## EPOS: European Plate Observing System
## *Research Infrastructure and E-Science for Data and Observatories on Earthquakes, Volcanoes, Surface Dynamics and Tectonics.*

# ANNEX 2
## *Building upon existing partnerships and networks*

The new infrastructure builds upon existing pan-European research networks and infrastructures. Some of these have been long established (e.g., ORFEUS, EMSC) whereas others started within FP5 and FP6 or are part of other multi-lateral programmes (e.g. ESF). It is expected that all these partnerships will both facilitate the planning, and provide knowledge and expertise in the establishment of EPOS.
In the following, we provide a list of the major existing pan-European networks that show effectively the degree of maturity of the RI.

**ORFEUS - Observatories and Research Facilities for EUropean Seismology**
ORFEUS (http://www.orfeus-eu.org/) is the non-profit foundation that aims at coordinating and promoting digital, broadband (BB) seismology in the European-Mediterranean area. It has been founded in 1987. ORFEUS is funded and governed by corporate founders from 13 European countries forming the board of directors. More then 60 research institutes and universities are registered participants. Its activities are distributed between the ORFEUS Data Centre (ODC), gathering, archiving and providing waveform data, and four working groups, coordinating data availability and relevant developments. The daily activities are performed by its staff and steered by an executive Committee which is appointed by the Board of Directors. The ODC acts as regional data centre within the International Federation of Digital Seismograph Networks (FDSN) and is hosted by the seismological division of the Royal Netherlands Meteorological Institute (KNMI) in The Netherlands. ORFEUS operates under the auspices of the European Seismological Commission (ESC) and cooperates closely with its sister organization in Europe, the European-Mediterranean Seismological Centre (EMSC).

**NERIES - Network of Research Infrastructures for European Seismology**
The NERIES infrastructure (http://www.neries-eu.org; FP6-2004-infrastructures-5, Contract No: 026130) has been established with the goal of monitoring and understanding the earthquake processes and mitigating their effects. In seismology this has been long recognized to require a concerted, dedicated, and international approach. NERIES responds to the needs of the seismological research and surveillance communities as well as to concerns from society. Earthquakes are recorded in the larger European-Mediterranean region by over 100 seismic monitoring systems and observatories in 46 countries. The goal of NERIES is to network these seismological infrastructures into a sustainable integrated pan-European cyber-infrastructure serving current and future needs of the scientific community and of society.
NERIES involves Networking, Transnational Access and Joint Research Activities to promote improved access to distributed databases, common protocols, standardized procedures and strategies for long-term archiving and distribution of seismological data. It is expected to develop a new generation of hazard and risk assessment tools designed to improve monitoring and understanding of the earthquake process. An important aspect of NERIES is that it Invests in capacity-building and technology-transfer to ensure access to modern technologies for infrastructures to the larger scientific community in the Euro-Med region.
The use of seismological data for scientific research is expected to boost the capability of the research community to investigate earthquake processes and Earth structure and dynamics and strengthen the role of European seismology in global seismic monitoring and hazard mitigation. In addition, the use e-Science technology will facilitate the outreach to the public at large and educational institutions in particular. Overall, this network infrastructure takes full advantage of the experience and the expertise matured in the field in many years by ORFEUS and EMSC. NERIES is leading the EU seismological infrastructures in building a key land-based segment of the GMES strategy and of the GEO 10-years implementation plan.

**EMSC - European-Mediterranean Seismological Centre**
The EMSC (http://www.emsc-csem.org/) was founded in 1975, following a recommendation from the European Seismological Commission (ESC). The ESC is a regional commission of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), itself a specialized association of the International Union of Geodesy and Geophysics (IUGG). The members are seismological Institutes and Observatories. In 2008, there are 77 members from 50 countries, from Iceland to Saudi Arabia and from Russia to Morocco. Its scientific activities are related to seismic hazard and earthquake monitoring. It

provides earthquake information at Euro-Med and global scale in coordination with the national institutes as well as the international agencies, the International Seismological Center (ISC) and the NEIC of the US Geological Survey. It also aims at extending the current integration process of the European seismological community towards Northern Africa and the Middle East.

**EXPLORIS – Explosive Eruption Risk and Decision Support for EU Populations Threatened by Volcanoes**

The main objective of the EXPLORIS research network (Contract No: EVR1-CT-2002-40026, http://exploris.pi.ingv.it/non_conf/description/index.htm) consists of determining through quantitative analysis the explosive eruption risk in densely populated EU regions. This follows from the large increase of conurbations at high risk from volcanic disasters induced by pyroclastic flows and tephra fallout. Whatever the policy to mitigate such a huge risk might be, quantification of risk in association with a range of eruption scenarios, their impact, and mitigation are the fundamental priorities. The project addresses these critical issues by advancing critical scientific and technological facilities (e.g. simulation codes, vulnerability databases, and risk protocols) needed in volcanic risk assessment and mitigation. The project also aims to apply the facilities to those European volcanoes at high risk (Vesuvius, Italy; Soufriere, France; Sete Cidades, Portugal; Teide, Spain) so that they become a technology platform for exploitation at volcanoes throughout the world capable of supporting officials in deciding development and planning priorities as well as decision making in volcanic crises.

