End-to-End Tsunami Warning and Emergency Response - A Race against Time

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FACTS:
- Every Ocean Basin and Sea impacted
- Next tsunami can occur anywhere and any time
- Some countries have coasts on 2 or more basins
- Comprehensive Tsunami Mitigation Programme required
- Hazard Risk Assessment, Preparedness, Warning Guidance
- Until 2005, no Tsunami Warning System except in Pacific (1965)

TSUNAMI WARNING AND MITIGATION SYSTEM
An EFFECTIVE system means:
All persons in vulnerable coastal communities are prepared to respond appropriately, and in a timely manner upon recognition that a potentially destructive tsunami may be approaching.
Reduction Tsunami Risk ...

... Requires end-to-end solution
1. Hazard / Risk assessment
2. Warning / guidance
3. Mitigation, Preparedness, Awareness

THE NEXT DESTRUCTIVE TSUNAMI
IT’S NOT IF, BUT WHEN

=> ASSESS
=> WARN
=> PREPARE

Tsunami Early Warning: What needs to be in place to save lives
- Early Detection and Alert (monitor, react / act)
  Earthquake trigger the process
  Sea Level Monitoring confirms tsunami
- Pre-event planning essential for safe response
  Hazard risk assessment
  Evacuation planning

3 BASIC WARNING NEEDS
- VERY RAPID EARTHQUAKE EVAL
- VERY RAPID SEA LEVEL EVAL
- VERY RELIABLE COMMUNICATIONS
  Multi-national, Global Nets
  Real-time transmission
  Data Sharing

ALL REQUIRED FOR WARNING
Tsunami Warning Operations: Earthquake detection and evaluation

- Where is the earthquake? Is it under the ocean? Is it shallow?
- How big was the earthquake? Magnitude > M8.0 or not?
- Though fastest, EQ = only tsunamiigenic potential

Sumatra earthquake, 26 Dec 2004

Complex Rupture: Discontinuous in time (8 min) space (1000 km)

Energy Release Imaged by Japan HINET Array

Tsunami Monitoring: Sea Level detection and tsunami threat evaluation

- Was a tsunami generated? Is obs wave big or small?
- What is wave forecast at coast? What is max wave height? What is max flooding extent inland?
  - Self-monitor through GTS, but instruments break

Estimating Tsunami Arrival Time

<table>
<thead>
<tr>
<th>Location</th>
<th>Forecast Point</th>
<th>Estimated Arrival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>12:00 AM</td>
<td>02:00 AM</td>
</tr>
<tr>
<td>Indonesia</td>
<td>07:15 AM</td>
<td>09:00 AM</td>
</tr>
<tr>
<td>Philippines</td>
<td>04:45 AM</td>
<td>06:00 AM</td>
</tr>
<tr>
<td>Thailand</td>
<td>01:15 AM</td>
<td>03:00 AM</td>
</tr>
<tr>
<td>Malaysia</td>
<td>08:45 AM</td>
<td>10:00 AM</td>
</tr>
<tr>
<td>Vietnam</td>
<td>16:15 AM</td>
<td>18:00 AM</td>
</tr>
<tr>
<td>India</td>
<td>23:45 AM</td>
<td>01:00 AM</td>
</tr>
</tbody>
</table>

JMA Flow of issuance of tsunami forecast and earthquake information

Seismic intensity information areas which observed 2 or above

Earthquake Information (location, magnitude) This information is issued when earthquake does not generate tsunami.

Tsunami Information (arrival times, observed tsunami height, highest tide times)

Tsunami Warning Operations:

- Earthquake detection and evaluation
- Sumatra earthquake, 26 Dec 2004
- Complex Rupture: Discontinuous in time (8 min) space (1000 km)
- Tsunami Monitoring:
  - Sea Level detection and tsunami threat evaluation
  - Was a tsunami generated? Is obs wave big or small?
  - What is wave forecast at coast? What is max wave height? What is max flooding extent inland?
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Hilo, Hawaii

Peru Tsunami 23 JUN 2001 Ms 8.0

Arica, Chile 1 hr

Honshu Tsunamis 5 Sep 2004 Mw7.2, 7.4
**Tsunami Warning Operations: Wave Forecasting**

NEED TO WARN BEFORE the wave hits:

- When will it arrive?
- Where will it hit?
- How big will it be?

⇒ WARN ONLY vulnerable coasts
⇒ To be included in PTWC new products (2013-14)

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**Tsunami Emergency Response: Alerting a Prepared Public to Evacuate Beaches**

- Which coasts / communities are vulnerable?
- How will Alerts be disseminated quickly?
- What to expect? What to do?
- Where to go?
- 1st choice: Inland to higher ground
  Last choice: vertical evacuation

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**Tsunami Public Awareness - Localization**

Know what to do: Earthquake 1st, then tsunami

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**Evacuation Maps – Safe Routes**

- Communities make maps:
  - Identify ALL Stakeholders
  - Workshops with Local Residents
  - Single Access Roads
  - Congregation areas
  - Walking the route

“Tsunami evacuation maps locally-developed from modeling, maps and local histories”

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**Alert & Warning**

- Technology assists people-based warnings

- Getting warning to responders
- Getting warning to public
- Use table top exercises to identify problems and for training
- Conduct drills in the community
- Test the notification systems
Satellite to low-tech Alerting
*ex: RANET dissemination, Chatty Beetle*

- Hard countermeasures
- Soft countermeasures
- Human response?

