DRAFT Minutes

ICG/IOTWS Working Group 2 on Sea Level Data Collection and Exchange, including Deep Ocean Tsunami Detection Instruments

Inter-sessional Meeting
1-2 May 2006, Melbourne, Australia

1. INTRODUCTION

Working Group (WG) 2 Sea Level Data Collection and Exchange, including Deep Ocean Tsunami Detection Instruments met on 1-2 May 2006 in Melbourne, Australia to follow upon the recommendations made at the ICG-II meeting in Hyderabad. The meeting was held jointly with the Sea Level working group for the Pacific Tsunami Warning System (PTWS).

2. ATTENDEES

The meeting was attended by about 40 scientists and government officials representing PTWS and IOTWS Member States, Organizations, and other Agencies and Universities. A list of Participants is given in Annex II. The WG was co-chaired by Mr Rick Bailey (Chair of PTWS WG-2) and Mr K. Premkumar of NIOT-MoOD, India (Chair of IOTWS WG-2).

3. AGENDA / PURPOSE OF MEETING

The inter-sessional meeting was initially scheduled to advance the development of the International Tsunameter Partnership and the development of core network concepts and instrument standards for the deep ocean stations in the IOTWS. The arrangement to meet jointly with the PTWS Working Group 2 presented an opportunity to have a broader exchange of information and to jointly progress other issues of common interest. These related to sea level measurement technology and instrument standards, observation network design, data exchange, and inter-ocean basin coordination.

ICG/PTWS and ICG/IOTWS Breakout Sessions were included to discuss basin-specific requirements of the sea level network.

An agenda item of particular importance to the Indian Ocean community was the consideration of a proposal by the US to contribute two deep ocean (DART) stations to support the IOTWS, and a request that the ICG review proposed locations, and the means by which IOTWS member states might contribute to the deployment and sustain

The Meeting Agenda is provided in Annex I

4. DISCUSSION RECORD

4.1 Review of Action Items from Previous Meetings

(Refer Annex IX)

4.2 Instrument Standards and Sea Level Network Design Principles for Tsunami Monitoring and Warning

The discussions covered the requirements for sea level observation stations, and networks, particularly for coastal stations, to support the detection and characterisation of tsunami waves, and the timely dissemination of observation data to meet the needs of national, regional or basin-wide warning systems and of modellers and researchers.

Discussion papers were circulated prior to the meeting. Mr Kelvin Wong (Australian Bureau of Meteorology) circulated a draft paper setting out proposed data formats for international sea level exchange (using the WMO CREX standard). Refer to paper at Annex VI.

Jane Warne (Australian Bureau of Meteorology), circulated a discussion paper *Reporting Rate and Data Transmission,* analysing instrument sampling and data reporting rates applicable to various applications of the data, including meteorological oceanographic applications, climate monitoring and tsunami detection. Refer to paper at Annex VII. The paper was supported by a presentation during the meeting.

Bernie Kilonsky delivered a presentation on the *GLOSS Sea Level Observing System*, which included consideration of different instrument sampling and reporting regimes according to the proximity of data users to tsunamigenic zones (see summary in discussion record below).

Alexander Rabinovich, (P.P. Shirsov Institute of Oceanology), delivered a presentation on *Open-Coast Tsunami Recording and Negative Influence of Infragravity Waves*
His presentation described two case studies from the coast of British Columbia, Canada, and the South Island of New Zealand. The results of both studies suggest that non-linear interaction of swell waves greatly increases the background noise measured at tide gauges, and therefore they are best located in sheltered areas such as harbours, rather than on open coastlines.

The following topics were discussed:

Discrimination of Wave Height and Dynamics:
The resolution of the smallest wave height of interest for confirming the presence of waves, for use by forecast systems, or for determination of an "all-clear" state. The need to discrimination of near-coast waves of 0.5m peak-to-trough was reported by some participants, with deep ocean wave discrimination of 1cm to 3cm peak-to-trough (dependent on the local noise environment). The sampling rates needed to estimate wave shapes with sufficient accuracy (especially for estimation of peak-to-trough wave heights), without serious compromise due to sample-rate aliasing.

It was noted that the ability to characterize small (non-damaging) waves and potentially to capture wave dynamics or superimposed higher-frequency wave artefacts could be of significant value for post-event analysis, for the tuning and improvement of warning systems, and for the longer term understanding of tsunami phenomenon.

Frequency of Reporting / Transmission
Dictated by the warning system decision time constraints, which are specific to local circumstances (eg proximity of threatened communities to a tsunami source). The IOTWS WG-2 meeting in Hyderabad had set out a minimum standard for instrument sampling and reporting (1 minute sampling and 15 minute reporting), aimed at basin-wide data transmission via the GTS. Mr Kilonsky included in his presentation on GLOSS a proposition for standards for a multi-tiered system of instrument sampling and reporting rates, according to the locality and circumstances of the end users - eg national, regional or basin scale. Features of this new standard, which are proposed by the ICG/NEAMTWS and ICG/CARIBE-EWS where local tsunami hazards are a large concern, are:

Sub-regional

- A sampling of 15 second averages and a continuous transmission cycle of 5 minutes for sites within 1 hour travel time of the tsunamigenic zones:
- Immediate retransmission via WMO's GTS to JMA, PTWC, and other appropriate warning centers. (The European and Japans' geostationary meteorological satellites can not be used as they are limited to a 15 minute transmission cycle.)

National

- A sampling of 15 second averages and a continuous or 1 minute transmission cycle for sites within 100 km of the tsunamigenic zones:
- Immediate retransmission via WMO's GTS to JMA, PTWC, and other appropriate warning centres.

These propositions are to be discussed at the IOTWS/ICG-III meeting in Bali.

Network Spatial Density
Required to ensure both timely recognition of tsunami waves and the timely cancellation of alerts. Again, dictated by local factors of warning time and proximity to tsunami sources.

Optimal Siting
The discussion of optimal location canvassed the relative merits and weaknesses of coastal sea level monitoring sites in harbours, islands, and open-ocean sites. Tradeoffs included the possibility of signal compromise due to noisy sea states (open ocean exposure), location-specific noise environments around islands, and exposure to delays and harbour resonances in "quieter" harbour sites.

Glossary of Terms / Common Language Set
The WG noted different use of terms by participants, and the need to standardise on a commonly used and understood language set, including terms such as "wave height" or "amplitude", (amplitude, or peak-to-trough measurement), "run-up", "arrival time" (initial vs maximum), "wave period", "inundation distance", etc

Mr Kilonsky's presentation on the GLOSS network reviewed the physical standards for the Indian Ocean instruments that were discussed at the ICG-I and ICG-II meetings. He reported that in addition to offering in-situ sea level gauges GLOSS also assists ICGs to set data standards, offers training courses, technical visits, technical manuals and training material, and holds workshops on special issues. He informed the WG of the activities in the Indian Ocean concerning the need for more densely spaced data networks to adequately monitor coastlines with significant tsunami hazards such as the western and southern parts of Indonesia and in the Makran source area of the Arabian Sea.

The WG noted that no single approach to network design, instrument characteristics, and data sampling and reporting rates fitted all end user requirements, and that:

- There is a need for the statement of a minimum set of specifications for interoperability, taking into account different regional or sub-regional requirements based on tsunami hazard and vulnerability assessments – network may need to be more dense in some regions (for example, in sub-regions where local tsunamis are a hazard).
- There is need for the identification of minimum wave detection thresholds for tsunamis (including warning cancellation), and to relate that to sampling intervals and to quantifiable uncertainty limits in instrument measurements.

Action: Joint WG to coordinate development of network design principles by ICG/IOTWS-III in Bali in July 2006 (Chair Jane Warne, Australia). This should consider the new proposed standards for sea level sites within 1 hour of tsunami travel time and/or 100 km of tsunami generation areas, and the implications of these standards in terms of network design.

The WG then further considered the importance of maintaining and sustaining a sea level observation network for infrequent hazards such as tsunami. Members of the WG2 noted that the sea level gauge specifications for tsunami detection and monitoring were different from those required for climate change detection (eg in the need for reference to a geodetic datum). Therefore instruments for tsunami detection could be cheaper to install and support, making it also possible for denser networks due to cost savings.

Recommendation: That the CREX format be adopted for the transfer of sea level data from one nation to other warning centre. (Member countries have been provided with copies of CREX format for their study and confirmation before IOTWS Bali meeting in July 2006.)

Recommendation: Wherever possible, installation should be of multi-purpose observing sites to facilitate the long-term sustainability of the observing network

Recommendation: Wherever possible, and in the interim, sea level stations should conform to GLOSS climate related standards, but the WG noted that requirements for tsunami detection need not coincide with those of GLOSS, and could conceivably be single-purpose or multi-purpose, with application to services other than climate monitoring.

Action: Bernie Kilonsky to advise by ICG/IOTWS-III in Bali July 2006 the additional cost of making a sea level gauge that is suitable for tsunami detection, to equip it to be also capable of monitoring sea level for climate change detection.

4.3 Sea Level Measurement Technology

The WG discussed the various present and future technologies available for measuring tsunami waves, and the plans of various Member States in both the Indian Ocean and the Pacific communities to enhance the monitoring networks. It was noted that a wide range amount of technologies are being explored, so coordination is highly desirable. The range of technologies in use or under consideration include:

- Coastal HF radar, altimeters, run-up gauges, coastal cameras, accelerometers on ships, GPS buoys, fibre-optic cables, current monitoring, sea level gauges using multiple technologies etc

Recommendation: Chairs of relevant IOTWS and PTWS Working Groups to ensure coordination and communication of outcomes from evaluations of existing and new technologies (e.g. radar).

4.4 Sea Level Data Exchange and Archival

Communal Access to Event Data Sets

The Working Group noted that communal access to data sets, including historical data sets with relevant metadata, and other information or evidential material was important both for the development of warning systems and forecast models, and for post-event analyses.

Alexander Rabinovich requested that any WG participant or ICG member country having access to observation data or other evidential material for the December 26 Sumatran tsunami event make that data available to him.

Bernie Kilonsky requested that any WG participant or ICG member country contact him with regard to historical data sets or evidential material, in whatever form (including paper based records), for the purposes of archiving.

Stuart Weinstein, PTWC, US Dept. Of Commerce, gave a presentation on *GTS Sea Level Data Processing.* His presentation included a demonstration of the TideTool software, using a Tcl/Tk decoder. Tcl/Tk is based on platform independent shareware, which is available to all countries. Indian Ocean countries wishing to use the software need to have GTS data downloaded onto a file on a PC.

4.5 Deep Ocean Stations – Instrument Technology

David McKinnie, NOAA, gave a presentation on *Recent DART Technology Developments*
His presentation opened with a review of the history of DART technology, including past and present operational DART II products, and the concept of a new easy-to-deploy variant, which is undergoing proof-of-technology trials. He emphasized the need for affordable, reliable tsunami detection systems, and introduced two alternate suppliers of the technology. Reference was made to other actual or prospective tsunami buoy suppliers, including Envirtech and Sonardyne, and the German-developed product that has deployed in Indonesia.

David then introduced representatives of two suppliers present at the meeting. Tony Elliott of Fugro Oceanor advised that their product had been delivered to Malaysia and deployed in

Malaysian waters. Rob Lawson of SAIC (USA) presented a summary of his company's current work in the production of operational DART buoys for the US network, and the state of SAIC's development of new product variants. Two tsunami buoy product concepts developed by a consortium involving Vaisala, Aanderaa and Benthos were also briefly presented.

4.6 Consideration of US Proposal to Contribute Two DART Buoys

Prior to the meeting, the US Government circulated a proposition for the contribution of two DART II Standard buoys as warning and inter-comparison stations to assist the development of the IOTWS. The U.S. government sought an ICG/IOTWS Working Group 2 review of the proposed contribution, and discussion and refinement of siting options. It also sought the Working Group's consideration of means by which the IOTWS member states might collaborate with the US on the development of a training and capacity building program that would lead to the long term sustainability of the DART stations. Refer attached US proposal at Annex IV.

