ISBN 978-3-00-024284-7

Why are you reading this book?

- Perhaps you deal with civil contingencies and environmental risk management
- Perhaps you are in insurance
- Perhaps your data and information content deserves exposure to broader markets
- Perhaps your domain expertise is needed in a time of emergency
- Maybe you are implementing part of a chain of services

Or perhaps you are reading this because you are keen to understand where current trends in technology and society are taking us and how these impact integrated risk management. If this is the case, then this is the book for you.

The **ORCHESTRA project** anticipated these trends and now has seen many of them develop into reality. ORCHESTRA is the acronym of Open Architecture and Spatial Data Infrastructure for Risk Management, a major Integrated Project in the Sixth Framework Programme of the European Commission. ORCHESTRA identified and addressed the major technological barriers between stakeholders for efficient information handling in risk management.

orchestra | an open service architecture for risk management

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by the ORCHESTRA Consortium

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[1] http://www.eu-ORCHESTRA.org/contact.shtml

Contents

Why ORCHESTRA? 1

WHY ARE YOU READING THIS BOOK? 1.1

- Perhaps you deal with civil contingencies and environmental risk management;
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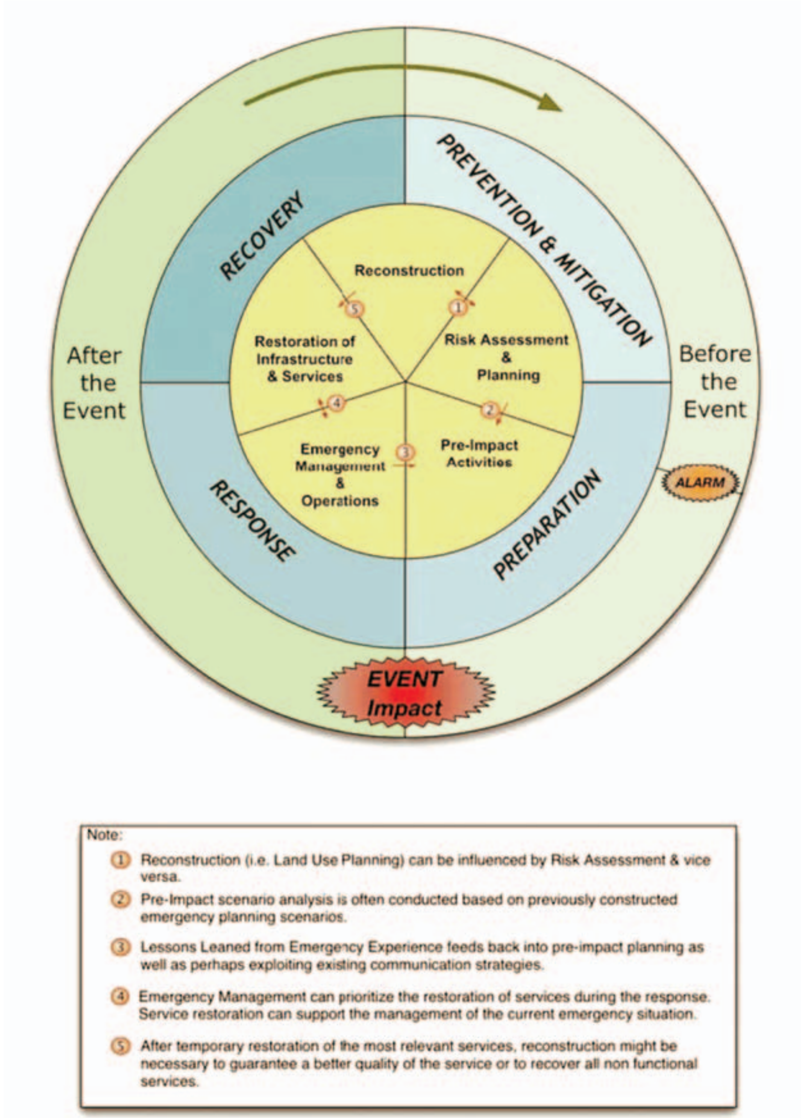
BORN OF NECESSITY 1.2

Natural and man-made disasters are on the increase. So too are the number of agents involved with different phases of the disaster cycle.

In ORCHESTRA disaster risk management is considered a systematic process. Effective administrative decisions and skills (both organisational and operational) underpin policies and strategies designed to lessen the impacts of natural hazards and related environmental and technological disasters. All activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards are considered in this definition. The following graphic outlines the different phases of disaster risk management:



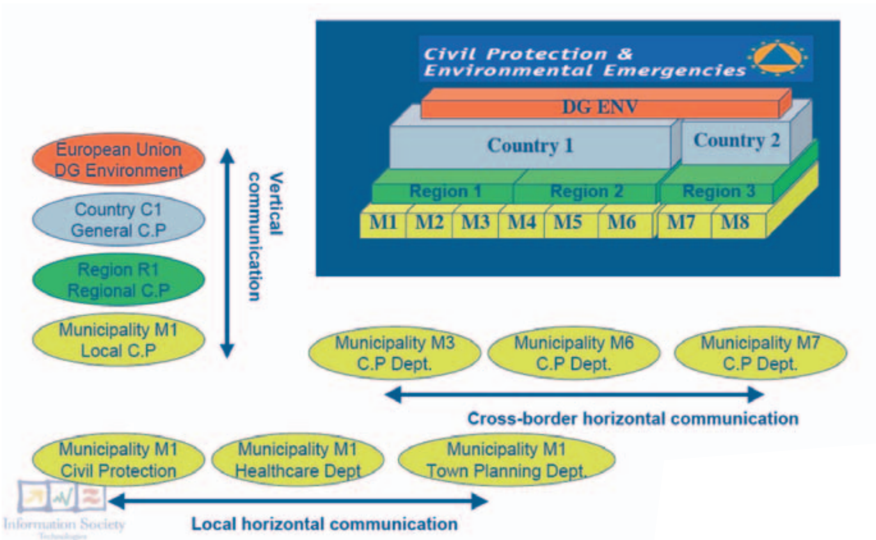
Floods, forest fires, landslides, storms, earthquakes and industrial accidents claim an increasing number of victims and cause increasing economic loss. Increasing even more rapidly is the capability of technologies and approaches to deal with these risks.

As governments and businesses seek more integrated information and systems the situation gets ever more complex. Issues of:

- accessibility to information;
- interoperation and shared standards;
- coordination; and
- terminology

potentially stand in the way of integrating information for efficient risk management; even within a single domain in a single country!

To attempt integration for cross-border applications and for multiple risks creates a challenge. That complexity is illustrated in the graphic below:



For this reason the EC's Directorate General INFSO (Information Society) specifically called for Integrated Projects that would foster the emergence of an information infrastructure and service platforms that will facilitate the use of interoperating components applied to risk management, security and the environment.

The 42 month-€14M ORCHESTRA project has now developed an open service-orientated infrastructure that supports risk management. The ORCHESTRA project team comprises 15 organisations with interests ranging from consultancy for specific risk domains to content provision and software engineering. Their collected wisdom is now ensconced in software, standards and the methodologies you can use to start building interoperable networks of services.

1.3 USING THIS BOOK

This book is broadly split into two halves. Start with the half you feel most comfortable with.

1.3.1 The Business Perspective (chapters 2 to 4)

The first half covers the trends, the purpose and the over-arching benefits (including an exploration of the cost and benefits) of a more networked approach to risk management.

Reading this section will:

- give you an awareness of why open architectures are important;
- provide you with trends in society and technology that support the growth of open and networked approaches;
- inform you of the value of the infrastructure in terms of opportunities and legislative drivers.

Overall, the section addressing the business perspective will give you the tools to justify your involvement in this new age of open, networked services.

1.3.2 The Technical Perspective (chapters 5 to 7)

The second part of the book deals with a key deliverable of the project, the ORCHESTRA Open Architecture for Risk Management (the RM-OA). Think of this as a cook-book for the setting up of services that are either generic or specific to a particular risk area.

Drawing on the published standards of the International Standards organisation (ISO) and the Open Geospatial Consortium (OGC) it provides a best practice framework for setting up services that can be readily networked.

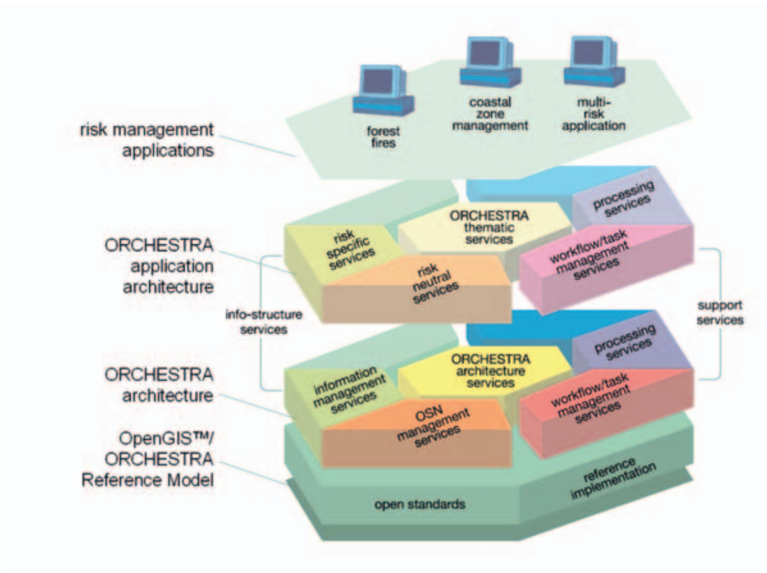
Once networked the end user (perhaps a risk manager working on a civil contingency scenario) can draw upon information from a greater variety of sources, allowing them to use the best information in the world rather than the best that they have on their hard drive.

This section will give you:

- the information you need to build your own Service Network;
- the information on all the software and services amassed during the project;
- demonstrations of the use of the Open Architecture within pilot projects;
- a discussion of the use of the architecture in sister projects already active around the globe.

Ultimately, this section will give you the information you need to locate the key software components, understand their purposes and implementation and build upon them to make your own service or chain of services.

That service architecture is illustrated in the following figure:



A BLUEPRINT FOR THE FUTURE? 1.4

Any approach that will support the exchange of and access to relevant information within the highly complex network of risk management information sources is an improvement. The ORCHESTRA proposition is solidly engineered, based upon a compelling vision and universal in its applicability to joining up services on-line.

In addition to the recent technological developments, on the policy side there is a push for more integrated approaches for the management of man-made and natural hazards. Under the umbrella of INSPIRE and GMES many new trends in regulation and policy that deal with environmental risk have an emphasis on data exchange.

Adopting the design principles of ORCHESTRA allows organizations to adjust to future national legal landscapes that are increasingly influenced by European initiatives.

As a project, it provides a vision of a necessary future. As a set of deliverables, it offers a blue-print of that future.

The ORCHESTRA Project 2

ORCHESTRA (an *Open Architecture and Spatial Data Infrastructure for Risk Management*) is a major Integrated Project in the Sixth Framework Programme of the European Commission. It focuses on the technological challenges that limit effective information handling in environmental risk management.

Risk management activities involve multiple organisations at various administrative levels, each having their own systems and services. Unfortunately the capacity to share relevant information between organisations is still too limited, thus preventing a truly efficient handling of incidents. This often becomes apparent in cross-border environmental disasters, such as oil spills or extensive flooding, yet often the same underlying issues hinder efficient information exchange at smaller scales as well.

The increasing number of man-made and natural disasters highlights the urgent need to consolidate information from disparate information systems to support citizen protection as well as disaster and emergency management operations. Hence, one of the most urgent and important challenges facing governments is to get these systems to work together and share information to allow proper data analysis and resource management. These are both critical elements of risk management.

ORCHESTRA targeted the technological challenges of information exchange in multi-disciplinary and multi-national use cases. The results of this work have been provided as input to the INSPIRE and GMES initiatives as well as to the relevant standardisation bodies and are taken up in a number of other reference projects.

To ensure widespread uptake and allow a continuation of the work of ORCHESTRA in other projects, the major results have been made available free of charge on the project website.

2.1 ORCHESTRA OBJECTIVES

The objective of ORCHESTRA was to improve interoperability among risk management authorities in Europe in order to support more effective disaster risk reduction strategies and emergency management operations.

According to this objective the main goal was to design and implement an open service-oriented software architecture, which improves the interoperability among actors involved in multi-risk management.

Another objective in the design process was to pay special attention to the combination of spatial and non-spatial data and services. A solution that follows the ORCHESTRA approach should be capable of making maps and related information from documents or databases readily accessible.

From the beginning of the project, the ORCHESTRA architecture has been anticipated as a precursor of the INSPIRE and GMES infrastructure. One of the project objectives is to assist and support the development of INSPIRE technical specifications and guidelines in the INSPIRE preparatory phase and to develop the software infrastructure for enabling risk management services.

2.2 PROJECT APPROACH

Three different communities of users were identified that would benefit from ORCHESTRA results:

- **System users** such as IT architects, system developers and integrators that conceive and develop risk management applications would be enabled to share and integrate data that can be transformed into relevant information. By facilitating the integration of their current technological solutions this group would be able to provide improved services to their end users.
- **Providers of data and application services** that are used for risk management will benefit from thematic information services that can be applied in many different risk scenarios. Information services represent a new channel to be exploited by this group. These information services should be more profitable, since they can be directed to more customer segments than mere data services.
- **End-users** such as members of public, agencies or private companies that use the thematic applications (built according to the ORCHESTRA specifications and using the ORCHESTRA services) benefit from more efficient interoperable services that easily integrate with the current technological reality. To coherently handle both spatial and non-spatial data and to assure the exchange of information among different actors at different levels from local to national is a major efficiency and effectiveness benefit.

The ORCHESTRA Architecture has been designed and developed by following an open and standards based approach to identify user requirements and translate them into generalised specifications. These specifications are now contained in a document called the *Reference Model of the ORCHESTRA Architecture* (RM-OA) which has been accepted by the Open Geospatial Consortium as an Approved Best Practise Paper[2].

ORCHESTRA designed and implemented specifications for a service-oriented spatial data infrastructure based on a review of available technologies, policies and standards, as well as dedicated user requirements.

To ensure that the developed specifications are useful and applicable to real world problems, ORCHESTRA has implemented a number of services as open source components and integrated them with use case pilots throughout Europe. It could, thus, be demonstrated that the developed services are useful for various multi-risk management applications based on the architecture specifications.

The following section briefly summarises the key results of ORCHESTRA.

KEY RESULTS 2.3

There are a number of major results, accomplishments and experiences that could be of benefit to users and stakeholders who wish to follow the ORCHESTRA approach. The following list provides a summary of the more important items that are publicly available:

- The **Reference Model for the ORCHESTRA Architecture (RM-OA)** provides a specification framework for system architects, information modellers and system developers. The ORCHESTRA Architecture is a platform-neutral (abstract) specification of the informational and functional aspects of service networks taking into account and evolving out of architectural standards and service specifications of ISO, OGC, W3C and OASIS.

[2] http://portal.opengeospatial.org/files/?artifact_id=23286

- The **ORCHESTRA Services**, which are the building blocks for applications, can be broadly divided in two groups: ORCHESTRA Architecture (OA) Services and ORCHESTRA Thematic (OT) Services:
  - Abstract specifications and implementation specifications of **OA Services** are also available for free at the ORCHESTRA website.
  - Specifications for **OT Services** are being finalised for publication as this book is written, and shall be available at the same link.
- Selected **ORCHESTRA software components** and tools are available free of charge and under open source licenses, so that future ORCHESTRA-based developments do not have to start from scratch and re-invent the wheel.
- A number of **interactive on-line training units** provide an introduction to ORCHESTRA as well as dedicated guidelines to understanding and adopting ORCHESTRA, e.g.;
  - Introduction to service-oriented architectures and standards,
  - How to build an ORCHESTRA Service Network,
  - How to apply the ORCHESTRA methodology to new Use Cases, etc.

Apart from these specific results, no matter how relevant, it is important to mention the broad experience gained during the design, development and deployment of the ORCHESTRA Architecture and the applications based on it.

The practical and hands-on experience achieved within the four pilot implementations in ORCHESTRA has been invaluable. An effort has been made to condense the most relevant findings into information contained in the technical section of this book and in the on-line training units.

There are other more specific items that may be offered for research or other purposes, so do not hesitate to contact the project coordinator[3] if you intend to adopt, re-use or build upon ORCHESTRA results.

[3] Refer to www.eu-orchestra.org for up-to-date contact details.

The Challenge: IT Evolution and Trends

3

Relatively recent technological developments such as: the World Wide Web, GPS, wireless broadband, mobile devices, digital cameras, sensors and the convergence of these technologies are changing the way information models, information architectures and platforms can and will be developed.

COLLABORATIVE ENVIRONMENTS 3.1

Our general information model has significantly changed: it has changed from a linear, push, publishing model to an inter-networked, participatory model where users create, share, and mash-up data. Information and computing are becoming ubiquitous and pervasive where the knowledge and distributed power is in the network:

The World Wide Web changes everything!

Now, in the next step, the Web2.0 world, as it is termed, everything changes again and this time the changes are characterised by the four principles of what Tapscott and Williams (2007) call 'Wikinomics':

- openness;
- peering;
- sharing;
- acting globally.

In the emerging Web2.0 environment the design principles become those of:

- taking cues from your leading users;
- building a critical mass for collaboration;
- provide infrastructures, frameworks and services for community participation and collaboration;
- concentrate on structures and governance;

- ensure all participants can harvest some value;
- think collaboratively to address the challenge.

The next generation of community and business leaders will apply this way of thinking naturally, for good and ill. The explosive use of social networking tools such as MySpace, Facebook and YouTube is testament to that fact. These will shortly be the technologies that drive collaborative, sharing, community-based approaches to problem solving.

Mass collaboration now changes everything again!

The following chapter provides a brief overview of the evolution of underlying IT concepts, reflecting the rapid development of technology capabilities as well as user requirements.

3.2 IT EVOLUTION: TOWARDS DISTRIBUTED SERVICES

During the second half of the 20th century, information science and management showed a clear trend towards fragmentation and distribution at several levels: computers experienced a dramatic reduction in size, accompanied by a parallel increase in performance and functionality, reduction in price and wide dissemination. The latter is more significant since the appearance of the personal computer (PC). But not only did the machines exhibit this evolution so did software.

Irrespective of the field of application or programming language, computer programs evolved from huge pieces of software with increasingly complex internal structures to more numerous but simpler pieces of code. In a sense, computer programs went through the process of specialisation that has been so common and widespread for some time among humans, especially in large institutions. The advantages of this trend were clear: even large computer programmes became manageable, there was an improvement in efficacy and efficiency when debugging and troubleshooting, it became easier to compose new pieces of software by re-using and re-combining existing ones (which were fairly small, well-described and provided limited and specialised functionality) and so forth.

Towards the end of the 20th century a key turning point was reached with the widespread acceptance and use of the Internet. It was quite straightforward for anyone to access a vast computer network where information of any kind is generated, shared and continuously modified.

The equivalent milestone for computer applications and programs was the appearance of the Service-Oriented Architecture (SOA) paradigm. The process of fragmentation and simplification of code had previously been reflected in ideas and paradigms such as modularity or object orientation. With SOA, an application becomes not just the result of the interaction among different pieces of code, but the result of the interaction among more atomic applications (software components) that provide very specific services.

Service-Oriented Architectures are based on loosely-coupled interacting software components that provide services.

SOA's basic underlying ideas are similar to those of a marketplace:

- A service is a specific piece of functionality made available by a service provider in order to deliver end results for a service consumer.
- A service consumer sends a service request to a service provider. The service provider returns a response to the service consumer containing the expected results.
- An application (from simple to complex ones) can be decomposed into the interactions among a set of services which, executed in a given order, end up providing the end user with the expected results.
- Not only the services but also the underlying computer infrastructure has to be taken into account.

Loose coupling means that the software components providing services are basically black boxes: their internal workings are interesting only to those developing or providing the service and what matters is their behaviour. Each service is described for provider and consumers by its interface, which specifies the functionality: the input that the service expects or is able to handle and the output it will provide.

Therefore, services are self-describing. They advertise their service capabilities, interface, behaviour, and even quality. The latter is measured by the QoS (Quality of Service), which describes both functional and non-functional service quality attributes, e.g. performance, security attributes, reliability, etc. This is important since it contributes to the overall quality of the software solution or application: the expected overall behaviour is defined generally in a Service Level Agreement between a providing company and its client institution, which is progressively mapped onto more detailed quality indicators and criteria down to the software service level. In this way overall quality can be ensured and managed from and through the specific QoS defined for each software service.

Services exhibit several other properties, for example:

- They are stateless, which means that users can use them without knowing the current conditions of the service;
- The usage of services is location-transparent, e.g. clients do not have to know if the service is local or only accessible over a network.

All these properties enable and support rapid and low-cost composition of services for distributed applications.

The following section will take a look beyond technology and focus on the challenges for the information society.

3.3 INFORMATION SOCIETY CHALLENGES

The need for information, as well as its production and consumption, grew so dramatically and quickly during the last decades of the 20th century that many Western societies have labelled themselves 'Information Societies'. As the generation and use of information has become greater and greater, information management is experiencing some important difficulties. One of them is the lack of interoperability: many systems cannot 'talk' to each other and exchange information effectively.

There are numerous reasons for that. Sometimes the problem is the incompatibility of data formats. Other times it is the incompatibility of platforms, of operating systems, of the meaning encapsulated in the messages or code (semantics) and so forth. In societies increasingly dependent on information, and where there are numerous providers and vendors, this problem becomes crucial and can only be solved by standardisation.

Standards create specifications to be followed by vendors, so that plural offers and competitiveness exist, while providing an underlying framework that makes different products or services compatible. This is always good for the customer, since the efforts of the vendor will be devoted to improving its delivery (rather than making more convoluted or cryptic products and services), and – more importantly – because the customer is no longer vendor-dependent! At any moment, since systems standards favour interoperability, a customer can choose an additional or a different provider, and the transition will be seamless with respect to information availability and management.

However, as described by Perens[4] open standards are not only specifications. They are open because they are available for any party to read and implement, with no associated cost (although going through a certification process may involve, naturally, a cost). Additionally, open standards do not favour some vendors over others, and the organisations that manage the standards only recognise the compliance or not of a vendor's products or services and ideally involves a fair share of users that bring in their real world requirements.

Eventually, information exchange is not only a technology issue, nor are IT evolution and trends the only driving factors. First and foremost it is the communication and information requirements of communities and their relation to society that need to be understood.

> **'People living now… have the opportunity, privilege, and responsibility to help to make all these things come true. All of humanity has struggled, dreamed, hoped, worked, and prayed for this moment in history. It is up to us to help make it happen.'**
> **Buckminster Fuller 1895–1983**
> Architect, Engineer, Mathematician, Cartographer

Humanity faces unprecedented challenges in managing people, processes, resources and the environment in a sustainable way. Our ability to identify both man-made and natural risks, and hence avert disasters, is associated with our understanding of the implications of future trends in the political, environmental, social and technological spheres. More importantly, it depends on our ability to collaborate and share the right information at the right time across potentially affected communities and domains.

> **'It's not the technology; it's the community, stupid!'**[5]

[4] http://perens.com/OpenStandards/Definition.html

[5] An open letter to Steve Ballmer http://communities-dominate.blogs.com/brands/2007/10/an-open-letter-.html

There are numerous political, environmental, social and technological challenges going forward, many of which add to the plethora of natural and man-made risks that need to be identified and managed:

- Global climate change has implications for sea level rise, changing weather patterns affecting the severity and frequency of flooding, drought, food and market security.
- Demographic trends, also influenced by globalisation and climate change, are illustrated by changing population movements across European and regional borders, reflected in a rapidly urbanising, older population, with increasing demands for scarce resources and government services and attempting to deliver more with less. There is growing competition for scarce resources be this land, property, clean air, soils, water, availability of transport or indeed energy resources where peak oil use (exceeding discovered reserves) is expected within this decade (Deffeyes, 2006).
- Competition for scarce resources, labour and markets will grow with the rapid growth of the Chinese, Indian, Eastern Europe and South American economies. These trends are likely to influence regional political and social pressures too and, in turn, contributing to natural and man-made risks.

These trends are recognised in the Lisbon agenda, and are the motivation behind European directives on, for example: ambient air quality, clean soils, ground water protection and the Water Framework Directive (see Annex 1: section A.2).

Given the above, governments and peoples are faced with what might be termed 'grand challenges' such as: global climate change and environmental sustainability, security and resilience (natural or man-made), transport congestion, managing scarce resources, aging populations, social exclusion, crime and disorder and education. 'Grand challenges' are considered to be cross-border and often global in nature. And, by their nature, they require a different mind set and approach to address them, which Jeffrey Sachs is calling a 'New politics of cooperation'[6].

[6] BBC Radio 4 – Reith Lectures 2007 – Lecture 5: Global Politics in a Complex Age http://www.bbc.co.uk/radio4/reith2007/lecture5.html

Addressing global climate change requires global, regional, national and local governance as well as corporate, community and individual involvement.

All are stakeholders in meeting the challenge!

To address these grand challenges and the risks they pose we therefore require information management and information sharing tools, infrastructures, services and attitudes that enable collaborative and community working. These requirements, combined with the various political, environmental, social and technological developments are the ingredients to the driving forces that will drive social change over the next 10–15 years (see for example Johansen, 2007). Parker and Stileman (2004) discuss these challenges with respect to information providers and users within the domain of disaster management and the research challenges they pose.

