# DEWS: Distant Early Warning System

Innovative system for the early warning of tsunamis and other hazards

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## Abstract

The tsunami disaster affecting the Indian Ocean region on Christmas 2004 demonstrated very clearly the shortcomings in tsunami detection, public warning processes as well as intergovernmental warning message exchange in the Indian Ocean region.
The DEWS project, co-funded by the European Commission under the 6th Framework Programme, aims at strengthening the early warning capacities by building an innovative generation of interoperable early warning systems. The system is based on service-oriented architecture concepts and on relevant standards (OGC, W3C, OASIS) and continuously gather, process and display events and data coming from open sensor platforms to enable operators to quickly decide whether an early warning is necessary and to send personalised warning messages to the authorities and, if desired, the population at large through a wide range of communication channels.
DEWS is independent of the risk, so it can be applied to multiple situations (earthquakes, tsunamis, floods, forest fires, etc.). The version of the system that we present here is designed for tsunamis, which are one of the most demanding hazards. If an earthquake relatively near the coast originates a tsunami, the first wave may arrive to the land in less than 20 minutes. The DEWS system is designed to allow operators to receive the necessary information, interpret it and launch an early warning with corresponding personalised messages in less than 10 minutes, in order to allow time for evacuation procedures.
Customized messages can be sent by more than ten dissemination channels: SMS to subscribers, SMS via cell broadcasting (under investigation and depending on arrangements with local operators), e-mail, fax, narrowcast and broadcast TV, RSS feed, social media (Facebook, Twitter etcetera), instant messaging, VoIP, FM radio/RDS and sirens.
DEWS is the result of the committed collaboration of 20 partners in the EU, Indonesia, Sri Lanka, Thailand, Japan and New Zealand, combining qualified technological competence and application experience. Interoperability with international cooperation mechanisms, including IOC/UNESCO, was also taken into account to ensure relevance and transferability of results to other tsunami-prone areas. The main scientific and technical outcomes are the DEWS National Centre, intended for use at national level; and the DEWS Wide Area Centre, intended for use at international level, in order to allow exchange of information among National Centres and to act as an umbrella centre for the whole region.

## KEYWORDS

tsunami, information management, disaster management, early warning, dissemination, standards, open sensor platform, international collaboration.

## 1. INTRODUCTION

The tsunami disaster affecting the Indian Ocean region on Christmas 2004 demonstrated very clearly the shortcomings in tsunami detection, public warning processes as well as intergovernmental warning message exchange in the Indian Ocean region.

Tis showed an urgent need for a new generation of reliable tsunami early warning systems based on an stable multi-sensor monitoring platforms. The time interval between an initial strong earthquake and the detection of the tsunami should be drastically reduced. Warning messages should be generated more rapidly and should only be disseminated to responsible authorities and people at risk. Initial warnings should be followed by in depth information that is understandable and reliable for people.

DEWS project [1], co-funded by the European Commission under the 6th Framework Programme, was born out of two main considerations:

- A considerable international and concerted effort is necessary in order to improve risk assessment and crisis management for the specific hazard of tsunamis
- The urgent need for building an innovative generation of interoperable early warning systems based on a stable multi-sensor monitoring platform.

The first consideration highlights two important aspects of DEWS. Firstly, the fact that its ultimate aim is to contribute to assisting those whose job is to save human lives and reduce as much as possible the negative social and economical impact of tsunamis in affected areas. Secondly, that DEWS is an important action which does not take place in isolation from the local and international initiatives being carried out by relevant actors and stakeholders long before the inception of DEWS.

The second consideration is more focused on the specific topic of DEWS. If risk and crisis management activities related to tsunamis are to be effectively improved, and specifically, those dealing with early warning, it is clear that the time interval between an initial strong earthquake and the detection of the tsunami has to be drastically reduced. This reduction provides more time for key activities such as issuing warnings to local stakeholders and assisting them in subsequently warning the population, as other emergency measures are launched in parallel. Therefore, warning messages must be generated more rapidly and only be disseminated to responsible authorities and the people at risk. Initial warnings should be followed by in depth information that is understandable by and reliable for the people.

These objectives have been achieved by the scientific and technical outcomes of the DEWS National Centre, intended for use at national level; and the DEWS Wide Area Centre, intended for use at international level, in order to allow exchange of information among National Centres and to act as an umbrella centre for the whole region.

Finally, DEWS is the result of the committed collaboration of 20 partners in the EU, Indonesia, Sri Lanka, Thailand, Japan and New Zealand, combining qualified technological competence and application experience. Interoperability with international cooperation mechanisms, including the Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO) [2], was also taken into account to ensure relevance and transferability of results to other tsunami-prone areas.

The following sections provide a general overview of the system, focusing on the first of the results: the DEWS National Centre.

## 2. GENERAL SYSTEM OVERVIEW

DEWS is independent of the risk, so it can be applied to multiple situations (earthquakes, tsunamis, floods, forest fires, etc.). The version of the system that we present here is designed for tsunamis, which are one of the most demanding hazards.

If an earthquake relatively near the coast originates a tsunami, the first wave may arrive to the land in less than 20 minutes, e.g. Indonesia near the Sunda trench. It is designed to allow operators to receive the necessary information, interpret it and launch an early warning with corresponding personalised messages in less than 10 minutes, in order to allow time for evacuation procedures.

