Assessment, Strategy And Risk Reduction for Tsunamis in Europe

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&
ASTARTE team

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EC Contribution: 5,999,677.80

Duration: 3 years (2013-2016)

Start Date: 01 November 2013

Consortium:26 partners, from 16 countries

Project Coordinator: Maria Ana Baptista

Leading Institution: Instituto Português do Mar e da Atmosfera, IPMA

Project Web Site: www.astarte-project.eu

Key Words: Tsunamis; social resilience; early warning; coastal impacts; structural performance; source mechanisms

THE CHALLENGE

Tsunamis are low frequency but high impact natural disasters. In 2004, the Boxing Day tsunami killed hundreds of thousands of people from many nations along the coastlines of the Indian Ocean. Tsunami run-up exceeded 35 m.

THE CHALLENGE

Seven years later, and in spite of the level of preparedness in the world, the Tohoku-Oki tsunami in Japan dramatically showed the limitations of scientific knowledge on tsunami sources, coastal impacts and mitigation measures.

THE CHALLENGE

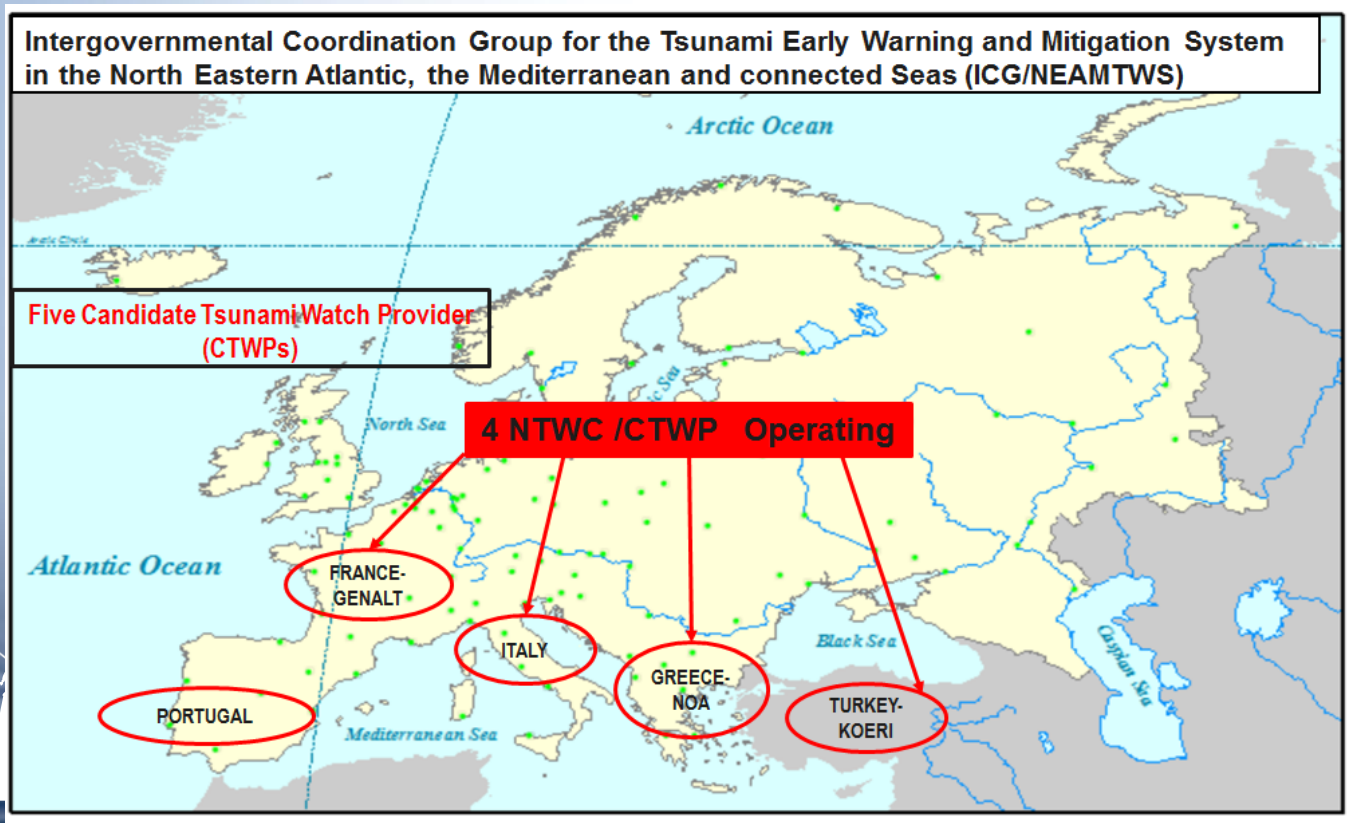
These events raised several questions:

- How to improve the resilience of coastal communities ?
- How to upgrade the performance of coastal defenses ?
- How to adopt a better risk management ?
- What are the strategies and priorities for the reconstruction of damaged coastal areas?

The on-going set up of the North Eastern Atlantic, Mediterranean and connected seas region (NEAM) tsunami warning system (TWS) needs to consider these lessons when developing societal and structural resilience

THE CONSORTIUM

The ASTARTE Consortium consists of research groups that contributed to the progress of tsunami science and technology in Europe and the five Tsunami Watch Providers (CTWP) in the NEAM region. There are currently 5 CTWPs: France, Greece and Turkey, Italy already in operation and Portugal (starting date Dec, 1, 2014)



