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RISK ASSESSMENT FOR THE ROAD NETWORK IN THE FRENCH-ITALIAN BORDER REGION USING WEB SERVICES

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This article discusses a pilot implementation of the architecture and web services being developed within the EC Framework Programme 6 Integrated Project 'Open Architecture and Spatial Data Infrastructure for Risk Management' (ORCHESTRA, http://www.eu-orchestra.org/) being undertaken by BRGM, JRC and Ordnance Survey with the collaboration of local partners in the French-Italian border region between Nice and Genoa. The basis of the pilot is the evaluation of risk to the road network and the impact of road network disruption by, for example: earthquakes, landslides, floods, fires and chemical spills. Road closures can have a dramatic impact on the economic, social and functional life of a region and these impacts can spread far from the site of the blockage and, even, across international borders. The region chosen for this pilot project is especially prone to hazardous events and also, due to the lack of redundancy in the road network within the region, disruption to a major route can have a large effect. This pilot will seek to create a distributed network of web services that will access hazard, route and traffic information held within databases based at the data providers.

Once completed, users of the system developed during the pilot will be able to: simulate events leading to road blockage or disruption; calculate estimated traffic, alternative routes and their level of traffic; estimate additional costs (time and money) caused by the disruption, and the subsequent economic losses for the affected region; and run these simulations to identify pinch points within the road network and improve planning and prevention.

Potential end-users comprise: experts within the Piedmont and Liguria regions; transport and toll motorway companies; and national and regional administrations.

The key technical aspects addressed are: access to diverse data sources; risk assessment from multiple hazards; and use of semantics (ontologies) for efficient multilingual and cross-organisational database querying.

1. Introduction

In today's rapidly changing world it is becoming more and more important that risk from natural and hazards with a human origin is correctly managed. Increasing urbanisation and the undertaking of high-value projects means that, in some areas, risk is increasing. In addition, due to climate change there is some evidence that the hazard level due to weather-related perils is becoming larger. As in all aspects of modern life information technology (IT) is playing an increasing role in risk management since it allows the undertaking of certain tasks and makes others easier to perform.

However, risk management in Europe and elsewhere is made more difficult by interoperability problems due to IT systems that cannot easily communicate with each other. Even those in organisations concerned with the same risk, e.g. two institutes concerned with different aspects of earthquake risk, may be running different computer systems. The problem is even worse when viewed across risk domains, e.g. IT systems concerned with industrial risk cannot often communicate with those concerned with earthquake risk, limiting the ability to undertake true multi-risk analysis. Multi-risk analysis is being increasingly recognised as an important tool because it gives a better overall picture of the level of and the interactions between risks in a region (e.g. Douglas, 2006). In order to overcome these problems, users often must spend valuable time reformatting files, for example, to the detriment of undertaking more fundamental risk management tasks. In addition, this effort is, in some sense, wasted since, in all probability it will need to be repeated when data is sourced from another organisation or when a new IT system is developed. These interoperability problems limit the work that can be achieved since it is difficult to access and use existing data; data which cost much time and effort to collect.

In Europe, these problems arise not only across different types of risk, but also across regional and national borders. In addition to interoperability difficulties, language differences also become an issue. It is often important to undertake risk management across borders because impacts of events are not limited by human borders and actions undertaken to mitigate risk are also not contained by political boundaries.

In order to address these difficulties on a large scale considering the whole range of geographical data, an EC directive called INSPIRE (http://inspire.jrc.it) was launched in 2001. It is planned that this directive will be fully implemented by 2013 (implementation will begin in 2007). The directive is concerned with the setting up of a European Spatial Data Infrastructure, to implement metadata rules for data and services, to implement rules for harmonised spatial data specifications (exchange and update, ID systems, thesauri, key attributes, etc.) and to implement rules for network services (upload, discovery, view, download, transformation, etc.).

To develop these ideas into the field of risk management, a Framework Programme 6 Integrated Project (FP6 IP) called Open Architecture and Spatial Data Infrastructure for Risk Management (ORCHESTRA, http://www.eu-orchestra.org) was launched in September 2004. In the following section the ORCHESTRA project is briefly introduced. The following sections are then concerned with the pilot implementation of an ORCHESTRA system in order to aid in undertaking risk assessments for the road network in the border region of France and Italy.

