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GEOGRAPHIC INFORMATION SYSTEMS

AND

RISK ASSESSMENT

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The Institute for the Protection and Security of the Citizen provides research-based, systems-oriented support to EU policies so as to protect the citizen against economic and technological risk. The Institute maintains and develops its expertise and networks in information, communication, space and engineering technologies in support of its mission. The strong cross-fertilisation between its nuclear and non-nuclear activities strengthens the expertise it can bring to the benefit of customers in both domains.

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1. Introduction

1.1 GIS and Risk Assessment

Risk assessment is a complex process aiming at evaluating the different aspects that can disrupt or destruct a system, providing means for understanding the causes and consequences of those risks. Traditionally, risk assessment relies on mathematical models to establish the likelihood of a given event occurring with a given degree of intensity in a given site. The major limitation of this type of approach is that risk necessarily entails uncertainty and it is necessary to make realistic hypotheses about possible future scenarios.

For complex systems, such as critical infrastructures, which comprise many components over significant geographical areas, the understanding of all factors involved in a risk situation is particularly demanding, Therefore, risk assessment approaches require to take into account all relevant social, economic, cultural, and political aspects, in order to define the vulnerability, resilience and capacity of response of a territorial system to different threats.

A fundamental principal of risk assessment is that natural or industrial hazards are location dependent, and that generally (within an acceptable range of uncertainty) reliable historical and location specific data are available – e.g. regarding failures, potential damages, etc.

Although risk maps should be considered the ultimate product of any risk investigation, and should be the first resource sought for any risk decision or evaluation, the whole process of risk assessment can benefit from geographical representations. GIS techniques can be central to these important and crucial processes of risk identification, quantification, and evaluation.

Many of the decisions we make every day involve being able to access, understand and utilize the space around us. This type of information is referred to as spatial information, and by visualizing, we can see relationships, patterns, and trends that may not otherwise be apparent.

A Geographic Information System (GIS) is mapping software that provides spatial information by linking locations with information about that location. It provides the functions and tools needed to efficiently capture, store, manipulate, analyze, and display the information about places and things.

GIS is a rapidly growing technological field that incorporates graphical features with tabular data in order to assess real-world problems. What is now the GIS field began around 1960, when discovering that maps could be programmed using simple code and then stored as digital information in a computer, allowing for future modification when necessary. This was a welcome change from the era of hand cartography when maps had to be painstakingly created by hand, and even small changes required the creation of a new map. The earliest version of a GIS was known as computer cartography and involved simple linework to represent land features. From that evolved the concept of overlaying different mapped features on top of each other to determine patterns and causes of spatial phenomenon (Figure 1).

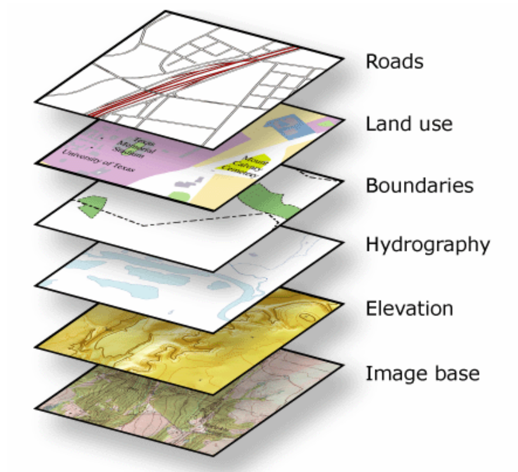

Fig. 1: The following figure illustrates how geographical elements are portrayed in maps through a series of map layers (cfr. ESRI).

The key components of GIS are:

- Tools for entering and manipulating geographic information such as addresses, political boundaries, geological features and building information;
- A database management system (DBMS);
- Tools that create intelligent digital maps you can analyze, query for more information, or print for presentation;
- An easy-to-use graphical user interface (GUI).

The importance of GIS for risk assessment and management issues derive the fact that hazards and consequences evolve spatially. There is an initial point of impact – whether an earthquake epicentre, a tornado path, or an industrial accident. There is also a geographical space where the impact develops – either defined socially, such as where people live, or physically, such as down river areas prone or flooding. Spatial data, spatial technologies and spatial models are needed to understand, prepare for and respond to any disaster.

