# Veðurstofa Íslands
# Report

Ragnar Stefánsson, Þóra Árnadóttir, Axel Björnsson, Chris Browitt, Hilmar Bungum, Reynir Böðvarsson, Bernard Dost, Sören Gregersen, Wolfgang R. Jacoby, Andreas Junge, Gabriele Marquart, Florence Riviere, Freysteinn Sigmundsson, Thierry Villemin

# Preparing the infrastructure for studying the dynamics of the Iceland Hotspot – HOTSPOT

## An EC proposal for theme 1.1.4.-9: Support for research infrastructures

VÍ-G99010-JA03
Reykjavík
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PART B

FULL NAME:
Preparing the infrastructure for studying the dynamics of the Iceland Hotspot

ACRONYM: HOTSPOT

PROGRAMME:
1.1.4.-9 Support for Research Infrastructures

PROPOSAL NUMBER: EESD-ENV-9 9-0068

**Chapter B3**

# Objectives

To study and to understand the dynamics of the Iceland Hotspot is one of the challenging objectives of earth sciences today. It is an objective of such a dimension and significance that it requires and deserves multinational, high quality input of scientific and technological skills. In the HOTSPOT project we plan to prepare for such large-scale research efforts by utilizing in full the existing geophysical observational facilities for this purpose. But this is only a first step of a much larger project. Therefore it is also an objective of the present proposal to design new facilities, which are necessary for the more general objectives of studying the Hotspot, and to create an international consortium to extend observations and encourage research.

### The Iceland Hotspot

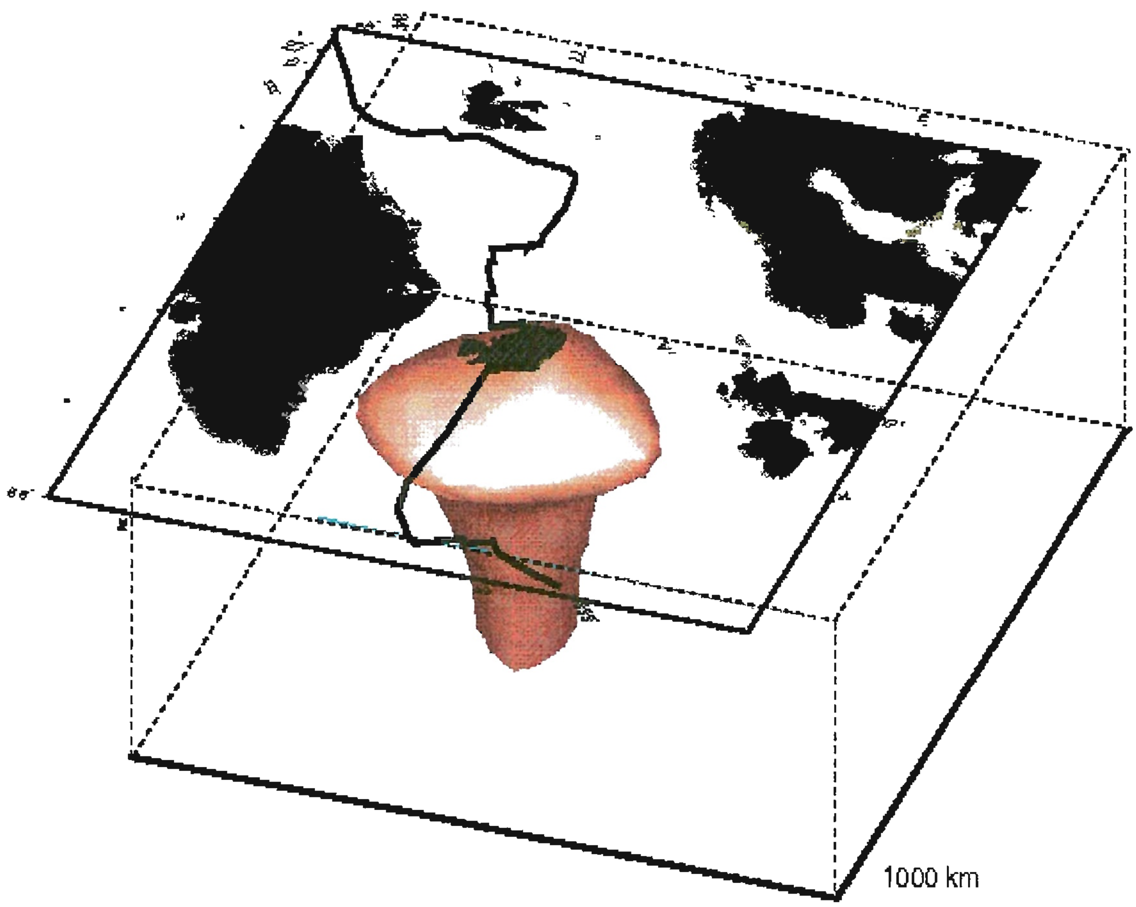



Figure 1. *A logical sketch of the uppermost 1000 km of a plume below Iceland, originating at the core mantle boundary, indicating its relation to Iceland and the surrounding North-Atlantic land areas.*

The Iceland Hotspot is a large scale feature on the earth. Its root is an active mantle plume located below the Mid-Atlantic. It can be traced by seismic tomography through the entire mantle (Figure 1). Gravity anomalies show its effects over an area of several hundreds thousands $km^2$. Horizontal stress compressions with direction towards the plume area are indicated on both sides of the Atlantic Ocean [4, 9, 10, 1].

Although seismic tomography work has added significant information about the Iceland plume during recent years, it has introduced new questions which can only be answered by more observations.

### Large temporal variations in activity and strain waves

Large temporal variations in seismic and volcanic activity and in strain rates, coincident over large areas, have been observed both on long-term and short-term basis in Iceland. Such strain waves or strain pulses increase the probability of seismic and volcanic activity in the crust over a large area.

Historical and geological evidence describe a large temporal variability in seismic and volcanic activity [7, 3]. An example of a period of high activity was the creation of a new island in an eruption on the Reykjanes ridge in early 1783, followed a few weeks later by the huge eruption of Laki, in the central highland of Iceland. In 1784 followed the largest earthquake in the history of Iceland (M=7.1), which occurred in the South Iceland seismic zone.

Short-term variations in stress and deformation fields, attributed to effects of plume activity, have been observed instrumentally over large distances. The intensified instrumental observations in Iceland related to seismic risk mitigation projects like the SIL project of the Nordic countries and the PRENLAB and PRENLAB-2 projects of EU have indicated that strain waves, probably related to intrusive episodes can be observed over large distances, 100-200 km. However, it has been very difficult to confirm such connections [8, 2, 6, 5].

The temporal variations in activity are still poorly understood, although it is often assumed that they are triggered by a common large source, i.e. a large intrusion of basaltic fluids into the crust from below. It is of an enormous significance to be able to understand the underlying mechanism of them and to monitor them intensively both near their origin as at distance.

### The significance of studying the Iceland plume

The Iceland Hotspot and its roots, the Iceland mantle plume, has attracted enormous global scientific interest during recent years. The research will try to answer some of the most challenging questions of the evolution of the earth and of crustal and upper mantle processes. New observations are needed for this research.

Studying the Hotspot dynamics, the causes of stress variations and their migration and effects require a huge amount of observations, technological development and scientific skills. It may lead to great advancements in understanding crustal processes which lead to earthquakes and volcanic hazards, not only in Iceland, but all over the world, and thus to mitigation of risks.

Studying the Hotspot dynamics requires multinational cooperation far beyond the present proposal.

**The large multidisciplinary geophysical observational networks in Iceland**

A high quality geophysical observational network exists and is currently being built up in Iceland. It is for the most part organized for the purpose of mitigating risks caused by seismic and volcanic hazards, and focusses on populated areas (Figure 2). Although

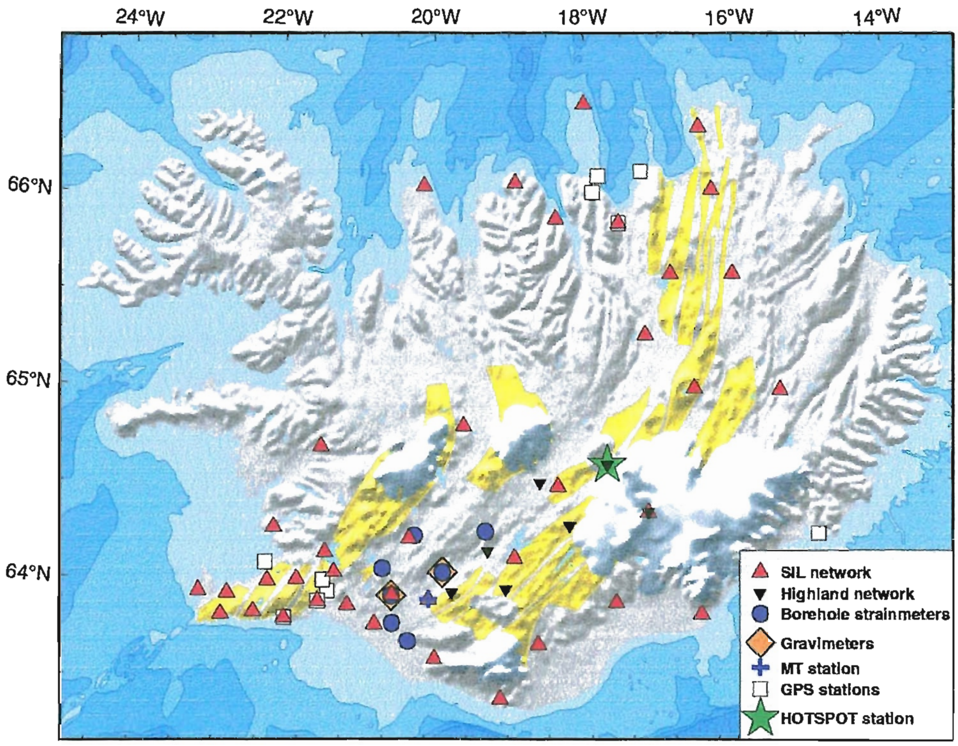



Figure 2. *The locations and types of the geophysical monitoring stations in Iceland, which HOTSPOT will make available to European research. The site marked HOTSPOT station is the station VON which is planned to be a test site for designing the unmanned European HOTSPOT station in the harsch conditions near the center of the active Hotspot.*

this network is aimed for alerts and for risk mitigation research it already provides other information significant for studying the Hotspot dynamics. The aim of HOTSPOT is to support this operative network to better serve these objectives. Especially the aim is to prepare the data and to make them more easily accessible for the international scientific community. We also aim to prepare the infrastructure, both the observational sites as well as the center facilities, so it can easily incorporate various new sensors and observations, provided by research projects and institutions all over the world which increasingly show interest in placing their sensors near and above the Iceland plume center. Besides preparing the network for enhancing the seismic and deformation observations, it should be prepared to include continuous gravity, continuous MT and continuous gas and hydrological monitoring, provided by other institutions.

A significant objective of the proposal is to design a remote, multidisciplinary, umanned observatory to be installed in the very harsh conditions of central Iceland, the European HOTSPOT Observatory Station. This design will become one of the main pillars for later extension of the HOTSPOT networks.

**The significance of a larger platform observations**

Although multidisciplinary observations in Iceland, in the very active area above the center of the Hotspot are extremely significant, it is also necessary to study the plume over a larger area to cover its dimensions.

Seismic observations from the surrounding areas, Scandinavia, Great Britain and Greenland, will also be integrated into the HOTSPOT infrastructure with the important aim to add data for seismic tomography of the plume. The networks in these areas will be supported to make their observations more easily accessible for research. The participation in the project will also give a boost for necessary extension of these networks. The most significant future extension is to initiate ocean bottom observatories in the area between Scandinavia, Greenland, Great Britain and Iceland.

**The objectives of the present proposal**

The objectives of the proposal are to create a European/Icelandic observational basis for a large-scale international project of studying the Hotspot dynamics. It will encourage scientists from all over the world to participate in building up the observational facilities and intepretation of data. Scientists from all over the world have shown interest and enthusiasm to participate in such an undertaking.

The objectives can be summarized as follows:

- To prepare and focus the geophysical observational infrastructure in Iceland to observe the dynamics of, and especially the variations of the activity of the Iceland plume, the Hotspot. This will be partly done by focussing the functions of the existing acquisition and evaluation system in Iceland, the SIL system, and related systems to that purpose by including available sensors in to the system and sensors provided by other projects. It also involves designing and testing an unmanned multidisciplinary automatic geophysical observatory in the remote area of Vonarskard above the center of the plume.
- To create a geophysical database of long-term and ongoing observations to facilitate European and international research of the plume dynamics and crustal processes, and to utilize existing multinational datacenters in Europe to make the observations easily accessible for scientific research.
- To prepare the seismic observatory infrastructure in neighbouring areas, Scandinavia, Great Britain and Greenland to widen the observational platform.
- To use the experience and cooperation gained in building up the European/Icelandic HOTSPOT observational facilities to create an international scientific consortium to promote further research of the Iceland plume dynamics.

By carrying out these HOTSPOT objectives we create the observational basis for research to address the following goals:

- To understand and model magma generation, segregation and intrusions from the mantle into the crust.

- To understand and model the deformation and stresses caused by such intrusions, i.e. how stresses are transmitted along the crust. These models should provide information about rheological conditions of the crust and upper mantle, that are significant for hazard assessment research everywhere on the earth.
- To create infrastructure for widening the observational bases for studying the Iceland plume to areas on both sides of the Atlantic.
- To add new elements to, and constraints on the dynamic modelling of the Iceland plume, to understand and monitor the episodic processes of crustal formation and relate it to plate motion in the North Atlantic on a geological scale.

Chapter B4

# Contribution to programme/key action objectives

HOTSPOT contributions to the objectives of the support for infrastructure programme are the following:

- It will make the multidisciplinary geophysical observational infrastructure of Iceland available for researchers in Europe.
- It will create a new public database of seismic observations in northern Europe, by linking them electronically through the established European databases of EMSC and ORFEUS and thus securing internal compatibility.
- It will create a new public database of geodetic observations of crustal deformation in Iceland, the first of its kind in Europe.
- It will design a new unmanned multipurpose geophysical observation station in the harsh conditions of the central highland of Iceland.
- It will improve existing infrastructure facilities by adding a variety of available sensors to them for enhanced geophysical observations.
- It will encourage scientists to participate in the project by making it easy for them to include their instruments to the observational network.
- It creates a network of researchers and end users for optimum use of resources, both observational networks as well as available observational facilities and skills.
- It will complement national and multinational initiatives by identifying gaps in the infrastructures in response to emerging scientific priority needs. It contributes to the design of new infrastructures and observational networks, and initiates new observations in parallel and forthcoming projects.

The data collected as a result of the HOTSPOT project will contribute to a wide variety of earth science research, particularly pertaining to seismic and volcanic risk, as well as large-scale phenomena such as Hotspot dynamics.

The project is a direct and logical continuation of significant European activities for seismic and volcanic risk mitigation, supported by EU, like the PRENLAB and PRENLAB-2 projects.

The HOTSPOT project therefore promotes advanced European research of global significance.

Chapter B5

# Innovation

## B5.a State-of-the-art of available observations

### B5.a.1 Iceland geophysical networks

The geophysical observational network in Iceland for studying crustal processes and plume/ridge activity consists of following main components:

- A 3-component digital seismic network of 38 stations spread over Iceland with highest concentration in areas of high seismic and volcanic risk, having various seismometer bandwidths. The system evaluates automatically small earthquakes for hypocenter location and magnitudes in real-time. In a semi-real-time it evaluates also for fault plane solutions and moment magnitudes. It evaluates automatically of the order of ten thousand earthquakes per year, and can cope with evaluating in near-real-time 1000-1500 earthquakes per day. The sensitivity of the system is down to magnitude 0 in the lowland areas, but down to magnitude 1-2 in the highland areas. All automatic evaluations are qualified and corrected manually, before putting them into database. The basic function of the system is to retrieve and to evaluate an almost continuous row of information carried by microearthquakes, information which is used for analyzing the state and possibly the outbursts of activity in the seismic and volcanic regions. Advanced software and 1 ms time accuracy in the waveform data makes it possible to map faults and fault instability at depth with a high accuracy. Although it is not the basic function of the system, it is also used for recording and storing information about distant earthquakes or teleseisms, providing information about structure to a large depth. An alert system provides automatic alerts about activity based on predefined parameters.

- A seven station network of 1-component analog seismic stations in the highlands.

- Volumetric strainmeters providing continuous digital data are operated in 7 boreholes in the South Iceland seismic zone (SISZ), linked to the SIL center.

- Continuous high accuracy GPS measurements for recording crustal deformation are in operation at five sites in the SISZ and at one site in Southeast Iceland, and four are in preparation in the North Iceland seismic zone.

- Continuous monitoring of conductuctivity by MT methods is carried out at two sites in Southwest Iceland, one of these linked to the SIL center.

- Continuously recording gravimeters are in operation at two sites in the SISZ, linked to the SIL center.

- Extensive information about deformation has been collected during the past decades, which are a very significant part of the infrastructure. Most significant are 600 points of repeated high accuracy GPS deformation measurements since 1986 and also high accuracy repeated geodimeter measurements from the last three decades. Information about deformation based on repeated SAR images exist for the last 5 years for a few sites.

- Measurements of water level in boreholes or pressures in closed systems are made by electrical or hydrothermal power companies. Significant and continuous row of these measurements can be made accessible.

Information of all the abovementioned observations, waveform data, parameter data and results of various high level evaluation will be made accessible for research by HOTSPOT.

### B5.a.2 Broadband seismic networks around the North Atlantic Ocean

Broadband seismic networks are in operation around the North Atlantic Ocean, significant for studying the Iceland plume dynamics. These include six stations in Sweden, three in Denmark, one in Greenland, and three arrays of seismic stations in Norway and one on Spitsbergen. Narrower band seismic stations of significance are in the Shetland Islands and the Faroe Islands.

Waveform data and parameter data of these stations will be made easily accessible in scientifically compatible form through the ORFEUS datacenter.

## B5.b Advances and innovation

The main advances and innovations of HOTSPOT are:

- It makes easily accessible to science multidisciplinary geophysical observations from all the abovementioned observational systems.

- It integrates observational facilities, which are available at various institutes, into this infrastructure and makes them operative.

- It prepares the existing infrastuctures to become able to adapt various new and significant observations into the system by other projects.

- In cooperation with a large number of end users and on basis of networking actions HOTSPOT designs new and necessary geophysical observatory systems, utilizing the experience gained by the available infrastructure.

By this HOTSPOT prepares facilities for innovative research and nescessary extension of observations:

- Research aiming at understanding how intrusive magmatic fluids break into the crust, and how to record such pulses of activity. This is significant for mitigating volcanic risks. The methods used may be applicable also in areas of minor fluid activity, as may be expected in seismic zones in relation to large earthquakes.

- Research aiming at understanding how stresses are transmitted in the crust and how these load the seismic zones and the rift zones. This is significant for seismic as well as volcanic risk mitigation efforts, anywhere on the earth.

- Research aiming at exploring the wider and deeper roots of the Iceland mantle plume by giving research an easy access to well controlled seismic data from a wide area. The very successful tomography exploration of the Iceland plume is mainly based on data from Iceland only, which do not express the total extension of the plume, neither horizontally or to depth.

- Wide area of geoscience research which relies on the availability and the easy access of well controlled geophysical data. High level observational systems in Iceland which are kept going with the main objective of immediate risk mitigation purposes or for power plant monitoring purposes are made available and extended to serve the general needs of research of crust/mantle dynamics and deformation processes.

- Research which aims at applying and testing new obseravations. By technically preparing the infrastructure by networking and by service HOTSPOT opens for input of new research initiatives, applying new sensors for new observations in the area, and collecting information far beyond the present scope and capability of the observational facilities.

- Extension of the infrastructure into the North Atlantic Ocean, between Greenland, Scandinavia and Iceland, applying permanent and well established stations in the islands, and ocean bottom observatories, is a challenging and timely step and creates basis for innovative earth science research. Going to ocean bottom observatories involves technological innovation work. It is outsite the scope of the present proposal. However, HOTSPOT will by experience and networking among potential end users of such geophysical ocean bottom observations prepare for realizing such a research. The infrastructures on land are a significant frame for this extension. Making these fully accessible for research will encourage and prepare further steps into the oceanic areas.

- The design of the remote automatic multidisciplinary observatory, the HOTSPOT Station, in the harsh conditions of Central Iceland, is in itself a technological innovation. It involves utilizing complementary methods for securing necessary power, methods based on utilizing modern communication methods in such conditions, methods securing unattended operation for a long period of time.

Chapter B6

# Project workplan

## B6.a Introduction

The workplan is based on the three general objectives of HOTSPOT:

- To utilize and adapt the existing geophysical networks in Iceland and in neighbouring North Atlantic countries to become a better basis for studying the dynamics of the Iceland Hotspot.
- To facilitate the use of this infrastructure for research by making the observations easily accessible in a scientific compatible form.
- To encourage international cooperation by networking and by other means aiming at:
  - New projects to enhance observations by input of new sensors into the existing infrastructure.
  - New projects to create new infrastructures necessary for innovative scientific research, aiming at further studies of the dynamics of the Iceland Hotspot.

WP 1 is a central part of the project. It is lead by the coordinator, in close cooperation with all other participants.