2. ORCHESTRA

ORCHESTRA involves 15 partners both from the risk management domain and from the IT industry. The purpose of the project is to design a platform-independent open service-oriented architecture (SOA) for risk management purposes, and implement it for Internet-based applications (web services) that can be called via the web to undertake a given process. They could be seen as subroutines located on the web to be used when needed by any user. The 'open' part of the project refers to the fact that the specifications of these services are being made public and free of charge so that they can be implemented by any interested party and can be accessed by all potential users. The actual procedure followed by the web service to perform the required task is not considered and is not specified; however, the inputs and outputs to the service and the actions it must undertake are specified. The philosophy behind this approach is that if the specifications are followed then risk management systems using these web services will be fully interoperable without needing to be created by a common entity. This philosophy has key advantages with respect to other approaches. For example, it is expected to favour the emergence of an operational market for risk management services in Europe, it eliminates the need to replace or radically alter the hundreds of already operational IT systems in Europe (drastically lowering costs for users), and it allows users and stakeholders to achieve interoperability while using the system most adequate to their needs, budgets, culture etc. (i.e. it has flexibility).

Interoperability of IT systems is a subject of much research and development in many countries. For example, the Open Geospatial Consortium (OGC) is an organisation that seeks to develop software standards in the field of systems concerned with geographical information. In addition, there are existing and under-development ISO and EC standards. ORCHESTRA bases its architecture on these standards and seeks to influence their development in order to make them applicable to risk management applications.

An additional advantage of the SOA approach in the risk management domain is that it allows applications to be updated with minimal effect on the services that call them. Procedures involved in risk management change often as experience is gained through disasters. Consequently it is important that the systems developed are agile allowing developments to be rapidly implemented in practice.

In the second half of the ORCHESTRA project four concurrent pilot projects concerned with different aspects of risk management in various European regions are being undertaken. The aim of these pilot projects is to validate the services and architecture developed during the course of the project and to demonstrate the results of the project to potential end users. In order to build on work already undertaken in earlier workpackages of the project and since it addresses truly multi-risk and cross-border aspects, BRGM, JRC and Ordnance Survey decided to develop a pilot project based on the risk to the road network from different hazardous events, such as earthquakes, landslides and industrial accidents. The following sections briefly introduce the problem and the work being undertaken.

