



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

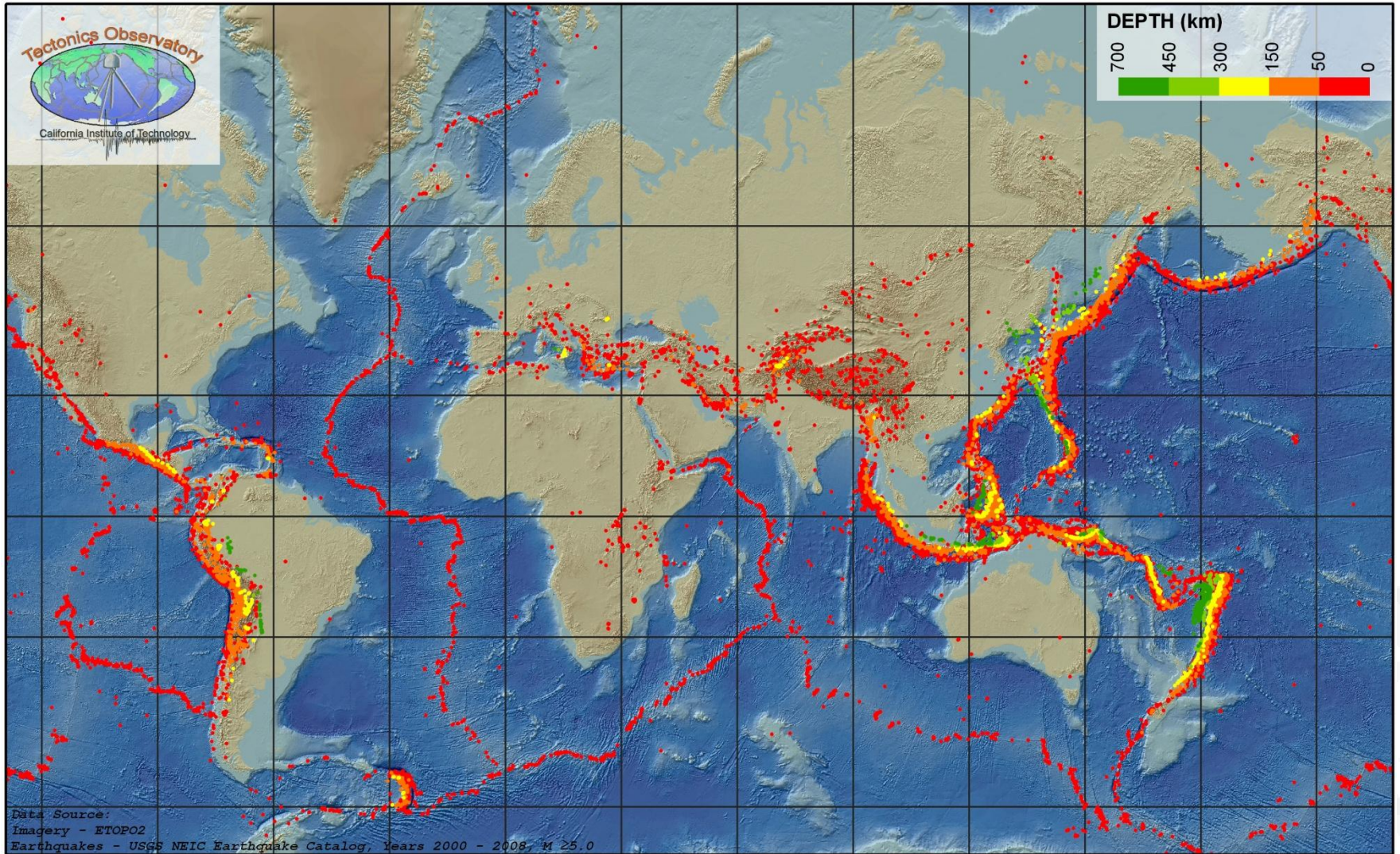
J. Wächter
Centre for GeoInformation Technology - CeGIT
Deutsches GeoForschungsZentrum - GFZ

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

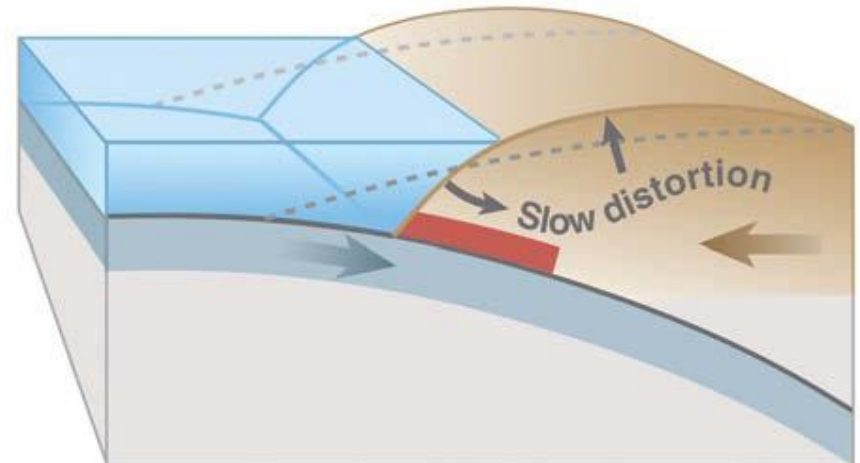
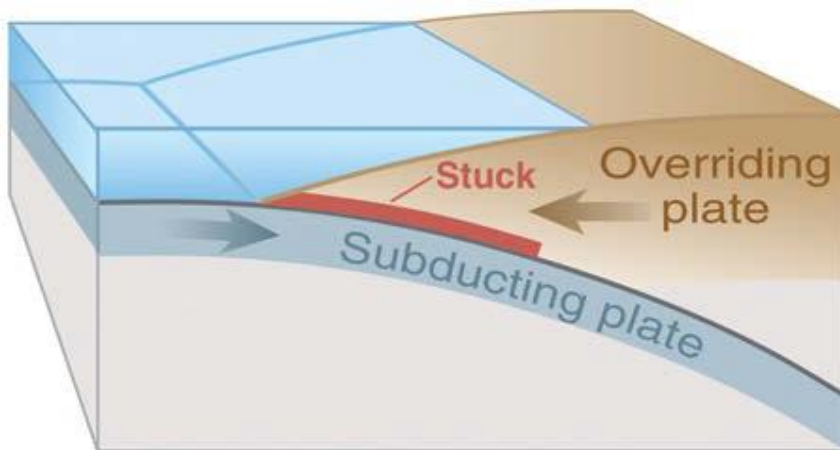
- 25.000 und 5000 v. Chr.: Storegga-Ereignis am Kontinentalhang vor Norwegen
- 16. Jh. v. Chr. Vulkanexplosion auf Santorin
- 1755: Erdbeben von Lissabon
- 1960: Erdbeben von Valdivia, Chile 1000 Opfer durch Tsunami
- 26. Dezember 2004: Erdbeben vor Sumatra, Magnitude um 9,3 mit 230000 Opfern
- ...



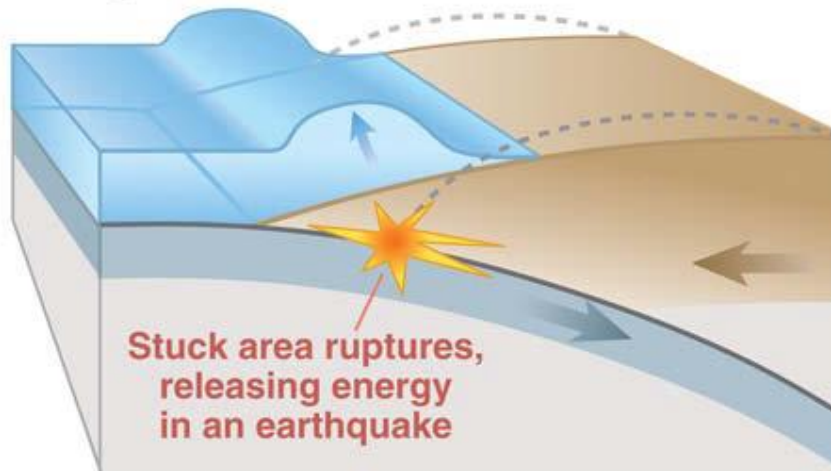
Thailand 2004

<http://de.wikipedia.org/wiki/Tsunami>

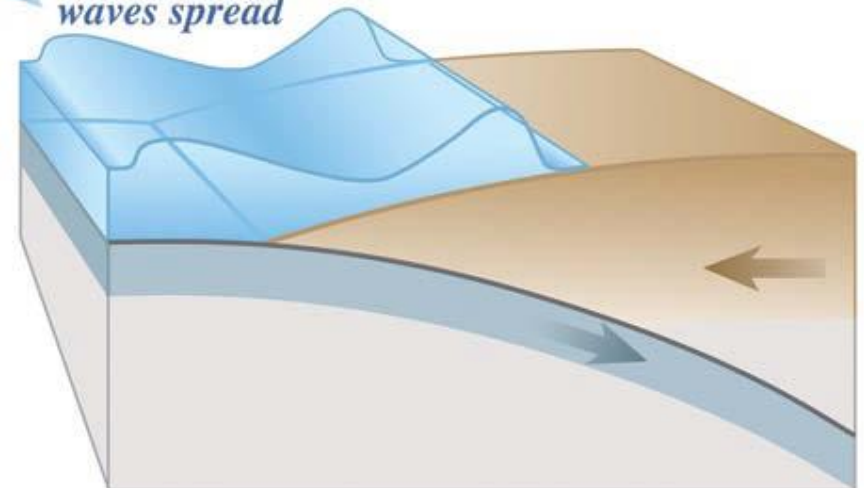
Tsunami Generation



Earthquake starts tsunami



Tsunami waves spread



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

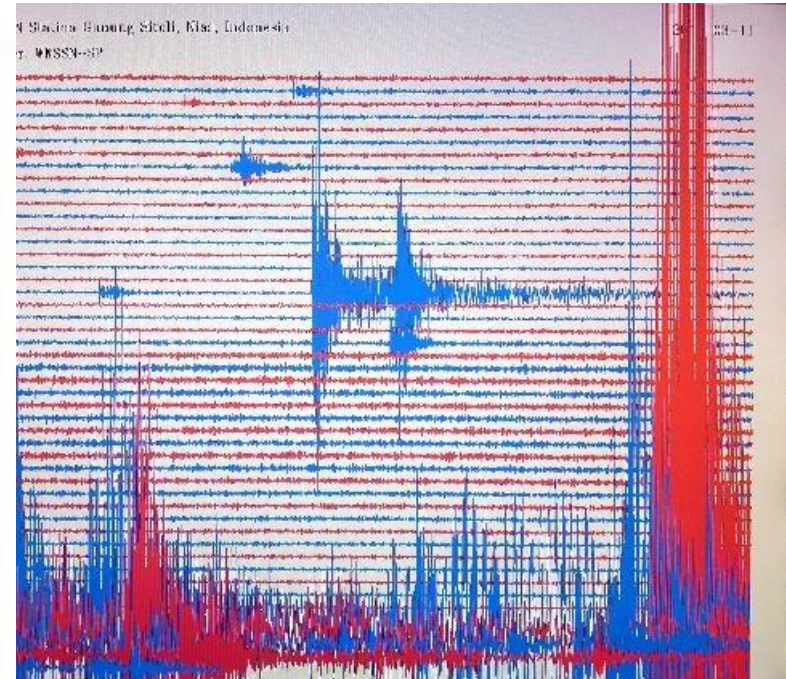
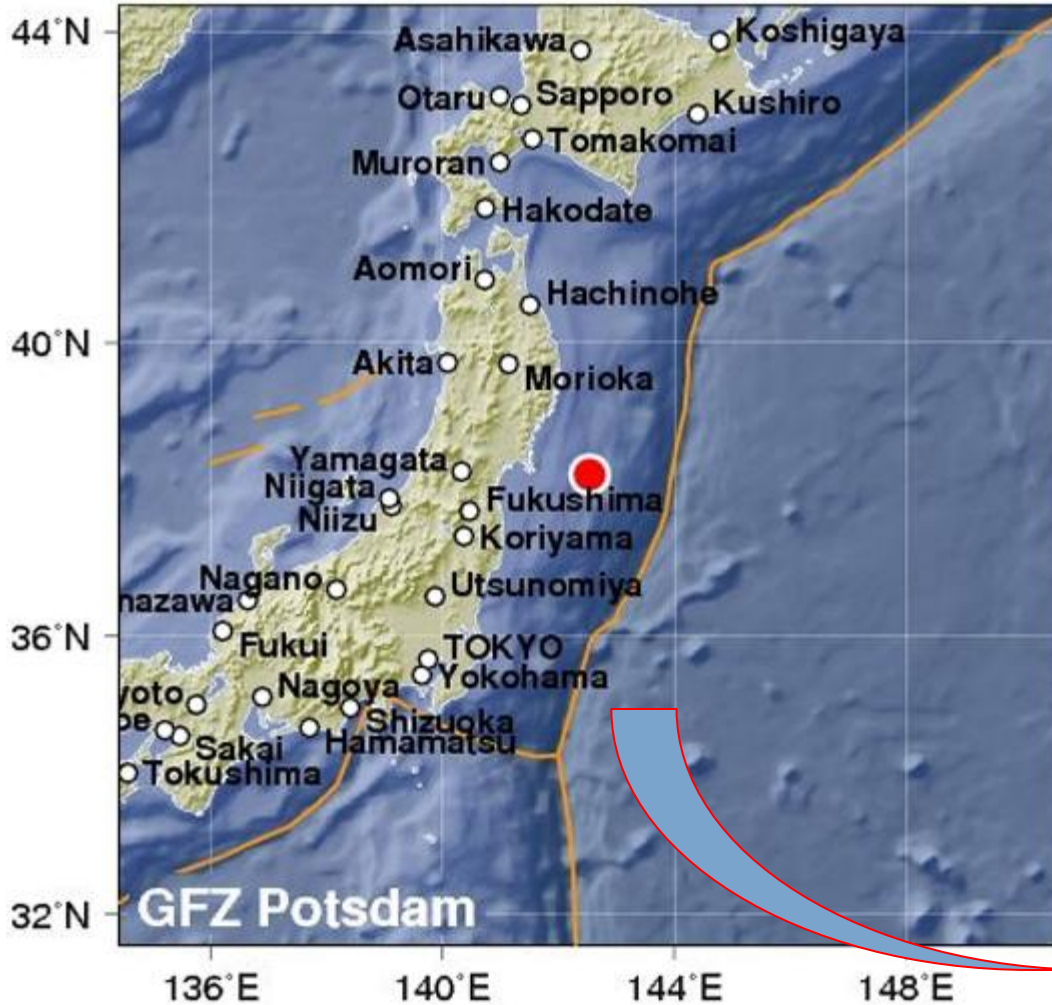
Status: **M** - manually revised