During the meeting, Dr Eddie Bernard (NOAA) (by teleconference) and David McKinnie (NOAA) delivered a presentation to support the WG2 discussion- *United States Proposal for DART Buoy Deployments in the Indian Ocean.*

It was explained that US Government legislation required that US contributions to the IOTWS focus on delivering benefits to five countries - India, Sri Lanka, Maldives, Thailand, and Indonesia. There was also a strong preference for the stations to be deployed outside the Exclusive Economic Zone (EEZ) of any one nation.

To develop siting options, NOAA conducted an analysis that refined the initial conceptual array discussed in Hyderabad by including population densities and major cities and the boundaries of exclusive economic zones. The results of new simulations were presented. They showed which siting options, outside any nation's EEZ, would provide the longest warning lead times to India, Sri Lanka, Maldives, Thailand, Indonesia for threats from the Sumatra fault and Sundra Strait.

As a result, three candidate sites were proposed (*Figure 1*), and staged deployment strategies considered. Two options for siting and deployment of the buoys were proposed.

The first option involved deployment of one buoy at 0°N 92°E between September and December 2006, and the second at 9°N 89°E between January and May 2007. This option provided best overall potential warning times for region by May 2007.

The second option involved deployment of the first buoy to provide an optimum initial coverage, and then relocation of that buoy at the time when the second DART station was deployed.

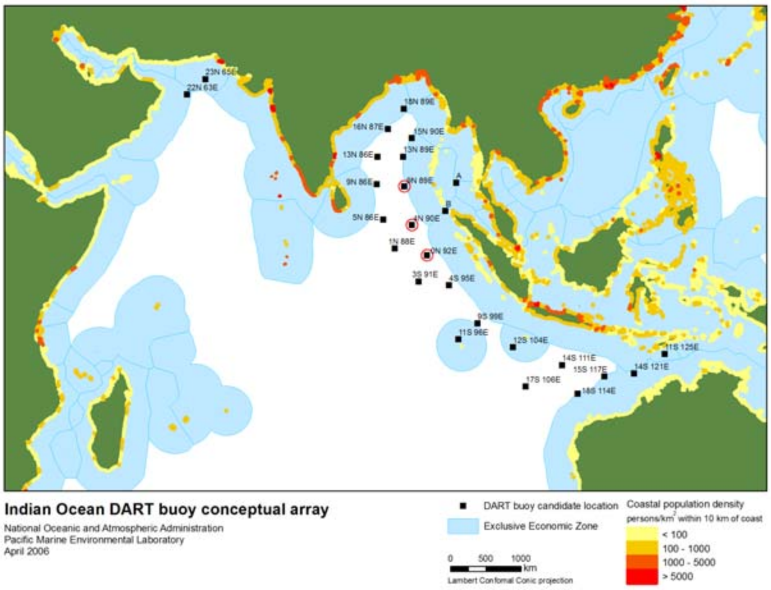


Figure 1 High Value Candidate Sites for DART Deployment within IO Conceptual Array

There was considerable discussion on the rationale for the location of the buoys, and their relationship to the priorities of IOTWS countries, and to neighbouring deep ocean stations planned for national warning networks.

A written communication was received prior to the meeting from Dr. Jörn Lauterjung, Coordinator of the German-Indonesian TEWS, who was unable to attend. It requested that the buoy positions proposed by the US be reconsidered to address the possibilities for locations within national EEZs to address the priorities of communities (including the Andaman Islands and Indonesia) that were subject to very short warning times from nearby tsunamigenic sources.

During the discussion, the WG noted and commended the plans by India to deploy nationally sourced deep ocean stations within Indian EEZ in close proximity to at least one of the deployment sites indicated in the US proposal (refer to National Reports). These Indian buoy deployments are to start in the second half of 2006.

Recommendation
After full discussion, the representatives of the IOTWS WG2 representatives agreed that:

- The Working Group appreciates the offer of 2 DART buoys
- The Working Group endorses the siting logic explained by NOAA, and recognises that it provides additional value to the Indian Ocean community.
- The constraints of not being able to extend similar assistance to other parts of the Indian Ocean are recognized and accepted.
- The Working Group encourages member countries to support the deployment and ongoing operation of the US donated buoys.

Malaysia strongly recommended the timely execution of the buoy deployment and the development of suitable support arrangements, preferably before the IOTWS meeting in Bali.

4.7 IOTWS Sea Level Network Design – National Reports

Time did not allow for a review of all national tsunami sea level observation networks, although presentations were made available from India and Malaysia.

India. Mr K Premkumar of NIOT, India delivered a presentation: *India's Plans for Deep Ocean Tsunami Buoy Deployments*

Mr Premkumar informed that India plans to deploy Deep Ocean tsunami buoys similar to NOAA DART Buoys. The planned deployment sites are within India's EEZ. Locations have been chosen to be consistent with the conceptual "core station" array provided by PMEL at the Hyderabad meeting. They were well placed to serve neighbouring countries, as well as India.

Mr Premkumar informed that NIOT has selected three firms namely FUGRO OCEANOR, Norway; Envirtech, Italy; Sonardyne, UK to supply the buoys. Two units from each supplier are to be acquired, with bottom pressure recorder systems having the same pressure sensor and detection algorithm as the US DART buoys. These bottom units will be coupled with NIOT's proven surface buoy system. India's tentative deployment locations are shown below.

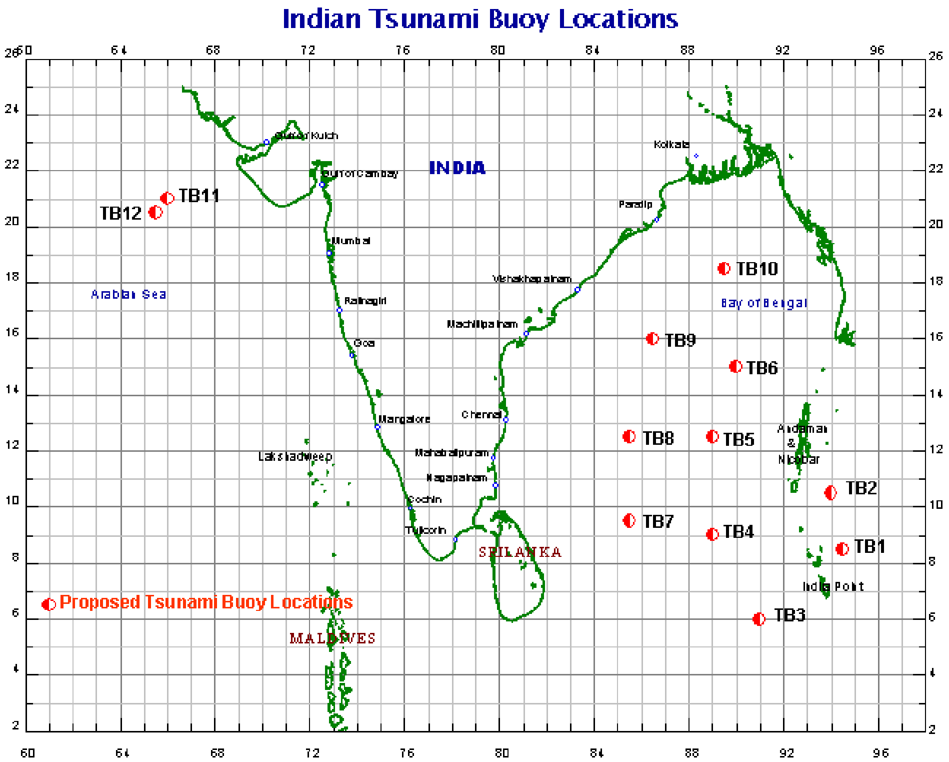


Figure 2 Planned Locations for Indian Deep Ocean Tsunami Buoys

Malaysia. Malaysia delivered a presentation that had been developed for the recently held meeting: *Round-table Dialogue on Earthquake and Tsunami Risks*. The presentation detailed the planned locations for three deep ocean tsunami buoys, and tide gauge stations and a coastal camera network. These are not presented in this report, but will be incorporated in a consolidated IOTWS database of planned and operational tsunami observation stations.

Indonesia. A written report from Indonesia (specifically, on the contribution of the German-Indonesian Tsunami Warning Project (GITEWS) – refer Annex V. It confirmed the plan to deploy 10 Buoy-Systems along the Sunda Arc structure from the northern edge of Sumatra to the region east of Bali, placed at a maximum distance of about 50 km from the trench, so they can register a tsunami west of the trench within 5-7 minutes. The two buoys deployed in November 2005 are designates test systems for the trial of new technologies. Experience with them will be used for system optimizations.

4.8 International Tsunameter Partnership

A number of national representatives to the International Tsunameter Partnership (as nominated in Hyderabad) were not able to be present at the meeting. The ITP Draft Terms of Reference that were tabled at the Hyderabad meeting had been circulated to those representatives, and some minor revisions to the Terms of Reference issued as a result of feedback. See Annex V for the revision. Ken Jarrott (WG Chair – Deep Ocean Stations) presented the Terms of Reference to the joint PTWS / IOTWS Working Group, which for the first time included representatives from PTWS nations. A recommendation was made to the ICG / PTWS to endorse the concept of the International Tsunameter Partnership.

Mr Premkumar (India) recommended that the concept of the partnership be considered for other novel technologies that may be applicable to the global tsunami warning systems.

Progress in respect of the IOTWS membership of the Tsunameter Partnership will be pursued at the Bali IOTWS meeting.

4.9 Other Matters

Dr Gary Meyer (CLIVAR / GOOS Indian Ocean Panel Chair) delivered a presentation on other elements of existing and planned sustained ocean observing systems in the Indian Ocean, including fixed ocean moorings, XBTs Argo Floats, tide gauges and drifting buoys. He raised the issue of synergies with the development and operation of the IOTWS tsunami observation network, including the potential to host other sensors on deep ocean tsunami stations, and the prospect of joint use of ship assets for buoy deployments and maintenance.

ANNEX I - MEETING AGENDA

Intergovernmental Coordination Group
Pacific Tsunami Warning System (ICG/PTWS)
Working Group 2 Inter-Sessional Meeting
Sea Level Measurement, Data Collection and Exchange
Melbourne 1-2 May 2006

Monday, 1st May

Time	Item	Comments
0830	**Morning Tea/Registration**	Plenary
0915	**Session Organisation** Introductions Confirmation of Representatives and Delegates Terms of Reference Work Group and Meeting Organisation and Responsibilities Review of Agenda and Timetable	Joint with ICG/IOTWS WG2
1000	Sea Level Data Requirements for Tsunami Monitoring & Warning Operational Tsunami Detection and Warning Modelling and Forecasting Post Event Analysis Longer Term Scientific Understanding and Forecasting of Tsunami.	Joint with ICG/IOTWS WG2 and Modelling and Warning WGs
1100	**Sea Level Network Design Principles** Sampling interval Accuracy/Resolution Frequency of Transmission Optimal siting (Open Ocean vs Coastal vs Island vs Harbour)	Joint with ICG/IOTWS WG2, Modelling and Warning WGs
1200	**Lunch**	
1330	Sea Level Measurement Technology: Tide gauges Instrument Requirements and Standards (tsunami stand-alone, GLOSS/climate, or other multi-role or “research” applications) Instrument Types and Experiences	Joint with ICG/IOTWS WG2
1415	Sea Level Measurement Technology: Deep Ocean Buoys Instrument Requirements and Standards (including special “event” modes) Instrument Types and Experiences	Joint with ICG/IOTWS WG2
1500	**Afternoon Tea**	
1530	Sea Level Measurement Technology: Other (e.g. New/Novel, GPS, satellite, etc) - Discussion	Joint with ICG/IOTWS WG2
1600	Respective WG Breakouts Terms of Reference Review Mode of operation Day’s issues/Planning for Day 2	
1700	Reception	

Tuesday, 2nd May

0900	**ICG/IOTWS WG2 Breakout Session** Review of Previous Meeting Action Items Tide Gauge Network Status and national plans Tsunami Data Buoy Network Status and national plans Agreement on “core” network	