3. Pilot project on risk assessment for the road network

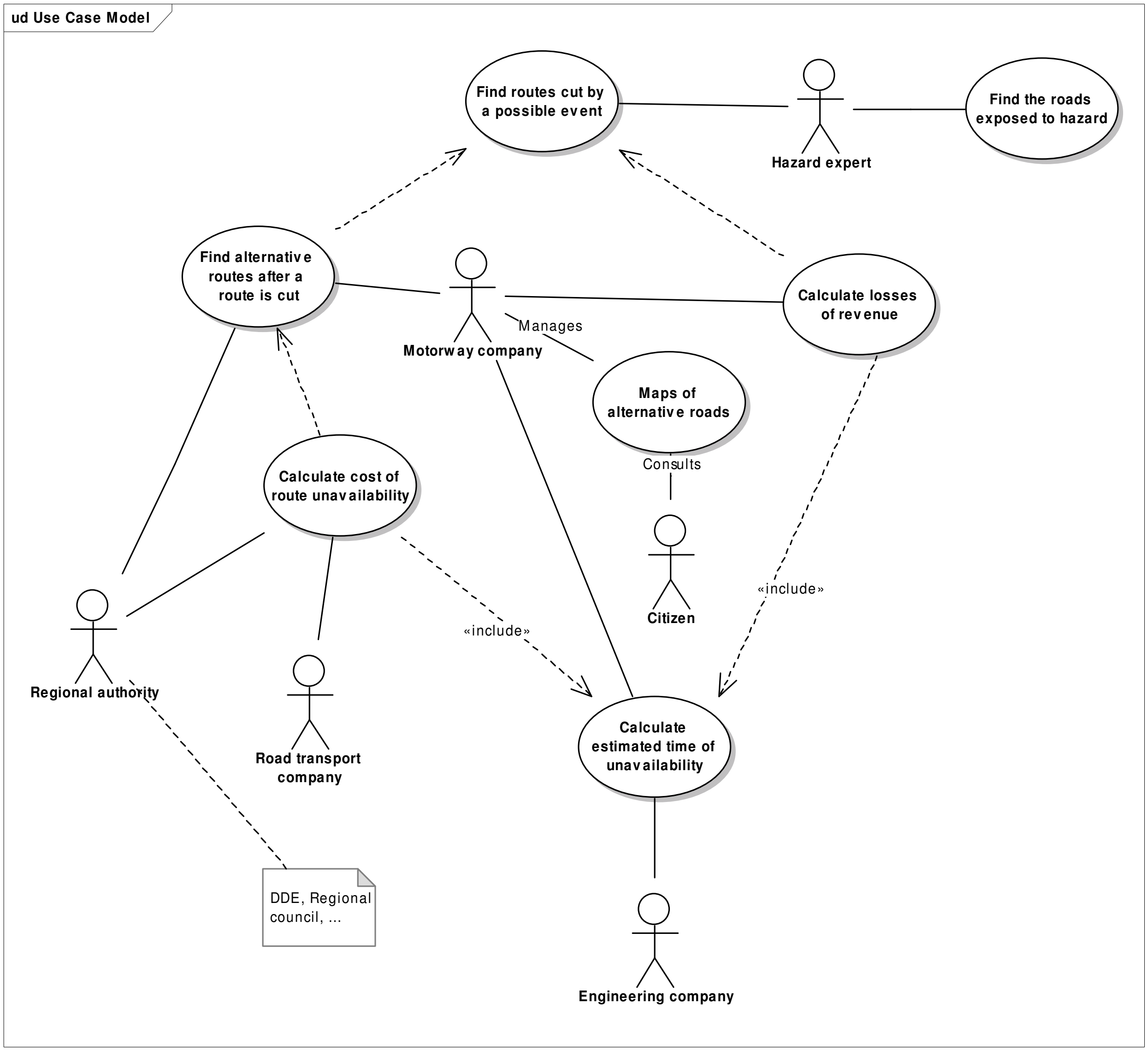
Road transport plays an important role in the economic, functional and social life of a region. For example, roads enable the transport of commodities from their source (e.g. a factory) to the distribution centre (e.g. a shop) and the consumers from their homes to the distribution centre. Therefore, disruption to a road can have a dramatic impact and lead to extra costs, inconvenience and, within the post-event phase of the disaster cycle, difficulties in accessing affected communities. Roads can be disrupted (e.g. blocked) by a number of different events, for example: direct surface rupture or liquefaction caused by an earthquake, landslides (however caused), fire (forest or otherwise), floods, chemical incidences, avalanches, volcanoes and storms (through the falling of trees). Cova and Conger (2004) provide a good review of the types of hazard that can affect the road network and also their consequences. By focusing on the effect of an event, where the cause of the event is not specified, the proposed pilot is multi-risk. In addition, many of the services required to undertake the pilot are risk-neutral and can be used for various other projects.

As an example of the large impact that disruption to an important trans-frontier road can have, consider the closure of the Frejus road tunnel in the Alps between France and Italy due to a fire on 4th June 2005, which killed two people. The average truck traffic each day through the tunnel was 3 800, all of which had to find alternative routes, such as through the Mont Blanc tunnel, which required a detour of about 200km. The tunnel accounts for about four-fifths of the commercial road traffic between France and Italy. The tunnel remained shut for about two months. This closure lead to large additional transportation costs. The three-year closure from 1999 to 2002 of the Mont Blanc tunnel due to another fire, which killed 39 people, was estimated to have cost the Italian economy 2.6 billion euros.

The area chosen for this project is the department of Alpes-Maritimes (06) in France and the Piedmont and Liguria regions in Italy, where BRGM and JRC already have good contacts with potential end users. The cross-border roads in this region, for example the E80 (A8 in France and A10 in Italy) motorway from Nice to Genova, pass through mountainous areas and feature many tunnels and viaducts. These make them particularly susceptible to hazards that block the road because it is not possible to easily by-pass or remove the blockage due to access difficulties. In addition, the mountainous relief in the region means the number of alternative routes is quite low.

4. Use cases

In this pilot project it is planned to implement six general well-defined procedures undertaken by end users (commonly called ‘use cases’ in IT parlance). It is expected that these six will test many aspects of the system and will demonstrate its ability to overcome current interoperability problems. Also the selected use cases involve varied interactions between different parties, e.g. different data providers and various end users. The following figure shows the relationships between the different use cases that will be considered and the following table gives brief details of these use cases. In order to aid with the implementation of these use cases their details have been transformed to Unified Modeling Language (UML). This pilot project is split into three phases of about six months each. Three use cases have been developed during Phase 1 and the final three more are being developed in Phase 2. Phase 3 concentrates on testing and improving the implemented system and installing it in the end users institutions.