The center of the HOTSPOT network is at the center of the Icelandic SIL system. It will enjoy the experience and knowhow of scientists and technicians responsible for the development and the operation of the SIL network.

Much of the work in preparing the existing networks in Iceland and adapting them into the HOTSPOT network is carried out in WP 1. It cooperates especially with WP 2 in linking new observations to the HOTSPOT network. Adapting the continuous GPS networks to the HOTSPOT center is carried out in close cooperation between WP 1 and WP 3.

The objective to make the multidisciplinary Icelandic data accessible is realized at the SIL center, in close collaboration with ongoing work there in building up multidisciplinary databases and an early warning system. This ongoing work is partly within the PRENLAB-2, an EU 4th framework project, and partly supported by Icelandic funding. This part of HOTSPOT will gain very much from the experience obtained at the SIL center in providing researchers and the public with information and research data. Very effective internet information service is run at the SIL center through its website.

One of the main targets of the HOTSPOT project is to strengthen and to organize the infrastructures in such a way that they will be attractive for various scientific institutions to use them for their observational purposes, collecting data of basic interest for their research work. It is a part of WP 1 to lead and encourage this by networking activities. A group of Icelandic scientists and technicians within WP 1 will be the core of the technical and infrastructure aspects of this work. WP 1 will cooperate closely with the WP 6 about the storing and dissemination of Icelandic teleseismic data from the 38

Icelandic SIL stations. WP 1 closely cooperates with all participants, especially in WP 4, encouraging observations and research projects to utilize the infrastructure, and to design new infrastructures.

WP 2 focusses on designing the infrastructure facilities, basically the SIL system, to adapt various types of available sensors to it, both to the computer facilities at the observational sites but also to the communication with the center facilities. This is a part of designing a multidisciplinary observatory in the difficult and remote area near the center of the Iceland Hotspot, i.e. the HOTSPOT Observatory Station. WP 2 cooperates closely with WP 1 to prepare a test site by upgrading one of the seismic stations in the central highlands to become the most multidisciplinary station of the HOTSPOT network, the prototype HOTSPOT observatory station. WP 2 cooperates closely with WP 3 and WP 1 in utilizing the SIL infrastructure as a basis for deformation observations with continuous Global Positioning System (continuous GPS or CGPS) observations.

WP 3 comprises the preparation and unification of all crustal deformation measurements in Iceland into one data structure. All continuous GPS (CGPS) networks in Iceland will also be included in this database. This new database will be created in cooperation between WP 1 and WP 3 to make all crustal deformation data collected in Iceland easily accessible to research.

WP 2 and WP 3 will cooperate on upgrading 10 SIL stations to include continuous GPS observations. WP 1 supervises the installation phase and is responsible for maintaining the stations and data retrieval.

WP 3 and WP 1 are responsible for GPS data processing and will provide the raw data and station coordinates to the HOTSPOT datacenter.

WP 5 will provide the project with an existing structure for efficient data distribution through the European datacenter EMSC, and necessary information to link to the HOTSPOT website for receiving data from there. It will provide the project with a special link to the EMSC website for direct access to the seismic data stored at this website.

WP 6 organizes the wider area seismic network integration as regards broad-band seismic waveform data observed in the countries around the North Atlantic Ocean, outside Iceland. It upgrades a few key stations to provide broader band data than earlier and better communication. It provides good access to broad-band waveform data from 16 stations and arrays. In cooperation with WP 1 it implements various HOTSPOT datasets from Iceland in the ORFEUS database and creates links to make the data easily accessible from the HOTSPOT center through the ORFEUS website.

WP 6 watches the preparation and operation of the wider area platform for the HOTSPOT infrastructure, mainly the seismic network infrastructure. The lead contractor of WP 6 will on basis of data and information supplied by his assistant contractors in different countries make accessible to research, data from seismic networks in countries on both sides of the Atlantic Ocean outside Iceland, which can be linked to from the HOTSPOT website. WP 1 prepares and provides the Icelandic teleseismic and regional seismic events to WP 6 in the same way. In cooperation with others, especially WP 1 and WP 4, WP 6 carries out special networking with the aim of planning necessary extensions of the existing infrastructures in light of the evolving scientific need for a still larger platform and denser observations for studying the plume dynamics.

WP 4 provides the scientific background for observing plume dynamics and activity within the HOTSPOT infrastructure at various temporal and spatial scales. In organizing observations within the infrastructure and in designing new infrastructures it is very significant to understand what will be measurable at different sites. On basis of ongoing modelling work WP 4 will advise the other participants and newcomers which want to introduce new observations about scales and recommended sites for the observations. It will also assist to initiate and to organize new projects for making observations inside the established infrastructures on basis of new and evolving models, and participate in design work for new infrastructures. The work is to a large extent carried out by participation in networking with all the partners of the project including end users outside the project. Especially in the networking part and in work aiming at a wider scope of the infrastructure and research based on that it is closely linked with WP 1.

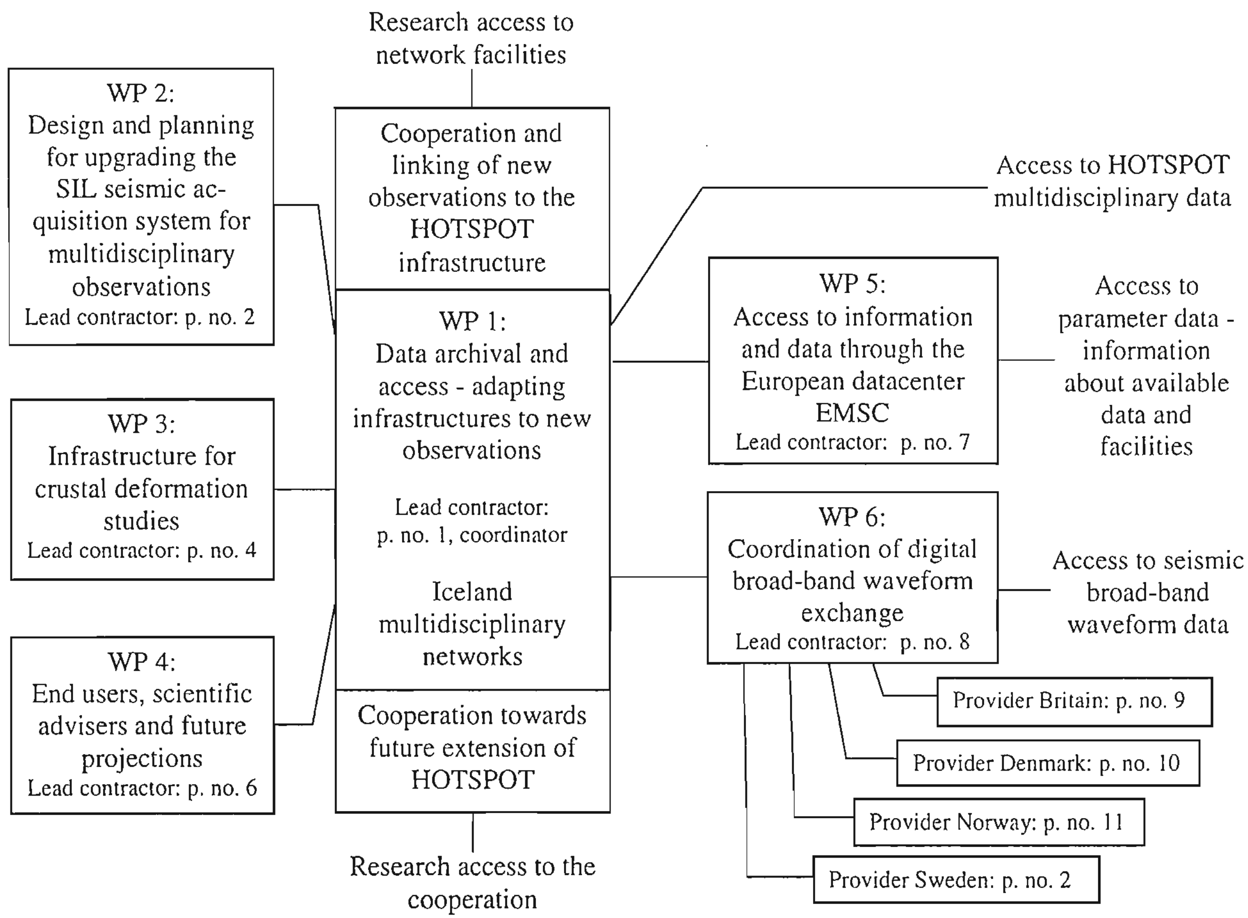
Yearly workshops for organizing the infrastructure and for initiation of new observations and of new infrastructures are the core of the networking activities of the project, with the participation of all contractors, assistant contractors, subcontractors, cooperators and end users. New potential end users and institutes with interest in extensions of the infrastructures will be attracted to these workshops. For all the workpackages the participation in the annual organizing workshops continues throughout the 4 year project time.

A special group consisting of Icelanders, participants and cooperators from Icelandic institutions concerned will meet for planning and discussion of future objectives to be a standing advisory board for the HOTSPOT coordinator.

# B6.b Project planning and time table (Gantt chart)

## B6.c Graphical presentation of the project's components (Pert diagram)

### HOTSPOT: Workplan and Access



# B6.d Detailed project description broken down into work-packages:

## B6.d.1 d-1) Workpackage list (form B1)

| Work-package No | Workpackage title | Lead contractor No | Person months | Start month | End month | Deliverable No |
|---|---|---|---|---|---|---|
| 1 | Data archival and access - adapting infrastructures to new observations. | 1 | 307 | 0 | 48 | D5,D6, D7,D8, D15,D16 |
| 2 | Design and planning for upgrading the SIL seismic acquisition system for multidisciplinary observations. | 2 | 28 | 0 | 48 | D9,D17 |
| 3 | Infrastructure for crustal deformation studies. | 4 | 50 | 0 | 48 | D10,D11, D12,D13, D18,D22 |
| 4 | End users, scientific advisers and future projections. | 6 | 8 | 0 | 48 | D1,D19, D20,D21 |
| 5 | Access to information and data through the European datacenter EMSC. | 7 | 5 | 0 | 48 | D2,D3 |
| 6 | Coordination of digital broadband waveform exchange. | 8 | 28 | 0 | 48 | D4,D14 |

## B6.d.2 d-2) Deliverables list (form B2)

| Del. No | Deliverable title | Delivery date | Nature | Diss. level |
|---|---|---|---|---|
| D1 | Expertise of medium- and large-scale dynamics for designing observatory configurations. | Month 3 | Re | RE |
| D2 | Installation at the HOTSPOT center of an automatic data retrieval system for efficient data distribution of parameter data. | Month 3 | Re,Eq | PU |
| D3 | Establishment of a special link from the HOTSPOT center to EMSC database for direct access to data stored there. | Month 6 | Re,Eq | PU |

Table continued on next page.

| Del. No | Deliverable title | Delivery date | Nature | Diss. level |
|---|---|---|---|---|
| D4 | Better and fast access to broad-band seismological stations around the North Atlantic Ocean, outside Iceland. | Month 6 | Da,Re | PU |
| D5 | General structure of the HOTSPOT data archival and data access facility. | Month 6 | Re | RE |
| D6 | Accessible parameter and waveform data of teleseismic events from stations in Iceland. | Month 8 | Da | PU |
| D7 | Accessible continuous strainmeter-, gravimeter- and MT-data. | Month 12 | Re,Da | RE |
| D8 | Preparations ready for attachment of new observational facilities to the HOTSPOT network. | Month 12 | Re,Eq | PU |
| D9 | Two available gravimeters upgraded and included in the HOTSPOT network. | Month 12 | Eq | PU |
| D10 | An overview of all available geodetic data and observational results regarding deformation in Iceland. | Month 12 | Re | PU |
| D11 | Technique for storing and providing access to geodetic deformation data. | Month 12 | Me,Re | PU |
| D12 | Data structure for storing and access to CGPS data. | Month 12 | Re | PU |
| D13 | Finish of preparations for upgrading SIL stations in the highlands by CGPS and the first made operational. | Month 12 | Me,Re | PU |
| D14 | Necessary upgrade of 3 key seismological stations on both sites of the North Atlantic Ocean. | Month 12 | Re | PU |
| D15 | The HOTSPOT observatory station design ready for testing functionally. | Month 24 | Re,Pr | PU |
| D16 | North Atlantic Ocean bottom network, preliminary design. | Month 24 | Re | RE |
| D17 | Model of conductivity distribution, basis for future monitoring of temporal changes. | Month 24 | Me,Re | PU |
| D18 | Storing of and access to GPS data and CGPS data available to the partners in a database. | Month 24 | Da,Re | RE |
| D19 | Finite element modelling of dynamic movements related to large deformations to become a basis for temporal and future network configurations. | Month 24 | Re | PU |
| D20 | Expertise on the data supply system provided for the end users by the HOTSPOT observatory. | Month 36 | Re | PU |
| D21 | Accomplishment of a user-friendly interactive tool to determine stress concentrations in the Icelandic crust to become a basis for temporal networks. | Month 44 | Re,Eq | PU |
| D22 | Access to all Icelandic GPS data and CGPS data in a database. | Month 48 | Re,Eq | PU |

### B6.d.3 A short description of each workpackage (form B3)

**Data archival and access - adapting infrastructures to new observations**

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| **Workpackage number:** 1 |
| **Start date or starting event:** Month 0 |
| **Lead contractor number:** 1 |
| **Person-months per partner:** 307 |

**Objectives**

To prepare the HOTSPOT Geophysical Observatory network and a European HOTSPOT datacenter on basis of existing networks in Iceland, operated by Icelandic institutions. The core of these are the SIL network and the SIL center. HOTSPOT will be prepared and operated as an integrated part of the SIL system.

To retrieve data from the multidisciplinary HOTSPOT network, control that the data have all significant information relevant to their content and to the method used to assimilate them. The HOTSPOT center archives the data and makes the data and the accompanying necessary information available.

Prepare the existing network stations and HOTSPOT center in Iceland for adding new, multidisciplinary observations, from available sensors or observational tools provided by the participants in HOTSPOT, or sensors provided by other institutes or projects during the lifetime of the project. It provides necessary assistance in installing and connecting these sensors with the HOTSPOT center.

Participates in designing and creating environment and infrastructure of a very multipurpose observatory station, the HOTSPOT Station, to be installed in the harsh conditions of Central Iceland. It participates by testing the design at various existing SIL stations and in creating a prototype multipurpose observatory station at an existing seismic station which is operated near the center of the active Hotspot area.

To organize networking with various objectives: firstly by coordination of HOTSPOT, secondly for attracting new observations to make use of the infrastructure, thirdly by creating links to other European or international projects with the purpose to create new infrastructures significant for the research efforts that HOTSPOT serves on a larger scale.

**Methodology/work description**

*Task 1: Data retrieval and access.*

The work will be carried out in the SIL center in Iceland. The SIL center includes the Icelandic seismic database structure and a more multipurpose database which is currently being built up for early warning purposes.

The seismic data of the local activity, parameter data and waveform data will be made accessible for the multinational European seismic datacenters together with information on how to access the data from the SIL center.

Waveform and parameter data of distant earthquakes recorded by the 38 Icelandic SIL type seismic stations will be made accessible to research through the European centers in their standardized formats.

Other continuous multidisciplinary HOTSPOT data and related data and information will be made accessible through a HOTSPOT website.

This task starts at the beginning of the project and proceeds through it.

*Task 2: Prepare the existing infrastructure for adding of new observations.*

All the SIL seismic stations in Iceland have a multitasking UNIX computer, and software utilities for retrieving sensor data, evaluation of these and communication with the SIL center. This makes it relatively easy to add new digital sensors to the stations. The station as well as the center software must be adapted to include these observations. This is done mainly under WP 2. The testings and implementation of available and significant sensors and environments into the infrastructure will be carried out under WP 1 in cooperation with scientists which provide new sensors for observations to be carried out.

In carrying out this task WP 1 gains from the close cooperation with and experience of technicians and scientists at the SIL center. Because it is expected that there will be many requests for input of new observations into the infrastructure this activity will be ongoing during the entire project.

*Task 3: Preparing environments for the HOTSPOT Observatory Station design and testing.*

A special unmanned multidisciplinary observatory will be designed and tested in the remote area near the center of the Iceland Hotspot activity. This will be made in close cooperation, especially with WP 2, which carries out the designing part. The necessary environment, including providing electrical power and appropriate network communication will be carried out by upgrading the seismic station VON. Among other activities to prepare the environments is the construction of observational piers and housing to fit the sensors to be introduced. This task will be carried out mainly during the first two years of the project.

*Task 4: Preparing and operating datacenter for all continuous GPS stations in Iceland.*

This is a very extensive workpart, that will be carried out especially in cooperation with WP 3. Continuous GPS measurements (CGPS) to observe ongoing deformation are in the initial phase in Iceland. During the last years 5 CGPS stations have come into operation in or near the South Iceland seismic zone and one in Southeast Iceland. In addition four CGPS stations are planned in near future in the North Iceland seismic zone, cost by Icelanders. These stations together with stations added into the HOTSPOT infrastructure will be integrated by basic evaluation to provide continuous information of deformation. Near-real-time information on deformation is significant for risk mitigation efforts, and therefore the data processing from all CGPS stations in Iceland will be carried out in close cooperation with WP 1. The basic processing that will be carried out in this cooperation is a necessary part of making the CGPS data available for research. This task will be carried out during the entire project period.

*Task 5: Networking which is significant for HOTSPOT objectives in general.*

Coordination of HOTSPOT includes various kinds of networking to fulfill the objectives.

Workshops will be organized every year for all the partners, subcontractors and various end users of the infrastructure, depending on ongoing work. The purpose for these workshops will be organizing of the infrastructure functions, making proposals for new initiatives in using it for observations. The workshops will thus serve as an advisory board for the coordinator.

Initiatives will be taken internationally to start cooperative actions for development of new infrastructure, projections towards future infrastructures. This will be done by presenting HOTSPOT at international scientific meetings, and its potential for research and future development.

A special advisory coordination group will be formed and organized to overlook and advise the infrastructure work carried out in Iceland. This group will meet relatively often and is constituted of scientists and technicians from the institutions in Iceland involved in the project, as well as from the Swedish partner involved in the infrastructure design.

### Deliverables

The deliverables are series of various geophysical data which are well controlled and scientifically compatible. These data will be available to research, to various end users through a parametric description available on the HOTSPOT website with its center in Reykjavík.

All data will be accessible through the European datacenters, EMSC and ORFEUS. Seismic waveform data from distant earthquakes of the 38 SIL station network in Iceland will be made available through ORFEUS.

Yearly reports will be presented at annual HOTSPOT workshops of the international consortium of HOTSPOT, participants and cooperators. These reports will also be issued on the HOTSPOT website.

Papers will be presented on a yearly basis at international conferences presenting the HOTSPOT observatory ideas and explaining the progress in carrying out its objectives, with the main aim of attracting new participation in the extension of the infrastructure facilities and observations, and to research actions based on the data made accessible.

### Milestones

The general structure of the data archival and data access facility will be finished within half a year of the start of the project. From that time on it will gradually be filled in with new data and containing information about plans for further data.

In the first year of the project parameter and waveform data of teleseismic events recorded at the larger platform networks will be available from the European datacenters, linked to the HOTSPOT center in Iceland.

Within a year the data from the volumetric strainmeters, continuous gravimeters, and continous MT stations will be available, based on information available in the EMSC center by linking to the HOTSPOT center in Iceland. A significant part of the GPS observations will be available after two years of the project.

Within the first year of the project raw CGPS station data will be available as well as station coordinates.

The prototype multipurpose HOTSPOT Observatory Station will be ready for testing to receive and to carry out various observations within the first two years of the project. Among these are seismic, gravimetric, MT, continuous GPS, volumetric strainmeter, and continuous gas monitoring.

Preparations will have advanced so far after the first year of the project that the first new observational facilities made available by other projects and institutions can be added to the HOTSPOT infrastructure. Such activity will proceed during the project period.

It is estimated that a very preliminary design for build-up of geophysical observatories on the ocean bottom between Scandinavia and Greenland will be ready within two years of the project for presentation to scientists and institutes likely to be interested in participating in such future preparations.

**Design and planning for upgrading the SIL seismic acquisition system for multidisciplinary observations**

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| **Workpackage number:** 2 | |
| **Start date or starting event:** Month 0 | |
| **Lead contractor number:** 2 | |
| **Person-months per partner:** 28 | |

## Objectives

The main objectives of this WP 2 is a design work and planning for upgrading the SIL data acquisition system for multidisciplinary observations. This includes a special design of a multipurpose observatory station in the remote area of Central Iceland, above what is believed to be the center of the Hotspot, the HOTSPOT Observatory Station. This multipurpose observatory station will need to be constructed within the project and will serve as a test laboratory for the technical solutions regarding local electricity production and data communications as well as test of various types of sensors in this adverse environment. It will serve as a laboratory for developing the HOTSPOT Observatory procedures, to by time being applied at other places.

Long period magnetotelluric sensors and gravimeters for continuous recording will be installed and adapted into the SIL data acquisition system. Various types of other automatic geophysical recordings are available or are being installed in Iceland. Volumetric strainmeters are operated in the South Iceland seismic zone, and a network of water level measurements in boreholes are being installed in the area. This data will be merged into the HOTSPOT center and made available to the scientific community.