The approach adopted gathers and combines knowledge deriving from different fields in order to provide a strategic multidisciplinary set of expertise. Competence in field volcanology, geology, physical modelling, applied mathematics, fluid-dynamics, computer science, engineering, architecture, medicine, and risk analysis are all involved in the project, and represent a unique opportunity to improve European capabilities to undertake the complex task of volcanic risk management. The project also contributes directly to improve the quality of life of millions of people in high-risk European regions through the establishing of safer life conditions. In particular, the assessment of volcanic risk on a probabilistic basis, as well as the identification of possible mitigation measures, will certainly help in the definition of a mitigation policy aimed at the reduction of risk for cities on volcanoes and volcanic islands.

**VOLUME – Volcanoes: Understanding subsurface mass movement**

The rationale behind the VOLUME research network (http://www.volume-project.net/; FP6-2004-Global-3, Contract No: 018471) is to increase our understanding of how subsurface mass movement manifests itself at the surface, in turn revealing the significance of such movements as precursors to impending eruptions. Volcanic eruptions are preceded by mass migration through a subsurface fracture network. A primary goal in monitoring active volcanoes is to capture, from the surface, measurements of sub surface mass movement. Such movements of multiphase fluids are generally detected at the surface in terms of changes in geophysical and geochemical observables.

This project employs and integrates seismic, gravimetric, geochemical, terrestrial and space based deformation data and it undertakes joint inversions of these datasets through iterative numerical forward modelling of coupled processes (e.g. multi-phase fluid pulses with elastic wave radiation in solids; gas and temperature with ground deformation and seismicity…).

Volcanoes and volcanic eruptions generate widespread interest in the public at large and are life and/or livelihood threatening to a small minority of people. Civil authorities rely on the information provided to them by the research community so that they can make informed decisions, based on the best scientific evidence available and VOLUME partners with the local communities and the civil authorities in the regions of interest.

**THYMER - Thermo-hydro-mechanical processes of rocks**

The main objective of THYMER (ESF programme) is to develop a network of European laboratories dealing with physical and mechanical properties of rocks, in order to improve communication, the exchange of idea and to promote technological innovation. The THYMER network will address complex problems that single laboratories cannot fully cope within the field of earthquake mechanics and volcanic processes. These themes require the contemporaneous activity of different labs with different expertise that can only be achieved in the frame of an established network.

The anticipated results of THYMER Programme will be achieved during the progress of the programme itself and can be summarized as follow:

- Sharing knowledge and expertise at the European scale to address wide and complex interdisciplinary
- themes that a single laboratory cannot address.
- Enhancement of ongoing national experimental work on different pieces of equipment and at different Earth's crust conditions.
- Starting a new generation of laboratory experiments and models able to improve the understanding of mechanisms which drive earthquake generation and volcanic eruptions;

- Stronger links with field scientists engaged in providing laboratory resources will become a further tool to interpret different geophysical and volcanological parameters.
- Provide a new level of interdisciplinary technical expertise, manpower and lab facilities to address the society demand in the oil industry, renewable energies like geothermal and storage of green house gas.

**TECTOMOD - Analogue and Numerical Modelling of Tectonic Processes**

In Europe, Earth Science Institutions have independently implemented numerical and analogue laboratories to simulate tectonic processes and surface deformation such as mountain building and basin formation. The scope of TECTOMOD (http://www.tectomod.eu) is to establish a synergy between these institutions and their different techniques and approaches to model the deformation of the lithosphere.

Novel tectonic modelling concepts and their implementation in numerical simulation software provide new opportunities for quantifying the interplay between stresses and rheology during deformation of the lithosphere. Computer simulations are used to focus on the links between mountain-forming and basin-forming processes, basin geometries and temporal and spatial distribution of vertical motions. Furthermore, thermo-mechanical numerical modelling schemes, accounting for the physics of strain localization in the lithosphere and its consequence for poly-phase deformation and associated vertical motions, can be designed and applied. Analogue (physical) experimental studies will provide independent validation of numerical models and will be particularly useful in complex tectonic settings, such as those with pronounced 3-D geometries. Various scales can be handled: shallow to deep, local to regional. While the numerical approach successfully handles issues such as the thermal and rheological evolution of the lithosphere. Analogue models are able to simulate faulting and being very efficient in the analysis of complex 3D problems, but are unable to suitably incorporate the temperature dependence of rock rheology during deformation.