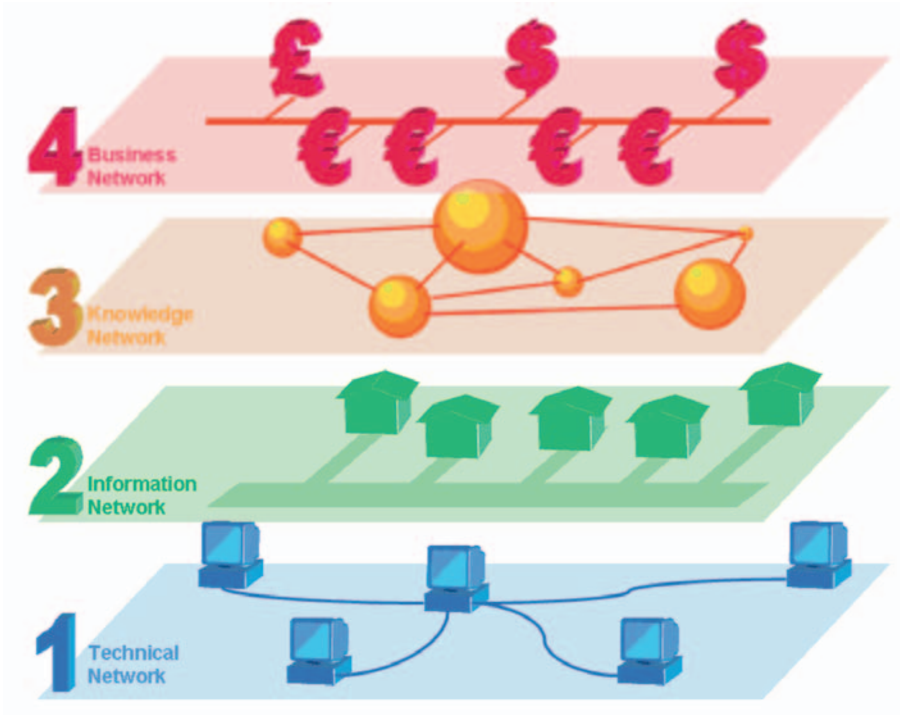
Within the ORCHESTRA project hands-on experience has been gained by implementing this philosophy of collaboration within distributed environments. To address this issue an open risk architecture has been designed and tested. Within this architecture emphasis is placed on the collaborative aspect of risk management.

Spatial Data Infrastructures and National Digital Networks 3.3.1

Spatial Data Infrastructures are the enabling organisational, information, and technical structures that underpin spatial applications. They allow geospatial information to be managed and distributed in a more interoperable and harmonised way making it easier for that information to be combined and analysed.

ORCHESTRA is an example of a risk management architecture that plugs in to the building blocks of the upcoming European Spatial Data Infrastructures built under the INSPIRE directive[7].

[7] Official Journal of the European Union, L108, vol. 50, April 2007, http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2007:108:SOM:EN:HTML



The figure above gives a highly simplified view of spatial data infrastructures. You can think of it as a set of inter-connected networks:

- **The Technical Network** is the technical infrastructure of the physical computer network and computers hosting the standardised services. Most Spatial Data Infrastructures depend on the Internet for aspects of the Technical Network to exchange service and spatial information.
- Spatial Data Infrastructures enable a rich network of information with spatial location as a powerful way of joining separate pieces of information. Building **an Information Network** draws on information encoding standards and data specification standards that enable the exchange and integration of spatial information.
- **A Knowledge Network** relates concepts and ideas based on their meaning. We are familiar with creating and using maps of the geospatial environment around us. Knowledge networks create maps of abstract concepts linked by meaning or semantic relationships. The concept of building Knowledge Networks has been driven forward by the Semantic

Web initiative lead by the World Wide Web Consortium (W3C). It was a focus research area within ORCHESTRA and a key aspect in developing the Reference Model for the ORCHESTRA Architecture. The purpose of the knowledge is to define the meaning or semantics of information in such a way that information encoded in different formats and languages may be more readily interpreted and understood.

- **The Business Network** represents the trading relationships among a set of organisations, where each organisation contributes by adding value and, in turn, receiving compensation for the work done within a complete value network. The Business Network is essential if the spatial data infrastructure is to be sustainable. A business network allows providers and consumers of information to exchange value. Consumers benefit from being able to access a broad range of accurate, maintained and authoritative spatial information. Producers benefit from being able to offer high quality and higher value products based the investment they have made in creating and maintaining that information. This can also lead to a range of new products that address market segments that could previously not be reached.

On a European scale, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 established an Infrastructure for Spatial Information in the European Community (INSPIRE). INSPIRE provides the legal framework to address availability, quality, organisation, accessibility and sharing of spatial information needed in order to achieve the objectives set out in the Sixth Environment Action Programme. It also shall assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment. INSPIRE should be based on the infrastructures for spatial information that are created by the Member States and that are made compatible with common implementing rules and are supplemented with measures at Community level. These measures should ensure that the infrastructures for spatial information created by the Member States are compatible and usable in a Community and transboundary context.

A successful and sustainable Spatial Data Infrastructure requires balanced investment in building and maintaining these networks.

The challenges for technology and society, which we have identified in this chapter, are well recognized by the European Commission and addressed in the INSPIRE directive as well as the current Research and Development agenda of the European Commission.

Every challenge provides opportunities and ORCHESTRA actually shows how to implement services that support SDI requirements.

The next chapter addresses the qualitative benefits that can be expected from following the ORCHESTRA example and adopting open-standards based best practise approaches.

The ORCHESTRA Value Proposition

4

Investments in IT infrastructure developments focus mostly on reducing direct costs. However, in the domain of environmental risk management investments should also help to make our environment a safer place to be.

The availability of reliable and actionable information holds the key to improved efficiency and effectiveness in risk management.

This requires more of a long-term view with regards to cost and benefits estimates and also adds aspects which, though they may not be directly quantifiable, can have a significant qualitative impact on investment decisions.

A detailed cost-benefit analysis was not within the scope of ORCHESTRA, yet the experience gained during the project work and especially the pilot implementations clearly indicated that the topic is highly relevant and should be addressed in this Book.

Existing IT solutions tend to be geared towards their specific business environments and underlying business models, but often do not necessarily provide the flexibility to accommodate additional external requirements on an *ad hoc* basis. Whilst our social and environmental concerns and responsibilities easily let us identify with the facts, trends and visions outlined in the previous chapter, business solutions still mostly follow selfish objectives. From a merely economic point of view, this often also seems to be the best, i.e. most efficient and economic, way forward.

Yet there are more aspects to value IT infrastructures than just looking at it from your own core business point of view:

Opening up data vaults and networked information services can also add new aspects to your business models, open up new markets and help you to provide customers with improved services.

To this regard, ORCHESTRA and INSPIRE share a common view on key principles like:

- Spatial data should be collected once and maintained at the level where this can be done most effectively;
- That it must be possible to combine seamlessly (spatial) data from different sources across (the EU) borders and share it between many users and applications;
- That it must be possible for (spatial) data collected at one level of government to be shared between all the different levels of government (e.g. cross-organisational borders);
- That it should be easy to discover which (spatial) data is available, to evaluate its fitness for purposes and to know which conditions apply for its use

ORCHESTRA cannot provide figures on costs and savings associated with implementing open-standards based solutions. However, in this section:

ORCHESTRA highlights aspects that should be accommodated in individual cost benefits calculations that a stakeholder would perform to justify an investment.

The following chapter will take a look at the business impact of adopting open-standards based service-oriented architectures as the underlying principle of IT solutions in an SDI context.

4.1 ASSESSING COSTS AND BENEFITS

Naturally everybody would like to have exact numbers available about how much a project costs and when it pays back but, in the case of infrastructure development, like an SDI or ORCHESTRA, this is not so easy to answer.

Following the ORCHESTRA approach and adopting ORCHESTRA results will provide the following direct benefits:

- becoming interoperable;
- using standards;
- making data discoverable and accessible; resulting in
- new addressable market segments.

To which degree these benefits translate into hard cash is highly dependent on the individual stakeholders' business model and costing framework.

The following discussion on cost and benefits is mainly based on the outcomes of a JRC workshop held in Ispra in 2006[8], one of the first workshops held in Europe addressing this topic.

There are only a few studies available, which are characterised by a large number of assumptions so their validity has yet to be tested. This is because they are by and large *ex-ante* studies, i.e. studies that have been undertaken to justify political and financial support before a project is started. The missing link to obtain credible figures on actual implementation costs, subsequent operation costs and a full comparison of real before and after figures rarely happens. Moreover, work to date has focused primarily on set-up costs, and short-term efficiency benefits which are relatively easier to assess, than wider measures including indirect and organisational costs and longer-term social, political and economic benefits.

Our collective lack of accountable knowledge of the costs and the benefits of establishing, operating, maintaining and updating an infrastructure like ORCHESTRA (or any SDI for that matter) is due not only to the paucity of studies in this field but also the difficulty in identifying the beneficiaries of these connected distributed infrastructures. Consequently the user community becomes more diffused and varied. This in turn increases the difficulty of identifying and quantifying the monetary benefits.

The report addresses a very crucial point as it states:

> 'Whatever the assumptions made to arrive to the Cost and Benefit Analysis figures, there seems to be no monitoring mechanisms put in place to validate the assumption made over time and therefore contribute to knowledge in this field.'

Thus we lack a real understanding not only of how much an infrastructure costs, but also of the proportion of this cost in relation to existing investments in geospatial information, technologies and other infrastructure-related components.

To support the acceptance and uptake of INSPIRE, an assessment approach evaluated in 2003–04 the expected impacts of INSPIRE. The details can be studied in Craglia et al. (2003) and Dufourmont (2004). The conclusion of this

[8] Report of International Workshop on Spatial Data Infrastructures' Cost Benefit/ Return of Investment – Ispra, Italy 12–13 January 2006)

assessment came up with the following interesting figure for the implementation of INSPIRE over a 10 year period, including the European Commission, as well as National, Regional and Local Authorities and Organisations:

The estimated annual investments will range from 93–138m€

The estimated annual benefits will range from 770–1150m€.

This would mean per invested 1€ you would gain 8€!

This study also lists some impressive quantified benefits for

- cost-effective expenditure on environmental protection (300m€/year);
- more effective environmental monitoring (100m€/year);
- improved delivery of risk prevention policies (up to 400 m€); and
- health and environment policies (up to 350m€).

So apparently there is a good reason to also take a long-term view on costs and benefits when considering futures investments in IT information services. To further support this view, the following chapter takes a quick look at one of the few examples of actually comparable projects costs in the context of choosing standards-based solutions.

4.2 BENEFITS OF USING STANDARDS

ORCHESTRA has taken a look at a number of related studies which are freely available and should be considered in IT strategies and procurement processes. One good example is an extensive study which was done by Booz Allen Hamilton in 2005[9] on behalf of NASA's Geospatial Interoperability Office. The study compared two government applications of geospatial technologies:

- one project utilizing to a high degree standards like the ISO 19100-series, Open Geospatial Consortium Specifications and the Standards of the Federal Geographic Data Committee, and
- another project implementing none or few of these standards.

[9] available at: http://www.ec-gis.org/sdi//ws/costbenefit2006/

Standards-based projects where shown to have a 119% return on investment over the program that did not implement standards. The study demonstrated to NASA the value of supporting geospatial interoperability standards.

€1.00 invested in open-standards based projects nets €1.19 in savings in operations and maintenance compared to projects not based on open standards.

In addition to the long-term costs of ownership and return on investment, it is even more interesting from the ORCHESTRA perspective that standards actually lowered the transaction costs for sharing geospatial data when semantic agreement can be reached between parties.

Though the initial costs, e.g. for system planning, development and implementation for the project utilizing a high degree of open standards were higher, the total costs dropped in the third year, reflecting lower costs for maintenance and operations.

On the overall scale the spending on maintenance and operations were significantly less then in the comparable project adopting none or few of these standards.

However, positive though these results are in the defence of higher up-front investment for sustainable solutions, decision makers need to appreciate two facts:

- that even if a case is made through a positive analysis of costs and benefits, management may perceive that the upfront costs exceed the long-term return and that benefits accrue only to external partners; and
- that the value of adopting standards is poorly understood. Standards may not be perceived as applicable for the typical application (standalone within an organisation and not networked) and the domestic market may feel little or no pressure (from market or government) to support standards.

The NASA study provided important evidence that the adoption of standards can improve information sharing, foster improved decision making, build business resilience and lower maintenance and operations costs over time.

Two smaller case studies (performed in Catalonia, Spain) showed that on a regional level direct access to data (geographic) using standardized mechanisms (e.g. OGC web services, WFS and WMS) will save sufficient money to justify the higher up-front investment in more sustainable approaches and solutions.

One case study was performed by Cartographic Institute of Catalonia (ICC), reviewing the implementation of the goal of Catalan SDI initiative (IDEC)[10], namely to compile information on existing GI data and produce, generate and make accessible metadata, and provide several interoperable services offering its technological services to other interested agencies:

ICC saves approx. 500 000 Euros per year offering direct access to their data instead of producing data CD/DVDs for data distribution.

The second case study was made with the Catalan Architects Association (COAC) and compared standardized and proprietary access. The analysis showed a reduction in time and savings of money based on the implementation of OGC standards and a policy of free of charge cartography. Although the savings are comparatively small on an individual transaction client basis (about €100 for one search of data for one architectural practice), if multiplied across all architectural practices and all data searches and downloads, it leads to significant savings per year.

The next chapter takes a look at another set of (probably) unquantifiable benefits one gets from actively following the open approach taken by ORCHESTRA: by actively engaging in open source and open standards developments.

4.3 BENEFITS OF PRO-ACTIVE ENGAGEMENT

Spatial Data Infrastructures depend on an open and collaborative implementation model. It is about creating and supporting a community of interested individuals and organisations that mutually benefit through the sharing of spatial information and resources.

Anyone with a serious interest can benefit from the community by pro-actively contributing to the community, by allowing developers to maintain and update open software and information resources that may be used by the community and in turn, by re-using the work and results of the community.

Contributions to an existing Spatial Data Infrastructure can, e.g.: consist of hosting spatial services, maintaining spatial information, or creating a new community of interest, which will be advancing the science in a particular field of interest.

[10] http://www.geoportal-idec.net

Spatial Data Infrastructures enable new and innovative ways of distributing and sharing geospatial resources. E-Commerce and Geo Rights Management Standards, such as the OGC Geospatial Digital Rights Management standard enable new ways of trading information and new information based business models.

It is an opportunity to understand the needs of this emerging market and build a viable business to exploit this potential.

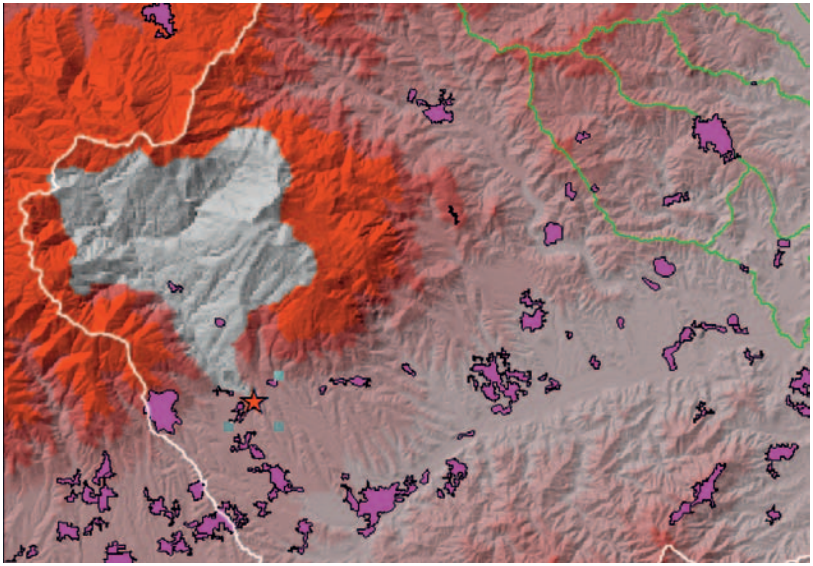
The following chapter provides a concise overview of the ORCHESTRA pilot implementations, which served to refine the specification and software developments and provided valuable insight into how an open-standards based and service-oriented architecture can support information exchange in environmental risk management.

5 ORCHESTRA's Use Cases and Pilots

The specification of the Service-Oriented Architecture (SOA) in ORCHESTRA has led to a comprehensive programme of interactions between software architects, software engineers and environmental risks management experts in the project consortium.

Four strategic pilots were specified and implemented to thoroughly test the SOA framework validity. As a result, four pilot use cases were tested against the usability and, to some extent, the re-usability of ORCHESTRA open services within the SOA framework.

A pilot on Risk and Damage Assessment of Forest Fires and Flooding had the main objective to test the ORCHESTRA architecture within the setting of pan-European risk and damage assessment. The pilot addresses the hazards of forest fires and flooding and enables stakeholders to access relevant information in an interoperable and interactive manner by providing appropriate web service-based tools. It also supports application developers to easily create service-based applications that support risk assessment by end users.



Example of forest fire simulation

The second pilot addressed the challenge of planning and management of multi-risk scenarios, in which different types of end-users, such as modellers, protection bodies members, policy makers and administrative managers, interact for the elaboration of common, collaborative risk maps due to several types of natural hazards, such as forest fires and flash floods. The main objective of this pilot was to improve the assessment context of decision-making processes during the joint prevention planning of various inter-related risks, in particular flash-floods and forest fires, in a typical Mediterranean river basin in Catalonia, Spain, with intense human activity in the landscape.

The main addressed challenge was to improve interoperability among the involved actors and systems to perform assessment through simulations and mapping of the possible expected risks due to forest fires, flash-floods and the combination of both. To achieve this, a set of services were deployed to increase the efficiency of information management, more specifically in regard to the query and access of the most appropriate data sources, thus adequately feeding the used models and processes. Two main knowledge and modelling domains have been synchronised, namely flash floods and forest fires, which have been physically and semantically related under the same temporal and spatial framework.

The third pilot addressed damage assessment, estimating the cost and disruption due to the closure of a portion of the road network in the French-Italian border region between Nice and Genoa. Such a closure could be caused, for example, by the occurrence of a natural (e.g. a landslide) or man-made (e.g. a chemical spill) event that physically blocks a route, makes it to dangerous to pass or limits its capacity. Since road closures can have a dramatic impact on the economic, social and functional life of a region it is important to be able to conduct 'what if?' exercises to forecast the type and size of disruption that could occur.

With the system developed within this pilot the user can:

- access data on hazard, historically damaging events, roads and traffic levels in the region;
- simulate events leading to road blockage;
- estimate pre- (without the blockage) and post-event (with the blockage) shortest routes between two points; and
- estimate the additional (infrastructure, functional and environmental) costs for journeys between these two points.

The last pilot described here, addresses marine environmental risks and as one example creates a risk map showing various types of toxicity risks to which marine species in the German Bight may be exposed. The displayed risk values on the map are calculated by the simulation component that accesses observation data and parameters from several data sources. The prediction of ship traffic environmental risks in the German Bight has been implemented as a web application with support for ontologies, workflows and document management.

Simulation of environmental risks from shipping traffic

All four pilots were implemented using open services designed under the ORCHESTRA SOA specifications. These services are remotely provided by the project partners, who in most cases are based in different locations.

The pilots demonstrate the use of distributed open services for integrated spatial information. They represent a technological milestone for improving environmental risk management practises and collectively challenge issues of:

- integrating fragmented information;
- systems interoperability;
- data sources multi-linguality; and
- cross-border information.

These are common and outstanding issues encountered by environmental risk operators, managers and decision-makers who want to achieve statutory compliance to the various EU environmental regulations.

ORCHESTRA provides an opportunity for service and solution providers to create new business relationships with European organisations who are involved in environmental risks management and decision-making: these stakeholders individually own valuable environmental data and tools that cannot be used unless they are integrated under a network of services such as those established in the ORCHESTRA pilots.

The added value of the integrated data and tools under the ORCHESTRA framework is very high and each data or tool provider will benefit from access to new information as a result.

This will also assist each individual organisation into improving their assessment of environmental risks, therefore their decision-making strategies.

More detailed technical descriptions of each individual pilot are provided in Chapter 7: Pilot Implementations.

This chapter now concludes the first section of this book, which has mainly addressed the business perspective of the work and results of ORCHESTRA and how they may be of relevance to third parties with an interest to adopt the ORCHESTRA approach.

The following chapters provide more detailed information on the ORCHESTRA Architecture, Pilot Implementations and a roadmap to the key results and options for using them for third party requirements outside ORCHESTRA.

6 The ORCHESTRA Architecture

There are undeniable trends that point the way to greater accessibility and flexibility in the design of services and their content. But what drives these trends? And how do these support the notion of an open architecture, particularly in the field of risk management?

Physically the demand for evidence-based decision making necessitates services based on the best data. Expectations from risk management communities are that these data can be accessed readily and incorporated into their applications with the minimum of fuss.

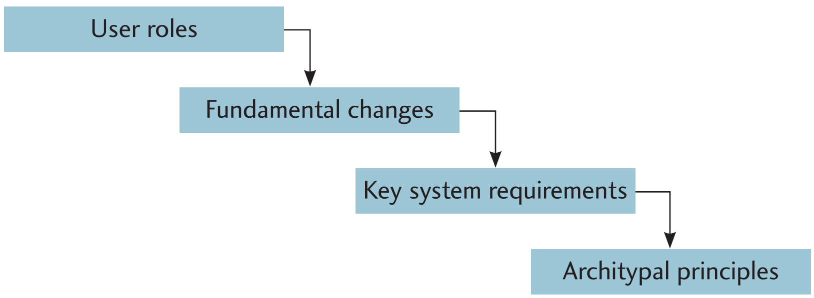
A range of new phenomena now support such 'free from hassle' services. The Web2.0 principle of embracing the wisdom of crowds points to a network of contributors working together, building upon each others' content and services to create a 'chain' of services meeting the end users need. Likewise the movement toward Open Innovation (Chesborough, 2003), by luminaries from personal care and medicine (Proctor and Gamble and Glaxo SmithKline) and mobile telephony (e.g. Motorola) demonstrates that organisations are willing to accept that external talent has a vital part to play in developing tomorrow's offerings. As Proctor and Gamble embrace a large proportion of its innovation from a network of external sources, so too the risk manager embraces the best data from outside of their immediate holding.

Open architectures, such as the Risk Management ORCHESTRA Architecture, enable this networking of services as already demanded by Denzer in 2004. Its approach is to enable a harmonisation of services on-line via non-proprietary tools. This allows those working on different technology platforms to integrate their content and services more readily. The ORCHESTRA Architecture reduces much of the technical barriers to networking of services.

Environmental risk and disaster management infrastructures, due to their cross-border nature, must deal with the requirements concerned with building and operating large-scale service networks. Such requirements were discussed and defined in a systems requirements activity.

System requirements for the ORCHESTRA Architecture encompass all functional and non-functional aspects that need to be considered in order to enable interoperability between systems. Interoperability here is defined as the capability to communicate, execute programs or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units. System requirements for the ORCHESTRA Architecture are requirements for the infrastructure, but are closely related to end-user needs. Within ORCHESTRA, these system requirements originated from the combined expertise of the consortium in the area of interoperability solutions. Thus, they are expressed in generic technical terms, i.e. independent of application domains.

The system requirements in the ORCHESTRA project were developed through a systematic process as illustrated in the figure below:



From user roles first fundamental integration challenges are derived. These challenges are used to define key system requirements, which in turn have the consequence that a large-scale architecture needs to follow certain sound architectural design principles. The whole chain is included in an annex of the Reference Model for the ORCHESTRA Architecture[11]. Here, just the architectural design principles are summarised:

- **Rigorous Definition and Use of Concepts and Standards**
  The ORCHESTRA Architecture shall make rigorous use of proven concepts and standards in order to decrease dependence on vendor-specific solutions, to help ensure the openness of the ORCHESTRA Service Network and to support the evolutionary development process of the ORCHESTRA Architecture.
- **Loosely Coupled Components**
  The components involved in an ORCHESTRA Service Network shall be loosely coupled, where loose coupling implies the use of mediation to permit existing components to be interconnected without changes.

[11] Available at the ORCHESTRA Web site under http://www.eu-orchestra.org/docs/RM-OA/RM-OA-V2-Annex-A2-Rev-2.0-Requirements_for_the_OA_and_the_OSN.pdf

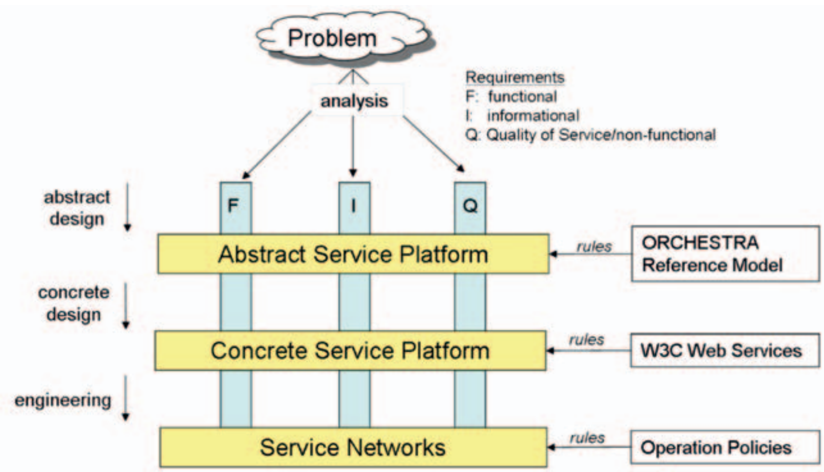
- **Technology Independence**
  The ORCHESTRA Architecture shall be independent of technologies, their cycles and their changes. It must be possible to accommodate changes in technology (e.g. the lifecycle of middleware technology) without changing the ORCHESTRA Architecture itself. The ORCHESTRA Architecture shall be independent of specific implementation technologies (e.g. middleware, programming language and operating system) and shall not be influenced by or deal with technical limitations of specific implementation technologies.
- **Evolutionary Development – Design for Change**
  The ORCHESTRA Architecture and an ORCHESTRA Service Network shall be designed to evolve, i.e. it shall be possible to develop and deploy the system in an evolutionary way. The ORCHESTRA Architecture and an ORCHESTRA Service Network shall be able to cope with changes of user requirements, system requirements, organisational structures, information flows and information types in the source systems.
- **Component Architecture Independence**
  The ORCHESTRA Architecture shall be designed such that an ORCHESTRA Service Network and source systems (i.e. existing information systems and information networks) are architecturally decoupled. This means that the ORCHESTRA Architecture shall not impose any architectural patterns on source systems for the purpose of allowing them to collaborate in an ORCHESTRA Service Network, and no source system shall impose architectural patterns on an ORCHESTRA Service Network.
- **Generic Infrastructure**
  The ORCHESTRA Architecture Services shall be independent of the application domain. This means that the ORCHESTRA Architecture Services should be designed in such a flexible and adaptable way that they can be used across different thematic domains and in different organisational contexts, and that the update of integrated components (e.g. applications, systems and ontologies) causes little or ideally no changes to the users of the ORCHESTRA Architecture Service
- **Self-describing Components**
  Components of an ORCHESTRA Service Network, such as data elements or services, shall include descriptions of their critical characteristics, including sources, assumptions and such like. The usage of self-describing components that provide context-sensitive formal and semantic descriptions of their interfaces can help to realise semantic interoperability.

