# WORLD METEOROLOGICAL ORGANIZATION

## WORKSHOP ON MULTI-HAZARD, EARLY WARNING CENTRES' CONCEPT OF OPERATIONS FOR THE INDIAN OCEAN TSUNAMI WARNING SYSTEM

**SINGAPORE, 21-23 NOVEMBER 2005**

**FINAL REPORT**

## Executive Summary

In the critical need to enhance the tsunami early warning system for the Indian Ocean, WMO organized this workshop to gather the wealth of knowledge and experience of its established Regional Specialized Meteorological Centres, the “RSMCs” and the related role of National Meteorological and Hydrometeorological Services (NMHS), and existing Tsunami Warning Centres (TWC) to further promote and develop the concept of operations of multi-hazard multi-purpose early warning systems.

WMO is working together with UNESCO-IOC, International Strategy for Disaster Reduction (ISDR) and other key partners at the international, regional, and national levels to contribute its relevant capabilities and existing infrastructure to the development of end-to-end tsunami early warning systems in the Indian Ocean and other regions at risk. WMO is also committed to developing the capabilities of the National Meteorological and Hydrological Services (NMHS) of the Indian Ocean Rim countries to establish an effective tsunami early warning system within a multi-hazard multi-purpose framework, particularly related to national multi-hazards alert and response mechanisms. The value of this effort applies not only to all the Indian Ocean Rim countries, but also to all regions at risk.

The workshop was informed about the WMO Tropical Cyclone Programme (TCP), established and maintained to primarily address the requirements for real-time operational meteorological watch, detection and to locate and forecast the trajectory and intensity of Tropical Cyclones, the WMO Emergency Response Activities (ERA) programme, established and maintained to primarily address the requirements for real-time operational meteorological support to nuclear accidents and radiological emergencies, the role of NMHSs, and the current operational practices and procedures of Tsunami Warning Centres (TWCs) established for the Pacific Ocean region, and the interim arrangements that have been put into place for the Indian Ocean. The operational objective of the Indian Ocean Tsunami Warning System (TWS) is to detect and locate major earthquakes in the Indian Ocean region, to determine whether they have generated tsunamis, and to provide timely and effective tsunami information, advisory and warnings to the populations of the Indian Ocean, to minimize the hazards of tsunamis. To achieve this, the TWS has to establish and implement sustainable practices and procedures that ensure continuous monitoring, processing and dissemination of the seismic activity and water-level information, and when required, alerts, warnings and related impacts.

Regarding the concept of operations, the workshop developed conclusions and recommendations for the organization of effective multi-hazard, early warning centres, and specifically for the Indian Ocean Tsuanmi Warning System of Regional Tsunami Advisory Centres (RTAC) and National Tsunami Warning Centes (NTWC), including the following main conclusions:

- The workshop recognized a two-tiered TWS would be necessary. This two-tiered system would consist of:
  RTACs:
  - The Regional Advisory Centres and National Warning Centres of the IO/TWS should be implemented as soon as feasible, since JMA and PTWC will continue to act as interim RTACs but wish to withdraw as soon as the region has capacity to carry on, and because PTWC and JMA are only able to provide limited services,

- The regional advisory and national tsunami warning centres should be encouraged to work as a network. They should be encouraged to build a common program including the exchange of knowledge and expertise. There should be a program of training of regional and national centres' staff. A proven model is the WMO Tropical Cyclone Program and the Nuclear Emergency Response Activities programme. The IOC Pacific system is a good example to follow. But we need to consider regional differences,
- Coordination is required among RTACs, NTWCs and media as well as national disaster management office (NDMO) or other agencies. This includes output coordination,
- With capacity to produce advisories and accomplish recommended actions,

NTWCs:
It is recognized that there will be different capabilities in National TWCs:

- Those using advice from Regional Centre without modification,
- Those capable of doing some analysis of sea level and/or seismic data to aid local decisions,
- Those wanting all possible sea-level and seismic data to independently carry out complex modelling and produce all aspects of local warnings;

- The workshop suggested the consideration of existing centres that are currently designated as WMO's regional advisory centres, (e.g. RSMCs) which may become the RTACs, because they currently provide 24/7 operations and have experience in providing advisories. On a national basis, there are specific characteristics of tsunami warnings justifying special requirement as compared to different types of warnings. When justified there is a need to keep processes separate, especially when the biggest difference is in the time scale for emergency response;
- An essential requirement is the free and unrestricted real-time exchange of observational data, analysis and forecast products, and related metadata, in standard formats via GTS and its future successor system, the WMO Information System (WIS).

