Innovation Technologies and Applications for Coastal Archaeological sites

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Technology4All

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Project and Consortium Introduction

- ITACA 27 months, 3 reporting Periods, 11 partners
- KO held 28 January 2014 Brussels, End User Conference held in Palermo 26-29 March 2014
- ITACA aims to prove a management system for underwater archaeological sites in coastal regions
- The discovering and monitoring service uses innovative satellite remote sensing techniques combined with image processing algorithms
- The project develops a set of applications integrated in a system that pursue the following objectives:

ITACA OBJECTIVES

1. Search and location of ancient ship wrecks
2. Monitoring of ship wrecks, ruins and historical artefacts that are now submerged
3. Integration of resulting search and monitoring data with onsite data into a management tool for underwater sites
4. Demonstration of the system's suitability for a service

ITACA OBJECTIVES HOW TO 1

- High resolution synthetic aperture radar and multispectral satellite data will be combined to derive the relative bathymetry of the bottom of the sea up to the depth of 50 meters
- The resulting data fusion will be processed using shape detection algorithms specific for archaeological items

ITACA OBJECTIVES HOW TO 2

- The new algorithms, the physical modelling and the computational capabilities will be integrated into the Web-GIS, together with data recorded from surface (2D and 3D modelling) and from underwater surveys
- Additional specific archaeological layers will be included into the Web-GIS to facilitate the object identification through shape detection techniques and mapping

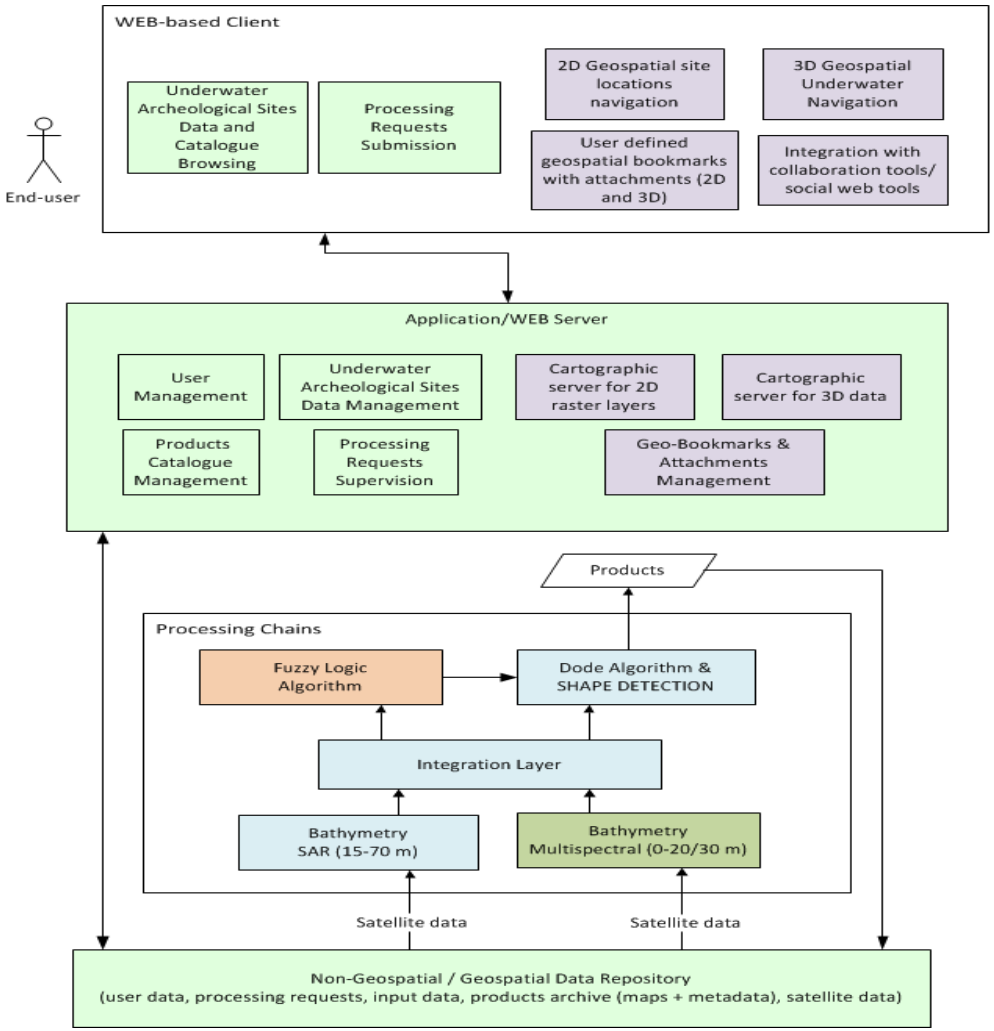
ITACA OBJECTIVES HOW TO 3

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

ITACA PARTNERS

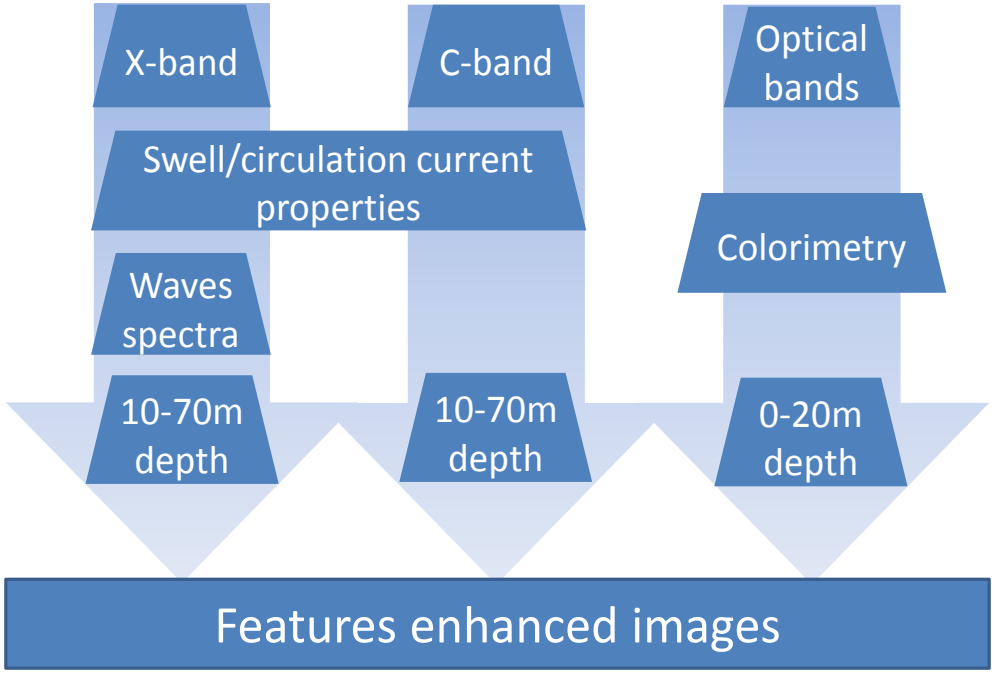
Partner	NAME	SHORT NAME	Country	WP
1	**Planetek Hellas**	PKH	Greece	**Project Management, WebGIS application**
2	**KELL SRL**	KELL	Italy	**Bathymetry SAR**
3	**NAIS SRL**	NAIS	Italy	**System Integration, Web site**
4	**GEOGRAPHIC RESOURCE ANALYSIS & SCIENCE AS*GRAS**	GRAS	Denmark	**Bathymetry optical / multispectral**
5	**INSTITOYTO ENALION ARCHAIOLOGIKON EREYNON SOMATEO**	I.EN.A.E	Greece	**End-user. Sea campaign in Greece**
6	**FACULTADE CIENCIAS UNIVERSIDADE LISBOA**	FFCUL	Portugal	**Fuzzy-logic algorithms for shape detection**
7	**ANESTI LIMITED**	ANESTI	United Kingdom	**Business Plan**
8	**Regione Sicilia**	REGIONE SICILIA	Italy	**End-user, Sea campaign in Sicily**
9	**ALMA SISTEMI SAS**	ALMA	Italy	**Shape detection, dissemination**
10	**CODEVINTEC ITALIANA**	CDV	Italy	**Equipment for sea campaigne (sub bottom profiles, sonar etc.**
11	**SME4SPACE VZW**	S4S	Belgium	**Dissemination, Satellite data procurement**
3rd Party	**Planetek Italia**	PKI	Italy	**Supporting Planetek Hellas**

