Intergovernmental Oceanographic Commission
Technical Series

73

Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and Connected Seas, NEAMTWS

Implementation Plan

Version 3.3
October 2008

UNESCO

Intergovernmental Oceanographic Commission
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UNESCO 2007

IOC Technical Series, 73
Paris, June 2007
English only*

For bibliographic purposes, this document should be cited as follows:
North-East Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System, NEAMTWS, Implementation Plan (Third Session of the Intergovernmental Coordination Group for the North-East Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System, NEAMTWS),
IOC Technical Series No. 73. UNESCO 2007. (Electronic copy, English only)

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Electronic version
by the United Nations Educational, Scientific and Cultural Organization
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EXECUTIVE SUMMARY

This Implementation Plan for the North-East Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System (NEAMTWS) specifies detailed requirements of the design and implementation of the tsunami warning and mitigation system for the North-East Atlantic, the Mediterranean and Connected Seas. As these are developing and therefore still are subject to changes or modifications, and as the implementation will progress, this Implementation Plan is a dynamic document. In constant use and development, it will only represent the status of the system at a specific time of viewing. As a living document it will be available on the Intergovernmental Oceanographic Commission (IOC) web site and subsequent versions will be distributed at Intergovernmental Coordination Group (ICG)/NEAMTWS meetings.

The Implementation Plan is structured to reflect the ICG and its Working Groups, WG 1 (Hazard Assessment, Risk and Modelling), WG 2 (Seismic and Geophysical Measurements), WG 3 (Sea Level Data Collection and Exchange, including Offshore Tsunami Detection and Instruments), and WG 4 (Advisory, Mitigation and Public Awareness).
After a status summary, details are condensed in Action Plans for all components of the system. Capacity building is explicitly addressed to highlight the importance of training and extend the basis of the people involved in operating the system at all levels. Reflecting the work as its progresses there are parts that are not yet as detailed as required.

The Implementation Plan is only one of the documents that describe the NEAMTWS and help in managing it. Others are, or will be available.

The NEAMTWS is a complex operation owned and operated by Member States through their designated agencies. Besides the national functions these agencies serve as conduits for information within the system that is amongst all participating partners. These are further augmented into international, mostly regional, functions that serve an agreed regional ensemble of member states. These functions need particular attention for the system to perform as a whole.

The performance of the NEAMTWS depends on the implementation of all its components, their sustained operation and the adherence to agreed common principles of operation, interaction and data policy. This performance needs to be monitored in order to improve the NEAMTWS, identify deficiencies and suggest remedial action. A real test of the NEAMTWS may never, or rarely happen. But it will then highlight the credibility of the system and all its participating partners. The public will only judge the performance or the success of the system from the impact, the loss of lives and the damages that occurred.

The timely and appropriate implementation of the NEAMTWS is crucial to its success. Recent events have shown that time to prepare, implement and train is short as the events are unpredictable. In its implementation priorities, requirements and details will change or have to be adapted. Member States are therefore asked to prioritize details they feel need special attention on both the national and international level. They also are invited to provide guidance as to further developing governance mechanisms for the NEAMTWS.

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1. INTRODUCTION

The current version of the Implementation Plan (IP) for the North-East Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System (NEAMTWS) contains the specifications of the requirements for designing and establishing the system for tsunami early warning and mitigation in the Euro-Mediterranean region.

In accordance with the resolution adopted in the first session of the ICG NEAMTWS held in Rome, 21-22 November 2005, and later confirmed in the second session held in Nice, 22-24 May 2006, the implementation of this TWS is foreseen to be realized in two main temporal phases, the first of which will lead to a initial TWS in place in the region within the end of 2007. The completion of the system will be realised in the second implementation phase that in the present document is assumed to take the following four years, posing therefore the goal of establishing an effective TWS by the end of 2011.

It is to be noticed that the implementation of the TWS is a complex operation involving the Member States through their agencies and institutions as well as international organizations and local communities. This complexity implies that changes and on-way corrections are to be put into account for this Implementation Plan in the course of the realization of the system, since implementation priorities, requirements or details may have to be adapted to new circumstances. Hence, the Implementation Plan will be at the same time a reference document, providing guidelines, and a dynamic document, reflecting the current status of the TWS implementation at a given time. Updated versions of the Implementation Plan will be maintained at the Intergovernmental Oceanographic Commission (IOC) web site and distributed at ICG/NEAMTWS sessions.

This IP incorporates the work and views of the ICG and of the sessional and inter-sessional WGs, namely of the WG 1 (Hazard Assessment, Risk and Modelling), of the WG 2 (Seismic and Geophysical Measurements), of the WG 3 (Sea Level Data Collection and Exchange, including Offshore Tsunami Detection and Instruments), and of the WG 4 (Advisory, Mitigation and Public Awareness).

As for the TWS in the other oceans, the performance of the NEAMTWS depends on the implementation of all its components, which is however only one aspect of the problem. Beyond the implementation, it depends upon the capacity of all involved to maintain the system operational at any time over the long term, since it has to deal with events that are rare, but that may have large and catastrophic impacts.

As recommended by Recommendation ICG/NEAMTWS-III.1 on Development and Implementation of the NEAMTWS, adopted at the Third Session of the ICG/NEAMTWS (Bonn, 7-9 February 2007), the operation of the NEAMTWS activities will be based on IOC Resolution XXII-6 on the IOC Oceanographic Data Exchange Policy,[1] adopted by the IOC-22 in 2003, the IOC Sea Level Manual,[2] and the IASPEI Seismological Observation Manual.[3]

[1] The IOC Oceanographic Data Exchange Policy stipulates that "[t]he timely, free and unrestricted international exchange of oceanographic data is essential for the efficient acquisition, integration and use of ocean observations gathered by the countries of the world for a wide variety of purposes including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible."
[2] IOC, Manual on Sea Level Measurement and Interpretation; Volume IV: An Update to 2006 IOC Manuals and Guides 14, Paris, UNESCO, 2006.
[3] IASPEI, New Manual of Seismological Observatory Practice (NMSOP), GeoForschungsZentrum Potsdam, 2002.

2. ACTION PLANS

This section describes actions needed to develop and maintain different components of an end-to-end tsunami warning and mitigation system for the North-East Atlantic, the Mediterranean and Connected Seas region for a 15-year planning horizon. Action plans represent a consolidation of planned, ongoing, and proposed actions based on working group outputs of the ICG/NEAMTWS and work plans of ongoing national and international programs in the region. These action plans are intended to provide a framework to periodically update and monitor status at a regional level. At present, long-term actions have not been specifically identified beyond the year 2011.

Among the regions that are covered by the ICGs established by the IOC, the NEAM region is at present the only one where at least an interim tsunami warning system is not in place, which shows how urgent it is for the ICG/NEAMTWS to make any efforts to establish a first nucleus of this TWS as soon as possible. Indeed, the Pacific Ocean is covered since mid ’60s by a system that is now called PTWS, the Indian Ocean was covered since a few months after the 2004 tsunami by Interim Coverage provided by the Japan Meteorological Agency (JMA) and by the Pacific Tsunami Warning Centre (PTWC), and the Caribbean region is ad interim covered by the PTWC. The main accomplishment of such initiatives is that the performance of the established systems is such that a large-scale tsunami occurring today in these regions is not expected to pass undetected and with no-warning issued to the population, and that disasters like the one of December 26, 2004, mainly due to lack of warning and knowledge, are not expected to be repeated. This at present is not available for the NEAM region, where it cannot be ruled out that a basin-wide tsunami may occur and hit population at the coasts before some form of warning can usefully be launched and before people have time to run to safer places away from the waves.

2.1. THE TWO-PHASE IMPLEMENTATION PROCESS

The key-point of the Implementation Plan is that the TWS will be implemented in a two-phase process with the objective of establishing the first core of the TWS in the NEAM region within 2007 – the initial phase. The second phase will be completed in the following 4-year period, that is within the 2011. All the Action Plans described here will be conceived according to the above two-phase structure.

The core TWS will be hereafter denoted as Initial TWS (ITWS). The main target of the ITWS is that of handling large-scale tsunamis, that is tsunamis that have a basin-wide propagation potential and can be destructive far from their source. Such tsunamis can occur in the NEAM region as is documented in the historical tsunami catalogues or as can be deduced by studying the regional tectonics. Examples of such occurrences are among others the 365 AD and the 1303 AD tsunamis with origin in the Hellenic Arc subduction zone, that affected the eastern and central Mediterranean sea, and the 1755 tsunami that occurred in the Atlantic Ocean off the Iberian peninsula and Morocco and that, travelling across the ocean, reached the north Europe countries, within the NEAM region, and the Caribbean sea islands outside our region. The objective is that the designed ITWS be effective in launching early warning messages to all population on the coasts that are far from the sources, where here by “far” one means those coastal segments that will be hit by the tsunami later than 30 minutes from the onset time.

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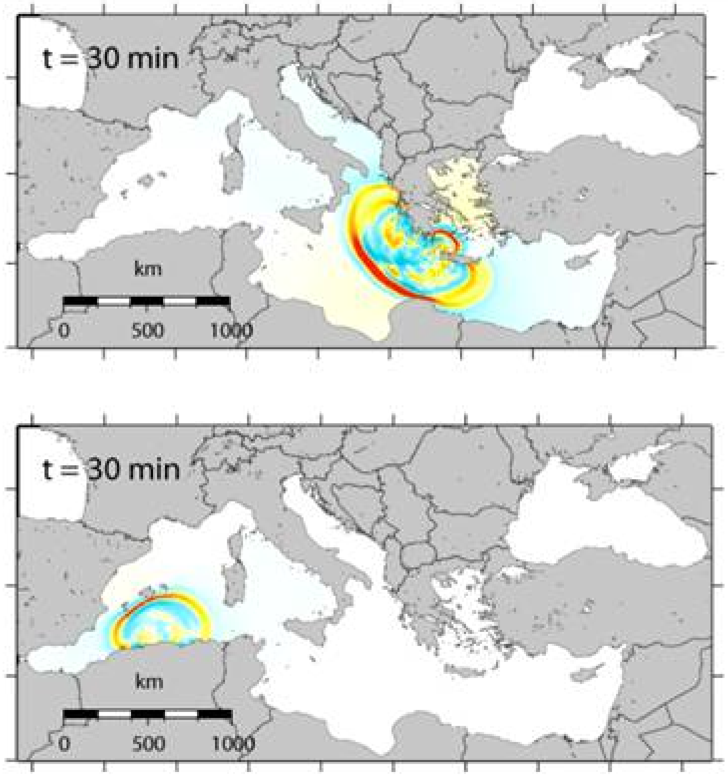

Figure 2-1. Tsunami fronts after 30 min propagation time from a source placed in the western Hellenic arc (above) and in north Algeria (below)

With the aid of the illustrative examples of Figure 2-1 giving the tsunami fronts calculated from two hypothetical earthquake sources placed in the western Hellenic Arc in Greek waters and in north Algeria, it may be seen that in the former case the ITWS would be effective to protect most of the Greek coasts of the Aegean sea, and for all other countries of the NEAM region, while in the latter case it would be effective for coasts of east and west Algeria as well as in the rest of the NEAM area. It has to be stressed that due to the limited area extension of the Mediterranean basin compared to the world's oceans and the vicinity of tsunamigenic source zones in the NE Atlantic to e.g. the Portuguese coastline, the propagation time of tsunamis is much less than the corresponding time in other Oceans, which poses some strong time constraints that even the initial TWS has to fulfil.

