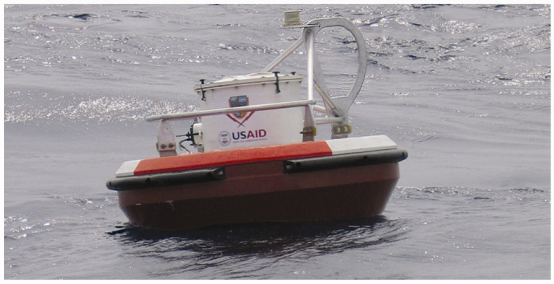
USAID | ASIA
FROM THE AMERICAN PEOPLE

U.S. Contribution to the Indian Ocean Tsunami Warning System

U.S. INDIAN OCEAN TSUNAMI WARNING SYSTEM (IOTWS) PROGRAM

FINAL PROGRESS REPORT

August 1, 2005 to March 31, 2008



March 2008

U.S. IOTWS Program Document No. 32-IOTWS-08

USAID FROM THE AMERICAN PEOPLE

NOAA

USGS science for a changing world

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

U.S. TRADE AND DEVELOPMENT AGENCY

US INDIAN OCEAN TSUNAMI WARNING SYSTEM (IOTWS) PROGRAM

FINAL PROGRESS REPORT

August 1, 2005 to March 31, 2008

March 2008

Prepared for US Agency for International Development
by IRG-Tetra Tech Joint Venture under Contract No. EPP-I-02-04-00024-00

US IOTWS Program Document No. 32-IOTWS-08

CONTENTS

ACRONYMS ..... **iv**

EXECUTIVE SUMMARY ..... **v**
PROGRAM ORGANIZATION v
PROGRAM PERFORMANCE v
PROGRAM CONTRIBUTIONS v
TOOLS AND MECHANISMS FOR SUSTAINABILITY vi
REPORT CONTENTS vi

I. INTRODUCTION **1**
1.1 THE TSUNAMI OF DECEMBER 26, 2004 1
1.2 INTERNATIONAL COMMUNITY RESPONDS 1
1.3 UNITED STATES CONTRIBUTION TO DEVELOPMENT OF AN IOTWS 1
1.4 THE CHALLENGE OF DEVELOPING AN IOTWS 2

2. OVERVIEW OF US IOTWS PROGRAM **4**
2.1 DEVELOPMENT OF THE US IOTWS PROGRAM 4
2.2 PROGRAM OBJECTIVES 5
2.3 MISSION AND OPERATING PRINCIPLES 5
2.4 US IOTWS PROGRAM FRAMEWORK 7
2.5 USG TEAM ROLES AND RESPONSIBILITIES 7
2.6 PROGRAM MANAGEMENT STRUCTURE AND APPROACH 9
2.7 RESULTS FRAMEWORK AND PERFORMANCE MANAGEMENT PLAN 9
2.8 ACHIEVEMENT OF RESULTS UNDER THE US IOTWS PROGRAM 11

3. US IOTWS PROGRAM CONTRIBUTIONS AND OUTPUTS **12**
3.1 TECHNICAL SUPPORT TO THE IOC AND OTHER UN PARTNERS 12
3.2 DETECTION AND FORECASTING 12
3.3 NATIONAL WARNING CENTER CAPACITY AND WARNING COMMUNICATIONS 16
3.4 PREPAREDNESS, MITIGATION, AND RESILIENCE 20
3.5 CROSS-CUTTING CONTRIBUTIONS 22

4. TOOLS AND MECHANISMS FOR SUSTAINABILITY **26**
4.1 CONTINUED SUPPORT TO IOC, ICG/IOTWS, AND OTHER PARTNERS 26
4.2 INTERIM NOTIFICATIONS FROM THE PACIFIC TSUNAMI WARNING CENTER 27
4.3 SEISMIC MEASUREMENTS, DATA COLLECTION, AND EXCHANGE 27
4.4 SEA LEVEL DATA COLLECTION AND EXCHANGE 27
4.5 RISK ASSESSMENT AND DATA SHARING 27
4.6 MODELING, FORECASTING, AND SCENARIO DEVELOPMENT 28
4.7 ESTABLISHMENT OF A SYSTEM OF INTEROPERABLE ADVISORY AND WARNING CENTERS 28
4.8 PREPAREDNESS, MITIGATION, AND RESILIENCE 28
4.9 CROSS-CUTTING TOOLS 29

5. LESSONS LEARNED **30**
5.1 PROGRAM INCEPTION 30
5.2 PROGRAM DESIGN 30
5.3 MANAGEMENT AND ADMINISTRATION 30
5.4 PROGRAM IMPLEMENTATION 30

6. CONCLUSIONS **31**
6.1 IS THE INDIAN OCEAN REGION BETTER PREPARED TODAY THAN IN DECEMBER 2004? 31
6.2 REMAINING CHALLENGES 32
6.3 FUTURE PRIORITIES 33

APPENDIX A. PERFORMANCE MANAGEMENT REPORTING—LIFE OF PROGRAM **36**
INTRODUCTION 36
RESULTS FRAMEWORK 36

APPENDIX B. US IOTWS PROGRAM TRANSITION MATRIX **52**

ACRONYMS

ADPC	Asian Disaster Preparedness Center
AIT	Asian Institute of Technology
BAKORNAS	National Disaster Management Coordinating Board of Indonesia
BPPT	Agency for Assessment and Application of Technology, Indonesia
BMG	Meteorological and Geophysical Agency, Indonesia
CCR	Coastal Community Resilience
CONOPS	Concept of Operations
DART	Deep-ocean Assessment and Reporting of Tsunamis
GTS	Global Telecommunication Systems
ICG	Intergovernmental Coordination Group
ICS	Incident Command System
IOC	Intergovernmental Oceanographic Commission
IOTWS	Indian Ocean Tsunami Warning and Mitigation System, or Indian Ocean Tsunami Warning System
ITB	Technological Institute of Bandung
ITTI	International Tsunami Training Institute
JMA	Japan Meteorological Agency
NGO	Nongovernmental organization
NOAA	National Oceanic and Atmospheric Administration
PMP	Performance Management Plan
PTWC	Pacific Tsunami Warning Center
PTWS	Pacific Tsunami Warning and Mitigation System
RANET	RAdio and InterNET for the Communication of Hydro-Meteorological and Climate Related Information
RDMA	USAID Regional Development Mission for Asia
RTWC	Regional Tsunami Warning Center
SOP	Standard Operating Procedure
TARNS	Tsunami Alert Rapid Notification System
TEWS	Tsunami Early Warning System
UNDP	United Nations Development Program
UNESCAP	United Nations Economic and Social Commission for Asia Pacific
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	US Agency for International Development
USFS	US Forest Service
USGS	US Geological Survey
USG	US Government
USTDA	US Trade and Development Agency
WG	Working Group
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

This report presents a final summary of activities and performance results of the US Indian Ocean Tsunami Warning System (IOTWS) Program from August 1, 2005 through March 31, 2008. The US Agency for International Development (USAID) launched the US IOTWS Program in response to the December 2004 tsunami disaster. Through this two-year, $16.6 million effort, scientists and experts from the United States shared their technical expertise, provided guidance, and helped build multi-hazard warning system capacity in the Indian Ocean region so that governments and communities will be able to detect and prepare for tsunamis and other coastal hazards.

PROGRAM ORGANIZATION

The Program served as the US Government's (USG's) direct contribution to the ongoing international efforts to develop the regional IOTWS under the leadership of the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Intergovernmental Oceanographic Commission (IOC). The Program promoted the development of an end-to-end, integrated warning system, working primarily in the countries most affected by the tsunami—Indonesia, Sri Lanka, Thailand, India, and the Maldives. The US program included several partner agencies with specialized expertise and access to resources for the region. In addition to USAID, these agencies include the National Oceanic and Atmospheric Administration (NOAA), US Geological Survey (USGS), US Department of Agriculture/Forest Service (USFS), and US Trade and Development Agency (USTDA).[1] USAID's Regional Development Mission for Asia (RDMA) in Bangkok managed the program with the coordination support of a contractor that served as the Program Integrator (PI).

PROGRAM PERFORMANCE

The US IOTWS Program contributes substantively to USAID's Special Objective (SpO) 498-045 to save lives and support government-led early warning and disaster preparedness efforts in the Indian Ocean region. Four sub-intermediate results were developed with a total of 10 indicators on which Program implementing partners reported monthly. Of the Program's 10 performance indicators, targets were met for four and exceeded for six.

PROGRAM CONTRIBUTIONS

The US IOTWS Program has provided substantial contributions towards the development of an IOTWS at the regional, national, and local levels. Working through the IOC and the Intergovernmental Coordination Group for the IOTWS (ICG/IOTWS), comprising all 28 Indian Ocean countries, the US IOTWS Program provided substantial input into shaping the overall design of the IOTWS and contributed to the development of common standards and protocols. Contributions at the regional level primarily focused on supporting the installation and upgrades of various detection systems to enable better forecasting of potential tsunamis. The US IOTWS Program provided support in all five countries affected by the December 2004 tsunami at national and local levels. National-level activities were largely focused on capacity building and technical assistance, and included targeted assistance in technology transfer, deployment, specialized training programs, and efforts to strengthen policy and institutional

[1] USAID managed all implementing arrangements with the PI and all participating US agencies except USTDA. While USTDA was independently responsible for activities supporting the US IOTWS Program, USTDA was considered a full partner in the Program, and its achievements are fully reflected in this report.

frameworks. The US IOTWS Program emphasized downstream issues in many of its activities with the aim of helping communities better prepare for and be able to respond to a variety of natural hazards.

TOOLS AND MECHANISMS FOR SUSTAINABILITY

Because the US IOTWS Program was designed to be catalytic and provide targeted support over a two-year period, the USG team structured its activities at the outset to help ensure sustainability well beyond the program period by building capacity within the region and establishing partnerships. The team has been actively working with partners in the region to help transition Program tools, products, and initiatives into sustainable, long-term platforms that will continue independently into the future. Most of the USG agencies involved in the US IOTWS Program will continue to play a role in developing and implementing the IOTWS through various mechanisms.

REPORT CONTENTS

This report provides a summary of the US IOTWS Program's accomplishments during the entire program and is divided into six sections:

- **Section 1** provides the context in which the program was initiated.
- **Section 2** includes an overview of the US IOTWS Program and guiding principles that were used to develop the program. Section 2 also includes a brief summary of results achieved as reported within the Results Framework.
- **Section 3** provides a narrative summary of key contributions under the program as they relate to the development of the end-to-end warning system.
- **Section 4** describes the tools and mechanisms that have been developed throughout the program to promote the sustainability of various activities and products that were initiated under the US IOTWS Program.
- **Section 5** provides a brief summary of a Lessons Learned Review that was conducted under this program to inform future, large-scale, complex initiatives in response to a natural disaster.
- **Section 6** identifies some of the key challenges that remain in developing and implementing the IOTWS, including future priorities.
- **Appendix A** includes the entire Performance Management Plan with final results for each indicator.
- **Appendix B** includes the complete Lessons Learned Review.
- **Appendix C** includes the transition matrix that was prepared as part of closeout activities for the program to identify opportunities to continue and build on the activities under the US IOTWS Program.

I. INTRODUCTION

1.1 THE TSUNAMI OF DECEMBER 26, 2004

On the morning of December 26, 2004, a magnitude 9.3 earthquake off the coast of Indonesia's Sumatra Island caused a massive tsunami that spread outward and struck coastlines of 22 countries across the Indian Ocean. Almost 300,000 people perished, and 1.5 million more lost their homes or livelihoods from more than 50 countries around the world. There are many factors that contributed to such a large loss of life that day. The sheer force of the undersea earthquake near western Sumatra and the vertical uplift of several meters of seafloor along the rupture displaced a tremendous volume of water. The shallow coastal topography adjacent to deeper ocean waters enabled the tsunami waves to rapidly gain height, upwards of 30 meters. Large population centers were in the path of the destructive waves, particularly in the low-lying areas of Banda Aceh, Indonesia. There was also an overall lack of awareness by populations on how to respond because of the infrequency of tsunamis in the region. Finally, there were no regional or national warning systems to alert communities of the impending tsunami.

While it would not have been possible to have prevented all loss of life from the December 2004 tsunami, the death toll would have been drastically reduced if an early warning system had been in place to alert communities to evacuate the coastal areas and move inland. To mitigate the damage and loss of life from future disasters, world leaders called for a coordinated effort by the international community and the Indian Ocean countries to develop an end-to-end early warning system for the entire Indian Ocean region.

1.2 INTERNATIONAL COMMUNITY RESPONDS

In addition to the extensive disaster relief and reconstruction that followed the tsunami, the international community took a series of steps to initiate a coordinated effort to develop an Indian Ocean Tsunami Warning and Mitigation System (IOTWS). Working through a series of meetings hosted by the UNESCO IOC, the governments of the region agreed to develop an IOTWS within an interconnected network to be coordinated through an ICG under the auspices of the IOC.

In addition to the management and technical support from the IOC itself, Germany, the United States, Japan, the United Kingdom, Sweden, France, and others have provided significant technical and financial support towards the development of the IOTWS. IOC ICG/IOTWS members such as Thailand, India, Indonesia, Malaysia, and Australia have also made significant financial commitments to support and strengthen their own IOTWS capabilities, as well as for international detection systems such as deep-ocean buoys, coastal sea-level gauges, and seismic stations.

1.3 UNITED STATES CONTRIBUTION TO DEVELOPMENT OF AN IOTWS

The United States responded immediately in the aftermath of the tsunami with massive amounts of relief to the region. In the days following the December 26, 2004, tsunami, in cooperation with other donors and private organizations, US support helped ensure that critical needs for food, shelter, and water and sanitation were met.

The USG's participation in the reconstruction efforts included rebuilding roads and other infrastructure, training to help develop new skills and livelihoods, strengthening community governance and political infrastructure, and supporting the development of an end-to-end IOTWS and strengthening disaster preparedness skills throughout the region.

As part of the USG's contribution to the international IOTWS effort led by the IOC, in 2005 the USAID launched the US IOTWS Program. Through this two-year, $16.6 million effort, US scientists and experts shared their technical expertise, provided guidance, and helped build multi-hazard warning system capacity within the Indian Ocean region so that governments and communities will be able to detect and prepare for tsunamis and other coastal hazards.

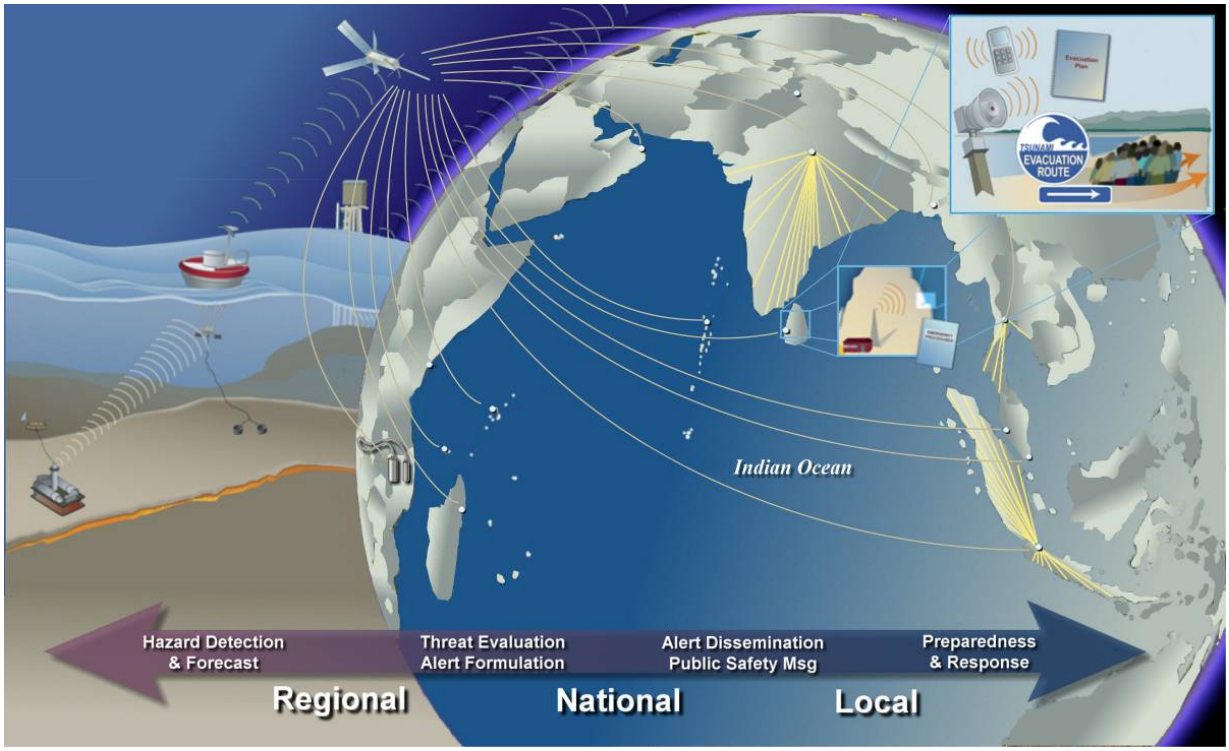
1.4 THE CHALLENGE OF DEVELOPING AN IOTWS

International efforts to develop a functional, end-to-end, early warning system for the Indian Ocean region faced several immediate challenges. Tsunamis are the most difficult of all natural hazards to prepare for, detect, analyze, and warn against, and the process of building a robust, reliable warning system was expected to take many years and require decades of long-term sustained investment and effort.

While the technical capability for developing an end-to-end system existed in December 2004, many of the technologies and systems were unknown to the region and many countries in the region lacked the expertise needed to operate and maintain much of the sophisticated instrumentation used in a multi-hazard warning system. It would take years to complete the installation and integration of the detection and warning system components and processes needed to provide the geographic coverage to accurately detect and communicate hazard warnings.

In additional to technical challenges, in many cases the institutional mechanisms needed to develop and maintain such a system did not exist. Before December 2004 many of the Indian Ocean countries lacked national policies and frameworks to deal with large-scale disasters. Many new agencies were established in the national governments in the Indian Ocean region following the December 2004 tsunami to address disaster management issues, but these agencies often had shifting mandates and authorities that resulted in overlapping or unclear responsibilities.

Finally, a significant challenge in the development of the IOTWS was the sheer numbers of international partners that wanted to provide support to the countries in the region and the need to coordinate these efforts so that the countries were not overwhelmed by well-meaning international donors. Each country had to first identify its own needs and priorities for the development of early warning capabilities before coordinating efforts with other partners.



COMPONENTS OF AN END-TO-END TSUNAMI WARNING SYSTEM

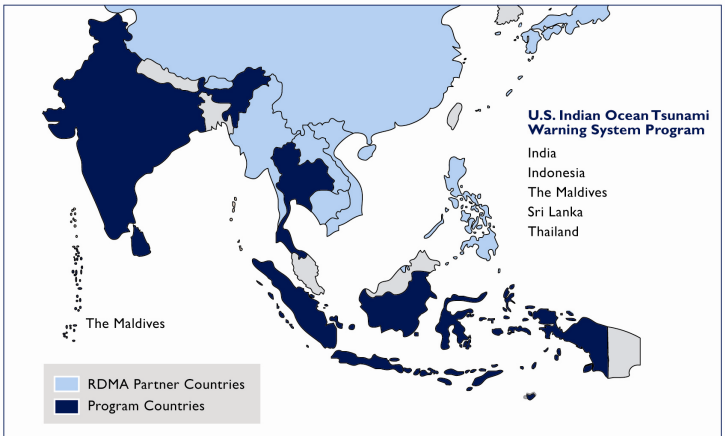
End-to-end refers to a system that incorporates several individual components that operate in a sequence to produce a fully functioning system. These components include the initial detection of an earthquake and potential tsunamis, data analysis, formulation and dissemination of the warning, and finally, response by the community to the warning. All the pieces need to fit together so that communications can be continuously received and transmitted along a chain that is initiated at a regional scale, moving toward a national level, and finally reaching local communities. The major steps for the development and dissemination of a tsunami warning include the following.

