Intelligent Systems for Environmental Applications

Final Report on the R&D activities carried out in the specific programme Information Society Technologies (IST) of the fifth Framework Programme

Volume 1: Areas of Work

December 2004
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Introduction

This brochure, consisting of two volumes, shows the environmental projects of the Information Society Technologies (IST) sub-programme of the Fifth European Framework Programme for Research (FP5). More specifically, the brochure presents the subset of IST projects, in which Information and Communication Technologies (ICT) were used for the protection of the environment.

In the present volume 1 each area of work is briefly introduced and then illustrated by some selected projects. The illustrative texts were written by the projects themselves. The aim of these texts is to provide information about the objectives set, the scientific approach chosen, the research carried out, the results achieved etc. in order to give both specialists and general readers a first exemplary insight into the work done. More details on all the projects in the domain co-financed by the European Union can then be found in volume 2. The current volume however concludes with a brief look forward to the IST activities in the area of environment under the Sixth Framework Programme for Research of the European Communities.

Further copies of both volumes of this brochure can be obtained from the address given at the back.

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1 The official title of FP5 was: “The fifth framework programme of the European Communities for research, technological development and demonstration activities (1998 to 2002)”.  
2 The views expressed in the illustrative texts are those of the projects. They may in no circumstances be regarded as official positions of the European Commission.
1. The areas of work

Application of ICT to the environment is a very broad topic which covers the range from satellite observation to miniature sensors, from flood prediction to noise measurement. Work in the Fourth Framework Programme had earlier prioritised the development of new sensors and sensor applications to provide better data about the environment. In the Fifth Framework Programme, the focus moved forward to using sensors and data in new information-based applications at a system level, in three key areas: (i) Intelligent Systems for Risk & Disaster Management; (ii) Intelligent Environmental Monitoring and Management Systems and (iii) Technologies for Humanitarian Mine Action.

The Mine Action results have already been reported in 2003 in the brochure “Humanitarian Demining research and technological development funded by the European Commission” ISBN 92-894-5942-5 which is available from the contact points listed at the back of this brochure.

Intelligent Systems for Risk and Disaster Management

Natural disasters not only pose a threat to the health and safety of Europe's citizens, but can also cause lasting damage to the environment. Contributing to the European Union's social objectives, the principle focus of this key area is:

- generating more accurate and earlier prediction of natural disasters by improving the information dissemination process and through better planning of long-term cross-border strategies.

Other goals within the cluster are:

- minimising health risks and fatal injuries from natural disasters,
- reducing the costs and financial losses through coordinated emergency procedures and information exchanges, and, ultimately,
- limiting environmental damage.

Nine projects with a total cost of 20,4 M€ were funded in this area with a total EC contribution of 12,2 M€.

Intelligent Environmental Monitoring and Management Systems

These projects focussed on providing and/or integrating environmental monitoring and management tools, such as decision support systems, intelligent data capture networks, innovative real-time information systems and novel sensors. The challenges were addressed under three headings:

- Air and noise: real-time predictions of air quality and noise levels;
- Water: sustainable management of inland, coastal and marine waters;
- Natural resources: intelligent exploitation of natural resources via optimised monitoring, rationalisation of costs and sustainable development solutions.

Fifteen projects with a total cost of 49,4 M€ were funded in this area with a total EC contribution of 26,6 M€.

In both areas, projects worked in the areas where ICT can have some of its greatest impact and add the most value, such as decision support systems which combine
heterogeneous data of varying type, scale and accuracy, or promoting the interoperability of environmental and risk management systems in a multi-lingual Europe, where standards, systems and procedures can change abruptly at national frontiers. Floods, fires, pollution and even noise do not recognise national borders and an integrated response is therefore necessary.

For ease of reading and clarity, a different order of key areas has been used in this brochure and projects have been grouped in the following themes:

Flood and inland water pollution (3 projects), Marine and coastal zone, oil spills and algal blooms (5 projects), Air pollution and noise (6 projects), Preparedness and crisis (4 projects), and other projects (6 projects). This last category covers forestry, flood/fire, solar radiation, volcanic monitoring, environment telematics and one of the greatest challenges of our age, global warming.

1.1. Flood and inland water pollution

The problem area

Economic losses due to natural disasters including floods have increased in the last decade. Risk management, which encompasses the process of identifying subjects/areas at risk and assessing their vulnerability, is therefore becoming an increasingly important issue. At the same time, the growing need for coordinated emergency response actions calls for strong European/international co-operation, which aims at the harmonisation of best practice and standardisation of emergency protocols.

All forms of polluted water, whether polluted by households, industry or agriculture, can cause damage to human health and/or the environment. Waste water treatment, together with waste management, represents almost 80% of the value of the environmental industry. At the same time, unsustainable usage of water resources places a real burden on the resources left for future generations. More efficient water monitoring technologies and management tools are therefore becoming essential.

Objectives and challenges

ICT and ITS applications hold the potential to offer relatively cheap and rapidly implementable improvements to currently applied risk management and water monitoring practices.

The key societal challenge regarding water resources is to ensure an efficient monitoring of natural resources and water quality. Such monitoring should include the assessment of likely risks and the development of an early warning, response and restoration mechanism to help in preventing floods and water pollution or to effectively mitigate their consequences.

Summary of the programme achievements

Research into ICT systems and services for environmental risk management cuts across a number of themes, including:

- intelligent, low-cost and self-sufficient sensors;
- earth observation and remote sensing;
- positioning systems;
- data mining of very large databases;
• data query systems including ontology agents;
• standards for environmental data and metadata;
• exchange formats, architectures and metadata;
• decision support systems;
• semantic web and data validation tools.
Environmental Data Exchange for Inland Water

The overall aim for the Environmental Data Exchange Network for Inland Water (EDEN-IW) project is to develop, at a European level, a service integrating disparate and heterogeneous government databases on inland water. This integration will make existing distributed environmental data available to users through an intelligent interface acting as a one-stop shop. The prototype, which operates on a limited number of databases and in a limited number of languages, creates a new standard for environmental data exchange and thereby eases environmental reporting and planning. The technical approach is to use software agent technology, i.e. to use a sophisticated set of independent, distributed software agents that advertise, broker, and exchange the data requested by the user.

The prototype in its present state comprises two databases (IOW for France and NERI for Denmark) with a multilingual user interface. There are currently three languages supported (English, French and Danish). The selection of measurement stations can be performed via a connected Geographical Information Service Map server as well as via direct entry of the name. The main graphical user interface (in French) is shown in Figure 2, and the GIS Map server in Figure 3. An example of a graphical presentation of the results is shown in Figure 4.

Figure 2: Main User Interface (in French)
Figure 3: EDEN-IW GIS Interface

Figure 4: Graphical presentation of the results (in French)
**GIMMI**  **IST-2001-34245**

**Geographic Information and Mathematical Models Interoperability**

Europe is aiming to define common frameworks and rules for environmental protection, so the availability of an inter-operable network of Geographic Information (GI) and GI-based web-services in the environmental domain is becoming increasingly important. One of the most relevant fields is Pesticide Impact Assessment for ground and surface waters.

**GIMMI** aims at bridging the large gaps in this domain between data providers (e.g. soil, meteorology, agronomy, and pesticide experts), scientists (chemists, geologists, modellers and academic institutions), service providers (local and central governments, public administration bodies, industries manufacturing pesticides) and end users (agronomists, consultants and citizens). This will be achieved by addressing current inter-operability problems between GI networks.

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**KEY FEATURES**

**On-line Data Access**

The user seeks to "drill down" into the huge amount of GI distributed at different sites in various formats. This information can be original GI or may be derived from studies and simulations already performed with **GIMMI** or other tools. **GIMMI** will support users to locate information of interest without the need to deal with or even to know the systems of data suppliers.

**On-line Simulation**

If the amount of data involved and the processing time required permit running the integrated assessment in an on-line environment, **GIMMI** will support end users in direct, web based interaction with **GIMMI** tools such as model and GI engines. In this case, input data may be provided directly by the user or come from a **GIMMI** data source.

**Off-line Study**

If a service requires huge amounts of data to be inter-operated, a long processing time or input by human experts, **GIMMI** starts a workflow agent which will conduct the
study process on behalf of the user and make results available for download or later online inspection in a report format.

Key Challenges

- Inter-operability of GI systems based on different technologies and different technical as well as semantic standards.
- Integration of GI with legacy code from mathematical models. Integration of model results and GI with advanced visual tools.
- Use of e-Commerce and workflow engines for scientists, practitioners, managers and citizens.
- Integration of all above mentioned tools with easy-to-use metadata and data access networks.