THE CONSORTIUM

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SEVENTH FRAMEWORK PROGRAMME

Part. no.	Participant legal name	Acron.	Country	Organisation type*
1 (Coord)	Instituto Português do Mar e da Atmosfera	IPMA	Portugal	Research and End-user
2	Fundação da Faculdade de Ciências da Universidade de Lisboa	FFCUL	Portugal	Research
3	Middle East Technical University	METU	Turkey	University
4	Kandilli Observatory and Earthquake Research Institute	KOERI	Turkey	University
5	Commissariat à l'énergie atomique et aux énergies alternatives	CEA	France	Research and End-user
6	Centre National pour la Recherche Scientifique	CNRS	France	Research
7	University of Bologna	UNIBO	Italy	University
8	Istituto Nazionale di Geofisica e Vulcanologia	INGV	Italy	Research and End-user
9	University of Cantabria	UC	Spain	University
10	University of Barcelona	UB	Spain	University
11	Hellenic Center for Marine Research	HCMR	Greece	Research
12	National Observatory of Athens	NOA	Greece	Research and End-user
13	University of Hamburg	UHAM	Germany	University
14	German Research Centre for Geosciences	GFZ	Germany	Research
15	University of Bremen	UNIHB	Germany	Research
16	Norwegian Geotechnical Institute	NGI	Norway	SME
17	University College of Dublin, National University of Ireland	UCD	Ireland	University
18	National Oceanography Center (NERC)	NOC	UK	Research
19	Technical University of Denmark	TUD	Denmark	University
20	Institutul National de Cercetare Dezvoltare Pentru Fizica Pamantului	INCD FP	Romania	Research
21	Special Bureau of Automation of Sciences Russian Academy of Sciences	SRB	Russia	Research
22	Centre National pour la Recherche Scientifique et Technique	CNRST	Morocco	Research

The ASTARTE Consortium gathers NEAM scientists with international high level expert teams in all fields of tsunami research.

Earthquake Research Institute, The University of Tokyo

PMEL

PARI
Independent Administrative Institution
Port and Airport Research Institute (PARI)

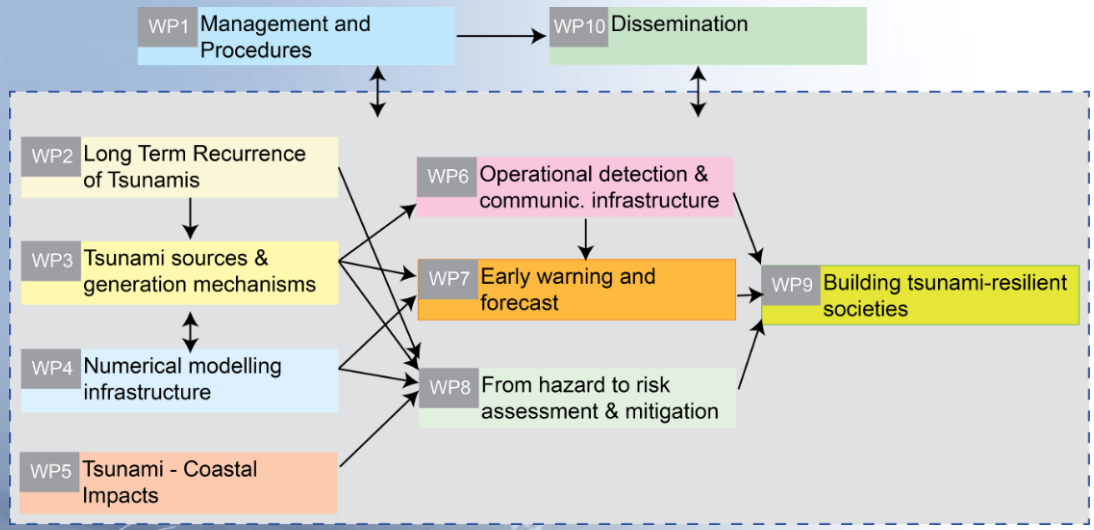
UNIVERSITY OF SOUTHERN CALIFORNIA 1880

THE OBJECTIVES

- To asses long term recurrence of tsunamis;
- To improve the identification of tsunami generation mechanisms;
- To develop new cost-effective computational tools for hazard assessment;
- To ameliorate the understanding of tsunami interactions with coastal structures;
- To enhance tsunami detection, forecast and early warning skills in the NEAM region;
- To establishing new approaches to quantify vulnerability and risk
- The ultimate goal of ASTARTE is to reach a higher level of tsunami resilience in the NEAM region!

METHODOLOGY

ASTARTE is organized into a number of work-packages that correspond to the different modules of research, operational development, and interaction with the stakeholders.



WP1 is devoted to Project coordination and management

WPs 2-5 focus on tsunami recurrence, generation mechanisms, numerical modeling and coastal impacts

WPs 6-8 focus on detection and communication infrastructures, early warning and forecast and risk assessment

WP9 aims at building tsunami resilient societies in Europe

WP10 is devoted to dissemination and exploitation of results.

WP2 - Long Term Recurrence of Tsunamis

Leaders P. Terrinha IPMA (PT), M. Meghraoui CNRS (FR)

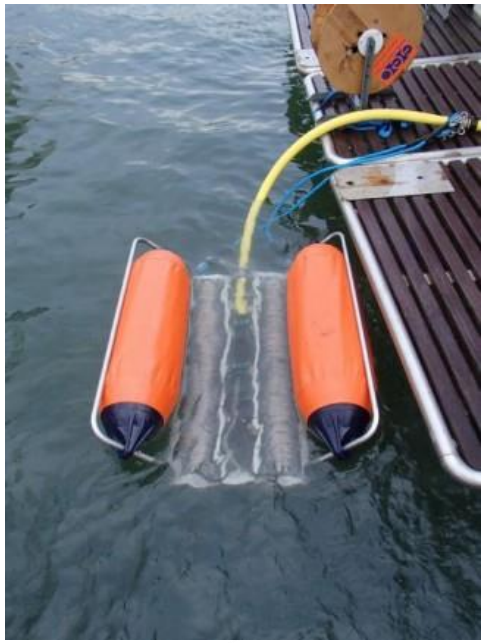
This WP2 intends to go beyond the improvement of tsunami catalogues. It will incorporate novel geological and geophysical contributions for the assessment of the long-term recurrence rates of large events in sensitive areas of the NEAM region.

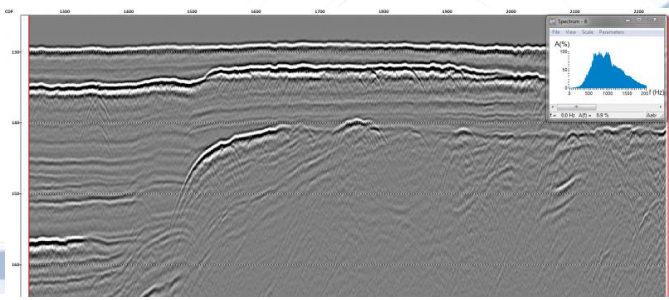
Objectives:

(i) calculation of the recurrence rates for large tsunamis from earthquake sources

(ii) calculation of tsunami recurrence rates from the recognized submarine and sub-aerial tsunami deposits

(iii) Upgrade of the tsunami deposit database incorporating detailed description on submarine or land deposits (e.g. age, geometry, sedimentology, and tsunami parameters).

