Project Partners

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EU FP7 Project [603839]

SEVENTH FRAMEWORK PROGRAMME

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ASSESSMENTS, STRATEGY AND RISK REDUCTION FOR TSUNAMIS IN EUROPE

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WHAT IS ASTARTE ?

ASTARTE (Assessment, STrategy And Risk Reduction for Tsunamis in Europe), an international project on tsunamis funded by EC-FP7 (Contract No. 603839), begun in November 1, 2013. The project was organized to foster tsunami resilience in Europe, through innovative research on scientific problems critical to enhance forecast skills in terms of sources, propagation and impact.

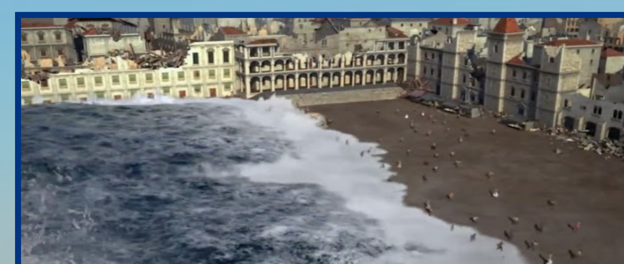
OBJECTIVES

The ultimate goals of ASTARTE were to reach a higher level of tsunami resilience in the NEAM Region, which included the NE Atlantic Ocean, Mediterranean Sea and Connected Seas to improve preparedness of coastal populations and, ultimately, to help saving lives and assets. The main objectives were:

- To assess long term recurrence of tsunamis;
- To improve the identification of tsunami generation mechanisms;
- To develop new computational tools for hazard assessment;
- To ameliorate the understanding of tsunami interactions with coastal structures;
- To enhance tsunami detection capabilities, forecast and early warning skills in the NEAM Region;
- To establish new approaches to quantify vulnerability and risk and to identify the key components of tsunami risk reduction and their implementation in the NEAM Region.

1755 LISBON TSUNAMI

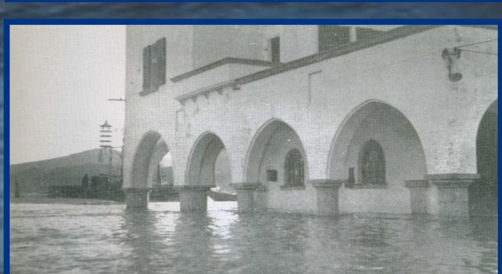
On the 1st November 1755, a massive submarine earthquake occurred in the North East Atlantic offshore Portugal around 9:40 in the morning. Current scientific estimates of the earthquake magnitude were 8.5 – 9.0. Less than half an hour after the shock first tsunami waves hit the South Portuguese Coast. In Lisbon, the tsunami entered the bar in Lisbon and propagated into the Tagus estuary flooding downtown and causing massive destruction of the ships in the harbor. The tsunami engulfed some villages and destroyed fortresses along the South Portuguese coast. In the Atlantic coast of Spain, the tsunami caused extensive damage to Cadiz and Huelva. In Morocco, the tsunami flooded the coastal areas, in the Atlantic, from Tangier to Safi and Agadir. The tsunami propagated all over the North East Atlantic causing damage in Madeira and Azores Islands.



Flooding of the tsunami after the Lisbon earthquake in 1755 (Smithsonian Channel).

1956 AEGEAN TSUNAMI

A strong tsunami occurred on 9 July 1956, caused by a M7.5 tectonic earthquake in Cyclades Islands, South Aegean Sea.

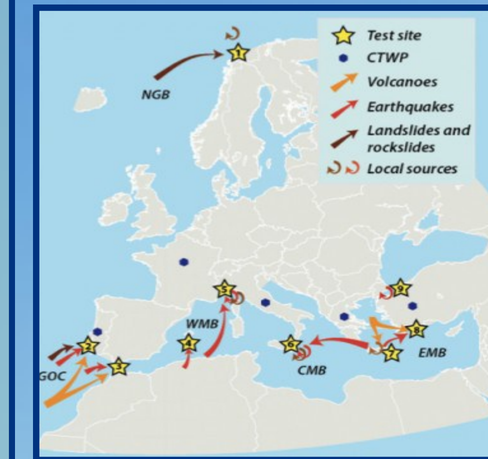


Tsunami inundation in Leros Island **(first picture from left)**. Fishing boat moved ashore in Kalymnos Island **(second picture from left)**.