The Pilot Areas

The project will be validated in two distinct pilot areas, characterised by different real life scenarios situated in Northern Italy (Lombardy) and Spain (Catalonia), and a technology observatory will be set up in Ecuador (Guayaquil gulf). At least four alternative EC validated pesticide leaching models, two state-of-the-art pesticide risk assessment Decision Support Systems and two pesticide and active ingredients databases will be included in the network of data/services providers feeding the two pilot applications.
SEWING IST-2000-28084

System for European Water monitoring

The main goal of the SEWING project is to develop a cheap and easily accessible system for “in the field” monitoring in real time non-organic ion pollution of water. The most important results which have been obtained in the project are:

- The fabrication of ISFET sensors selectively sensitive to a chosen set of non-organic ions. Currently this includes: NO$_3$, NH$_4$, K, and pH sensors. The sensors are optimised in terms of selectivity and life-time (approximately one month). Two versions have been fabricated: BSC (Back Side Contacts) and FSC (Front Side Contacts). Examples of the characteristic curves for three sample ISFETs are shown in Figure 6.

- Algorithms, software and hardware for data processing have been produced, leading to easy visualisation of the polluting ion concentration.

- The hydraulic part of the system, responsible for introducing measured samples and calibrating samples, according to commands reserved from the controller, has been developed.

These component parts, together with the electronic interfaces, the power supply and the data transmitter, make up a self-contained smart probe, the prototype of which is shown in the photo named Figure 7.

![Figure 6: Ammonium response curves of three sample CHEMFETs](image)

![Figure 7: SEWING smart probe](image)
The sensors are tested on a specially built automatic measuring stand shown in Fig. 8.

The most crucial problem is to obtain reproducible and reliable sensors. Although good results have already been obtained, further improvements are under investigation.

The project will be concluded on December 31, 2004, and prototypes will be verified in real conditions in the field. Surface water is considered the object for the final measurements.
1.2 Marine and coastal zone, oils spills, algae blooms

The problem area

The strategic importance of the coasts, the sea and inland waters for Europe is well known. This is clearly demonstrated by the number of international conventions for their protection and the global scale of relevant research efforts.

Water contamination (and the habitat destruction it can cause) has been a major focus of regulatory attention and the topic is addressed in a number of EC Directives. Marine and inland water pollution is of vital importance for the health, economy and the environment of European coastal regions. In addition, the role of the ocean as a regulator of global climatic changes and as a biodiversity reservoir is widely recognised. Phenomena occurring at smaller scale in the oceans provide key indicators of the health of the ecosystem.

Over the past decade, numerous systems at national, European and international levels have monitored the natural environment. Despite the wealth of data and information potentially available, very little is actually utilised by the end user, or for the immediate benefit of the community in cases such as risk minimisation and efficient response to emergencies.

Objectives and challenges

Information and communication technologies have an important role in demonstrating regulatory compliance and, more generally, in the management and utilisation of marine and coastal environment datasets. A major obstacle to the use of existing environmental information is the link between the data generator/provider and the end-user.

Novel advances in data management, fusion and modelling techniques may achieve the needed integration of data from many sources and models with varying information infrastructures and priorities.

Summary of the programme achievement

Key results of the Research and Technological Development (RTD) projects addressing this area include:

- A prototype system delivering information on the environmental quality of coastal waters;
- GIS-based, distributed systems for monitoring and forecasting the marine environment; Integration of data from various observing platforms and modelling systems;
- A decision support system to manage cross border water pollution crises, in particular oil spills and algal blooms;
- Autonomous sensors for environmental monitoring, safe and sustainable exploitation of natural resources.
I-MARQ      IST-2001-34039

Information system for Marine Aquatic Resource Quality

The I-MARQ project has made significant progress in the development of advanced techniques to forecast contaminant risk within dynamically changing marine waters. A fusion and modelling engine forms the core of the system, based on a combination of regression analysis, Kalman filter technology and Lagrangian stochastic models. This allows propagation of contaminant levels in space and time to be modelled, based on multiple observation datasets of varying data quality. Phenomenological models can also be used to generate additional data, thereby creating a powerful capability in (normally) data-sparse situations.

The I-MARQ system has been developed around a generic architecture, the Meta Information System (MIS). Data sources and data processes (including the fusion and modelling engine) can exchange data seamlessly through the MIS, creating a fully scalable system.

The GIS-based user interface can also access data through the MIS, for display to different user types (see Figure 9). The project has identified several user categories which are essential to the successful exploitation of the I-MARQ technology. Public authorities are one such user type, and collaboration has been established to apply I-MARQ approaches within a newly-started Interreg IIIB project.

Figure 9: The display of I-MARQ data on the Internet
**DISMAR IST-2001-37657**

**Data Integration System for MARine pollution and water quality**

The main goal of **DISMAR** is to develop a distributed system for monitoring and forecasting of the marine environment, integrating data from various observer platforms and modelling systems. This distributed system will be used to improve the management of natural or industrial pollution crises in the coastal and ocean regions of Europe. **DISMAR** will support public administrations and emergency services responsible for prevention, mitigation and recovery of crises such as oil spills and harmful algal blooms. **DISMAR** will provide a single entry point, via a web portal, to a range of services delivering many types of observed data and model results, and conforming to international standards for both the data and the metadata.

A prototype decision support system (DISPRO) is being developed for the integration and distribution of multi-source data and results from numerical models. The DISPRO architecture is consistent with INSPIRE's general model of an SDI (Spatial Data Infrastructure).

DISPRO is a multi-tier system with four main groups of components: user applications, geo-processing and catalogue services, catalogues and content repositories.

The implementation of DISPRO is based on INSPIRE, Open GIS and W3C standards, using Open Source software where available. Metadata plays a central role in DISPRO. All data products and services are described in accompanying metadata files. The latter is a profile of the ISO 19115 geographic metadata standard, restricted mainly to the core 'discovery' metadata elements. Metadata are provided in XML format, validated against an XML Schema. The metadata are stored in a native XML database and transformed to HTML for presentation using XSLT style sheets.

![Figure 10: Chlorophyll map from the North Sea based on SeaWiFS ocean colour images. These maps are useful for monitoring some categories of algal blooms and for validation of models used to forecast algal blooms.](image)
The DISPRO system will be demonstrated in six coastal zone and ocean areas in Europe where Web Map servers are installed, namely: (1) North Sea / Skagerrak area, (2) German coast, (3) coast of Italy, (4) coast of France, (5) coast of UK, and (6) South-West Ireland.

Users of the system will have online access to a number of EO (Earth Observation), *in situ* and modelled data and products. Some of these products are shown in Figure 11, below. Satellite ocean colour data and SAR images will be used in combination with ferry-box data, an oil drift model and ecosystem models to show how algal blooms and oil spills can be forecast and monitored. Aircraft observations using infrared and ultraviolet sensors, and coast radar, will be used to observe water quality parameters at a local scale. Users in each of the demonstration areas will be involved in testing and evaluating the distributed system.

Figure 11: Ocean model showing surface currents on 17 November 2002 during the Prestige accident. Modelling of surface currents is an important part of oil spill prediction models.
SUMARE IST-1999-10836

Survey of Marine Resources

The role of the ocean as a regulator of global climatic changes and as a biodiversity reservoir is widely recognized, as is demonstrated by the number of international conventions for its protection and coordinated initiatives for its observation at a global scale. At the same time, it is also acknowledged that phenomena occurring at a smaller scale are also important, providing key indicators of ocean health as an ecological system. While global observation systems providing massive amounts of information have been deployed over recent years, they are mainly restricted to the ocean surface and offer very low spatial resolution.

In SUMARE, the use of small autonomous mobile sensors which are able to provide detailed information about phenomena occurring inside the water column has been addressed. Capable of moving freely inside the ocean, these sensors are able to directly acquire maps of specific features of interest of the observed fields, provided that they are equipped with the relevant sensors. The project developed integrated information processing, control and mapping algorithms, implementing a wide range of targeted observation behaviours.

Special attention has been given to the task of directly mapping contours of benthic habitats using underwater robots. This has a wide variety of applications, ranging from more industrially orientated tasks such as cable and pipeline tracking, to the delineation of the spatial patchy structure of certain biological species which is of major importance for sustainable development policy in matters such as coral reef protection.

Figure 12: The SUMARE submersible
The technologies developed have been demonstrated both with acoustic (sonar), visual (video cameras) and scalar sensors, providing point measurements of a given field (altitude, temperature, zooplankton concentration,...), and for platforms with distinct types of degrees of freedom. Moreover, special care has been taken to keep the system independent of the need for detailed prior information about the specific characteristics of the observed regions. This, together with the modular structure of the information processing and control chains, enables easy transfer of the technology developed to underwater platforms other than those used in the project.
The **SISCAL** project aims at developing an internet-based service for providing water quality parameters derived from Earth Observation data in Near-Real-Time for coastal areas and lakes. Targeted customers are public authorities, NGOs and research institutions with an interest in such products, but without the resources to do the required processing in-house.

The **SISCAL** web site is available at http://www.siscal.net. It provides information on the project for the general public and provides access to order forms and derived data products for registered users.