Issues of dependability and security have not been considered explicitly during the project, because the ORCHESTRA 'mission' as defined by the European Commission was to look mainly into non-emergency risk management[12]. This also implies that the ORCHESTRA Architecture as it stands today can be used as an information backbone for emergency management systems but additional functionalities not provided by ORCHESTRA would have to be implemented in order to guarantee dependability in crisis situations. Issues of dependability would certainly become an issue if the ORCHESTRA Architecture were used in an emergency management context.

THE ORCHESTRA APPROACH 6.1

The ORCHESTRA approach has been specified in a Reference Model for the ORCHESTRA Architecture[13], or ORCHESTRA Reference Model in short. It is built upon two main pillars: a **process model** and a **conceptual model**.

The ORCHESTRA process model follows an incremental, iterative approach for the analysis and design phases across several abstraction layers. ORCHESTRA distinguishes between an abstract service platform that is specified independently of a given middleware technology and a concrete service platform:



[12] The project OASIS (Open Advanced System for Disaster and Emergency Management, http://www.oasis-fp6.org/) was working, in parallel, on command-and-control type emergency management systems.
[13] OGC Best Practices Document 07–097 by (Usländer (Ed.), 2007)

- In the analysis phase, the 'problem' is analysed together with the user and transformed into a set of requirements. These are categorised as:
  - functional requirements (F) that describe the use cases and the processes that a SOA system has to support; the
  - informational requirements (I) that describe the major terms and concepts the SOA system has to deal with; and the
  - qualitative requirements (Q) that describe non-functional requirements that deal with quality, dependability and security aspects.
- The abstract design phase leads to platform-neutral specification following the rules of the abstract service platform provided by the ORCHESTRA Reference Model. They represent the functional requirements in abstract service specifications, informational requirements in the information model and non-functional requirements as specifications of the quality of service of the problem domain.
- The concrete design phase maps the abstract specifications to a chosen concrete service platform. In the current ORCHESTRA project this is the ORCHESTRA Web Services platform consisting of the rules of the W3C Web services and a profile of the Geography Mark-up Language (GML) as the current mainstream service platform technologies for geospatial applications.
- In the engineering phase the platform-specific components are organised into service networks taking into account the qualitative requirements and translating them into operational policies.

In practice these individual phases are often interlinked and repeated in an iterative fashion. Sometimes the abstract design phase is not required in the first place. Furthermore, existing services and OGC service standards for Web services make a pure top-down approach improper. Thus, in practice, a middle-out design approach is often the appropriate method.

However, what is required is a clear structure for the documentation of the ideas and the results of the design phases. Like OGC, ORCHESTRA has adopted the ISO/IEC Reference Model for Open Distributed Processing (RM-ODP)[14] for this task. RM-ODP subdivides the specification of a complete system into the so-called viewpoints. However, as the RM-ODP has originally been conceived in the spirit of distributed object-oriented middleware, the ORCHESTRA process

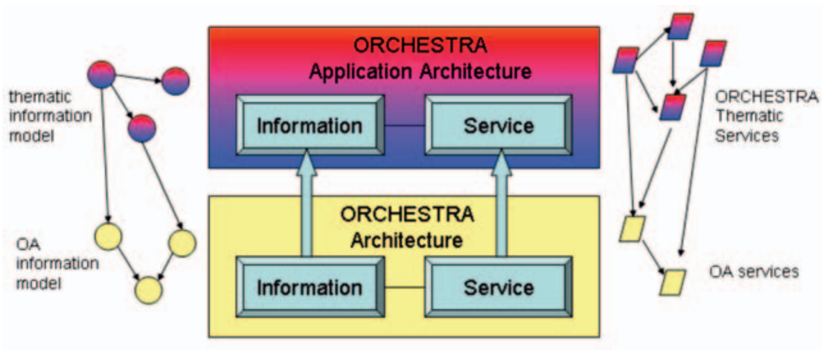
[14] ISO/IEC 10746–1:1998 Information technology – Open Distributed Processing – Reference model

model has adapted the RM-ODP viewpoints to the design of geospatial service-oriented architectures and service networks:

- In the **Enterprise Viewpoint** the user requirements, in terms of their functional, informational and qualitative aspects, are analysed and documented.
- The **Computational Viewpoint** is referred to as the Service Viewpoint in ORCHESTRA in order to stress that the focus is not on providing a distributed computing support with tightly-coupled components but on inter-connecting functionalities and information in terms of services. Thus, the Service Viewpoint classifies and specifies the functional requirements in terms of services. Specific to ORCHESTRA is the aim of specifying the services first in a platform-neutral manner (e.g. in UML) in order to be able to map to different service platforms as required.
- The **Information Viewpoint** classifies and specifies the informational requirements in terms of an information model. As for the services, the aim is to do this first in UML to be platform-independent.
- The **Technology Viewpoint** specifies the characteristics of the service platform upon which the services and information models are to be mapped for a specific geospatial service network.
- The **Engineering Viewpoint** specifies the mapping of the service and information model specifications to the chosen service platform(s). Furthermore, the operational policies of the service networks are derived from the qualitative requirements.

Now, in light of these viewpoints, the specification of the Information and Service Viewpoint resulting from requirements of the Enterprise viewpoint leads to an abstract architecture. Abstract here means that the service and information models are neutral with respect to a specific service platform and do not contain any particular dependencies on the peculiarities of a given platform.

The **ORCHESTRA Architecture** (OA) provides significant help in this design phase as it provides a generic modelling toolbox in terms of pre-defined but generic information and service types (OA services) upon which the functional and informational user requirements may be mapped. It is specified itself as an abstract architecture.



Of course, not all requirements may be directly mapped to existing generic information and service models. Thus, the ORCHESTRA Architecture also comprises a **conceptual model**[15] that provides detailed rules about how to specify in UML an information model[16] and service model (additional interface and service types) that fit to the pre-defined ones and adapt them for a particular application. Such additions lead to **ORCHESTRA Application Architectures** tailored to satisfy dedicated thematic user requirements which are expressed in thematic information models and thematic services.

However, ORCHESTRA does not stop at the abstract level but also provides an **ORCHESTRA Implementation Architecture** for the ORCHESTRA Web Services platform. Here, ORCHESTRA delivers a software toolbox comprising implementation specifications and implementation components derived from and compliant with the abstract specifications.

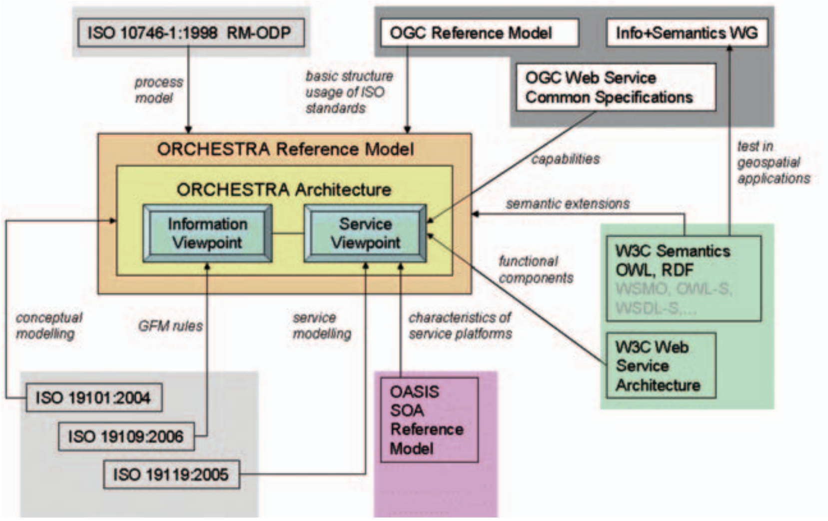
For the thematic information and service models of an application architecture tools are provided to map them to the platform.

6.2 THE STATE-OF-THE-ART: EXISTING STANDARDS OF ISO, OGC, W3C AND OASIS

On one hand, the thinking about an open architecture for risk management has to target an ideal future IT infrastructure. On the other hand, it is essential to consider and to start from the state-of-the-art technology in order to enable rapid implementation and migration.

[15] In modelling terms, this conceptual model is a meta-model.

[16] In modelling terms also referred to as application schema consisting of feature types and their relationships.



Nowadays, besides the products and the technology available on the IT market, this approach requires considering in detail the work of standardisation bodies. In the case of geospatial service-oriented architectures this approach results in a complex braiding as illustrated in the figure above and explained in more detail in (Usländer/Denzer, 2008).

As the ORCHESTRA Architecture is not exclusively tailored to risk management applications, it builds upon existing reference models and architecture specifications of different standardisation organisations in the geospatial and Web service community:

- The International Organization for Standardization (ISO) is a network of the national standards institutes of 157 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system.
  - The process model as applied in the RM-OA has been taken from ISO/IEC RM-ODP. As mentioned above, the RM-ODP has been interpreted for its application in the design of a service-oriented architecture.
  - The conceptual modelling of the ORCHESTRA Architecture has been performed according to the basic concepts (e.g., to abstract from real-world phenomena by means of ‘features’) of the ISO Reference model for Geographic Information[17].

[17] ISO 19101:2004(E) Geographic information – Reference model

- The ORCHESTRA Meta-model for Information is an evolution of the General Feature Model according to ISO rules for the design of geographic application schemas[18].
- The ORCHESTRA Meta-model for Services extends the ISO model for geographic information services[19].

- The Open Geospatial Consortium (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. On the architectural level, the following OGC Standards have influenced the ORCHESTRA Reference Model:
  - The OGC Reference Model[20] describes a framework for the ongoing work of OGC: that is, its specifications and implementations of interoperable solutions and applications for geospatial services, data, and applications. The ORM has influenced the basic structure of the RM-OA and the usage of the pertinent ISO standards (see above).
  - The OpenGIS Service Architecture[21] as OGC equivalent to the ISO model for geographic information services (see above).
  - The OpenGIS® Web Service Common Implementation Specification[22] details many of the aspects that are, or will be (because harmonization efforts are underway), common to all OGC Web Service interface Implementation Specifications. This idea has been adopted for the specification of common service characteristics in terms of re-usable interfaces, e.g. for the specification of their capabilities.
  - The final version of the ORCHESTRA Reference Model has been accepted by the Open Geospatial Consortium as Best Practices Document 07-097 (Usländer (Ed.), 2007).
- The World Wide Web Consortium (W3C) develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential.

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[18] ISO 19109:2006. Geographic information – Rules for application schema

[19] ISO 19119:2005. Geographic Information – Services

[20] Open Geospatial Consortium Doc. No. 03–040. OGC Reference Model, Version 0.1.2, 2003–03–04 http://portal.opengis.org/files/?artifact_id=3836

[21] Open Geospatial Consortium: Abstract Specifications – Topic 12 – The OpenGIS Service Architecture. OGC Doc. No. 02–112, 2002

[22] Open Geospatial Consortium: OpenGIS® Web Service Common Implementation Specification. OGC Doc. No. 05–008c1

- The W3C Web Services Architecture[23] identifies the functional components and defines the relationships among those components necessary to achieve the desired properties of the overall architecture. Although not applied identically, the ORCHESTRA Service Meta-model re-uses some of the concepts and their relationships as identified in the W3C Web Service Architecture document.

■ The Organization for the Advancement of Structured Information Standards (OASIS) is a not-for-profit, international consortium that drives the development, convergence, and adoption of e-business standards.

- The OASIS Reference Model for Service-Oriented Architecture[24] specifies the common characteristics of service-oriented architectures independent of a particular service platform implementation. The ORCHESTRA Architecture assumes these characteristics as requirements for service platforms upon which the platform-neutral ORCHESTRA Architecture may be mapped.

■ Furthermore, there is ongoing research work in the field of semantic extensions of the Web (Semantic Web) which has already led to a series of basic W3C recommendations such as:

- RDF[25] (Resource Description Framework) as a general method of modelling information as statements about resources in the form of subject-predicate-object expressions, called triples in RDF terminology.
- OWL[26], the W3C Web Ontology Language to define and instantiate ontologies with an increasing expressiveness according to the sub-variant of the language used (OWL Lite, OWL DL or OWL Full).

■ Work on semantic extension of Web Services (Semantic Web Services) is carried out in various research projects and is currently reflected in submissions to the W3C like:

- WSMO[27] (Web Service Modeling Ontology) and WSMX[28]

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[23] W3C 2004. World Wide Web Consortium: The Web Services Architecture, http://www.w3.org/TR/2004/NOTE-ws-arch-20040211

[24] OASIS Reference Model for Service-Oriented Architecture 1.0. Committee Specification 1, 2 August 2006. http://www.oasis-open.org/committees/download.php/19679/soa-rm-cs.pdf

[25] http://www.w3.org/TR/2004/REC-rdf-concepts-20040210

[26] http://www.w3.org/TR/2004/REC-owl-ref-20040210

[27] http://www.w3.org/Submission/WSMO

[28] http://www.w3.org/Submission/WSMX

(Web Service Execution Environment), OWL-S[29] (Semantic Markup for Web Services), WSDL-S[30] (Web Service Semantics) and SAWSDL[31] (Semantic Annotations for WSDL and XML Schema).

Currently, there is no standardised architecture that unifies the approaches of OGC, W3C and OASIS for spatial and non-spatial information in a harmonised and consistent way. There are partial solutions addressed by various projects, e.g. in the context of the OGC semantic web technologies have been applied to geospatial applications in 2005 in a Geospatial Semantic Web Interoperability Experiment (Lieberman et al 2005) and submitted to W3C as a position paper. Current activities towards a geospatial semantic web are being pursued in the Geo-Semantics Working Group of the OGC.

The ORCHESTRA Architecture team is convinced that it will be a challenge for the next several years to address the integration of the different approaches, not for the sake of integration but purely for practical needs of real world end users. Most likely, it will be up to the OGC to address the harmonisation of the current OGC Reference Model with the W3C and OASIS work on service-oriented architecture and its semantic extensions.

The ORCHESTRA Reference Model and the ORCHESTRA Architecture may be seen as a test case or architectural blueprint for such a harmonisation activity. The requirements for the ORCHESTRA Architecture are derived from risk-management applications, a field which in itself is very broad and requires generic approaches. Lessons learned from ORCHESTRA can be well extrapolated to even more general application domains.

6.3 ELEMENTS OF THE ORCHESTRA ARCHITECTURE

6.3.1 Functional Domains of the ORCHESTRA Service Network

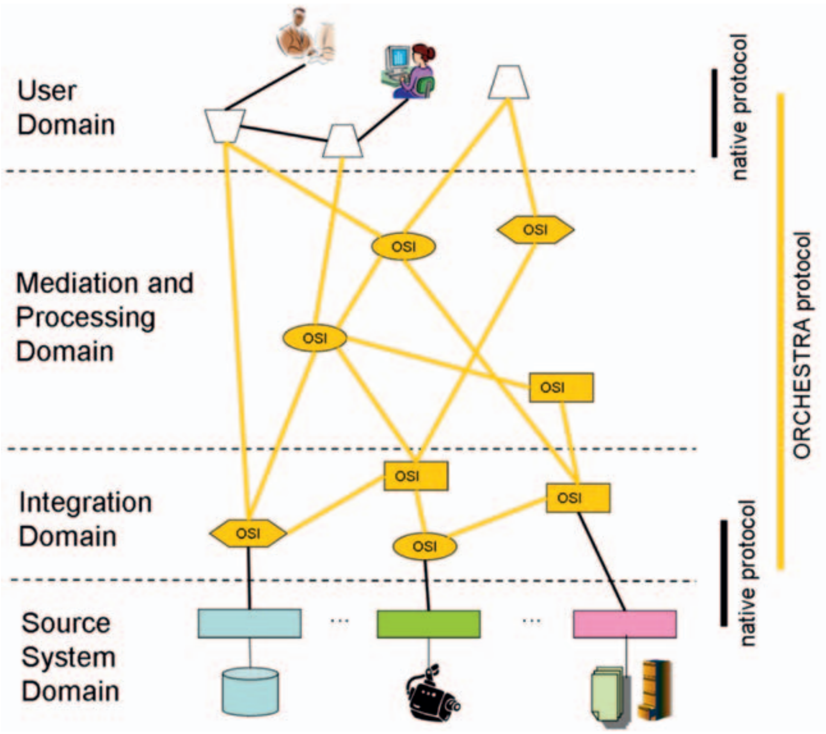
The ORCHESTRA Architecture has to face the problem of integrating environmental risk management systems that are networked across and between organisations. This is the objective of the ORCHESTRA Service Networks as running instances of the ORCHESTRA Architecture.

[29] http://www.w3.org/Submission/OWL-S

[30] http://www.w3.org/Submission/WSDL-S

[31] http://www.w3c.org/TR/sawsdl

The running components of an ORCHESTRA Service Network are the **ORCHESTRA Service Instances** (OSIs). These offer their functionality and interact among each other according to the **ORCHESTRA protocol**, i.e. the set of the ORCHESTRA rules given by the ORCHESTRA Meta-Model as described below. By their joint functionality and interaction, they resolve the gap between the information demand of the user and the existing resources (data and services) offered by source systems. The service instances are organised in the following functional domains:



- Software components in the User Domain provide the interface to a user component (a human or another software component). Their interaction is outside the scope of an ORCHESTRA Service Network, e.g. they may use a native protocol. However, when interacting with an ORCHESTRA Service Instance, they have to use the ORCHESTRA protocol.
- Service instances in the Mediation and Processing Domain provide the main functional part of an ORCHESTRA Service Network. They mediate the service calls from the User to the Integration Domain based on meta-

information exchanged with the components of the Integration Domain (e.g. by means of a publishing pattern or a retrieval pattern).

- OSIs in the Integration Domain provide support for the integration of source systems into an ORCHESTRA Service Network. The OSIs in this domain have two-sided interfaces. On one hand, they interact with other OSIs according to the ORCHESTRA protocol. On the other hand, they interact with the components of the Source System Domain according to their native protocol.
- The Source System Domain incorporates the so-called source systems, i.e. the systems and system components (e.g. a relational data base) of a thematic application area (e.g. risk management) to be integrated into an ORCHESTRA Service Network. In practice, this means that their data and functionality have to be wrapped with an ORCHESTRA-compliant service interface. In order to facilitate this re-engineering process, ORCHESTRA provides a dedicated software framework as described in (Kutschera et al, 2007).

6.3.2 Abstract Service Platform

On the level of the abstract service platform, the ORCHESTRA Architecture provides the following elements:

- A description framework and document templates for the textual specification of interface and service types.
- A coherent set of rules to specify interface, service and feature types in UML and to organise them in service and information models. This rule set is referred to as ORCHESTRA Meta-Model (OMM). The key aspects of the OMM are:
    - The OMM is an extension of the General Feature Model (GFM) as used in the OGC Reference Model. It treats both information and service aspects in a consistent manner.
    - In contrast to the mandatory usage of the ISO meta-information standards (ISO 19115/19119) in the GFM, the OMM information part does not prescribe a particular meta-information model but it just provides rules about how to specify meta-information models. This approach leads to a higher flexibility since meta-information in the OMM is considered to be purpose-specific, e.g. for the purpose of discovery a different set of meta-information elements may be defined than for service composition (Schimak et al 2007).

- The OMM service part puts the interface type into the spotlight for re-usability. Interface types are specified such they may be re-used across several service type specifications. Examples of the application of this concept include the service capabilities interface type that is mandatory for all ORCHESTRA service types or the schema mapping interface type that is being re-used in a variant of the ORCHESTRA Feature Access Service.

- A specification of important feature types (e.g. document types) that may be re-used and refined in information models.
- A specification of a series of generic interface and service types that may (and should) be re-used by service modellers in the design of their geospatial SOA: starting from the interface types as the re-usable specification unit, assembling them to service types and possibly enriching them by domain-specific functionality.

The following table describes the currently specified architecture service types:

SERVICE/INTERFACE	APPLICATION
Basic Interfaces	■ Interface types enabling a common architectural approach for all ORCHESTRA Services: ◆ self-description of service instances (capabilities) ◆ synchronous and asynchronous interactions ◆ transactional support ◆ predefined exception types
Authentication Service	■ Proves the genuineness of principals (i.e. the identity of a subject which may be a user or a software component) using a set of given credentials. Selected authentication mechanism is up to implementation specification.
Authorisation Service	■ Provides an authorisation decision for a given authorisation context. ■ Selected authorisation paradigm is up to implementation specification.

SERVICE/INTERFACE	APPLICATION
Catalogue Service	■ Ability to publish, query and retrieve descriptive information (meta-information) for resources (i.e. data and services) of any type. ■ Specific characteristics are described in (Hilbring/Usländer, 2006), such as: ◆ not tied to a particular schema of a meta-information standard (e.g. ISO 19115) ◆ supports application schemas for meta-information designed according to the ORCHESTRA rules ◆ may be used as a data catalogue or a service registry ◆ may be cascaded with OGC catalogues or OASIS UDDI ◆ includes an adapter to Internet search engines (e.g. Yahoo) ◆ includes an extension for ontology-based query expansion and result ranking
Document Access Service	■ Supports access to documents of any type (e.g. textual documents and images). A document is referenced by a document descriptor which is considered to be a specific kind of a feature type.
Feature Access Service	■ Selection, creation, update and deletion of feature instances and feature types available in a service network.
Map and Diagram Service	■ Enables geographic clients to interactively visualise geograffphic and statistical data. ■ Transforms geographic data (vector or raster) and/or numeriffcal tabular data into a graphical representation using symboliffzation rules. The main output of this service is an image document which may be a map, a diagram or a thematic map (visualization of the spatial distribution of one or more statistical data themes).
Name Service	■ Encapsulates the implemented naming policy for service instances in a service network, e.g. creates globally unique service instance names using a defined naming policy. Important if several service networks across different platforms are to be interconnected.

SERVICE/INTERFACE	APPLICATION
Ontology Access Service	■ Supports the storage, retrieval, and deletion of ontologies as well as providing a high-level view on ontologies. It further includes an optional Knowledge Base interface that provides operations to query and update models contained in a knowledge base
Sensor Access Service	■ Basic interfaces for accessing sensor data, configuring a sensor and publishing sensor data. These interfaces will be replaced by interfaces and services of the OGC Sensor Web Enablement initiative through the developments of the Integrated Project SANY (Sensors Anywhere) (Havlik et al 2007).
Service Monitoring Service	■ Provides an overview about service instances currently registered within service network, e.g. ■ Actual status (e.g. running, stopped or offline) ■ Statistical information (e.g. average availability and response times)
User Management Service	■ Creates and maintains subjects (users or software components) including groups (of principals) as a special kind of subjects.

Concrete Service Platform 6.3.3

The ORCHESTRA Meta-Model also provides also rules that describe how to map the abstract specifications to a concrete service platform. There are software tools available from ORCHESTRA that support this mapping process for the ORCHESTRA Web services platform. In this mapping process, UML information models have to be translated to XML/GML whereas UML interface and service models have to be mapped to WSDL documents.

For the service types listed in the previous chapter, ORCHESTRA provides corresponding implementation specifications and implementations, most of them integrated in the common ORCHESTRA Service Container Framework as described by (Schmieder et al, 2007) and offered under an open source license.

See the ORCHESTRA web site for the most recent information about the delivery and status of ORCHESTRA software.

6.4 ONGOING WORK

The focus of the ORCHESTRA Architecture as specified today lies on syntactic interoperability. The thorough analysis of user requirements has led to the specification of a series of generic services that provide powerful and indispensable functionality for the design of geospatial service-oriented architectures in the domain of environmental risk management and beyond. As concrete service platforms, W3C Web services and GML have been chosen as the current mainstream technology. Implementation specifications and implementations are available and will be offered under an open source license, too.

However, the ORCHESTRA Architecture has already opened the door towards enhancements. More powerful service platforms currently being specified within OASIS by the Semantic Web Services community are emerging[32]. Ongoing activities in the ORCHESTRA architecture group aim at extending the ORCHESTRA Reference Model such that these new technologies may be embedded and exploited. The application of semantic ORCHESTRA services in pilot test beds (Bügel/Hilbring, 2007) are first steps in this direction and will provide important feedback about how semantics may be used in real world use cases. Further extensions such as the inclusion of Sensor Web environments and the integration of information fusion technologies are investigated and specified in the ongoing European Integrated Project SANY (Sensors Anywhere, http://sany-ip.eu/) (Havlik et al 2007).