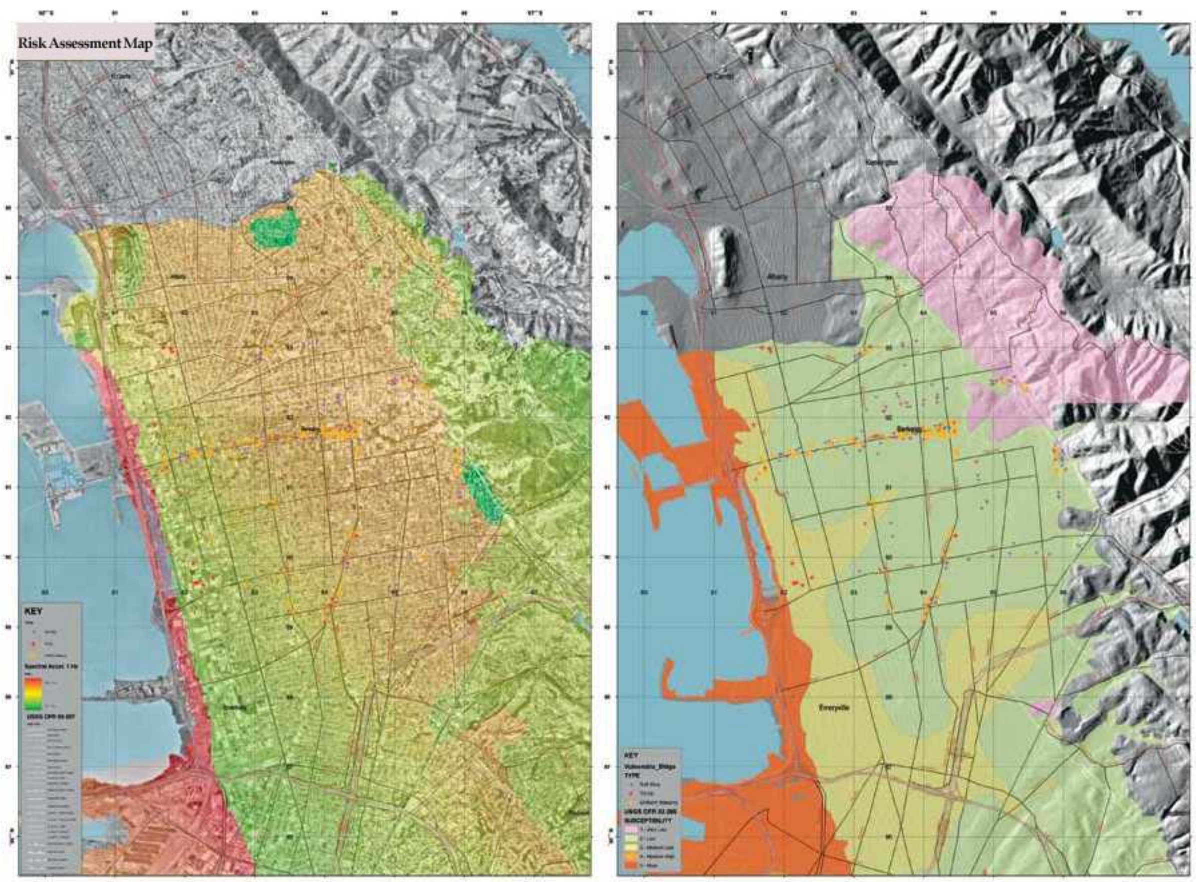

Fig. 2: Representation of the risk assessment using GIS instruments.

Risk assessment has two main components - hazard and vulnerability. The hazard is a measure of the physical intensity of the threat at a particular location and the associated probabilities of these intensities. Hazard is location dependent. For example a location which is surrounded by seismic faults and has a weak surface geology has a higher hazard potential than a location far away from faults and with strong surface geology. Similarly, hurricane, hazard at a location near the coast and with a flat, bare terrain is far higher than at a location which is inland and has a rugged terrain.

Vulnerability is a measure of the damage that the peril can cause to the system under study, and or to the surrounding elements – e.g. the built environment (house, buildings, infrastructure and utilities) at that location. Manmade structures respond to different perils in different ways, depending on the design of their structural systems and methods of constructions.

The synthesis of data and the essential mapping of the spatial relationships between natural or malicious hazard phenomena (earthquake, landslide, industrial accident, physical or logical attacks) and the elements at risk (people, buildings, infrastructure) can benefit from the use of tools such as GIS. Many factors and relationships that are most significant in risk analysis and modelling are largely spatial.

GIS can be used in the very beginning of the risk assessment process, for the identification of hazards. It can also be used to determine new hazards through overlay of hazard data sets. Hazard and vulnerability data which is both spatial and non-spatial in nature can be stored in GIS databases.