1. **An earthquake and changes in sea-level are detected.** Oceanographic equipment and sensors are placed in the ocean, on the seafloor, and in seismically active areas to detect seismic activity in the Earth's crust and changes in sea level. These buoys, sea-level stations, and seismic monitors provide data to indicate a potential tsunami.
2. **Seismic and oceanographic data from the monitoring systems are transmitted to tsunami warning/notification centers to process the information.** In some cases, in the language adopted by the ICG/IOTWS, the tsunami warning center is a National Tsunami Warning Center (NTWC) that provides warnings, watches, and advisories to its citizenry and public and private agencies. A Regional Tsunami Watch Provider (RTWP) provides tsunami forecasts and other information to another or several other countries in a region. An RTWP may also serve a dual role as the NTWC for the country in which it resides. International communication methods such as the World Meteorological Organization's (WMO) Global Telecommunications System (GTS) are used to communicate the data to the warning centers.
3. **A bulletin is developed.** Seismic and sea-level data is incorporated and analyzed to forecast the possibility of a tsunami. Next, potential threats from a tsunami are predicted to enable the issuance of credible warnings that cover only areas actually affected.
4. **The tsunami warning center issues the bulletin to disaster management agencies.** The tsunami warning center issues the bulletin regarding the potential tsunami, which may take many forms. Adhering to international formats and standards, the tsunami warning center may issue a warning, a watch, an advisory, or an information statement. Advisories are usually updated to upgrade to a warning or cancel the advisory.
5. **Disaster management agencies and local authorities disseminate the bulletin to the affected areas.** Using a variety of communication tools such as regional satellites, SMS text messaging, radio broadcasts, and sirens, the affected public is alerted to the bulletin. In coordination with neighboring tsunami warning centers, the center should issue a cancellation, extension, or final bulletin as appropriate.
6. **Local authorities receive the bulletin and respond.** The affected areas receive the bulletin and responds based on the information received. If a warning has been issued, communities follow established procedures for evacuation and wait for a signal that it is safe to return.

2. OVERVIEW OF US IOTWS PROGRAM

2.1 DEVELOPMENT OF THE US IOTWS PROGRAM

The US government responded to the need for an IOTWS as part of the emergency supplemental appropriation for tsunami recovery and reconstruction in early 2005. That appropriation included a $16.6 million allocation for developing the IOTWS within the two-year time frame provided through the legislation. After extensive initial interagency coordination involving the Department of State, USAID, and other USG agencies, USAID was designated to serve as the lead agency and initiated an interagency consultation process with the key USG agencies specializing in tsunami early warning systems and disaster management to shape the scope and direction of the program. Key agencies included NOAA, USGS, and USFS. USAID's RDMA in Bangkok, which took the lead role within USAID, developed an initial concept paper to provide a framework for an integrated program approach that was used as a starting point for discussion with the USG agencies. This paper first outlined the concept of an end-to-end system that would apply a multi-hazard approach to early warning. Because of the compressed time frame, the breadth of geographic scope, and the number of agencies involved, it was critical to operate within a transparent framework ensuring participation from all of the relevant USG agencies at the outset. USAID later also engaged the USTDA, to which funding was directly transferred through USAID's Asia and Near East Bureau.



US IOTWS Program focus countries

Consistent with the priority focus of the US tsunami emergency supplemental, the US IOTWS Program focused its efforts on the countries most affected by the tsunami—Indonesia, Sri Lanka, Thailand, India, and the Maldives.

Through this collaborative and transparent process, USAID/RDMA and its partner agencies outlined the USG objectives on how the United States could most effectively contribute toward the international efforts to develop the IOTWS. Each agency identified activities based upon areas of expertise and developed respective scopes of work. RDMA then developed a Program Description that formed the basis for individual Inter-Agency Agreements (IAAs) with NOAA, USGS, and USFS, as well as the scope of work for an outside contractor to provide technical, logistical, administrative, and coordination support as the Lead Program Integrator (LPI).[2] Aligning the technical skills and experience of each USG agency within a consolidated and integrated projected work plan focused the proposed activities and enabled a rapid, coordinated response.

[2] LPI was later to be shortened to Program Integrator (PI).

The USG agencies also provided early technical support to the overall international response such as participation in an IOC planning meeting in Mauritius in May 2005 as well as the first IOC ICG/IOTWS-I meeting held in Perth, Australia in August 2005. Several officials from NOAA and USGS also participated in country assessments in August and September 2005 in Bangladesh, Indonesia, Thailand, and Malaysia to begin identifying gaps in national early warning system capacity and to initiate discussions with country counterparts on possible technical assistance activities needed. These early consultations were part of 16 national assessments conducted in the region to help shape the framework of the US IOTWS Program and produced a cohesive, comprehensive approach in an accelerated time frame. In support of the IOC, USAID assigned the PI to analyze and consolidate the results of all 16 assessments into a report that helped define the components and implementation actions of an effective and durable warning system and identified related capacity building opportunities.

2.2 PROGRAM OBJECTIVES

The objective of the US IOTWS Program was to provide strategic support to the international effort led by the IOC to develop an operational IOTWS that provides integrated end-to-end capabilities at the regional, national, and local levels within a multi-hazard framework. Working in partnership with the international community, host country governments, and private sector and non-governmental organization (NGO) partners, USG activities supported each of the essential elements of an IOTWS, which include the following:

- Detection and Forecasting;
- Warning Dissemination; and
- Preparedness, Mitigation, and Resilience.

To be most effective, the program was designed to involve coordinated efforts that *simultaneously* enhance hazard detection, prediction, warning, communication, mitigation, and preparedness, and do so at regional, national, and sub-national/community scales. The aim of the program was to be comprehensive in coverage—through strategic collaboration with the international community, other donors, the private sector, and NGOs—without necessarily seeking to address every need everywhere.

2.3 MISSION AND OPERATING PRINCIPLES

To achieve maximum effectiveness given the limited resources and accelerated schedule for the program, the USG approach incorporated several key principles and themes to guide program design and implementation. Several of these principles are mutually reinforcing, but each reflects the need to address a range of interconnected but complex challenges, including a web of diverse multilateral, bilateral, and national activities to develop various components of an IOTWS that are not yet effectively coordinated.

Sustainability and Long-Term Impact

The USG approach aimed to ensure sustainability and long-term effectiveness of program activities, particularly by promoting greater institutional and technical linkages to existing global systems/networks by strengthening the national institutions and policy frameworks that would form the backbone of an effective, integrated, end-to-end IOTWS. The most successful management systems will be built upon a multi-sectoral approach in which all organizations—government, private, and community—are involved and understand their individual roles and responsibilities in tsunami warning and have allocated the recurrent budgets needed to sustain operations over time.

Coordination

Catalytic Leadership, Leverage, and Partnerships. In further support of the goal of sustainability and to make the best use of limited resources, the USG approach was intended to be *strategic* and *catalytic* to mobilize and leverage resources of the international community, country governments, the private sector, and NGOs, and sought to *create synergies* with the ongoing efforts of regional, national, and local institutions and stakeholders. Recognizing that the US IOTWS Program is but one contribution of a multifaceted international response, all project activities were closely coordinated with the IOC and the donor community to achieve maximum synergy and use of resources.

Integration and Complementarity with Ongoing Disaster Management Programs. In view of limited resources and the importance of local stakeholder involvement, it was imperative that the US response complemented, was consistent with, and added to existing USG-funded and other disaster management programs in each country and facilitated linkages with regional activities. All activities sought to complement other ongoing or planned programs in disaster management.

Adaptive Management

Because individual countries in the region are in different stages in developing their disaster management systems and the requirements for initiating efforts to develop tsunami warning system capabilities were not yet known, USAID and the USG team adhered to a *rolling design* concept in program implementation. As a result, the USG team incorporated an adaptive management approach into the Integrated Program Work Plan that provided the flexibility to adjust the scale and nature of activities depending on changing or new circumstances at the international and national levels.

Technical Assistance

Centralization, Standardization, and Interoperability. It is critical for national early warning systems to become fully integrated into both regional and global frameworks to ensure interoperability of all systems. To accomplish this, there must be uniform standards and protocols for collecting and disseminating relevant data, products, and services. US delegations have expressed in international forums the US interest, experience, and capability in helping to develop standards and protocols at the regional scale, while providing limited technical assistance to individual nations that may lack data processing and exchange capabilities.

Regional Cooperation and Cross-Learning. Regional cooperation is essential: (1) to maximize and amplify the impacts of the USG program through sharing of knowledge and experience; (2) to ensure the interoperability of national and regional early warning systems within a global framework; and (3) to support uniform standards and protocols for information sharing. As a cross-cutting theme, the US IOTWS Program encouraged and supported regional cooperation and the sharing of experiences and lessons learned within the region, as well as with the United States and the international community.

Multi-Hazard and Multidisciplinary Approach. All national-level tsunami warning systems should be integrated into national disaster management systems and plans as part of a multi-hazard approach—one that recognizes the value of being able to simultaneously address multiple types of disasters through the same disaster management systems. Wherever possible and relevant, the USG program encouraged national disaster management organizations to adopt a multidisciplinary approach that incorporated mitigation, preparedness, response, and recovery objectives for the multiple hazards threatening communities in the region.

Stakeholder Involvement and Empowerment. Stakeholder involvement and empowerment at the community level are critical to the program's practical effectiveness on the ground. Successful disaster management systems are built on the vertical integration and cooperation among local communities and their

governments, as well as the horizontal integration among stakeholders and community members that may not otherwise have shared the same ideal. Community-based approaches to disaster mitigation, preparedness and response are more likely to be effective and sustainable when they are intertwined with local experience, practices, and knowledge, particularly taking into consideration the needs of women and marginalized communities.

2.4 US IOTWS PROGRAM FRAMEWORK

The US IOTWS Program was organized into the following seven program areas that addressed regional, national, and local levels of tsunami warning system development, as well as cross-cutting support activities. These program areas include the following:[3]

Regional

- Technical support to the IOC
- Regional hazard detection, observation, and forecasting systems

National

- National warning center capacity and warning communications

Local

- Local preparedness, mitigation, and resilience

Cross-cutting

- Regional exchanges, training, and information resources
- Overarching coordination, administrative support, and program outreach
- Small grants program

The US IOTWS Program contributions and major outputs from these program areas are described in Section 3 of this report.

2.5 USG TEAM ROLES AND RESPONSIBILITIES

The integrated assistance package of the United States drew on the expertise and resources of a number of US agencies and strategic private and public sector partners to strengthen the capacity of governments, national warning centers, and local communities to undertake an integrated disaster management approach. With presence in the region through its Regional Development Mission for Asia (RDMA), USAID led the interagency program and provided overall coordination and support to the USG team. In addition to USAID, these agencies included NOAA, USGS, USFS, and USTDA. USAID procured the services of IRG-Tetra Tech, Inc., to serve as the PI to provide both leadership and broad coordination, logistical, training, and administrative support in all areas and at all levels of program implementation.

Table 1 provides a summary of the various roles and responsibilities of the core USG agency team.

[3] Program area titles have been revised from the original Integrated Program Work Plan to reflect refinements in activity area definitions.

Table 1. Summary of USG Agency Responsibilities by Technical Program Component

Program Component	Level	USAID/ PI	NOAA	USGS	USFS	USTDA
1. Technical support to IOC and other UN partners	Regional	●	●	○		
2. Regional hazard detection, observation, and forecasting systems	Regional	○	●	●		
3. National warning center capacity and warning communications	National	●	●	●	●	●
4. Preparedness, mitigation, and resilience	Local	●	●	○	●	
5. Regional and sub-regional exchange of lessons learned and best practices	All	●	○	○	○	○
6. Overarching coordination, admin support, and program outreach	All	●				
7. Small grants program	All	●				

● Major role ○ Support role

USAID provided overall management, coordination, and administrative support for the integrated USG program from RDMA in Bangkok, Thailand. USAID/RDMA coordinated directly with appropriate USAID Mission personnel and programs in India, Indonesia, and Sri Lanka, with the USAID Office of Foreign Disaster Assistance (OFDA), and with USAID/Washington. USAID managed the PI for the US IOTWS Program, coordinated directly with each of its USG agency partners.

NOAA provided an array of technical support at multiple levels of engagement, which included institutional and technical support to the IOC; technology transfer for DART buoys, sea-level gauges, and related detection equipment; tsunami detection, prediction, and warning formulation; communications systems and integration; hazard mapping and modeling; and support for local preparedness including development of a coastal community resilience (CCR) program.

USGS provided complementary interventions, often in coordination with NOAA, that supported seismic and tide station technology transfer; regional and global interoperability within the IOC framework; and capacity building at both the detection/warning formulation and local preparedness levels in data analysis and prediction and in hazard/vulnerability/risk mapping and modeling standards, protocols, and methods.

USFS provided expertise to help integrate Incident Command Systems (ICS) into the existing disaster response systems of a country (or countries) in the region, helping to institutionalize national capabilities in ICS while working to ensure standardization and interoperability among nations for cross-border cooperation. USFS also worked with NOAA to support development of national-level Tsunami Alert Rapid Notification System (TARNS).

USTDA engaged private sector expertise in communications and emergency operations systems and technologies necessary for the tsunami warning system. USTDA facilitated dialogues and linkages among US and Asian businesses, the USG, and others working directly with regional institutions and national governments, and identified entry points for accessing leaders in Asia's technology and communications markets.

Program Integrator (PI). The PI coordinated USG agency efforts with a view towards achieving the overall expected results for the USG program, reporting those results, and publicizing successes. In addition to overarching support, the PI provided rapid access to and deployment of specialized technical expertise, supported targeted technical assistance in areas not already addressed by the USG agency team, facilitated national and regional events such as conferences, workshops, and training activities, and implemented the Small Gants Program (SGP) to build capacity of stakeholder institutions at the local level. The PI included international partners such as the Asia Disaster Preparedness Center (ADPC) as well as country coordinators in Sri Lanka and Indonesia to provide support in most program areas.

2.6 PROGRAM MANAGEMENT STRUCTURE AND APPROACH

The US IOTWS Program team members prepared an integrated work plan, communications plan, and a performance management plan (PMP) to serve as the core management tools for USAID and the program team. The Integrated Program Work Plan mapped the planned activities of the various implementers, and the PMP described the results framework, data collection sources and methods, and performance indicators and targets for the Program. The initial Integrated Program Work Plan was drafted in November 2005 by the PI and, following revisions, approved by RDMA in March 2006. An updated Work Plan was completed in February 2007. Using an adaptive management process, the activities were responsive to regional, national, and local capacity building needs and effectively coordinated with other donor efforts to minimize overlaps or redundancies.

The PI provided support to the US IOTWS Program team members to facilitate the exchange of information, to coordinate complementary activities, and to provide a forum to discuss outstanding issues. The US IOTWS Program formed a Program Coordination Group (PCG) comprising representatives from each agency partner. The PCG met biweekly throughout the program period to maintain communication and coordinate all program activities.

In addition to the immediate USG team members, there were additional program partners with whom the team interacted regularly to communicate US IOTWS Program activities to a larger audience and to help establish coordination and partnership mechanisms for targeted program activities. For example, the US IOTWS Program team engaged UN agencies and other donors to promote coordination and complementarity of activities, avoid duplication of effort, and seek opportunities for partnering on targeted IOTWS activities. In an effort to bring together external partners, the US IOTWS Program held three coordination workshops—the first during September 12-14, 2005; the second during January 29-31, 2006; and a final transition workshop on December 6-7, 2007—that engaged participants from donor organizations and other partners.

2.7 RESULTS FRAMEWORK AND PERFORMANCE MANAGEMENT PLAN

The results framework for the US IOTWS Program is used to provide a reporting framework to measure progress and report results throughout the program. The results framework falls under USAID SpO 498-045, which is, "to save lives, help individuals rejoin the workforce and return to communities, support host government-led reconstruction and early warning/disaster preparedness efforts."

The PMP was developed to effectively measure the accomplishments of the diverse and numerous program activities. The PMP describes the results framework, data collection sources and methods, and performance indicators and targets for the US IOTWS Program. The PMP incorporates SpO-level intermediate results as well as a series of sub-intermediate results. These performance measures provide a critical function in tracking the overall effectiveness of the US IOTWS Program, and in reflecting the gradual additions and improvements to the Program.

Version 2.0 of the PMP (February 2007) includes the results of a mid-program review process in October 2006, which led to a number of revisions to the US IOTWS Program Work Plan and PMP and the final target results to be achieved through the end of the program. In addition, the PMP indicators, definitions, and data sources were updated and clarified. Appendix A includes the entire revised PMP Version 2.0, including indicator tables reflecting planned targets and actual results.

Table 2. Results Framework and Performance Indicators for US IOTWS Program

USAID Special Objective (SpO) for Tsunami Recovery and Reconstruction:
To save lives; help individuals rejoin the workforce and return to communities; support host government-led reconstruction and early warning/disaster preparedness efforts.

SpO Intermediate Result (IR) 3: Early Warning System Installed
SpO Indicator 3.1: Number of Communities Trained in Disaster Preparedness
SpO Indicator 3.2: Number of Communities Included in National Emergency Operations Center Alert System

SpO IR 4: Technical Assistance, Good Governance & Reconciliation
SpO Indicator 4.1: Number of government agencies that received technical support

Sub-IRs (Program-level IRs)

Initial Performance Indicators	Revised Performance Indicators after Year 1
Sub-IR 1. Early warning system for IOTWS designed and adopted	**Sub-IR1: Scientifically sound design for IOTWS developed**
Indicator 1.1: Early warning system design formally adopted by IOC	**Indicator 1.1:** Draft and refined versions of conceptual IOTWS design provided to and accepted by ICG/IOTWS
Indicator 1.2: No. of protocols, agreements, and products related to the regional IOTWS system design developed, adopted, and implemented by IOC member nations through participation in IOC and ICG-IOTWS working groups	**Indicator 1.2:** No. of protocols and products established by or with ICG/IOTWS member nations that enable interoperability of the regional IOTWS system
Sub-IR 2. Tsunami detection and early warning capabilities improved	**Sub-IR2: Tsunami detection and early warning capabilities improved**
Indicator 2.1: No. of regional-level tsunami detection and communication systems designed, demonstrated, upgraded, or operated in the region in collaboration with key partners	**Indicator 2.1:** No. of agreements developed for the installation, deployment, or integration of tsunami detection and communications system components
Indicator 2.2: No. of national- and local-level tsunami warning system components connected to regional-level systems that have been newly demonstrated, upgraded, or operated	**Indicator 2.2:** No. of tsunami detection and communication system components installed, deployed, and/or upgraded
	Indicator 2.3: No. of tsunami detection system components integrated into the IOTWS and operated in accordance with ICG/IOTWS standards and criteria (NEW)
Sub-IR 3. National capacity in disaster mgt planning, tsunami warning dissemination, and vulnerability assessment improved	**Sub-IR3: National capacity in tsunami warning dissemination and disaster management improved**
Indicator 3.1: No. of national policies, plans, protocols, procedures, and analytical capabilities developed or improved through training and technical assistance	**Indicator 3.1:** No. of tsunami/all-hazards warning dissemination and disaster management system components designed, developed and/or improved at the nation level
Indicator 3.2: No. of communities included in national alert systems	**Indicator 3.2:** No. of communities included in national alert systems
Indicator 3.3: No. of government agencies (e.g. central government offices, municipalities) that received technical support	**Indicator 3.3:** No. of government agencies that received technical support
Sub-IR 4. Local preparedness and coastal mitigation for tsunamis and related hazards improved	**Sub-IR4: Local preparedness and coastal mitigation for tsunamis and related hazards improved**
Indicator 4.1: No. of communities trained in disaster preparedness	**Indicator 4.1:** No. of communities trained in disaster preparedness
Indicator 4.2: No. of coastal communities, adopting, and/or implementing criteria and/or benchmarks for coastal disaster preparedness	**Indicator 4.2:** No. of coastal communities initiating activities that support resilience
Indicator 4.3: Kilometers of coastline under improved, sustainable environmental management	Deleted
Sub-IR 5. Private and public resources leveraged for the USG program	
Indicator 5.1: US$ leveraged through private sector, NGO, donor, and public sector resources in support of the development of an end-to-end IOTWS	Deleted

2.8 ACHIEVEMENT OF RESULTS UNDER THE US IOTWS PROGRAM

The PMP included 10 program-level indicators to measure results under the US IOTWS Program. For each performance indicator, a number of specific targets were set. Of the Program's 10 performance indicators, targets were met precisely for four and exceeded for six, including one case in which the target was exceeded by a factor of 28. In this case—the number of communities trained in disaster preparedness—where the target was 712 communities, 20,290 communities were ultimately trained in disaster preparedness and evacuation procedures due largely to the success of one grantee under the SGP. This result was not anticipated in the PMP because the grant was designed in collaboration with the PI and approved after revising the PMP. Highlights of results achieved under the US IOTWS Program through February 2008 are summarized below.