[32] OASIS Semantic Execution Environment TC. Reference Model for Semantic Service-Oriented Architecture. Working Draft 0.1, 2006

The ORCHESTRA Pilot Implementations

7

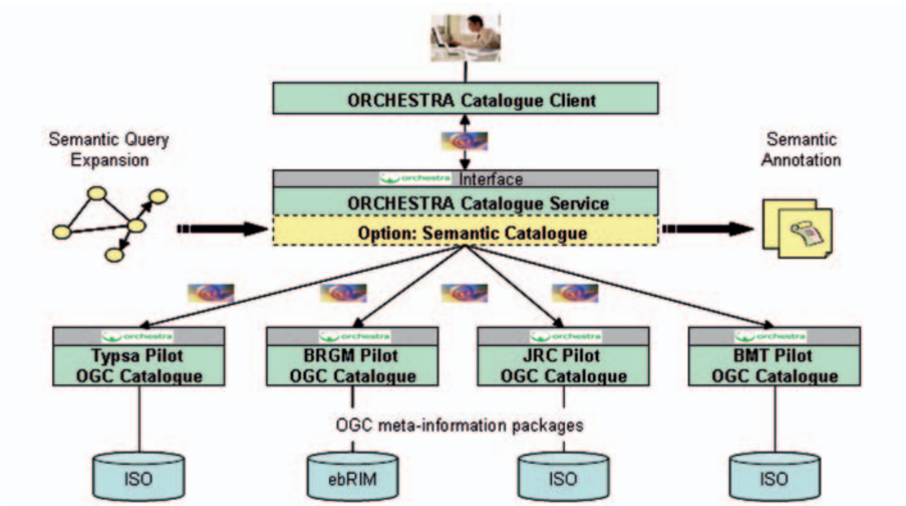
This chapter describes the four pilot implementations that are based on the ORCHESTRA architecture and services. It provides specific implementation details and discusses the technology aspect of each pilot.

A whole range of services, components and tools have been specified and developed for the field of environmental risk management. With these, applications were rapidly developed to fulfil the expectations of a number of end users working in different domains: floods and flash floods, forest fires, road network disruption due to natural or man-made hazards, and coastal zone management.

Since all pilots are quite complex and cover many aspects of risk management and information technology, the descriptions focus on single, particularly innovative, aspects of each pilot. These are:

- service chaining and distributed geo-processing,
- multi-risk assessment,
- data security, and the
- execution of simulations.

All pilots offer their resources, being data or services, through instances of the ORCHESTRA Catalogue Service using either the ISO or the ebRIM meta-information packages. In order to enable a cross-pilot resource discovery, all four pilot-specific catalogues have been integrated through a common entry point, also realised as a catalogue. The resulting catalogue cascade allows a user to perform a query (e.g. a search for an instance of a Map and Diagram service) across all pilots in a single request and retrieve the results in one single harmonised result set.



Furthermore, the catalogue portal contains an optional semantic extension which enables an improvement of the query based on an ontology. As an example, let's take again the search request for the Map and Diagram Service. If the user does not know exactly the name of this service, he/she may simply ask for 'architecture service' or 'map service'. As the ontology 'knows' that semantic relationships between these terms, the catalogue portal may ask back which query term is actually to be used or, depending on the choice of the user, it expands the query to search for all of these terms. By offering a semantic annotation of the results (i.e., by linking the terms to concepts in the ontology), the system helps in 'understanding' the individual result elements Through these two options, the user needs less pre-knowledge in order to discover resources in service networks.

The following chapters provide detailed information on each pilot.

7.1 FOREST FIRE HAZARD AND RISK ASSESSMENT

This pilot's main objective is to test the ORCHESTRA architecture within the setting of pan-European risk and damage assessment related to the hazards of forest fires and flooding.

7.1.1 Pilot Scope and Objectives

Forest fires are particularly relevant to southern European countries, such as Spain, Portugal, Italy and Greece. This was dramatically shown during summer 2007 and each year fires cause damage to the environment, infrastructure, economic sectors and private property.

Forest fire information at the European level has been collected by EU member states since the 1990s. This includes information on fire outbreaks, like the ignition point, the cause of the fire, the time it was detected and extinguished and the burnt area.

Analysing this data allows the creation of forest fire hazard maps (i.e. the likelihood of forest fires), forest fire damage maps, and through their combination, forest fires risk maps. These in turn support decisions on measures for risk prevention on a European scale. To support this, the JRC-IES pilot has developed an application based on fire records for:

- hazard mapping through forest fire frequency based on the number of fires per administrative unit, and forest fire density describing the normalised fire frequency as fire frequency per km2;
- risk mapping through the combination of forest fire density (hazard) and burnt area (damage) into risk classes.

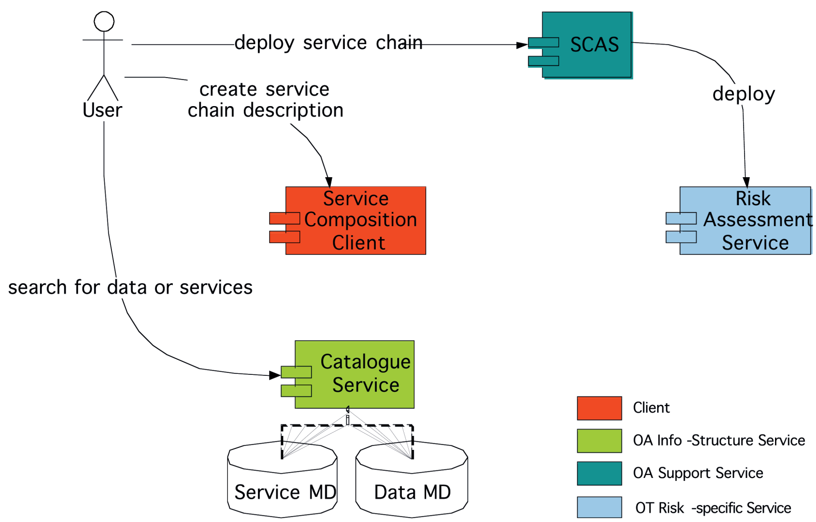
The chaining of various services and the distributed geo-processing aspects of this pilot are discussed in this chapter. The focus is on the experience gained from creating a service-based application for forest fire analysis, with a focus on:

- Enabling distributed interoperable geo-processing to support ad-hoc analysis within an ORCHESTRA Service Network (OSN). The geo-processing will focus on analyses that support both spatial information and decision support through normalisation, aggregation and classification of data.
- Defining workflows that combine several services into one value-added service chain that achieves a certain goal. Then deploying such workflows as executable service instances.

In particular, the solution uses several services distributed over the network that are orchestrated by an additional service that directly interacts with the client and executes the workflow defined in WS-BPEL, using activeBPEL, an Open Source BPEL engine.

In order to deploy the defined workflow the Service Chain Access Service (SCAS), a service type described in the RM-OA, providing a means to create and delete service chain instances in the OSN was used. The creation of a new service chain instance that can be invoked as a 'single' service accordingly with the opaque chaining defined in ISO 19119 is based on an explicit description of the workflow (the current SCAS implementation supports workflows expressed via

WS-BPEL). The service chain creation and deploy phase, whose aim is to provide to the end-user application a service supplying new functionalities implemented by using existing ones, is depicted below. The domain-expert developer searches for appropriate data sources and services in a Catalogue Service and then uses a Service Composition Client to create a service chain workflow description. Using this description, a service chain instance can be deployed through the SCAS creating, in this case, the 'Risk Assessment Service' responsible for providing the forest fire hazard and risk analysis functionalities:



The following sub-sections describe in detail:

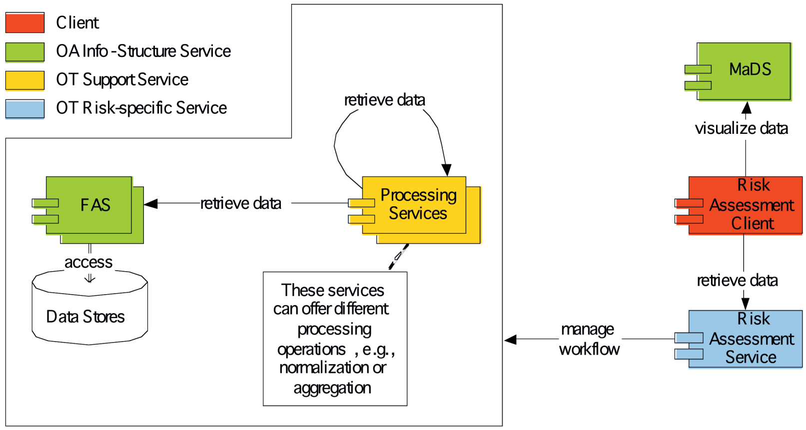
- the services involved in the application,
- the implemented Risk Assessment workflow and the
- related issues.

7.1.2 Application for Forest Fire Hazard and Risk Assessment

The main functionalities of the created application are the calculation of:

- the forest fire frequency or density by administrative unit, and
- user-defined forest fire risk classes.

The graphic below depicts the basic schema of the used service components and the interactions occurring between services:



The implemented risk assessment client performs all interactions with the user. It formulates all queries towards the Risk Assessment Service as a service chain instance that executes the workflow and channels any interaction with the analyst.

The underlying services are described in the following section:

Implemented Services 7.1.3

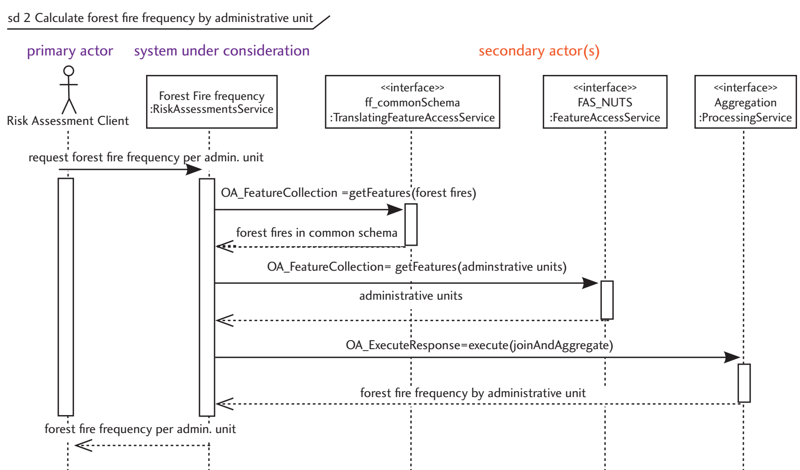
In order to implement the outlined use cases the following service types described in the RM-OA have been used:

SERVICE NAME	APPLICATION
Feature Access Service (FAS)	■ These services provide access to a number of data sources, e.g. member state forest fire registration data including information on the location and the fire cause, administrative units and the European grid population density data.
Processing Service (PS)	■ These services provide different processing operations, such as normalization, classification, join and aggregation operations.
Map and Diagram Service (MaDS)	■ This service renders data using a given symbology. In this case the MaDS is used in the client GUI to visualize the data produced by the Risk Assessment Service.

SERVICE NAME	APPLICATION
Risk Assessment Service	■ This service controls the workflow of the application

7.1.4 Service Chaining for Forest Fire Risk Analysis

The service chain supporting the forest fire risk analysis functionalities has been designed using the WS-BPEL language and the ActiveBPEL designer framework. Starting points were application data flow schemata and UML use case and system sequence diagrams describing the three risk assessment functionalities. These diagrams were prepared in cooperation with the system end users during the requirements phase of the pilot development. The graphic below shows the system sequence diagram for the 'forest fire frequency' as one of the three functionalities:



After receiving a 'Forest fire frequency by administrative units' request the Risk Assessment Service invokes the getFeatures operation of two (possibly different) FAS instances for retrieving the administrative units and the forest fire data. Such data are necessary for invoking the Aggregation processing service operation that finally returns the forest fire frequency by administrative unit. The sequence diagrams of the other functionalities differ only in the number of invoked processing operations: the density use case also includes the invocation of the normalize processing operation, which uses the result of the forest fire frequency use case, while the classification use case also invokes the classify processing operation, which uses the result of the forest fire density use case.

The first step when designing the WS-BPEL workflow has been to define the Risk Assessment Service interface. As it emerges from the sequence diagram the service has no intermediate interactions with the user and this means that the invocations of the Risk Assessment Service must include the parameters for all the invocations that the chain performs. In our case, besides all the necessary parameters (e.g. bounding box and feature types) we also included additional non-mandatory parameters to make the service more flexible, such as the endpoint of the services involved in the chain. This option is particularly useful when some of the used services are replaced with new ones or for selecting, for example, the specific FAS instance containing the features we are interested in.

The operations invocations performed by the chain may require not only parameters coming from the client but also other information obtained by previous invocations and, in our pilot, this is true for the invocation of the Aggregation processing operation. If on one hand defining and using the input parameters that we receive from the client application is straightforward, on the other hand mediation between data returned by and passed to other services has been the most critical development phase.

In particular, the deployed Processing services expect requests where the feature collections (e.g. administrative units or forest fire data) are passed by a reference, i.e. a URL address referring to the data. Since features can involve a huge amount of data this way of passing the values avoids unnecessary transfers of large data sets, thus improving the performance. Such data are the result of the previous getFeatures operation invocations that, being based on SOAP bindings, cannot be expressed using a URL, which is possible when services support HTTP GET requests (e.g. the Web Feature Service's getFeatures operation).

The solution for this Pilot is based on an additional Repository service that permits the storage of data returned by getFeatures operations and then makes them available via a URL, which is passed to the Processing service.

MULTI-RISK ASSESSMENT 7.2

The second pilot addressed the challenge of planning and management of multi-risk scenarios, in which different types of end-users, such as modellers, protection bodies' members, policy makers and administrative managers, work together to develop a set of common, collaborative risk maps due to several types of natural hazards, such as forest fires and flash floods.

7.2.1 Pilot Scope and Objectives

Flash-floods and forest fires are two of the most significant risks that Regional Administrations in Cataluña, Spain, have to face every year. Dealing with these well-known risks appears to be simple at first glance, but in reality poses a major challenge. Each administration, department and even service has developed proprietary legacy systems and data, which hinder the real, comprehensive and coherent interaction among the actors involved in each of the risk planning steps.

This fact indicates a pressing need for a high level of collaboration and inter-operation among the stakeholders and information systems. A common framework is required which enables the connection of data sources, models, querying and mapping in an interoperable, transparent way. The implementation of ORCHESTRA components and specifications supports the development of this service framework in a consistent way:

- by ensuring coherent and common procedures for search, discovery, retrieval and representation of data
- by facilitating the inter-operation between the different users, systems and models used.

Risk planning includes the creation of a set of documents (maps and reports) in which the different sources of risk are identified together with the threatened items (people, properties, infrastructures and natural ecosystems), in order to obtain a clear idea of the distribution, type and importance of such risks, and to provide an action list to mitigate or eliminate them.

7.2.2 Application for Multi Risk Assessment

The study of the effects of a forest fire event on the basin hydrological response has been selected as a multi-risk chain scenario to test the inter-operability between the models used in this pilot. The objective of the test is to obtain a differential risk analysis of the hydrological and hydraulic basin response with and without fire. The simplified workflow of this scenario is:

- Firstly, the hydrological and hydraulic original (non-altered by forest fire) basin response to standard events (50, 100 and 500 year-storm) is studied.
- Then, the study of a forest fire that affects the river basin (burning some areas and altering the land cover) is carried out.
- Finally, the study of the hydrological and hydraulic basin response to the same standard events but with altered land cover is carried out. In this

case consequences are worse than assessed, because the flood peak discharge, velocity and stage are higher and the flood extent wider than would be with the unaltered land cover conditions.

Testbed location 7.2.2.1

After a Flood Master Plan in Catalonia on a regional scale, the Water Catalan Agency is currently developing several more detailed studies on a smaller scale (basin scale) called PEF (Fluvial Area Planning). These studies deal with the hydrological, hydraulic and geomorphologic aspects that allow, among other issues, the definition of flows in flood areas. Furthermore, they offer a diagnosis on the ecological state of the whole fluvial area and an inventory of the cultural and historic heritage there may be in this area. Finally, they conclude by proposing and assessing the measures required to correct the problems detected.

The Tordera river basin, which PEF studies have recently been finished, is a typical middle-sized Mediterranean basin (approximately 881 km2), with large woods at the headwaters. It is prone to flood, as well as to forest fire and pollution events. In fact, in the last years it has suffered several events: fires, floods, flash floods and remarkable sediment transport.

7.2.2.2 Hypotheses

The current scenario hydrological hypotheses that have been adopted are the same that the PEF study had adopted. That means:

- six-hour duration precipitation with the centre of maximum precipitation in the Sant Celoni rain-gauge.
- rain-fall spatial distribution adopted corresponding to the maximum precipitation focus in the Montseny Mountains.

The infiltration loss analysis and the precipitation excess-runoff computations have been carried out with the HEC-HMS (v3.1.0) model. Some specific adjustments of the employed hydrological model, as the adoption of specific unit hydrographs for each one of the studied subbasins, have been done in order to adapt it to the original PEF hydrological model and tackle the altered land cover basin response due to forest fires.

Once the hydrograph of each one of the subbasins have been obtained, the hydraulic computations have been carried out with the MIKE-11 (v2002) model developed by DHI Water and Environment. The model set-up employed in ORCHESTRA has been an improved version of the original PEF hydraulic model, in order to consider the effects of some additional structures, as bridges or culverts.

The hydrological and hydraulic model computation process have been done off-line of ORCHESTRA, due to their complexity and the need of technician frequent intervention.

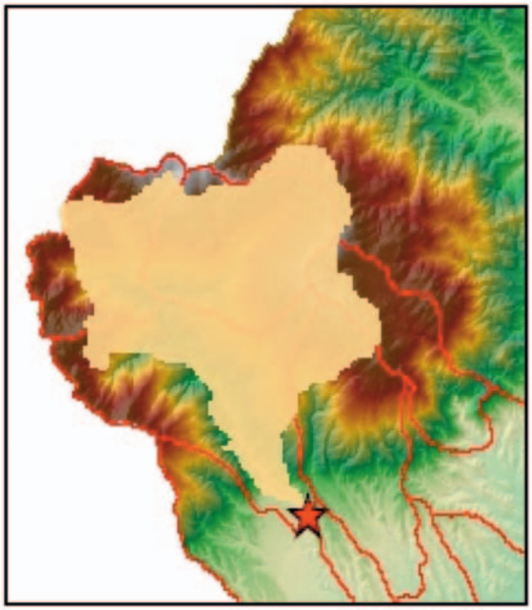
A forest fire affecting a large portion of the head of the basin has been simulated under the following hypotheses:

- Vegetation dry conditions (live fuel moisture 70%, dead fuel moisture 3%)
- Strong wind conditions up to 30 km/h blowing Southeast – Northwest
- Fire starting in the base of the mountain, in a urban settlement
- The forest fire catches stand canopy driving crown fires
- Cell resolution of used maps is 20 m.

The simulation has been carried out with the fire spread algorithm implemented in ORCHESTRA as a thematic service. The system has simulated a fire run of six hours.

The output is based on the fire's spread rate and direction, the flame front linear intensity and the flame residence time. These are the key values required to estimate the effect of fire on the soil.

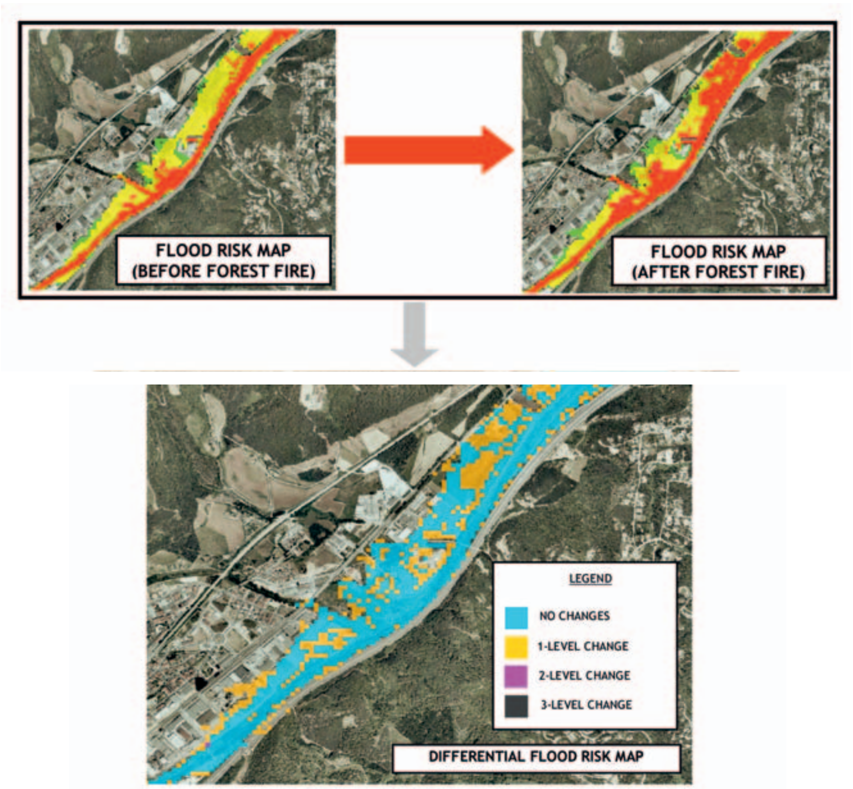
The result of the forest fire simulation affecting a large portion of the basin (in orange) is shown on the graphic on the right (the red star indicates the location of the fire outbreak).



Results 7.2.2.3

Two teams of modellers have participated in this exercise: the forest fire progression modellers, and the hydrological and hydraulic modellers. Both teams have used a common user interface provided by the ORCHESTRA main application. The data search and retrieval application has been done through the existing catalogue, map access and feature access services, whilst simulations have been performed using the specific thematic services for forest fires, and offline simulations for the hydrological and hydraulic response. A critical aspect has been the coordination and synchronisation in time of the obtained maps from the fire simulation, specifically the effects of fire on the vegetation, to be stored accordingly in the ORCHESTRA environment and afterwards retrieved by the hydrological-hydraulic modellers.

The results of the simulations presented a clear effect of the fire on the hydraulic response, increasing the expected flow discharges. Some examples of the resulting flood maps are presented below. In them relevant changes in flood extension and, specially, in risk level due to the effects of forest fire in the basin can be observed.



7.2.3 Implemented Services

To achieve system interoperability and build the multi-risk assessment application, the following ORCHESTRA Architectural services have been implemented:

SERVICE NAME	APPLICATION
Document Access Service	■ Selection (creation) of flood hazard scenarios based on different hypothesis
Interception-Infiltration Parameter Service	■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ requests the maps of affected vegetation due to forest fire

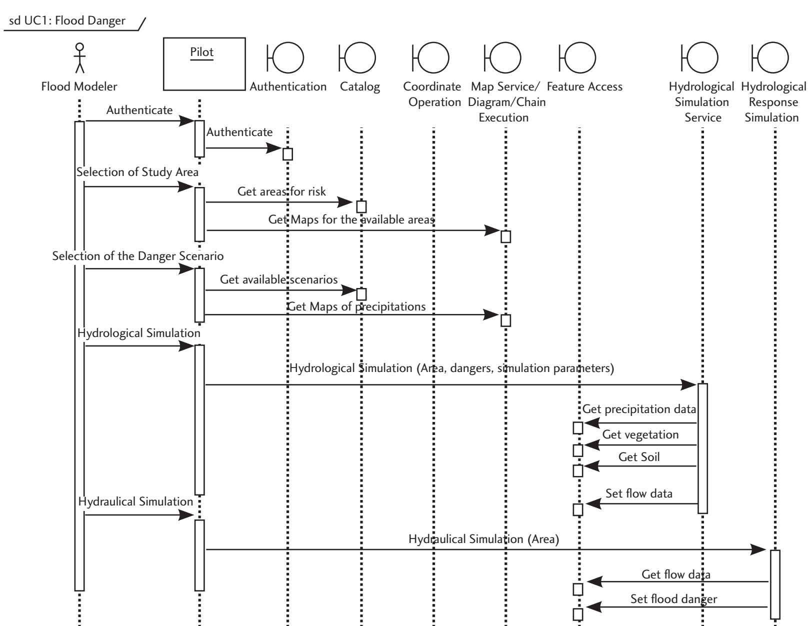
SERVICE NAME	APPLICATION
Catalogue Service	■ Catalogues available map sources and is used for: ■ Search for and request of basic maps for visual reference ■ Selection (creation) of flood hazard scenarios based on different hypothesis ■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ requests the maps of affected vegetation due to forest fire ■ map of potentially exposed-to-flood elements ■ Elaboration of hazard, severity and risk maps ■ Elaboration of common risk map ■ Elaboration of differential risk map
Map Access Service	■ Request for basic maps for visual reference and simulation ■ Request for meteorological data ■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ Request for the maps of affected vegetation due to forest fire ■ Request for the map of potentially exposed elements ■ Elaboration of hazard, severity and risk maps ■ Elaboration of common risk map ■ Elaboration of differential risk map
Risk specific service: Fire Spread Engine	■ Simulation of fire progression
Feature Access Service	■ Request for basic maps for simulation ■ Selection (creation) of flood hazard scenarios based on different hypothesis ■ Request for meteorological data from stations for the same period ■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ Elaboration of flood hazard maps ■ requests the maps of affected vegetation due to forest fire ■ map of potentially exposed-to-flood elements ■ Elaboration of differential risk map

SERVICE NAME	APPLICATION
Map and Diagram Access Service	■ Selection (creation) of flood hazard scenarios based on different hypothesis ■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ requests the maps of affected vegetation due to forest fire ■ map of potentially exposed-to-flood elements ■ Elaboration of common risk map
Processing (Geospatial Calculation) Service	■ Elaboration of the interception-infiltration parameter map for the hydrological model ■ calculate fire severity ■ Elaboration of the map change due to fire ■ Elaboration of common risk map ■ Elaboration of differential risk map

7.2.4 Service Chaining for Multi-risk Assessment

Implementation of services was done following the workflow presented in UML diagrams for each of the use cases. In these, the inputs, outputs and interaction with users and other systems, as well as the use of services, is detailed.