DEWS is based on SOA concepts and on relevant standards such as the Open Geospatial Consortium (OGC) [3], the World Wide Web Consortium (W3C) [4] and Organization for the Advancement of Structured Information Standards (OASIS) [5]. The system continuously receives relevant information from open distributed multi-sensor platforms, processes it and supports operators, e.g. by use of a simulation system to forecast probable tsunami wave propagation, in order to decide whether an early warning must be issued. In the event of an early warning, the system is able to integrate relevant information packages on the fly, and distribute them to a multiplicity of actors dealing with crisis management and emergency activities.

DEWS has an interface to sensor networks which abstracts completely the sensor networks from the rest of the system. In order to achieve this goal the system requires that sensor data complies with the OGC-SWE standard [8], thus enabling a deeper and less generic access to the components of the sensor network. This approach improves the efficiency of the early warning generation. In case the sensor data do not comply with the mentioned standard, DEWS must be provided with a plug-in to make the data conversion.

The second conceptual interface takes place between DEWS and the specific communications infrastructure available in user countries or regions for the distribution of the warnings. For this purpose a wide range of communication means are provided in order to allow the provision of information in case of an early warning.

## 2.1 UPSTREAM & DOWNSTREAM

Basic concepts behind the nature of early warning systems describe the flow of information (as shown in Figure 4) which consists of an upstream and a downstream part:

- In the upstream part sensor information is directed from the sensor platform systems (detection and monitoring of hazards) to the warning centre. The upstream part includes sensor system management and real-time processing of data streams.

- In the downstream part hazard information, i.e. customized, user-tailored warning messages and alerts flow from the warning centre to responsible authorities and/or the public with their different needs and responsibilities.

DEWS encompasses both upstream and downstream information flows.

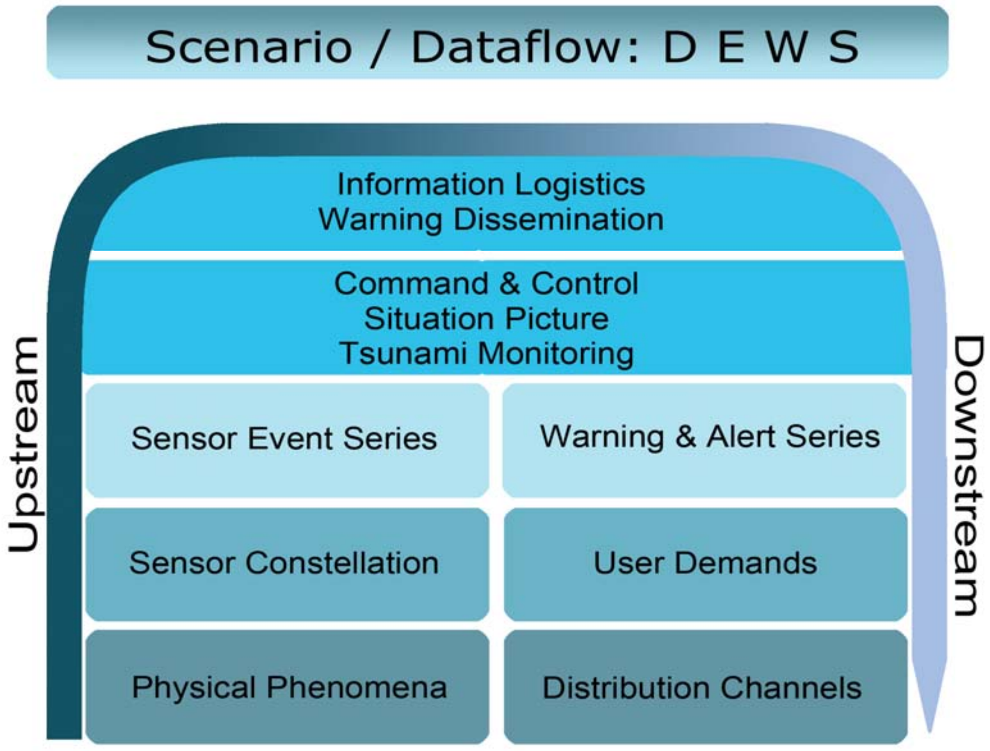


Figure 1: Upstream & Downstream dataflow

## 2.2 GENERAL ARCHITECTURE

DEWS is designed to be a modular system (see Figure 2) following the principles of SOA.

In normal conditions, and when an event starts, the operator works with the Command and Control User Interface (CCUI). After an early warning is issued, the operator starts the message composition process. The Information Logistics Component (ILC) generates tailored warning messages for each user that must receive the message. User profiles are stored in a separate database and contain several parameters for registered users like settings for language, interested areas, dissemination channels and other settings, which enable personalization of the warning messages to be disseminated. The generated messages are sent to the Information Dissemination Component (IDC) that provides adapters for several dissemination channels. It converts the messages into channel specific formats and disseminates the messages.

Other components like the sensor platform, the simulation and the map servers are connected via standardized OGC services such as OGC Sensor Web Enablement (SWE) [6], OGC Web Map Service (WMS) [7], OGC Web Feature Service (WFS) [8], OGC Web Processing Service (WPS) [9], etc.

