GIS TECHNOLOGY

Geoinformation for Crisis Management

Theme group Crisis Management,
Section GIS technology

Sisi Zlatanova

GISt Report No. 51

TU Delft

OTB Research Institute for Housing, Urban and Mobility Studies

Delft University of Technology

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Summary

This report presents the vision of the group on Geoinformation for Emergency Management.

Geographical information & communication technology have been proven to be an important instrument for supporting decision-making in Integrated Crisis Management. Crisis Management activities are extremely information demanding and involve many parties, which poses high challenges to collection, discovery, analysis, visualization and exchange of information.

The theme group on Geoinformation for Crisis Management focuses on building advanced frameworks, developing solutions and testing prototypes, allowing knowledge-based use of geoinformation to assist the decision-making process in crisis situations. The research of the theme group is derived from, and therefore shared with the fundamental technological research scope of section GIS technology on Geo-DBMS.

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Section GIS technology
OTB Research Institute for Housing, Urban and Mobility Studies
TU Delft
Jaffalaan 9, 2628 BX Delft, the Netherlands
Tel.: +31 (0)15 278 4548; Fax +31 (0)15-278 2745
Websites: http://www.otb.tudelft.nl
Http://www.gdmc.nl

E-mail: s.zlatanova@tudelft.nl

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1 Introduction

Crisis management is a complex process consisting of several phases named prevention, mitigation, preparation, response and recovery. Recent natural and technological disasters have clearly shown various shortcomings and failures in existing technologies and policies. Amongst all, many barriers exist in making data available, providing the most appropriate data and making systems co-operate. Until now, the data are searched and requested by humans. Sometimes automation is provided but in a specific domain carrying out dedicated tasks and unable to deliver intelligence to heterogeneous multi-user groups. The challenges in sharing and analysing geoinformation are especially critical. Most geo-data currently available are designed, stored, and managed by organisations that normally have distinct mandates. In normal circumstances, these organisations operate largely independent of each other and are only partly designed to work in a multidisciplinary environment and therefore having interoperability limitations.

Systems for efficient and effective crisis management are gaining a high priority in the political agenda's of national governments and in EU. Intensive research has been initiated seeking for service-oriented knowledge-based utilities to support interoperability of geoinformation in crisis response. European Commission has initiated INSPIRE and GMES respectively for harmonisation of geoinformation and global monitoring for environment and security, as well as, funded numerous large projects within FP 6, e.g. for defining services (ORCHESTRA), developing data models (WIN), monitoring and data processing of *in-situ* sensor networks (OSIRIS) co-operation between different systems (OASIS), developing integrated alert systems (CHORIST).

Section GISt has started its work in the domain of crisis management several years ago with the formation of two large consortia willing to contribute to the development of knowledge-based systems for time-critical application, organisation of the first symposium on Geoinformation for Disaster management in 2005 (and several other related workshops and activities), and building of an international network of researchers working in the area of crisis management and response. Currently the section participates in several national and international projects related to use of geoinformation in emergency response and risk prevention and has built excellent contacts with crisis response sector such as fire brigade, police, GHOR (Geneeskundige Hulpverlening bij Ongevallen en Rampen) and municipalities.

Bearing in mind the worldwide tendencies and the internal scientific interests, the Section GISt has decided to organise a theme group Geoinformation for Crisis Management. The goal of the group is advanced research in geoinformation to automate and facilitate decision-making in Crisis Management sector. The work of the group should contribute the synchronisation of the research on crisis management within GISt (and OTB) and help involved researchers to understand crisis management specifics and requirements.

2 Mission

The work of the theme group focuses on data used in crisis management. In case of crisis, 'mountains' of data are available and have to be found and analysed if they are useful/necessary for the current scenario. Depending on the crisis management phase, different types of data might be needed, but generally, data can be subdivided into existing (static) and dynamic (temporal). Response is the extreme phase that requires management, fusion, analysis and presentation of both existing and dynamic or operational (*in situ*) data, i.e. obtained shortly before, during and after the incident.

The experiences have clearly shown numerous problems in this process: lack of information about the data, various data formats and representations, different terms and notations, vocabulary and language, etc. The dynamic of operational data further complicates this process, requiring in many cases updates every hour or even couple of minutes. Analysing such volumes of data clearly overwhelms the traditional methods of data analysis, which are performed by humans (with limited automation) and are based on ad-hoc queries to particular data sets and dedicated scripts. Furthermore, the results of analysis have to be appropriately communicated to the different user groups (crisis response units, decision-makers, citizens, press, urban planners, etc.) taking into account their context, i.e. backgrounds, knowledge, location, needs, etc.