An example of a UML diagram, for Flood Danger calculation, is shown below.



IMPACT ASSESSMENT ON TRANSPORT INFRASTRUCTURE 7.3

Pilot Scope and Objectives 7.3.1

The third pilot addressed the estimation of the cost and disruption due to the closure of a portion of the road network in the French-Italian border region between Nice and Genoa. Such a closure could be caused, for example, by the occurrence of a natural (e.g. a landslide) or man-made (e.g. a chemical spill) event that physically blocks a route, makes it to dangerous to pass or limits its capacity.

Since road closures can have a dramatic impact on the economic, social and functional life of a region it is important to be able to conduct 'what if?' exercises to forecast the type and size of disruption that could occur.

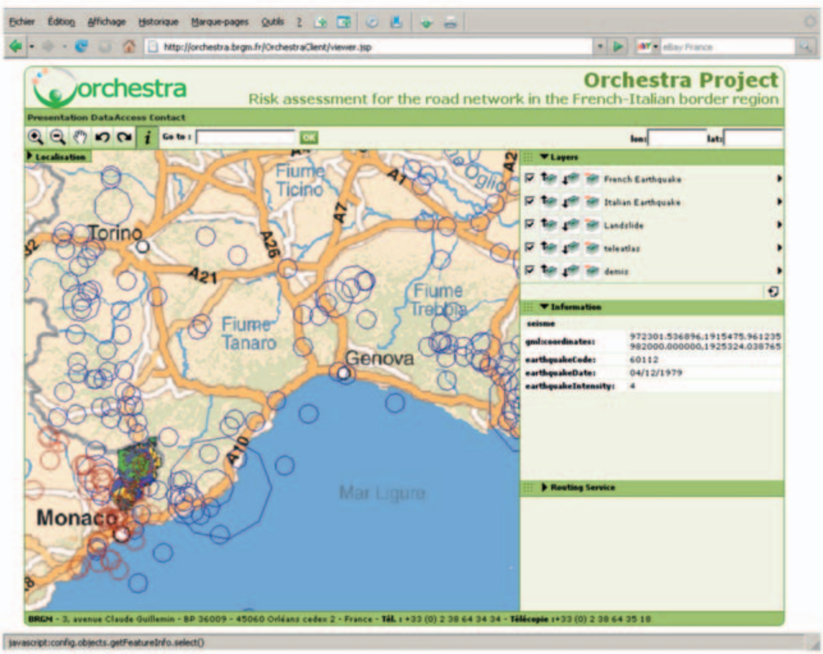
By their very nature road networks often cross borders and the effect of road disruptions can be felt far from the location of the blockage. This is particularly true for the region chosen for this pilot because of its mountainous nature close to the Mediterranean Sea where there are few alternative routes available if, for example, the main E80 motorway from Nice to Genoa is closed, thereby leading to long detours.

Application for Impact Assessment 7.3.2

The client application manages the workflow and user interaction, allowing the user to:

- search for data (historical events, hazard maps, road network) on the selected area;
- display these data;
- simulate an event, drawing the related polygon;
- search for roads cut by this event;
- ask for an alternative road; and
- calculate related costs according to the unavailability of the road.

The figure below shows the browser based user interface:



Multiple simulations can be run to identify pinch points within the road network and hence improve planning and prevention. The user can interact with the client and retrieve information in French, Italian or English. One particularly novel aspect of the developed system is that it implements tools to licence use of data and services.

Data security is an important consideration when undertaking analysis via a distributed architecture across the Internet that accesses information stored in many locations. Providers of geospatial information would often like to protect their data and provide it with conditions of use only to known (and registered) users. In addition, service providers would like to be able to restrict access to their products and only allow their use by authorised persons, who agree to licensing agreements. The system developed within this pilot includes the ability to provide access to data and services with a number of different conditions that cover many types of licences currently in use within the geospatial information community to manage and protect their intellectual property.

The client application was developed using Community Map Builder. The client communicates with ORCHESTRA Services or other OGC services by means of the Java Connectors. The mapbuilder-lib provides a set of components that are dedicated to the development of web client applications for GIS systems. It supports OGC standards to communicate with external map servers.

Some specialised components were added for gazetteer service, catalogue service, routing and cost calculation services. The components needed for Digital Rights Management were developed by University of Münster (Germany) as a subcontractor to Ordnance Survey.

Implemented Services 7.3.3

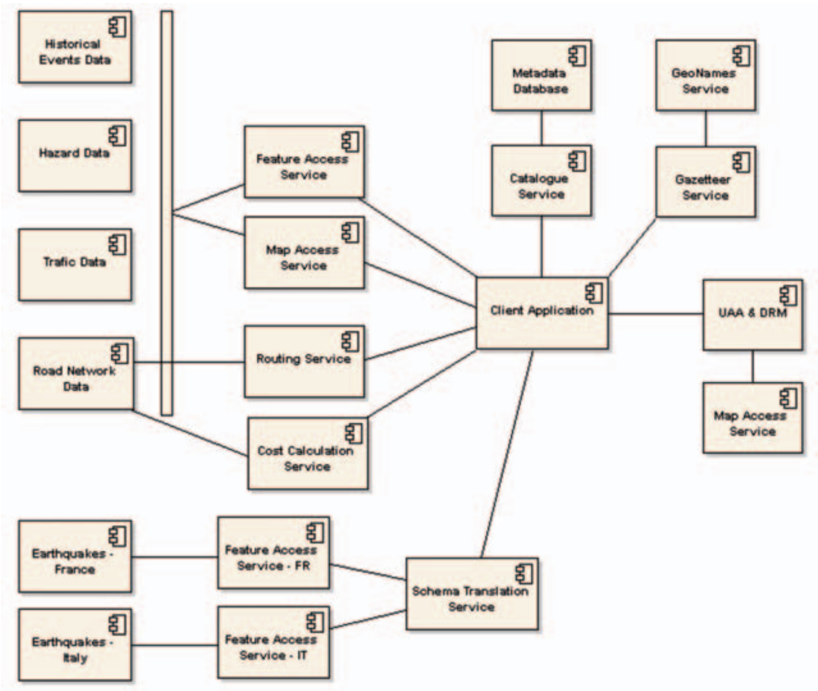
The following services are used for this application:

SERVICE	APPLICATION
Catalogue Service	■ The Catalogue Service is used for searching for services and datasets. Datasets are historical events, hazard maps and the road network.
Map Service	■ The Map Service is used by the client application to display selected data to help the expert decide where an event could occur and cut the road network.
Schema Mapping Service	■ The Schema Mapping Service is used to provide a collection of features (for example earthquakes) described with the same application schema, while original data from France and from Italy are provided by two WFS using two different application schemas. This service is also used to translate French and Italian data into a common language.
Feature Service	■ The Feature Service is used to provide features (e.g. historical events and road network). Some Feature Services are used by the client application only through the Schema Mapping Service.
Gazetteer Service	■ The Gazetteer service is used to provide a location when the client application provides a geographic name.
Routing Service	■ The Routing Service, a kind of Processing service, is used to find a route between two points, taking into account polygon(s) defining the area where roads are cut by the event(s).
Cost Calculation Service	■ Cost Calculation Service, a kind of Processing service, is used to calculate the different costs due to the cutting of a road (infrastructure cost, functional cost and environmental cost).

7.3.4 Service Chaining for Impact Assessment

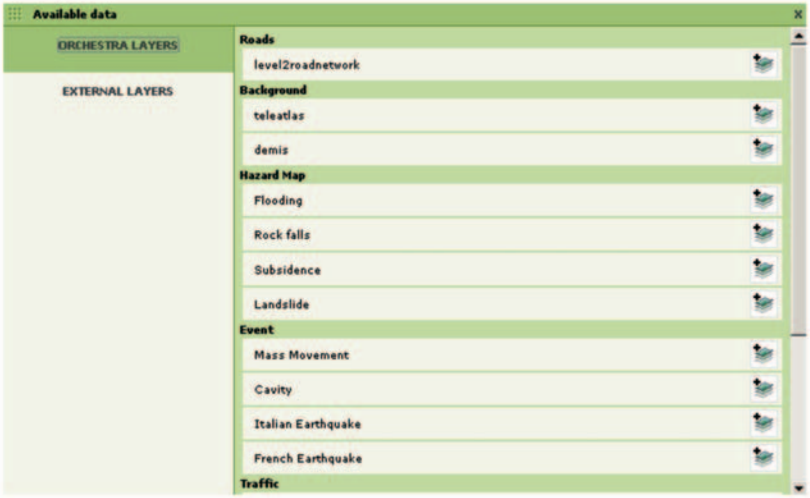
Since the main aim of this pilot application is to calculate the cost of alternative routes there are some implicit assumptions concerning the network and requirements for its representation. First, the road network topology is accessed using a Feature Access Service for the purpose of obtaining a graphical representation of the network. Second, to determine roads segments that are blocked due to the hypothetical consequence of an event occurring, it is necessary to have the detailed graphical format of the road network and the extent of the damage caused by the event. Finally, in order to support the algorithms for determining the best alternative routes the directed graph of the road network is required with a cost associated to the traversal of each vertex.

Another aim in the pilot is to demonstrate the possibilities of extending the architecture with UAA and DRM services. The figure below gives an overview of the main elements of the pilot application:

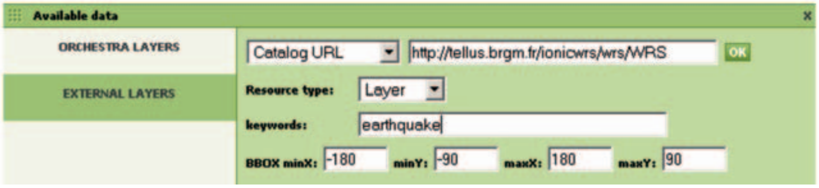


The catalogue service enables the user to search for relevant data either using a predefined list of layers (this definition is stored in a Web Map Context) or from searching a catalogue of metadata.

Examples of using these two approaches are displayed below:



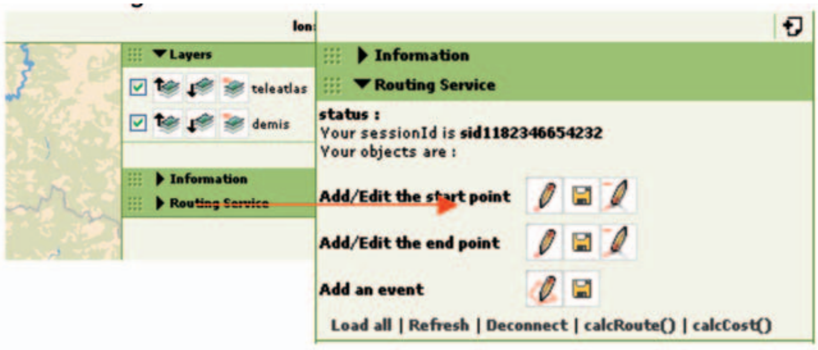
The catalogue service displays either a predefined list of layers,



or alternatively supports a free search in a catalogue and returns the query results as a list of layers:

The application uses an OGC Catalogue implementing the ebRIM profile. The wrappers developed for the ORCHESTRA Catalogue service to use OGC Catalogues are available for Catalogues with the ISO or ebRIM profiles.

Route calculation and calculation of alternative route is implemented as a routing service:



The routing service can be invoked from the client application and requires the user to define a starting point and an end point.

The service then calculates the shortest path between the start and end point and display the result in the map window:

The result is visualized on the map as a green line between start and end point.

After the user defines a polygon that represents a hazard footprint, the calculation of an alternative route that avoids the road sections that intersect with the hazard polygon can be started.

The alternative route is visualized on screen with a green line:

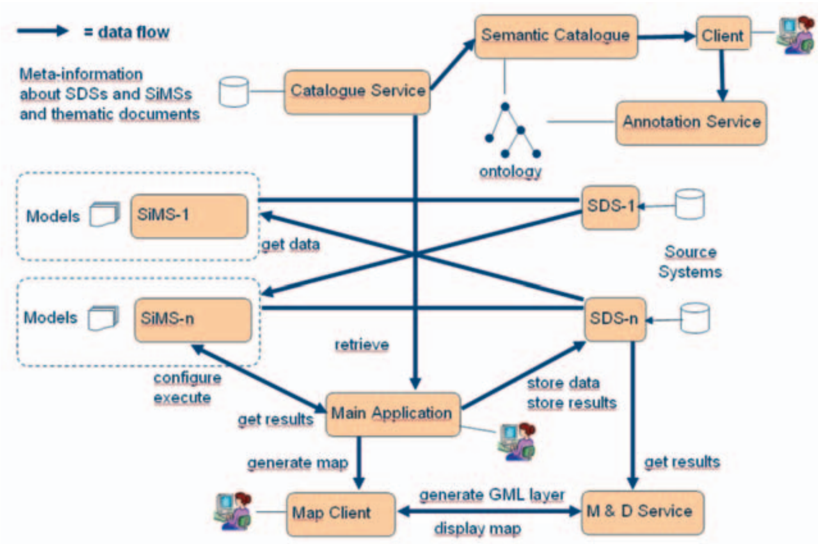
In addition to the routing service the user can invoke a cost calculation service, which calculates the cost of the alternative route relative to the shortest path that was calculated without the hazard intersecting the road sections. Cost Categories that are calculated by this service include estimates on the structural damage, extra time needed for the alternative route and the resulting environmental impact, e.g. based on additional fuel consumption.

ENVIRONMENTAL SHIPPING RISKS 7.4

Pilot Scope and Objectives 7.4.1

The pilot assesses risks associate with shipping traffic in the German Bight – that part of the North Sea surrounded by Germany, the Netherlands and Denmark. The main objective of the pilot is to provide users and stakeholders with information for predictive risk management systems for coastal zones. The intention is to provide an ability to assess the environmental risks and to support avoidance decisions relating to ship traffic activity. The pilot focuses on the pollution of water by the antifouling agent TBT in the German Bight. TBT is a strong biocide used in ship paints to prevent fouling of the ship hull. Over time it leaks into the water leading to serious malformations in organisms, such as oysters and snails. TBT is toxic to shellfish in a number of ways and interrupts growth, development and reproduction. It can also accumulate in food chains with potential ecological and economic impacts.

The main goal of Pilot 4 is the creation of a risk map showing various types of toxicity risks to which marine species in the German Bight can be exposed. The displayed risk values on the map are calculated by the simulation component that accesses observation data and parameters from several data sources – this section describes this simulation component. The ORCHESTRA Service Network of the German Bight Pilot is shown in the figure below. It contains the following services and clients.



7.4.2 Application for Environmental Shipping Risks

The pilot application gives the user the ability to:

- access data on shipping lanes, bathymetry, currents, TBT, toxicity data and wind;
- simulate the spatial distribution of a chemical pollutant like TBT over a given time;
- choose different species and toxicity thresholds; and
- generate risk maps.

Various simulations can be run and spatially gridded levels of environmental risks will be visually presented to the user overlayed on a map of the German Bight. The results of various simulations can be compared and, for example, help to identify areas with lower risk of TBT contamination. One particularly novel aspect of the developed system is that it allows simulations to be undertaken within a distributed architecture.

The Pilot Main Application realises the workflow of the risk management application. It is based on the framework of the content management system WebGenesis©.

It starts with searching the Catalogue Service for available Simulation Services (SiMS). The user decides which SiMS will be used for the simulation. According to the meta-information of the SiMS stored in the Catalogue Service (CS), the Pilot Main Application knows which Simulation Data Services (SDSs) need to be accessed for data to be delivered to the SiMS.

The Pilot Main Application gathers the necessary data and delivers it to the SiMS. The SiMS calculates the risk and sends the result of the simulation back to the Pilot Main Application which in turn sends it to the Map Client for display.

The Map Client enables the display of the created risk map. It is capable of accessing layers from the ORCHESTRA Map and Diagram Service and of accessing layers from conventional OGC Web Map Services. As for the Main Pilot Application, the Map Client is based on Web Genesis©. This ensures a good interaction between the client components.

In addition to the already discussed components, which are used to fulfil the main goal of this pilot, two additional services (Semantic Catalogue and Annotation Service) were included into the OSN to enhance the user's understanding of the background to the pilot.

Implemented Services 7.4.3

The following ORCHESTRA services were used for the pilot application:

SERVICE	APPLICATION
Catalogue Service	■ The Catalogue Service stores meta-information about all available services of the OSN. It uses the ORCHESTRA meta-information schema, which contains various sections describing general aspects of a service like meta-information for discovery or invocation and also specific sections for all services used in this pilot. Thus, with the meta-information stored in the Catalogue Service, clients can collect valuable information about available services before accessing them. Also, the Catalogue Service contains meta-information on documents describing the thematic issues concerning the pilot.

SERVICE	APPLICATION
Simulation Management Service (SiMS)	■ The Simulation Management Service wraps the simulation used for the creation of the pollutant exposure map. Depending on the type and quality of simulation to be performed it needs to be provided with adequate data from several data provider services, the SDSs. Using this data the simulation creates results, which are provided in GML. ■ Invocation of the SiMS by the pilot application is performed through a W3C web service client stub generated from the WSDL description of the service. Simulations are run by passing appropriate input parameters and a simulation result ID is received upon completion. The simulation result ID is then used to retrieve an XML structured file containing two information layers (ship lanes geometry and substance concentration areas). Based on the information contained in one of the layers the pilot application computes derived information layers (risk areas according to some criteria) and invokes the MaDS client to visualise a map collecting all the computed layers.
Simulation Data Services (SDSs)	■ A Simulation Data Service wraps proprietary data sources in ORCHESTRA Services, which can be included in the OSN. They provide necessary data for the simulation such as: bathymetry data, MetOcean data, pollutants with toxic effects on marine species and toxicity data, which include critical exposure thresholds and their classification against specific marine organisms.
Map and Diagram Service (MaDS)	■ The Map and Diagram Service provides an additional feature that is not available from a conventional WMS. It is capable of receiving GML data for the creation of a new layer. This feature is used by the Map Client for the creation of the layer showing the actual risk values created by the SiMS.
Semantic Catalogue (SC)	■ The Semantic Catalogue realizes a semantic extension of the Catalogue Service via the use of an ontology, describing the thematic coherences of topics and components related to the German Bight Pilot. Using this ontology, concepts connected to a user's queries are identified. In addition to the original query, the Semantic Catalogue searches for these new concepts in the contents of the Catalogue Service.

SERVICE	APPLICATION
Annotation Service (AS)	The Annotation Service uses the same ontology in order to connect words in documents describing the pilot with concepts in the ontology. This is useful in improving the user's understanding of the complicated thematic background that leads to the risk map created by the main workflow.

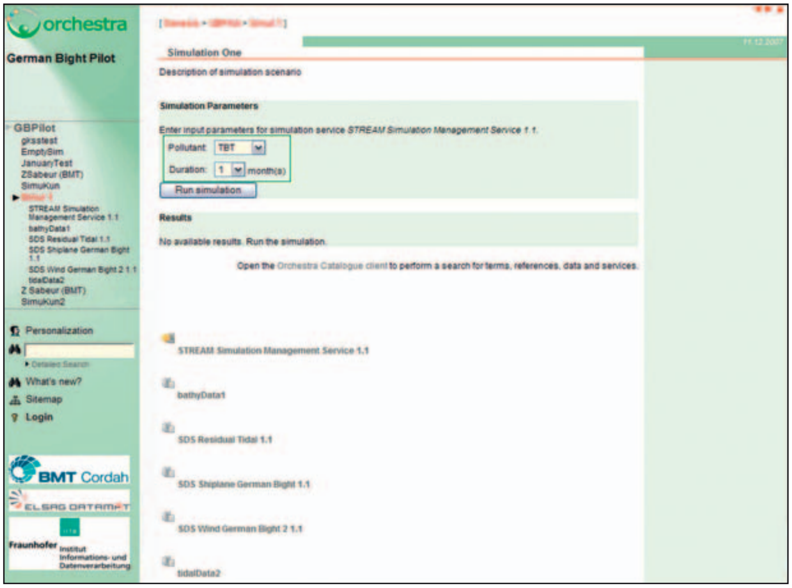
Chaining of Services 7.4.4

The prediction of ship traffic environmental risks in the German Bight has been implemented as a web application using the WebGenesis, an extensible and programmable content management system with support for ontologies, workflows and document management.

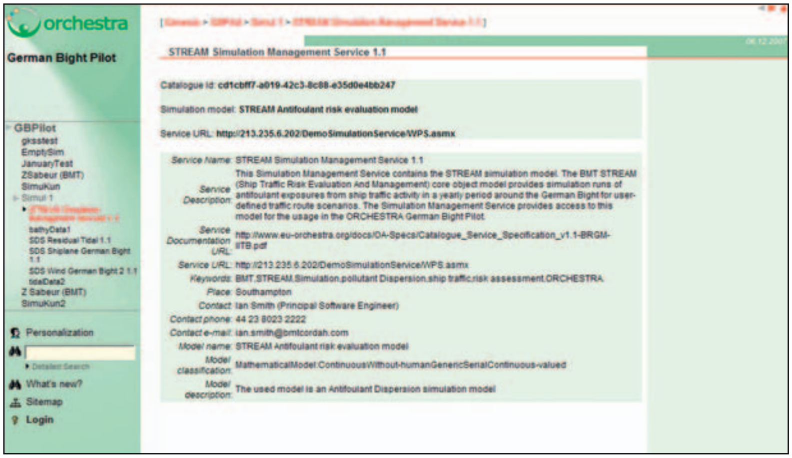
The user uses a web browser to link to the pilot web site. Then a welcome page showing introductory information and guidance about the pilot application is displayed:

Within the application window, the user can create and manage 'Simulation Scenarios' items as needed. The user can also check on previous Simulation Scenarios and display their respective summary information accordingly.

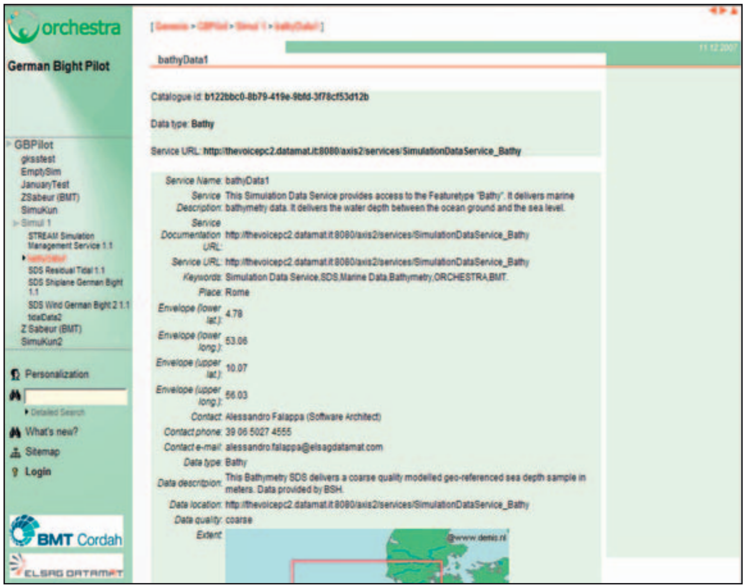
When a scenario is completed, its simulation can be run after the required BMT STREAM model parameters are entered correctly:

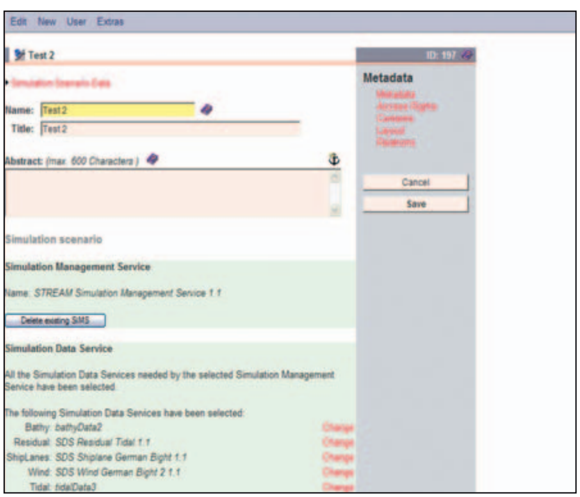


A simulation scenario contains references to one SiMS instance, while multiple SDS instances are involved in the same scenario:

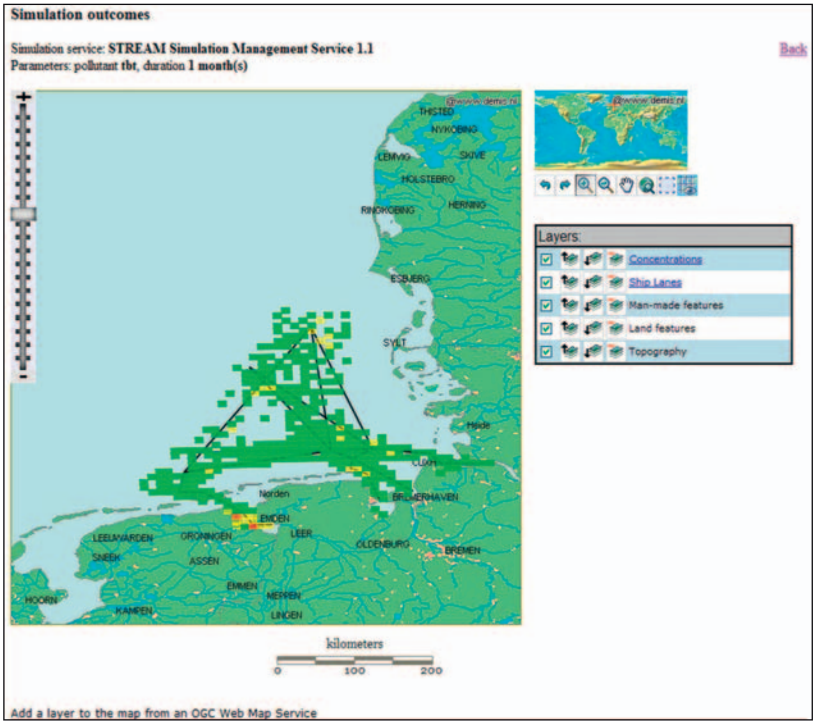


For more detailed information about data sources and services, the user can display SiMS and SDS metadata records from the Catalogue Service, as shown in the two figures below:





In addition, for a given SDS, a map can be drawn to provide the geographical extent of the data provided by the SDS. The user can trigger simulations after entering the simulation parameters. Then the simulation results can be graphically rendered by the MaDS, through a map viewer.



