Warnsysteme - von der Sensor-Integration zum System-of-Systems

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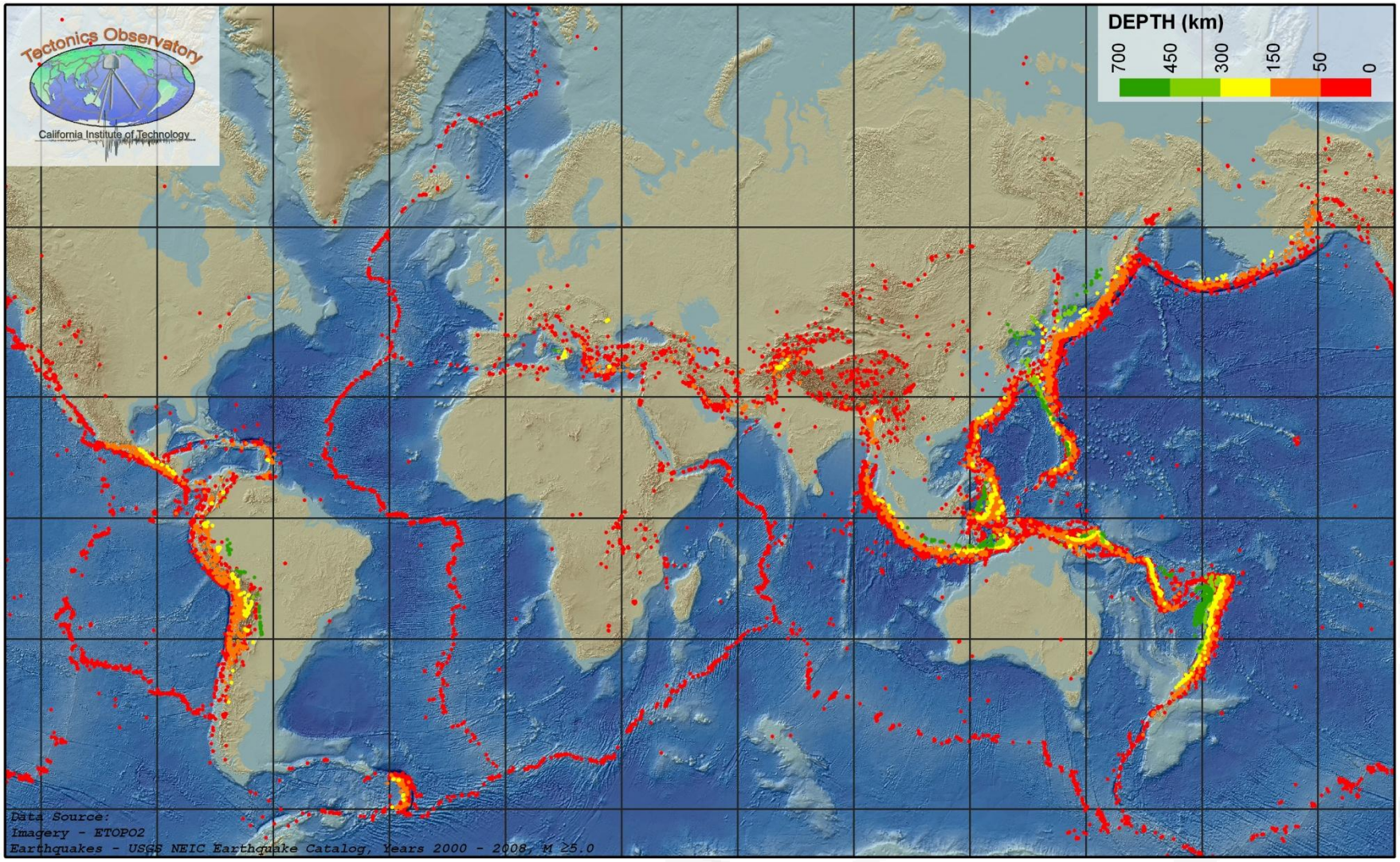
Deutsches GeoForschungsZentrum - GFZ

Potsdam, 15. Januar 2013

Agenda

- Geologische Desaster und Tsunami
- Anforderungen an Warnsysteme
- Upstream: Sensor-Integration
- Decision Support
- Downstream: Information Dissemination
- Warnsysteme als System-of-Systems
- Architektur und Middleware
- Zusammenfassung

Global Seismic Activities

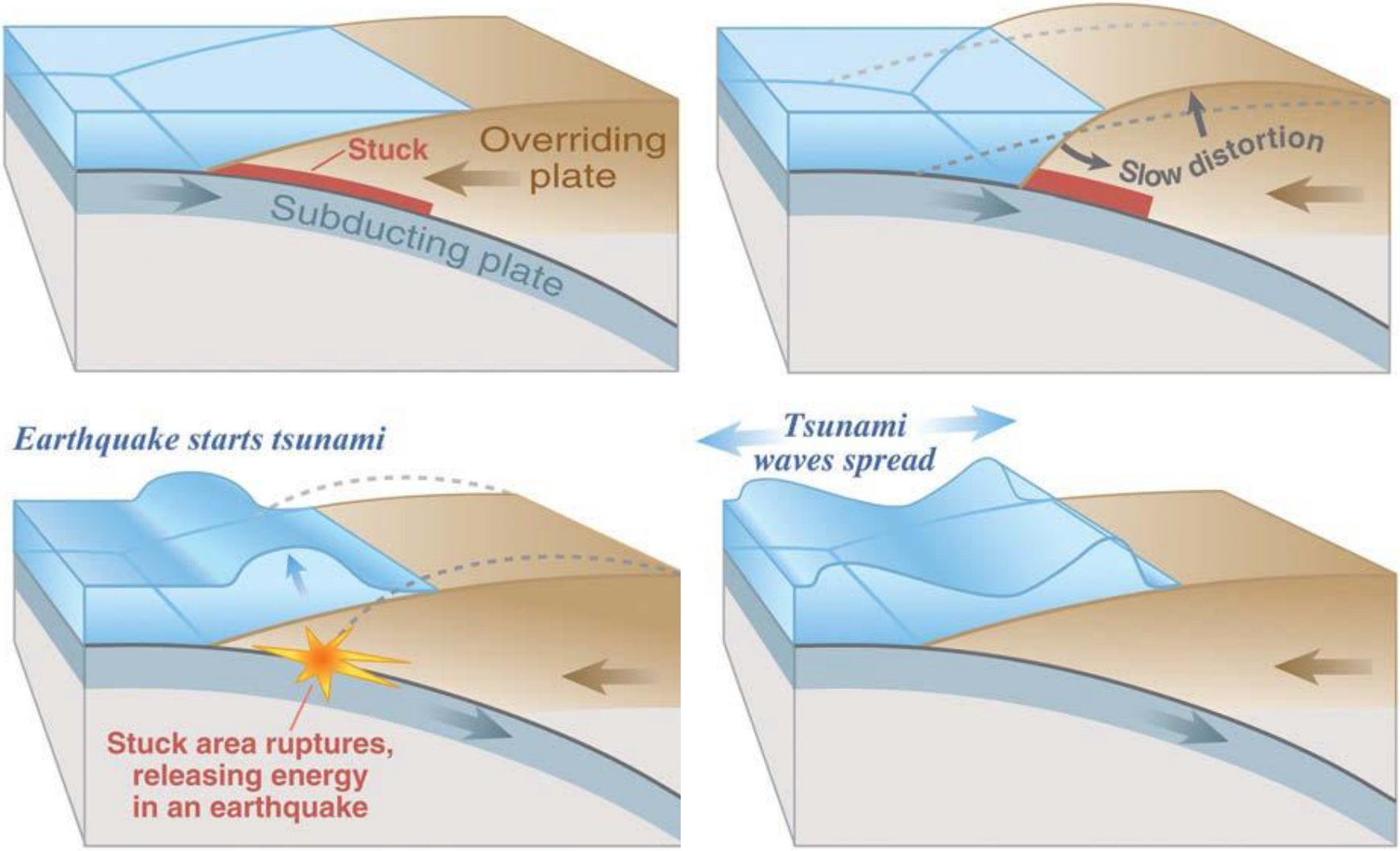


Tsunami

- **Tsunami**
  - japanisch für ‚Hafenwelle‘
  - extreme Wellenlänge > 100 km
  - geringe Amplitude <1 m
  - Geschwindigkeit 800 km/h
- **Beispiele**
  - 25.000 und 5000 v. Chr.: Storegga-Ereignis am Kontinentalhang vor Norwegen
  - 16. Jh. v. Chr. Vulkanexplosion auf Santorin
  - 1755: Erdbeben von Lissabon
  - 1960: Erdbeben von Valdivia, Chile 1000 Opfer durch Tsunami
  - 26. Dezember 2004: Erdbeben vor Sumatra, Magnitude um 9,3 mit 230000 Opfern
  - …

