Best Practices implemented in Project Management of Tsunami Early Warning System Solution

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Contents

Abstract:

Occurrence of natural disasters is beyond human control, but taking preventive measures to reduce its impact is very much within human capabilities. The sub continent like India has many times witnessed recurrences of these devastating disasters like earthquakes, floods, droughts, and cyclones effecting the population, property and other valuable resources.

Tsunami is a system of ocean gravity waves formed as a result of large-scale disturbance of the sea floor that occurs in a relatively short duration of time.

There is a desperate need of establishing early warning systems in order to raise alerts for taking preventive measures before a natural hazard occurs. GIS in its entirety is a very powerful and established technology which can be integrated as part of these early warning systems to query and analyze the occurrence and its impact for taking proactive measures.

Recognizing the imperative to put in place a Tsunami Early Warning System (TEWS) for mitigation of Oceanogenic disasters that cause severe threat to nearly 400 million of Indian population that live in the coastal belt with devastation of life and property, and further driven by the national calamity due to the Tsunami of December 26, 2004, The National Tsunami Early Warning Centre has been set up at INCOIS, Hyderabad with all the necessary computational and communication infrastructure that enables reception of real time data from the network of national and international seismic stations, tide gauges and bottom pressure recorders (BPRs).

As part of this initiative TCS has successfully developed a GIS based solution integrated with the N2Model Application, Seismic Subsystem, Tide Gauge subsystem, BPR subsystem and Decision Support System (DSS) for analyzing the real time seismic events to generate the Travel time contours and Directivity Maps using the real-time data from the Tide gauges and BPRs and to generate the Tsunami advisories following a standard operating procedure, for dissemination to the Scientists, Administrators and general public through Tsunami web site, emails, Fax and SMS alerts.

TCS implemented the best practices in Project Management and quality processes for development of TEWS system within a record time of 11 months, one month ahead of the schedule and achieved 100% Customer Satisfaction Index (CSI).

Keywords:

BPRs, CFPs, CSI, DSS, GIS, N2Model, Project Management, Tide gauges, Tsunami, Seismic Stations

1.1 Introduction

Tsunami is a system of ocean gravity waves formed as a result of large scale disturbance of the sea bed in a short duration of time, mostly due to earth quake (or volcanic eruption or submarine landslides). As displaced sea water return by the force of gravity to an equilibrium position, a series of oscillations both above and below sea level take place, and waves are generated which propagate outwards from the source region.

On 26th December 2004 the Indian coastline experienced the most devastating tsunami in recorded history. The tsunami was triggered by an earthquake of magnitude of between 9.1 and 9.3 Mw on the Richter scale at 3.4° N, 95.7° E off the coast of Sumatra in the Indonesian Archepelago at 06:29 hrs IST (00:58:53 hrs GMT).

Recognizing the imperative to put in place an Early Warning System for mitigation of Oceanogenic disasters that cause severe threat to nearly 400 million of Indian population that live in the coastal belt with devastation of life and property, and further driven by the national calamity due to the Indian Ocean Tsunami of December 26, 2004, the Ministry of Earth Sciences (MoES) has taken up the responsibility of establishing the National Tsunami Early Warning System.

The Warning System has been established by MoES as the nodal ministry in collaboration with Department of Science and Technology (DST), Department of Space (DOS) and the Council of Scientific and Industrial Research (CSIR). The National Tsunami Early Warning Centre has been set up at INCOIS, Hyderabad.

The end-to-end Tsunami early warning system solution has been designed and developed by Tata Consultancy Services with the state of the art Geospatial Technology.

The solution includes GIS based N2modeling subsystem, real time data monitoring subsystems for Seismic data, Tide gauge, Bottom Pressure Recorders (BPRs) from national and international sources, Data Warehousing and Data Mining for Spatial and Non-Spatial data, GIS based Decision Support System (DSS), WebGIS based website application and dissemination application for dissemination of Tsunami bulletins through emails and SMS alerts.

In this paper, the success story of Indian Tsunami Early Warning System including the components of Tsunami Early Warning System, Solution Architecture along with various Application Software Subsystems like N2Model Viewer, Seismic, Tide gauge, and BPR data monitoring Subsystems, Data warehousing and Data Mining, DSS and WebGIS based Website Applications, Output reports and project management best practices implemented in TEWS have been illustrated.