The creation of new scenarios or the modification of existing ones requires the user to go through a basic authentication procedure provided by WebGenesis. The user enters identification data (Name and Title) and descriptive data (Keywords, Abstract and/or Text). The pilot application guides the user in choosing the instance of a SiMS and related SDS instances by querying the Catalogue.

However, a simulation scenario that contains a SiMS instance with unsatisfactory SDS dependencies cannot be run and is consequently rejected. A message is given listing what additional data is needed.

7.5 DIGITAL RIGHTS MANAGEMENT

The management of user access and digital rights is a major issue for all operational implementations of risk management services. The topic has been addressed in ORCHESTRA Pilot 3 Impact Assessment on Transport Infrastructure and the results are summarised in this chapter.

User Authentication and Authorisation 7.5.1

The first stage of securing access to data and services conducted within this pilot was the implementation of the User Authentication and Authorisation (UAA) services developed within the project. This allows a user to enter the system once they have provided a valid log-in and password. Within the pilot three different kinds of user-roles were identified: citizen, hazard expert and transport company representative, with different levels of access to information and services. The roles are defined within the pilot as 'pre-packaged' bundles of permissions, thereby replacing some of the work of the UAA administrator.

Digital Rights Management 7.5.2

UAA services do not facilitate the whole range of behaviour that typical data and service providers would like to support. Therefore, within this pilot, aspects of Digital Rights Management (DRM) have been incorporated using elements of the UAA services plus work undertaken within the OGC Geo Rights Management (GeoRM) Working Group. This development is discussed in this section.

Rights Management Standards 7.5.3

OGC formed a Geo Rights Management (GeoRM) Working Group with the mission to '*coordinate and mature the development and validation of work being done on digital rights management for the geospatial community*'. The key output from the group is the OGC Geospatial Digital Rights Management Reference Model (GeoDRM RM)[34].

UAA and DRM Development Approach 7.5.4

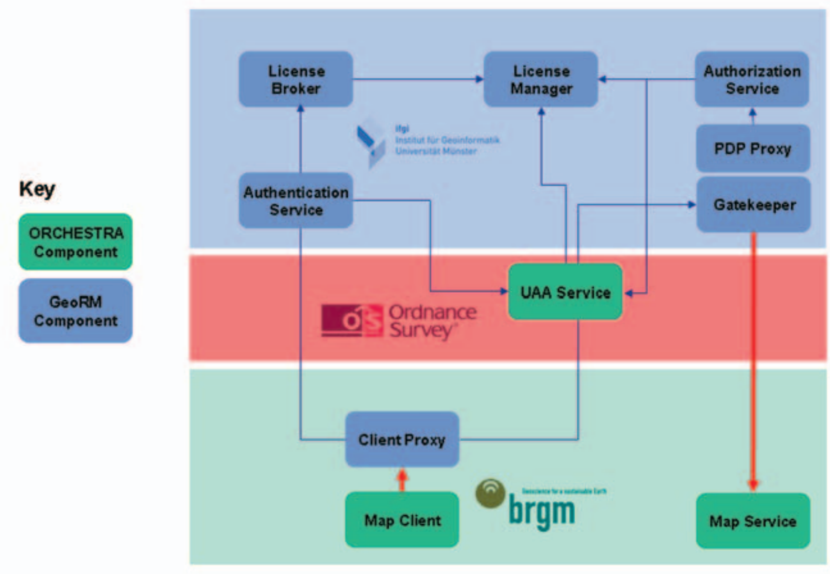
The development and implementation of the access right services of the pilot was split into three consecutive stages:

- Stage 1: **Open Access Services** – initial integration of services with no authentication and authorisation. The objective of this phase was to build the initial pilot capability and test the implemented services;
- Stage 2: **Authentication and Authorisation Services** – installation and configuration of the OSN Architecture Services for UAA;
- Stage 3: **Prototype Rights Management Capability** – this stage addressed the challenging aspects of implementing technical measures to manage and protect the content owners intellectual property.

[34] http://www.opengeospatial.org/standards/as/geodrmrm

Essentially, Stage 3: Prototype GeoRM capability automates the transfer of rights to a given user based on the terms specified in an electronic licence. It automates aspects of licence negotiation, creation and enforcement which would otherwise need to done in a manual way.

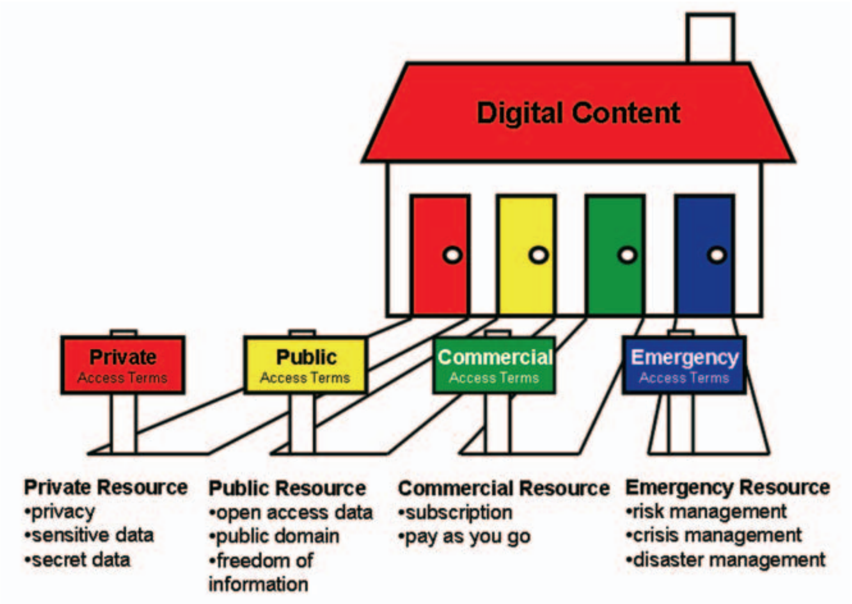
The key difference between the prototype GeoRM capability and traditional user authentication, authorisation and access control, is that the GeoRM components enable electronic licenses to be created and enforced in an automated way – putting the content owner in control of how their intellectual property is used.



For the purposes of the pilot development and demonstration the software components were integrated and deployed as above. Components shown in green are standard ORCHESTRA components; components shown in blue were developed initially by the OGC OWS4 Interoperability Testbed, and were adapted to integrate with the ORCHESTRA services architecture. The software components have been designed so they may be flexibly deployed, the deployment shown above was appropriate for the needs of the pilot, but could be readily adapted for other services oriented applications.

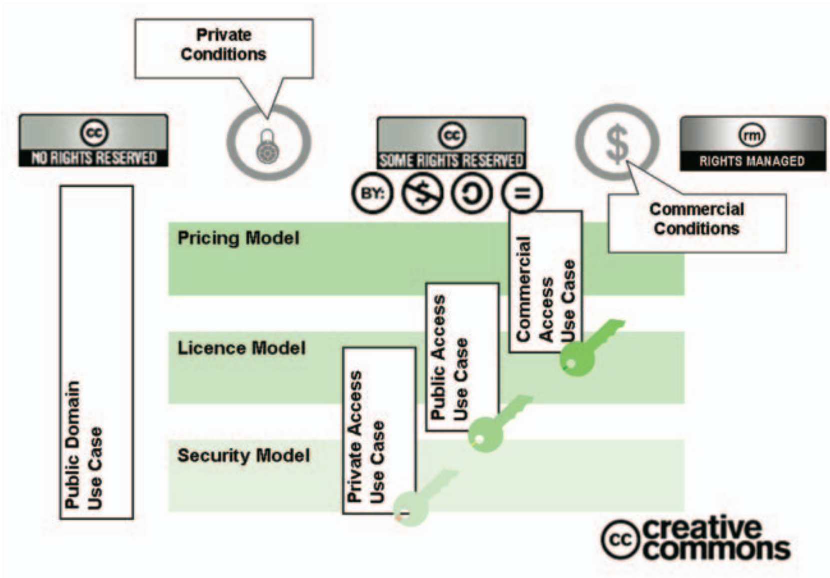
7.5.5 Electronic Licensing Terms

One aspect that makes automated rights management so challenging is that the social and cultural conventions for sharing digital property have not yet been fully established. To illustrate this point consider the social conventions we have established to access physical property. If you want go into a private home or office, social convention and the law require you to have permission. Similarly, when you go into a public building such as a public library or art gallery you know you are subject to an implicit set of terms and conditions. Finally, if you enter a commercial cinema or theatre you know that the terms and conditions will require you to pay to go in.



The key challenge we faced in implementing the prototype rights management capability was defining a set of licensing terms that could be both easily understood from the user perspective and could be encoded electronically. There is no existing standard or convention that defines standard licensing terms and allows them to be encoded electronically. Therefore for the purposes of the prototype rights management capability we drew inspiration from and extended the standard licensing terms as defined in Creative Commons[35].

[35] http://www.creativecommons.org



Creative Commons licensing terms (represented by 'terms buttons') are defined to enable the public sharing of creative works. The additional requirements of the ORCHESTRA prototype were to support the private, commercial and emergency use of digital content. Therefore for the purposes of the pilot, we created additional licensing terms (shown above as grey terms buttons).

This is to allow content owners to enable to access to their content and ensure that it remains private or can be used for commercial purposes.

The additional licensing terms defined for the pilot where for illustration purposes only. Outside the scope of the pilot there is a need to standardise licensing terms for different data sharing communities.

Warning: We are using Creative Commons for illustrative purposes only – we don't see it as a panacea for all rights management situations

creative commons

Creative Commons is an example licensing model – not necessarily 'the' licensing model

Attribution	You let others copy, distribute, display, and perform your copyrighted work –and derivative works based upon it – but only if they give credit the way you request
Non-commercial	You let others copy, distribute, display, and perform your work – and derivative works based upon it – but for non-commercial purposes only
No Derivative Works	You let others copy, distribute, display and perform only verbatim copies of your work, not derivative works based upon it
Share Alike	You allow others to distribute derivative works only under a license identical to the license that governs your work
Non-disclosure	You let others use your copyrighted work – on the condition that the work or any derived work is not disclosed to a third party
Commercial	You let others use your copyrighted work for commercial purposes – and may expect financial compensation
Emergency	You let others use your copyrighted work for emergency purposes

Standard Creative Commons licensing terms are shown above in black. Additional terms created for the purposes of the pilot are shown in grey. Creative Commons uses HTML tags to create the 'digital code' for Creative Commons licensing.

Creative Commons digital code enables users to tag their content in such a way that it may be searched on the Internet. This very powerful feature allows users of content to search for content licensed under a specific Creative Commons licensing type. However, it is worth noting that Creative Commons does not provide any enforcement of licensing terms and relies entirely on the 'force of the law' to enforce the terms of the licences.

Protected	You let others use your copyrighted work subject to additional constrains –which may be enforced using a technical protection measure
Identity	Is established electronically
Click-through	Agree to terms and conditions
Temporal	For a specified period of time
Geographic	For a specified geographic area
Trial access	Access limited for trial purposes
Encrypted	Content is digitally encrypted

The key innovation introduced by the ORCHESTRA pilot was to add an additional set of licensing terms (shown above) which indicate that the content is *technically protected*. The owner of the digital content is able to define the terms under which the digital content is licensed – *and those terms are then enforced by the computer*.

The following section describes how these licensing terms were combined together in different ways to support the pilot use cases.

7.5.6 Example Electronic Licences

For the purposes of the pilot some example licenses were created, approximately based on the 'doors' representing the access terms to digital content we described previously. Each rights management use case we were required to support needed the definition of a data sharing licence based on the extended licensing terms. The types of licences supported within this pilot are the following (although other types can be created by combining the available building blocks of the Creative Commons and GeoRM structures):

- Private: Non-disclosure, Protected Identity for Trial Access (known as Trial Licence)
  This license lets others use your copyrighted work privately where disclosure to a third-party is prohibited and the content is protected where identity is established electronically and access is constrained for trial access.
- Private: Non-Disclosure, Protected Identity for specified period of time (known as Time-Limited Licence)
  This license lets others use your copyrighted work privately where disclosure to a third-party is prohibited and the content is protected where identity is established electronically and access is constrained for a specified period of time.
- Emergency: Protected Identity (known as Break-the-Glass Licence)
  This license lets others use your copyrighted work in an emergency where identity is established electronically.
- Public: Attribution, Non-commercial, No Derivatives
  This license extends the standard creative commons licence (by-nc-nd) by adding protection with a click-through agreement

In order to make these licences easier to understand, four scenarios have been implemented with roles played by fictitious people, which are given below:

- Dan: He works for a Hazard Management company and wants trial *access* to Hazard Expert Services.
  The *subject* 'Dan' and *principle* 'Dan Login1', and role of Hazard Expert are in the UAA database. A *Trial Licence* allowing 10 calls (countdown by access) to the Hazard Expert Services has been created.
- Edward: He works for a Transport Company and wants *time-limited access* to Transport Company Services.
  The *subject* 'Edward' and *principle* 'Edward Login1' and role of Transport Company are in the UAA database. A *Time-Limited Licence* (expires in six months) to the Transport Company Services has been created.
- Fred: He works for the Fire brigade, is a registered ORCHESTRA user, and requires immediate emergency access to the Transport Company Services.
  The *subject* 'Fred' and *principle* 'Fred Login1' and role of Transport Company are in the UAA database. A *Break-the-Glass Licence* to the Transport Company Services has been created for use in case of an emergency.
- George: He is an unregistered citizen who requires access to Maps of Alternative Routes. George is a citizen who is not registered in ORCHESTRA. A licence to access the Maps of Alternative Routes has been created for Citizens.

CONCLUSIONS 7.6

Achievements 7.6.1

The ORCHESTRA pilot implementations addressed two main objectives:

- To Improve the decision-making process for prevention planning of various risks in both regional and pan-European instances; and to do this via the implementation of interoperable services of data management and modelling. These models are usually run separately in each domain, but here we have created common multi-risk maps in a consistent way.
- To test the adequacy of the ORCHESTRA Architecture and components as a solution to meet the mentioned challenges and, in turn, identify which parts need to be corrected or modified towards a fully operational implementation in other similar cases at larger scales.

Accordingly the pilots addressed the most common challenges in real-life multi-risk management based on examples of what is requested in many other regions of Europe.

On a higher level, these challenges are:

- **Regulatory**
  The pilot studies are in line with the actual promotion policy of new regulations in territorial planning, integrating Civil Protection, risk management and environmental points of view, with common and unique criteria. They are also in line with the European Directive on the Assessment and Management of Floods
- **Political**
  The development of the pilots serves as an example to drive future policies towards a common and standardised European space of knowledge and information.
- **Technical**
  ORCHESTRA components and specifications will improve the execution of projects, by diminishing the time needed to find and process standardised information, and also by promoting access to already developed technical applications and services.
- **Societal**
  The pilots are improving stakeholder's awareness on risk management, through the access to more accessible, complete and understandable information.
- **Commercial**
  Currently, the implementation of ORCHESTRA components and specifications in the pilots is opening a new horizon of opportunities to data and service providers in risk management, delivering information products of higher quality at competitive prices

Since most risk management implementations are facing a cross-border geographical and administrative framework at the provincial, regional and international levels, they require an interaction among different administrations, each one with its own structure and geographical competences.

The ORCHESTRA Pilots have demonstrated a way forward to overcome at least some of the most pressing issues in this context:

- **Spatial and non-spatial information integration**
  Characterisation of river basins morphology and its associated hydraulic and hydrologic response entails the gathering, checking and integration of a wealth of information, some of which has no specific geographical reference, nor a relation to socio-economic factors. One of the most difficult challenges in combined prevention planning is the estimation of vulnerability of the different values at risk and to estimate loses and costs associated to the different levels of damage in a unified way and integrated in a geographical context. The way to achieve this is by combining rules of risk —function of exposure, vulnerability and danger, which usually is non-spatial information— with the affected area polygons or cells of a grid – spatial information
- **Multi-linguality**
  in the planning context, entailing the extensive use of different European languages for the interaction with the neighbouring municipalities.
- **Semantic interoperability**
  Interoperability presents several facets, not only technical and scientific terminology used in each domain, but particularly the same terminology used to describe and measure different concepts, which hinder the understanding and synthesis of common risk maps.

Issues and Solutions 7.6.2

Based on the experience of the pilot implementations, the following aspects should be taken into consideration in the design and implementation of risk management information services:

- **Performance**
  This is measured not only considering the computation but also the time spent in transferring data between services. Since the data sets transferred are potentially very big and are transferred over a network (usually the Internet), it is crucial to prevent redundant data transfers by investigating data passing modalities. In particular, the solution based on the Repository service requires three exchanges of features: first between the FAS and the chain controller, then from the chain controller to the Repository and, finally, from the Repository to the Processing service.

Since the chain controller does not need to store such features an improved solution could be proposed, e.g.: by integrating the repository with the FAS (e.g. by using a 'store' flag in the getFeatures request) or by a Processing service supporting a more sophisticated data reference (some efforts in this direction appear in the OGC Web Processing Service, candidate version 1.0) that could reduce the number of feature exchanges from three to one.

- **Stateful communication**
  The concurrent execution of the Risk Assessment Service sessions raises issues concerning the routing of messages exchanged between services to the proper session. Available solutions are based on correlation sets that basically use some input parameters to identify the corresponding session, or on the WS-Addressing information that can be stored in the SOAP header. The former is more flexible and permits the management of the message correlation at the level of workflow description, while the latter basically uses the communication infrastructures functionalities. The implemented solution uses the WS-Addressing to deal with stateful communication.
- **Dynamic service binding**
  As previously mentioned it could be useful to define at run time the location of the services that the chain has to invoke. WS-BPEL integrates WS-Addressing functionalities that allow assigning the endpoint of the partners during the execution of each session.
- **Interaction modalities**
  The implemented Risk Assessment Service uses and provides only synchronous operations. The larger the size of selected features the greater time is spent completing the workflow. Therefore, in some cases it would be useful to asynchronously invoke the Risk Assessment Service operations, monitor the execution state and retrieve the results when it completes. It is worth noting that such interaction modality complicates the client as well as the service chain implementation.

Roadmap to using ORCHESTRA

8

ORCHESTRA applications are today running in four pilot implementations and are built on distributed services which are remotely provided by parties inside and outside the project consortium. The pilots are using both proprietary and open source software. Results of ORCHESTRA are now also being applied to the tsunami early-warning system of the Indian Ocean, and other significant uses of ORCHESTRA are foreseen for the near future.

From a technical point of view, ORCHESTRA represents a milestone in the use of and contribution to open standards from an architectural perspective, with the goal of providing interoperability.

From the business point of view, ORCHESTRA represents a great opportunity for service and solution providers to make business at no added cost (specifications are public and free of charge). It is also a great opportunity for institutions in the environmental risk management field to solve their interoperability problems, enhance their performance and ultimately lowering their costs, with a moderate investment in making their existing systems compatible to ORCHESTRA principles, without embarking on long, costly, repetitive and often non successful integration efforts.

This Chapter concludes the ORCHESTRA Book, which in its first part has mainly addressed the business perspective of the work and results of ORCHESTRA and how they may be of relevance to third parties. The second part provided the more detailed technical descriptions addressing stakeholders with an interest to adopt the ORCHESTRA approach. This chapter aims to provide some brief guidance on the steps required to leverage the work of ORCHESTRA.

WHY ADOPT ORCHESTRA? 8.1

There are a number of compelling reasons to adopt ORCHESTRA from different perspectives:

- To **achieve interoperability** and be able to exchange information fluently and effectively with customers, providers, collaborating organisations, etc.

As a positive side effect, which we ourselves have experience in the first ORCHESTRA deployments, once information is effectively exchanged, **organisational and cross-organisational benefits start to emerge**. Once teams are able to exchange hitherto inaccessible information, new information and collaboration patterns emerge: joint teams – physical or virtual – are created, issues that were tackled from different views (vulnerable elements according to a forest fire or a flood expert) are now jointly addressed, etc.

- To benefit from the **cost reductions that standardisation makes possible**. If you want to know more about this, please check chapter 4 on Business Models.
- If you design and develop IT systems or software, you will be able to **quickly and cost effectively design and develop new applications** that help you to meet the mandates and business goals of your customer. You will have the benefits of SOA and open standards (see section 2.5) that ORCHESTRA has successfully coupled, plus others like flexibility, technology independence, design for change or extensibility, which mean savings in the mid and long term.
- If you are not a technical supplier, you can **obtain better and quicker service** from your vendors or providers if they adopt ORCHESTRA for your software. In addition, **you will not be tied to a single vendor** (thanks to the use of open standards) and your IT systems and applications will benefit from the features listed in the previous bullet point.
- If you are an information **or data provider**, you can deliver your product to a wider audience in an interoperable manner. In addition, the flexibility of the ORCHESTRA Architecture enables you to offer all or part of your information for free or under the payment scheme of your choice, and under some or no security restrictions.

In particular, **for the risk management field**, you will be able to exchange information and collaborate better with relevant actors and stakeholders in your domain or business. You will also be better prepared to respond to cross-organisational and cross-border situations, and to near real-time situations (by discovering quickly services that can provide you with the necessary information, whether locally or remotely). Another important topic is the possibility of enhancing your existing IT systems and applications, making them meet ORCHESTRA principles with a moderate investment, and avoiding costly and painful integration processes. For new IT systems and applications, having them developed according to ORCHESTRA principles will provide you the benefits outlined in this section, and in particular, their possibilities for re-use and evolution, and their design for change (reducing future investments to cope with obsolescence).

HOW TO ADOPT ORCHESTRA 8.2

The objective of this section is to provide you with hints on how to proceed with the adoption of ORCHESTRA principles and results.

Although detailed analysis of different profiles of ORCHESTRA users have been carried out, for the sake of simplicity we will focus on three main groups, namely:

- Risk management actors and stakeholders
- IT providers
- Information or data providers

Risk Management Actors and Stakeholders 8.2.1

Interoperability and long term perspective are two key drivers for ORCHESTRA adoption. In the area of risk and crisis management, interoperability primarily means improved information exchange within one organisation and easy access to information offered by other organisations. Equally important is the assurance that ORCHESTRA systems and applications can grow with your organisational needs. ORCHESTRA networks can be altered fairly easily to accommodate emerging needs without the need to make large investments in extensions or integration. New applications of relevance for your objectives (be it internal applications, or applications for joint work with other actors and authorities, or for informing the general public) can be added in a cost-effective manner, both by re-using already existing components and by building new ones following ORCHESTRA architectural rules.

In this case, the options are to go for in-house or external developments. For the first case, please refer to the section (6.3.2) intended for IT providers. For the second case, you may use this book (as well as referenced material) and the on-line Training Units at the ORCHESTRA website in order to get a clear picture of what ORCHESTRA can do for you and why. With this information in mind, you can elaborate your invitations to tender (or whatever form of supply request applicable) more accurately. Thus, you can specify which items and criteria must be met by your potential providers: meeting ORCHESTRA architectural principles, using OGC standards, re-using ORCHESTRA software (provided free of charge under open source licences), using the ORCHESTRA methodology for building ORCHESTRA service networks or for applying ORCHESTRA principles and results to new use cases, appropriate use of open standards, etc.

Depending on your available time and resources, it may be more economic for your organisation to have the support of an expert in ORCHESTRA. If this were the case, do not hesitate to contact the ORCHESTRA consortium in order to analyse your situation and the support that can be provided.

8.2.2 IT Providers

If your organisation designs, develops or integrates systems and applications, your main drivers for adopting ORCHESTRA are to be able to quickly and cost effectively provide your products to your customers, knowing that you are providing the benefits of the SOA approach and those of using open standards, providing interoperable solutions, while efficiently re-using available code. In the particular case of integration, ORCHESTRA results may be used to encapsulate existing third party systems or products (which are of interest to your customer) in a way that they remain virtually untouched but fulfil ORCHESTRA principles, hence greatly diminishing integration efforts.

In this case, your relevant teams should examine in detail the available ORCHESTRA documentation listed in Section 6.3 (RM-OA, High-Level Requirements, Meta-Information Model, OA and OT service specifications) and technical on-line Training Units, in order to gain knowledge of the approach, architectural principles, possibilities and existing methodologies. Also, keep in mind that soon relevant ORCHESTRA software will be available free of charge under open source licences, so that your institution can re-use it for learning or commercial purposes (according to the conditions of the licenses involved in each case).

As mentioned before, depending on your available time and resources, it may be more economic for your organisation to have the support of an expert in ORCHESTRA. This support may be available for training your staff, for providing consultancy on specific technical topics, or to assist you during development phases. If this were the case, do not hesitate to contact the ORCHESTRA consortium in order to analyse your situation and the support that can be provided.