	Status reporting US offer of DART Buoy deployments Deployment opportunities/collaboration Sea Level Network Design Review Coordination/Status Reporting Action Items	
1030	**Morning Tea**	
1100	International Deep-Ocean Buoy Partnership Breakout Session Planning Supply and deployment issues Actions	
1200	**Lunch**	
1330	**ICG/PTWS WG2 Breakout Session** Tide Gauge Network Status and national plans Tsunami Data Buoy Network Status and national plans Agreement on “core” network Status reporting Deployment opportunities/collaboration Sea Level Network Design Review Coordination/Status Reporting Action Items	
1430	**Sea Level Data Exchange & Archival** International Data Exchange Protocols, Communications Channels and Message Formats Data Quality Assurance Global Data Archiving	Joint with ICG/IOTWS WG2
1530	**Afternoon Tea**	
1600	**Intra- and Inter-Ocean Basin Coordination** Summaries from Breakout Sessions Relationships to other international forums (e.g. JCOMM, GLOSS, DBCP, etc) Coordination mechanisms	Joint with ICG/IOTWS WG2
1700	**Close**	

ANNEX II – ATTENDEES LIST

Dr K. Premkumar,NIOT-MoOD India, Chair
Dr. Bernie Kilonsky,GLOSS, University of Hawaii - Vice Chair, Coastal Stations
Mr Ken Jarrott, BOM**,** Australia - Vice Chair, Deep Ocean Stations
Dr Jane Warne, BOM**,** Australia (National Representative)
Dr. Leong Chow, MMS, Malaysia (representing Alui Bahari, National Representative)
Admiral Thaweesak Daengchai, Asst. Exec. Director Admn., NDWC, Thailand
Mr David McKinnie, NOAA
Dr. Stuart Weinstein, PTWC
Masahiro Yamamoto, IOC
Mr.Igarashi, JMA,Japan
Mr Bill Erb, IOC
Mr Rick Bailey, BOM**,** Australia
Mr. Alexander B. Rabinovich, Dept of Fisheries & Oceans, Institute of Ocean Sciences, Canada
Dr. David S. Green, NOAA, USA
Capt Rodrigo Nunez, Chile
Dr Eddie Bernard (teleconference), NOAA, USA
Dr Sok Appadu, Mauritius
Dr Gary Meyer, (CLIVAR / GOOS Indian Ocean Panel Chair
Mr Kelvin Wong, BOM, Australia
Dr Jane Cunneen, IOC

Observers
Mr. Robert A. Lawson, Naval & Maritime Solutions, SAIC, USA
Mr. Tony Elliott (Fugro Oceanor)

ANNEX III
Draft Terms of Reference for the International Tsunameter Partnership

International Tsunameter Partnership
Terms of Reference
(DRAFT February 2006)

1. Shared Vision

1.1 Tsunameters are instruments that measure tsunamis in the open ocean. To deliver tsunami measurements in real-time requires that a tsunameter be coupled to a highly sophisticated communication system to report the passage of tsunami in deep ocean waters to tsunami warning centers. For the purposes of this Terms of Reference, a tsunameter is a real-time reporting tsunameter.

1.2 In the aftermath of the Indian Ocean tsunami of 26 December 2004 a number of countries have announced national plans to operate tsunameters or increase the number of tsunameters they operate in pursuit of our common goal of preserving lives and property. Over the next few years the number of tsunameters deployed globally are expected to increase from less than ten in 2005 to eighty or more.

1.3 Tsunameters are critical to the rapid detection and forecast of tsunamis.

1.4 The Intergovernmental Coordination Group of the Intergovernmental Oceanographic Commission's Indian Ocean Tsunami Warning and Mitigation System established the International Tsunameter Partnership (Partnership) to create a voluntary, non-legally binding framework for international cooperation on the research, development, production, deployment, operation and maintenance of tsunameter instruments, buoys and moorings. The Partnership aims to directly support the establishment, effectiveness and on-going viability and enhancement of operational tsunami detection and warning systems, including the Indian Ocean Tsunami Warning and Mitigation System (IOTWS) and the Pacific Ocean Tsunami Warning and Mitigation System (PTWS) and other tsunami warning systems as they are established.

1.5 The Partners recognise that the success of regional tsunami warning systems depends on close collaboration among IOC member states in technology development and transfer; data and information sharing; and operations. Partners commit to sharing information about research, development, production, operation and maintenance to the maximum extent possible.

1.6 The Partners recognise that the regional tsunami warning and mitigation systems operate under the auspices of the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

1.7 The Partners note also that IOC / UNESCO is the competent international organisation in the field of transfer of marine technology for provision of advice on Part XIV of the 1982 United Nations Convention on the Law of the Sea (UNCLOS). The Partnership draws upon the IOC Criteria and Guidelines on the Transfer of Marine Technology developed by the IOC Advisory Body of Experts on the Law of the Sea and adopted by the IOC Assembly through Resolution XXII-12 at its 22nd session in 2003.

2. Purposes

The purposes of the Partnership are to:

- establish, coordinate and support international tsunameter research and development efforts, including joint activities;
- set common tsunameter standards, including performance standards and testing and calibration protocols, to ensure that designers and operators of tsunami warning systems

can rely on the consistency, comparability and availability of tsunameter data to the maximum extent possible;

- provide input as appropriate to sea level observation network design with a view to optimizing the contribution of tsunameter instruments to the operational and cost effectiveness of tsunami warning systems;
- maximise the sharing of tsunameter technology and cooperation among Partners and with suppliers of tsunameter equipment and components to achieve secure global supplies of high quality systems;
- cooperate where appropriate on the testing and calibration of tsunameter instruments, buoys and moorings;
- maximise opportunities for coordination and cooperation among Partners with regards to the siting, ship access, deployment, operation, maintenance and support of tsunameter systems; and
- help build capacity among Partners to accelerate the viability and success of regional tsunami warning systems.

3. Common Tsunameter Standards

Partners will collaborate to maximise the benefits of tsunameter standardisation. These benefits include, among others, the promotion of data consistency, reliability, durability, interoperability, and the facilitation of technology sharing among different economies. In seeking to maximise standardisation with regard to tsunameter technology, buoys, and moorings, the Partnership shall take into account differing regional geographical and operational environments. For example, tsunameters typically deployed in high latitude environments must be able to withstand more severe ocean conditions than buoys deployed in mid-latitude or tropical waters. Some areas require surviving a cyclone or hurricane. And tsunameters deployed in some operational environments face greater risk of anthropogenic interference and harm.

4. Research, Development and Production

4.1 Tsunameters are highly sophisticated systems and will be operated by a limited number of countries in small total global numbers, taking into account the global geographical coverage and proximity to tsunami generation zones. There is great potential for communal benefits to be gained from pooling research, development and production activities where possible and appropriate, and for collectively working to ensure viable and trusted long term and cost effective sources of supply, whether the technologies involved are sourced from public or private sectors.

4.2 The unique nature of the tsunami threat makes it the most challenging of all coastal hazards to detect and warn against. Partners agree that cooperation on tsunami detection research and development has national, regional, and global benefits in our common goal of establishing effective and durable regional tsunami warning systems that will save lives and protect property.

4.3 Partners will exchange technical information and collaborate in the research, development, and production of tsunameter systems to achieve important benefits in standardisation, agility, efficiency, effectiveness, and redundancy that will further the success and durability of tsunami warning systems.

5. Operations

The Partners recognise that the effectiveness of their national tsunami warning efforts is greatly enhanced through integration with regional tsunami warning systems. The Partners acknowledge the benefits to be gained from collaboration in siting, ship access, deployment, maintenance, and other forms of support for tsunameters in terms of increased detection coverage, and efficiencies as well as reduced operational costs.

6. Organisation

6.1 The Partnership shall meet as a single Working Group with a Chair and Vice-Chair. The Working Group shall address policy, technical and operational matters relating to the Partnership. The Working Group may establish sub-committees to address specific matters for referral back to the Working Group. Sub-committee leaders may be invited to meetings to present recommendations. The Working Group shall produce and adopt an annual report of the Partnership's activities, which shall be provided upon adoption to IOC. It is desirable that the Working Group meets at least semi-annually.

6.2 Working Group members shall be country representatives, who may be supported by a delegation. It is desirable that Working Group members be well versed in the policy and technical issues related to tsunami detection and warning systems.

6.3 The Partnership shall operate by consensus among members. At meetings of the Working Group, the Chair shall ascertain whether consensus has been reached on proposals before the group. Consensus is the absence of stated objection. Although unanimity is not necessary, the Chair is required to declare that there is no consensus if there is a stated objection to approve a proposal under consideration.

6.4 The Working Group may agree if so required on additional rules of procedure at its first or subsequent meetings.

6.6 The Chair, working with the Vice Chair, shall coordinate the work of the Partnership, coordinate activities of any work teams that are established, and prepare reports. Partners request that the IOC provide Secretariat support to organize and facilitate meetings.

7. Support

7.1 Each Partner will bring significant value in terms of critical resources to the Partnership. Work Group members should either own, as part of an operational tsunami warning system, either own and operate a tsunameter or intend to own and operate a tsunameter in the immediate future.

7.2 Support for tsunameter operations implies multi-year national contributions of critical resources to the domestic research, development, operations and maintenance of tsunameter. Critical resources are defined as including funding for national research and development, specialised mooring hardware and/or instrumentation, provision of ship time, funding for operations, and support for training and capacity building.

7.3 Each partner may, at its discretion, contribute funds, personnel, and other resources to the Partnership subject to the laws, regulations, and policies of the Partner. Any costs arising from the activities contemplated in these terms of reference are to be borne by the Partner that incurs them, unless other arrangements are made.

8. Intellectual Property

All matters relating to intellectual property and the treatment thereof arising from cooperative activities of the Partnership are to be addressed on a case-by-case basis within the specific context in which they appear, bearing in mind the purposes of the Partnership.

9. Amendments

The Board may make recommendations to the ICG to amend this Terms of Reference at any time by consensus of the Partners on the Board.

10. Commencement

10.1 Cooperation under this Terms of Reference will commence on [insert date of agreement of the terms of reference]. The first meeting of the Working Group under these terms of reference will be in Melbourne in April 2006 to coincide with the 21st Assembly of the PTWS.

10.2 Any Partner may terminate its membership upon written notice to the Chair of the Board 90 days prior to the anticipated termination.

ANNEX IV
Proposal by US for Contribution of Two DART Buoys to the IOTWS

United States Proposal for DART Buoy Deployments in the Indian Ocean
for discussion at the
Indian Ocean Tsunami Warning System Intergovernmental Coordination Group
Intersessional Working Group on
Sea Level Detection and Data Exchange—ICG/IOTWS Working Group 2
1-2 May 2006
Melbourne, Australia

I. Introduction

Through its program to contribute to the development and implementation of a regional Indian Ocean Tsunami Warning System (IOTWS), the U.S. government is proposing to provide at least two Deep ocean Assessment and Reporting of Tsunami (DART) stations to the region. The purpose of the contribution is to support:

- improved warning times for tsunami events and the saving of lives;
- the accelerated development of an "initial operating capacity"[1] for the IOTWS;
- demonstration of U.S. and new IOC/ICG standards and protocols for moored deep ocean tsunami detection stations; and
- development and operation of an end-to-end tsunami warning system for the Indian Ocean region, including providing a reference for future development of new government and commercial tsunami detection technologies.

The U.S. proposes, in collaboration with the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System (ICG/IOTWS), to deploy these stations between September 2006 and May 2007 as "warning and reference stations" at locations identified as part of the "conceptual array" of tsunami detection stations for the Indian Ocean the U.S. has provided to the ICG/IOTWS Working Group 2 on Sea Level Monitoring and Data Exchange.

The U.S. government seeks an ICG/IOTWS Working Group 2 review of the proposed contribution, and discussion and refinement of siting options. We also seek collaboration on development of a training and capacity building program that will lead to the long term sustainability of the DART stations. Specifically, we are seeking consultation on the overall contribution, station locations, assistance with deployments, and help developing a strategy for long term sustainability of the DART stations.