1.2 Components Of Indian Tsunami Early Warning System

Tsunamigenic zones that threaten the Indian Coast have been identified by considering the historical tsunamis, earthquakes and their magnitudes, location of the area relative to a fault, and also by tsunami modeling. The east and west coasts of India and the island regions are likely to be affected by tsunamis generated mainly by subduction zone related earthquakes from the two potential source regions, viz., the Andaman-Nicobar-Sumatra island arc and the Makran subduction zone north of Arabian Sea. **[1]**

The Indian Tsunami Early Warning System comprises a real-time network of seismic stations, tide gauges and Bottom Pressure Recorders (BPR) to detect tsunamigenic earthquakes and to monitor tsunamis.

A state-of-the-art early warning centre has been established at INCOIS with all the necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure.

Seismic and sea-level data are continuously monitored in the Early Warning Centre using Seismic, Tide gauge and BPR applications developed by TCS, that generates alarms/alerts in the warning centre whenever a pre-set threshold is crossed.

At the time of event, the closest scenario is picked from the database for generating advisories. Water level data enables confirmation or cancellation of a tsunami. Tsunami bulletins are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, following a standard operating procedure.

The National Early Warning Centre will generate and disseminate timely advisories to the Control Room of the Ministry of Home Affairs for further dissemination to the Public. In case of confirmed warnings, the National Early Warning Centre is equipped with necessary facilities to disseminate the advisories directly to the administrators, media and public through SMS, e-mail, Fax, etc.

The efficiency of the end-to-end system was proved during the large under-sea earthquake of 8.4 M that occurred on September 12, 2007 in the Indian Ocean.

1.3 Solution Architecture

The solution Architecture and Functional Architectures for Indian Tsunami Early Warning System are illustrated in the following diagrams.

The entire Tsunami early warning centre infrastructure has been hosted on highly reliable hardware designed for mission critical applications with necessary redundancies.

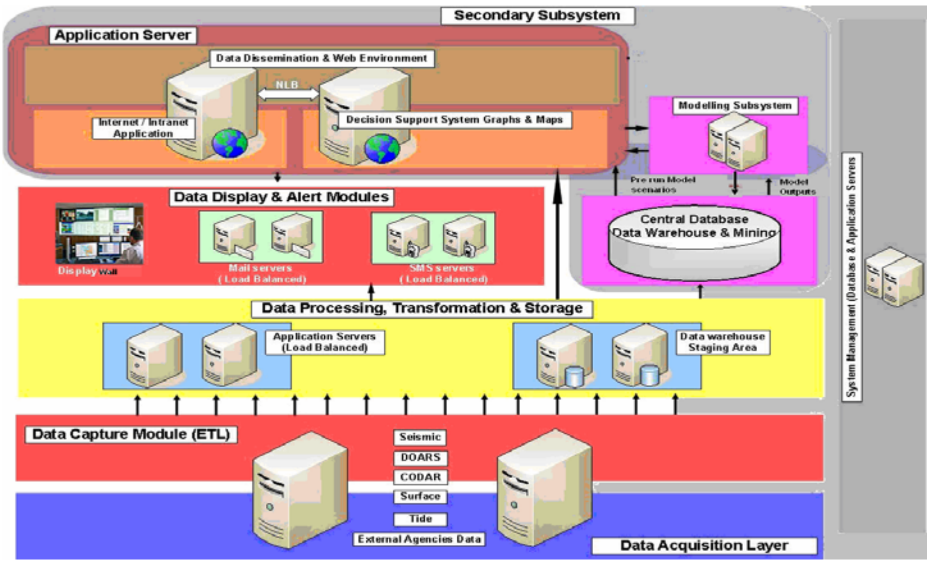

Fig1. Solution Architecture

Indian Tsunami Early Warning System has been developed using the following software tools:

- Programming Tools : Visual Studio.NET 2005, J2EE, Java Struts Framework
- Database : IBM DB2

- Data Warehouse Tools : IBM Ascential Data Stage
- Operating System : IBM AIX 5.3
- GIS Tools : ESRI ArcGIS 9.2, ArcSDE 9.2, ArcIMS 9.2

Indian Tsunami Early Warning System Solution comprises of the following Sub systems

- Tsunami N2 Modeling Subsystem
- Seismic data monitoring Subsystem
- Tide Gauge Monitoring Subsystem
- BPR / DOARS Monitoring Subsystem
- Data Warehousing and Data Mining
- Decision Support System (DSS)
- Tsunami Website – WebGIS based web application
- Dissemination Tool

1.3.1 Tsunami N2Modeling Subsystem

Tsunami N2Model which is a modified form of TUNAMI N2 developed by Prof. Shuto and Prof Imamura has been used in the development of N2Model Subsystem. **[2]** N2Model subsystem has been developed by integrating the TUNAMI N2 Model open source available in FORTRAN.

