Data management and SDI – Experiences from the GITEWS project

R. Kiefl [a,*], C. Strobl[a], F. Henkel[a] and T. Riedlinger[a]

[a] German Aerospace Center (DLR), German Remote Sensing Data Center (DFD) Oberpfaffenhofen, 82234 Weßling, Germany – (ralph.kiefl, christian.strobl, fabian.henkel, torsten.riedlinger)@dlr.de

Abstract – For the BMBF project GITEWS, the German contribution to a tsunami early warning system for the Indian Ocean, a geodata repository was established. This repository contains all geodata, which were required for the development and implementation of GITEWS. During the stage of requirements analysis all available and relevant data were acquired and collected. This process was realized in close collaboration with the Indonesian partner organizations. During the harmonization process several quality control procedures were performed to ensure the maximum possible quality and reliability.

On the on hand the geospatial data were provided to the different work groups in the project. On the other hand the data repository was integrated in the Early Warning and Mitigation System, providing a large geodatabase for the Decision Support System. The data access to the repository was realized by using OGC compliant web services (WMS, WFS, WCS, CSW 2.0).

Keywords: Tsunami Early Warning, data harmonization, spatial data infrastructure, data management, CSW, WMS, WFS

1. INTRODUCTION

In recent years numerous tsunami events in the Indian Ocean, demonstrated the vulnerability of human society and the environment to this sudden-onset type of disaster. Especially the December 2004 tsunami pointed out the need for an effective tsunami early warning system for the Indian Ocean. Within the Framework of UNESCO-IOC and its Intergovernmental Coordinating Group (ICG), various efforts on national and bilateral basis are coordinated and combined to ensure a fast and reliable tsunami warning for the whole Indian Ocean and its 27 rim countries.

The presented work is embedded in the German-Indonesian Tsunami Early Warning System (GITEWS) project. GITEWS is funded by the German Federal Ministry of Education and Research (BMBF) to develop a Tsunami Early Warning System for the Indian Ocean in close cooperation with Indonesia, the country most prone for tsunamis in the whole Indian Ocean.

The paper describes the development of the geodata repository for GITEWS and the implementation of an internal Spatial Data Infrastructure, using open standards, defined by the Open Geospatial Consortium (OGC) for access to huge geodata, risk and vulnerability databases.

2. THE EARLY WARNING AND MITIGATION SYSTEM

Tsunami detection for Indonesia is a challenging task since there is on the one hand the extremely short time window between tsunami generation - in most cases caused by an earthquake along the Sunda Arc - and the arrival time at the nearest Indonesian coastline, and on the other hand the lack of sensor technologies that detect and measure tsunamis as such. The GITEWS project uses the best sensor technologies available today to detect indicators for a tsunami and up-to-date modeling techniques. Combining a-priori knowledge, simulation runs and analysis results with real-time information from the different types of sensors, the newly developed GITEWS Decision Support System (DSS) serves as a back-bone to allow an assessment for the tsunami threat and support the decision maker whether to issue a tsunami warning or not (Raape et al., 2008).

The systems concept is based on a modular architecture of different systems deployed in the BMG Warning Center in Jakarta as part of the GITEWS Early Warning and Mitigation System (EWMS). Figure 1 gives an overview of the EWMS architecture concept.

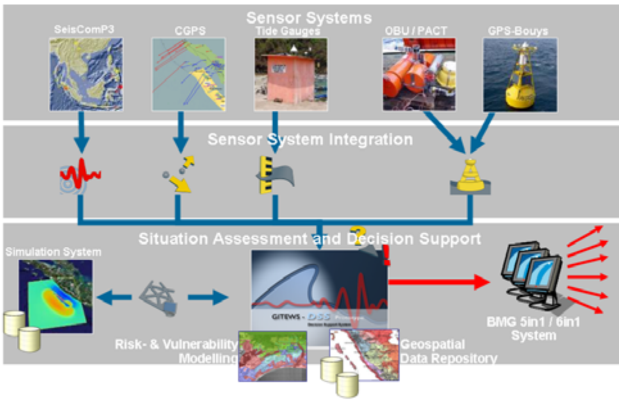

Figure 1. The Early Warning and Mitigation System Concept. (Raape et al., 2008)

The EWMS consists of following elements:

- SeisComP3 by GFZ Potsdam, a sophisticated Earthquake Monitoring System, collects real-time data from seismic sensors in the region and worldwide and is able to detect and locate earthquakes very quickly.
- Based on very precise GPS measurements a continuous GPS System (CGPS) describes the seafloor deformation in (near) real-time
- A Deep Ocean Observation System collects and processes sensor information transmitted from Ocean Bottom Units (OBUs), located on the seafloor and Buoys equipped with tsunami-detecting instruments.
- In order to detect sea level anomalies, a Tide Gauge System (TGS) collects and processes measurements of a network of tide gauges.