Risk assessment programs can be called within the GIS to access this data and evaluate potential damages and risks. Finally, by displaying the potential damages that can be caused by the hazards, GIS helps planners and insures to take preventive actions. GIS thus plays an almost indispensable role in the process of risk assessment.

1.2 Critical Infrastructures at risk

An infrastructure is a social technical system that delivers a vital service on universal basis, and in which something is transferred between the nodes of the system. The nodes, together with the links among them, form a network. An infrastructure includes all the elements required for its functioning: subsystems, as well as the governance, management and control process. The 'infrastructure' refers to basic services that include, inter alia, transportation (roads, railways, airports, water navigation canals etc..), utilities (power plants, transmission and distributing grids, oil, gas and derivates pipelines, water supply systems, sewer, telephone etc.), municipal services (police, fire departments, garbage collection), some key civil installation (important bridges, dams), health related services.

What makes an infrastructure critical? The notion of criticality relates to the potential risks to people (workers, bystanders, the population at large), goods (installations, buildings), environment, business (supplies, continuity), and society (well–being, economic output) — and depends on several factors, as for instance the standpoints of the different stakeholders.

Infrastructures are critical because they provide services that are vital to one or more broad governmental or societal functions or attributes. Therefore, critical infrastructures are systems and assets, both physical and cyber, so vital to society that their impairment or destruction would have a debilitating impact on national security, and/or national public health and safety, resulting in detrimental supply shortages, substantial disturbance to public order or similar dramatic impact

Nevertheless, there is no universally accepted definition of critical infrastructures. The only general rule could be that: the highest the development of a society, the longer the list of its critical infrastructures and the more severe the society's dependence on them. State and society can only function smoothly if the necessary infrastructures are continuously available and fully functional.

If such infrastructures are affected by deliberate disruption (physical aggression, hackers, information warfare, etc.) or accidental failures or natural hazards, this could have the effect of triggering a chain reaction of disruption in other areas as well. Internal security and, in some cases, even external security could be affected as a result.

1.3. Critical Infrastructure Sectors

The proposed EU-Directive of the Council establishes the necessary procedure for the identification and designation of European Critical Infrastructure (ECI).

No horizontal provisions on critical infrastructure protection currently exist at EU level. The directive launches a common approach to the assessment of the needs to improve the protection of such infrastructures. The selection of the identified sectors depends upon the particular situation and conditions of each geographical region.

For the EU-Directive a number of sectorial measures exist including: the IT sector, the health sector, the financial sector, the transport sector, the chemical sector, the nuclear sector.

The following is a list of Critical Infrastructure sectors typically considered in different countries. Obviously the selection of the sectors depends upon the particular situation and conditions of each geographical region.

Transportation

Industry, commerce and public life all require goods which are not always used directly in the locations or manufacturing facilities where they are produced and/or may undergo further processing. Again, people have to be mobile to get to their place of work or to conclude transactions of a professional or private nature. To make all this possible, transportation organizations provide structural infrastructures (e.g. roads, railways and airports) and undertake or organize the transportation of persons and goods. They also direct and control the flow of traffic.

Energy

Most of the technical equipment used today cannot function without energy. This applies from the simple radio at one extreme to the highly complex industrial production facility at the other. Again, information technology cannot be continuously available without an interruption-free supply of energy. Often users are not aware of this dependency relationship, as today the use of technical equipment is taken for granted and a reliable energy supply is virtually guaranteed (in Western industrialised nations). Energy is a distinct infrastructure sector, but this infrastructure also cuts across sectors, all the other sectors being dependent on it.

Hazardous materials

Materials and products of a potentially hazardous nature are required to produce important economic goods and also to protect our state. It is therefore of critical importance that these goods and materials are not only protected against misuse but also that they can be used in a controlled manner as well. This includes the transportation of these goods and materials to the places where they are used, processed or held in depots.

Telecommunications and information technology

Today's information society not only uses information and information technology on a daily basis, but is also dependent on it. The benefits of information and IT are used equally by the state, industry, commerce and the public. The capabilities of communication independent of location, fast data transmission and process control and optimisation play a critical role here. Information technology and telecommunications constitute a separate infrastructure sector, but at the same time this infrastructure also cuts across sectors and all the other sectors are dependent on it. A key role in this area is performed not only by the classic means of information transmission, such as telephone, radio and broadcasting, but above all by modern technologies such as mobile telephony services and the internet.