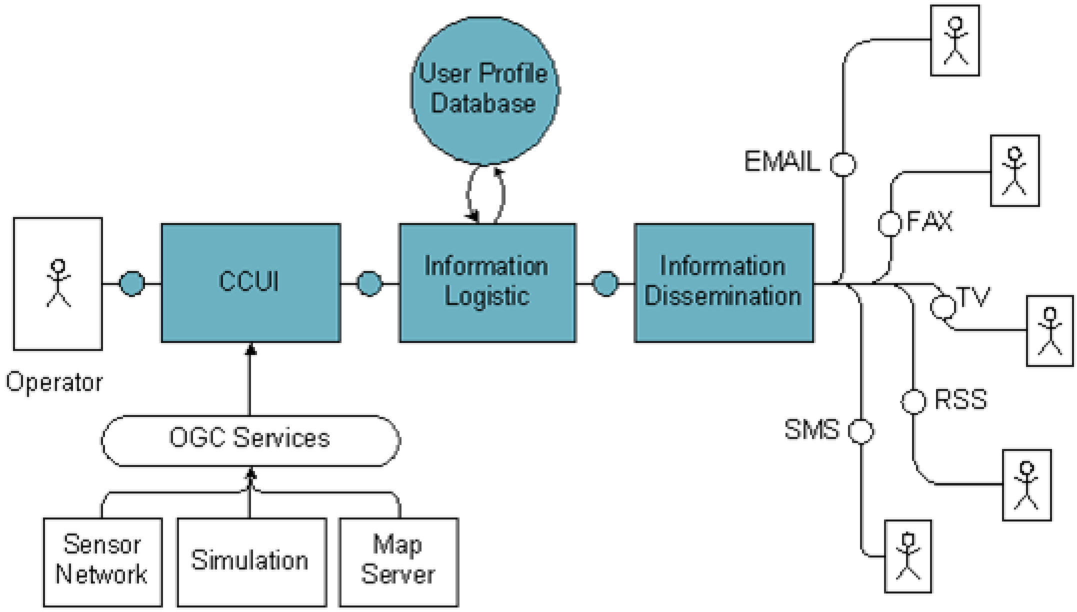


Figure 2: General Architecture

## 2.3 CCUI – COMMAND & CONTROL USER INTERFACE

The CCUI is the point of access to the system for the operator. The CCUI offers different perspectives that meaningfully show and encapsulate all functionality associated with the comprehensive tasks fulfilled by the operator on duty.

The perspectives of the CCUI are:

- Administration Perspective: it enables the management of the users of the system and information logistics (persons, institutions, preferred language for messages, preferred dissemination channels, etc.).
- Monitoring Perspective: it enables operators to monitor running events (i.e. incoming earthquake alert from the seismic sensor network).
- Forecasting Perspective: it enables operators to combine actual current data with the results of previously obtained simulations.
- Message Composition Perspective: it enables operators to prepare and send warning messages.
- Dissemination Perspective: it enables operators to observe and monitor all messages delivered to the specific user groups.

The functionality provided by each of these perspectives is further detailed in section 3.

## 2.4 ILC - INFORMATION LOGISTICS COMPONENT

While the sensor platform and the simulation and map servers are providing DEWS with upstream data, the Information Logistics Component focuses on delivering user-tailored warning messages (according to the user requirements and preferences, see Figure 3).

Common Alerting Protocol (CAP) [10] and Emergency Data Exchange Language Distribution Element (EDXL-DE) [11] are the chosen message formats. CAP is an XML-based data format for exchanging public warnings and emergencies between alerting technologies. CAP allows a warning message to be consistently disseminated simultaneously over many warning systems to many applications. CAP increases warning effectiveness and simplifies the task of activating a warning for responsible officials.

The CAP and EDXL-DE specifications of the OASIS Emergency Management Technical Committee are standards with increasing application in the fields of emergency management. For DEWS these specifications serve a fundamental base to build upon.

DEWS does not support arbitrary messages that can be translated into different languages or vocabularies via services. Instead templates are used as boilerplate documents with placeholders that will be replaced with situation based values. Finally, those templates are used by the ILC to assemble the EDXL-DE/CAP message and converted into dissemination channel specific format and sent to the user (according to the user's stored preferences) by means of the IDC.

Figure 3 depicts how the information is managed within the ILC.

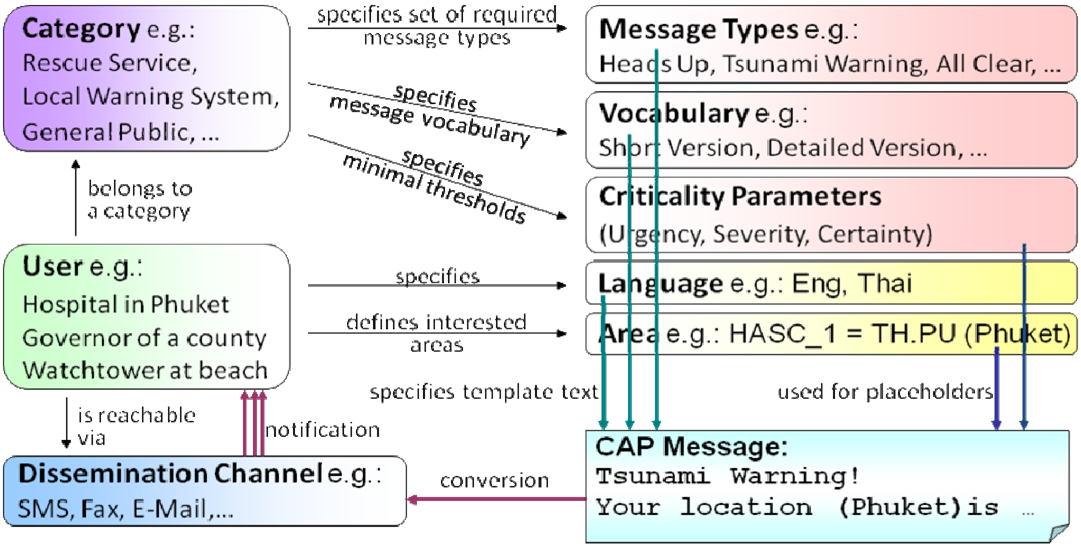


Figure 3: Information Management within the ILC

Each user (like a district hospital, a tourist or a Governor) belongs to a certain category. This category defines:

- The message types: E.g. a tourist shall not get minor earthquake information or test messages to avoid panic

- The vocabulary of the message: The differences of the user groups and their needs are reflected by the vocabulary and the jargon of the disseminated messages. This guarantees a correct understanding of the message and the precise information since the user needs to react to a certain situation. Therefore, for instance, while local rescue service will get more detailed message civilians need only basic information and clear instructions.