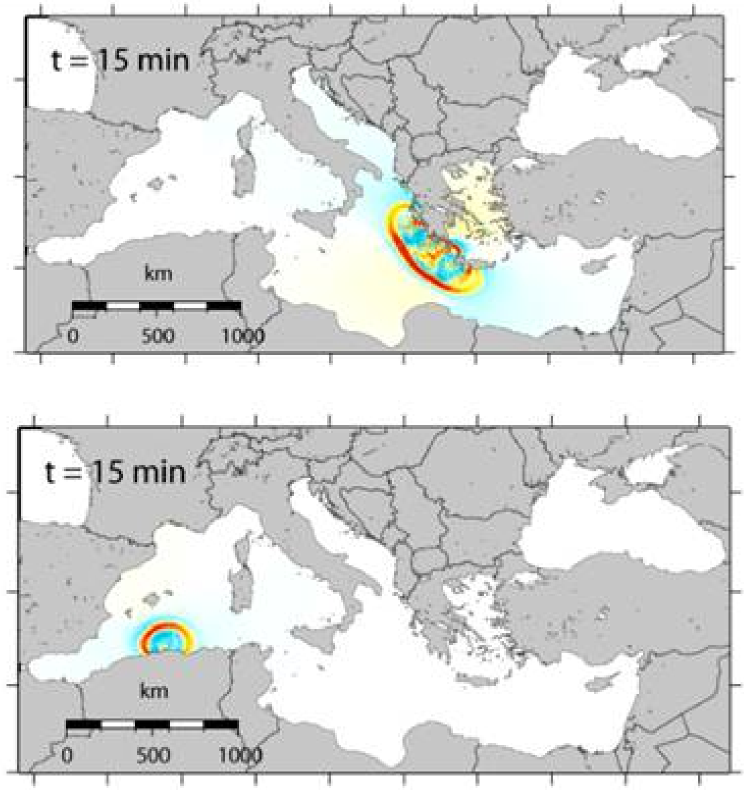

Figure 2-2. Tsunami fronts after 15 min propagation time from a source placed in the western Hellenic arc (above) and in north Algeria (below).

At the completion of the second phase, the fully-developed Early Warning System, will cover both distant and local tsunamis, as well as other marine physical hazards, including storm surges and extreme wind-forced waves. In terms of time elapsed from a tsunami generation, the target would be to launch warnings at most after 10 minutes from tsunami initiation wherever the location of the tsunami source be placed in the NEAM region. This upper limit does not exclude that in some areas local TWSs be effective in less time, if proper resources are employed and proper plans are implemented. Technology is today available to meet this requirement as is proven by the current practice of Japan Meteorological Agency's TWS that reduces the first alarm time usually down to 5 minutes for local tsunamis hitting the Japanese coasts. Figure 2-2 shows the 15 min propagation fronts of tsunamis for the same sources in Greece and Algeria used in the examples given before.

2.2. THE OCEAN BASIN GEOMETRY IN THE NEAM REGION

The sea basins included in the NEAM region are all interconnected, but they can hardly be involved altogether by the same tsunami or other coastal inundation hazard event, irrespective of its size. This applies to tsunamis occurring in basins that are almost closed, like tsunamis due to rock falls in the Norwegian fjords, tsunamis caused by earthquakes or landslides in the Corinth Gulf, Greece, or tsunamis generated in the Marmara sea that lose very little energy through the Dardanelles and Bosporus straits, as well as even extensive submarine landslides e.g. off the Eastern Atlantic continental shelf that may trigger huge and energy rich tsunamis.

So straits like the Bosporus form an obstacle difficult to overcome for all tsunamis that occur in the Black Sea, that cannot penetrate in the next Marmara Sea. Likewise, the Gibraltar straits are a natural barrier for tsunamis generated in the Atlantic Ocean (see the 1755 case) that attenuate strongly while crossing this strait as well as for tsunamis produced in the Mediterranean Sea. The same is true for tsunamis across the Messina straits, Italy, that divides the Tyrrhenian sea from the Ionian sea. In addition, one may identify other less effective barriers preventing the free propagation of tsunamis, such as the broad and relatively shallow Sicily channel between eastern and western Mediterranean. One possible implication of such basin configuration leading to a sort of domain partition as regards tsunami propagation is that the TWS in the NEAM region may be architecturally conceived as a set of distinct TWSs with distinct sub-regional responsibilities, though with common concepts and practices and common coordination. To make the example concrete, one can consider the case of a tsunami generated in the Gulf of Corinth, Greece, that is known to be a highly active tectonic region with substantial tsunamigenic potential. The Gulf belongs entirely to Greece, and due to its configuration (narrow and elongated east-west) tsunamis generated on the south coast reach the northern coasts in less than five minutes, and take about 30 minutes to travel all along from east to west. This means that the initial TWS as described in section 2-1 could be of little use in this basin, and that even the TWS could have an unsatisfactory performance. To reach the goal of launching timely early warnings and of saving human lives, it may be necessary to implement a local TWS with a dense monitoring network and a very short tsunami detection time.

In the North-east Atlantic and the Baltic other types of hazards are affecting coastal zones. In Europe, almost 100,000 km^2 lie below a 5 m elevation above sea level, half of which are located less than 10 km from the sea, which is commonly used to define the coastal zone. Sea level rise and other climatic impacts and flooding resulting from marine storms and high waves expose several European countries to marine hazards: 85% of the coastal zone of Netherlands and Belgium is under a 5 m elevation while 50% of coastal zone in Germany and Romania fall in that category. The percentages for Poland are 30 %, Denmark (22 %), France, the United Kingdom, and Estonia (10–15 %), see figures 2-3/2-4. These problems are less relevant in the Mediterranean, where, however, significant hot spots can be found (e.g. Venice). The likelihood of severe storm surges— surge heights with 50-year extremes of up to 3 m above the mean high tide level—make the coastlines of the southern North Sea and of the eastern Baltic Sea very vulnerable to flooding. To reduce exposure to marine hazards, defence systems need to be complemented by monitoring, detection and forecasting systems, better spatial planning, procedures for the safety of the population and disaster management. On the other hand, problems associated with potential sea level rise can be particularly significant in low-lying, highly-populated areas of the Mediterranean, such as the Nile delta (Figure 2-5), including decline in water quality that would affect freshwater fish, the flooding of agricultural land and damage to infrastructure.

Taking also in consideration the long term sustainability of an Early Warning System, it is desirable that Tsunamis should be included in a multi-hazard mitigation strategy.

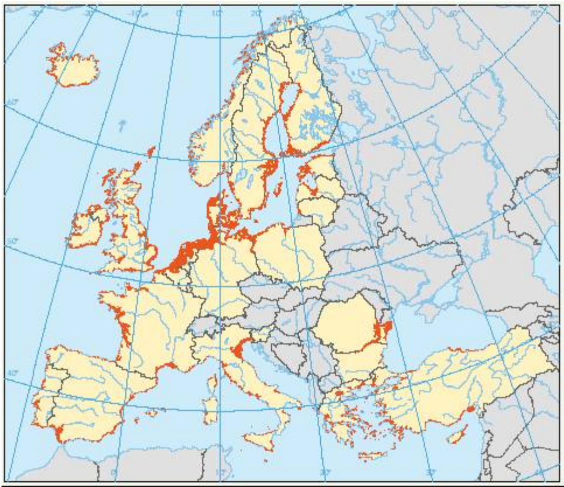

Figure 2-3. European low-lying (below 5 m) coastal zones (EEA 2005/2006)

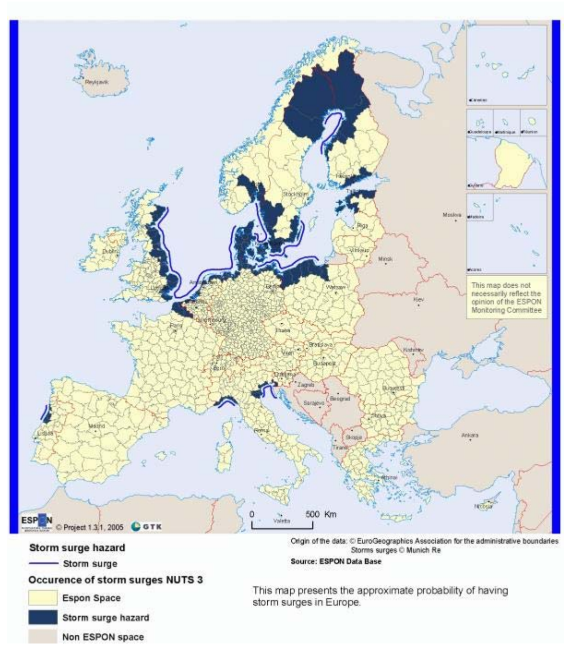

Figure 2-4. Storm surge hazard zones in Europe (ESPON 2006)

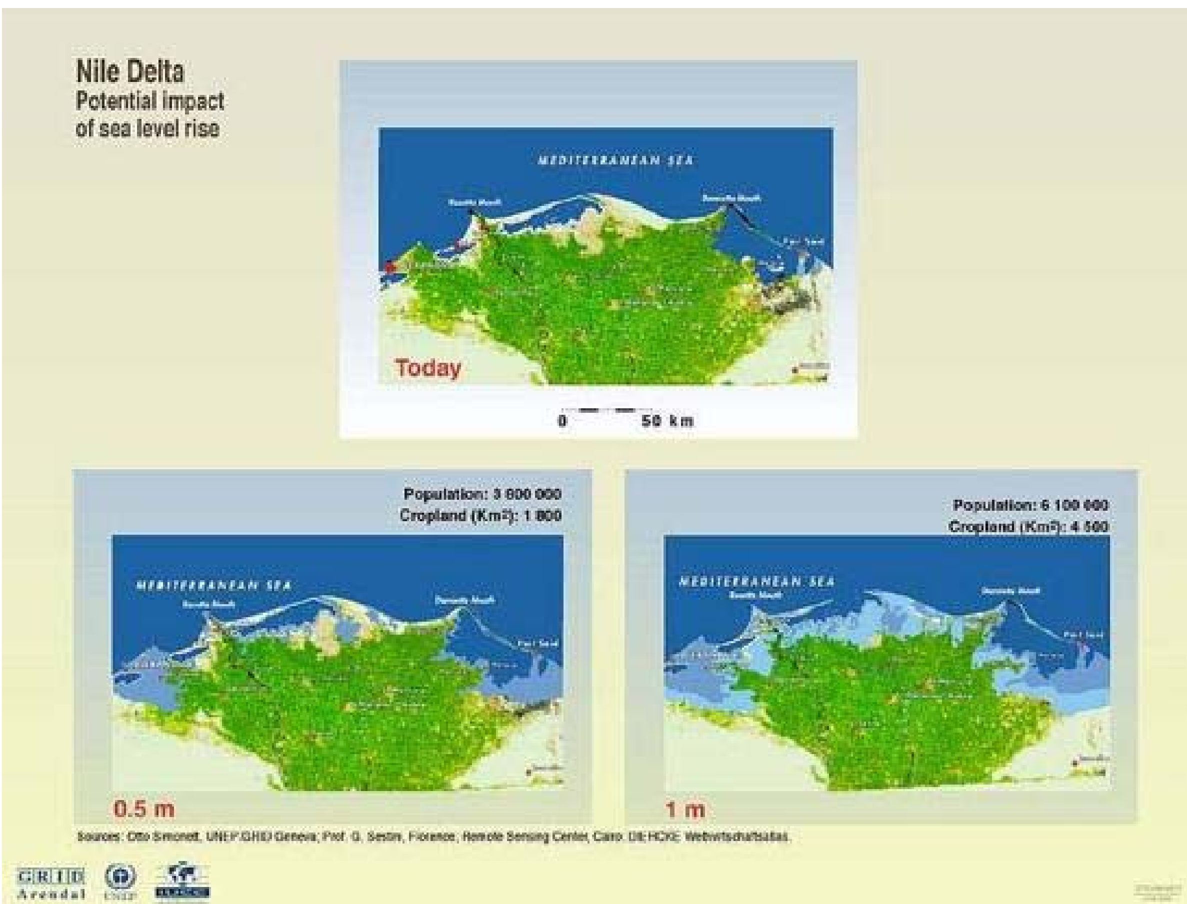

Figure 2-5. Potential impact of sea level rise on the Nile Delta (UNEP/GRID-Arendal 2002)