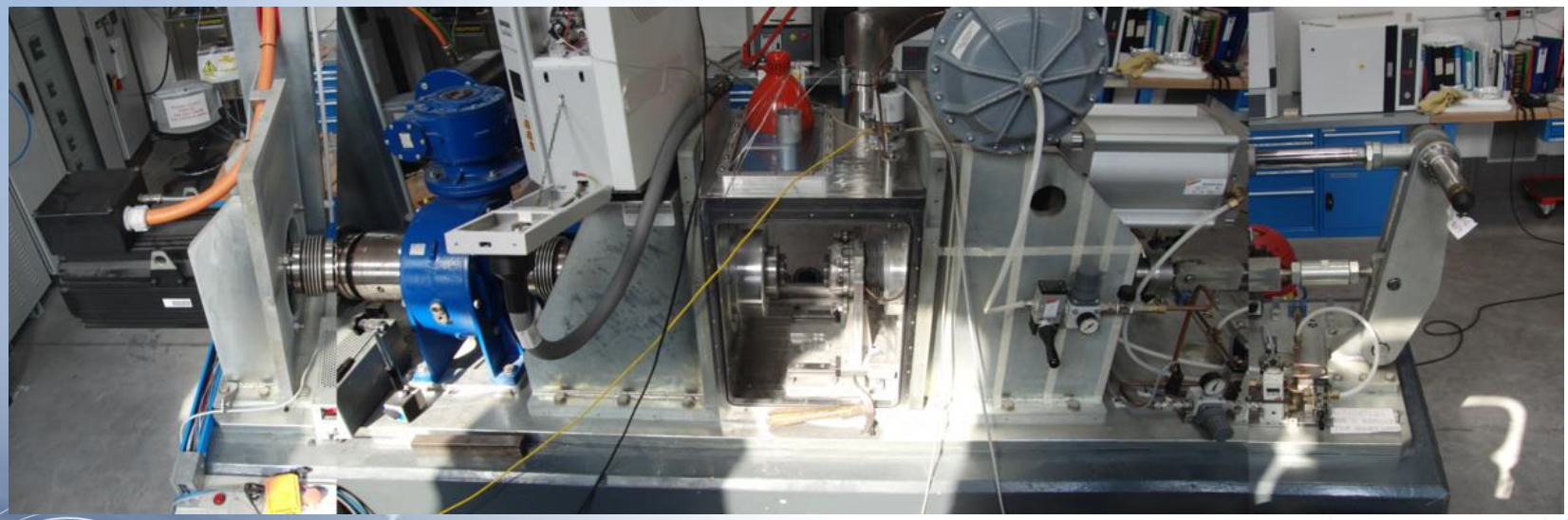




WP3 – Tsunami Generation Mechanisms

Leaders S. Lorito INGV (IT), C. Harbitz NGI (NO)

This WP focuses on understanding the source mechanisms for tsunami generation, particularly in relation to the potential sources and magnitudes of future tsunamis corresponding to the source areas (with associated test sites) and recurrence rates characterized in WP2. The study encompasses **tsunami generation by earthquakes, submarine and sub-aerial landslides, and volcanic activity.**



SHIVA machine (INGV, funded by ERC) that will be used to perform rotation and compression experiments. The apparatus able to create the extreme conditions of deformation typical to earthquakes

WP 4 - Numerical Modeling Infrastructure

Leaders J. Beherens UHAM (DE), U. Kanoglu METU (TR)

This work package aims at upgrading the modelling infrastructure for hazard assessment, and uncertainty quantification.

New modelling technology is one of the objectives, where dispersive and non-hydrostatic tsunami wave behaviour will be introduced into operational modelling tools. Additionally, high-performance computing techniques will be applied to those tools.

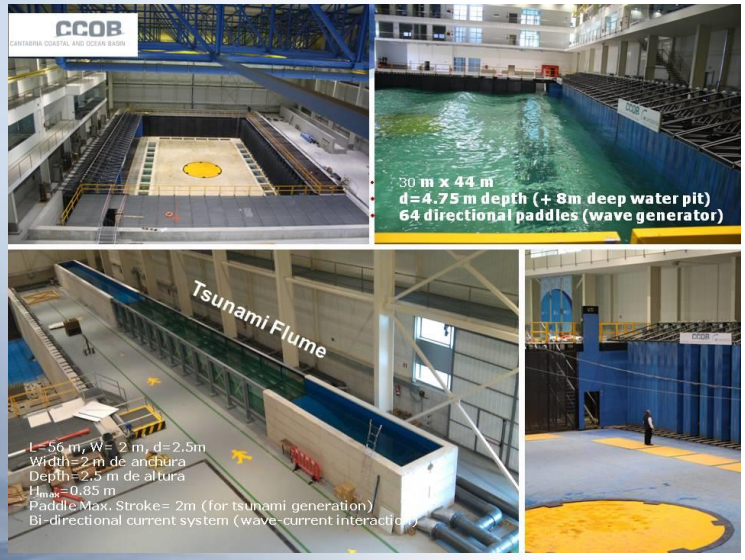
Some Deliverables:

- Complex multi-scale ocean-to-shore tsunami model by CEA (FR)
- Suite of new benchmark problems (METU, TR)
- Statistical emulator for tsunamis (UCD, IE)
- Instant computing framework (UHAM; DE)

WP 5 - Tsunami-Coastal Impacts

Leaders M. Gonzalez UCantabria (SP), D. Fuhrman TUD (DK)

This WP focuses on gaining a better understanding of tsunami impacts in coastal areas and on structures. It will study the stability and performance of coastal defences, critical and strategic structures, to identify lessons and new innovative and cost-effective design concepts and solutions for coastal and marine structures, and to investigate the tsunami-induced boundary layer, sediment transport, and morphological changes on coastal areas.