A database of pre-run scenarios has been created covering all the tsunamigenic sources in the Indian Ocean region. In the current database each unit source has a length of 100 km and width of 50 km that represents a rupture caused by an Mw 7.5 magnitude earthquake with a slip of 1m. At the time of earthquake occurrence, based on the location and magnitude of the earthquake, the basic unit source open ocean propagation scenarios in scenario database are selected to merge and scaled up/down using scaling relations. The warning centre continuously monitors Seismic activity in the two tsunamigenic source regions and sea level through the network of national and international seismic stations as well as tide gauges and bottom pressure recorders BPR's). The monitoring of water level enables confirmation or cancellation of a tsunami. A custom-built software application developed by TCS generates alarms/alerts whenever a pre-set threshold is crossed. Tsunami bulletins are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, following a Standard Operating Procedure (SOP).

The N2Viewer application has been developed using Microsoft Visual Studio.NET 2005 framework with DB2 with ArcSDE (for storing spatial data) as backend and ArcGIS 9.2 has been customized using ArcGIS Engine 9.2 to develop GIS functionalities like Overlays with On/Off layers facility, GIS tool bar with Zoom In, Zoom Out, Full Extent, Zoom to Previous and Next, Identify, Creation of Travel time and Directivity Map layers, Representation of Seismic, Tide gauge and BPR stations with appropriate symbology, Zoom to Location for CFPs etc.,

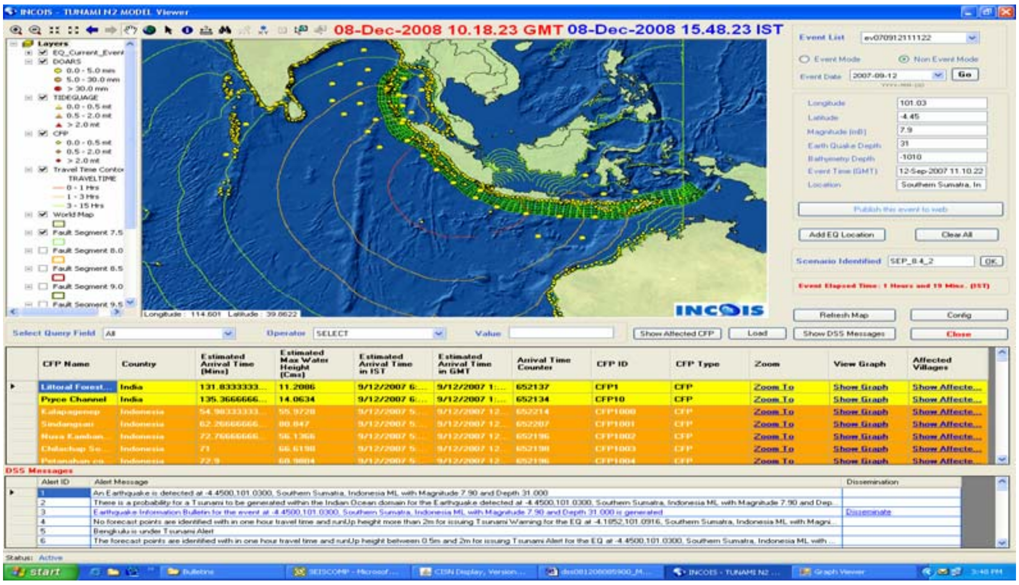

Fig2. N2 Model Viewer Application

1.3.2 Seismic Data monitoring Subsystem

Seismic Subsystem has been designed and developed to display the seismic events on the map with appropriate symbolgy to display the seismic events based on the earth quake origin times and earth quake magnitudes.

A query builder has been provided to select the desired time intervals and the magnitudes for the display of seismic events on the maps with appropriate symbology.

The seismic subsystem has been developed using J2EE Struts framework and DB2 with ArcSDE9.2 as backend. ArcGIS9.2 has been customized with Java APIs for the development of GIS functionalities.

1.3.3 Tide gauge Subsystem

Tide gauge subsystem has been designed and developed to monitor the Tide gauge data acquired from various national and international Tide gauge stations.

GIS functionality has been designed and developed to display the tide gauge network of national and international tide gauge stations on the map with appropriate symbology to display the reporting / non reporting status along with the attribute information of the selected tide gauge station.

A facility has been provided to display the real time graph of the tide gauge values for selected Tide gauge stations along with the latency of the data received from the selected Tide gauge station.

The Tide gauge subsystem has been developed using J2EE Struts framework and DB2 with ArcSDE9.2 as backend. ArcGIS9.2 has been customized with Java APIs for the development of GIS functionalities.