Finance and Insurance

State, industry, commerce and also the public rely heavily on banking, insurance and financial services. Services that depend on information technology, such as online banking and IT-supported tax returns, are increasingly taken for granted. Large-scale transactions, e.g. on the stock markets, are no longer possible without IT. Society places great trust in this infrastructure sector and hence also in the IT that supports it. Financial, monetary and insurance systems constitute a separate infrastructure sector, but at the same time this infrastructure too cuts across sectors and all the other sectors are dependent on it.

Supply and Services

The supply sector covers a number of facilities which provide preventive protection of basic needs of the population (e.g. the supply of water and food) and provide reactive help, either directly or indirectly, in cases where there is a danger to health and life (e.g. health and emergency services). Even if this assistance can to a large extent also be provided without the use of IT, information technology still plays a critical role, above all in communications, organisation and operations control.

Public administration and Justice system

The provision of services for the public and the maintenance of public security and order, including in times of crisis, are the responsibility of government, public administration and justice. Information technology is of critical importance in safeguarding the provision of these services and, above all, the communications, command and decision capabilities of these institutions.

Miscellaneous

This sector encompasses those segments which cannot be assigned to any of the other sectors but still fit the definition of critical infrastructures. There are institutions and establishments that are of critical importance to society or which play a prominent role for identification with a country’s history, culture and way of life. Whereas the media and large research establishments are still directly dependent on information technology, since they entail the creation, management and communication of information, and production and control processes are also controlled by IT resources, outstanding buildings and cultural assets are largely of a symbolic value and dependent only to a small extent on IT.

Critical infrastructures are endangered by threats. This is no different today than in earlier times. What has changed, however, is the type of threat as well as its relevance. Interruptions and shutdowns occurred rarely in the past. As a result of the limited extent of networking and limited interdependencies, there was only little consequential damage.

Today's situation is rather different: We have become increasingly dependent on critical infrastructures. Who can still imagine life without continuous access to electrical power or information technologies? In addition, subsequent to the attacks of 11 September 2001, there has been a substantially rising public interest in critical infrastructures. Since then, sensitivity with regard to protecting critical infrastructures from any and all threats has increased significantly worldwide.

This is particularly true for threats resulting from the massive use of information technology. These new threats have not simply replaced the previously existing threats. They came in addition to them, and their character is global: National borderlines and classical means of protection have, for the most part, become irrelevant. IT-related threats may originate anywhere in the world and affect our critical, national infrastructures. When considering threats for critical infrastructures, it is therefore absolutely necessary to always consider at both kinds of threats: (1) classical, i.e. mostly physical, and (2) the new, i.e., primarily IT-related specific ones.

2. The European Program for Critical Infrastructure Protection (EPCIP)

The security and economy of the European Union as well as the well-being of its citizens depends on certain infrastructure and the services they provide. The destruction or disruption of infrastructure providing key services could entail the loss of lives, the loss of property, a collapse of public confidence and moral in the EU.

The European Program for Critical Infrastructure Protection (EPCIP) has been requested and promoted by the European Council, in order to counteract these potential vulnerabilities. For this purpose, a comprehensive preparatory work has been undertaken, which has included the organization of relevant seminars, the publication of a Green Paper and discussions with both public and private stakeholders.

The issue at hand which requires action is the vulnerability of critical infrastructures in Europe and the ensuing vulnerability of the services they provide. This applies to all critical infrastructures in Europe regardless of whether they can be considered as having EU or national importance.

The EU level action is needed for several reasons. Firstly some infrastructures are becoming increasingly European, which means that a purely national approach is insufficient (for instance, the energy pipelines and transmission network). Moreover, a growing number of Member States are preparing their own approaches to critical infrastructure protection and are waiting for the Commission to put forward a general European CIP program, so that they can take into account the common EU approach. Delaying the adoption of a common framework would increase the chance that various incompatible approaches to CIP would be developed by the Member States.

Weak links have to be eliminated especially where transboundary effects came into play. The risk of one Member State suffering because another has failed to adequately protect infrastructure on their territory needs to be minimized. Additional costs for companies operating in more than one Member State resulting from differing security measures need also to be minimized.

In general, even if it is clear that the protection of critical infrastructures is first and foremost a national responsibility, all stakeholders acknowledge that due to interdependencies and the general nature of today's economy, there exists in the EU a certain number of critical infrastructures which if disrupted or destroyed would have a serious impact on the entire Community or on a number of Member States.

There is therefore a need to identify and designate in a coherent way (using the same sector-based criteria in the entire EU) the above mentioned critical infrastructures and assess whether they require additional protection measures.