The workshop made the following recommendations regarding the centres of the early warning system, that:

- Regional Centres, like National Centres should be operational on a 24/7 basis;
- Current JMA and PTWC Operating Procedures should be synthesized to form an initial guide for the establishment of Regional and National Centres;
- Regional Centres should be able to access all seismic waveform data via the Internet or other communication means and generate parametric data in real-time for distribution on the GTS;
- Each Regional Centre should have arrangements in place to be backed up by another Regional Centre, and those arrangements should be regularly tested;
- Regional Centres should have the capability to run operational tsunami propagation models, which generate products relevant to that Region;
- Structured training in tsunami warning procedures and science should be established and be applied in all Regional and National Centres. Event simulators, which can be played back in real-time, are very desirable;

- There needs to be a designation and accreditation process for the regional advisory centres through IOC ICG/IOTWS. If IOC decides to use either the WMO RSMC framework concept or to apply a multi/hazard approach, then it is recommended that consultation be conducted with WMO. It is recommended that each centre would have a defined area of responsibility with a designated backup centre for each area. A geographic balance between designated centres would be desirable;
- On a national basis, the distribution of warnings will be handled most efficiently through an agency that operates on a “24/7” basis, and is active on routine operations on a continuous basis;
- For reliability, multiple data sources and communication links should be employed by Regional Advisory and National Warning Centres for receipt and transmission of tsunami-related data and information;
- The advisory dissemination system should be tested regularly;
- IOTWS ICG WG 1 should be requested to resolve the issue of differing seismic waveform data formats to ensure that the data can be used by all those who require it;
- National Centres should make their national seismic waveform data available to all in real-time in a standard format, using the Internet or other networks with sufficient bandwidth. Metadata should also be made available;
- Existing tsunami historical databases should be merged and national centres should be encouraged to extend them;
- Sea-level data frequency should be at least 1-min sampling and 15-min reporting, with overlapping reporting periods to capture missed transmissions. Compiled bulletins from multiple sites may be preferred by recipients, but transmission should not be delayed;
- Countries installing the Deep ocean Assessment and Reporting of Tsunami (DART) system should ensure standard data formats and reporting frequencies are used. Procedures need to be developed to ensure that DARTs can be triggered when required, possibly by a designated Regional Centre;
- Quality control strategies should be developed at both the national and Regional levels to ensure that raw seismic and sea level data are accessible, accurate and reliable;
- Regional Centres should have the capability to process seismic and sea level data and provide to national TWCs processed products. Output from advisory centres should be provided in a variety of formats (text, graphic) and include all parameters required for national warning centres to produce their own warnings (listed in the detailed recommendations);
- The ICG/IOTWS should establish an agreed set of thresholds for determining tsunamigenic potential so that there is consistency in advisories from different centres. The regional centre determines the magnitude and location of an event. These values are then issued by RTACs as guidance to NTWCs. National centres could use the same criteria in instances where the time is too short to wait for advice from a regional advisory centre.

## 1. Opening

1.1 The WMO Workshop on Multi-Hazard, Early Warning Centre's Concept of Operations for the Indian Ocean Tsunami Warning System was, at the kind invitation of the Singapore Meteorological Service, held at Hotel Rendezvous in Singapore from 21 to 23 November 2005. Mr Foong Chee Leong Director-General Meteorological Services and Permanent Representative of Singapore with WMO opened the workshop. He welcomed participants to the workshop and to Singapore.

1.2 Mr Foong noted that many lives were lost in the countries rimming the Indian Ocean as a result of the 26 December 2004 tsunami tragic disaster. Many of these lives could have been saved if a tsunami monitoring and early warning system had been in place. Since then there has been consensus that such a regional system would comprise a network of national warning systems. On the national fronts, he observed that there has been much progress. Many countries had begun to procure or upgrade their existing seismic detection systems to better detect earthquakes, and also acquire tide gauges to better assess tsunamis generation but realised that the observation system a country puts in place allows it to see only part of a big picture. To see the full picture, it is essential that a system be put in place for free and open data sharing.

1.3 Mr Foong emphasized that besides accurate and timely observations, which would help assess whether a disastrous tsunami has been generated, what is equally important is for centres to pass the warning message down to the last person at risk. On a national level, it means reaching down to every coastal province, every coast and every beach, and every person on the beach. On an international level, it means that a country that observes a tsunami would be able to forewarn downstream countries and allow them to take preparatory measures. He urged you, the workshop to consider how to facilitate the sharing of not just data and advisory forecasts but also of instances of tsunami observations.

1.4 Mr Foong recognized that WMO has built up extensive experience and a working system that allows national meteorological centres to share weather observation data openly and freely across continents. Besides sharing observation data, the WMO Global Telecommunications System (GTS) also allows countries to report significant weather and share warnings with one another. In fact the system is already being used for the Pacific Tsunami Warning Centre and the Japan Meteorological Agency to share their tsunami advisory with the Indian Ocean countries. He expressed hope that the regional community could tap upon this system to shorten the learning curve and quickly put in place a tsunami early warning system for this region.