Relationships between the different use cases that are considered in the pilot project.

Use case	Details
Find roads cut by a possible event	The end user retrieves data on the road network and the possible hazardous events in the region. Then they simulate the triggering of an event and the system is used to identify which roads will be cut by such an event. This information is stored for use by other use cases.
Find roads exposed to hazard	The end user collects data on the road network and maps of the level of hazard for different types of event (earthquake, landslide, flood etc.). From this information they compile an inventory of the roads that are at risk.
Find alternative routes after a route is cut	Firstly the user retrieves road and traffic information for the region. Next they collect information on which roads will be blocked by an event (e.g. from the first use case) and they indicate within the road network information where these blockages are. Finally the system calculates alternative routes for different types of traffic and stores these routes for future use.
Calculate estimated time of unavailability	This use case simply retrieves from an external source an estimate of the amount of time that a road will not be usable. This estimate is stored for later use.
Calculate loss of revenue	The user compiles information on the length of time that given roads will be unavailable (from the previous use case). Then they search for traffic that uses these roads and from combining these pieces of information arrives at an estimate of the loss of revenue to an industry due to the closure of the road.
Calculate cost of route unavailability	This use case combines information coming from previous use cases to estimate the overall economic cost of a road being unavailable. In the first step, the user collects information on the road network, the traffic that uses the unavailable roads and how long these roads will be unavailable for. From this information and the list of alterative routes for each traffic type the system computes an estimate of the cost of the road being blocked.

5. Data required

In order to accomplish the use cases described above it is necessary to access and process a number of different types of data, namely: hazard maps, catalogues of historical hazardous events, traffic data, road network data, political division data and topographical information. These data are accessed via the developed web services. Due to differences in the data structures and the languages used (French, Italian and English) between the various accessed information a simple

WFS-X service has been developed in order to undertake the schema mapping and the language translation. The table below lists the various data that are employed to date within the pilot although there are plans to use data from many other sources. To aid in the search for relevant hazard maps the metadata of the maps used within the pilot are entered into the IGOS Geohazards GeoHazData metadata catalogue (http://www.igosgeohazards.org/). This metadata catalogue is being developed as a contribution towards the aims of the Group on Earthquake Observations (GEO).

Type of data	Data source
Historical events	French earthquakes: SISFRANCE http://www.sisfrance.net/ French mass movements: BD Mvt http://www.bdmvt.net/ French underground cavities : BD Cavités http://www.bdcavite.net/ Italian earthquakes: INGV CPTI04 http://emidius.mi.ingv.it/CPTI04/ Italian earthquake faults: INGV DISS http://www.ingv.it/DISS/
Hazard maps	Maps for rockfall, subsidence, landslide and flooding hazard produced by BRGM for the Roya valley
Traffic levels	French data: from the DDE and ESCOTA Italian data: data collected from various regions
Road network	TeleAtlas
Political divisions	IGN for France and Tele Atlas for Italy
Topography	Tele Atlas and Demis

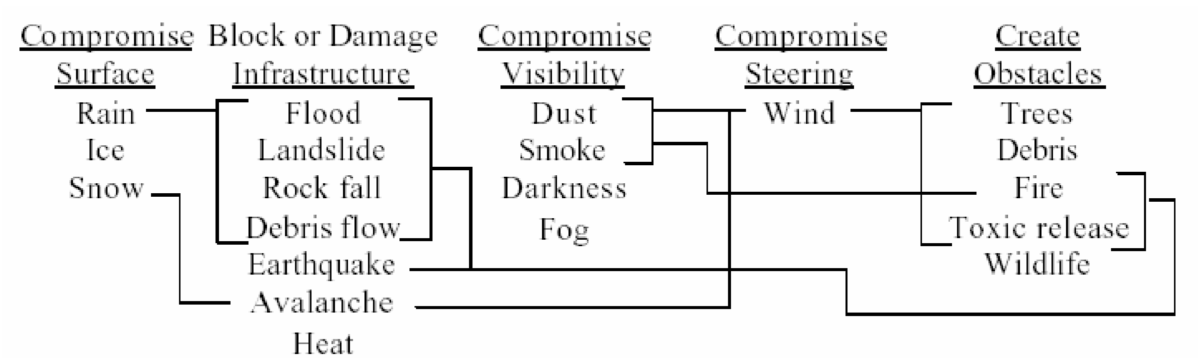
6. Services used

The following table lists the web services and the implementations being used within this pilot.