System Overview



Data processing

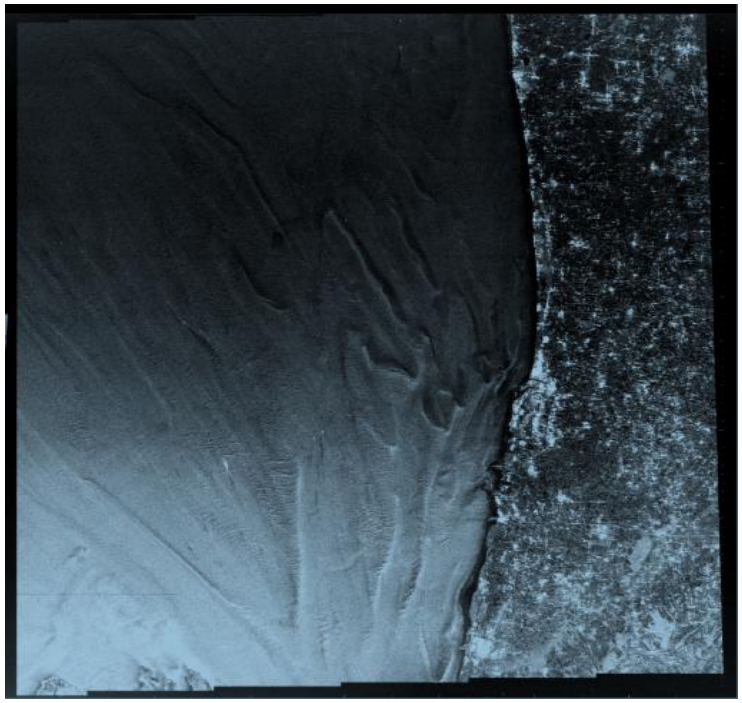
Image processing chain



WP 13

Bathymetry: SAR

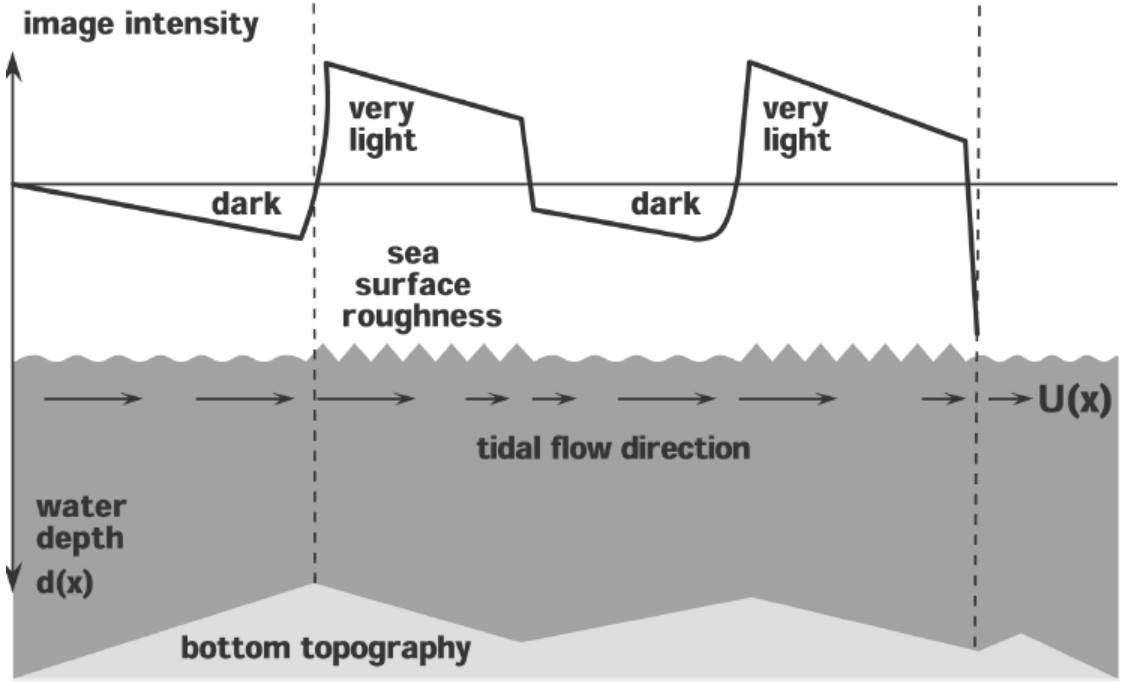
- Microwaves emitted by SAR can penetrate into seawater *(Ulaby et al. 1986)* **only to a depth** which is **small** in comparison to the electromagnetic wavelength (mm scale), but..
- …underwater bottom **topography is imaged** by real and synthetic aperture radar



Topography sensed indirectly via surface effects

Bathymetry: SAR

Radar – Sea wave interaction



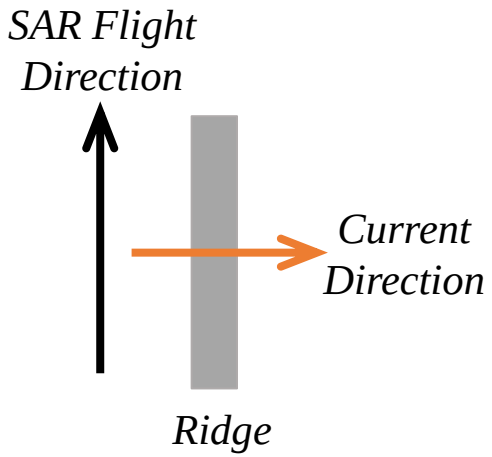
Backscattered radar power, or **Normalized Radar Cross Section** (NRCS), **proportional** to the spectral energy density of the waves, or to the **square of sea wave amplitude**

SAR Bathymetry boundaries conditions

1) Known wind field at sea level at the time of acquisition with low intensity

2) Strong steady currents flowing orthogonally with respect the SAR orbit

3) Sea waves with the wave crests orthogonal with the current direction



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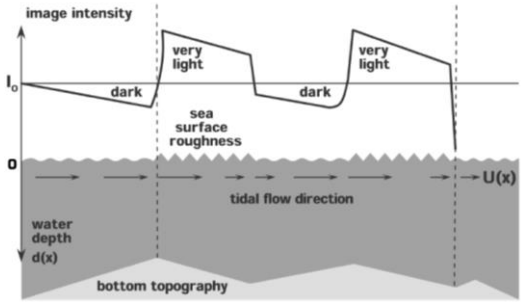
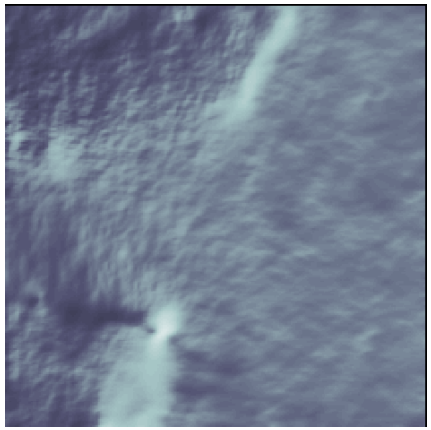
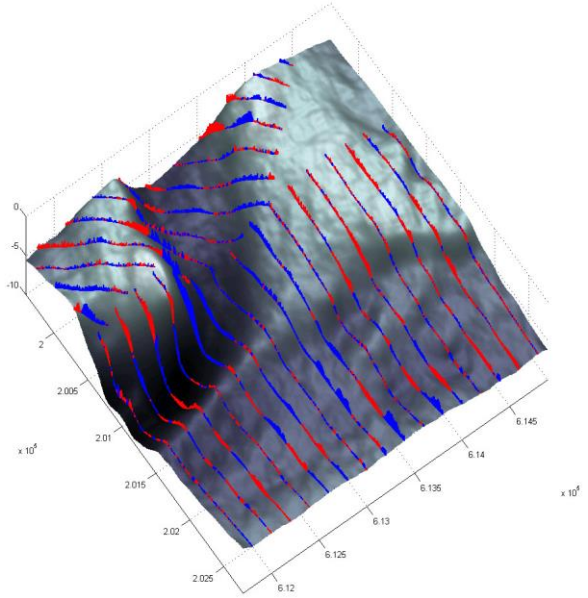
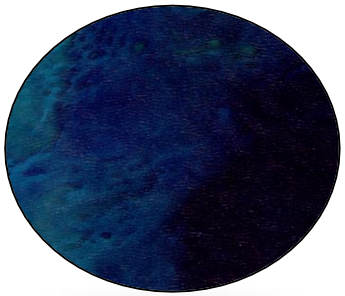
Bathymetry: SAR







Deriving Bathymetry from optical satellite data



Satellite Image

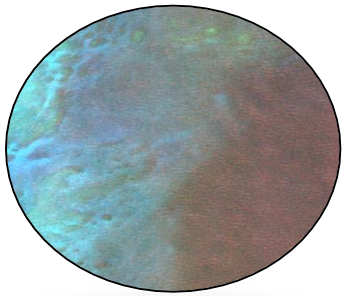
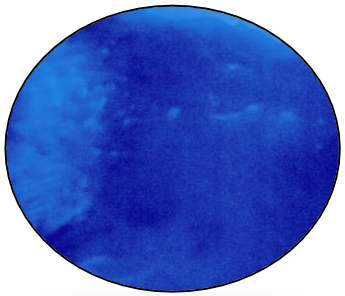
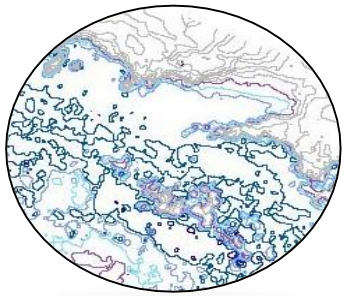