Physical and chemical properties of the crust and upper mantle have large impact on its electrical conductivity. Variations of these properties in space and time directly effect the conductivity. Continuous measurements of the natural electromagnetic field variations provide a powerful tool to monitor changes of the electrical parameters. The main objective is to monitor temporal changes of the conductivity distributions, which might give indications of variations of the stress field and migration of magma in the crust and mantle in geodynamically active regions. Those data will be made available to the scientific community and authorities for use in research and for risk assessment of natural hazards.

The surface observable gravity reflects the underground density distribution. Temporal gravity variations forced by tidal and tectonic forces reflect mass flow and density change, height change and temporal change of mechanical (elastic, rheological) properties of crust and mantle (the latter affecting amplitudes and phases). These 'parameters' are supposed to be influenced by plume activity and can be investigated on short and medium time scales by recording at critical locations of plume/ridge interaction. Magma injections, e.g., have strain and thermal effects on the crust resulting in continuous and brittle deformation. Observations, analyses and modelling are to be prepared.

## Methodology/work description

Three major tasks are planned:

*Task 1:*

Overall design and planning of the multi-site multi-parameter observatory in Iceland including modifications of the present sites to allow for various type of sensors to be connected and design and evaluation of infrastructure including electricity production and communications solutions for the very remote data acquisition sites. Corresponding design and planning for facilities at the center in Reykjavík to allow for the multiparameter observations transmitted from the sites. Design and planning for integration of data from the strainmeter network and water-level network into the observatory procedures will be performed. Various alternatives of electricity production methods will be evaluated including the combination of windmills and solar cells. Different remote communication technics will be evaluated and tested in the remote areas. This will include spread-spectrum data links and satellite communication systems. Different methods of data compression for the different types of data will be investigated.

*Task 2:*

Two long period MT-stations (LMT-sites) are presently continuously running in Iceland on an experimental basis, recording 2 components of the electrical field and 3 components of the magnetic field with a sampling rate of 1 s. One station is in Haukadalur in South Iceland and is linked to the SIL station HAU; the other one is in Húsafell in West Iceland. One of these stations will be rebuilt and installed the SIL station in Skrokkalda. The time series will be transmitted automatically to the SIL center in Reykjavík and made available to the scientific community on a daily basis. (The real-time exchange of field-data via satellite data transfer will be tested).

The LMT recordings will in the first phase of the project be supplemented by several short-period data acquisition systems (AMT-sites) at various locations in the vicinity of the observatory, in order to estimate distortions by near-surface conductivity anomalies, and by far remote LMT-sites to serve as a reference. Studies of noise and sensitivity will show the possibilities and limits of the method. Furthermore the frequency analysis of the observed fields will give a detailed image of the conductivity structure and thus provides an important parameter for geodynamic modelling.

From the results of the sensitivity study optimal locations for permanent recording sites will be proposed. The frequency analysis will give frequency ranges with the highest possible sensitivity for the target depth in the context with other geophysical investigations. This will have large impact on the choice and design of the optimal observatory instruments.

*Task 3:*

To prepare the deployment of three Lacoste-Romberg gravimeters which will be made available to the project by partners and cooperators. The gravimeters will be modified for continuous recordings through implementation of electronic feedback system with digital output. The gravimeters will be in continuous operation for most of the time but two of them will occasionally be used for other purposes during shorter periods. Selection of sites will be done in cooperation with WP 3 and the digital data from the gravimeters will be merged into the SIL data acquisition system.

### Deliverables

Continuous time series of various type of geophysical measurements in Iceland will be made available to the scientific community. This includes continuous time series of electromagnetic MT-data in a seismotectonically active area delivering information on time variations in electrical conductivity in the crust and mantle. These series will be available on-line or on a daily basis for the scientific community and authorities. A sophisticated model of the electrical conductivity distribution is within the area of interest. The model will serve as a reference for future investigations of temporal changes of the conductivity distribution.

Permanent installation of two gravimeters modified for continuous measurements and one additional gravimeter for a period of four years. Effort will be made to get access to additional gravimeters from other institutions for a long-term deployments at stations where continuous GPS measurements will be performed.

Milestones

Design and planning of the Hotspot Observatory is to be completed. Long-term continous measurements regarding seismology, gravity and magnetotelluric measurements will also be initiated through WP 2. Preparation for long-term operation of various geophysical properties measurable at earth's surface will be planned through cooperation with the international scientific community. A complete geophysical observatory concerning the crucial questions of the earth's evolution.

**Infrastructure for crustal deformation studies**

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| **Workpackage number:** 3 |
| **Start date or starting event:** Month 0 |
| **Lead contractor number:** 4 |
| **Person-months per partner:** 50 |

**Objective**

Our objective is to encourage scientists in using and collecting deformation data related to Hotspot activity. We will make available as much as possible of previously collected Global Positioning System (GPS) data in Iceland, as well as other data such as synthetic aperture radar interferograms, distance and levelling measurements, that have been collected in a number of areas in Iceland since the 1960s. The objective is to provide complete time series of deformation, for both stations in the interior of Iceland and at more distant places from the Hotspot center. This way we will create the favoured infrastructure for European researchers working with geodetic measurements in Iceland. Furthermore, our objective is also to ensure full and free access to new Continuous GPS (CGPS) measurements of crustal deformation, by combining ongoing CGPS measurements in Iceland under one infrastructure, the HOTSPOT CGPS network. An integral part of this work is to augment already ongoing CGPS efforts by adding stations and infrastructure in the center of Iceland, to be able to better provide information to all users interested in the dynamics of the mantle plume.

**Methodology/work description**

Input to WP 3 includes all accessible geodetic data regarding crustal deformation in Iceland, collected previously by partners of the proposal, other agencies in Iceland, and agencies elsewhere. Currently the raw observational data are distributed in a number of institutes, and only some of the observational results have been published. Because of its poor accessibility, the complete dataset of crustal deformation in Iceland is of limited benefit for the partners of this proposal, and other scientists in Europe. We will change this by creating and maintaining an Icelandic geodetic database. Importantly, partner 5 will utilize his good contacts with most groups involved in collecting geodetic data in Iceland, ensuring they will provide all, or significant part, of their geodetic data as an input into the database.

Deformation studies by repeated GPS measurements have been carried out in Iceland since 1986 by several groups. They have shown significant variability of deformation rates, both in time and space. This technique has successfully been used for deformation studies and modeling of rifts, transform and volcanic zones in Iceland. All GPS data previously acquired in Iceland potentially represent an opportunity to have a coverage of the deformation at a large-scale.

Semi-continuous GPS measurements at one SIL station in the South Iceland seismic zone have shown the overall plate motion. Continuous GPS measurements (CGPS) is an extremely valuable method to provide temporal coverage of the deformation, in addition to borehole volumetric strainmeter recordings. CGPS measurements have been initiated for seismic and volcanic risk mitigation purposes at four sites in the Hengill area, Southwest Iceland. Four other CGPS stations are planned in the seismic risk area near Húsavík, North Iceland, also for that purpose. Two CGPS stations in South Iceland are currently operated by the IGS and EUREF permanent networks, for determining coordinates and velocities of reference points and satellite orbits. These new CGPS stations create a start, but an incomplete network of CGPS in Iceland. Because of the significant build-up and operation of continuous deformation measurements already in the lowland seismic risk areas of Iceland it is a scientific necessity to improve the infrastructure with CGPS stations where we most probably could observe, localize, and quantify the initial effects of crustal deformation related to the mantle plume activity, that is near the Hotspot center, in the highlands. To reach this goal we will start to collect and process data from CGPS stations in Iceland and unite all ongoing CGPS networks in Iceland. We also propose to improve the infrastructure in the highlands and install facilities to encourage scientists and surveyors to temporarily leave their GPS instruments in the network for semi-continuous measurements.

*Task 1:*

To gain a complete overview of all available geodetic data regarding deformation in Iceland. A report containing a list of all geodetic data and observational results, research groups, and published results relating to deformation in Iceland, will be prepared.

*Task 2:*

Explore and develop a suitable technique and scheme for storing geodetic data relating to crustal deformation in a database, and define an interface so that this database can be easily accessed via the internet. The database will be linked to the European HOTSPOT Data Center.

*Task 3:*

Store all data owned by the partners and subcontractors of this proposal into the database. Open the database. Prepare guidelines on how to use the database.

*Task 4:*

Add data from other agencies into the database and complete it.

*Task 5:*

Partners 1 and 4 will start CGPS measurements at the HOTSPOT Observatory Network stations. This includes upgrading 5 existing SIL stations by installing GPS instruments at ASK, VON, GRI, HVE and SKR to add CGPS measurements to the data acquired at these stations.

*Task 6:*

Partner 1 will maintain the 5 HOTSPOT CGPS stations in the field. He will provide daily control and download the data and incorporate the data in the European HOTSPOT Data Center.

*Task 7:*

Partners 1 and 4 will prepare facilities at 5 other SIL stations.

*Task 8:*

The data from the CGPS stations in the HOTSPOT Observatory Network will be processed by Partners 1 and 4 using the Bernese software (BPE 4.0). Partner 4 will include in his processing data from several IGS and EUREF stations at a large distance (3000 km) from the Hotspot center. Partner 1 will process all CGPS data collected in Iceland, including REYK and HOFN as reference stations. Partners 1 and 4 will also estimate tropospheric and ionospheric models from these data.

### Deliverables

Complete database (Da) regarding crustal deformation in Iceland. Reports (Re) with complete list of the available data, and guidelines on how to use the database.

The efforts in CGPS will result in the following deliverables, that will be placed on the websites of the European HOTSPOT Data Center (WP 1). These data are the following: Data collected at the HOTSPOT CGPS Network in Rinex format. Daily station coordinates in the EUREF reference frame with error bars. Tropospheric and ionospheric models estimated during GPS processing.

The European HOTSPOT Data Center will be archivist and distributor of these data.

The deliverables give the necessary foundation for stress and strain modelling of the Hotspot activity and a large variety of other scientific studies for people working on Hotspot, plate tectonics, glacial rebound, volcanic and seismic risk, in Iceland and elsewhere.

The HOTSPOT CGPS Network would facilitate the acquisition of new geodetic measurements because it provides data from permanent GPS stations in new areas, hence making GPS measurement campaigns easier. The data will also increase greatly the accuracy obtained for numerous existing local networks measured through short campaigns or as semi-continuous GPS networks. Vertical displacement would be easier to detect, and this is of a great interest because several network are installed around volcanoes where vertical changes are expected. Positioning data would be directly used as constrain in a great variety of models. Models of precipitable water vapour in the troposphere estimated from CGPS data are of great interest in meteorological forecasting.

### Milestones

Tasks 1 and 2 will be completed in the first year, as well as installation of CGPS instruments at 3 SIL stations. Task 3 will be completed in the second year, as well as installation of CGPS instruments at 2 SIL stations. Task 4 be conducted in year 3 and 4, as well as well as upgrading of 5 SIL stations to include CGPS observations.

**End users, scientific advisers and future projections**

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| **Workpackage number:** 4 |
| **Start date or starting event:** Month 0 |
| **Lead contractor number:** 6 |
| **Person-months per partner:** 8 |

**Objectives**

Surface observables as seismicity, surface deformation, gravity or MT-data on Iceland and the entire North Atlantic region are strongly related to the interaction of a rising plume and diverging plates on various spatial and temporal scales. While the far field observations are mainly caused by mantle flow and the viscoelastic response of the lithosphere, reflecting the internal rheologial structure, the near-field observations on Iceland are the result of continuous and brittle deformations triggered by magma intrusions and formation of new crust above the plume center. Numerical modelling is the suitable instrument for understanding the physics of interior mass transport and stress accumulation in the earth. By employing different types of observations on various temporal and spatial scales. it is possible to infer a number of characteristics for plume/ridge interaction. Numerical dynamic modelling will help to relate short time scale deformations on Iceland to geological plate tectonic movements; it further allows to investigate the physics of melt generation and ascent and to predict the propagation of strain waves through the Icelandic crust following an intrusion event, which is very significant for research towards seismic and volcanic hazard assessment.

**Methodology/work description**

The contribution of this workpackage to the HOTSPOT infrastructure preparations has three different tasks.

*Task 1:*

During the period of preparing the networks towards observations aimed for HOTSPOT objectives, modelling will be performed to help designing proper observatory configurations, instrument characteristics and data acquisition schemes to ensure the best temporal and spatial scales for monitoring plume activity and dynamics.

*Task 2:*

Regional scale Finite Element modelling of the dynamic movements following episodes of volcanic activity will help planning the supply of temporal instruments from other projects and/or future network configurations. This work will be started on the basis of existing deformation data from GPS and ground observations of German geodetic groups during and after the Krafla fissure eruptions in North Iceland. This work will be linked to, and gain from, the future permanent recordings of the HOTSPOT Observatory.

*Task 3:*

As end users of the high quality datasets we expect to constrain the large scale numerical modelling of the ridge/plume interaction and to demonstrate for other researcher groups the potential of the HOTSPOT Observatory infrastructure.

**Deliverables**

The workgroup responsible for WP 4 will acompany the HOTSPOT project during its entire life-time as a scientific advisory board, giving expertise on different stages of the project, based on application of results from parallel ongoing projects.

Physical models will be provided to explain the observation datasets (seismicity, surface deformation, gravity or MT-data) on different spatial and temporal scales. From these models we will estimate: - on regional scale, the stress accumulation and propagation of strain waves in the crust. These results constrain the deployment of temporal GPS instruments and seimometers. This structural Finite Element model of the Icelandic crust should develop in its final state to a user supplied tool of the Hotspot Observatory to interactively estimate stress concentrations and deformations. - on medium scale, information about the generation and segregation of melts. These results constrain the deployment of MT intruments. - on large scale, using models for plume-ridge interaction, the size of the plume and the rheological parameters in the North Atlantic.

Part of the work and the deliverables described above is already in progress under national research contracts.

Milestones

Years 1 and 2:

- 2 months after signature of contract, accomplishment of an expertise on the medium- and large-scale dynamics of the Iceland plume, including a proposition for the HOTSPOT Observatory network configuration and data acquisition and future improvements.
- 3-D numerical models of plume activity to determine the sensitivity requirements to detect strain waves on medium- and large-scale.
- Preliminary Finite Element model on strain propagation in the crust based on existing data.

Years 3 and 4:

- Expertise on the data supply system provided for the end users by the HOTSPOT Observatory.
- Accomplishment of a user-friendly interactive tool to determine stress concentrations and deformations in the Icelandic crust.

### Access to information and data through the European datacenter EMSC

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| **Workpackage number:** 5 |
| **Start date or starting event:** Month 0 |
| **Lead contractor number:** 7 |
| **Person-months per partner:** 5 |

Objectives

In the framework of the HOTSPOT project, the EMSC will contribute to enhance visibility of the project by providing a data distribution support. Although mainly dedicated to the establishment of a dedicated infrastructure for research, the project aims at providing the European research community not only with a research facility but also with all data being gathered over the course of the project. The specific role of the EMSC in the European research community is to be a parametric data repository center for seismic bulletins in general, and for data related to specific projects in particular.

**Methodology/work description**

The contribution is to provide the participants with an existing structure for efficient data distribution. This support to parametric data distribution may be split into two categories. A direct support to the coordinator of the project to implement a data distribution system at the laboratory, and/or a distribution directly through the EMSC website.

*Task 1:*

Technical assistance to install an automatic data retrieval system, and to improve the local website in the sense of a better data availability and an user-friendly interface.

*Task 2:*

To provide the project with a special link to the EMSC website, not only for description but also for direct access to the seismic data stored in the EMSC database. Other data type will be either access through a link to the local website or other institutes.

**Deliverables**

Installation of an automatic data retrieval system. Description for data availability on the website covering all technologies of the project. Implementation of user access to these data at the local and EMSC websites.

**Milestones**

Inventory of the data depository sites and their content.
Development of public access to these sites.
Archiving of parametric data in the EMSC database.
Development of public access to these data through the EMSC website.

**Coordination of digital broad-band waveform exchange**

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| **Workpackage number:** 6 |
| **Start date or starting event:** Month 0 |
| **Lead contractor number:** 8 |
| **Person-months per partner:** 28 |

**Objectives**

Within the HOTSPOT project the lead contractor aims at coordinating digtal, broad-band earthquake waveform exchange within a broader region around Iceland. This is required as a basic infrastructure for any seismological research in the HOTSPOT project.

**Work description and deliverables**

*Task 1:*

To upgrade existing key seismological stations in the region to broad-band and establish a fast and reliable communication. This applies to remote areas like the Faroe Islands and the Shetland Islands. It will be carried out by assistant contractor, partner 9. In eastern Greenland a broad-band station in Scoresbysund is available, but lacks reliable communication. This will be improved by assistant contractor, partner 10.

*Task 2:*

Improvement of the access to data from existing broad-band seismological stations by development of automated procedures. In Denmark stations MUD, COP and BSD will be made available through the lead contractor using an ISDN connection. Data from modern arrays, belonging to Norway, ARCES, NORSAR, NORESS and SPITS will be made available through semi-automated procedures by assistant contractor, partner 11. In Sweden data from stations UPP, DEL, UDD, NOR, UME and KUR will be made available to ORFEUS. Station UPP in near real-time, the others with a delay of up to 24 hours.

*Task 3:*

The third part of the work is the implementation of the HOTSPOT datasets in the lead contractors database and to make the data easily and rapidly accessible through the its website.

### Milestones

Upgrade of key-stations in the region of interest to broad-band with reliable access.
Coordinated data exchange through ORFEUS.
User access to the data through the ORFEUS website.

PART C

FULL NAME:
Preparing the infrastructure for studying the dynamics of the Iceland Hotspot

ACRONYM: HOTSPOT

PROGRAMME:
1.1.4.-9 Support for Research Infrastructures

PROPOSAL NUMBER: EESD-ENV-99-0068

Chapter C3

# Community added value and contribution to EU policies

The Iceland Hotspot and its roots, i.e. the Iceland mantle plume has for a long time been a center of attention of earth scientists all over the world.

Effects of the Hotspot are seen by gravity anomalies thousand of kilometers outside Iceland. It is indicated by measurements that crustal stresses in northern Europe and northern America are influenced by the Hotspot. The mantle plume has been modelled by studying teleseismic signals from earthquakes around the world as a narrow chimney of upwelling mantle material from a depth of 400 km, and it is indicated that the roots may be much deeper, i.e. at the intersection between the mantle and the core of the earth.

Iceland is the center of the Hotspot activity, where frequent magma intrusions of various intensity modify stress conditions all over the country, and sometimes rupture the crust, resulting in earthquakes, frequent volcanic eruptions and episodes of large land deformations. The largest lava eruption in history started near the center of the Hotspot in 1783. This was the Laki eruption, which caused climatic changes in Europe and northern America. It caused such difficulties in farming in Europe, that some historicans claim it was a contributing factor in triggering the French revolution.

HOTSPOT creates a European research basis which is of an enormous significance for scientific activities in various fields of earth sciences, ranging from direct contribution to hazard assessment and warning research to basic understanding of crust/mantle dynamics and processes.

Hotspot contributes to the EU activities of using Iceland with its intensive earth activity and high level observations as a Natural Laboratory for research aimed at natural hazards mitigation and for understanding the cause of natural hazards and migration of stresses along the earth's crust.

HOTSPOT is based on and consolidates the results obtained in the two 4th framework projects of EU, the PRENLAB project and the PRENLAB-2 project. The good results of these multidisciplinary and multinational projects signify the idea of concerted European efforts in utilizing the natural and technological facilities of the "Iceland Natural Laboratory" for research. HOTSPOT consolidates and brings that idea further.

Chapter C4

# Contribution to Community social objectives

HOTSPOT contributes in general to understand better the earth we live on and its too often unexpected behaviour. Such an understanding is a social objective and a social value. HOTSPOT contributes to higher level research, to scientific and technological skills by preparing an observational basis for challenging research efforts on a global scale. By its networking among the most pronounced researchers, both internally in Europe as well as by initiating research efforts, for studying the Iceland plume dynamics on a more international scale, HOTSPOT will advance European objectives of higher education and high quality research.

HOTSPOT concentrates its infrastructure geophysical preparation to the center of the Iceland Hotspot activity. The infrastructure is the base for research which has the potential of understanding how large-scale eruptions may build up there in the future, as well as large deformation or rifting episodes and large earthquake potential.

This is of great significance for people living in Iceland, a significant contribution to improving the quality of life, health and safety.

But this is also of a great significance for all Europeans. Volcanic eruptions in Iceland may have direct influence on conditions for life in a large part of Europe. Understanding on a long-term basis when a large eruption might start there and the expected severity, as well as short-term warnings for it, are a significant social objective.

Awareness of natural hazards which may have strong influence of the life of people, are a basis for all risk mitigation efforts and preparations for helping actions. Understanding the need of cooperating and helping each other in risk situations or after catastrophes is increasingly a social objective with increased cooperation.

Chapter C5

# Project management

The coordinator, lead contractors, assistant contractors, subcontractors and cooperators are summarized in the following diagram. The participating consortium is described in Chapters C6 and C7 as well as the roles of the various partners. The Gantt chart in Chapter B6 summarizes the work periods for the various tasks of the project. It also summarizes the time for the annual workshops and the time for reporting to EU.

The division of work within the project is well defined. The participants will carry out their work to be disseminated at the annual workshops. The participants are all more or less depending on each other work, and that it is decently carried out. They are specialists in various fields in earth sciences. The annual workshops, attended by all contractors, assistant contractors, many of the subcontractors and open to the cooperators will thus provide significant quality assurance measures.