Despite the intensive research and many technological advances from the last several years, still numerous challenging issues remain to be addressed:

- 3D spatio-temporal models and operations that will allow for monitoring of dynamic processes (e.g. distribution of plume), management of data (e.g. integrated sensor networks) and performing complex 3D dimensional analysis (e.g. computing of areas or volumes affected by air pollution)
- Algorithms for knowledge-based 2D/3D indoor/outdoor navigation, which is needed for fast and safe evacuation of citizens and efficient routing of rescue units.
- 3D standardisation and harmonisation of data allowing for fusion of data from different domains
- Semantic interoperability and ontology, which will provide basis for successful cooperation and communication between different user groups will allow for automations in the decision-making process
- Seamless indoor/outdoor positioning and tracking of rescue units and other users
- Appropriate presentation of data with respect to user.

The ultimate scientific goal of the theme group is developing concepts, frameworks and prototypes that will ensure providing the most appropriate information to all users in crisis management at any time and place.

The research of the theme group will be focussed on geo-DBMS, which is also a core research topic of the section GISt. This means that research and developments will address wider range of technology needed for crisis management, but linked to geo-

DBMS technology. Geo-DBMS has been proven to manage large data sets, ensuring multi-user control, secure transactions for updates, advanced database recovery mechanisms, data security, data integrity and (standardized) operations. The spatial functionality offered by geo-DBMS increases every year allowing complex analysis to be performed at database level. The theme group will work on further extension of geo-DBMS to support crisis management.

The research group will promote 3D geoinformation when applicable for use in crisis management. Numerous investigations have shown advantages of 3D geoinformation compared to 2D geoinformation, e.g. better and faster orientation (perception of the situation) as well as ability for sophisticated analysis. It is expected that extending the spatial data management functionality into the third dimension will be a breakthrough in fighting crisis situations in urban areas. Three-dimensional data (instead of 2D maps), supplied directly, for example, to a fire brigade working in a dense built-up area will increase the possibilities for orientation and reduce 'expensive' time when performing navigation and location tasks.

3 Scientific relevance

The research and developments within the theme group will contribute to all the scientific areas as specified in the research agenda of the section GISt, i.e. geo-DBMS and related to it spatiotemporal data modelling, computational geometry, networking/interoperability and knowledge engineering, as well as, to the supporting areas of data collection, positioning and presentation. Some of the expected scientific contributions are listed bellow:

- A spatio-temporal model for management of operational data according to the response procedures in the Netherlands, ensuring fast extraction of data, elaborated queries, ability to filter information with respect to type of users and corresponding needs.
- Contributions to Spatial Data Infrastructure for Crisis response in the Netherlands
- The concepts developed for the Netherlands will be a complementary to standardisation processes and harmonisation of data for crisis management in the Europe.
- A formal semantics (ontology) for 3D spatio-temporal geoinformation allowing for machine-based integration from different domains. The ontology will be defined for data and users (roles), which will facilitate and progressively complete the automation of the decision-making process in crisis management.
- Algorithms for knowledge-based 2D/3D evacuation and navigation (inside, outside)
- The innovation aspect in geo-DBMS is related to maintenance of 3D spatio-temporal data. The research has the ultimate aim to make geo-DBMS appropriate for real-time geographic applications. The research will also provide formalism for coupling of existing models with the newly developed ones, functions for consistency check to be used in the transition period (from 2D to 3D)
- Possibilities to supply 3D to crisis response, a technology that will be the new solid basis for an efficient time-critical decision-making.

4 Social relevance

The mission of the theme group is in coherence with the initiatives of the European Commission and more specifically the Working Group 3 on 'Risk and disaster management' within UNIT G5, 'ICT for the environment'. Research areas as geospatial web, information mining, in-site monitoring, 3D/4D GIS (indoors and outdoors), SII, integrated information and decision-support systems, geo-simulations, system interoperability (in the domain of geo-ICT) are considered of primarily importance for the member countries in the period 2007-2012.