Mw 8.9

Tohoku, Japan

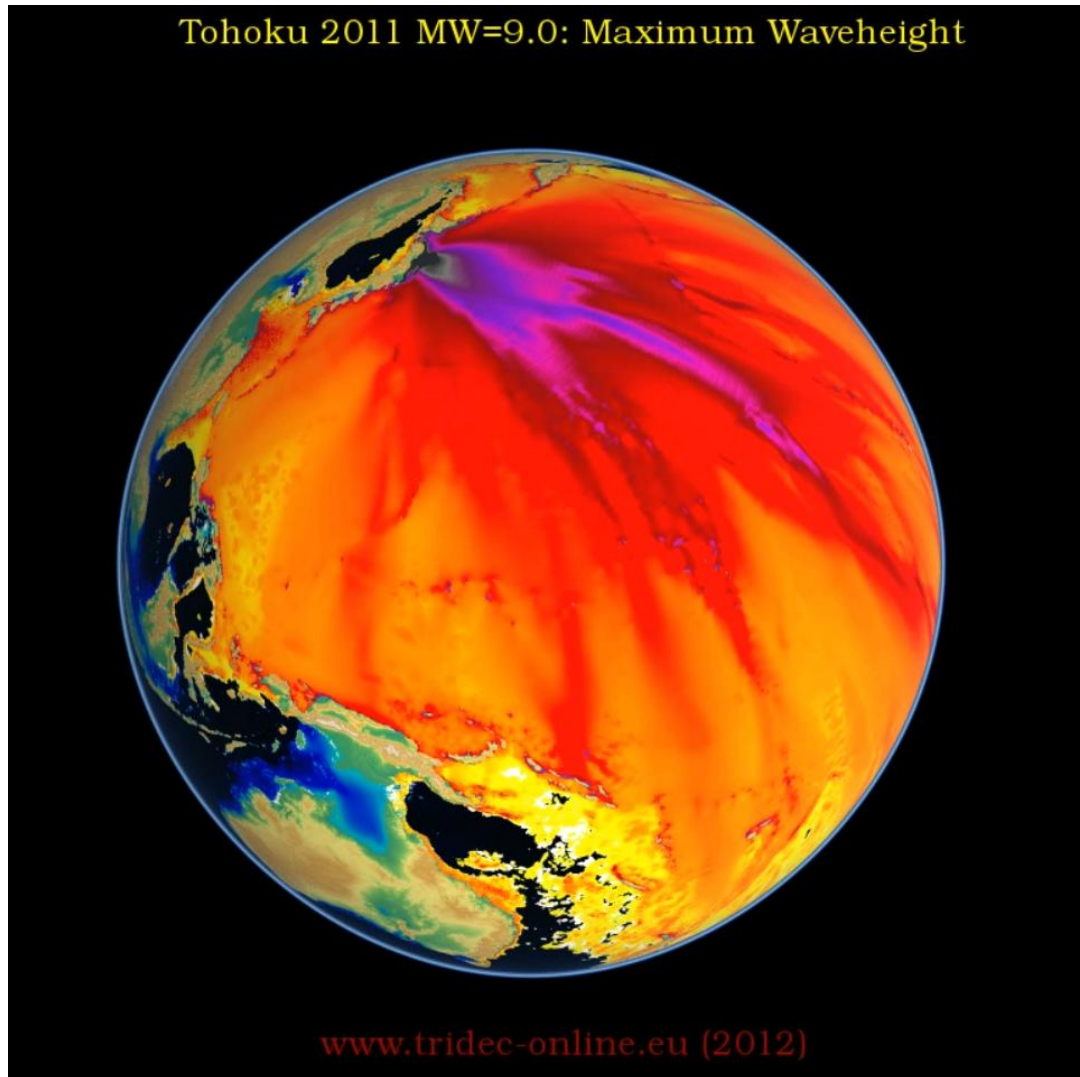
11.03.2011 5:46



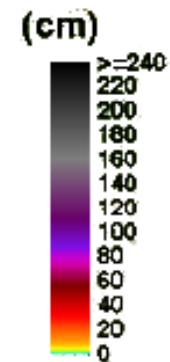
GEOFON-Station in Indonesien



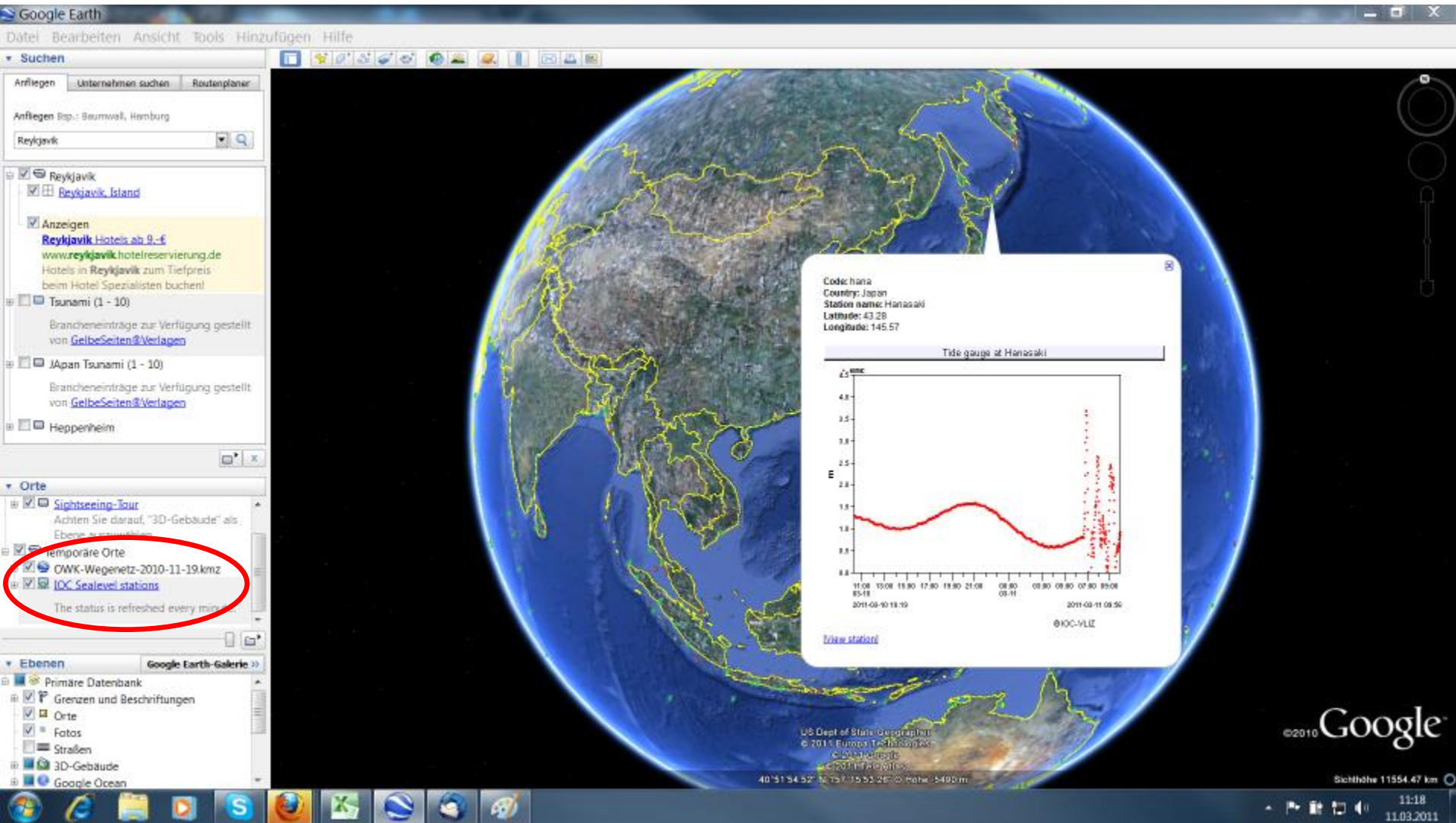
7 Wellenhöhen



Tohoku, Japan
11.03.2011



Bojen-Mareogramme Tohoku-Tsunami



Tohoku Tsunami

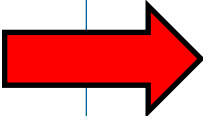


Kyodo/Reuters

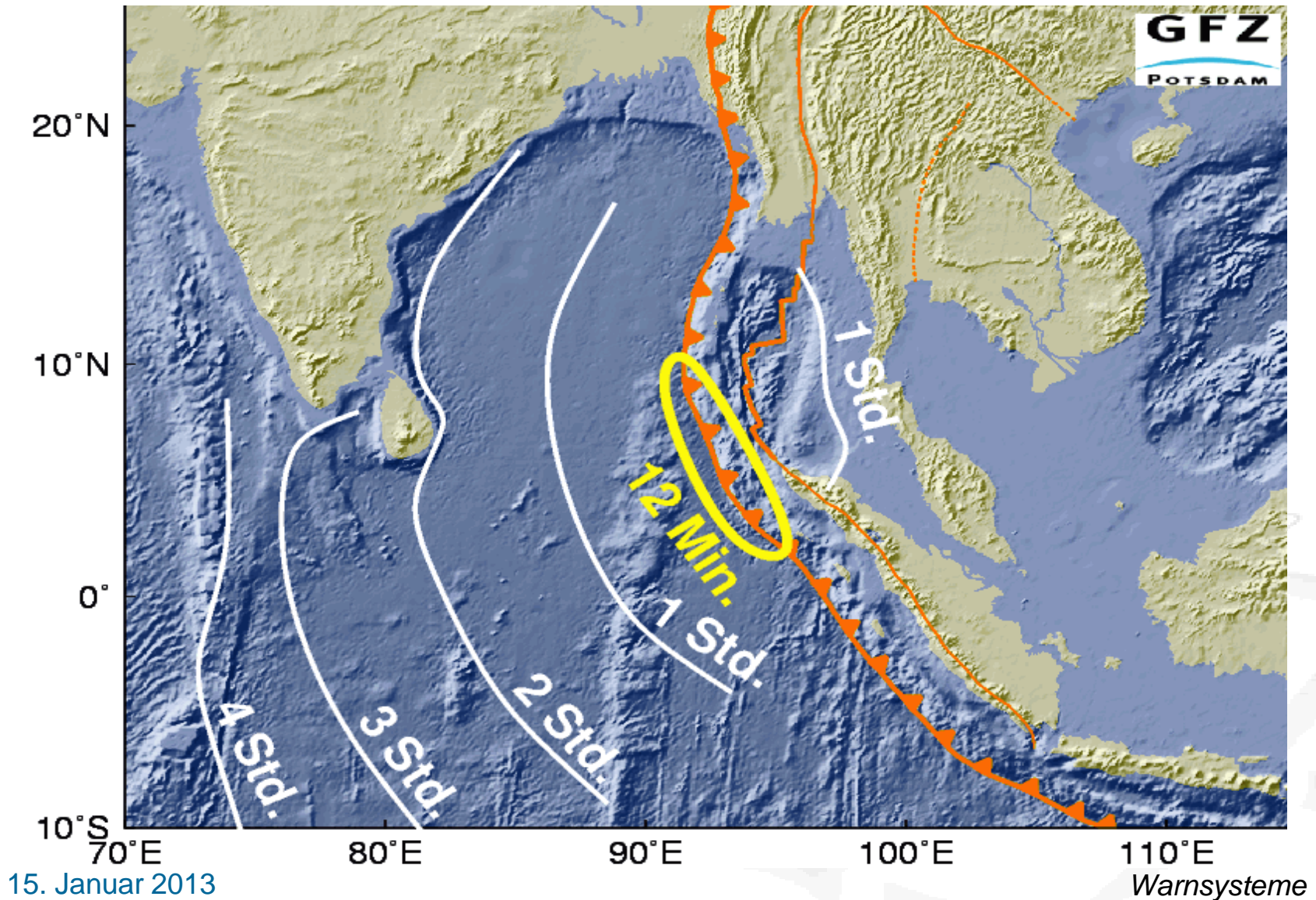


Mosque at Lampuuk, Banda Aceh, after Tsunami, 25.12.2004

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Challenge Indonesia





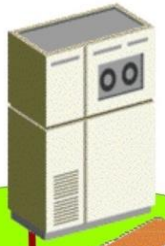
Overall Schema

Kommunikations-satellit

GPS-Satellit

Modellierung/
Simulation

GPS-
Altimetrie



Warnzentrum

Küstenpegel

GPS-Bojen

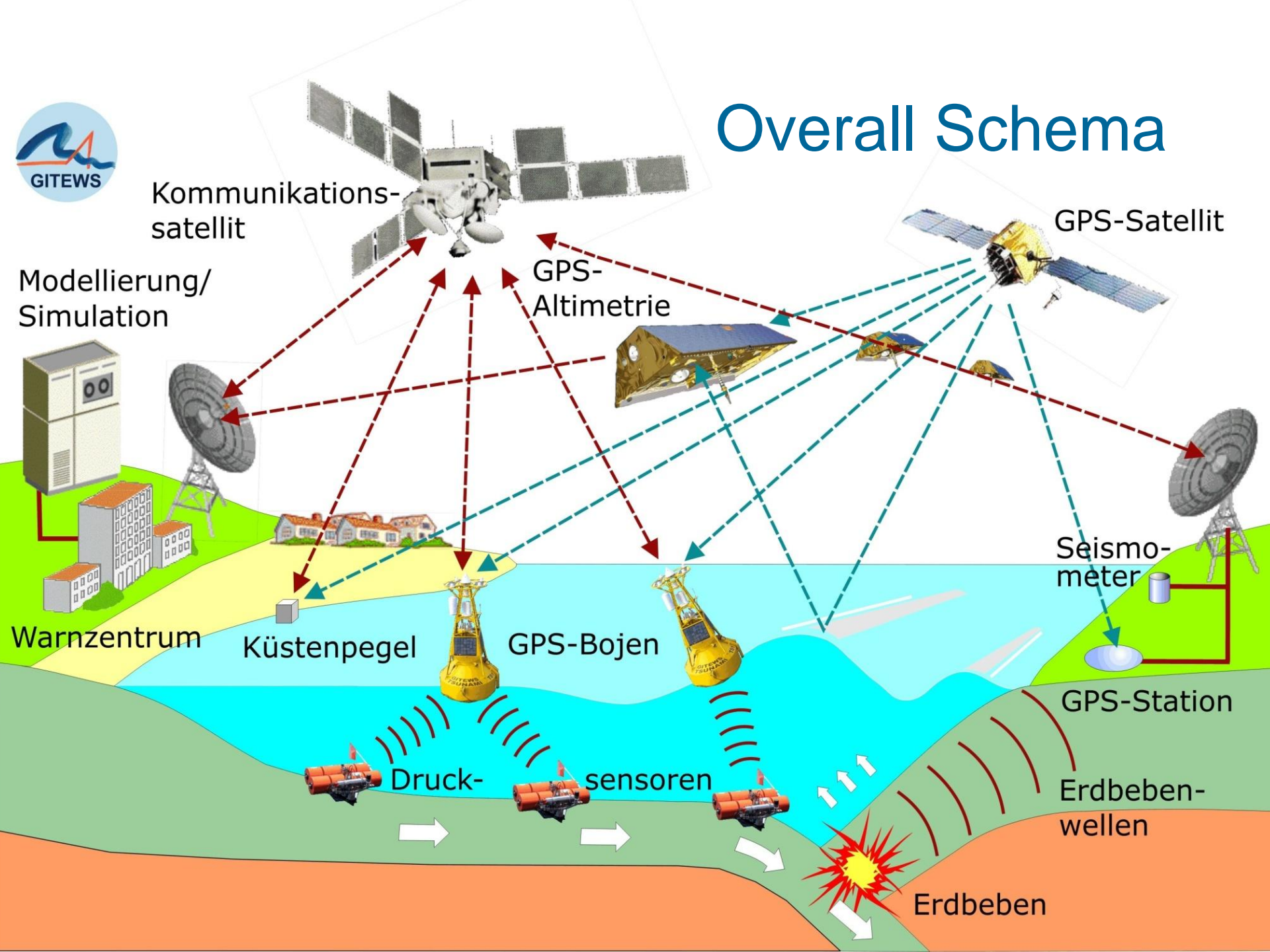
Seismo-
meter

GPS-Station

Druck-
sensoren

Erdbeben-
wellen

Erdbeben



GITEWS Partner - National

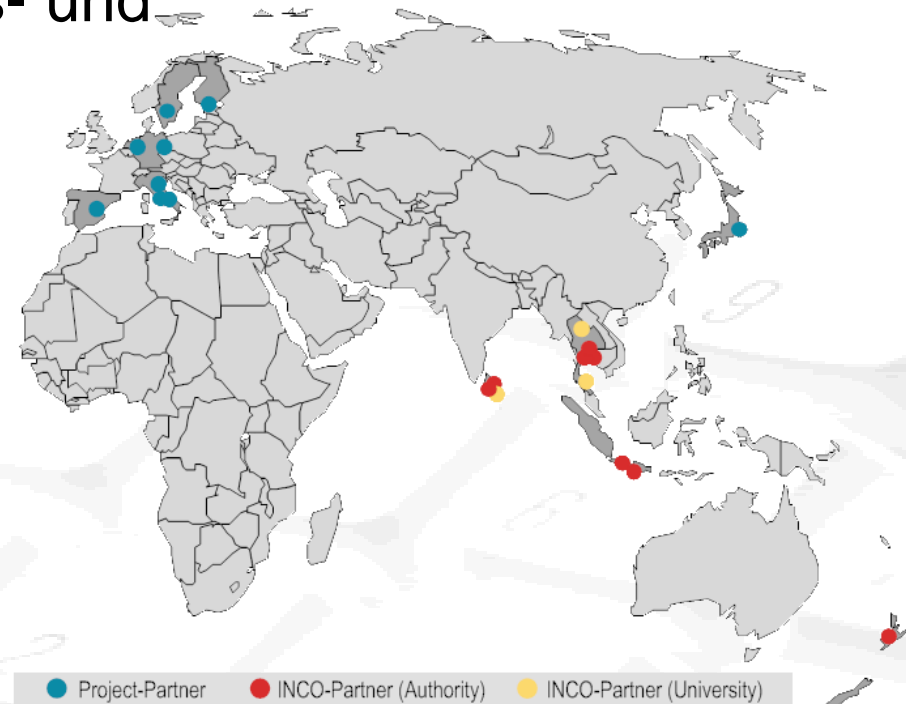
- **Helmholtz-Gemeinschaft deutscher Forschungszentren (HGF)**
 - GeoForschungsZentrum Potsdam (GFZ)
 - German Aerospace Center (DLR), Oberpfaffenhofen
 - Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven
 - Forschungszentrum GKSS, Geesthacht
- **Konsortium Deutsche Meeresforschung (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

TRIDEC³

Collaborative, Complex and Critical
Decision-Support in Evolving Crises

www.tridec-online.eu



- Helmholtz Centre Potsdam GFZ - German Research Centre for Geosciences (*Germany*) Centre for GeoInformation Technology



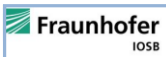
- University of Southampton, IT Innovation Centre (*United Kingdom*)



- 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*)



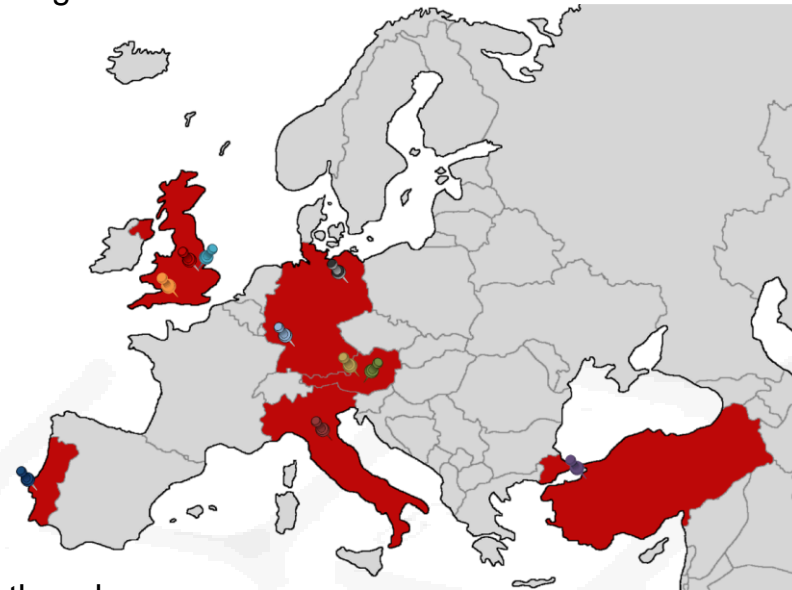
- Alma Mater Studiorum- Universita di Bologna - Department of Physics (*Italy*)



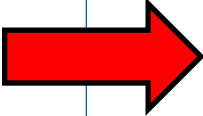
- Bogazici Universitesi - Kandilli Observatory and Earthquake Research Institute (*Turkey*)



ICT-2009.4.3 Intelligent
Information Management; 258723



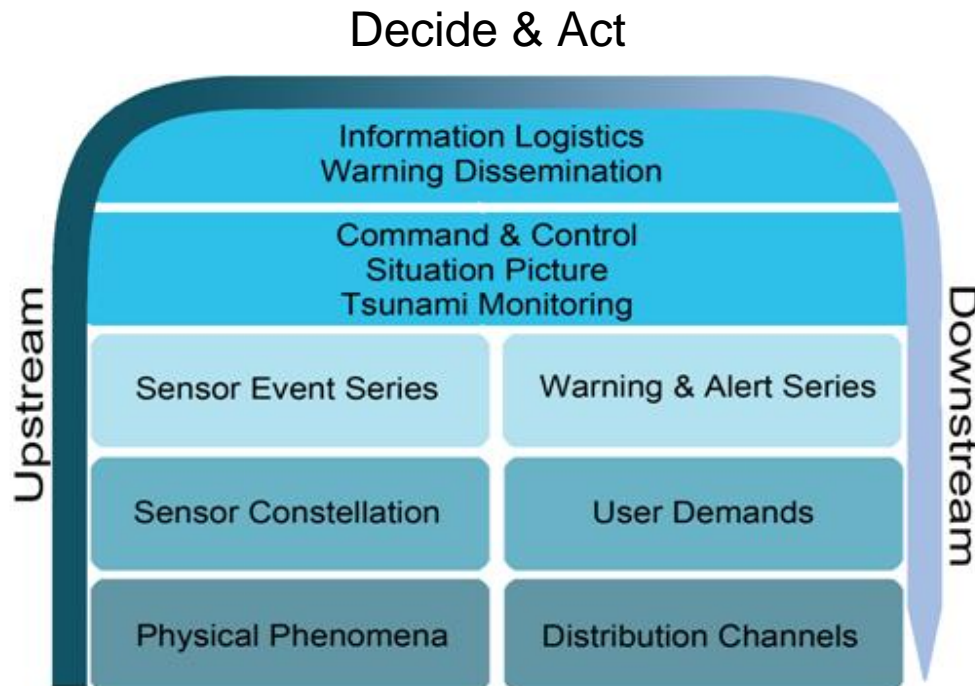
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Integrated Approach

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

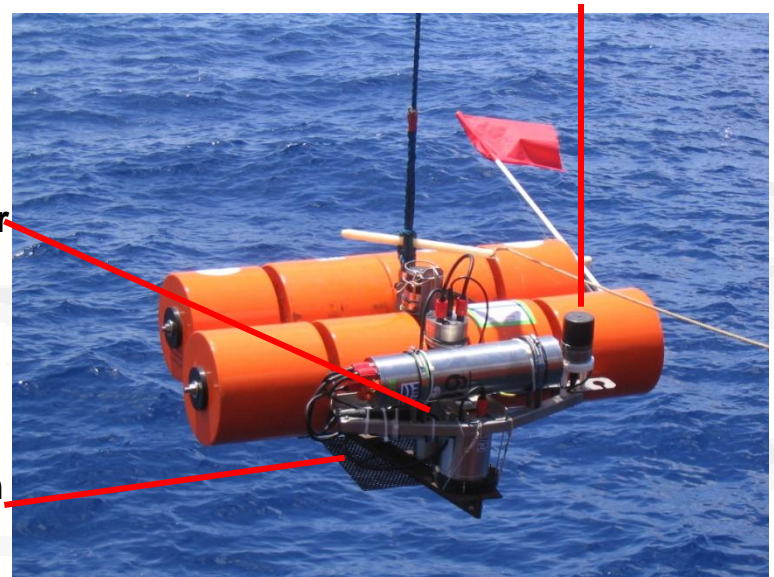
GPS-Antenna
 Communication
 Wind generator
 Meteorological
 Instruments