The task of ensuring critical information infrastructure protection is posing quite a challenge. It requires multi-faceted approaches from a variety of government and private sector actors.

An important aspect of CIP is international collaboration. Because of interconnection and interdependence, any weaknesses may have repercussions elsewhere in the infrastructure. International discussions of different national approaches and exchange of best practice will have a beneficial effect on the quality of CIP policy.

Taking into account the principles of subsidiarity and proportionality, EU level action should concentrate on those critical infrastructures having an EU importance. With this in mind, EPCIP will develop into a process leading over time to an assessment of vulnerabilities of particular CI sectors and the preparation of proposals on how to best address these vulnerabilities. These key activities and especially the development of specific protection measures will concentrate on European Critical infrastructure, with the Member States however being encouraged to adopt similar approaches concerning their national critical infrastructure.

The Commission's actions will then focus on European Critical Infrastructures. With due regard to existing Community competences, the responsibility for protecting National Critical Infrastructures falls on the NCI owners/operators and on the Member States. The Commission will support the Member States in these efforts only where requested to do so. The EPCIP will therefore also include the possibility for Member States to take action themselves on their national critical infrastructure.

2.1. Proposal for a Council Directive COM(2006) 787

As part of the EPCIP framework dealing specifically with European Critical Infrastructures, a proposal for a Directive of the Council on the identification and designation of European Critical Infrastructure and the assessment of the need to improve their protection plays an important role. The proposed Directive establishes the necessary procedure for the identification and designation of European Critical Infrastructure (ECI), and a common approach to the assessment of the needs to improve the protection of such infrastructure.

The most relevant principle rising from the proposed Directive is that the identification and protection of infrastructures having an importance for the EU (ECI) cannot be done below EU level as an EU perspective is needed in order to assess interdependencies and develop common minimum protection measures. Such measures are needed in order to make sure that a minimum level of security exists in the EU and weak links cannot be exploited.

The proposed Directive satisfies both the subsidiarity and proportionality principle. The subsidiarity principle is satisfied as the measures proposed in the Directive cannot be achieved by any single Member State on its own. Although it is the responsibility of each Member State to protect the critical infrastructures present under its jurisdiction, it is crucial for the security of the European Union to make sure that the most important infrastructures having an impact on the entire Community or on two or more Member States are protected to a satisfying degree and that particular Member States are not made vulnerable because of the existence of lower security standards in other Member States.

The proportionality principle is fulfilled, since the draft proposal does not go beyond what is necessary in order to achieve the underlying objectives of improving the protection of critical infrastructures in Europe. No other approach would allow the EU to achieve the required objective within a reasonable period of time. At the same time, common rules in the CIP field will be of benefit to businesses, which are currently subjected to various regimes in the MS. The proposal puts forward a minimal number of measures needed to improve the protection of critical infrastructures. The underlying objective cannot be sufficiently achieved through other measures, namely by adopting a guideline approach to EPCIP, as this would not guarantee similar levels of protection across the entire EU and weak links could be exploited.

The ECI Directive lays down the procedure on how to identify and designate ECI:

- First, the Commission together with the Member States and relevant stakeholders develop cross-cutting and sectoral criteria for the identification of ECI, which are then adopted through the comitology procedure.
- The cross-cutting criteria are developed on the basis of the severity of the disruption or destruction of the CI. The severity of the consequences of the disruption or destruction of a particular infrastructure should be assessed on the basis, where possible, of:

a. Public effect (number of population affected);

b. Economic effect (significance of economic loss and/or degradation of products or services);

c. Environmental effect;

d. Political effects;

e. Psychological effects.

Each Member State then identifies those infrastructures which satisfy the criteria and notifies the Commission of the critical infrastructures which satisfy the established criteria.

Following the identification procedure the Commission prepares a draft list of ECI. The draft list is based on the notifications received from the Member States and other relevant information from the Commission. The list is then adopted through comitology.

The ECI Directive only imposes two obligations on the owners/operators of those critical infrastructures, which are designated as European Critical Infrastructures, that is the establishment of an Operator Security Plan which would identify the ECI owners' and operators' assets and establish relevant security solutions for their protection and the designation of a Security Liaison Officer (SLO).

The costs for ECI owners/operators for implementing the ECI Directive obligations would vary among the Member States. Costs can reasonably be expected to be higher for owners/operators who have not addressed security or business continuity issues at all. It could however be expected, that even without the adoption of EPCIP, certain costs concerning business continuity plans would be incurred at a certain point in the future.

