Ten Projects
Horizon 2020 for Cultural Heritage
Pre-Kick Off Meeting

RICH 2015
Project

Second draft, March, 2015

A.I.C. – Associazione Investire in Cultura

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Publishing coordination, revision and realization: Angelo Ferrari - CNR, Inst. of Chemical Methodologies, Italy;

Digital Editing and Data Processing: Stefano Tardiola and Gianni Pingue - CNR, Inst. of Chemical Methodologies, Italy;

Secretariat: Enza Sirugo - CNR, Inst. of Chemical Methodologies, Italy; Manuela Manfredi, A.I.C. Secretariat, Italy.

B - TECHNICAL ANNEX

COVER PAGE

Title of Proposal: Robotics: Innovation for Cultural Heritage

Acronym: RICH 2015

List of Participants:

Participant No *	Participant organisation name	Country
1	X	X
2	Y	Y
3	Z	Z
4	W	W
5	K	K
6	K	K
7	K	K
8	K	K
9	K	K
10	S	S
11	L	L
12	A	A
13	O	O.

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RICH 2015

"Robotics: Innovation for Cultural Heritage"

1 – Excellence

1.1 – Objectives

How large and spread all over the world is the cultural patrimony we want to preserve?
The vagueness of this terminology makes rather difficult to answer such a question. In any case, we may for sure state that the patrimony worth saving is made up of many million pieces.
Today, many scientific and technological methodologies are employed to preserve our world cultural patrimony; however, only in a few cases the enormous potentialities offered by the Robotic Systems were exploited.
The complexity of the activities needed to safeguard Cultural Heritage strictly depends on the complexity of what we vaguely defined ***world cultural patrimony*** or ***Cultural Heritage***, putting together ***items*** as different as metal moneys, paintings, historical buildings and monuments like churches and mosques, books and manuscripts, musical instruments, bones and mummies, ancient trees, and so on.
The potentialities offered by the use of Robotic Systems for Cultural Heritage are extremely appealing and represent a challenge for scientists and entrepreneurs who want to experiment new ideas and new products.
The challenge:
1 - Cultural Heritage items amount to many millions, spread all over the world where local communities are ready to spend money to preserve their own Cultural Heritage because it represents their own Cultural Identity as well as a source of money from tourism fluxes.
2 - There are significant advantages in terms of costs and manageability for the Robotic Systems with respect to other ***classical*** technologies and methodologies. Compact, intelligent machines may prove to be competitive with respect to other complex machines that need a continuous presence of a human being, 24 hours per day.
3 - Robotic Systems must be mobile, lightweight, and easily portable, with easy manageability: no prototypes needing continuous presence of scientists, or IT experts or technicians. End users are generally employees, civil servants of public or private institutions, with no specific scientific background.
4 - Robotic Systems must be always conceived and developed in collaboration with experts of Cultural Heritage.
5 - Robotic Systems developed for Cultural Heritage may find further employs in close fields like environmental studies of the territory, in domotics, etc.

1.2 – Relation to the Work programme

The Work programme topic to which RICH 2020 relates is Robotics ICT 24 – 2015 because the proposal fulfils the Call requirements, i.e.:
a) Call Specific Challenge:
"Collaborative projects will cover multi-disciplinary R&D and innovation activities like technology transfer via use-cases and industry-academia cross fertilisation mechanisms. PCP will further enable prototype development and stimulate deployment of industrial and service robotics."
b) Call Scope:
"Innovation Actions: Technology transfer - Robotics use cases

Using leading edge science and technology, a targeted effort will aim at introducing, testing and validating promising and innovative robotics solutions in industrial and service sectors. The focus will be on the robust operational deployment of these robotic solutions, based on performance objectives, metrics, and user needs. The strong involvement of all relevant stakeholders in the value chain is essential."

c) Call Expected impact:

"Increase Europe's market share in domestic service robots to at least 20% by 2020.

·Improve the competitiveness of Europe's manufacturing sector, in particular SMEs, address pressing technological challenges and the effect of an aging workforce.

·Increase Industry-Academia cross-fertilisation and tighter connection between industrial needs and academic research via technology transfer, common projects, scientific progress on industry-driven challenges.

Deploy robotics technologies in new application domains.

·Create and maintain world-class research in Europe and achieve excellent standards of publications and research outputs.

Ensure sufficient numbers of well-trained professionals required by the growth of the industry.

·Ensure wide use of shared resources.

d) Call Types of action:

Innovation Actions – A mix of proposals requesting Small and Large contributions are expected

Code 1 (to be written once all Work packages are ready)

1.3 – Concept and approach

There is large ***system diversity***: each scenario is to some extent specific for the characteristics of the Robotic operational environment, the Robotic task, and the Human-Robotic System interaction requirement.

There is also a large ***environment diversity*** i.e. Buildings, Monuments, Archaeological sites, Underground sites, etc. They need a large diversity of tasks i.e. Monitoring, Sampling, Diagnosis, Surveillance and a large diversity of Human expertise i.e. Structural Engineers, Archaeologists, Civil Servant, etc.

Each scenario requires specialized Robotics Systems, (mobile platforms, sensors, actuators, etc.) properly configured with adequate functionalities provided by specialized software control systems.

Nevertheless, Robotic Systems are highly versatile and configurable "machines" that can be conceived as complex systems, whose capabilities and properties emerge from the interaction of a limited number of hardware and software constituent parts, giving rise to specific embodiments, i.e. wheeled or flying robots, etc. possessing RGB cameras, IR sensors, laser scanners, etc. with different software systems providing Robotics functionality like localization, navigation, mapping, manipulation, tele-control, autonomous control, Human-Robot interaction, etc.

The Proposal approach is to develop Robotics technologies to engineer versatile Robotic Systems that can be used in multiple scenarios, providing end-users like Experts in Cultural Heritage, and Civil Servants with low ICT tools, the possibility to easily operate Robotic Systems without being Robotics Experts

Robotics Systems should be multifunctional and flexible to allow different operations like analysis, restoration, consolidation and preservation; these Systems must be small enough to reach difficult, narrow or dangerous places. They should be low-cost in order to be manufactured by SMEs and finally proposed to a large number of small Companies operating in the European market.

Code 2 (to be written once all Work packages are ready)

(Describe the overall project starting from the activities of WP2, WP3, and WP4: their approach, methodology, etc. and any national or international research linked to this project).

1.4 Ambition

Code 3 (to be written once all Work packages are ready)

(Describe for the overall Project, i.e. for the activities reported in WP2, WP3, and WP4:

1 - the state-of-the-art

2 – the progress beyond the state-of-the-art

3 – the literature concerning the previous points)

2 – Impact

2.1 –Expected impacts

The expected impact of RICH 2020 is to support European Robotics stakeholders with technological tools useful to achieve business value in the field of Robotics for Cultural Heritage, with a minimum of technological diversity and at minimal cost.

Code 4 (to be written once all Work packages are ready)

(Describe how a lasting impact of the Project will be ensured by the following strategic Project choices):

…………………………………………...

(In particular, describe the following Project outcomes that will become available in a practical use):

…………………………………………...

2.2 –Measures to maximize impact

RICH 2020 will increase significantly the expertise of European scientists thus allowing Europe to become a global hub for Robotics innovation in Cultural Heritage safeguard. As before mentioned, many actions will be promoted to allow civil Administrations to appreciate the use of Robotic Systems for their needs of safeguarding their local needs, in place of other more expensive and risky technologies.
An appropriate set of activities, promoted within this Proposal, will enhances the knowledge about the use of Robotic Systems for Cultural Heritage; see next work packages for communicating activities.

Code 5 (to be written once all Work packages are ready)

a) Dissemination and exploitation of results

Preparation of a draft plan for dissemination of project results

All Partners will prepare items for publication (scientific papers, conference abstracts, website updates, etc.). Full details about how to publish Project results are outlined into the Consortium agreement.

b) Communication activities

All partners will describe, according to their opinion:

- Market impacts of the project

- Market size and potential

- Steps towards commercialization
- Necessity of a European approach

3 – IMPLEMENTATION

3.1 Work plan - work packages, deliverables and milestones

Code 6 (to be written once all Work packages are ready)

(Describe the overall Work Plan based on the activities of the five Work packages.)
Timing of the Work plan (Gantt chart)
Inter-relation of the components (Pert chart)

The following five Work Packages: WP1, WP2, WP3, WP4 and WP5 represent the structure of this Work plan

Table 3.1a: Work package WP1 description

Work package number 1			**Start Date or Starting Event**				
Work package title	**Coordination**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

This WP guarantees that:

- an effective coordinating structure is created
- the research project is carried out according to the time schedule and budget established,
- meetings are organized to enable collaboration and management of consortium partners,
- the project progress of the WPs is managed and monitored against contractual deliverables,
- the WPs objectives are achieved efficiently,
- a system is created to provide a continuous evaluation feedback and a constant project monitoring.
- the project is managed according to the contract between the RICH 2015 consortium partners and the EC, maintaining a continuous link with the EC, and the overall legal, contractual, ethical, financial and administrative management activities are performed ensuring accurate and timely distribution of funds, reporting on activities, etc.).