The HOTSPOT website on the internet is an integrated part of the project, to inform about datastructures, how to link to observations and about the progress of the work. Most of this information is open to public which helps to secure quality.

The regular workshops will be held in Iceland, where the basic HOTSPOT infrastructure and HOTSPOT center is located. These meetings will serve as a kind of advisory steering committee meetings for the coordinator and the various participants of the project. This is very significant for many reasons, besides reporting to EU.

One reason is that HOTSPOT aims at organizing common data structures and monitoring methods serving many disciplines of earth sciences. Representatives for these disciplines will attend the workshops.

These meeting are also very significant for the objective of HOTSPOT to extend the observations, both in multiplicity as well as geographically, and then to encourage wide participation in research on the basis of the data.

These workshops will be well announced among potential end users of the data and providers of sensors to be included in the HOTSPOT infrastructure to secure good and growing participation in the work.

# Preparing the infrastructure for studying the dynamics of the Iceland Hotspot
## HOTSPOT
### Coordinator: Ragnar Stefánsson

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WP 1:
**Data archival and access - adapting infrastructures to new observations**

Lead contractor:
Ragnar Stefánsson
ICELAND

Collaborators:
Staff members of the Department of Geophysics, Icelandic Meteorological Office
ICELAND

Cooperators:
15 scientists from institutes in
UNITED KINGDOM
DENMARK
USA
ICELAND
FRANCE
SWEDEN
ITALY
GERMANY

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WP 2:
**Design and planning for upgrading the SIL seismic acquisition system for multidisciplinary observations**

Lead contractor:
Reynir Bödvarsson
SWEDEN

Assistant contractor:
Wolfgang R. Jacoby
GERMANY

Assistant contractor:
Axel Björnsson
ICELAND

Assistant contractor:
Andreas Junge
GERMANY

Subcontractor:
Martin Beblo
GERMANY

Subcontractor:
Michel van Ruymbeke
BELGIUM

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WP 3:
**Infrastructure for crustal deformation studies**

Lead contractor:
Thierry Villemin
FRANCE

Assistant contractor:
Thóra Árnadóttir
ICELAND

Assistant contractor:
Freysteinn Sigmundsson
ICELAND

Subcontractor:
Páll Einarsson
ICELAND

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WP 4:
**End users, scientific advisers and future projections**

Lead contractor:
Gabriele Marquart
GERMANY

Subcontractor:
Harro Schmeling
GERMANY

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WP 5:
**Access to information and data through the European datacenter EMSC**

Lead contractor:
Florence Riviére
FRANCE

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WP 6:
**Coordination of digital broad-band waveform exchange**

Lead contractor:
Bernard Dost
THE NETHERLANDS

Assistant contractor:
Chris Browitt
UNITED KINGDOM

Assistant contractor:
Sören Gregersen
DENMARK

Assistant contractor:
Hilmar Bungum
NORWAY

Assistant contractor:
Reynir Bödvarsson
SWEDEN

Chapter C6

# Description of the consortium

## C6.a Workpackage 1: Data archival and access - adapting infrastructures to new observations

- **Lead contractor: Ragnar Stefánsson (coordinator).**
  Department of Geophysics, Icelandic Meteorological Office, Reykjavík, Iceland (partner 1).
- **Collaborators:**
  Staff members of the Department of Geophysics.
- **Cooperators, that will participate in planning and design of the observational networks:**
  - *Iceland, crust and upper mantle structure, operation of broad-band seismic stations, hotspot seismic tomography:*
    Robert S. White and Keith Priestley, Bullard Laboratories, University of Cambridge, United Kingdom.
    Hans Christian Larsen and Ólafur Gudmundsson, Dansk Lithosfærecenter, Copenhagen, Denmark.
    Guust Nolet, Princeton University, Princeton, New Jersey, USA.
    Ingi Th. Bjarnason, Science Institute, University of Iceland, Reykjavík, Iceland.
  - *Inferring information about stresses, stress changes and faults from microearthquakes:*
    Jacques Angelier, Laboratorie de Tectonique Quantitative, Université Pierre et Marie Curie, Paris, France.
    Stuart Crampin, Department of Geology and Geophysics, University of Edinburgh, United Kingdom.
    Ragnar Slunga, Department of Earth Sciences, Uppsala University, Sweden.
  - *Theoretical modeling, especially of stress modification:*
    Maurizio Bonafede, Department of Physics, University of Bologna, Italy.
    Frank Roth, GeoForschungsZentrum, Potsdam, Germany.
  - *Continuous monitoring of borehole volumetric strainmeters and modelling of stress changes caused by intrusions measured by strainmeters and GPS:*
    Selwyn Sacks and Alan Linde, Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington DC, USA.
  - *Continuous gas monitoring:*
    Salvatore Lombardi, Department of Earth Sciences, University of Rome, Italy.
    Níels Óskarsson, Nordic Volcanological Institute, Reykjavík, Iceland.

Ragnar Stefánsson is also a coordinator of the project. The Department of Geophysics is in center position in the project. It operates and develops the SIL network and SIL center, which is the core of the geophysical observational facilities in Iceland. It serves the public and the authorities in Iceland with information and warnings related to earthquake and volcanic hazard, and is working on preparing an easy accessible seismic database and an early warning database for that purpose. The experience of the staff in creating the SIL system in Iceland and in information and warnings makes it to a very valuable partner in preparing the Icelandic infrastructures in the HOTSPOT project. Besides creating the SIL system the staff built up other systems in Iceland which will be valuable part of the HOTSPOT infrastructure, like the continuous volumetric borehole strainmeter system, continuous measurement of gravity, and now most recently continuous GPS measurements in the seismic areas of Iceland. The HOTSPOT dedicated Icelandic infrastructure will be operated as an integrated part of the SIL system at the Department of Geophysics. The testing of observational methods and attachment of new observational facilities to the system will be carried out in close cooperation with the staff members.

## C6.b Workpackage 2: Design and planning for upgrading the SIL seismic acquisition system for multidisciplinary observations

- **Lead contractor: Reynir Bödvarsson.**
  Department of Earth Sciences, Uppsala University, Sweden (partner 2).

- **Assistant contractor: Wolfgang R. Jacoby.**
  Department of Earth Sciences, Johannes Gutenberg-Universität Mainz, Germany (partner 3).

- **Assistant contractor: Axel Björnsson.**
  Nordic Volcanological Institute, Reykjavík, Iceland (partner 5).

- **Assistant contractor: Andreas Junge.**
  Institute of Meteorology and Geophysics, University of Frankfurt, Germany (partner 6).

- **Subcontractor: Michel van Ruymbeke.**
  Royal Observatory of Belgium, Brussels, Belgium.

- **Subcontractor: Martin Beblo.**
  Geophysical Observatory Fürstenfeldbrück, University of Munich, Germany.

It is the main task of this workpackage to prepare the existing Icelandic infrastructures for more multidisciplinary observations and to integrate some observational facilities to the HOTSPOT infrastructure. This includes designing the HOTSPOT observatory station. The lead contractor, Reynir Bödvarsson, was the technical designer of the SIL system and is still active in its ongoing and further development. The assistant contractor Wolfgang R. Jacoby has a long-time experience in geophysical research in Iceland. He will start continuous gravity measurements in the Iceland highlands with existing gravimeters, which will be upgraded and prepared for continuous observations by Michel van Ruymbeke. Axel Björnsson, Andreas Junge and Martin Beblo have a long-time experience in observing conductivity in the crust by MT-method. They will integrate such measurements with available MT equipment in a continuous mode to the HOTSPOT infrastructure. All this will be carried out utilizing the experience and skill of the scientists and the technicians of the Icelandic Meteorological Office for the implementation.

## C6.c Workpackage 3: Infrastructure for crustal deformation studies

- **Lead contractor: Thierry Villemin.**
  Laboratory of Alpine Belts Geodynamics, Université de Savoie, Chambéry, France (partner 4).
- **Assistant contractor: Thóra Árnadóttir.**
  Department of Geophysics, Icelandic Meteorological Office, Reykjavík, Iceland (partner 1).
- **Assistant contractor: Freysteinn Sigmundsson.**
  Nordic Volcanological Institute, Reykjavík, Iceland (partner 5).
- **Subcontractor: Páll Einarsson.**
  Science Institute, University of Iceland, Reykjavík, Iceland.

Observations of deformation by use of GPS techniques is the general target of WP 3. It includes to organize within the HOTSPOT structures a deformation database center containing ongoing continuous GPS measurements as well as results of other GPS studies. It initiates and prepares for introducing continuous GPS in the highlands of Iceland. The lead contractor has experience in GPS measurements in Iceland for several years and is building a continuous GPS in the Alps. Thóra Árnadóttir is responsible for the ongoing build-up of continuous GPS measurements in the seismic zones of Iceland. Freysteinn Sigmundsson and Páll Einarsson have a long experience in deformation measurements in Iceland, GPS, SAR and geodimeter measurements.

## C6.d Workpackage 4: End users, scientific advisers and future projections

- **Lead contractor: Gabriele Marquart.**
  Institute of Meteorology and Geophysics, University of Frankfurt, Germany (partner 6).
- **Subcontractor: Harro Schmeling.**
  Institute of Meteorology and Geophysics, University of Frankfurt, Germany.

Will help in designing proper observatory configurations, instrument characteristics and data acquisition schemes during the entire period of the project. Gabriele Marquart and Harro Schmeling are leading a large innovative project for modelling the Iceland Hotspot, and will base their designing work for the system on that ongoing work, and on previous ground deformation work. Besides advices in designing observatory configurations, networking and demonstration of the capability of the evolving HOTSPOT infrastructure among end users are significant tasks of WP 4.

## C6.e Workpackage 5: Access to information and data through the European datacenter EMSC

- **Lead contractor: Florence Rivière.**
  Euro-Mediterranean Seismological Center, Bruyéres-le-Châtel, France (partner 7).

Will contribute to enhance visibility of the project by providing a data distribution support. The role of the EMSC, where Florence Rivière is Secretary-General, in the European research community is a parametric data repository center for seismic bulletins in general and for data related special projects in particular. The contribution will be very significant in demonstrating to European scientists the wealth of multidisciplinary observations available in the HOTSPOT infrastructure and in providing direct access to these and by linking to the HOTSPOT datacenter.

## C6.f Workpackage 6: Coordination of digital broad-band waveform exchange

- **Lead contractor: Bernard Dost.**
  The Royal Netherlands Meteorological Institute/ORFEUS, De Bilt, The Netherlands (partner 8).
- **Assistant contractor: Chris Browitt.**
  British Geological Survey, Edinburgh, United Kingdom (partner 9).
- **Assistant contractor: Sören Gregersen.**
  Kort og Matrikelstyrelsen, Copenhagen, Denmark (partner 10).
- **Assistant contractor: Hilmar Bungum.**
  NORSAR, Kjeller, Norway (partner 11).
- **Assistant contractor: Reynir Bödvarsson.**
  Department of Earth Sciences, Uppsala University, Sweden (partner 2).

The lead contractor, Bernard Dost, will coordinate the broad-band waveform data exchange in the larger platform area for plume dynamics observations, i.e. on both sides of the North Atlantic Ocean. In cooperation with providers of data and operation of broad-band stations in the four countries, the assistant contractors, Chris Browitt, Sören Gregersen, Hilmar Bungum and Reynir Bödvarsson, he will perform an upgrade of some of the stations and improve the access to data from the existing broad-band stations by development of automatic procedures. It will make Iceland broad-band data accessible to end users in cooperation with the HOTSPOT center staff in Iceland. The experience of the lead contractor and the assistant contactors in seismological measurements and research projects will give them a very significant role in designing the larger area and denser network platform, going into ocean bottom observatories.

Chapter C7

# Description of the participants

## C7.a Workpackage 1: Lead contractor/coordinator Ragnar Stefánsson

### C7.a.1 Department of Geophysics, Icelandic Meteorological Office

The Icelandic Meteorological Office (IMO) with its 100 staff members covers a wide range of scientific disciplines in meteorology and geophysics.

In the Department of Geophysics, 13 persons are currently devoted to seismological research. Of these two are technical engineers, the others are scientists in the fields of seismology, geophysics and geology.

The main duties of the Department of Geophysics are monitoring of earthquakes and earthquake related changes and research based on instrumental as well as historical earthquake data. It operates the SIL network which consists of 38, 3-component seismic stations in the seismic zones of northern and southern Iceland and the central highland, and a real-time evaluation system in Reykjavík. An alert system watching the seismic activity for different parts of the country is in automatic operation in the Department. Now the continuous monitoring of 7 borehole strainmeters is also included in the SIL system, as well as of 2 gravimeters to mention the most significant real-time monitoring.

The Department now operates 4 stations with continuous GPS monitoring in Southwest Iceland.

The Department of Geophysics is the backbone of the successful SIL project for earthquake prediction research and the construction of the SIL system which is the main achievement of the SIL project. The staff of the Department is also the backbone and coordinator of the PRENLAB and the PRENLAB-2 projects, which are seismic risk projects in the 4th framework programme of EU. The Department also lead other multinational research projects in Iceland. The borehole strainmeter project in the South Iceland seismic zone is one of these projects of benefit for the HOTSPOT project.

The research policy of the Department is focussed towards reducing seismic risk. It covers everything from general hazard assessment to the development of technology for short-term alerts. The seismic system with its alert facilities and the strainmeter system is also significant for watching volcanoes and thus the Department is contributing significantly to volcanic research too, and to reducing volcanic risk.

Ragnar Stefánsson:
Born: August 14, 1938. Citizenship: Icelandic.

Education:
1961: Fil. kand. (B.Sc.) in mathematics and physics, Uppsala University.
1962: Fil. kand. in geodesy with geophysics, Uppsala University.
1966: Fil. lic. (Ph.D) in seismology, Uppsala University.

Career: 1962–1963 and 1966–present: Head of Department of Geophysics, Icelandic Meteorological Office.

Chairman of the Icelandic National Committee for the mitigation of earthquake risk.
1987–1995: Chairman of the steering committee of the Nordic SIL project.
1988–1995: Project manager of the SIL project.
1994–1998: Vice-president of the European Seismological Commission.
1994–present: Member of the European Advisory Evaluation Committee for Earthquake Prediction, instituted by the Council of Europe.
1996–present: Coordinator in the EU-supported PRENLAB and PRENLAB-2 projects.

References relevant to the proposal:

Stefánsson, R. & P. Halldórsson 1988. Strain release and strain build-up in the South Iceland seismic zone. *Tectonophysics* 155, 267–276.

Stefánsson, R., R. Bödvarsson, R. Slunga, P. Einarsson, S. Jakobsdóttir, H. Bungum, S. Gregersen, J. Havskov, J. Hjelme & H. Korhonen 1993. The SIL project, background and perspectives for earthquake prediction in the South Iceland seismic zone. *Bull. Seism. Soc. Am.* 83, 696–716.

Stefánsson, R. 1996. Towards earthquake prediction in Iceland. In: B. Thorkelsson (editor), *Seismology in Europe*. Papers presented at the XXV ESC General Assembly, Reykjavík, Iceland, September 9–14, 1996. 3–8.

Stefánsson, R. 1998. Earthquake-prediction research in a natural laboratory - PRENLAB. In: C.P. Providakis & M. Yeroyanni (editors), *EU-Japan Workshop on Seismic Risk.* Proceedings of the first expert meeting, Chania, Greece, March 24-26, 1998. European Commission, 113-122.

Stefánsson, R., F. Bergerat, M. Bonafede, R. Bödvarsson, S. Crampin, P. Einarsson, K. Feigl, Á. Gudmundsson, F. Roth & F. Sigmundsson 1999. Earthquake-prediction research in a natural laboratory - PRENLAB. In: M. Yeroyanni (editor), *Seismic risk in the European Union* II. Proceedings of the review meeting, Brussels, Belgium, November 27-28, 1997. European Commission, 1-39.

### Staff members working on the project:

Sigurdur Th. Rögnvaldsson:

1994: Ph.D in seismology, Uppsala University, Sweden.
1994-1995: Research fellow at Nordic Volcanological Institute, Iceland.
1995-present: Research scientist at the Icelandic Meteorological Office.
He has a strong background in seismology. He has worked extensively with microearthquake data from the Icelandic seismic network with emphasis on fault plane solutions and accurate relative locations. He is responsible for developing earthquake data processing at the institute.

Kristján Ágústsson:

1996: Fil. lic. from Uppsala University, Department of Earth Sciences.
1987–present: Geophysicist at the Icelandic Meteorological Office, maintainance and development of the strainmeter network, and the alert system of the seismic network, analysis and interpration of strainmeter data.

Gunnar B. Gudmundsson:

1986: B.S. in geophysics from University of Iceland, Reykjavík.

1985–present: Geophysicist at the Icelandic Meteorological Office. Main work has been on the SIL network. In 1990, 1991 and 1994 he organized and participated in OBS experiments in Iceland in collaboration with Hokkaido University, Japan.

Páll Halldórsson:

1979: Dipl. Phys. from University of Göttingen, Germany.

1979–present: Geophysicist at the Icelandic Meteorological Office. Main tasks are seismicity research and seismic hazard assessment.

Steinunn S. Jakobsdóttir:

1985: Cand. scient. in geophysics from University of Copenhagen. Thesis on interpretation of sonobuy–data from off coast East–Greenland.

1979–1984: Research assistant at the Geological Survey of Greenland.

1985–1987: Geophysicist at the Geological Survey of Greenland.

1987–present: Geophysicist at the Icelandic Meteorological Office. Working mainly on the SIL network since 1988, building up and installing stations, developing and debugging software and running the network.

Bergthóra S. Thorbjarnardóttir:

1985: M.S. in geophysics from University of Utah, Salt Lake City, Utah, USA.

1995-1997: Research assistant at the Science Institute, University of Iceland, Reykjavík.

1998-present: Geophysicist at the Icelandic Meteorological Office. Main work on earthquake database.

Bergur H. Bergsson:

1991: B.S. in electrical engineering from Technical University of Copenhagen.

1991-present: Electrical engineer at the Icelandic Meteorological Office. Main work has been on the SIL network, installation and maintainance of stations and development of hardware and software.

Pálmi Erlendsson:

1996: B.S. in geology from University of Iceland, Reykjavík.

1996–present: Geologist at the Icelandic Meteorological Office. Main work has been on the SIL network.

References relevant to the proposal:

Linde, A., K. Ágústsson, I.S. Sacks & R. Stefánsson 1993. Mechanism of the 1991 eruption of Hekla from continuous borehole strain monitoring. *Nature* 365, 737–740.

Rögnvaldsson, S.Th. & R. Slunga 1993. Routine fault plane solutions for local networks: a test with synthetic data. *Bull. Seism. Soc. Am.* 83, 1232–1247.

Rögnvaldsson, S.Th. & R. Slunga 1994. Single and joint fault plane solutions for microearthquakes in South Iceland. *Tectonophysics* 237, 73–86.

Slunga, R., S.Th. Rögnvaldsson & R. Bödvarsson 1995. Absolute and relative locations of similar events with application to microearthquakes in South Iceland. *Geophys. J. Int.* 123, 409–419.

Bödvarsson, R., S.Th. Rögnvaldsson, S.S. Jakobsdóttir, R. Slunga, & R. Stefánsson 1996. The SIL data acquisition and monitoring system. *Seism. Res. Lett.* 67, 35–46.

Gudmundsson, G., S. Jakobsdóttir & R. Bödvarsson 1996. Automatic selection of teleseismic data in the SIL system. In: Abstracts from the XXV ESC General Assembly, Reykjavík, Iceland, September 9–14, 1996. Icelandic Meteorological Office, Ministry for the Environment, University of Iceland.

Jakobsdóttir, S. 1996. Alert–detector in the SIL–network. In: Abstracts from the XXV ESC General Assembly, Reykjavík, Iceland, September 9–14, 1996. Icelandic Meteorological Office, Ministry for the Environment, University of Iceland.

Thorbjarnardóttir, B.S., I.Th. Bjarnason & P. Einarsson 1997. Seismic tremor in the Vatnajökull region in 1995-1996. *Report* RH-03-97. Science Institute, University of Iceland, Reykjavík.

Rögnvaldsson, S.Th. Á. Gudmundsson & R. Slunga 1998. Seismotectonic analysis of the Tjörnes fracture zone, an active transform fault in North Iceland. *J. Geophys. Res.* 103, 30117-30129.

Rögnvaldsson, S.Th., G.B. Guðmundsson, K. Ágústsson, S.S. Jakobsdóttir, R. Slunga & R. Stefánsson 1998. Overview of the 1993-1996 seismicity near Hengill. *Rit Veðurstofu Íslands* VÍ-R98006-JA05. Research report, Icelandic Meteorological Office, Reykjavík, 16 pp.

Ágústsson, K., A.T. Linde, R. Stefánsson & S. Sacks 1998. Strain changes for the 1987 Vatnafjöll earthquake in South Iceland and possible magmatic triggering. *J. Geophys. Res.* 104, 1151-1161.