How high is high enough?

Considering Vertical Evacuation?
*If … No High Ground, No Time, Traffic*

Designating tsunami-safe structures

Engineering response to tsunami loading

Tsunami Signage:
Reminding of prior tsunamis and Where to go

Experiments (Japan PARI, 2010)

- Inundation height is about 50cm
- Inundation speed is about 4.0m/s
**End-to-End Tsunami Warning System**

- **Tsunami Warning Center**: Detection, Threat Evaluation, Warning Products
- **Emergency Management**: Public Alerting, Evacuation, All-Clear, Tsunami Safety
- **Prepared Public**: knows what to do

**Stakeholder Coordination is Essential**

- **Science and Engineering**
- **Warning Center**
- **Emergency Management**
  - 1st Responders (police, fire, water safety)
  - medical svcs, search & rescue

- **Civil Society & NGOs**:
  - Community organizations: social, gender, cultural, age, language, religious...
  - Disaster response & relief
  - Trade, commerce, workers

- **Local Communities**
  - Mass Media
  - Energy, Telecomm
  - Tourism
  - Private Sector

- **Government Agencies**:
  - Regional Planning
  - Social Infrastructure Works
  - Agriculture & Forestry
  - Health & Sanitation
  - Environment, Transportation...

**Be Prepared - Tsunami Exercises**

**Indonesia, 2005 – 2012+**

**Samoa – 2007+**

National Tsunami Early Warning System Test
29th October 2007

- Keep mobile phones switched on.

**Tsunami Awareness**

- **Before**
- **After**

- Stakeholder Coordination is Essential

**What does a tsunami do? – have a plan**

**Tsunami Warning Center**: Detection, Threat Evaluation, Warning Products

**Tsunami Warning in Japan**
- Tsunami Height is 50cm
- Inundation depth (m)

**Probability of falling or sliding**

- 10%
- 20%
- 50%
- 60%
- 70%

**Be Prepared**

- Indonesia, 2005
- Samoa, Japan PARI, 2010

**Preliminary Results:**

Probability of falling or sliding

- For falling only [men]
ICG/PTWS (ICG/ITSU)

- UNESCO/IQC convened ICG/ITSU - 1968
- PTWS name change - 2005
  Recommend / Coordinate incl timely int'l warnings - 45 countries
- NOAA PTWC – 1965 - PTWS Operational Center HQ
- IOC-NOAA ITIC – 1965 - Support PTWS

- Successful international scientific program
- Direct humanitarian aim
- Mitigate tsunami effects - save lives/property
- Pacific Basin monitoring – seismicity, sea levels

GLOBAL TSUNAMI SYSTEM
Organizational Chart

Intergovernmental / International and US agencies working on tsunamis

REGIONAL TSUNAMI WARNING
AND MITIGATION SYSTEM:
Supporting Elements

NOAA’s Tsunami Warning System

- 24/7 Tsunami Warning Centers
- Detection and Evaluation of Earthquakes
  - 400+ seismic stations (national and global)
- Detection and Tsunami Threat Evaluation
  - 39 deep-ocean DART Buys
  (Pacific, Atlantic, Caribbean)
- 400+ coastal sea-level stations (national and global)
- Forecasting the Tsunami Impact
  - Modeling – travel times, wave height, inundation
  - Coastal Forecast System
  (assists evacuation decision-making)
- Product Generation and Dissemination
  - Warnings, Watches, Advisories and Bulletins
  - Emergency Alert System, NOAA Weather Radio
- WMO GTS, EMWIN, AFTN
- Web, fax, email, RSS, SMS

NOAA’s Tsunami Mitigation Efforts

- TsunamiReady Program - building a WeatherReady nation
  - Improves community awareness, preparation, and education
  - Strengthens local Emergency Operations
  - 109 local communities in U.S.
- National Tsunami Hazard Mitigation Program
  - Partnership among Federal and State Agencies
  - Enhance National Tsunami Outreach and Education Efforts
  - Promotes a Culture of Tsunami Preparedness and Response
- Outreach to public and partners
  - Through and with Media
  - Community Presentations
  - Brochures and Websites