Thailand 2004
http://de.wikipedia.org/wiki/Tsunami

Tsunami Generation

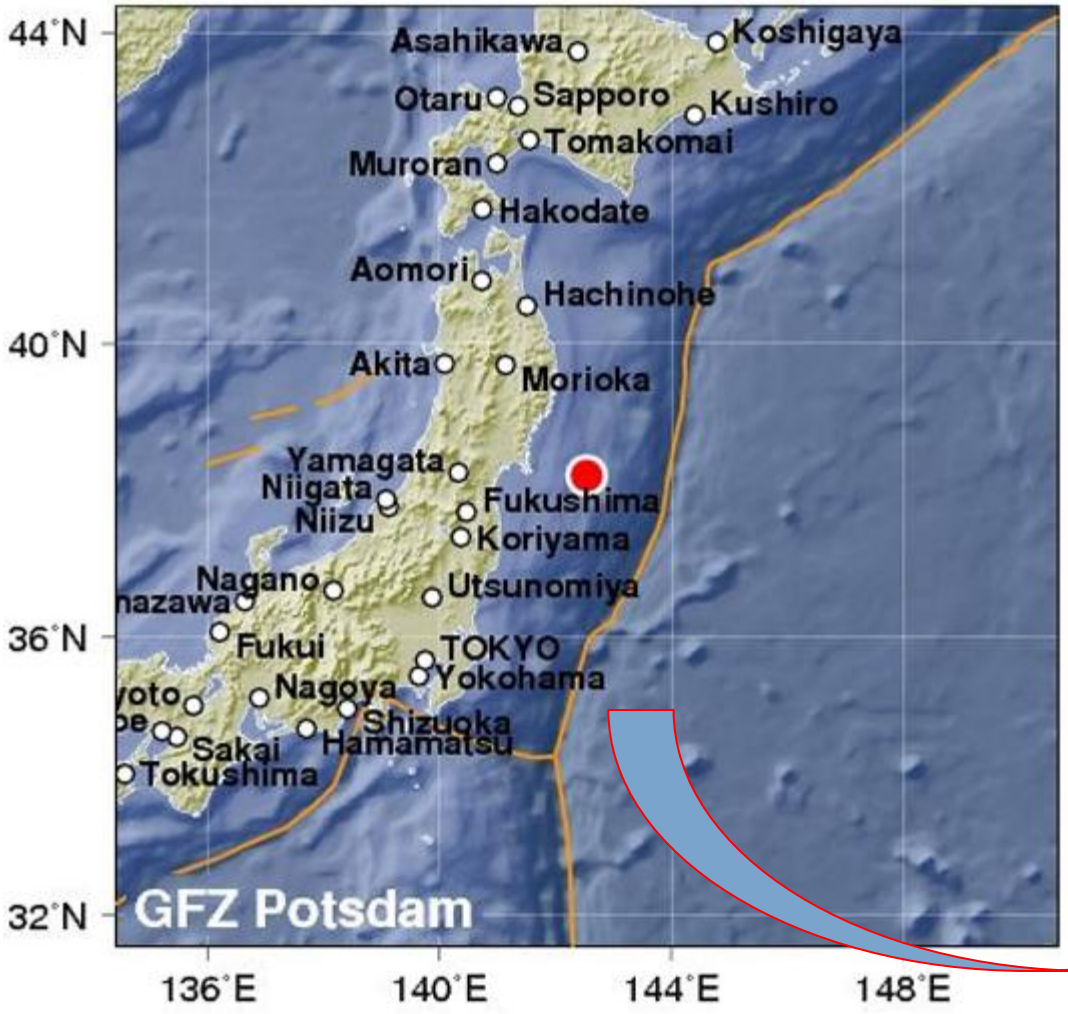


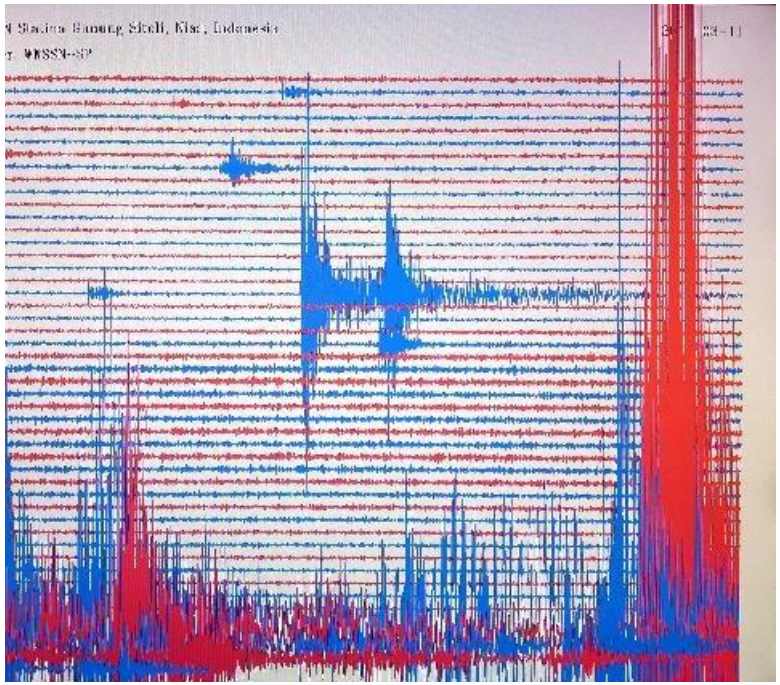
Tsunami Warning Center Reference Guide

Tohoku, Japan 11.03.2011 5:46

GFZ Potsdam - Earthquake Bulletin

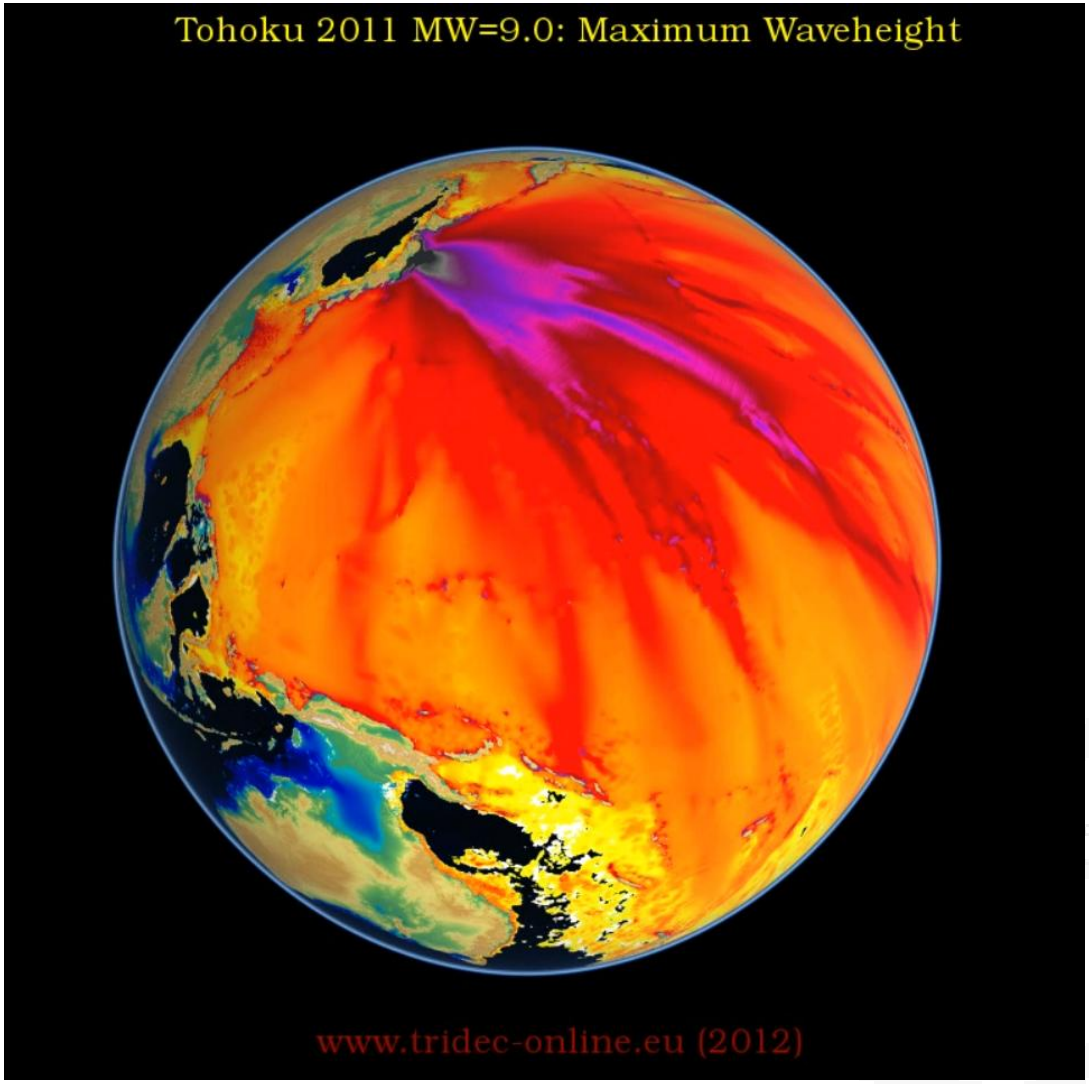
Region: **Near East Coast of Honshu, Japan**
Time: **2011-03-11 05:46:23.0 UTC**
Magnitude: **8.9 (Mw)**
Epicenter: **142.53°E 38.23°N**
Depth: **15 km**
Status: **M - manually revised**



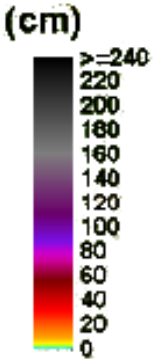


GEOFON-Station in Indonesien

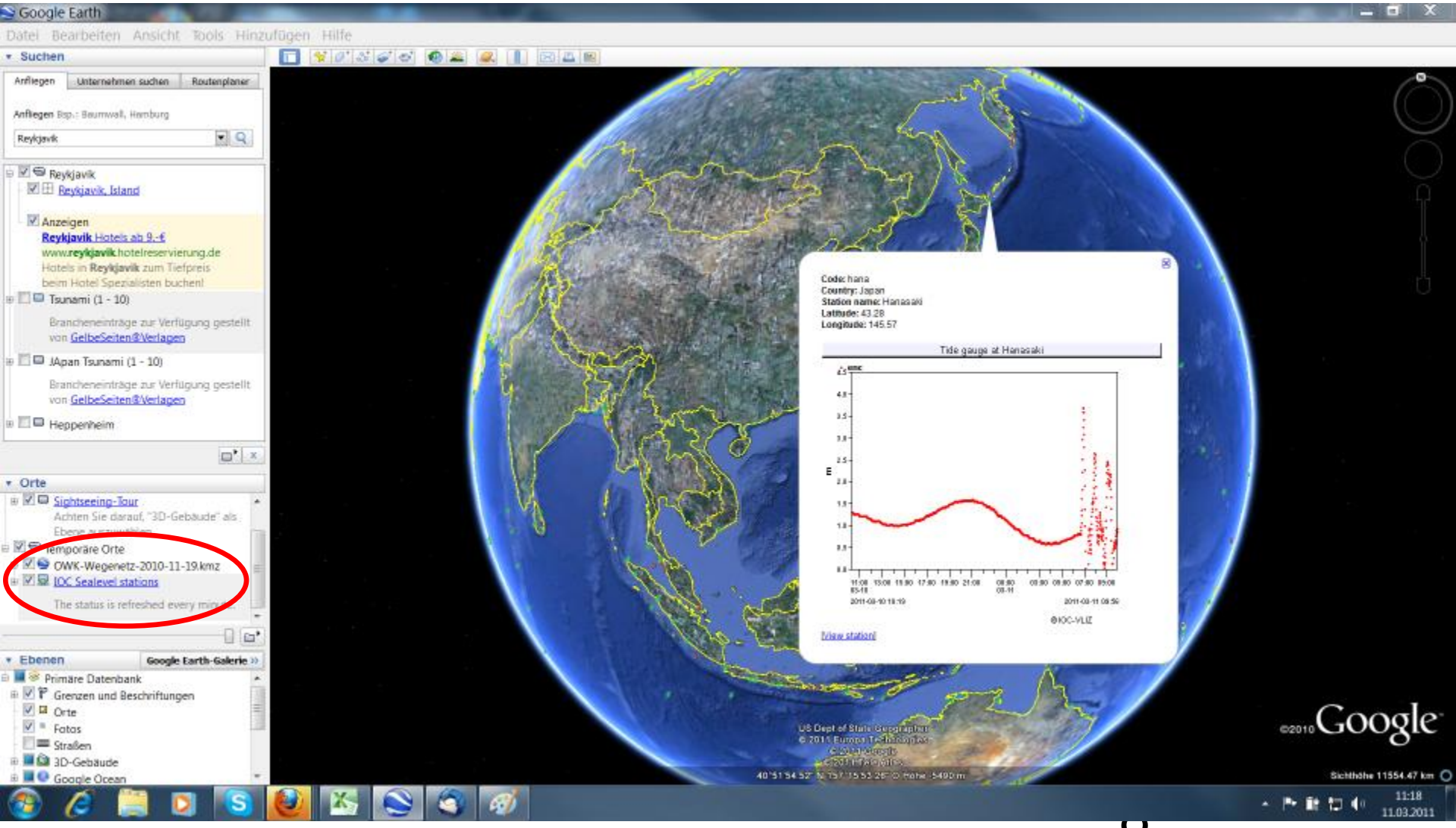
Wellenhöhen



Tohoku, Japan 11.03.2011



Bojen-Mareogramme Tohoku-Tsunami



Tohoku Tsunami

Kyodo/Reuters

Mosque at Lampuuk, Banda Aceh, after Tsunami, 25.12.2004

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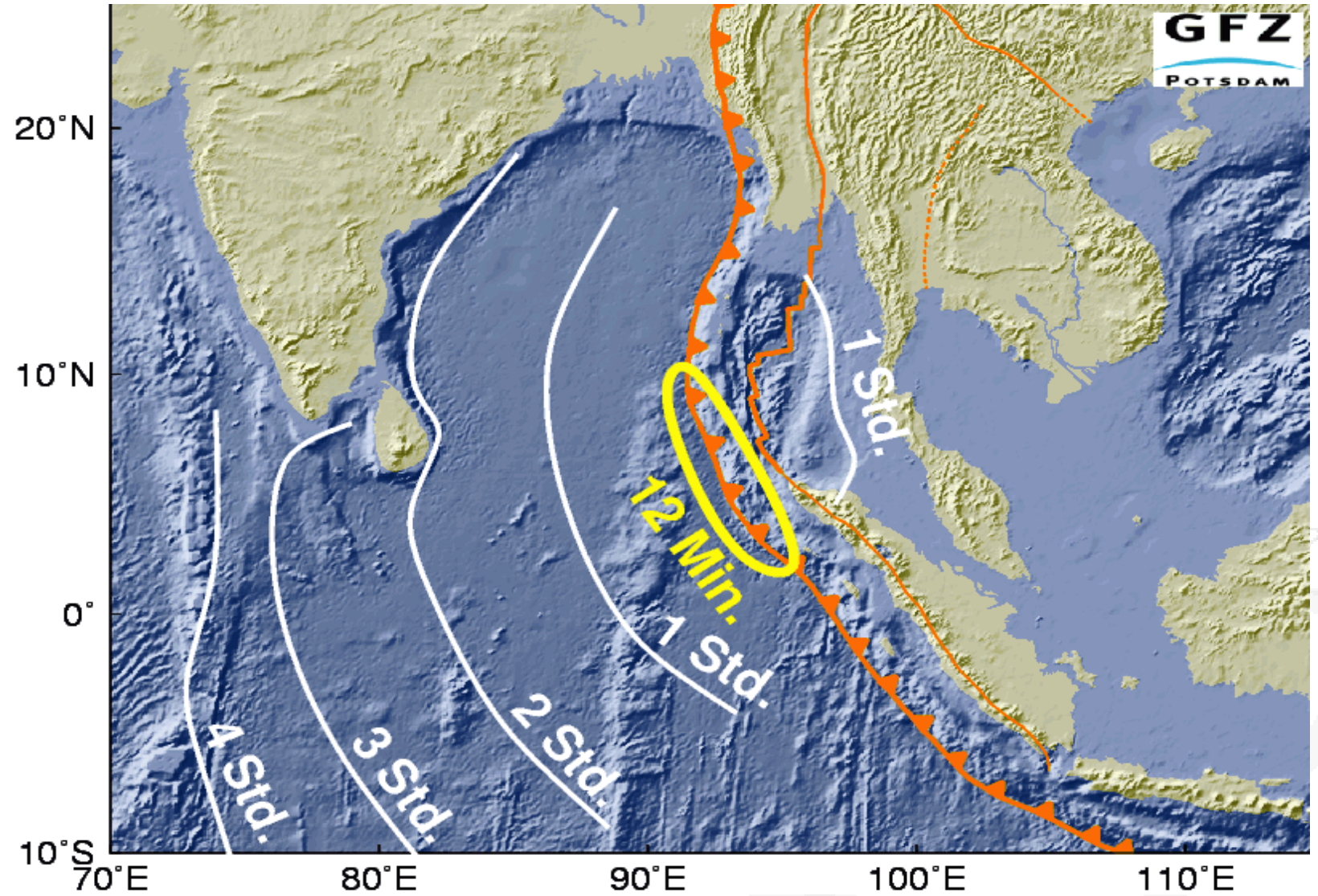
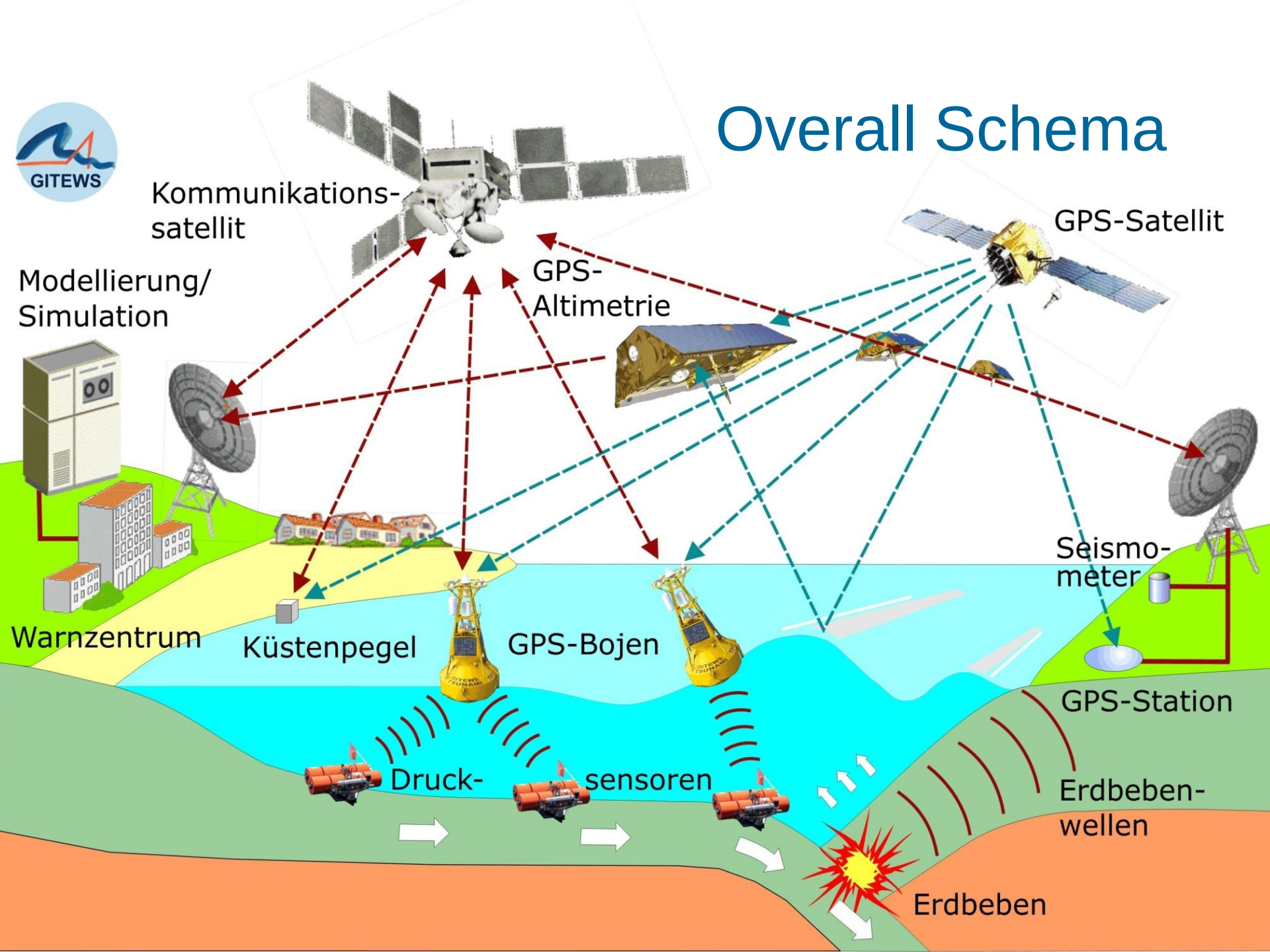
Challenge Indonesia