The research agenda of theme group is directly and indirectly contributing to a number of social problems caused by crisis occurrences. At first place, the formal models, tools and components will provide better access, analysis and presentation of exiting and incoming geoinformation by providing:

- Harmonised data management of static and dynamic data coming from different domains and systems
- Formalism for Spatial data Infrastructures for Crisis Management.
- Improved abilities for data analysis and guiding people from dangerous areas
- Automation of processes, data storage and update (performed currently manually)
- High-level of data integration and knowledge discovery (by building ontologies), which will allow for partial or complete automation of decision-making process.

The research within the theme group is carried out in collaboration with other universities (research groups), companies, governmental institution, end-users, national and international organisations (see Section 5), which promises possibilities for realisation of results and prototype developments. These implementations will have direct impact on the crisis management process. We expect improvements in several directions:

- Fast and adequate handling of the fist period of emergency, achieved by providing appropriate targeted information rapidly and by collecting relevant information from the field, which would help in efficient coordination of operations. This period, called the golden hour, is often mentioned as the most critical for the success of the entire operation, as concerns the ability to save lives and reduce material damages.
- Easy and fast access to data, as well as possibility to share information, which should lead to situational awareness and an improved communication and coordination of rescue works. Besides organisational and legal aspects, the problems in sharing information are considered amongst the most critical ones
- A knowledge-based support to all users (at any time) on the field and in the offices, with respect to their location, roles, gender, emergency of situation, etc., which can on the one hand lead to faster and more effective operations, and in the other hand ease the burden of stress on the operations theatre.
- Possibilities to provide accurate and appropriate information to citizens (and media) not directly affected by the incident. At present, no specific attention

is paid on preparing briefings for the large public. In many cases the media relies on own sources for collecting information.

- An improvement in the logistics of crisis operations by providing 3D navigation capabilities for indoor and outdoor environments. This will essentially increase the net availability of resources for the core crisis tasks and limit as much as possible the chaotic nature of crisis handling.

Moreover, the developments within the group will have impacts on the entire crisis management sector. The spatio-temporal models will guarantee archiving of data, which can later be studied and analysed. This will have reflections in prevention, mitigation and preparedness. Direct results will be a better preparation to crisis management, leading to shorter response times and more focused and efficient emergency operations.

5 Relationships with other research groups

The research within this group will be carried out in close cooperation with the partners of Section GIS technology within the Geo-Database Management Center (GDMC), such as Oracle, Bentley, ESRI, and Intergraph. Numerous joint research and development initiatives are currently taking place, i.e. Bentley Research Seminar (Bentley), beta testing with Oracle Spatial 11, etc.

The research topics are of interest to groups within OTB and TUD. Research cooperation is discussed with the Section 'Verkeer and Vervoer' (Milan Janic, OTB), on optimization of the performance of rescue teams with respect to distance to the incident, available resources, type of the incident, etc.; with the Section 'Optimaticering van hulpdiensten in stedelijke gebieden' (Ben Ale, TUD) on standardisation of procedures within crisis response sector; and within TUD via the initiative 'ICT and crisis management' (Els van de Kar) aiming at establishing contacts and a common platform for research in the area of crisis management.

Another group of partners is formed by organizations (officially) responsible for the production of geo-data (in the Netherlands). The Section GIS technology does have a long-term research (2006-2010) cooperation agreement with RWS/AGI. In collaboration with the Kadaster, the foundation for the future 3D Cadastral registration has been developed. Numerous some smaller projects have been conducted on separate contracts: harmonization of the DTB-Nat, Beheerkaart-Nat en de Regiokaart-Nat (the basic geoinformation sources of RWS in the wet-sector), geo-DBMS consultancy to both Kadaster and TNO/NITG (conversion strategies of existing geo-data to the geo-DBMS structure/often Oracle, benchmarks and suitability tests), (geo) information architecture research and tests (using OGC/ISO standards to realize a new geoinformation infrastructure within RWS together with leading edge consultancy companies such as IONIC, Liege/Belgium and Geodan, Amsterdam).

This research framework of the theme group (for more details see section 6) has been discussed with several different groups of users (prior and within the RGI-239), e.g. Fire brigade, Police, GHOR and municipalities in province Gelderland, and Havenbedrijf Rotterdam). Several workshops, brainstorm meetings and interviews were organized to investigate user requirements.

During the last several years, the Section GISt has established many relationships with groups working on crisis management. The following organizations and people have shown interest in cooperation and joint developments:

- End users: RWS/AGI (M. Grothe), Province Zuid Holland (J van Arragon), Municipality Arnhem (J. van der Heide), Fire Brigade Midden Gelderland (S. Diehl).
- Institutions offering geoinformation services: Kadaster/Topografische Dienst, Netherlands (Martin Salzmann), and Ordnance Survey, UK (Chris Parker).