The ECI Directive establishes a process leading to the identification of security gaps. The Member States should report to the Commission on a generic basis on types of security gaps identified in particular sectors. Based on this information, concrete proposals concerning additional protection measures can be put forward. The underlying idea behind this approach is nevertheless the fact that dialogue between particular owners/operators and the Member States should lead to the implementation of improved security measures. EPCIP does not put forward any concrete protection measures. The ECI Directive establishes a procedure leading to the identification of protection gaps. If such gaps are identified the relevant Commission service may put forward binding or nonbinding measures to address them. This however is not part of the current initiative.

3. GIS technologies

3.1 Applying GIS

Which is easier to use: a page full of numbers and other bits of data, or a map that shows with pinpoint accuracy where important geographical features are in relation to the surrounding area? Of course the answer is the map. A GIS can provide just that.

Geographic Information Systems (GIS) can be seen from two viewpoints: the supporting technology and their application to problem solving. GIS can be considered as a special-purpose digital database in which a common spatial coordinate system is the primary means of storing and accessing data and information. GIS systems have the ability to perform numerous tasks utilizing both the spatial and attribute data stored within them.

These functions distinguish GIS from other management information systems:

- GIS is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.
- GIS allows integrating a variety of geographical technologies, such as remote sensing, global positioning systems, etc.
- GIS is for making decisions. The way in which data are entered, stored, and analysed within a GIS must mirror the way that information will be used for a specific analysis or decision-making task.

With a geographic information system (GIS), one can link information (attributes) to location data, such as people to addresses, buildings to parcels, or streets within a network. One can then layer that information to give you a better understanding of how it all works together. One chooses what layers to combine based on what questions you need to answer.

Geographical data are any data that have been collected for a specific location. Geographical information's are georeferenced data that have been processed into a form that is meaningful to the recipient and is of a real or perceived value in the decision-making process.

Why is GIS so helpful? It can incorporate all of these components in one framework.

- maps show
- geographic features and relationships
- results of data analysis
- Databases store
- technical data related to the infrastructures
- environmental data (physical and chemical information, land use, …)

Spreadsheets can be used for:

- target level calculations
- concentration data analysis

Models can be used to develop:

- sophisticated transport simulations.

GIS can manipulate data from a database and place the data on its corresponding coordinates on a map. By utilizing a GIS, one can chose which information is desired from a database, and put it on a map that represents the area from which the data was retrieved. The GIS can also manipulate the data, so that only the data that is needed is placed on the map. It can also overlay several different sets of data on one map to show the interaction between to sets of data, such as water run off and the location of farmland.

With a GIS, it is possible to see the locations of any natural resources that need to be examined.

For example, if anyone needs to look at areas in a certain country which can perk for a stand-alone septic tank, he has only to plug the data into a GIS and see in full detail the areas that can either perk or will need a sewer system. In order to see from where creeks get their run-off water, if the information are put into a GIS, not only it is possible to see where the water flows, but other important details can also be added to the map, such as the locations of farms in the area or where there may be an overabundance of soil erosion.

Moreover, in order to know if the site of a proposed housing development was suitable for building, using a GIS, it is easy to have all of the necessary information on one convenient map and look it all at the same time. Just by looking at a map one could tell in an instance if the land perked, what the zoning requirements were, if there were any endangered species in the area.

Seeing is believing. Since a GIS is as easy to use as a regular map, most anyone can use a GIS. So not only is it a useful tool in creating policy, it can also be a useful tool in educating the public on policy matters. Normally people are not going to understand several pages full of complicated land-use data, but they will be able to understand a simple map, with a simple map key to explain the different areas within the map.

If the map has the streets in the area on it, then citizens can not only see the information to convey, but how close it is to where they live. People want to know if someone is building in their backyard. People are just as interested to know if something will not affect them. For instance, the local citizenry may be more inclined to agree to a zoning change if they could see with their own eyes which properties will be affected. It may be much harder to convince the local population with a large batch of numbers, or a simple assurance that one is telling them the truth.

GIS can be used for a wide variety of tasks. It can be used for simple tasks such as street mapping, which is useful for address matching as well as making evacuation plans. GIS can be used for natural resources management. With a GIS, one can see in detail the different types of natural resource areas, including wildlife habitation, forests, rivers, streams, and wetlands. For facilities management, one can show exactly where such items as underground cables and sewer pipes are, in relation to there geographic location, as well as where they are located in relation to other items, such as people's street addresses.