Facilities at the University of Cantabria

WP – 6 Operational detection and communication infrastructure

Leaders O. Necmioglu BOUN - KOERI (TR), N. Melis NOA (GR)

This work package focus on research related detection, monitoring, forecasting, prediction and early warning capabilities concerning tsunami hazard.

Emphasis on the determination of the optimum seismic, sea-level including coastal GPS and GPS Buoy Systems - Networks and their configuration.

Installation of a seafloor station in the Sea of Marmara (KOERI)

WP – 7 - Early Warning And Forecast

Leaders F. Schindele CEA (FR) A. Rudloff GFZ (DE)

The major goal of WP7 is to broaden and intensify the forecast and early warning skills in the NEAM (North Eastern Atlantic and Mediterranean) region. To do this, it will tackle the following questions:

- Specific needs of the European Regional TWS in the NEAM region;
- Fast source determinations to be used in the European Regional TWS;
- Assessment of early tsunami forecast methodologies for the European Regional/National TWS;
- Proposal of improvement of the international governance and architecture of the tsunami warning systems.

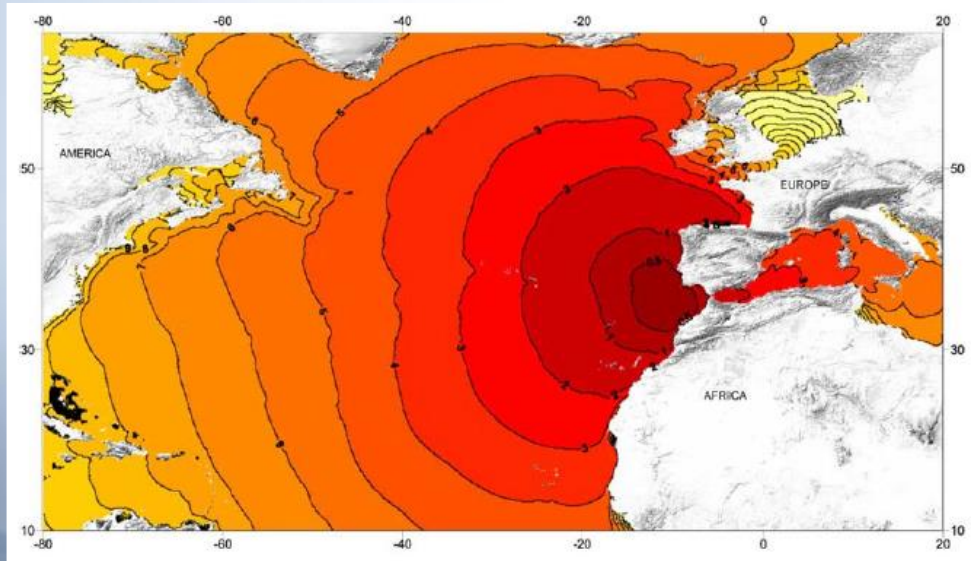


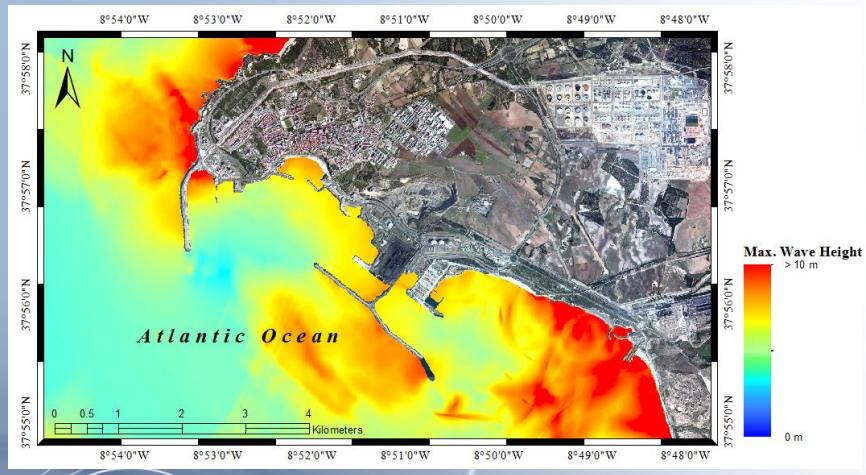
Figure 2: NEAMWave14 Scenario: Tsunami travel time (black contours in hour).

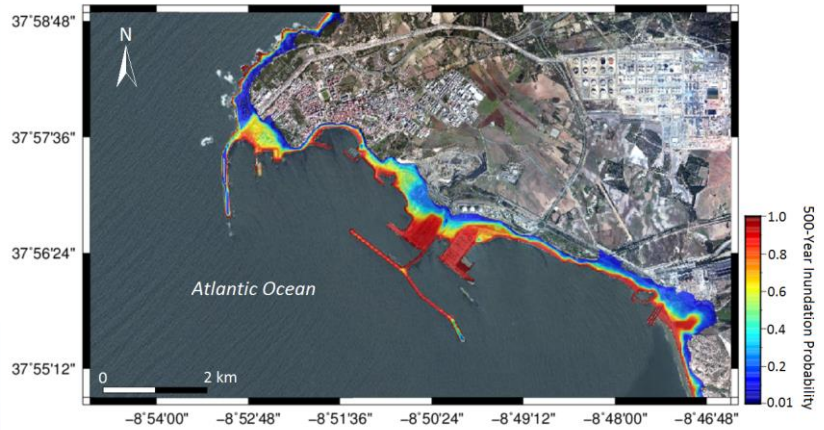
WP – 8 From Hazard to Risk Assessment

Leaders S. Tinti UNIBO (IT) G. Papadoupolos NOA (GR)

WP8 will answer the following questions: hazard assessment methods; exposure and vulnerability assessment approaches; risk assessment methods; quantifying and managing uncertainties; and Evaluation Support Tool (EST) and GIS Risk database of ASTARTE Products.