## C7.b Workpackage 2: Lead contractor Reynir Bödvarsson

### C7.b.1 Department of Earth Sciences, Uppsala University

The Uppsala seismology group consist of staff members of both the Section of Solid Earth Physics and the Section of Seismology at the Department of Earth Sciences, Uppsala University. These sections did constitute the former Department of Geophysics (with about 35 academic staff) prior to the merge into the new Institute of Earth Sciences with about 200 employees. The seismology group conducts research in a number of different fields such as large- and microearthquake source studies, earthquake fault mapping, local earthquake tomography, seismicity studies and seismic hazard assessment. Members of the group were responsible for the design of the seismological network in Iceland (the SIL network) and the group is responsible for the Swedish seismological network which is now being modernized with 18 new digital stations using the SIL technology.

Reynir Bödvarsson:

Born: 1950 in Iceland.

Education:

1974-1976: Electrical engineering at New Mexico Institute of Mining and Technology, Soccoro, New Mexico and North Carolina State University, Raleigh, North Carolina, USA.

1977-1980: Computer Science at University of Uppsala, Sweden.

Career: 1980-present: Principal investigator for several national and international research projects at Uppsala University. Contractor in three EU projects within the 4th framework programme.

References relevant to the proposal:

Bödvarsson, R. 1988. Design of the data acquisition system for the South Iceland Lowland (SIL) project. Vedurstofa Íslands, 18 pp.

Bödvarsson, R. & S.Th. Rögnvaldsson 1992. The SIL acquisition system, a new tool for earthquake prediction research. In: *Natural Disasters 92*, proceedings of the International Conference on Preparedness and Mitigation for Natural Disasters, Reykjavík, Iceland, May 28–29, 1992. Association of Chartered Engineers in Iceland, 81–90.

Stefánsson, R., R. Bödvarsson, R. Slunga, P. Einarsson, S. Jakobsdóttir, H. Bungum, S. Gregersen, J. Havskov, J. Hjelme & H. Korhonen 1993. The SIL project, background and perspectives for earthquake prediction in the South Iceland seismic zone. *Bull. Seism. Soc. Am.* 83, 696–716.

Slunga, R., S.Th. Rögnvaldsson & R. Bödvarsson 1995. Absolute and relative locations of similar events with application to microearthquakes in South Iceland. *Geophys. J. Int.* 123, 409–419.

Bödvarsson, R., S.Th. Rögnvaldsson, R. Slunga & E. Kjartansson 1998. The SIL data acquisition system - at present and beyond year 2000. *Rit Veðurstofu Íslands* VÍ-R98005-JA04. Research report, Icelandic Meteorological Office, Reykjavík, 22 pp.

Ragnar Slunga:

Born: 1943 in Haparanda, Sweden.

Education and career:

Educated at Hoegre Allmaenna Laeroverket i Haparanda and at the Royal Technological University (KTH) in Stockholm during the years 1955-1968. Employed for research at the Swedish National Defence Research Institute (FOA) since 1969. Part time professor in tectonophysics at Uppsala University since 1989. Most professional work has been aimed at earthquake and microearthquake analysis.

References relevant to the proposal:

Slunga, R. 1988. Frictional sliding and the crustal stresses, In: A. Boden & K.G. Eriksson (editors), *Deep Drilling in Crystalline Bedrock* 2, 444–453.

Slunga, R. 1991. The Baltic Shield earthquakes. *Tectonophysics* 189, 323-331.

Rögnvaldsson, S.Th. & R. Slunga 1993. Routine fault plane solutions for local networks: a test with synthetic data. *Bull. Seism. Soc. Am.* 83, 1232–1247.

Rögnvaldsson, S.Th. & R. Slunga 1994. Single and joint fault plane solutions for microearthquakes in South Iceland. *Tectonophysics* 237, 73–86.

Slunga, R., S.Th. Rögnvaldsson & R. Bödvarsson 1995. Absolute and relative locations of similar events with application to microearthquakes in South Iceland. *Geophys. J. Int.* 123, 409–419.

### C7.b.2 Department of Earth Sciences, Johannes Gutenberg-Universität Mainz

Johannes Gutenberg-Universität Mainz is a typical complete German state university (with all faculties, except engineering) funded through Rhineland-Palatine, one of the German federal states. There are about 700 professors and lecturers and about 25.000

students. ERASMUS links have been established among others between Mainz and Reykjavík universities. The Department of Earth Sciences of Mainz University, with 14 senior and 12 junior teaching staff in geology, geophysics, mineralogy and paleontology, concentrates, besides on higher education, on research and emphasizes geodynamics globally in close cooperation with Max-Planck-Institute for Chemistry, Mainz. International collaboration is a general mode of research of the institution. Financial support of research comes typically from the German Science Foundation (DFG), other foundations, and EU. Organizing international cooperation is well established. DFG is funding a 'Graduate College' with 12 Ph.D students two of whom work on subjects related to Iceland. Expertise and experience exist with work in Iceland in some university departments of languages, biology and in earth sciences. Geological and geophysical work has been supported and funded by the university in the fields of gravity, seismology and isotope geochemistry. Most of the work is in cooperation with Icelandic and other European institutions.

Wolfgang R. Jacoby:

Born in Tallinn, Estonia, 1936.

Education and career:

Higher education at Braunschweig and Kiel universities in physics and geophysics; Ph.D in geophysics 1966. Employments at Kiel university. Dominion Observatory, Ottawa, Canada 1967-1972 (research in gravity, geological and geodynamic modelling, seismic crustal studies). Professor for applied geophysics and geodynamics at University of Frankfurt 1972-1984 (research in geodynamics, mantle convection, volcanism, inversion problems in gravity, Iceland). Since 1984 professor for geophysics, Johannes Gutenberg-Universität Mainz (research in geodynamics, especially in Iceland). Coordinator of EU-INTAS project 94-1099 on geodynamic modelling. Editor-in-chief of Journal of Geodynamics.

Experience and expertise on research in Iceland:

My research in Iceland began in 1972. In 1976 to 1977 I was co-organizer of the long-range seismic refraction experiment RRISP77. 1986-1989 I recorded earthquakes with a local network of mobile seismic stations in North Iceland. Since 1990 I do repeated gravity observations in Iceland to observe temporal variations in the vicinity of the Krafla system and near shrinking Vatnajökull (in collaboration with Icelandic institutions). This work is closely related to the aims of HOTSPOT since the Iceland plume is expected to cause temporal gravity variations. Related to this is the study of plumes, especially the Iceland plume; my inversion of the gravity field in and around Iceland (unpublished) demonstrates the existence of a low-density cylindrical plume under Iceland in good agreement to recent seismic tomographic studies.

References relevant to the proposal:

Jacoby, W.R. 1979. Iceland and the North Atlantic: a review. *GeoJournal* 3, 253-262.

Jacoby, W.R., A. Björnsson & D. Möller (editors) 1980. Iceland: evolution, active tectonics and structure. *J. Geophys.* 47.

Jacoby, W.R., H. Zdarsky & U. Altmann 1990. Geodetic and geophysical evidence for magma movement and dyke injection during the Krafla rifting episode in North Iceland. In: Evolution of Mid-Ocean Ridges. *Geophys. Monograph* 57, IUGG Vol. 8, AGU, Washington, D.C., 65-77.

Jacoby, W.R. 1995. Problems posed by the Krafla volcanic rifting episode. *Tiré Centre Eur. Géodyn. et Sismol.* 8, 245-257.

Jacoby, W.R. & B. Higgs 1995. On the rifting dynamics of plate divergence and magma accumulation at oceanic ridge axes. *Pure Appl. Geophysics* 145, 505-521.

### C7.b.3 Nordic Volcanological Institute

See WP 3 for description of the institute.

Axel Björnsson:
Born: September 25, 1942, Reykjavík, Iceland. Nationality: Icelandic.

Title: Dr. rer. nat. (Ph.D), geophysicist.

Present position:
Research scientist at the Nordic Volcanological Institute, Reykjavík.

Education:
1965: University of Göttingen, Germany. Prodiploma (B.Sc.) in physics.
1968: University of Göttingen. Diploma (Ph.D) in physics and geophysics.
1972: University of Göttingen. Dr. rer. nat. in physics and geophysics.

Employments:
1968-72: Research assistant at the University of Göttingen, Germany.
1972-90: The Icelandic Energy Authority (Geological Survey of Iceland), research scientist, geothermal research manager, and acting vice director of the Geothermal Division from 1988.
1990-94: The Icelandic Research Council, director from 1991.
1995: Lecturer in geosciences at the University of Akureyri.
1995-present: Research scientist at the Nordic Volcanological Institute, member of the Nordic Science Policy Council.

Fields of scientific specialization:
1) Volcanological surveillane and geophysical exploration, especially geoelectrical, magnetic and temperature measurements in high and low temperature geothermal fields. Teaching at university level in this field.
2) Magnetotelluric research of the earth's crust and mantle.
3) Scientific management and science policy administration.

Publications:
Some 35 scientific papers in international journals, 18 short abstracts and communications and 43 research reports.

Other duties:
Member of the Board of Governors of the Joint Research Center of the European Community. Vice president of the Icelandic Academy of Sciences.

References relevant to the proposal:

Johnsen, G.V., A. Björnsson & S. Sigurdsson 1980. Gravity and elevation changes caused by magma movement beneath the Krafla caldera, Northeast Iceland. *J. Geophys.* 47, 132-140.

Beblo, M., A. Björnsson, K. Árnason, B. Stein & P. Wolfgram 1983. Electrical conductivity beneath Iceland - constraints imposed by magnetotelluric results on temperature, partial melt, crust- and mantle structure.' *J. Geophys.* 53, 16-23.

Björnsson, A. 1985. Dynamics of crustal rifting in NE-Iceland. *J. Geophys. Res.* 90, 10151-10162.

Ewart, T., B. Voight, & A. Björnsson 1990. Dynamics of Krafla magma reservoir: 1975-1985. In: M.P. Ryan (editor), *Magma transport and storage.* John Wiley and Sons Ltd., 225-276.

Kristmannsdóttir, H., A. Björnsson, S. Pálsson & Á.E. Sveinbjörnsdóttir: The impact of the 1996 subglacial volcanic eruption in Vatnajökull on the river Jökulsá á Fjöllum, North Iceland. *Journal of Volcanology and Geothermal Research* (in press).

## C7.b.4 Institute of Meteorology and Geophysics, University of Frankfurt

See WP 4 for description of the institute.

Andreas Junge:

Born: August 25, 1956 in Mülheim/Ruhr, Germany. Nationality: German.

Title: Prof. Dr. rer. nat. (Ph.D), geophysicist.

Present position:

Professor of geophysics at University of Frankfurt, Germany.

Education:

1982: University of Göttingen, Diplom (M.Sc.) in physics.
1986: University of Göttingen, Dr. rer. nat (Ph.D) in physics.
1994: University of Göttingen, habilitation in geophysics.

Main employments:

1986-1992: Akademischer Rat (Lecturer) at the Institut für Geophysik, Universität Göttingen.
1995-present: Full Professor at University of Frakfurt.

References relevant to the proposal:

Bahr, K., A. Berktold, H.J. Brink, V. Haak, St. Hofer, H. Jödicke, A. Junge, K. Knödel, W. Losecke, R. Volbers & H. Winter 1992. An electrical resistivity crustal section from the Alps to the Baltic Sea (central segment of the EGT). *Tectonophysics* 207, 123-129.

Junge, A. 1994. *Induzierte erdelektrische Felder - neue Beobachtungen in Norddeutschland und im Bramwald.* Habil., math.-nat. Fachb., Universität Göttingen.

Junge, A. 1996. Characterization of and correction for cultural noise. *Surveys in Geophysics* 17, 361-391.

Ritter, O., A. Junge & G.J.K. Dawes 1998. New equipment and processing for magnetotelluric remote reference observations. *Geophys. J. Int.* 132, 535-548.

Bigalke, J. & A. Junge 1999. Using evidence of non-linear induced polarization for detecting extended ore mineralizations. *Geophys. J. Int.* 137, 516-520.

## C7.b.5 Geophysical Observatory Fürstenfeldbrück, University of Munich

The Geophysical Observatory Fürstenfeldbrück is a part of the Institute of Theoretical and Applied Geophysics, University of Munich. The observatory consists of two divisions, the geomagnetic observatory (head: Dr. Martin Beblo) and the seismological observatory (head: Dr. Eberhard Schmedes). Since 1939 the Geomagnetic Observatory Fürstenfeldbrück (FUR) - follower of the observatories Munich (MUC, 1841-1926) and Maisach (MAS, 1927-1932) - runs permanent observations of the time variations of the earth magnetic elements, mainly for the study of secular variation of the earth magnetic field. Every 5 to 10 years FUR carries out geomagnetic surveys in Germany in co-operation with the two other German observatories in Niemegk (NGK) and Wingst (WNG). FUR has a long tradition in construction of geomagnetic instruments, nowadays both in developing hardware and software. These instruments and software are widely used by the geomagnetic community in the developing countries. In addition to this scientists at the observatory are engaged in writing the history of geosciences. Studies of the electrical conductivity of crust and mantle are essential part of the observatory. The main survey areas have been the Eastern Alps, South Germany, Iceland and Antarctica. During the last years basic research in environmental geophysics has been carried out and transferred to industry.

Martin Beblo:

Born: March 1, 1942 in Strasbourg.

Present position:

Head of Geomagnetic Observatory Fürstenfeldbrück, University of Munich.

Education:

1965-1967: Studies in geophysics, University of Innsbruck, Austria.
1967-1972: Studies in geophysics, University of Munich.
1972: Diploma in geophysics.
1974: Dr. rer. nat. (Ph.D) in geophysics.

Employment:

1972-1977: Institute of Theoretical and Applied Geophysics, University of Munich.
1978: Head of Geomagnetic Observatory Fürstenfeldbrück.

References relevant to the proposal:

Beblo, M. & A. Björnsson 1978. Magnetotellluric investigations of lower crust and upper mantle beneath Iceland. *J. Geophys.* 45, 1-16.

Beblo, M., A. Björnsson, K. Árnarson, B. Stein & P. Wolfgram 1983. Electrical conductivity beneath Iceland - constraints imposed by magnetotelluric results on temperature, partial melt, crust- and mantle structure. *J. Geophys.* 50, 16-23.

Beblo, M. 1990. A digital magnetometer system using conventional magnetometers and opto-electrinic converters. *Phys. Earth Plan. Interiors* 59, 82-88.

Beblo, M. & V. Liebig 1990. Magnetotelluric measurements in Antarctica, *Phys. Earth Plan. Interiors* 59, 89-99.

Beblo, M. 1997. *Umweltgeophysik* (environmental geophysics). Verlag Ernst und Sohn, Berlin.

### C7.b.6 Royal Observatory of Belgium

Royal Observatory of Belgium (ROB) will give access and assistance to the already existing integrated Environmental Data Acquisition System (EDAS) for volcano and seismic zone monitoring. It includes sensors, electronics interfaces, data transfers, pretreatment software, supplies, calibration procedure, etc. Concerning the use of spring gravimeters LaCoste-Romberg, ROB has developed a special electrostatic feedback interface which is recognized by the maker of the gravimeters as suitable for permanent monitoring of gravity field. Complementary signals registration is justified by the strong perturbations which could exist in volcano sites. Tiltmeters and climatological stations could be prepared with EDAS approach.

Expertise of ROB in the project domain:

- Geodynamical researches using geodetic tools for the ground deformation records, like seismic networks including local and worldwide GPS survey with permanent stations, like highest precision measurements achieved with superconducting gravimeters.
- Monitoring of aquifers interacting with tidal variations.
- High precision meterological sensors including thermometry.
- Volcano monitoring including oceanic interactions.

Michel van Ruymbeke:

Nationality: Belgian.

Functions:

Chef de Travaux at the Royal Observatory of Belgium. Professor at the Department of Physics, Université Catholique de Louvain, Belgium. Responsible of a laboratory dedicated to the development of instruments and sensors for researches in geodynamics.

Scientific domains are principally dedicated to:

Gravimeters technology including feedback systems and calibration tools.
Earth tides and oceanic tides monitoring.
Underground laboratory equipments including microvariations sensors.
Ground deformations tools for seismic and volcanic zones.
Boreholes probes including water level and temperature sensors.

References relevant to the proposal:

Van Ruymbeke, M. 1991. Calibration platforms for gravimeters. XI International Symposium on Earth Tides, Helsinki, Finland, July 31-August 5, 1989, 95-100.

Van Ruymbeke, M. 1991. A new feedback system for instruments equipped with a capacitive transducer. XI International Symposium on Earth Tides, Helsinki, Finland, July 31-August 5, 1989, 51-60.

Van Ruymbeke, M. 1991. New feedback electronics for LaCoste-Romberg gravimeters. Proceedings of the Workshop "Geodynamical Instrumentation Applied to Volcanic Areas", Walferdange, Luxembourg, October 1-3, 1990. *Cahiers du Centre Européen de Géodynamique et de Sismologie* 4, 333-338.

Van Ruymbeke, M., R. Vieira, N. d'Oreye, A. Somerhausen & N. Grammatica. Technological Approach from Walferdange to Lanzarote: the EDAS concept. Proceedings of the XII International Symposium on Earth Tides, Beijing, China, August 4-7, 1993. Science Press, Beijing, New York.

Van Ruymbeke, M., A. Somerhausen & N. Grammatica. Calibration of gravimeters with the VRR 8601 calibrating platform. *Metrologia* 32, 209-216.

## C7.c Workpackage 3: Lead contractor Thierry Villemin

### C7.c.1 Laboratory of Alpine Belts Geodynamics, Université de Savoie

The "Laboratoire de Géodynamique des Chaînes Alpines" (LGCA) (Laboratory of Alpine Belts Geodynamics) is a laboratory of both University of Savoie (Chambéry) and University Joseph Fourier (Grenoble). The LGCA is also an associated Laboratory of the "Centre National de la Recherche Scientifique" (CNRS) (ESA nr 5025). The LGCA has a staff of 30 academic people, and about 40 reaseach students. The LGCA belongs also to the Grenoble Astronomy & Earth Sciences Observatory. Among the main fields of research at the LGCA is the characterization, measure and modelization of recent and present-day deformation. Ongoing GPS studies concern the Himalayas, the Alps and Iceland where the LGCA follows a network of 45 GPS points since 1995. The LGCA has also installed and maintained 5 stations among a continuous GPS network in the Alps (REGAL network). The LGCA monitor deformation with GPS on several landslides in the Alps.

Thierry Villemin:

Born: September 10, 1958. Citizenship: French.

Education:

1981: Master's degree in "Sciences Naturelles", Université Pierre et Marie Curie, Paris.
1982: "Agrégation de Biologie-Géologie"
1986: Ph.D in earth sciences from Université Pierre et Marie Curie, Paris.

Experience and expertise:

1986-1989: "Professeur agrégé", lecturing at Université Pierre et Marie Curie.
1989-present: "Maître de Conférences" at Université de Savoie. Lecturing in structural geology, tectonics, remote sensing and geodesy. Research on fracture mechanics, brittle deformation and present day deformation measurements (GPS, SAR, photogrammetry). He organized 4 GPS campaigns in North Iceland where a 45 points network is followed since 1995. He is at the head of the present-day and recent deformation research group of the LGCA. He is an author of around 30 papers in international journals.

**Other staff:**

François Jouanne:

1994: Ph.D in earth sciences from Université de Savoie.

1994-present: Maître de Conférences in earth sciences at the Université de Savoie. Main work on GPS measurements of deformation in seismic area (Himalaya, Iceland) and in the Alps.

Laurent Serrurier:

1994: DEA de Géophysique Interne from IPGP.

1997: Engineer at Université de Savoie. GPS data processing, continuous GPS station installation and maintenance.

## C7.c.2 Department of Geophysics, Icelandic Meteorological Office

See WP 1 for description of the institute.

Thóra Árnadóttir:

Born: December 17, 1963. Citizenship: Icelandic.

Education:

1986: B.S. in geophysics, University of Iceland, Reykjavík, Iceland.

1989: M.A. in geophysics, Princeton University, Princeton, New Jersey, USA.

1993: Ph.D in geophysics, Stanford University, California, USA.

Career: 1994-1995: Research fellow in the Research School of Earth Science at Victoria University of Wellington (VUW), Wellington, New Zealand.

1996-1998: Research associate in the Department of Geosciences, Princeton University, New Jersey, USA.

1998-present: Research scientist at the Iceland Meteorological Office.

Experience and expertise:

She has a strong background in GPS measurements, data processing and modelling methods using geodetically observed surface deformation to sources. She has extensive field experience collecting geodetic data (GPS, EDM, levelling and tilt). She is responsible for running and processing data from the continuous GPS network that is currently being set up in Iceland.

References relevant to the proposal:

Árnadóttir, Th., & P. Segall 1994. The 1989 Loma Prieta earthquake imaged from inversion of geodetic data. *J. Geophys. Res.* 99, 21835–21855.

Árnadóttir, Th., J. Beavan & C. Pearson 1995. Deformation associated with the 18 June, 1994, Arthur's Pass earthquake, New Zealand. *New Zealand J. of Geol. and Geophys.* 38, 553–558.

Árnadóttir, Th., F. Sigmundsson & P.T. Delaney 1998. Sources of crustal deformation associated with the Krafla, Iceland, eruption of September 1984. *Geophys. Res. Lett.* 25(7), 1043-1046.

Árnadóttir, Th., S. Thornley, F.F. Pollitz, & D.J. Darby 1999. Spatial and temporal strain rate variations at the Northern Hikurangi Margin, New Zealand. *J. Geophys. Res.* 104, 4931-4944.