Ocean Bottom Unit

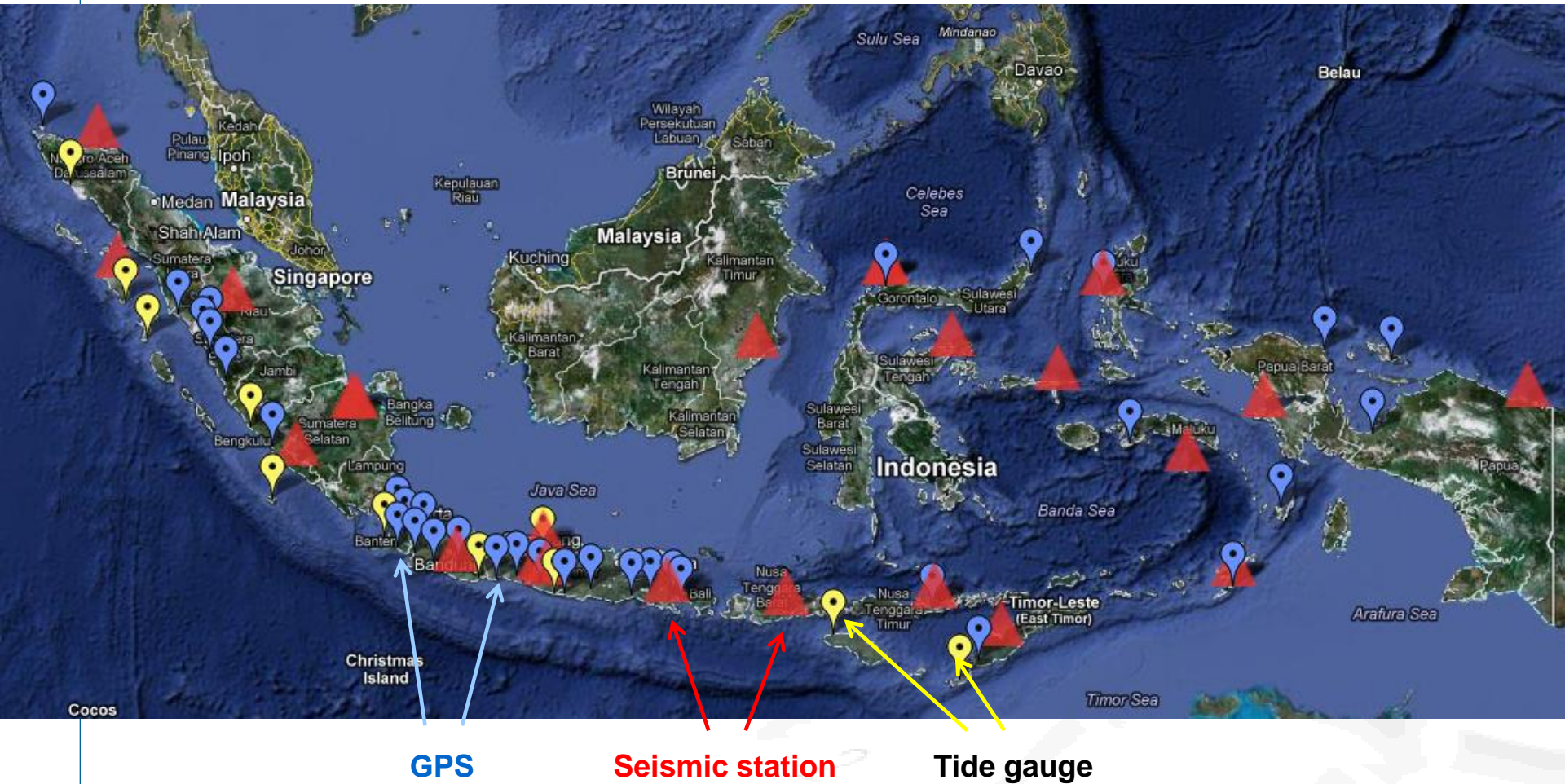
Acoustic Modem

Pressure Sensor

Ocean Bottom
 Seismometer

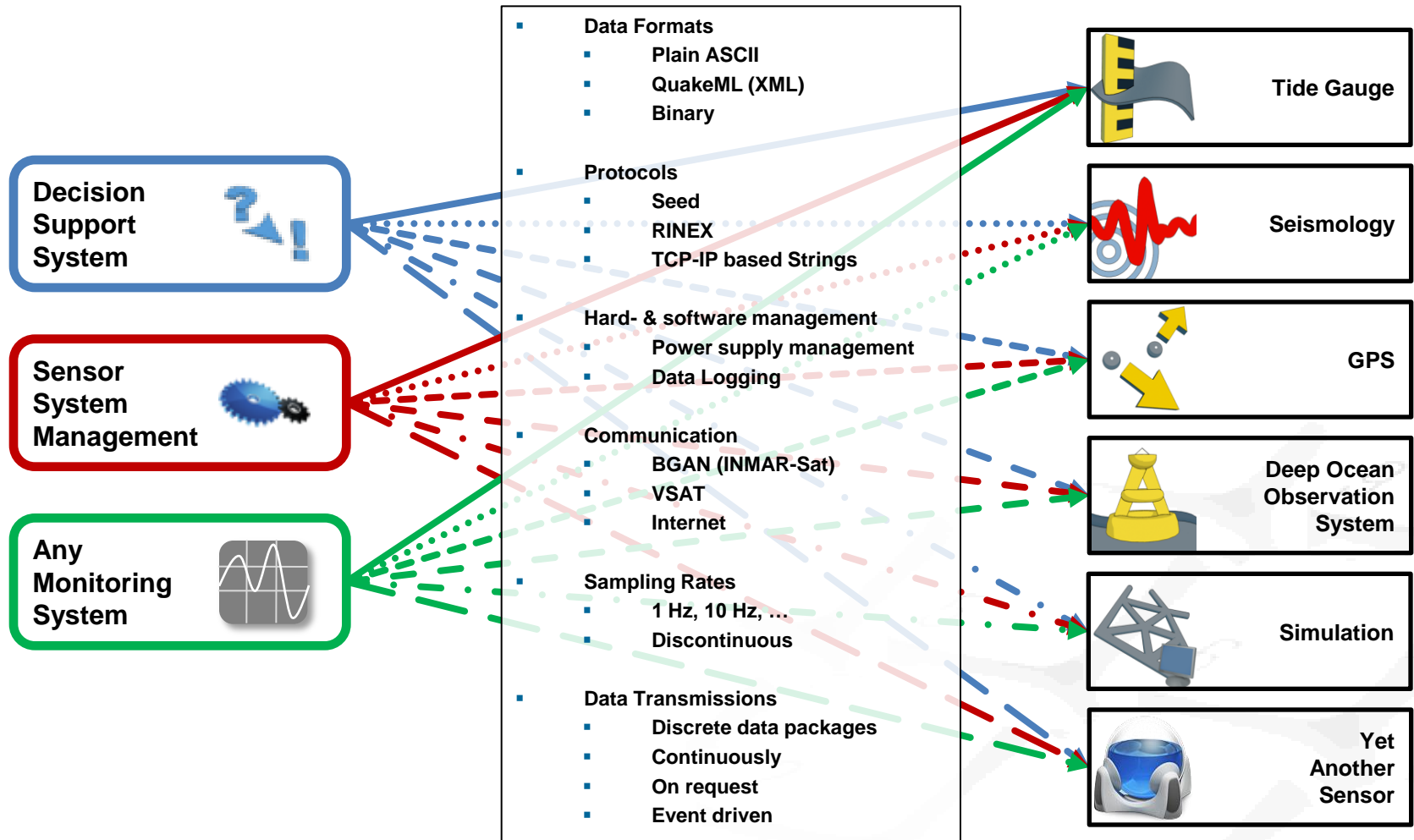


Sensor Network - Indonesia



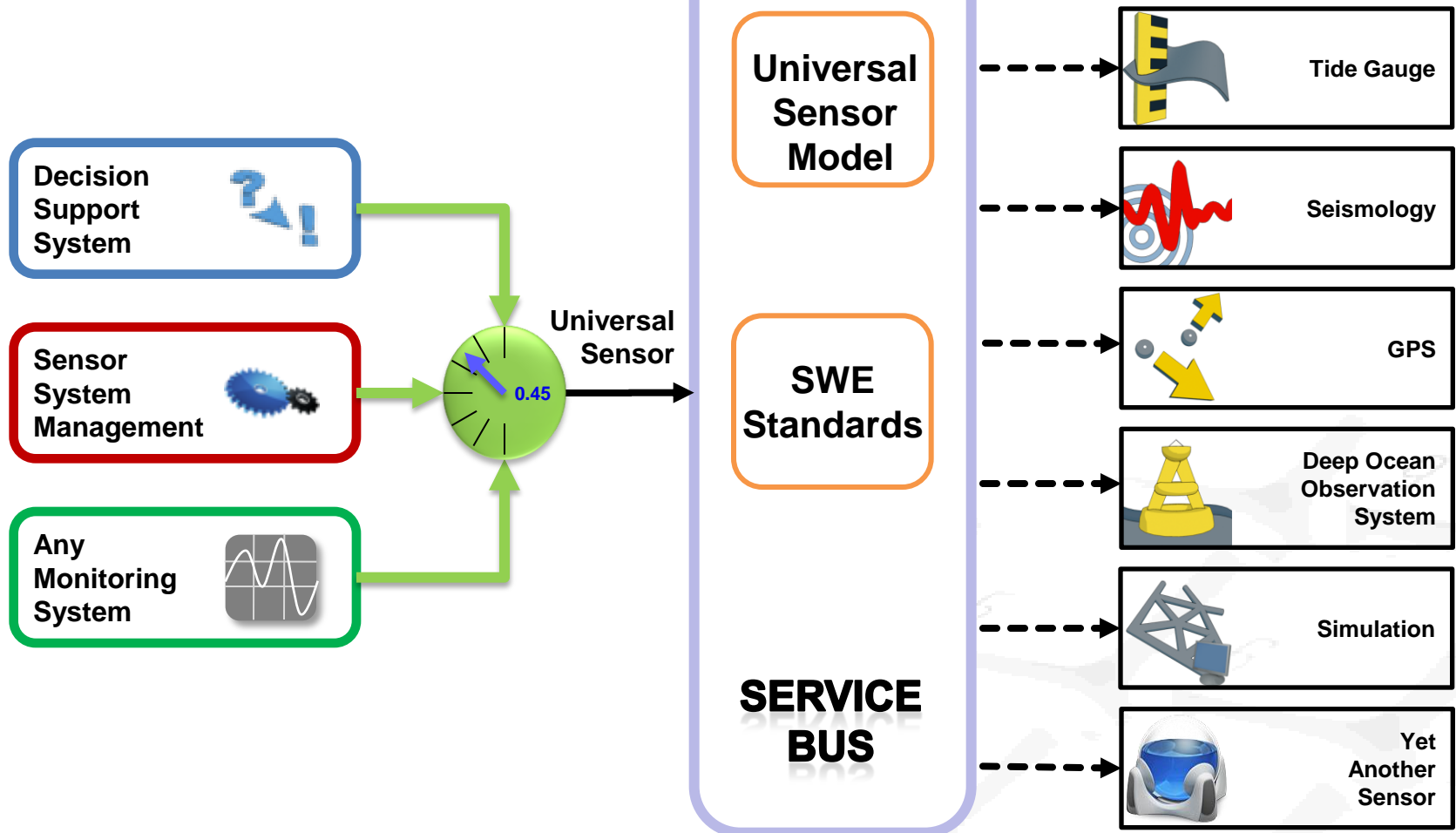
Herausforderung Heterogenität

Anwendungen



Lösung: Standardisierung

Anwendungen



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

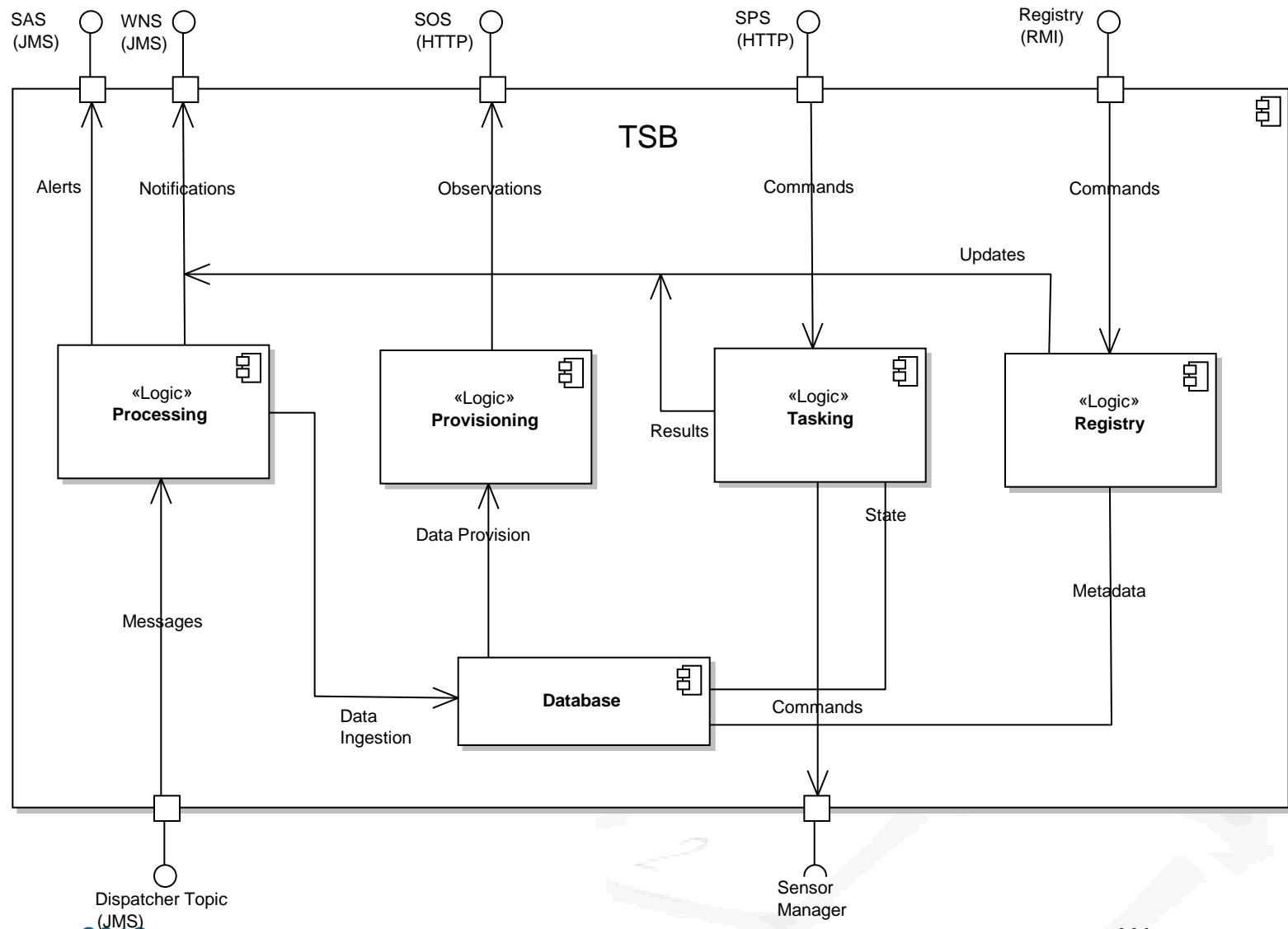
SOSSPSSASWNS

Encoding

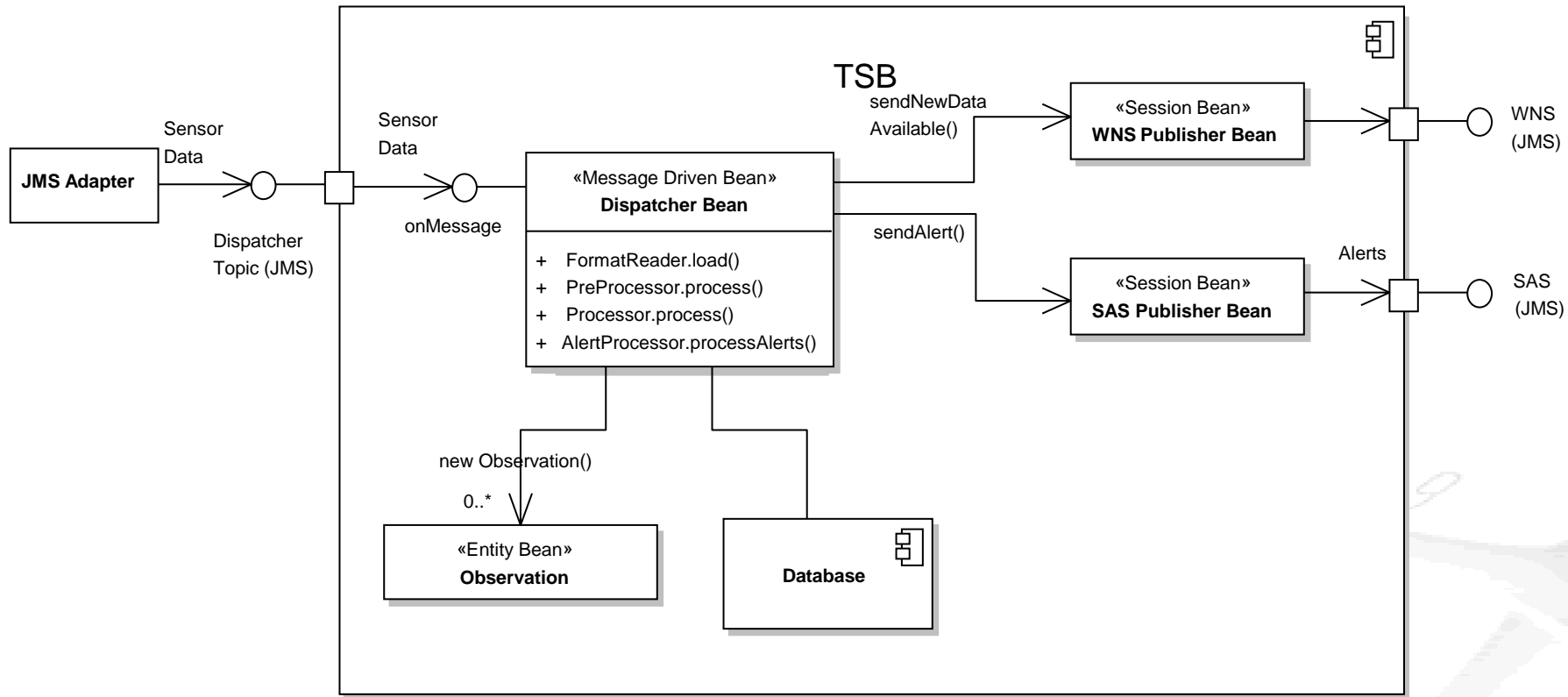
- **Sensor Model Language (SensorML)**
standardized description of sensors
- **Observations and Measurements (O&M)**
model and encoding of sensor measurements

SensorMLO&M

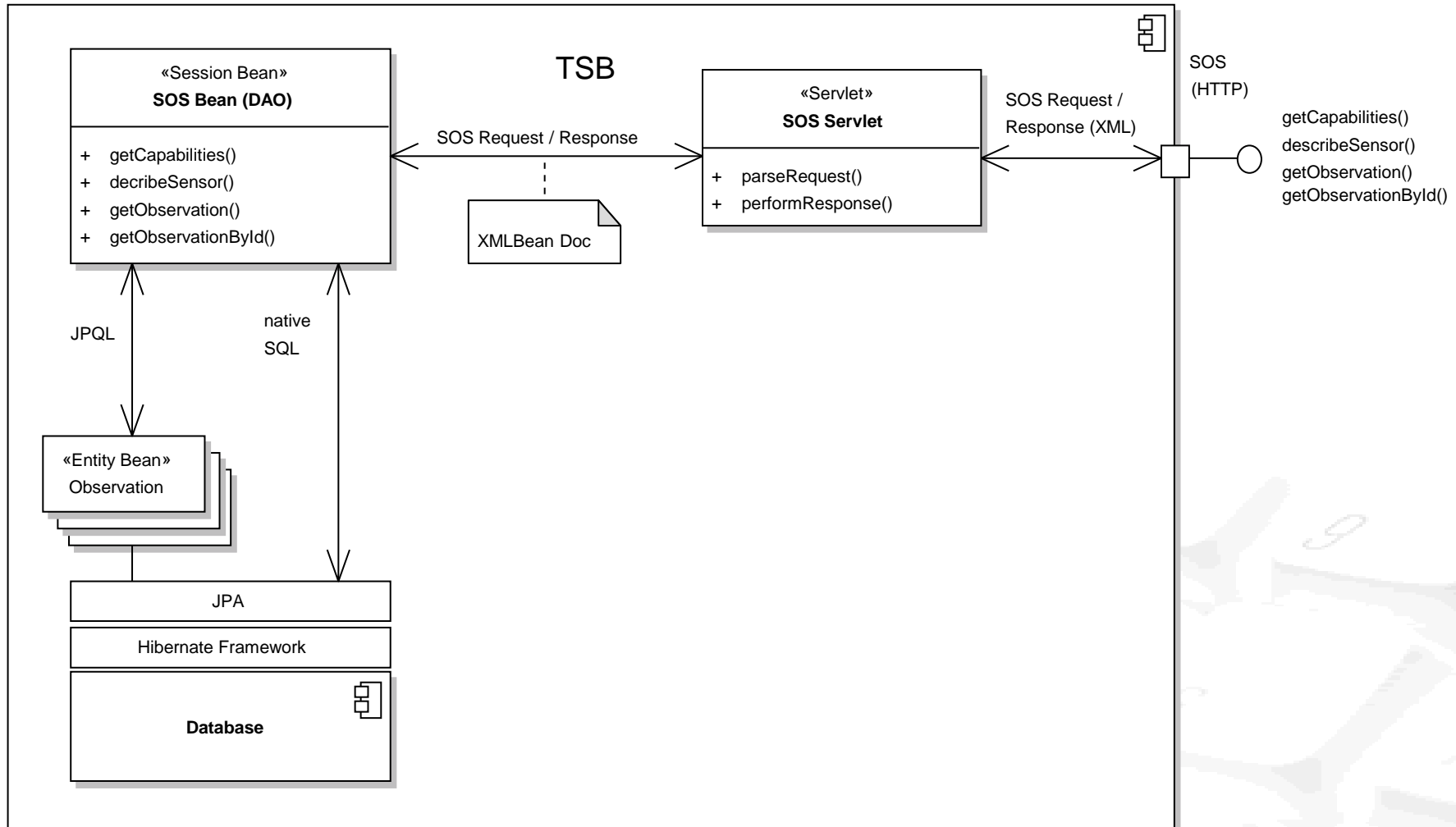
TSB - Funktionalität



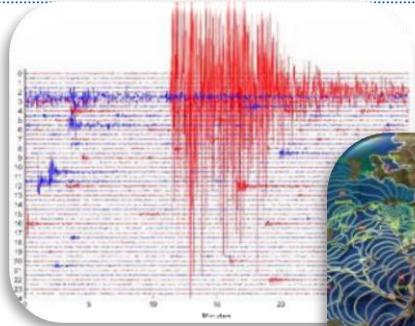
Processing



Data Provisioning via SOS



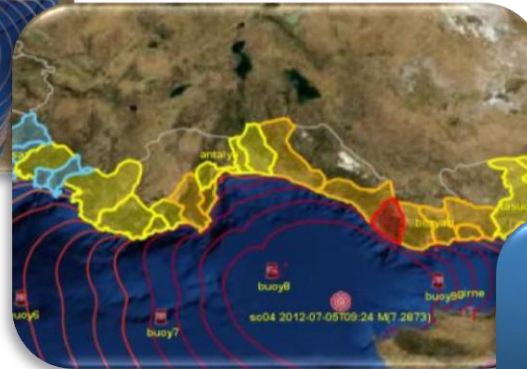
Decision Support



Step 1:
Monitor
Earthquake
Activity



Step 2:
Detect
Tsunami



Step 3:
Detect
Affected Areas



Step 4:
Issue
Warning
Messages

Step 1: Monitoring

CCU: TR

Forecasting Monitoring

Situation Picture

Map Elements Sensor Networks

Type/Name

- Earthquake
 - sc02(mag:8.60,depth:27.93)
- Buoy
 - CGPS
- Seismic System
- Tide Gauge
- Affected Areas
- Affected Points

Information View

Earthquake

General Information:

Event ID: sc02
 Active Refinement ID: 121029133312937
 Origin Time: 2012-10-29T13:31:37+0000
 Location (lon/lat): 29.0231, 34.914
 Depth: 20.3606
 Magnitude: 7.47

Related Seismic Refinements:

Sampling ...	Refinement ID	Location	Magnitude	Depth
14:33:11	121029133311...	28.99,34.9366	7.41	23.0556
14:33:12	121029133312...	29.0231,34.914	7.47	20.3606
14:33:15	121029133315...	28.9405,34.9371	7.56	21.0223
14:33:19	121029133319...	29.0089,34.9519	7.64	19.1205

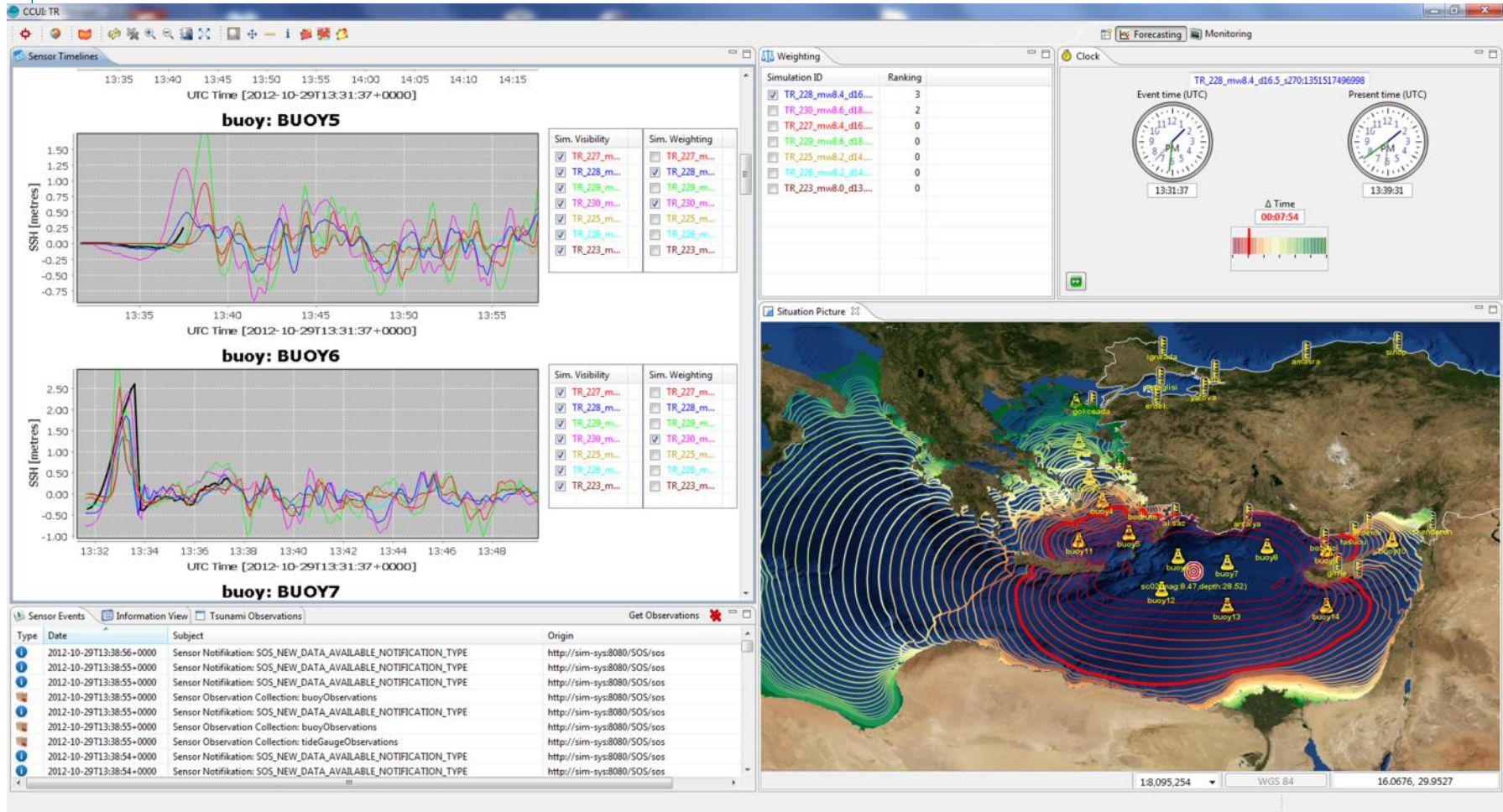
16,573,877 WGS 84 44.7826, 34.9859

Get Observations

Incidents Sensor Events DecisionMatrix

Type	Date	Subject	Origin
🚨	2012-10-29T13:33:27+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:25+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:24+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:21+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:20+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:20+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:20+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:18+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:15+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems
🚨	2012-10-29T13:33:12+0000	Sensor Alert: seismicAlerts: ems	urn:gfz:gitews:def-procedure:seismology:system:ems