2.3. SEISMIC AND NON-SEISMIC TSUNAMI SOURCES

Tsunamis in the NEAM region as well as in the other oceans are mainly due to submarine earthquake dislocations, but they can be also caused by slides, submarine and subaerial, by volcanic activity resulting in explosive eruptions or in mass failures for coastal or island volcanoes, and by atmospheric disturbances, such as sudden air pressure impulses leading to the so-called meteorological tsunamis. It is also known that when sources are located in coastal regions, multiple tsunami sources can be activated, since for instance earthquakes may trigger landslides that in turn can originate tsunamis. The TWSs today in place (PTWS) or in course of implementation (IOTWS) are tailored to detect seismic sources with direct tsunamigenic potential and do not handle non-seismic tsunamigenic sources. Likewise, it is observed that the initial TWS is currently designed to cope only with seismic tsunamigenic sources. Since implementing a TWS dealing with tsunamigenic landslides, volcanic eruptions and meteorological disturbances requires additional efforts in terms of research and technological advancement, the incorporation of these events in the TWS operation will be left as an issue to be discussed for the second phase of the NEAMTWS implementation.

2.4. HAZARD AND RISK ASSESSMENT AND MODELLING

Hazard and risk assessment for tsunamis and other coastal hazards is a key element of any TWS. These are mainly characterized on the basis of documentation of historical events and impacts, of the geological and geophysical knowledge of the sources and of their dynamics, of tsunami generation, propagation and inundation modelling, and of the exploration of an expected range of scenarios. A key issue for establishing the tsunamigenic potential of an earthquake is the relationship between the earthquake source parameter (mainly epicentre, focal depth and size in terms of magnitude or seismic moment) and the expected tsunami size. This knowledge is crucial since it provides the basis to build the TWS decision matrix, namely the matrix that is used in the TWS operations to evaluate the size of the potential tsunami and to respond with the appropriate action. Auxiliary data sets required for a proper analysis of hazard are the tectonic setting of the region, inclusive long-term and short-term deformation pattern of the plates, the distribution of the major active seismic faults, the historical seismicity in the coastal zones and offshore. Further data include update bathymetry in the open sea and detailed bathymetry in the coastal belt, especially in the shallow-water zone with depth less than 100 m up to the coastline, where tsunami interaction with sea bottom becomes quite complex and non-linear wave behaviour may prevail. In addition, topographic data at the coast in terms of digital terrain or elevation models are required.

Analysis of vulnerability and of risk implies collection of data on a number of parameters and components such as coastal geomorphology, soil conditions and exposure, infrastructures, port facilities, tourist resorts, industrial plants, as well as population demographics and land-use designations. WG4 will ensure that guidelines for mainstreaming consideration of tsunamis and other marine-related hazards are developed through ICAM plans and programmes. Geographical Information Systems (GIS) are powerful and versatile tools to display these multi-disciplinary data sets in a way easy to use and to comprehend. The results of hazard, vulnerability and risk assessment serve as a basis for decision support mechanisms and to identify and implement appropriate mitigation measures to reduce the vulnerability of coastal communities.

Seismic catalogues are available in the area for most countries and on a regional and a global basis. Tsunami catalogues were gathered, but they need refinement and update. Tsunami records are rare and concern a minority of events. Run-up heights are available only for some events, while mostly observations and qualitative descriptions allow for tsunami intensity estimations. Little work has been done to extend the record of historic and prehistoric tsunamis through the study of tsunami sediment deposits or signatures.

There are few examples of tsunami hazard assessment in the NEAM region. Even less numerous are the studies carried out on vulnerability and risk, and apply only to limited areas of special interest (for urban settlements or industrial plants) with specific needs.

Table 2-1. Action Plan for hazard and risk assessment modelling

Task/Action	***Timeline***	***Responsibility***	***Required Budget****	***Status***
Compilation of Data Base	April 2007 2009 2011	Contribute : MS Greece Italy France		INEAMTC Review TRANSFER Review 2
Decision Matrix to classify local, regional and basin tsunamis (criteria in magnitude, depth, focal mechanism)	NEAMTWS-IV	Greece Italy, Portugal, Spain France		Details provided in chapter 2
Research on seismic sources 365 1693 1856 (2 events)	2009	Greece Italy		C
Compilation of references and Data Base; Stromboli, Vulcano Izmit 1999, Corinth Gulf 1963, 1956 Balearic Islands, Canary	NEAMTWS-IV	Italy Greece Spain		C
List of island, submarine and coastal volcanoes in activity, with their characteristics of activity (effusive, explosive, etc.)	NEAMTWS-IV	Italy, Greece Spain, Portugal		C
Model review and collection				
Design template for questionnaire and distribution		Spain / Germany		C
Model collection and assessment of documentation		Whole community /National Representatives		C
Define a standard output (kinds of data) for a model for the NEAMTWS system – proposal for next meeting	NEAMTWS-IV	Germany		
Input data requirements				
Provision of data of the historical seismic and tsunami events (seismic parameters, topo-bathymetry, sea level data, run-up....) Portugal 1755, Messina 1908, Greece 1956, Izmit 1999, Algeria – Balearic 2003	NEAMTWS-IV 2011	WG3 (Sea level) Portugal, Italy, Greece, Turkey, France, Algeria, Spain		Seismic parameters for Izmit 1999, Algeria 2003. Several sources are supposed for the other

Task/Action	Timeline	Responsibility	Required Budget*	Status
				events. Spain (Balearic)
Credible scenario for all other areas	2010	Member States TRANSFER		Seismo-tectonic Studies will be performed
Inventory of available bathymetries (emphasis on shallow water < 100 m)	NEAMTWS-IV	Contribution : MS IOC – IHO		MS must complete 2 maps
Inventory of available topographies and land usage maps	2009	Member states		
Make topo-bathymetric data available	NEAMTWS-IV	National Authorities/National representatives		NEAMTWS-IV
Model simulation				
Benchmarks case computation	NEAMTWS-IV			Lisbon 1755 Messina 1908
Sensitivity analysis	2009	TRANSFER		
Tsunami source and hazard assessment (examples, priority regions, etc.)	2009	TRANSFER Member States		
Define tidal gages locations (based on model sensitivity)	NEAMTWS-III			C
Provision of Impact and damages input for data base Portugal 1755, Messina 1908 Greece 1956, Izmit 1999 Algeria – Balearic 2003	April 2007	Contribution . Member States Italy		Initial report NEAMTC
Methodology of coastal vulnerability assessment		A. Cavalletti (Italy)		*Doc* available WG4 will take that issue into account

Status: P – Planned, C – Completed, O – Ongoing

*Note: These actions will require no additional budget or they are either being planned within existing project budgets.

2.5. SEISMIC AND GEOPHYSICAL MEASUREMENTS

Existing seismic networks in the NEAM region are unequally distributed with much denser networks in European countries than in northern Africa and Middle East countries. Short-period, long-period and broad-band digital seismic stations, operated by national agencies and university institutions cover most of the seismogenic zones on land and off-shore, with network resolution and detection capability much better for on-land sources than for submarine ones. An inventory of the existing stations and of their capability to meet the requirement for the NEAMTWS in terms of data quality and of real-time transmission capability has shown that the overall coverage of the tsunamigenic seismic zones strongly inhomogeneous with the most crucial gap in the northern Africa countries either due to lack of stations or due to data unavailability.

A subset of existing stations has been selected to be part of the ITWS and a larger subset to form the backbone of the TWS. The selected stations will provide essential data relevant to monitoring and detecting earthquakes with potential for tsunami genesis. Selection was made considering the network configuration, the reliability of the stations in terms of performance and of how long they have been in operation, and the availability of the data. In areas, such as northern Africa, where the station density was considered inappropriate to fulfil the requirements for the TWS, new site locations have been proposed. In those countries where stations exist, but data are not made available for some reasons (e.g. off-line stations, non-public real-time stations), any efforts should be made by the ICG and the IOC to promote effective data-exchange policies and to extend the detection capability of the TWS by reinforcing the international co-operation in view of the common goal of protecting the coasts of all the countries of the NEAM region. A map of the core network suitable for the TWS in the NEAM region with existing and required broad-band stations was provided by WG 2 and is displayed in Figure 2-6. In a next step, North American stations have to be added to properly locate events in the NE Atlantic. Also, for computation of moment tensor or slip distribution from teleseismic data, some more distant stations should be used.

Earthquake detection may be improved by deployment of OBS or sea-floor platforms with multi-parameter acquisition capabilities that can provide real-time waveforms if proper connections (e.g. submarine cable) with on-land acquisition centres are established. Examples come from Italy (SN-1 installed off eastern Sicily and off Naples) and from France (installation off Toulon, southern France). Systematic implementation in the context of the TWS requires a higher flexibility to cover large marine areas, where no cable connections are available.

Rapid determination of focal parameters (mainly location, focal depth and magnitude) is an essential issue of the TWS, and depends upon real-time availability of high-quality, broad-band seismic waveform data and on computational algorithms. A delay of even a minute in data transmission may reflect in a detection delay and consequently in delayed dissemination of earthquake information which may result in increased casualties from earthquake and from tsunami. Earthquake location and magnitude need to be determined within 2 to 3 minutes of the earthquake, which seems to be feasible with the today technology. Different new quick magnitude determination algorithms have been implemented or are under test by different organisations, such as GEOFON and INGV, and some of them (e.g. mBc and MED) seem to be very promising to meet the accuracy and time requirements of the TWS, though further research and test is needed for their validation. Strong motion sensors such as accelerometers as well as GPS stations are needed for areas that are close to the tsunamigenic sources, i.e. within 30-minute tsunami travel time, to improve detection capability of the TWS.