TEST SITES

ASTARTE considered 9 test sites in the Mediterranean and Northeast Atlantic. Locations of the ASTARTE test sites were chosen to be representative in terms of potential tsunami sources, vulnerability and diversity of landscapes and socioeconomic elements. The selected test sites are:

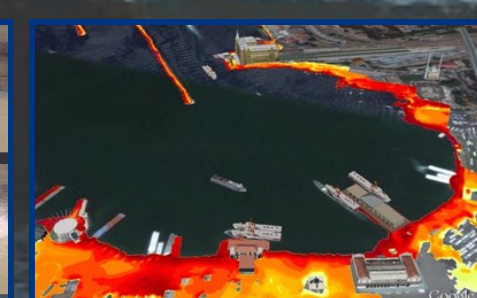
- LYNGEN, Norwegian coast, NE Atlantic;
- SINES, Portuguese coast, NE Atlantic;
- TANGIER, Moroccan coast, Strait of Gibraltar, NE Atlantic;
- COLONIA SANT JORDI, Baleares coast, Western Mediterranean;
- NICE-ANTIBES, French coast, Western Mediterranean;
- SIRACUSA, Sicily coast, Ionian Sea;
- HERAKLION, Cretan coast, Eastern Mediterranean;
- GULLUKBAY, Turkish coast, Eastern Mediterranean;



ACHIEVEMENTS

ASTARTE:

- Completed a general assessment of potential tsunami sources (seismic and nonseismic) in the NEAM (NE Atlantic, the Mediterranean, and Connected Seas), including uncertainty treatment, and tsunami sensitivity to source parameter values.
- Presented new methods for inverse modelling, novel forecasting techniques
- Performed Physical experiments to address the tsunami structure interaction on rubble mound breakwaters.
- Developed a smartphone app for disaster management FIND – Finding People in Natural Disasters
- Developed new methods to cover the assessment chain from tsunami hazard to tsunami vulnerability and risk, and the application to the specific test sites of the NEAM region, and, for some segments of the chain, to wide basins like the NE Atlantic and the Black Sea.
- Contributed to the implementation of TEWS in the NEAM region
- Paved the road for the ambitious implementation of the first ever probabilistic tsunami hazard curves for the NEAM Region through TSUMAPS-NEAM Project
- The success of the test site approach in ASTARTE has helped to (1) highlight the diversity of settings, boundary conditions assets and risk that apply to different locations in Europe in terms of tsunami hazard; (2) make tangible, at specific locations, key concepts and approaches and their practical implementation, and (3) evidence differences in background information that is critical to address site specific analyses and propose prevention and mitigation schemes. Contributed to the implementation of TEWS in the NEAM region.
- One of the major added values of ASTARTE had been the gathering of many of the best tsunami experts, from different disciplines and viewpoints, from Europe and beyond. This gathering was by itself a major achievement and it would be highly convenient for the benefit of the European society to take action to maintain and foster it for a lively tsunami science targeting future major advances.
- All these efforts at the end led Europe to be more knowledgeable and better prepared against tsunami hazard.



Wave evolution on the rubble mound structure (courtesy to UC) **(left)**
Inundation at Haydarpasa test site (courtesy to METU) **(top)**

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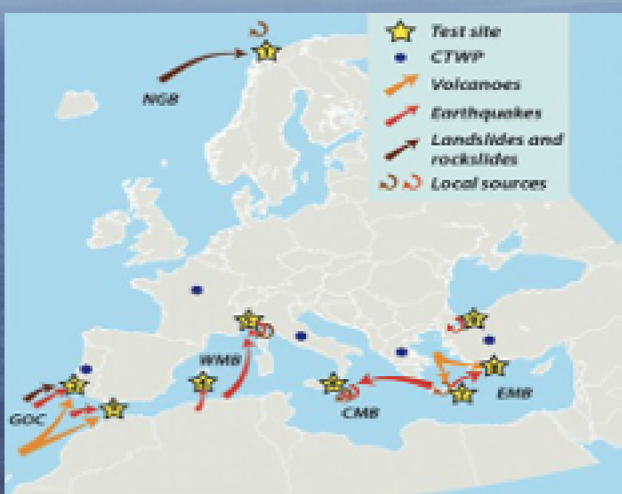
- HAYDARPASA , Turkish coast, Marmara Sea.