II. DART Warning and Reference Stations

Since ICG/IOTWS-I in Perth, there have been significant advancements in the development of new tsunami detection instruments and systems in governments and in the private sector. Meanwhile, the ICG/IOTWS continues to make substantial progress in designing a regional system to which the Member States can contribute. As ICG/IOTWS Working Group 2 has addressed issues of system design, protocols, and standards (including the concept of "core stations") the opportunity for a useful, sustainable contribution has become more clear.

In the context of the ICG and ICG/IOTWS Working Group 2 priorities, a U.S. tsunami detection station contribution must both support operational tsunami detection, and so the saving of lives— and help to encourage and, to the extent possible, accelerate development of the IOTWS:

- W*arnings and Saving Lives* Any DART stations the U.S. contributes will serve a vital role in saving lives in the Indian Ocean region. The data from Indian Ocean buoys could allow PTWC and JMA to increase lead times and provide for timely cancellation of watches for the Indian Ocean region, including East Africa, during the period they provides interim notifications. Regional Tsunami Watch Providers and National Tsunami Warning Centers in the Indian Ocean region would be able to use the data as national and regional systems are developed.

- *Use Reference Stations to Accelerate Development of the IOTWS* The DART stations the U.S. proposes to contribute have additional "Reference stations" functions: Through the ICG/IOTWS working group on sea levels, these stations would be used to:

  - validate ICG standards and performance requirements
  - establish a baseline for comparison of simultaneous observations
  - accelerate development of new tsunami detection designs and evaluate their performance in an operational context
  - conduct intercomparisions between reference stations and other technologies for tsunami detection
  - demonstrate functionality (e.g. triggering, data requests, diagnostics, distinguishing between actual events and false alarms from non-seismic events, instrument noise)
  - record and evaluate broad spectrum oceanographic signals in the Indian Ocean
  - conduct on-going training and capacity building.

  The U.S. believes these additional functions serve to advance the development of the IOTWS beyond what would be possible by providing a DART station or stations to meet warning and notification purposes alone. The warning and reference station concept sets a framework for technology transfer and collaborative investigations of new scientific and technical approaches to the tsunami detection program. These warning and reference stations would simultaneously serve as critical elements of the IOTWS.

  The U.S. believes this approach reflects the evolution of the IOTWS design, accelerates development of a fully operational IOTWS, and provides a model for supporting development of tsunami warning systems in other oceans.

III. DART Deployment Considerations and Requirements

Any U.S. contribution of DART stations or other resources to the region is guided by U.S. legislation and by policy considerations that support the IOC process and regional collaboration on a coordinated Indian Ocean Tsunami Warning System. It is the U.S.'s intent to:

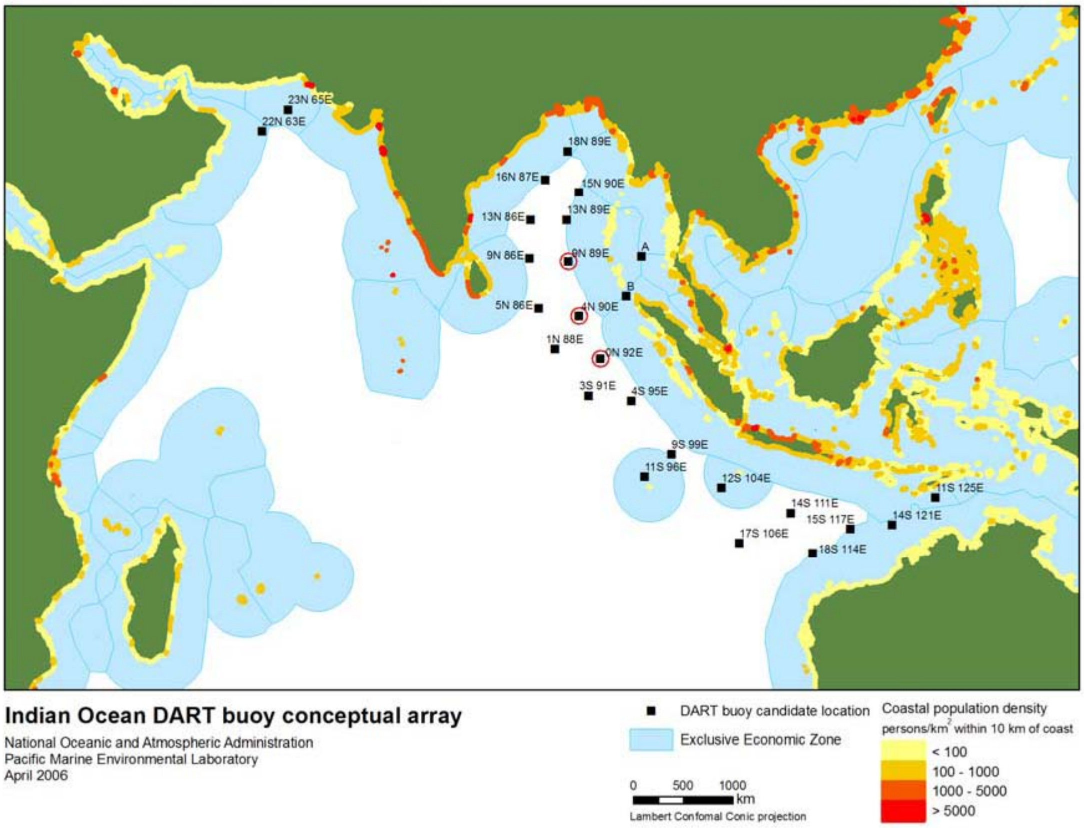
Support long-term capacity for operational detection of tsunami (and verifications of nonevents) in the Indian Ocean;
Contribute to the conceptual array for tsunami detection stations endorsed by the ICG/IOTWS;
Demonstrate the implementation of all IOC and NOAA standards and protocols for reliability, accuracy, interoperability, free and open exchange of data, and integration;
Demonstrate the operation of "core" IOTWS observation stations critical to a tsunami detection and forecasting system;
Contribute to the development and validation of new tsunami detection technologies; and
Promote tsunami watch provider capacity for the IOTWS.

In addition, the legislation that funds the U.S. contribution to the IOTWS requires that five nations primarily benefit from U.S. activities: India, Indonesia, Maldives, Sri Lanka, and Thailand. As a result, appropriate country-level training support may also be provided to several of these countries in addition to any capacity building organized through IOTWS/ICG Working Group 2. It is strongly preferred that U.S. DART stations be sited outside of the Exclusive Economic Zone of any one nation.

Finally, the U.S. is funded to support development of the IOTWS only through September 2007 and any direct contributions to the IOTWS must be completed by then.

IV. DART Deployment Options

The U.S. has identified several possible siting options that maximize potential warning lead times for the region and also support the requirements associated with reference stations. These are stations at 9°N 89°E, 4°N 90°E, and 0°N 92°E depicted on the graphic below circled in red.



The following graphics show the results of U.S. analysis of potential warning times different buoy configurations could provide. The analysis is based on the travel times from tsunamigenic events--from anywhere in the source region shaded in gray--to the DART sites of the conceptual array and to a selection of coastal sites. The "potential warning time" is simply the difference between the arrival of a tsunami at an impact site and the earliest arrival of that wave at a deployed DART station.

This is not the actual warning time in the sense that it does not take into account the time to process the DART signals and disseminate the warning. "Actual warning time" will be less. Among two-buoy cases, DARTs at 9°N and 0°N provide the best region-wide warning, as reflected by the color codes associated with the impact sites. For the tsunami sources considered, for example, Male receives at least 2 hours warning, Columbo and Phuket at least one hour, and Kakinada some warning (though possibly limited for event sources in the Andaman region).

Padang and other Indonesian locations are too close to many sources for any tsunami detection station to provide advance warning of sufficient length to allow for evacuation. Predictions of later waves or an early warning cancellation, however, still provide value to Sumatra and other Indonesian areas.

Among the one-buoy options the 4°N site offers the best regional warning. Illustrations of the warning properties of other deployment options are included in the appendix.
Because the U.S. will provide one station between September and December 2006 and an additional station between January and May 2007, various deployment options are possible. For example,

Option I: Deploy at 0°N 92°E in fall 2006 and 9°N 89°E in the later deployment. This option provides the best overall coverage for the region when both are deployed and allows for relatively easy access for reference station intercomparison deployments and other activities.

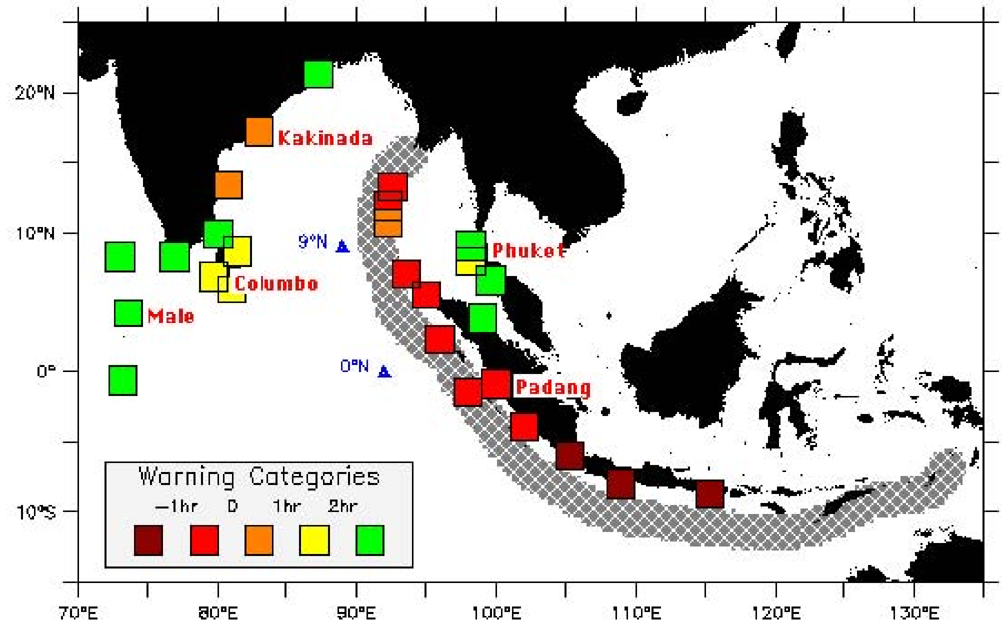
Option II: Deploy at 4°N 90°E in 2006, then deploy at 9°N 89°E in early 2007 and shift the 4°N station south, to 0°N 92°E. This option provides the best one-buoy interim coverage for the region and allows for relatively easy access for reference station intercomparison deployments and other activities. It is more expensive, however because it involves a station shift.

Options I and II would achieve the same ends on different time scales. Other options could place the stations at different locations or deploy/shift in a different sequence.

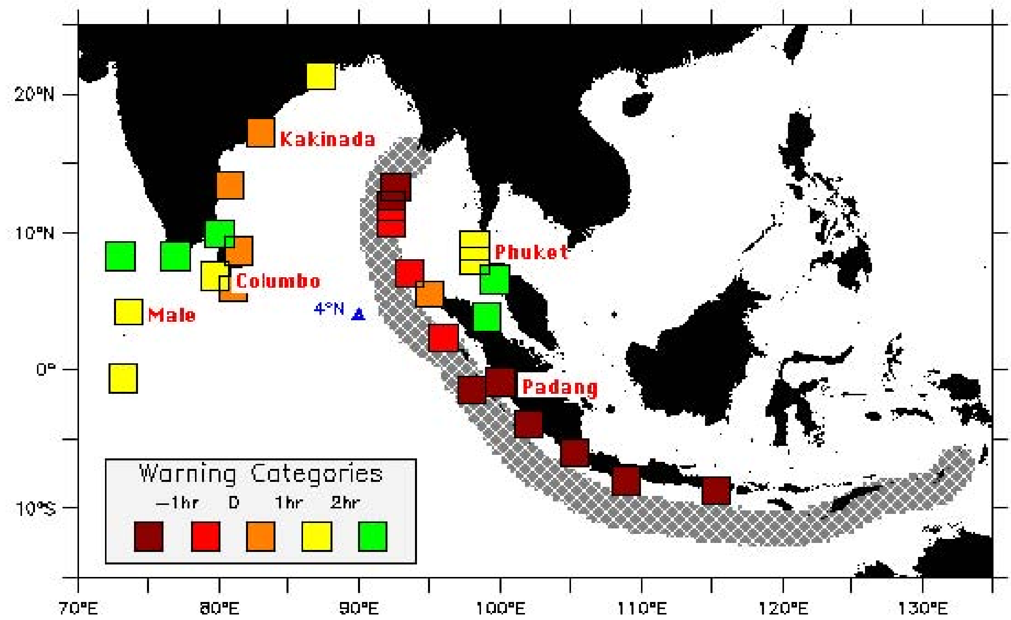
Any of these options depend on ICG/IOTWS Working Group 2 members playing an active role in deployments and training, and on member nations contributing ship time and other resources to make it possible to deploy and/or relocate.