Image Processing



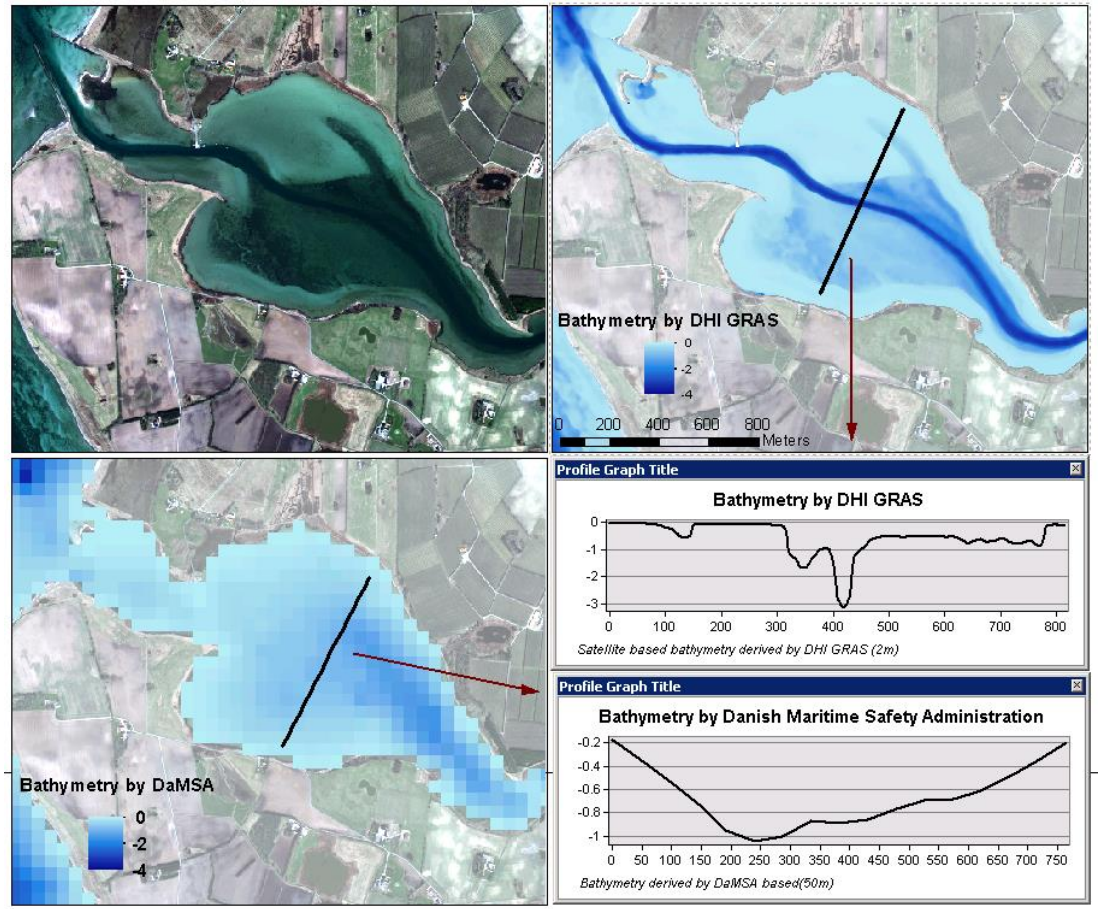
Water Depths



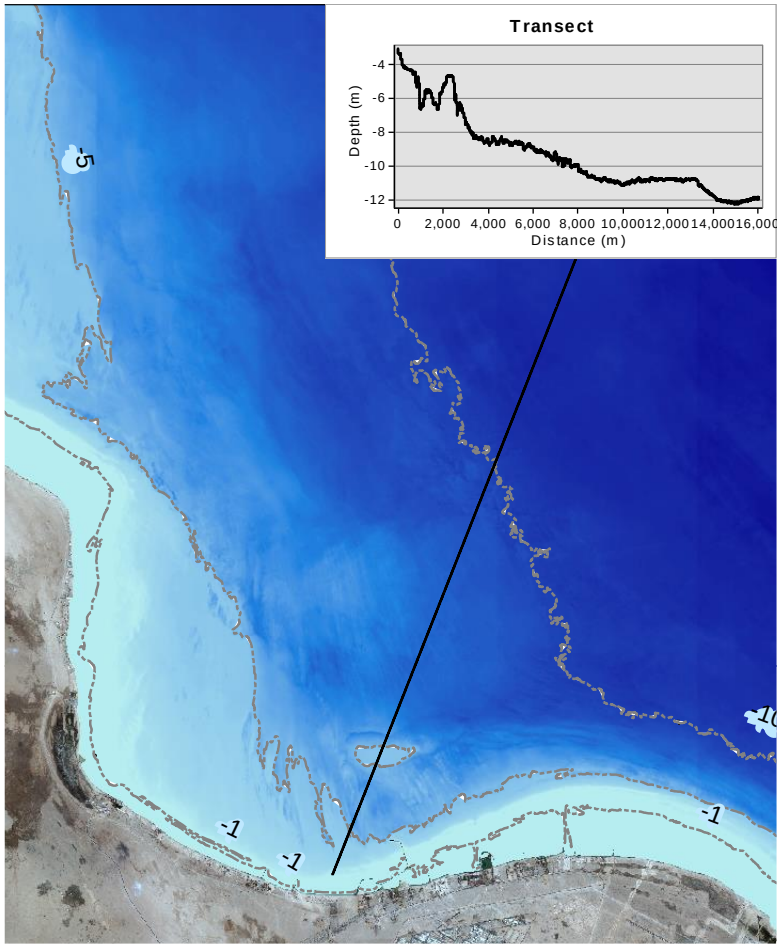
Bathymetry Contours

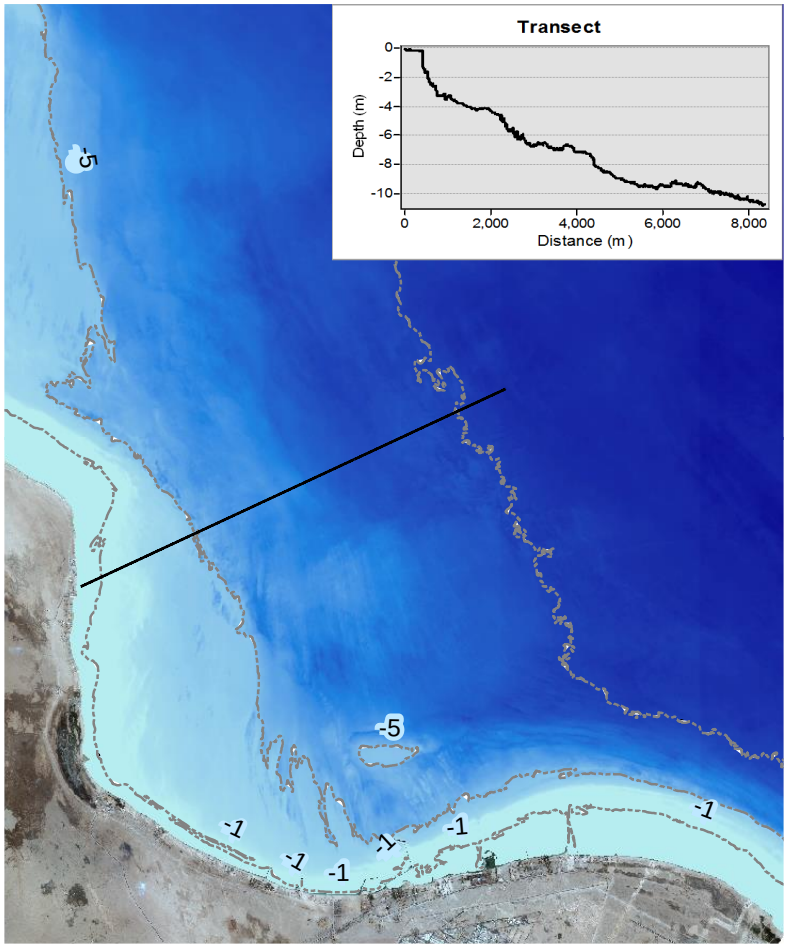
Satellite Image → Image Analysis → Water Depths