1.5 Mr Foong recognized that besides data and information sharing, another area of WMO expertise is in public weather service, warning the public well in advance of severe weather such as hurricanes or typhoons. This requires warning centres to work with different agencies within their community, such as the emergency planners, the broadcast media and the police. In this regard, many countries would already have some existing systems to communicate quickly to the public impending danger posed by different hazards. He expressed hope that countries could build on these existing systems and communications channels between the warning centres and the emergency planners. He stressed the importance of making use of existing arrangements as much as possible to shorten the process of establishing a working multi-hazard early warning system for the region, while the memory of last year's tsunami is still

fresh in our people's mind before other more immediate issues push the tsunami out of the agenda.

1.6 Mr Foong noted that notwithstanding its favourable geographic position, Singapore is developing a system for tsunami monitoring and early warning as part of the Indian Ocean tsunami warning system that is being developed for the region. The system is based on a multi-hazard concept for natural events such as earthquakes/tremors, tsunamis, etc. The work involves upgrading our existing seismic system and sea-level observing systems. We will contribute the data from this enhanced system to the regional network to allow faster and better assessment of earthquake parameters and tsunami generation. He expressed hope that participants will use this meeting to share experience and ideas to make the regional early warning system materialise.

1.7 On behalf of Mr Michel Jarraud, the Secretary-General of the WMO, Mr Dieter Schiessl, Director of World Weather Watch Department, welcomed the participants. Mr Schiessl noted that The WMO Executive Council at its fifty-seventh session in June 2005 emphasized that WMO's core technical and scientific capabilities should be optimally integrated into disaster risk reduction strategies at the international, regional and national levels. Council had noted among other related issues that WMO will work on strengthening contributions by National Meteorological and Hydrological Services (NMHSs) to hydro-meteorological risk assessment and their active involvement in disaster mitigation and prevention platform at the national level. In particular, the Council strongly supported WMO's contributions to the establishment of the Tsunami Warning System in the Indian Ocean, which is being developed jointly with the Intergovernmental Oceanographic Commission of UNESCO-IOC, the UN Secretariat of the International Strategy for Disaster Reduction and other key partners and relevant international, regional and national agencies.

1.8 Mr Schiessl noted that as a response to the December 2004 tsunami disaster WMO launched an action plan in early 2005, aimed at upgrading WMO Global Telecommunication System (GTS) on the Indian Ocean rim to meet the information exchange requirements for the IO-TWS. The WMO GTS is a dedicated global network of telecommunication facilities operated by countries, which interconnect all NMHSs for the 24/7 exchanges of meteorological and related data, forecasts and alerts. It already provides for the exchange of advisories related to cyclones and severe weather, including in the Indian Ocean region, and supports the Pacific TWS. The GTS will facilitate the exchange of tsunami alerts and related information in the Indian Ocean rim. It is being upgraded for this purpose. He informed workshop that national assessments carried out by WMO experts have, so far, identified the need for upgrade actions in Bangladesh, Comoros, Djibouti, Indonesia, Kenya, Madagascar, Maldives, Myanmar, Pakistan, Somalia, Sri Lanka, Tanzania and Yemen.

1.9 He recalled that WMO cooperates with UNESCO-IOC, ISDR and other key partners towards the establishment of end-to-end tsunami early warning systems in the Indian Ocean and other regions at risk. WMO promotes a multi-hazard, multi-purpose approach to Early Warning Systems with a view to achieving synergies, economies and sustainability.

1.10 Mr Schiessl emphasized that the goal of this workshop was therefore twofold. For one, the workshop should help advancing the development of the multi-hazard, multi-purpose warning systems by developing recommendations on integrating the experience and functions of the existing 24/7 WMO early warning centres, such as selected Regional Specialised

Meteorological Centres (RSMCs) and associated NMHSs. The second goal was to contribute the to defining the operational concept of Tsunami Early Warning Centres in the Indian Ocean.

## 2. Organization of the Workshop

2.1 Election of the Chairs of the Workshop.

2.1.1 The workshop participants elected and installed Mr James WEYMAN (USA) as chair of the workshop.

2.1.2 The workshop designated Mr Kew Leong LIM (Singapore) and Mr René Servranckx (Canada) as Chairs of the Subgroups 1 and 2 respectively of the workshop.

2.2 Approval of the agenda.

2.2.1 The adopted workshop agenda is given in Appendix I

2.2.2 The Workshop participants adopted the agenda as is given in Appendix II.

2.3 Agreement on working arrangements.

2.3.1 The Workshop agreed on the organization of its work including working hours and other arrangements and worked both as a whole for the first day and a half and subsequently in two parallels Subgroups as well.