* Corresponding author

- All processed data from the sensor systems are collected by the central Tsunami Service Bus (TSB), which provides the information to the Decision Support System
- A Simulation System (SIM) is able to perform a scenario selection, comparing a large number of pre-calculated tsunami scenarios with a given set of observations and resulting in a list of best matching tsunami scenarios (Behrens et al., 2008).
- The Decision Support System (DSS) receives sensor observations via the TSB, requests best matching scenarios for the current sensor observations from the SIM system and communicates with the dissemination systems for message distribution and delivery.

3. RISK AND VULNERABILITY ANALYSIS

Based on the pre-calculated tsunami scenarios and a large number of different types of geospatial data, a risk and vulnerability analysis component determines probable consequences and impacts on coastal communities exposed to tsunamis, including the determination of potentially endangered coastal regions (hazard impact analysis) and the vulnerability assessment of society and the environment.
The risk assessment generally encompasses three steps:

- Identifying the nature, location, intensity and probability of a threat (hazard assessment)
- Determining the existence and degree of vulnerabilities and exposure to those threats (e.g. the physical and socioeconomic spheres)
- Identifying the coping capacities and resources available to address or manage threats

Focusing on the GITEWS project, the risk assessment serves two different functions: In case of a “warning situation” the Decision Support System (DSS) at the national level needs detailed information on the hazard situation at a specific location in order to estimate potentially affected people, whereas decision makers at the local level require all those indicators that provide information for pre- or post event risk management, such as the recovery potential of various social groups from a tsunami impact (Post et al., 2008).

4. GEOSPATIAL DATA REPOSITORY

In order to perform the task of tsunami early warning for Indonesia given the constraints and requirements mentioned previously, a two-fold approach was implemented by GITEWS:

- Usage of all available technologies to detect/measure tsunami waves or indicators
- Collection of as much a-priori information that helps interpreting the online input, assessing the tsunami and forecasting the consequences

Whereas the Earthquake Monitoring System, ocean Instrumentation and GPS Technologies provide real-time data Tsunami Modelling, the Geospatial Data Repository and the Risk and Vulnerability Analysis improve the situation awareness by providing additional a-priori information.
Geodata are an integral part of the entire process of Early Warning, from the selection process of appropriate sensor locations and the Tsunami wave distribution modeling to the risk and vulnerability assessment.

In the first project phase, the requirements of the different sensor and modeling working groups were requested and a concept for the collection, harmonization and derivation of the requested data was developed.
To fulfill the very heterogeneous requirements of the project partners and working groups in the GITEWS project, a scale approach was applied. Broad scale data were collected and analyzed for the complete coastal regions of the islands Sumatra, Java and Bali in order to provide a homogenous database for the modeling groups. For three focus regions very high resolution data were processed in order to allow very detailed assessments and to calibrate the broad scale models.
The database comprises the following thematic data types:

- Digital elevation models
- Bathymetric data
- Earth observation data satellite
- Data on critical and road infrastructure
- Socioeconomic and population data
- Administrative units
- Physiographic / topographic features such as land use / land cover and water courses
- Topographic maps and nautical charts (especially for identifying suitable sensor locations)

Since no data in appropriate scales were available in freely accessible SDIs for Indonesia during the project duration, all required data had to be acquired from different project partners, (commercial) data providers or derived from satellite imagery.
Extensive quality controls following the specifications of TC211/ISO 19113 (ISO/TC211, 2002) and TC211/ISO 19114 (ISO/TC211, 2003) concerning completeness, consistency, geometric accuracy were performed.

Since the requirements on the geometric accuracy were not achieved by a large number of input data, extensive correction and postprocessing procedures (including a definition of a high resolution coastline definition for the project region) had to be performed, using the complete spectrum of topologic editing capabilities of GIS software tools.
Especially high resolution and very high resolution data on critical infrastructure or land cover / land use were not available or outdated and thus had to be derived within the project.

All geodata were described regarding data quality and performed processing steps with metadata conformal to TC211/ISO 19115 (ISO/TC211, 2003b).

5. DATA SERVICES AND INTEROPERABILITY

The data access to the repository was realized by providing direct data access with commonly used data formats such as GeoTIFF or ESRI shapefile as well as OGC compliant web services (WMS, WFS, WCS, CSW 2.0). This approach enables all users the interoperable acquisition of all project related geodata via the internet.
To realize the data access a project SDI was established using the conventional service-based configuration, which consists in different layers for data storage, server and clients (Figure 2). The advantages of this service-based architecture are on the one hand the extensibility and scalability of the system and on the other hand the interoperability with external data sources and systems.