As of April 2004, MERIS, SeaWiFS and AVHRR data are being operationally processed in order to derive the following products: concentration of chlorophyll and total suspended matter, diffuse attenuation coefficient, and sea surface temperature. In the evaluation phase in the summer of 2004, the instruments MODIS-AQUA and AATSR will be integrated into the system as well. It is intended to transform **SISCAL** into a sustainable service after the end of the project in December 2004.
In order to increase the user-friendliness of the service, a tool based on a commercial off-the-shelf Geographical Information System has been developed which facilitates data archiving as well as user-specific product visualisation and analysis (Figure 13). For simple visualisation and map generation, a web mapping tool has also been developed (Figure 14).
**MERMAID**  **IST-1999-10637**

*Marine Environmental Response Data Management and Acquisition using Internet data brokerage*

**MERMAID** aims to develop an Internet-based Data Broker capable of cataloguing, storing/referencing and accessing environmental datasets. Users will be able to search for, choose, purchase and download data subsets for their specific and immediate data requirements. The Data Broker technology will be designed as an ‘open to all’ service for data providers and users, and will be demonstrated within the project by application to the marine emergency response domain.

Over the past decade, numerous national, European and international programmes have focused on the generation of data for the natural environment. Very little of this large amount of data is actually utilised by the ultimate end user who provides services to the citizen *e.g.* in the case of maritime emergencies such as marine pollution or search and rescue. The major hurdle to widening the usage of this existing data is the problem of linking the data generator/provider and the end-user. It is this link that **MERMAID** seeks to address through the development of a generic data brokerage technology suited to large temporal/spatial varying datasets.

The primary aim of **MERMAID** is to provide a seamless, minimum intervention link to allow end users working in the marine environmental emergency application domain to access and use large distributed datasets of environmental parameters.

*Figure 15: The British Maritime Technology (BTM) control station*

Following a major user requirements definition phase, the project is focused on delivering a major ‘virtual shopping centre’ for environmental data providers and users. This virtual shopping centre will provide near-real-time user access to major
international datasets with inherent support at user sites for sophisticated end user applications, and simple web browser based data reader/viewer applications. The MERMAID technology will be based on web-enabled neutral formats for environmental data transmission and will use exchange based on existing standards with improvements for temporal knowledge representation and management. This to be combined with the development of web-enabled methods (incorporating E-commerce) to search, extract, compress and transmit the variety of data types routinely encountered.

The system will be designed to allow users to browse and view samples of datasets from the on-line vendors. Datasets will be ordered, paid for, and delivered on-line with data delivery via email, download, or direct interface to an operational system. Datasets will either be held locally by the broker in a data warehouse, or be maintained by the vendor with data extraction and delivery robot software that is capable of extracting data subsets from large scale 4-dimensional data matrices.

Two demonstrations are planned. One will be an example of a data viewer application typical of the sort that might be issued free of charge by a vendor to add value to their datasets. The second will be an operational system in which the MERMAID interface is embedded, allowing direct download and usage within the operational system. The marine emergency response domain has been selected for this demonstration with applications for oil/chemical response and search and rescue.

MERMAID will deliver a pre-operational integrated on-line system capable of delivering local and remote environmental datasets on a seamless basis to users. The system will be fully e-commerce enabled and able to deliver data via a number of mechanisms to suit the users' operational needs. The system will be populated with demonstration datasets and have two demonstration applications of data usage from the broker. The project will be supported by detailed exploitation plans for future commercialisation of the service.
1.3. Air pollution and noise

The problem area

Air pollution and noise are of major concern for many European citizens especially in major cities. According to the 1995 Eurobarometer environment survey, air pollution and noise were the second and fifth most important areas of complaint about the local environment (traffic, air pollution, landscape, waste, noise), respectively.

Air pollution is a major issue for the health of citizens in big cities, and is the cause of a large number of avoidable deaths. According to the “Institut de veille sanitaire” the death of 379 persons could be directly attributed to the elevated ozone concentration between 3rd and 17th August 2003 in nine major French cities.

Many Europeans consider environmental noise, caused by traffic, industrial and recreational activities, as their main local environmental problem, especially in urban areas. It has been estimated that around 20 percent of the inhabitants of Western Europe suffer from noise levels that scientists and health experts consider to be unacceptable, and where adverse effects on health are to be expected.

Objectives and challenges

Air and noise pollution monitoring are both domains which already rely heavily on ICT technologies and which can be further enhanced by improvements to these technologies.

Both areas present the problem that exact measurements are very expensive due to the price of measurement stations, and are extremely difficult to achieve in the case of noise.

Therefore the improvements to measurement methods, as well as the integration of these data with other techniques such as modelling, are of major interest, especially for the political decision makers with their need to defend their (unpopular) decisions on a solid scientific basis.

Summary of the programme achievement:

- Development of novel sensors and sensor networks;
- Integration of air pollution and traffic related data into a decision support system;
- New modelling approaches;
- Citizen centred information on air pollution via multiple measurement channels;
- Harmonised methodologies for noise mapping.
**HEAVEN IST-1999-11244**

*Healthier Environment through Abatement of Vehicle Emission and Noise*

Within **HEAVEN** new concepts and tools have been developed to allow cities to assess, in near-real-time, the impact of traffic on air quality and noise pollution and to support decision making. These innovative tools that merge monitoring and simulation by means of Information and Communication Technologies (ICT) are integrated into a Decision Support System (DSS) in order to:

- Provide a better description in near-real-time of the environmental impact of traffic and
- Assist cities in identifying Traffic Demand Management Strategies (TDMS) that most reduce the impact of traffic on the environment.

The main products of the **HEAVEN** project are:

- A Common System Architecture (CSA) for the integrated assessment of the impact of urban traffic on air quality and noise
- Six applications of the CSA resulting in operational Decision Support Systems tested and demonstrated in the project’s participant cities (Berlin, Leicester, Paris, Prague, Rome and Rotterdam)
- A range of validated applications comprising new and enhanced traffic and environmental models, tools and interfaces
- A set of validated short and long-term traffic scenarios to abate the adverse effects of traffic on the environment
- Practical experience of the environmental benefits of the implemented traffic measures

The **HEAVEN** project has contributed to the implementation of EU regulations on air and noise quality by developing and demonstrating new IST-environmental management tools.

The application of the **HEAVEN** DSS in large urban areas provides a sound sustainable development perspective. It aims at improving the quality of life in European cities by reducing transport related noise and air pollution through the identification of innovative combinations of efficient TDMS and integrated environmental Information Society Technologies.

*Figure 16: Impact Assessment on Air Quality of the National & European “Car Free Day” (Paris)*
Figure 17: HEAVEN Scenario User Interface (Rome)
**ADA**  **IST-2000-28452**

**Advanced Distributed Architecture for telemonitoring services**

**ADA** is an innovative solution to the increasing necessity of having monitoring systems in a wide range of applications, e.g. in environmental, transportation and infrastructure surveillance networks.

**ADA** combines a new network architecture, based on a JINI operating system with a low-cost, low-consumption, miniaturized sensor system, and enables collection of geographically referenced information without any administrative effort.

The project work included establishing a flexible network architecture for air-quality monitoring, embedded in an existing telecommunication framework. The palm-size sensing terminals host monolithic miniaturized gas sensor systems that are fully integrated in CMOS technology. Each terminal, which also includes a gas intake system and a wireless communication module, makes use of Jini-like methods to dynamically set up a data network via GSM/GPRS and Bluetooth. Two fundamentally different applications will be served within the project:

- Integrated sensor terminals for monitoring of CO, CH₄, NO₂, (Figure 20) in outdoor and indoor environments: The terminals rely on an innovative CMOS monolithic micro sensor system (Figure 18), which represents a very attractive technology platform for a wealth of applications such as air quality surveillance in industrial and domestic settings, gas and fire alarms, as well as personal safety devices in industry;

- An advanced Distributed Sensor Network (DSN) for indoor and outdoor air quality monitoring applications: This network includes the sensor terminals and an innovative network architecture, which provide pollution data at high spatial and temporal resolution under real time conditions. Additionally, the ADA network provides geographically referenced access to the measuring sensors and access to the DSN services for data gathering and administration through intranet/extranet interfaces.

![Figure 18: Packaged ADA sensor chip as sent out for measurements.](image)
Figure 19: ADA sensor demonstrator: Laptop connected via USB to the ADA Microsystem

Figure 20: Sensor unit with HW modifications for Madrid field trial.
**APNEE IST-1999-11517**

*Air Pollution Network for Early warning and on-line information exchange in Europe*

*APNEE* aims to contribute to European research at the service of the citizens by enabling citizens to access and exchange information on air pollution in urban regions.

*APNEE* is going to establish information services for a human-centred management of cities in building a geographic information portal for air quality in cities. The project addresses citizens as well as professionals, local and regional authorities across Europe and European relevant institutions. The information portal will provide online visualisation means about real-time air pollution, and special features like early warning, discussion boards, an online newsletter, etc.

The *APNEE* project aims to increase the knowledge of citizens on air quality and develop the exchange of information both on a local level in European cities and at national and regional levels among European institutions.

Key objectives are to:

- Implement user-friendly information services for citizens, public and private organisations, and business communities. No special expertise is required to benefit from these services. Each will be designed to have an appropriate interface to typical real users, especially citizens who have little or no computer skills.
- Co-found the city of tomorrow as one step towards the information society of Europe. Citizens will benefit from an overall accessible information service, be it by web, mobile phone, or street panel.
- Improve the quality of life of the citizens in Europe: citizens will be capable of understanding the importance of air quality information and use it to their benefit.
• Build an easy-to-use novel interface on air pollution data for citizens by employing highly sophisticated GIS technologies.