Overall Schema

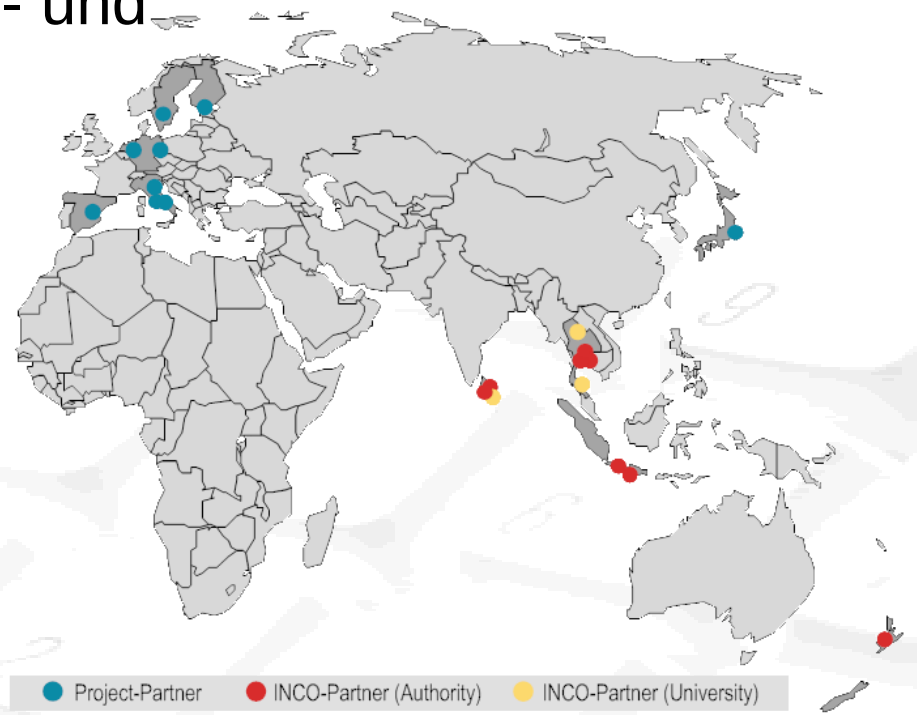


GITEWS Partner - National

- **Helmholtz-Gemeinschaft deutscher Forschungszentren (HGF)**
  - GeoForschungsZentrum Potsdam (GFZ)
  - German Aerospace Center (DLR), Oberpfaffenhofen
  - Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven
  - Forschungszentrum GKSS, Geesthacht
- **Konsortium Deutsche Meeresforschung (KDM)**
  - Leibniz Institute of Marine Sciences (IFM-GEOMAR), Kiel
- **United Nations University (UNU)**
  - Institute for Environment and Human Security (UNU-EHS),
- **Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn**
- **Federal Institute for Geosciences and Natural Resources (BGR), Hannover**

Distant Early Warning System (DEWS)

- EU-Projekt FP6 6.5 M€
- Technischer Koordinator
- Themenbereich Informations- und Kommunikationstechnologie
- EU-Partner: Industrie und Forschung
- INCO-Partner: Universitäten und Behörden
- Laufzeit 2008-2011



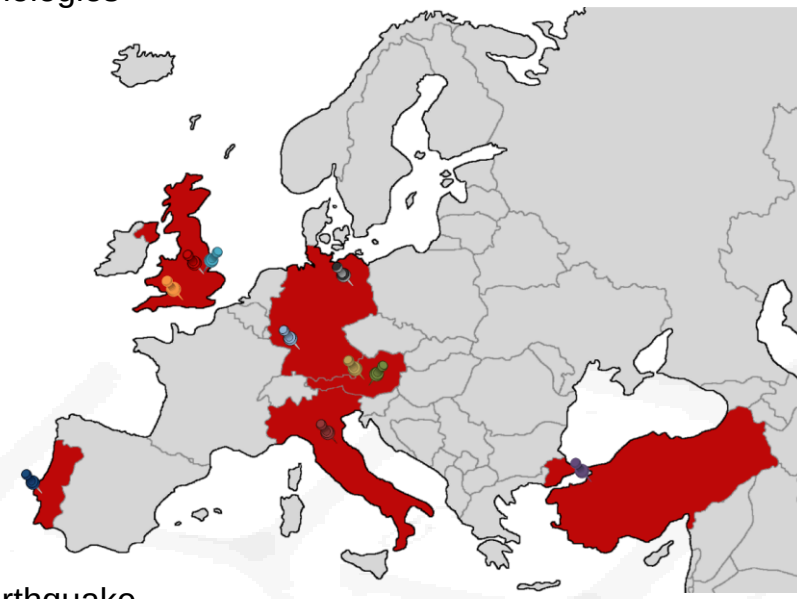
TRIDEC Partners

TRIDEC
Collaborative, Complex and Critical Decision-Support in Evolving Crises

www.tridec-online.eu

ICT-2009.4.3 Intelligent Information Management; 258723

- Helmholtz Centre Potsdam GFZ - German Research Centre for Geosciences *(Germany)* Centre for GeoInformation Technology
- University of Southampton, IT Innovation Centre *(United Kingdom)*
- Queen Mary and Westfield College, University of London - Department of Electronic Engineering *(United Kingdom)*
- JOANNEUM RESEARCH Forschungsgesellschaft mbH - DIGITAL - Institute of Information and Communication Technologies *(Austria)*
- IOSB - Fraunhofer-Institute of Optronics, System Technologies and Image Exploitation *(Germany)*
- TDE Thonhauser Data Engineering GmbH *(Austria)*
- Q-Sphere Limited *(United Kingdom)*
- Instituto de Meteorologia, I.P. - Departamento de
- Sismologia e Geofísica *(Portugal)*
- Alma Mater Studiorum- Universita di Bologna - Department of Physics *(Italy)*
- Bogazici Universitesi - Kandilli Observatory and Earthquake Research Institute *(Turkey)*



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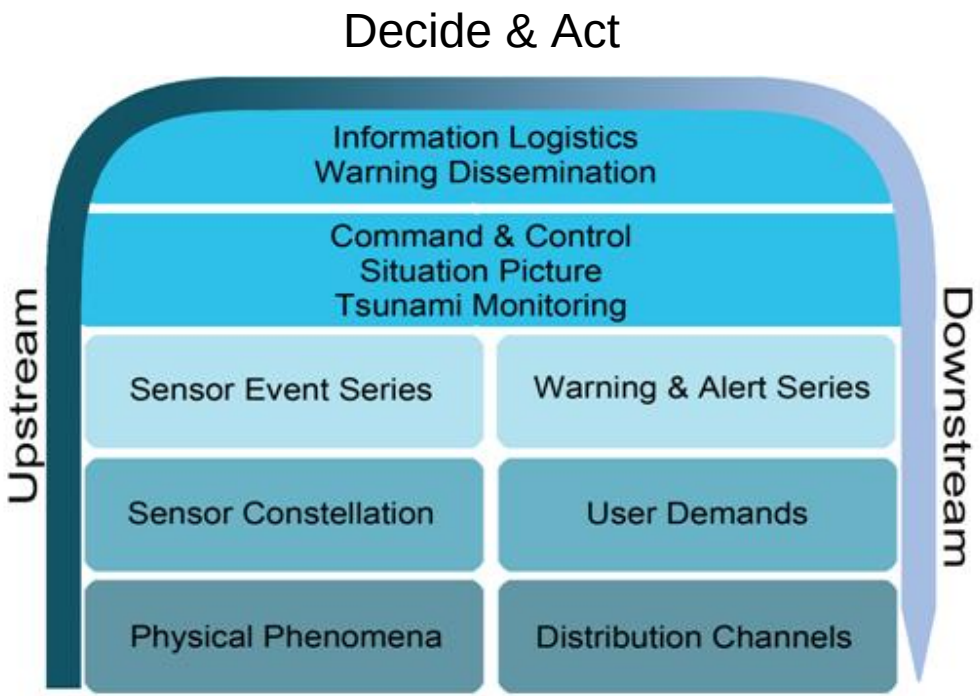
Integrated Approach

Development of warning system components:

- GITEWS: German Indonesian Tsunami Early Warning System, Sensor integration platform >> Upstream
- DEWS: Distant Early Warning System, FP6, Information logistics >> Downstream
- TRIDEC: Decision Support in Evolving Crisis, FP7 >> DSS Architecture



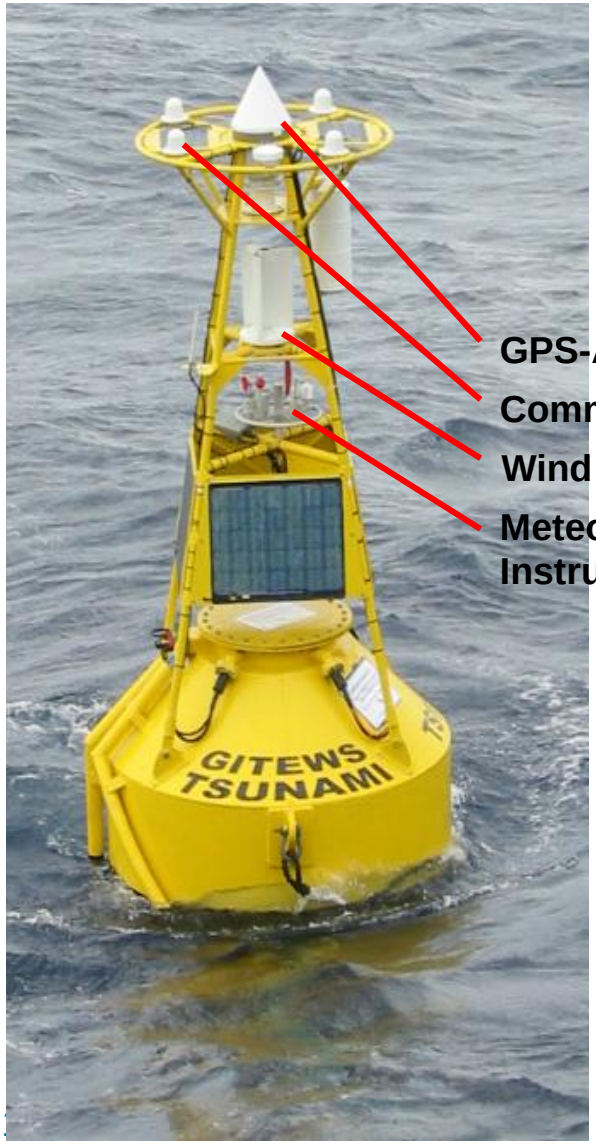
- Upstream
  - Sensor data
  - Context information
  - Dynamic evaluation and filtering
- Decide & Act
  - Decisions based on data and context information
  - Validation of alternatives
  - Initiation of warning activities
- Downstream
  - Preparation of Warning messages based on target group parameters
  - Multi-channel dissemination of messages
  - Control of actuators

Seismic Station Gunungsitoli (Nias)