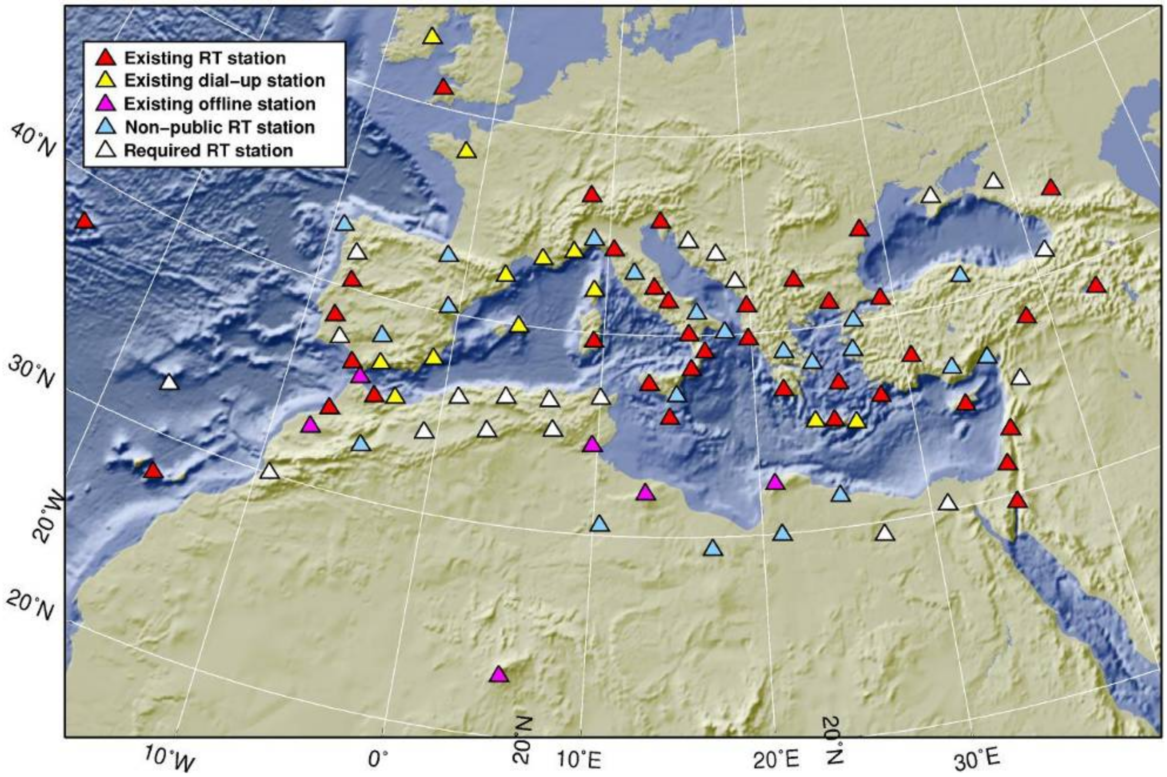

Figure 2-6 Backbone seismic network envisaged for the NEAMTWS

Table 2-2. Action Plan for Seismic Monitoring (1 Notes: – Status: P – Planned, C – Completed, O – Ongoing)

Task	***Timeline***	***Responsible***	***Required Budget***	***Status***
Networks inventory and check of real time data availability: invite countries contributing to the backbone	Sept. 06	France	none	O
Define backbone network of real-time BB stations - priority: North-Africa	Nov. 06	Germany	none	O
Possible implementation of data exchange through internet or other links	June 07	France	Limited funding available (EERWEM)	P
Any additional seismological real-time data available will be considered	ongoing	All WG members	none	O
Exploring possibilities and “best practice” for earthquake location and magnitude determination	January 07	Italy, France, Germany	none	P
Technical scheme for the VSAT backbone and required budget	January 07	Germany	none	O
Description and demonstrations of near real-time OBS	January 07	France, Italy, Turkey	none	O

Real time data transmission is the only viable means to sustain TWS operations. Satellite connections, namely VSAT (Very Small Aperture Terminal) data link seem to be the most adequate ones for the TWS, though other types of link can be used according to circumstances. Free (or leased) connections through Internet can be accepted in a first step of development of the TWS. Some of the stations presently used for rapid earthquake locations and magnitudes in the NEAM region have public Internet links and show good performance, with latencies compatible with the TWS. At national level, dedicated telephone lines are broadly and efficiently used for real time data transmission (as in Italy for instance). These connections are more expensive than VSAT, but have very low latency and are robust. As regards VSAT, this is proposed to be the backbone communication system for both the ITWS and the TWS. Experience in seismic data transmission via VSAT has been gained through operational practice by national agencies and institutions operating the national seismic networks, such as INGV that has presently about 120 BB real-time stations in operation in Italy and in surrounding countries. Also useful is the experience gained by European countries from their involvement in designing and implementing TWS in other areas outside the NEAM region, such as Germany being active in the Indian Ocean TWS through the project GITEWS (Germany-Indonesia Tsunami Early Warning System).

Goals of the NEAMTWS seismic monitoring network are that the backbone network stations have data latency values less than 20 seconds, that all earthquakes in the region with magnitude 6 or greater can be accurately located and quantified, that the time required for the determination of the focal parameters relevant to the TWS be confined to 10-15 minutes for the ITWS and reduce down to less than 5 minutes for the TWS.

2.6. SEA LEVEL MONITORING

Real time sea-level data are basic components of tsunami and storm surge warning systems. They are used first of all as a validation tool, that is to confirm that a major tsunami was generated by an earthquake or, on the contrary, to cancel alert messages in case of no tsunami observations. Traditionally, such observations are carried out through tide gauges typically placed in harbours, and through pressure gauges on the sea floor deployed offshore far from the coast. Tide-gauge stations are operated in the NEAM region by a number of national agencies and of research institutions that usually process their own data. Data transmission and exchange in real-time with the characteristics required by the TWS are rarely met.

There is a recognised need to establish new standards to enhance sea-level stations to operate in real-time, with higher frequency sampling rates (possibly in the range of 30-60 sec or less). There is an immediate need for specific gauges to become fully operational for the initial TWS. All other required sea-level gauges must be fully operational in the medium term. A possible list of sea-level gauges as proposed by the WG3 is displayed in the map of Figure 2-7. To complement the system, denser networks are required in the areas of the NEAM region that are close to the tsunamigenic zones and may be hit by dangerous waves soon after the earthquake occurrence. Network densification is a task to be designed in the initial phase and accomplished in the second phase of the TWS implementation.

Offshore buoys are considered useful to record tsunami as they travel in the open ocean; the tsunami signals are not affected by the amplification and other interactions known to take place in coastal areas. They can intercept the tsunami along its propagation path to distant coasts and their records can be used, in conjunction with modelling tools, for forecast purposes, as has been shown by recent cases of tsunamis in the Pacific Ocean. Usually they are installed on the open sea-side in positions between the tsunami sources and the distant coasts. Examples of installation in the NEAM region are related to test experiments. Experience gained in the Pacific Ocean and in the Indian Ocean, where such instruments have been deployed, and used in TWS operations by European countries (see f.i. the GITEWS project) can be usefully transferred to the NEAM region to integrate the tide-gauge sea-level network, especially in view of recording major basin-wide tsunamis.

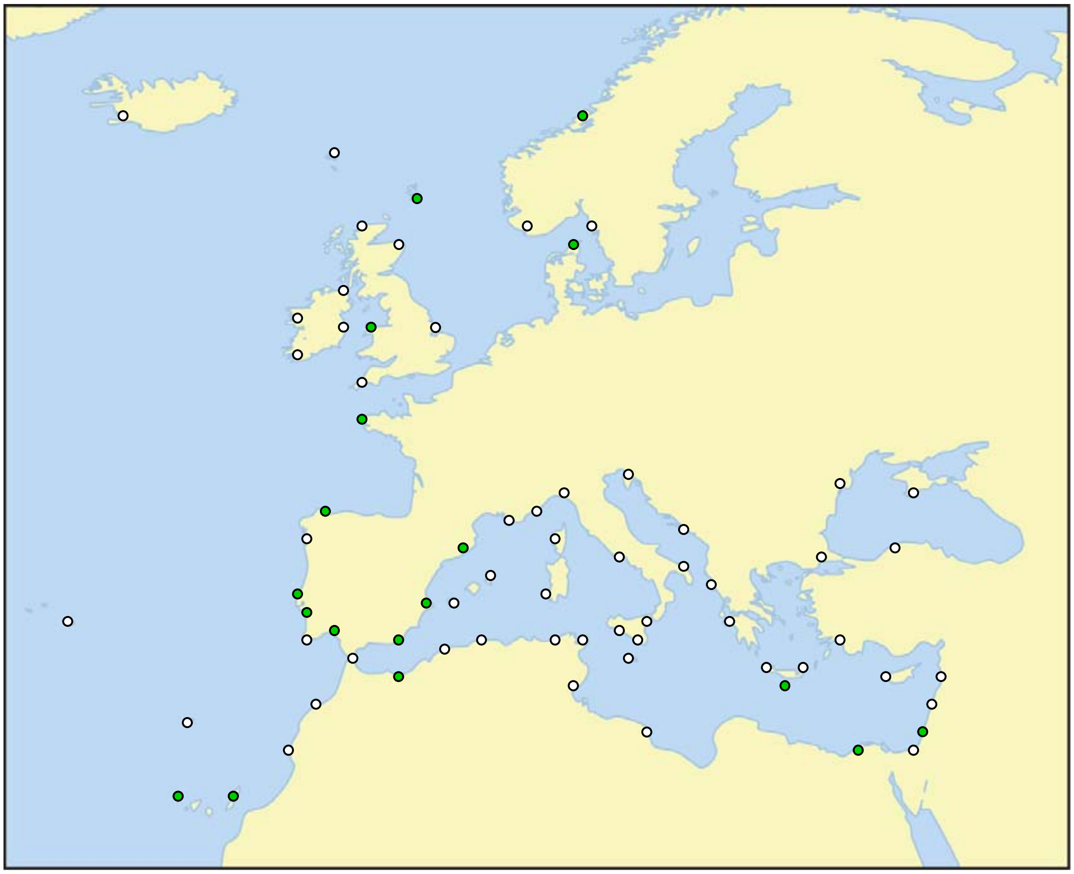

Figure 2-7. Final regional network of coastal sea level stations to be part of the system agreed upon during the ICG/NEAMTWS IV meeting in Lisbon (November 2007) and actual status (October 2008). Green dots correspond to the ones which are already available to become part of the system.

A densified GLOSS network may give relevant contributions to the TWS sea-level monitoring systems, and also considered valuable is the collaboration with existing bodies active in the coordination of offshore observation networks mostly for operational oceanography, such as MedGOOS and BOOS and NOOS (regional components of GOOS in the Euro-Mediterranean region). Other projects such a SLEAC (Sea Level Along European and Atlantic Coast-line) will provide real-time enhancement.

Reliable and efficient data transmission links should be used for the real time systems. Secure and redundant transfer of data from the instrument to the operators should be guaranteed to ensure that communication links remain operational after earthquakes, floods, etc. Advantage should be taken of existing and evolving systems. This is especially the case of WMO GTS, that the WMO even has offered to upgrade to take account of the requirements of the system, and others such as IP networks, satellite communications, VPN internet, etc. There is a need to communicate such requirements to telecommunications standards development organizations such as ITU. Standards on data format and data transmission protocols should be adopted from already existing systems (ex. XML, GTS).

Rapid detection of tsunamis in the records of the sea-level sensors is essential to validate tsunami occurrence. Time constraints are very demanding in the NEAM region where tsunami travel times are short and even more demanding than for seismic detection algorithms, since normally the time available between the tsunami arrival at the sea-level gauges and the tsunami attack on the coasts is less (or considerably less) than the corresponding time available for the assessment of earthquake parameters.

Working Group 3 (Sea level data collection and Exchange, including offshore tsunami detection instruments) has the following Terms of Reference: “The working group will be responsible for defining, based on existing organizations and functions, a transnational sea-level observing network, based on both coastal and offshore instrumentation, that can be integrated in an early warning tsunami detection system, as well as for providing recommendations on the data processing and analysis, provide a list of possible sea-level stations for the ITWS, report on status and needs of upgrade, and final requirements on priority of site”.