1.3.4 BPR / DOARS Monitoring Subsystem

BPR subsystem has been designed and developed to monitor the BPR data acquired from various national and international buoy stations.

GIS functionality has been designed ad developed to display the BPR network of national and international buoy stations on the map with appropriate symbology to display the reporting / non reporting status along with the attribute information of the selected tide BPR station.

A facility has been provided to display the real time graph of the BPR values for the selected BPR stations along with the latency of the data received from the selected BPR station.

The BPR subsystem has been developed using J2EE Struts framework and DB2 with ArcSDE9.2 as backend. ArcGIS9.2 has been customized with Java APIs for the development of GIS functionalities.

1.3.5 Data Warehousing and Data Mining

Data Warehousing and Data Mining facility has been deigned to organize the data received from various Seismic data sources, national and international tide gauge stations, national and international BPRs, and to store the data in a central database server with appropriate load balancing. The entire data is organized using state-of-the-art user friendly database DB2 for storing, analyzing and quick retrieval at the time of the event.

Central and Staging DB2 databases have been designed including the geodatabase design for the integration with ArcSDE9.2 for storing spatial data and Meta data.

IBM Ascential data stage Warehousing tool has been implemented for running the data stage jobs for storing the data received from various Seismic sources like Seiscomp, Hydra and earlybird etc., national and international tide gauge stations, national and international BPRs.

Also, the N2Model scenarios generated using the N2Model runner and loader applications have been stored in central database server.

IBM Tivoli Storage Manager has been implemented for the online database backups and file system backups. A disaster recovery site has been designed and implemented as part of the business continuity plan for the primary site in case of any natural disasters.

1.3.6 Decision Support System (DSS)

At the time of event, the closest scenario is picked from the database for generating advisories. Water level data enables confirmation or cancellation of a tsunami. Tsunami bulletins are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, following a standard operating procedure designed by INCOIS.

DSS Application has been designed and developed using Visual Studio.NET 2005 and DB2 with ArcSDE as backend for storing scenario database and to generate the DSS messages like watch, warning and alerts.

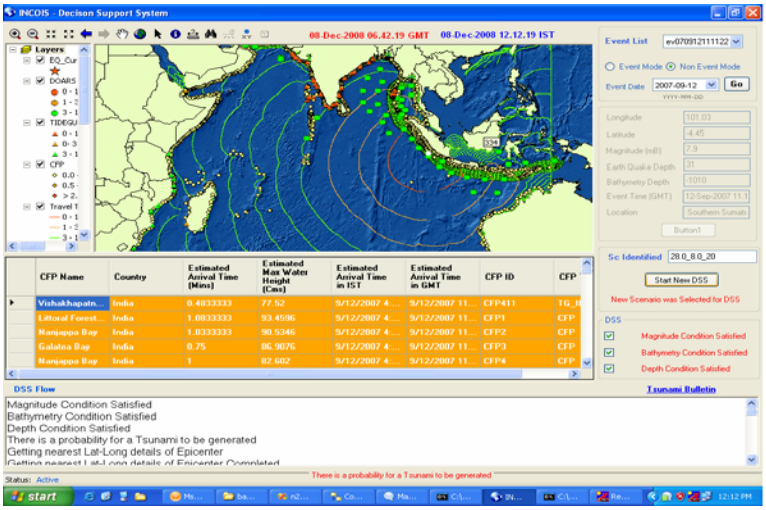

Fig 3. DSS output Scenario details and DSS messages

1.3.7 Tsunami Early Warning System Website – WebGIS based web application

Tsunami website has been designed and developed for publishing Static pages on Tsunami events and Tsunami history, and dynamic pages representing real time data of various Seismic, Tide gauge, BPR stations.

Tsunami website has been integrated with ArcIMS9.2 for publishing the latest seismic events, real time data from tide gauges and BPRs and to display the N2 model outputs like travel time contour and directivity maps on the web. Also, the Tsunami website has been integrated with Google maps using KML.