Land management is also made easier by GIS, which can give exact detail to the location of zoning areas, give ownership details, as well as help with such tasks as water quality management and environmental impact studies.

GIS is a very important tool for the policy maker. It can show as little or as much detail as needed in a form most people can understand. With its ability to be easily understood, GIS enables policy makers to take the information to the public. This allows the public the opportunity not only to understand what is going on, but enables the public to be able to offer informed feedback, which is as important to the policy politician as it is to the policy analyst.

3.2 Web GIS technologies

As already mentioned, GIS refers to a computer-based system for storing, analyzing, and displaying map and database information. A regular map shows only spatial data such as lakes, roads, and vegetation. A geographic information system (GIS) goes further by linking attribute data to spatial data. For example, address ranges and street names can be linked to street segments. This link creates "intelligent" map features and provides the ability to analyze spatial data, giving the possibility to use map data in a whole new way.

When GIS data and functionality are made available over the Internet, the system is referred to as a "Web GIS". With Web GIS, users do not need to purchase and install expensive GIS software in order to access and work with maps and databases. Also, users do not need to become experts in sophisticated GIS applications, since the functionality is made available through a regular web browser and an integrated Viewer with a simple, user-friendly interface.

Web-based GIS is becoming more and more prevalent as time passes. The World-Wide-Web is a useful tool for the gathering and manipulation. Most information that is available in the world is now available over the Internet. Now much the same is true concerning GIS information. Where formerly an individual would have to buy an expensive software package to use and manipulate the data needed for GIS, the same is not so today.

With the advent of Java based programming, software applications for web-based GIS work are now available. Some of these programs require the user to buy some software, and others require plug-ins to be added to web browsers, but some require no special software additions at all. These use only the capabilities of your existing web browsers.

Internet based geographical data services involve management spatial and non-spatial (attribute) data.

Geographic Information System (GIS) has come to be an indispensable tool for analyzing and managing spatial data. Data pertaining to spatial attributes can be efficiently managed using Relational Database Management System (RDBMS).

The development of a Web-based system by integrating GIS and RDBMS would serve two crucial purposes. Firstly it would allow the user to operate the system without having to grapple with the underlying intricacies of GIS and RDBMS technology. Secondly, it would allow sharing of information and technical expertise among a wide range of users.

The Geospatial Web or Geoweb is a relatively new term that implies the merging of geographical (location-based) information with the abstract information that currently dominates the Internet. This would create an environment where one could search for things based on location instead of by keyword only – i.e. “What is Here?”

The Geoweb would allow location to be used to self organize all geospatially referenced data available through the Internet. The interest in a Geoweb has been advanced by new technologies, concepts and products. Virtual globes such as Google Earth and NASA World Wind as well as mapping websites such as Google Maps, Windows Live Local and Yahoo Maps have been major factors in raising awareness towards the importance of geography and location as a means to index information. The increase in advanced web development methods –e.g. Ajax– are providing inspiration to move GIS (Geographical Information Systems) into the web.

The capacity of Geospatial Web would be similar to Google Search and likely provide similar value. It is conceived that the Geospatial Web will present as a visual medium and geospatial platform for data self-organization, discovery and use. Capabilities that allow every Internet user to post to this flow of information and anyone to poll or pull the information will lead to a new commons, media or marketplace for publication, trade and commoditization of information.

Some of the characteristics, functionalities and advantages of using Web GIS technologies, are mentioned below:

- rationalization of geographic dataset storage;
- simplification and automation of data transmission and acquisition;
- simplification of data access and data distribution, with the possibility of establishing different access and security levels;
- improvement of the continuous control on data flow, due to the possibility of integrating spatial analysis procedures on demand and instruments for the automatic detection of situation of interest;
- possibility of creating personalized interfaces by using PDA/wireless devices;
- automation of enterprise reporting (creating tables, diagrams, graphs..);
- integration with data belonging to different sources;
- data download (if possible) and possibility of printing the map of interest;

- direct access to all the meta information related to the data of interest

The Internet Map Server offers support for a variety of platform and server options, and this allows individual participating agencies to implement their own data systems and services. In the process of managing the emergency, they can maintain an aggregated system-wide interoperability.

Moreover, a Web-based Internet Map Server can be used by emergency scene decision makers and spatial analysts, usually in command and control centers, to collect and process information via a secure intranet or encrypted mobile wireless network. Two data warehouses (one operational and one for emergency backup) should be established to provide the gateway for accessing geo-spatial data and remotely sensed imagery for various applications. Map serving capacity can easily be increased during an emergency by adding supplementary instances of your mapping applications or by connecting additional computers to your Web server network.