Please see appendix for additional detail.

Stations at 9°N and 0°N



Single Station at 4°N



V. Marine Operations and Maintenance

The U.S. can provide a DART II Standard station to the Indian Ocean region in late 2006. Limited funds and ship time prevent the U.S. from deploying the station, or an additional station, without contributions, support, and engagement from ICG members.

Deployment

Initially, the U.S. seeks contribution of a suitable vessel for deploying the first station. Please see appendix for vessel requirements and considerations. The U.S. proposes that the deployment planned for late fall 2006 be considered an opportunity for technical training and will work with the ICG/IOTWS Working Group 2 members to ensure deployments provide the greatest possible training benefit to ICG Member States.

Maintenance

Without contributions of ship time and other resources, the U.S. is not able to service the DART stations at sea should such service be required. The U.S. will provide technical and engineering assistance through September 2007 and collaborate with ICG/IOTWS Working Group 2 partners to conduct any needed maintenance. After that time the U.S. can still provide technical and engineering consultation, but the primary maintenance responsibility must belong to other parties.

Long Term Strategy

It is the U.S. intent to work closely with ICG/IOTWS Working Group 2 to design and implement strategies for funding operations and maintenance of the buoys indefinitely through existing or new mechanisms. For example, the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) may offer an appropriate organizational infrastructure to support ongoing and sustained DART station maintenance.

VI. Tsunami Operations

The DART II stations the U.S. proposes to contribute will relay data through the standard DART II communications system: from Bottom Pressure Recorder to buoy, from buoy to a gateway via Iridium, and from the gateway to GTS. All Indian Ocean DART II data will be available to any nation able to access GTS.

The Pacific Tsunami Warning Center, as a provider of tsunami relevant information to the Indian Ocean region at this time, will monitor the Indian Ocean DART II data stream and determine when the stations should be accessed to trigger a higher sampling and higher reporting rate. The U.S. will provide diagnostic, test, and repair services via existing DART II communications systems. These routine activities offer important opportunities for technology transfer and training.

The U.S. will also develop and install the numerical modeling infrastructure at PTWC to interpret the DART II data for tsunami notification purposes (see below).

The U.S. will work through the ICG/IOTWS to identify an appropriate operator to assume responsibility for DART station operations when the PTWC no longer provides tsunami notifications because IOTWS Regional Tsunami Watch Providers are operational.

VII. Tsunami Modeling Infrastructure

A DART station by itself can not produce a tsunami forecast. Real-time tsunami data from DART stations need to be fed into a forecast system composed of coupled tsunami numerical models. Development of a practical tsunami forecast system uses a two-step process. The first step is data assimilation of DART data and inversion, which combines real-time seismic and tsunami data with the pre-computed scenarios using a tsunami propagation model (forecast propagation database). The second step is the site-specific inundation forecast using a tsunami inundation model coupled to the propagation model.

The tsunami forecast propagation database for the Pacific Ocean has been completed with 804 potential sources pre-computed using the NOAA propagation model (step 1). As of May 2006, 15 DART stations have been deployed. Inundation forecast models have been completed for 10 U.S. communities and will eventually exist for 75 US coastal communities (Step 2). Verification and validation testing of this forecast method along with two real tsunami events provides evidence that this system works for real time tsunami warning situations and should be of value for the Indian Ocean Tsunami Warning System.

Under the U.S. government project to contribute to the IOTWS, both steps will be addressed. An Indian Ocean forecast propagation database will be created using approximately 150 potential sources and each case will be computed using the NOAA propagation model (Step 1) before DART stations are installed in the Indian Ocean. This database will be installed at PTWC along with the Indian Ocean propagation model. Tests will be conducted using available tsunami data and synthetic data to verify and validate the models. To address Step 2, site specific inundation models will be created though a web-based community inundation model effort, which will be made available to Indian Ocean nations at IGC/IOTWS III in Bali, Indonesia (schedule for 31 July 4 August 2006. Indian Ocean nations will be able to use the web-based inundation model to conduct inundation studies and, with the appropriate real-time tsunami warning apparatus, site specific tsunami forecasts.

VIII. Requested ICG/IOTWS Working Group 2 Actions

The U.S. requests that time be allocated at the Melbourne intersessional meeting to discuss this proposal and for ICG/IOTWS Working Group 2 to consider these questions, among others:

1 What are the opportunities from ICG/IOTWS Working Group 2 members' perspectives for using warning and reference stations to support development of the IOTWS?
2 Are the proposed station locations appropriate or are there other appropriate alternatives of value to the region?
3 Can ICG/IOTWS Working Group 2 members offer ship time or other resources to help facilitate deployment and operation of U.S. DART II buoys?
4 What strategies can we develop collaboratively for technical transfer and training?
5 What strategies can we develop collaboratively for sustained operations?

Appendix I

Glossary of Terms
for the
U.S. DART Contribution to the Indian Ocean Tsunami Warning System

Core Station In the context of the Indian Ocean Tsunami Warning System, "core station" means an observing station that meets all ICG/IOTWS performance, reliability, data exchange, and other criteria. For example, a tsunami detection station is a core IOTWS station if it meets the standards and protocols developed in the sea level detection working group and it reports on GTS in real time. A tide station that does not report on GTS or does not report in real time on the other hand, is not a "core station" and so is not part of the regional system.

Conceptual Array The IOTWS conceptual array is a proposed network of deep-ocean tsunami detection stations for the Indian Ocean region. At ICG-IOTWS-I in Perth (August 2005), the U.S. offered an initial conceptual array design and other information for ICG consideration. ICG/IOTWS Working Group 2 has discussed the design as a potentially viable baseline for the IOTWS. The U.S. has continued to refine the array design and will over a new version with additional information at the ICG/IOTWS Working Group 2 meeting in Melbourne (1-2 May).

DART Station A DART Station consists of a Bottom Pressure Recorder (BPR) on the seafloor that includes a pressure sensor, batteries, acoustic transducer, and other components; a sea surface buoy that houses two-way, real-time communications systems and acoustic transducer, and a mooring system.

a) *DART II Standard* is the current operational NOAA deep-ocean tsunami detection station.

b) *DART II Easy-To-Deploy (ETD)* is a station under development that uses DART II instrumentation and communication systems, but is packaged in a self-deploying mooring that has a BPR acoustically linked to the surface mooring.

DART Warning and Reference Station The U.S. defines "DART warning and reference station" as an operationally proved deep-ocean tsunameter that serves both a detection and warning function and supports development of non-NOAA tsunami detection stations by: validating ICG standards and performance requirements; establishing a baseline for comparison of simultaneous observations; accelerating development of new tsunami detection designs and evaluate their performance in an operational context; conducting intercomparisions between reference stations and other technologies for tsunami detection; and demonstrating functionality (e.g. triggering, data requests, diagnostics, distinguishing between actual events and false alarms from non-seismic events, instrument noise), and other services.

Intercomparison Deep-ocean tsunami detection station intercomparison is a scientific process of validating the performance of a station against the performance of an operationally proven station. Intercomparison usually requires that two stations are nearly collocated to compare simultaneously collected data including amplitude and phase comparison with tides, data comparisons at tsunami warning centers, trigger mode data comparisons, and other tests to show that a station meets applicable standards and protocols. In the Indian Ocean context, the U.S. expects that intercomparison will be a collaborative process between sea level detection working group members and the entity requesting intercomparison.

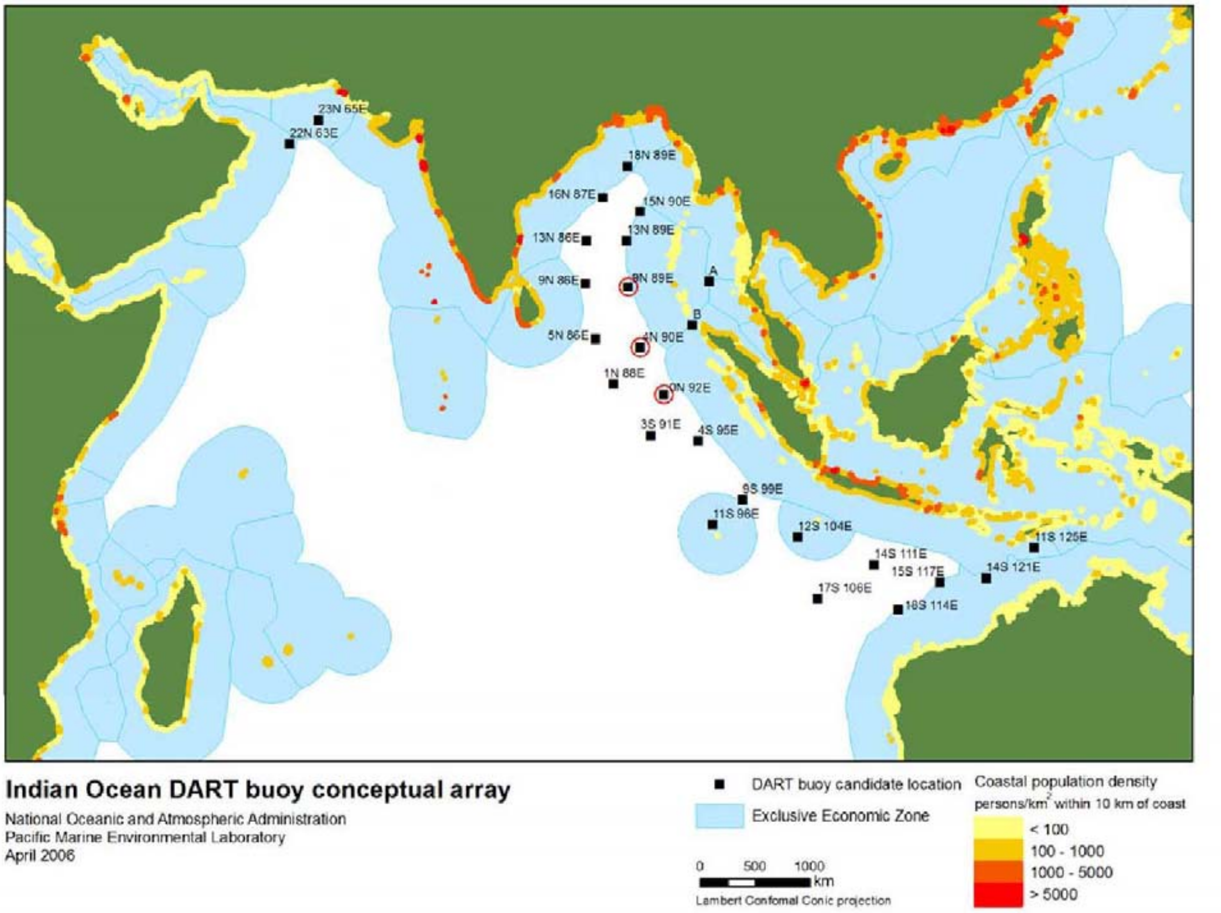
Interoperability In the context of the IOTWS, interoperability is the ability of different elements of the IOTWS to interact seamlessly. The concept applies to all elements of the end-to-end tsunami warning and mitigation system.

IOTWS Initial Operating Capacity As used in this document, the term "IOTWS Initial Operating Capacity" means that at least one Regional Tsunami Watch Provider is operational that meets ICG/IOTWS standards and is providing tsunami watches and information to interested parties.

