International Coordination meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a global framework
UNESCO HQ, Paris
March 5-8, 2005

Early Warning System for Oceanogenic Disasters in Indian Ocean (Tsunami and Storm Surges)

The Indian Initiative

HARSH GUPTA
Department of Ocean Development
India

The Indian Ocean

- More than 50 Nations around
- Many are Developing Countries
- More than 1.5 Billion Population
- More than 66,500 km coastline
Oceanogenic Disasters

- 13% of World's cyclones in the Seas around India
- Annual, Frequent phenomenon
- Inundation of Coastal areas

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Tsunami

- A system of ocean gravity waves formed as a result of large-scale disturbance of the Sea bed mostly due to Earth quakes (or Volcanic eruptions or submarine Landslides),
- Propagates at very high speed
  - 500 to 1000 km per hour in Deep Ocean
- Height
  - Less than a Metre in the Deep Ocean
  - Grows to Tens of metres in the shore line
- Time Period
  - In the order of hours
<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Magnitude</th>
<th>Annual frequency in the world</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great</td>
<td>8 and higher</td>
<td>1</td>
</tr>
<tr>
<td>Major</td>
<td>7–7.9</td>
<td>18</td>
</tr>
<tr>
<td>Strong</td>
<td>6–6.9</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>5–5.9</td>
<td>800</td>
</tr>
<tr>
<td>Light</td>
<td>4–4.9</td>
<td>6200</td>
</tr>
<tr>
<td>Minor</td>
<td>3–3.9</td>
<td>49,000</td>
</tr>
<tr>
<td>Very Minor</td>
<td>2–2.9</td>
<td>about 1000 per day</td>
</tr>
<tr>
<td>(micro)</td>
<td>1–1.9</td>
<td>about 8000 per day</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnitude of Earthquake</th>
<th>Energy released in TNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>170 gm</td>
</tr>
<tr>
<td>3.0</td>
<td>180 kg</td>
</tr>
<tr>
<td>6.0 (Koyna 1967)</td>
<td>5,700 ton</td>
</tr>
<tr>
<td>8.5 (Assam 1897 &amp; 1950)</td>
<td>2,870,000 ton</td>
</tr>
<tr>
<td>M~8.5 earthquake</td>
<td>12,000 Hiroshima atom bombs</td>
</tr>
</tbody>
</table>
### Off west coast of Sumatra island (Indonesia)

<table>
<thead>
<tr>
<th>Date:</th>
<th>26th December, 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin Time</td>
<td>06 Hours 29 Minutes of IST</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Mw 9.3</td>
</tr>
</tbody>
</table>
| Epicentre        | Latitude: 3.7 degree North  
                      Longitude: 95.0 degree East |
| Region           | Off west coast of Sumatra Island (Indonesia) |
Great Nicobar Islands

Date: 26th December, 2004

Origin Time 09 Hours 52 Minutes of IST

Magnitude Mw 7.3

Epicentre Latitude: 7.3 degree North
Longitude: 92.7 degree East

Region Off coast of Great Nicobar

Location of the 26th Dec 2004 Java earthquake extension of aftershocks from Java epicenter to Andaman and Nicobar group of islands, and several major aftershocks.

Data from USGS
The diagram shows a comparison between the aftershock zone with the minimum area of slow slip inferred from normal modes (after Stein and Okal, 2005).

Tide Data from NIOT ATG at Port Blair, Andamans

![Tide Data Graph]

- Tide in cms
- Time from 21-12-04 to 5/1/05
- 7:14 peak
The continents and sea floor that cover the earth’s surface are part of a world-wide system of plates that are in motion. These motions are very slow, only an inch or two per year. Earthquakes occur where the edges of plates run into one another. Such edges are called fault lines or faults. Sometimes the forces along faults can build-up over long periods of time so that when the rocks finally break an earthquake occurs. When powerful, rapid faulting occurs underneath or near the ocean, a large earthquake is produced and, possibly, a tsunami.
CAPABILITIES

- Good Seismic Network
- Research Vessels
- Bathymetry Surveys
- Tide Gauges
- Data Buoys
- Satellites
- Communication
- Networking
- Modelling