Deterministic and Probabilistic Tsunami Hazard Assessment – Sines Test Site





WP – 9 Building Tsunami Resilient Societies

Leaders F. Lavigne CNRS (FR) N. Karanci METU (TR)

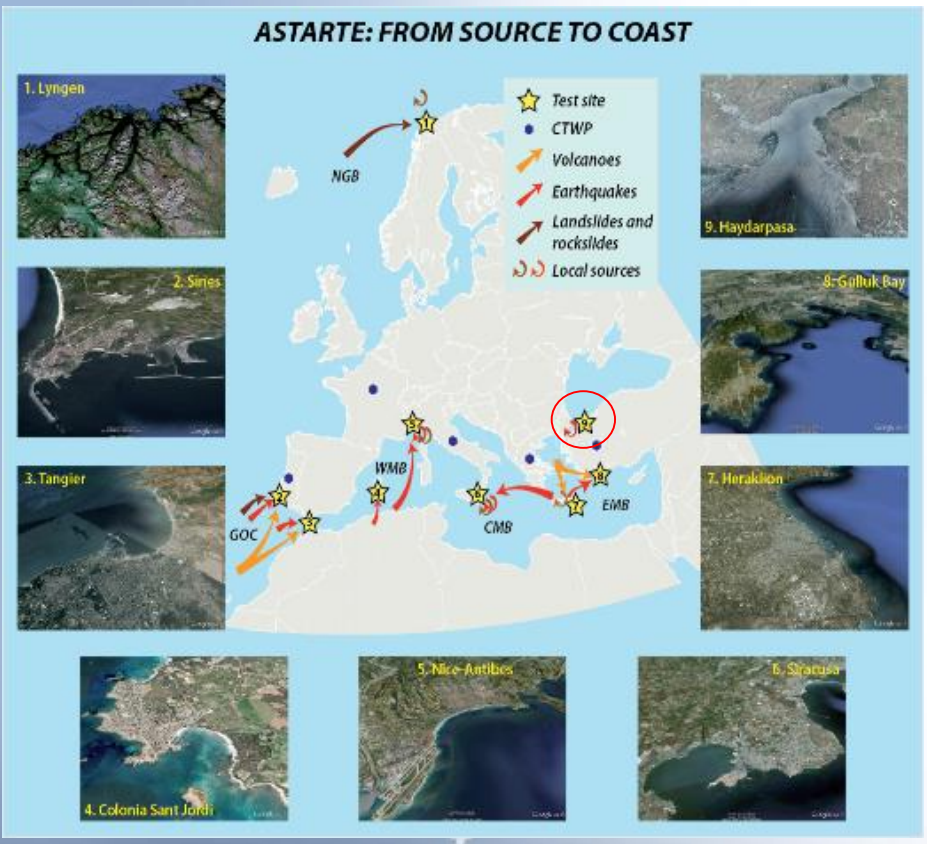
The aim of this WP is to identify the key components of tsunami resilience, the characteristics of a tsunami resilient society, and the enabling conditions for its implementation in the North-Eastern Atlantic, the Mediterranean and connected seas (NEAM).The activities of the WP9 will be undertaken in the main ASTARTE test sites in France, Sicilia, Crete, and Turkey, in order to make best use of the activities undertaken in the other WPs.

Tsunami questionaire at Gulluk Bay

WP – 10 Dissemination

This work package focus on dissemination and exploitation of project results

TEST SITES



- Test sites can be impacted by regional and local tsunami sources, which put different levels of stress on detection and forecasting;
- Different tsunami source types, such as earthquakes, landslides, volcanoes and rockslides
- Different values at risk including industry, harbours and other infrastructures, and ecosystems
- Different coastal communities such as fishing communities, coastal cities and tourist developments.
- Test sites include a broad geographical coverage, in both North-east Atlantic and Mediterranean coasts

TEST SITES

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Lyngen Fjord Norway - Submarine landslides and rock slides are the most hazardous tsunami sources in the Norwegian Greenland basin . At the same time, numerical modeling of tsunami generation by landslides represents huge challenges in terms of landslide disintegration and flow mechanisms, water/landslide interaction, huge dimensions and long run-out distances, as well as propagation and inundation in complex geometries.

Submarine landslides in the Norwegian Basin (left panel); instable rock slopes along the Lyngen fjord (mid panel); simulations of an 11 Mm3 rock slide tsunami, NGI 2008 (right panel).

TEST SITES

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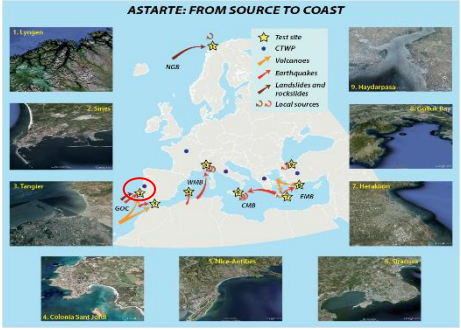

Sines: a strategic industrial hub in Portugal, NE Atlantic, exposed to possible tsunamis from earthquakes in the SW Iberia margin, landslides from Gorringe Bank and volcano eruption from Canary Islands.

The Southwest coast of Portugal, due to its particular location close to the Azores Gibraltar Fracture Zone separating the African and Eurasian lithospheric plates, is one of the areas most vulnerable to tsunamis triggered by offshore earthquakes. The most devastating tsunami in historical reports is the November, 1st, 1755 Lisbon event. In the 20th century three earthquakes of magnitude close to 8 have generated tsunamis that were recorded by the Portuguese tide gauge network on 25.11.1941 and 26.05.1975 both along the Gloria fault and 28.02.1969 in the South west Iberian margin