Description of work

WP 1 is the Coordination Work Package, which will last for the whole duration of the project.

1 - Coordinator

The responsibility of the project coordination will be taken by ……… who will supply the Project Coordinator. The project coordinator is responsible for all deliverables.

The coordinator's main activities concern the monitoring and management of the agreed deliverables and milestones in the contract between the consortium and the EC, and the smooth running of the project as a whole. The coordinator will maintain continuous relationships with the General Assembly including the Work Package leaders and will report to the EU. For the day-to-day project management, the Project Officer (PO) supports the coordinator. She/he will focus on the daily management, coordination and administrative and financial aspects of the project.

Coordinator activities:

a) Kick Off meeting.

Upon signature of the contract with the European Commission, the project coordinator will organize an initial kick-off meeting for all personnel involved in the project. This kick-off meeting will enable the participants to obtain a better perspective of their role in the RICH 2015 project. Prior to concluding the contract with the EC, a Consortium Agreement will be signed between the project partners

b) Process Management tasks.

The Project Coordinator will conduct the overall project management, as specified in the contract between the consortium and the EC, i.e.:

˜ Organize the project meetings, workshops, and receive reports;

˜ Oversee the drawing up and timely signing of the Consortium Agreement;

˜ Ensure that all parties will sign the contract with the EC on time;

˜ Initiate, prepare and preside over regular project progress meetings and the dissemination of information to all partners pertaining to these meetings;

˜ Act as liaison to the European Commission on behalf of the group in all verbal and written communication;

˜ Inform the Commission properly about the situation and progress of the work;

˜ Inform the Commission in advance of the date and subject of the meetings;

˜ Coordinate the overall financial, administrative and contractual activities of the project, including monitoring and maintaining the overall adherence to the financial budgets;

- Report the overall budgetary situation of the project to the EC, based on the cost declarations from the individual partners;

˜ Coordinate the dissemination of knowledge and deliverables.

3 - Operational project management

The consortium agreement and contract conditions with the EC will be monitored by the General Assembly to ensure compliance by all participating parties.

For each work package, a WP leader has been appointed to take primary technical control of and responsibility for the proper management and execution of the tasks related to the particular WP. He/she establishes (in co- ordination with the Project Coordinator) the detailed schedule of his/her WP. He/she is also responsible for the quality of, and the correct and timely submission of deliverables relating to his/her WP. Each WP leader is also appointed to chair the meetings among the partners participating to his/her WP and will communicate frequently both formally and informally with the workers in the WP.

4- Monitoring:

a) Internal reporting

In order to monitor and guide the consortium, each individual partner will regularly (after the first four months and thereafter at four-monthly intervals) submit a progress report to the respective Work Package leaders. On the basis of these reports, the WP leaders will monitor progress and take any necessary action to ensure the work package remains on schedule.

Each WP leader is required to provide the PC regularly (after four months and thereafter at four monthly intervals) with a progress report concerning his/her WP and containing sufficient technical information to enable the PC to be assured that work is progressing according to plan.

The status of the project will be updated by the PC in a Project Dashboard that will highlight all key progress indicators of the project and areas at risk.

b) External reporting

The combined WP reports (task of the PC) will be discussed and evaluated during meetings of the General Assembly and will constitute the interim reports and form the basis for the annual and final reports that will be submitted to the European Commission by the PC.

Based on the EU model format the coordinator will ensure that all partners provide a consistent flow of information containing key points on the financial progress in the form of a financial report and associated financial plan, as well as an activity report and updated implementation plan.

c) Internal communication

A communication plan will be agreed upon by the General Assembly at the kick-off meeting and will define means and methodology of communication among the project partners.

5- Financial / administrative management

The Project Officer of …… will ensure that all budgetary actions are performed according to the rules and regulations of the EC and the consortium agreement. This includes amongst others establishing a good operating practice for financial management adapted to the financial system of each participating party, to ensure that the received funds are correctly distributed, accounted for, cost statements are received.

Deliverables

– ***Consortium Agreement.*** A Consortium Agreement will be concluded among the project partners.
– ***Kick-Off meeting minutes.***
– ***Meeting/workshop minutes.***
– ***General Assembly meeting minutes.***
– ***Internal website with public areas for communication and data sharing***
– ***Partners progress report.*** Each individual partner will regularly submit a progress report to the respective Work Package leaders in order to monitor progress and to ensure the work package remains on schedule.
– ***Work Package progress report.*** Each WP leader is required to provide the PC regularly with a WP progress report concerning his/her WP to enable the PC to be assured that work is progressing according to plan.
– ***Interim reports.*** The PC will combine the WP progress reports and will constitute the interim reports.
– ***Progress reports to the EC.*** Annually the PC will submit progress reports to the EC.
– ***Final report (technical, financial, deliverables).*** The PC will submit the final report to EC.

Table 3.1a: Work package WP2 description

Work package number 2		**Start Date or Starting Event**					
Work package title	**Land Survey**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

Robotic functions for scouting, exploration and preliminary intervention should be addressed to scenarios where Human action is not possible, for instance for dangerous or limited access, or not economical like in large areas with need of high-resolution details.
Robotic function for surveillance con be implemented with a double aim: to control sensors of stability to prevent Human access in case of risk related to former or foreseen seismic activities and to control sensors against intrusion, typically with surveillance purpose to prevent robberies.

(Distante Cosimo)

Role of CNR-INO

In the project "RICH", the Institute of Optics (CNR-INO) will focus on the study and implementation of the algorithms aimed at achieving surveillance task from visually guided small-UAVs equipped with sensors of different types. The CNR-INO has already developed a custom micro-UAV (quadro-copter) with visual capabilities, which focus on the security sector of detection and tracking of objects of interest.
The vehicle will operate in conjunction with other surveillancecomponents considered in the project. In particular, UAVs vehicles will intervene when other agents have found critical or unexpected events that need further investigation.
In cases like this the UAV will reach and then fly over the area of interest and provide detailed information extracted by on-line processing data coming from sensorial devices.
In particular visual information will be extracted from data acquired by an on board camera.
In this project three different challenging problems will be mainly explored: Super Resolution, Mosaicing and Object Tracking.
The extracted information could eventually also be used in order to improve localization and flight control capabilities.

(Distante Cosimo)

(Panayotis Carydis)

The preservation and benefit of goods of Cultural Heritage need careful surveying and restoration that can be understood as service tasks for suitable robotic systems. New service robots can be conceived once the specificity of the application in the Cultural Heritage area for architectural goods is carefully considered, both with technical aspects and from operators' viewpoints.
For example, despite of a very large and intensive research carried out along the last centuries there are few doubts that many evidences of past civilisations are still hidden along the world. Robotics can be highly helpful to detect and explore those sites and this is especially true if the environmental conditions raise the costs for the quest at very high levels.
The main objective to analyse the characteristics, potentials and problems that are related to the analysis and conservation of historical architectural cultural heritage, within an innovative approach with robotised systems.

(Panayotis Carydis)

(Bacco) Robotic functions for scouting, exploration and preliminary intervention should be addressed to scenarios where human action is not possible, for instance for dangerous or limited access, or not economical, like in large areas, where high-resolution details are needed.
Robotic function for surveillance can be implemented with a double aim: to control stability sensors to prevent human access in case of risk related to former or to foresee seismic activities and to collect data from sensors against intrusion, typically with surveillance purpose to prevent robberies. **(Bacco)**

(Latti) For centuries the Baltic Sea has been the main trade route and war arena and for these reasons it is a great source of research for underwater archaeologists who study the very important material this sea has to offer. The Baltic Sea is a relatively cold sea and the water has low salinity and little amount of oxygen. The shipborer (*teredo navalis*) doesn't live in the Baltic and therefore the shipwrecks on the seabottom are among the best preserved wrecks in the world. There are signs, however, that the conditions in the Baltic Sea are due to a change. The spreading of the shipborer to the Baltic Sea endangeres the very valuable wooden shipwrecks and the need for exact monitoring of their condition is therefore vital.
Many interesting wrecks have been found from Estonian waters, where they are covered with mud and located in shallow waters. There they are threatened by waves and winter ice. A new threat is hobby diving, during which wrecks may be damaged (often unintentionally). Another problem beside hobby divers is looters, who remove objects from archaeological sites and cause irreversible damage. A relatively new and popular hobby diving in Estonia helps to introduce the underwater world and the work of archaeologists, but diving to the wrecks may damage them and increase the speed of deterioration. For this reason there is a great need for a system, that would help to choose wrecks that the hobby divers could damage as little as possible and which would simplify the evaluation of wrecks and make is less costly. Assessing important wrecks may also reduce the risk of looting, which unfortunately is also a rising trend. Although the protection of national cultural heritage is in the competence of the National Heritage Board who cooperates with museums and law enforcement institutions, the new technologies could make this work much more cost-effective and precise.
The current research has mainly focused on deep water wrecks. The historic map data and research of ships routes give a reasonable ground to believe there are still many wrecks to be found in on Estonian coastal waters.
The solutions that the project will offer will help to simplify work on all these matters. The constant supervision of the wrecks helps to coordinate the work of heritage boards, giving valuable information to conservators and marine biologists. Specific information about the conditions of the wrecks in shallow waters helps to react faster and make decisions regarding the methods of how the wrecks are protected.
(Latti)