Example of satellite derived bathymetry



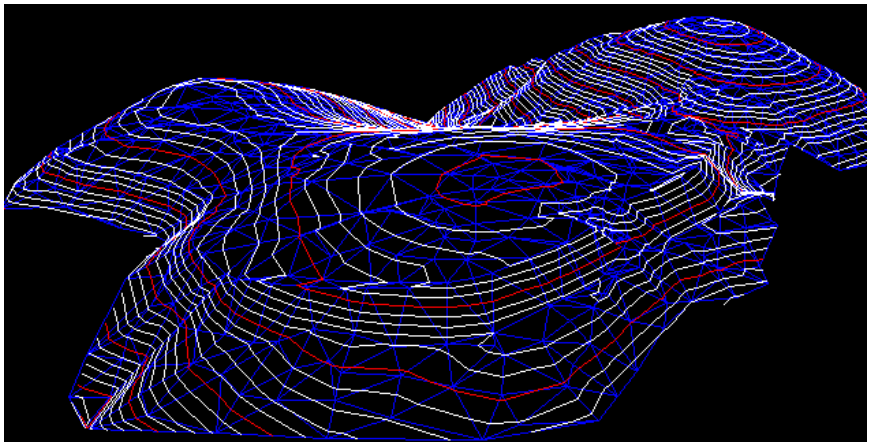
Example of satellite derived bathymetry





WP 14

Data Fusion

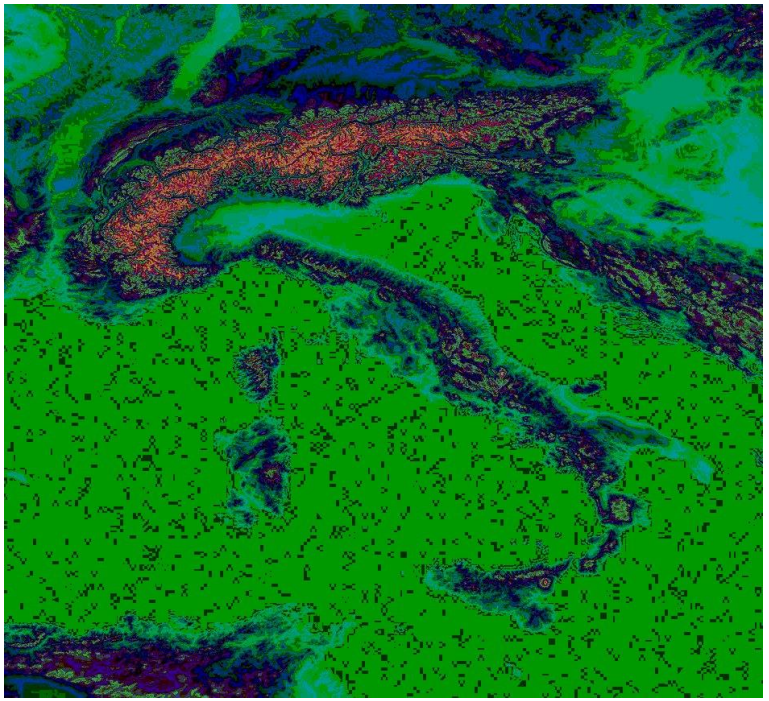


TIN: Triangular Irregular Network

SAR Bathymetry Data format

DEM: Digital Elevation Model

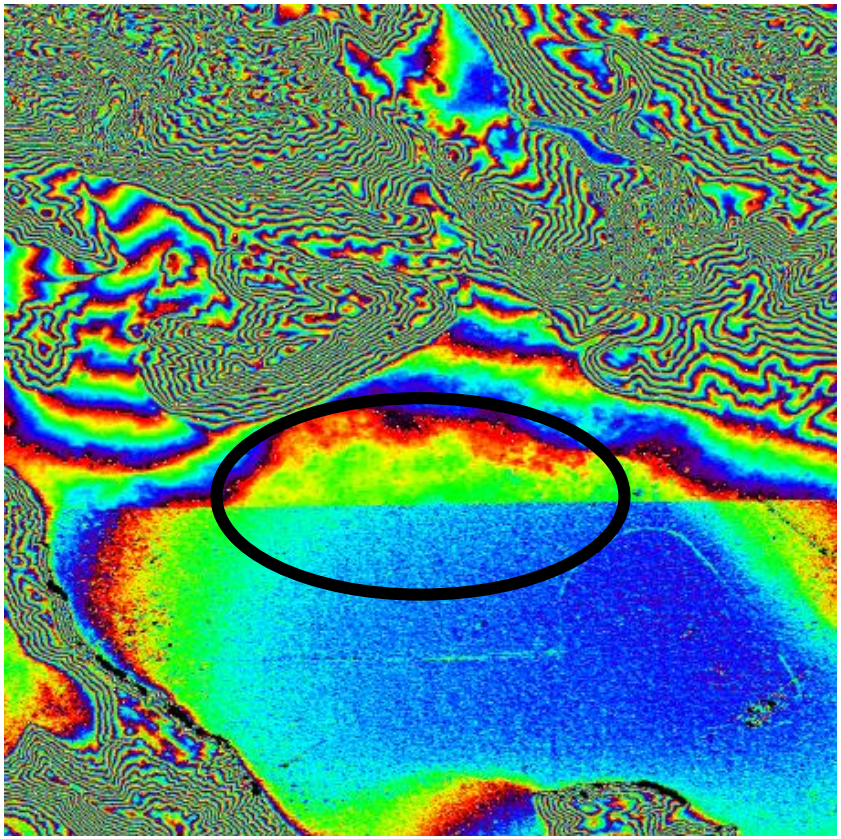
Optical Data format

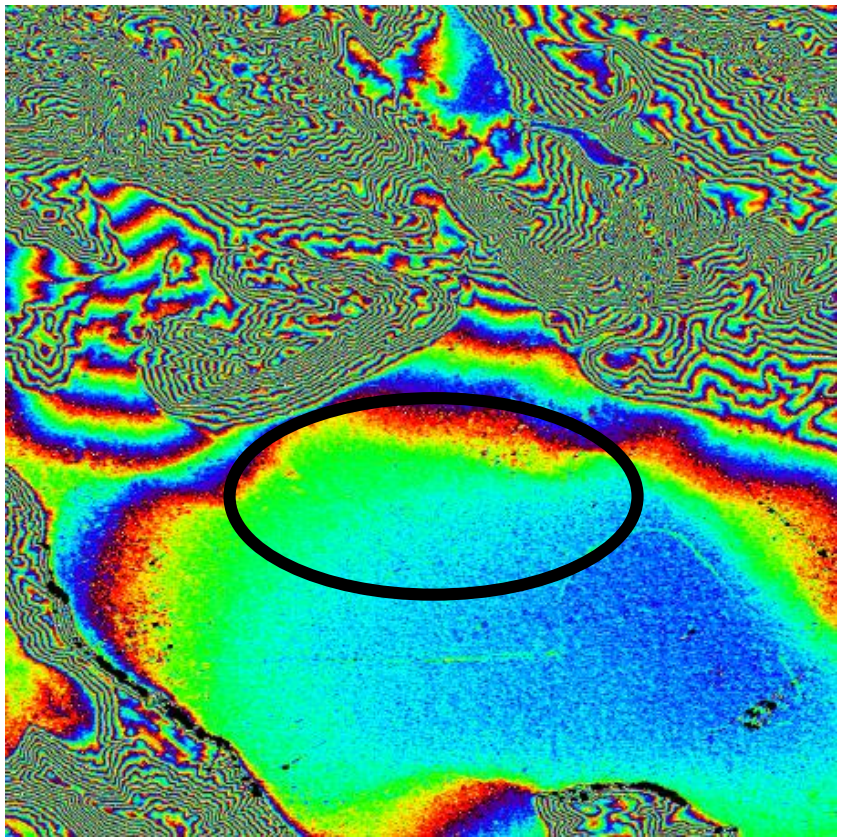


WP 14

Data Fusion

Classic vs. Normalized Mosaicking

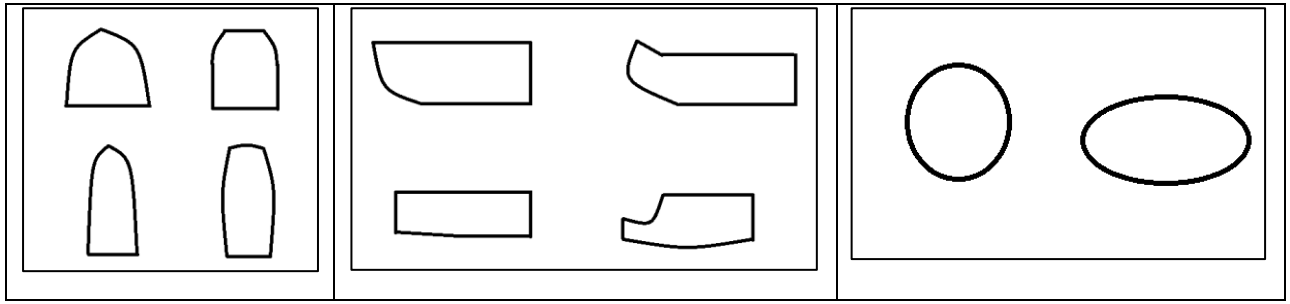




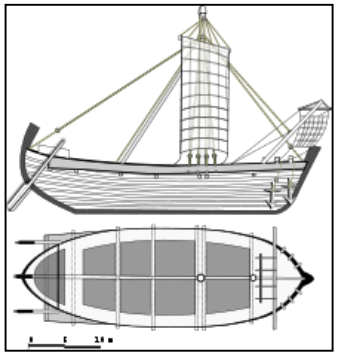
Shape detection

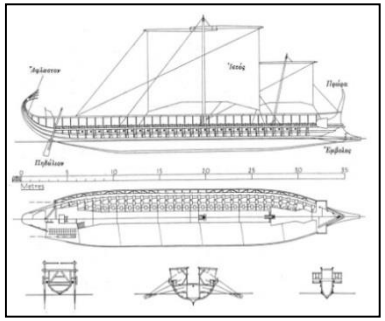
→This Work packages (WP15-16) aim at definition, implementation and test of the DODE shape detection processing modules integrated with the recognition algorithm based on Fuzzy Logic to be applied to the Data fusion layer.

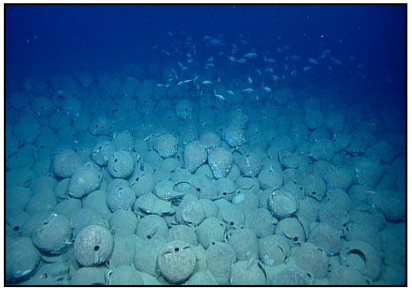
→Algorithms will also applied to sub-bottom profile data.

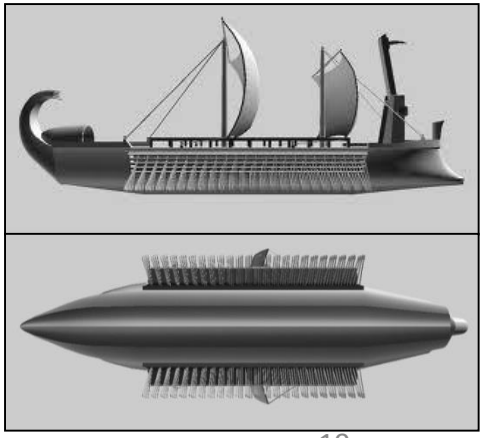


Ship wreck shapes in horizontal (right), side positions (centre) and cargo cluster (ceramics, pottery, amphorae etc.)



