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SAFER - Seismic eArly warning For EuRope

An earthquake early warning and response research program

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Introduction

Earthquakes and accompanying phenomena such as tsunamis and landslides are a serious threat for many countries in and around Europe. As a contribution to efforts to mitigate such dangers, the EC (2½ years) project **SAFER** (Seismic eArly warning For EuRope) has been instigated.

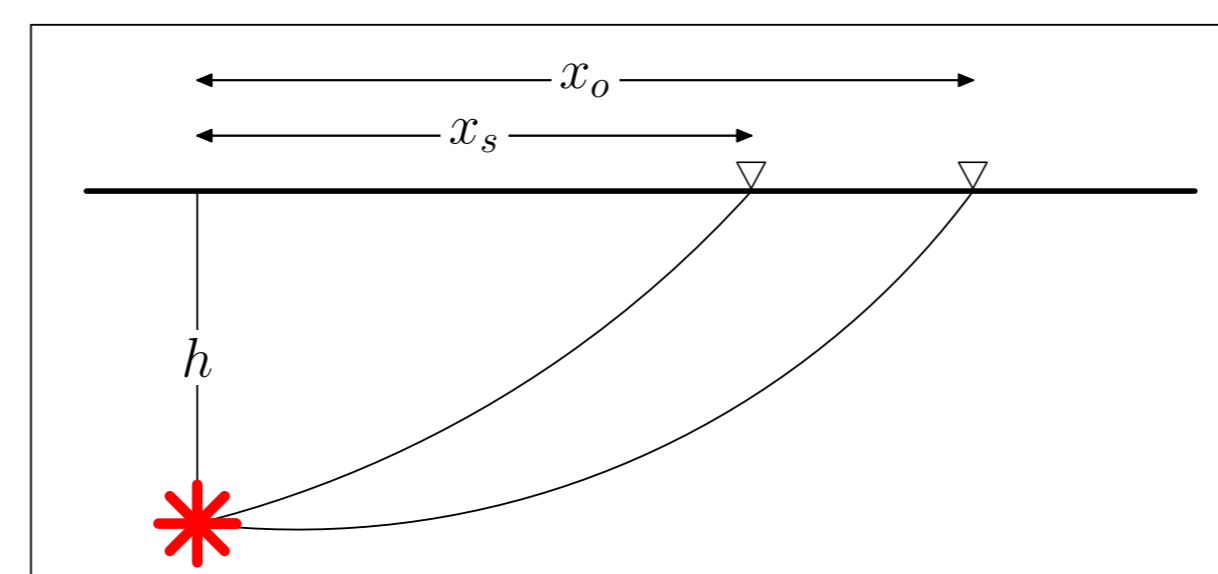
SAFER aims to exploit the real-time analysis of signals from seismic networks for a range of actions, performed over time intervals of seconds to minutes. Such actions include the shutting down of critical systems, activating protective control mechanisms for crucial structures, and supplying information to emergency management services.



Despite technological and scientific advances, society is still under grave risk from earthquakes and secondary events in many parts of Europe. It is therefore the aim of SAFER to develop early warning and associated methodologies to mitigate such hazards.

Earthquake Early Warning

The physical basis for earthquake early warning (EEW) depends upon the faster (and weaker) P-waves from a seismic event being detected and analyzed before the slower (and potentially destructive) S-waves arrive.