Árnadóttir, Th., S.Th. Rögnvaldsson, K. Ágústsson, R. Stefánsson, S. Hreinsdóttir, K. Vogfjörd & G. Thorbergsson 1999. Seismic swarms and surface deformation in the Hengill area, SW Iceland, *Seism. Res. Lett.* 70, 269.

### C7.c.3 Nordic Volcanological Institute

Nordic Volcanological Institute (NVI) will participate in preparing infrastructure relating to research on structure and changes in the North Atlantic mantle plume by magnetelluric methods, and from geodetic measurements.

NVI has participated in numerous international collaborative projects, such as PRENLAB and PRENLAB-2 that have focussed on earthquake prediction research, using Iceland as a natural laboratory. Extensive crustal deformation studies have been conducted at the institute for over 20 years, in Iceland and elsewhere in the world, and the institute is well equipped for that kind of research. The institute is also leading efforts utilizing continuous magnetelluric measurements to study the earth.

NVI is a multinational organization sponsored jointly by the Nordic countries, Denmark, Finland, Norway, Iceland and Sweden. The NVI was founded in 1974 and now has 14 employees. The institute focusses on basic research in plate tectonics and volcanology. Further information can be found at http://www.norvol.hi.is.

Freysteinn Sigmundsson:

Born: July 22, 1966, married, 2 children. Citizenship: Icelandic.

Education:

1988: University of Iceland, B.S. in geophysics.
1992: University of Colorado, Ph.D in geophysics.

Professional societies:

American Geophysical Union.
European Geophysical Society.
International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).
Geoscience Society of Iceland.
Iceland Physical Society.

Career experience:

1988-1989: University of Colorado, research assistant. Deformation monitoring of the Long Valley Caldera, and research on application of the Global Positioning System (GPS) for tectonic studies.
1989-1990: University of Iceland, research assistant. Research on post-glacial rebound, GPS, and crust/mantle structure in Iceland.
1990-1992: University of Colorado, research assistant. Research on crustal deformation in sub-aerial parts of the world-oceanic rift system, Iceland and Afar, and application of the Global Positioning System for tectonic studies. Holder of a NATO Science Fellowship in 1990, and NASA Global Change Fellowship in 1992. Leaded a GPS expedition to Tibet in 1991 to participate in trans-Himalayan geodetic measurements.
1992-1999: Nordic Volcanological Institute, research geophysicist. Temporary position before April 1, 1995, but permanent thereafter. Principal field of work:

Research on active processes at volcanoes and in seismic zones, and crustal deformation related to volcanic and seismic activity using GPS geodesy. Comparison of crustal deformation and seismicity. Application of satellite remote sensing techniques to study geological processes and measure deformation, including SAR (synthetic aperture radar) interferometry. Involved in crustal deformation research in various parts of the world, including Iceland, Azores, Greece, Ethiopia and Djibuti, and La Reunion, France.
1999: Director, Nordic Volcanological Institute.
Advisor to the Icelandic Civil Defence Authorities since 1994, member of scientific panel.

References relevant to the proposal:

Sigmundsson, F., P. Einarsson, R. Bilham & E. Sturkell 1995. Rift-transform kinematics in South Iceland: Deformation from Global Positioning System measurements, 1986-1992. *J. Geophys. Res.* 100, 6235-6248.

Gudmundsson, M.T., F. Sigmundsson & H. Björnsson 1997. Ice-volcano interaction of the 1996 Gjálp subglacial eruption, Vatnajökull, Iceland. *Nature* 389, 954-957.

Sigmundsson F., H. Vadon & D. Massonnet 1997. Readjustment of the Krafla spreading segment to crustal rifting measured by satellite radar interferometry *Geophys. Res. Lett.* 24, 1843-1846.

Sigmundsson, F., P. Einarsson, S.Th. Rögnvaldsson, G.R. Foulger, K.M. Hodgkinson & G. Thorbergsson 1997. The 1994-1995 seismicity and deformation at the Hengill triple junction, Iceland: Triggering of earthquakes by minor magma injection in a zone of horizontal shear stress. *J. Geophys. Res.* 102, 15151-15161.

Vadon H., & F. Sigmundsson 1997. Crustal deformation from 1992-1995 at the Mid-Atlantic Ridge, SW Iceland, mapped by satellite radar interferometry. *Science* 275, 193-197.

### C7.c.4 Science Institute, University of Iceland

The University of Iceland is a state university with 5000 students in 9 departments: law, medicine, dentistry, theology, philosophy, social sciences, engineering, natural sciences, and economics. The Department of Natural Sciences encompasses the subjects physics, mathematics, computer science, chemistry, biology and geology, and has 800 students. B.S. and M.S. degrees are offered in these subjects. Yearly number of physics students (including geophysics) is 5-10. The Science Institute is a research institute of the Department of Natural Sciences, but with a separate budget. It has divisions of mathematics, physics, geophysics, geology, chemistry, and computer science. Most of its funds come from the government budget, but a substantial part comes from grants and contracts. The Geophysics Division has a staff of 14: 2 professors, 4 senior research scientists, 3 research scientists, 3 technicians and 2 research assistants. Main research areas are seismology, crustal movements, glaciology, paleomagnetism, geomagnetism, mass spectrometry, and geothermal research. The division runs a geomagnetic observatory (Leirvogur), 20 seismographs throughout the country, and a mass spectrometer. The Geophysics Division has conducted research on seismicity and crustal movements for almost 30 years. Studies of the South Iceland seismic zone go back to 1974, with emphasis on seismicity, crustal deformation, radon precursors and mapping of recent earthquake faults.

Páll Einarsson:

Born: March 27, 1947, in Iceland. Citizenship: Icelandic.

Education:

University of Göttingen, Germany, 1967–70. Major in physics, minors in mathematics and chemistry. Vordiplom in physics 1970.
Columbia University, New York, USA, 1970–75. Major in seismology, minors in general geology, physics and structural geology. M.Phil. in 1974, Ph.D in 1975.

Career: 1970-1975: Graduate research assistant, Lamont-Doherty Geological Observatory, USA.
1974-1975: Teaching assistant, Columbia University, USA.
1975-1977: Research scientist, Science Institute, University of Iceland.
1977-1994: Senior research scientist, Science Institute, University of Iceland.
1983-1987: Head of the Geophysics Division and member of the Board of Directors of the Science Institute.
1986-1990: Member of the University Senate, University of Iceland.
1975-1994: Lecturer in the Department of Natural Sciences, University of Iceland, teaching courses in geophysics, physics, seismology, tectonics and volcanology.
1994-present: Professor of geophysics, University of Iceland.

References relevant to the proposal:

Einarsson, P., S. Björnsson, G. Foulger, R. Stefánsson & Th. Skaftadóttir 1981. Seismicity pattern in the South Iceland seismic zone. In: D. Simpson & P. Richards (editors), Earthquake Prediction - an International Review, Am. Geophys. Union, *Maurice Ewing Series* 4, 141–151.

Einarsson, P. & J. Eiríksson 1982. Earthquake fractures in the districts Land and Rangárvellir in the South Iceland seismic zone. *Jökull* 32, 113–120.

Einarsson, P. 1991. Earthquakes and present-day tectonism in Iceland. *Tectonophysics* 189, 261–279.

Sigmundsson, F., P. Einarsson, R. Bilham & E. Sturkell 1995. Rift–transform kinematics in South Iceland: Deformation from Global Positioning System measurements, 1986 to 1992. *J. Geophys. Res.* 100, 6235–6248.

Erlendsson, P. & P. Einarsson 1996. The Hvalhnúkur fault, a strike-slip fault mapped within the Reykjanes peninsula oblique rift, Iceland. In: B. Thorkelsson (editor), *Seismology in Europe.* Papers presented at the XXV ESC General Assembly, Reykjavík, Iceland, September 9–14, 1996, 498–504.

## C7.d Workpackage 4: Lead contractor Gabriele Marquart

### C7.d.1 Institute of Meteorology and Geophysics, University of Frankfurt

The institute is a part of University of Frankfurt and responsible for research and academic education. Research at the geophysical unit is based on theoretical work in the field of geodynamics and seismology, on applied geophysics using geoelectric and on laboratory high pressure rock physics. The unit currently comprises 20 academic staff members, a number of students and technical staff. The unit of geophysics is equipped with a numerical laboratory consisting of 3 high performance computers and a number of smaller units, self-developed and commercial softwares for calculation of earth dynamics and the related necessary visualization hard- and softwares.

Research in the geodynamic group (Harro Schmeling and Gabriele Marquart) focusses on interaction between mantle convection and the lithosphere, plume dynamics, melt generation, mineral phase changes in the mantle, and geographically on the regions of the North Atlantic and the Southeast Pacific.

Gabriele Marquart:

Born: January 11, 1954. Citizenship: German.

Education:

1980: Diploma in geophysics from University of Frankfurt.

1983: Doctoral degree from University of Frankfurt, with a thesis about the modelling of the deformations associated with the Krafla fissure eruption.

1991: Appointment to "Docent of geophysics" from of Uppsala University, Sweden.

Career: She was first a post-doc and then a researcher and teacher at Uppsala University from 1984-1993. She was a reasercher at the Geodetic Insitute of the Technical University of Berlin 1993-1994. In 1994 she obtained a Heisenberg-fellowship of the German Research Concil running until 1997. Now she is working as a researcher and teacher at the Universities of Frankfurt and Mainz. Here main interests are physical modelling of lithosphere behavior, mantle dynamics and interpretation of the earth's gravity field. She is speaker for the "German Iceland Research Group". She is teaching in general geophysics, lithosphere physics, plate kinematics and satellite geodesy and geodynamics.

References relevant for the proposal:

Schmeling, H. & G. Marquart 1993. Mantle flow and the evolution of the lithosphere. *Phys. Earth Planet. Int.* 79, 241-267.

Braun, A. & G. Marquart 1997. Interpreting the evolution of extensional margins in the Norwegian-Greenland Sea using gravity from altimetry. *Terra Nova* 9, 209.

Marquart, G. & T. Ruedas 1998. The Iceland-Plume Project. *Mitteilungen der DGG* 3/98, 2-8.

Marquart, G., H. Schmeling & A. Braun 1999. Small scale instabilities below the cooling oceanic lithosphere. *Geophys. J. Int.* (in press).

Marquart, G., H. Schmeling, G. Ito & B. Schott 1999. Conditions for plumes to penetrate the mantle phase boundaries. *Geophys. J. Int.* (submitted).

Harro Schmeling:

Born: November 26, 1954, in Hamburg, Germany. Nationality: German.

Education:

1979: Diplom (M.Sc.), University of Frankfurt. Thesis on numerical calculations on mantle convection using different rheologies.

1984: Dr. phil. nat. (Ph.D), University of Frankfurt. Thesis on numerical models on the influence of partial melt on elasticity, anelsticity and electrical conductivity of rocks with applications to laboratory data and the asthenosphere.

Career and employment:

1980-1983: Scientific assistant at the Institute of Geophysics, Frankfurt.

1983-1988: Research assistant (assistant professor) at Uppsala University, Sweden. Research programmes on diapirism, mantle convection and dynamics of the lithosphere.

1987-1988: Temporal representative of the chair of Geophysics at the Institute of Geophysics at University of Karlsruhe, Germany.

1989-1990: Docent of the Swedish Research Council at the Uppsala University. Establishing of a "Numerical laboratory".

1990-1994: Full professor (C3) of geophysics at University of Bayreuth.

1994-present: Full professor (C4) in physics of the Earth at University of Frankfurt.

Specialization:

Main field: Theoretical and experimental geophysics.

Other fields: Geodynamics, rock physics, tectonophysics, rheology.

Current research interests: Dynamics of partially molten systems, mantle convection and dynamics of the lithosphere and crust.

References relevant for the proposal:

Schmeling, H. & G. Marquart 1993. Mantle flow and the evolution of the lithosphere. *Phys. Earth Planet. Int.* 79, 241-267.

Bittner, D. & H. Schmeling 1995. Numerical modelling of melting processes and induced diapirism in the lower crust. *Geophys. J. Int.* 123, 59-70.

Schmeling, H. & G.Y. Bussod 1996. Variable viscosity convection and partial melting in the continental asthenosphere. *J. Geophys. Res.* 101, 5411-5423.

Becker, T.W. & H. Schmeling 1998. Earthquake recurrence time variations with and without fault zone interactions. *Geophys. J. Int.* 135, 165-176.

Schmeling, H. 1998. Partial melting and melt segregation in a convection mantle. In: N. Bagdassarov, D. Laporte & A.B. Thompson (editors), *Physics and chemistry of partially molten rocks.* Kluwer Academic Publishers (in press).

## C7.e Workpackage 5: Lead contractor Florence Rivière

### C7.e.1 Euro-Mediterranean Seismological Center

The Euro-Mediterranean Seismological Center (EMSC) was established 20 years ago with the goal of providing the community with rapid information about large earthquakes in the European-Mediterranean region. This activity has undergone major upgrades over the past three years thanks to an EC contract for the 'Rapid Warning System for Earthquakes in the European-Mediterranean Region'. Another task of EMSC was to act as the collection and archiving center for parametric data in the European-Mediterranean region. This service has been operational for many years and is well-known in the scientific community. For several years, the EMSC issued manually a seismic bulletin including all information available at the EMSC. Because of the shortage of human resources, the service has been discontinued. The EMSC has investigated to possibility to provide an automatic bulletin, and has recently contributed to the development of a data fusion software. With now 41 seismological laboratories as members, the EMSC has developed the secretarial and the administrative structure for dealing with a large number of institutes. Its key position in the research community has allowed the EMSC to coordinate actions in an international environment.

Florence Rivière:

Nationality: French.

Experience and expertise:

She has been the EMSC Secretary General since January 1998. She has been involved in international projects for almost ten years, including five years at the prototype International Data Center in the USA, spent on research on event identification, and on operational aspects of bulletin production. In France, at the LDG, her duties covered the evaluation of automatic system for event location in the framework of GSETT-3, and the participation to the technical discussions for the set-up of CTBTO in Vienna. Her responsibilities at EMSC require to evolve in an international environment and competencies to coordinate projects involving several participants.

## C7.f Workpackage 6: Lead contractor Bernard Dost

### C7.f.1 The Royal Netherlands Meteorological Institute/ORFEUS

The Royal Netherlands Meteorological Institute (KNMI) is the national Netherlands center for weather, climate and seismology research. The seismology division of the KNMI is involved in applied research in regional seismicity (natural and induced). It also hosts the National Data Center in the framework of the Comprehensive Test Ban Treaty and the European center for broad-band seismology: ORFEUS. Observatories and Research Facilities for European Seismology started in 1988 with the aim to "coordinate broad-band seismology in Europe". ORFEUS is funded by 13 European countries and has at present 55 institute participants. In the past 11 years the ORFEUS Data Center built up a large database of on-line and off-line broad-band data from European stations. Also, ORFEUS coordinates station planning, technical support, mobile experiments and software developments devoted to broad-band seismology. This coordination is organized through a series of working groups that communicate through the ORFEUS website (http://orfeus.knmi.nl).

Bernard Dost:

Nationality: Dutch.

Experience and expertise:

He is director of the ORFEUS Data Center since 1988. He has expertise in the organization of digital broad-band data exchange in Europe for more than 10 years and is involved as secretary of the working group on data exchange of the Federation of Digital Seismograph networks in international definitions of data formats and exchange procedures. He is also deputy head of the division of seismology of the KNMI.

References relevant to the proposal:

Dost, B. 1994. The working group III on data exchange, *Annali di Geofisica* XXXVII(5). Special FDSN volume, 1099-1102.

van Eck, T. & B. Dost 1999. ORFEUS, a European initiative in broad-band seismology; status and future plans, *Physics of the Earth and Plan. Interiors* (in press).

## C7.f.2 British Geological Survey

The British Geological Survey (BGS) is a daughter institute of the Natural Environment Research Council which is the legal entity.

BGS is the UK National Centre for earth science information and expertise. The role of the Survey is to acquire and maintain up-to-date knowledge of the UK landmass and its adjacent continental shelf by systematic geological geophysical, geochemical hydrogeological and geotechnical surveys and monitoring. It undertakes high-quality research to underpin its strategic activities. Many of the BGS scientific groups apply their capabilities overseas, which for seismic and geomagnetic monitoring is a worldwide role.

BGS operates the National Geosciences Information Service (NGIS) which is the focus for the nation's geosciences data and information. It represents the public interface to the Survey's data resources and expertise, and it is responsible for the provision of advice on geological matters and for the dissemination of data in forms meaningful and relevant to end users.

The British Geological Survey's Global Seismology and Geomagnetism Group (GSGG) is responsible for the operation of the UK national seismic network which includes 141 short period seismograph stations operating to modern digital standards. Telephone links provide access to all the data which is collected automatically under the control of a central computer, enabling a rapid response to be made to any seismic event. GSGG works on the development of instruments and data acquisition and analysis software, ensuring that advantage is taken of opportunities presented by new technology and that use is made of the latest techniques for analysis and interpretation of seismic data.

The proven success in running the UK seismic network has led a number of institutions overseas to employ GSGG's experience when specifying, deploying and commissioning seismic networks in their own countries. Both hardware and software are tailored to suit the requirements of the operating institution, training of local staff in the network operations and in data processing are provided, and post-installation maintenance is arranged. The most recent examples of work of this type have been carried out for the Geotechnical Engineering Office in Hong Kong where a seismic network was commissioned in May 1997, and on the Montserrat volcano where BGS' first broadband network was established after eruption commenced in 1995.

Chris Browitt:

Nationality: British.

Experience and expertise:

Dr. Chris Browitt is responsible for direction and leadership of the Petroleum Geology, Geophysics and Offshore Surveys Division of the British Geological Survey with a remit covering surveys and deep geological investigations of offshore and coastal waters, earthquake and geomagnetic monitoring and the biostratigraphical service. As head of the Global Seismology Research Group for 14 years, he led the development of the 141-station, short period UK seismic monitoring network and coordinated data exchange programmes in 10 member states under EC Transfrontier projects. He is president of the European Mediterranean Seismological Centre (EMSC) and a member of the Board of Directors of ORFEUS.

**Brian J. Baptie:**

Nationality: British.

Experience and expertise:

Dr. Brian J. Baptie is a research seismologist who will take responsibility for broad-band stations as they are developed within the UK short period network. He brings experience from the operation and interpretation of the Montserrat broad-band seismic network established in 1996 to monitor this erupting volcano. He had overall responsibility for the seismic aspects of its surveillance and continues to research the active process using the wealth of data created.

### C7.f.3 Kort og Matrikelstyrelsen

Kort og Matrikelstyrelsen in Copenhagen, Denmark, has research in geodesy and cartography as well as seismology. Approximately 25 employees out of more than 500 are scientists. The seismology section has 6 employees working on improvements of the seismograph networks in Denmark and Greenland, reporting traditional readings of seismic phases to European and global earthquake centers, as well as doing original research, especially in the regional earthquake occurrence, the regional deep seismic structure, and microseisms. In these years a deep lithosphere study is carried out in central Greenland from east coast to west coast. The seismology section functions as the national authority for the Danish involvement in the Comprehensive Test Ban Treaty for nuclear weapons. The Danish Survey and Cadastre has the responsibility to map the Danish land and sea area, and it administers the Danish cadastre. It supports Danish authorities with basic surveying and mapping. And sales of maps to national and regional authorities as well as to private companies and individuals is an important income. The scope of the Danish Survey and Cadastre includes research, from basic to applied, in the fields of interest. Many international research projects have been based in the institution, especially in geodesy.

**Sören Gregersen:**

1968: Danish candidate of geophysics from University of Copenhagen. Employment as seismologist in the Danish Geodetic Institute. 1974: Ph.D from Lamont-Doherty Earth Observatory, Columbia University, New York. Continued employment in the Danish Geodetic Institute (now the Danish National Survey and Cadastre). 1985: Dr. scient. from University of Copenhagen. Appointed senior researcher 1994, and state seismologist and chief of the seismology section 1997. Adjunct professor in University of Copenhagen 1997. Two times recipient of the Inge Lehmann stipend 1985 and 1989. Involvement in the World Stress Map Project 1986-1993. Involvement with stress measurements and explosion crustal studies in the European Geotraverse 1987-1991. Member of the Danish national committees for IUGG, for IUGS as well as for lithosphere studies. Member of the steering committee for the Nordic SIL project 1991-1995. Chairman of the 10-nation working group Tor on Teleseismic Tomography across the Tornquist

Zone. Danish representative in the EU-project Rapid Transfrontier Seismic Data Exchange Network 1996-1997. Responsible as principal investigator for several Danish projects funded by the Danish research council. More than 100 research presentations at scientific meetings. More than 50 research papers in scientific journals. Editor of several books and papers for a general audience. Contributor to the New Danish Encyclopedia these years.

References relevant to the proposal:

S. Gregersen & P.W. Basham (editors) 1989. *Earthquakes at North-Atlantic passive margins: neotectonics and postglacial rebound.* Kluwer Academic Press, 716 pp.

S. Gregersen 1992. Crustal stress regime in Fennoscandia from focal mechanisms. *J. Geophys. Res.* 97, 11821-11827.

S. Gregersen et al. 1999. Important findings expected from Europe's largest seismic array. *Eos, American Geophysical Union* 80, 1 and 6.