Table 3. Summary of Targets Achieved Under the US IOTWS Program

Indicator	Target	Achieved
Indicator 1.1: Draft and refined versions of conceptual IOTWS design provided to and accepted by ICG/IOTWS.	2	2
Indicator 1.2: Number of protocols and products established by or with ICG/IOTWS member nations that enable interoperability of the regional IOTWS system.	31	31
Indicator 2.1: Number of agreements developed for the installation, deployment, or integration of tsunami detection and communications system components.	11	18
Indicator 2.2: Number of IOTWS or national tsunami detection and communication system components installed, deployed, and/or upgraded.	18	18
Indicator 2.3: Number of tsunami detection and communications system components integrated into the IOTWS and operated in accordance with ICG/IOTWS standards and criteria.	16	16
Indicator 3.1: Number of tsunami/all-hazards warning dissemination and disaster management system mechanisms designed, developed and/or improved at the nation level.	62	70
Indicator 3.2: Number of communities included in national alert systems.	320	399
Indicator 3.3: Number of government agencies that received technical support.	160	195
Indicator 4.1: Number of communities trained in disaster preparedness.	712	20,290
Indicator 4.2: Number of coastal communities initiating activities that support resilience.	67	83

3. US IOTWS PROGRAM CONTRIBUTIONS AND OUTPUTS

The US IOTWS Program has provided substantial contributions towards developing an IOTWS at the regional, national, and local levels. Working through the IOC and the ICG/IOTWS, the US IOTWS Program provided substantial input into shaping the overall design of the IOTWS and contributed to developing common standards and protocols. Contributions at the regional level primarily focused on installing and upgrading various detection systems to enable better forecasting of potential tsunamis. The US IOTWS Program provided support in all five countries affected by the December 2004 tsunami at the national and local levels. Activities were largely focused on capacity building and technical assistance, and included targeted assistance in technology transfer, deployment, and training. The US IOTWS Program focused many of its activities on downstream issues to help communities better prepare for and be able to respond to a variety of natural hazards. A summary of contributions and major outputs is provided below. Mechanisms and tools to help ensure the sustainability of these products are described in section 4.

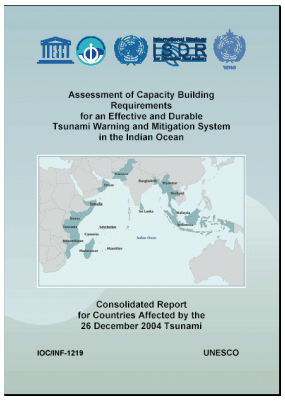
3.1 TECHNICAL SUPPORT TO THE IOC AND OTHER UN PARTNERS

NOAA, USGS, and USAID have extensively participated in and supported the IOC and the ICG/IOTWS. NOAA, with assistance from USGS and USAID, provided the overall conceptual design for the IOTWS, and many of the tools developed under the Program, described below, have been introduced and endorsed by ICG Working Groups. USG experts also participated in IOC-sponsored national assessments in four Indian Ocean countries to determine their tsunami warning capacities in 2005, and USAID's PI prepared the IOC's final report on all 16 national assessments. The USG helped establish protocols and standards for regional warning system interoperability. These protocols are primarily generated in the ICG working groups, in which the US IOTWS Program team members participate.

In coordination with the World Meteorological Organization (WMO), NOAA has outlined the detailed architecture for regional and national tsunami warning systems (Concept of Operations, or CONOPS) and conducted regional- and national-level trainings.

3.2 DETECTION AND FORECASTING

Interim Tsunami Notifications to Indian Ocean Region



Since 2004 the USG has supported continuous 24/7 tsunami notification support to the Indian Ocean from the Pacific Tsunami Warning Center (PTWC), operated by NOAA in Hawaii. This has enabled the Indian Ocean countries to receive notifications and warnings while the IOTWS is under development. As of February 2008, notifications had been issued for two tsunamis and 17 non-tsunami events. PTWC will continue to provide interim notifications until permanent regional warning capabilities are established in the region. In addition to supporting the continued operation of the PTWC, the US IOTWS Program funded an Indian national to train at the PTWC for 18 months to further build capacity in the region for developing and issuing notifications.

Deep-ocean Assessment and Reporting of Tsunamis (DART)

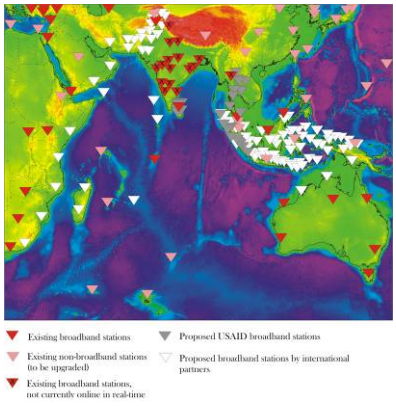
The DART is a monitoring system that detects, measures, and reports the presence of tsunamis. This US-designed system includes two components: (1) a bottom pressure recorder (BPR) that sits on the sea floor to measure differences in water pressure, and (2) a surface buoy for real-time satellite communications. DART data, along with data from seismometers and tide gauges, is processed through a forecast model that provides the information to tsunami warning centers to issue alerts and warnings—or to cancel them.

US IOTWS PROGREAM

Technician lowers the DART tsunami detection buoy into the waters off of Phuket, Thailand.

On December 1, 2006, Thailand and the United States jointly launched a DART II tsunameter into the Indian Ocean at 9^{0}N and 89^{0}E. Indonesia and the United States launched a second tsunameter on September 19, 2007, at 0^{0}N and 92^{0}E. These two DART stations contribute to a planned array of stations to support comprehensive detection capability in the Indian Ocean as endorsed by the ICG/IOTWS. Through its technical training on the deployment, maintenance, and operation of DART stations, NOAA and its partners have demonstrated the implementation of IOC standards and protocols for reliability, accuracy, interoperability, free and open exchange of data, and integration.

DART II is the current generation of DART technology and allows warning centers to access information more quickly. The first DART II helped in determining that no damaging tsunami had been generated by the September 12, 2007, earthquake off Sumatra, thus limiting unnecessary and costly evacuations. In that case, the non-damaging tsunami was quickly detected, assuring that cancelling the warning was the appropriate action. This deep-ocean sensor capability improves quality assurance and reliability of the warning system, reduces the risks of false alarms, and provides much longer warning lead times as compared to a network of sea-level gauges alone.



USGS

Suggested seismic station deployments and upgrades for the Indian Ocean region

In an effort to encourage the development of DART systems independently in the region and worldwide, NOAA provided diagnostic information and specifications for developing DART systems and made this information readily available online for potential users within a few months after the Program began. Using this information, national tsunameter development programs and private sector suppliers have developed and deployed new tsunameter technology in the Indian Ocean. Notably, under an agreement with NOAA, Indonesia has developed and is testing a fully functional tsunameter that has already recorded a small tsunami. As a result, instruments based on the NOAA DART technology are actively being deployed and tested in the Indian Ocean region, accelerating completion of the baseline IOTWS tsunameter array.

Sea-level Monitoring Stations

The ability to warn a vulnerable population of an approaching tsunami depends on a variety of measurements—initially seismic network data and deep-ocean observation, but also on a network of gauges that measure the sea level along the coasts. Real-time data transmission without significant time

delays is essential because of the high speed at which a tsunami wave propagates and the time needed to implement decision-making and mitigation procedures before a warning is issued. Sea-level gauges are generally located at the land-sea interface, usually in locations somewhat protected from the heavy seas that are occasionally created by storm systems. Sea-level gauges that initially detect tsunami waves provide little advance warning at the actual location of the gauge, but can provide an indication for other communities of a tsunami's existance, its speed, and its approximate strength.

Under the US IOTWS Program, through its partnership with University of Hawaii's Sea Level Center (UHSLC) NOAA upgraded six sea-level stations, one each in Sibolga, Prigi, and Cilacap, Indonesia; Hanimaadhoo and Gan, Maldives; and Colombo, Sri Lanka. Scientists can now collect data and disseminate it more quickly for analyses in case of a tsunami. The stations themselves are now stronger and able to better withstand damage from storms and floods. In addition, all six stations have been integrated into the Global Sea Level Observing System (GLOSS), an international monitoring network that is coordinated by the WMO and the IOC. The GLOSS network provides essential real-time data that warning centers can access. By enabling the stations to deliver data in real-time, warning centers are notified almost immediately when an event occurs or if there is a problem with the gauge. In addition, the data become available for many other applications within operational oceanography, such as flood warnings or for using sea-level data in ocean circulation models.

In addition to the six stations supported under the US IOTWS Program, NOAA supported upgrades to nine GLOSS stations for the Indian Ocean through separate funding.

Seismic Monitoring System Support

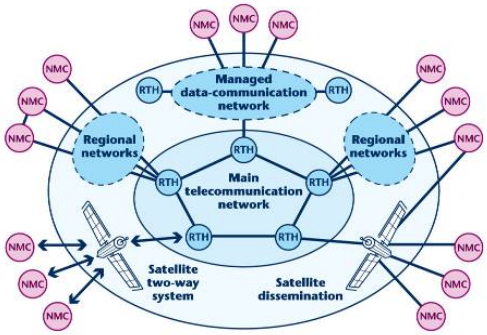
Seismic network data is crucial to the initial warnings that are generated to alert populations of the threat of a tsunami. Building multiple data collection points is critical to developing an effective warning system that addresses multiple coastal hazards, including earthquakes and tsunamis. The USGS has a Global Seismic Network (GSN) that includes more than 120 stations in more than 80 countries on all continents. The GSN improves the quality, coverage, and quantity of data for earthquake reporting and research. Data are reported to orbiting satellites and then to the Internet where information can be viewed publicly. Many stations are now part of a warning system that monitors earthquakes that may generate tsunamis.

Under the US IOTWS Program, USGS has helped governments in the region to upgrade their seismic monitoring capacity. This includes the integration of four seismic stations (one in Thailand and three in Malaysia) into global networks; installation of two accelerometers and three broadband stations in Indonesia; and strengthening of technical skills to monitor seismic activity using specialized software. Seismologists in warning centers and research institutes in Indian Ocean countries now have improved capacity to obtain and analyze data from seismic monitoring stations, which helps determine the location and magnitude of large seismic events in the region. With this data, they can assess the depth and type of the earthquake, and whether it has the potential to cause a tsunami.

USGS also developed a five-day technical training program for Indonesia, Sri Lanka, Thailand, the Maldives, and India, and conducted many of the trainings in cooperation with UNESCO's IOC. The training addressed earthquake monitoring and tsunami warnings, with an emphasis on seismology. In addition, the courses included discussions of methods to facilitate interagency coordination, communicate warnings, and share seismic and oceanic data among participating regional countries.

USGS helped scientists from Thailand, Indonesia, Sri Lanka, and India more effectively investigate evidence of tsunamis that have occurred over the past several hundred years. This paleotsunami field research has led to several landmark discoveries that will help better assess tsunami risk and can help to define the probabilities of future tsunamis—a key parameter in planning coastal development around the unique features of the Indian Ocean.

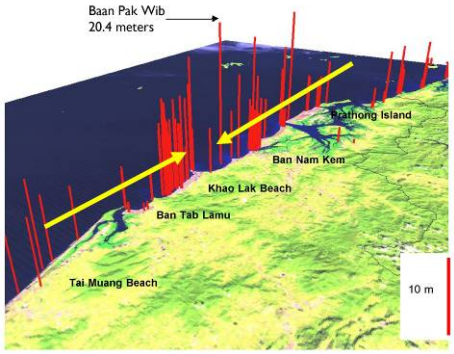
With a good understanding of the use of earthquake and tsunami detection instruments, and through cooperation with the international community, Indian Ocean nations have increased their ability to detect and analyze earthquakes and to issue warnings within the time frame needed to save lives.



Basic structure of the GTS with regional telecommunications hubs (RTH) and national meteorological centers (NMC)

Global Telecommunications System (GTS)

Collecting data and information from locally maintained and international Earth data observation networks is a crucial function of national tsunami warning centers and regional tsunami watch providers. Warning centers and watch providers have three basic data and information collection requirements, which are to collect seismic and sea-level observational data; receive event impact reports from national, state, and local agencies, and the public; and share data and information with other warning centers. The primary data collection pathway is the Global Telecommunications System (GTS) operated by the WMO. The GTS is a global network for transmitting meteorological data with standardized data formats and content from weather stations, satellites, and numerical weather prediction centers. The Indian Ocean countries have agreed to use the GTS as the region's primary communication system.



Results from the model showing tsunami run-up heights, with the highest level at 20.4 meters in Baan Pak Wib, Phang Nga province, Thailand

Under the US IOTWS Program, NOAA provided Sri Lanka and the Maldives with state-of-the-art communication systems in June 2007. The upgrade of GTS equipment supports the fast and reliable data exchange that is essential for responding to multi-hazard events, including tsunamis. The upgrades include installing a message switching system and meteorological workstations, replacing the previous communications links that were too slow to allow the two countries timely access to GTS data, such as observations from tide gauges, all-hazards data, watches, forecasts, warnings, and bulletins. Technical support from NOAA has also included training for operational staff and a one-year maintenance contract while longer-term capacity is built at the national centers.

Tsunami Inundation Modeling

Computer modeling programs help analyze sea-level data to generate forecasts of tsunami wave height and the expected inundation for specific coastal areas. The refinement of initial seismic-based warnings by more sophisticated computer models can greatly increase the accuracy of the warnings and decrease false alarms. The rapid detection and characterization of tsunami-generating earthquakes by models provide the first indication of a potential tsunami in an end-to-end tsunami warning system. A *community* modeling program is one that is freely available with source code and documentation for use by the scientific community.

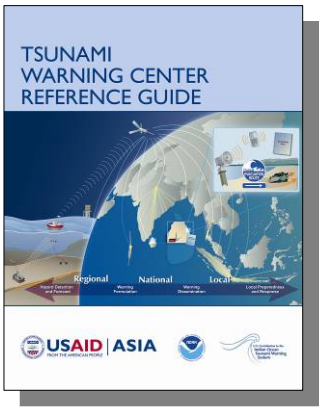
Under the US IOTWS Program, NOAA developed the Community Model Interface for Tsunami (ComMIT), a critical risk analysis tool that allows Indian Ocean nations to run tsunami models and share information through the Internet using data from local or remote databases. This approach has provided several advantages: (1) countries without a significant cadre of trained modelers have built tsunami modeling capability for forecast and hazard assessment; (2) countries with restrictions on sharing geospatial data have been able to share their model results; and (3) most significantly, the Internet-based approach creates a virtual global community of modelers, using the same tools and approaches to understand tsunami threats, who are all able to share information and insights.

The IOC, NOAA, and several regional partners jointly conducted three training workshops for technical staff from more than 15 Indian Ocean countries in Asia and Africa on using ComMIT. During the workshops, held in Australia, Thailand, and Indonesia, participants took part in hands-on training and produced analyses of potential tsunami inundation using ComMIT.

3.3 NATIONAL WARNING CENTER CAPACITY AND WARNING COMMUNICATIONS

Concept of Operations (CONOPS)

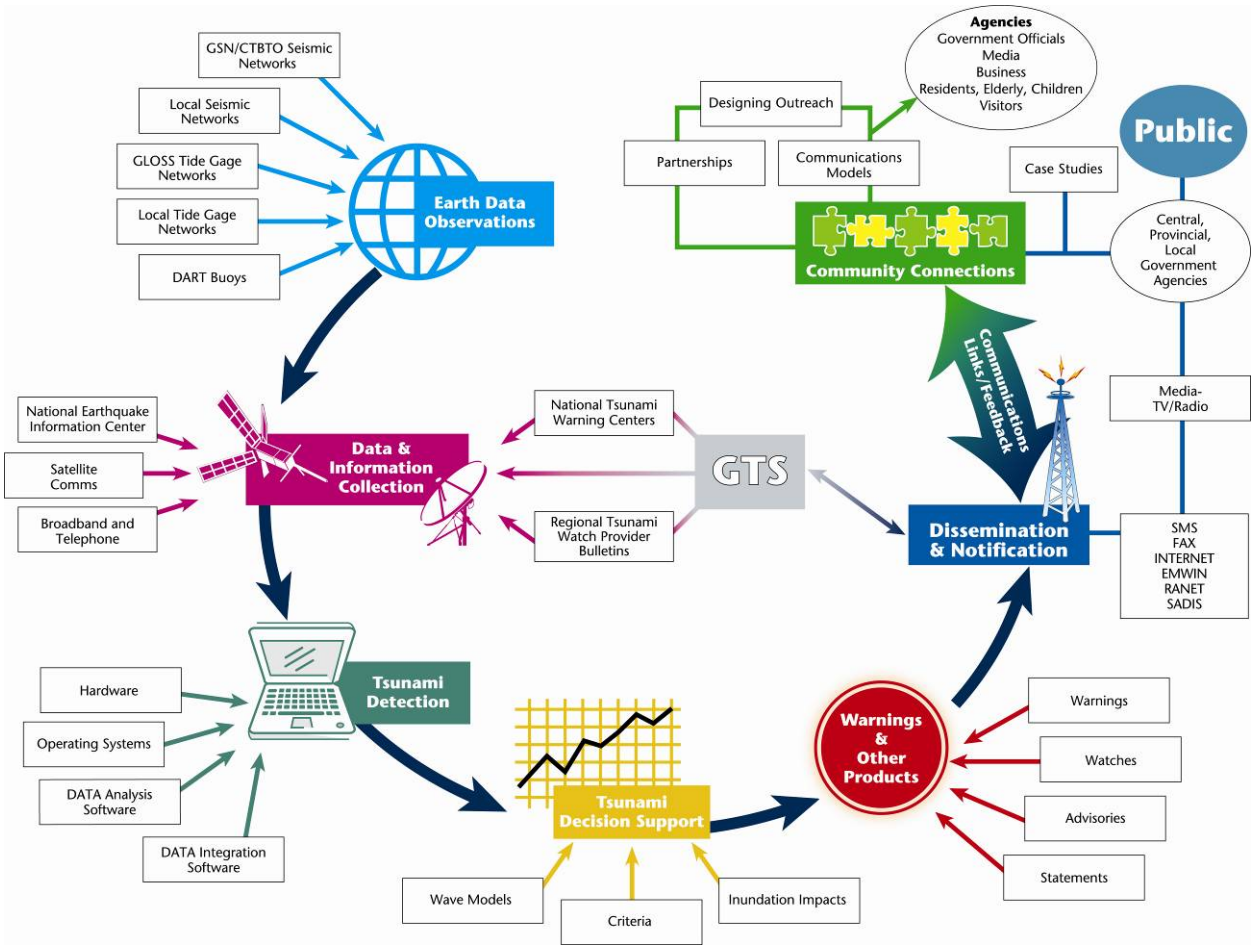
The operation of a tsunami warning center is a vital part of an end-to-end tsunami warning system. A tsunami warning center is not only involved in acquiring and processing data for detecting a tsunami, but also in formulating and disseminating tsunami warnings and connecting with communities at risk to ensure that they understand the warning and have the capacity to respond. Tsunami warning centers must develop partnerships with international organizations; national, sub-national, and local agencies; community leaders and organizations; businesses; and local citizens to ensure warnings are received and understood by local communities. The *concept of operations*, or CONOPS, describes the operational flow of hazard and non-hazard information between organizations and between departments within an organization. It also includes the decision-making processes required to generate warnings to enable officials to take appropriate actions when needed.



NOAA drew on its experiences over 40 years as part of the ICG for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) to support the development of a comprehensive regional and national CONOPS in the Indian Ocean region. The *Tsunami Warning Center Reference Guide* is one of NOAA's contributions toward that effort. The guide provides a critical reference tool for countries that are establishing new warning centers or maintaining and enhancing existing centers as part of an overall end-to-end tsunami warning system. It also provides outreach and education resources for warning centers. During the US IOTWS Program, NOAA conducted CONOPS training for disaster management officials in Sri Lanka and Indonesia.