8.2.3 Information or Data Providers

If the main objective (or one of the main objectives) of your organisation is the provision of geospatial information or data (or information with an important geospatial component or use), your main drivers for adopting ORCHESTRA are to be able to quickly and cost effectively provide your information or data to your customers, in an interoperable way, in an automated or semi-automated way if desired, 24/7, using IT systems and applications that are cost-effective and which can be easily modified according to future needs, and – above all – in a way that is fully aligned with your business model(s). ORCHESTRA enables you to achieve these goals while accommodating different business models (provision of data for free or under different payment schemes, restrictions of access, different licensing schemes, etc.).

In this case, the options are to go for in-house or external developments. For the first case, please refer to the earlier section (6.3.2) intended for IT providers, paying special attention to the work carried out in DRM (sections 7.3 and 7.5). For the second case, please refer to section 6.3.1, intended for parties requesting external developments.

PROJECTS USING ORCHESTRA RESULTS 8.3

During the lifetime of ORCHESTRA numerous collaborations have been carried out with other project working either in risk and crisis management or in related technological fields of mutual interest.

Project SANY 8.3.1

SANY (Sensors Anywhere; www.sany-ip.eu) is an FP6 Integrated project co-funded by the Information Society and Media DG of the European Commission within the RTD activities of the thematic priority 'Information Society Technologies'. The project started in September 2006, with intended duration of 36 months.

The main research goal of SANY is to specify a coherent service-oriented architecture including a set of services, protocols and information models that allow seamless 'plug and measure' type of environmental risk sensor networks, and to provide a reference implementation of these specifications.

Interoperability and long term perspective ('design for change') are equally important for environmental monitoring, as they are for risk and crisis management. Moreover, these two domains share a great number of functional requirements. In fact, data gathered by environmental monitoring networks is one of the most important inputs for risk and crisis management.

Consequently, SANY adopted the general ORCHESTRA approach for specifying a service-oriented architecture. The complete specification methodology, all generic system requirements, the general service framework and implementations of most important generic services (e.g. catalogues, source system access services, authorisation etc.) existed when SANY started.

Other important technologies used and further developed within SANY include the OGC Sensor Web Enablement initiative, MASS/SSE (Service Support Environment), the IEEE 1451 standard for smart transducers, and a number of legacy environmental monitoring systems.

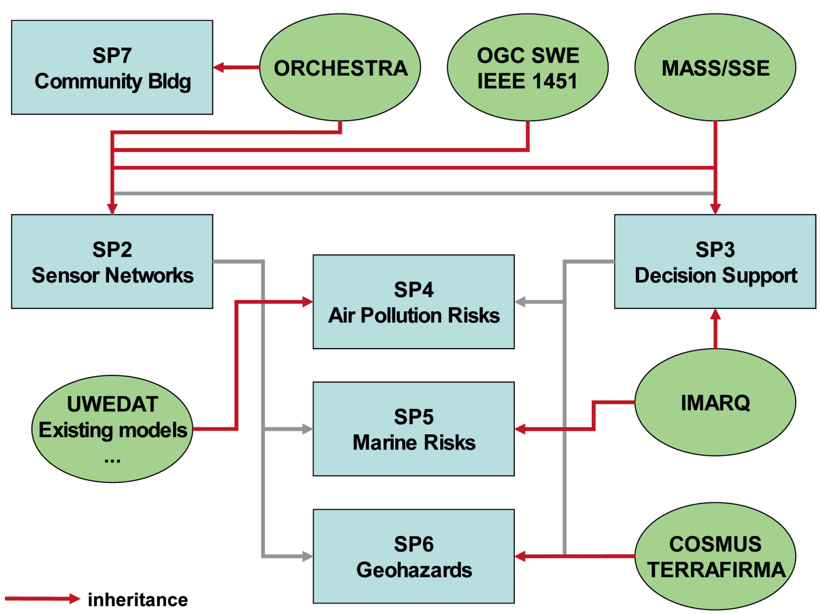


Figure from 'SANY (Sensors Anywhere) Integrated Project' article published in ISESS 2007 proceedings. Authors: Denis Havlik, Gerald Schimak, Ralf Denzer and Bernard Stevenot

The importance of SANY for ORCHESTRA is twofold:

- SANY will prototype risk and environmental information systems to demonstrate and validate the use of the ORCHESTRA architecture in real situations relevant to environmental monitoring in the domains of geo-hazard, marine risk and air pollution.
- SANY, especially the Fraunhofer IITB has committed to maintain and extend the RM-OA during SANY live time.

Project GITEWS 8.3.2

After ORCHESTRA published the first version of the RM-OA, conversations started between project GITEWS and ORCHESTRA. Project GITEWS (the German contribution to the Indian Ocean tsunami early warning system) is an ambitious project funded by the German government and carried out by coordinator GeoForschungsZentrum (GFZ) Potsdam and its partners German Aerospace Centre (DLR), Alfred-Wegener-Institute for Polar and Marine Research (AWI), GKSS Research Centre, Leibniz-Institute for Marine Sciences (IFM-GEOMAR), United Nations University (UNU), Federal Institute for Geosciences and Natural Resources (BGR), German Agency for Technical Cooperation (GTZ), as well as Indonesian and other international partners.

The objective of GITEWS is the implementation of an effective Tsunami Early Warning System for the Indian Ocean, mainly off-coast Indonesia. The system integrates terrestrial observation networks of seismology and geodesy with marine measurement techniques and satellite observations. The Early Warning System for the Indian Ocean consists of different sensor components as broadband seismometers, GPS, tide gauges, ocean-bottom pressure sensors and GPS-buoys. Warnings are generated on the basis of registered data and modelling results.

While GITEWS focuses on the upstream part of the system, project DEWS was launched (with support from the European Commission's FP6 IST programme) in order to apply ORCHESTRA to the downstream part of the system and, specifically, to guarantee good use of standards and the achievement of interoperability. Project DEWS is covered in more detail in the next section.

Project DEWS 8.3.3

Project DEWS (Distant Early Warning System) was started for a number of important reasons:

- The tsunami 2004 event in the Indian Ocean region revealed critical shortcomings.
- There is an urgent need for a new generation of reliable tsunami early warning systems based on a stable multi-sensor monitoring platform.
- The time interval between an initial strong earthquake and the detection of the tsunami has to be drastically reduced.
- Warning messages should be generated more rapidly and should only be disseminated to responsible authorities and people at risk.

- Initial warnings should be followed by in-depth information that is understandable by and reliable for people.
- Another important challenge is the international communication and warning exchange in the Indian Ocean region.

For these reasons, and in order to complement the efforts of project GITEWS (see section 8.3.2) which aims to deliver an interoperable tsunami early warning system for the Indian Ocean, ORCHESTRA, GITEWS and other parties joined efforts in project DEWS. The consortium has several objectives:

- To strengthen early warning capacities by building an innovative generation of interoperable tsunami early warning systems.
  - Tsunami detection will be based on an open sensor platform, integrating sensor systems for earthquake (seismic), sea level (tide gauge, buoys) and ground displacement (GPS land stations) monitoring provided by German project GITEWS (led by GFZ).
- Based on this improved upstream information flow, the downstream capacities will be enhanced by improving information logistics and multi-channel warning dissemination.
- Warning messages have to be disseminated to the public, authorities and emergency management forces. Of special importance is the distant communication of warning information among warning centres in the Indian Ocean region.

The decision to adopt ORCHESTRA in the DEWS project was originated by the expected problems of lack of interoperability due to:

- the numerous source systems to be integrated in the upstream flow, from seismic sensors or tide gauges, up to the mix of information and combination with pre-processed scenarios in order to trigger an early warning,
- the complex information management scenarios taking place when the early warning is triggered, and critical associated information has to be produced in different formats, languages and layouts (according to the different user profiles) for authorities, stakeholders and the population in different South-East Asian countries.
- In addition, such authorities and stakeholder must collaborate on a supra-national level both in the prevention and crisis phases, with the cultural, organisation and languages problems that this type of scenarios entail.

Training sessions are under preparation so that technical partners in DEWS become adequately acquainted with ORCHESTRA objectives, principles and results, in order to effectively re-use available results (including methodologies) along the project. The methodology for applying ORCHESTRA to a new use case is being used to decide on the necessary applications and ORCHESTRA services that will compose them, which are necessary to fulfil the requirements of DEWS stakeholders. In this case, and it can be applied to others, many of the OA Services are going to be used while not many OT Services can be applied, since tsunami is a theme not covered in ORCHESTRA. However, some OT Services from ORCHESTRA that cannot be directly used (risk-specific ones, in contrast to risk-neutral services), may be subject to modifications in order to optimise development by re-use of code.

The task to accomplish in DEWS is definitely not easy by sheer size and complexity, and substantial hardware infrastructure has to be taken into account in the upstream flow (sensor networks, where collaborations with SANY are foreseen) and in the downstream flow (communications hardware for warning and alert distribution). However, it is expected that key aspects such as interoperability, integration with national systems and centres, and flexibility for application to other risks and geographical areas will be made possible and substantially facilitated by the adoption of ORCHESTRA.

9 Conclusions

We live in globally challenging times. Environmental concerns are some of the most important topics identified by developed societies to ensure sustainable growth and the well-being of citizens. The multifaceted nature of the challenge requires solutions that both use and address several aspects; socio-economic, business, technological, policy, scientific, etc.

Within the environmental domain, ORCHESTRA has focused on a more specific – but nevertheless critical and ambitious – problem: environmental risk management. Its present and future relevance has been highlighted by the increasing number of man-made and natural disasters. These show the urgent need to consolidate information from disparate information systems to support citizen protection as well as disaster and emergency management operations. From a technological point of view, the challenge is to get those systems to work together and share information to allow proper data analysis and resource management.

The ORCHESTRA value proposition stressed that the availability of reliable and actionable information holds the key to improved efficiency and effectiveness in risk management.

In order to fulfil the project objectives and deliver results in line with this value proposition, ORCHESTRA coupled its scientific and technological tasks with business, policy and standards activities, carried out together with some of the main players in each domain. ORCHESTRA also targeted the technological challenges of information exchange in multi-disciplinary and multi-national use cases. The results of this work have been provided as input to the INSPIRE and GMES initiatives as well as to the relevant standardisation bodies.

In this book we have presented:

- the project, its rationale, objectives and main results;
- the current IT environment and relevant trends for the future, for which ORCHESTRA has been designed;
- the value proposition, including aspects such as cost-benefit analyses and benefits of using open standards and proactive engagement;
- the ORCHESTRA Architecture (RM-OA), currently the only architecture with 'best practise' status at the standards organisation OGC;
- the deployed multi-risk pilot implementations, including different aspects such as geospatial rights management and service chaining;

- current interoperability challenges, as well as relevant policies and regulations and
- the roadmap to using ORCHESTRA results, addressing different types of users probably including users similar to your organisation.

We are convinced that the necessary elements exist for our organisations and societies to effectively address current challenges. Furthermore, action is also necessary on the part of organisations in order to ensure the fulfilment of their objectives as well as their own sustainability in a rapidly changing world.

ORCHESTRA provides a set of results that can be readily used in order to significantly improve the efficacy and efficiency of an environmental risk management organisation. Furthermore, and more importantly from a business perspective, these results will require moderate investments (in comparison with usual approaches) and should lead to reduced costs in the mid and long term.

The ORCHESTRA consortium has made a substantial effort to provide these results in an open manner to the extent that a number of key basic results are being offered free-of-charge in order to facilitate their testing and eventual adoption by interested parties.

We invite you to reflect upon the observations, ideas and results presented in this book, and to consider the benefits of their use. We would also like to invite you to contact us if you are interested in these ideas and approaches and would like to explore their application for your organisation, or to launch initial implementations.

The future is being built on IT systems that favour information exchange and community work to solve societies' challenges. ORCHESTRA provides not only a vision but also a blue-print of that future.

Annex 1: Interoperability Challenges

This chapter looks at various challenges that have been encountered during work in the ORCHESTRA project. The following topics are addressed:

- Technologies and Standards by example of OGC
- Environmental Risk Regulations and Policies
- Challenges in Cross Border Scenarios

It then takes a look at how an SDI can help to address these issues and the current state of Initiatives such as INSPIRE, GMES and GEOSS.

A.1 TECHNOLOGIES AND STANDARDS

Interoperability is defined as the ability of diverse systems and organisations to work together; a difficult but worthwhile accomplishment.

In emergency response, the presence or absence of interoperability can mean life or death. This claim was demonstrated to be literally true in the United States when terrorists struck New York City and the Pentagon in 2001. Dispatch systems in neighbouring political units had been purchased independently, and had served their communities well for the 'ordinary' emergencies of a house fire or a heart attack. However, an event of the scope of the attack on 11 September requires emergency response teams to assemble and function across political borders.

Environmental hazards such as a flood or an explosion at a chemical plant similarly deliver devastation with no respect for political boundaries. Only when the independently-selected systems are interoperable do they actually deliver the protection, mitigation and remediation for which they are intended.

A.1.1 The Experience of the Open Geospatial Consortium (OGC)

The Open Geospatial Consortium (OGC) is a standards organisation dating back to 1994. Its experience offers relevant information to decision-makers in the field of risk management, because interfaces based on open standards enable diverse systems to communicate directly over networks, a capability that contributes economy, efficiency and effectiveness to both the planning and response aspects of emergency situations.

OGC's purpose is to develop such open standards in the geospatial arena by collaboration among all interested parties, so that 'the full societal, economic and scientific benefits of integrating electronic location resources into commercial and institutional processes worldwide' will be realized[36].

The issues inhibiting interoperability include both technical challenges and a broad array of challenges that may include social, political and organisational components. While the primary focus of OGC's efforts is to provide the process that leads to useful solutions to the technical issues,

the availability of standards is not the solution to any interoperability problem; implementation of the standards is what solves the problem.

Since standards must be implemented in order to deliver a return on the investment involved in solving the technical issues, OGC allocates some of its resources to outreach efforts to deal also with the non-technical issues.

The challenges of making information sources interoperable begin with enormous semantic problems. How do we come to develop a common understanding of words, objects and processes? Even when the interested parties all speak the same language, they may not all mean the same thing when they use a particular word. Thus the development of a shared dictionary becomes a basic step toward interoperability; every OGC Specification (Standard) has a section 'Terms and Definitions' to establish the necessary common understanding. The collaborative process leading to common definitions involves rigorous thought and intense discussion, generally over a period of at least a year or two in OGC's experience.

Other challenges include variation in symbols and in coordinate reference systems. The experience of OGC in identifying and addressing a range of challenges is described, by looking at some of its 22 openly and freely available standards (listed at http://www.opengeospatial.org/standards/). The standards are released by agreement of OGC members as the result of a well-defined collaborative process that brings all affected parties into the process regardless of their business model, and that is careful to respect intellectual property.

Available Interoperability Specifications A.1.2

The first OGC Specification to be approved by the membership was the Simple Features Specification, released in 1997. It specifies the interface that enables diverse systems to communicate in terms of 'simple features.' The supported

[36] http://www.opengeospatial.org/ogc/vision

geometry types include points, lines, curves, and polygons, all based on two-dimensional geometry. Each geometric object is associated with a Spatial Reference System, which describes the coordinate space in which the geometric object is defined. This highlights the fact that, in order for interoperability in the geospatial realm to succeed, not only words but also spatial reference systems must be well-defined.

In 1999, OGC released two more key specifications: Grid Coverages and Catalog Services.

- The Grid Coverages Specification promotes interoperability between vendors of raster (gridded) data and vendors of software providing grid analysis and processing capabilities. To manage environmental risk, decision-makers want to be able to use data from a variety of sources—for example, aerial photography from different suppliers (pre-event and post-event), lidar data and satellite imagery—in available software products that may also come from different suppliers, without wasting precious life-saving time and other resources re-formatting data.
- The Catalog Service Interface Specification defines a common interface that enables diverse applications—as long as they are conformant—to perform discovery, browse and query operations against distributed and potentially heterogeneous catalogue servers. Looking again at risk management, if we imagine an avalanche in a populated area such as a ski resort, the topographic data may be on one server, the roads and other transportation data on another server, and the emergency management assets on yet another server. Being able to find and query all of these data sources is essential to successful recovery efforts. Being able to find data quickly facilitates informed and timely response.

In 2000, the Coordinate Transformation Services Specification and the Web Map Server Specification were released.

- OGC's Coordinate Transformation Services Specification fills the need that arises when data are available in different coordinate reference systems, by providing a standard way for software to specify and access coordinate transformation services for use on specified sets of spatial data. Every coordinate system used to represent the spherical Earth on flat paper is limited in the geographic extent it represents with minimal distortion; to keep distortion within acceptable limits, coordinate systems are implemented in zones. Political entities may include more than one zone, and at the zone boundary features do not meet properly. For example,

- The State of Kentucky lies in Universal Transverse Mercator zones 16 and 17, and North and South zones of the State Plane Coordinate System. As established by law (KRS 1.020 The Kentucky Coordinate System of 1983), the State Plane coordinate System is also used for legal referencing of survey monuments and property boundary corners. Having a seamless coordinate system, that encompasses the entire state as one piece, has been a conundrum for Kentucky GIS users from the very early days of the use of GIS technology in the State. Over the time, different agencies have taken different approaches to resolving this issue,… GIS data had been stored and distributed in UTM coordinate system zones 16 and 17, or State Plane North and South zones by state and local government agencies. For areas that were on the border of UTM Zones 16 and 17 usually, one or the other UTM zone was picked. Usually, local governments used the State Plane coordinate zone that covered the area within their jurisdictional boundaries. Many state agencies used UTM zone 16, that covers about two thirds of the State, when they needed to represented spatial data statewide. Alternatively, Kentucky Transportation Cabinet had developed and been using a seamless custom coordinate system, which was based on Lambert Conformal Conic projection, and provided a more balanced representation of the state, than UTM zone 16[37].
- Considering this example in the case of an emergency, one can see the value of an interoperable Coordinate Transformation Service.

■ The Web Map Server (WMS) Specification standardizes the way in which Web clients request maps. Clients request maps from a WMS by naming map layers and providing parameters such as the size of the returned map and the spatial reference system to be used in drawing the map. Interoperability enables analysts to pull the appropriate data from any number of sources for the area of an environmental hazard consistently.

[37] http://training.esri.com/campus/library/ConfProc/urisa/2001/2001a-44.pdf

In 2002, three specifications were released: OpenGIS Web Feature Service Specification, OpenGIS Geography Markup Language Specification (GML 2.1), and OpenGIS Styled Layer Descriptor Implementation Specification.

- The OpenGIS® Web Feature Service (WFS) Implementation Specification allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. The specification defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform. Via these interfaces, a Web user or service can combine, use and manage geodata – the feature information behind a map image – from different sources.
- The OpenGIS® Geography Markup Language (GML) Encoding Specification is an XML encoding for the modeling, transport and storage of geographic information including the spatial and non-spatial properties of geographic features. The specification defines the XML Schema syntax, mechanisms, and conventions that:
  - Provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects
  - Allow profiles that support proper subsets of GML framework descriptive capabilities
  - Support the description of geospatial application schemas for specialized domains and information communities such as risk management.
  - Enable the creation and maintenance of linked geographic application schemas and datasets
  - Support the storage and transport of application schemas and data sets
  - Increase the ability of organizations to share geographic application schemas and the information they describe

In the case of risk management, coordination across agencies and political boundaries may involve in some cases storing geographic application schemas and information in GML, and in other cases converting from some other storage format on demand and using GML only for schema and data transport. The specification facilitates interoperability at different steps in the process, a technical solution that helps address the non-technical impediment created by interagency competition and intra-agency 'stovepipes.'

- The OpenGIS Styled Layer Descriptor Implementation Specification. This document explains how the Web Map Server specification can be extended to allow user-defined symbolization of feature and coverage data (see also the Symbology Encoding Implementation Specification). Different application domains differ in the symbols they use on maps. Being able to apply the symbol set appropriate to risk management to feature and coverage data originally collected for other reasons minimizes training time and misunderstandings, contributing to timely and effective response.

In 2003, OGC released the Web Map Context (WMC) Implementation Specification. A companion to the OpenGIS® Web Map Service above, it describes how to save a map view comprised of many different layers from different Web Map Servers. A 'context' can be encoded and saved so that Web maps created by users can be automatically reconstructed and augmented by the authoring user or other users in the future. A Context document is structured using eXtensible Markup Language (XML). Potential uses for context documents in the risk management environment include creating default initial views for Web maps for different hazards, saving the state of a user's work on a viewer client to preserve information such as how geospatial layers are added or modified, and saving the state of a client session for sharing with other users. Because emergency response requires 24/7 analysis and updates, this mechanism is valuable for efficiently communicating across shift transitions. Also, context documents can be catalogued and discovered for reuse by others; this allows analysts to benefit from lessons learned in previous episodes.

In 2004 the OGC membership approved the OpenGIS Location Services (OpenLS) Specification. This Specification describes OpenGIS Location Services (OpenLS): Core Services, Parts 1–5, also known as the GeoMobility Server (GMS), an open platform for location-based application services. It also outlines the scope and relationship of OpenLS with respect to other specifications and standardization activities. The primary objective of OpenLS is to define access to the Core Services and Abstract Data Types (ADT) that comprise the GeoMobility Server, an open platform for location services. In emergency management, interoperability in location services facilitates responders in the field providing updates to a central server and being able to retrieve the common operating picture real-time.

A.1.3 Interoperability: Technical Solutions Facilitate Solutions to Non-Technical Issues

When visionary leade rship at multiple organisations want to work together, they may find themselves dealing with one or more of the challenges faced by government agencies in the United States after September 2001: interagency competition, resistance to change, lack of resources or outdated computing systems, a lack of project management expertise or staff inadequately trained in relevant technologies, and lack of interoperability.

The technical issues of interoperability are being addressed by standards.

When all affected parties work together to hammer out the technical issues, and share the experience of demonstrating a prototype, some of the non-technical issues become manageable too.

A.2 ENVIRONMENTAL RISKS REGULATIONS AND POLICIES

This chapter takes a look at current issues and challenges encountered in exchanging information across the EU for those who are involved in the implementation of compliant risk management methods under the current and future EU regulations concerning the environment.

Over the years, European Member States have signed up to several regulations with regard to the protection, security and management of the environment. In essence these involve the improvement of methods for monitoring the environment, exchanging information for integrating risk management and also publishing information to end-user communities in order to comply with the environmental regulations. While the standard guidelines for spatial information management and Earth or in situ observation data generation are overarched by INSPIRE and GMES respectively, many of the environmental risk regulations have been specified with a view of exchange of information under statutory rules dictated by numerous Directives. These include for example: The Water Framework Directives, Bathing Water Directives, Habitat Directives, Flood Directives, Civil Protection and so on. Such Directives are implemented by regulators and performed by operators with a view to challenge cross-border and interoperability issues in 21st Century Europe.

The Water Framework Directive (WFD) A.2.1

The Water Framework Directive (2000/60/EC) entered into force on 22 December 2000. The Directive covers all water categories (rivers, lakes, groundwater, as well as coastal and transitional waters). Its primary goal is the improvement of water quality across Europe. This will be achieved by a combined approach of emission limit values and quality standards. In the case of transboundary water bodies, co-operation between countries is needed. Another important goal is the sustainable use of water resources throughout Europe. To ensure the achievement of these ambitious objectives and the consistent implementation of the directive in all Member States and across borders, implementation is carried out cyclically in a three step process.

The specific aim of the WFD is to promote sustainable usage and prevent the deterioration of water resources in the EU. The stated aims of the Directive are to:

- Prevent the deterioration, and protect and enhance the status of water ecosystems and associated wetlands;
- Promote the sustainable consumption of water;
- Reduce pollution of waters from harmful substances;
- Reduce pollution of groundwater; and
- Contribute to mitigating the effects of floods and droughts.

There is also a requirement to investigate and learn more about catchment processes in order that more informed management decisions about the care of all water movements may be made.

Furthermore, the WFD requires the introduction of a statutory system of analysis and planning based upon the typical 'river basin'. As a consequence, new plans known as River Basin Management Plans (RBMPs) will have to be devised. The overarching requirement of the WFD is to achieve 'good ecological and good chemical status' by 2015; unless there are grounds for derogation. A further requirement is the reduction and ultimate elimination of priority hazardous substances and the reduction of priority substances to below agreed thresholds. Water companies in Europe are already installing advanced water treatment plants to ensure compliance with the new statutory limits. Advanced technologies for sewage treatment works are also available to install for the prevention of pesticides, nitrates and phosphates of re-entering the water cycle. In this sense, the intended improvement of waterways and wetlands throughout Europe, aims at using water in a sustainable manner, with the reduction of water pollution and also the effects of floods and droughts.

All Member States are obliged to follow an agreed programme of the implementation of the WFD. There are strict targets in the implementation of the WFD over time. In 2015, all Member States should reach good water quality status in all their water basin districts. Then, the implemented RBMP programme for each basin district will ultimately be updated on a six-yearly basis indefinitely across the EU.

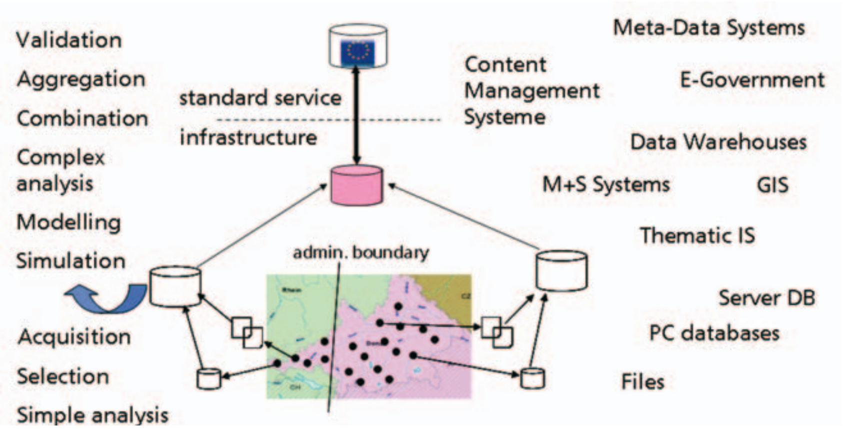
The WFD is not only a fundamental rethink of the EU water policy, its implementation is also a challenge for the supporting information technology (IT) and, especially, for a WFD-specific information management (Usländer, 2005).