US Partnership: Building a Global System

- Providing timely, accurate Tsunami Warning advice by Regional Advisory Centers
- Helping countries build national systems
  - International Tsunami Information Center (ITIC)
  - Caribbean Tsunami Warning Program (CTWP)
  - USAID / OFDA Programs for DRR
- Strengthening Partnerships
  - Global (GEO, UNESCO / IOC, WMO, APEC, UNDP, IFRC/Red Cross, World Bank, etc)
  - Regional (SPC/SPREP/SOPAC, CDEMA, ASEAN, etc)
- Technical (ICSU WDS, USGS/FDSN, IUGG/Tsunami Comm)
  - Move beyond bi-lateral to multi-lateral engagement, global cooperation and coordination in development assistance
Guarding against Tsunamis in the Pacific

- Focus on Local Tsunamis (cause 99% of deaths)
  - Sub-regions based on hazard and risk
    (Central / South America, SW Pacific, South China Sea)
  - Community Preparedness - Education and Awareness
  - Identify Tsunami Hazard Zones and Evacuation
  - Emergency Response Plans and Procedures
  - International and National Tsunami Exercises
- New, accurate PTWC products in 2013/2014
  - Wave forecasts in tsunami products
  - Understandable, actionable warning advice
  - Denser real-time detection networks
  - Better and faster earthquake and tsunami analysis
- Strengthening Communications
  - Reach geographically remote island states
  - Redundant warning dissemination technologies (low/high-tech)

ITIC – INTERNATIONAL Mandate – Functions (1977)

- Monitor / Recommend improvements to PTWS and other tsunami warning systems - communications, data networks, evaluations, info dissemination
- Assist in establishing regional and national tsunami systems - comprehensive risk reduction
- Serve as technology transfer resource; Encourage research to improve evaluations, conduct trainings to build capacity
- Serve as information resource for preparedness / education; Develop, publish, and distribute materials
- Serve as an information resource on historical tsunamis – database, surveys

ICG / PTWS

TECHNICAL WORKING GROUPS
- WG 1 – RISK ASSESSMENT & REDUCTION – FRANCOIS SCHINDELE (FRANCE) TASK TEAM - TSU MODELLING HAZ ASSESSMENT – VASILY TITOV (USA)
- TASK TEAM - TSU RISK ASSESSMENT – NGUYEN HONG PHUONG (VIETNAM)
- WG 2 – DETECTION, WARNING, DISSEMINATION – CHIP MCCREERY (USA)
- TASK TEAM - WARNING DIS - FILomena Nelson (SAMOA), ED YOUNG (USA)
- TASK TEAM - ENHANCING PRODUCTS – CHIP MCCREERY
- TASK TEAM - PACWAVE11 – JO GUARD (NZ), LAURA KONG (ITIC)
- TASK TEAM - SEA LEVEL MONITORING – CHRIS RYAN (AUSTRALIA)
- TASK TEAM - SEISMIC DATA SHARING IN SW PACIFIC – KEN GLEDHILL (NZ)

REGIONAL WORKING GROUPS
- SOUTH EAST PACIFIC – MIGUEL VASQUEZ (CHILE)
- CENTRAL AMERICA – PACIFIC – a.i., ANGELICA MUNOZ (NICARAGUA)
- SOUTH CHINA SEA - MOHD ROSAI DI BI CHE ABAS (MALAYSIA)
- SOUTH WEST PACIFIC – FILomena Nelson (SAMOA)

ITIC - Share Information

PRINTED
- Tsunami. Great Waves [75,000 copies]
- Tsunami Glossary 2008 [25,000 copies]
- Surviving a Tsunami - Lessons from Chile, Hawaii, and Japan
  - USGS Circular 1187 (English) - Revised 2009 [40,000 copies]
  - USGS Circular 1218 (Spanish) - Revised 2009 [5000 copies, SHOA]
- Global Earthquakes / Tsunami / Volcanic Eruptions posters
  - 2010 version: [2000 copies of each]: 2008: [1000 tsunami, SHOA];
  - 2011 Tsunami version [3000]
- Tsunami iconshendron globe maps [50,000 copies printed in 2010, 2012]
- Where First Wave Arrives in Minutes (2004, 2008 Indo) [50,000 copies]
- Tsunami Warning! children booklet [20,000 copies]

FINALIZED
Tonga Tsunami Survivor Stories – Tongan, English, JICA, Tongan
Broadcasting Cooperation, ITC, UNESCO Apta
50,000+ awareness distributed globally [50% to US] ➔ FREE
ITC 2011-12 Activities – Summary

- **Participate as technical expert** on to ICG meetings, workshops, trainings, assessment country visits
- **Conduct International Trainings**, esp Tsunami SOP for TW and ER: ITP-Hawaii, ITP-International, in-country
- **Conduct Domestic Trainings** (develop and train AWR-217)
- **Develop / Distribute tsunami warning decision support tools**; train on request: 6 basic tools, updated continuously
- **Develop / Revise / Distribute tsunami awareness materials.**
  Web site: itic.loc-unesco.org or www.tsunamiwaves.info
- **Post-Tsunami Survey Coordination** – US and Intl