- The minimal thresholds of the three criticality parameters urgency, severity and certainty: Each threshold must be reached or exceeded – only then the user will receive the message.

The user itself defines:

- The language: Used to communicate the warning message to the end recipient

- The areas of interest: Only if the affected areas intersect with the user's areas he will be informed. DEWS is using Hierarchical Administrative Subdivision Codes (HASC) [12] that enables to register countrywide (level 0), for states (level 1), districts (level 2) or even smaller administrative areas (level 3). With this mapping of user profiles to areas the user is not informed on messages related to areas away from his position or his area of interest. This reduces the number of disseminated warning messages and avoids false alarms and panic.

- The dissemination channel: The user can specify one or more dissemination channels to be used in order to receive the warning message from DEWS. The final message sent to the end user depends on channel constraints to be delivered completely and user-friendly. For instance one end user has registered to get notified via email and SMS. Since the template for an email message might be very exhaustive this template cannot be used for SMS because of the limited character amount in SMS.

## 2.5 IDC - INFORMATION DISSEMINATION COMPONENT

Early warning systems, such as DEWS, require that the dissemination of early warning messages has to be executed in way that ensures that the message delivery is timely; the message content is under-standable/usable and accurate. To that end, diverse and multiple dissemination channels must be used to increase the chance of the messages reaching all affected persons in a hazard scenario. The significant difference in the implementation and capabilities of different dissemination channels (e.g. SMS, email, TV) has bearing on the information processing required for delivery and consumption of a DEWS CAP or EDXL-DE over each dissemination channel. The capacity limitations of the dissemination channel or message rendering limitations of the user terminal device could be factors that limit the length and capability of attaching resources (e.g. maps) to the actual disseminated message. For instance, the SMS dissemination channel has a message length limitation (160 characters for un-concatenated SMS) and precludes the attaching of images.

Therefore, the DEWS CAP/EDXL-DE messages are pre-processed by channel adaptors in the IDC to ensure that the message is adapted for the dissemination channels without any semantic distortion. The dissemination channel gateways provide further processing of the message converting it into a format that is suitable for end-to-end delivery over the dissemination channel, Depending on the channel, the dissemination channel gateways may be provided by an external entity (e.g., ISP, mobile network operator etc.) or internally by the organization operating the DEWS system. The eventual format (e.g. text, map or still images, audio, video) of the consumed DEWS message will be dependent on the formats supported on both the dissemination channel and message consumer's terminal device that will render the message.

## 2.6 DISSEMINATION CHANNELS

More than ten dissemination channels are currently set up and connected to DEWS infrastructure with the respective channel gateways or servers: SMS to subscribers, SMS via cell broadcasting (under arrangements with local operators), e-mail, fax, narrowcast TV, broadcast TV, RSS feed, social media (Facebook, Twitter etc.), instant messaging, voice communications (e.g. using VoIP), FM radio/RDS and sirens. They make it possible to alert the authorities and the general public in a wide range of situations and with high flexibility.

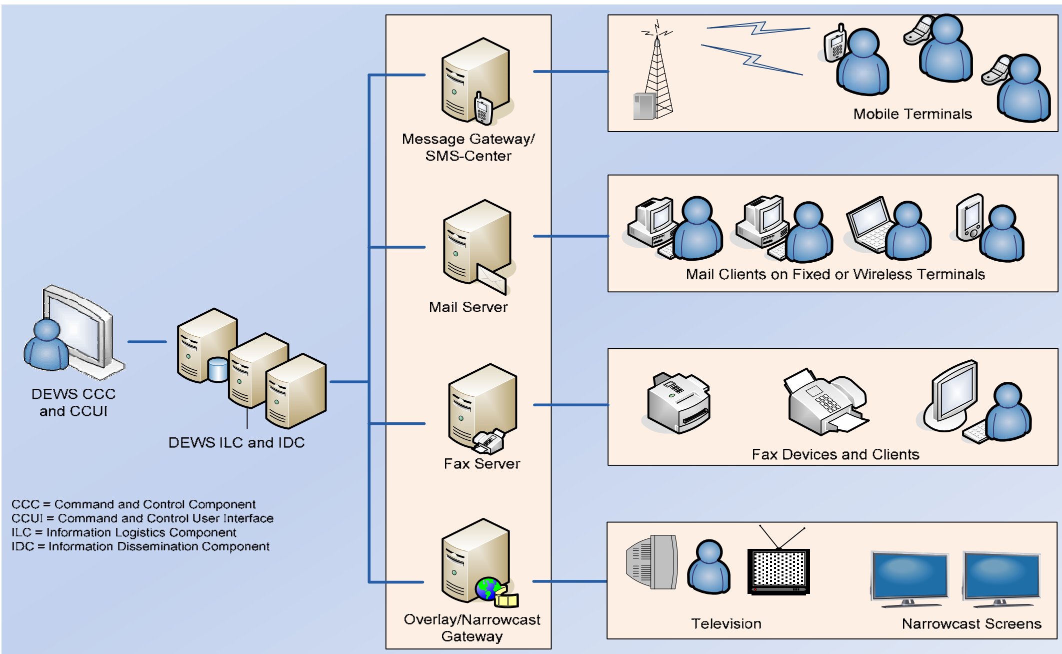


Figure 4: Dissemination Channels

## 3. DEWS NATIONAL CENTRE AT WORK

This section provides an overview of the DEWS National Centre at work, with Thailand as example scenario.