Potential and Actual Warning Times In the context of the U.S. proposed contribution, "potential warning time" is the time between detection of a tsunami wave and the arrival of that tsunami at a particular location. "Actual warning time"—the time available for evacuation--is less because detection data must also be processed, analyzed, posted to GTS, and warnings developed and disseminated.

Tsunami Watch Provider "Regional Tsunami Watch Provider" (RTWP) has been defined initially in Working Group 5 at ICG/IOTWS-II as: national offices with full tsunami detection and analysis capabilities able to provide tsunami relevant information to other nations in the region and meeting the standards and requirements developed by Working Group 5 and adopted by ICG/IOTWS. Working Group 5 continues to refine the RTWP concept intersessionally.

Appendix II
IOTWS Conceptual Array for Deep-Ocean Tsunami Detection Stations



ANNEX V
Progress Report: German – Indonesian Tsunami Early Warning Project

Indian Ocean Tsunami Warning System Intergovernmental Coordination Group Intersessional Working Group on Sea Level Detection and Data Exchange—ICG/IOTWS Working Group 2 1-2 May 2006 Melbourne, Australia

Contribution of the German-Indonesian Tsunami Early-Warning Project (GITEWS)

As already communicated in the course of several IOC and ICG-IOTWS meetings, e.g. Paris, Perth and Hyderabad, we want to present again the basic concept of the DART contribution of the GITEWS project.

It is planned to deploy 10 Buoy-Systems along the Sunda Arc structure from the northern edge of Sumatra to the region east of Bali (see figure attached). The main challenge of a Tsunami Early-Warning for Indonesia is the fact that any earthquake occurring at any location along the Sunda Arc structure may trigger a tsunami. The travel time of such a tsunami to the coastline of Indonesia will be almost 15-20 minutes. To include oceanographic measurements with buoy systems in the warning process and the elaboration of a warning dossier, the buoys must be positioned such that they register a tsunami west of the trench within 5-7 minutes. This implies that these systems have to be placed at a maximum distance of about 50 km from the trench. The German-Indonesian concept follows this condition.

The first two buoys have already been deployed offshore of Sumatra as reported during the Hyderabad meeting. These two systems are test systems as some very new technology is used like GPS-based measurements of vertical movements of the buoy in order to detect waves or a real broadband acoustic data transmission from the ocean bottom to the surface with the aim to transmit aside pressure data also seismic data of a 3-axis ocean-bottom seismometer. Some system optimizations have to be decided on after testing in a realistic environment.

The complete array of 10 buoy systems will give considerable input to online tsunami modeling and simulation facilities at the data and early warning centre in Jakarta, which is currently set up. Therefore the data of the buoy array will also serve for the improvement of Indian Ocean wide tsunami models to be used for issuing warnings in other countries. This strategy is in full accordance with the ICG-strategy of distributed national warning centers with different status. As discussed in Hyderabad last december Indonesia will host a Category-A data centre with full capability of sensor networks, modeling facilities and warning dissemination.

We would like to take these activities into consideration when discussing the future plans for the Indian Ocean Tsunami Early-Warning System.

It is highly appreciated if other donor countries will also contribute to the oceanographic network in the frame of ICG-IOTWS. We feel that the WG 2 shall take over the responsibility to take care on a well balanced and scientifically sound proposal for the deployment of buoy-systems and also the question of maintenance and data distribution. As we are dealing with extremely short time scales in early-warning, especially for Indonesia, all efforts should aim to produce as much protection as possible for Indonesia. This is of utmost benefit to all other countries as good validated warning messages from Indonesia will also help all Indian Ocean rim countries to the most earliest time. We wonder that the proposal of US considers the deployment of buoys outside of the Indonesian and Indian (Andaman/Nicobar Islands) EEZ which leaves these areas almost unprotected.

Taking the arguments as mentioned above into account WG2 should reconsider the locations as proposed by US in order to make the efforts more suitetable for the closer regions like Sumatra and Andaman/Nicobar Islands. If a tsunami hits almost the complete coastline of western Indonesia before its signal arrives at the Early-Warning buoys at the proposed locations, then a dense network of tide gauges at the islands would be an essential investment.

We therefore strongly recommend that all international efforts should concentrate on the fact that extremely short warning times are needed in the Indian Ocean, probably different to the Pacific. The earlier measurements and a warning are available the better for all countries in the region of the Indian Ocean.

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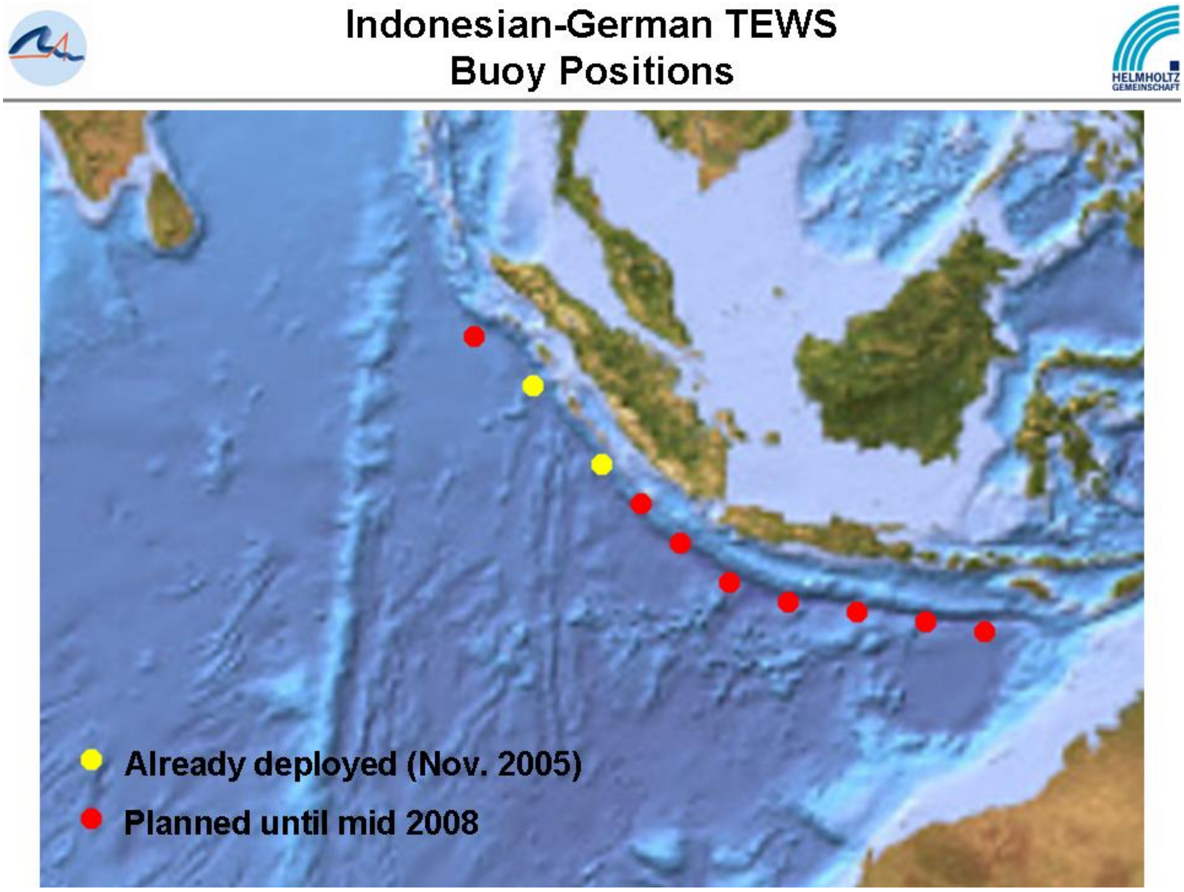

ANNEX VI
Discussion Paper – CREX Sea Level Coding

Description of an oceanographic CREX sequence for tidal reports

D06025 is one of the CREX oceanographic sequences for reporting tide elevation series described in the Manual on Codes Part C (WMO No. 306). A sample message reporting 6 half-hourly readings of tide elevation and residual is given in the codes handbook. The following is a brief description of the code:

```
CREX ++
```

CREX master table 00 Edition 01 Ver 01

surface data - sea

```
T000101 A001 D06025++
```

station ID

YYYY MM DD HH min

sea temp 276.1° K

automated check

manual check

RI010 1998 01 23 15 00 2761 00 00 30 –30

6 pairs of tide elevation and residual h1r1 h2r2 … h6r6 reported in mm

first report starts at 1500 UTC (1530 – 30)

time now is 1530 UTC

01407 1225 01384 1217 01382 1221 01395 1220
01473 1262 01502 1227+

Time	Tide Elevation (mm)	Residual (mm)
1500	1407	1225
1430	1384	1217
1400	1382	1221
1330	1395	1220
1200	1473	1262
1230	1502	1227

Next report from another station

CT010 1998 01 23 15 00 2781 01 00 30 -30
02024 1757 02043 1717 02124 1728 02177 1716
///// //// 02259 1670++
7777

The automated and manual water level checks are 2-character code figures referred to the code tables and flag tables (0 22 120 and 0 22 121) associated with the CREX tide gauge template. The tide elevation reported is with respect to the local chart datum and the residual is the difference between tidal elevation and the predicted value. Residual values are compiled and reported by the tidal processing centre and they are not normally directly reported from the station or sensor.

The CREX bulletin consists reports from two stations. Each report is terminated by the character "+" called "the subset terminator" except the last report which is terminated by the characters "++" called the "section terminator". A missing value in this section is represented by a string of solidi ("/") characters equal in number to the number of characters allowed for that group. The end of a CREX message is indicated by the characters "7777" and it does not require a section terminator.

Sea level data reported in non WMO code form

Sea level data from the GLOSS tide gauge network and other organisations use a non WMO code form, an example of which received from the DCP in Colombo, Sri Lanka collected via the GMS in JMA is the 1-minute observation transmitted every 15 minutes. The message received at RTH centres on GTS for its report at 0430 UTC on 29 March 2006 is as follows:

```
SWIO40 RJTD 290430
:ENB 1 #1 M 3763 3761 3761 3759 3758 3758 3755 3754 3752 3750 3749
3746 3745 3744 3743 3743 3743 3742 3742 3742 3742 3741 3741 3741 3739
3739 3738 3737 3737 :ENC 0 #2 3269 3265 3263 3263 3260 3256 3250 3246
3247 3246 3245 3243 3244 3243 3242 3239 3237 3234 3233 3233 3232 3230
3232 3232 3233 3233 3232 3228 3229 3230 :BATTLOAD 0 13.36 :NAME=
```

The first line of the message is the abbreviated header (TTAAii CCCC YYGGgg) of the bulletin for identification and transmission on GTS. The date/time group YYGGgg given in the abbreviated header is 0430 UTC on 29th of the month. The month and year (March 2006) are not reported in the message.

The latest observation time reported in this message is 0431 UTC, i.e. 0430 + 1 min. 29 tidal measurements at 1-minute intervals are included in the report but 14 out of the 29 observations have already been reported in the last bulletin. The observations are reported in reverse order.