Step 2: Detect Tsunami



Step 3: Detect Affected Areas **TRIC³DEC**

The screenshot displays the CCUE TR software interface, which is used for detecting affected areas and generating messages. The main window shows a map of Bodrum, Turkey, with affected areas highlighted in red and yellow. The interface is divided into several panels:

- Information View:** Shows details for the selected area (Bodrum), including Name/ID, ETA, Hazard, CAP Criticality, CAP Severity, and CAP Urgency.
- Affected Areas:** A table listing affected areas with columns for Label, ETA (UTC), Severity, and Hazard.
- Affected Points:** A table listing affected points with columns for Name and Geocode.
- Message Form:** A panel for generating and disseminating messages, including fields for Message Type, Message Form, and Message References.
- Disseminated Messages:** A table listing disseminated messages with columns for Label and Timestamp.

The map shows a satellite view of the Bodrum region, with affected areas highlighted in red and yellow. The map includes a scale bar and coordinates (1:3,987,538, WGS 84, 36.9149, 36.448).

Label	ETA (UTC)	Severity	Hazard
Köycegiz	2012-10-2...	Extreme	SSH: 18.43
Dalaman	2012-10-2...	Extreme	SSH: 18.10
Serik	2012-10-2...	Extreme	SSH: 6.36
Bozyazi	2012-10-2...	Extreme	SSH: 3.27
Bodrum	2012-10-2...	Extreme	SSH: 4.56
Datça	2012-10-2...	Extreme	SSH: 6.21
Ula	2012-10-2...	Extreme	SSH: 3.21
Fethiye	2012-10-2...	Extreme	SSH: 14.98
Gazipasa	2012-10-2...	Extreme	SSH: 5.81
Marmaris	2012-10-2...	Extreme	SSH: 14.98
Mugla Merkez	2012-10-2...	Extreme	SSH: 3.71
Manavgat	2012-10-2...	Extreme	SSH: 6.27
Ortaca	2012-10-2...	Extreme	SSH: 11.65

Name	Geocode
Egypt	EG
Gaza	PS
Greece	GR
Israel	IL
Lebanon	LB
Libya	LY
Syria	SY
Turkey	TR

Label	Timestamp
TR_CAP1	2012-10-29T13:57:54+00...

Step 4: Issue Warning Messages TRI³DEC

The screenshot displays the TRI3DEC software interface. The main window is titled 'Review Message' and shows a tsunami warning message for the phone number +3516543210110. The message details include:

- Address:** +3516543210110
- Headline:** Tsunami Warning
- Description:** A Tsunami is imminent. Location Fethiye (HASC_2 : TR.MG.FE): ETA= 2012-10-30T17:45:00+0000, max SSH= 3.36, Certainty= likely, Severity= extreme, Urgency= immediate; Location Bodrum (HASC_2 : TR.MG.BO): ETA= 2012-10-30T18:01:00+0000, max SSH= 1.58, Certainty= likely, Severity= severe, Urgency= expected; Location Marmaris (HASC_2 : TR.MG.MA): ETA= 2012-10-30T17:48:00+0000, max SSH= 2.72, Certainty= likely, Severity= severe, Urgency= immediate; Location Datca (HASC_2 : TR.MG.DT): ETA= 2012-10-30T17:52:00+0000, max SSH= 1.87, Certainty= likely, Severity= severe, Urgency= immediate; Location Milas (HASC_2 : TR.MG.MI): ETA= 2012-10-30T18:06:00+0000, max SSH= 1.21, Certainty= likely, Severity= severe, Urgency= expected; Location Mugla Merkez (HASC_2 : TR.MG.MG): ETA= 2012-10-30T18:12:00+0000, max SSH= 1.68, Certainty= likely, Severity= severe, Urgency= expected; Location Dalaman (HASC_2 : TR.MG.DL): ETA= 2012-10-30T17:45:00+0000, max SSH= 2.02, Certainty= likely, Severity= severe, Urgency= immediate; Location Ortaca (HASC_2 : TR.MG.OR): ETA= 2012-10-30T17:45:00+0000, max SSH= 3.12, Certainty= likely, Severity= extreme, Urgency= immediate; Location Ula (HASC_2 : TR.MG.UU): ETA= 2012-10-30T18:14:00+0000, max SSH= 1.68, Certainty= likely, Severity= severe, Urgency= expected; Location Koycegiz (HASC_2 : TR.MG.KO): ETA= 2012-10-30T17:48:00+0000, max SSH= 2.12, Certainty= likely, Severity= severe, Urgency= immediate;
- Instruction:** Invoke alert phase 2. Inform local community. Inform your staff. Prepare for incoming Tsunami. Continuously observe the evolving situation.

The 'Send Message' button is visible at the bottom of the review window.

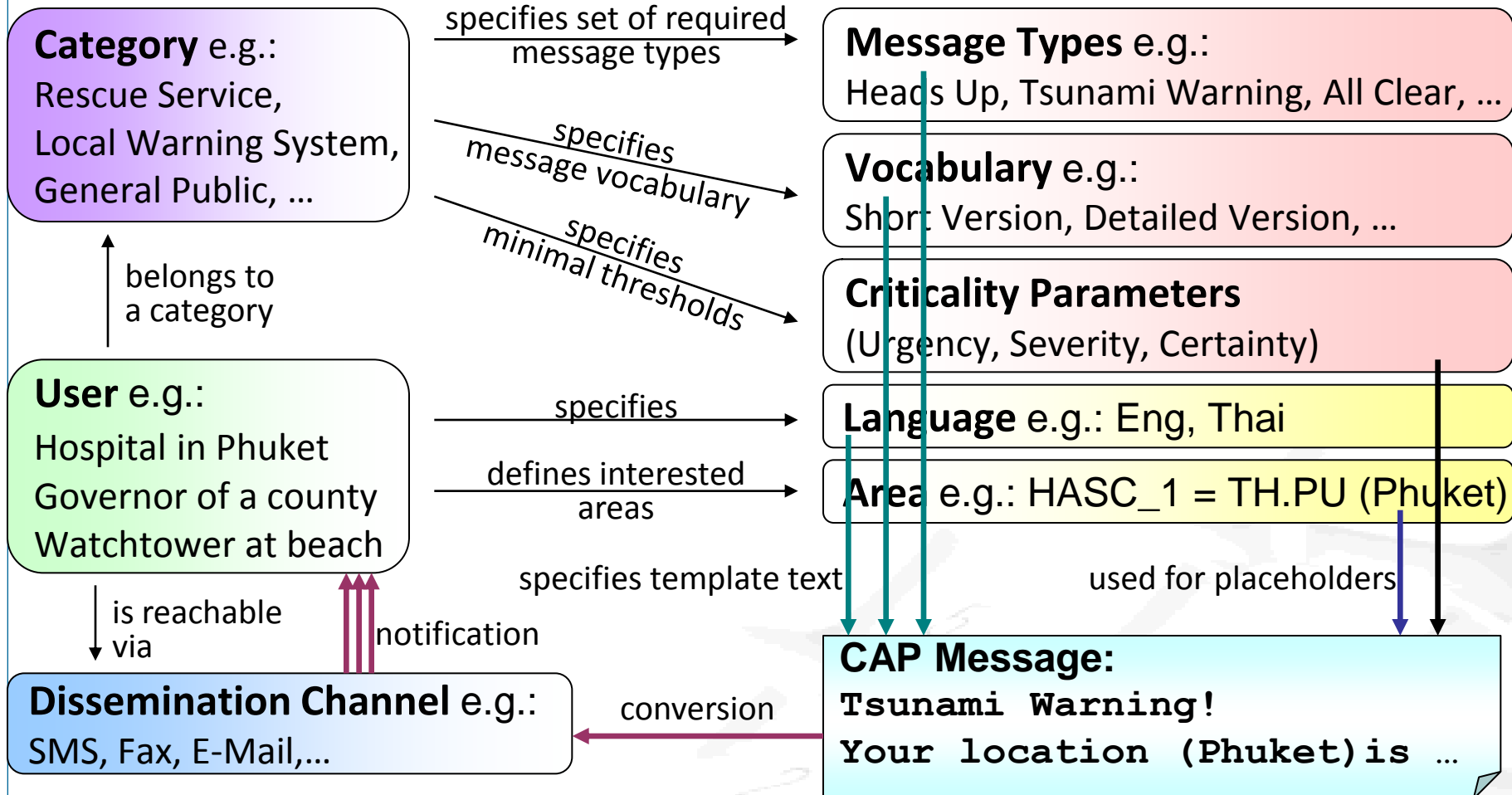
On the right side, the 'All Dissemination Channels' window shows a progress bar for 'Disseminated Messages (%)' at 100%. The status summary indicates: Successful Messages: 1, Failed Messages: 0, Pending Messages: 0, Total Messages: 1. Below this is a table of 'Global Disseminated Messages':

Channel Type	UTM ID	DSM ID	Dissemination Time	Explicit Address	Status
FAX	MRM2012-10-30T17...	DSM0	2012-10-30T17:38:16+0000	+3516543210110	SUCCESS

The 'FAX Channel' window also shows a progress bar at 100% and a summary: Successful Messages: 1, Failed Messages: 0, Pending Messages: 0, Total Messages: 1. Below is a table of 'Disseminated Messages':

UTM ID	DSM ID	Dissemination Time	Explicit Address	Status
MRM2012-10-30T17...	DSM0	2012-10-30T17:38:16+00...	+3516543210110	SUCCESS_DELIVERY_TO_M

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.

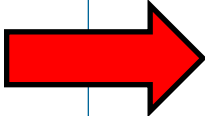
A TSUNAMI IS A SERIES OF LONG OCEAN WAVES. EACH INDIVIDUAL WAVE CREST CAN LAST 5 TO 15 MINUTES OR MORE AND EXTENSIVELY FLOOD COASTAL AREAS. THE DANGER CAN CONTINUE FOR MANY HOURS AFTER THE INITIAL WAVE AS SUBSEQUENT WAVES ARRIVE. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND THE FIRST WAVE MAY NOT BE 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.

\$\$

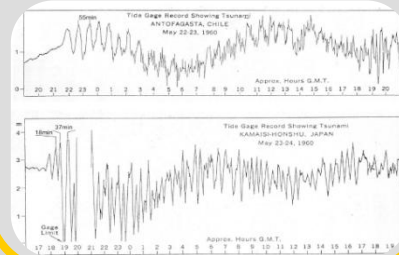
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- Zusammenfassung

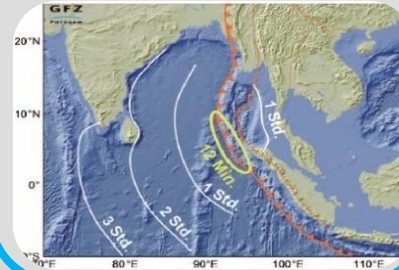
SOA!?