### 3.1 MONITORING PERSPECTIVE

As the name indicates, the Monitoring Perspective provides a survey of a specific area and contributes an overall situation picture to the operator with geo-spatial information, displayed in a central map, and additional details, contained in multiple views surrounding the map.

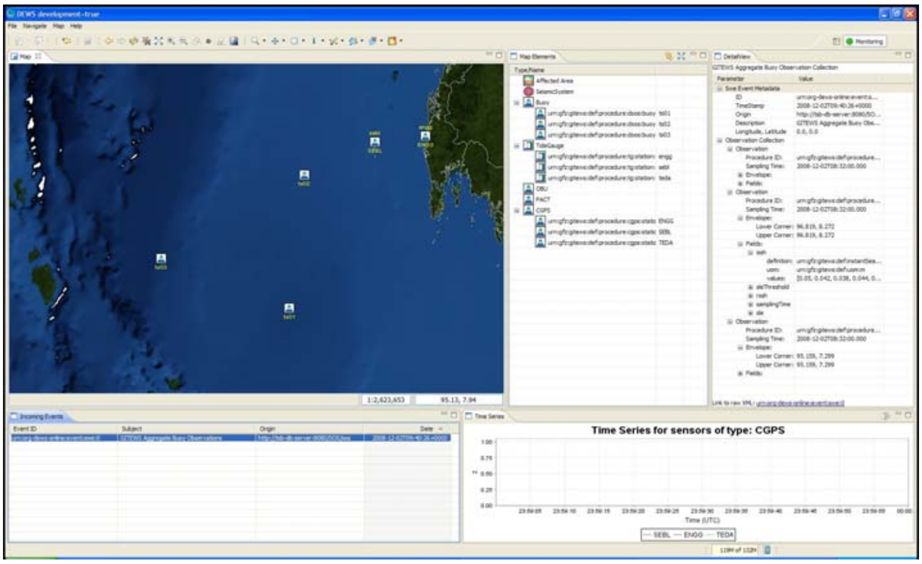


Figure 5: Monitoring perspective

The specific area is displayed in a map containing bathymetry of the ocean floor and topography of the coastal area as well as the respective sensors (in the picture: buoys and tide gauges) delivering sensor information to the warning centre. In case of an earthquake, its location and magnitude is also depicted. Later on, the map contains the tsunami wave propagation and affected areas.

To aid the operator to view details of the specific area, it is possible to zoom and pan the map.

On the right hand side, a panel lists the elements contained in the map. Typical elements that appear in this list are:

- Sensors, for example buoys and tide gauges displayed with their respective identifiers
- Seismic alerts, that have occurred and have been depicted in the map, and
- Affected areas, generated while message composition

This view supports the operator while working with the map – for example trimming the map to the selected map elements.

At the bottom (left hand side), a list of incoming events tracks ongoing incidences reported by the system with its sensors, sensor networks, other warning centres and any other available source that is able to report a status. An event could be an earthquake detected by a seismometer, an anomaly detected by a pressure sensor at the ocean floor, or simply a message from a sensor reporting low battery status.

Furthermore, this view not only constitutes the inbox for received events but also serves as a historic log. The events are organized by date, with the latest events are always automatically displayed on top.

In addition, all measured data are displayed in form of time series for the different sensors (at the bottom, right hand side). Graphs allow the operator to track the incoming data successively. The information is the same as in the view of the incoming events but depicted graphically. The Time Series in this example depicts the sea surface height measured by each buoy of the sensor network.

According to the selected event further details are displayed in another view for a close understanding of the respective event data. The appearance of this view strongly depends on the event type selected. For example the information displayed could be all sensed earthquake information regarding to a seismic alert selected within the event list.

Moreover, the event list provides an action in the context menu to start a simulation for the evaluation of probable forecasts based on one more selected events. The measurements contained in the selected events serve as input for this computation.

## 3.2 FORECASTING PERSPECTIVE

The Forecasting Perspective supports the operator in analyzing the different probable forecasts provided by the simulation system, and in comparing them to the actual current event data. The perspective is divided into:

- A view with predicted sensor time series compared to real measurements
- The same event list known from the Monitoring Perspective
- A ranking list with probable predictions
- A view with absolute and relative time measurements, and
- Again the map showing the result of the selected forecast

The view with the predicted time series contains one diagram for each sensor (upper left hand side). The diagrams for the sensors are ordered one below the other. Which sensors are displayed, depends on the available sensors within the considered geographic area.

Each diagram for the respective sensor includes differently coloured graphs for each prediction calculated by the simulation system and a graph in black representing the real measurement of the sensor. The operator is enabled to compare and approve the forecasts that better match the real measurement.

On top of each diagram the name and type of each sensor is displayed. The predicted time series for each sensor are also listed in the two small boxes to the right of a chart. Simulation Visibility is used to select all or only single time lines which should be displayed in the chart. Simulation Weighting is important for the ranking of the probable predictions. The operator selects the best fitting simulation whereas the rest is disregarded.