Pegel mit GPS-Landstation

Tsunami Buoy System

Tsunami Buoy



GPS-Antenna

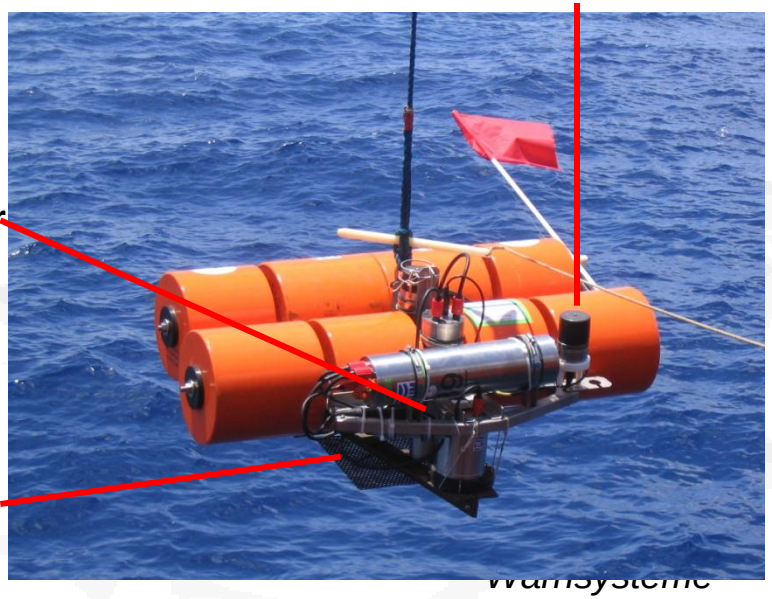
Communikation

Wind generator

Meteorological Instruments

Ocean Bottom Unit

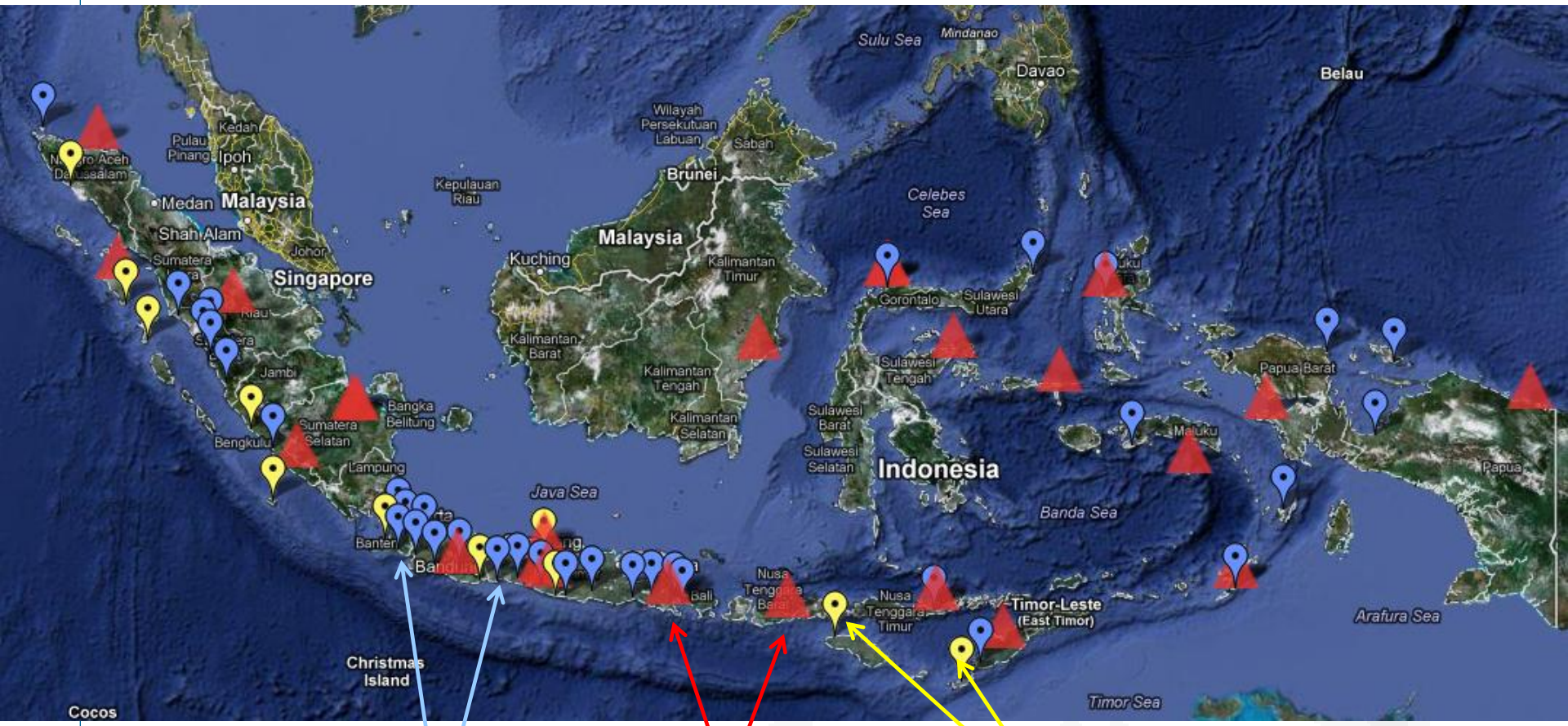
Acustic Modem



Pressure Sensor

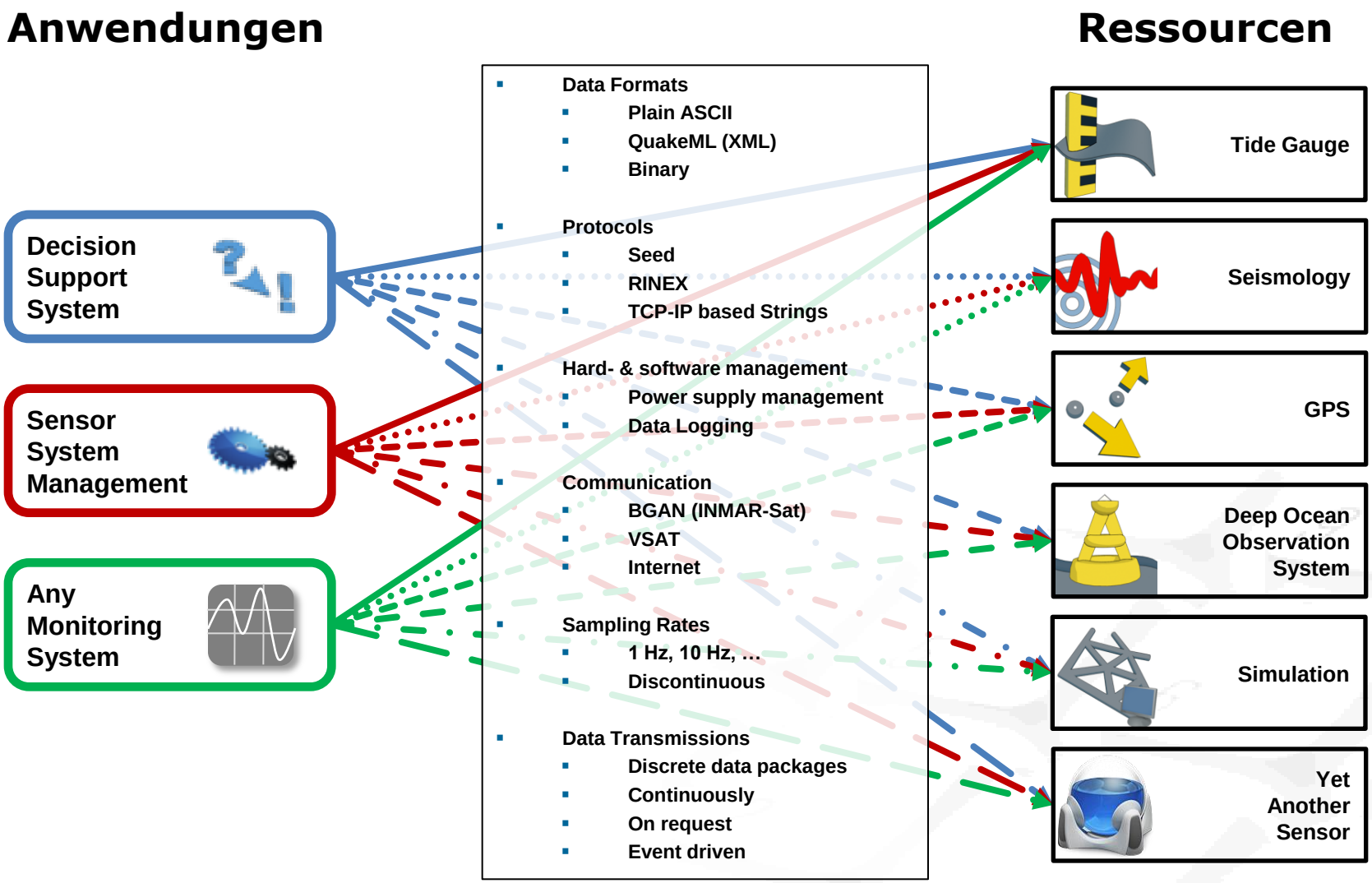
Ocean Bottom Seismometer

Sensor Network - Indonesia

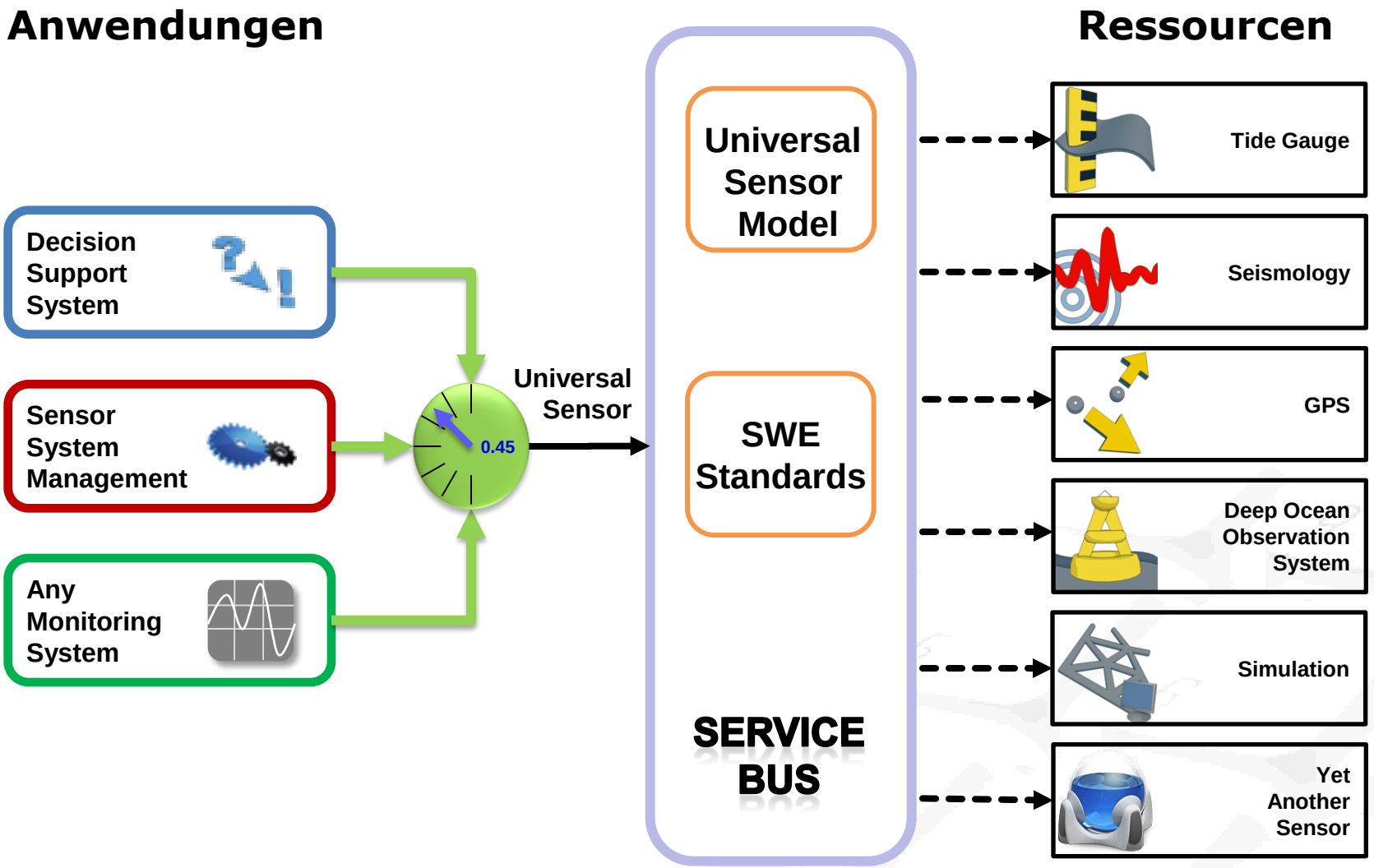


GPS Seismic station Tide gauge

Herausforderung Heterogenität



Lösung: Standardisierung



SWE Services

Services

- Sensor Observation Service **(SOS)**
  standardized access to sensor data
- Sensor Planning Service **(SPS)**
  controlling of sensors and sensor networks
- Sensor Alert Service **(SAS)**
  active sending of data if defined events occur
- Web Notification Service **(WNS)**
  conduction of asynchronous dialogues

SOS

SPS

SAS

WNS

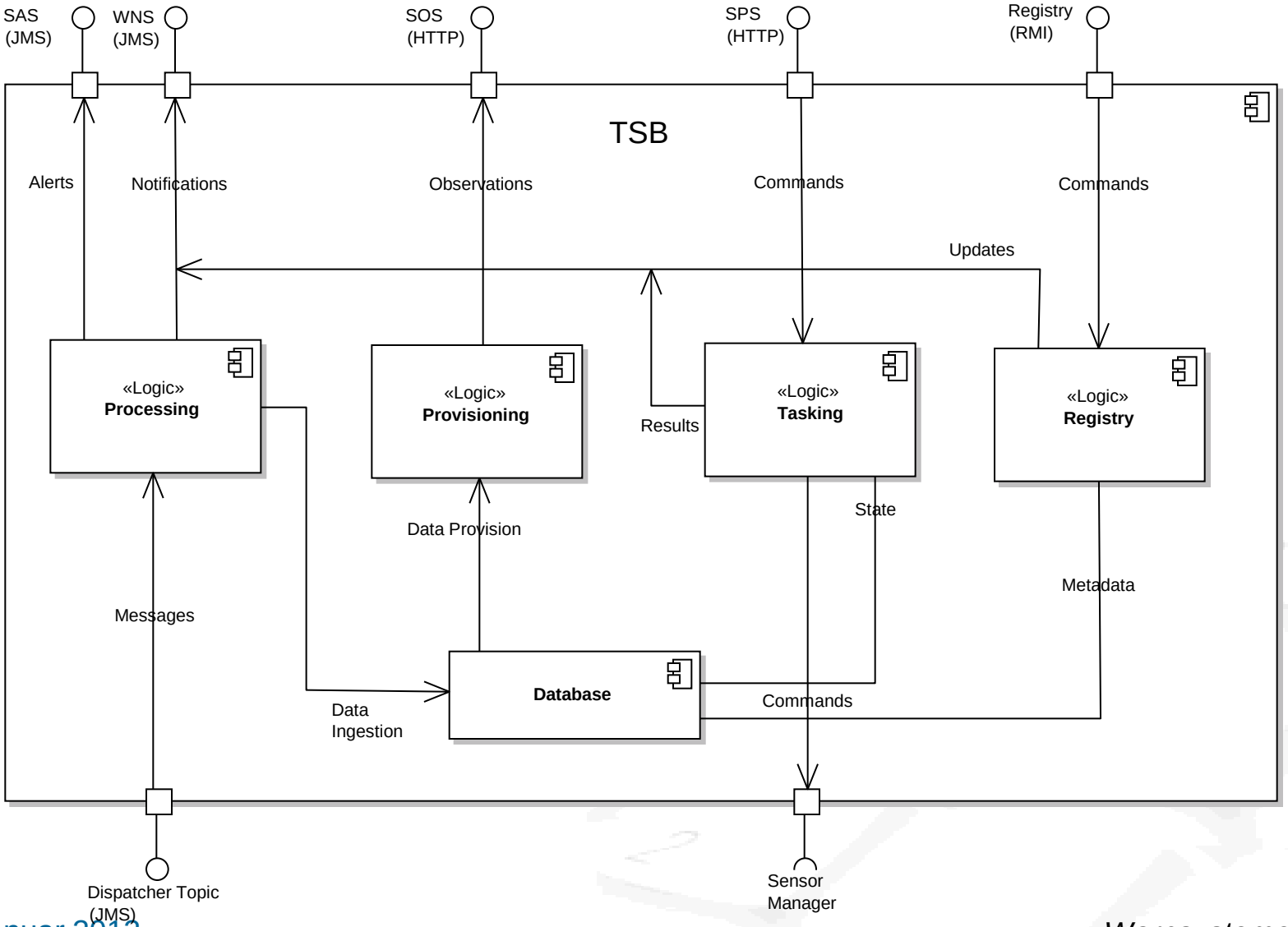
Encoding

- Sensor Model Language **(SensorML)**
  standardized description of sensors
- Observations and Measurements **(O&M)**
  model and encoding of sensor measurements