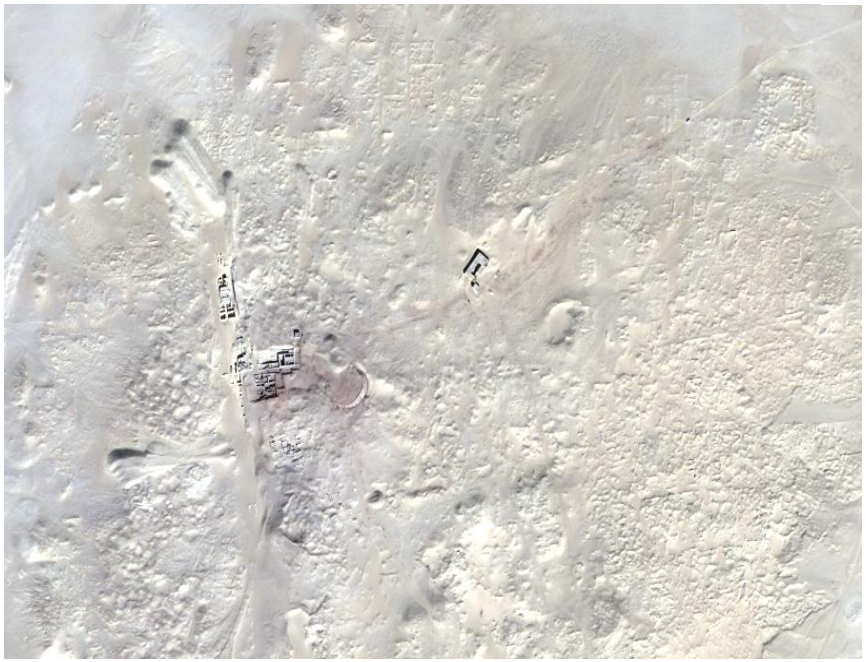


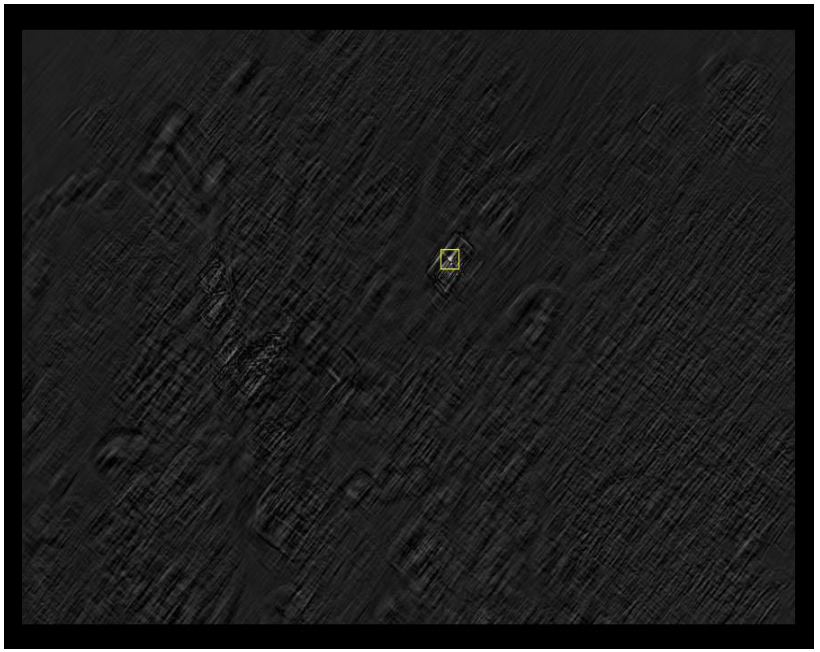




Example: shape detection (optical)

Example: shape detection for archeology (optical)

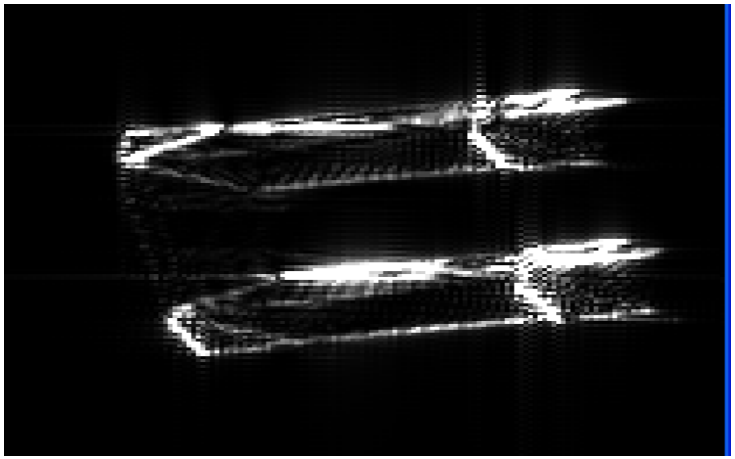


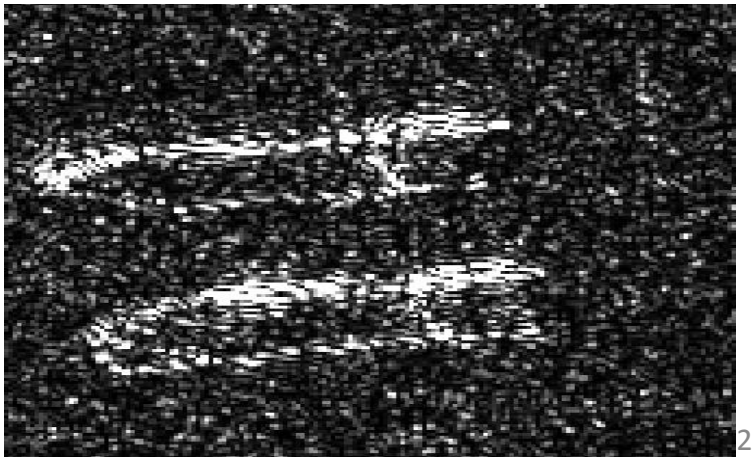


Example: SAR simulator for shape detection

Upper left. Urban area with DEM. Upper right: DEM of the target building.

Lower right SAR simulator output . Lower left … without "clutter"





WebGIS

- WebGIS functional requirement analysis
  - Define engineering plan for whole WebGIS system
- WebGIS Component design
  - Architecture design for Web-GIS
  - Use and refine Interface Control Document (ICD) (D8.1)
  - Provide input for Integration and Validation (D9.1)
- WebGIS Component implementation
  - Implemented in iterative phases
  - Produce incremental features

What WebGIS will do

- Flow of information:
  - WP12: Multispectral Bathymetry (GRAS)
  - WP13: SAR Bathymetry (KELL)
    - WP14: Data Fusion (KELL)
      - WP15: Fuzzy Logic (INESC ID)
      - WP16: Shape Detection (ALMA)
- Incorporate and visually present calculations and results produced by previous Work Packages
- Wrap an authentication and authorization layer
- Provide a final Web-GIS application

Test cases & Conferences

Test cases in Sicily and Greece

- ❑ Review of the selected test sites and trade-off analysis
- ❑ Acquisition of existing data and information on the selected test site in Sicily, Italy.
- ❑ Test campaign planning and execution
- ❑ Mapping campaign on boat using: multi-beam echo sounder, side-scan sonar, laser scanner
- ❑ Production of the 3D scenario
- ❑ Underwater campaign
- ❑ Data processing and Analysis of the results

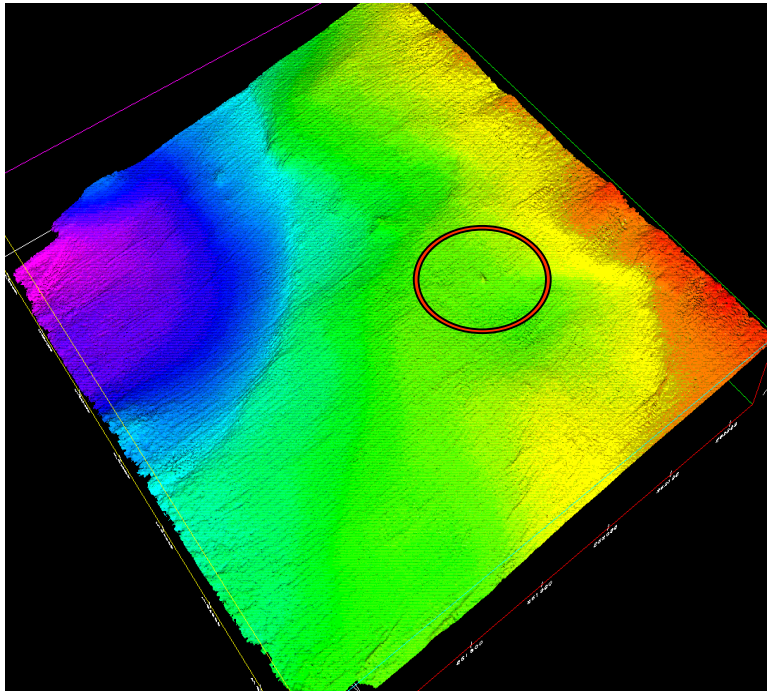
Conferences

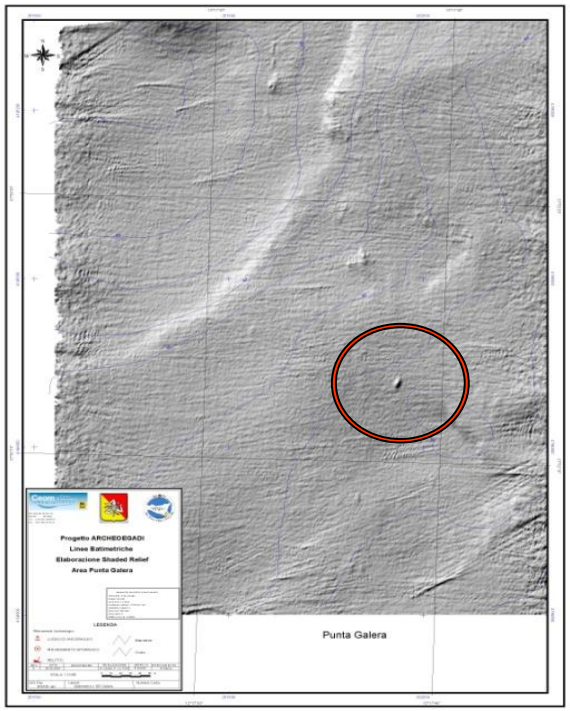
- **Regione Sicilia: (M3)** End User Workshop on Coastal Archaeological sites management project documentary and Acts.
- **I.EN.A.E. : (M27)** Mediterranean Conference on Underwater archaeology project documentary and Acts. Will be held in conjunction with the final meeting

WP 21: Test case Italy

WP 21: Test case Italy: Punta Galera (Favignana)

Two miles out of Favignana's southern coast, in front of Punta Galera and near the Secca del Toro, there are the remains of a wreck located at a depth of about 70 m on the sandy sea bed. Its cargo is almost totally preserved and it is composed by various types of vases and row of tiles stocked in their original position. According to the typological features of the pottery we can date the ship to the X cent. A.D. that means the period of Muslim rule on Sicily.