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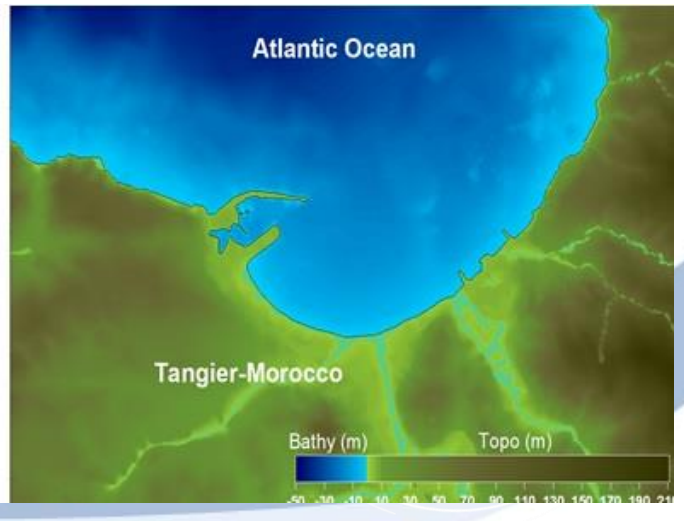
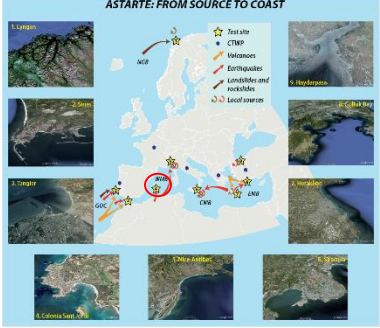
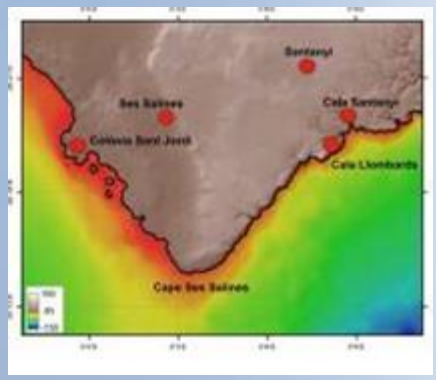
Tangier - An important Touristic and Economic pole of Morocco, NE Atlantic, exposed to possible tsunamis from earthquakes in the SW Iberia margin and volcano eruption from Canary Islands. The new harbour is under construction.

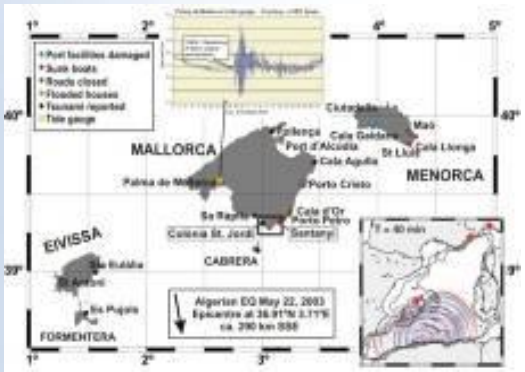
The site can be impacted by tsunamis generated along the South West Iberian Margin, earthquakes from Gloria fault (North East Atlantic), submarine landslides and volcanic eruptions in the Canary Islands





Colònia Sant Jordi, South of Mallorca, with permanent residents, buildings, leisure ports and high tourism (mainly in summer months) exposed to earthquake-generated tsunamis from North Africa.





Following the MW 6.9, May 21 2003 Boumerdes-Zemmouri earthquake, tsunami waves reached the Balearic Islands, producing damage to boats, port facilities and roads. In the test site, several boats sunk while anchored in Cala Santanyí or around the Cape. Three other tsunamis originating from N African margin have impacted in historical times (1756, 1856, 1980).

TEST SITES

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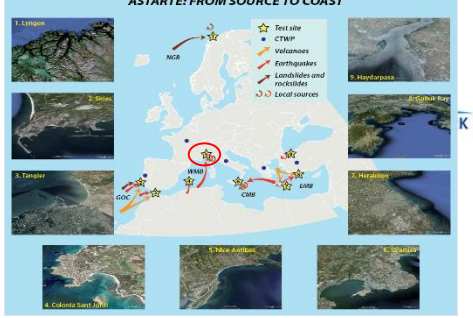
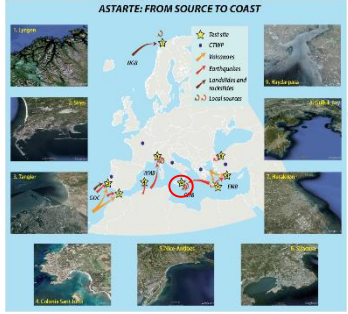
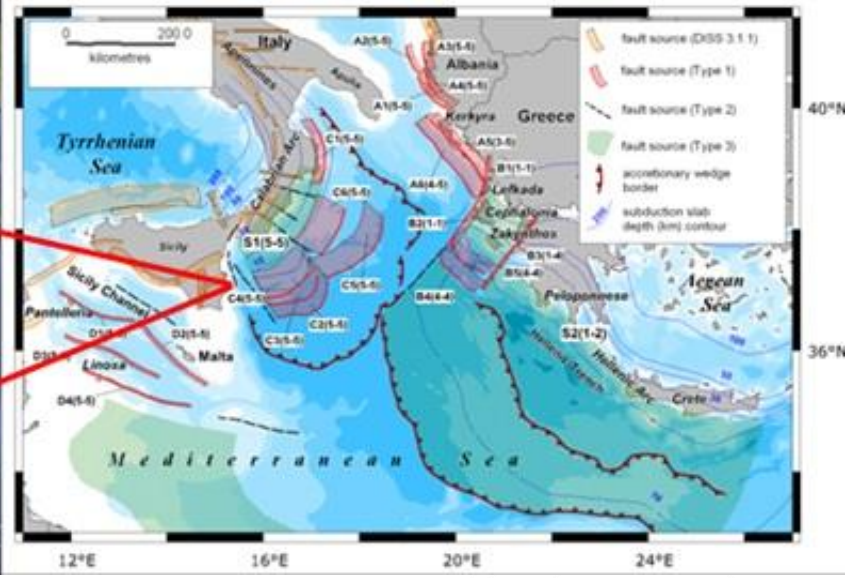


Nice : Located on the eastern French Riviera, 30 km West of the Italian border. It is a major coastal city in the region, gathering 350,000 inhabitants. Nice is the second most visited city in France, right behind Paris, with 4 million visitors a year and a € 1.5 billion income from tourism

Identified historical runups reached 3.5m in **Antibes in 1979, when a landslide-triggered tsunami** impacted this area, killing a few people. More recently, in **2003 the Boumerdès-Zemmouri earthquake generated a tsunami** that impacted several harbours of this area at night, generating important economic loss.



Siracusa in Sicily, South Italy; Harbor of Siracusa, harbor of Augusta. Petrochemical pole of Priolo Gargallo. Possible sources: earthquakes in the Messina Straits, along the Calabrian Arc and in and off Eastern Sicily. Earthquakes in the western Hellenic Arc



Oblique view of the Siracusa-Augusta harbor area (center) with several petrochemical terminals and industrial facilities (left); relative location of the test site with respect to the tsunamigenic crustal and subduction faults in the central Mediterranean Sea (right).