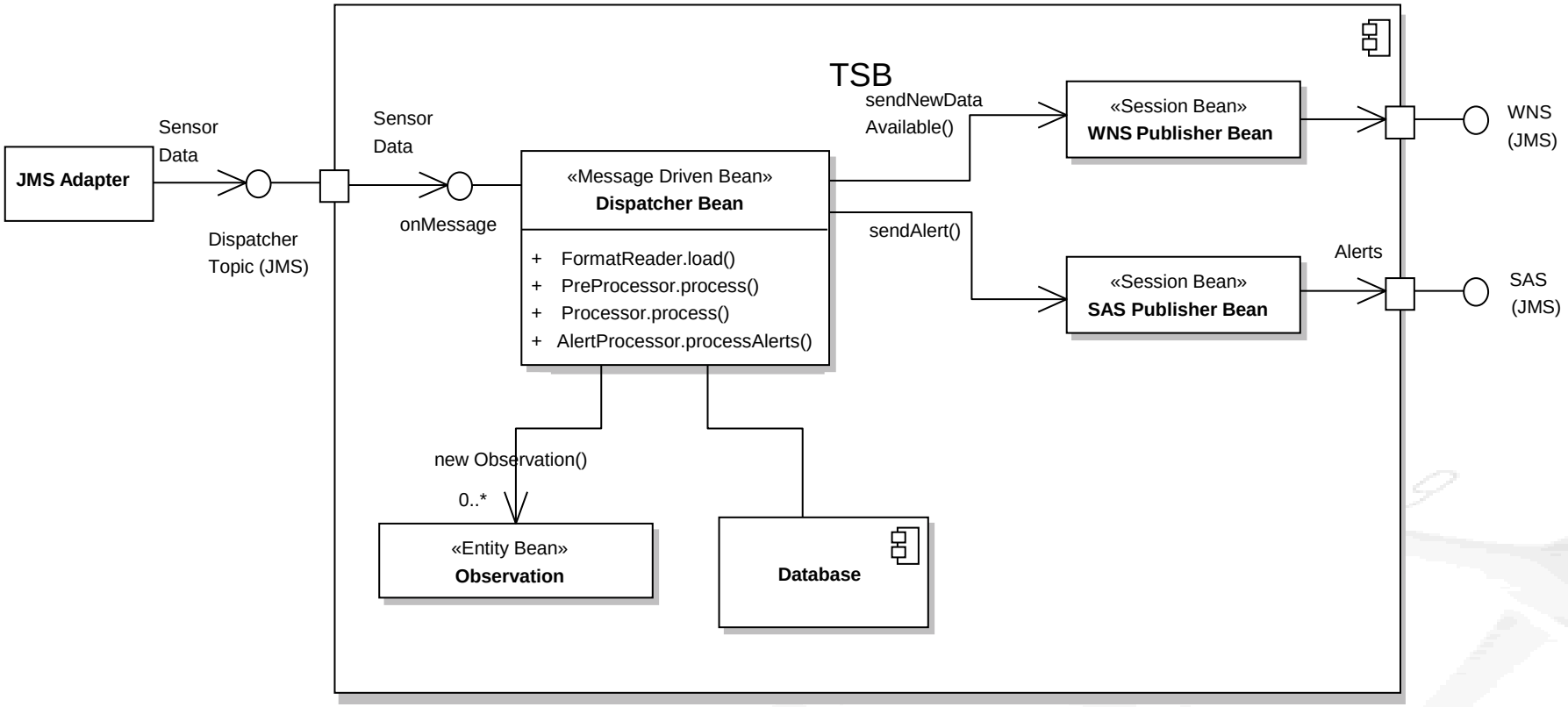
SensorML

O&M

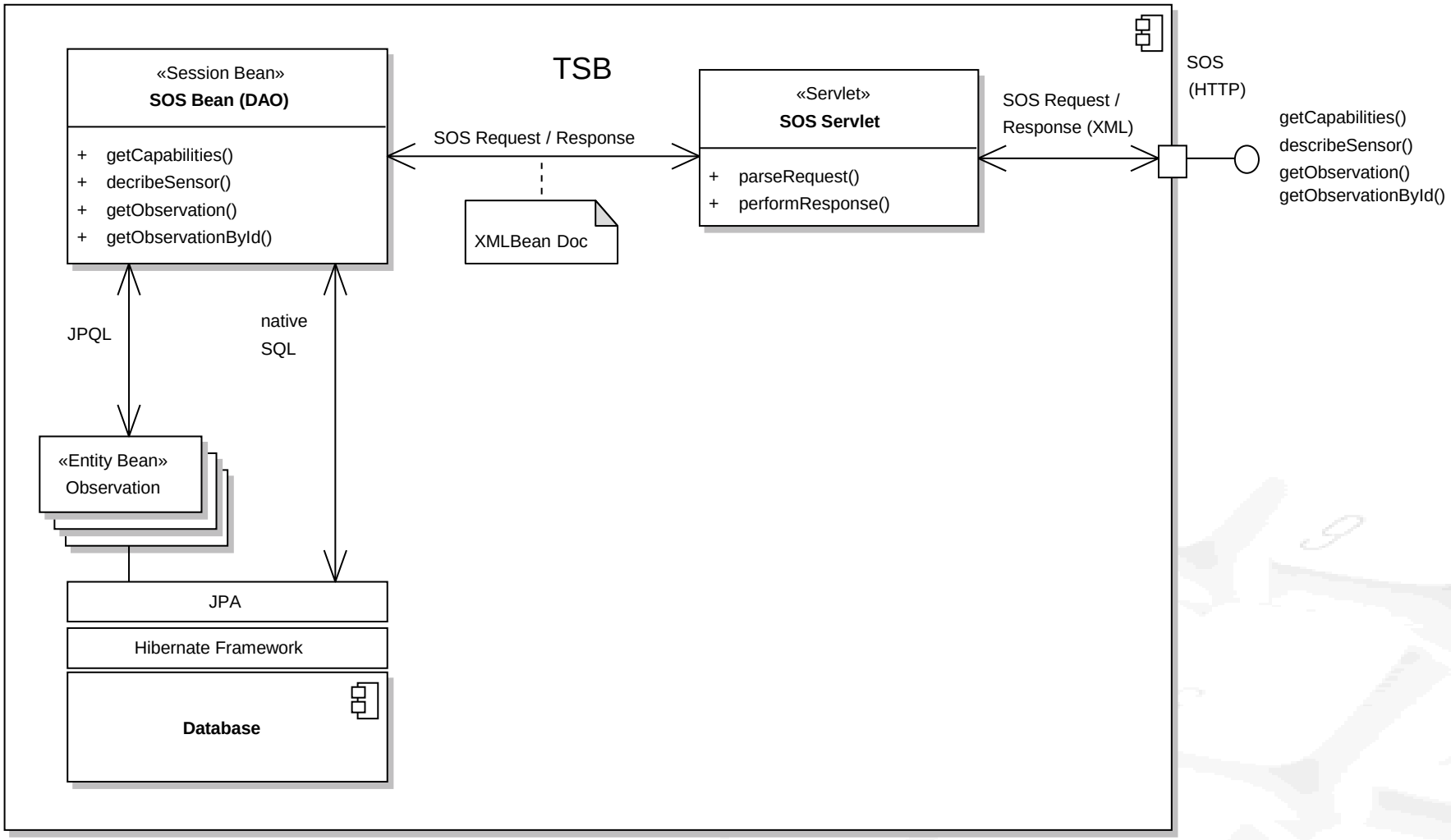
TSB - Funktionalität



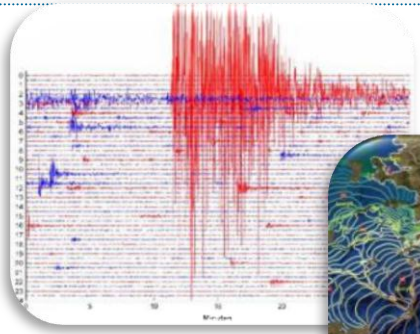
Processing


TSB
JMS Adapter
Sensor
Data
Dispatcher
Topic (JMS)
Sensor
Data
onMessage
«Message Driven Bean»
Dispatcher Bean
+ FormatReader.load()
+ PreProcessor.process()
+ Processor.process()
+ AlertProcessor.processAlerts()
sendNewData
Available()
«Session Bean»
WNS Publisher Bean
WNS
(JMS)
sendAlert()
Alerts
«Session Bean»
SAS Publisher Bean
SAS
(JMS)
new Observation()
0..*
«Entity Bean»
Observation
Database

