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Status of the SAFER Project (Seismic eArly warning For EuRope)

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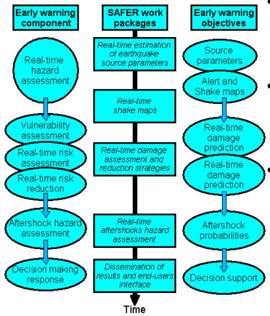
Introduction

As part of efforts to mitigate the potential dangers posed by earthquakes, the European Commission is supporting the **Seismic eArly warning For EuRope** or **SAFER** project. SAFER began in June, 2006, and will continue until the end of 2008. SAFER consists of 23 partners from 14 countries, including 3 from outside of Europe and the Mediterranean region.

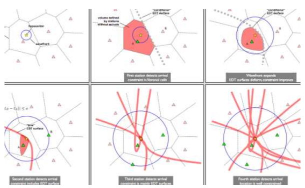


- SAFER products will advance earthquake early warning (EEW) by exploiting real-time seismic analysis.
- SAFER is primarily a *research* project, whose results will eventually be integrated into existing and future networks.
- SAFER will test these products at five major earthquake-prone cities that already have local seismic networks; Athens, Naples, Bucharest, Cairo and Istanbul, as well as sites in Iceland, Switzerland and the Gulf of Corinth.

Real-time estimation of earthquake source parameters

The methods being developed in this work package employ an evolutionary approach, where results are updated as new data is obtained.
Some of the key concepts being built upon are:

- Different ground-motion observables for magnitude determination.
- Near real-time fault mapping through highly refined fore and after shock location determination.
- Implementation and testing of the Virtual Seismologist.
- Testing of ElarmS within an European context.
- A new energy magnitude using frequency attenuation functions.

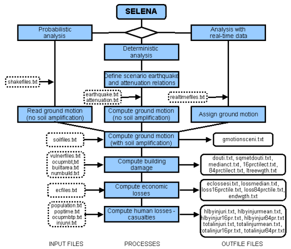


Left: RTLoc (Real-Time Location) uses information from triggered and not-yet-triggered stations. With one recorded arrival, the hypocenter's location is constrained by a Voronoi cell constructed using travel times to the not-yet-triggered stations. With more arrivals, the location is constrained by the intersection of the Voronoi cell volumes for the remaining, not-yet-triggered stations, until the location solution converges.

Real-time damage assessment and reduction strategies

This work package provides an interface between seismological and engineering aspects of SAFER. Its activities include:

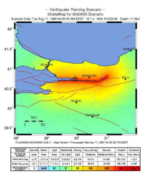
- Real-time damage scenarios, including the damage estimation model SELENA. SELENA uses real-time seismic data, and computes damage to the physical environment, economic losses and casualties. Right: Flowchart of SELENA *(Gaetano Manfredi, AMRA).*



- Assessment of earthquake-induced landslide risk using empirical models coupled to shake map products.
- Real-time active and semi-active controls for structures. An important issue involves setting thresholds for the optimal alarm level, taking into account the relative consequences of false and/or missed alarms.

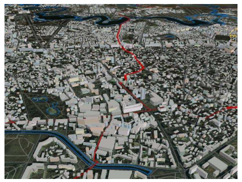
Real-time shake maps

Earthquake damage is a function of ground-motion severity and the built environment's vulnerability. Hence tools are required to obtained detailed knowledge of this ground motion, and its effect on structures.

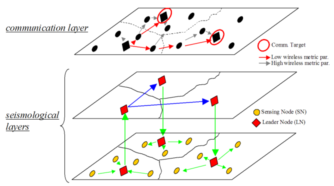


One tool will be the USGS program ShakeMap. It will be adapted to several SAFER test cities, namely the modules dealing with region-specific characteristics. Left: Scenario intensity map for the 1999 Kocaeli Earthquake *(Can Zulfikar, KOERI).*

Under development is a self-organising network that will adapt as the numbers of sensor changes. Damage estimates will be generated using the loss-estimate tool QUAKELOSS2, which employs city models inferred from satellite imagery .



Model of Bucharest inferred from satellite images. *(Max Wyss, WAPMERR).)*

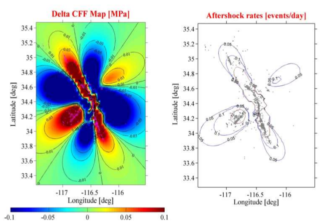


Seismological and communications layers for the self-organising network *(Matteo Picozzi, GFZ).*

Real-time aftershock assessment

Aftershocks are a crucial factor, given their potential to further damage weakened structures and disturb an already traumatised population. Hence, providing reliable forecasts is crucial for disaster response and informing the general public. The aims of this work package include:

- Improving our knowledge of the physics of aftershocks.
- Deriving and testing more accurate forecast models.
- Calibrating models for real-time aftershock assessment at locations with diverse tectonic settings.
- Development of the Rapid Aftershock Forecasting Toolbox (RAFT) for forecasting aftershock probabilities and ground motion severity.
- Developing physically-based tools using Coulomb models incorporating poroelastic rebound, afterslip and viscoelastic relaxation, to estimate co- and post-seismic stress changes.

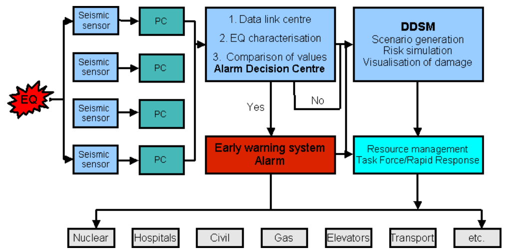


Far left: Coulomb stress changes along the optimally oriented fault planes after the 1992 Landers earthquake and aftershock activity ($M \geq 2.0$) for the following 90 days. Left: Spatial distribution of forecasted aftershock rates 90 days after the Landers earthquake. Superimposed are the aftershocks that occurred during the 90-day time period. *(Bogdan Enescu, GFZ).*

Dissemination of results and end-user's interface

It is essential that SAFER makes its results known not only to other specialists, but also to end-user groups and the general public. This involves:

- The project webpage.
- Inviting representatives of different civil protection authorities to SAFER meetings.
- The development of an user-orientated *Dynamic Decision Support Module* (DDSM). It will consist of an area-independent software framework and use GIS databases that may vary in content, accuracy and resolution, depending upon the subject area.



Above: Elements of an EEW system that includes the DDSM. The DDSM will visualise relevant spatial data (topography, soil etc.), simulate earthquake scenarios and provide post-seismic information about the area affected *(Christina Rönnau, cedim AG.).*