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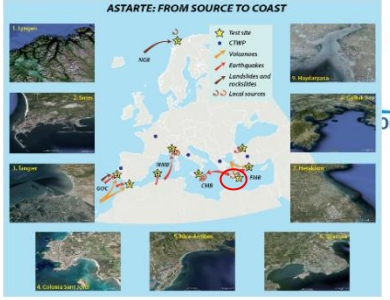

Heraklion coastal zone, Crete, Greece. Main endangered assets in Heraklion coastal zone: Main Shipping Port and ferry dock; International Airport (the second largest in Greece-major tourist destination; Coastal city of Heraklion; Hotel Complexes, Marina, Tourist attractions, Ancient Knossos Palace, Crowded Beaches; Main Power Plant for Crete, Oil, Petrol and Gas Storage Tank facilities. Earthquakes in the South Aegean region; Volcanic eruptions in the Aegean region - Santorini; Landslides in the South Aegean region and possibly other areas in the East Mediterranean

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DiDim Peninsula, Gulluk bay Turkey Gulluk Bay is one of the seven largest gulfs on the west coast of Turkey. Didim, is a small town located at North of the bay. At Didim tsunami deposit of Santorini event and tsunami observations in 1956 event are known. The new Marina (D-Marin Didim) was constructed in 2009 and serving as 1000 yacht capacity with 400-ton boat lift, dry docks, hangars, maintenance yard, yacht club, shopping mall, restaurants and visitor facilities. Local industries are mainly based on fish farming (about 80% of Turkey's aquaculture production)

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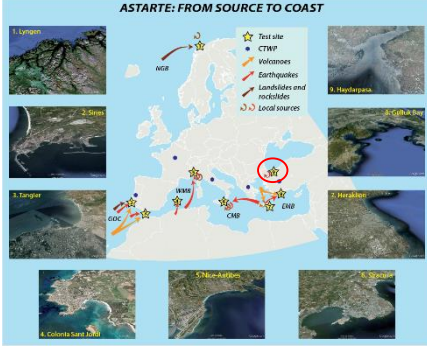

Haydarpasa Turkey: coastal areas in and around Haydarpasa Port, Turkey (North coast of the sea of Marmara). The Port of Haydarpasa is a general cargo port, ro-ro and container terminal, located in Haydarpaşa, Istanbul at the Southern entrance to the Bosphorus.

Possible tsunami sources: earthquakes along North Anatolian fault Zone in the sea of Marmara; submarine landslides

END-USERS

- National Tsunami Warning Centers
- Member-state National and Local Civil Protections agencies
- European and Member-state regulatory bodies related with civil engineering;
- Non-Governmental Organizations related with environmental policy.
- Special collaboration with IOC-UNESCO ICG-NEAM & Caribbean (as well as other ICGs)

EXPECTED RESULTS

- **To improve the knowledge on tsunami generation** involving novel empirical data and statistical analyses so that the long-term recurrence and associated hazards of large events in NEAM region can be established
- **To develop numerical techniques for tsunami simulation** concentrating in: real-time codes and novel statistical emulations, and in new/refined methods for assessment of tsunami hazard, vulnerability and risk
- **Better tools for tsunami forecast and early warning** for the candidate Tsunami Watch Providers and National Tsunami Warning Centers
- **Guidelines** for tsunami Euro Codes and Guidelines for decision makers
- **In summary, ASTARTE will contribute to foster tsunami resilient communities in NEAM region**

ASTARTE EAB

The EAB includes four well-known international experts in the fields of Tsunami Science, Tsunami Warning, Disaster Management and Coastal Engineering, and Tsunami Social impacts. **Emile Okal** – is world expert in tsunami science - Northwestern University, USA; **Christa Andrade** Inter-Governmental Coordination Group of Caribbean Tsunami Warning **Hitomi Murakami** is a world expert in Disaster Mitigation and Planning - Yamaguchi University, Japan, and **Fumiko Imamura** is world expert on coastal engineering (Tohoku University, Japan).

SOME RESULTS

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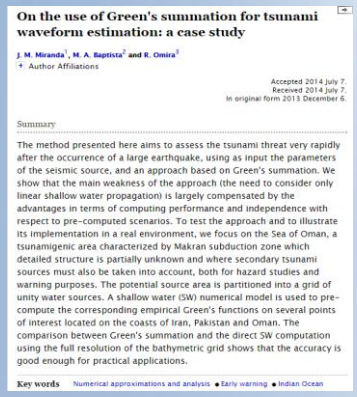
SEVENTH FRAMEWORK PROGRAMME

ASTARTE publications


On the use of Green's summation for tsunami waveform estimation: a case study

J. M. Miranda[1], M. A. Baptista[2] and R. Omira[3]

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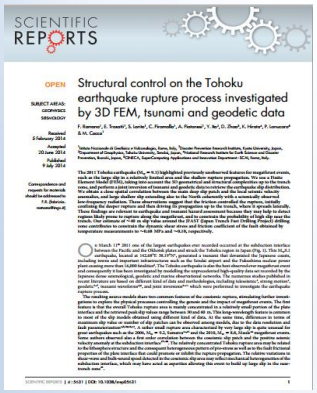
Summary

The method presented here aims to assess the tsunami threat very rapidly after the occurrence of a large earthquake, using as input the parameters of the seismic source, and an approach based on Green's summation. We show that the main weakness of the approach (the need to consider only linear shallow water propagation) is largely compensated by the advantages in terms of computing performance and independence with respect to pre-computed scenarios. To test the approach and to illustrate its implementation in a real environment, we focus on the Sea of Oman, a tsunamigenic area characterized by Makran subduction zone which detailed structure is partially unknown and where secondary tsunami sources must also be taken into account, both for hazard studies and warning purposes. The potential source area is partitioned into a grid of unity water sources. A shallow water (SW) numerical model is used to pre-compute the corresponding empirical Green's functions on several points of interest located on the coasts of Iran, Pakistan and Oman. The comparison between Green's summation and the direct SW computation using the full resolution of the bathymetric grid shows that the accuracy is good enough for practical applications.