USTDA worked with Thailand's National Disaster Warning Center (NDWC) to develop procedures and a decision support system for warning system operations that alleviates bottlenecks in communications and improves response time for public notifications. In addition, USTDA issued two grants to Indonesia's Meteorological and Geophysical Agency (BMG) for developing a disaster management plan and technology strategy for rapid notification of emergency information during hazardous events. USTDA has also issued grants in Sri Lanka and Indonesia to assess additional emergency communication needs and to guide the procurement of emergency communications equipment. Three additional grants for Sri Lanka have helped to facilitate real-time information flow on distant seismic events and oceanographic indicators, develop its Disaster Management Center's (DMC)

standard operating procedures and emergency communication/notification procedures, and provide technical assistance to assess emergency communications and technology options.



Schematic showing the key operational components of a tsunami warning center.

Tsunami Early Warning Systems (TEWS) Frameworks

Tsunami Early Warning Systems frameworks as used in the context of national efforts in the Indian Ocean region refer to a set of common protocols and procedures used to ensure that tsunami advisories or warning messages are sent from a national focal point to all relevant government officials and the public quickly and accurately. The first part of the TEWS framework consists of an overall design outlining the respective roles and responsibilities of government agencies, the media, and other organizations. It also describes the communication pathways for warning and standard operating procedures that are updated annually. The second part is the appropriate technology to facilitate the rapid movement of warning information. The final part is to establish the testing and evaluation procedures of all aspects of the system on a routine basis.

Under the US IOTWS Program, USFS supported Thailand's NDWC to develop the TARNS as a quick-response system for tsunami alerts, and it has expanded to include alerts for other disasters as well. As part of the TARNS effort and with extensive support from USAID, USFS, NOAA, and USTDA, the Thai Government conducted Andaman Wave, a large-scale tsunami warning simulation, in six provinces along

the Andaman coast in July 2007 to test and evaluate the warning system procedures. All 79 siren towers in the six provinces were activated and tested, while local evacuations tested disaster preparedness and response plans. Disaster management officials from Indonesia, Sri Lanka, and the Maldives participated in the evacuation as observers to gain insights for similar activities in their countries.

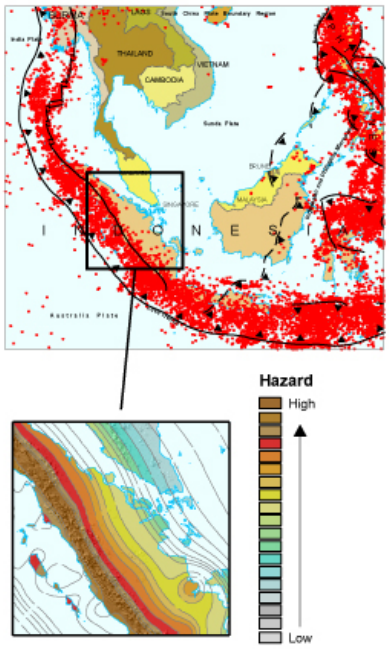
In Indonesia, the US IOTWS Program also strengthened capacity for local level warning systems in Banten Province. Through TEWS activities, the US IOTWS Program helped promote links among provincial and local government officials, NGOs, and other relevant stakeholders to communicate warning messages effectively to the public at risk. These activities helped prepare disaster management specialists to conduct a highly successful tsunami simulation drill on December 26, 2007, in the province.


US IOTWS PROGRAM

One of 79 siren towers along the southern coast of Thailand

Multi-Hazard Risk Assessment Tools

Knowing the location of potential earthquakes is the first line of defense to help save lives and property. Scientists develop maps that clearly show where earthquakes are likely to occur so that communities can use them when locating and designing buildings to make them more earthquake-resistant. Under the US IOTWS Program, scientists from USGS developed seismic hazard maps for Thailand and Indonesia that will be used to help communities identify the location of potential earthquakes so that communities can use the maps to design more earthquake-resilient buildings. USGS also conducted training in Thailand in January 2007 for more than 150 disaster management specialists on interpreting and applying the maps to building designs and specifications for other structures that are appropriate for the associated seismic hazards in the area. Subsequent trainings were also held in Indonesia.



Seismicity map of Southeast Asia and seismic hazard map for a portion of Sumatra, Indonesia showing high hazard along the Sumatra fault and the subduction zone (Petersen and others, 2004).

Seismic Data Sharing Tools

To develop effective, accurate notifications and warnings requires the analysis and interpretation of hundreds of data sets from different monitoring systems. A common problem that exists when analyzing multiple data sets is the varying formats in which the data is received. This delays, if not prohibits, the development of warnings or notifications. Several software tools have been developed to address data incompatibility. The first tool, the Common Alerting Protocol (CAP) is a data format used to exchange public warnings and emergencies among various technologies. CAP allows a warning message to be consistently disseminated simultaneously over many warning systems to many applications, increases warning effectiveness, and simplifies the task of activating a warning for responsible officials. A similar data sharing tool, the Earthquake Information Distribution System (EIDS) collects and disseminates seismic notification messages in standardized reporting formats.

Under the US IOTWS Program, USGS worked with the disaster management agencies in Indonesia, the BMG and the Technological Institute of Bandung (ITB), to install CAPs and EIDS seismic software onto their computer systems to enable seismic data to be exchanged in common reporting formats. BMG will have the ability to locally integrate BMG earthquake information with that from NOAA and USGS, and be able to locally feed BMG web displays and other distribution systems.

National Assessments for Improving Policy and Institutional Frameworks

Early warning systems can only be as effective as the collective strengths of policies, laws, institutional frameworks, and the capacities of national and local agencies and officials responsible for disaster management systems. In some cases the technical capacity exists for forecasting a warning, but the institutional mechanisms and procedures needed to convey and respond to the warnings at the national level are inadequate.

Under the US IOTWS Program, USAID's Program Integrator conducted national institutional capacity and policy assessments for disaster management agencies in Sri Lanka, Indonesia, and Thailand. The purpose of the assessments was to assess current policy and regulatory frameworks that define the countries' approach to disaster management. Through interviews with key disaster management specialists, the PI used an indicator-based approach to rank each of the major elements that are part of a disaster management system. The results of the interviews were analyzed and assembled into country-specific reports that were presented to the stakeholders at follow-up workshops.

Participants reviewing the policy and institutional capacity assessment report.

The report provides a summary of current disaster management approaches, evaluates strengths and weaknesses in the programs, and makes recommendations to strengthen their overall national policy framework for disaster management. The Program team presented the findings of the Sri Lanka assessment to national government, disaster management, and NGO counterparts in a National Consultation Workshop in March of 2007. Sri Lankan counterparts responded enthusiastically to the findings and immediately identified priorities and developed an action plan to address them. The Program conducted similar National Consultation Workshops for Indonesia and Thailand in June and September 2007, respectively. The resulting workshops have offered national counterparts critical recommendations for improving governance frameworks that can lead to more effective disaster management and warning capabilities.

"Last Kilometer" Communications

Low-cost emergency radio technology, known as Radio and Internet Technologies for the Communication of Hydro-Meteorological and Climate-Related Information (RANET), is a critical communications tool for providing disaster warning communications in vulnerable, remote locations. Funded by USAID both through the US IOTWS Program and other programs, NOAA's RANET initiative is a collaborative effort of many national hydro-meteorological services, NGOs, and communities. RANET aims to make weather and climate information available to rural and remote populations, which are often among the most in need of environmental forecasts, observations, and

warnings. While significant advances have been made in our ability to predict and observe our environment, much of this valuable information remains inaccessible to those outside major cities.

The US IOTWS Program introduced this important technology to Indonesia's tsunami warning system, as well as to other countries in the region. NOAA distributed radio phones and trained disaster management technicians from the region on RANET warning communications. Technical field staff from 10 Asian countries participated in RANET workshops that were held in Indonesia and Sri Lanka. Through the US IOTWS Program, 103 RANET units have been disseminated to tsunami-affected communities in Indonesia and another 36 units in Sri Lanka.

NOAA

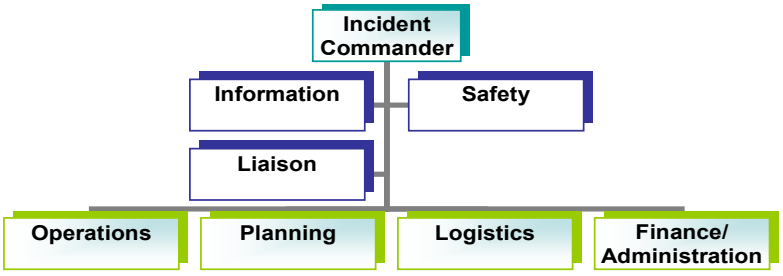
One of several models of digital satellite receiver used to download RANET content

To close the communications gaps in reaching vulnerable people at the *last kilometer*, RANET is a solution that is inexpensive to deploy, does not require much training, and can be maintained and serviced with local resources. The Program has encouraged partners to use the RANET network for other educational and humanitarian purposes beyond that of earth science and services. Doing so has increased the sustainability of the Program and ensures that people will continue to receive vital tsunami and other hazard information.

3.4 PREPAREDNESS, MITIGATION, AND RESILIENCE

Incident Command System (ICS) Support

All emergencies and crisis events are by definition chaotic and highly dynamic, creating physical, emotional, and social disorder. The ICS is a means for government agencies to effectively manage such incidents and restore a modicum of order in a chaotic environment. USFS developed the management system in the 1970s to provide accurate information, strict accountability, planning, and cost-effective operations and logistical support for any kind of disaster incident. ICS is flexible and allows for organizational expansion or contraction in a modular fashion. Thus, as incidents change in complexity or operational focus, the ICS can accommodate it accordingly. ICS is structured to integrate a wide range of resources including police, military, technical experts, international organizations, and NGOs, and can be used to manage sudden onset disasters, long-term relief efforts, or non-emergency events.



ICS can be used to address emergencies of all sizes and complexities

Under the US IOTWS Program, USFS worked with countries in the region to implement the disaster management system in the government. USFS supported the DMC in Sri Lanka in conducting a series of ICS courses, through which more than 130 professionals in the fields of disaster management, health, and other sectors have been trained. Of these, eight officials are now part of a group of *master trainers*

who are further building capacity in every district and at the community level in Sri Lanka. The government has also committed to implementing ICS as part of its disaster risk reduction strategy.

As a result of US support, Indonesia's National Coordination Board for Disaster Management (BAKORNAS) has expanded its efforts to implement ICS concepts by assigning Incident Commanders in its provincial and district units and including ICS in the new Disaster Management Law. Other government agencies and NGOs have also committed to building capacity for ICS through a train-the-trainer program covering all major island groups, beginning with Sumatra. Officials from Thailand and the Maldives participated in the Foundational ICS course in September 2007.

Coastal Community Resilience Initiative

Coastal communities around the world, large and small, are becoming increasingly vulnerable to a wide range of coastal hazards including severe storm events, tsunamis, shoreline erosion, and coastal resource degradation. Most of the coastal population lives in rural areas and in small to medium cities, where basic services and disaster warning and response mechanisms are limited. Population density coupled with increasing frequency and duration of storms, sea level rise, and other coastal hazards cause the effects of disasters to be more severe and recovery to be slower and less sustainable. Proactive measures can be taken to reduce vulnerability and provide the enabling conditions for communities to absorb and bounce back from disruptions in basic services and economic activity. Working with partner agencies and organizations throughout the Indian Ocean region, the US IOTWS Program developed a unifying framework, benchmarks, and assessment methods for CCR designed to reduce risk, accelerate recovery to disasters, and adapt to changes resulting from both episodic and chronic hazards.

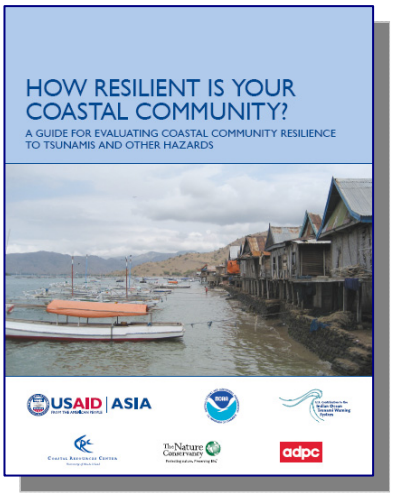
To ensure broad buy-in and promote long-term sustainability, the CCR framework was developed, tested, and applied with the input and participation of more than 100 government agencies and NGOs in the Program's five focus countries. Partners included the UN International Strategy for Disaster Reduction (UNISDR), International Federation of the Red Cross and Red Crescent, ICG/IOTWS Working Group 6, and many international, regional national, and local-level government agencies, NGOs, and other organizations. Regional and national workshops, five-day training courses, and a variety of field activities were conducted between May 2006 to August 2007 to develop and refine the CCR framework and assessment methods. Through this participatory process, eight elements of resilience were identified as essential for CCR. These elements incorporate long-term planning, disaster planning and preparedness, governance, and risk knowledge. Enhancing resilience in all of these elements is considered essential to reduce risk from coastal hazards, accelerate recovery from disaster events, and adapt to changing conditions in manner that is consistent with community goals.

The CCR framework was applied and tested in a variety of ways. A number of multidisciplinary teams of national and local governmental agencies, NGOs, and community groups with experience in community development, coastal management, and disaster management conducted CCR assessments in more than 50 coastal communities in the Indian Ocean region during January to August 2007. In conducting CCR assessments, partners identified the need in some cases to modify the benchmarks to make them more relevant to the local context. Some partners adapted the benchmarks to questions for use in surveys of stakeholder knowledge, attitudes, and practices. Others used the

elements of resilience and benchmarks to conduct an internal organizational evaluation on their ability to provide various services to coastal communities, and identified opportunities to integrate CCR into existing plans, programs, and training activities.

As an organizational assessment tool, the review of elements of resilience and the benchmarks helped organizations identify strengths in delivering services in a particular element of resilience, such as emergency response or to clarify their role in the framework and to develop partnerships with organizations that had complimentary roles. National government agencies recognized the importance of CCR as a unifying framework to facilitate multi-agency collaboration needed to reduce risks from coastal hazards. In some cases, CCR workshops and training activities provided the first opportunity for disaster managers and coastal managers to work together.

Each CCR assessment provided a broad overall evaluation of a community's capacity and vulnerability to tsunami and other coastal hazards. New partnerships between government agencies and NGOs were formed as a result of conducting CCR assessments, and NGOs and academic institutions identified many opportunities to integrate CCR into existing training programs and graduate studies.



The US IOTWS Program team incorporated the output from each of these events and field activities into a CCR guidebook for the region titled *How Resilient Is Your Coastal Community? A Guide for Evaluating Coastal Community Resilience to Tsunamis and Other Hazards* (2007).

3.5 CROSS-CUTTING CONTRIBUTIONS

Small Grants Program

Small-scale pilot projects are often developed to reinforce major concepts in a program and to provide a catalyst for larger-scale efforts. One of the major challenges in developing the IOTWS has been the need to address downstream issues such as community preparedness and response activities over a large, culturally diverse geographic area.

An SGP was designed under the US IOTWS Program to provide grants to local implementing partners to help catalyze and replicate pilot activities at the sub-national level that would strengthen community resilience and improve last-kilometer warning linkages. One of the objectives of the SGP was to reinforce and encourage regional cooperation and the sharing of lessons learned in the region while emphasizing field-level support in the target Indian Ocean countries.

Two rounds of grants applications yielded 42 proposals. From these proposals, a total of 17 grants were awarded between May 2006 and June 2007 to NGOs and universities for a total of $693,800 (see Table 4 for a breakdown of the awards by country).

Table 4. US IOTWS Program Small Grant Awards by Country

Project Title	Grantee	Award Value	Country Focus
Capacity Building of Coastal Communities on Coastal Mitigation	Asian Institute of Technology	$23,700	Thailand
Tsunami Education for Teachers in Southern Thailand Coastal Communities	Chulalongkorn University, Department of Geology	$23,000	Thailand
Last Mile Warning Communications Inventory	Disaster Tracking Recovery Assistance Center (D-TRAC)	$84,905	Thailand
Building Community Capacity and Technical Assistance to Effectively Respond to Warnings of Tsunamis and Other Hazards	Save Andaman Network	$68,640	Thailand
Strengthening Coastal Community Resilience and Coral Reef Management at Had Thai Muang, Phang-nga Province, Thailand	WWF Thailand	$94,313	Thailand
School Education Roadshow in Padang, Indonesia	KOGAMI	$14,166	Indonesia
Outreach and Public Dialogue on Decentralizing Legal Reform for Disaster Management	MBPI	$25,000	Indonesia
Revision, Expansion, and Multi-stakeholder Endorsement of IDEP's Community-Based Disaster Management Kit	Yaysan IDEP Foundation	$25,000	Indonesia
Rehabilitation of Fisheries and Aquaculture in Tsunami-Affected Coastal Communities in Aceh Province	WorldFish Center	$87,945	Indonesia
Coastal Community Institutional Strengthening in Coastal Hazard Analysis, Mitigation, and Preparedness, and Disaster Response and Recovery	Sewalanka Foundation	$25,000	Sri Lanka
Risk Assessment and Design of Countermeasures for Tsunami Hazards: Case Study for the Port City of Galle	University of Moratuwa	$25,000	Sri Lanka
Development of Tsunami Hazard Zonation Maps for the Coastal Belt of Sri Lanka	University of Peredeniya	$25,000	Sri Lanka
Multi-faceted Capacity Building and Community-Based Disaster Preparedness in Tsunami Hit Areas of Coastal Tamil Nadu	Exnora Foundation	Cancelled[4]	India
India Tsunami Response Program: Community-Based Disaster Management	Sustainable Environment & Ecological Development Society (SEEDS)	$25,000	India
Building Community Capacity and Technical Assistance to Effectively Respond to Warnings of Tsunamis and Other Hazards	East Tennessee State University	$23,970	Regional
Assessment of the local institutions on the National Policies and Measures Towards Disaster Preparedness and Mitigation	Asian Institute of Technology	$23,500	Regional
Strengthening Capacity on Multi-hazard Risk Assessment in Tsunami-Affected Countries (SCRATCH)	Asian Institute of Technology, Geoinformatics Center	$94,860	Regional

The grant recipients used various approaches to increase community preparedness and resilience. For example, IDEP, an Indonesian NGO, revised and expanded a community-based disaster management kit that was distributed to stakeholders throughout Indonesia. In Sri Lanka, the Sewalanka Foundation

[4] The grant was eventually cancelled due to concerns regarding the financial performance of the organization, as well as significant burdens on staff resources as a result of a USAID/India audit.

launched a disaster risk reduction initiative to increase the resilience of vulnerable communities to damaging coastal impacts. The WorldFish Center worked with coastal communities in Aceh, Indonesia, to mesh the needs and desires of the community with sustainable, scientifically proven management options for their fishery resources.

Evacuation simulation as part of KOGAMI's Small Grant.

Many of the small grants recipients developed tools that can be used to further assess vulnerabilities at the local level. Peredeniya University developed tsunami hazard zonation maps for coastal Sri Lanka, which provided a graphical representation of damage-prone areas with the expected depth of flooding in case of a tsunami. In Thailand, D-TRAC used an extensive interview process canvassing 200 villages throughout the country to provide a comprehensive snapshot of how the TEWS is actually interpreted by individuals at the local level. Researchers from East Tennessee State University analyzed data from almost 700 tsunami survivors in Thailand to ascertain their experience with official and informational tsunami warnings or notifications and knowledge of evacuation procedures.

Finally, several of the grantees focused on building capacity at the local level for communities to be better prepared for natural disasters. Chulalongkorn University worked with teachers to promote local preparedness for earthquakes and tsunamis. SEEDS India worked in 52 villages in the Andaman and Nicobar Islands to enhance the ability of these communities to withstand and respond to multiple hazards. Representatives from Asian Institute of Technology's (AIT's) Geoinformatics Center trained government officials and academics in Thailand, India, Indonesia, and Sri Lanka to be able to assess and develop appropriate responses to risk. Finally, KOGAMI developed *The School Education Roadshow*, which was used to train more than 18,600 teachers, school staff, principals, and students in basic disaster preparedness and conducting evacuation exercises using hazard maps developed under the program.