Time	Data Value
0431	3763
0430	3761
0429	3761
0428	3759
0427	3758
0426	3758
0425	3755
0424	3754
0423	3752
0422	3750
0421	3749
0420	3746
0419	3745
0418	3744
0417	3743

15 new observations

0416	3743

0415	3743
0414	3742
0413	3742
0412	3742
0411	3742
0410	3741
0409	3741
0408	3741
0407	3739
0406	3739
0405	3738
0404	3737
0403	3737

14 observations reported in previous bulletin and repeated in this bulletin

Additional reporting requirements for sea level data

There are many other DCPs reporting sea level reports given in plain text format similar to the GLOSS tide gauge network. However they all use slightly different data formats with not much description of the data, instrumentation, status of operation, location, sampling information, quality flags, etc. The CREX code form for tidal observations was made available about 10 years ago but apart from the Centre for Operational Oceanographic Products and Services (CO-OPS) in the National Ocean Service (NOS) it is not implemented in other organisations. A version of its implementation using the CREX oceanographic sequence D06024 similar to the sample presented above also lacks a sufficient description of the metadata of the data.

```
SOPA56 KWBC 280359
CREX++
T000101 A001 D06024++
SDBC1 2006 04 28 04 00 //// 00 00 0030 -30
01796 //// 01943 //// ///// //// ///// //// ///// //// ///// ////+
LJAC1 2006 04 28 04 00 //// 00 00 0030 -30
01703 //// 01844 //// ///// //// ///// //// ///// //// ///// ////+
OHBC1 2006 04 28 04 00 //// 00 00 0030 -30
01710 //// 01856 //// ///// //// ///// //// ///// //// ///// ////+
SMOC1 2006 04 28 04 00 //// 00 00 0030 -30
01694 //// 01828 //// ///// //// ///// //// ///// //// ///// ////+
CA050 2006 04 28 04 00 //// 00 00 0030 -30
01551 //// 01714 //// ///// //// ///// //// ///// //// ///// ////+
PSLC1 2006 04 28 04 00 //// 00 00 0030 -30
01414 //// 01555 //// ///// //// ///// //// ///// //// ///// ////+
MTYC1 2006 04 28 03 00 2875 00 00 0030 -30
00971 0083 01128 0066 ///// //// ///// //// ///// //// ///// ////+
FTPC1 2006 04 28 03 00 2866 00 00 0030 -30
00849 0213 00969 0199 ///// //// ///// //// ///// //// ///// ////+
FRDW1 2006 04 28 02 00 2822 00 00 0030 -30
01993 -0141 02069 -0117 ///// //// ///// //// ///// //// ///// ////++
7777
```

The following are suggested reporting requirements not all of which are essential but a subset of which may be necessary for real time reporting and distribution on GTS both for tsunami warning and climate purposes:

Reporting Requirement	Table Reference in the BUFR Table B
STATION INFORMATION	
Network Identification	e.g. WMO, GLOSS, NOS, etc. No provisions in table, need to create code table
Tide Station Identification	0 01 075 (5 characters)
Station Name	0 01 015 (Name 20 characters) 0 01 018 (Short name 5 characters) 0 01 019 (Long name 32 characters)
Latitude	0 05 001 (High accuracy in 0.00001 degree) 0 05 002 (Coarse accuracy in 0.01 degree) Create new tables for datum (e.g. AGD66, WGS84, etc.)
Longitude	0 06 001 (High accuracy in 0.00001 degree) 0 06 002 (Coarse accuracy in 0.01 degree) Create new tables for datum (e.g. AGD66, WGS84, etc.)
Datum	The datum against which measurements are made is implicit for the sequence being used 0 22 037 (Tide elevation with respect to national chart datum) 0 22 038 (Tide elevation with respect to local chart datum) Create new tables for vertical chart datum (e.g. LAT, MSL, AHD, Indian Spring Low Water, etc.)
Owner/Agent	Create new code table or use string
META DATA INFORMATION	
Data Acquisition Identification	Create new code table
Software Version No.	Create new code table or use string
Instrument Type	e.g. Radar, acoustic, bubbler, pressure, stick Create new code table
Manufacturer	Create new code table
Model	Create new code table
Measurement Method	e.g. stilled, unstilled Create new code table
Siting	e.g. harbour, open ocean, stilled, unstilled Create new code table
QUALITY FLAG INFORMATION	
Measurement Type	Overall rating for instrument and method Add code figures in table 0 22 120 and 0 22 121 or use tables 0 33 002, 0 33 003 and 0 33 015
Operational Status	Combined flag (Good, adequate, poor, dead) indicating satisfactory operation based on e.g. battery voltage, internal temp and other engineering Battery voltage in 0.1 volts using 0 25 025 (3 characters) or 0 25 026 (4 characters)
Last maintenance	Date Need new time significance qualifier
Last Calibration	Date Need new time significance qualifier
MESSAGE INFORMATION	
Message Number	Sequential number

Message Year	0 04 001 (4 characters)
Message Month	0 04 002 (2 characters)
Message Day	0 04 003 (2 characters)
Message Hour	0 04 004 (2 characters)
Message Minute	0 04 005 (2 characters)
Reporting Rate	e.g. 5 min The number of reports is implicit in the specified replications, the time of the first report and time increment
Check Sum	Optional check digit available in Data Section of CREX
SAMPLING INFORMATION	May be required for each instrument
Sampling Frequency	10Hz, 1Hz, 0.1Hz etc Create new code table
Averaging Period	e.g. 1 sec, 10 sec, 1 min Possible to use 0 04 025 (minutes in 4 characters) and 0 04 026 (seconds in 4 characters)
Sampling Timing	e.g. the start, middle or end of sampling period Create new code table or new time significance qualifier
Time between Samples	
Number of Samples	0 08 022 (5 characters)
Number of Outliers	0 08 020 (5 characters)
Max in sample	Use first order statistics in code table 0 08 023
Min in sample	Use first order statistics in code table 0 08 023
Standard deviation	Use first order statistics in code table 0 08 023
SEA LEVEL INFORMATION	
Tide Level	Predicted values of tide, currently reported as residual
Water Level 1	See description for datum above 0 22 037 (Tide elevation with respect to national chart datum) 0 22 038 (Tide elevation with respect to local chart datum)
Tide Difference 1	Residual of predicted and observed tidal elevation 0 22 039 (4 characters) 0 22 040 (5 characters)
Water Level 2	As above New significance qualifier to distinguish different sensors (main and backup)
Tide Difference 2	As above
METEOROLOGICAL INFORMATION	
Sea Surface Temperature	0 22 042 (0.1 degree K - 4 characters) 0 22 043 (0.01 degree K - 5 characters)
Pressure at MSL	0 10 051 (hPa - 5 characters)
2 m Dry Bulb Temperature	0 12 004 (0.1 degree C - 3 characters)
10 m Wind Direction	0 11 011 (degrees - 3 characters)
10 m Wind Speed	0 11 012 (0.1 m/s - 4 characters)
Relative Humidity	0 13 003 (% - 3 characters)
Current	Possibly at several depths 0 22 004 (direction in degrees - 3 characters) 0 22 031 (speed in 0.01 m/s - 4 characters)
Salinity	0 22 062 (0.01 parts per thousand - 5 characters) 0 22 064 (0.001 parts per thousand - 6 characters)
CO2 in water	Table for class 15 is for atmospheric constituents, may require

	separate table for constituents in ocean) 0 15 025 (New code figure for type of pollutant) 0 15 026 (concentration of pollutant in mol/mol)

Examples of reporting replications in CREX reports

Several CREX oceanographic data sequence can be used for reporting the time series of the 1-minute sea level observations depending on how frequent the message should be disseminated. Examples are as follows:

(i) Six 1-minute observations transmitted every 6 minutes. Observations reported in the earlier message bulletin are not repeated.

```
D06025
```

(ii) 30 observations transmitted every 15 minutes, 15 data values which are reported in the previous message are repeated. This is the general practice of sea level reports transmitted on GTS.

```
D06019 R02030 B22038 B22039++
```

D06019 is part of the standard oceanographic data sequence used in D06025 as described earlier including the tide report identification, water level checks and time increments. It is followed by 30 replications of tide elevation and residual.

(iii) Unlimited number of observations

```
D06019 R02000 B22038 B22039++
```

Similar to example (ii) but the number of replications is not specified.

ANNEX VII
Discussion Paper on (Sea Level) Reporting Rate and Data Transmission

Issues Paper for Intersession meeting of the ICG/IOTWS-II WG-2
Comments and General Observations. By Dr Jane Warne

Reporting Rate and Data Transmission
Previous meetings of ICG working groups of the Indian Ocean, Europe and the Caribbean have discussed various reporting models for data transmission within and across basins. The latest proposal is for three reporting standards for sea-level data, transmitted via GTS to JMA, PTWC and other warning and watch providers.

- Basin wide data transmission of minimum 1 minute averages every 15 min.
- Sub-regional (within 1 hour of seismic source) data transmission of minimum 15 sec averages every 5 min.
- National (within 100km of source) data transmission of 15 second averages on a continuous basis.

The current practice of 15min reporting fits well in to the existing international communications regimen. This may be satisfactory for countries several hours from Tsunami source; however for much of the region 15 min reporting is not frequent enough. For example in Australia most sources are 2 to 4 hours from our mainland. This means a minimum 40mins before the earliest wave confirmation and typically 60mins this equates to a minimum warning time of about one hour. Other nations have even shorter decision times, and greater sensitivity to sea-level data latency. Within the Indian Ocean basin many countries will need to exchange data at a much higher rate than 15mins. Some may even need to exchange on a continuous basis with their immediate neighbours. This would suggest a consistent basin wide reporting rate of at least 5 mins. With careful coding of data this should be feasible from a communications cost perspective. Given the continuing reduction in communications costs real-time reporting of 1min data could be considered.
There has been discussion of switching the systems to a higher reporting rate during events. This has cost benefits but could be a significant issue in real events. Communication systems that are not regularly or continuously tested at the higher transmission rate are subject to higher failure rates in times of crisis. During these times, demands on local and international communication channels increases. This can result in failure of networks and total loss of communication. Similarly quality assurance processes for data are most reliable if they are run continuously. There is also an increase in the complexity of operational warning systems and the decision making process, increasing the likelihood of errors. The problem with continuous operation is the impact on power consumption, especially for remote stations, such as islands or deep ocean buoys.

Sampling Frequency
Studies of the Dec 26th 2004 Tsunami are revealing interesting information about the way sea-level is measured. A comparison of satellite data and sea-level data from a number of GLOSS stations revealed significant aliasing of the waveform for sample averages of greater than 1 min. *(Leonard 2006, submitted Geophysical Research Letters)*.
A small Japanese tsunami confirms this effect. See attachment A. There is clear evidence of aliasing of the data even at 1min averages. This only disappears at a sample rate of 15 sec or less. This would indicate a need for significantly higher sampling rate to accurately monitor and characterise the Tsunami waveform. This is not surprising given periods of the waves, 1000s and down to a few hundred seconds, and the structure within them. The Nyquist period for these waves would be 45 to 450 seconds. Tsunami waves are not pure sinusoidal waveforms therefore a sampling rate higher than the minimum Nyquist frequency is required. From the Japanese example and the Leonard paper it is clear that longer sampling periods can result in significant underestimates of the wave amplitude. In the case of the Ofunato the two-minute sample under estimated by 50%. Even the 1 min samples underestimate the wave amplitude (peak to trough); 0.55m compared to 0.8m from 1-second sampling. This means the 1 min averages under-estimate the amplitude by 30%. It also means that the presence of a Tsunami signal is difficult to resolve in the last third of the trace and may impact on data assimilation into models.

This argues for a minimum sampling period of 15 sec but that higher sampling rates could be advantageous. While 15 sec allows characterisation of longer period waves it does not accommodate the secondary benefit of monitoring shorter period wave behaviour. A higher sampling frequency (1 Hz) has advantages for the general ocean meteorology community. 1-minute samples are adequate for measuring long period waves (>500s).

Measurement Accuracy Standards
For tsunami monitoring and warning sea-level measurement is a relative measurement over period of minutes, hours and days rather than an absolute measurement as required for climate sea-level rise. An uncertainty[1] of less than 10mm for a 1 minute or less than 20mm for 15sec averages incorporating short-term drift, precision, temperature and pressure effects, response time characteristics and sampling frequency is sufficient. Absolute traceability to geodesic references, while desirable, is not essential to the broader tsunami community. It is however desirable to be able to trace the measurement broadly back to local reference point.

Communications
Many of both the sampling and reporting frequency thinking arises out of the use of GTS as the communications mechanism. This presumes a model of local/national data collection and quality checking. The data is then distributed on the GTS. It may be worth investigating alternate communication methods. For such a model to work internationally there is a need for common standards of operation and message dissemination.

The format needs to be systematic and expandable, it also needs to avoid costly re-coding of systems each time a simple addition or change is made. One option under consideration is CREX which is flexible, and human and machine-readable making it suitable for use by countries of varying technological development.