- Companies developing software such as Oracle Spatial (Xavier Lopez), Bentley (Oscar Custers), Geodan (Henk Scholten), Intergraph (Pieter Jongert), Geodan (Henk Scholten), Plangraphics (Mike Kevany), TNO-FEL (Marius Cloostermans), VNET, Nieuwland (Wim Ploeg), IONIC (Belgium) (Alain Kabamba), Systems in Motion, Norway (Oyvind Ridering), FORTHnet, Greece (Manolis Stratakis), YDreams Informatica, Portugal (Antonio Camara).
- Disaster management institutes and consultancy groups: NIBRA (Ben Ale), Octaaf Adviesgroup (D. de Jong).
- Universities and research institutes: FUA (Andrea Fabri), Fraunhofer Institute Darmstadt, Germany (Daniel Holweg), Stuttgart University of Applied Sciences, Germany (Volker Coors), University of Applied Science, Mainz, Germany (Alexander Zipf), Aalborg University, Denmark (Lars Bodum), University College London/CASA, UK (Mike Batty), SINTEF, Norway (Rune Aasgaard), Centre for advanced Studies, Research and Development in Sardinia (Stefano Sanna), European Media Lab, Germany (Rainer Malaka), University Teknologi Malaysia (Alias Rahman), University of Waterloo, Toronto, Canada (Jonathan Li). The contacts with these universities contribute to different stages of the outlined research. On-going research and common developments are already reported in series of papers.

This research framework is complementary also to the JB of GIS Ad-hoc Group 'Geoinformation for Risk and Disaster management', the ISPRS Working Group IV/8 on '3D Spatial Data Integration for emergency response and environmental monitoring' (chair Sisi Zlatanova) (2008-2012) and the Working Group 3 'Risk, Disaster and Crisis Management' within EC, Unit 5, 'ICT for Sustainable growth'.

Section GISt is already cooperating actively with many of the mentioned institutions and companies within national and international projects as well as various other activities such as organization of workshops, symposia, books, etc.

6 Research areas

The research within the group will be further clustered according to the major research topics of section GISt, as specified in:

Table 1: GISt research topics and theme groups

	GISt Research Topics	**Crisis management**	**Spatial infrastructures**
B1. Core research	Geo-DBMS	√	√
B2. Related research	3D spatiotemporal modelling	√	√
	Computational geometry	√	√
	Networking/interoperability/web	√	√
	Knowledge-based engineering	√	√
B3. Supporting research	Data collection	√	√
	Positioning and geoinformation	√	√
	Visualisation	√	√

A new specific theme will be devoted to the investigation of the process and requirements in crisis management namely User requirements.

Most of the research topics of GISt are currently active, although not specifically crisis management oriented. The following sections discuss the research areas of the theme group in more details.

6.1 Geo-DBMS

Section GISt carries out a fundamental research on geo-DBMS, which is of critical importance also for crisis response. For example, within the project RGI 232, a very fast multimedia DBMS will be developed, which will be able to manage very large data sets (e.g. from video cameras). To overcome information overload, appropriate filters and analysis will aggregate the data into meaningful features. The research output from this project is complementary to management of operational data in crisis response. PhD research 3D data types and 3D spatial operations (within RGI 11) contribute by providing a platform for 3D spatial analysis, e.g. affected buildings (floors) by pollution cloud. PhD research on data integration and extension of CityGML will contribute to developing a (semantic) 3D Integrated Model (3DIM) for objects on, above and bellow the earth surface. Other related research is devoted on new data types such as 3D volumetric data type and NURBS data type (MSc research). Various tests performed within different geo-DBMS provide valuable information regarding functionality and performance of commercial geo-DBMS.

6.2 3D spatio-temporal modelling

This research topic focus on the challenges related to modelling of data (static and dynamic) in various systems (Geo-DBMS, GIS, CAD, etc.), as well as investigating new concepts for representation and modelling.

Topics related to 3D modelling are investigated by almost all the scientific staff of the section (e.g. RGI-011, 3DTOPO, Friso Penninga). Some initial investigations have been completed (with MSc Students and as case studies) on 3D indoor modelling but the topic needs to be further defined and structured.