## 3. Contribution of WMO RSMCs to the operational concept of Multi-hazard Early Warning Centres

3.1 The meeting established a common understanding of the goal of the WMO Workshop on Multi-Hazard, Early Warning Centre's Concept of Operations for the Indian Ocean Tsunami Warning System on the basis of conclusions and decisions of the June 2005 LVII session of the WMO Executive Council as recorded in paragraph 1.7 above. The WMO goal is to contribute its relevant capabilities to the development of end-to-end tsunami early warning systems in the Indian Ocean and other regions at risk. WMO is also committed to developing the capabilities of the National Meteorological and Hydrological Services (NMHSs) of the Indian Ocean Rim countries to establish an effective tsunami early warning system within a multi-hazard framework, particularly related to national multi-hazards alert and response mechanisms. The value of this effort applies not only to all the Indian Ocean Rim countries, but also to all regions at-risk. As contribution to the development of the concept of operations of the candidate Tsunami Warning Centres within multi-hazard framework presentations were made on the concept and the goals of the workshop. In particular the following main conclusions were made:

- Reliable and sustainable Early Warning Systems (EWS) are an effective means to mitigate or prevent losses from natural disasters. Synergies, economies and sustainability of EWS can be enhanced if such systems and corresponding operational warning centres are set up within a framework of multi-hazard multi-purpose strategy to cover several types of natural hazards and address a range of end users and communities. WMO promotes such a strategy and contributes to its implementation

through the generation and exchange of critical information on the occurrence of weather-, water and climate-related hazards. WMO's 24/7 infrastructure of 187 inter-connected National Meteorological Centres (NMCs), which include 32 Regional Telecommunication Hubs (RTHs), 3 World Meteorological Centres (WMCs) and 40 RSMCs, operated by the NMHSs of its Members, effectively contribute to the protection of life and goods, society and economy from natural disasters through timely and reliable advisories and warnings. WMO also contributes significantly to the mitigation of industrial (nuclear and chemical) emergencies and large wild-land fires, which may threaten health and the environment due to large-scale atmospheric pollution.

- Need for integrating WMO's core operational and scientific capabilities into an internationally coordinated multi-hazard disaster mitigation strategy and further the concept of multi-hazard Early Warning Centres (EWCs) as contribution to sustainable and effective disaster mitigation and prevention, and thus directly and practically contribute to the establishment of the Indian Ocean TWS.

Objective of Workshop:
To develop advice and recommendations for Tsunami Warning Centres' concept of operations (i.e. arrangements, procedures, standards) for a "24/7" Tsunami Warning System in a multi-hazard, early warnings approach with respect to:

•Organizational arrangements,
•Operations and Procedures,
•Standards,
•Communications,
•Output coordination,
•International collaboration.

Essential aspects of early warning system:

•Risk assessment - prior knowledge of the risks faced by communities and the various socio-economic sectors
•Operational monitoring, detecting, forecasting and warning - technical facilities and warning services
•Alert - dissemination of understandable warnings to authorities and those at risk
•Preparedness and Response - knowledge and preparedness to act appropriately in response to alerts

Challenges:

•Development of a practical framework (flexible enough to respond to emerging needs and challenges)
•Technical – development of inter-disciplinary approach to EWS (bridging disciplines, methodologies, information exchange)
•Legislation – clarification of the roles of different players/agencies working in a multi-disciplinary international decision making process
•Organizational – identification of responsibilities, incentives to overcome organizational turf issues
•Operational – coordinated effective utilization of resources and expertise

WMO will organize a multi-agency symposium to advance this area:

•Geneva, Switzerland (March 1-2, 2006)
•Involving major international agencies and top experts involved in EWS

•Goal is to develop recommendations towards development and implementation of multi-hazard, multi-purpose EWS
•Outcomes will be input into EWC-III (Germany, March 2006)

The USAID/NOAA goal:

•Under USAID funding, National Oceanic and Atmospheric Administration (NOAA) plans to upgrade portions of the Indian Ocean Global Telecommunications System so that data and warnings for all hazards including Tsunamis will reach selected National Centres within a few minutes of the time the message was sent. NOAA is partnering with the World Meteorological Organization and plans to upgrade slow links in the GTS Indian Ocean regional network in Sri Lanka and Maldives among others.
•NOAA is also assessing functionality of National Wide Area Networks that link data and warnings from National Meteorological Offices, National Disaster warning and response centres and seismic centres so that Warnings can be transmitted instantaneously to people at risk in coastal regions.