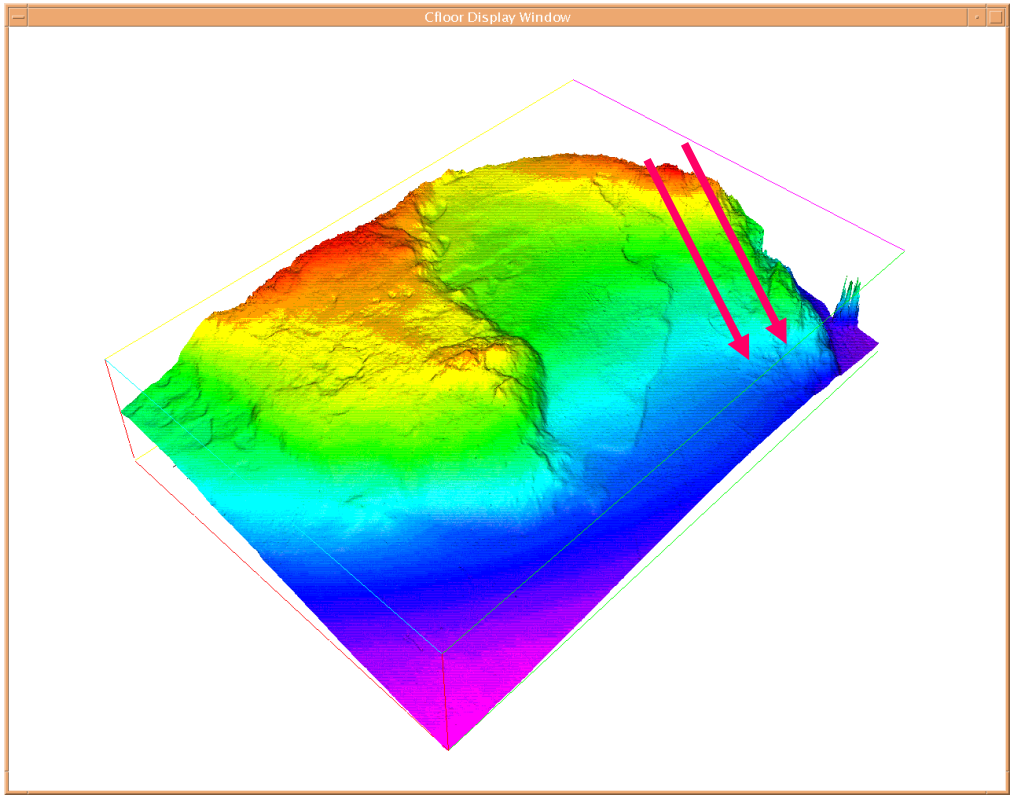


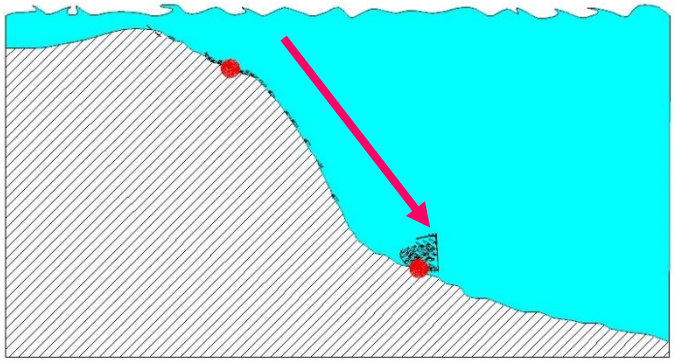


WP 21: Test case Italy: Punta Galera (Favignana)

WP 21: Test case Italy: Cala Minnola (Levanzo)

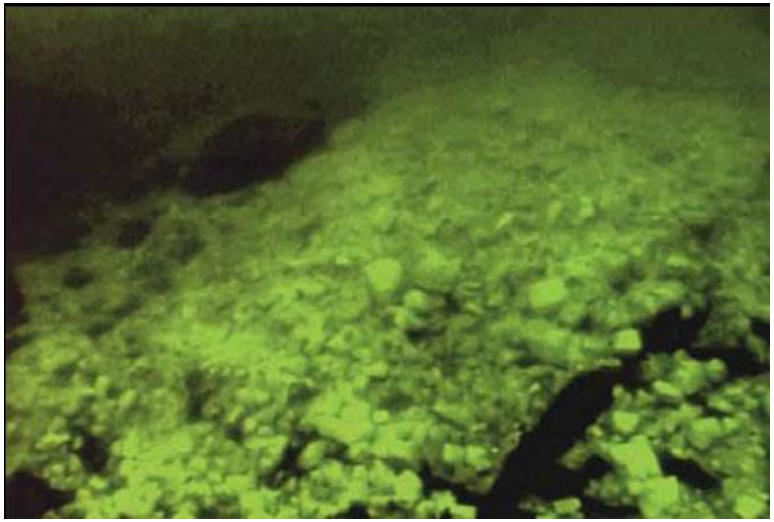
In Cala Minnola, on the eastern coast of the island of Levanzo, a wreck was found many years ago at a depth of – m 27 – 30. Although it was heavily looted there are still about 60 amphorae still visible on the soil. The area is non far from Punta Altarella where there are the remains of some plastered basins cut into the rock that are belonging to a garum farm of Hellenistic and Roman period.



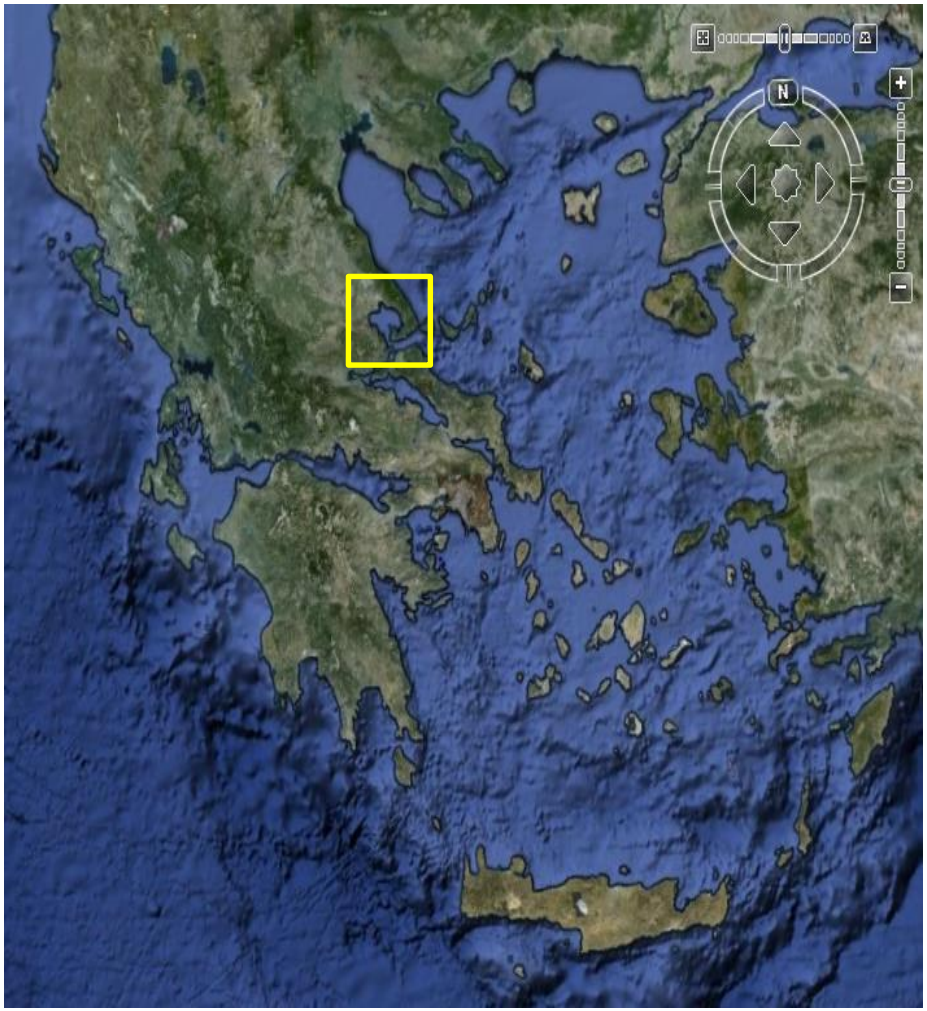


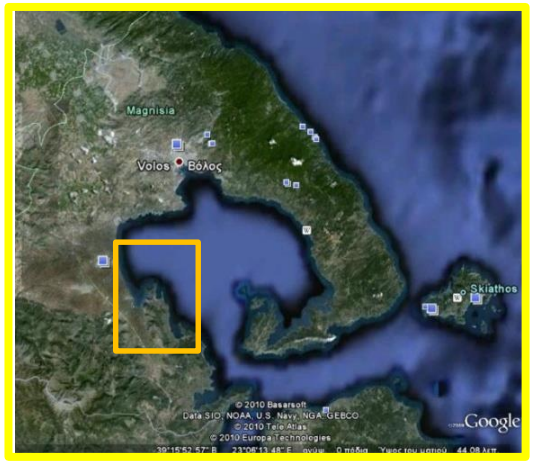
WP 21: Test case Italy: Maraona, “relitto dello zolfo”

Maraona is the smallest deserted island of Egadi archipelago between Levanzo island and Trapani coast. A wreck was identified at about 50 m deep near the island. It belongs to a transport vessel of the end of XIX century full of sulfur bars. Its importance is due to the integrity of both the load and the hull.