International Tsunami Training Institute (ITTI)

Ed Quarles, Washington State Emergency Management Center, describes emergency response procedures to ITTI participants.

Training is one of the most important tools used to build technical and institutional capacity for organizations and institutions. Substantial training has been conducted in the Indian Ocean region following the tsunami to train national and local counterparts in the operation and maintenance of forecasting and detection systems, development of procedures and policies to disseminate warning messages, and to educate communities on how to assess their resilience to natural hazards. While these training courses and workshops have had a tremendous impact in the region, repeated and institutionalized training is needed to truly build and sustain capacity over the long term. To help achieve this goal, representatives from the University of Washington (UW) and NOAA created the International Tsunami Training Institute (ITTI) to serve as both a physical training center and to provide a virtual platform where participants can learn new skills and reinforce concepts that have been presented in earlier sessions.

This accredited training program was developed with support through the US IOTWS Program and is being offered jointly through UW and the AIT. Through a combination of lectures, group exercises, simulations, and field visits, participants strengthened their understanding of forecasting and detection,

hazard assessment, and community preparedness and response. Many of the products and training materials developed under the US IOTWS Program were used by the course instructors in the ITTI and have been archived in a web-based repository for future references. Thirty-one participants from Indonesia, Sri Lanka, Thailand, India, and the Maldives—the countries most affected by the December 2004 tsunami—took part in the August 2007 inaugural two-week training course in Seattle, Washington, marking the initial ITTI offering. AIT organized and conducted the second offering of the ITTI in Bangkok, Thailand, in March 2008 in conjunction with NOAA and UW. Several of the US IOTWS Program team members served as instructors at the Bangkok ITTI offering.

Program Web Site and Outreach Materials

The US IOTWS Program developed several communication tools to inform stakeholders on developments under the program. The Program web site (www.us-iotws.gov) provided users with up-to-date information on issues related to the development of the IOTWS, a library of information and resources, topic-specific fact sheets, contact information for partners throughout the Indian Ocean region, and a calendar of upcoming events. The web site served as the primary communication tool for the Program Team as well as for external audiences. The web site was updated weekly to provide a calendar of upcoming events, notification of new information that has been posted, and additions to an extensive library of resources. After the closeout of the US IOTWS Program, the web address, www.us-iotws.gov, directs users to a site that presents IOTWS information and relevant key documents, maintained by ADPC. The URL will continue to function for a period of up to one year.

Fact Sheets. The PI developed an overall program brochure and five country fact sheets that provide an overview of the various activities to be conducted by the program team—regionally and by country. In addition, the PI has prepared a series of technical fact sheets covering issues such as DART technology, ICS, TARNS, hazard assessment maps, and CCR.

Monthly Updates. To inform partners of all major program developments, the PI prepared an electronic monthly update that was distributed to more than 750 partners and stakeholders in the region and worldwide. This update includes a summary of key activities from the past month, based on weekly update submissions to RDMA, as well as highlights of upcoming events.

In addition to the US IOTWS Program monthly updates, the PI submitted information to be included in other periodic journals such as the UNISDR updates. This helped to disseminate information about the US IOTWS Program to a larger audience.

4. TOOLS AND MECHANISMS FOR SUSTAINABILITY

Because the US IOTWS Program was designed to be catalytic and provide targeted support over a two-year period, the USG team structured its activities at the outset to help ensure sustainability in the long-term by building capacity in the region and establishing partnerships. Ongoing needs will continue to be addressed by long-term domestic programs, as well as through other donor efforts, such as Germany's €45 million five-year German-Indonesia TEWS (GITEWS) program with Indonesia, UNESCAP's US$12.5 million Tsunami Regional Trust Fund established in 2005, and the United Kingdom's UK£7.5 million tsunami funds reserved for early warning systems. In addition, the USG will continue to remain actively involved in developing the IOTWS after the conclusion of most program activities through participation from their respective agencies.

To help ensure long-term sustainability, the team has been actively working with partners in the region to help transition Program tools, products, and initiatives into sustainable, long-term platforms that will continue independently into the future. As part of its closeout activities, the US IOTWS Program prepared a transition matrix that clearly outlines the process and timeframe for transferring products, tools, and initiatives developed under the US IOTWS Program to its regional partners (see Appendix C). The document also describes the continuing involvement of USG partners in developing the IOTWS after program closeout.

Most of the USG agencies involved in the US IOTWS Program will continue to play a role in developing and implementing the IOTWS through various mechanisms, consistent with each agency's core areas of expertise. USAID will continue to support IOTWS activities through the individual missions, such as USAID/RDMA and USAID/Indonesia, to promote greater CCR in connection with other programs. NOAA and USGS intend to continue to focus on IOTWS activities through their participation in the ICG/IOTWS process. In addition, NOAA is working with the US Embassy in Jakarta to raise funds from the US private sector firms operating in Indonesia to support implementation of the Indonesian TEWS (Ina-TEWS). USFS will seek continued support for ICS and early warning capacity building through funding vehicles such as USAID bilateral missions and related donors such as UNESCAP, and USGS expects to continue activities in Indonesia supporting improvements to seismic detection systems.

4.1 CONTINUED SUPPORT TO IOC, ICG/IOTWS, AND OTHER PARTNERS

A primary vehicle for sustaining efforts initiated under the US IOTWS Program is through the ICG/IOTWS. NOAA and USGS will continue to participate in ICG Working Groups on various issues including:

- the siting of tsunami detection systems,
- development of standardized CONOPS and forecasts for national warning centers,
- development of tools to better predict geographic areas most at risk, and
- downstream warning issues such as CCR and "last kilometer" communications.

In addition to working through the ICG, USG partners intend to work closely with the State Department to strengthen diplomatic outreach efforts, that would: help publicize US contributions to the IOTWS; reinforce US messages through participation in global forums such as the WMO Congress, the IOC Executive Council, and the Group on Earth Observations (GEO) Summit; and stimulate private sector interest in the sustainability of the detection systems.

4.2 INTERIM NOTIFICATIONS FROM THE PACIFIC TSUNAMI WARNING CENTER

NOAA will continue to issue real-time tsunami advisory bulletins to the IOTWS region through the PTWC and the Japan Meteorological Agency (JMA) until a Regional Tsunami Watch Provider is established.

4.3 SEISMIC MEASUREMENTS, DATA COLLECTION, AND EXCHANGE

Seismic Monitoring Maintenance

Carrying forward in its technical support role throughout the US IOTWS Program, the California Institute of Technology will continue to provide assistance and funding for the maintenance of seismic monitoring equipment through ongoing support to the Sumatran GPS Array (SuGAr) network. Each of the countries will maintain and use the expanded monitoring capacity for hazard detection and tsunami analysis.

Seismology and Tsunami Hazard Capacity Building

The ITTI, which will be jointly sustained through the AIT and UW, includes capacity building in seismology and hazards assessment. In addition, representatives from USGS will continue to conduct training programs in seismology, paleotsunami research, and hazards assessment as funding becomes available through separate sources.

4.4 SEA LEVEL DATA COLLECTION AND EXCHANGE

DART Systems Operation and Maintenance

Under formal agreements, Indonesia and Thailand will maintain the DART stations to ensure that the stations continue to contribute to the IOTWS array and all nations in the region have free and open access to the data in real time. NOAA will continue to provide technical guidance to its partners through these agreements and to encourage knowledge transfer to Indian Ocean nations through the IOC ICG/IOTWS process.

NOAA will provide technical guidance to its partners and through the IOC. It will also continue to develop and strengthen partnerships with Thailand and Indonesia for installing the complete DART array for tsunami warning and detection.

Sea-level Station Maintenance

NOAA and UHSLC will continue working together with national agencies to maintain the sea-level monitoring stations and communication systems. The operation and maintenance of the sea-level gauges will be supported through the GLOSS network, which is operated through the WMO and IOC. Researchers will continue to conduct training and capacity building activities through the existing GLOSS Program.

4.5 RISK ASSESSMENT AND DATA SHARING

Multi-Hazard Risk Assessment tools

The materials that were used to train disaster management specialists on developing seismic hazard maps will be incorporated into the ITTI curriculum. USGS will continue to provide updated versions of CAPS and EIDS software to the Indonesian disaster management agencies, BMG and ITB. In addition,

USGS is working with European scientists to finalize a QuakeXML standard for exchanging earthquake parametric data through EIDS.

4.6 MODELING, FORECASTING, AND SCENARIO DEVELOPMENT

ComMIT Training

NOAA will continue to host ComMIT platform and provide technical support through ITTI and other opportunities. In addition, the IOC plans to jointly sponsor additional ComMIT workshops with NOAA throughout the region.

4.7 ESTABLISHMENT OF A SYSTEM OF INTEROPERABLE ADVISORY AND WARNING CENTERS

CONOPS Capacity Building

NOAA will continue to update the *Tsunami Warning Center Reference Guide* and distribute copies of the guide to countries in the region using NOAA funds. NOAA also plans to expand the scope of the guide to present it in a multi-hazard context. The ITTI will also provide capacity building on CONOPS.

Capacity Building in TEWS Frameworks

USFS will seek to continue to provide technical guidance and support for TEWS from the national to local levels. The Governments of Thailand and Indonesia are implementing systems that disseminate warning information from the national to the community level, while regional organizations such as ADPC have incorporated the technical tools into their ongoing activities to support robust warning systems.

National Assessments for Improving Policy and Institutional Frameworks

ADPC led completion of the national disaster management policy and institutional strengthening assessments and will continue to provide support to each of the participating countries in implementing recommendations that were identified in each of the reports.

RANET Deployment and Maintenance

To support the continued flow of information and the RANET network, NOAA will maintain satellite broadcast operations on the WorldSpace satellite for approximately eight years. Partners in government agencies will manage the deployment, use, tracking, and deployment of RANET while continuing to support multiple uses of the technology.

4.8 PREPAREDNESS, MITIGATION, AND RESILIENCE

ICS Capacity Building

USFS will seek to continue to provide technical guidance and support for the further implementation of ICS. Sri Lanka's DMC and the Sri Lanka Institute of Development Administration have adapted the curriculum and are now using it in training courses. Indonesia will continue to implement ICS as part of its national disaster management strategy. In addition, ADPC has incorporated ICS into its disaster management training curriculum.

CCR Capacity Building

The CCR concept already has proven to be a valuable addition to Hyogo Framework for Action implementation in the Indian Ocean region and elsewhere. For example, ICG/IOTWS Working Group 6 on Mitigation, Preparedness, and Response is expected to adopt CCR as its framework for considering downstream issues. Several organizations, including ADPC, Sri Lanka's DMC, Indonesia's Department of Marine Affairs and Fisheries, CARE, the Nature Conservancy, SurfAid International, and other organizations have incorporated the application of CCR tools into their ongoing activities.

With funding from the Regional Tsunami Trust Fund facilitated by UNESCAP, ADPC is implementing the CCR initiative in three countries including the Maldives, Sri Lanka, and Myanmar. In addition to these programs, ADPC has conducted CCR workshops in Vietnam and Cambodia and translated CCR materials into Vietnamese and Khmer with funds from Danida. The IOC is also supporting the continued training of CCR and has recently sponsored a CCR workshop in the Seychelles.

4.9 CROSS-CUTTING TOOLS

ITTI Course Offerings

UW will continue to sponsor the ITTI and add training materials developed under the US IOTWS Program to its archives. An additional ITTI course offering will be held in the summer of 2008 at UW. Many of the products and training materials developed under the US IOTWS Program have been incorporated into the ITTI curriculum and are now widely available as a resource on the Internet. UW and AIT have finalized a Memorandum of Understanding that outlines the general operating framework for the ITTI and the specific AIT roles and responsibilities.

5. LESSONS LEARNED

A study was conducted at the end of the US IOTWS Program to capture key lessons learned to assist future, large-scale, complex USG initiatives in developing countries responding to large-scale disasters. Highlights from the lessons learned study are provided in this section while the entire lessons learned report from the Program will be available electronically from US-IOTWS.gov. The lessons learned findings were roughly divided into four major sections.

5.1 PROGRAM INCEPTION

The end-to-end design is a unifying vision and provided a context for much of the discussion with country counterparts and the formulation of strategic activities. The compressed timeframe for the program (two and one-half years) encouraged the partners to achieve quick results but at some cost to sustainability and coordination. Nonetheless, a comprehensive work plan with a *rolling design* provided structure with flexibility and lessons learned from similar past programs, such as the response to Hurricane Mitch in 1998, contributed to the program's success.

5.2 PROGRAM DESIGN

The US IOTWS Program proved to be an effective model for large-scale, complex USG disaster programming. Establishing common program planning frameworks such as a work plan and a PMP helped achieve a balance between centralized program management and the flexibility needed by different agencies to implement activities according to their needs. As a large regional program, an in-country presence was very important to maintain momentum and ensure effective coordination. The designated PI with a permanent coordination role provided critical continuity, administrative, and logistical support and facilitated communication among partners.

5.3 MANAGEMENT AND ADMINISTRATION

Effective coordination systems, including a PCG, provided essential integration, coherence, and capacity critical in allowing the multi-agency regional programming initiative to succeed. Flexible resource-sharing mechanisms, such as a centralized exchange budget, enhanced the overall quality of programming by ensuring that multiple perspectives and sources of information were involved in the programming process. Regular communication was essential with donors, partners, and stakeholders throughout the Indian Ocean region. In addition, the Program web site served as the central forum for disseminating and archiving Program-related materials.

5.4 PROGRAM IMPLEMENTATION

The US IOTWS Program equipped itself with various implementation approaches and mechanisms to provide assistance and support capacity development. The combination of approaches was considered balanced and included direct provision and improvement of technology and equipment; research, assessments, pilot programs, the development of guides, trainings, workshops and study tours; an SGP; and more general technical assistance and coordination. To a large extent, sustainability strategies were incorporated and implemented from the beginning of the program, and this approach led to most activities being carried forward in some meaningful way beyond the program end date. Government buy-in, ownership, and institutionalization of activities were seen as key elements to long-term success.

6. CONCLUSIONS

6.1 IS THE INDIAN OCEAN REGION BETTER PREPARED TODAY THAN IN DECEMBER 2004?

Indian Ocean countries are significantly better prepared to issue early warnings in the event of another destructive tsunami than they were two years ago. If a major tsunami were to occur, many communities would now receive timely warnings and know how to react, and lives would be saved. Critical detection and communications systems—including seismic stations, sea-level gauges, and now the first fully operational tsunami detection buoys—are in place and providing hazard data in real time.

The national governments have made significant advances to national warning system networks, communications, and government operations and procedures and are now able to rapidly disseminate warnings to local populations. Numerous multilateral, bilateral, and NGOs, including the US IOTWS Program, have widely supported disaster preparedness for coastal communities across the region, primarily in the countries most affected by the 2004 tsunami.

September 12, 2007 Tsunami

On September 12, 2007, a tsunami struck Padang, Indonesia, as a result of an 8.4 magnitude earthquake near Sumatra Island. The response to this tsunami demonstrated that the USG's five partner countries have made significant advances with their tsunami warning systems since the tsunami disaster of 2004. According to a recent assessment of national efforts conducted by the ICG/IOTWS Secretariat, the installation of or upgrades to seismic and sea-level monitoring stations have greatly enhanced hazard detection, disaster management institutions and coordination systems are stronger, warnings are more effectively disseminated, and communities are better prepared to respond. In addition to receiving information from PTWC, in many cases the countries formulated their own warnings after receiving available seismic and oceanographic data. Indonesia, for example, was able to issue a national warning to local authorities within 10 minutes of the earthquake, comparable to the speed of issuing tsunami warnings in the United States or Japan.

Building on this progress, the ICG/IOTWS expects that one or more Regional Tsunami Watch Providers (playing a similar function to PTWC) will become operational by 2008 or 2009, potentially meaning that the region will no longer rely solely on tsunami notifications from PTWC and the JMA.

Critical US Contributions to the UN-led IOTWS Effort

The United States has provided technical leadership at international, regional, national, and local levels and made a number of strategic technical contributions to help develop various components of the IOTWS that either were underrepresented in ongoing assistance efforts, or would have taken much longer to achieve. US-funded activities have been implemented in close coordination with international, regional, national, and local counterparts, and most have been incorporated into the IOTWS Implementation Plan, which was developed by the ICG/IOTWS with support of Tetra Tech of the US IOTWS PI. With its end-to-end approach, the US IOTWS Program has achieved progress supporting all aspects of the development of an IOTWS, from oceanographic and seismic hazard detection to local community resilience.

In many cases, US IOTWS Program support proved important because the team mobilized quickly and provided operating principles to serve as a guide for the subsequent efforts of national and regional partners. In addition, the assistance was based on US experience establishing the PTWS and combined

relative speed with established expertise. This expertise allowed the US IOTWS Program to provide leadership within the ICG/IOTWS process in critical areas including the IOC's baseline assessment of national warning capacities in 16 Indian Ocean countries, the conceptual design for the IOTWS, the development of protocols and standards for regional warning system interoperability, and architecture for regional and national tsunami warning systems. The end-to-end Program scope also enabled each of these contributions to be placed in relation to one another and within the broader context of the overall IOTWS. In addition, while the relatively compressed program timeframe of two and one-half years proved a challenge, it also encouraged the Program Team and partners to work as quickly as possible to achieve concrete and meaningful results.

6.2 REMAINING CHALLENGES

While developing end-to-end IOTWS capabilities has been and remains an enormous, complex, long-term undertaking, the rapid pace now demonstrated in the Indian Ocean region is already both unprecedented and unmatched by the other regions developing tsunami warning systems. This largely results from the significant financial and technical resources dedicated by donors and governments over the past two years, including USG efforts, as well as accelerated implementation schedules among all. Not unexpectedly, however, international and national partners will continue to face several important challenges.

Institutional Challenges

While the US program was among the first donor efforts and was highly active over a two-and-a-half-year period, some partners have not all been able to provide similar immediate impact or leadership. Some national governments are only now beginning to resolve financial commitments and national-level government coordination to effectively oversee and manage the national warning system. Regional cooperation also remains difficult in some respects, largely because of the practical limitations of convening all 28 countries every six or 12 months to ICG/IOTWS or Working Group meetings.

Maintaining sustained and constant vigilance is one of the biggest challenges becasue tsunamis are relatively rare events. Even in the Pacific, where some form of a warning system has existed for about 40 years, national governments and communities regularly fall behind in meeting warning system and preparedness requirements in more developed and less developed countries alike. Given the more immediate risks of other types of hazards and the high cost of developing and maintaining a tsunami warning system, some governments are already backing away from tsunami-specific warning capabilities.

Financial Challenges

The United States has met all program objectives on schedule and is viewed as having made highly valuable contributions to the IOTWS since 2005. However, it is important to recognize the US IOTWS Program sought to address the most strategic, immediate needs in the international response. Although the funding for the IOC and ICG/IOTWS is limited and designed primarily to support the coordination and provide direction to the member states, many ongoing needs will continue to be addressed by other donor efforts, such as the €45 million GITEWS program in Indonesia that runs to 2010, as well as by long-term domestic programs in Australia, Indonesia, India, Thailand, Malaysia, Sri Lanka, the Maldives, and elsewhere. Many of the national IOTWS plans developed under the ICG/IOTWS process have 5- to 10-year timeframes.

Also, because tsunami reconstruction funding was mainly directed to the five countries most affected by the 2004 tsunami, ongoing needs remain elsewhere in the region. Bangladesh, Pakistan, countries along eastern coasts of Africa and the Arabian peninsula, and numerous small island states in the Indian Ocean have received extremely limited or no funding to date to address IOTWS needs. Those countries that

have participated to date have done so through the IOC or ICG/IOTWS funding sources, which will increasingly diminish in the years ahead.

As donor countries expend the funding that was initially allocated for developing the IOTWS, countries in the region, bilateral donors, and the UN will need to increase financial contributions and identify long-term financing mechanisms. After the tsunami, there was a tremendous outpouring of support accompanied by funding from relief agencies, donor countries, and international organizations.

6.3 FUTURE PRIORITIES

Through the IOC Secretariat's assessment of the September 12 tsunami, the IOC plans to identify ongoing needs for the entire region on both *upstream* tsunami detection, communications, and warning center capacity and *downstream* warning dissemination and preparedness. Many of the upstream warning components established to date have provided an important foundation for national systems. Having these systems in place is helping local authorities and disaster managers better focus on downstream issues. Ideally, efforts to address downstream IOTWS needs should be integrated with broader disaster risk management initiatives.