A large number of heterogeneous tide gauges exist in the region, and an increasing number have some automatic data transmission system for less demanding warning systems, such as the storm surge forecasts. Nevertheless, we are far away from having this information from the North African countries, something that has been tried during the last years within GLOSS and MedGLOSS networks. A complete survey on the status on data transmission was initiated by ESEAS (European Sea Level Service) and is now being completed within the TRANSFER project. The use of existing infrastructure, whenever possible, is the basis for the selection of stations, taking into account the need to convince national governments and institutions that no large extra funding would be needed.

This first task of the working group aimed to establish the starting point for the implementation of a sea level network for the initial tsunami warning system, to be operational in December 2007. This was a very short time, taking into account that there were no sea-level stations in Europe which completely fulfil the requirements of a TWS before that year. So, mainly focusing first on those sea-level stations with some kind of automatic data transmission (near real time), an initial set was defined, considering in principle those with better conditions to be upgraded in the near future, and following the recommendations of WG1 about optimal location. The next step was asking the institutions in charge of the selected stations about the actual status, plans of upgrading and availability of data, as well as their agreement with the selection. A detailed review of the status of the stations proposed by WG3 following national breakdown can be seen in Annex A.

WG3 regional goal for the implementation of stations

An initial prototype system based on a minimum number of sea level stations, meeting the established requirements and standards, was intended to be operational by December 2007: this minimum number will be based both on already available and upgraded sea level stations and the priority sites defined by WG1. As it has already mentioned, at the end of that year only a few of them fulfilled these requirements. In November 2007, a more dense network was proposed, taking into account the real needs of a minimum regional system, and a preliminary proposal for deep ocean stations to be in operation by the end of 2011 was incorporated to the implementation plan. The complete and final monitoring network should be much denser and probably run by national tsunami warning systems.

The instrumentation and stations that will be part of the sea level monitoring with application for tsunami detection should fulfil the requirements established by the working group, which are based on the experience of the corresponding sea level working group for the Indian Ocean, with small modifications. The accepted standards are based on the “Manual on Sea Level Measurements and Interpretation, Volume IV. An update to 2006. IOC Manuals and Guides No. 14, IOC of UNESCO, 2006”.

Concerning the network of offshore stations for the NEAMTWS, there are a number of priority sites: North of Algeria, South of Hellenic Arc, Azores, Gulf of Cádiz, Marmara Sea and South

Eastern Mediterranean (Figure 2-8). The European Research Infrastructure EMSO can be a reference for the location of sea floor observatories equipped with tsunami detection sensors in the future. EMSO will be based on the work done within ESONET CA and ESONET NOE.

There are also a number of off-shore stations that are being established by the Member States that need to be inventoried by the WG3 for possible inclusion in the final system.

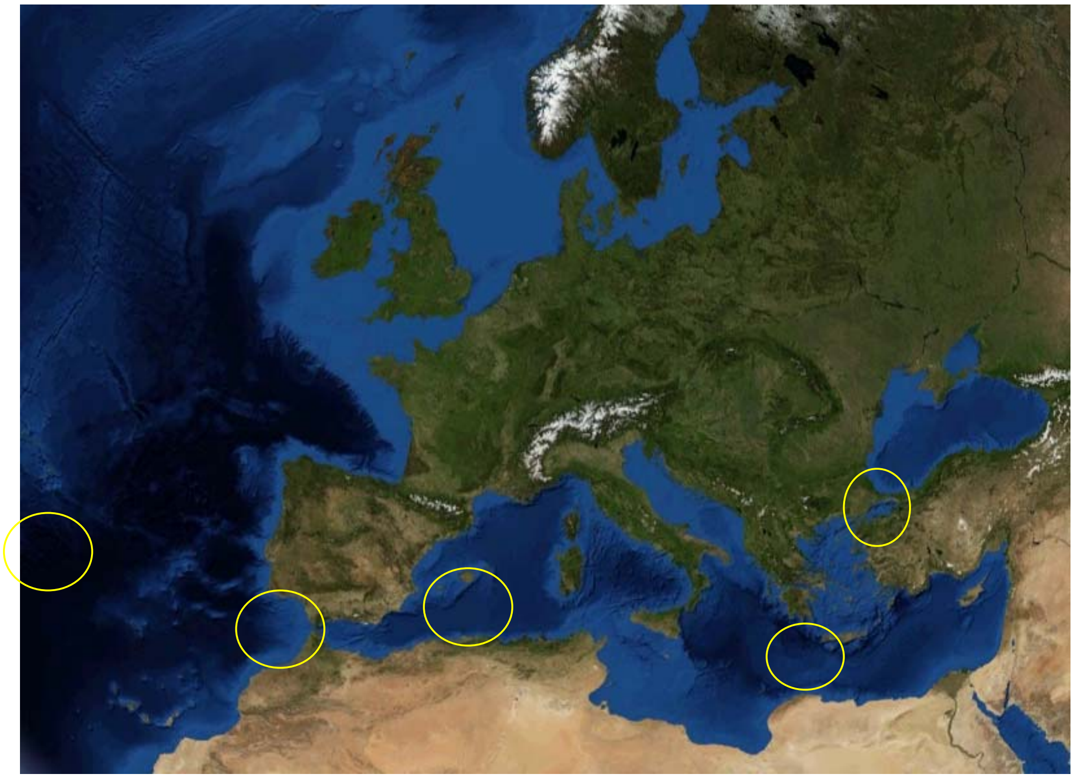

Figure 2-8. Priority sites for establishment of offshore sea level instrumentation for NEAMTWS, as proposed by WG3.

Instrumentation Requirements and Standards for the Initial Tsunami Warning System:

<u>Sea Level Stations:</u>

- *Data sampling and transmission:* 1 min data sampling will be enough for this initial system. However, higher frequency data of the order of seconds is recommended for the future system, at those stations closer to tsunamigenic zones and supposed to detect also landslide tsunamis. A continuous transmission cycle of 1 min, for stations within 1 hour of travel and/or 100 km from the tsunami generation areas.

- *Quality control:* quality assurance of the data is the responsibility of the national data providers and preliminary and quick quality control is recommended as far as no data is removed but flagged. The data received are assumed to be interpreted by experts at the tsunami watch center, who could make use however of automatic algorithms of tsunami detection.

- *Communications:* redundancy of systems of data transmission based on technologies such as BGAN, ADSL, GPRS or Internet connection. Data will be transmitted each 1 min to the established warning center (to be defined). The integration of the data in the WMO's GTS is also strongly recommended and should be explored and implemented.

- *Equipment:* The accuracy of the equipments should be < 1 cm for being useful for multipurpose stations, as the GLOSS sea level stations. Besides, they should have the possibility of data sampling below 1 min (seconds) and capable of measuring higher and lower water levels than normally experienced by a GLOSS sea level station. In situ data storage capacity.

- Redundancy of equipments is desirable.

- Redundancy of power supply (batteries, solar panels, etc)

<u>Offshore Stations</u>

- *Equipment:* main sensor for tsunami detection should be a bottom pressure sensor that is able to determine the tsunami amplitude before it arrives to the coast. Measurement accuracy of water column pressure should be 0.5 cm.

- *Data sampling and transmission:* 1 min or less averages data sampling, measurement processing within 2 minutes and measurement availability within 5 minutes.

- *Communications:* a reliable data transmission should be used (following the experience of existing offshore stations in other regions) and data must be placed on GTS operated by the WMO.

Sea level data exchange:

Sea level data in real time must be transmitted to the designed warning centers, and analysed by expert staff within the integrated warning system. The working group however, in order to be able to follow the status of the different tide gauges that are becoming part of the core regional network, decided to use the interim data portal facility for GLOSS stations, developed by VLIZ (Oostende) for UNESCO. The portal provides the status of the different stations and visualizce the recent sea level data. (http://www.vliz.be/gauges)

Gaps and Deficiencies

Several countries are already making efforts to upgrade their national sea level networks, most of the times as part of a multi-purpose/multi-hazard system approach. This is the case especially for countries from the Atlantic coast and North of Europe, where besides data are normally available and open to be included in the system. The situation is completely different in the Mediterranean, where the most at risk areas are found: tide gauges here are not being upgraded now, and if they are, the availability of the data is not confirmed sometimes. In this part of the region there are more difficulties to get the funds, and countries sometimes have no adequate mechanisms to carry out this task. In the North of Africa the problem is enhanced, as even there is no news of the existence of operational stations with data that can become available to the community, so there is a need of installation of completely new stations. Funds for these new stations may be provided sometimes by ODINAFRICA, but are not available in other cases, such as the new station to be established in Lebanon. For the already existing stations, smaller amount of funds will be needed for upgrading to tsunami requirements, such is the case of several MedGLOSS stations. In any case, the Member States needs to make the commitment to provide the data and maintain the stations on a permanent basis for the stations proposed by WG3.

Action Plan

The planned, ongoing and new proposed actions concerning sea level monitoring for the NEAM region are included in Table 2-3. The main and key activities are:

- Installation and upgrade of an initial backbone network of coastal sea level stations to be operational by the end of 2009
- Upgrade of additional sea level stations to the system based on the WG3 proposed list and national needs during the second stage of the implementation plan (end of 2013).
- Design and implementation of the network of offshore sea level monitoring stations to be also in operation by the end of 2013.
- Use of GTS real time codes for sea level
- Proposal on Regional Data Centers for reception and quality control of sea level data

A detailed estimate of the required budget for the implementation of each station remains to be done, but a rough estimate for completely new stations would be of the order of 20.000 Euros of investment and 6000-9000 Euros/per year for maintenance and communications, although this last item will vary from one place to other. For the first year, up to 12 completely new stations will have to be installed according to the last recommendation of WG1 about priority of sites. Some of them have already funds available, for others funds need to be allocated.

Table 2-3. Action plan for sea level monitoring

Task/Milestone	Country/ Location	Responsibility	Timeline	Required budget	Status
Final selection of initial stations to be upgraded/installed within 2007	Regional	Member States	NEAMTWS-III		C
Completion of survey on data transmission of existing sea level stations in NEAMTWS region	Regional	UK, Spain	2008		D
Report on initial sea level stations status and needs of upgrade	Regional	Spain	Continuous		O
Final requirements on the priority of the sites	Regional	WG1	NEAMTWS-III		C
Existing offshore instrumentation report	Regional	UK, Spain	2008		D
Standard format description for sea level (based on Indian and Pacific warning systems)	Member States		2011		D
Test of the GTS new codes for real time transmission of sea level data	Regional	Spain	2011		D
Upgrade / install backbone network sea level sensors for the ITWS	Member States	Member States	December 2009		D
Selection of deep ocean stations to be part of the final TWS (2011)	Regional	Italy	2007		C
Organization of a meeting of existing sea level organizations (GLOSS, MedGLOSS, ESEAS, EuroGOOS...) for proposals on the RTWC for sea level data		IOC	Paris Sea Level Meeting October 2007		C
Upgrade national sea level networks for the NEAMTWS	Member States	Member States	2013		O
Upgrade national (enhanced) sea level networks tailored to specific national needs.	Member States	Member States	2013	380.000 E *	O
Establish deep ocean sea level	Member	Member	2013		P

Task/Milestone	Country/ Location	Responsibility	Timeline	Required budget	Status
monitoring stations in the TWS network	States	States			