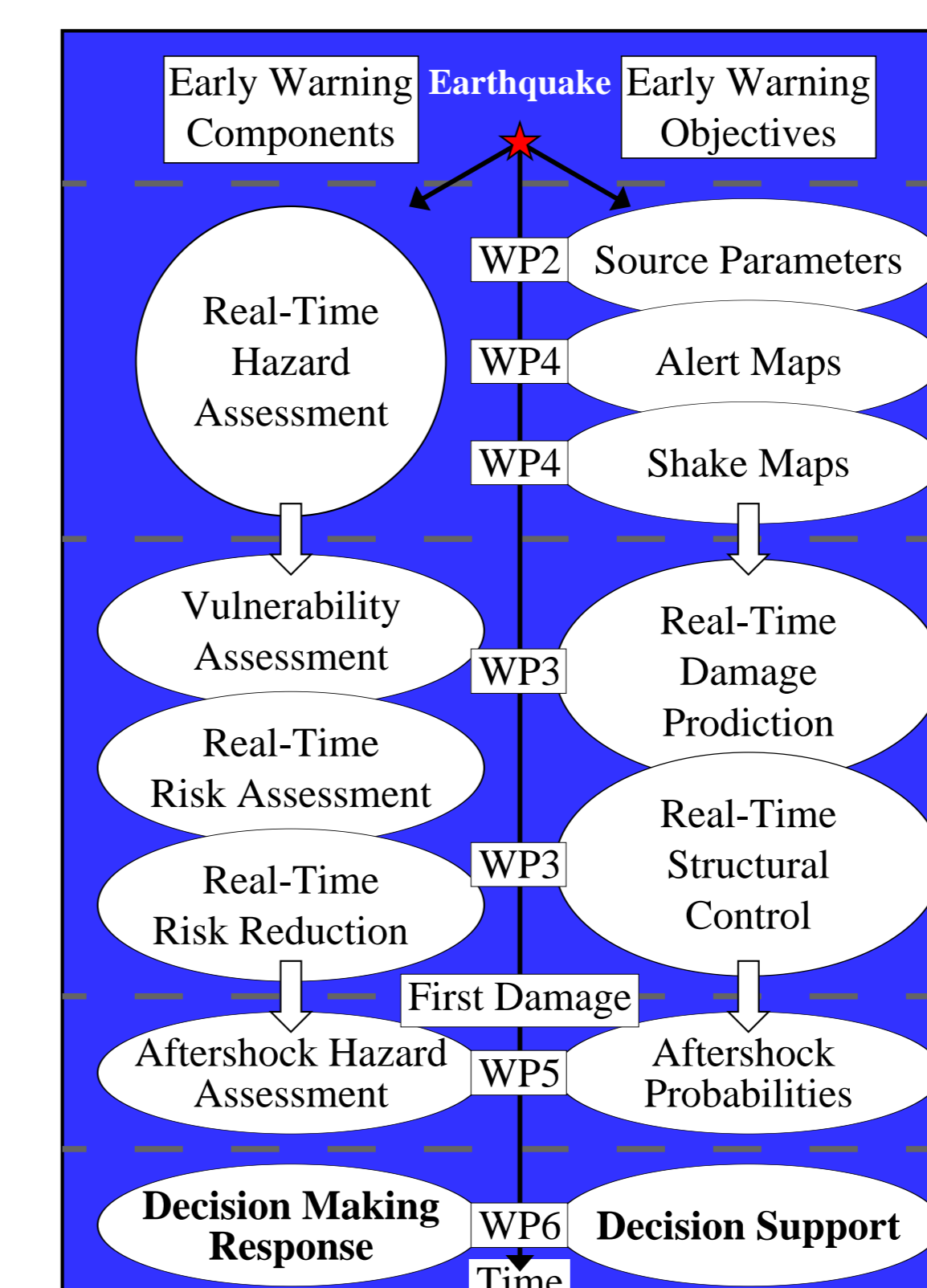
The resulting warning time, Δt_w , may be approximated as

$$\Delta t_w \approx \frac{\sqrt{x_o^2 + h^2}}{v_s} - \frac{\sqrt{x_s^2 + h^2}}{v_p} - \Delta t_p$$

where v_p and v_s are the P- and S-wave velocities, x_s and x_o are the distances of a seismic station and the observer being warned from an earthquake's epicenter, h is the depth of the event, and Δt_p is the required processing time. The realistically expected Δt_w times are of the order of 10's of seconds.