Applications

Monitoring



Simulation Modeling



Warning



Service Platform

Simulation



Sensors (SWE)



Geodata (OWS)



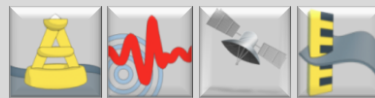
Dissemination



Ressources



Server



Sensor Systems

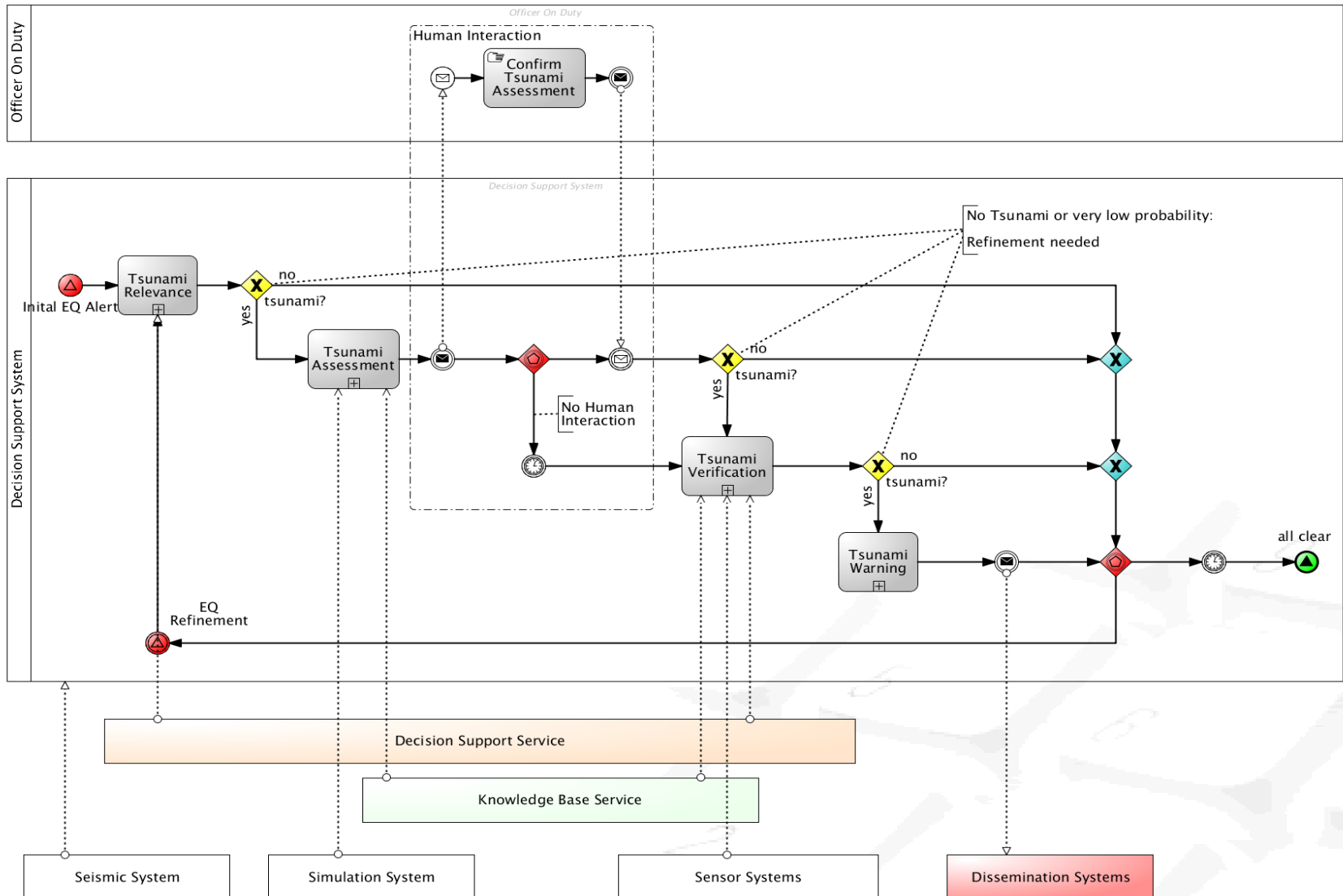


Repositories

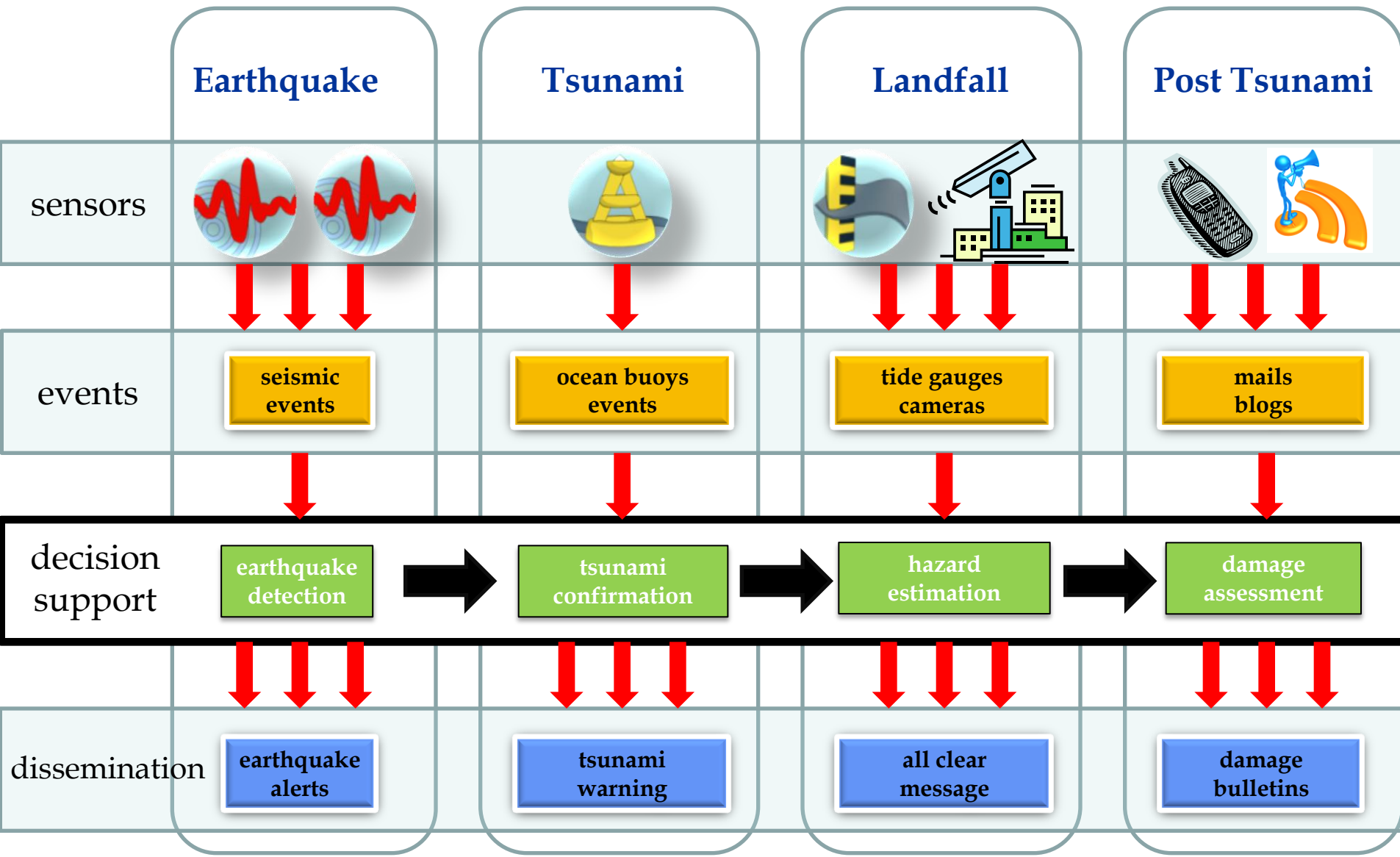


Dissemination Channels

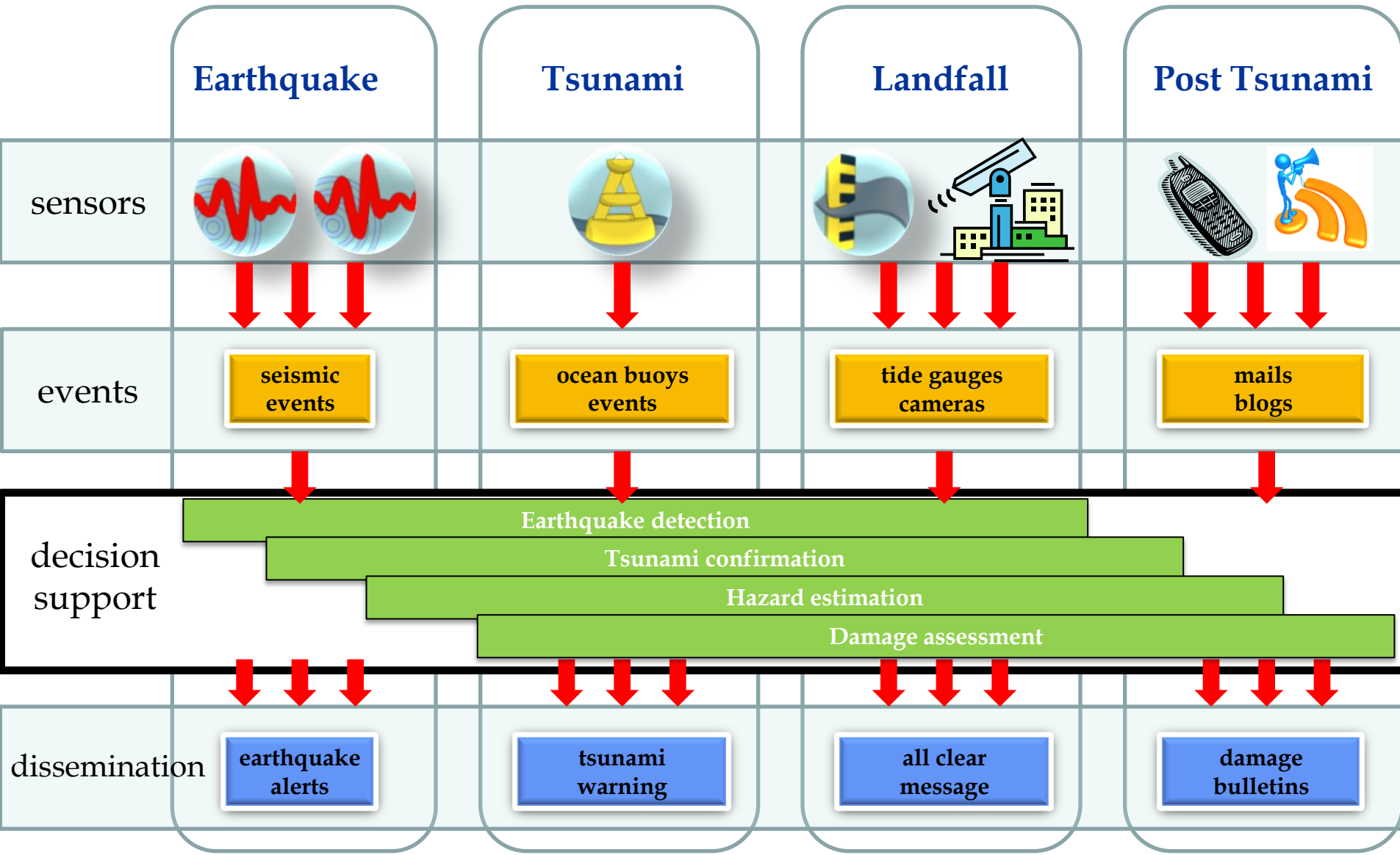
General Information Flow



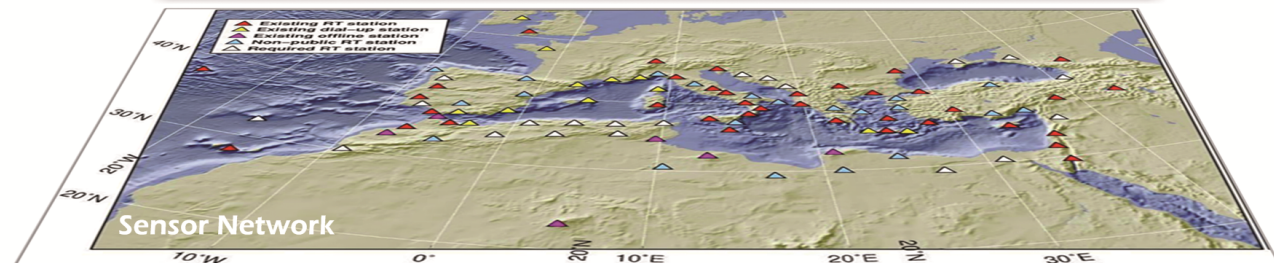
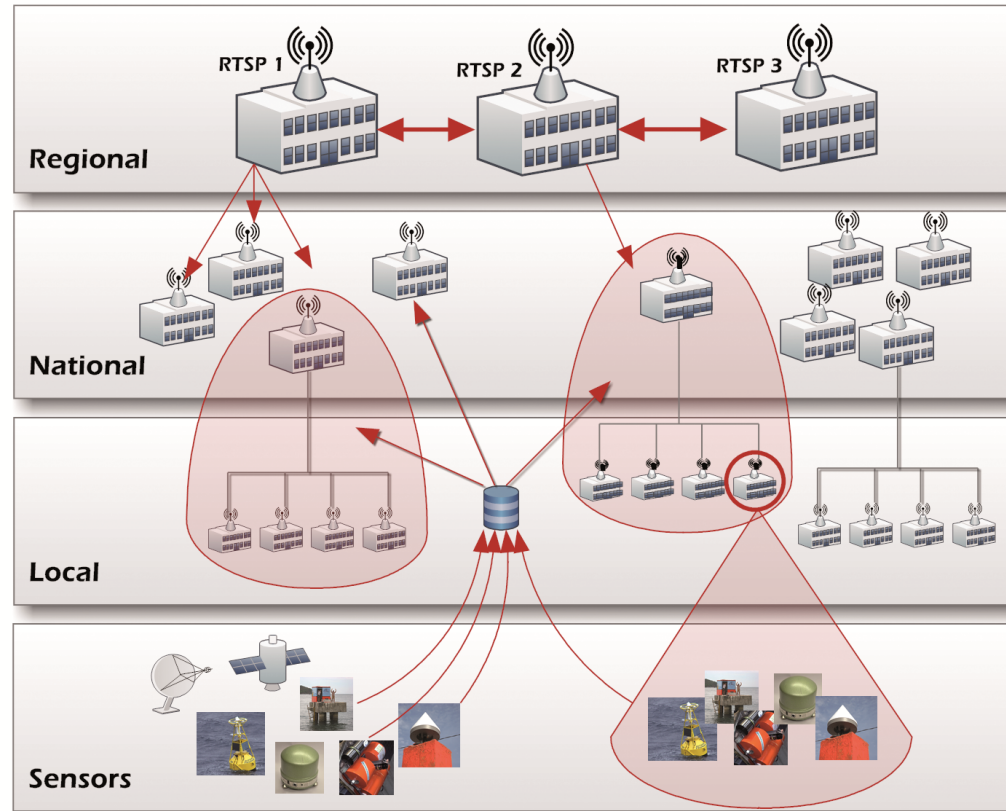
Events überall!