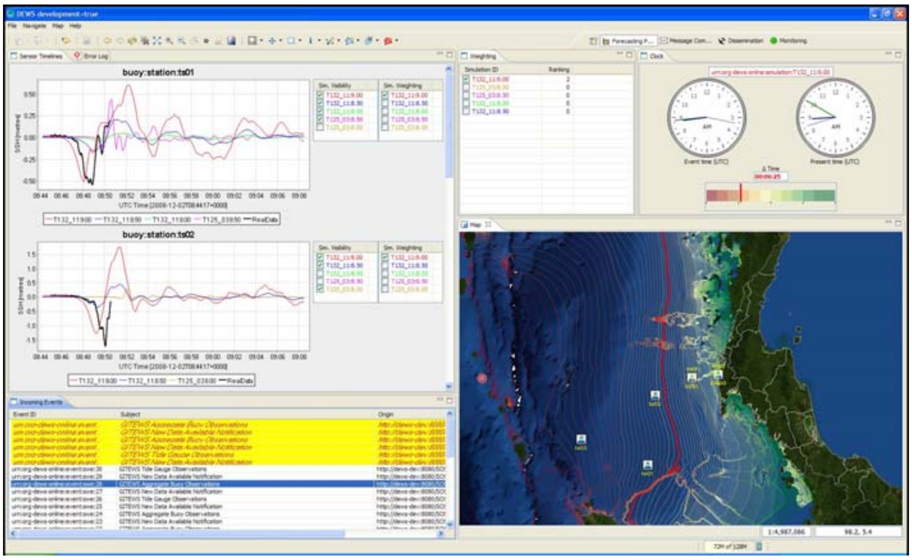


Figure 6: Forecasting perspective

The time series are updated in real time with each incoming refinement of a simulation calculation. That means the operator continuously receives events according to an incident that already has a simulation calculation. But the incoming events are inputs to refine the selection of forecasts and to display the most likely forecast only. Then the operator starts the simulation calculation again with additional inputs or rather fresh events followed by an iterative analysis and comparison.

In the ranking list the forecasts are simply ordered by the order of their selection done within the Simulation Weighting of each sensor graph. By this selection process, the simulation with the highest probability leads to an optimal forecast result and can be used for the dissemination of warning messages.

When selecting a simulation in the ranking list, updated information is displayed in the map and in the time measurements.

The time measurements provide the following information:

- The left clock shows the time – based on the Coordinated Universal Time (UTC) - of the occurrence of the initial earthquake.
- The right clock displays the present time in UTC.
- In between the relative time difference between the event time and the present time is shown as a delta value.
- Furthermore a bar with lines in the isochrones colour scheme represents the time axis of the calculated simulation. The current position of the proceeding time in the hazard threat is highlighted with a fat red line.

It must be noted that time management within DEWS is of special relevance since it has an important impact when ensuring that the available information is processed timely and effectively. Therefore, UTC is consistently used as the reference time in order to maintain the coherence of the information received from different sensor sources (e.g. buoy sensors deployed in different areas of the Indian Ocean with different time zones) and the disseminated waning messages to the different areas (e.g. the time zone for Bangkok, Thailand is different from the time zone for Colombo, Sri Lanka).

The forecast selected in the ranking list is displayed in the map (bottom, right hand side) with coloured isochrones. The outlined isochrones represent the tsunami wave propagation time between the earthquake location and the impact at the coast. The distance between two isochrones normally accounts for two minutes.

To start the dissemination process based on a forecast the ranking list provides a context menu with the action "Start Tsunami Warning Wizard". By opening the Tsunami Warning Wizard a separate view for the wizard is shown in the Message Composition Perspective.

## 3.3 TSUNAMI WARNING WIZARD

The Tsunami Warning Dissemination Wizard represents an automatic support system to identify affected areas on the basis of the best fitting simulation. The simulation result contains predictions for hundreds of coastal points and it is nearly impossible for the operator to check every point and to analyze the situation for each area. The Tsunami Warning Wizard calculates the Estimated Time of Arrival of the wave and the maximum Sea Surface Height for each of the administrative areas.