Data Provisioning via SOS

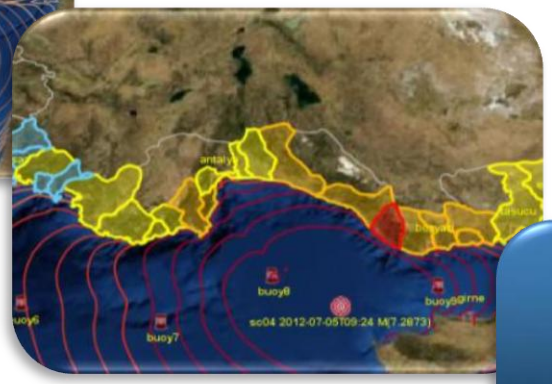


Decision Support



Step 1:
Monitor Earthquake Activity

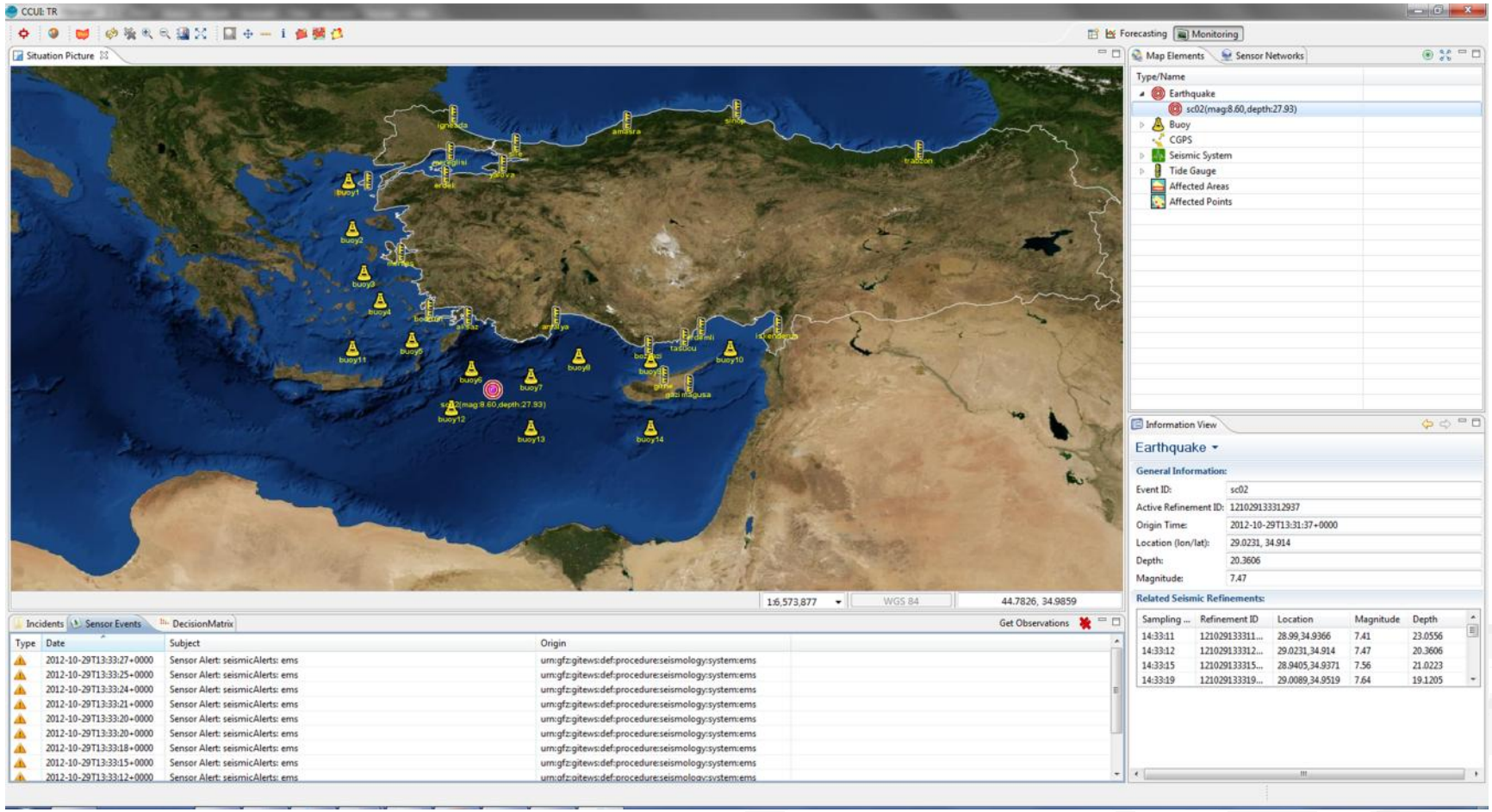
Step 2:
Detect Tsunami



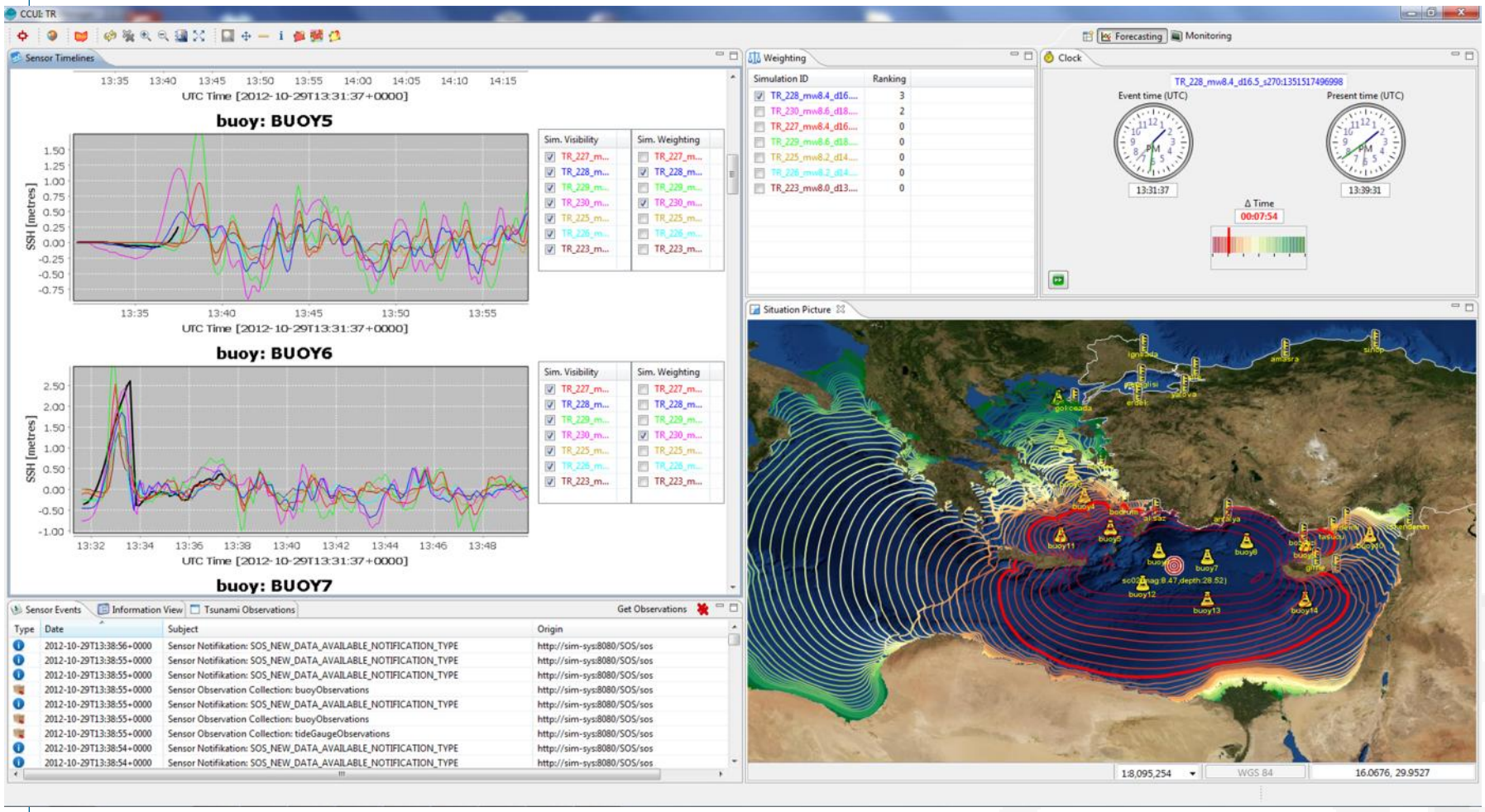
Step 3:
Detect Affected Areas

Step 4:
Issue Warning Messages

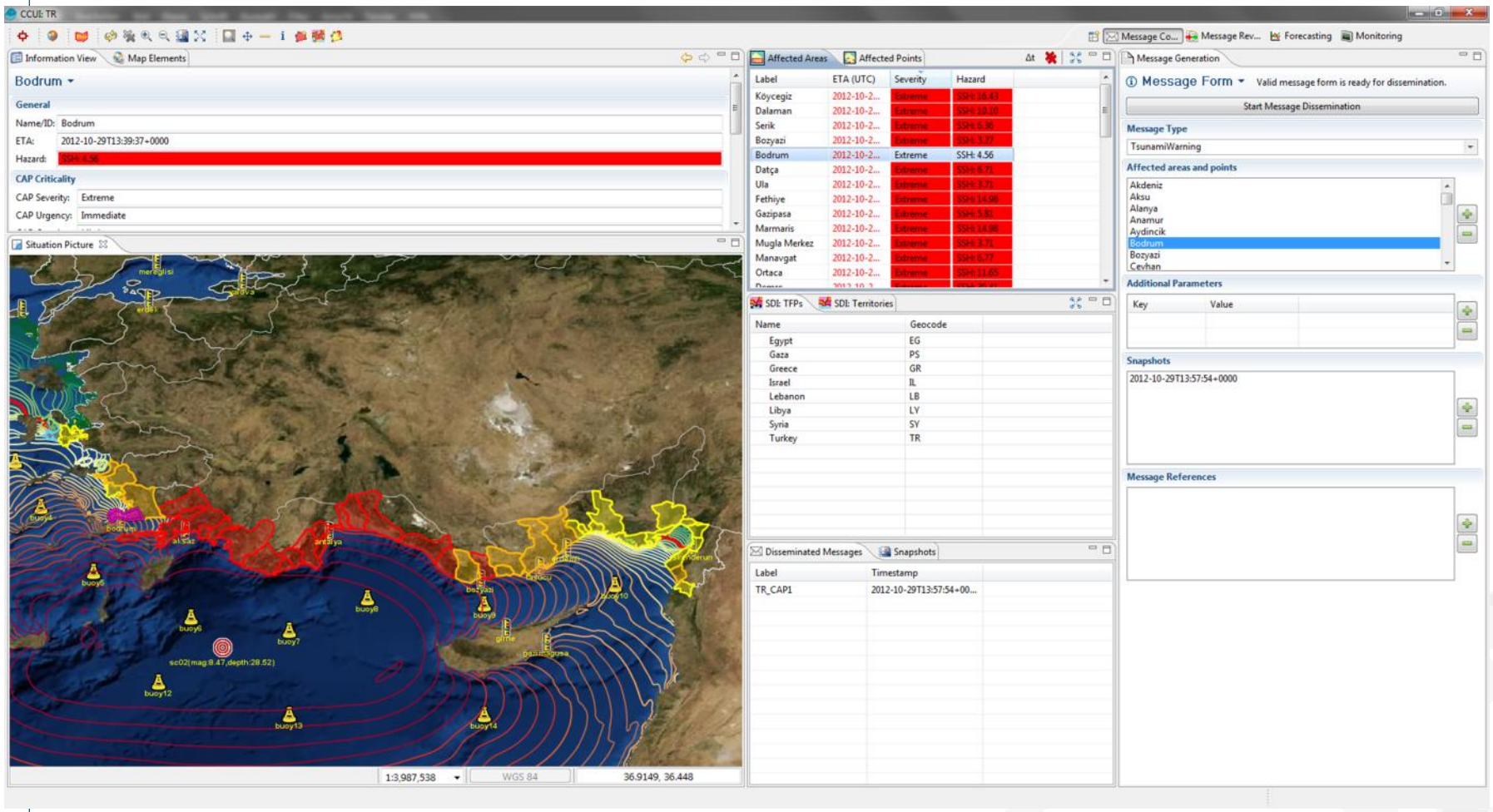
Step 1: Monitoring



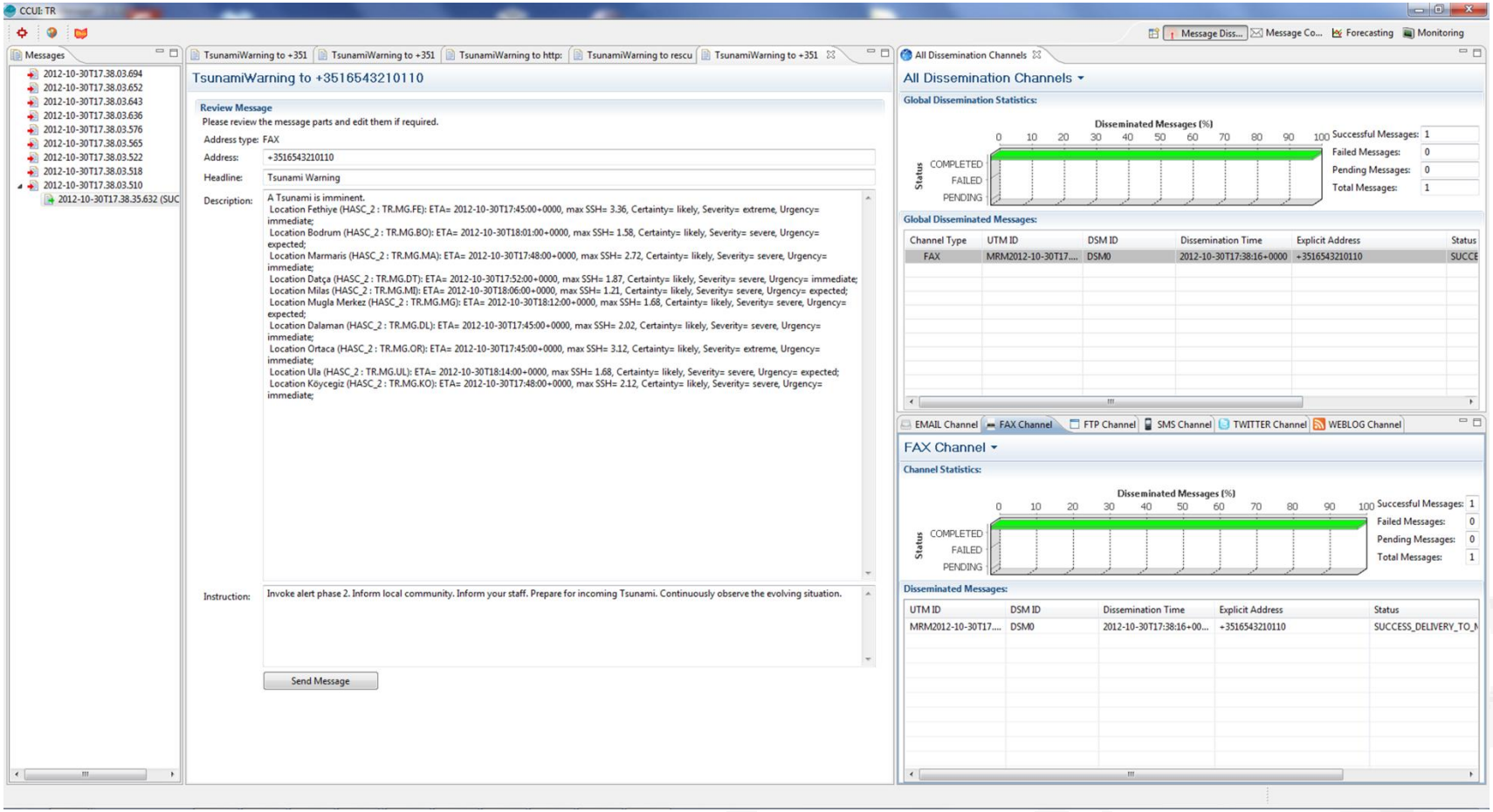
Step 2: Detect Tsunami



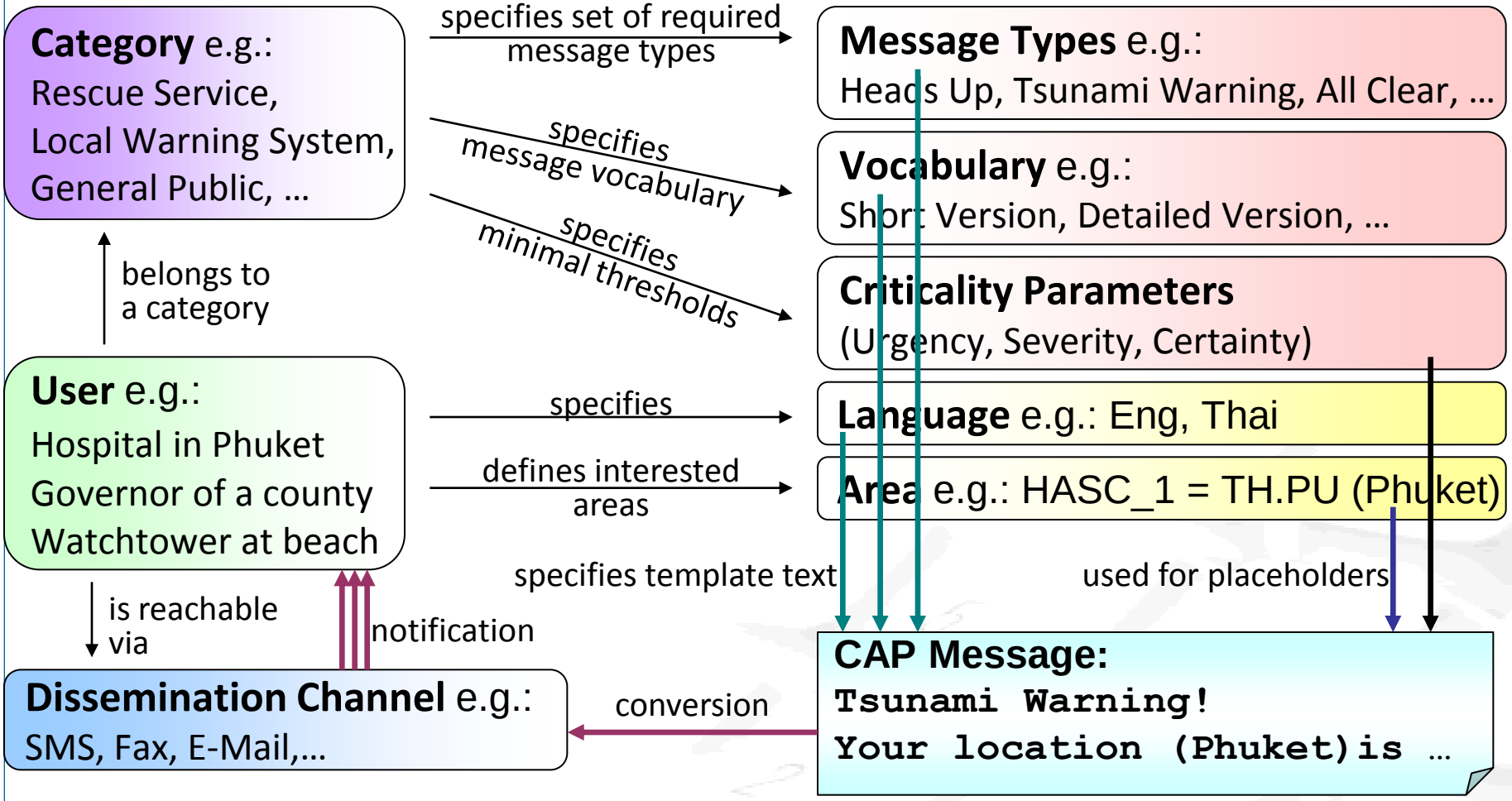
Step 3: Detect Affected Areas



Step 4: Issue Warning Messages



Downstream Information Provision



Communication Example PTWC

WEAK51 PAAQ 030202
TSUNAMI BULLETIN NUMBER 004
PACIFIC TSUNAMI WARNING CENTER
0902 PM HST 03 SEP 2005

TO - CIVIL DEFENSE IN THE STATE OF HAWAII

SUBJECT - TSUNAMI WARNING BULLETIN
A **TSUNAMI WARNING IS ISSUED FOR THE STATE OF HAWAII** EFFECTIVE AT 0902 PM HST.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS
ORIGIN TIME - 0112 PM HST 03 SEP 2005
COORDINATES - 16.0 SOUTH 73.3 WEST
LOCATION - NEAR COAST OF PERU
MAGNITUDE - 8.2 MOMENT
MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION LAT LON TIME AMPL PER
Arica, Chile 18.1S 178.4W 0050Z 0.88M 12MIN
Antofagasta, Chile 17.8S 168.3E 0220Z 0.91M 10MIN

Communication Example PTWC cont.

TIME - TIME OF THE MEASUREMENT

AMPL - AMPLITUDE IN METERS FROM MIDDLE TO CREST OR MIDDLE TO TROUGH OR HALF OF THE CREST TO TROUGH

PER - PERIOD OF TIME FROM ONE WAVE CREST TO THE NEXT EVALUATION

A TSUNAMI HAS BEEN GENERATED THAT COULD CAUSE DAMAGE ALONG COASTLINES OF ALL ISLANDS IN THE STATE OF HAWAII. URGENT ACTION SHOULD BE TAKEN TO PROTECT LIVES AND PROPERTY.

A TSUNAMI IS A SERIES OF LONG OCEAN WAVES. EACH INDIVIDUAL WAVE CREST CAN LAST 5 TO 15 MINUTES OR MORE AND EXTENSIVELY FLOOD COASTAL AREAS. THE DANGER CAN CONTINUE FOR MANY HOURS AFTER THE INITIAL WAVE AS SUBSEQUENT WAVES ARRIVE. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND THE FIRST WAVE MAY NOT BE THE LARGEST. TSUNAMI WAVES EFFICIENTLY WRAP AROUND ISLANDS. ALL SHORES ARE AT RISK NO MATTER WHICH DIRECTION THEY FACE. THE TROUGH OF A TSUNAMI WAVE MAY TEMPORARILY EXPOSE THE SEAFLOOR BUT THE AREA WILL QUICKLY FLOOD AGAIN. EXTREMELY STRONG AND UNUSUAL NEARSHORE CURRENTS CAN ACCOMPANY A TSUNAMI. DEBRIS PICKED UP AND CARRIED BY A TSUNAMI AMPLIFIES ITS DESTRUCTIVE POWER. SIMULTANEOUS HIGH TIDES OR HIGH SURF CAN SIGNIFICANTLY INCREASE THE TSUNAMI HAZARD.

THE ESTIMATED ARRIVAL TIME IN HAWAII OF THE FIRST TSUNAMI WAVE IS
0221 AM HST 04 SEP 2005

BULLETINS WILL BE ISSUED HOURLY OR SOONER AS CONDITIONS WARRANT.
$$

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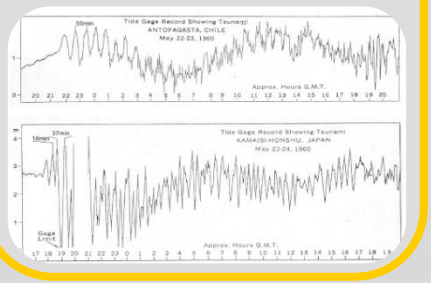
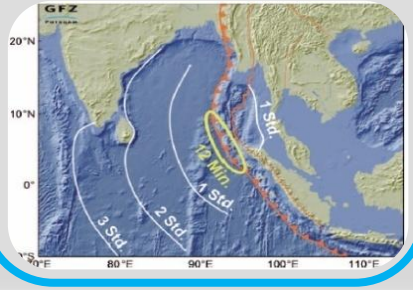
SOA!?