• Combine several data sources with online information.
• Provide different technology access methods (push and pull) such as Web, mobile phone (SMS, WAP and Voice), and interfaces to electronic street panels.

• Develop the exchange of information among professionals, local and regional authorities across Europe, and European level institutions.
Many authorities are currently investigating the use of modern communication technologies to expand their information service portfolio, but face the problem of mastering the technical challenges of new communication technologies with their rapid change of standards as well as a large variety of mobile devices offering different technical capabilities. For efficiency, these information services should be operated by one single party, however, an inter-disciplinary business chain is required, ranging from a trusted source of information on air quality, via technology providers for customising information services, up to portal providers offering and maintaining such information services.

Projects APNEE and **APNEE-TU** established a multi-channel information service on current and forecast air quality in different European regions. **APNEE(TU)** disseminates air quality information using modern communication channels, such as the World-Wide-Web, SMS, MMS, WAP via mobile phones, PDAs, and smart phones, as well as voice servers and street information panels.

The **APNEE/APNEE-TU** projects include nine test sites (Oslo, Greenland, Athens, Thessalonica, Marseilles, Canary Islands, Madrid, Andalusia, and the whole of Germany) working with 21 partners from research, government, as well as the IT and telecommunication sectors.

This “business collaboration concept” has proven successful:

- In each Apnee region an authority provides and authorises the measured air pollution data.
- Research institutes and universities operate and control models for forecasting of air pollution.
- Technological partners designed and implemented the Internet, message service, PDA, and WAP portals as well as street panel interfaces.
- Mobile and Internet information portal providers integrated the Apnee solution in their portals.
- Telecommunication companies distribute the messages over their communication lines.
Figure 22: APNEE-TU public information panel in Andalusia

Figure 23: PM10 levels in Germany – 27.1.2004 – Source German Federal Environmental Institute
**HARMONOISE**  IST-2000-28419

**HARMOnised, accurate and reliable prediction methods for the EU directive on the assessment and management of environmental NOISE**

The **HARMONOISE** project will develop methods to predict community noise levels due to roads and railways. Such methods already exist separately in many countries and have been applied for a long time. However, for a European citizen, even if they are a noise specialist, it is difficult to compare the results of different methods: they use different quantities to characterise community noise, they may even use different quantities for different noise sources. The level of precision also differs widely: some methods are indicative only, others are quite complex and precise. The harmonised methods developed in **HARMONOISE** avoid this confusion, and are suitable for noise predictions everywhere in Europe.

The second goal of the project is to achieve general acceptance of the proposed methods, which is required for an easy and rapid implementation of the methods in the Member States.

Unlike existing models, the **HARMONOISE** model has a strict separation between the source description and the description of the propagation. At this stage in the project (with just half a year to go), the source description of road and railway sources has been finalised. Individual sources will be defined by their physical properties such as sound power and directivity. The relationship between source power and (road) car speed is described in a deterministic way, i.e. logarithmically with speed. For railway vehicles, physical parameters are used: wheel and rail roughness. Default values for source parameters are made available for typical vehicles and roads/tracks in Europe, and measurement methods are provided in order to determine the source strength for vehicles and roads or tracks that are non-standard.

![Figure 24: Array measurements on a stationary vehicle (TNO)](image-url)
The propagation method adopted in HARMONOISE is based on the existing methods Nord 2000 and NMBP, but is backed up in special cases by a reference model based on linearised Euler equations, Parabolic Equations (for sound propagating through turbulent and stable atmospheres) and Boundary Element Method (for complicated barrier shapes). A summary of the achievements so far is given in a Position Paper, of which a copy can be downloaded from the project’s website (see below).

In order to achieve the second goal, general acceptance, the HARMONOISE consortium has defined an end-user group and has established contact with them. All members of this group are invited to give feedback on reports, and on the information presented on our website. Meanwhile, presentations on the progress and results are being given at conferences all over Europe (please check our website for dates). A final HARMONOISE conference will be organised by the end of October 2004, in the South of Europe, on which the results of the HARMONOISE project will be presented.

Figure 25: Intensity measurements on a rotating wheel (TUG)

Figure 26: Measuring noise propagation from road sources (DebAKOM)
**ICAROS NET**  IST-2000-29264

**Integrated Computational Assessment of urban air quality via Remote Observation Systems NETwork**

*ICAROS NET* aims to develop and demonstrate a networked interactive computational environment which allows the integration and fusion of environmental information from satellite-based remote sensing observations, ground air quality measurements, and pollution transport models. This will reduce uncertainty in decision-making regarding operational air pollution control and abatement. The goal is to maximize cost-effectiveness of urban air quality management and increase the reliability of environmental monitoring in European cities.

The project has four pilot sites, covering urban and regional settings in three EU member states (Milan, Athens and Munich) and one accession country (Budapest, Hungary).

The *ICAROS NET* research team includes the European Commission’s Joint Research Centre, the University of the Aegean, FZK, the University of Athens, the National Observatory of Athens, McMaster University (Canada), the Atomic Energy Research Institute of the Hungarian Academy of Sciences, the National Centre for Public Health of Hungary, Telespazio srl and Space Imaging Europe.

Earth observation (EO) from satellites can provide synoptic air pollution indicators, such as atmospheric turbidity, as measured by the atmospheric aerosol optical thickness (AOT). Fusion of the air quality information stemming from EO and ground data with the output of atmospheric models gives detailed maps of surface concentration of pollutants over the whole terrain of interest at a very high spatial resolution. By introducing the aerosol concentration values in exposure-response relations obtained from epidemiological investigations, maps of health indicators, such as expected morbidity from particulate loading, can be calculated. Fusing these maps with density maps of vulnerable populations gives estimates of health vulnerability and from this risk maps can be produced.

![Image of PM10 concentration map](image)

*Figure 27: Horizontal distribution of ambient air PM10 concentration in the Athens basin on 17 October 2002 calculated with the **ICAROS NET** fusion method.*
Figure 28: Map of estimated increase in hospital admissions for respiratory problems in Athens based on the fine particle loading in the lower troposphere (17 October 2002)

Figure 29: Map of the US EPA Air Quality Index based on PM10 for the Athens basin on 17 October 2002
1.4. Preparedness and crisis

The increasing frequency of natural hazards such as extreme weather events, combined with increasing urbanisation and growth in economic activities, has in turn significantly increased the vulnerability of our society. The economic losses due to natural hazards and industrial accidents are growing rapidly. Several studies show the potential of information technologies to improve the management of these risks and the mitigation of their consequences, and to accelerate recovery. The range of current applications is incomplete and often driven by technology push; isolated risks are better understood than the overall scenario, but the systemic nature of risks is still generally overlooked.

**Preparedness:**

There is a need to collect data better, to connect different sources of information owned by different agencies and to observe the patterns that can warn of natural disasters, such as earthquakes or floods, or human attacks such as terrorism. New methods of risk management resulting from such scientific research need to be integrated and pilot services launched.

**Crisis:**

During the response phase, the availability of high performance telecommunications is critical to support the wide range of command, control and coordination activities between the different actors: civil protection, emergency health care, transport, utilities, etc.

The challenge is to develop and pilot tests on how to combine total information awareness with distributed command, control and coordination. The goal is to allow seamless cooperation between civil protection agencies in case of major disaster in a network centric approach.

A new vision of the crisis coordination centre and its associated methodology has been proposed by the project *FORMIDABLE*, whilst *EGERIS* has developed advanced functionalities at the mobile control room level.
EGERIS IST-2000-28345

European Generic Emergency Response Information System

The EGERIS (European Generic Emergency Response Information System) project objective was to increase the safety and the efficiency of civil protection organisations and other authorities involved in disaster management operations.

EGERIS allows users to gain real time, up-to-date knowledge of the situation in order to take the right decision and to minimise the consequences of the disaster. The project provides a complete chain of information, linking all the people in charge of taking action: crews in the field, and the mobile command post and control rooms.

EGERIS provides:

• A real-time picture of the situation, acquired through the use of lightweight equipment carried by the crews in the field - a Personal Digital Assistant (PDA) or a portable PC connected to a GPS and a telecommunication device. The tactical information includes the location of all vehicles involved in the operations and the characteristics of the event (fire or flood contour, or building status after an earthquake). It is available immediately in the fixed and mobile Control rooms and the information may be also delivered to the devices used in the field. This data transmission could be made available on any type of IP network, including low bandwidth PMR (Private Mobile Radio) networks used by civil protection authorities;

• Automatic exchange of information between the control rooms of several authorities involved in a crisis, allowing, for example, the fire-brigade emergency centre to quickly display the rainfall forecasts from the meteorological institute and the flood prediction computed by the river basin agency. These information exchanges are monitored and individual information flows can be stopped (according to their priorities) in order to avoid network saturation by less important information during a crisis.