(Spanò 1) The research program has its main focus in the study, the development and the finalizing of an integrated robotic system mainly aimed to the documentation of Cultural Heritage and the related territorial and environmental contexts with the following features:

- Heritage localized in scarcely or difficultly accessible areas for environmental, social or political reasons.
- Heritage localized in areas that are subject to different kind of risks that can be spatially located; i.e. areas seriously affected by many natural and human-caused pressures, such as problems of unauthorised building operations, coastal erosion, seismic events, floodings, landslides or subsidence situations.
- Heritage localized in post disaster areas (floodings earthquakes, hurricanes)

The robotic system to be developed has the following basic characteristics:

- It enables the real-time documentation (especially in relation to the urgent nature of the request, due to the imminent risk or to the disaster already happened) and it even enables the maintaining and the continuous updating of the information.
- The system is aimed to integrate already available technologies and different solutions (many of them are high-cost solutions) in order to pursue contemporary the low cost, the high-performance in terms of accuracy and data quality and easy to use solutions.
- The last aim is indeed to provide to the actors involved in the management and in the protection of the CH some smart tools that allow to support the decision-making processes. A digital platform will be implemented to manage, visualize, analyze and query the acquired 3D data; this platform will be designed to be a 3DGIS for a correct and exhaustive documentation of our CH also through a semantic representation.

The robotic system being developed belongs to the innovative tools category of Mobile Mapping System, MMS; the carrier can be e a UAV (unmanned aerial vehicle) or ground vehicles, both motor-driven vehicles and bicycles.
From the technological point of view , the effectiveness of innovative products have to be searched in the most complete integration of sensors, in order to balance their accuracy and reliability of positioning
- The navigation sensors such as GNSS receivers (Global Navigation Satellite System) and inertial sensors (IMU, Inertial Measurement Unit) conveniently integrated
- the high resolution digital cameras acquiring in visible range, aimed to collect sequences of correctly geo-referenced images and also able to contribute in order to estimate the solution of navigation(image-based navigation);
- The geometric sensors (laser scanners, range cameras or 3D cameras) that are able to acquire three-dimensional information as dense points clouds, in accurate and quick way and eventually they can contribute to the estimate the navigation solution (LiDAR based Navigation);
- the image sensors over the visible range such as thermal cameras in order to describe non vsible phenomena.

One of the main innovation component is the use of some tools available on the market dedicated to other mass market applications such as smart phones, tablet PCs,iPad, and whatever else they are often equipped with various sensors (GPS / GNSS, IMU simple, digital camera) that make them potential tools for detecting and useof geo-referenced information. Analyzing the issues mentioned before, special attention will be devoted to environmental issues (Smart Environment) for risk mapping and prevention of damage associated with catastrophic events in real-time. Special attention will be given to all environmental issues (Smart Environment) for real-time mapping of risk and prevention of damage associated with catastrophic events.

The proposal strategy is even the chance to involve many non-expert actors in the collection of spatially controlled data regarding the Heritage.

- Experts involved in the Heritage conservation plans, or employees of the public administration, everyone non expert in the spatial information field.
- People from a vast public of non expert and volunteers involved in the pre-post crisis management.

In every case the finalizing of a system aimed to the use and manage of a collaborative data modeling environment (Crowdsourcing)will be provided. **(Spanò 1)**

Description of work

(Distante Cosimo)

Task 1 Mosaicking and Super resolution
Most intelligence, surveillance and reconnaissance platforms rely on relatively low resolution NTSC and PAL imagers, due to the constraints of the datalinks used in today's aerial and remote sensing platforms. This results in imagery that is fine when looking for large scale movement or monitoring a large area, but poor for trying to identify items like license plates, registration numbers, faces or smaller shapes.
By using multiple frames of video that contain the same objects, it's possible to create new frames of information that are effectively higher resolution. By registering images very accurately, we can interpret pixels present in individual frames, even if they are not present in other frames. By 'filling in the gaps', we can create new frames that contain more information than the originals.
Robust local descriptors that resolve geometric and photometric invariances under images registration will be addressed in this task. This will be coupled with Robust parameter estimators which are advancements of Ransac methods for homography estimation. Super-resolution will be applied to the individual sub-frames from the overlapping region.
Finally, multi-band blending will be used to stitch these resolution-enhanced frames to form the final image. So far, a combination of low-cost GPS, video and attitude sensors will be used to estimate the interesting objects on the ground position whilst a simple super-resolution technique used to enhance images of the object of interest.
Mosaicking and super resolution will be addressed in a post-processing stage, while leaving visual computation algorithms related to navigation (attitude estimation) processed on board. In this task, stability of

the flight control system will be improved by making use of the extracted visual features that are used for mosaicking and super resolution.

Role of Partners:
CNR will develop algorithms for mosaicking and super resolution imaging

Task 2 Object detection
This activity will be carried out by building specific detectors both for mobile and stationary cameras. For both kind of views, detectors for intruders such as humans or vehicles will be developed.
The activities of this task can be grouped in two blocks: the extraction of relevant features for object characterization, and the classification of such features to perform the objects detection/recognition.
Each algorithm will be specialized according to the operative context.
With reference to the feature extraction, statistical features obtained by comparing relevant frames will be used for detection modules running on the stationary cameras; on the other hand, in presence of mobile cameras, other features such as histograms of oriented gradients and local binary patterns will be investigated as a texture characterization of the object to be detected.
Then classifiers such as min-max and support vector machines will be analysed and compared in order to satisfy the tradeoff between detection rate and computational load. This because the algorithms will run in real-time on embedded systems of UAV or the stationary camera processors.
This task will start with the construction of an opportune dataset for the training of the detectors. Detectors are different for stationary or mobile systems since intruders have different poses and then textural information.

Role of Partners
CNR will develop feature extraction algorithms for a reliable characterization of objects, and classifiers that permit the detection and recognition of specific objects.

Task 3 Object tracking with appearance models
This taskwill be addressed to develop of a new concept of visual tracking algorithm. It will be based on appearance-adaptive models and dense local feature descriptors.
The algorithm initialization is made by using the results of the previous task (Object Detection) which will provide the first frame object bounding box coordinates.
The dense local invariant representation of the object with a robust object/context nearest neighbour classifier allows the visual tracker to reach high performances.

This method will be able to track an object in very longvideo sequences under a complex interaction between illumination, occlusion and object/camera motion. The basic objective will be to separate context from object features in order to remove background included in the bounding box. Mechanisms that include adaptation of dense features (object/context appearance) and frame by frame robust transformations will be studied, in order to estimate the evolving relationship among the different object poses and the mobile camera, which means "continuously object tracking".

Role of Partners:
CNR will implementthe novel tracking algorithm studying in particular: i) how it discriminates the object from the context;ii) the way in which it estimates the object status; and iii) how it updates the object/context appearance. At the end of this phase, CNR will carry out first lab prototype.

(Distante Cosimo)

(Panayotis Carydis)
Our contribution could be based on our last 50 years' experience related to various subjects of the proposal as follows:
a) Design of instrumentation for monitoring of any type of structure. We have designed the instrumentation of strong motion accelerographs installed in PARTHENON on 1973. We have designed the instrumentation for more than 150 different large scale models using shaking tables. As a result of this experience is the "know how" on optimizing the installation on structures of any type of measuring instrument. Under the term "optimization" we mean: the selection of the best fitting type of the instrument, its calibration, its positioning, the communication and data selection, the data evaluation – exploitation – application.
b) On 1973 we have performed a rather large number of ambient vibration measurements on PARTHENON. The measurements were carried out in a way so that to be easily evaluated. For example, top and bottom on

the various pillars, on the two sides of the corners, e.tc. These results of the measurements are still unpublished since we wont to compare them with now measurements that could be carried out, 40 years later, possibly under the framework of the present proposal.
c) We possess a rather rich data bank on dynamic characteristics based on ambient vibration measurements of traditional structures.
(Panayotis Carydis)

(Bacco) The task 1.1 leverages on the possibility to exploit an UAV (Unmanned Aerial Vehicle) in a fully automatic way, by a-priori activities planning. This planning is transferred to the drone that repeatedly executes the activities. It allows a periodic report of the state of the area or of the building of interest (i.e., data collected by on-board sensors), with a very minimal human intervention.
The main challenges of this task are:

- Exploration of large areas exploiting an UAV in a fully automated way in order to periodically report collected data
- UAV flying control techniques in order allowing the use of any onboard sensor (such as high resolution cameras, etc. etc.)
- The data flow from the UAV to the entity deputed to collect and present data can be in real-time or time-deferred: in the former case, a reliable communication link must exploit data protection techniques to ensure a reliable transmission for data and control traffic; in the latter, data will be collected when the UAV lands, i.e. no real-time communication is expected
- The UAV payload may be subject to weight, size and energy constraints **(Bacco)**

(Latti) To reach project goals it is necessary to carry out following steps:

1. Composing criteria for evaluation of wrecks in cooperation with specialists and conservators of National Heritage Board. During this phase of work, the material gathered about shipwrecks and their state of preservation is studied and evaluated. The preservation of a wreck depends on the material, cause of sinking, location and many other criteria. Based on those criterias, an objective system is created which enables a researcher to evaluate the condition of a found wreck and estimate the speed of deterioration. Those criterias help to describe the potential dangers and issues concerning the preservation, and further diving to the wrecksite. In this stage involvement of conservators and specialists from Estonian National Heritage Board is crucial. As a result, a document consisting of evaluation criterias for shipwrecks is created.
2. Testing the technology (AUVs, ROVs etc) in the Baltic Sea region and writing down possible repair / improvement suggestions. The Baltic Sea is a very demanding environment with cold water, poor visibility and constantly changing weather. The technology used for underwater works must be very durable and reliable, equipped with sensors capable of providing good quality data for research. At the same time, the equipment must be simple to handle and easy to repair. Testing the equipment in the Baltic Sea could be very useful for testing its reliability and ability to work in the difficult conditions.
3. Mapping the known endangered wrecks. The Estonian Maritime Museum monitors the situation of wrecks during fieldwork every summer, but this work is relatively fast, not too thorough and dependent of the location of the current fieldwork region. For this project certain wrecks are chosen in cooperation with the National Heritage Board and their condition is carefully recorded. It is necessary to gather information from very different ships to get a comprehensive overview about the wrecks with different material and age. Therefore, wooden and metal ships with different age (eg 200 years, 100 years, 75 years etc) are chosen from specific area and their condition is evaluated and compared. Also the wrecks studied during previous projects (e.g. SHIPWHER and ARROWS) are re-visited, which enables the researchers to compare the changes since the last visit.
4. Use of professional technology to evaluate wrecks used for hobby diving. In this phase of the project, newly developed technology will be used for mapping the potentially suitable wrecks for hobby diving and evaluating their condition. Cooperation with amateur divers is necessary to achieve the best solution for the researchers and amateur divers alike. The task at hand is quite difficult, since the wrecks in question have to be easy to reach, without archaeological value, well preserved and at the same time attractive and safe for divers. This phase also serves as a valuable method to popularize underwater archaeology and responsible handling of underwater heritage.

5. Popularisation of the project and underwater heritage though articles and an exhibition. The interest about archaeology and maritime archaeology is very high and even quite short news about fieldworks at sea or about the discovery of a new wreck will reach news headlines very fast. Also the exhibitions we have organized so far about the underwater archaeology have proved to be popular. Various articles and exhibition can help to explain the work of archaeologists and the need to protect our cultural heritage. **(Latti)**

(Spanò 1) The attempt is to identify, study and develop the most innovative tools / procedures / products adapted to involve, when it is possible, citizens themselves in various stages of knowledge of reality providing for them the needed tools to participate.
The operating procedure can be summarized in the following phases:

A. selection and design of some types of instruments to capture georeferenced spatial data (mass marker, low-cost land and air, high-end) called the mobile mapping system (MMS) to be applied both in ground environment and by aerial platform of UAV (Unmanned Aerial Vehicle) kind.
B. defining the specific operational procedures applied to the types of instruments and levels of data quality to produce as quickly and economically as possible the necessary information to the description of the city, land and environment;
C. classification of the different levels of data quality in terms of accuracy, and completeness of information contained in the application and definition of their associated metadata;
D. proposal for innovative products that allow to represent a complete, correct and three-dimensional reality in an accessible (with open formats and in the public domain), easy to use (with visualization software in the public domain that allow untrained users to use), with few demands in terms of hardware performance (and thus implementable on tablet PCs, smartphones or iPad).
E. Classification and definition of different activities workflows in relation with the above described points and in relation to the diverse CH typologies. (Archaeological sites and ancient cities, environment or landscape interest sites, historical centres, cities interested by seismic emergencies, Monuments, architectural complex set in one or more structures, buildings, gardens and historical parks). This classification has to be connected with the different natural risks or just happened disaster, and with the intrinsic vulnerability of CH.

In the phase A are included:
1. Study of state of the art
-methods of sensors calibration e.g. non-metric camera distortions, IMU biases, influence of dynamic models in GPS / GNSS positioning)
- mass-market solutions derived by non-specific instruments (iPod, smartphone, tablet PC …);
- aerial platform available in micro UAV (Unmanned Aerial Vehicle) class, such as VTOL (Vertical Take-Off and Landing) with the aim to a definition of an aerial MMS

2 Design and implementation of MMS : low cost ground segment and low cost aerial instrumentation.
- design specific mechanical sensors support in order to realize a rigid structure, in which other equipment will be installed.
- Some dedicated time synchronization systems will be developed with purpose to have one reference time scale
- A ground pedestrian version will be also realized with the usupport of a dedicated polygon to calibrate these instruments.

In the phase B are included:
1. Operative methods for mass-market instruments (based on state of art and testings, possible finalizing of some operational modalities that allow the use of mass-market instruments such as MMS very cheap, portable and distributed
2. Sensors integration
-GNNS/IMU integration (study of different calculation techniques, such as the extended Kalman filter (EKF), the Unscented Kalman filter (UKF) or the Fast Kalman filter (FKF), beginning to the existing studies. Artificial Neural Network (ANN) and Particle filter (PF) approaches will be studied with the aim to develop novel integration algorithms. The study should also have consider the different GNSS / IMU integration approaches, analyzing what is the best strategy for low-cost data.
3. Development of photogrammetric frames acquired by UAV
- Automatic selection of tie points through some operators of interest (SIFT or SURF);
- Robust techniques (Least Median Square, LMS) for rejection of tie points using procedures related to the relative orientation;

- Solution of photogrammetric triangulation using DLT (Direct Linear Transformation);
- Compensation to projective stars (Boundle Block) and robust diagnostics;
- if the LiDAR data is not available, it is possible to generate a final elevation model using dense multi-image matching algorithms applied according to an approximate elevation model generated with both the connection and ties points;
- Generation of precise orthophotos using a multi-image approach.

Related to the phase C, D, E, some enhancement studies have to be develop in order to optimize the fruition of 3D accurate models. The capacity to obtain dense and accurate surface models, generated from active (LIDAR) and Passive sensors (multi image matching , Structure from motion, SFM), in the visible or other spectral range, enable to analyse in death the studied phenomena. The processing, archiving representation and comunication of large sets of 2D-3D georeferenced impose the study of proper strategies for the results sarin and diffusion.

1. 3D models optimization: fusion of techniques and products to enhance the geometric and thematic quality of models. Enhancement of texture projection.
2. Segmentation techniques according to semantic structuring of 3D models..
3. 3DGIS / WEB GIS
   Spatial standards, 3Dcity GML, enhancement of Level of Details (LoDs) and implementation of architectural Lod.

Open tools /open standards (Qgis, Sql server, postgre sql) **(Spanò 1)**

Deliverables

(Panayotis Carydis)

Main deliverables will be:

1) An extensive list of measurements from 1973-2015 (using year 1999 and the Athens earthquake as focal point).These measurements will be used for analysis, comparison and evaluation in the potential use of robotics in the preservation of cultural heritage

(Panayotis Carydis)

(Latti)

1. Demands for working out technology for use in the Baltic Sea. 4th month of the Project. As said before, Baltic Sea is quite a demanding environment. The technology has to be reliable and to be able to provide high quality data for research. In this deliverable, requirements for the technology are discussed.
2. Evaluation of the results of testing the technology. Dependent on the testing time. The deliverable will be a “mission log” about the field testing of the equipment. Various sensors and other systems are tested and the test results are presented, discussed and evaluated.
3. Overview of preservation conditions of wrecks and their problems. 6th month of the project. The deliverable will give an overview of the wrecks chosen to be monitored during the project. The current state of preservation is presented and methods of protecting them in the future are presented and discussed.
4. Exhibition about the shipwrecks in the Baltic Sea, their significance and preservation. The exhibition may be web-based or housed by the Maritime Museum. With the exhibition, a series of seminars or lectures could be organized to present the project and its results to wider audience. Various educational programs concerning schools and universities are also possible.
5. Project final report. The final report summarizes the results of the project. **(Latti)**