Applications

Monitoring



Simulation Modeling



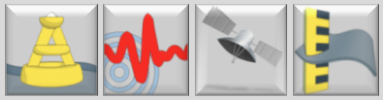
Warning

Service Platform

Simulation	Sensors (SWE)	Geodata (OWS)	Dissemination
Grid	SOS	SAS	CS-W	WFS	CAP
WPS	SPS	WNS	WMS	WCS	EDXL

Ressources

Server

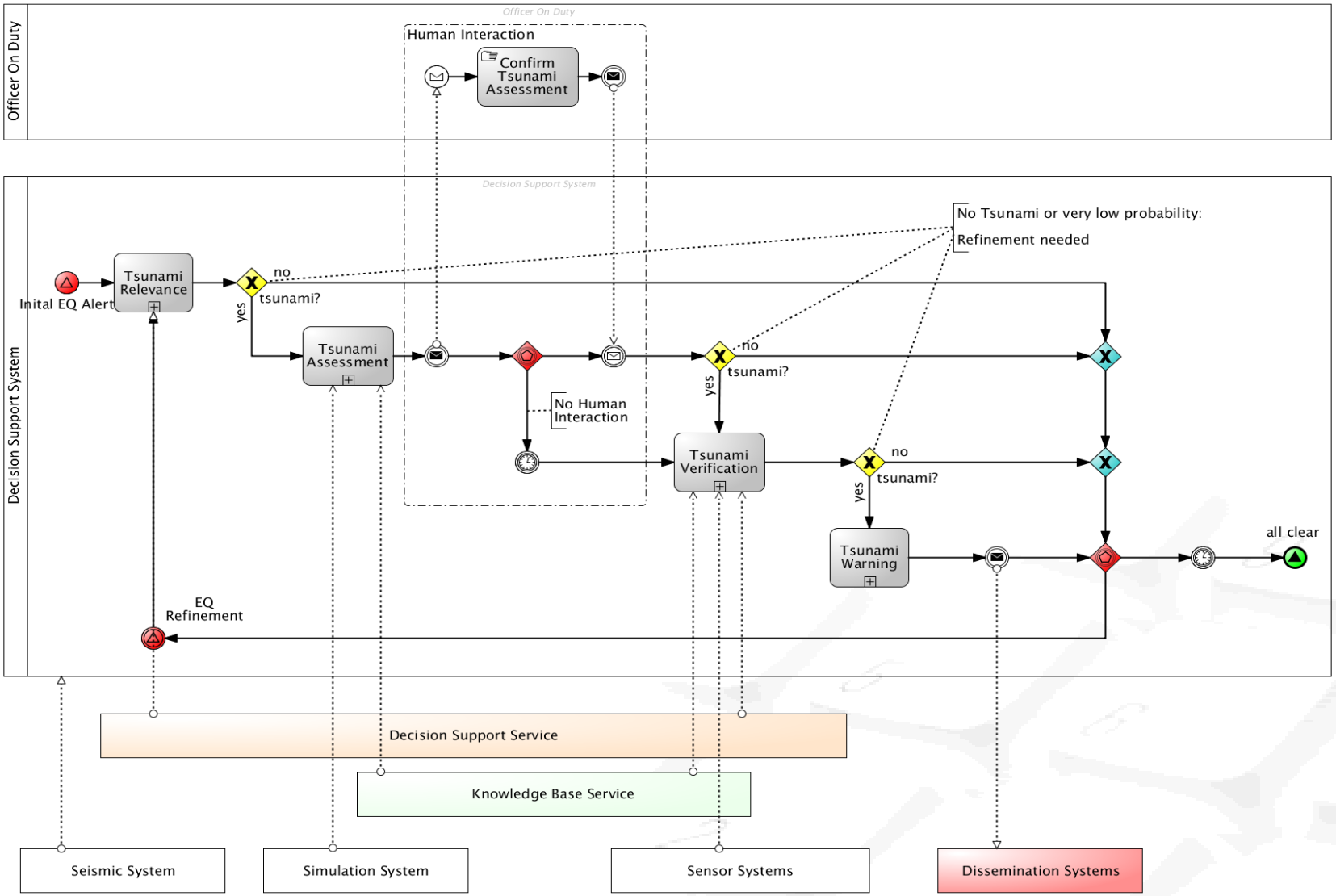


Sensor Systems

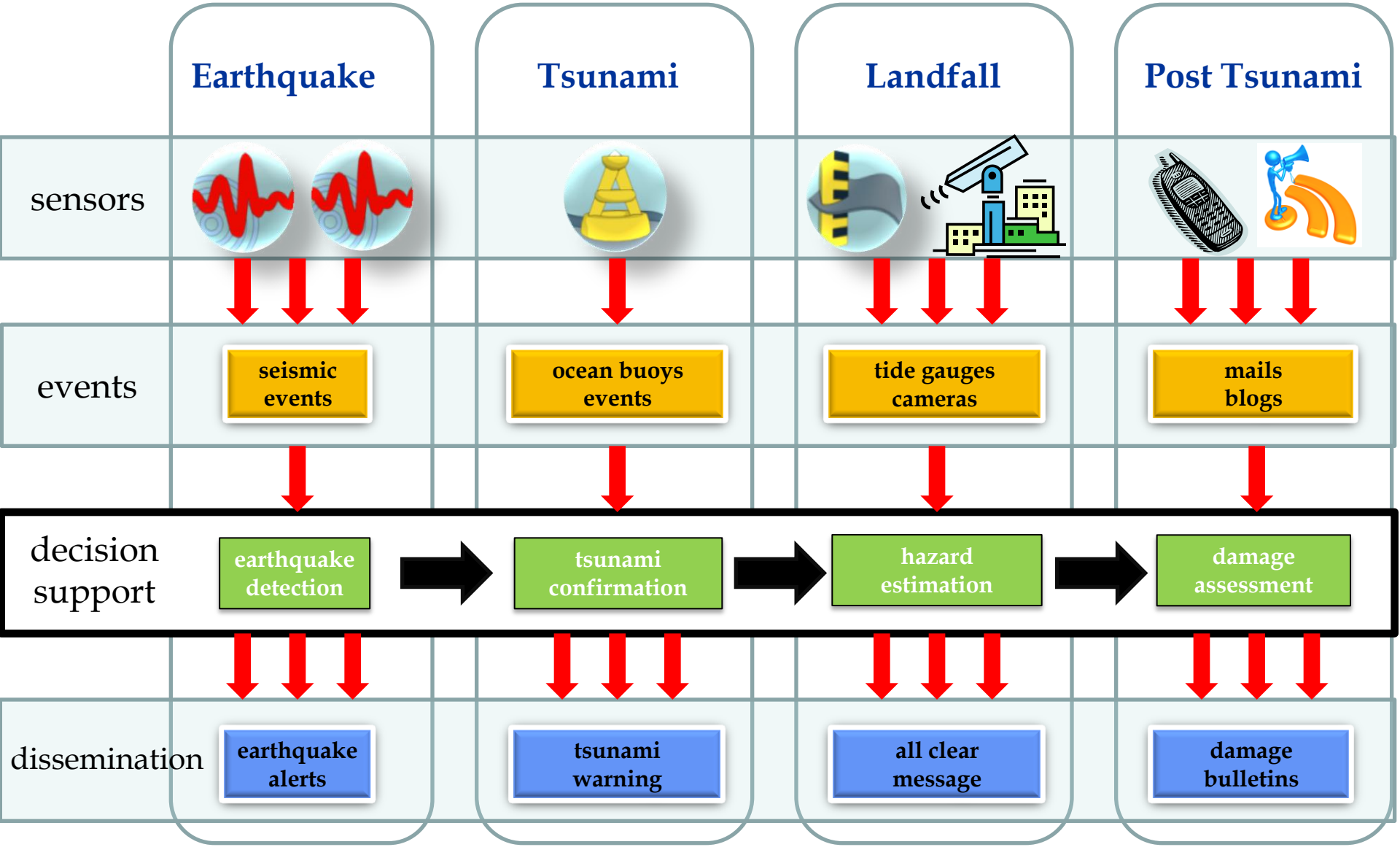
Repositories

Dissemination Channels

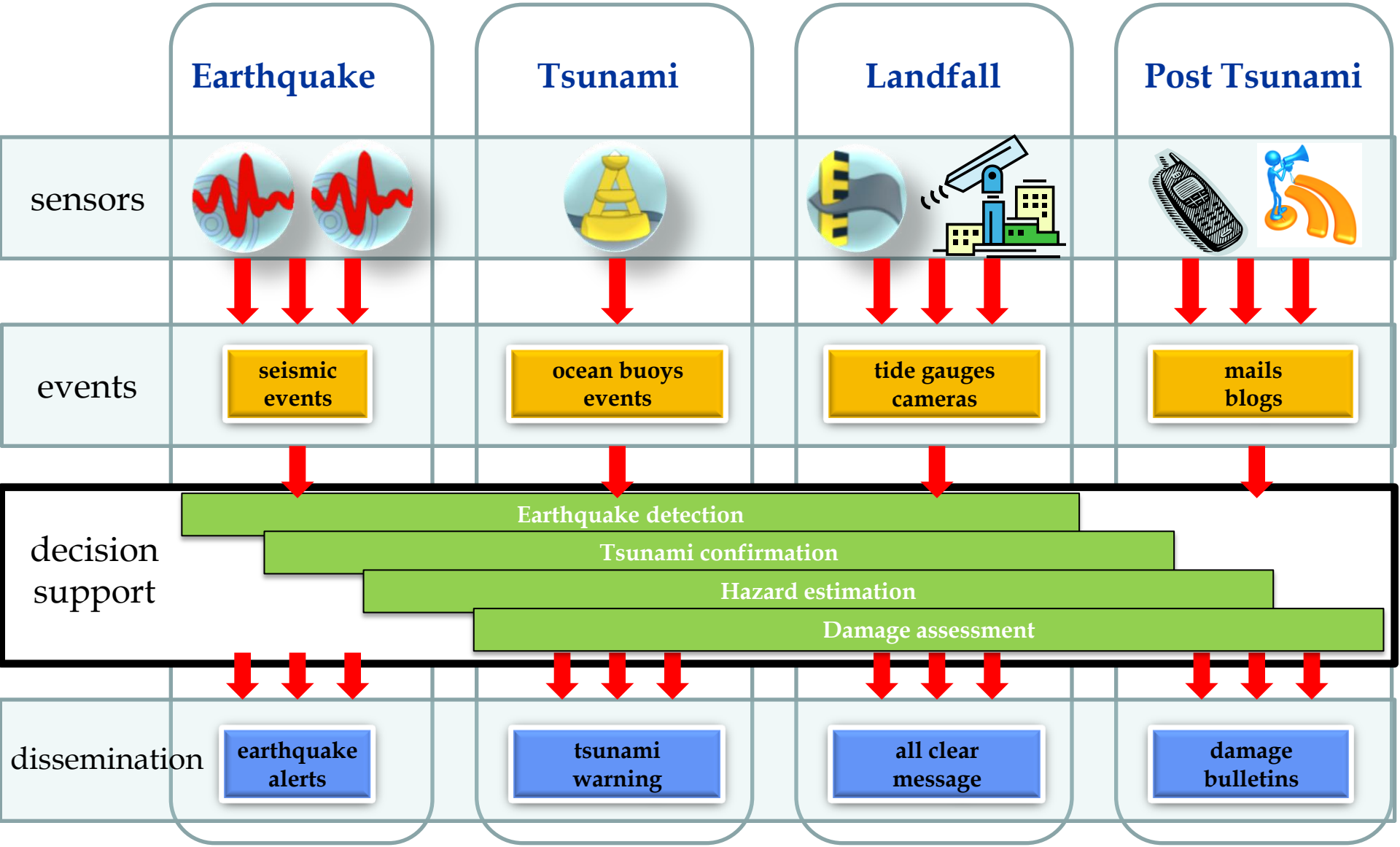
General Information Flow



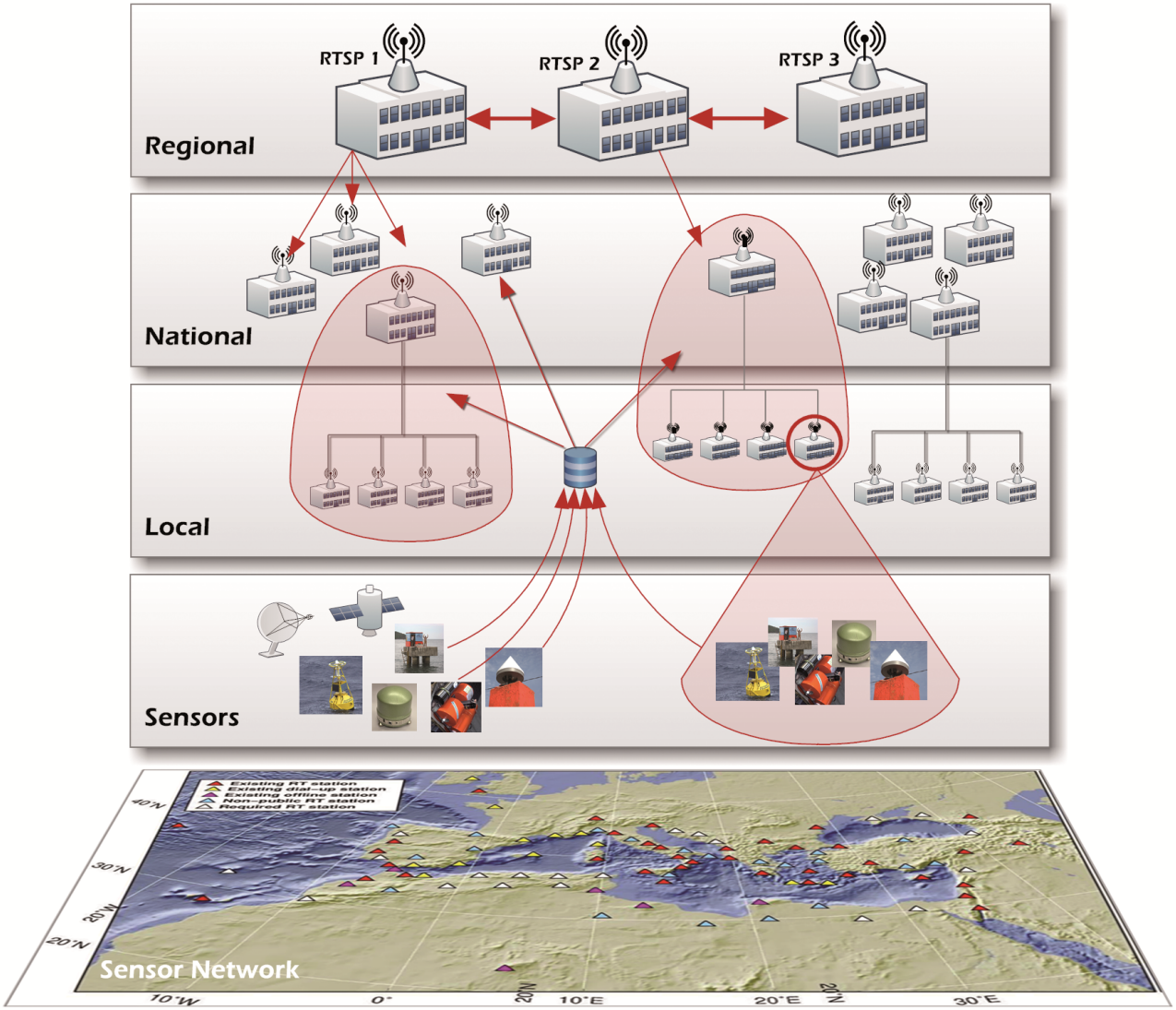
Events überall!