### C7.f.4 NORSAR

NORSAR, which presently is affiliated with the Research Council of Norway, was established in 1968, and is expected to be established as an independent foundation as of July 1, 1999. NORSAR conducts research, development and consulting within various fields of seismology and applied geophysics, including seismological verification. NORSAR is today one of the world's largest seismological observatories, with more than 30 years of experience with advanced seismological processing and data analysis techniques.

NORSAR has been a main contributor to the technology presently being implemented at the International Data Centre (IDC) in Vienna for verification of the Comprehensive Nuclear Test Ban Treaty (CTBT). NORSAR scientists were instrumental in developing the concept of regional seismic arrays in the 1980's, a technology which today is constituting a backbone in the International Monitoring System (IMS) consisting of 170 seismic stations being prepared for data transmission to the IDC.

The basis for these efforts has been the establishment and operation by NORSAR of a number of seismic arrays in Norway and at Svalbard, and in addition NORSAR has participated in establishing and operating several arrays in other countries, including Russia, Finland, Germany and Sweden, still receiving data in real-time from all of these installations.

The NORSAR staff consists of scientists (c.a.15) and software engineers (c.a.15) which are actively participating in research projects within array seismology, seismological verification, seismotectonics and earthquake hazard, and seismic exploration techniques.

Hilmar Bungum:

Nationality: Norwegian.

Education and career:

1974: Dr. philos. (Ph.D in seismology), University of Bergen, Norway.
1991-present: Professor of seismology, University of Oslo.
1997-present: Director of Seismological Research, Deputy Director, NORSAR.
Member, Norwegian National Committee for IUGG.
Member, evaluation committees for full professorships, etc.
Referee for scientific journals, funding agencies, etc.

Experience and expertise:

Extensive, more than 25 years of project management experience.
Specialization: Seismotectonics, lithospheric dynamics, array seismology.
49 papers in international journals, 34 in proceedings, 132 scientific reports, 120 oral presentations (talks).

References relevant to the proposal:

Bungum, H. & C. Lindholm 1997. Seismo- and neotectonics in Finnmark, Kola, and the southern Barents Sea, Part 2: Seismological analysis and seismotectonics. *Tectonophysics* 270, 15-28.

Villagran, M., C. Lindholm, A. Dahle, H. Cowan & H. Bungum 1997. Seismic hazard assessment for Guatemala City, Guatemala. *Natural Hazards* 14, 189-205.

Camacho, E., C. Lindholm, A. Dahle & H. Bungum 1997. Seismic hazard assessment in Panama. *Eng. Geology* 48, 1-6.

Lindholm, C. H. Bungum, E. Hicks & M. Villagran. Crustal stress and tectonics in Norwegian regions determined from earthquake focal mechanisms. *J. Geol. Soc. London* (in press).

Byrkjeland, U., H. Bungum & O. Eldholm. Seismotectonics of the Mid-Norwegian continental margin. *J. Geophys. Res.* (in press).

## Tormod Kværna:

Nationality: Norwegian.

Education:

1994: University of Oslo, Ph.D in geophysics.
1984: University of Oslo, cand. real, geophysics.

Experience and expertise:

He has fifteen years of experience in seismological research. Among his primary interests are development of methods for real-time processing of seismic data, and he has conducted general seismological research in seismic wave propagation, earthquake location and wave scattering. He initially worked on optimizing the automatic processing performance of the small-aperture arrays NORES and ARCES. This included studies on phase detection, f-k analysis, noise characteristics and array performance. Later he got heavily involved in the development of new methods for automatic network processing. In particular, the problems of automatic onset time estimation, phase association, event location and magnitude threshold estimation were studied.

References relevant to the proposal:

Ringdal, F. & T. Kværna 1989 A multi-channel processing approach to real-time network detection, phase association, and threshold monitoring. *Bull. Seism. Soc. Am.* 79, 1927-1940.

Kværna, T. & D.J. Doornbos 1991. Scattering of regional Pn by Moho topography. *Geophys. Res. Lett.* 18, 1273-1276.

Kværna, T. & F. Ringdal 1992. Integrated array and 3-component processing using a seismic microarray. *Bull. Seism. Soc. Am.* 82, 870-882.

Kværna, T. 1994. Accurate determination of phase arrival times using autoregressive likelihood estimation. *Annali di Geofisica* XXXVII(3), 287-300.

Kværna, T. & F. Ringdal 1994. Intelligent post-processing of seismic events. *Annali di Geofisica* XXXVII(3), 309-322.

**Johannes Schweitzer:**

Born: September 9, 1956, in Hadamar, Germany.

Education and career:

1985: Diplom in geophysics from University of Frankfurt.
1990: Dr. phil. nat. in geophysics from University of Frankfurt.
1990-1994 and 1995-1997: Postdoc and Senior Scientist, University of Bochum.
1994-1995: Guest scientist at NORSAR.
1997-present: Senior scientist at NORSAR.

Experience and expertise:

Main work topics (main key words): Seismological studies about earth core, core-mantle boundary, and lithosphere in Europe, automatic processing of array data, monitoring nuclear test sites, magnitude estimations, locating seismic events, history of seismology, referee for international jounals, 57 publications (10 reviewed), 78 talks/posters.

References relevant to the proposal:

Harjes, H.-P., M.L. Jost, J. Schweitzer & N. Gestermann 1993. Automatic seismogram analysis at GERESS. *Computer and Geosciences* 19, 157-166.

Harjes, H.-P., M.L. Jost & J. Schweitzer 1994. Preliminary calibration of candidate alpha stations in the GSETT-3 network. *Annali di Geofisica* XXXVII, 383-396.

Schweitzer, J. 1995. Blockage of regional seismic waves by the Teisseyre-Tornquist zone. *Geophys. J. Int.* 123, 260-276.

Jost, M.L., J. Schweitzer & H.-P. Harjes 1996. Monitoring nuclear test sites with GERESS. *Bull. Seism. Soc. Am.* 86, 172-190.

Schweitzer, J. & T. Kværna 1999. Influence of source radiation patterns on globally observed short-period magnitude estimates (mb). *Bull. Seism. Soc. Am.* 89, 342-347.

### C7.f.5 Department of Earth Sciences, University of Uppsala

See WP 2 for description of the institute.

**Reynir Bödvarsson:**

See WP 2 for curriculum vitae.

Chapter C8

# Economic development and scientific and technological prospects

## C8.a Method and prospects

The HOTSPOT project responds to very urgent scientific need to study the dynamics of the Iceland Hotspot, a study of global interest and dimension.

HOTSPOT prepares a basis for research in earth sciences, especially research aiming at mitigating risks caused by earthquake and volcanic hazards. HOTSPOT paves the road for research which will be a significant boom for scientific and economical development.

HOTSPOT prepares the research basis by providing access to well controlled observational data, by preparing the existing infrastructure for carrying out new observations cost by others, and by designing and initiating new research infrastructures on basis of experience gained and in light of the needs of end users.

The method of HOTSPOT is that of intensive networking between the operators of the infrastructures and the end users of the data. Yearly workshops will be held for planning the steps of preparing the infrastructures as well as for introducing new observations into the infrastructure and for designing new infrastructures. These workshops will be attended by the large group of participants and cooperators which compose the HOTSPOT consortium. But they will also be open to scientists outside the group which show interest for own input into the infrastructures and for participation in expanding and modifying the functions of the them. The HOTSPOT website on the internet will contain good access to new and old observational data. But it will also contain steadfast upgrade of information about the functions of the infrastructures as well as plans and prospects. In this way a secure participation of all potential users and providers is granted.

In Iceland a local advisory board will cooperate with frequent meetings and workshops to plan implementations and to take contacts with new groups of observatory providers and end users.

Based on pressing need for challenging research of global dimension HOTSPOT is preparing a huge infrastructure for observations and designing further infrastructures. This is not a new institution, because the operation of the infrastructures will be in the hands of institutions in Iceland and institutions in the neighboring North Atlantic countries and the operation will basically be cost by these. The build-up and extension of the infrastructures will be cost by various projects, national, European or international. The work will be lead by the coordinator based on advices from participants and cooperators and in accordance with the willingness of the scientific community to participate in the extensions.

In this way HOTSPOT proposes, besides its timely infrastructure actions, a rational way for developing a European Natural Laboratory of huge dimensions and global significance.

## C8.b The object

There is a growing interest among scientists world over for studying the Iceland Hotspot, its ruptures into and through the crust, and its large-scale dynamics. Answers can be sought to scientific questions where nowhere else on earth can be answered.

But there is another reason for the significance of studying the Iceland Hotspot. Its ruptures into the crust cause large variations in stress conditions in Iceland, sometimes apparently triggering large earthquakes and large eruptions. This variability in stress build-up limits the value of the conventional hazard assessment methods based on 300 years of historical information and 75 years of instrumental information.

Huge eruptions like the Laki eruption in the eastern volcanic zone of Iceland in 1783 would cause huge destruction in Iceland in modern times, different though from its effects in 1783, which lead to a famine. It also caused temporal climatic changes in Europe, leading to reduced harvest and economic as well political instability. We have in fact no knowledge to predict if such an event or similar might happen in our times. The earthquake that occurred the following year in the South Iceland seismic zone was the largest earthquake known in the history of Iceland, estimated magnitude was 7.1. Such an earthquake would cause huge economic losses in modern times, though directly only limited to Iceland.

The economic and social effects of such events as described above would be huge in the modern society and cause instability and great losses. Only the prospects that such events might happen are an economic disadvantage. Understanding of what kind of hazards might happen and when or on what time-scale will lead to economic gains and stability. At least such understanding triggers and helps to design risk preventive measures.

Two large RTD projects in the field of seismic risk mitigation, PRENLAB and PRENLAB-2 were supported by the EU under the 4th framework programme. These projects utilize Iceland as a huge laboratory for studying crustal processes which can lead to large earthquakes and for studying their effects. The seismic acquisition and evaluation system, the SIL system, which was developed under that project and a previous cooperation project of the Nordic countries, will become the core of the HOTSPOT infrastructure project. HOTSPOT will consolidate the advances of the PRENLAB projects and become a basis for further projects in research towards mitigating seismic and volcanic risks. These two projects and the present infrastructure project are significant steps forward for European research and have much potential to improve European competitiveness in this field in the years to come.

By building up Iceland and its Hotspot as a laboratory for studying crustal/mantle processes in real-time and on a longer time-scale European earth scientists can be in the forefront of innovative scientific evolution. By this continuity Europe is building a natural laboratory which scientists from all over the world will like to use, laboratory which is attractive for worldwide scientific cooperation.

Among the objectives of HOTSPOT is to open the infrastructures for input of new observational facilities and large cooperative efforts in earth sciences. Such a cooperation with USA and Japan, which has been discussed, will further lead to the build-up of the observations and research based on them and will further improve competitiveness and technological and scientific progress in Europe.

## C8.c Future prospects

On basis of experience and by networking HOTSPOT designs new infrastructures which will lead to further steps forward.

The HOTSPOT unmanned observatory station which will be designed based on comparing and testing various methods for following deep subsurface processes in a remote area has the potential to become a significant tool to monitor processes at depth, which can lead to volcanic eruptions and earthquakes. It has the potential of application all over the world.

By preparing existing observational infrastructures on land in and around the North Atlantic Ocean, by opening these to new observations and by making the multidisciplinary data accessible to researchers, HOTSPOT prepares a new step in advancement of earth sciences, the build-up of a geophysical ocean bottom observational network in the area, an achievement which most probably will be carried out in cooperation with other fields of environmental sciences and marine research.

# References for PART B

[1] Bijwaard, H. & W. Spakman 1999. Tomographic evidence for a narrow whole mantle plume below Iceland. *EPSL* 166, 121–126.

[2] Foulger, G.R., M.A. Hofton, B.R. Julian, C.H. Jahn & G. Seeber 1994. Regional post-dyking deformation in NE Iceland: a third epoch of GPS measurements in 1992. *J. Geod. Soc. Japan*, special issue, 99–105.

[3] Larsen, G., M.T. Gudmundsson & H. Björnsson 1998. Eight centuries of periodic volcanism at the center of the Iceland hotspot revealed by glacier tephrostratigraphy. *Geology* 26, 943–946.

[4] Morgan, J. 1981. Hotspot tracks and the opening of the Atlandic and Indian Oceans. In: C. Emiliani (editor), *The Oceanic Lithosphere*. Wiley, New York, volume 7, 443–488.

[5] Stefánsson, R., F. Bergerat, M. Bonafede, R. Bödvarsson, S. Crampin, P. Einarsson, K.L. Feigl, Á. Guðmundsson, F. Roth, F. Sigmundsson & R. Slunga 1998. PRENLAB - final report, March 1, 1996 - February 28, 1998. *Greinargerd Vedurstofu Íslands* VÍ-G98041-JA07. Report, Icelandic Meteorological Office, Reykjavík, 129 pp.

[6] Stefánsson, R., R. Bödvarsson & G. Gudmundsson 1996. Iceland plume tectonics. Some speculations and facts. In: B. Thorkelsson (editor), *Seismology in Europe*. Papers presented at the XXV ESC General Assembly, Reykjavík, Iceland, September 9–14, 1996, 505–511.

[7] Stefánsson, R., R. Böðvarsson, R. Slunga, P. Einarsson, S. Jakobsdóttir, H. Bungum, S. Gregersen, J. Havskov, J. Hjelme & H. Korhonen 1993. Earthquake prediction research in the South Iceland seismic zone and the SIL project. *Bull. Seism. Soc. Am.* 83, 696–716.

[8] Tryggvason, E. 1989. Ground deformation in Askja, Iceland: its source and possible relation to flow of the mantle plume. *J. Volcanol. Geotherm. Res.* 39, 61–71.

[9] Tryggvason, K., E. Huseby & R. Stefánsson 1983. Seismic image of the hypothesized Icelandic hot spot. *Tectonophysics* 100, 97–118.

[10] Wolfe, C.J., I.Th. Bjarnason, J.C. VanDecar & S.C. Solomon 1997. Seismic structure of the Iceland mantle plume. *Nature* 385, 245–247.

Annex

# Proposal submission forms

Shared Cost RTD Proposal Form – Form A0

EUROPEAN COMMISSION
RESEARCH DIRECTORATES
GENERAL
SHARED COST
RTD PROPOSAL FORMS

EN A 1 FP5RTD

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For guidelines see in relevant "Guide for Proposers"

# Proposal submission forms for financial support from the EC for shared-cost RTD actions: research and technology development projects, demonstration projects, and combined projects

If possible, these forms should be prepared using the Proposal Preparation Tool (ProTool), which is available via the Commission Internet site http://www.cordis.lu/fp5, by E-mail or on CD-ROM. Use of the Proposal Preparation Tool is preferred by the Commission. However applicants may also use the forms in the Guide for Proposers. Using the ProTool, forms may be submitted electronically, or printed out and returned on paper.

## Information on the Proposal [1]

| | | | | |
|---|---|---|---|---|
| Proposal Full Name | Preparing the infrastructure for studying the dynamics of the Iceland Hotspot | | | |
| Proposal Acronym [5] | HOTSPOT | | Proposal No [6] | EESD-ENV-99-0068 |
| Call Identifier [3] | EESD-ENV-99-1 | | | |
| Research Programme(s) [2] | 1.1.4. | | | |
| Thematic priorities [2] | 1.1.4.-9 | | | |

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Post stamp __ / __ / ____ Reception date __ / __ / ____

Shared Cost RTD Proposal Form – Form A1

| EUROPEAN COMMISSION<br>RESEARCH DIRECTORATES GENERAL<br>SHARED COST<br>RTD PROPOSAL FORMS | EN B 1 FP5RTD<br>FOR COMMISSION USE ONLY |
|---|---|

| | | | |
|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## A1. Proposal Administrative Overview [1]

| | | | | |
|---|---|---|---|---|
| Thematic priorities [2] | 1.1.4.-9 | | | |
| Type of Action [4] | RS | | | |
| Proposal Full Name | Preparing the infrastructure for studying the dynamics of the Iceland Hotspot | | | |

### Contact person for the proposal(s) [7]



| | | | | | | |
|---|---|---|---|---|---|---|
| Title (Dr, Prof., ...) | Dr | Gender [8] | F | | M | X |
| Family Name | Stefansson | | | | | |
| First Name | Ragnar | | | | | |
| Organisation Legal Name [9] | Iceland Meteorological Office | | | | | |
| Department / Institute Name [10] | Department of Geophysics | | | | | |
| PO Box [11] | | | | | | |
| Street Name and Number | Bustadavegur 9 | | | | | |
| Post Code [12] | 150 | Cedex [13] | | | | |
| Town/City | Reykjavik | | | | | |
| Country Code [14] | IS | Country Name [14] | Iceland | | | |
| Telephone No [15] | (354-)5600600 | Fax No [15] | (354-)5528121 | | | |
| E-mail | ragnar@vedur.is | | | | | |



### Proposal abstract (maximum 1000 characters) [16]


HOTSPOT aims to focus the geophysical networks in Iceland to observe the dynamics of, and especially the variations in the activity of the Iceland Hotspot. It will prepare the networks in such a way that it will be easy to include other necessary observations by other projects. It enhances and provides access to necessary seismic observations in areas near and around the center of the Hotspot, i.e. in Scandinavia, Great Britain, Greenland and Iceland. In this way HOTSPOT provides access to significant data for research aiming to understand mantle plume dynamics and for reducing seismic and volcanic risks. HOTSPOT is a part of a much larger project needed for studying the dynamics of the Hotspot. However, it is significant basis for such studies, a European basis for research of global interest and cooperation. HOTSPOT aims its activity into the future by designing new facilities for necessary observations.


| | | | | | |
|---|---|---|---|---|---|
| Duration (In Months) [17] | 48 | Total Eligible Cost (In euro) [18] | 2828172 | EC Contribution requested (In euro) [19] | 1742546 |
| Keywords [20] | | | | | |

| | | | | |
|---|---|---|---|---|
| Have you or any of your partners, previously or currently, submitted this proposal or one similar in content to any Community Programme? If yes, please give details of the proposal [21] | Y | | N | X |

| | | | | | |
|---|---|---|---|---|---|
| Programme Name | | Year | | Proposal No | |

Duly authorised by the consortium partners to send this proposal to the Commission, I certify that the description of this proposal and the information on forms A1, A2, A3 and A4 is accurate and agreed to by the consortium partners and that the consortium collectively agrees to carry out a project as described herein.

| | |
|---|---|
| Date (DD/MM/YYYY) | 14/06/1999 |
| Signature of person authorised to submit a proposal in the co-ordinating organisation | Magnús Jónsson<br>VEÐURSTOFA ÍSLANDS |

| | |
|---|---|
| | EUROPEAN COMMISSION<br>RESEARCH DIRECTORATES GENERAL<br>SHARED COST RTD PROPOSAL FORMS |

EN C 1 FP5RTD

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |
|---|---|---|---|

# A2. Proposal Summary [22]

## Objectives (maximum 1000 characters)

1) To prepare the geophysical networks in Iceland to observe the dynamics of, and especially the variable activity of the Iceland Hotspot. This involves firstly to aim the existing acquisition and evaluation systems in Iceland to that purpose, secondly to design and test an unmanned multidisciplinary observatory in the remote area above the center of the plume. 2) To prepare the seismic observatory networks in nearby areas, Scandinavia, Great Britain, Greenland, Spitsbergen and Iceland to widen the observational platform. 3) To create a geophysical database of long-term observations to facilitate European and international research to study the plume dynamics and crustal processes. To utilize established data centers in Europe and to create a good access to the data. 4) On basis of the established cooperation to create an international consortium to promote further research of the Iceland plume dynamics.

## Description of the work (maximum 2000 characters)

To provide good access for European research to the existing geophysical networks in Iceland and on both sides of the North Atlantic Ocean and to prepare extensions of the observations under other projects and with international participation.
The geophysical networks in Iceland consist of 57 stations. In addition there exist several monitoring facilities which can be used for that purpose. The largest part of the observations are monitored and evaluated at the Icelandic Meteorological Office, in the SIL center which is located there. In uniting these networks in one structure and aiming them to the purpose of Hotspot studies the European HOTSPOT center will be created. It will operate as a part of the SIL center. Much of the work in organizing the networks, providing access to them and to the data will be carried out there, making use of the available facilities and the experiences of the staff. A significant task is to prepare the network facilities so that they can easily incorporate new sensors from other projects. The design part of this will be carried out at the Uppsala University in Sweden. All available deformation measurements in Iceland mostly carried out during the last two decades will be integrated with the databases of the project, and the University of Savoie in France will organize and upgrade continuous measurements of deformation by GPS to become a part of the accessible HOTSPOT database. Upgrade and access to the seismological observations in the countries around the North Atlantic Ocean will be carried out by institutes in these countries through the ORFEUS datacenter at De Bilt in Holland. The Euro-Mediterranean Seismological Center in Bruyeres-le-Chatel in France will contribute by effective distribution of data and information to the European research community. University of Frankfurt in Germany will perform theoretical modelling to help designing proper observatory and networks configurations during the project period.

## Milestones and expected results (maximum 500 characters)

HOTSPOT provides European research community with geophysical facilities in Iceland to study the Hotspot dynamics. It upgrades the networks by inputs from other projects. It develops automatic procedures to give research access to well controlled data from the Iceland networks and from the seismic networks in the countries around the North Atlantic Ocean. On basis of experience HOTSPOT designs new observation facilities. It creates an international consortium to extend observations and research.