![Figure 30: Real-Time visualisation of the position of the fire brigades](image-url)
Figures 31 (above) and 32 (below) showing the EGERIS Event Monitor User Interface
**FORFAIT IST-1999-10649 + IST-1999-70649**

Forest fire risk and hazard assessment: a holistic approach

**FORFAIT** sets out to develop and demonstrate a Decision Support System (DSS) to assist planners, regulators and industry, in optimising the management of forest fire risks, on a holistic, integrated and traceable basis. It will aid in implementing measures that eliminate or mitigate harm to humans, the environment and business, by using a cost benefit approach where appropriate. Local regulatory requirements will be taken into account.

**FORFAIT** will uniquely combine generic and time varying site-specific information (via electronic links from field and satellite data sources), state-of-the-art predictive models, and expert knowledge. Recognising that, in general, there are many different decisions that could be made in any given situation, the system will use fuzzy logic to suggest the most appropriate course of action and a probabilistic framework to take account of uncertainty in the parameters.

![Figure 33: FORFAIT logo](image)

**Main Project Objectives**

To contribute to the protection of national resources and improvements in health and safety, as applicable to forest fires;

To integrate well established and emerging technologies, including electronic data gathering, in order to design and build a Decision Support System for use as a tool in planning, educational, regulatory and business contexts.

**Key Milestones**

The project lifetime, which spans a period of 30 months, consists of four key phases:

- production of a software development specification, software and hardware requirements, and the functional elements of the **FORFAIT** design;
- Implementation of a pilot version via the project website, with feedback from interested groups;
- Application of **FORFAIT** to real world trial sites, and peer review;
• Dissemination and exploitation of system.

**Major Innovations**

*FORFAIT* will uniquely combine generic and time varying site specific information, state-of-the-art predictive models, and expert knowledge, to enable well informed defensible decisions to be made on a case specific basis. The innovative aspects that will give FORFAIT advantages over current approaches include:

- Use of an integrated, quantitative, and holistic approach in a geographic context, where the various costs associated with different contributions to risk are evaluated, and the uncertainty in the decision making process is taken into account;
- The adoption of a Decision Support System framework which emphasises communication, collaboration and negotiation between stakeholders. Experts from a wide range of disciplines will be involved, including foresters, emergency service personnel, environmentalists, industrial, economic and social science specialists;
- A variety of outputs will be provided for use in decision-making and report production. Outputs will be in terms of measures of severity, cost and risk, taking into account social, environmental and commercial concerns;
- The system will be tested and demonstrated in real situations for sites in Italy, Greece, Spain and Poland.

**Expected Benefits**

- Helping to improve the early warning and prediction of fires;
- Helping to prevent fatal injuries to people;
- Helping to save money through better co-ordination of emergency information;
- Helping to prevent financial loss to individuals and businesses;
- Improving the prevention of damage to the environment;
- Encouraging the protection and best use of environmental resources;
- Encouraging common guiding principles rather than relying on disparate national policies;
- Improving general forest management planning information and long term strategies;
- Providing a means for the management of risks taking full account of the associated uncertainties using state-of-the-art data gathering technologies.
- Bringing together the concerns and expertise throughout Europe to tackle a major ecological issue of our time.
- A range of public and private organisations representing a wide array of potential markets may benefit from this project.
- Forest fire management and planning organisations- improved management of forest fire risks through a well-informed decision making process considering a large number of factors (historical, climatic, topographical, land-use, health & safety, environmental and socio-economic) affecting that process;
- Forest fire fighting departments- through better understanding of conditions leading to wildfires- their behaviour and propagation, adoption of various effective preventative measures and training in efficient fire fighting tactics;
- Tourism- benefiting from well-informed decisions regarding the potential hazards associated with forest fires to their customers and infrastructure in planning and operational stages.
- Insurance companies - dealing with emergency service organisations, property insurance against natural disasters such as forest fires, timber and paper industries, insurance against product losses, etc;
- Property developers - in or near forested areas to appraise the risk of fire and related hazard before buying land;
- Industry and regulatory bodies - to assess regulatory compliance of new projects;
- Academic institutions, research and development centres - pursuing scientific research dealing with the different aspects of forest fires and the risk they present to the society and environment as a whole.

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**System Design**

At the heart of the system will sit a central decision engine, incorporating an extensive Fire Management Knowledge Base, and utilising the latest Fire Propagation and Mitigation Models. The Decision Support framework places emphasis on effective communication, collaboration and negotiation between stakeholders and allows the problem to be approached from an integrated, quantitative and holistic perspective.

Inputs to the system will take the form of local, site specific data collected in the field, and timely satellite derived information. By making use of such Remote Sensing data, the system is able to exploit unique indices of fire-related information sources, which can be created and updated rapidly. The user interface and system outputs will build upon the growth of Geographical Information System (GIS) technology to present a map-based view of social, environmental and economic risk.

**Pilot Sites**

Demonstration tests, carried out at each of the four pilot sites, involve the creation of a conceptual site representation, generation of predicted results, calibration, establishment of parameter uncertainty and application of the DSS to chosen scenarios. The trial sites comprise of:

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*Figure 34: The FORFAIT system architecture*
• Comunità Montana di Elba e Capraia (CoMEC) – situated in the North Tyrrhenian Sea and subject to severe forest fires in summer season, with significant impacts on tourism;
• Mount Parnitha, Greece – the largest mountain in the Attica region, contains areas of ancient forest, including land declared as a National Reserve;
• Autonomous Community of Galicia, Spain – located in NW Spain. Around two thirds of the territory is prone to forest fires as a result of the vegetation composition, agricultural practices and leisure activities;
• Kampinos National Park, Poland – positioned close to Warsaw and under great pressure from tourism, with annual fires a common problem.
**FORMIDABLE IST-1999-11679**

**Friendly Operational Risk Management through Interoperable Decision Aid Based on Local Environment**

*FORMIDABLE*, a European Union funded research and technological development project, represents a solid contribution of the scientific, operational and industrial community to improving the management of natural hazards.

The intended users of *FORMIDABLE* are civil protection authorities and local administrations that access data to manage both interventions and responsibilities (main users), those who access the system during the execution of emergency plans while dealing with a hazardous event (operational users), entities that will access the system to provide the auxiliary data necessary to generate products to be used for emergency management (service users), mass media and citizens, who will access the basic level of information (generic users).

**Key issues:**

In the Emergency Management of natural hazards, one of the major constraints to the effectiveness of interventions and relief actions is difficulty in circulating reliable information among involved organisations and citizens, when a hazardous event occurs. This can have a dramatic impact on the planning and execution of safety procedures, such as moving people to safety, thus increasing the loss of life and of goods.

A critical analysis of where emergency management operations have encountered major problems, causing partial failure or delay in recovery action, highlights a generic lack of co-ordination, and a poorly unified and homogeneous approach. From this analysis, some requirements on the “Emergency Management” of Natural Disasters arise:

- the need to ensure flexible and easy tasks to ensure efficient interventions and immediate relief for affected citizens;
- the need for all involved national and local authorities to share common knowledge and methods for the management of natural disasters, from planning to post-event assessment phase;
- the need for quick response times for receiving accurate and homogeneous information containing detailed descriptions of both expected crisis scenarios and current ones.

According to the above requirements, *FORMIDABLE* is aimed at:

- Contributing to the definition of a Methodology, initially tailored to the Mediterranean region, but targeted at European Level, for the definition and execution of Emergency Plans. It will be able to be customised for different types of environmental risks, and will be in line with Council Decision 98/22/EC of 19 December 1997;
- The specification and development of an interoperable Emergency Management System prototype, compliant with the proposed Methodology, capable of supporting the decision making process of the authorities responsible for Emergency Management, and integrating new advances in technology.
- The validation and promotion of the above results within the Emergency Management community, through the development of specific applications, which
are able to provide suitable test beds for the methodology procedures and the operational tasks to be performed in realistic emergency management scenarios.

Technical approach

The definition of a Methodology will be consolidated through a close interaction with all the participant user groups, establishing the procedures needed to generate and maintain emergency plans. In particular, the following aspects will be considered:

- basic information used to classify natural disasters;
- analysis of the main tasks with related responsibilities valid at European level;
- generation of guidelines that define procedures suitable to support different phases of emergency management, from risk prevention to damage assessment.

This phase will be carried out in close co-ordination with the Civil Protection Authorities of the European Countries involved in the project (initially Greece, Italy, and Spain).

The starting point of this activity is represented by the existing Augustus Methodology, conceived and used by the Italian Civil Protection Department in all the emergency situations they have managed during recent years. Augustus addresses a general method for the definition, preparation, management, and updating of all emergency plans issued by Civil Protection, with the main purpose of defining standard criteria in Emergency Planning and optimising interventions in complex environmental scenarios. It builds upon 14 Support Functions (Technical and Scientific Support, Health, Social Assistance and Veterinary Services, Mass-media and Information, Volunteers, Material and Resources, Transport and Mobility, Telecommunications, Utilities, Damage Assessment, Search and Rescue, Local Authorities, Dangerous Materials, Population Logistics, Operational Co-ordination), the use of which provides the answers to the different needs arising during emergency management. The relevance of each function may change according to the effects produced by the event and its geographical scale, keeping emergency plans flexible and effective.