Future IOTWS requirements include ongoing technology transfer and capacity and institutional strengthening. On December 6-7, 2007, the US IOTWS Program and IOC cosponsored a forum to review progress and discuss strategies for sustaining activities with partners. The Governments of Indonesia, Sri Lanka, Thailand, Maldives, and India joined the IOC, ICG/IOTWS Secretariat, USG officials, US IOTWS Program team, and other disaster experts and business representatives, in Bangkok, Thailand, to define priorities for future development and sustainability of the regional IOTWS. Several priorities were identified that will require significant donor investment, as summarized below.

Regional and Cross-Cutting Needs

- ***Continuing technical support and training.*** Partners emphasized the need for continued technical assistance and capacity building in all areas. ITTI provides a unique opportunity for training on all components of the end-to-end tsunami warning system. In Asia, AIT will continue to work with its ITTI partner, UW, NOAA, and other organizations to identify additional funding to sustain the Institute. AIT also plans to incorporate the curriculum into its own graduate disaster management program. Participants noted the value of outside review and consultation for SOPs and other aspects of the end-to-end warning and mitigation system, and cooperation between USG technical agencies and country partners helps to incorporate international standards with local needs and established protocols.

- ***Maintaining equipment and systems.*** Countries have made significant investments in installing and upgrading tsunami warning equipment and technical capacities. Continued operations and maintenance of these systems is crucial to ensuring effective tsunami warning services. Models and mechanisms should be identified that enable regional (multinational) contributions for maintaining equipment and systems that provide a regional benefit but that may currently be supported solely by individual countries, e.g., DART stations.

- ***Strengthening regional partnerships and professional support networks.*** An effective IOTWS requires the sharing of information and experiences among Indian Ocean neighbors. For example, periodic assessments, including regional simulation exercises, will help to confirm IOTWS achievements and identify remaining gaps, and provide valuable direction for ongoing and planned activities to support sustainability. Organizations such as the IOC and institutions like the ITTI can help promote exchanges among professionals, but other mechanisms are needed as well. While programs may need to focus on a subset of Indian Ocean countries,

networks should encourage the participation of all countries across the region. In addition, more effectively engaging the private sector is one avenue to better promote sustainability.

- ***Promoting engagement in the ICG/IOTWS process***. The ICG/IOTWS process is essential to the continued development of an effective "system of systems" for tsunami warning and mitigation. Continued engagement of the USG in the ICG/IOTWS Working Group process is critical to the future of the IOTWS. Similarly, consistent and active participation by member states is required if the process is to serve the need of the countries in the region. Given the limited funds and resources available to IOC/IOTWS member states, it will be important to develop increasingly efficient coordination and meeting arrangements across the region. Holding working group meetings simultaneously is one step that would help ease the burden on member states.

Detection and Forecasting

- ***Improving data collection, data sharing, and data quality.*** Free and open access to data is critical to successfully developing the IOTWS. The appropriate international forums should address national data-sharing policies that could hamper the effective operation of the IOTWS in the event of a tsunami. There is a need to promote data collection and more robust seismic, coastal sea level, and deep-ocean sea level networks. In addition, more bathymetric and topographic information for risk analysis, hazard mapping, and inundation models will be needed.

- ***Bolstering national- and local-level modeling.*** In many countries there is insufficient data to use standard hazard risk assessment tools or to develop tsunami forecast and inundation models. More data is needed and the quality of the data collected should be improved and presented in a usable way. There is a need to encourage broader access to existing geospatial data through government policies that support the appropriate use of these data for disaster risk reduction. There is also an ongoing need for increased human resource capacity in data analysis, GIS, and other analytical disciplines.

Warning Dissemination

- ***Strengthening local tsunami early warning systems.*** Programs to promoted effective communication of national warnings to provincial governments and local communities should continue. Countries should test versatile, multi-hazard communications mechanisms, such as RANET, in a wide range of areas to increase the utility of the system. Simulations and mock drills should serve as a way to test early warning systems and identify gaps, which enables further improvement.

- ***Adapting information for local/community use.*** Hazard maps and numerical models used to present complex information should be carefully adapted for training, awareness events, and materials in local communities. National officials may assume locals will receive and understand their warning messages, but repeated testing in communities is necessary to gather feedback on how warning messages are interpreted. It is also important to work with the media in crafting messages and sharing information to avoid panic.

Preparedness, Mitigation, and Resilience

- ***Testing and further implementation of CCR tools.*** Mitigation activities, response systems, and public safety solutions at the community level will be needed over the long term. National and regional partners conducted assessments of community resilience in three countries using the CCR tools and benchmarks; the findings and recommendations of those assessments should be taken forward.

- ***Increasing efforts for tsunami and multi-hazard resilience.*** Many of the upstream warning components established to date have provided an important foundation for national systems. However, just as disaster risk management and preparedness remain significant challenges requiring greater investment in general, the downstream aspects of the IOTWS require increased support to adopt appropriate SOPs, local response systems, and awareness-building programs. Efforts to address downstream needs should be integrated with broader disaster risk management initiatives. Priorities for *last kilometer* assistance include increasing education, mitigation efforts, identifying safe areas, and developing local decision-making procedures.

USG partners will continue pursuing options for future collaboration to assist the IOC and other regional and national partners in addressing the long-term priorities for the IOTWS. Technical agencies, such as NOAA and USGS, also plan to remain engaged with partners in the region through new and ongoing partnership agreements focused on technology transfer, research and development, and capacity building. Ongoing funding, technical, and coordination needs that have been identified through the US IOTWS Program will be considered at the ICG/IOTWS-V meeting in April 2008 to be held in Kuala Lumpur, Malaysia.

APPENDIX A. PERFORMANCE MANAGEMENT REPORTING—LIFE OF PROGRAM

US Indian Ocean Tsunami Warning System (IOTWS) Program Integrated Program Work Plan 2005-2007

February 2008 Version 2.1

INTRODUCTION

The US IOTWS Program directly contributes to USAID's SpO 498-045 for Tsunami Recovery and Reconstruction. The Program's principal program management tool is the Integrated Program Work Plan, which describes the roles and responsibilities of all USG agency partners and the PI, along with planned implementation activities. The primary tool for monitoring program performance is the PMP, which describes the Program's results framework, data collection sources and methods, and performance indicators and targets.

The information presented below represents results achieved for the US IOTWS Program, from August 1, 2005 to February 28, 2008. Results reported here are based on PMP Version 2.0 updated in February 2007. The US IOTWS Program duration was initially planned to span from August 1, 2005 through September 30, 2007, but was granted a no-cost extension for a completion date of March 31, 2008.

RESULTS FRAMEWORK

The results framework for the US IOTWS Program is provided in Table A-1. The US IOTWS Program falls under SpO 498-095 and SpO Intermediate Result (IR) 3. Four program-level intermediate results and their respective indicators incorporate and refine the expected results included in the IAAs for NOAA, USGS, and USFS and in the scope of work for the USAID and the PI. Both Table A-2, which provides a summary of targets and results for the life of program, and Table A-3, which summarizes all actual results achieved, are based on the approved indicators and targets provided in Version 2.0 of the PMP.

For ease of calculation, original 2006 planned targets are substituted with 2006 actual results achieved as results were used to calculate life of program total targets during the PMP Version 2.0 revision process. (Original planned targets for FY2006 and FY2007 are provided in the original PMP, Version 1.0, dated March 2006, Appendix B of the Integrated Program Work Plan 2005-2007.)

Table A-1. Results Framework for the US IOTWS Program

USAID Special Objective (SpO) for Tsunami Recovery and Reconstruction: To save lives; help individuals rejoin the workforce and return to communities; support host government-led reconstruction and early warning/disaster preparedness efforts

SpO-Level IRs

SpO IR 3: Early Warning System Established
- SpO Indicator 3.1: Number of communities trained in disaster preparedness
- SpO Indicator 3.2: Number of communities included in national alert system

SpO IR 4: Technical Assistance, Good Governance & Reconciliation
- SpO Indicator 4.1: Number of government agencies that received technical support

SpO Special Interest Reporting Indicator
- SpO Special Indicator C: Kilometers of coastline under improved, sustainable environmental management

Sub-IRs (Program-level IRs)

Sub-IR 1. Scientifically sound design for IOTWS developed
- Indicator 1.1: Conceptual design for early warning system design provided to and accepted by ICG/IOTWS
- Indicator 1.2: Numbers of protocols, and products established by or with ICG/IOTWS member nations that enable interoperability of the regional IOTWS system

Sub-IR 2. Tsunami detection and early warning capabilities improved
- Indicator 2.1: Number of agreements developed for the installation, deployment, or integration of tsunami detection and communication system components
- Indicator 2.2: Number of IOTWS or national tsunami detection and communication system components installed, deployed, and or upgraded
- Indicator 2.3: Number of tsunami detection and communication system components integrated into the IOTWS and operated in accordance with ICG/IOTWS standards and criteria

Sub-IR 3. National capacity in disaster management improved
- Indicator 3.1: Number of tsunami/all hazards warning dissemination and disaster management system mechanisms designed, developed, or improved at the national level
- Indicator 3.2: Number of communities included in national alert systems (ref. SpO Indicator 3.2)
- Indicator 3.3: Number of government agencies that received technical support (ref. SpO Indicator 4.1)

Sub-IR 4. Local preparedness and coastal mitigation for tsunamis and related hazards improved
- Indicator 4.1: Number of communities trained in disaster preparedness (ref. SpO Indicator 3.1)
- Indicator 4.2: Number of coastal communities initiating activities that support resilience

Table: A-2. Performance Monitoring Plan Summary of Results – Life of Program

INDICATOR	Revised Targets	Actual Results
Sub-IR1: Scientifically sound design for IOTWS developed		
Indicator 1.1: Draft and refined versions of conceptual IOTWS design provided to and accepted by ICG/IOTWS	2	2
Indicator 1.2: Number of protocols and products established by or with ICG/IOTWS member nations that enable interoperability of the regional IOTWS system	31	31
Sub-IR2: Tsunami detection and early warning capabilities improved		
Indicator 2.1: Number of agreements developed for the installation, deployment, or integration of tsunami detection and communications system components*	11	18
Indicator 2.2: Number of IOTWS or national tsunami detection and communication system components installed, deployed, and/or upgraded	18	18
Indicator 2.3: Number of tsunami detection and communication system components integrated into the IOTWS and operated in accordance with ICG/IOTWS standards and criteria.*	16	16
Sub-IR3: National capacity in tsunami warning dissemination and disaster management improved		
Indicator 3.1: Number of tsunami/all-hazards warning dissemination and disaster management system mechanisms designed, developed and/or improved at the national level	62	73
Indicator 3.2: Number of communities included in national alert systems (SpO 3.2)	320	399
Indicator 3.3: Number of government agencies that received technical support (SpO 4.1)	160	195
Sub-IR4: Local preparedness and coastal mitigation for tsunamis and related hazards improved		
Indicator 4.1: Number of communities trained in disaster preparedness (SpO 3.1)	712	20,290
Indicator 4.2: Number of coastal communities initiating activities that support resilience	67	83

Table A-3. Performance Monitoring Plan Indicator Tables

USAID SPECIAL OBJECTIVE 498-045 **To save lives, help individuals rejoin the workforce and return to communities, support host government-led reconstruction & early warning/disaster preparedness efforts**			
SPO-LEVEL INDICATORS			
IR 3. Early Warning System Established	**FY**	**Planned/ Revised**	**Actual Result**
SpO Indicator 3.1: Number of communities trained in disaster preparedness *(See Program Indicator 4.1 below)*	**06**	**187**	**187**
	07	**525**	**20,103**
	Total	**712**	**20,290**
SpO Indicator 3.2: Number of communities included in national alert systems *(See Program Indicator 3.2 below)*	**06**	**260**	**260**
	07	**60**	**139**
	Total	**320**	**399**
IR4: Technical Assistance, Good Governance & Reconciliation	**FY**	**Planned/ Revised**	**Actual Result**
SpO Indicator 4.1: Number of government agencies (e.g. municipalities, central government offices) that received technical support *(See Program Indicator 3.3 below)*	**06**	**112**	**112**
	07	**48**	**83**
	Total	**160**	**195**

PROGRAM-LEVEL INDICATORS

Sub-IR1: Scientifically sound design for IOTWS developed	FY	Planned/ Revised	Actual Result
Indicator 1.1: Draft and refined versions of conceptual IOTWS design provided to and accepted by ICG/IOTWS	06	2	2
	07	0	0
	Total	2	2

Unit of measure: Design

Definition: The conceptual IOTWS design, including refinements of the design, serves as the regional technical baseline to guide development of national systems. The conceptual design consists of a conceptual framework, a description of requisite components, and an outline of required standards and other metrics; for example, details of location for detection devices, protocols for sharing information/data, essential channels of communications, etc.

Relevance: Provides scientifically sound basis for design of IOTWS, specifically for use by ICG/IOTWS member states.

Results for FY2006:

Agency	2 Results Achieved in FY2006	Achieved
NOAA	1 Draft Conceptual Design	✓
NOAA	1 Refined Conceptual Design	✓

Data Collection and Analysis Methodology: NOAA experts will develop one draft design and one refined version. Data collection will be undertaken by NOAA and analyzed through file reviews. Data collected will include the following:

- Materials directly relevant to the design process;
- Minutes of the ICG or ICG Working Group meetings at which the various draft conceptual designs are discussed and recommendations made;
- Copies of draft design; and
- One or more documents that attest to acceptance of the draft and refined conceptual design by the ICG/IOTWS.

Data Source: NOAA, USG delegations to IOC meetings.

Data Verification: Draft and refined copy of conceptual design. Meetings minutes or proceedings indicating acceptance of concept design documents and refinements by ICG/IOTWS. Copies of documents will be retained by PI.

Sub-IR1: Scientifically sound design for IOTWS developed	FY	Planned/ Revised	Actual Result
Indicator 1.2: Number of protocols and products established by or with ICG/IOTWS member nations that enable interoperability of the regional IOTWS system	06	8	8
	07	23*	22
	08	0	1
	Total	31	31

Unit of measure: Protocol or product

Definition: "Protocols" are a common set of rules and instructions that govern how systems can operate compatibly with each other. For the IOTWS, these protocols include technical designs and operating standards, performance criteria, and data access standards to ensure interoperability of the various tsunami detection system components. "Products" are analyses, studies or publications which address critical knowledge gaps and further regional interoperability. Protocols and products may result from both direct and indirect US assistance and are developed by or with ICG/IOTWS member states.

Relevance: Agreement on the content of technical protocols and how these would be implemented provide the basis for achieving interoperability of each component in the US IOTWS Program and thus provide the basis for establishing a functional end-to-end early warning system that is robust and reliable.

Results for FY2008:

Agency	1 Result Achieved in FY2008	Achieved
NOAA	1 Adoption of National Warning Center CONOPS Standards and Practices	✓

Targets for FY2007:

Agency	23 Targets Planned for FY2007	Achieved
NOAA	1 Tsunami Model Standard for the IOTWS	✓
NOAA	1 Inundation Model Performance Standards	✓
NOAA	1"Core Station" Concept and Definition	✓
NOAA	1 Tsunameter Conceptual Array/ Baseline	✓
NOAA	1 Thailand adoption of IOTWS/NOAA DART Operation Standards (MOU/IA)	✓
NOAA	1 RANET technologies upgraded to meet IOTWS country requirements	✓
NOAA	1 Indonesia adoption of IOTWS Interoperability Principals (Multi-hazard MOU)	✓
NOAA	1 ComMIT Web Interface developed and completed	✓
NOAA	1 Tsunami Propagation Database for Indian Ocean	✓
NOAA	1 Indonesia Adoption of Standards for Tide stations (Indonesia Sea Level IA – Australia IA)	✓
NOAA	1 Australia Agreement to support and augment IOTWS (Australia IA)	✓
NOAA	1 Indonesia Adoption of IOTWS/NOAA DART Operations Standards, Adoption of Modeling Standards (Indonesia IA)	✓
NOAA	1 Establishment of International Tsunameter Partnership to promote Tsunameter Interoperability	✓
NOAA	1 Adoption of Standards for Deep-Ocean sea level stations	✓
NOAA	1 Adoption of Standards for coastal sea level stations	✓
NOAA	1 Adoption of Data Format Standard for sea level stations	✓
NOAA	1 Adoption of National Warning Center CONOPS Standards and Practices	Delayed (see FY2008 above)
USGS	1Thailand Fault Map	✓
USGS	1 Indonesia Fault Map	✓
USGS	1 CISN display installed at BMG	✓
USGS	1 Training on use of CISN software	✓
USGS	1 Development of seismic station template	✓
USGS	1 Training on installation of EID server	✓

Results for FY2006:

Agency	8 Results Achieved in FY2006	Achieved
NOAA	1 MOA between NOAA and Australia	✓
NOAA	1 Agreements reached for GTS Maldives upgrade	✓
NOAA	1 Agreement for GTS upgrade in Sri Lanka	✓
NOAA	1 Agreement from IOTWS implementation plan to upgrade sea-level stations	✓
NOAA	1 Agreement from IOTWS implementation plan to install buoys	✓
USGS	1 Agreement from IOTWS implementation plan to install or upgrade GPS systems	✓
USGS	1 Agreement from the IOC/IOTWS implementation plan to install or upgrade seismic stations	✓
PI	1 Consolidated Report for 16 Countries Affected by the 26 December 2004 Tsunami to the IOC in October 2005	✓

Data Collection and Analysis Methodology: Data collection will be undertaken by US IOTWS Program Activity Managers and analyzed through document reviews.

Data Source: US IOTWS Program Activity Managers and ICG/IOTWS Member Country Counterparts

Data Verification: Protocols, communications and documents referring to adoption of or intention to apply protocols enabling interoperability with regional IOTWS system, and products. Copies of documents will be retained by PI.

*Note: Target was readjusted from December 2005 Version 1.0 PMP to reflect the disaggregation of Indicator 1.2 to two different indicators in February 2007 Version 2.0. The Version 1.0 Indicator 2.1 included "agreements" which has now been made a separate indicator, 2.1. The previous Indicators 2.1 and 2.2 have subsequently become indicators 2.2 and 2.3 respectively.

Sub-IR2: Tsunami detection and early warning capabilities improved	**FY**	**Planned/ Revised**	**Actual Results**
Indicator 2.1: Number of agreements developed for the installation, deployment, or integration of tsunami detection and communications system components*	**06**	**n/a***	**n/a***
	07	**11**	**17****
	08	**0**	**1**
	Total	**11**	**18**

Unit of measure: Agreement

Definition: An agreement refers to a formal or informal expression of intent between two parties confirming the acceptance of plans to install, deploy or integrate a tsunami detection and communication system component (or components). Agreements may involve issues such as: operations and maintenance related to the various tsunami detection components; software used for communication and detection systems; data transfer and use, etc. Agreements may result from direct of indirect US assistance and are developed by or with ICG/IOTWS member nations.

Relevance: Agreements provide the basis for determining the strength of national level support for the end-to-end system and the reliability of operations of each component in the IOTWS and help provide the basis for establishing a functional end-to-end early warning system at a regional level.