Überlappende Phasen



Warnsysteme im Mittelmeerraum



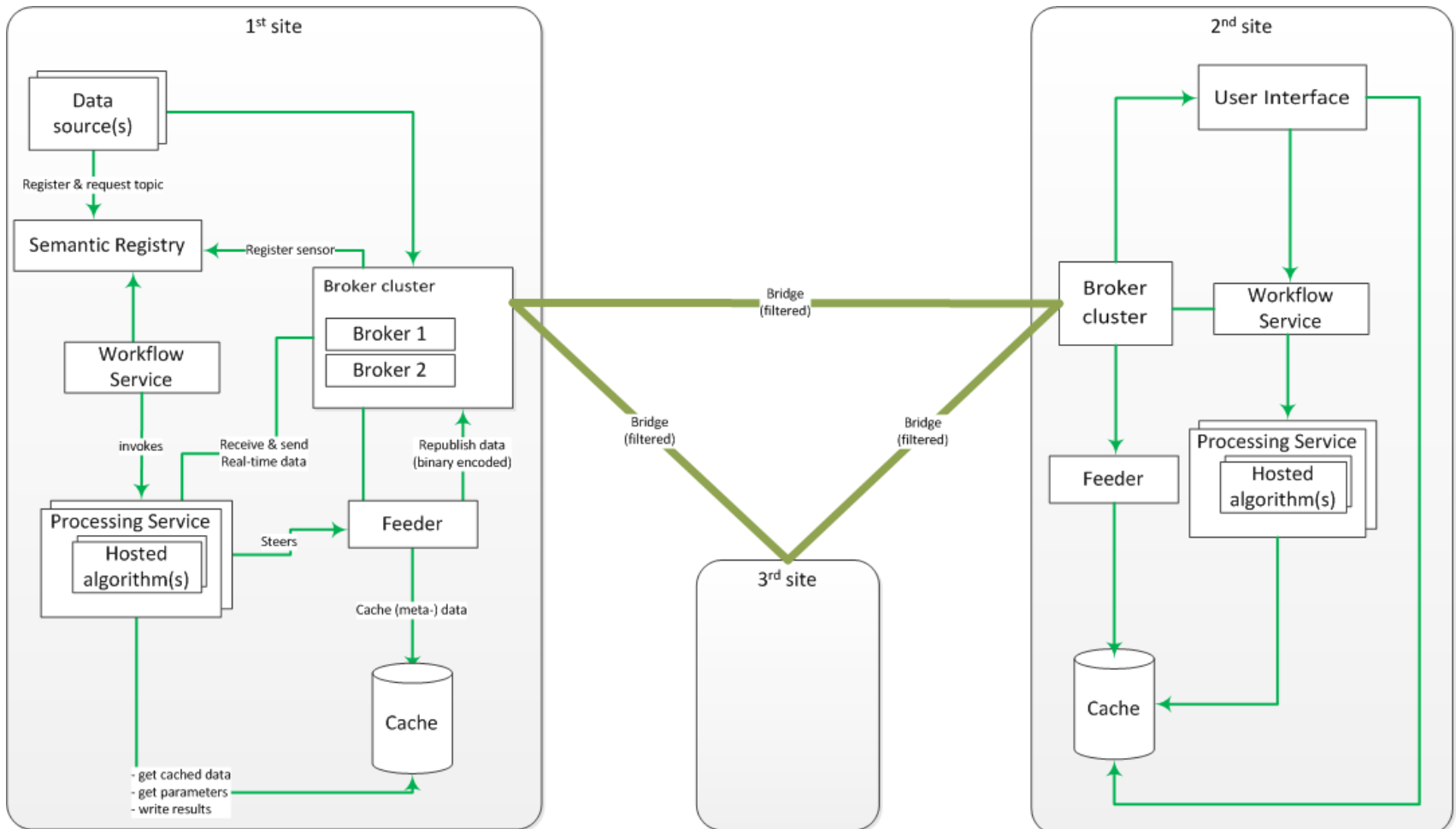
System-of-Systems

- 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:
 - Spatial 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

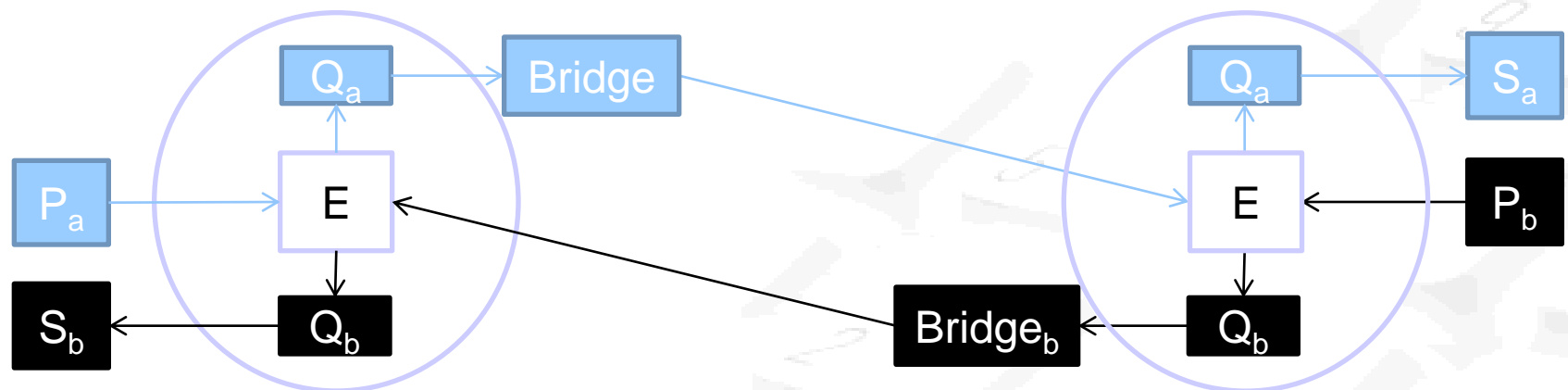
- Unterstützung der asynchronen oder synchronen Kommunikation von Komponenten und Systemen durch die Übertragung von Nachrichten
- Vorteile
 - Lose Kopplung von Server/Clients, bzw. Systemen
 - Message-Warteschlangen
 - Parallele Verarbeitung von Nachrichten
 - Unabhängige Weiterentwicklung von Komponenten 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

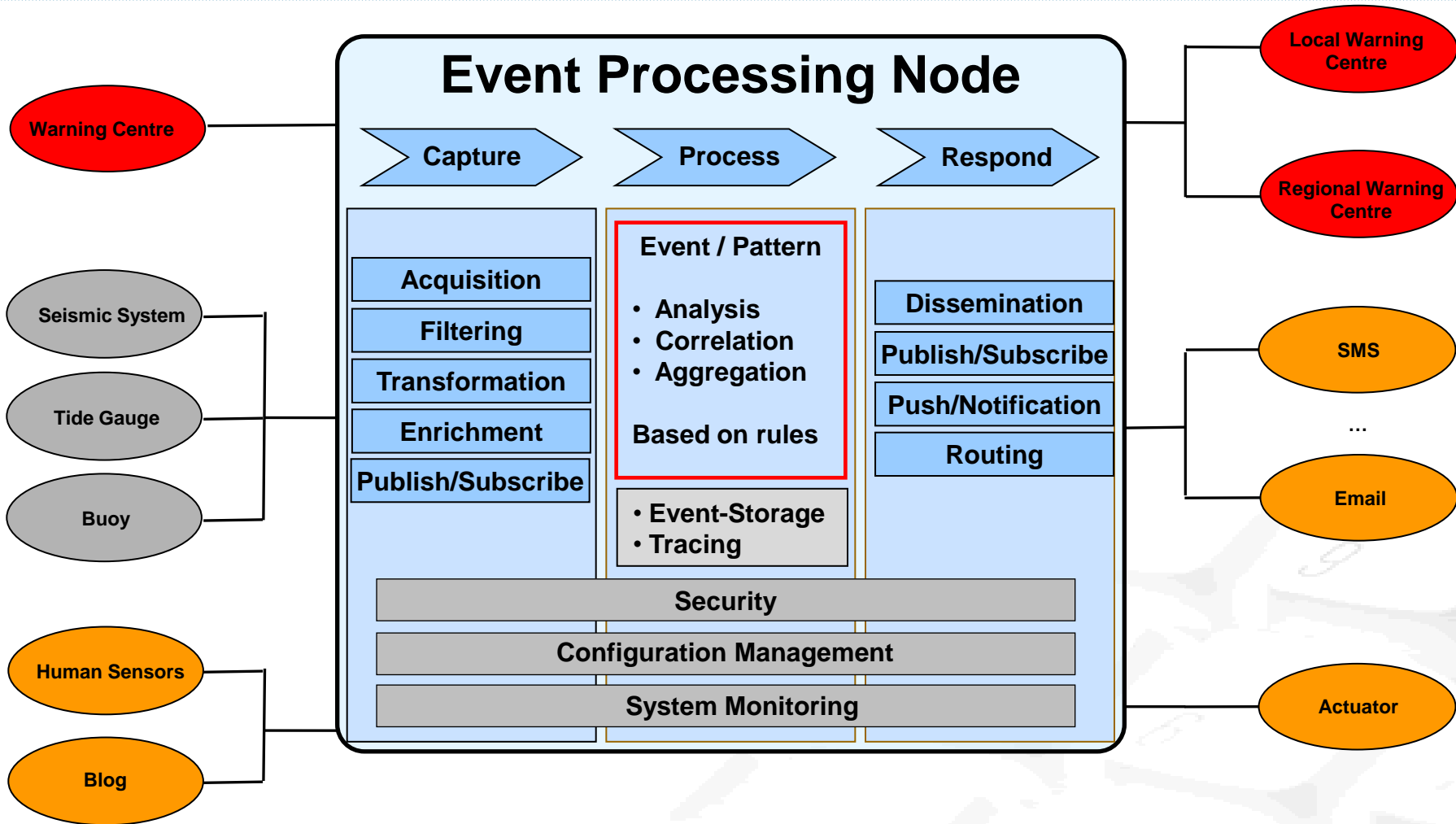
- Java Qpid does not directly provide broker federation functionality
- To provide broker-to-broker communication a “Bridge” is developed
 - A MoM Client
 - Receives messages from local broker and sends the message to the message queue in remote broker



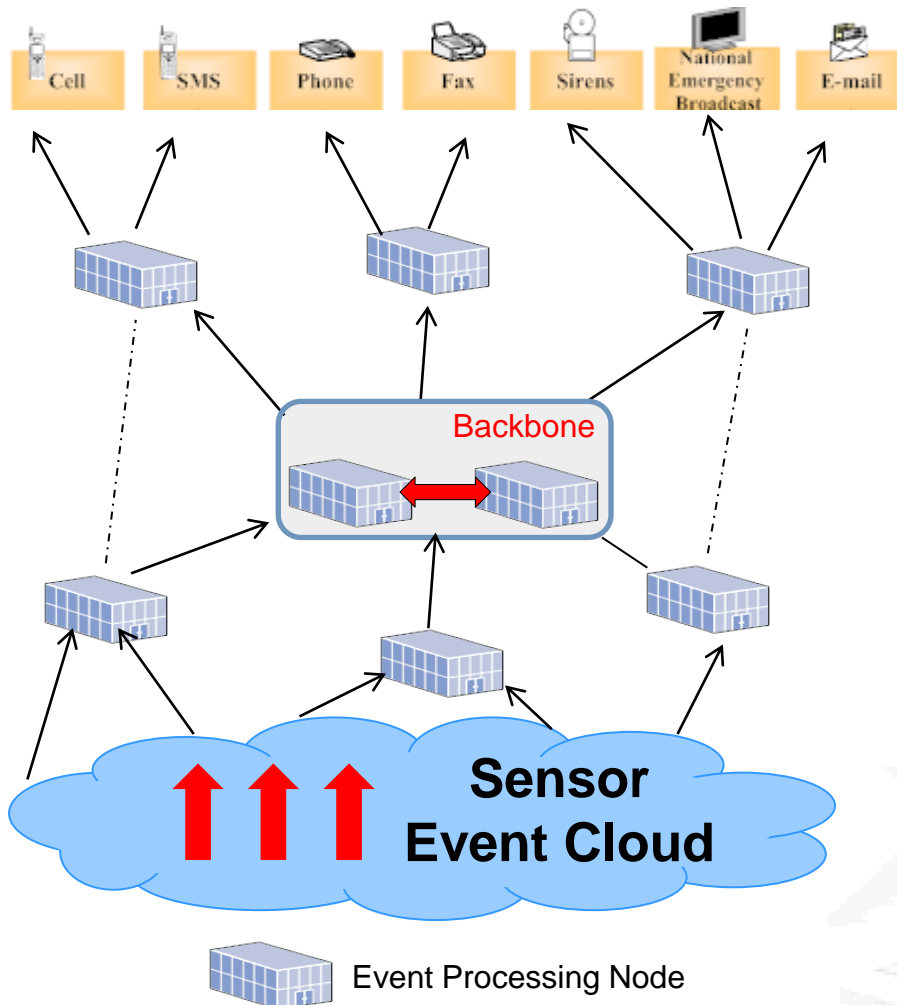
Distributed Management Agent (MA)

- 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 entscheidungsrelevanten 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
- Entwurfsmuster 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