An initial draft of the type of information for transmission between nations is included for discussion. This is neither comprehensive, nor prescriptive, but provides a starting point for conversation. One of the key issues is what meta-data needs to transmitted with data and how to access other meta-data at later stage.

[1] Uncertainty as defined by the ISO Guide to the Estimation of Uncertainty, excluding in this case the component attributable to absolute accuracy and traceability.

	Notes	Tsunami	Climate	Harbour	Oceanography	Meteorology
STATION INFO						
Network Id.	e.g. WMO, GLOSS	Yes	Yes	Yes	Yes	Yes
Station Id.		Yes	Yes	Yes	Yes	Yes
Station Name		Yes	Yes	Yes	Yes	Yes
Latitude		Yes	Yes	Yes	Yes	Yes
Longitude		Yes	Yes	Yes	Yes	Yes
GIS Datum		No	Yes	Desirable	Desirable	No
Hydrographic Datum		Desirable	Yes	Desirable	Desirable	Desirable
Owner/Agent		Yes	Yes	Yes	Yes	Yes
META DATA INFO						
Hardware Version/Serial #		Desirable	Desirable	Desirable	Desirable	Desirable
Software Version #		Desirable	Desirable	Desirable	Desirable	Desirable
Sea Level Sensor Type	e.g. Radar, acoustic, bubbler, pressure, stick	Yes	Yes	Yes	Yes	Yes
Sea Level Sensor Manufacturer		Yes	No	No	Desirable	Desirable
Sea Level Sensor Model		Desirable	No	No	Desirable	Desirable
Filters	e.g. Mechanical damped, analogue or digital filters	Yes	Desirable	Yes	Yes	Yes
Siting	e.g. harbour, open ocean	Yes	No	Yes	Yes	Yes
Quality Flags & info						
Measurement Type	Overall rating for instrument and method	Yes	Yes	Yes	Yes	Yes
Operational Status	Combined flag (Good, adequate, poor, dead)	Yes	Yes	Yes	Yes	Yes

	indicating satisfactory operation based on e.g. battery voltage, internal temp and other engineering information					
Last maintenance	Date of	Desirable	Yes	Desirable	Desirable	Desirable
Last Calibration	Date of	Desirable	Yes	Desirable	Desirable	Desirable
MESSAGE INFO						
Message Number	Sequential number	Desirable	Desirable	Desirable	Desirable	Desirable
Message Year	UTC	Yes	Yes	Yes	Yes	Yes
Message Month	UTC	Yes	Yes	Yes	Yes	Yes
Message Day	UTC	Yes	Yes	Yes	Yes	Yes
Message Hour	UTC	Yes	Yes	Yes	Yes	Yes
Message Minute	UTC	Yes	Yes	Yes	Yes	Yes
Reporting Rate	e.g. 5 min	Yes	Yes	Yes	Yes	Yes
Number of Samples	# of samples in message	Yes	Yes	Yes	Yes	Yes
Check Sum	Yes	Yes	Yes	Yes	Yes	Yes
SAMPLING INFO	Maybe required for each instrument					
Sample Year	UTC	Yes	Yes	Yes	Yes	Yes
Sample Month	UTC	Yes	Yes	Yes	Yes	Yes
Sample Day	UTC	Yes	Yes	Yes	Yes	Yes
Sample Hour	UTC	Yes	Yes	Yes	Yes	Yes
Sample Minute	UTC	Yes	Yes	Yes	Yes	Yes
Sample Second	UTC	Yes	No	No	No	Yes
Measurement Freq	10Hz, 1Hz, 0.1Hz etc	Yes	Yes	Yes	Yes	Yes
Averaging Period	e.g. 1 sec, 10 sec, 1 min	Yes	Yes	Yes	Yes	Yes
Sampling Timing	e.g. the start, middle or end of sampling	Yes	Yes	Yes	Yes	Yes

	period					
Time between Samples		Yes	Yes	Yes	Yes	Yes
Number of Samples		Yes	Yes	Yes	Yes	Yes
Number of Outliers		Desirable	Yes	Desirable	Desirable	Desirable
Max	Within sample	Yes	Yes	Yes	Yes	Yes
Min	Within sample	Yes	Yes	Yes	Yes	Yes
Std	Within sample	Yes	Yes	Yes	Yes	Yes
SEA LEVEL INFO						
Tide Level	To hydro datum	Yes	No	Yes	Yes	Yes
Water Level 1		Yes	Yes	Yes	Yes	Yes
Tide Difference 1		Desirable	No	Desirable	Desirable	Desirable
Water Level 2		Yes	Yes	Yes	Yes	Yes
Tide Difference 2		Desirable	No	Desirable	Desirable	Desirable
OTHER						
Sea Surface Temp		Desirable	Desirable	Desirable	Desirable	Desirable
Barometer		Yes	Desirable	Yes	Yes	Yes
Air Temp		Desirable	Desirable	Desirable	Desirable	Desirable
Wind Speed		Yes	Desirable	Desirable	Desirable	Yes
Wind Direction		Yes	Desirable	Desirable	Desirable	Yes
Relative Humidity		No	Desirable	No	No	No
Current	Possibly at several depths	Desirable	Desirable	Desirable	Desirable	Desirable
Salinity		Desirable	No	Desirable	Desirable	Desirable
CO2		Desirable	No	Desirable	Desirable	Desirable

Sustainability
One of the key issues for the international community is ensuring the long-term viability of the field hardware. One method of ensuring commitment to the system is to have it provide data to a variety of users.

There are a number of users of sea level data,

Climate –	interested in absolute measurement of the sea level over years to a very high precision and accuracy (low uncertainty). Their need for data in real time is not high, being able to deal with days delay in delivery.
Tides –	primarily shipping or harbour managers who are also interested in both the absolute and relative measurement of sea level but typically to a lower precision and accuracy. Typically they are also capable of tolerating some delay in transmission.
Meteorological -	for whom absolute accuracy is secondary to the short term variation of the sea level and who require real-time data delivery. They rely on additional measurements including wind and pressure
Oceanography –	are interested in longer periods of days but not at the level of uncertainty of the climate community. Their requirement for data tends not to be real time being able to tolerate hours of delay.
Tsunami -	for whom absolute accuracy is secondary to the short term variation of the sea level, but who need real time data delivery.

One of the greatest treats to the long-term viability of both national and international tsunami systems is the ongoing maintenance costs. One technique to address this is to ensure the sites have multiple roles. This results in the spreading of maintenance and other lifecycle costs across a number of users. However the multi role model does have drawbacks. These include higher initial capital and installation cost as well as sometimes increases lifecycle costs. The advantage is that encourages routine maintenances and results in better quality data as it is used between tsunami event. Any errors with the data are identified quickly.

Linking exclusively to the requirements of the climate community will be expensive for many users, both in the set up phase and the on going maintenance. The requirement for geodesic surveying on a regular basis, the support and maintenance and sometimes the higher quality sensors is costly. Multi-role sites that meet the needs of other users, such as the oceanography community and the metrological community, may result in some greater installation and capital costs however the lifecycle costs tend to be lower. Secondly the linkage into other communities will diversify the type of data provided to the research community in general. For example the meteorological community will provide discriminative information for sea-swell/long wave phenomenon and continuous testing and validation of the system. Inclusion of sea surface temperature, salinity, higher frequency sampling and current will support the oceanographic and ocean meteorological communities, and help in developing a better understanding of tsunami wave propagation.

It is evident that the science of tsunamis still has a long way to develop and will do so over the coming years. Being constrained to a single sampling methodology there is a risk that the ability to perform further research on tsunamis is compromised.
Below is a table that looks at some of the criteria relevant to tsunami and sea level monitoring in general.

ANNEX VIII
Review of Actions from Previous Meetings

Summary of Actions from ICG / IOTWS II WG2 – Hyderabad – Dec 05

No	Action	Responsible	Due Date	Status
2-1	Members agree to content of the WG Terms of Reference	K Jarrott	1 Dec	ICG to follow up on membership of WG2 and circulate to all member states.
2-2	Coastal Sea Level Stations Instrument Standards - minimum standards to be developed for instruments in tsunami watch only (non GLOSS). To be submitted to VC – Coastal Sea Level Stations	K Jarrott	End Mar 06	Discussion draft circulated by Jane Warne (Aust) at Inter-sessional WG2 Meet, Melb 2006. J Warne to circulate specific proposition via Vice Chair for ICG/IOTWS III, Bali, July 31 2006
2-3	Performance Standards for Deep Ocean Stations – minimum set of instrument characteristics to be developed in consultation with members and suppliers, for review by members.	VC - Deep Ocean Stations	End Jan 06	Continuing. Draft standard to be circulated prior to ICG /IOTWS III, Bali for endorsement. Input or review by modellers (WG4) and Warning Centres (WG5) required.
2-4	Final “Target” Configuration of CORE Coastal Sea Level Network – to be developed	VC – Coastal Sea Level Stations	ICG /IOTWS III (Jun 06)	Continuing. To be ready by Bali (July 31 2006)
2-5	Database for Capturing Progress and Plans for Deep Ocean Network Development – concept proposed	(Australia) (VC - Deep Ocean Stations)	End Feb 06	No progress. Initial realisation of database to be presented at Bali (July 31 2006)
2-6	Final “Target” Configuration of CORE Deep Ocean Sea Level Network – to be refined from conceptual network design of PMEL	VC - Deep Ocean Stations	End Mar 06	Continuing – initial conceptual array of evenly spaced stations presented at Hyderabad by Dr Eddie Bernard, as basis for donor communications. Proposed revised of core network design and its relationship to national plans to be developed.
2-7	Nomination of National Focal Points for WG-2 – confirmation by host countries	TBD	End Dec 05	Not completed. To be finalised prior to Bali meeting (July 31 2006).
2-8	First response to Details of Terms of Reference for International Tsunameter Partnership	All nations intending to join	End Dec 05	Limited responses received. Processed into second draft of Terms of Reference.
2-9	Conduct Inter-sessional Meeting – International Tsunameter Partnership	(VC - Deep Ocean Stations)	April 06	Expanded to joint PTWS / IOTWS WG2 Meet - Melbourne, May 06.

ANNEX IX
New Action Items and Recommendations from Inter-sessional Meeting

1. RECOMMENDATIONS

Recommendation: That the CREX format be adopted for the transfer from one nation to other warning centre. (Member countries have been provided with copies of CREX format for their study and confirmation before IOTWS Bali meeting (July 31 2006))

Recommendation: Wherever possible, installation should be of multi-purpose observing sites to facilitate the long-term sustainability of the observing network.

Recommendation: Wherever possible, and in the interim, sea level stations should conform to GLOSS climate related standards, but the WG noted that requirements for tsunami detection need not coincide with those of GLOSS, and could conceivably be single-purpose or multi-purpose, with application to services other than climate monitoring.

Recommendation: Chairs of relevant IOTWS and PTWS Working Groups to ensure coordination and communication of outcomes from evaluations of existing and new technologies (e.g. radar).

Recommendation
With respect to the US Govt proposal to contribute 2 DART buoys to the IOTWS, WG2 representatives agreed that:

- The Working Group appreciates the offer of 2 DART buoys
- The Working Group endorses the siting logic explained by NOAA, and recognises that it provides additional value to the Indian Ocean community.
- The constraints of not being able to extend similar assistance to other parts of the Indian Ocean are recognized and accepted.
- The Working Group encourages member countries to support the deployment and ongoing operation of the US donated buoys.

Malaysia strongly recommended the timely execution of the buoy deployment and the development of suitable support arrangements, preferably before the IOTWS meeting in Bali (July 31 2006).

2. ACTIONS

Action: Joint WG to coordinate development of network design principles by ICG/IOTWS-III in Bali in July 2006 (Chair Jane Warne, Australia). This should consider the new proposed standards for sea level sites within 1 hour of tsunami travel time and/or 100 km of tsunami generation areas, and the implications of these standards in terms of network design.

Action: Bernie Kilonsky to advise by ICG/IOTWS-III in Bali July 2006 the additional cost of making a sea level gauge that is suitable for tsunami detection, to equip it to be also capable of monitoring sea level for climate change detection.