Überlappende Phasen



Warnsysteme im Mittelmeerraum



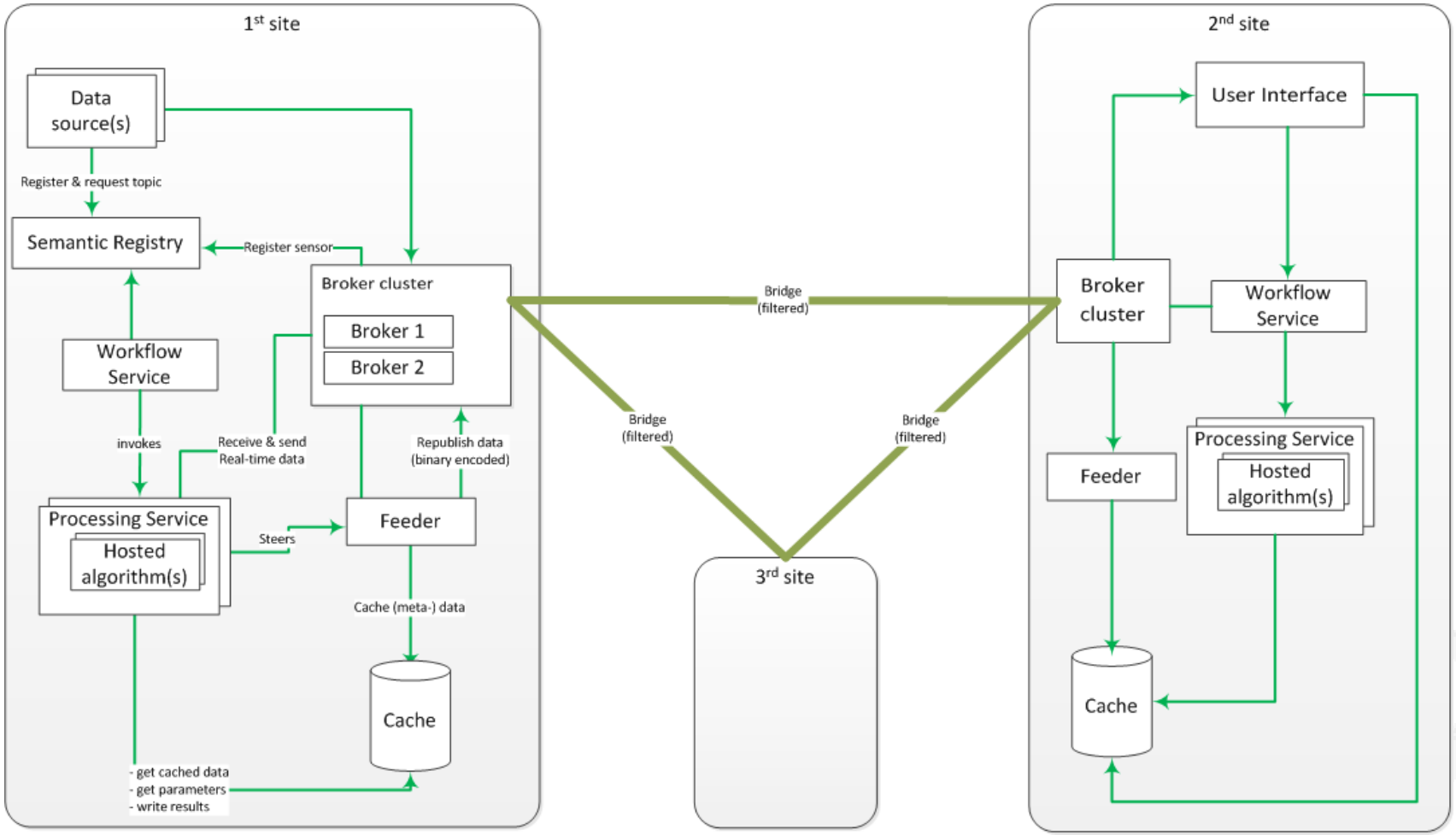
System-of-Systems

- Operational / managerial independence of the elements
  - Different governments and institutions
  - Warning Centres, Task Forces, Scientific Institutions, Data Centres
- Evolutionary development
  - Integration of new sensors
  - Analysis algorithms
- Geographic distribution
  - Tsunami Early Warning System for the Euro-Mediterranean area (> 20 national and at least one regional centre)
- Examples:
  - Spacial Data Infrastructures (GDI-DE, INSPIRE)
  - GEOSS Global Earth Observing System-of-Systems
- Emergent behaviour
  - Combines the knowledge of parts
  - Platform for new developments

Message Broker

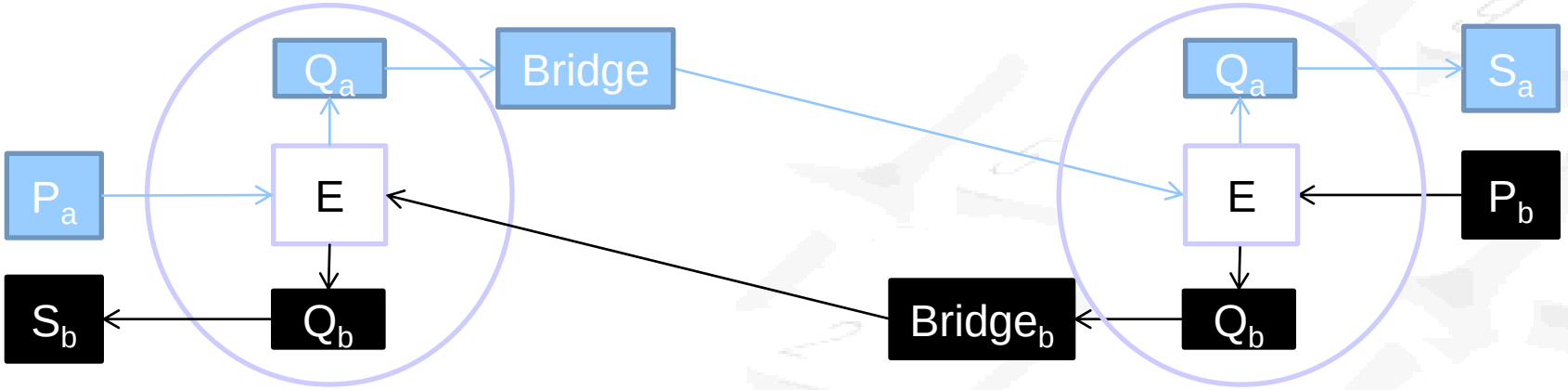
- Unterstützung der asynchronen oder synchronen Kommunikation von Komponenten und Systemen durch die Übertragung von Nachrichten
- Vorteile
  - Lose Kopplung von Server/Clients, bzw. Systemen
  - Message-Warteschlangen
  - Parallele Verarbeitung von Nachrichten
  - Unabhängige Weiterentwicklung von Komponenten und Systemen
- Kommunikationsprotokolle
  - Message Passing: Direkte Kommunikation zwischen Anwendungen
  - Message Queueing: Indirekte Kommunikation über eine Warteschlange
  - Publish & Subscribe: Herausgeber publiziert Nachrichten für Abonnenten

Generic TRIDEC Architecture



Broker Federation

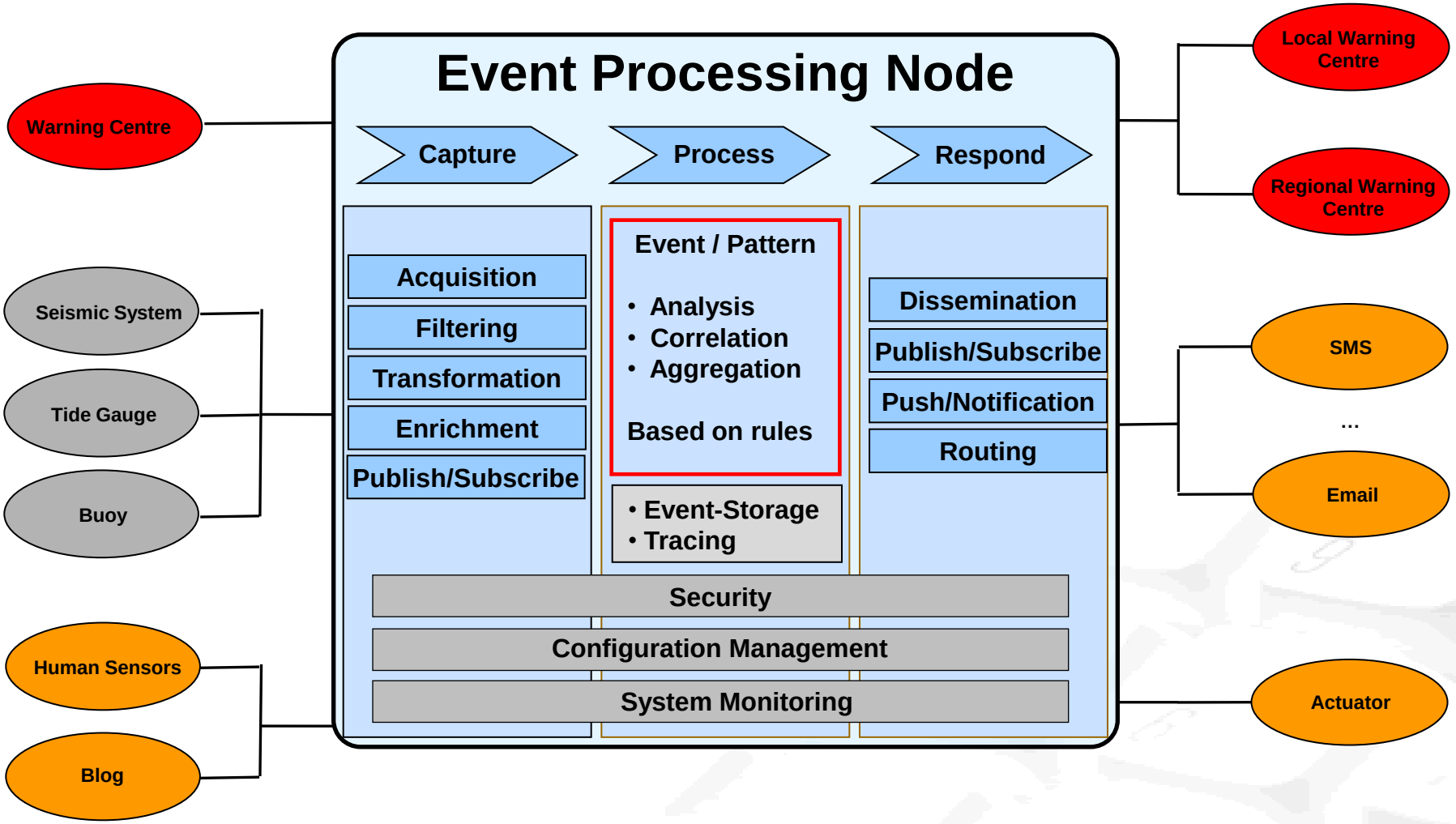
- Java Qpid does not directly provide broker federation functionality
- To provide broker-to-broker communication a “Bridge” is developed
  - A MoM Client
  - Receives messages from local broker and sends the message to the message queue in remote broker



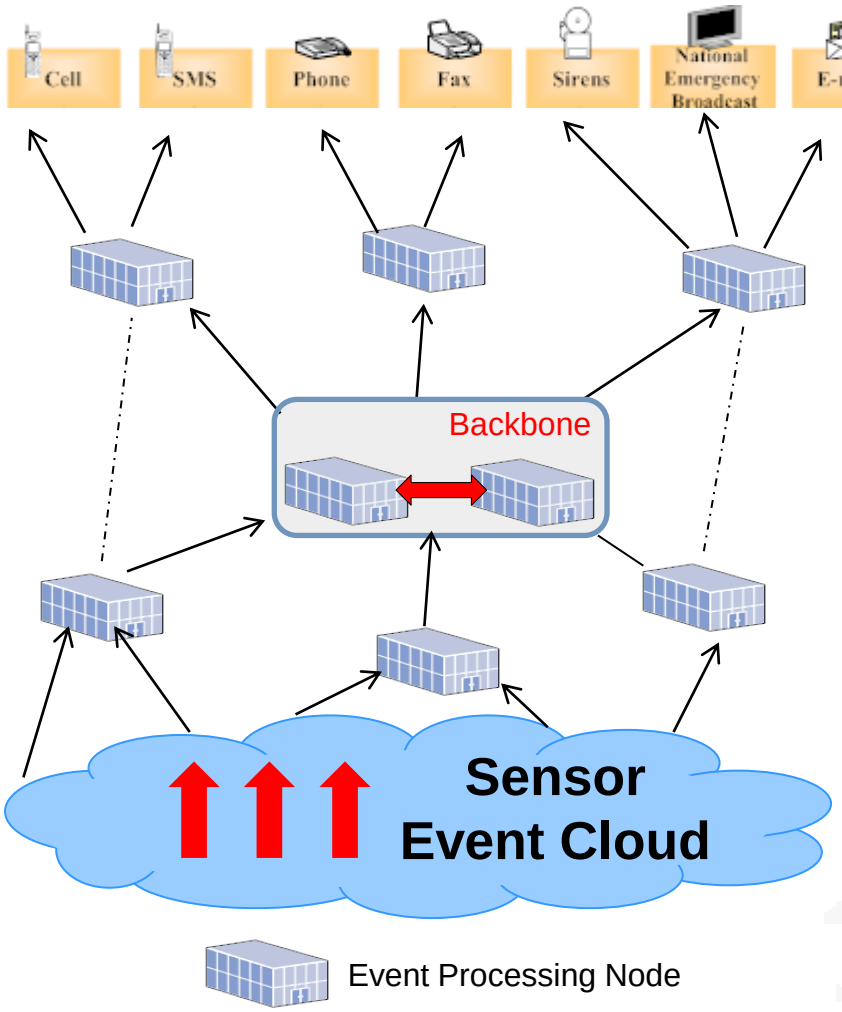
Distributed Management Agent (MA)

- Each broker has its related MA
- In general, a MA consists of following components:
  - Detectors
    - Load Detector: detect the load status of broker
    - Link Detector: detect link state
    - Failure Detector: detect the broker failure
  - Load Analyser
    - Analyse the load distribution
  - Resilience Manager
    - Compute resilience policy, e.g., mirroring, workload allocation
  - Overlay Manager
    - Interact with clients, e.g., allocate brokers to client

Event Processing Node



Event Processing Network



- Connection and collaboration of warning centres via Message Broker
  - Sensor systems to warning centre
  - Warning centre to warning centre
  - e.g. National to local warning centre
- Broker dedicated to communication
  - Sensor events
  - warning messages
  - Load and link management
  - Resilience
  - Robustness
- Components/Systems responsible for their reaction
  - Specific business processes
  - Information logistics
- Implementation of **System of Systems** (SoS)

Entwicklung von Warnsystemen

++ Verfahren der Informationslogistik
- Vom Monitoring zu endscheidungsrelevanten Informationen
- Detektion von Ereignissen
- Analyse von Auswirkungen
- Einbettung in spezifische Kontextinformation und Dissemination

++ Verfügbarkeit von Komponenten
- Sensor-Systeme
- Service-Plattformen
- Decision Support
- Knowledgebase einschl. Registries

++ Referenz-Architektur
- Spezifikation von Referenzmodellen
- Enwurfsmuster für Schnittstellen und Interaktionen
- Ergebnisse als FOSS veröffentlicht und verfügbar

\+ Standardisierung der Betriebsabläufe von Warnzentren (ITIL)

\+ Integration von Warnzentren in übergeordnete Infrastrukturen

Perspektiven

- Weiterentwicklung der Sensorik
  - Sensor-Plattformen (Hardware, Software, Kommunikation)
  - IPv6
  - Social Networks, Crowd Sourcing, Human Sensors
- Ubiquitous Computing
  - Daten-Akquisition
  - Internet of Things
  - Personalisierte Entscheidungsunterstützung
- Neue Betriebskonzepte für Warnsysteme
  - Simulation: Infrastructure-as-a-Service (IaaS)
  - Sensor-Systeme oder Warnsysteme: Software-as-a-Service (SaaS)
- Neue Konzepte für Warnsysteme
  - Hochauflösende Monitoring-Konzepte
  - Adaptives Verhalten im Krisenfall
  - Anpassbarkeit von SOPs
  - Test von produktiven Systemen