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Developed new methods to cover the assessment chain from tsunami hazard to tsunami vulnerability and risk, and the application to the specific test sites of the NEAM region, and, for some segments of the chain, to wide basins like the NE Atlantic and the Black Sea.

Contributed to the implementation of TEWS in the NEAM region

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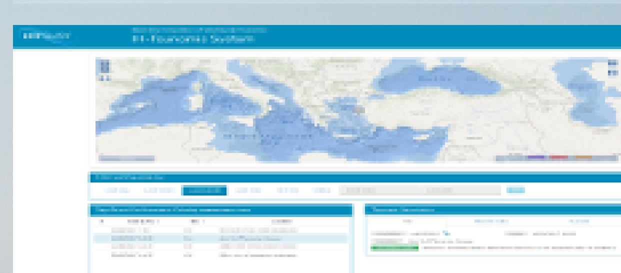
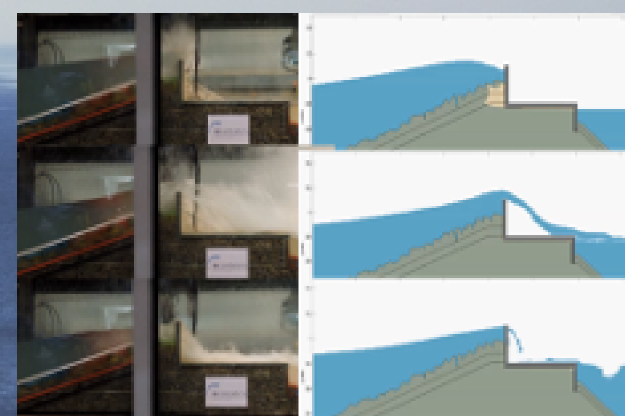




Comparison of the physical and numerical model experiments performed in ASTARTE (courtesy to UC) (top)

IH-Tsunamis System (IH-Tsusy) is an online tool that calculates the propagation of actual tsunamis. (courtesy to IH-cantabria) (bottom)

ASTARTE- Assessment Strategy and Risk Reduction for Tsunamis in Europe

Collaborative Project 603839 FP7-ENV2013 6.4-3

Project Information

ASTARTE, an international project on tsunamis funded by EC-FP7 (Contract No. 603839 is organized to foster tsunami resilience in Europe, through innovative research on scientific problems critical to enhance forecast skills in terms of sources, propagation and impact.

ASTARTE is a collaborative project, with a multidisciplinary team, devoted to tsunamis in the North East Atlantic, Mediterranean and Adjacent Seas