Results for FY2008:

Agency	**1 Result Achieved in FY2008**	**Achieved**
NOAA	1 Partnership with the Asian Institute of Technology for the ITTI	✓

Targets for FY2007:

Agency	**11 Targets Planned for FY2007**	**Achieved**
NOAA	1 Agreement for PTWC to provide notification of tsunami relevant information to IO nations	✓
NOAA	1 Agreement for partnership with University of Washington Extension to establish the ITTI	✓
NOAA	1 MOU/IA with Thailand for collaboration on 1st DART deployment and follow-on operation and maintenance	✓
NOAA	1 MOU with Indonesia on Multi-hazards assessment, warning and preparedness	✓
NOAA	1 implementing agreement under multi-hazards MOU with Indonesia for sea-level station upgrades	✓
NOAA	1 Implementing arrangement with Indonesia for collaboration on 2nd DART deployment, operations, and maintenance	✓
NOAA	1 Implementing arrangement with Indonesia for tsunameter research and development	✓
NOAA	1 Implementing arrangement with Australia for collaboration on DART deployments in the Indian Ocean	✓
NOAA	1 Partnership with the Asian Institute of Technology for the ITTI	Delayed
USGS	1 GPS agreement, Indonesia	✓
USGS	1 seismic agreement, Indonesia	✓

Additional Results for FY2007:

Agency	7 Additional Results for FY2007	Achieved
USTDA	1 Agreement with BMG for Disaster Management Plan and Technology Strategy Project, Indonesia	✓
USTDA	1 Agreement with the DMC for the Strategic Advisory and ICT Systems Project, Sri Lanka	✓
USTDA	1 Agreement with NDWC for Disaster Warning System Integration and Capacity Building Project Thailand	✓
USTDA	1 Agreement with BMG for National Emergency Communications Strategy Project, Indonesia	✓
USTDA	1 Agreement with the Department of Meteorology for the Disaster Early Warning Center Capacity Development and Systems Project, Sri Lanka	✓
USTDA	1 Agreement with the Ministry of Disaster Management and Human Rights for the Emergency Communication Strategy Project, Sri Lanka	✓
USTDA	1 Agreement with BMG for the Earthquake Detection and Seismology Training Project, Indonesia	✓

Data Collection and Analysis Methodology: NOAA and USGS will retain files of copied agreements and/ or communications for planned installation, deployment or integration system components relevant to their respective activities.

Data source: US IOTWS Program Activity Managers, ICG/IOTWS, NDMOs, and other relevant partners.

Data Verification: Documents confirming agreement in addition to other relevant communications, plans, or technical materials. Copies of documents will be retained by PI.

*Note: A new Indicator, 2.1, was added in the process of PMP revision. The previous PMP Indicator 2.1 as related to the US IOTWS Program Integrated, "Program Work Plan 2005 – 2007" has subsequently become Indicator 2.2 and the previous Indicator 2.2 is now Indicator 2.3.
**Note: Numbers reflect seven USTDA results which were planned as activities but erroneously had not been included in 2007 target projections.

Sub-IR2: Tsunami detection and early warning capabilities improved	**FY**	**Planned/ Revised**	**Actual Results**
Indicator 2.2: Number of IOTWS or national tsunami detection and communication system components installed, deployed, and/or upgraded*	**06**	**4**	**4**
	07	**14****	**9**
	08	**0**	**5**
	Total	**18**	**18**

Unit of measure: System component

Definition: A "component" refers to an instrument or other technology required for a core station. A "core station" is an observing station that enables tsunami detection and transmission of tsunami data to warning centers and 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 the Global Telecommunications System (GTS) in real time.

Components may be installed, deployed, and/or upgraded as a result of direct or indirect US assistance. *Direct* US assistance encompasses: tsunami detection and communication system components, including seismometers, geodetic instruments (GPS), tide gauges, DARTs, and GTS upgrades, which, together form what have been identified as core stations in the regional conceptual plan design. *Indirect* US assistance includes both an array of equipment provided by NOAA outside of the US IOTWS Program, including upgrades to existing equipment in member states and/or providing advice on installation, deployment or upgrading of relevant equipment.

Relevance: Successful installation and operation of these components are essential milestones to detect tsunamis and transmit data about them to tsunami warning centers.

Results for FY2008:

Agency	5 Results Achieved in FY2008	Achieved
USGS	2 accelerometers, Indonesia	✓
USGS	3 new broadband Stations for Indonesia	✓

Targets for FY2007:

Agency	14 Targets Planned for FY2007	Achieved
NOAA	First DART station deployed	✓
NOAA	1 Prigi, Indonesia sea-level station	✓
NOAA	1 Cilacap, Indonesia sea-level station	✓
NOAA	Second DART station deployment	✓
NOAA	1 RANET ground receivers installed in Indonesia	✓
NOAA	1 RANET ground receiver installed in Sri Lanka	✓
NOAA	1 GTS upgrade for Maldives	✓
NOAA	1 GTS upgrade for Sri Lanka	✓
USGS	1 Thai seismic station integrated into NEIC	✓
USGS	2 accelerometers, Indonesia	Delayed[5] (see 2008 above)
USGS	3 new broadband Stations for Indonesia	Delayed (see 2008 above)

Results for FY2006:

Agency	4 Results Achieved in FY2006	Achieved
NOAA	4 Coastal sea level stations: 1Indonesia; 2 Maldives; 1 Sri Lanka	✓

Data Collection and Analysis Methodology: NOAA and USGS and will keep files of identified core station needs and technical specification required (where necessary) of the "components" of the various systems to be installed, deployed and/or upgraded. Evidence for completed activities for component interventions including certifications of receipt, acceptance letters, work orders etc. will be filed. Additional evidence related to post installation, deployment, or upgrade activity/ usage by recipient/ end user including tests, performance data, personal communications should be solicited and analyzed on a rolling basis.

Data Source: US IOTWS Program Activity Managers, NDMOs, and other relevant partners.

Data Verification: Signed acceptance letters from recipient IOTWS partners or completed work orders for equipment installation, deployment or upgrade. When possible and practical, additional supporting data in the form of photographs, test data, follow up communications related to core station activity post US IOTWS intervention should be collected. Copies of documents will be retained by PI.

*Note: A new Indicator, 2.1, was added in the process of PMP revision. PMP Indicator 2.1 as related to the US IOTWS Program Integrated, "Program Work Plan 2005 – 2007" has subsequently become Indicator 2.2 and the previous Indicator 2.2 is now Indicator 2.3.

[5] Results were scheduled to be achieved by December 2007 but USGS inadvertently reported them as January 2008.

Sub-IR2: Tsunami detection and early warning capabilities improved	FY	Planned/ Revised	Actual Results
Indicator 2.3: Number of tsunami detection and communication system components integrated into the IOTWS and operated in accordance with ICG/IOTWS standards and criteria.*	06	5	5
	07	11	11
	Total	16	16

Unit of measure: System component

Definition: A "system component" refers to a tsunami system detection, analysis or communications element integrated into an international network, such as the GTS or Global Seismic Network (GSN). Integration will necessarily involve an iterative process of testing and systematic linking of the various components of the detection and warning system along with developing standard operating procedures to ensure that data and interoperability with the member state is compatible and consistent with ICG/IOTWS technical standards.

Relevance: Installing detection hardware alone does not alone produce a functioning system. This indicator measures the number of functioning system components (seismometers, geodetic instruments (GPS), tide gauges, DART buoys, and communication networks) integrated and contributing to a sustainable overall end-to-end tsunami early warning system.

Targets for FY2007:

Agency	11 Targets Planned for FY2007	Achieved
NOAA	2 coastal sea level stations	✓
NOAA	2 DART II stations	✓
NOAA	2 GTS upgrades, Sri Lanka and Maldives	✓
NOAA	2 RANET	✓
USGS	3 Malaysian Seismic Stations	✓

Results for FY2006:

Agency	5 Results Achieved in FY2006	Achieved
NOAA	4 Coastal sea level stations: 1Indonesia; 2 Maldives; 1 Sri Lanka	✓
USGS	1 seismic station integrated in NEIC production system (Chang Mai, Thailand)	✓

Data Source: US IOTWS Program Team, NDMOs, and other partners and contractors working on equipment installation or protocols.

Data Collection and Analysis Methodology: The US IOTWS Program Activity Manager works with relevant organizations of ICG/IOTWS member states to document the integration process and the results of tests of the system to ensure successful integration. Where necessary, test data may be analyzed further by team to recommend additional fine-tuning, in which case, interim integration results may be reported. Documentation should show schematically how integration is achieved within the national system and between national systems and the IOC.

Responsible: US IOTWS Program Activity Managers

Data Verification: Integration documentation including Activity Manager reports and test data. Copies of documents will be retained by PI.

*Note: As a new Indicator 2.1 was added in the process of PMP revision. PMP Indicator 2.1 as related to the US IOTWS Program Integrated, "Program Work Plan 2005 – 2007" has subsequently become Indicator 2.2 and the previous Indicator 2.2 is now Indicator 2.3.

Sub-IR3: National capacity in tsunami warning dissemination and disaster management improved	FY	Planned/ Revised	Actual Results
Indicator 3.1: Number of tsunami/all-hazards warning dissemination and disaster management system mechanisms designed, developed and/or improved at the national level	06	17	17
	07	45*	52**
	08	0	4
	Total	62	73

Unit of measure: System mechanism

Definition: "System mechanisms" are sets of procedures and structures that contribute to the institutionalization of disaster management operations. Mechanisms include organizational leadership structures; enabling policies to ensure NDMOs possess authority and resources for decision making and response; communication systems for warning dissemination; warning dissemination and disaster response processes and protocols; replicable training modules/programs/simulation exercises/drills; and resource centers at national, provincial, or local institutional levels, as appropriate. Definition of system mechanism areas include:

- *Organizational leadership structures*: Includes chain-of-command with clear articulation of responsibilities in routine and emergency situations. Will usually link to political decision-makers and military or other emergency "first responders"
- *Enabling policies*: Agency and government-wide policies, laws, regulations, decrees, technical guidance, personnel procedures and other instruments that provide legal basis for warning system and which guide the system's functioning vis-à-vis other parts of the government, private sector and the public.
- *Communication systems for warning dissemination*: Articulates structures and functioning of these for disseminating warnings. Should include not only physical parts of the system (warning towers, mass media) but also organization of private and public agencies and community leadership to receive, interpret and act on messages received.
- *Warning dissemination and disaster response processes and protocol:* Structure and rules for ICS, TARNS, others. These should come from the agencies but need evidence of how these are incorporated into equivalent structures in member countries. This integration (or transfer) should be governed by formal or informal protocols within the context of the US IOTWS Program.
- *Replicable training modules/programs/simulation exercise/drills:* Training of personnel and/or information on how to train personnel. Schedule of simulation exercises/drills and documentation that these have occurred, preferably with Program staff witnessing and evaluation.
- *Resource center components*: Information dissemination mechanisms (through Internet and/or hardcopy) at designated member country "node" or center established for this purpose or provided role for this purpose.

Relevance: This indicator measures the warning dissemination and disaster management components that need to be in place to communicate warnings at national levels and up to the "last kilometer" and to respond to disasters.

Results for FY2008:

Agency	4 Results Achieved in FY2008	Achieved
NOAA	1 CCR guidelines	✓
NOAA	1 ITTI course developed and institutionalized at AIT	✓
NOAA	1 National Warning Center CONOPS adapted for Indonesia, Thailand and Sri Lanka	✓
NOAA	1 Training module for Elements of Tsunami/Multi-hazard warning system, Indonesia	✓

Targets for FY2007:

Agency	45 Targets Planned for FY2007	Achieved
NOAA	1 ITTI at University of Washington	✓
NOAA	2 RANET Sri Lanka, Indonesia	✓
NOAA	3 Web based Community Model (ComMIT)	✓
NOAA	3 CCR national framework/training systems, Indonesia, Thailand, Sri Lanka	✓
NOAA	1 CCR regional framework/training system	✓

NOAA	1 National and Regional CONOPS compendium	✓
NOAA	2 GTS upgrades, Maldives, Sri Lanka	✓
NOAA	1 Training module for Elements of Tsunami/Multi-hazard warning system, Indonesia	Delayed (see FY2008 above)
NOAA	1 Training module for Elements of Tsunami/Multi-hazard warning system, Sri Lanka	✓
NOAA	1 Training module for Elements of Tsunami/Multi-hazard warning system, Thailand	Cancelled
NOAA	1 National Warning Center CONOPS adapted for Indonesia, Thailand and Sri Lanka	Delayed (see FY2008 above)
NOAA	1 Multi-hazards Identification and Analysis Tool	✓
NOAA	1 CCR guidelines	Delayed (see FY2008 above)
NOAA	1 ITTI course at AIT	Delayed (see FY2008 above)
USGS	1 Software module	✓
USGS	1 Public Server	✓
USGS	1 NEIC Implementation	✓
USGS	1 EIDS Evaluation	✓
USGS	1 EIDS External Transport Protocol implemented	✓
USFS	7 ICS training modules	✓
USFS	1 ICS study tour	✓
USFS	2 ICS protocols/procedures	✓
USFS	1 ICS simulation	✓
USFS	1 ICS operational structure	✓
USFS	3 TARNS simulation exercises	✓
USFS	2 TARNS protocols/ procedures	✓
USFS	1 TARNS multi-hazard	✓
USTDA	2 Prototype Emergency Management Systems to Sri Lanka	Delayed (see FY2008 above)

Additional Results for FY2007:

Agency	**14 Additional Results for FY2007**	**Achieved**
USGS	2007 Additional Planned	✓
USGS	1 Internal transport protocol mechanism	✓
USGS	1 Seismic Hazard Training, Thailand	✓
USGS	1 Seismology, Data Analysis and Tsunami Warning Training, Indonesia	✓
USGS	1 NEIC Training Exchange, Golden CO, USA	✓
USGS	1 Regional Training in Advanced Seismology and Tsunami Warning, Malaysia	✓
USGS	1 GTS Advanced Seismology and Tsunami Warning Training, Thailand	✓
USFS	2 ICS training modules	✓
USFS	1 ICS study tour	✓
USTDA	1 Disaster Management Plan and Technology Strategy, Indonesia	✓
PI	3 Disaster Management Policy Reviews, Indonesia, Sri Lanka, Thailand	✓
PI	1 Series of four SOP Workshops, Indonesia	✓

Results for FY2006:

Agency	**17 Results Achieved in FY2006**	**Achieved**
USFS/ NOAA	1 TARNS	✓
USFS/ NOAA	1 NDWC Thailand operation structure improved for warning dissemination	✓
USFS/ NOAA	1 NDWC internal operations structure improved for media outreach	✓
USFS	1 ICS leadership management structure, Sri Lanka	✓

USFS	1 ICS module, Sri Lanka; 2 ICS study tours	✓
USFS	1 Standard Operating Procedure/protocol in train-the-trainer process, Sri Lanka	✓
USFS	1 ICS resource center, Sri Lanka	✓
USGS	1 Training, Application of Seismology in Tsunami Detection and Alert	✓
USGS	1 Training, Methods for Estimating Seismic Source Parameters	✓
USGS	1 Training Seismic and Tsunami Warning Center, Indonesia	✓
USGS	1 Regional Seismic Training	✓
USGS	1 Seismic and Tsunami Warning Training, Maldives	✓
USTDA	2 Operational CONOPS, Thailand	✓
USTDA	1 CONOPS simulation, Thailand	✓

***Data Collection and Analysis Methodology*:** US IOTWS Program Activity Managers will collect relevant documentation related to system mechanism activities. Methodology involves determining with stakeholders, the point at which the particular component has been designed, developed or improved.

Data Source: US IOTWS Program Activity Managers, NDMOs, other relevant partners.

Data Verification: Design, implementation and monitoring documents related to the activities. Where training occurs in the course of activity implementation, the provider will ensure that signed participant sheets are maintained and reported to TraiNet (via the PI). Copies of documents will be retained by PI.

*Note: Target was readjusted up from 44 in December 2005 Version 1.0 PMP to reflect needs.
**Note: Numbers reflect four PI results and five USGS results which were planned as activities but erroneously had not been included in 2007 target projections.

Sub-IR3: National capacity in tsunami warning dissemination and disaster management improved	**FY**	**Planned/ Revised**	**Actual Results**
Indicator 3.2: Number of communities included in national alert systems	**06**	**260**	**260**
	07	**60***	**139**
	Total	**320**	**399**

Unit of measure: Community

Definition: A national alert system refers to a national tsunami warning and alert system which may also be part of an all hazards warning and alert system. This indicator will specifically measure the number of communities that have become or will become included in a national tsunami warning and alert system as a result of US IOTWS Program activities. For the purpose of this indicator, communities are defined as 100 households of 5 persons (i.e. 500 persons on average) that are located in tsunami vulnerable areas.

Relevance: Communities vulnerable to disasters will be notified earlier and thus able to take steps to protect themselves.

Targets for FY2007:

Agency	**60 Targets Planned for 2007**	**Achieved**
USFS	60 communities	X

Additional Results for FY2007:

Agency	**139 Additional Results for FY2007**	**Achieved**
NOAA	103 RANET Indonesia	✓
NOAA	36 RANET Sri Lanka	✓

Results for FY2006:

Agency	**260 Results Achieved in FY2006**	**Achieved**
USFS	260 communities	✓

***Data Collection and Analysis Methodology*:**

US IOTWS Program Activity Managers and relevant partners to provide data/evidence of communities included in national alert system as a result of US IOTWS Program activities.

Data Source: PI, USFS and other partners will collect TARNS data. Additional data to be collected by US IOTWS Program Activity Managers, NDMOs, other relevant partners.

Data Verification: Questionnaires, data summaries and analysis reports for TARNS. Other relevant evidence as collected. Copies of documents will be retained by PI.

*Note: Target was readjusted down from 800 in December 2005 Version 1.0 PMP to reflect a more robust approach to data validation in measurement.

Sub-IR3: National capacity in tsunami warning dissemination and disaster management improved	**FY**	**Planned/ Revised**	**Actual Results**
Indicator 3.3: Number of government agencies that received technical support	**06**	**112**	**112**
	07	**48***	**83**
	Total	**160**	**195**

Unit of Measure: Agency

Definition: A "government agency" refers to any government institution either at the national or sub-national level. Technical support received may be a result of either direct or indirect US assistance. Technical assistance and training provided to government technical agencies, research bodies and administrative levels of government include all forms of training, consultations, technology transfers, assistance with preparation of plans and other forms of assistance that build capacity of the agency in early warning systems and disaster preparedness.

Relevance: The primary mode of technology transfer through the US IOTWS Program will be through capacity building of national and local government agencies and selected research bodies.

Targets for FY2007:

Agency	**48 Targets Planned for FY2007**	**Achieved**
NOAA	6 agencies	Partial (3)
USGS	12 agencies	✓
PI	30 agencies	✓

Additional Results for FY2007:

Agency	**38 Additional Results for FY2007**	**Achieved**
USGS	19 agencies	✓
USFS	19 agencies	✓

Results for FY2006:

Agency	**112 Results Achieved in FY2006**	**Achieved**
NOAA	9 agencies	✓
USGS	8 agencies	✓
USFS	73 agencies	✓
PI	22 agencies	✓

Data Collection and Analysis Methodology: USFS, USGS, PI and NOAA Activity Managers will collect data for each government agency receiving technical support identifying relevant activity and recipient details. Analysis will be from file reviews. Different sub-sections of any single government administrative area will be treated as a separate agency for the purposes of measurement. For example, a training workshop provided to the Ministry of Interior at the national level and a separate training provided to Ministry of Interior at a district level will be counted as two agencies.

Data Source: US IOTWS Program Activity Managers
Data Verification: Training materials, description of assistance provided, and activity reports. Participant

lists with daily signed attendance sheets. Copies of certificates of completion. Correspondence from recipients describing and verifying type of assistance received. Copies of documents will be retained by PI.

*Note: Target was readjusted up from 90 in Version 2.0 PMP to reflect the fact that original FY07 Targets were exceeded in FY06.

Sub-IR4: Local preparedness and coastal mitigation for tsunamis and related hazards improved	**FY**	**Planned/ Revised**	**Actual Results**
Indicator 4.1: Number of communities trained in disaster preparedness	**06**	**187**	**187**
	07	**525***	**20,103**
	Total	**712**	**20,290**

Unit of measure: Person(s) trained

Definition: This indicator consists of the number of government officials, NGO representatives, and local leaders trained in disaster preparedness and, indirectly, the communities represented or reached by these individuals and their organizations/agencies. Persons trained will consist primarily of individuals who live in the potentially tsunami-affected communities, provide tsunami relevant public services to these communities or work for NGOs working in these communities. Persons trained by or in collaboration with other regional programs and partners such as the IFRC which use US IOTWS Program training materials and modules will be included in calculations.

Relevance: By making citizens more aware of emergency procedures, the impact of disaster can be mitigated.

