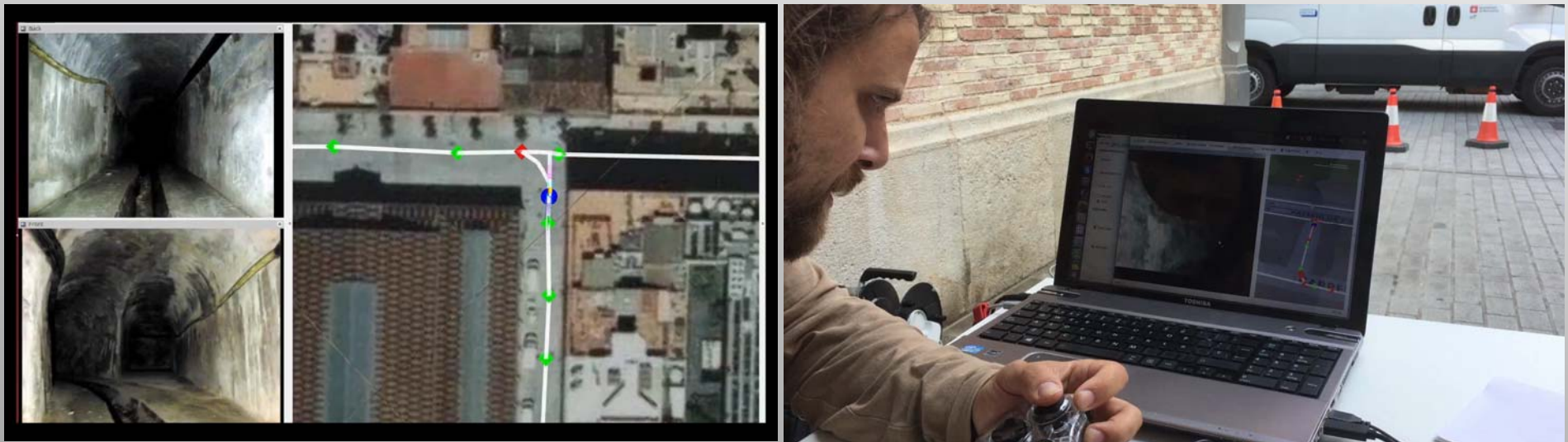
ARSI



ECHORD++



SIAR



PDTI Sewer. Phase II. September 15th, 2017– 2018

Expert Panel Meeting. October 15th, 2017

POSITIVE GOALS IN PROTOTYPING

ARSI consortium has achieved an important milestone, which is demonstrating stable semi-autonomous flight in the sewer. This is of crucial importance for the viability of the solution, as manually controlled flight is almost impossible in the narrow sewers.

The following goals set by the consortium were successfully demonstrated:

- Safe and stable take & landings
- Simple trajectories low level commands
- Improved height estimation
- Satisfactory wall following



The localization of the MAV in the YZ plane is satisfactory and allows relatively stable flight. The flight Control and the straight navigation are satisfactory.

The control interface is simple and adequate for the purpose, which is commendable.

PDTI Sewer. Phase II. September 15th, 2017– 2018

Expert Panel Meeting. October 15th, 2017

RECOMMENDATIONS TO IMPROVE THE ARSI PROTOTYPE

- **Platform:**
 - Flying time is too short: Go beyond 7-8min
 - Payload restriction implies not carrying all required on-board sensors for inspection
 - The odometry is okay but has to be improved, it diverges 20%
- **Flight control**
 - Ground detection has to be improved in case of water
 - Collision detection has to be improved.
- **Communication**
 - Communication bandwidth has to be improved
- **Inspection**
 - It is restricted due to the few sensors in the robot. 3D image resolution has to be improved.
- **Mission operation**
 - Too much time is needed for operation.



PDTI Sewer. Phase II. September 15th, 2017– 2018

Expert Panel Meeting. October 15th, 2017

POSITIVE GOALS IN PROTOTYPING

SIAR consortium has made commendable progress. The design of the robot has been significantly improved, the addition of the spring-loaded suspension with variable width has increased the reliability of operation and the versatility of the system.

The following milestones have been achieved:

- Safe and stable start, motion and stop
- Simple trajectories
- Wall following and following a trajectory in straight line
- Ground obstacle observation
- Autonomy (duration of continuous operation): 4 hours which is satisfactory.

Communication with the robot is satisfactory, as is the repeater system. Visual data is acceptable by end users and 3D reconstruction is adequate. The payload of the vehicle is satisfactory. Lighting: Is adequate. The control interface is simple and adequate for the purpose.



PDTI Sewer. Phase II. September 15th, 2017– 2018

Expert Panel Meeting. October 15th, 2017

RECOMMENDATIONS TO IMPROVE THE SIAR PROTOTYPE

- **Platform:**
 - It has to be improved the recovery when the robot gets stuck
 - The robot arm can be removed
- **Localization and navigation**
 - Sometimes the system requires to past to manual operation, to negotiate bends and obstacles. The operator needs for visual information to overcome the situations
 - Dead zones around the robot should be reduced
 - Wheel traction has to be improved
- **Communication**
 - Working procedures for deployment should be improved
- **Inspection**
 - The software for inspection treatment can be improved
 - The platform can improve incorporating sampling and monitoring gases



PDTI Sewer. Phase II. Conclusion



PDTI. Other Outcomes

PDTI Outcomes in Public Bodies Decisions

- **Modification in the Procurement rules in the Barcelona City Council (Spain)**
 - All the new **Procurements** include a clause of **INNOVATION** . The consortia have to demonstrate that they will do innovation in their proposal during the contract period.
- **New PCP on Circular Economy in the region of Tuscany (Italy)**
 - In the region of Tuscany a procurement on **CIRCULAR ECONOMY** will be launch in few months. This is a consequence of the ECHORD++ effort on PDTI.



**Thank you for your
attention!**