3.2 Presentations of the unique experience of the WMO RSMCs on tropical cyclone forecasting of operational practices and procedures and role of associated national Meteorological Services (NMSs) were made by RSMCs Honolulu, Tokyo, New Delhi and La Réunion as contribution to the development of the concept of operations of the candidate Tsunami Warning Centres within multi-hazard framework. These presentations were compiled and made available to participants on a CD-ROM. The WMO Tropical Cyclone Programme (TCP) is established and maintained to primarily address the requirements for real-time operational meteorological watch, detection and to locate and forecast trajectory and intensity of Tropical Cyclones. WMO has implemented and maintained the operational Global and Regional Arrangements for the provision of specialized tropical cyclone advisory products provided by 6 designated WMO Regional Specialized Meteorological Centres (RSMCs), with activity specialization in tropical cyclone forecasting, to its Members. The role of the national meteorological service includes interpretation of the advisory products and providing warnings to national disaster management agencies, other responders and the public. These presentations were made available on a CD-ROM and distributed to participants.

3.3 Presentations were also made by the chairman of the WMO Emergency Response Activities Coordination Group, RSMC Melbourne, and the ASEAN Specialized Meteorological Centre of their unique experiences of the WMO RSMCs, ASMC and role of NMSs in, nuclear emergency response activities, detection and forecast of volcanic ash and smoke from wild-land fires. These presentations were made available on the CD-ROM distributed to participants. The WMO Emergency Response Activities (ERA) programme is established and maintained to primarily address the requirements for real-time operational meteorological support to nuclear accidents and radiological emergencies. The WMO, jointly with the International Atomic Energy Agency, has implemented and maintained the operational Global and Regional Arrangements, for provision of specialized atmospheric transport modelling products provided by 8 designated Centres of the WMO to its Members. The role of the national meteorological service includes interpretation of the products and providing advice to national disaster management agencies. The lead role in issuing warnings to disaster management agencies rests with the national atomic energy/radiation protection agency. In particular the following main concepts, practices and operational procedures were identified as essential elements in a multi-hazard early warning centre:

Key elements for a real-time warning system

•The success of the IAEA/WMO RSMC real-time operational response system is based on a number of key elements. Many of these can be considered in a generic sense as applicable to the overall question of making a real-time warning system work:

Clear and well defined procedures and operations

•WHO CAN REQUEST RSMC SUPPORT? IAEA or Delegated Authority
•HOW? Fax or phone call with use of specific request form
•WHAT ACTIONS ARE EXPECTED? Defined on the request form
•WHO CAN RECEIVE RSMC PRODUCTS? IAEA and specific national contact point in each of WMO Member States

24/7 Real-time operational response system (IAEA, RSMCs, NMHSs)

Equally important: Operational efficiency/timeless (ability to respond and deliver products quickly) and accuraty of products (based on sound and sophisticated global meteorological and transport / dispersion models)

Respect of the International and National roles/authority of agencies and states

Redundancy and backup systems and centres (joint response by 2 or 3 RSMCs; independent mirror web pages; agreement of mutual assistance between RSMCs)

Communication tools adapted to national capabilities (Fax, web, email, etc.)

Regular testing
Regular Regional and International tests are conducted between the RSMC and IAEA. For example, monthly tests are done by RSMCs Montreal, Melbourne and Washington; quarterly tests are conducted between the IAEA and the RSMCs, while full blown international tests are done every 2 to 4 years. These help maintain an operational readiness and facilitate the identification of problems in the response system.

Documentation and training (web page, WMO training document 778 and occasional workshops)

Ongoing review of procedures, issues and requirements for future work and developments (WMO Coordination Group on Nuclear Emergency Response Activities)

Some factors identified to be considered in Building a warning and response system include:

- Global-Regional-National-Community,
- Build an integrated End-to-End System,
- Be collaborative- Go cross-sector,
- Involve Stakeholders,
- Build it to last,
- Go all-Hazards.

Issues to be considered in concepts of operation for the multi-hazard forecast centre:

- What is mission? Regional? National?
- Who are users?
- What is infrastructure?
- Personnel requirements
- Hours of operation
- Hardware needed?
- Software? Models?

- How do you define forecast operations?
- How operate in routine vs. extreme event?
- What are the roles & responsibilities of forecasters (training requirements)?
- What are forecast centre products and deadlines?
- Describe data flow and communications of products, data, forecasts, warnings,

- Standard operating procedures,
- Emergency procedures and backup,
- Non-forecasting activities,
- Training,
- Data quality control and archive,
- Back up procedures,
- Trouble shooting,
- Forecast verification.