Research on 2D spatio-temporal modelling (operational data in emergency response) is carried out within the RGI-239 project 'Geographical Data Infrastructure for Disaster Management' (GDI4DM). The research completed is adopted within the Dutch IMOOV (Information model for public order and safety). Some initial investigation on 3D spatio-temporal modelling has been started not specifically for crisis response. Case studies related to 3D spatio-temporal modelling are planned also within the FP6 funded project HUMBOLDT.

Various aspects of data integration and data harmonisation are extensively investigated within another Bsik project, RGI 029, Geoinformation Management in large Civil-engineering Works (GIMCIW), the EU directive INSPIRE and the EU FP6 funded Integrated Project HUMBOLDT. Several case studies within the HUMBOLDT project focuses directly on crisis response such as cross-border security, flood, air pollution, and oil spill.

6.3 Computational geometry

This topic comprises research and developments on computational algorithms, which are needed to perform specific analysis such as computing evacuation and navigation routes, defining affected areas (volumes), simplification of models for visualisation, compression of data, etc., or investigate approaches for fast retrieval of data. Within this theme most of the attention will be focussed on indoor environments but in combination with outdoor environments.

Some initial research (performed with MSc students and colleagues from other research groups) has revealed promising results for fast navigation and 3D route visualisation by using combinations of geometry and graph models currently supported by geo-DBMS (Oracle Spatial). This research will be further clarified, structured and submitted for funding.

6.4 Networking/interoperability/web

The geo-data (needed for crisis management) are usually acquired and managed within a specific domain (cadastre, topography, utilities, water, soil, etc.) using specific terms, representations and notations. Similarly, to many other areas, to be able to exchange and use geoinformation from different domains, a spatial data infrastructure has to be built up also for crisis management. This topic is already under investigation within the project RGI-239, GDI4DM. Work on spatial data infrastructures (although not specifically for crisis management)), including metadata, interoperability standards, services, networks and web visualisation is a permanent activity of the section involving several researchers.

6.5 Knowledge-based engineering/semantic/ontology

Successfully discovering and combining data under time constraints, as in crisis response, might be rather problematic, if left only on humans. Therefore, we believe machine automation has to be employed for fast discovery, evaluation and appropriate presentation of data. However, machine supported decision-making requires not only standards but also a strong formalism to deal with the most difficult problem, i.e. semantic heterogeneity. One possible solution is the use of ontology, which can formally describe hidden and implicit knowledge. This knowledge should help in building user-oriented applications (in contracts to the traditional application-oriented applications).

The section GIS technology has initiated research on ontology, which has to use crisis management as a case study. Ontologies will be built for specific data domains (such as police, fire brigade, GHOR, utility companies, Kadaster, CAD and GIS, etc.) but also for the processes within emergency response, which will be used to facilitate the knowledge-based search.

6.6 Supporting research in data collection, positioning, visualisation

The theme group will investigate some related topics on data collection, positioning and visualisation whenever required within some of the other research areas as specified above. For example, there is on-going research on indoor positioning within RGI-150 project '3D positioning infrastructure in built-up environments'. The outputs of this research will contribute to 3D indoor navigation. Another related subject is geo-DBMS generalisation for mobile devices, a research carried out within RGI-233 Mobi Maps.

6.7 User requirements

The last research topic will concentrate on users and their roles in crisis management. The investigations will be in two directions: getting familiar with specifics of emergency response, referred here as to *Formal Modelling* and 2) promoting geoinformation (and 3D) to the end users, named here *Education*.

Users, getting involved in de different phases of crisis management, are practically from every domain of the society. Their manner of work is normally restricted to the specific domain, which is practically not multidisciplinary. Investigations completed in the last several years have clearly shown that the tools developed for crisis management should be very similar to the ones used in daily routine activities. This tendency is especially strong for emergency response phase. Therefore, user requirements (defined through roles and activities in daily life and during incidents) have to extensively studied and formally modelled. Investigations within emergency sector (fire brigade and police, Arnhem) have already started within the RGI-239. First formal descriptions (UML use-case, activity and class diagrams) are already available for some of the processes defined within province Gelderland. Investigations on user requirements are completed also in the risk prevention sector (RGI-138 'Geoinformation for risk prevention' and a SUA project on 'Comparative study on use of GIS in land-use planning in UK and NL').