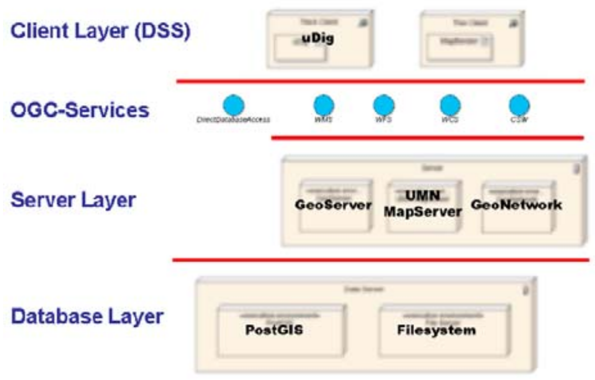

Figure 2. SDI implementation concept for the GITEWS-Project.

Whereas partly commercial GIS software was used for data processing and analysis, the implementation of the project SDI is exclusively based on open source software. Besides the cost-efficiency, availability, adaptability and a powerful worldwide user and developer community are good arguments for the application of open source software.
The metadata catalogue service is based on a CSW 2.0 interface (OGC, 2005); the implementation is realized by the GeoNetwork software.

In order to provide easy access to the geospatial data for the Decision Support System the SDI was finally implemented in the framework of the EWMS as a part of the DSS data management center. All vector datasets – e.g. base data or results of the vulnerability and risk assessments - are stored in a PostgreSQL / PostGIS database following the simple feature specification (OGC, 1999). The data access was realized by applying the established OGC standards Web Mapping Service (OGC, 2001) and Web Feature Service (OGC, 2002). UMN Mapserver and GeoServer are used for the implementation of the SDI server layer. The front-end of the DSS is realized as a Thick Client based on the open source software uDig, which uses the provided data for visualization and the automatic generation of documents, supporting the Early Warning process.

6. CONCLUSIONS

Within the project GITEWS as part of the German contribution to a Tsunami Early Warning System (EWMS) for the Indian Ocean a geospatial data repository was established. Based on the requirements of the contributing project partners a large amount of geospatial data from heterogeneous data sources and with different scales and data qualities were acquired or derived, harmonized and finally described with metadata conformal to the ISO standards.
During the project the data repository served mainly as a common data source for the different working groups. A spatial data infrastructure was realized by applying open source software, the data access was implemented by OGC-conformal web services.
Finally the repository was integrated in the EWMS framework. The usage of OGC standards for implementing the DSS Data Management Center has proven beneficial for comfortable data access. Future updates of single data layers or extensions by using distributed data sources can realized easily.

REFERENCES

J. Behrens, F. Klaschka, and L. Mentrup, "Simulation system selection overview", Tsunami Project Documentation, Alfred Wegener Institute for Polar and Marine Research Bremerhaven, No. 14, 2008.

ISO/TC211, „ISO 19114: Geographic information - Quality evaluation procedures," International Organization for Standardization TC 211, 2003a.

ISO/TC211, "ISO 19115: Geographic Information - Metadata," International Organization for Standardization TC 211, 2003b.

ISO/TC211 "ISO 19113: Geographic information - Quality principles," International Organization for Standardization TC 211, 2002.

OGC, "OpenGIS® Catalogue Services Specification 2.0 - ISO19115/ISO19119 Application Profile for CSW 2.0 (Version 0.9.3)," OpenGIS®-Project Document OGC 04-038r2, OGC, 2005.

OGC, "Web Feature Service (WFS) Implementation Specification (Version 1.0.0)," OpenGIS®-Project Document OGC 02-058, OGC, 2002.

OGC, "Web Map Service (WMS) Implementation Specification (Version 1.1.1)," OpenGIS®-Project Document: OGC 01-068r3, OGC, 2001.

OGC, "OpenGIS® Simple Features Specification for SQL (Revision 1.1)," OpenGIS®-Project Document 99-049, 1999.

J. Post, K. Zosseder, S. Wegscheider, T. Steinmetz, T. Riedlinger, G. Strunz, H. Mehl, S. Dech, J. Birkmann, N. Gbert, H. Z. Anwar, H. Harjono, "Risk assessment to low frequency – High impact coastal hazard in Indonesia: Integrating Tsunami Hzard and vulnerability assessment in the context of Early Warning," International Conference on Tsunami Warning (ICTW) Bali, Indonesia, November 12-14, 2008.

U. Raape, Fauzi, T. Riedlinger, S. Tessmann, M. Wnuk, M. Hunold, T. Kukofka, C. Strobl, E. Mikusch and S. Dech, "A newly developed Decision Support System for improved Tsunami Early Warning in Indonesia," International Conference on Tsunami Warning (ICTW) Bali, Indonesia, November 12-14, 2008.

ACKNOWLEDGEMENTS

The presented work is integrated in the framework of the GITEWS project (German Indonesian Tsunami Early Warning System), which is funded by the German Federal Ministry for Education and Research (BMBF), Grant 03TSU01.