Shared Cost RTD Proposal Form – Form A3

EUROPEAN COMMISSION
RESEARCH DIRECTORATES GENERAL
SHARED COST
RTD PROPOSAL FORMS

EN D 1 FP5RTD

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| | | | |
|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## A3. Participant Profile/Information (1 form per participant) [23]

### Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | CO | Participant No [25] | 1 | Assistant to Contractor No [26] | |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | Icelandic Meteorological Office | | | | |
| Short Name [29] | IMO | | Legal Registration No [30] | | |
| Activity Type [31] | OTH | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | | User/Supplier[35] (U / S) | S | Cost Basis [36] (FC / FF / AC) | FF |

### Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | T1 | Annual Balance Sheet Total [39] | B1 | Number of employees [40] | S4 |
| Is Your Organisation independent [41]? | | | | Y X | N |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y | N X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

### Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Icelandic Meteorological Office | | |
| PO Box [11] | | | |
| Street Name and Number | Bustadavegur 9 | | |
| Post Code [12] | 150 | Cedex [13] | |
| Town/City | Reykjavik | | |
| Country Code [14] | IS | Country Name [14] | Iceland |

### Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Dr | Gender [8] | F / M X |
| Family Name | Stefansson | | |
| First Name | Ragnar | | |
| Telephone No [15] | (354-)5600600 | Fax No [15] | (354-)5528121 |
| E-mail | ragnar@vedur.is | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 14/06/1999 | |
| Signature of authorised person | | Ragnar Stefansson |

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|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## A3. Participant Profile/Information (1 form per participant) [23]

### Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | CR | Participant No [25] | 2 | Assistant to Contractor No [26] | |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | UPPSALA UNIVERSITY | | | | |
| Short Name [29] | UU | Legal Registration No [30] | 202100-2932 | | |
| Activity Type [31] | HES | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 731 | User/Supplier [35] (U / S) | S | Cost Basis [36] (FC / FF / AC) | AC |

### Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | N/A | Annual Balance Sheet Total [39] | N/A | Number of employees [40] | S7 |
| Is Your Organisation independent [41]? | | | | Y: X | N: |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y: | N: X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

### Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Department of Earth Sciences Att: Reynir Bödvarsson | | |
| PO Box [11] | | | |
| Street Name and Number | Villav. 16 | | |
| Post Code [12] | SE-752 36 | Cedex [13] | |
| Town/City | UPPSALA | | |
| Country Code [14] | S | Country Name [14] | SWEDEN |

### Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Dr. | Gender [8] | F: M: X |
| Family Name | Roberts | | |
| First Name | Roland | | |
| Telephone No [15] | +46 18 4712384 | Fax No [15] | +46 18 501110 |
| E-mail | rr geofys.uu.se | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 07/06/1999 | Roland Roberts |
| Signature of authorised person | | |

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|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

# A3. Participant Profile/Information (1 form per participant) [23]

## Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | AC | Participant No [25] | 3 | Assistant to Contractor No [26] | 2 |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | JOHANNES GUTENBERG UNIVERSITÄT MAINZ | | | | |
| Short Name [29] | JOGU | | | Legal Registration No [30] | N/A |
| Activity Type [31] | HES | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 80 | User/Supplier [35] (U / S) | S | Cost Basis [36] (FC / FF / AC) | AC |

## Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | N/A | Annual Balance Sheet Total [39] | N/A | Number of employees [40] | |
| Is Your Organisation independent [41]? | | | | Y X | N |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y | N X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

## Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | INSTITUT FÜR GEOWISSENSCHAFTEN / PROF. JACOBY | | |
| PO Box [11] | N/A | | |
| Street Name and Number | N/A | | |
| Post Code [12] | D- 55099 | Cedex [13] | N/A |
| Town/City | MAINZ | | |
| Country Code [14] | D | Country Name [14] | DEUTSCHLAND / GERMANY |

## Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Dr. | Gender [8] | F / M X |
| Family Name | SPATH | | |
| First Name | K.P. CHRISTIAN | | |
| Telephone No [15] | +49 6131 39 5891 | Fax No [15] | +49 6131 39 4741 |
| E-mail | planung@verwaltung.uni-mainz.de | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | |
|---|---|
| Date (DD/MM/YYYY) | 07/06/1999 |
| Signature of authorised person | |

Dr. K. P. C. Spath
Head of Department I
- Research, Planning, Technology -
Johannes Gutenberg-Universität
D-55099 Mainz

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

# A3. Participant Profile/Information (1 form per participant) [23]

## Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | CR | Participant No [25] | 4 | Assistant to Contractor No [26] | |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | UNIVERSITE DE SAVOIE | | | | |
| Short Name [29] | UNISAV | Legal Registration No [30] | SIRET 197 308 588 00015 | | |
| Activity Type [31] | HES | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 73L | User/Supplier [35] (U / S) | | Cost Basis [36] (FC / FF / AC) | AC |

## Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | N/A | Annual Balance Sheet Total [39] | N/A | Number of employees [40] | S6 |
| Is Your Organisation independent [41]? | Y | X | N | | |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | Y | | N | X | |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

## Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | LABORATOIRE DE GEODYNAMIQUE DES CHAINES ALPINES - LGCA | | |
| PO Box [11] | | | |
| Street Name and Number | CAMPUS SCIENTIFIQUE | | |
| Post Code [12] | 73376 | Cedex [13] | |
| Town/City | LE BOURGET DU LAC | | |
| Country Code [14] | F | Country Name [14] | FRANCE |

## Authorised person [46]

| | | | | | | |
|---|---|---|---|---|---|---|
| Title (Dr, Prof., ...) | Prof., Vice Président CA Univ. Savoie | Gender [8] | F | | M | X |
| Family Name | FAIVRE | | | | | |
| First Name | Pierre | | | | | |
| Telephone No [15] | +33 (0) 479 8445 | Fax No [15] | +33 (0) 479 75 8555 | | | |
| E-mail | pierre.faivre@univ-savoie.fr | | | | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 07/06/1999 | P. Faivre |
| Signature of authorised person | | |

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|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

# A3 Participant Profile/Information (1 form per participant) [23]

## Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | AC | Participant No [25] | 5 | Assistant to Contractor No [26] | 4 |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | Nordic Volcanological Institute | | | | |
| Short Name [29] | NVI | Legal Registration No [30] | | | |
| Activity Type [31] | REC | Legal Status [32] | INO | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 73.1 | User/Supplier[35] (U / S) | S | Cost Basis [36] (FC / FF / AC) | AC |

## Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | T1 | Annual Balance Sheet Total [39] | B1 | Number of employees [40] | S3 |

| | | | | |
|---|---|---|---|---|
| Is Your Organisation independent [41]? | Y | X | N | |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | Y | | N | X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | |

## Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Nordic Volcanological Institute | | |
| PO Box [11] | | | |
| Street Name and Number | Grensásvegur 50 | | |
| Post Code [12] | 108 | Cedex [13] | |
| Town/City | Reykjavík | | |
| Country Code [14] | IS | Country Name [14] | Iceland |

## Authorised person [46]

| | | | | | | |
|---|---|---|---|---|---|---|
| Title (Dr, Prof., ...) | Director | Gender [8] | F | | M | X |
| Family Name | Sigmundsson | | | | | |
| First Name | Freysteinn | | | | | |
| Telephone No [15] | (354) 525-4491 | Fax No [15] | (354) 562-9767 | | | |
| E-mail | fs@norvol.hi.is | | | | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 07/06/99 | NORDIC VOLCANOLOGICAL INSTITUTE |
| Signature of authorised person | | Freysteinn Sigmundsson |

| | |
|---|---|
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|---|---|---|---|
| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

# A3. Participant Profile/Information (1 form per participant) [23]

## Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | CR | Participant No [25] | 6 | Assistant to Contractor No [26] | |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | University of Frankfurt | | | | |
| Short Name [29] | Frankfurt University | Legal Registration No [30] | | | |
| Activity Type [31] | REC | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 73 | User/Supplier [35] (U / S) | U | Cost Basis [36] (FC / FF / AC) | AC |

## Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | N/A | Annual Balance Sheet Total [39] | N/A | Number of employees [40] | S7 |
| Is Your Organisation independent [41]? | | | | Y: X | N: |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y: | N: X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

## Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Institute of Meteorology and Geophysics | | |
| PO Box [11] | | | |
| Street Name and Number | Feldbergstrasse 47 | | |
| Post Code [12] | D-60323 | Cedex [13] | |
| Town/City | Frankfurt/M | | |
| Country Code [14] | D | Country Name [14] | Germany |

## Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Reg. Dir. | Gender [8] | F: M: X |
| Family Name | Duecker | | |
| First Name | Rudolf | | |
| Telephone No [15] | +69 798 22230 | Fax No [15] | +69 798 23936 |
| E-mail | | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 08/06/1999 | JOHANN WOLFGANG GOETHE-UNIVERSITÄT |
| Signature of authorised person | | |

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|---|---|---|---|
| ...onym [6] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## Participant Profile/Information (1 form per participant) [23]

**...ation on the participating organisation**

| | | | | | |
|---|---|---|---|---|---|
| ...ole [24] | CR | Participant No [25] | 7 | Assistant to Contractor No [26] | |
| No with the European Commission's Research Programmes [27] | | | | | |
| Legal | European Mediterranean Seismological Centre | | | | |
| ...[9] | EMSC | Legal Registration No [30] | | | |
| [31] | INO | Legal Status [32] | INO | If 'PRC', Specify [33] | |
| ...a [34] (NACE) | 73 | User/Supplier [35] (U/S) | S | Cost Basis [36] (FC/FF/AC) | AC |

**...n details [37]**

| | | | | | |
|---|---|---|---|---|---|
| ...ver | T1 | Annual Balance Sheet Total [39] | B1 | Number of employees [40] | S2 |

| | | | | |
|---|---|---|---|---|
| ...nisation independent [41]? | Y | X | N | |
| ...indicate ...) of ...own [42] | | | | |
| ...nisation affiliated to any other participant(s) in the proposal [43]? | Y | | N | X |

| | | | |
|---|---|---|---|
| ...indicate ...o, Short character ...(s) | 0 | | – |
| | 0 | | – |
| | 0 | | – |

**...he main department carrying out the work [45]**

| | | | |
|---|---|---|---|
| ...e [10] | European Mediterranean Seismological Centre | | |
| | B.P. 12 | | |
| ...and | c/o DASE/LDG | | |
| | F-91680 | Cedex [13] | |
| | Bruyeres-le-Chatel | | |
| ...e [14] | F | Country Name [14] | France |

**...person [46]**

| | | | | | | |
|---|---|---|---|---|---|---|
| ...f., ...) | Dr. | Gender [8] | F | | M | X |
| | Browitt | | | | | |
| | Chris | | | | | |
| ...o [15] | (44-1)316500320 | Fax No [15] | (44-1)316671877 | | | |
| | c.browitt@bgs.ac.uk | | | | | |

...he above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| ...mm) | 31/03/1999 | |
| ...authorised person | C W A Browitt | |

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## A3. Participant Profile/Information (1 form per participant) [23]

### Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | AC | Participant No [25] | 9 | Assistant to Contractor No [26] | 8 |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | NATURAL ENVIRONMENT RESEARCH COUNCIL (BRITISH GEOLOGICAL SURVEY) | | | | |
| Short Name [29] | NERC (BGS) | | Legal Registration No [30] | N/A | |
| Activity Type [31] | REC | Legal Status [32] | GOV | If 'PRC', Specify [33] | |
| Business Area [34] (NACE) | 73L | User/Supplier [35] (U / S) | S | Cost Basis [36] (FC / FF / AC) | FC |

### Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | T3 | Annual Balance Sheet Total [39] | B3 | Number of employees [40] | S7 |
| Is Your Organisation independent [41]? | | | | Y: X | N: |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y: | N: X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

### Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Global Seismology/Geomagnetism Group, British Geological Survey | | |
| PO Box [11] | | | |
| Street Name and Number | Murchison House, West Mains Road | | |
| Post Code [12] | EH9 3LA | Cedex [13] | |
| Town/City | Edinburgh | | |
| Country Code [14] | UK | Country Name [14] | United Kingdom |

### Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Mrs | Gender [8] | F: X M: |
| Family Name | Williams | | |
| First Name | Sandra | | |
| Telephone No [15] | (44 115) 936 3100 | Fax No [15] | (44 115) 936 3200 |
| E-mail | s.williams@bgs.ac.uk | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | |
|---|---|
| Date (DD/MM/YYYY) | 08/06/99 |
| Signature of authorised person | AWP Brown pp S Williams. |

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

## A3. Participant Profile/Information (1 form per participant) [23]

### Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [24] | AC | Participant No [25] | 10 | Assistant to Contractor No [26] | 8 |
| Registration No with the European Commission's Research Programmes [27] | | | | | |
| Organisation Legal Name [28] | Kort & Matrikelstyrelsen<br>National Survey and Cadastre - Denmark | | | | |
| Short Name [29] | KMS | | Legal Registration No [30] | | |
| Activity Type [31] | OTH | Legal Status [32] | GOV | If 'PRC', Specify [33] | - |
| Business Area [34] (NACE) | 93 | User/Supplier [35] (U / S) | N/A | Cost Basis [36] (FC / FF / AC) | AC |

### Organisation details [37]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [38] | T2 | Annual Balance Sheet Total [39] | N/A | Number of employees [40] | S6 |
| Is Your Organisation independent [41]? N/A | | | | Y | N |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [42] | | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal [43]? | | | | Y | N X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) (D / I) [44] | | | | | |

### Address of the main department carrying out the work [45]

| | | | |
|---|---|---|---|
| Department/ Institute Name [10] | Seismology section / Geodynamics Department KMS | | |
| PO Box [11] | | | |
| Street Name and Number | Rentemestervej 8 | | |
| Post Code [12] | 2400 | Cedex [13] | |
| Town/City | Copenhagen NV | | |
| Country Code [14] | DK | Country Name [14] | Denmark |

### Authorised person [46]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Dr. | Gender [8] | F ☐ M X |
| Family Name | Forsberg | | |
| First Name | Rene | | |
| Telephone No [15] | +45 35 87 50 50 | Fax No [15] | +45 35 87 50 52 |
| E-mail | rf@ kms.dk | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date (DD/MM/YYYY) | 14 JUN 1999 | R. Fg |
| Signature of authorised person | | |

Kort & Matrikelstyrelsen
Landkort- og Geodæsiafdelingen
Geodynamikkontoret
Rentemestervej 8
DK-2400 København NV
Tlf. 35 87 50 50

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |

# A3. Participant Profile/Information (1 form per participant) [23]

## Legal information on the participating organisation

| | | | | | |
|---|---|---|---|---|---|
| Participant Role [2] | AC | Participant No [25] | 11 | Assistant to Contractor No [26] | 8 |
| Registration No with the European Commission's Research Programmes [2] | | | | | |
| Organisation Legal Name [2] | Norwegian Seismic Array | | | | |
| Short Name [2] | NORSAR | Legal Registration No [3] | 974 374 765 | | |
| Activity Type [3] | REC | Legal Status [32] | JRC | If 'PRC', Specify [33] | |
| Business Area [3] | NA3 | User/Supplier[35] | S | Cost Basis [36] | FC |

## Organisation details [3]

| | | | | | |
|---|---|---|---|---|---|
| Annual turnover [3] | T1 | Annual Balance Sheet Total [3] | B1 | Number of employees | S3 |
| Is Your Organisation independent ? | | Y | | N | X |
| If No, please indicate legal name(s) of owner(s) who own 25 % or more [2] | NORSAR will be an independent foundation from 01 July 1999. At the moment NORSAR is formally and legally part of and adminitrated by the Research Council of Norway | | | | |
| Is Your Organisation affiliated to any other participant(s) in the proposal ? [3] | | Y | | N | X |
| If Yes, please indicate Participant No, Short Name(s) and character of affiliations(s) | | | | | |

## Address of the main department carrying out the work [5]

| | | | |
|---|---|---|---|
| Department/ Institute Name | Norwegian Seismic Array | | |
| PO Box | 51 | | |
| Street Name and Number | Granaveien 33 | | |
| Post Code [2] | N-2027 | Cedex [3] | |
| Town/City | KJELLER | | |
| Country Code | NO | Country Name | Norway |

## Authorised person [6]

| | | | |
|---|---|---|---|
| Title (Dr, Prof., ...) | Dir. | Gender | F ☐ M X |
| Family Name | Dahle | | |
| First Name | Anders | | |
| Telephone No [5] | (47-)63805900 | Fax No [5] | (47-)63818719 |
| E-mail | anders@norsar.no | | |

I certify that the above information is accurate and that my organisation has agreed to participate in this proposal.

| | | |
|---|---|---|
| Date | 04/06/1999 | HBungum (for A. Dahle) |
| Signature of authorised person | | |

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| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |
|---|---|---|---|

## A4. Cost Summary in euro [47] (part 1/2)

| Participant Role [24] | Participant No [25] | Assistant to Contractor No [26] | Participant Short Name [51] | Number of person/months [52] | Personnel Costs [53] | Durable Equipment [54] | Consumables [55] | Travel and Subsistence [56] | Computing [57] | Subcontracting [58] | Subtotal part 1/2 [59] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO | 1 | [48] | IMO | 303 | 1100000 | 35000 | 0 | 40000 | 0 | 0 | 1175000 |
| CO | 1 | [49] | Co-ordination | 4 | 22000 | 0 | 0 | 4000 | 0 | | 26000 |
| CO | 1 | [60] | Total co-ordinator costs | 307 | 1122000 | 35000 | 0 | 44000 | 0 | 0 | 1201000 |
| CR | 2 | | UU | 28 | 154000 | 0 | 4000 | 28000 | 0 | 44000 | 230000 |
| AC | 3 | 2 | JOGU | 0 | 0 | 14000 | 0 | 5000 | 0 | 0 | 19000 |
| CR | 4 | | UNISAV | 36 | 140000 | 115000 | 5000 | 20000 | 20000 | 0 | 300000 |
| AC | 5 | 4 | NVI | 14 | 43000 | 0 | 12000 | 16000 | 3000 | 12200 | 86200 |
| CR | 6 | | Frankfurt University | 8 | 36560 | 24000 | 12000 | 26000 | 0 | 8000 | 106560 |
| CR | 7 | | EMSC | 5 | 45500 | 0 | 1000 | 7500 | 0 | 0 | 54000 |
| CR | 8 | | KNMI | 13 | 52036 | 0 | 1000 | 8000 | 0 | 0 | 61036 |
| AC | 9 | 8 | NERC (BGS) | 6 | 60000 | 60000 | 0 | 56000 | 0 | 0 | 176000 |
| AC | 10 | 8 | KMS | 3 | 30000 | 15000 | 0 | 8000 | 0 | 0 | 53000 |
| AC | 11 | 8 | NORSAR | 6 | 30000 | 10000 | 0 | 6000 | 0 | 0 | 46000 |
| | | | | | | | | | | | |
| TOTAL [66] | | | | 426 | 1713096 | 273000 | 35000 | 224500 | 23000 | 64200 | 2332796 |

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EUROPEAN COMMISSION
RESEARCH DIRECTORATES
GENERAL
SHARED COST
RTD PROPOSAL FORMS

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FOR COMMISSION USE ONLY

| Proposal Acronym [5] | HOTSPOT | Proposal No [6] | EESD-ENV-99-0068 |
|---|---|---|---|

## A4. Cost Summary in euro [47] (part 2/2)

| Participant Role [24] | Participant No [25] | Assistant to Contractor No [26] | Participant Short Name [51] | Subtotal of part 1/2 [59] | Other Specific project Costs [60] | Protection of knowledge [61] | Overhead Costs [62] | Total Costs [63] | Costs Basis : FC/FF/AC [37] | % Requested from the Community [64] | Requested Contribution from the Community [65] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO | 1 | 48 | IMO | 1175000 | 135000 | 0 | 165000 | 1475000 | | | 737500 |
| CO | 1 | 49 | Co-ordination | 26000 | 0 | 0 | | 26000 | | | 13000 |
| CO | 1 | 60 | Total co-ordinator costs | 1201000 | 135000 | 0 | 165000 | 1501000 | FF | 50 | 750500 |
| CR | 2 | | UU | 230000 | 0 | 0 | 37200 | 267200 | AC | 100 | 267200 |
| AC | 3 | 2 | JOGU | 19000 | 0 | 0 | 0 | 19000 | AC | 100 | 19000 |
| CR | 4 | | UNISAV | 300000 | 0 | 0 | 24000 | 324000 | AC | 57 | 184680 |
| AC | 5 | 4 | NVI | 86200 | 0 | 0 | 14800 | 101000 | AC | 100 | 101000 |
| CR | 6 | | Frankfurt University | 106560 | 0 | 0 | 0 | 106560 | AC | 100 | 106560 |
| CR | 7 | | EMSC | 54000 | 0 | 0 | 10800 | 64800 | AC | 100 | 64800 |
| CR | 8 | | KNMI | 61036 | 0 | 0 | 78576 | 139612 | FC | 50 | 69806 |
| AC | 9 | 8 | NERC (BGS) | 176000 | 0 | 0 | 0 | 176000 | FC | 50 | 88000 |
| AC | 10 | 8 | KMS | 53000 | 0 | 0 | 0 | 53000 | AC | 100 | 53000 |
| AC | 11 | 8 | NORSAR | 46000 | 0 | 0 | 30000 | 76000 | FC | 50 | 38000 |
| | | | | | | | | | | | |
| TOTAL [66] | | | | 2332796 | 135000 | 0 | 360376 | 2828172 | | | 1742546 |

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