The emergency management support system

The emergency management support system will be specified according to the proposed methodology, through detailed system requirements analysis and operational concept definition. A preliminary architecture of the system is shown in Figure 35. Each support function will be implemented on, and operate on, a dedicated workstation. Both static (e.g. topography, risk maps, land use, event history) and dynamic (e.g. meteorology, positioning, earth observation, in-situ measurements) data will be used. State-of-the art technologies such as high performance Internet GIS, multimedia user interface tailored to different operators, data fusion, optical and microwave earth observation, and mobile communications will be taken into account.

Within the scope of the EU co-funded project, a reduced implementation of the specified system will prototype specific functions in order to provide a test bed for the methodology on specific application cases.
Validation & Promotion

For the purpose of validating the project results, two applications will be implemented on different sites. The first one will address seismic risks, while the second one will address floods.

The selection of these two applications is based on the need to analyse the prototype behaviour in different types of natural risks, in particular unpredictable risks such as earthquakes and predictable risks such as floods. Moreover, these two sites provide a better coverage of a European scenario. The Civil Protection authorities of the two countries, Italy and Spain, will be involved in providing their operational experience, and related organisation, as specific sets of test data. The prototype will be tailored to fit the application scenarios by:

- Specification of the application to identify the functions, the interfaces and the data required;
- Application development by using the FORMIDABLE prototype for database population, to input specific information, e.g. maps of the two areas within the SW architecture of the prototype;
- Field Trials execution, to test the prototype's main features e.g., performance, user friendliness and data access in different operational contexts.

Dissemination is considered one of the key aspects of FORMIDABLE. User groups will be established - within the consortium for the use of the prototype, and in the wider community, for the enlargement of the initiative – to continuously assess the
intermediate outcomes of the project. Dissemination activity will make use of publications, exhibitions, workshops, media events, production of CD-ROM and Internet web pages. Specific effort will be spent towards the participation of non-EU Mediterranean countries in the workshops.
Quiescent but active volcanoes in regions of high geodynamic unrest represent a severe hazard and risk potential and require integrated monitoring, satellite surveying and modelling. Monitored geodetic, seismic and geochemical data together with satellite images will be transferred and unified in a coherent way to allow integration into a geo-spatial information system (GIS).

An interactive and user-friendly multimedia tool will then be introduced as the platform for graphical 2 to 4D landscape models and all monitored data. Hazard and scenario modelling in space and time will be achieved within the CD-ROM based multimedia platform. An early-warning system and emergency plan, applicable to other volcanic areas, as well as educational video spots, will be delivered to generate public awareness. The volcanic island of Nisyros (South Aegean Sea) that suffered a seismic crisis between 1996 and 1998 is seen as a unique example from which to derive the multi-parametric data set. The Nisyros case will then be compared with the quiescent, active volcanoes of Vesuvius and the Phlegrean fields in Italy.

**Project Objectives**

Large parts of Southern and Central Europe are situated in tectonically, seismic and volcanologically extremely active zones. With population and tourism growth, vulnerability to, and risk from, natural hazards have expanded over large areas. Socio-economical aspects, land use, tourism and industrial planning, as well as environmental protection, increasingly require natural hazard assessment.

The availability of extensive and reliable satellite, geophysical and geochemical information and warning systems is therefore increasingly vital. Moreover, once such systems have proven to be effective, they can be applied for similar purposes in other European areas and worldwide.

Research has shown that early warning of volcanic activity can be achieved by monitoring measurable changes in geophysical and geochemical parameters. Correlation between different monitored data sets, which would improve any prediction, is either very scarce or missing. Visualisation of all spatial information and integration into an “intelligent cartographic concept” is of paramount interest in order to develop 2-, 3- and 4-dimensional models to approach the risk and emergency assessment as well as environmental and socio-economic planning.

**The GEOWARN Design**

The major aim of the proposed project will be the development of a multimedia-based geo-spatial warning system that comprises graphical and numerical geo-spatial data.

- Remote sensing data: Satellite images (e.g. infrared thermal imaging and displacement observations analysed by new interferometric image processing);
• Real time monitoring: Surface movements derived from geodetic differential global positioning measurements; seismic activity; heat and gas fluxes and chemical changes in fumarole gases and hydrothermal waters.

Integration of these independent parameters will lead to the development of useful modelling techniques that are suitable for detecting dynamic processes such as reactivation of a quiescent volcano or earthquakes. Deep crustal seismic soundings, monitored from land and at the sea floor, using the new technology of ocean bottom seismographs, should provide regional as well as local volcano-tectonic and structural models.

All relevant graphical data will first be geo-referenced in a Geographical Information System (GIS), in order to derive a numerical topographic and thematic Digital Landscape Model. Useful information can be generalised and prepared for presentation through transformation to a Digital Cartographic Model. The cartographic modelled data layers will be integrated in the innovative concept and user-friendly Atlas Information Systems in a multimedia environment on Internet platform and on CD-ROM. The potential of Atlas Information Systems lies in the integration of visualisation techniques as well as multimedia and adapted GIS-functionality, offering better information access and a versatile palette of presentation tools. The integration of all the data into an interactive multimedia environment releases the user from the necessity of acquiring specialised GIS knowledge.

Volcanic hazard forecast as a non-precise statement of time and place is a complex problem. It will be approached through combined deterministic and stochastic methods. This procedure, based on stochastic processes and hazard functions, enables the observed temporal and spatial correlation of volcanic eruptions to be taken into account and allows the generation of hazard maps and scenario simulation.

Milestones

Four major milestone packages are envisaged within the proposed three-year project:

• After 6 months: Recognition of sites and zones which are heavily exposed to future volcanic hazards and associated seismic hazards, slope instabilities, rock falls, and tsunami exposures. Installation of seismic and geochemical monitoring. Satellite data transfer;
After 15 months: Evaluation of vulcanological, geophysical and geochemical data; first integrated data analysis; hazard assessment and first layout of hazard maps.

After 24 months: 2-D and 3-D visualisation of geological multi-hazard maps and hazard zonation in premium graphic quality. 4-dimensional modelling of hazard probabilities. First interpretation of hazard, vulnerability and risk modelling at the end of the 24th month of the project.

After 30 months: First documentation of GIS combined with an interactive multimedia CD-ROM for the assessment of vulnerability and risk (modelling of damage and loss, crisis scenarios).

Innovations

The innovation and the main measures of success of the project are expected in the localisation of seismicity in space and time within active but quiescent volcanic fields, and in the identification of useful parameters to characterise precursors of volcanic activity.

A major advantage of the proposed system is its fully interactive environment. Edited information from the basic cartographic data, the results of correlation, simulations and modelling can be instantly presented graphically on the screen. It is planned to provide this functionality both in 2D and in 3D mode and to add all real-time monitored data in the 4D-mode via the Internet. These deliverables will serve as the base for hazard assessment, scenario simulation, early warning, emergency and socio-economic planning.

Five major groups of benefits will result from the proposed project:

- GIS and cartographic modelling of monitored parameters on 2- and 3-dimensional DLM; presentation of multimedia volcanic and seismic hazard zone maps;
• 4-dimensional modelling of hazard probabilities; crisis scenario design; development and testing of a multimedia information system; GIS combined with interactive multimedia for early-warning systems and assessment of vulnerability and risk (damage and loss);
• Communications for saving lives; increasing public awareness of volcanic and associated hazards, preparation of educational material;
• Improvement of Ocean Bottom Seismographs (OBS) of GeoPro for long term multi-purpose operation.
1.5. Other Projects

**FOREMMS**  
**IST-1999-11228 + IST-1999-71228**

Forest environmental monitoring and management system

The statement of Forest Principles, signed at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992 – the first global consensus on forests, deals with the needs of people who want to protect forests for environmental and cultural reasons and with the needs of people who use trees and other forest life for economic development. The Rio statement says that forests, with their complex ecological processes, are essential to economic development and the maintenance of all forms of life.

Europe has a long tradition in recognising the importance of forests. One project, which deals with forest monitoring, is **FOREMMS**. Data from *in situ*, airborne and spaceborne instruments are integrated in order to get an overview of the environmental situation of the forests in Europe. Integration of such data on different scales is far from straightforward. A novel result of the **FOREMMS** project is a statistical data analysis method to combine data from different sensors at different scales.

The methodology has been demonstrated using five different types of data sources:

- Point measurements using portable instruments;
- Automatic environmental monitoring stations running continuously and providing long time-series’ of stationary point data;
- Airborne very-high-resolution spectrometer and radar data resolving individual trees (1 metre pixel resolution);
- High-resolution satellite measurements from multispectral sensors (30 m pixel resolution);
- Moderate resolution satellite data from multispectral sensors (1 km pixel resolution).