Service	Implementation
Feature Access Service	WFS of GeoServer
Map and Diagram Service	ORCHESTRA
Schema Mapping Service	WFS-X created by BRGM
Authentication Service	ORCHESTRA
Authorisation Service	ORCHESTRA
Catalogue Service	IONIC
User Management Service	ORCHESTRA
Gazetteer Service	WFS-X and Gazetteer of BRGM + Geonames
Processing Service	GRASS
Cost Calculation Service	BRGM
Route Calculation Service	JRC-IPSC

7. Calculation of affected area

Within this pilot it is necessary to estimate the roads that may be blocked by the occurrence of a particular event, e.g. an earthquake, landslide or flood, given in the catalogues listing the location and size of previous hazardous events. Ideally this would be performed by combining an estimate of the hazard with the vulnerability of each road to compute the expected damage. From this estimated damage the roads affected by the event could be computed. This could be performed using fragility curves (expressing the expected level of damage given a level of hazard), which are dependent on the road's vulnerability, for each type of hazard. However, except for earthquakes, there are difficulties in constructing fragility curves for other natural hazards and few such curves exist (Douglas, 2006). A discussion of the computation of the risk to the road network from earthquakes is provided by D'Andrea et al. (2005). Cova & Conger (2004) present a more general discussion of risk to the road network from various hazards. The following diagram summarises the hazards affecting the road network. Within this pilot the main focus of interest are those in the second column (block or damage infrastructure) and those in the final column (create obstacles).



Summary of hazards affecting the road network (after Cova & Conger, 2004).

In Phase 1 of the pilot a simple scheme was employed to estimate the area affected by a hazardous event by simply assuming that the area is a circle that is a function of the size of the event depending on empirical relationships. In Phase 2 and 3 the area is more accurately estimated by making use of additional information. For example, in the case of the repeat of an historical earthquake (such as the destructive 1887 event in the region) the observed macroseismic intensities from the SISFRANCE database are used as input to a geospatial interpolation algorithm based on kriging in order to predict the area in which the road network could be blocked.

8. Digital rights managment

An important part of this pilot project is a consideration of data security and the handling of access rights to data – two growing issues in the creation of geospatial data infrastructures. In risk management, as in other domains, some data is sensitive (e.g. the locations of Seveso plants) and it is important that access to this data is well managed so that it can only be viewed by authorised users. In addition, there are important issues over payment and access rights to some types of information and services. All these important considerations will be investigated and will be implemented within the pilot in the following three step approach.

Phase 1: Open Access Services – initial integration of services with no authentication and authorisation. The objective of this phase is to build the initial pilot capability and test the implemented services.

Phase 2: Authentication and Authorisation Services – installation and configuration of the ORCHESTRA Service Network Architecture Services for authentication and service authorisation.

Phase 3: Prototype Digital Rights Management Capability – this stage will address the higher risk aspects of implementing technical measures to manage and protect the content owners' intellectual property. The content owners requirements will be understood during phases 1 and 2, and key elements of these requirements will be prototyped during this stage.

9. Client

So that the end user can easily make use of the services developed and the data collected during this pilot implementation a web-based client has been developed using MapBuilder v1.5 and BRGM libraries.

10. Interoperability experiment with a pilot of the FP6 WIN IP

It is planned to demonstrate the interoperability between this pilot and demonstrations of the system developed within the FP6 IP Wide Information Network (WIN, http://win-eu.org/), which has similar goals to ORCHESTRA. This experiment will consist of a use case scenario concerning a simulated event in the pilot region where the WIN demonstration will access and use results from the ORCHESTRA pilot on traffic re-routing and cost and time evaluations. In return, it is planned that this pilot will use services developed by WIN concerning, for example, multiple language thesauruses of risk concepts.

11. Conclusions

As in many aspects of IT, risk management is currently hampered by interoperability difficulties due to a variety of data formats, procedures, platforms etc. These difficulties are being addressed, on a general, scale by the ORCHESTRA project and, for specific cases, by a series of associated pilot projects. This brief article discusses the pilot project being undertaken by BRGM, JRC and Ordnance Survey concerned with assessing the risk to the road network in the France-Italy border region. The complete implementation of this pilot project should be completed by summer 2007 when the developed system will be demonstrated to end users and other concerned parties at a workshop to be held in the pilot region.

12. Acknowledgements

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