Total Cost: 7,884,882.47 €

EC Contribution: 5,999,677.80 €

Duration: 3 years+6 months

Start Date: 01 November 2013

End Date: 30 April 2017

Consortium:26 partners, from 16 countries

Project Coordinator: Maria Ana Baptista

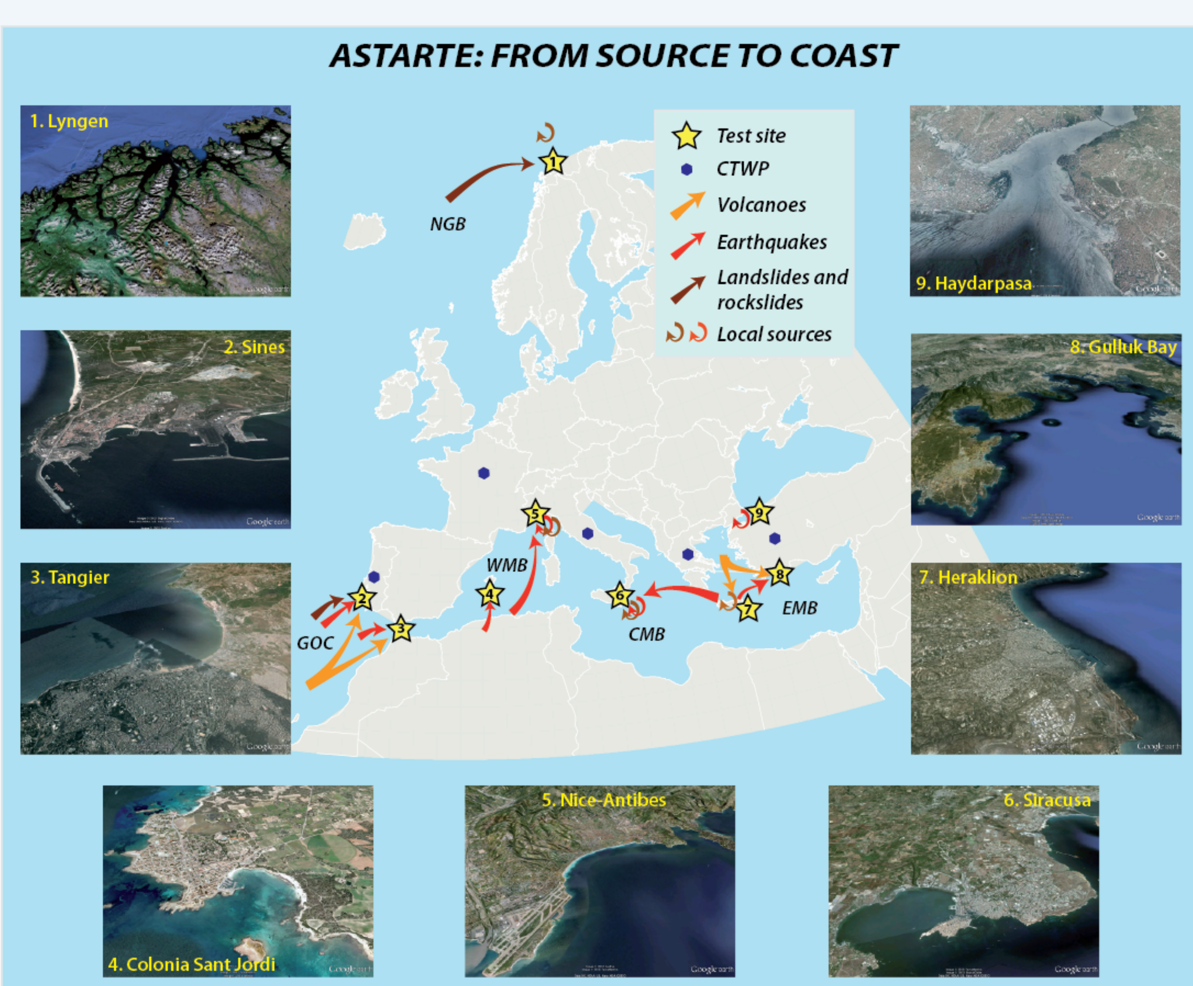
Lead Institution: Instituto Português do Mar e da Atmosfera, IPMA, Portugal

Project Web Site: www.astarte-project.eu

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

Test Sites

Locations of the ASTARTE test sites were chosen to be representative in terms of potential tsunami sources, vulnerability and diversity of landscapes and socio-economic elements. The selected test sites are:



The Challenge

Tsunamis are 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. Seven years later, and in spite of some of the best warning technologies and levels 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 experience from Japan raised serious questions on how to improve the resilience of coastal communities, to upgrade the performance of coastal defences, to adopt a better risk management, and also on the strategies and priorities for the reconstruction of damaged coastal areas. Societal resilience requires the reinforcement of capabilities to manage and reduce risk at national and local scales.

ASTARTE Goals

The ultimate goals of ASTARTE were to reach a higher level of tsunami resilience in the NEAM Region, which included the NE Atlantic Ocean, Mediterranean Sea and Connected Seas to improve preparedness of coastal populations and, ultimately, to help saving lives and assets. The main objectives were:

- To assess long term recurrence of tsunamis;
- To improve the identification of tsunami generation mechanisms;
- To develop new computational tools for hazard assessment;
- To ameliorate the understanding of tsunami interactions with coastal structures;
- To enhance tsunami detection capabilities, forecast and early warning skills in the NEAM Region;
- To establish new approaches to quantify vulnerability and risk and to identify the key components of tsunami risk reduction and their implementation in the NEAM Region.