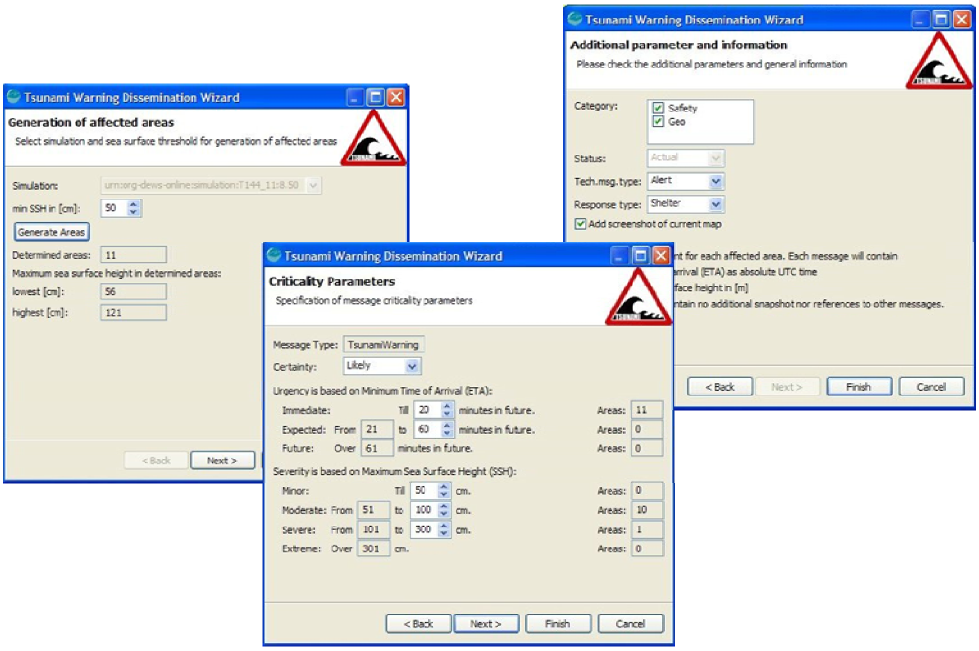


Figure 7: Tsunami Warning Wizard

These values are used to categorize the message according to the severity and urgency attributes of the standardised Common Alerting Protocol, briefly named CAP. The operator configures additional CAP relevant attributes and adds a screenshot of the current map. By pressing the finish button warning messages are sent to each single administrative area considering the area-specific predicted parameters like Estimated Time of Arrival and Sea Surface Height.

## 3.4 MESSAGE COMPOSITION PERSPECTIVE

The Message Composition Perspective is opened automatically when starting the Tsunami Warning Wizard in the ranking list with a selected forecast.

The Message Composition Perspective supports the operator in its task to prepare, to send and to observe the initiated warning dissemination.

The map still depicts the specific geographic region with the information provided by the other perspectives. Additionally affected areas are displayed in the map. According to the selected forecast they are automatically calculated or manually selected by the operator. Automatically calculated areas are symbolized with different colour schemes for the estimated wave height. Red coloured areas are at high risk. Less endangered areas are depicted in yellow or green.

The map is editable by the operator with different tools. One of the tools enables the operator to select multiple geographical regions or areas. Thus the operator selects the areas for dissemination. Selected areas are stored in a list so that the operator is able to manage the affected areas and reuse them later on – for example when composing refined warning messages. The listed areas serve as input for the message composition of the intended warning dissemination and are attached with drag and drop to a warning message.

To attach an evident situation picture to a warning message, a snapshot of the currently displayed map might be taken. When the operator clicks the respective button, snapshots of the map are taken and stored in a list. The operator selects snapshots from that list and attaches them with drag and drop to the respective warning message.

For the composition of warning messages this perspective contains a form considering elements of the CAP standard. The operator has to select a specific message type first to edit the details of the message. Each message type defines its own range of values for the message details. The operator selects the appropriate value for each message element according to the ongoing situation. Both the affected regions and the resources can be assigned to the message by drag and drop. All values except the resources are mandatory. Resources are optional and serve as input for the warning messages disseminated through the different channels (except for SMS, sirens, VoIP and FM radio / RDS channels). The composed message will be sent when each value has been configured appropriate and the operator has triggered the button for dissemination.

Composed and sent messages are listed in the Disseminated Messages View with additional processing information. Each message might be re-used as boilerplate for a refined message in future and presets the form values of the Message Composition View.

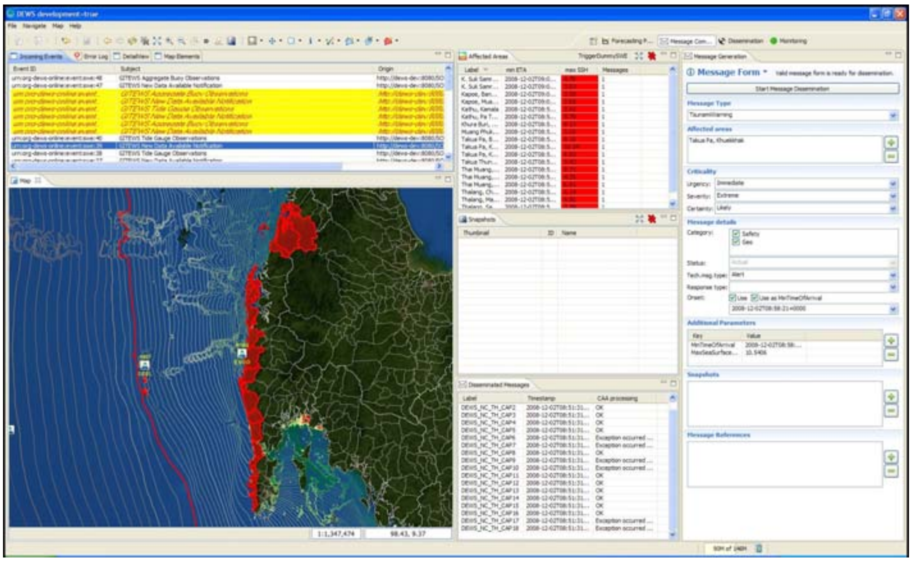

Figure 8: Message Composition Perspective

## 3.5 DISSEMINATION PERSPECTIVE

The Dissemination Perspective provides a comprehensive overview of the status of disseminated messages sent through the different dissemination channels. This overview is based on status reports received and aggregated from the respective telecommunication providers.

There are more than ten available channels:

- Electronic mail – E-Mail dissemination channel
- Short message service – SMS dissemination channel, to subscribers
- Short message service – SMS dissemination channel, via cell broadcasting, under arrangements with local operators that provide the service (on-going work)
- Facsimile – Fax dissemination channel
- Television – TV Overlay dissemination channel
- Narrow Casting dissemination channel
- RSS Feed channel
- Instant Messaging
- Sirens
- VoIP
- FM radio / RDS channel

Moreover, the Dissemination Perspective has the respective channel views containing status information of the ongoing dissemination.