Within the theme, special attention will be paid to promoting geoinformation to crisis sector (primarily) and land-use planners. Although is it widely accepted that geoinformation helps in managing crisis, still insufficient awareness exist of the advances in geoinformation technology. To facilitate this process, with several colleagues from different universities (FUA, TUD and WUR) we have investigated possibilities to initiate an education on geoinformation for crisis management. We have completed a lecture course (initially intended as a module in UNIGIS), which was given to PhD students during the 2nd Vespucci Summer School in 2005. The intentions are to offer such a course as an elective within the MSC Geomatics or as an independent short course for professionals within OTB.

Other aspects included in education activities are: 1) dissemination of obtained results and 2) following international research and developments. In this respect, the theme group will continue the active support of the International Symposium Gi4DM and other disaster management societies such as ISCRAM and TIEMS. The research results within large projects such as ORCHESTRA, WIN, OSIRIS, and OASIS as well as INSPIRE and GMES will be followed, analysed and discussed at theme meetings.

7 Organisational aspects

The cooperation within the theme will be realised via discussions, presentations of on-going research, reports on new developments, activities etc., and preparing papers for international conferences and journals. These activities will be organised as lunch meetings (a part of the regular GISt meetings) or afternoon meetings. The number of researchers participating in such a meeting will depend on the topic to discuss. The theme can be related to a particular project, GISt general theme, a particular PhD research topic or an important international development. The intention of these meetings is to increase the awareness of new development and sharpen (adapt) the on-going research, which has to result increasing the scientific level of the group. The involvement of the members of GISt section within the theme group is variable and depends on involvement in projects and education:

Several new researchers have joined or will join the section, which will also be integrated in the research scope of the theme group.

8 Perspectives 2007-2012

The theme group has the potential to complete the planned tasks and even to initiate new research directions.

Various interesting results on 3D modelling are expected in 2007, e.g. TEN model, spatial schema for integration of real world (including beneath surface) and design data. Research on spatio-temporal schema for operational data has to be completed by 2008. Depending on the results, the research can be extended to 3D objects (and combined with the developments on 3D modelling). Critical results on harmonisation of data from different domains are expected also in 2007 and yearly 2008.

The research on ontology will be completed by 2010, but some initial ontology implementations are expected at beginning of 2008. Agreements on basic information to be used in emergency response are expected in 2007, which will boost the developments of prototypes also within the theme group.

Research on 3D evacuation is expected to give first results in mid 2008 mostly in developing a spatial schema for 3D indoor models. Algorithms and 3D visualisation are expected in late 2009. As mentioned before a new researcher will be acquired to work specifically on this topic. If the application is successful, results can be expected an year earlier. Indoor positioning is an ongoing research, which has to be completed in 2009.

Investigation and formal modelling of user requirements has given partial successful results. The method has to be applied to all the 25 processes. The formal modelling is expected to be completed in 2008.

With few exceptions, the group has, currently, insufficient information on activities performed in emergency response sector in the Netherlands. The very first goal will be provide as much as possible information on the processes and way or working. This gap has to be closed in the beginning of 2007 to be able to gain knowledge on international practice afterwards.

In general GISt group has relatively many publications in conference proceedings. The goal of the theme group will be increasing of the number of publications in scientific journals. Some scientific results can be presented in refereed journals. It is expected that first journal papers resulting from the cooperative work within the theme group will be available in 2008.

To be able to promote geoinformation and the work of the group, several courses on geoinformation for disaster management are going to be organised within summer schools (ISCRAM, Gi4DM, Vespucci Summer School, etc.). The possibilities to organise an elective course within the MSc Geomatics (for which the section GISt is responsible) will be studied.

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1. CHORIST, Integrating Communications for Enhanced Environmental Risk Management and Citizens Safety, EU project, http://www.chorist.eu
2. HUMBOLDT, EU project, http://www.esdi-humboldt.eu/home
3. INSPIRE, Infrastructure for Spatial Information in Europe, EU directive, http://www.ec-gis.org/inspire
4. OASIS, Open Advanced System for Disaster and Emergency Management, EU project, http://www.oasis-fp6.org
5. OSIRIS, Open Architecture for Smart and Interoperable Networks in Risk Management Based on *in-situ* Sensors, EU project, http://cordis.europa.eu/fetch?CALLER=PROJ_IST&ACTION=D&DOC=13&CAT=PROJ&QUERY=1165973560920&RCN=80164
6. ORCHESTRA, Open Architecture and Spatial Data Infrastructure for Risk Managwement, EU project, http://www.eu-orchestra.org
7. UNIT G5, 'ICT for the Environment', Directorate G 'Component and Systems', European Commission, http://cordis.europa.eu/ist/environment/index.html
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