1 Notes: – Status: P – Planned, C – Completed, O – Ongoing, D- Delayed)

Table 2-3 (continue) Action plan for sea level monitoring post NEAMTWS IV

Task/Milestone	Country/ Location	Responsibility	Timeline	Required budget	Status 1
Send to the WG3 members the ITP (Subgroup of Indian Ocean WG2) documentation about offshore stations, to review and see their adequacy to the NEAMTWS region	Regional	WG3 chair	2008		D
Request to the IODE Project Office for collecting, secure displaying and disseminate to the GTS the sea level data in the NEAMTWS for at least 4 years. If positive answer, information about how to provide the data.	Regional	ICG chair	December 2007		C
Request the WG1 to advise on the final sea level network proposed by WG3, including offshore sites selection	Regional	WG1 chair	June 2008		O
Update existing offshore instrumentation report	Regional	Israel, France, and JCOMM	June 2008		O
Survey of algorithms of tsunami detection from sea level/pressure data	Member States	Spain-UK	June 2008		D
Support WG1 to access historic sea level data in the region	Regional	UK	2008		P
List of institutions with sea level data	Regional	UK	2008		P

1 Notes: – Status: P – Planned, C – Completed, O – Ongoing, D- Delayed)

* Budget estimated only for the installation of the 13 new stations: 260.000 Euros Installation + 120.000 Euros maintenance first year. Costs of upgrade very diverse and difficult to estimate

2.7. ADVISORY, MITIGATION AND PUBLIC AWARENESS

The impact of tsunamis and other marine-related hazards can be even substantially mitigated if timely warnings are issued to population by the TWS and if coastal communities are prepared to the tsunami attack or storm surge through appropriate programmes of preparedness and education, leading to effective response in the emergency and to the reduction of vulnerability and risk. Proper advisory schemes tailored to the local communities, mitigation and adaptation measures and public awareness sustained and maintained in the long term are essential components of an end-to-end tsunami warning and mitigation system for the NEAM region, as with all the other TWS regions. If the issues of mitigation and population response are key points for tsunami warning systems in all the oceans, these are even more crucial in the NEAM region where tsunami travel times are very short, and there is a relevant possibility that the tsunami attacks before the population can be properly alerted by the TWS or soon after the TWS has issued warnings. It is important therefore that national and local emergency response plans be prepared for coastal regions, that regular preparedness exercises and drills be undertaken in all countries throughout the NEAM region, starting from the coastal areas identified as the most exposed to the tsunami and storm surge threat, and that coastal communities undertake sustained efforts to reduce risks from tsunamis and storm surges by mitigation and adaptation. Education and outreach campaigns, including preparation of ad-hoc educational material, have to be undertaken on tsunami and storm surge risks, warning systems, and emergency response in coastal regions.

As a key part of this Implementation Plan, recommendations for guidance to authorities will be prepared that relate in general to coastal flood risk management in the context of ICAM (ICZM). They will concern the well-being of coastal communities that are threatened by inundation not only from tsunamis, but also from other catastrophic marine physical hazards including storm tidal surges and unusually large, wind-induced waves (Table 2-4). For completeness, the guidance will also cover the implications for coastal flood risk management of the progressive impacts of sea-level rise and predicted climate change over the long term. It is emphasized that the implementation of responses within individual Member States is the responsibility of those MS, and is outside the scope of the operational parts of NEAMTWS, such as seismic detection and sea-level monitoring.

Implementation will be carried out in consultation with other TWSs, regional bodies including the European Commission and the Barcelona Convention, and the UN agencies dedicated to disaster reduction and risk management, including UN/ISDR and with IOC's ITIC.

The guidance will be presented in four sections:

The first covers information on hazard events received from Regional Tsunami Watch Centres by National Tsunami Warning Centres, and their dissemination via local authorities as warnings or alerts to vulnerable communities. A priority task will be to make recommendations for the harmonization and standardization of the nomenclature used for the various advisory and warning messages delivered in the event of a tsunami incident or a developing storm surge.

The second section deals with emergency responses of MS, and particularly local authorities, for coping with marine inundation and determining the priorities of designated authorities for emergency response preparedness.

The third relates to communication systems, both for the transmission of event-related information and warnings, and for use in emergency response operations. A priority will be to make recommendations for standards covering the communications systems used in end-to-end advisory and warning networks.

The fourth section will deal with the mitigation of, and adaptation to, the impacts both of extreme marine hazard events and of long-term, progressive sea-level rise which will exacerbate the impacts of extreme events. This latter section will include recommendations for assessing vulnerability, reducing or minimizing human and economic vulnerability through public awareness and education, strategic planning and flood risk management, taking into account environmental and demographic changes within the planning timescale. The activities will include the development by IOC of "Guidelines for Mainstreaming Awareness and Mitigation of Marine-related Hazards and Risks in Integrated Coastal Area Management (ICAM)". These guidelines will be global in their scope.

Table 2-4. Characteristics of, and responses to, marine physical hazards

MARINE HAZARD →	**Tsunami**	**Storm surge***	**Extreme wind-forced waves***	**Long-term sea-level rise**
Likely frequency of event	Decades to millennia, depending on regional tectonic regime	Months to decades, depending on regional climate regime	Months to decades, depending on regional climate regime	On-going, a consequence of global warming and local factors
Type of impact	Initial withdrawal; catastrophic inundation and drainage surges, may be multiple	Catastrophic, single-event inundation	Multiple, localized inundation and drainage surges	Progressive rise of mean high (tidal) water level
Limits of area likely to be affected	Local run-up limit for specified wave amplitudes predicted by modelling	Flood limit for specified surge level predicted by terrain modelling	Flood limit for specified wave heights predicted by terrain modelling	Mean high water mark predicted by terrain modelling with allowance for extreme events
Potential warning time	Minutes to hours, depending on proximity of source location	Hours to days, depending on climatic factors	Hours to days, depending on climatic factors	Decades to centennia
Action by Regional Watch Centre(s)	Issuance of Watches and event information to National Warning Centres			No action
Action by National Warning Centre(s)	Issuance of Warnings to appropriate Local Authorities			No action
Emergency actions by Local Authorities	Launch of emergency response action on receipt of Warning			No action
Mitigation and adaptation by Local and National Authorities	Vulnerability assessment of coastal populations, ecosystems, and infrastructure; Strategic spatial planning and regulation to minimize exposure and vulnerability: Participatory approach; Decision tools and software for analysing hazard loss and risk			
	Public awareness and readiness campaigns, including recognition programs and emergency response exercises (preparedness) and education (preparedness and adaptation); Promoting community resilience.			

*Risks of inundation are greatest when surge and wave events coincide

Mainstreaming tsunami and other marine-related hazard warning and mitigation practices into development planning for coastal areas will ensure sustainability of development through adequate prevention programmes and through structural and non-structural mitigation measures, such as the establishment of coastal buffer zones and protection of coastal vegetation and habitat. Coordination among national and international agencies responsible for disaster risk reduction and disaster management to lead, monitor, and coordinate the emergency response in countries throughout the NEAM region will identify gaps, avoid duplications, rationalise resources, harmonise plans and initiatives in the interest of the local communities. With particular regard to tsunamis, building capacity of national and local agencies and institutions to prepare for and respond to tsunami and storm surge emergencies is a priority for many countries of the NEAM region. Developing national and local emergency response plans including assessment of critical infrastructure and production of evacuation maps is an objective that is still far from being accomplished.

The implementation will recognize the diversity of the region and accept that flexibility is needed in order to accommodate the circumstances and requirements of individual countries. The guidance therefore will aim to highlight principles of good practice that may be generally applicable, illustrated by examples chosen from within this TWS region and, where appropriate, other regions. A key consideration in the preparation of these guidelines will be the assessment of the risk of flooding and its consequences, geographically, socio-economically and temporally. Within the region, the Mediterranean Sea coasts – and especially the eastern Mediterranean – have the greatest incidence of tsunami impact, while Northern Europe's coasts have the greater risk of storm surge events – southern North Sea coasts and estuaries being most prone. In particular, it is important that implementing national and local authorities understand the levels of vulnerability of coastal communities and infrastructure, as well as the nature of the hazard impacts, including the likely warning time for potential emergency response, the possible return periods of tsunami and storm surge events, and the timescales over which significant sea-level rise may occur (Table 2-4). Such information should form the basis for any response, whether for early warning, for emergency preparedness and response, or for mitigation and adaptation, so that the response arrangements are credible, sustainable and appropriate to the risk.

Table 2-5. Action Plan for Advisory, Mitigation and Public Awareness

Activity	***Country/ Location***	***Timeline***	***Responsibility***	***Required Budget***	***Status***
Make recommendations on harmonization of warnings nomenclature and standards by consultation between all TWS and in consultation with Barcelona Convention and European Commission	Regional	Phase 1 Oct 2007 Continued output to 2009	IOC TWS Member States	$ 15 000	O
Make recommendations for best practice and standards for emergency preparedness and response for national and local authorities; consultation with civil protection agencies (including coastal cities) and the European Commission	Regional	Phase 1 Oct 2007 Continued output to 2009	IOC assisted by UNU EHS and ISDR	$ 15 000	O
Make recommendations on communications, including standards, authentication and spectrum requisition; consultation between all TWS; also with European Commission; liaison with WG1 and WMO in respect of output	Regional	Phase 1 Oct 2007 Continued output to 2009	IOC TWS	$ 20 000	O

messages from RTWCs					
Develop IOC Guidelines for mainstreaming consideration of tsunamis and other marine-related hazards into ICAM plans and programmes; taking account of on going research (TRANSFER; FLOODSITE, etc); and including vulnerability assessment, mitigation and adaptation.	Global	End 2008	IOC Member States	tba	P

1 Notes: – Status: P – Planned, C – Completed, O – Ongoing

Table 2-5. (continue) Action Plan for Advisory, Mitigation and Public Awareness

Activity	*Country/ Location*	*Timeline*	*Responsibility*	*Required Budget*	*Status*
Further develop recommendations to Civil Protection authorities and agencies on tsunami warning nomenclature and standards	Regional	Continued output to 2009	IOC TWS Member States		O
Further develop recommendations to Civil Protection authorities and agencies on emergency preparedness for tsunami impacts	Regional	Continued output to 2009	IOC assisted by UNU EHS		O
Further develop recommendations to Civil Protection authorities and agencies on communications for tsunami impacts	Regional	Continued output to 2009	IOC TWS		O
Complete IOC Guidelines for mainstreaming awareness and mitigation of tsunami, storm surge and other sea-level related hazards and risks in ICAM	Global	End 2008	IOC Expert Group		O
Workshop on stakeholder participation in marine-related hazards mitigation processes	Regional	End 2008	Portugal		P

2.8. FUNCTIONS OF THE NEATMWS

Regional Watch Centres, Tsunami National Contacts, Tsunami Warning Focal Points, and National Warning Centres are basic structural elements of the TWS in the NEAM region. The functions of such components of the NEAM TWS, that have been adopted by the ICG at the second session of the NEAMTWS held in Nice, 22-24 May 2006, are given here below.

Regional Tsunami Watch Centres (RTWC) functions

- Collection, record, processing and analysis of earthquake data for the rapid initial assessment (locate the earthquake, the depth, the magnitude, the origin time) as a basis for the alert system
- Computing the arrival time of the tsunami in the forecasting points listed in the Communication Plan
- Collection, record, processing and analysis of sea level data for confirming and monitoring the tsunami or for cancelling elements of the alert system.
- A decision making process in accordance with the Communication Plan to elaborate messages
- Dissemination to the Member States focal points (and national warning centres) of the messages in accordance with the Communication Plan, included the tsunami travel time, the amplitude and period of tsunami measured, and cancellation messages

ICG Tsunami National Contact

The person designated by an ICG Member State government to represent his/her country in the coordination of international tsunami warning and mitigation activities. The person is part of the main stakeholders of the national tsunami warning and mitigation system program. The person may be the Tsunami Warning Focal Point, from the national disaster management organization, from a technical or scientific institution, or from another agency with tsunami warning and mitigation responsibilities.