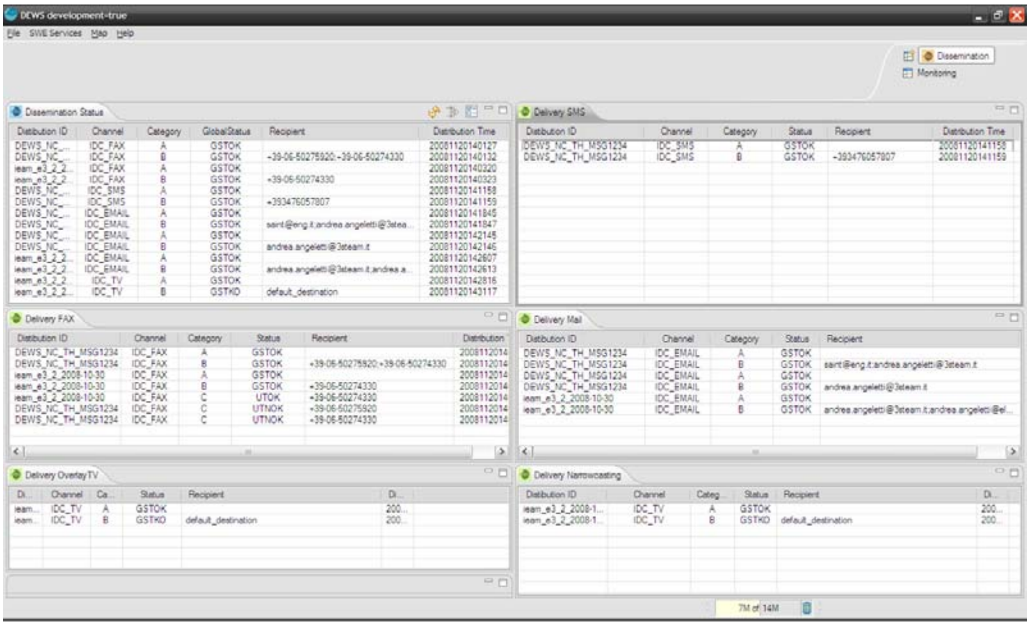

Figure 9: Dissemination Perspective

The main view aggregates information of all channels related to the message exchange between the DEWS dissemination infrastructure and the respective dissemination channel provider. The remaining views for E-Mail, SMS, Fax, TV Overlay and Narrow Casting, RSS, Sirens/Siren networks, Instant Messaging, VOIP show all status information according to the respective channel dissemination.

Figure 10 shows the tsunami warning message delivered to two different mobile phones, one in English and another in Thai language.


Figure 10: Examples of warning messages: SMS

## 4. CONCLUSIONS

The DEWS approach, namely the adoption and use of open standards, interoperability and (whenever possible) free open source software, has proven successful. The results achieved also prove that it was possible, as originally claimed, to produce an innovative new generation of early warning systems that can be applied to different hazards and geographical areas while enabling a high degree of personalization to a specific hazard and needs (in this case, tsunami in the Indian Ocean) in order to satisfy user requirements.

From this, it is possible to highlight the main distinctive features of DEWS: is quite powerful due to its capacity to interface (in a standardized manner) with different sensor platforms, its speed in integrating relevant information, its no-nonsense approach to presenting expert operators with the information and functionality necessary for a key decisions to be made quickly, and its speed, richness, multiplicity of dissemination channels and degree of personalization.

Early warning technologies appear to be mature in certain fields but not yet in others. Considerable progress has been made thanks to advances in scientific research and in communication and information technologies. Nevertheless, a significant amount of work remains to fill existing technological, communication, and geographical coverage gaps [13], which are also shared and of interest for DEWS partners:

(i) Development and use of geospatial data models, risk maps and scenarios,

(ii) Cost-effective observations systems,

(iii) Data generation and assimilation (e.g. bathymetry for tsunami models),

(iv) Improvement of core prediction system models and prediction tools,

(v) Warning decision system tools for disaster managers,

(vi) Management under warning uncertainty,

(vii) Evaluation and comparison of warning communication methods effectiveness,

(viii) Models of human response behaviour including evacuations,

(ix) Visualization of impacts and response options for community preparedness,

(x) Role of early warning as an adaptation to climate change,

(xi) Warning system performance, indicators, benchmarks, and

(xii) Economic assessments of warning system effectiveness.

Some of these gaps have been significantly addressed by DEWS (i, iii, v, vi, ix) but they all remain as key topics for further research and analysis work.

In addition to those gaps, and in accordance with UNEP's Early Warning Systems: State-of-the-Art Analysis and Future Directions Draft Report [14], although several early warning systems are in place at global scale in most countries for most hazard types, there is the need to work towards the establishment of a worldwide early warning system for all natural hazards with regional nodes, building on existing national and regional capacity. By building upon ongoing efforts to promote early warning, a multi-hazard early warning system will have a critical role in preventing hazardous events from turning into disasters.

DEWS project has already taken into consideration this issue by designing and implementing a first approach of a globally comprehensive early warning system: The DEWS Wide Area Centre. It is not a single, centrally planned and commanded system, but a networked and coordinated assemblage of nationally owned and operated systems based on DEWS approach. It makes use of existing observation networks, warning centres, modelling and forecasting capacities, telecommunication networks, and preparedness and response capacities. This global approach to early warning will also guarantee consistency of warning messages and mitigation approaches globally, improving, as a result, coordination at a multi-level and multi-sector scale.

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