Why are these three scales needed? Simply expressed, you can either cover large areas frequently (e.g., daily) with low spatial resolution or the same areas more seldom with high resolution (e.g., monthly or annually). In order to compensate for this trade-off between the spatial resolution levels and frequency of coverage, a novel statistical model has been developed that links the different levels. Information from a higher-resolution level is used to calibrate the data interpretation method at a lower resolution level.

In practice, only small areas, carefully selected to represent “a little Europe”, are chosen for monitoring at the very-high-resolution scale. At the next level, the whole of Europe will be covered every few years. At moderate resolution level, the whole of Europe is in principle covered each day (if clouds are absent).

The statistical model allows calibration results to propagate between the three levels up to the coarsest resolution. Hence, accurate information about the forest at the highest resolutions is applied for the extraction of as much information as possible from the lowest resolution. With this approach, it is possible to detect small environmental changes in the European forests from one year to the next. Thereby, the forest environment can be monitored accurately in the short term as well as in the long term.
Figure 39: Examples of data from the three remote sensing scales, all covering parts of Italy: aircraft with AISA spectrometer (1 m pixel resolution), Landsat satellite (30 m) and Terra satellite with the MODIS sensor (1 km). The three pixel grids are illustrated in the bottom left corner.

Figure 40: Example from the FOREMMS web portal, which has produced an environmental forest map for parts of Southern Europe using the multi-scale data analysis methodology.
LOCCATEC IST-2000-29401

LOw Cost CATastrophic Event Capturing

Effective search & rescue operations are, along with the training for self-protection, the most promising means to reduce human casualties due to building collapses. Time is the critical factor for a successful rescue. The prompt availability of reliable information on the position of people trapped and the structural state of the ruins is therefore vital.

The prime objective of the LOCCATEC project is the design and realisation of a system which would make reliable information on the presence (or not) of people in each closed space of the building during its collapse available quickly and cost-effectively to the rescue teams.

The LOCCATEC system comprises capturing devices (small, low-cost, autonomous devices, pre-installed in each building space) and central unit(s) (portable units to be carried by the rescue teams).

Each capturing device, adequately integrated and packaged so as to survive a possible collapse of the building, uses a highly sophisticated system for capturing and treating images taken in any lighting conditions. Once the device is properly installed and configured, the image processing algorithm is able to detect a structural modification leading to a collapse, allowing the images taken during the collapse to be stored.

Figure 41: The developed sensing elements and boards of the LOCCATEC capturing device (1)
The rescue team, equipped with the **LOCCATEC** central unit, upon arriving at the vicinity of the collapsed building, will transmit a signal, triggering the wireless download of the information stored in each capturing device. The stored images (together with other information like identification keys, location etc) are transmitted using a wireless connection based on the IEEE 802.11b standard and a dedicated encrypting algorithm.

Finally, the Rescue Team can quickly browse the images and assess the presence (or not) of trapped people, using a user-friendly HMI, specifically developed for use during an emergency. Such a complete system has been described in the file application for a European Patent.

Project Web site: [http://www.loccatec.org](http://www.loccatec.org)

![Figure 42: The developed sensing elements and boards of the LOCCATEC capturing device (2)](image-url)
CLIFF IST-1999-14104 + IST-1999-14104E

Cluster Initiative for Flood and Fire emergencies

Natural disasters can span large regions, with the possible involvement of several countries; this increases the difficulty of coordinating disaster management activities. Different policies, procedures, data standards and systems, result in problems related to data analysis, information delivery and resource management; these are critical elements of Disaster Management (DM).

CLIFF studied such critical DM elements, analysing some 20 past and ongoing flood and fire projects, and, in what is considered as the main result of the project, identified the main problems, guidelines, (near 50) recommendations and possible strategies to progress towards standardisation of key DM activities. The focus of CLIFF was on the use of Earth observation data.

The final recommendations of CLIFF cover follow-up activities and include: the creation of a DM glossary; the update of VADEMECUM of Civil Protection (European Commission (EC), Directorate-General Environment) based on DISMAN (ESA study-2000) database; the on-line publication of historical disaster events; similar analysis activities for further countries and more disaster types; the use of further initiatives with an early focus on related potential business matters concerning the exploitation of the data, their inherent capabilities and utilisation; a move to operational views and an implementation strategy covering operational services; and parallel RTD studies to launch for services sustainability. Some ideas for follow-up initiatives by the EC are:

- The European Commission’s Directorate-General Information Society could promote operational implementation with appropriate emerging technologies (GRID, wireless, web-services, sitcoms, Earth observation, etc.);
• Its Directorate-General Research could create a network of excellence for some remaining issues: detailed weather forecasts, EO and meteo merged for prediction, fire modeling, validation of model for operational use, etc.
• CLIFF recommendations should be merged with INSPIRE and EU-MEDIN initiatives and maybe others….

The **CLIFF** results are a basis for different international initiatives like GMES (Global Monitoring for Environment and Security), and the Civil Protection and the environmental emergencies European network (PROCIV-NET).

![Figure 44: CLIFF did not only study projects analysing fires but also flood projects](image.png)
**SODA IST-1999-12245**

Integration and exploitation of networked solar radiation Databases for environment monitoring

The **SODA** Service offers one-stop access to a large amount of information relating to solar radiation and its exploitation. This service itself is not a warehouse. The innovation is an intelligent system (**SODA IS**) that builds links to other services (called resources) that are located in various countries. To answer a request, the **SODA** service invokes several resources to elaborate the appropriate answer and ensures the flow and exchange of information between the resources and itself, and with the customer. A resource can be a database, or an algorithm that operates on data to create new information, or an application that provides information that can be directly used by professionals.

Many applications are covered by the **SODA** web service: solar resources, solar energy and solar radiation and its uses, such as renewable energy systems (photovoltaic, solar systems for water heating, solar plants, solar heating and cooling), energy efficiency in buildings and solar energy systems, architecture, day lighting in buildings, environment, meteorology, climatology, global climate change, health, air quality and pollution, oceanography, water (reservoirs, eutrophication), primary production, vegetation, agriculture, forestry, horticulture, material weathering...

![Figure 45: Solar panels for photovoltaic electricity production in a desertlike landscape](image)

The service is in operation since 2002 and receives approximately 600 visits per month.

Recently, the **SODA** Service provided an insight into the heat wave that killed 15,000 people in France in August 2003. A large increase of solar radiation enhances the increase in air temperature, especially in the absence of wind and precipitation. This happened in July and August 2003. The map (Figure 46) exhibits the monthly mean values of the daily irradiation (in Wh/m²), observed over France and surroundings, for the month of August, averaged over the period 1993-2002 (left map), and for the month of August 2003 (right map). The difference is striking. One can clearly see the increase in radiation in August 2003 with respect to the mean value for the 10 previous years. This increase of approximately 1 kWh/m² is almost constant over the whole of France. It indicates a relative increase of 20 % with respect to the normal. One may note that in northern countries there was no change with respect to normal levels. This strong
increase over France explains the heat wave that killed many elderly people because of respiratory problems.

Furthermore, the strong sunshine, combined with absence of wind, caused long episodes of pollution due to traffic in large cities. Recent studies report that nearly 3 million inhabitants were affected.

Figure 46: A cloudless sky contributed to the heat wave in France in summer 2003. The left figure shows the average irradiation in Wh/m² in August in a ten-year period, the right one the comparative figure for August 2003. The spectral bar below represents the daily irradiation in Wh/m².
**ROBOVOLC    IST-1999-10762**

**A Robot for Volcano Exploration**

The main objective of this project was the development and demonstration of an automatic robotic system to perform measurements in a volcanic environment. There are currently 1500 volcanoes on Earth which are potentially active, 500 of them have been active during last 100 years and about 70 are presently erupting. Ten percent of the world's population lives in areas directly threatened by volcanoes, and far more are affected if the effects of eruptions on climate or air-traffic for example, are included. About 30,000 people have died from volcanic eruptions in the past 50 years, and billions of euros of damage have been incurred. As a consequence, it is important to study volcanoes and develop the technologies to support the volcanologists in this process.

In the last decade alone, due to both the unpredictable timing and to the magnitude of volcanic phenomena, several volcanologists have died while surveying eruptions. A major aim of the proposed robotic system was therefore to minimise the risk for volcanologists and technicians involved in working close to volcanic vents during eruptive phenomena. It should be noted that observation and measurement of the variables relating to volcanic activity are of greatest interest during paroxysmal phases of eruptions, which unfortunately are also the time of greatest risk for humans.

The principal results of the project were the development and test of a prototype robot suitable for autonomous and/or semi autonomous exploration of natural irregular and extremely rough unstructured environments. The locomotion system of the robot is able to operate in a typical volcanic environment scenario. In particular, the materials to be adopted are resistant to the temperatures and contaminated atmosphere encountered during missions and to the impact of volcanic bombs and blocks.

Another result was the development of a small measurement system for lava and volcanic gas analysis, sample collecting and the measurement of the main physical parameters of a volcanic eruption.

**ROBOVOLC** was a 42 month project (1 March 2000 – 31 August 2003) co-funded by the EC Fifth Framework under the IST Programme (contract number IST 1999 10762), total effort approximately 300 person months, project cost 2.5 M€ with 1.7M€ EC contribution.