NATIONAL DATA BUOY PROGRAMME

2002-03 20- Buoy Network
Data buoy observations during the cyclone in Arabian Sea (May 2001)

Buoys Observations of Arabian Sea Cyclone during 4-11th May 2004
Indigenisation of Buoy Technology

- Design, production, assembly
- Deployment & system testing
- Fully indigenisation with INSAT communication
- 6 simple & 2 advanced met buoys
- Deployed & the Data are consistent
- Data management & dissemination
- Tamper Proof Buoys

Rs. 57.87 lakhs [Cost] Rs. ~ 20 lakhs

EEZ Surveys program involves mapping 2 mill. Sq.km of EEZ in 2 phases.
Diagram showing the distribution of earthquakes and major plate boundaries. It may be noted that globally, more than 75% of earthquake energy is released in the circum-Pacific belt, about 20% in the Alpine-Himalayan belt, and remaining 5% through the mid-oceanic ridges and other Stable Continental Region earthquakes. For a tsunami to hit Indian coast, it is necessary that a tsunamigenic earthquake occurs and its magnitude should be larger than M 7, and the possible locations of such events are enclosed in blue circle and ellipse.
An Early Warning System is imperative for the Indian Ocean to mitigate the loss of life and property due to Tsunamis and Storm Surges. The Indian Tsunami Early Warning System incorporates the needs of storm surge forecast too. The System design is based on end-to-end principle encompassing:

- Near-real time determination of earthquake parameters in the two known Tsunamigenic zones of Indian Ocean region, using a network of land-based Seismic Stations

- Establishing a comprehensive real time Ocean observational network comprising Bottom Pressure Recorders around the two Tsunamigenic zones, Tide Gauges, Radar-based Coastal Monitoring Stations etc.

- Developing numerical models for Tsunami and Storm Surges with all associated data inputs

- Generating Coastal inundation and Vulnerability maps

- Setting up a dedicated Tsunami Warning Centre (include Storm Surge) in India and operating it on 24x7 basis for generation of timely advisories

- Capacity building, training, education of all stakeholders

- International connectivity
Existing Seismological Observatory Network

Epicentres of earthquakes of magnitude 6.0 and above, from 1800 to Feb 2003, with major tectonic fault features; tentative location of Seismic Stations to be interconnected for near real time determination of earthquake parameters, and proposed locations of DART kind of Ocean Bottom Pressure sensing Data Buoys.
40 automated Tide Gauges having real time data communication for East and West coast of India by 2005-2007
HF Radar-based Monitoring of Surface Current and Wave

Partners in Project Implementation

<table>
<thead>
<tr>
<th>Nodal Implementing Agency</th>
<th>DOD through its Institutions (INCOIS, NIOT, ICMAM)</th>
</tr>
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<table>
<thead>
<tr>
<th>Partners</th>
<th>DST</th>
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</thead>
<tbody>
<tr>
<td>Seismic Stations, Detection of Earthquake</td>
<td>DST</td>
</tr>
<tr>
<td>Communication between Seismic stations, Sensor Selection for Bottom Pressure Recorder, Communication from BPR</td>
<td>DOS</td>
</tr>
<tr>
<td>Coastal Topography</td>
<td>DST and DOS</td>
</tr>
<tr>
<td>Research inputs in Geophysics, Ocean Sciences</td>
<td>CSIR, DOD, Academia</td>
</tr>
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Project Cost and Schedule

- Project Cost : Rs.125 crores
- Project Duration : 30 months
- Project start : February 2005
- Operational : September 2007

In Conclusion

1) Indian Initiative for the Dual-use Earning System covers the two known Tsunamigenic zones that affect Indian Ocean region
2) It is an end-to-end system that is scientifically and technically sound
3) It is comprehensive and covers the required observations, modelling, data communication, warning Centre, capacity building
4) There is an excellent technological and institutional base to realise the system and operate on 24x7 basis
In Conclusion

5) There is synergy of the Scientific Departments in implementation

6) There is participation of stakeholders in the process

7) There is commitment at the highest level in Government for implementation of the System at the cost of Rs 125 Crores

8) The key elements will be in place by March 2006 and the entire system will be operational by September 2007

9) India is willing to contribute to the region by disseminating the warnings

Thank You