Even in the first reporting phase of the WFD, there is a huge need for harmonisation and possibly standardisation to achieve an efficient implementation of the WFD within Europe. The need is even higher when considering that the WFD reporting obligations have also to be fulfilled by the new EU members or future member states whose environmental information infrastructure may have to be built from scratch with limited financial resources. Having this in mind, the European Commission has set up a WFD Common Implementation Strategy. In this context, a series of mostly thematic working groups and joint activities has been launched to support the development and testing of coherent WFD methodologies. From the IT point of view, the working group Geographical Information System (GIS) is the most relevant one.

However, the WFD implementation goes far beyond the implementation of just the geographical elements of the WFD. Regarding the IT infrastructure, the main proposal of the GIS working group is a stepwise WFD implementation approach by means of three different European WFD 'products', mainly defined in terms of the GIS aspects:

1. seamless and harmonised geometric data, e.g. with respect to the topological consistency
2. centralised WFD database (1 st phase) with a data exchange based on ESRI shapefile format or the Geography Markup Language (GML)
3. federation of spatial WFD data servers (2nd phase) based on the OGC standards recommendations and aligned with other pan-European activities on spatial data integration, such as INSPIRE.

The Reporting Service Infrastructure for the WFD Implementation is outlined in the figure below:



For the implementation of the 2nd phase there is a need for a more generic IT Framework Architecture that integrates the following views within a single concept:

- an organisational view that considers the information flow across regional, national and organisational boundaries,
- a process view that considers the life cycle of the information involved,
- an informational view that integrates both geospatial data, tabular and textual data, thematic documents and meta-data, and
- a functional view that considers what generic and specific functions (services) are required on which level as well as their signatures and access methods across networks.

Comparing these requirements with the achievements and the architectural concepts of ORCHESTRA, there is a huge potential to take-up the ORCHESTRA solutions for the ongoing and future WFD implementation[38].

[38] Usländer, T., 2005. 'Trends of environmental information systems in the context of the European Water Framework Directive'. ELSEVIER Journal Environmental Modelling and Software 20 (2005) 1532–1542.

A.2.2 FLOOD Directive

On 18 January 2006 the Commission adopted its proposal for a Directive on the assessment and management of floods (COM(2006)15 final).

The legal instrument intends to translate the approach outlined in the Communication on Flood Risk Management of July 2004 and the discussions during the stakeholder consultation process into operational actions. It includes the following proposed obligations for the Member States:

1. Preliminary flood risk assessment in areas where potential significant flood risks exist or are reasonably foreseeable in the future.
2. Flood risk maps for the river basins and sub-basins with significant potential risk of flooding, in order to: increase public awareness; support the process of prioritising, justifying and targeting investments and developing sustainable policies and strategies; support flood risk management plans, spatial planning and emergency plans.
3. Flood risk management plans at river basin/sub-basin level to reduce and manage the flood risk. These plans would include the analysis and assessment of flood risk, the definition of the level of protection, and identification and implementation of sustainable measures applying the principle of solidarity: not passing on problems to upstream or downstream regions and preferably contributing to reduction of flood risks in upstream and downstream regions.

Within each river basin the Member States will determine the level of protection most appropriate for each locality. As flood risks may change over time due to climate change and changes in land use, it would be important to regularly review and where necessary update the three elements of the legal instrument.

The proposed Directive is subject to the co-decision procedure, which means that the European Parliament and the Council of Ministers will negotiate a text that can be jointly agreed, with the opinions sought also from the Committee of the Regions and the Economic and Social Committee.

The importance of close links with the Water Framework Directive was emphasised all through the consultation process. There are also important actual or potential links between the purposes and methods of flood risk management and the achievement of water quality objectives under the WFD. The proposed Flood Directive therefore includes a number of links to ensure close coordination in the two implementation processes.

The Habitats Directive A.2.3

Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora entered into force on 21 May 1992. The EC 'Habitats Directive' sets out a framework of protected sites within Europe called 'Natura 2000'. The central goal of the Directive is to conserve biodiversity across the area of the European Union through a network of Special Areas of Conservation (SACs). SACs together with the 'Special Protection Areas' (SPAs) identified under the Birds Directive create the network of sites 'Natura 2000'. Each Member State proposed a national list of sites, which was evaluated in order to form a European network of Sites of Community Importance (SCIs). There are 189 habitats listed in Annex I of the Directive and 788 species listed in Annex II. The Member States have to ensure the protection of species listed in the Annexes, to undertake surveillance of habitats and species and produce a report every six years on the implementation of the Directive.

According to the EU Biodiversity Action Plan (Halting the loss of biodiversity by 2010 – and beyond), which was developed in 2006, the Member states are required to designate Marine Protected Areas by 2008 under the Habitat Directive. The establishment of a marine network of conservation areas under Natura 2000 will contribute to the target of halting the loss of biodiversity in the EU and to broader marine conservation and sustainable use objectives. The implementation of the Habitats and the Birds Directives in the marine environment are challenging, especially in relation to the offshore (as opposed to the coastal) marine environment due to the lack of scientific knowledge on the distribution/abundance of species and habitat types.

Marine Strategy Directive A.2.4

The Proposal for a Marine Strategy Directive (COM(2005)504) was adopted in 2005. The Strategy aims to achieve good environmental status of the EU's marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend. It addresses major threats like: an inadequate framework for the management of the seas, given institutional and legal complexities and the number of actors concerned; insufficient basic knowledge, due to insufficient links between research areas in need of action and priorities; and lack of a dedicated policy.

Council and Parliament have the responsibility of adopting the proposed legal instrument. Thereafter, Member States will have to ensure that good environmental status in the marine environment is achieved by the year 2021 at the latest, and to continue the protection and preservation of that environment and the prevention of its deterioration.

Actions to be taken by Member States to deliver good environmental status have to be based on sound and reliable assessments of the impact of human activities on the marine. The proposed Directive makes every effort to ensure that proper systems of monitoring and assessment are set. These systems will include current monitoring obligations defined by the Habitats and the Birds Directives. The Marine Strategy is consistent with the WFD from 2000, which requires that surface freshwater and ground water bodies (lakes, streams, rivers, estuaries, coastal waters…) achieve a good ecological status by 2015 and that the first review of the River Basin Management Plan should take place in 2021.

The Marine Strategy for the protection and the conservation of the marine environment will directly contribute to the work on the future EU Maritime Policy. On 7 June 2006, the European Commission adopted a Green Paper on a Future Maritime Policy for the European Union. The need for such a policy stems from the economic, social, and environmental importance of the maritime dimension in Europe. The vision is to develop Europe's dynamic maritime economy in harmony with the marine environment supported by excellence in marine science.

A.2.5 Integrated Coastal Zone Management (ICZM)

Many of Europe's coastal zones face problems of deterioration of their environmental, socio-economic and cultural resources. Since 1996, the European Commission has been working to identify and promote measures to remedy this deterioration and to improve the overall situation in our coastal zones. In June 2007 the Commission Communication set out the main policy directions for further promotion on ICZM in Europe (COM(2007)308 final).

The overall aim of the EU ICZM Recommendation is to achieve a more coherent and integrated approach to coastal planning and management. This strategic approach should provide a better context to benefit from synergies, to level out inconsistencies, and ultimately to better and more effectively achieve sustainable development.

The Recommendation lists eight principles defining the essential characteristics of ICZM. Integration across sectors and levels of governance, as well as a participatory and knowledge-based approach, are hallmarks of ICZM. Based on these principles, the EU ICZM Recommendation invites coastal Member States to develop national strategies to implement ICZM. Given the cross-border nature of many coastal processes, coordination and cooperation with neighbouring countries and in a regional sea context are also needed. Member State reports on the implementation of the ICZM Recommendation will be required.

Civil Protection A.2.6

On 12 June 2007 the Council adopted a recast of the Community Civil Protection Mechanism. This Mechanism is designed to strengthen the co-ordination of European civil protection and enable the Union to react more rapidly and effectively to any type of disaster in the future. It is based on a number of earlier Commission documents, notably its Commission Communication of 20 April 2005.

At the operational level, the proposal aims to facilitate the pooling of national transport resources. It also allows for the mobilisation of extra transport equipment, when necessary, to remedy the shortcomings of previous operations. This system will allow for those cases where some assistance cannot be deployed or may arrive late due to a lack of transport facilities.

The proposal provides the Commission with a platform upon which to contribute to the development of early warning systems. These projects effectively complement the projects for cooperation, exchange of knowledge and best practice currently supported under the EU Action Programme for civil protection, which is due to end later this year. It also incorporates the concept of civil protection modules, which would be readily deployable in the event of a major disaster.

To reinforce the Civil Protection mechanism both politically and operationally the Commission prepared a legislative proposal. This Civil protection financial instrument was adopted on 5 March 2007.

Structural Eurocodes A.2.7

The Structural Eurocodes are a new series of European structural design codes for building and civil engineering works, which have been developed by the European Committee for Standardization (CEN) since 1990. They will eventually replace national design codes (by March 2010) and are intended to be mandatory for European public works and will likely become the de-facto standard for the private sector (in Europe and elsewhere). These are being published in all main European languages between 2002 and 2007 by European national standards bodies. Sections of these codes are explicitly concerned with the design structures to withstand the effects of earthquakes, strong wind, snow and fire, with a controlled level of damage. In particular, parts of Eurocode 1, concerned with actions on structures, are related to wind, snow and fire loading (amongst other types of loading) and Eurocode 8 is concerned with the design of structures in seismically active zones.

A.3 CHALLENGES IN CROSS-BORDER SCENARIOS

Damaging natural and man-made hazardous events do not respect political boundaries and therefore the appropriate management of the risk from such potentially disastrous events depends on the exchange of information across borders. For example, the Danube river traverses or forms the border of ten European countries, which themselves are comprised of many regions, and effects at one point (for example, heavy rainfall or the opening of sluices) on the river can impact far upstream. Similarly, large earthquakes can affect many thousands of square kilometres covering many regions or countries. Each of these regions or countries has potential one or more data providers with potentially important information for the appropriate management of risk and therefore data from these providers should be easily accessible and usable by risk managers even if they are based in different regions. However, the efficient exchange of information across borders encounters many difficulties, which are discussed below. The difficulties concern both the way the end users use the system and the way in which data providers supply their data.

A.3.1 Multiple Languages

Within Europe there are dozens of languages, which are used for the collection and dissemination of information. It is necessary to be able to cope with the various languages when managing risk. The adoption of a common language for the digital storage of information is not envisaged by distributed IT architectures, such as ORCHESTRA, rather tools are being developed to enable the querying of databases in different languages and the translation of the results into the language of choice. In contrast to simply providing different language versions of an Internet client (which is, of course, also required) this requirement means that metadata (such as the names of the data fields) and the data itself needs to be translated in real-time.

A.3.2 Different Naming Conventions

Even within the same language various words can be used to refer to the same (or similar) concepts. The minimisation of difficulties to the user from such differences can be tackled through automatic means by the creation of rules to map one term to another and through word hierarchies. Some aspects of this automatic translation are tackled within one of the pilot demonstrations of the ORCHESTRA project discussed in Chapter 5 (that concerned with risk assessment for the road network in the French-Italian border region).

Various Symbologies A.3.3

A connected issue concerns the different symbols used to represent the same geographical object in different countries, which can cause confusion to a user familiar with a different set of symbols. For example, in France motorways (autoroutes) are usually represented on maps as blue lines whereas across the border in Italy motorways (autostrada) are often shown as green lines. Although this is mainly a visualisation preference it should be considered when developing systems to be used across borders.

Different Data Structures A.3.4

Due to limited interaction between organisations on two sides of a frontier the structure of the data storage used often differs, which can be due to differing priorities and available data. A simple example of possible differences in data structure is the representation of the date, e.g. 16th March 1977, 16/03/1977 or 03/16/77 (or numerous other formats) or the representation of the same date as three separate elements in the database (e.g. day '16', month '03' and year '1977') rather than just one. Although simple for a human to handle, such differences in data structure need to be able to be automatically processed by systems accessing various data sources, particularly when they come from different countries. Accessing of data concerning information on historical earthquakes in France and Italy from a French national database of BRGM and an Italian national database of INGV with differing data structures is undertaken in the pilot concerning the road network in the French-Italian border region (see Chapter 5).

Data Security Issues A.3.5

There can be security concerns when accessing potentially sensitive information across frontiers therefore it can be necessary to restrict access to data and services by, for example, a password and through the acceptance of licence conditions. Different data providers could impose different constraints on the use of their data and therefore the developed system should be able to cope with various licence types. An implementation of a system to manage users' rights to access various data sources is made within the pilot concerning the risk assessment of the road network in the French-Italian border region (see Chapter 5).

Legal Constraints A.3.6

Risk managers in different countries will be constrained by various legal rulings based on regional, national, European and international laws when accessing data and when making decisions, especially when there could be impacts on neighbouring regions or countries. These various constraints should be obeyed by developed IT systems and decisions should be reached by partnership with the potentially-affected parties.

A.3.7 Different Legal and Institutional Contexts

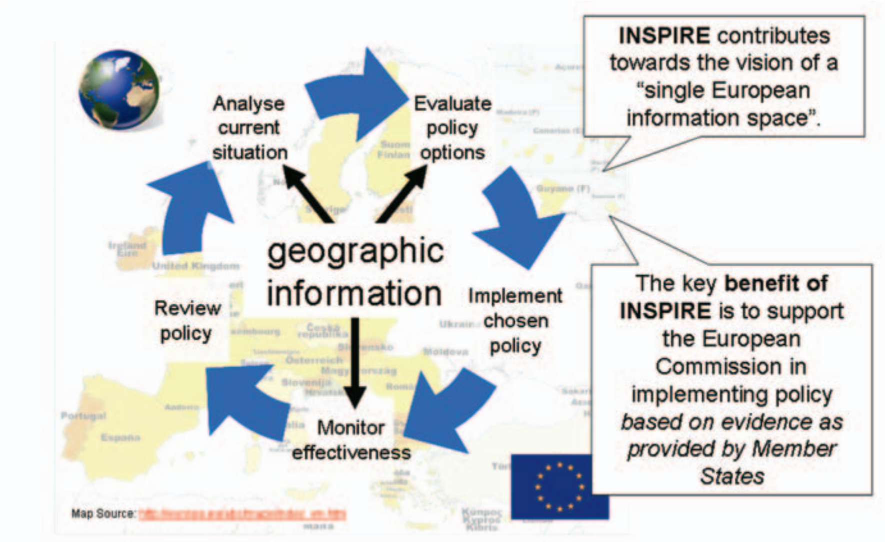
Risk managers in different countries will be constrained by various legal rulings based on regional, national, European and international laws when accessing data and when making decisions, especially when there could be impacts on neighbouring regions or countries. This becomes most apparent when looking at the structure of the civil protection organizations. A number of differences exist between France and Italy[39] and these differences should be obeyed in case of emergency. For example: In France the prefect coordinates inter departmental coordination in case of emergencies whereas in Italy the prefect is appointed by province, a much smaller administrative unit, and coordinates inter-provincial coordination of disasters. Already the differences in scale impose slightly different user requirements on systems for cross-boundary cooperation and data sharing. These various constraints should be obeyed by developed IT systems and decisions should be reached by partnership with the potentially-affected parties. Adopting to open standards overcomes part of this problem as it o longer is the problem of finding the right organization but the right data owner.

A.4 SPATIAL DATA INFRASTRUCTURES AND DATA HARMONISATION INITIATIVES

A.4.1 Infrastructure for Spatial Data in Europe (INSPIRE) and the Benefit to Europe

INSPIRE (inspire.jrc.it) is a European initiative lead by the European Commission. It provides the legal framework in terms of a European Directive and a set of *Implementing Rules* defining how Member States of the European Union shall provide their existing spatial information for analysis by institutions of the European Commission:

[39] See: CEP Handbook 2006 http://www.krisberedskapsmyndigheten.se/upload/3040/cep_handbook_2006.pdf



The INSPIRE initiative is conceived to 'trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services'. It is an ambitious initiative that has successfully completed the initial phase with the formal adoption as a European Directive. It is currently in the 'Transposition Phase' where the Directive is transposed into Member State law.

Much of the current focus is on drafting the INSPIRE Implementing Rules, which is a significant activity coordinated by the European Commission with and supported by national experts representing 'Legally Mandated Organisations' and 'Spatial Data Interest Communities'. Implementation of the Directive starts in 2009 with a roadmap extending to 2019.

GMES and GEOSS A.4.2

The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth system.

GEOSS will provide the overall conceptual and organizational framework to build towards integrated global Earth observations to meet user needs. GEOSS will be a 'system of systems' consisting of existing and future Earth-observation systems, supplementing but not supplanting their own mandates and governance arrangements.

GEOSS will yield advances in the societal benefit areas defined by its purpose and scope. There are nine societal benefit areas related to weather, climate, oceans, atmosphere, water, land, geodynamics, natural resources, ecosystems, and natural and human-induced hazards which are crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, reducing disaster losses, and achieving sustainable development.

Over the last two years GEO has been a catalyst for the development and implementation of numerous Earth Observation systems, programmes and activities for the integration and dissemination of data and information and for the development of applications and services relevant to all SBAs. These GEO activities have led to the progressive implementation of GEOSS.

GMES (Global Monitoring for Environment and Security) is a European initiative for the implementation of information services dealing with environment and security. GMES will be based on observation data received from Earth Observation satellites and ground based information.

Through GMES the state of our environment and its short, medium and long-term evolution will be monitored to support policy decisions or investments. GMES is a set of services for European citizens helping to improve their quality of life regarding environment and security. GMES is the European main contribution to GEOSS.

The different services developed under GMES and its underlying infrastructure are relevant to most SBAs and to the four horizontal activities covered by specific GEOSS Committees (Architecture and Data, User Interface, Science and Technology and Capacity Building Committee).

ORCHESTRA contributes to the global definition of a GEOSS architecture especially regarding the key aspects of accessibility, flexibility, interoperability and standardization.

Furthermore, through the experiences gained in the research and development of the different services in the pilots ORCHESTRA contributes towards the improved risk management of natural and human-induced disasters SBA within GEOSS, and also towards the GMES services and especially towards the Emergency Response Core Service by providing valuable know-how.

9.4.3 Google Earth, Microsoft Virtual Earth, and de facto Standardisation

Recent initiatives on the Internet (including Google Earth, Google Maps, Microsoft Virtual Earth and Yahoo! Maps) have seen a rapid growth in the use of spatial information within a wider community outside of ‘traditional’ users of spatial information.

In many cases these activities have been built on light-weight de facto standards and have not depended on the de jure standards for spatial information as developed by organisations such as the International Standards Organisation (ISO) and the Open Geospatial Organisation (OGC).

The de facto standards driving forward these activities include Google Maps Application Programmer Interface (API), Google's Keyhole Mark-up Language (KML) and Geospatial Really Simple Syndication (GeoRSS). These de facto standards have enabled a new community of 'neogeographers' to rapidly build 'fit-for-purpose' applications which combine spatially related information in new and innovative ways for a mass-market community.

Annex 2: Acronyms and Glossary

application schema
Conceptual schema for data required by one or more applications [ISO 19101]

client
Software component that can invoke an operation from a server

conceptual model
Model that defines concepts of a universe of discourse [ISO 19101], whereby the universe of discourse comprises the extract of the real or hypothetical world that includes everything of interest for a particular application

coordinate reference system
Coordinate system that is related to the real world by a datum [ISO 19111], whereby a datum defines the position of the origin, the scale, and the orientation of the axes of the coordinate system. Note that for geodetic and vertical datums, the coordinate reference system will be related to the Earth

coverage
Feature that associates positions within a bounded space (its spatiotemporal domain) to feature attribute values (its range)
NOTE: This includes agreements about coordinate reference systems, classification systems, application schemas, etc.

data product specification
Detailed description of a dataset or dataset series together with additional information that will enable it to be created, supplied to and used by another party [ISO/DIS 19131]

data specification
Data product specification that describes INSPIRE or GMES datasets of a specific theme from different data providers in a harmonised way

dataset
Identifiable collection of data [ISO 19115]

dataset series
Collection of datasets sharing the same product specification [ISO 19115]

DCP
Distributed Computing Platform

ESDI
European spatial data infrastructure based on the INSPIRE framework directive

feature
Abstraction of a real world phenomenon [ISO 19101] whereby the ORCHESTRA understanding of a 'real world' explicitly comprises hypothetical worlds. Features may but need not contain geospatial properties. In this general sense, a feature corresponds to an 'object' in analysis and design models

general feature model
Meta-model of feature types, i.e. it provides a framework of rules for the specification of application schemas that describe the properties of features

geodetic coordinate system
Coordinate system in which position is specified (in the two-dimensional case) by geodetic latitude and longitude

geographic feature
Feature associated with a location relative to the Earth

GFM
General feature model
GML
Geographic Markup Language
GMES
GMES is the abbreviation of 'Global Monitoring for Environment and Security' a concerted effort to bring data and information providers together with users, so they can better understand each other and make environmental and security-related information available to the people who need it through enhanced or new services [http://www.gmes.info]

ICZM
Integrated Coastal Zone Management
INSPIRE
Framework directive for building an infrastructure for spatial information in the Community [http://inspire.jrc.it]
interface
Named set of operations that characterize the behaviour of an entity [ISO 19119]
interoperability
A) Capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units [ISO 2382-1]
B) Ability of two or more systems or components to exchange information and to use the information that has been exchanged [IEEE]
NOTE: It is worth noting that strictly speaking there is no 'interoperability' between data sets. The only things that can interoperate are services and systems. In the case of several heterogeneous data sources, interoperability requires 'wrapping' data sources into services that conform to standards. The output of these services is what is to be harmonised, not their inputs (database schemas). Thus the legacy is maintained and can evolve to support the specified service interfaces. As a result, data producers will not have to change the structure of their data.

Interoperability in the ESDI context means that each country maintains their own infrastructure, but adopts a framework that enables existing datasets to be linked up from one country to another (e.g. via transformation or translation).
ISO
The International Organization for Standardization. A network of the national standards institutes of 157 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system
IT
Information technologies

map projection
Coordinate conversion from a geodetic coordinate system to a planar surface
metadata
Data about data
meta-information
Descriptive information about resources in the universe of discourse. Its structure is given by a meta-information model depending on a particular purpose.
NOTE: In ORCHESTRA specifications the term meta-information is preferred instead of metadata in order to stress the architectural principle that the required metadata always depends on a particular purpose, i.e., metadata always needs interpretation. A resource by itself does not necessarily need meta-information. The need for meta-information arises from additional tasks or a particular purpose (like catalogue organisation), where many different resources (services and data objects) must be handled by common methods and

therefore have to have/get common attributes and descriptions (like a location or the classification of a book in a library).

OASIS
Organization for the Advancement of Structured Information Standards [http://www.oasis-open.org]
OGC
Open Geospatial Consortium [http://www.opengeospatial.org]
operation
Specification of an interaction that can be requested from an object to effect behaviour [ISO 19119]
OSI
ORCHESTRA Service Instances
OA
ORCHESTRA Architecture
OA Service (Architecture Service)
Service that provides a generic, platform-neutral and application-domain independent functionality. Also simply called 'architecture service'
OSN
ORCHESTRA Service Network. An OSN is a set of networked hardware components and service Instances that interact in order to serve the objectives of applications. The basic unit within an OSN for the provision of functions are the service instances
OT Service (Thematic Service)
Service that provides an application domain-specific functionality built on top and by usage of architecture services (OA Services) and/or other OT Services. Also simply called 'thematic service'
OWL
W3C Web Ontology Language to define and instantiate ontologies with an increasing expressiveness according to the sub-variant of the language used (OWL Lite, OWL DL, OWL Full)
OMM
ORCHESTRA Meta-model; an extension of the General Feature Model (GFM) as used in the OGC Reference Model. It treats both information and service aspects in a consistent manner, i.e. it specifies a uniform meta-model for informational and functional aspects
ORM
OGC Reference Model

property
A facet or attribute or an object referenced by a name

QoS
Quality of Service

RDF
Resource Description Framework; a general method of modelling information as statements about resources in the form of subject-predicate-object expressions, called triples in RDF terminology
RM-OA
Reference Model for the ORCHESTRA Architecture
RM-ODP
Reference Model for Open Distributed Processing

SAWSDL
Semantic Annotations for WSDL and XML Schema
SDI
Spatial Data Infrastructure
service request
A request by a client of an operation from a service
service
A collection of operations, accessible through an

interface, that allows a user to evoke a behaviour of value to the user [ISO 19119]

service chain
Sequence of services where, for each adjacent pair of services, occurrence of the first action is necessary for the occurrence of the second action [ISO 19119]

SOA
Service-Oriented Architecture

UML
Unified Modelling Language. UML is a graphical language for visualizing, specifying, constructing and documenting the artefacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual things such as business processes and system functions, as well as concrete things such as programming language statements, database schemas, and reusable software components [ISO/IEC 19501]

W3C
The World Wide Web Consortium (http://www.w3.org/). An international consortium whose mission is 'To lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web'

Web Service
Self-contained, self-describing, modular service that can be published, located, and invoked across the Web. A Web service performs functions, which can be anything from simple requests to complicated business processes. Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service

WS-BPEL
Web Services Business Process Execution Language

WMS
Web Map Service

WPS
Web Processing Service

WFS
Web Feature Service

WSDL
Web Services Description Language

WSMO
Web Service Modeling Ontology

WSMX
Web Service Execution Environment

XML
eXtensible Markup Language

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