(Spanò 1) The proposal to use, as MMS, some electronic equipment that are not predominantly dedicated to the measurement of the region but that are equipped with navigation sensors integrated with digital cameras such as iPad, iPhone, smartphones, cameras with integrated GPS and electronic compass, is innovative: it is necessary to verify the characteristics in terms of accuracy and usability that have not been

yet carried out in an organic way; this idea is surely to be considered as an innovation (this is a strategy line focused by horizon 2020 program: Science of Excellence-SE); There are many examples of terrestrial high-end MMS, but there have never been produced low-cost instruments that integrate navigational sensors (GNSS and IMU), one or more digital cameras, LiDAR, or Range camera allowing anyway performances usable in various speditive applications (SE). The project proposal, after the testing and engineered phase, could become a commercial instrument with high impact, especially considering the its mass-market distribution; (this s another strategy line focused by horizon 2020 program: Industrial leadership IL); Some solutions of UAVs equipped with photogrammetric instruments exist in the literature; it is also possible to find deeper studies based on similar high-end systems. The aim of this project is not directed to the aerial vehicle (also a low-cost system), but to the development of a real MMS aerial platform that allow a correct integration of navigational sensors, digital cameras and LiDAR sensor or range camera. Nowadays there are no low cost solutions that enable the optimal integration between all of these sensors As in previous, the idea is to develop a commercial version with widely distribution (IL) if the system is functional and low-cost; **(Spanò 1)**

Table 3.1a: Work package WP3 description

Work package number 3		**Start Date or Starting Event**					
Work package title	**Underwater survey**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

Robots may include their own scanning system or be a stable platform for higher resolution scanning system belonging to specific (eg. Laser based) sensors. Requirements are on short terms stability, during the measurement to prevent spoiling the 2D or 3D imaging, and on long terms during the path loading to the point where the carrier should stop to perform the measurements. Weight and size of the sensors should be accounted for sensors, where a optical head can be remotized (by fiber-optics) with respect to its control unit, should be developed.

(Roig 1) Mobile or fixed underwater observatory

The main aims of this task are:

- Design of underwater observatory
- Design of remote surface station
- Development of the base station equipment
- Construction of the observatory, remote surface station and base station

Abstract:

The output of this work package is the development and manufacturing of a remote observatory for *underwater archaeological site real time monitoring. Monitoring will be performed either with a fixed series of underwater video cameras systems or with a ROV based system, where the user will be able to navigate through the site for sensing and monitoring. Communication and control of cameras or ROV will be performed through a buoy with solar rechargeable battery system which will be linked with a high speed connection to a base station on earth.*

This system will also be able to be used for a short term deployment for remote survey of an archaeological site. The system should be deployed from a ship near the site, and scientists could perform a ROV survey remotely form earth station or lab. **(Roig 1)**

(Roig 2)
The main aims of this work package is the development of an autonomous tool based on AUV technologies and main objectives are:
- Design of the AUV platform
- Definition of the on board equipment of the vehicle
- Mechanical and electronic design of the vehicle
- Control and navigation software development
- Construction and outfitting of the vehicles

Abstract:
The output of this work package is the development and manufacturing of an Autonomous Underwater Vehicle for underwater archaeological site real time survey and monitoring.
(Roig 2)

Description of work

(Salerno Emanuele)
Description of Workto be performed by the CNR-ISTI team
Vehicles (to be done by other partners?)
WP3 activity includes all the signal processing and understanding methods to detect, classify and recognizearchaeological targets on the seabed.Moreover, methods toexploit the whole amount of raw and processed datawill be developed.
WP3 outputs:
i)Aset of interactive tools for the quantitative analysis and study of the detected objects;
ii) A virtual environment where the underwater site scene is recreated realistically, to allow the study of the archaeological findings in the proper context, and the dissemination ofthe acquired knowledge to both the specialists and the public at large.

Task 1 - The underwater survey data will come from one or moreautonomous underwater vehicles (AUVs) equipped with heterogeneous payloads, including sensors tailored for any specific mission. The set of sensors will be selected considering the specific requirements related to the peculiar environmental conditions. Typical choices in the field of oceanography and marine mappinginvolve optical and acoustic devices, such asdigital cameras, side-scan sonars or multi-beam echo-sounders. The data collected will be processed to discover the presence of human-made artefacts in the scene. This will be doneby extracting and emphasizing those features that exhibitregular patterns,as opposed to chaotic background or unstructured clutter. The site maps reconstructed will be processed to i) classify the different areas through texture analysis, and ii) detect geometrical regularities such as primitive curves (arcs of ellipses, line segments). A further issue will concern the processing of the data to obtain large scale maps of the surveyed environment. These maps, obtained by aligningand stitchingmultiple maps of the same area taken from different viewpoints, will be available for offline display/analysis, dissemination and further exploitation. The multi-modal description of the underwater scenario will finally be exploited to implement robust object recognition procedures by properly integrating and cross-correlating the data.

Task 2 - The 3D models obtained from Task 1 will be integrated in a virtual scenario mixing data captured during the project missions and data simulated by 3D computer graphics engines. This simulated scenario, very accurate in terms of the environment, the object models, and their positions,will become a technical tool

for the archaeologist, who will be able toperformpart of their quantitative analysis of the site under studythroughmeasurements and observations on the reconstructed 3D models rather than on the real underwater scene. On the other hand, the integration of advanced gestural devices (Kinect, Leap Motion, etc.) and stereoscopic visor (Oculus Rift) will enable non-specialized users to navigate the scenario in an appealing and stimulating way,hence providing new channels and methodologies for dissemination.
(Salerno Emanuele)

(Roig 1)
Task 1.1 – Design of underwater observatory
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: This task will deal with the design of the new underwater observatory, definition of video, imaging and sensor requirements, both for the fixed camera housings as for the ROV system.
Task 1.2 - Design of remote surface station
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: This task will deal with the design of the new tether system between observatory and surface buoy, specification of power, solar panel and battery requirements. Mooring line design will also be defined during this task, along with the buoy and watertight housings. Last objective is the definition of requirements for the communication between observatory and base station.
Task 1.3 - Development of the base station equipment
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: This task will define the main requirements of the base station design, based on communication requirements. User interface for the remote control system will be programmed using internet/web based protocols.
Task 1.4 - Construction of the observatory, remote surface station and base station
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: The main objective of this task is the manufacturing of the observatory, remote surface station and base station, based on the design and specifications defined in previous tasks. Main housings of observatory will be manufactured and outfitted with selected cameras. ROV system will be manufactured according to requirements, and main observatory modules. Surface buoy with mooring line and communication and power tether will be manufactured and outfitted with power and wireless communication equipment. **(Roig 1)**

(Roig 2)
Task 1.1 Vehicle design
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: This task will deal with the design of the new Autonomous Underwater Vehicle, specifically adapted to the requirements stated in Task X.X. Components, modules, and equipment for optimal navigation and sensing will be specified. The vehicle will be designed as a combination of endurance and operational requirements, having mainly in account archaeological specifications.
Task 1.2 Vehicle control and navigation
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: This task will define the control system for autonomous navigation of the vehicle. The goal of this task is the development of the algorithms that will use the on-board sensor data

fusion for the navigation and positioning of the vehicle, performing the self-localization and mapping operations.
Task 1.3 Construction and outfitting of the vehicle
Task leader:
Other involved partners:
Duration: Months 1-12
Activity: The main objective of this task is the manufacturing of the robot, based on the design and specifications defined in previous tasks. Main vehicle and modules will be manufactured. Main modules are the battery and power system, propulsion and thrusters system, watertight housings, structure and hull. Outfitting of internal electronic components and modules will be performed in this task, as well as testing of all subassemblies.
(Roig 2)

Deliverables

Table 3.1a: Work package WP4 description

Work package number 4		**Start Date or Starting Event**					
Work package title	**Continuous monitoring**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

Preservation and conservation of tangible Cultural Heritage depends on different factors, summarized into the following two points:
- Prevent the deterioration through the reduction of the causes of alteration like the application of hydrophobic compounds for reducing the negative effects caused by water and its solutions on porous materials;
- Monitor the state of conservation in order to plan timely maintenance operations, avoiding drastic and expensive repairing interventions.
Particular attention must be paid to “effective” monitoring, because it may allow a sustainable conservation of works of art.

At present, several attempts of monitoring of different artefacts are performed, however they are often not inserted in a specific "conservation project", and therefore the results are not completely exploited. In addition, only few parameters which identify the decay (precursor symptoms of damage) are identified and the measurements, although often performed in situ in a non-destructive and non-invasive way, are not always fast, easy to perform and at low cost.
In this situation, the collaboration between experts in robotics and Cultural Heritage may give a synergic effect and greatly improve the quality of monitoring. Thanks to the advanced technology of robotics, in fact, it is possible to detect and monitor any critical surface of cultural assets (accessible and non-accessible) with instruments easy to use, at low cost and with the required accuracy.

(Bacco) Preservation and conservation of tangible Cultural Heritage depends on different factors, summarized into the following two points:

- Prevent the deterioration through the reduction of the causes of alteration like the application of hydrophobic compounds for reducing the negative effects caused by water and its solutions on porous materials;
- Monitor the state of conservation in order to plan timely maintenance operations, avoiding drastic and expensive repairing interventions.

Particular attention must be paid to "effective" monitoring, because it may allow a sustainable conservation of works of art.