In this programme, the foremost European numerical and analogue laboratories join together to collaborate and share laboratory equipment and knowledge in approaching process like mountain building, basin formation and the interplay between tectonics and surface process, including the effect of climate. Tecto-Mod Network is also closely related to ESF Euro-Margin and TOPO-Europe programmes.

**TOPO-EUROPE: the Geoscience of Coupled Deep Earth – Surface Processes**

TOPO-EUROPE (http://www.esf.org/activities/eurocores/programmes/topo-europe.html; ESF programme) addresses the 4-D topographic evolution of the orogens and intra-plate regions of Europe through a multidisciplinary approach that links geology, geophysics, geodesy and geotechnology. TOPO-EUROPE integrates imaging, reconstruction and modelling of the interplay between processes controlling continental topography and related natural hazards. Until now, research on neotectonics and related topography development of orogens and intra-plate regions has received little attention. TOPO-EUROPE initiates a number of novel studies on the quantification of rates of vertical motions, related tectonically controlled river evolution and land subsidence in carefully selected natural laboratories in Europe. From orogen through platform to continental margin, these natural laboratories include the Alps/Carpathians-Pannonian Basin System, the West and Central European Platform, the Apennines-Aegean-Anatolian region, the Iberian Peninsula, the Scandinavian Continental Margin, the East-European Platform, and the Caucasus-Levant area. TOPO-EUROPE integrates European research facilities and know-how essential to advance the understanding of the role of topography in Environmental Earth System Dynamics. The principal objective of the network is to integrate activities among TOPO-EUROPE institutes and participants.

Key objectives are to provide an interdisciplinary forum to share knowledge and information in the field of the neotectonic and topographic evolution of Europe, to promote and encourage multidisciplinary research on a truly European scale, to increase mobility of scientists and to train young scientists.

**SPICE - Seismic wave Propagation and Imaging in Complex media: a European network**

The SPICE Consortium aims at integrating institutions with specializations in physical, mathematical, geological, and computational aspects of wave propagation (http://www.spice-rtn.org/). The goal is to develop, verify and apply computational tools for wave propagation and imaging problems on all scales. With the novel computational algorithms we expect breakthroughs in (1) the determination of global Earth structure; (2) the quantitative estimation of shaking hazard; (3) the characterization and monitoring of reservoirs; (4) understanding the structure and processes inside volcanoes; (5) simulating the physical processes of earthquake rupture; and (6) characterizing the small-scale properties of rocks.

The theory and applications of acoustic (elastic, seismic) wave propagation are entering a new era in fields such as seismology, oceanography, meteorology, acoustics, engineering, material sciences, medical sciences and others. In the past ten years the methodologies used in those fields have dramatically converged due to the massive use of numerical methods.

Modern computational techniques in combination with parallel computer architectures allow the simulation of the complete three-dimensional phenomena of wave propagation for realistic complex structures with

unprecedented detail. This suggests that the reverse processes (e.g. imaging of the Earth's internal structure, physical description of hydrocarbon reservoirs, monitoring of zones of weakness in constructions, characterization of earthquake rupture processes, etc.) will experience a quantum jump in resolution and accuracy over the next decade.
Computational methodologies play an increasingly important role in Earth Sciences. However, the curricula are not able to provide the required teaching to equip young scientists with the necessary background in mathematical and computational aspects of a rapidly expanding field. The goal of the proposed network is to compensate for this and to provide open training facilities for the next generation of researchers in the field of computational wave propagation. This shall be achieved by regular training courses involving the network team and leading scientists in the associated fields of research.

EPOS will also include the relevant results and major developments obtained within several STREP-FP6 EC projects, such as **SAFER** (Seismic eArly warning For EuRope - www.safer**project**.net/) and **TRANSFER (**Tsunami Risk ANd Strategies For the European Region - www.transferproject.eu/) focused on the developing of Early Warning Systems for earthquakes and tsunami, respectively. The goal is to apply the scientific outcomes of these projects to the development and the implementation of monitoring infrastructures and ICT applicable tools. In addition, results of the FP6 ICT Project DEWS (Distant Early Warning System - www.dews-online.org) will give valuable developments for parts of e-science tools. Based on the sensor integration platform of GITEWS (German Indonesian Tsunami Early Warning System – www.gitews.org) the project aims in the development of a new generation of interoperable tsunami early warning systems integrating reliable tsunami detection and effective warning dissemination. It is foreseen to integrate so-called upstream functions as earthquake, sea level and ground deformation monitoring based on a multi sensor platform and standard based reference models for data integration and data dissemination with special focus to integrated early warning systems.