## 4. Current practices and procedures of tsunami warning centres (TWCs)

4.1 The workshop was informed of the outcome of the IOC Intergovernmental Coordination Group (ICG) Working Group 4 report. Presentations were made of the current experiences of the JMA national tsunami warning practices and procedures and PTWC tsunami advisory and warning practices and procedures for the Pacific basin, and their respective interim operational arrangements for the Indian Ocean. Presentations were also made of current operational practices and procedures of Australia and India National Tsunami Warning Centres (NTWCs)/NMSs. These presentations were provided on the CD-ROM and distributed to participants. The operational objective of the Tsunami Warning System (TWS) is to detect and locate major earthquakes in the Indian Ocean region, to determine whether they have generated tsunamis, and to provide timely and effective tsunami information, advisory and warnings to the population of the Indian Ocean to minimize the hazards of tsunamis, especially to human life and movable property. To achieve his objective, the TWS has to establish and implement practices and procedures that ensure continuous monitoring, processing and dissemination of the seismic activity information and related impact on sea level of the relevant Ocean and if appropriate suggested response actions to national disaster management agencies, other responders and the public. In particular the following concepts, practices and operational procedures were emphasized as essential elements in a multi-hazard early warning centre:

PTWC key operational activities:

- Seismic data collection & analyses,
- Tsunami wave measurements,
- Decision-making processes,
- Message creation & dissemination.

PTWC operations for Local Tsunami:

- Analysts review & revision (1-3 min),
- Verify it's an actual local earthquake,
- Select from automatic hypocenters,
- Revise hypocenter with additional data,
- Interactively compute magnitudes,
- Decide best hypocenter and magnitude,
- Check run-up and sea level data,
- Compare to criteria and issue message.

The public must be educated to respond immediately based upon having felt shaking from the earthquake and upon hearing sirens, EAS, or NWR alerts. There is no time to verify the warning or wait for instructions.

PTWC operations for a Teletsunami:

- Analysts review & revision (1-3 min),
- Verify it's a large pacific earthquake,
- Select from automatic hypocenters,
- Revise hypocenter with additional data,
- Interactively compute magnitudes,
- Decide best hypocenter and magnitude,
- Compare to criteria and issue message.

Designated Agencies must be prepared with an Operations Plan to respond quickly and alert the public when necessary based upon the information received from PTWC and any supplemental data or information they may receive. This could include advice from local experts.

## 5. Development of recommendations for concept of operations of regional Tsunami Advisory Centres (RTACs) and NTWCs

5.1 Presentations were made by the representative of the UN/ISDR on Multi-hazard approach for better early warning and disaster risk reduction, and the participants from Tsunami Warning Centres (TWCs) of Thailand and Malaysia, NTWCs of Mauritius, Tanzania and Singapore on status of planning and operation of the emerging centres. These presentations were also available on the CD-ROM and distributed to participants.

5.2 The Workshop formed two sub-groups and developed advice on practices and procedures, needed to assure the IOTWS operational objective and other multi-hazard early warning systems are achieved.

Subgroup 1 Chaired by Mr Kew Leong LIM (Singapore) addressed the following issues among others:

- Notification and provision of incident data with tsunamic generating potential to TWCs,

- Collection and provision of sea-level and sea state including deep sea-wave monitoring data and information to TWCs,

- Reliability and readiness of related aspects of the above bullets
  - Contingency plans, preparedness (tests and exercises), operational redundancy.

Subgroup 2 Chaired by Mr René Servranckx (Canada) addressed the following issues among others:

- Generation and dissemination of tsunami advisories at regional advisory centres,
- Generation and dissemination of tsunami warnings at national warning centre,
- Dissemination to national disaster management agency and other responders including the targeted local communities,
- Reliability and readiness of related aspects of the preceding two bullets
  - Contingency plans, preparedness (tests and exercises), operational redundancy.

## 6. Presentation of reports of sub-groups on Conclusions and Recommendations

6.1 The Chairman of each sub-group made presentations of their respective discussions and their conclusions and recommendations. The workshop plenary session reviewed and adopted the Conclusions and Recommendations for Concept of Operations of TWS within Multi-Hazard Warning Systems as given in the *Annex to this paragraph.* The guidance as developed by the workshop will be used by WMO in further development of its multi-hazard concept of operations and will also be provided to the IOC Intergovernmental Coordination Group (ICG) for the IOTWS, in particular its Working Group 4.

## 7. Adoption of final report of the workshop

7.1 The workshop plenary session reviewed and approved this report.

## 8. Closure

8.1 The workshop was closed on the 23 November 2005

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**Reference**: *WMO Workshop CD-ROM of all presentations*

## Annex to paragraph 6.1

### Conclusions and Recommendations for Concept of Operations of TWS within Multi-Hazard Warning Systems

### 1 Concept of Operations: Conclusions

**Early Warning Centres**
The Regional Advisory Centres and National Warning Centres of the IO/TWS should be implemented as soon as feasible, since JMA and PTWC will continue to act as interim RTACs but wish to withdraw as soon as the region has capacity to carry on, and because PTWC and JMA are only able to provide limited services.