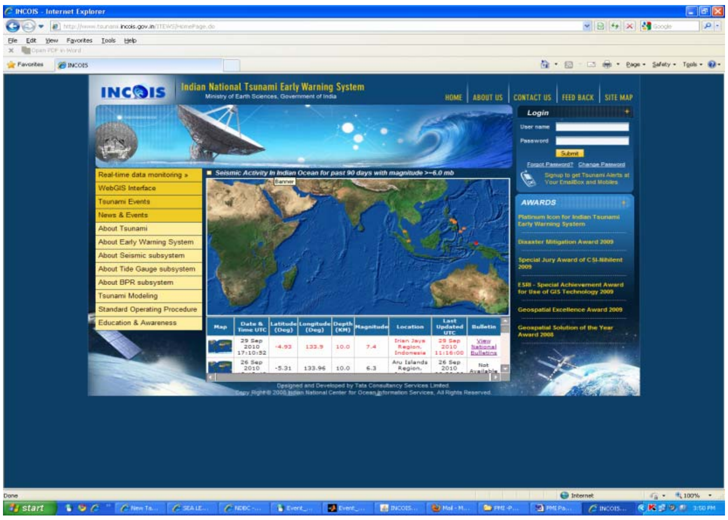

Fig 4. Tsunami Early Warning System Website

1.3.8 Dissemination Tool

The application software enables dissemination of tsunami bulletins to designated contact points using SMS, e-mails, fax, telephone, VPNDMS, etc.,

1.4 Best Practices Implemented In ITEWS Project

Best Practices:

The following Project Management best practices were implemented during the development phase of the project:

- Plan the work by utilizing a project definition document.
- Create a planning horizon.
- Define project management procedures up front.
- Look for other warning signs.
- Ensure that the sponsor approves scope-change requests.
- Guard against scope creep.
- Identify risks up front.
- Continue to assess potential risks throughout the project.
- Resolve issues as quickly as possible.

Critical Success Factors:

- Senior Management Sponsorship
- Visibility of Senior Management commitment
- Participation of (buy-in) of all Associates
- Process Improvements driven by business goals
- Trainings
- Measurements
- Customer Focus
- Resources Availability

TCS implemented the best practices in Project Management using iPMS (Integrated Project Management System) tool which was designed as per PMI guidelines and aligned to PMBOK latest version.

TCS Team has implemented the best practices in the following knowledge areas as per *PMBOK*®,Guide 4th Edition (2009).

1. Project Integration Management
2. Project Scope Management
3. Project Time Management
4. Project Cost Management
5. Project Quality Management
6. Project Human Resource Management

7. Project Communications Management
8. Project Risk Management
9. Project Procurement Management

The detailed activities implemented in each of these knowledge areas are illustrated in figure5.

KNOWLEDGE AREA	PROJECT MANAGEMENT PROCESS GROUPS				
	INITIATING	PLANNING	EXECUTING	MONITORING & CONTROLLING	CLOSING
Project Integration Management	Develop project charter, Develop preliminary project scope statement	Develop project management plan	Direct and manage project execution	Monitor and control project work, Integrated change control	Close project
Project Scope Management		Scope planning, Scope definition, Create WBS		Scope verification, Scope control	
Project Time Management		Activity definition, Activity sequencing, Activity resource estimating, Activity duration estimating, Schedule development		Schedule control	
Project Cost Management		Cost estimating, Cost budgeting		Cost control	
Project Quality Management		Quality planning	Perform quality assurance	Perform quality control	
Project Human Resource Management		Human resource planning	Acquire project team, Develop project team	Manage project team	
Project Communications Management		Communications planning	Information distribution	Performance reporting, Manage stakeholders	
Project Risk Management		Risk management planning, Risk identification, Qualitative risk analysis, Quantitative risk analysis, Risk response planning		Risk monitoring and control	
Project Procurement Management		Plan purchases and acquisitions, Plan contracting	Request seller responses, Select sellers	Contract administration	Contract closure

1.5 Conclusion

The efficiency of the end-to-end system was proved during the large under-sea earthquake of 8.4 Magnitude that occurred on September 12, 2007 in the Indian Ocean.

With the success of Indian Tsunami Early warning system, there is a need to deploy the similar early warning systems in all the coastal countries to predict the occurrence of tsunamis ahead of time to reduce the devastation of life and property.

With the implementation of following Project Management best practices the project was delivered ahead of schedule with quality and achieved the customer satisfaction.

- Plan the work by utilizing a project definition document.
- Create a planning horizon.
- Define project management procedures up front.
- Look for other warning signs.
- Ensure that the sponsor approves scope-change requests.
- Guard against scope creep.
- Identify risks up front.
- Continue to assess potential risks throughout the project.
- Resolve issues as quickly as possible.

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1.6 Author(s) Profile

Mr. Janardhana Chandrasekhara Rao Putrevu has been working with TCS as a Project Manager. He has over 15 Years of experience in IT Industry. He has M.Tech in Remote Sensing & GIS Specialization. He has been involved in Project Management of various eGovernance Projects and Geospatial Technology Solutions for various Scientific applications.

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