Key words Numerical approximations and analysis • Early warning • Indian Ocean


SCIENTIFIC REPORTS

OPEN

Structural control on the Tohoku earthquake rupture process investigated by 3D FEM, tsunami and geodetic data

ASTARTE @ EGU 2014


Assessment of Tsunami Inundation map for Bulgarian coasts of in the Black Sea

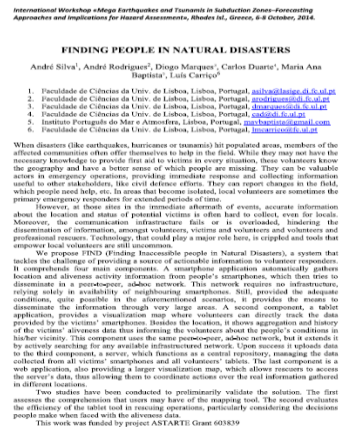

The Hellenic National Tsunami Warning Centre (HL-NTWC): Recent updates and future developments


Tsunami hazard assessment for the area of Siracusa and Augusta (eastern Sicily, Italy) by means of numerical techniques


High Resolution Tsunami Modelling and Assessment of Harbor Resilience: Case Study in Istanbul

ASTARTE smart phone app

ASTARTE Marine cruises


International Workshop «Mega Earthquakes and Tsunamis in Subduction Zones–Forecasting Approaches and Implications for Hazard Assessments, Rhodes Isl., Greece, 6-8 October, 2014.

FINDING PEOPLE IN NATURAL DISASTERS

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When disasters (like earthquakes, hurricanes or tsunamis) hit populated areas, members of the affected communities often offer themselves to help in the field. While they may not have the necessary knowledge to provide first aid to victims in every situation, these volunteers know the geography and have a better sense of which people are missing. They can be valuable actors in emergency operations, providing immediate response and collecting information useful to other stakeholders, like civil defence efforts. They can report changes in the field, which people need help, etc. In areas that become isolated, local volunteers are sometimes the primary emergency responders for extended periods of time.

However, at those sites in the immediate aftermath of events, accurate information about the location and status of potential victims is often hard to collect, even for locals. Moreover, the communication infrastructure fails or is overloaded, hindering the dissemination of information, amongst volunteers, victims and volunteers and volunteers and professional rescuers. Technology, that could play a major role here, is crippled and tools that empower local volunteers are still uncommon.

We propose FIND3 (Finding Inaccessible people in Natural Disasters), a system that tackles the challenge of providing a source of actionable information to volunteer responders. It comprehends four main components: A smartphone application automatically gathers location and aliveness activity information from people's smartphones, which then tries to disseminate in a peer-to-peer, ad-hoc network. This network requires no infrastructure, relying solely in availability of neighbouring smartphones. Still, provided the adequate conditions, quite possible in the aforementioned scenarios, it provides the means to disseminate the information through very large areas. A second component, a tablet application, provides a visualization map where volunteers can directly track the data provided by the victims' smartphones. Besides the location, it shows aggregation and history of the victims' aliveness data thus informing the volunteers about the people's conditions in his/her vicinity. This component uses the same peer-to-peer, ad-hoc network, but it extends it by actively searching for any available infrastructured network. Upon success it uploads data to the third component, a server, which functions as a central repository, managing the data collected from all victims' smartphones and all volunteers' tablets. The last component is a web application, also providing a larger visualization map, which allows rescuers to access the server's data, thus allowing them to coordinate actions over the real information gathered in different locations.

Two studies have been conducted to preliminarily validate the solution. The first assesses the comprehension that users may have of the mapping tool. The second evaluates the efficiency of the tablet tool in rescuing operations, particularly considering the decisions people make when faced with the aliveness data.

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LOST-Map: A Victim-Sourced Rescue Map of Disaster Areas

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Abstract. In the aftermath of natural disasters, members of the affected communities are often the de facto first responders. Local volunteers can respond quickly, are strongly motivated, and have the necessary ground knowledge. However, their search and rescue efforts may be misdirected in the absence of information about the location and status of victims. We propose LOST, a system that gathers data from smartphones in affected areas, even when the regular communication infrastructure fails, and aggregates it in a web interface for visualization. For each individual, LOST-Map shows location traces and activity indicators. The information can be explored by selecting time-frames and/or applying filters over activity indicators. This paper briefly describes the design of LOST, introduces the visualization tool LOST-Map, and reports on a study (n=10) that suggests that it can be effectively used by untrained volunteers.

Keywords: Disaster management, Emergency response, Location services.

1 Introduction

When disasters (like earthquakes, hurricanes or tsunamis) hit populated areas, members of the affected communities often offer themselves to help in the field. While they may not have the necessary knowledge to provide first aid to victims in every situation, these volunteers know the geography and have a better sense of which people are missing. They can be valuable actors in emergency operations, providing immediate response and collecting information useful to other stakeholders, like civil defence efforts. They can report changes in the field, which people need help, etc. In areas that become isolated, local volunteers are sometimes the primary emergency responders for extended periods of time. However, when information flows are chaotic, it is difficult, even for locals, to have an accurate account of the location and status of potential victims. Often the communication infrastructure fails or is overloaded, hindering the dissemination of information.

Technology plays a crucial role in emergency response. Yet, tools that empower local volunteers aren't still common. LOST is a system that tackles the challenge of providing a source of actionable information to volunteer responders. With LOST,

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The General Assembly meeting will take place 16th and 17th October 2014 in Siracusa, Italy, one of ASTARTE's test sites, followed by a field trip.

Location: Siracusa, Sicily, Italy

Organized by University of Bologna and Local Civil Protection

THANKS !


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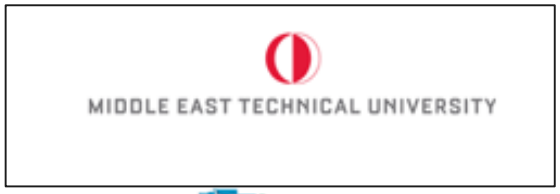
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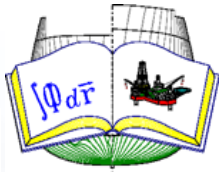


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