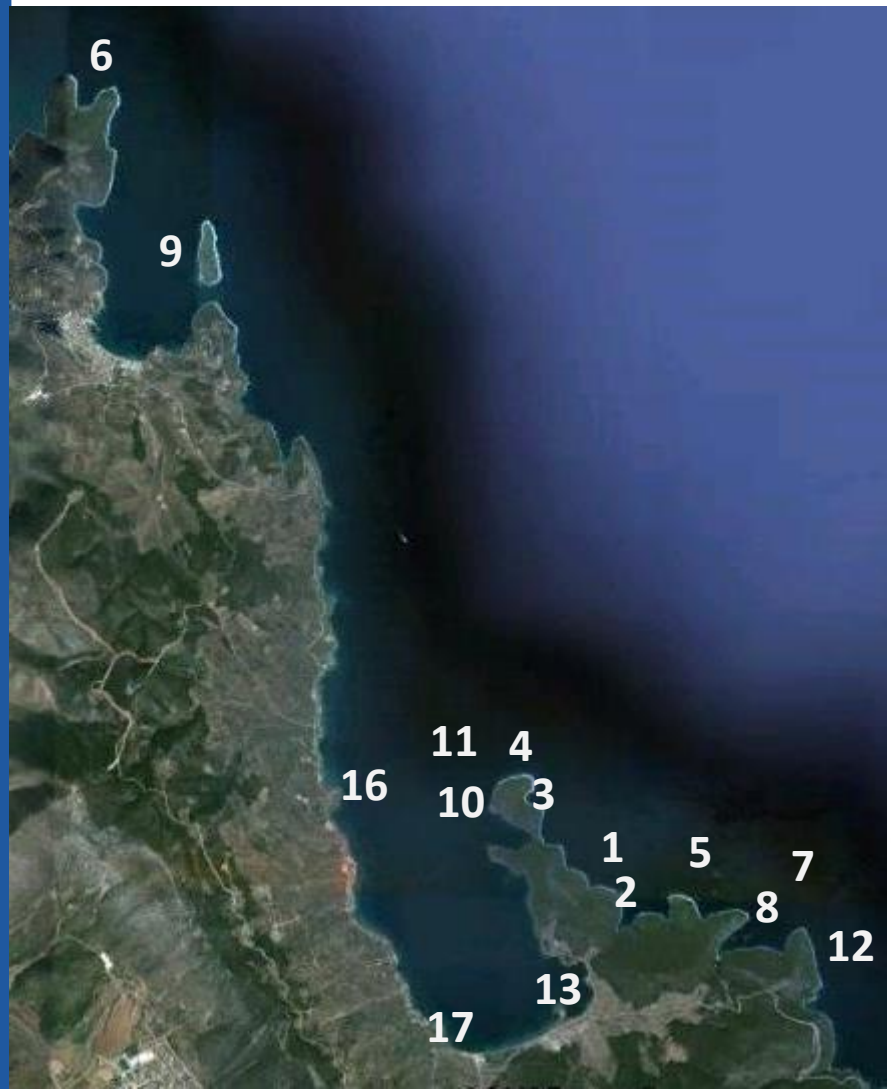
The I.EN.A.E.'s Survey Area where ITACA's Innovation Technologies will be applied.

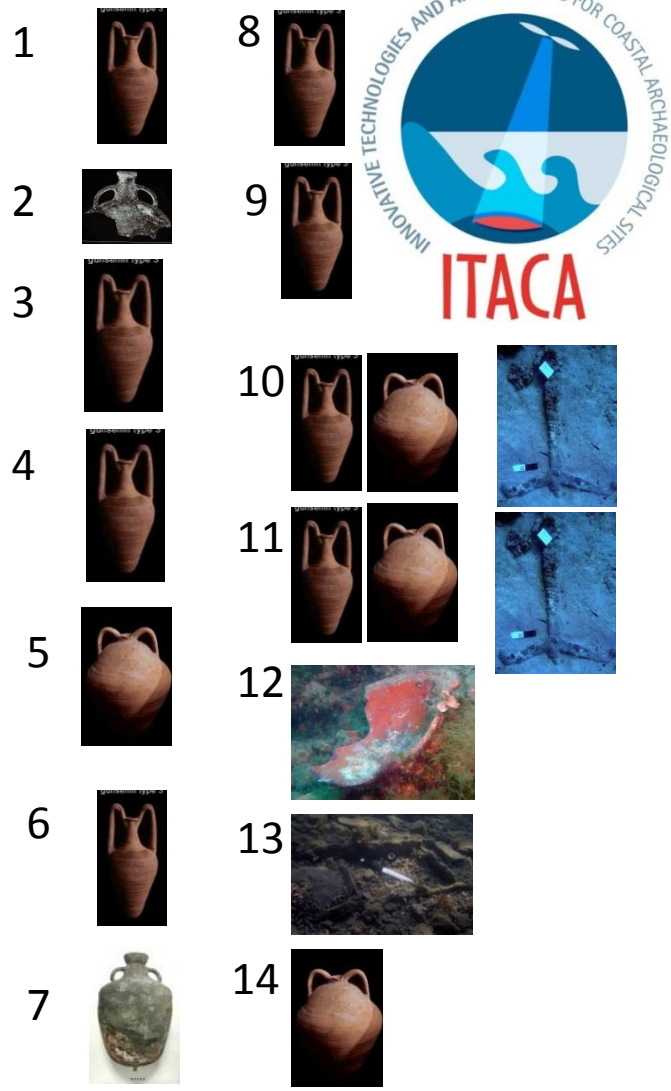




THE PAGASETIKOS SURVEY AREA

Along a coastal zone of 7n.m. long,
16 archaeological sites (shipwrecks and settlements) have been recovered.

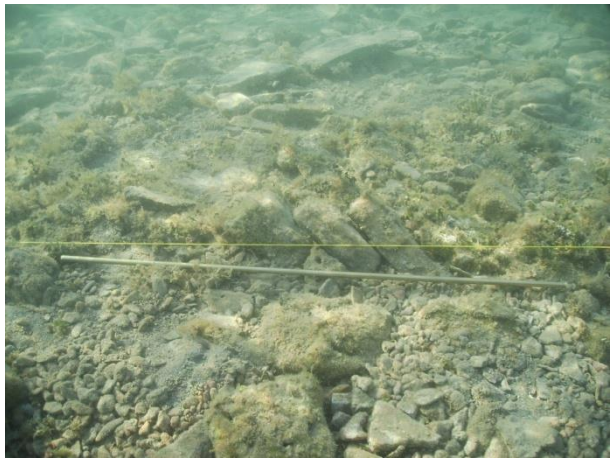




Late Roman
Middle Byzantine
Prehistoric settlement
Ottoman
Anchors

THE METOHI TEST CASE

Metohi
Prehistoric settlement
2000/1700 BC



Metohi prehistoric settlemet- *Intra muros* burials

Up to this day:

- 16 cist graves - some could have formed part of a burial complex.
- made of limestone slags laid in rectangular shape.
- one cist grave maintains its cover stone slab *in situ*.
- within the pile of stones that cover most of the sea bottom, at least seven walls have been located.
- the stones of a wall have been laid in the herringbone pattern.
- two wall corners are visible.

Execution Test Case in Greece – Research Objectives

ITACA Innovation Technologies:

- Satellite Images (Algorithm)
- SAR Bathymetry

Verification:

- Archaeological Survey and Documentation
- Geophysical Survey

Remote sensing data processing will be verified and validated versus the actual location of the artifacts.

3D virtual reality scenario that will be used for the planning of the underwater excavation operations.

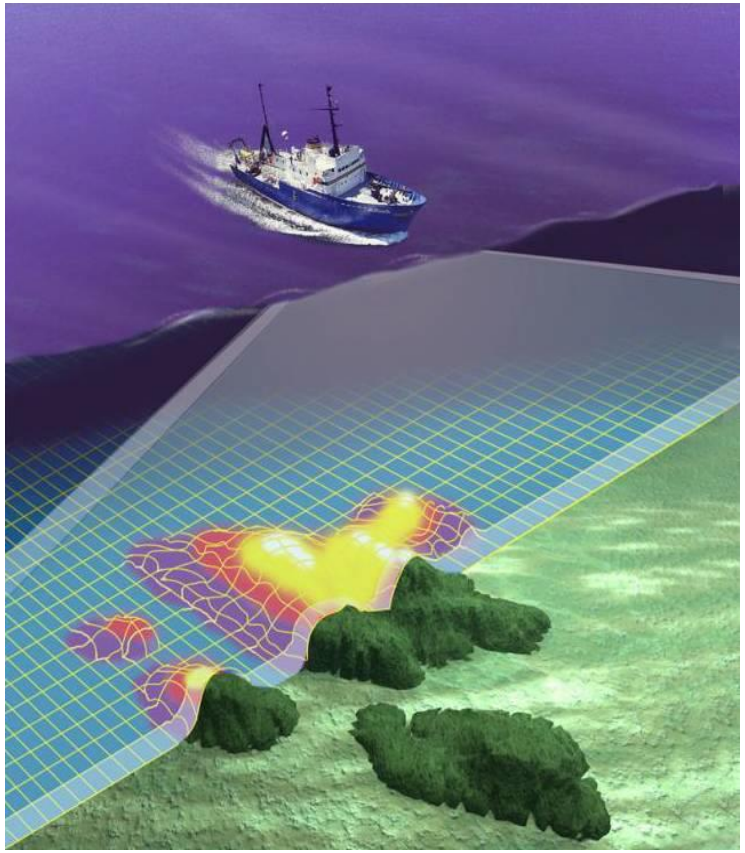
Recorder data (remote sensing, 3D scenario) as well as all the results of the excavation project will be included in the management and operation tool.

Test cases (Codevintec)

- **Test case Italy**

✓ Review of the selected test sites and trade-off analysis
✓ Acquisition of existing data and information on the selected test site in Sicily, Italy.
✓ Test campaign planning
✓ Test campaign execution
  - o Mapping campaign on boat using: multi-beam echo sounder, side-scan sonar, laser scanner
  - o Production of the 3D scenario
  - o Underwater campaign (limited scuba dive, if required)
✓ Produce Test Report
✓ Data processing and preliminary Analysis of the results

Together with Regione Sicilia, PKH and I.EN.A.E.