At present, several attempts of monitoring of different artifacts are performed, however they are often not inserted in a specific "conservation project", and therefore the results are not completely exploited. In addition, only few parameters which identify the decay (precursor symptoms of damage) are identified and the measurements, although often performed in situ in a non-destructive and non-invasive way, are not always fast, easy to perform and at low cost. **(Bacco)**

(Spanò 2)
The metric survey applied to Cultural Heritage for the conservation plans, in its various meanings, takes care to analyze every "particular sign", in order to allow the elaboration of a "history" of the building, through the recording of the various steps of aggregation and stratification, is in order to define it dimensionally, objectively, and still, in order to record and to get interpretable every decay manifestations.
Traditionally measuring and monitoring techniques of deformation conditions of structures, mainly applied with topographic methods, have been largely applied to control and test engineering structures, infrastructural works and historical architectural heritage. Instruments and methodologies to determine absolute movements, relatives ones, deformation and rotations belong to operative practice, that consists in a phase that cannot be omitted.
Monitoring and control techniques have increased during last time, thus, nearby traditional methods- still reliable and precise new instruments devices and control systems introduced new applying capabilities.
At the same time, the development of microelectronics, of data transmission techniques, of computer sciences have allowed application able to provide measures with a large level of automation and able to offer real time results.

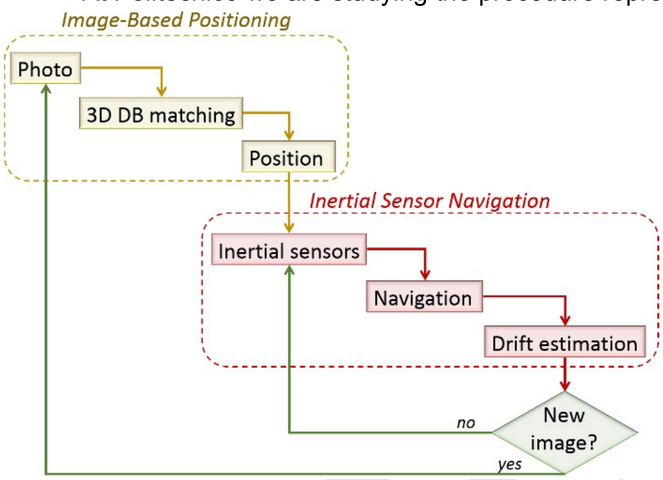
Even in the metric documentation for continuous monitoring of CH, particular attention is directed to buildings and artifacts stricken by natural disasters as floods, earthquakes, landslides, etc.. The main objective of this project is therefore the improvement of the CH monitoring trough the critical storage and management of technical-scientific heterogeneous data collected after disaster.
Joining perfectly the multi-scale approach, by now typical for the CH documentation, the well develop integration between different 3D survey approaches such as terrestrial LiDAR and traditional/spherical Photogrammetry enables to obtain good results in built heritage documentation that can be usefully exploited for static elaluation. (1)
Starting and contemporary with the activities directed to 3D models, other two main objectives of the project are the finalizing and test of an innovative laser scanner for monitoring purpose (2) , and the introduction of Image Based Navigation (IBN) in the workflow of data acquisition to generate models for the assessment purpose of buildings. (3)

A. The first challenge consists in permutation of dense and accurate models into models that are able to be suitable for static assessments. Than, such 3D models can be used to reference the results of non destructive diagnostic inquiries or for the evaluation of focused interventions on the structures.

The main objective is the use of simplified or advanced 2D or 3D models suitable for the evaluation of stability control and to support the seismic characterization and safety of buldings or parts of them.

B. Testing of an innovative laser scanner system especially designed for historical structures and archaeological sites monitoring.
The operation phase is automatic and permanent and the system is able to detect the movements of points or sufaces without the use of targets .or signals
Without the human involvements the system is able to spotlight the presence of stability problems, also after a disaster such as an earthquake.

C. the Image Based Navigation (IBN) is a very interesting approach since it can be very useful in hard-urban environment or for indoor positioning, as alternative to GNSS positioning. In this perspectives, situations of historical centres stricken by seismic events can be highly supported by IBN, since a urgent and general estimation of damages is extraordinarily important.
The Image-Based Navigation (IBN) procedure is an approach devotes to define position and attitude of the user, in real time navigation using images and photogrammetric algorithms, and eventually inertial sensors.
At Politecnico we are studying the procedure represented in next picture.



(Spanò 2)

Description of work

(Bacco) task 2.1 deals with the data transmission issues between a mobile gateway and a remote central server. The gateway is responsible to collect data from several sensor sources and to forward them to the central server in a reliable way; the central server is responsible for storing data in a permanent way and to ensure its accessibility at any time.
Several techniques can be adopted to reduce the impact of unreliable communication links (i.e., in mobility conditions and/or when a given level of Quality of Service is crucial); one of the most interesting ones is the channel coding approach. This approach allows adding redundancy to the original data to have a more robust data transmission, by relying on Network Coding techniques. In addition, the contemporary presence of a control and a data channel can be exploited in a multihoming approach, using both channels at the same time.
Starting from a simulation approach, the most promising techniques able to ensure the robustness and reliability of the proposed approach will be finally demonstrated.
The main challenge of this task is:

- Data transmission to a remote central server through a mobile gateway by relying on innovative, reliable and adaptive techniques
    - able to handle channel errors in difficult conditions, such as during the UAV flight (that will be

the test case for the demonstration of the proposed approach)

- able to guarantee real-time communication for data and control traffic **(Bacco)**

(Spanò 2)
For the optimizazion of models with purpose to use them in the static evaluation environment (point A of objectives) the next enhancing studies are requested:

A1. Point cloud extraction using multi image matching techniques After the first study phase of techniques for multi image matching, the unit will proceed to their implementation in a scientific software:
° Automatic homologous points extraction and relative orientation by projective stars triangulation.
° Automatic point extraction from the oriented images using operators of interest
° Extraction of radiometric edges
° Study of the algorithms for calculating the three-dimensional coordinates of points and radiometric edges, using the epipolar geometry and a first approximation
surface model
° Study and implementation of least square matching algorithms to improve the geometric accuracy
° Optimization of the data filtering algorithms
These algorithms have already been the subject of studies in the course of more doctoral theses and some have already been implemented and available to the Research Group of Politecnico di Torino..
A2. Integration between digital photogrammetry and LIDAR
The unit will study the topics of integration of different acquisition technologies and of the use of the different information from each, in order to optimize the
performance of segmentation techniques for, in part already studied by the research unit and implemented in software.
° Alignment in a single reference system of the data acquired using different technologies.
° Extraction of radiometric edges and refinement by least square matching.
° Extraction of geometric edges.
° Implementation of assisted segmentation algorithms.
° Optimization of the point clouds.
° Exports to the three-dimensional modeling.
The algorithm will be rigorously tested in a wide range of operating conditions to determine the geometric accuracy and the potential in terms of completeness of the information obtained.

C. The most common device for location based services are based on smartphones technology, where several sensors are installed, as GNSS (Global Navigation Satellite System) receiver, video-cameras, pressure sensor, inertial Measuremente Unit (IMU) with accelerometers, gyroscopes and magnetometers. All of them contribute to define a 3D position, and they could be used for Geomatics purpose also.
The image-based localization (IBL) procedure adopts well-known algorithms for image matching, such as SIFT and RANSAC, while the Image Based Navigation approach can help to estimate and correct the inertial sensors drift, in order to improve the quality of positioning up to 0.4 m.

Surely, in the perspective to use this technology for high considerable and sensitive data collection (such as the post disaster data collection), almost every segment of the system and step of the procedure have to be studied.

- *Wi-Fi*: this technology is especially dedicated for indoor environments in a transmission range between 30-200 m. In particular, the positioning is based on the time-of-flight range measurements observed from several base stations applying a triangulation. This procedure brings to have good performance, but it suffers from outliers, signal coverage and depends to Access Points (AP) and geometric distribution (DoP) (Schatzberg et al., 2014; Hatami et al., 2005; Werner et al., 2014);
- *pedestrian tracking system*: this procedure is based on the use of a pedometer, that is now also available in the modern smartphone (Yunye et al., 2011; Woodman and Harle, 2008; Shin et al., 2014). The possibility to adopting external sensors as low-cost IMU-MEMS (Micro Electro-Mechanical Systems), which was directly installed on the foot of the user has been investigated (Yuan et al., 2014);
- *Bluetooth*: the technology is based on the use of Bluetooth Low Energy by adding direction finding capability (Kallioka, 2011). There is also another approach based on a range-free localization system using commercial smartphones with Bluetooth capabilities. In the range-free localization system, each smartphone periodically scans nearby Bluetooth enabled devices and sends the results to the

localization server. This server collects the scanning results into a short period and find their locations using range-free algorithms (Lee et al. 2014).

- *Inertial sensor navigation* (Woodman 2007): another alternative approach is to use the accelerometers (Kunze et al. 2009), the gyroscope and magnetometers in the pedestrian navigation in order to correct the drifts (Afzal et al. 2011) and also in the use of barometer sensor to identify the movements (Frank et al. 2014), with purpose to realize a navigation.