Tsunami Warning Focal Point (TWFP) functions

- Reception of the messages transmitted by the Regional Tsunami Watch Centres
- Evaluate and issue national warnings in accordance with the National Emergency Plan
- Transmission of warning messages to the National Emergency Authorities
- Operating 24/7

Additionally to the TWFP functions National Tsunami Warning Centres (NTWC)

- collect, record, and process earthquake data for the rapid initial warning (locate the earthquake, the depth, the magnitude, the origin time)
- Compute the arrival time of the tsunami in the national forecasting points
- Collect, record, and process sea level data for confirming or cancelling the warning

Warning Centres strive to be:
- Rapid, by providing warnings as soon as possible after a potential tsunami generation
- Accurate, by issuing warnings for all destructive tsunamis while minimizing false warnings
- Reliable, by making sure they operate continuously, and that their messages are sent and received promptly and understood by the users of the system.

Table 2-6. Action plan for the NEAMTWS structural components

Task/Milestone	*Country/ Location*	*Responsibility*	*Timeline*	*Required budget*	*Status 1*
Designation of Focal Points	Member States	Member States	2007		O
Establish the Communication Plan for the ITWS	Regional	ICG	2007		
Establish the RTWC for the ITWS	Regional	IOC, ICG, Member States	2007		
Establish the NTWC for the ITWS	Member States	Member States	2007		
Establish the Communication Plan for the TWS	Regional	ICG	2008		
Establish the RTWC for the TWS	Regional	IOC, ICG, Member States	2008		
Establish the NTWC for the TWS	Member States	Member States	2008-2011		

1 Notes: – Status: P – Planned, C – Completed, O – Ongoing

ANNEX A. REVIEW OF STATUS OF PROPOSED SEA LEVEL NETWORK

SPAIN:(Spanish Harbours Authority)
Status and plans:
Barcelona: acoustic sensor already upgraded to a new FMCW radar sensor.
Ibiza/Mahón: (Balearic Islands) there is a pressure sensor already in place in Ibiza, to be upgraded to a new FMCW radar sensor. No plans of when, however. Conversations with the Harbour Authority are taking place, it could be that a FMCW radar sensor (new station) were established in Menorca Island (Mahon) first (Mahon would then be selected for the system).
Almería: FMCW radar sensor already in place (installed January 2006).
Huelva: acoustic sensor upgraded to a new FMCW radar sensor in November 2007 (now).
Ferrol: FMCW radar sensor already in place (installed November 2006).
La Gomera: FMCW radar sensor already in place (installed November 2006).
Melilla: New FMCW radar sensor already installed in October 2007. New station
Data transmission is mainly by Internet in all the stations, although other alternatives such as VSAT or BGAN will be explored in the future.
Other Spanish Institutions: the Spanish Institute of Oceanography will be ready to contribute to the network if the working group suggests the installation or upgrade of a particular station important for the system, that is not already planned or maintained by other Spanish institutions,

*UK: (Proudmann Oceanographic Laboratory)
Status and plans: three systems for tsunami applications will be operational by April 2008, with the following programme of work:
Holyhead: station already working with the ITWS requirements.
Newlyn: installation in 2008.
Cromer: installation in 2008.
Lerwick: station already working with the ITWS requirements, a priority location in the Shetland Islands.
Gibraltar: a FMCW radar sensor is already in place. An additional pressure sensor will be installed during 2007.

The former four stations will be based on pressure sensors mounted close to the seabed with vented cables to the data logging system. At Holyhead, sampling periods of 1-10 seconds will be tested. Final decision of the measuring system will be done after checking these data with a bubbler gauge for the first site. Communications: broadband (phone). BGAN direct text messages is being tested for future communications.

IRELAND:
Three stations will be incorporated to the NEAMTWS network by the end of 2008:
Malin Head (North, Donegal)
Castletownbere (Southwest corner)
Dublin Bay

They are also working on a proposal of adding a bottom pressure sensor in a meteo-oceanographic buoy already operational in the Porcupine area (3000 m depth). If the place is not considered adequate by WG3, they would propose a dedicated buoy in the recommended position.

FRANCE: (SHOM)
Status and plans: initially SHOM had not funds to upgrade stations in the Mediterranean, although this could be solved after recent conversations with France

representatives. The planning of upgrading (radar sensors and real time transmission) applies only to the Atlantic and the Channel by the moment.
Le Conquet: this station in the Atlantic coast, very close to Brest, but in a more open ocean site, will be upgraded to real time data transmission in 2007.
Ajaccio
Monaco: Monaco Authorities have confirmed interest to SHOM in upgrading their tide gauge (waiting for news).
November 2007: only Le Conquet is and will be ready for the ITWS. Monaco will have the station ready to be incorporated at the beginning of 2008.

NORWAY: (Norwegian Mapping Authority)
Status and plans: Rorvik and Tregde stations are now being upgrade to 1 min data sampling and data could be available as they are. If the full requirements have to be fulfilled some extra funds would be needed.

SWEDEN:
Stockholm has been eliminated of the initial proposal because it does not seem interesting for tsunami purposes. Instead, Smogen station will be included in the system.

GREECE: (Techn. Univ. of Crete and Hellenic Navy Hydrographic Service - HNHS)
Status and plans: Gavdos is at this moment responsibility of the Technical University of Crete, but the final responsibility and decision for data transmission will correspond to the Hellenic Navy Hydrographic Service (HNHS). On the other hand, the Observatory of Athens is planning new tide gauges in Ionian Sea for tsunami applications, although no contact with them has been established yet.
HNHS is responsible for operating the Hellenic Network (21 stations). All of them ar float gauges in stilling wells, and only 7 are now digital with a GSM connection for data transmission (Alexandroupolis, Chios, Siros, Samos, Peiraeus, Lefkas and Katakolo). HNHS is interested in participating in the project and in knowing the exact requirements for sampling interval and data transmission.

Up to 7 new stations for tsunami applications will be installed in Greece during 2007, 3 of them (names remain to be confirmed) will be part of the initial system.

November 2007:
TUC (Technical University of Crete):
Gavdos is already upgraded and ready (acoustic Aquatrak and Kalesto radar sensors). An offshore station could be established also close to Gavdos in a near future.
Kasteli: planned new station with a Kalesto radar sensor (Northern Coast of Crete)
NOA: two stations will be installed in the next two months in the following coordinates: (35º30'N, 23º39'E), NW Crete and (35º18'N, 23º31'E), W Crete. The equipments (SBE26 PLUS) have already been purchased.
HCMR: planning installation or SL stations in 2008, with ITWS requirements, in collaboration with NOA and HNHS.

CYPRUS:(Oceanography Centre, University of Cyprus)
Status and plans: The Oceanography Centre (University of Cyprus) is looking for funds to upgrade the sea level station of Paphos, operating in the framework of MedGLOSS and ESEAS, in order to be included in a Mediterranean tsunami warning system. They plan to do so also with their open sea station, SW of Cyprus.

ISRAEL: (Israel Oceanographic & Limnological Research)
Status and plans: Hadera and Ashdod stations can provide 30 s averaged data and in the coming months with new software also 5, 10 or 15sec averaged data. Data

transmission by means of a triggering mechanism from the station will be established in the coming months.
November 2007: Hadera is already upgraded and able to be incorporated to the network. It will start 1-min data transmission in December 2007. Ashdod and Haifa (a Miros radar) will be added probably shortly after.

ITALY: (APAT)
Status and plans: APAT has confirmed the availability of the data of stations: Napoli, Imperia, Carloforte, Porto Empedocle and Otranto for the NEAMTWS system. All of them will be upgraded soon to tsunami requirements.
November 2007: the stations will be upgraded probably around February 2008.

CROATIA:
Split will be replaced by Dubrovnik as it is best located for tsunami applications, to be included in the second stage of the implementation plan.

SLOVENIA:
Slovenia will contribute to the system with their station at Koper, where two radars and one float tide equipment are in operation at this moment (10 min sampling and 30 min latency now, it will be upgraded to 1 min with continous transmission)

BULGARIA:

UKRAINE:
Kacively station will be upgraded for the system when funds are available.

ROMANIA:
Constantza station will be upgraded for the system when funds are available.

TURKEY: (National Delegate, KOERI)
The General Command of Mapping (HGK) is planning the installation of 7 new sea level stations with real time data transmission and high frequency sampling for tsunami applications; one or two of these stations could be part of the NEAMTWS system. A proposal has been made within the WG to include one station in the Aegean Sea (Bodrum) and other one in the Black Sea (Sinop). Confirmation and dates are needed.

NORTH OF AFRICA
ALGERIA:
CRAAG director, contacted the Algerian Hydrographic Service. They have two old stations, not digital. CRAAG will provide three new stations adequate for tsunami applications in the next few months.

November 2007: the acquisition of the equipments is being done at this moment. One will be installed in the east (Djidjelli or Annaba), other in Algiers and other in Oran. They are trying to have them ready at the end of the year.

EGYPT:
ODINAFRICA and IOC have recently selected a site in Alexandria for a new ODINAFRICA location with a radar and pressure gauge, that could be a possible station contributing to the tsunami warning system. (Philip Woodworth communication).

November 2007: Alexandria is already installed and working following the ITWS requirements. It is one of the priority sites.

MOROCCO:

Possibly one station in Morocco (Atlantic coast) also within ODINAFRICA. (Philip Woodworth and Thorkild Aarup communication).

TUNISIA:
Two new stations will be installed during 2007: Gulf of Gabés (with ODINAFRICA funds) and Cape Bon (funds not yet available, this is one of the stations included in the initial list because of the priority of the site).

November 2007: the stations of Gulf of Gabés and Cape Bon are already installed and in place, transmitting data in real time. Burocratic work remains to be done to make the data available for the community. Expected date of availability for the ITWS: February 2008.

ANNEX B. REVIEW OF STATUS OF EXISTING PLANS OF OFFSHORE SEA LEVEL INSTRUMENTATION FOR TSUNAMI APPLICATIONS

A significant number of offshore or open sea stations exist in Europe, that could potentially be used also for tsunami detection purposes. The instrumentation includes both meteorological-oceanographic buoys and OBS systems (seismic sensors at the sea bottom). The objective of this task is to have available a detailed inventory of the existing open sea stations around the NEAMTWS region and information about the possibilities and costs of upgrading. This upgrading normally will refer to the inclusion of bottom pressure sensors and adequate data processing and transmission for tsunami applications.

Apart from the national buoy networks (Spanish Harbours, APAT – Italy, POSEIDON-Greece), a European Sea Floor Observatory Network (ESONET) is planned. All these positions should be explored.

National plans concerning open sea stations for tsunami applications:

Italy:
An offshore station with a bottom pressure recorder has been installed close to the Marsili Vulcano, North of Messina Strait, at about 2000 m depth.

Cyprus:
The Oceanography Centre is planning to upgrade their open ocean observatory (70 km SW of Cyprus) for tsunami applications, but funds are not yet available.

Greece:
An offshore station at 2000 m depth will be established within POSEIDON project for tsunami detection.

Turkey:
5 deep sea stations for tsunami and seismic applications installed in the Marmara Sea.

NEAREST project:
A seafloor multiparameter observatory (GEOSTAR class), including bottom pressure sensor and innovative software will be operational in the Gulf of Cádiz. Previous ESONET station (?). (Laura Beranzoli communication).