ASTARTE Consortium Members

ASTARTE resulted in new

- Methods for inverse modelling that can help determining optimal sensor locations as well as regions of influence to critical infrastructures;
- Analytical and experimental benchmarks for model validation;
- Novel forecasting techniques, based on tsunami emulation rather than simulation with instant simulation workflows;
- Tank experiments to address the tsunami interaction with structures, such as rubble mound breakwaters;
- Numerical models for simulating tsunami-induced flow, sediment transport, and consequent morphological change of the sea bed, spanning an impressive range of scales;
- Refined CFD modelling improving the understanding of sediment dynamics during the surge of a tsunami-like breaking bores;
- Methods to cover the assessment chain from tsunami hazard to tsunami vulnerability and risk, and the application to the specific test sites of the NEAM Region, and, for some segments of the chain, to wide basins like the NE Atlantic Ocean and the Black Sea,
- Scenario-based and seismic probability tsunami hazard assessment (SPTHA) in real world situations using the 9 ASTARTE test sites in the Mediterranean Sea and the NE Atlantic Ocean. The subsequent contract TSUMAPS-NEAM (Probabilistic Tsunami hazard maps for the NEAM Region) with DG ECHO constitutes a direct application of the seismic PTHA study within ASTARTE for the whole NEAM Region;
- New vulnerability studies at local scales in most ASTARTE test sites targeting coastal infrastructural, urban, recreational and industrial assets;
- GIS Database of thematic maps;
- New paleo tsunami database on the long-term record of the occurrence of past tsunamis providing a much needed long-term vision of this type of natural hazard in the NEAM Region;
- New educational materials for populations on the process of tsunami evacuation;
- Applications for disaster management such as FIND – Finding People in Natural Disasters, smartphone app for disaster management;
- Refined numerical models for seamless tsunami propagation and inundation with adaptive mesh refinement, hardware optimization and better physical representations, considering dispersive effects of wave interactions.

ASTARTE assessed

- Operational infrastructures in the NEAM Region and the possibility of integration of meteo-oceanographic data to improve TEWS in the NEAM Region;
- The governance of the existing tsunami warning systems, coordinated by the UNESCO/IOC;
- New decision matrices for different sub-basins;
- The level of tsunami awareness of coastal communities in NEAM Region and adjacent seas. ASTARTE concluded that the area is in need for corrective actions concerning evacuation plans and official evacuation sites.

ASTARTE- Assessment Strategy and Risk Reduction for Tsunamis in Europe

Collaborative Project 603839 FP7-ENV2013 6.4-3

ASTARTE completed…

A general assessment of potential tsunami sources (seismic and nonseismic) in the NEAM Region, including uncertainty treatment, and tsunami sensitivity to source parameter values. These results show that:

- An important percentage of submarine earthquakes may be tsunamigenic (i.e., 70% for magnitudes greater than 8.0, 25% for magnitudes greater than 7, and 7% for magnitudes greater than 6.0);
- Large earthquakes in oceanic transpressive fault zones can generate tsunamis (i.e., Gorringe Bank and the thrust systems of the Gulf of Cadiz in the NE Atlantic and the fault system along the Algerian coastline and continental margin);
- Results off Algeria In the Mediterranean Sea indicate clustering and ciclicity for large earthquakes and related tsunamis with recurrence intervals as short as 50 years and periods of quiescence that may last for several centuries;
- Major historical earthquakes (last 700 years) led to offshore mass transport deposits, which are valuable proxies for pre-instrumental seismicity eventually leading to tsunamis;
- Submarine volcanic eruptions and associated instability processes in the Canary Islands and in other volcanic settings in Europe may contribute to tsunami generation, especially if there is explosiveness in shallow water and magma injection pushing unbutressed island flanks seaward;
- The need to consider an independent Alboran micro-plate in the Africa Eurasia configuration.

Beyond ASTARTE - Gaps & Recomendations

Generation Mechanisms

Landslide-induced tsunamis

- New monitoring schemes for potential landslides;
- Identification of precursor signs for submarine and subaerial coastal landslides;
- Improvement knowledge on landslide-induced tsunami generation mechanisms.

Earthquake-induced tsunamis

- Field investigation mainly in areas of short historical record supported by absolute dating;
- Inclusion of the record of tsunami-triggered mass transport deposits in tsunami hazard assessment analyses;
- Research on long-term slip rates of submarine faults;
- Need to implement solutions to address the near-field problem, namely by improving the assessment of the earthquake focal mechanism, focusing on the integrated GNSS, strong motion seismic and submarine cabled seismometer/pressure sensor networks.