Another theme useful to study and enhance is the Visual Odometry. The visual odometry (VO) is the process of estimating the egomotion of an agent (e.g., vehicle, human, and robot) using only the input of a single or multiple cameras attached to it. Application domains include robotics, wearable computing, augmented reality, and automotive. The advantage of VO with respect to wheel odometry is that VO is not affected by wheel slip in uneven terrain or other adverse conditions. It has been demonstrated that compared to wheel odometry, VO provides more accurate trajectory estimates, with relative position error ranging from 0.1 to 2%. This capability makes VO an interesting supplement to wheel odometry and, additionally, to other navigation systems such as global positioning system (GPS), inertial measurement units (IMUs), and laser odometry. (Scaramuzza Fraundorfer, 2011)
(Spanò 2)

(Falorni Pierluigi)

1) Microwave holography

We propose the use of a light and compact robotic scanner capable to scan with fine spatial sampling lar ge areas in order to produce holographic images of the subsurface objects. The holographic radar will be equipped with compact and light weight (<400gr) monostatic antenna with integrated electronics which f acilitate the design of the mechanical scanner mounted on the robotic vehicle. The trajectory of the roboti c vehicle will be automatically programmed in order to optimally cover the required areas and eventually to avoid local obstacles. The holographic images have a plane resolution that is about a quarter of the w avelength in the reference material (soil, stone, wood) and they reproduce accurately dimensions and sh ape of shallow objects thanks to their dielectric contrast. The full three dimensional reconstruction, which contains also depth information, can be obtained by using multiple frequencies and migration software. T he following list describes the main activities proposed by the research group: - LIDAR/ULTRASOUND to get distance from first surface - Development of a quadrature radar - Data acquisition HW/SW interface - Signal/image processing src - Write test plans - Write instruction manual - Design and fabrication of holo graphic antenna

2) Detection of insects activity in wood

An advanced design of the piezoelectric sensor and the electronic front end is proposed to develop a hig h performance monitoring system of
xylophagous insects (particularly H. Bajulus (L.)) that attack and damage wooden items in cultural heritag e and civil engineering structures. The novelty of the method is that the monitoring is done with a modula r system with multiple sensors specifically designed for long-term monitoring and be left in places not acc essible. The acquired information is processed with an advanced HW/SW system to provide detailed info rmation on the species of insect pests and their possible location and send the information to a remote sy stem. The development of this continuous monitoring system is intended for easy use and installation on wooden items of artistic value or wooden civil structures.
The following list describes the main activities proposed by the research group:
- Development of highly interconnected/high sensitivity monitoring devices
- Agreements for a standard upstream communication protocol - Preparation of Functional/Integration/Fie ld TESTs
- Study of acoustic coupling of sensor to wooden material
- Development of a SW library for the detection of active insects with:
  + environmental noise cancellation
  + long term monitoring
  + tracking of insects activity
- Writing of a instruction manual

(Falorni Pierluigi)

Deliverables

(Spanò 2)
Testing and engineered phase for the laser scanner for continuous monitoring.
Involvement of the Image Based Navigation (IBN) in the workflow of the Disaster Management, and first evaluation of Damages (mainly seismic events).
(Spanò 2)

(Falorni Pierluigi)

1) Microwave holography
   - Holographic antenna
   - 2D/3D modeling
   - Specifications for data interface
   - Functional TEST - Integration TEST
   - Field TEST
   - SW library for signal processing
   - Instruction manual

Detection of insects activities in wood
- Highly interconnected/high sensitivity monitoring devices
- Specifications for data interface
- Operating procedure for optimal sensor coupling
- Functional TEST
- Integration TEST
- Field TEST
- SW library for signal processing
- Instruction manual

(Falorni Pierluigi)

Code 7 (All Partners received empty templates for Work packages WP2, WP3, and WP4; please, any Partner should return these templates to each2014@gmail.com compiled as a first draft).

Table 3.1a: Work package WP5 description

Work package number five		**Start Date**				
Work package title	**Project results diffusion**					
Participants number						
Short name						

Pearson/months per Participant:							

Objectives

Objectives if this Work package are

1 - Dissemination and exploitation of results

Definition of a work plan for dissemination and exploitation of the project results; implementation of a social platform

2- Communication activities

Organization of events concerning the partners of the Consortium; preparation of a website; organization of mid term workshops and final conference open to EU Commission experts

Description of work

This Work package aim is to improve the dissemination of information about the project results and deliverables: it is a core measure of the project's success. According to this preliminary consideration, different promotion and dissemination actions are foreseen and addressed to both experts in the field and any other Stakeholders.

1 - Dissemination of project results through scientific journals and through participation in Congresses, conferences and workshops

All project results will be shared and disseminated among the project Partners. In order to ensure high visibility of the project within the scientific community, publication in high impact factor scientific journals will be encouraged, as will be presentation at relevant workshops and conferences. Each research institution in this proposal will contribute to this dissemination as participants in WP 5.

2 - Organization of a workshop and a conference

In particular, within six months from the starting of the project a workshop will be held open to specific stakeholders.

3 - Demonstration event. In close collaboration with the WP2, WP3 and WP4 teams a demonstration event will be arranged in order to show how the newly developed techniques work.

This will exhibit the validity and usefulness of the new tools to a competent audience, able to comment and discuss the results obtained.

4 - RICH 2015 Website. Promotion of the demonstration event will be made through this website.

Other activities:

1 – Organization of the partners consortium meeting before and throughout the project activity according to the Coordinator suggestions (for 24 months); application of tools and methodologies of risk management to the governance of single parts of the project according to the suggestions of the project coordinator.

2 - Dissemination and exploitation of results deliverables, elaboration of a website concerning the activities of the project; maintenance and adjournments of the website during and after the project preparation; organization of events.

3– Project internal communication of documents and deliverables among the project partners
Deliverables ˜ ***Workshop and conference in and related information & dissemination material*** ˜ ***Papers in scientific journals*** ˜ ***Launch of fully functional Knowledge Base*** ˜ ***Demonstration even*** ***- Commercial service development*** ***-Business Plan for exploitation of products and services***

Next Table 31b shows the list of work packages:

Code 8 (to be written once Work packages are ready)

TABLE 3.1b – List of Work packages

Work Package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End Mo nth
One						
Two						
Three						
Four						
Five						
				Total months		

Next Table 3.1c shows the list of Deliverables for each Work package:

Code 9 (to be written once Work packages are ready)

TABLE 3.1c – List of Deliverables

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date
		One				
		Two				
		Three				
		Four				
		Five				

3.2–Management structure and procedures

In order to efficiently manage the project, a specific WP dedicated to coordination and management has been foreseen in the project work plan, to ensure that suitable priority and attention will be given to project management. Within this WP 1 all the aspects related to administrative and quality management of the project will be included. The responsibility of the project coordination will be taken by XXX that will supply the Project Coordinator (PC) and a Project Officer (PO).

The project partners are fully committed and agree to work together with the utmost cooperation for the timely fulfilment of their responsibilities. Previous experiences and participations in European framework programs have led to the decision to keep this management structure as simple as possible. The **overall organizational structure** proposed for the RICH 2015 project is presented in Figure 1. It is aimed at ensuring the fulfilment of the project objectives, by allowing clear and continuous communication among the project partners.

a) Project Coordinator

The overall management of the project will be the responsibility of XXX as coordinating partner. Key to this is the role of the Project Coordinator, which will be carried out by ……….

The **Project Coordinator** (PC) will be responsible for the **overall coordination** of the **technical and scientific activities, and all other aspects of the project** including **management of potential conflicts** and compromise negotiation in the unlikely event of conflict and will also be the primary contact person for the European Commission. Hence he/she will be responsible for all communication with - and reporting to - the EC.

The **Project Officer** (PO) will be responsible for day-to-day **legal and contractual management** of the project and **administrative and financial activities.** The PO will report to the PC.

In particular, according to the Consortium Agreement, the Coordinator shall be responsible for:

- Monitoring compliance by the Parties with their obligations
- Keeping the address list of Members and other contact persons updated and available
- Collecting, reviewing and submitting information on the progress of the project and reports and other deliverables (including financial statements and related certification) to the Funding Authority
- Preparing the meetings, proposing decisions and preparing the agenda of General Assembly meetings, chairing the meetings, preparing the minutes of the meetings and monitoring the implementation of decisions taken at meetings
- Transmitting promptly documents and information connected with the project
- Administering the financial contribution of the Funding Authority and fulfilling the financial tasks
- Providing, upon request, the Parties with official copies or originals of documents which are in the sole possession of the Coordinator when such copies or originals are necessary for the Parties to present claims.

The following Table 3.2a gives a list of milestones.

Code 10 (to be written once Work packages are ready)

TABLE 3.2a – List of milestones

Milestone number	Milestone name	Related work package(s)	Estimated date	Mean of verification

The following Table 3.2b gives the critical risks identified and the possible mitigating actions.