Targets for FY2007:

Agency	**525 Targets Planned for FY2007**	**Achieved**
NOAA/PI	145 persons trained [120 CCR; 25 Tsunami Education Program]	✓
USFS	380 persons trained [160 TARNS; 220 ICS]	✓

Additional Results for FY2007:

Agency	**19,578 Additional Results for FY2007**	**Achieved**
NOAA/PI	21 persons trained [CCR, Tsunami Education Program]	✓
USFS	326 persons trained [ICS and TARNS]	✓
PI	19,231 persons trained [Small Grants Program (KOGAMI (18,674), SEEDS (341)) and SOP (216) training]	✓

Results for FY2006:

Agency	**187 Results Achieved in FY2006**	**Achieved**
NOAA/USFS	144 persons trained [TARNS]	✓
NOAA/PI	43 persons trained [CCR]	✓

Data Collection and Analysis Methodology: US IOTWS Program Activity Managers and partners will take headcounts at each training session. Trainings cover trainings and workshops including all modules of ICS, TARNS, CCR, or other trainings that target local/community level disaster preparedness. Information will be collected on trainees and forwarded to the PI who will disaggregate data according to gender; whether they are local, national government representatives or NGOs; and which communities they represent.

Data Source: The number of people trained will be based on TrainNet database populated by attendance sheets from each workshop.

Data Verification: Participant lists with daily signed attendance sheets. Copies of certificates of completion. Evaluation sheets. Copies of documents will be retained by PI.

*Note: Target was readjusted down from 1000 in December 2005 Version 1.0 PMP to reflect program activities.

Sub-IR4: Local preparedness and coastal mitigation for tsunamis and related hazards improved	FY	Planned/ Revised	Actual Results
Indicator 4.2: Number of coastal communities initiating activities that support resilience	06	2	2
	07	65*	81
	Total	67	83

Unit of measure: Community

Definition: For the purpose of this indicator, "communities" are defined as 100 households of 5 persons (i.e. 500 persons on average) that are located in tsunami vulnerable areas. "Resilience" is defined as combination of three characteristics: magnitude of a shock that a system can absorb and remain within a given state; the degree to which the system is capable of self organization; and the degree to which the system can build capacity for learning and adaptation. Resilience activities will include the development of a coastal community resilience assessments or the initiation of an action plan to increase resilience based on an assessment. Targets include communities whose representatives or development agents received the CCR Guide and training sessions.

Relevance: By organizing communities to adopt appropriate disaster preparedness measures, the impact of tsunamis and other disasters can be mitigated in particularly vulnerable areas. [NOTE: Done to differentiate between 4.1]

Targets:

Targets for FY2007

Agency	65 Targets for FY2007	Achieved
NOAA	15 communities [CCR]	✓
PI	50 communities [small grant recipient communities]	✓

Additional Results for FY2007

Agency	16 Additional Results for FY2007	Achieved
NOAA	14 communities [CCR]	✓
PI	2 communities [small grant recipient communities]	✓

Results for FY2006

Agency	2 Results Achieved in FY2006	Achieved
PI	2 communities [small grant recipient communities]	✓

Data Collection and Analysis Methodology: NOAA, PI and collaborating USG Activity Managers will track trainees in their community assessment process and obtain copies of assessments, which include action plans. The assessments and/or action plans will be sent into the PI as a part of the deliverable of community trained represented. Activities undertaken by grantees to support resilience will be documented and reported to PI. PI will undertake file reviews, site visits, and other follow up activities to monitor progress.

Data Source: US IOTWS Program Activity Managers, Grantees, and other relevant partners.

Data Verification: Community assessments and action plans. Activity and monitoring reports. Copies of documents will be retained by PI.

*Note: Target was readjusted down from 200 in December 2005 Version 1.0 PMP to reflect program activities.

APPENDIX B. US IOTWS PROGRAM TRANSITION MATRIX

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
1. Support to IOC and ICG/IOTWS Working Groups (WGs)	NOAA; USGS; USAID	Regional	National Assessments; IOTWS Conceptual Design; Participation in Working Groups	None	Continue	Not applicable; USG engagement to be continued	IOC Secretariat, ICG/IOTWS WGs	Continued participation of **NOAA** and **USGS** in future IOC ICG/IOTWS Working Group meetings
2. PTWC Interim Notifications	NOAA	Regional	Real-time tsunami advisory bulletins	Continued issuance of real-time tsunami advisory bulletins to IOTWS region by Pacific Tsunami Warning Center (PTWC) and Japan Meteorological Administration (JMA)	Continue	2010, or until a permanent RTWP is established	future Regional Tsunami Watch Provider (RTWP) TBD; IOC Secretariat; IOC International Tsunami Information Center (ITIC); ICG/IOWTS WG5	Continued cooperation and coordination between **NOAA-PTWC**, JMA, and future RTWPs
I. Seismic Measurements, Data Collection, and Exchange								
3. Seismic Station Equipment installation/ upgrades	USGS	Indonesia	Seismic equipment and instruments	Continuing through USGS Caltech contract; Caltech to provide assistance and funding for maintenance	Continue	Not applicable; Caltech engagement to be continued	Badan Meteorolgi & Geofisika (BMG), Indonesia; Institute Teknologi Bandug (ITB)	Maintenance and utilization of equipment to conduct seismic hazard detection and tsunami analysis work by **Caltech**, BMG and ITB
4. Seismology and Tsunami Hazard trainings	USGS	Regional	Seismicity, Tsunami, Paleo-earthquake and Paleo-tsunami training materials	Transfer of International Tsunami Training Institute (ITT) training materials to AIT	Transfer	March 2008	Asian Institute of Technology (AIT)	Potential additional trainings as need and funding available from USGS
II. Sea Level Data Collection and Exchange, Including Deep-Ocean Tsunami Detection Instruments								
5. Deep Ocean Assessment and Reporting of Tsunamis (DART) tsunameter, Thailand	NOAA	Thailand	DART buoy system	Ensure NDWC has maintenance contract in place; Technical consultation	Transfer	January 2008	National Disaster Warning Center (NDWC), Thailand; Thai Meteorological Department	Government of Thailand to provide maintenance to ensure continuous tsunameter real-time operation

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
6. Deep Ocean Assessment and Reporting of Tsunamis (DART) tsunameter, Indonesia	NOAA	Indonesia	DART buoy system	Support through agreement and additional funding mechanism	Transfer	January 2008	Indonesia Agency for the Assessment and Application of Technology (BBPT)	Government of Indonesia to provide maintenance to ensure continuous tsunameter real-time operation
7. Sea Level Station upgrades	NOAA	Sri Lanka, Indonesia, Maldives	Sea level station design package documents and installation of stations at: Gan, Maldives; Hanimaadh, Maldives; Colombo, Sri Lanka; Sibolga, Indonesia; Cilacap, Indonesia; Prigi, Indonesia	Transfer of maintenance responsibility to UHCSLC and Governments of Sri Lanka, Indonesia and Maldives	Transfer	September 2007 (completed)	UN Sea Level Center, University of Hawaii (UHCSLC); NARA Sri Lanka; Department of Meteorology, Maldives; Bakourtanal, Indonesia	Maintenance by UHCSLC and Governments of Sri Lanka, Indonesia and Maldives to ensure continued transmission of data with funding from multiple regional and global partners; UHCSLC to work with countries to maintain sites and communications and further develop their capabilities
III. Risk Assessment								
8. Hazard Analysis Tool	NOAA	Region; Sri Lanka	Hazard Assessment Tool Template based on ArcIMS software and training materials	Limited technical assistance to ADPC with the development of similar tools utilizing the IOTWS Hazard Assessment Tool Template	Continued	Not applicable; NOAA engagement to be continued	Sri Lanka Disaster Management Center (DMC); EMSO Sri Lanka; Asian Disaster Preparedness Center (ADPC); Asian Institute of Technology (AIT)	Continuing limited assistance through **NOAA**. Sri Lanka DMC to maintain Sri Lanka Hazard Assessment tool and incorporate new GIS datasets as become available; ADPC incorporating training materials into Regional Expansion Strategy

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
9. Multi-hazard risk assessment, data sharing, and warning communication	USGS	Indonesia, Thailand	CAP, EIDS, seismic hazard maps	Materials provided to AIT/ITTI for incorporation into training curriculum. Support provided on "as needed" basis	Transfer	September 2007 (completed)	Badan Meteorolgi & Geofisika (BMG), Indonesia; Institut Teknologi Bandug (ITB); Chulalongkorn University, Thailand; Asian Institute of Technology (AIT)	Continuing through **USGS** and AIT/ITTI; Maintenance and utilization of CAP and EIDS software as well as hazard maps by all USGS, ITB, Chulalongkorn University and AIT/ITTI
IV. Modeling, Forecasting and Scenario Development								
10. ComMIT - Community Model	NOAA	Regional, Australia, Thailand, Indonesia	ComMIT training materials	Limited technical support in region, further general development of ComMIT	Continued	Not applicable; NOAA engagement to be continued	ICG/IOTWS	TBD - Continuing through **NOAA**
V. Establishment of a system of Interoperable Advisory and Warning Centers								
11. Warning Center Concept of Operations (CONOPS)	NOAA	Region, Sri Lanka, Indonesia, Thailand	CONOPS - Concept of Operations; TWCG - Tsunami Warning Center Guide	NOAA to continue monitoring and updating of TWCG; Public product made available on US IOTWS website; Printing and distribution of guide	Transfer	March 2008	IOC Secretariat; ICG/IOTWS WG5; University of Oregon Natural Hazard Reduction Center; Pacific Disaster Center (PDC); Asian Disaster Preparedness Center (ADPC)	Continuing through **NOAA**, ICG/IOTWS, ADPC and AIT/ITTI; IOC to monitor TWCG and report to NOAA for need to upgrade; Training on CONOPS through ADPC and AIT/ITTI
12. Tsunami Alert Rapid Notification System (TARNS) Early Warning System (EWS)	USFS; NOAA; USAID	Thailand Indonesia	TARNS workshop materials TARNS/ EWS materials	Transferred to ADPC, Governments of Thailand and Indonesia	Transfer Continue TBD	August 2007 (completed) TBD: USFS, NOAA engagement to continue pending funds availability	Thai National Disaster Warning Center (NDWC); Badan Meteorolgi & Geofisika (BMG), Indonesia; Ministry of Research and Technology, (RISTEK), Indonesia; CARE Indonesia, Asian Disaster Preparedness Center (ADPC)	Continued **USG** engagement with partners if funding can be identified; Governments of Thailand and Indonesia to implement EWS - Early Warning System; ADPC institutionalizing technical materials from TARNS and developed activity plan within existing budget; CARE partnering with ADPC to promote EWS in Indonesia

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
13. RANET	NOAA	Sri Lanka; Indonesia	Worldspace receivers, computers, and GSM modems; training materials	Continued through NOAA and Governments of Indonesia and Sri Lanka	Transfer/ Continue	September 2007 (completed)	NOAA/NWS/IA; Badan Meteorolgi & Geofisika (BMG), Indonesia; Sri Lanka Disaster Management Center (DMC); Sri Lanka Department of Meteorology	**NOAA** to maintain broadcast operations on WorldSpace satellite for duration of satellites life (approx. 8years); Government counterparts to manage deployment, utilization, tracking and deployment of RANET equipment; Continued training by NOAA
14. National Disaster Warning Systems Integration and Capacity Development	USTDA	Thailand	Recommendation report for organizational structure and technology for tsunami preparedness and warning	Completed; distribution of report	Transfer	February 2007 (completed)	Thai National Disaster Warning Center (NDWC); Pacific Disaster Center (PDC), East-West Center	Implementation of a decision support system to improve NDWC's tsunami early warning capability; Funding proposal has been forwarded to USTDA for next phase
15. National Disaster Management plan and Technology Strategy	USTDA	Indonesia	Designed decision making system; hardware and software for pilot decision making platform; study of communications/ emergency notification and impact assessments	Completed; distribution of study and assessments	Transfer	December 2007	Badan Meteorolgi & Geofisika (BMG), Indonesia; Techno-Sciences	Implementation of technical recommendations and utilization and maintenance of equipment by BMG
16. National Emergency Communications Strategy	USTDA	Indonesia	Assessment of requirements, comparison with international best practices, gap analysis	Completed; distribution of Assessment	Transfer	December 2007	Badan Meteorolgi & Geofisika (BMG), Indonesia; Techno-Sciences	Implementation of technical recommendations and utilization and maintenance of equipment by BMG

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
17. National Disaster Management Policy and Institutional Strengthening	USAID	Regional	National Disaster Management Policy and Institutional Strengthening Assessments	Completed; transferred to ADPC	Transfer	October 2007 (completed)	Asian Disaster Preparedness Center (ADPC); Governments of Thailand, Indonesia, and Sri Lanka	Modification and updates as needed by each country facilitated by ADPC
VI. Mitigation, Preparedness and Response								
18. International Tsunami Training Institute (ITTI)	NOAA; USAID	Regional	ITTI archive, course curriculum and materials	Support to AIT for implementation of second ITTI course in March 2008	Transfer	March 2008	Asian Institute of Technology (AIT); University of Washington, Seattle (UoW)	Continued support to AIT by **NOAA** until ITTI fully institutionalized through TBD funding; Incorporation of ITTI curriculum into AIT and UoW course offerings
19. Coastal Community Resilience (CCR)	NOAA; USAID/ PI	Regional	CCR Guide	Distribution of CCR guide to CCR partners; NOAA to collect feedback on CCR guide as it is being used in field; Continued advocacy to strengthen CCR programming regionally	Transfer	March 2008	Asian Disaster Preparedness Center (ADPC), ICG/IOTWS WG6; IUCN-Mangroves for the Future; Asian Institute of Technology; The Nature Conservancy, USAID Indonesia; Department of Marine Affairs and Fisheries, Indonesia; Disaster Management Center (DMC) Sri Lanka; Coastal Conservation Department (CCD), Sri Lanka; University of Rhode Island (URI)	Continued through **ADPC** and partner agencies through UNESCAP funding; Partner organizations to incorporate CCR guide into program operations; Continued trainings through URI activities

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
20. Incident Command System (ICS)	USFS; USAID	Sri Lanka Indonesia	Course curriculum and reference materials		Transfer Continue TBD	July 2007 TBD: USFS, engagement to continue pending funds availability	Disaster Management Center; USAID Sri Lanka; American Red Cross, Sri Lanka; UNDP; Sri Lanka Institute of Development Administration (SLIDA); Government of Indonesia	Continued **USG** engagement with partners if funding can be identified; DMC and SLIDA adapting and using curriculum in training courses; ICS in process of being written into National Policy and legislated; ARC and UNDP providing ICS trainings as part of their programming. Government of Indonesia exploring training options
21. Knowledge-Sharing Information Systems	USAID/ PI	Regional	Program website	Complete website and upload all products completed under program	Transfer	September 2007 (completed)	Asian Disaster Preparedness Center (ADPC)	ADPC will host and maintain site, and provide updates and information of follow on activities
22. GRANT: Strengthening Capacity on Multi-hazard Risk Assessment in Tsunami-affected Countries (SCRATCH)	USAID/ PI	Regional	Training manual; Case studies	None	Transfer	September 2007 (completed)	Asian Institute of Technology (AIT) Geoinformatics Center	Maintenance of materials on AIT Geoinformatics Center web portal
23. GRANT: Assessment of Local Institutions on the National Policies and Measures towards Disaster Preparedness and Mitigation	USAID/ PI	India, Sri Lanka	Inventory of disaster management and mitigation resources; Recommendations for policy; Disaster preparedness of manual	None	Transfer	September 2007 (completed)	Asian Institute of Technology (AIT)	Continued use of materials through AIT courses and programs

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
24. GRANT: Tsunami Response Program, Community Based Disaster Management (CBDM)	USAID/ PI	India	Training materials; Village Disaster Management Plans for 52 villages.	None	Transfer	September 2007 (completed)	Sustainable Environment & Ecological Development Society (SEEDS)	Training materials and knowledge maintained in SEEDS Citizen Resource Center being developed in Port Blair
25. GRANT: Revising, Expansion, and Multi-stakeholder Endorsement of IDEP's CBDM kit	USAID/ PI	Indonesia	Community Based Disaster Management kit	None	Transfer	September 2007 (completed)	IDEP Foundation	Funding sought by IDEP for translation and printing of kit into Indonesian
26. GRANT: Rehabilitation of Fisheries and Aquaculture in Tsunami-affected Coastal Communities in Aceh Province	USAID/ PI	Indonesia	Technical research studies and reports: Community Action Plans in Aceh Jaya	None	Transfer	September 2007 (completed)	World Fish (ICLARM)	Continued monitoring and evaluation in project area by World Fish; Replication of work to Aceh Barat and use of lessons learned in FoN-funded project
27. GRANT: Outreach and Public Dialog on Decentralization in Legal Reform for Disaster Management	USAID/ PI	Indonesia	Case Study; Guidebook for creating legal reform in DM at provincial and district level	None	Transfer	September 2007 (completed)	Indonesian Society for Disaster Management (MBPI); Ministry of Home Affairs (MoHA)	Use of materials in ongoing MBPI work; Launch of "The Guidebook of Legal Reform" by MoHA
28. GRANT: School Education Road Show in Padang, Indonesia	USAID/ PI	Indonesia	Educational materials	None	Transfer (continue if funding is identified)	September 2007 (completed)	Komunitas Siaga Tsumai KOGAMI	Trainings of schools in Padang Indonesia not covered by initial grant to KOGAMI; Continued use of training materials and experience gained from Grant in other KOGAMI activities; **USAID/Indonesia** and **USAID/RDMA** to facilitate identification of funding for expansion of activities

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
29. GRANT: Community Institutional Strengthening in Coastal Hazard Analysis & Mitigation, Disaster Response, and Disaster Recovery	USAID/ PI	Sri Lanka	Training materials	None	Transfer	September 2007 (completed)	Sewlanka Foundation	Sewelanka exploring funding with DMC for follow on work in grant and additional communities.
30. GRANT: Development of Tsunami Hazard Zoning Maps for the Coastal Belt of Sri Lanka	USAID/ PI	Sri Lanka	Tsunami hazard maps for five coastal cities; Training materials	None	Transfer	September 2007 (completed)	University of Peredeniya; Disaster Management Center (DMC)	Inclusion of training materials into University of Perideniya Master's program in Disaster Management; Use of hazard maps by DMC
31. GRANT: Risk Assessment and Design of Countermeasures for Tsunami Hazard: Case Study for the Port City of Galle	USAID/ PI	Sri Lanka	Numeric and physical tsunami impact models. Socio-economic surveys; Risk assessment study	None	Transfer	September 2007 (completed)	University of Moratuwa (UoM), Coastal Conservation Department (CCD) and Disaster Management Center (DMC)	Research will be published by University of Moratuwa; Research will be expanded and utilized by UoM, CCD, and DMC
32. GRANT: Capacity Building of Coastal Communities on Coastal Mitigation	USAID/ PI	Thailand	Coastal mitigation plan and training materials	None	Transfer	September 2007 (completed)	Asian Institute of Technology (AIT)	Training materials will be utilized by AIT in its course curriculum for coastal management
33. GRANT: Last Mile Communications Inventory	USAID/ PI	Thailand	Report	None	Transfer	September 2007 (completed)	D-TRAC	None
34. GRANT: Building Community Capacity and Technical Assistance to Effectively Respond to Warnings of Tsunamis and Other Hazards	USAID/ PI	Thailand	Education materials	Distribution of education materials; Ongoing monitoring and evaluation of education materials	Transfer	September 2007 (completed)	East Tennessee State University (ETSU); Save Andaman Network (SAN)	Distribution of education materials; Ongoing monitoring and evaluation of education materials by ETSU and SAN

US IOTWS Program Transition Matrix *December 6, 2007*

Activity	USG Agency Lead	Countries	Handover product(s)	Action Required Prior to Handover	Action	Handover Date/Status	Handover Partners/ Recipients	Partner & USG Follow-on Activities After Handover
35. GRANT: Coastal Community Resilience and Coral Reef Management in Tay Muang District, Phang Nga	USAID/ PI	Thailand	Baseline biodiversity and socio-economic reports; Coastal resources maps; Nature education curriculum. Educational materials	Materials provided to local community and National Park Advisory Committee	Transfer	September 2007 (completed)	World Wildlife Fund (WWF)	Continued engagement and monitoring in target communities by WWF
36. GRANT: Workshop on Earthquake and Tsunami Education for Phang Nga Coastal Communities	USAID/ PI	Thailand	Training materials	Training materials made available on Chulalongkorn University site	Transfer	September 2007 (completed)	Chulalongkorn University	Training materials maintained on Chulalongkorn University site