Modelling

- Improve modelling capabilities for medium size tsunamis;
- Comprehensive multi-source tsunami hazard and risk assessment with full uncertainty treatment;
- New numerical models for coastal evolution numerical models for beaches, estuaries and the inland zones;
- Need for faster methods to compute the tsunami amplification from deep-sea to coastline uncertainties of such amplitude estimation.

Coastal Processes

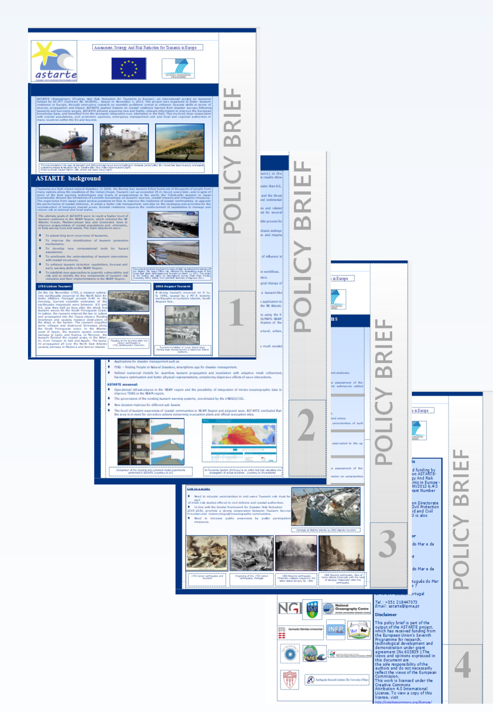
- Foster an in depth knowledge on hydrodynamic behavior and sediment transport processes associated to the up rush and down rush flows in beaches, estuaries and inland flooded zones;
- Better understand tsunami-induced scour around monopoles.

Early Warning

- Need to implement solutions to address the near-field problem, namely by improving the assessment of the earthquake focal mechanism;
- Warning messages in the future should include enhanced products and understandable information on uncertainties about risk estimation.

Link to Society

- Need to educate uncertainties to end-users. Tsunami risk must be part of multi-risk studies offered to civil defense and coastal authorities;
- In line with the Sendai Framework for Disaster Risk Reduction, promote a strong cooperation between Tsunami Service Providers and meteorological/oceanographic communities;
- Need to increase public awareness by public participation measures.



For FIND SMART APP Go to play store or contact:lmcarrico@fc.ul.pt
http://accessible-serv.lasige.di.fc.ul.pt/~find/)

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The Challenge

Tsunamis are 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. Seven years later, and in spite of some of the best warning technologies and levels 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 experience from Japan raised serious questions on how to improve the resilience of coastal communities, to upgrade the performance of coastal defences, to adopt a better risk management, and also on the strategies and priorities for the reconstruction of damaged coastal areas. Societal resilience requires the reinforcement of capabilities to manage and reduce risk at national and local scales.

ASTARTE completed…

A general assessment of potential tsunami sources (seismic and nonseismic) in the NEAM Region, including uncertainty treatment, and tsunami sensitivity to source parameter values. These results show that:

- An important percentage of submarine earthquakes may be tsunamigenic (i.e., 70% for magnitudes greater than 8.0, 25% for magnitudes greater than 7, and 7% for magnitudes greater than 6.0);
- Large earthquakes in oceanic transpressive fault zones can generate tsunamis (i.e., Gorringe Bank and the thrust systems of the Gulf of Cadiz in the NE Atlantic and the fault system along the Algerian coastline and continental margin);
- Results off Algeria In the Mediterranean Sea indicate clustering and ciclicity for large earthquakes and related tsunamis with recurrence intervals as short as 50 years and periods of quiescence that may last for several centuries;
- Major historical earthquakes (last 700 years) led to offshore mass transport deposits, which are valuable proxies for pre-instrumental seismicity eventually leading to tsunamis;
- Submarine volcanic eruptions and associated instability processes in the Canary Islands and in other volcanic settings in Europe may contribute to tsunami generation, especially if there is explosiveness in shallow water and magma injection pushing unbutressed island flanks seaward;
- The need to consider an independent Alboran micro-plate in the Africa Eurasia configuration.