Code 11 (to be written once Work packages are ready)

TABLE 3.2b – Critical risks for implementation

Description of risk	Work package(s) involved	Proposed risk-mitigation measures

b) The General Assembly

The General Assembly is the decision making body of the Consortium.
The General Assembly shall consist of one representative of each Party (hereinafter referred to as "Member").
Each Member shall be duly authorised to deliberate, negotiate and decide on all matters listed in the Consortium Agreement.

The Coordinator shall chair all meetings of the General Assembly, unless decided otherwise by the General Assembly.
The Parties agree to abide by all decisions of the General Assembly.
This does not prevent the Parties from submitting a dispute for resolution in accordance with the provisions of settlement of disputes.
Operational procedures for the General Assembly representation in meetings
Any Member:
- should be present or represented at any meeting;
- may appoint a substitute or a proxy to attend and vote at any meeting;
- shall participate in a cooperative manner in the meetings.

c) The Work Package leaders

All technical and scientific issues of the project, in particular relating to the interdependence between and coherence of the different WPs - will be managed and consolidated by **the Work Package leaders** who will **report to the PC directly**. To achieve the R&D objectives of the project, the experimental, scientific and technical work has been organized into 3 R&D WPs (WP2,WP3, and WP4).
For each of them, a WP leader will be appointed to take primary technical control of and responsibility for the proper management and execution of the tasks related to the particular WP. In particular, he/she establishes (in coordination with the PC) the detailed schedule of his/her WP and the work in progress. Each WP leader is also responsible for identification of risks and for proposing solutions to the PC in respect of his/her WP. Taking into account that any of these R&D WPs will be the responsibility of three/four partners, WP leaders will be rotated among partners any four months.
Each WP leader is required to provide the PC at four monthly intervals with a progress report concerning his/her WP and containing sufficient technical information to enable the PC to be assured that work is progressing according to plan.

d) Means for governance and control

The means for governance and control (quality assurance, consortium agreement and communication plan) will be tailored to the scale of the RICH 2015 project. A correctly empowered governance and control for the overall project management will be guaranteed by following means:
The Consortium Agreement: All the RICH 2015 rules will be included and described in detail in the **Consortium Agreement**.
This document will define:
- the responsibilities, mutual obligations and roles of the partners;
- the division of the budget;
- the strategy for the exploitation of results;
- the rules for the settlement of disputes

The Consortium Agreement will be signed within the first month of the project and will define in a very clear and detailed way: roles of each partner, formal rules of participation, voting mechanisms, criteria for evaluation of activities realized by each partner, rules for budget re-allocation, etc.
The Quality Plan: A **quality plan** will be agreed by the General Assembly at the Kick-off meeting, and will ensure that appropriate quality assurance is undertaken. It will include:
- persons responsible for quality assurance, quality standards, methodologies and procedures;
- procedures for identification, distribution, collection, filing, maintenance and disposal of quality records resources, schedule and responsibilities for conducting the quality assurance activities

Quality control will represent a key issue in the overall management of the project, since it plays a critical role in keeping the action aligned towards its final objectives.

d) Project Meetings

An initial „launch/kick-off meeting will be organized at the start of the RICH 2015 project for all the personnel involved in the project. The purpose of the kick-off meeting is to:
- Present to all involved an overview of the project;

- Enable each participant to obtain a better perspective of his/her role in the RICH 2015 project and set this in context with the roles and skills of other project members;
- Define the main outline of the Consortium Agreement;
- Establish procedures for Quality Assurance and formalize policies for publication, intellectual property rights and any arbitration procedures.

3.3 –Consortium as a whole

Partners of the Consortium will be all the partners working on the five Work packages. Each partner will designate a member to participate to the meetings of the Consortium.
All the rules reported in the EU suggested Consortium Agreement must be followed.
The Consortium partners belong to very different scientific disciplines, from IT engineers to archaeologists, from robotics and mechanical experts and they have to complement one another in order to create a Robotic System suitable for this project.
Analogously, the presence inside the Consortium of Enterprises is fundamental for building and experimenting the products of project.
The RICH 2015 project is proposed by a consortium of xx **partners** from **X EU Member States** and comprises all the appropriate key players to ensure the availability of resources, capacities, technologies, capabilities, technical and operational knowledge required for the timely achievement of the goal of the project.
The consortium will bring together European efforts and methodological/technological developments and has therefore a high potential for developing and validation of innovative non-destructive diagnosis techniques to assess and monitor the state of preservation of the European heritage.
The partners to the RICH 2015 project have the following areas of interest and activity, Table 3.3.

Code 12 Any Partner should send these data by mail to each2014@gmail.com; please only one sentence!)

Table 3.3 Areas of interest/activity for RICH 2015 project partners

P	Area of interest / activity

3.4 – Resources to be committed

Code 13 (Section 3.4 to be written only after all other points and sections are ready)

According to costs as stated in the budget table in Part A of the Proposal, the following Table 3.4.1 shows the costs distribution.

Table 3.4.1 Total Costs

	WP 1	WP 2	WP 3	WP 4	WP 5	Total
Personnel costs						
Other costs						
Total direct costs						
Indirect costs						
Subcontracting						
Total costs						
Requested subsidy	2					

In order to achieve the objectives of RICH 2015, duration of 24 months has been foreseen for the project. The overall project cost is € xxx.xxxx and **the overall EU contribution requested is € xxxx.xxx**, both reasonable and necessary considering the number of partners, the ambitious objectives and the duration of the project.
In the following, more details are provided about the costs in the main cost categories of the project.

3.4.1 - Personnel Costs

Personnel costs represent a significant part of the project budget, in total **€ xxxx.xxx**. For each work package, the personnel costs have been calculated considering the appropriate man-power (see Table 3.4 a – Summary of staff effort) needed to complete the proposed activities.

TABLE 3.4a – Summary of staff effort

	WPn	WPn+1	WPn+2	Total Pearson/ Months per Participant
Participant Number/Short Name				
Participant Number/Short Name				
Participant Number/Short Name				
Total Person/Months				

The weighted average monthly rate costs of the personnel that will be working in the work package are provided in Table 3.4.2

Table 3.4.2 – Weighted average monthly personnel costs in € per partner and work package

Partner	W	W	W	W	W

Next Table 3.4b shows "other direct costs" for participants where those costs exceed 15% of the personnel costs.

TABLE 3.4b – "Other direct cost" items

Participant Number/Short Name	Cost (€)	Justification
Travel		
Equipment		
Other goods and services		
Total		

3.4.2 - Travel costs (other direct costs)

The total travel costs are **€ xxxx** and refer to meeting, working session and other issues related to the coordination of participants' contributions, as well as to the attendance of conferences and events for dissemination purposes. In more detail, the following travels have been foreseen, so far, for calculating the travel costs:

- ***Project meetings***: technical and management meetings where all participants will be present, and where technical issues as well as management issues will be discussed. 6 project meetings are foreseen for the project duration (one meeting each 6 months of project).
- ***Technical meetings***: meetings needed among two or more partners collaborating on the same tasks. The twice yearly Project meetings will form a significant venue for inter WP discussions, and will make provision for specific subsets of WP managers to meet outside the main workshop on request, e.g. for inter- and intra-WP decision-making purposes.

Dissemination meetings: participation to international conferences/workshops to present the RICH 2015 results, and for attendance to the RICH 2015 workshop. Each participant involved in WP5, will receive travel costs.

3.4.3 - Consumables (other direct costs)

The total costs for consumables amount to **€ xxxxx**.
The consumables with RICH 2015 are mostly related to preparation, analysis, characterisation, validation, process optimisation, pre-prototype development and tests and are summarized in table 3.4.3

Table 3.4.3.a – Consumables per work package

	Consumables description

A total of **€ xxx** has been included for the purchase of durable equipment by the project partners. The equipment costs were calculated on depreciation basis, considering the duration of usage of the equipment within the project. The table 3.4.3.b provides an overview of the planned equipment purchases

Table 3.4.3.b – Equipment purchase per participant

rtner short na me	V a l u	E l i g	Description	W P

3.4.4 - Other costs (other direct costs)

The other remaining costs amount to **€ xxxx**. These are listed in Table 3.4.4

Table 3.4.4 – Other direct costs per Work package

	Other costs

4 – Members of the Consortium

Code 14 (All Partners, starting from now, should write at least about three pages plus the relevant publications lists, concerning both the Organizations they belong to and the persons who will carry out the proposed activities)

4.1 – Participants

- A description of the legal entity and its main tasks, with an explanation of how its profile matches the tasks in the proposal;
- a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities;
- a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content;
- a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal;
- a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;
- any other supporting documents specified in the work programme for this call.

4.2 – Third parties involved in the Project

No third parties involved in this project

5 – Ethics and Security

5.1 – Ethics

There is no ethics issue in the ethical issue table in the Administrative Proposal Form of RICH 2015, Part A.

5.2 – Security

The activities or results of this project do not raise security issues.