Object: Proposal for FP7 call ENV.2012.6.2-6 Development of advanced technologies and tools for mapping, diagnosing, excavating, and securing underwater and coastal archaeological sites.

Project Title: Innovative Technologies and Applications for Coastal Archaeological sites (ITACA)

ITACA project proposal is addressing underwater archeological sites in coastal regions with the main objective of discovering and monitoring using innovative satellite remote sensing techniques combined with image processing algorithms.

This includes the development of a set of applications integrated in a system and the demonstration of its suitability for a service targeting the following objectives:

A. Search of undiscovered ruins / historical artifacts that are now submerged and their continuous monitoring;
B. Search and location of ancient ship wrecks.

High resolution synthetic aperture radar (SAR) and multispectral satellite data will be combined to derive the relative bathymetry of the bottom of the sea up to 70 meters deep; the resulting data fusion will be processed using shape detection algorithms specific for archeological items.

The above techniques will be integrated into a GIS and web-GIS system where additional specific archaeological layers will be included to facilitate the object identification and mapping. The GIS will also be used as a tool to develop methodologies to define risk map of underwater archaeology.

The system will be verified and validated through an extensive on-ground campaign carried out with both cutting edge technologies (sub-bottom profiler, side-scan sonar, multi beam echo sounder) and traditional means (submarine exploration with professional scuba divers).

To reach the goal of the project the following advance technologies will be addressed:

- Tuning of an innovative high sensitivity magneto-gradiometer sensor (existing but not yet used in such context) for underwater survey of archaeological sites. The goal is to perform high definition surveys on a coastal archaeological site where the natural hazard and the submerged/buried archaeological evidence are combined. Test will be performed using an “a-magnetic autonomous underwater vehicle” (AUV).
- Development of a real time simulator for the training of remotely operated vehicle (ROV) operators and a software tool for planning the underwater excavation and salvaging. The tools will be used to increase the efficiency of the archaeological underwater excavation operations.
- Development and test of an innovative inversion algorithm for the joint inversion of electrical resistivity tomography (ERT) and controlled source multi-frequency (CSEM) data for enhancing the detection of underwater targets and reconstructing the subsurface geological structure.

All the above innovative technologies will be deployed in the frame of the validation campaign of the remote sensing technique.

A six months trial service on selected coastal zone will complete the service demonstration while the dissemination of the project results will be carried out by means of a yearly international user conference.

The project will be carried out using the following techniques:

1) Innovative remote sensing: satellite high resolution SAR radar data (TerraSAR-X, Como-SkyMed, ERS, etc.) complemented by information on the underwater currents and winds able to provide relative bathymetry maps up to 70 m deep with spatial resolution up to 1-2 m.
2) Traditional remote sensing: high resolution satellite panchromatic and multispectral data (selecting wavelengths were optical penetration is maximized) able to provide relative bathymetry up to 20-25 m deep with resolution 2 to 10 m. As a complement, existing airborne multispectral data may be used with spatial resolution up to 20-50 cm.
3) Application of a specifically tailored image processing algorithm based on shape detection[1] on the data fusion of the relative bathymetry produced by 1) and 2). This algorithm will be enhanced using local fuzzy-logic algorithms.
4) Existing cutting-edge technology for on ground verification: High resolution multi-beam echo sounder combined with sub-bottom profiler and side-scan sonar aboard of a boat able to provide 3D reconstruction of the underwater seabed. These techniques are able to provide bathymetry up to 200 m and up to 10 cm spatial resolution. The provided information will be used to build up the augmented virtual reality scenario for the real time simulator and software tool.
5) ROV real time simulator and training system, useful to display a 3D representation of the underwater "reconstructed site". The complete missions can be simulated by means of an immersive visualization to plan discoveries and rescue missions, by defining discovery paths and setting "waypoints" with associated "operation lists" to be performed "on the run. The simulator will be used to train "newcomers" ROV operators in a "sandbox" before performing real operations, not paying the risk of wrong operations which could potentially damage the items or risk the mission.
6) As an additional search tool to be interoperated, the retrofitting of an innovative vectorial magneto-gradiometer (VMG) and related software is proposed. The instrumentation will be embedded in a non-magnetic AUV, specifically engineered in order to avoid magnetic interferences and electro-magnetic noise
7) Employment of the methods of Electrical Resistivity Tomography (ERT) and Controlled Source Electromagnetic Multi-frequency method (CSEM) to collect tomographic data which will be processed through individual and joint inversion algorithms.

The integration of all available data in a Geographic Information System (GIS) will provide detailed maps of the area under study, possible new discoveries, and monitoring of the existing sites (issue of alerts when a change/treat to the site is detected) will be provided applying the remote sensing and image processing techniques to time series satellite imagery. Results will be provided in form of maximum likelihood maps that can be superimposed to existing GIS data for algorithm verification.

Verification will be provided in the following test sites:

- Italy: Archaeological park of Baia (Naples) addressing A
- Greece: : Metohi, Northern Greece addressing A and B
- Turkey: Cape Celydonia, addressing B.

where GIS data, maps, bathymetries and archeological information of the underwater sites are available and no need of on-site validation is required for these sites.

Validation will be provided in following test sites:

[1] The shape detection algorithm has been already tested in the ESA project HORUS (Heritage Observation and Retrieval Under Sand) focused in search and monitoring of archaeological sites in Egypt.

- Italy (Tindari Cape, Sicily, Italy) where a detailed an on-ground campaign will provide detailed 3-D maps and where the vectorial magneto-gradiometer (VMG) will be tested and validated on field. The validation campaign will target item A).
- Greece (Metohi, Northen Greece) targeting items A) and B) where possible new discoveries are expected and on ground campaign will be provided using both 3-D technique and traditional methodologies (e.g. scuba diving exploration).
- Turkey (Mindos / Knidos) targeting items B) where possible new discoveries are expected and on ground campaign will be provided using both 3-D technique traditional methodologies.

The dissemination will be provided by an End User coordinator[2] with the aim to:

- Disseminate the intermediate and final project results amongst the Mediterranean user community
- Provide end-user advice and feedback to improve the effectiveness and usability of the technologies addressed in the project as a service
- Develop policies and strategies to the end user community in order to maximize the impact of the available technologies to protect the underwater heritage

The dissemination task includes the implementation of 6 months of detection and monitoring trial service for the End User Coordinator on selected sites. The End User will also be in charge to perform the final validation of the project results. A web site with a Content Management System and a WebGIS will be used for data exchange and result evaluation between partners and institution involved, integrating, the primary source of information about the project to be diffused according to the users privileges.

The end user coordinator will organize and carry out three end-user conferences in combination with the project meetings. The preliminary identified conference locations are:

- Palermo (Sicily, Italy) – International End User Conference
- Chania (Crete, Greece) – International Workshop
- Istanbul (Turkey) - International End User Conference

Special paper and electronic publication will be realized in coordination of dissemination events.

The team includes companies, SME, no-profit organizations and research institutes from:

- Belgium
- Italy
- Greece
- Portugal
- United Kingdom
- Turkey
- Egypt

[2] The selected partner has been coordinator of the FP6 ARCHEOMAP focused on Archaeological Management Policies