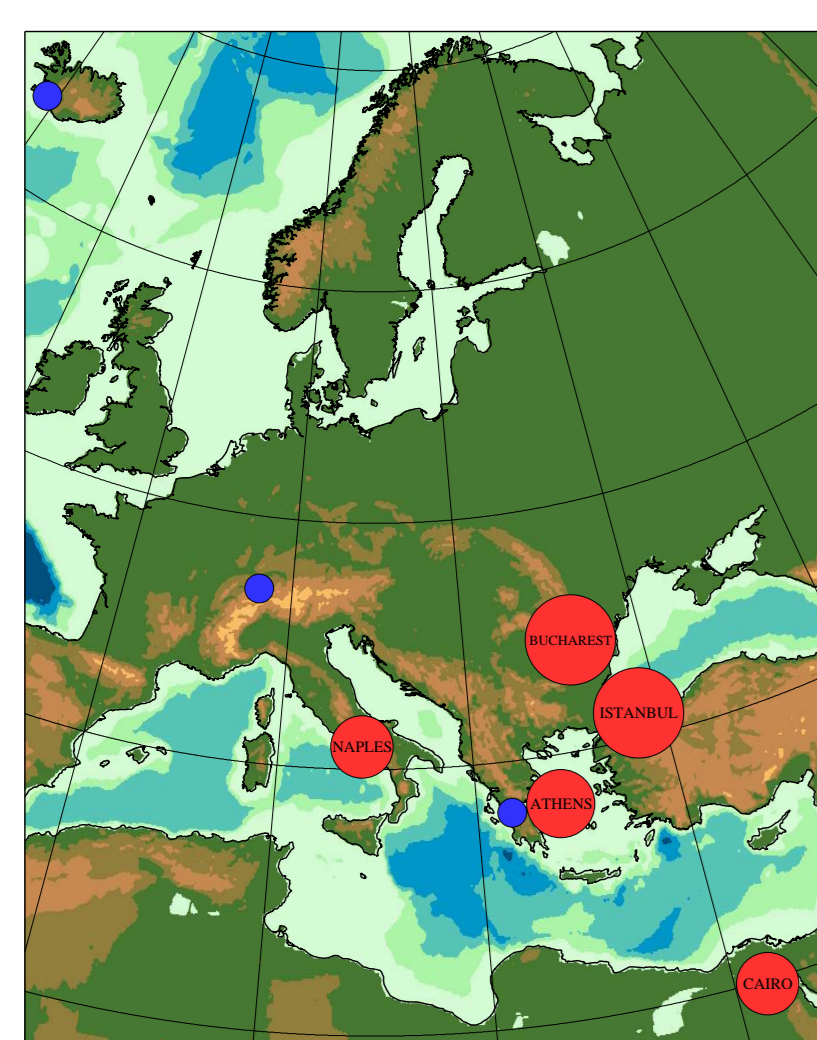
Work Packages

The SAFER work packages (including **WP1** Project coordination and management) are:



- **WP2** Real-time estimation of earthquake source parameters. This WP will develop, test and optimize algorithms for real-time earthquake location and magnitude estimation.
- **WP3** Real-time damage assessment and reduction strategies. The aim of this WP is to develop methods of real-time damage assessment, as well as semi-active and active control systems.
- **WP4** Real-time shake maps. This work will use observed ground motion to produce real-time shake maps, while developing a prototype of a low-cost self-organizing sensor system.
- **WP5** Real-time aftershock hazard assessment. This WP will use the physical and statistical behavior of aftershocks to develop systems that will predict their spatial and temporal distribution.
- **WP6** Dissemination of results and end-user interface. Part of this WP involves developing a Dynamic Decision Support Module for the test cities.

Test Cities



The project will focus on five major earthquake prone cities around the Mediterranean, with a combined population of ca. 40 million inhabitants, as well as test sites in Iceland, Switzerland, and the Gulf of Corinth.

- **Athens** This area is characterized by an intermediate hazard level, having experienced damaging earthquake sequences in 1981 and 1999. The national seismograph network consists of 30 permanent stations, with 5 in metropolitan Athens.
- **Naples** The Campania Region is highly exposed to seismic risk, as shown by the 1980 Irpina earthquake, which caused over 3000 casualties. A prototype early warning system based on a dense seismic network in the Apenninic belt region is currently being developed and tested.
- **Bucharest** Since the devastating 1977 earthquake, an early warning system has been operational, helped by the relatively stable radiation patterns and stationary epicenters of Romania seismic events.
- **Cairo** Most earthquakes in Egypt have magnitudes less than 5, but because of the dense population, poorly constructed buildings and high site amplification effects, the potential for damage is very high.
- **Istanbul** Seismic risk is very high for Istanbul. There has been an east to west progression of events along the North Anatolian Fault over the past 70 years, with a major event in the Marmara Sea expected within the next few decades.

Expected Goals & Outcomes

- The development of new and improved algorithms for real-time determination of earthquake source parameters, magnitude/moment determination and fault mapping.
- Further elaboration of new concepts, including the virtual seismologist, that will provide real-time alert maps and predicted shake maps within seconds and minutes, and measured shake maps within several minutes.
- Development of fast algorithms for damage scenario simulations and the improvement of existing methods for real-time simulation and prediction of earthquake-triggered secondary events (e.g. landslides) and the related human and infrastructure losses.
- Deployment of real-time structural control mechanisms for the immediate protection of endangered infrastructure.
- Improvements in real-time aftershock hazard prediction.
- Development of a low-cost seismic instrument that will be incorporated into a self-organizing flexible network for use by public and private parties.
- Development of a Dynamic Decision Support Module that will be applicable to the needs of the test cities assessed during this project.

SAFER Consortium

- GeoForschungsZentrum Potsdam, Germany
- AMRA Scarl, Italy
- University of Karlsruhe, Germany
- Bogazici University, Turkey
- Humboldt University - Berlin, Germany
- National Institute of Geophysics and Volcanology, Italy
- Institute of Geodynamics, National Observatory of Athens, Greece
- National & Kapodistrian University of Athens, Greece
- Centre National de la Recherche Scientifique, France
- European-Mediterranean Seismological Centre, France
- Swiss Federal Institute of Technology Zurich, Switzerland
- National Institute for Earth Physics, Romania
- Norsar, Norway
- Norwegian Geotechnical Institute, Norway
- Icelandic Meteorological Office, Iceland
- World Agency of Planetary Monitoring & Earthquake Risk Reduction, Switzerland
- University of California Berkeley, USA
- National Taiwan University, Taiwan
- Selex Communications S.p.A., Italy
- National Research Institute of Astronomy & Geophysics, Egypt
- National Research Institute for Earth Science & Disaster Prevention, Japan
- Royal Netherlands Meteorological Institute, Netherlands
- Cedim AG, Germany