Test cases (Codevintec)

Test case Greece

- ✓ Review of the selected test sites and trade-off analysis
- ✓ Acquisition of existing data and information on the selected test site in Metohi, Greece.
- ✓ Test campaign planning
- ✓ Test campaign execution
  - o Mapping campaign on boat using: multi-beam echo sounder, side-scan sonar, laser scanner
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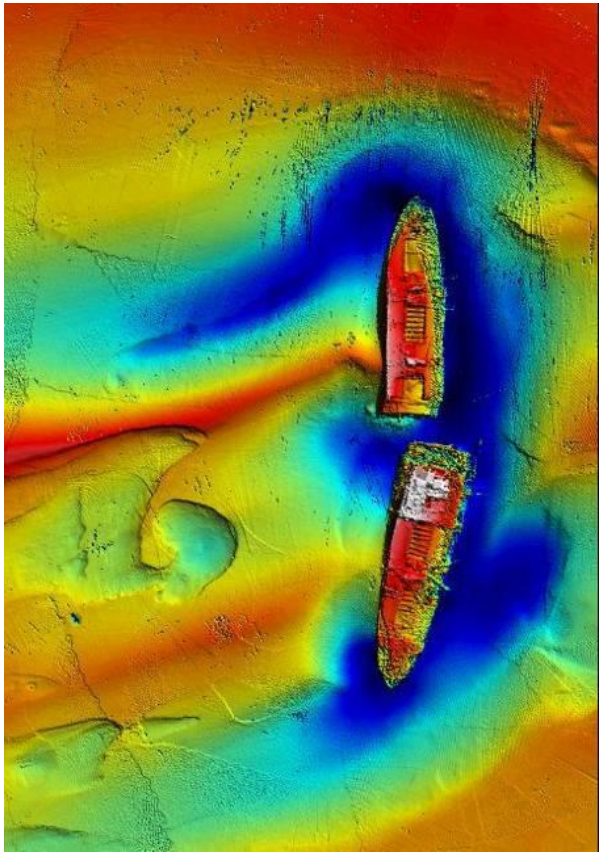
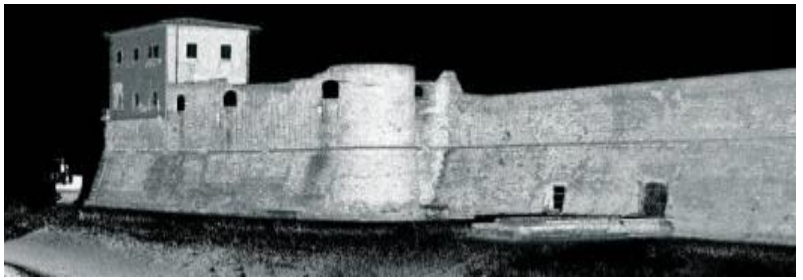


Data processing (Codevintec)

- **WP24 – Data Processing & Analysis**



- ✓ Processing and inclusion of the results of the trial service in the WebGIS
- ✓ Processing of the data collected during the surface campaign and inclusion of the reconstructed 3-D model of the underwater target areas in the WebGIS
- ✓ Inclusion of other relevant data in the WebGIS
- ✓ Produce maps & reports

CDV together with Regione Sicilia, PKH, KELL, GRAS, I.EN.A.E. and ALMA

Final Analysis

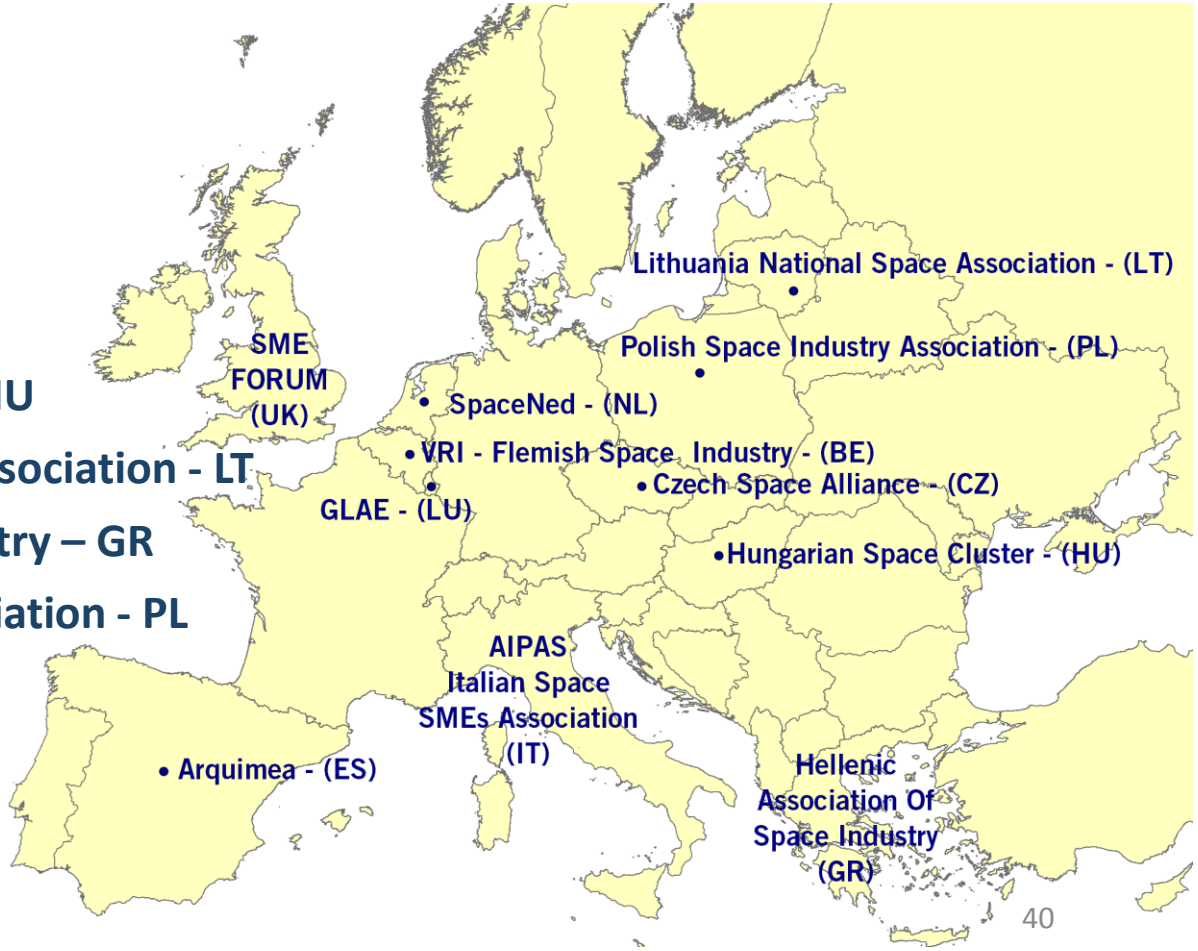
WP25 – Final Assessment -

- ✓ Review of the outcome of the project
- ✓ Analysis of the report of the test cases
  - o Italy
  - o Greece
- ✓ Analysis of the report of the service trial
- ✓ Preliminary assessment of the overall results
- ✓ Verification of the actual vs the expected results
- ✓ Assessment of the impact of the overall project
- ✓ Presentation of the results at the Final meeting
- ✓ Final recommendation and future perspective

CDV Together with Regione Sicilia, PKH, KELL, NEXTANT, GRAS, I.EN.A.E., INESC ID, ALMA and S4S

SME4SPACE MEMBERS

- AIPAS – IT
- Arquimea – ES
- Czech Space Alliance - CZ
- GLAE – LU
- Hungarian Space Cluster – HU
- Lithuania National Space Association - LT
- Hellenic Ass. of Space Industry – GR
- Polish Space Industry Association - PL
- SME Forum – UK
- SpaceNed – NL
- VRI – BE



Satellite Data Acquisition (for the algorithm verification)

- This WP aims at selecting and acquiring satellite data, using inputs coming from system architecture and Verification and Validation Plan
- The selection of satellite data (SAR VHR data) providers will be done using all the opportunities offered by ESA/EC (DATA Warehouse), ASI and DLR (mainly X-band sensors - TerraSAR-X or Cosmo SkyMed, and C-band sensors (ASAR) will be employed).

WP Duration: Months 3-15

Further S4S involvement in ITACA

SME4SPACE will also contribute to the following WPs:

- WP 3 End User and Final Conferences
- WP 4 Dissemination, Web site & Media
- WP 5 Service Model & Exploitation
- WP 6 Market Analysis & Business Plan
- WP 25 Final Assessment

Thank you

ITACA project is coordinated by Planetek Hellas E.P.E. (GR) and includes the following institutes and companies: Kell Srl (IT), NAIS Srl (IT), DHI GRAS (DK), I.EN.A.E (GR), FFCUL (PT), ANESTI Ltd (UK), Regione Sicilia (IT), ALMA sas (IT), CODEVINTEC Srl (IT), SME4SPACE (BE)

ALMA Sistemi sas

- ALMA Sistemi sas di Di Iorio Alessio & C is an Italian SME established in 2005 providing high level consultancy in the space and defence market.
- ALMA provides services in
  - Business Development & Market Analysis
  - Project and Proposal Management
  - System and Software Engineering (EO, image processing, Check-out systems).
- ALMA has contributed in behalf of its international clients to a number of key space projects funded by the European Commission, European and Italian Space Agencies.
- Past research projects: HORUS (ESA), PAGIS (ASI), WHERE (ASI)
- On going projects: APHORISM (FP7), ITACA (FP7)
- Alessio Di Iorio E-Mail: adi@alma-sistemi.com , web site: www.alma-sistemi.com