The regional advisory and national tsunami warning centres should be encouraged to work as a network. They should be encouraged to build a common program including the exchange of knowledge and expertise. There should be a program of training of regional and national centres' staff. A proven model is the WMO Tropical Cyclone Program and the Nuclear Emergency Response Activities programme. The IOC Pacific system is a good example to follow. But we need to consider regional differences.

Coordination is required among Regional Tsunami Advisory Centres (RTACs), NTWCs and media as well as National Disaster Management Office (NDMO) or other agencies.

The workshop recognized a two-tiered TWS would be necessary. This two-tiered system would consist of:

RTACs

- With capacity to produce advisories and to accomplish recommendations included in paragraph 2.

NTWCs

It is recognized that there will be different capabilities in National TWCs:

- Those using advice from Regional Centre without modification.
- Those capable of doing some analysis of sea level and/or seismic data to aid local decisions.
- Those wanting all possible sea-level and seismic data to independently carry out complex modelling and produce all aspects of local warnings.

A possible model for the concept of operations of the TWS of tsunami advisories and warnings is given in the Appendix to this Annex.

The workshop suggested the consideration of existing centres that are currently designated as WMO regional advisory centres, (e.g. RSMCs) may become the RTACs, because they currently provide 24/7 operations and have experience in providing advisories.

It was suggested that the TWS be within the framework of a multi-hazard multi-purpose system. This system needs to be robust, resilient and flexible to accommodate all current and future hazards. But need to work on a generic system, and then ensure it handles tsunami requirements. For shipping in international waters, liaison is needed between regional and national centres to reach an agreed advice statement.

On a national basis, there are specific characteristics of tsunami warnings justifying special requirement as compared to different types of warnings. When justified there is a need to keep processes separate, especially when the biggest difference is in the time scale. A distant event is more similar to other warning situations. For a close event there is a requirement for a virtually automated system because there is insufficient time for manual intervention.

On a national basis, the distribution of warnings will be handled most efficiently through an agency that operates on a 24/7 basis, and is active in routine operations on a continuous basis. NMS operate on this basis and are appropriate candidate agencies to do this. Where National Disaster Warning Centres (NDWC) or other centres also operate continuously they could be included in the real-time distribution process. The national dissemination system should include redundancy to cover possible outage at the time of an event.

**Telecommunications**
The future GTS communications architecture (WIS), initially to be implemented by mid-2006 will overcome some current shortcomings including access by external agencies.

**Data / Information / Products**
An essential requirement is the free and open real-time exchange of essential observational data, metadata, products and catalogues of available information in standard format via GTS and its future replacement system, WMO Information System (WIS).

## 2 Concept of Operations: Recommendations

### 2.1 Early Warning Centres

**Regional Advisory Centres**
Regional Centres, like National Centres should be operational 24/7.

Current JMA and PTWC Operating Procedures should be synthesized to form an initial guide for the establishment of Regional and National Centres.

Regional Centres should be able to access all seismic waveform data via the Internet or other communication means and generate parametric data in real-time for distribution on the GTS.

Each Regional Centre should have arrangements in place to be backed up by another Regional Centre, and those arrangements should be regularly tested.

Regional Centres should have the capability to run operational tsunami propagation models, which generate products relevant to that Region.

Structured training in tsunami warning procedures and science should be established and be applied in all Regional Centres. Event simulators, which can be played back in real-time, are very desirable.

It is recommended that there needs to be a designation and accreditation process for the regional advisory centres through IOC ICG/IOTWS. If IOC decides to use either the WMO RSMC framework concept or to apply a multi/hazard approach, then it is

recommended that consultation be conducted with WMO. It is recommended that each centre would have a defined area of responsibility with a designated backup centre for each area. A geographic balance between designated centres would be desirable.

**National Warning Centres**
On a national basis, the distribution of warnings will be handled most efficiently through an agency that operates on a 24/7 basis, and is active on routine operations on a continuous basis.

Structured training in tsunami warning procedures and science should be established and be applied in National Centres. Event simulators, which can be played back in real-time, are very desirable.

## 2.2 Telecommunications

For reliability, multiple data sources and communication links should be employed by Regional Advisory and National Warning Centres for receipt and transmission of tsunami-related data and information.

The advisory dissemination system should be tested regularly.

## 2.3 Data / Information / Products

IOTWS ICG WG 1 should be requested to resolve the issue of differing seismic waveform data formats to ensure that the data can be used by those who require it.

National Centres should make their national seismic waveform data available to all in real-time in a standard format, using the Internet or other networks with sufficient bandwidth. Metadata should also be made available.