Several laboratory, and indoor and outdoor tests were carried out to assess the functionality of the final system. In addition, three on-site test campaigns on Etna volcano were performed in September 2002, June 2003 and August 2003, to demonstrate the functionalities of locomotion, rock and gas sampling, terrain reconstruction, tele-operation capabilities, operational life, and telemetry. On the project web site [http://www.robovolc.dees.unict.it](http://www.robovolc.dees.unict.it), more details concerning the final tests and results are reported.

The main innovation of this project is the capability of taking measurements during volcanic eruptions through the development of a specific mobile robotic system for this purpose.
This robot will have an impact on the mitigation of the volcanic risk both in general, since it will contribute to increasing knowledge about volcanic phenomena, and in particular because it will be integrated in the volcanic surveillance system to be used when the approach to active vents becomes too dangerous for humans, but information is vital for a correct forecast of dangerous eruptions. For instance, during the volcano unrest that precedes a large eruption when the gas emission, thermal variation and ground deformation inside a crater or caldera, related to the ascent of new magma, give direct information for forecasting the approaching eruptive event; or during long-lived volcanic eruptions, such as large dome inflation, the evaluation of the lava dome stability will significantly improve the forecasting of dome failures and pyroclastic-flow forming eruptions.

The robot activity will contribute to an integrated risk management system by means of updating, using GIS, of areas potentially threatened by catastrophic eruptions with geographical information. This will include information about the volcanic products dispersion and volcanic hazard assessments, to allow almost real-time early warning and to inform Civil Protection authorities about imminent dangerous volcanic eruptions.

The field tests demonstrated the usefulness of a mobile robot in contributing to scientific research for vulcanology. The system is now a new tool owned by Istituto Nazionale di Geofisica e Vulcanologia in Sicily, who are responsible for surveillance of Mt. Etna and the other Sicilian volcanoes in the Aeolian Islands. The ROBOVOLC system is ready to be used in the next active volcanic phases.

*Figure 47: The ROBOVOLC robot “in action”*
One of the greatest threats to mankind is climate change. Weather patterns indicate that environmental conditions are changing with increasing speed. One of the most significant changes is warming of the global climate. However, although there may be warming on the global scale, there will be large regional variations in climate that will affect different parts of the world in different ways.

In fact, Europe may be the most sensitive part of the world and it is not yet known whether we will experience regional cooling or warming in a future warmer world.

The EUROCLIM project is developing a monitoring system for climate change and provides information through a web portal. Up-to-date climate-change information is retrieved from satellite data and applied to a climate model. The result is regional information on current changes and the potential future climate in Europe. The information is tailored to three main user groups:

- **Citizens**: Overall information understandable to non-professionals (including educational institutes, schools and the media)
- **Operational users**: Organisations supplying decision makers with information, typically using climate-change indicator variables (e.g., European Environment Agency)
- **Scientific users**: Research organisations using detailed products in order to derive new information and make comparisons with other climate models.

The satellite observation products cover the whole Arctic basin, Greenland, Svalbard and Fennoscandia.

- The system monitors changes in sea ice, snow and land ice (Svalbard glaciers and Greenland ice sheet).
- The satellite observations are used to improve a regional climate model.
- The climate model output is also available through the portal.
- Users can study possible trends for key climate change indicators (like precipitation, temperature and wind speed) for the whole of Europe.
- The data can be viewed on screen as maps and charts or downloaded as products for local analysis.
Figure 48: Sea ice concentration in the Arctic. Observations show that the sea ice is decreasing. Loss of sea ice may change sea currents and thereby the climate in Europe. The web portal shows how the sea ice develops from month to month and from year to year.

Figure 49: Satellite observations show that Greenland is getting warmer. If the ice covering Greenland melts, the sea level will increase several metres. The web portal provides information on the current state of the Greenlandic ice sheet.
The TEASE project studies the infrastructure needs for European GMES networks. By considering three relevant complementary scenarios on GMES themes - risk management, international convention monitoring, and environmental monitoring - sizing requirements are assessed for an open, highly configurable and evolving architecture for GMES infrastructure.

For natural Disaster Management it is essential to have good, secure and interactive communication between the different actors (e.g. civil protection authorities, value-adders, data providers and modellers). For environmental monitoring and international convention monitoring, a lot of heterogeneous data and processes are commonly used all over Europe. It is essential to have a common data understanding and representation of these data (symbols, keywords…).

The objective of TEASE is to study the potential architecture of a GMES infrastructure which favours communication between the actors and data sharing, and to study suitable organisational models for the future deployment of this infrastructure all over Europe.

TEASE will also issue recommendations on how to fulfil this objective under technical, legal or financial constraints.

TEASE consists of the following steps:

- An analysis of requirements from relevant actors;
- A review and analysis of GMES-like operational and on-going infrastructure projects funded by ESA and the EC;
- The design of an architecture including the following functional aspects: Security for data storage; Interoperability; Telecommunications; Commercial and contractual aspects.

The architecture concept consists of sub-networks and charters such as mission, business, quality or interoperability. The architecture also proposes generic services at administrator level and specific services at end-user level, depending on their application needs. It is expected that the outcome of TEASE will serve as a basis for developing a Europe-wide operational infrastructure.

TEASE concepts should foster the development of GMES infrastructure by proposing an easy way to develop new sub-networks on specific GMES themes. A sub-network is adapted to the user’s profile, e.g. secured for risk management, widely spread (at European scale) for environmental monitoring.

TEASE should not only improve the communication between actors, but should also foster the development of the market for intermediate actors such as value-adders service providers and hence contribute to GMES development.
2. Moving into the 6th framework Programme

Focus on environmental risk management

Under the Sixth Framework Programme (2003-2006), RTD activities in the field of environmental applications focus on the management of environmental risk due to natural hazards, industrial accidents or even terrorist attacks.

The problem area

Currently, almost all of the 25 member states of the EU have very different information systems, operational procedures and communication systems that cannot readily talk to each other. Since 2000, significant R&D activities address those issues, including the development of a software platform that improves interoperability between civil protection systems as well as enhancing contingency and continuity planning in the public and private sectors.

The intention of this work is to create, validate and demonstrate a generic, open, integrated risk management system to support the whole chain of activities from assessment to recovery. Special attention will be given to the operation of European civil protection organisations in the case of large-scale natural and industrial disasters across all 25 European Union member states.

The RTD activities are divided into two sub-activities: the first one covering the monitoring, planning, forecasting, preparedness and recovery phases; the second dealing mainly with the alert and the response phase.

Risk planning and forecasting

Until recently, risk management components were developed independently by a vast range of institutions and organisations. Exchange of relevant information needed in dealing with risk is too often hindered by administrative and legal boundaries as well as a lack of interoperability on the technical side. The recently approved INSPIRE initiative (see http://www.ec-gis.org/e-esdi/) aims at harmonising geo-spatial information across the EU. This new deal offers a unique opportunity for a major overhaul of disaster preparedness and contingency planning as well as community involvement in risk reduction.

Improved accessibility to a wide range of socio-economic information will allow a more holistic approach, in which hazard vulnerability and risk assessment are addressed in an integrated manner, with the aim of mitigating the environmental, social and economic effects of natural disasters.

Current projects are working on service architectures for risk management based on open standards. This approach should dramatically reduce the cost of building and maintaining risk management applications, it will also allow the appropriate handling of systemic risk and the domino effect between risks. Future projects are expected to work on the improvement of in-situ monitoring systems and the quality of risk related data.
Crisis management operations

In planning FP6, it appeared that civil protection organisations had not benefited as much as other professionals from the new Information and Communication Technologies (ICT). Most of these organisations are poorly equipped and, since this market is rather small, provider companies are slow to invest in up-to-date applications and equipment. This was the one of the reasons for the EU to invest in this field, another was perceived as the opportunity to improve equipment interoperability, to allow different emergency actors, possibly belonging to different regional or national European authorities, to work jointly in case of large scale disaster.

Crisis management operations are based on a three level architecture concept developed during FP5: the coordination and command centre supported by function specific control rooms, the mobile command centres and the crew in the field. The function specific control rooms host the local management and interface with auxiliary functions (technical & scientific support, short term forecasting, meteorological office, emergency health care, public utilities, damage assessment, etc.)

Several FP5 projects populated this concept with a full range of advanced applications and emergency management tools which were tested and validated by end-users. These elements are to be integrated in Emergency Information Systems over a communication infrastructure supporting voice and data exchange through a robust messaging service.

A key objective of the current projects is the creation of a civil crisis management methodology and an interoperable command and control infrastructure. The current approach is building on NATO experience in coordinating multi-lingual teams and adapts successful methods to the needs of civil protection agencies. The project(s) will examine the effectiveness of an EU network of trans-national headquarters with the capability of dealing with more than one trans-regional crisis at any one time and integrate applications into a fully fledged C4I (Command Control Communication Computer & Intelligence) for civil protection operations.

Future developments should address the need for better integration of the wide range public safety communications and evolve towards network centric crisis management.
Further information is available from the

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