ANNEX C. STATUS OF SEA LEVEL PROPOSED STATIONS BASED ON BEST AVAILABLE INFORMATION (OCTOBER 2008)

Station Name	Coordinates	Country	Basin/Sea	Current status	Type of sensor	Current Sample (min)	Transmission interval (min)	Type of transmission	Network
Kacively	44º.42N,34º.05E	Ukrania	Black Sea	3	Pressure	0.5	60	PSTN/Internet	MedGLOSS
Constantza	44º.17N,28º.67E	Romania	Black Sea	3	Pressure	0.5	60	PSTN/Internet	MedGLOSS
Paphos	34º.78N,32º.40E	Cyprus	E. Mediterr.	3	Pressure	No working	60	PSTN/Internet	MedGLOSS-ESEAS
Hadera	**32º.47N, 34º.86E**	**Israel**	**E. Mediterr.**	**2**	**Pressure**	**0.5**	**60**	**GSM-modem/Internet**	**MedGLOSS-ESEAS**
Ashdod	31º48'N,34º38'E	Israel	E. Mediterr.	2	Pressure	0.5	60	GSM-modem/Internet	MedGLOSS-ESEAS
Gavdos	**34º.85N, 24º.12E**	**Greece**	**E. Medterr.**	**2**					
NWCrete	35º30'N,23º39'E	Greece	E. Mediterr.	4	Pressure	0.5	0.5	Satel/Internet	NATNEG
Wcrete	35º18'N,23º31'E	Greece	E. Mediterr.	4	Pressure	0.5	0.5	Satel/Internet	NATNEG
Porto Maso	35º.91N, 14º.52E	Malta	C. Mediterr.	3	Pressure	0.5	60	GSM/Internet	MedGLOSS-ESEAS
Dubrovnik	42º39'N, 18º04'E	Croatia	Adriatic	3	Pressure	10	10		MedGLOSS-ESEAS
Napoli	40º50'N, 14º16'E	Italy	C. Mediterr.	3		15s-1min	5-15min		
Imperia	43º53'N, 08º01'E	Italy	C. Mediterr.	3		15s-1min	5-15min		
Carloforte	39º09'N, 08º 18'E	Italy	C. Mediterr.	3		15s-1min	5-15min		
Calabria	38º07'N, 15º39'E	Italy	C. Mediterr.						?
Porto Empedocle	37°17'N, 13°31'E	Italy	C. Mediterr.	3		15s-1min	5-15min		
Otranto	40º 09'N, 18º30'E	Italy	Adriatic	3		15s-1min	5-15min		
Ajaccio	**41º56'N, 08º46'E**	**France**	**W. Mediterr.**	**3**	**Acoustic**	**10**	**None**	**None**	**ESEAS**
Le Conquet	**48º22'N,04º46'W**	**France**	**Atlantic**	**2**	**Radar**	**1s**	**None**	**ADSL**	**ESEAS**
Monaco	43º44'N, 07º25'E	Monaco	W. Mediterr.	3	Acoustic	10	None	None	

Barcelona	**41º21'N,02º10'E**	**Spain**	**W. Mediterr.**	**2**	**Acoustic**	**5**	**60**	**GSM**	**MedGLOSS-ESEAS**
Gandía	**39º00'N, 0º9'E**	**Spain**	**W. Mediterr.**	**1**	**Radar**	**1**	**1**	**Internet**	
Ibiza	38º55'N,01º27'E	Spain (Balearic Islands)	W. Mediterr.	3	Pressure	5	60	GSM	MedGLOSS-ESEAS
Mahón	39º52'N, 04º18'E	Spain (Balearic Islands)	W. Mediterr.	4	Radar	1	1	Internet	
Palma de Mallorca	39º33' N,02º38' E	Spain (Balearic Islands)	W.Mediterr.	3	Float	1	hours	Internet	MedGLOSS
Almería	**36º50'N,02º29'W**	**Spain**	**W. Mediterr.**	**1**	**Radar**	**1**	**1**	**Internet**	
Huelva	**37º08'N,06º50'W**	**Spain**	**S. Atlantic**	**1**	**Radar**	**1**	**1**	**Internet**	**ESEAS**
Ferrol	**43º17'N,08º08'W**	**Spain**	**S. Atlantic**	**1**	**Radar**	**1**	**1**	**Internet**	
La Gomera	**28º03'N,17º05'W**	**Spain (Canary Islands)**	**S. Atlantic**	**1**	**Radar**	**1**	**1**	**Internet**	
Arrecife-Lanzarote	**29º01'N,13º31'W**	**Spain (Canary Islands)**	**S. Atlantic**	**4**	**Radar**	**1**	**1**	**Internet**	
Tarifa	36º00'N,05º36'W	**Spain**	**W. Mediterranean**	**3**	**Float**	**10**	**Hours**	**Internet**	**ESEAS**
Melilla	**35º17'N,02º56'W**	**Spain**	**W. Mediterr.**	**1**	**Radar**	**1**	**1**	**Internet**	
Ceuta	35º54' N 05º19' W	**Spain**	**Gibraltar Strait**	**3**	**Float**	**10**	**hours**	**Internet**	**GLOSS**
Cadiz	**36º32'N,06º17'W**	**Spain**	S.Atlantic	3	Float	5	60	Internet	
Cascais	**38º41'N,09º25'W**	**Portugal**	**S. Atlantic**	**2**	**Acoustic**	**6**	**6**	**Internet**	**GLOSS**
Sines	**37º57'N,08º53'W**	**Portugal**	**S. Atlantic**	**2**	**Radar**	**1s**		**ADSL**	
Ponta Delgada	37º45'N,25º42'W	Portugal (Azores)	W. Atlantic	3					GLOSS
Funchal	32º39'N,16º54'W	Portugal	W. Atlantic	3	Acoustic				

		(Madeira)							
Newlyn	50º06'N,05º33'W	U.K.	Atlantic	2	Bubbler	15	15	Internet	GLOSS-ESEAS
Holyhead	**53º19'N,04º37'W**	**U.K.**	**Irish Sea**	**1**	**Bubbler/Pressure**	**1**	**1**	**Internet-broadband telf**	
Cromer	52º56'N,01º18'E	U.K.	North Sea	2	Bubbler	15	15	Internet	
Lerwick	**60º09'N, 1º10'W**	**U.K. (Shetland Islands)**	**North Atl.**	**1**	**Bubbler/Pressure**	**1**	**1**	**Internet-broadband telf**	
Gibraltar	36º09'N,05º22'W	U.K.	Gibral. St.	2	Radar	15	60	PSTN/Internet	MedGLOSS-ESEAS
Malin Head	55º20'N,07º14'W	Ireland	N. Atlantic	3					
Castletownbere	51º39'N,09º54'W	Ireland	N.Atlantic	3					
Dublin Bay	53º22'N,05º59'W	Ireland	Irish Sea	3					
Clare Island	53º47'N,09º58'W	Ireland	N.Atlantic	3					
Rorvik	**64º52'N,11º15'E**	**Norway**	**N. Atlantic**	**3**	**Float**	**1**	**1**	**GSM/Internet**	**GLOSS**
Tregde	58º00'N,07º34'E	Norway	North Sea	3	Float	1	1	GSM/Internet	GLOSS
Torshavn	62º01'N,06º44'W	Denmark -Faroe Isl	N. Atlantic	3	Float	15			GLOSS
Hanstholm	57º07'N,08º36'E	Denmark	North Sea	3		10	10	Internet	
Tejn	**55º19'N,15º11'E**	**Denmark**	**Baltic Sea**	**3**		**10**	**10**	**Internet**	
Smogen	58º22'N,11º13'E	Sweden	North Sea	3	Float	10	60	PSTN modem	
Reykjavik	64º07'N,21º54'W	Iceland	N. Atlantic	3	Float / pressure	10			GLOSS
Oran	35º43'N,00º38'E	Algeria	S. Mediterr.	4	Radar	1	1		
Algiers	36º46'N,03º04'E	Algeria	S. Mediterr.	4	Radar	1	1		
Annaba	36º54'N,07º47'E	Algeria	S. Mediterr.	4	Radar	1	1		
Djidjelli	36º49'N,05º43'E	Algeria	S. Mediterr.	4	Radar	1	1		
Alexandria	**31º16'N,29º57'E**	**Egypt**	**E. Mediterr**	**4**	**Radar/Pressure**	**1**	**15**	**Meteosat/GTS**	**ODINAFRICA**
Cape Bon	37º04'N,11º04'E	Tunisia	S. Mediterr	4					ODINAFRICA
Gulf of Gabés	34º43'N,10º46'E	Tunisia	S. Mediterr.						ODINA FRICA

Bodrum	37º01'N,27º27'E	Turkey	Aegean Sea						
Sinop	41º43'N,34º50'E	Turkey	Black Sea						
Beirut	33º54'N,35º31'E	Lebanon	E. Mediter	4					
Koper	45º33'N,13º43'E	Slovenia	Adriatic	2	Radar	10	30	Internet	ESEAS

Notes:
Current status: 1-upgrade completed, 2- upgrade underway, 3- requires upgrade, 4- planned new installation
Coloured: completely new installations

ANNEX D. LIST OF ACRONYMS

APAT	L'Agenzia per la protezione dell'ambiente e per i servizi tecnici
BGAN	Broadband Global Area Network
BOOS	Baltic Operational Observing System
CRAAG	Centre de Recherche en Astronomie, Astrophysique et Géophysique
EERWEM	Earthquake monitoring and Earthquake Risk in WEstern Mediterranean
ESEAS	European Sea-Level Service
ESONET	European Sea Floor Observatory Network
EUROGOOS	Global Ocean Observing System in the European Seas and Adjacent Oceans
FMCW	Frequency Modulated Continuous Wave
GEOSTAR	Geophysical and Oceanographic Station for Abyssal Research
GIS	Geographical Information Systems
GITWES	Germany-Indonesia Tsunami Early Warning System
GLOSS	Global sea level Observing System
GOOS	Global Ocean Observing System
GPS	Global Positioning System
GTS	Global Telecommunication System
HNHS	Hellenic Navy Hydrographic Service - Index Page
ICAM	Integrated Coastal Area Management
ICG	Intergovernmental Coordination Group
INGV	Italian Institute of Geology and Vulcanology/Istituto Nazionale di Geofiscia e Vulcanologia
IOC	Intergovernmental Oceanographic Commission
IOTWS	Indian Ocean Tsunami Warning System
IP	Implementation Plan
ITIC	International Tsunami Information Centre
ITU	International Telecommunication Union
ITWS	Initial Tsunami Warning System
JMA	Japan Meteorological Agency
KOERI	Kandilli Observatory and Earthquake Research Institute

MedGOOS	The Global Ocean Observing System for the Mediterranean
NEAMTWS	Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and Connected Seas
NOOS	North West Shelf Operational Oceanographic System
NTWC	National Tsunami Warning Centre
OBS	Ocean Bottom Seismometer
ODINAFRICA	Ocean Data and Information Network for Africa
PTWC	Pactific Tsunami Warning Centre
PTWS	Pacific Tsunami Warning System
RTWC	Regional Tsunami Watch Centre
SHOM	Service Hydrographique et Océanographique de la Marine
SLEAC	Sea Level Along European and Atlantic Coast-line
TWS	Tsunami Warning System
UNESCO	United Nations Educational Scientific and Cultural Organisation
UN/ISDR	United Nations International Strategy for Disaster Reduction
UNU/EHS	Institute for Environment and Human Security of the United Nations University
UPS	Uniteruptable Power Supply
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WMO	World Meteorological Organization