Existing tsunami historical databases (x2) should be merged and national centres should be encouraged to extend them.

Sea-level data frequency should be at least 1-min sampling and 15-min reporting, with overlapping reporting periods to capture missed transmissions. Compiled bulletins from multiple sites may be preferred by recipients, but transmission should not be delayed.

Countries installing DARTs should ensure standard data formats and reporting frequencies are used. Procedures need to be developed to ensure that DARTs can be triggered when required, possibly by a designated Regional Centre.

Quality control strategies should be developed at both the national and Regional levels to ensure that raw seismic and sea level data are accessible, accurate and reliable.

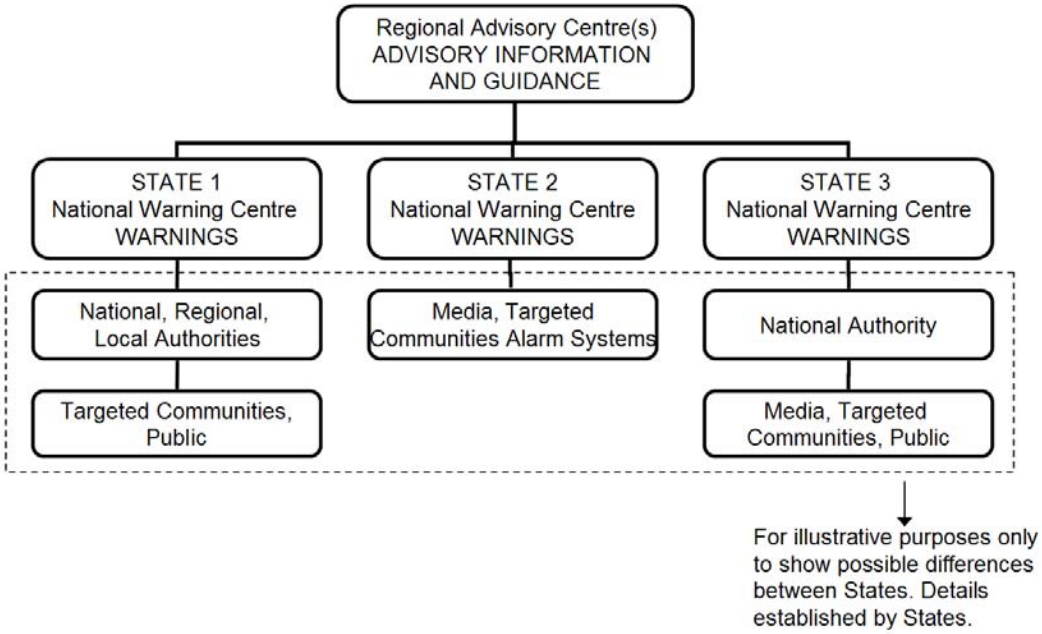
Regional Centres should have the capability to process seismic and sea level data and provide to national TWCs processed products. Output from advisory centres should be provided in a variety of formats (text, graphic) and include all parameters required for national warning centres to produce their own warnings. Event information and products should include such things as:
**seismic** : magnitude, location, depth, and time
**sea level** : evidence of an actual tsunami having been generated
**travel time** : preferably graphical information
**threat** : local, regional, global, general severity

**issue of advisories** : as soon as possible but within 30 minutes and if amendment required including a requirement to cancel.
Map of earthquake location
Map of tsunami travel times from earthquake location
Map showing historic tsunamigenic events in the vicinity of the event
Real-time sea-level data with tidal fluctuation removed.
Maps of modelled tsunami energy distribution

The ICG/IOTWS should establish an agreed set of thresholds for determining tsunamigenic potential so that there is consistency in advisories from different centres. The regional centre determines the magnitude and location of an event. These values are then issued by RTACs as guidance to NTWCs. National centres could use the same criteria in instances where the time is too short to wait for advice from a regional advisory centre.

**Appendix of Annex to paragraph 6.1**

## Concept of Operations for Indian Ocean Tsunami Regional Advisory Centres and National Warning Centres



## Appendix I

## AGENDA

**1. Opening**

**2. Organization of the Workshop**

2.1 Election of Chair of the Workshop and designated chairs of in-session subgroups

2.2 Approval of the agenda.

2.3 Agreement on working arrangements.

**3. Contribution of WMO Regional Specialized Meteorological Centres (RSMCs) to the operational concept of Multi-hazard Early Warning Centres**

**4. Current practices and procedures of Tsunami Warning Centres (TWCs)**

**5. Development of recommendations for concept of operations of Regional Tsunami Advisory Centres and National TWCs**

**6. Presentation of reports of sub-groups on Conclusions and Recommendations**

**7. Adoption of final report of the workshop**

**8. Closure**

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## Appendix II

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