3.3. Spatial data infrastructures

Geographic information is vital to make sound decisions at the local, regional, and global levels. Crime management, business development, flood mitigation, environmental restoration, community land use assessments and disaster recovery are just a few examples of areas in which decision-makers are benefiting from geographic information, together with the associated infrastructures (i.e. Spatial Data Infrastructure or SDI) that support information discovery, access, and use of this information in the decision-making process.

The term “Spatial Data Infrastructure” (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general.

The word infrastructure is used to promote the concept of a reliable, supporting environment, analogous to a road or telecommunications network, that, in this case, facilitates the access to geographically-related information using a minimum set of standard practices, protocols, and specifications.

An SDI must be more than a single data set or database; an SDI hosts geographic data and attributes, sufficient documentation (metadata), a means to discover, visualize, and evaluate the data (catalogues and Web mapping), and some method to provide access to the geographic data. To make an SDI functional, it must also include the organisational agreements needed to coordinate and administer it on a local, regional, national, and or trans-national scale. Although the core SDI concept includes within its scope neither base data collection activities or myriad applications built upon it, the infrastructure provides the ideal environment to connect applications to data – influencing both data collection and applications construction through minimal appropriate standards and policies.

4. Using GIS in public policies

4.1. GIS based risk analysis

A GIS based risk analysis procedure can be synthesized by the following steps:

Planning**:** Security programs begin with understanding the problem. This involves strategic and tactical planning to locate and identify potential emergency management problems and, using GIS, identifying these hazards and evaluating the consequences of potential attacks, emergencies, or disasters. The plan should identify obvious hazards such as nuclear plants, infrastructure hot spots (such as the intersection of gas mains and high-voltage assets), and other potential hazards or targets. The hazard data can be viewed with other maps data (population density, streets, pipelines, power lines) to develop a risk assessment.

Mitigation**:** Once the risk assessment has been completed, GIS analysis can easily determine adjoining structures, utilities, and affected population areas to the hazard. It can identify the potential impact of outages. Other mitigation efforts may target hazardous leaks and establish security buffers around high-risk structures or environmental health monitoring. Mitigation involves understanding potential hazards at risk from these emergencies and targeting them for protective and/or preventive action.

Preparedness**:** Preparedness includes those activities that prepare for actual emergencies. These activities include contingency planning, model building, and training. In an emergency, GIS can be used to answer questions such as "Where should first responder teams be staged to improve response time and capability?" or "What critical assets have been lost?"

Response**:** The first priority in responding to a disaster is the safekeeping of people and the management of life-threatening situations such as fire, explosions, loose wires, or collapse of structures. Managers seek to stabilize the situation and reduce the probability of secondary damage (for example, shutting off contaminated water supply sources or cordoning off affected areas to prevent further injury) as well as to speed up other emergency operations for victims.

***Recovery*:** Recovery efforts begin when the immediate threat to life, property, and critical infrastructure is over. Recovery efforts are often in two phases—short term and long term.

As a consequence, the Geographic Information Systems (GIS) could be employed by industry and at all levels of government for risk management and in all stages of emergency management – preparation and planning, response, recovery and mitigation – Geographic Information Systems have become the most significant basic tool for mapping and modelling in disasters.

Short-term recovery efforts can be visually displayed and quickly updated. A visual status map can be accessed and viewed from remote locations by critical decision makers. This is particularly helpful for large emergencies or disasters where multiple efforts are ongoing at different locations. GIS is critical to understanding the scope, complexity, and severity of the emergency as well as distinguishing available assets from those lost or no longer available. In addition, laptop computers and handheld wireless devices can update the primary database from the field.

Long-term recovery means restoring all services to normal or better. Long-term recovery, such as replacement of buildings, facilities, power systems, and streets, can take several years. GIS can be used during this period to identify facilities, assess damage, and establish prioritization for major restoration projects. As funds are allocated for repairs, accounting information can be recorded and linked to each location.

4.2 The need of a common Spatial Data Infrastructure

Interactions among private and public actors for the preparedness for protection sharing data between the entities involved is of paramount importance in a common prevention and response to an event.

A response system needs to be able to support a common language system for integrating information, activities, and processes. GIS provides an ideal framework for cross-community sharing, offering task solutions from inventorying and forecasting to decision and policy making.

GIS also offers a language for working on common problems: from global communities to local communities, GIS can create common spatial data infrastructures.

The critical effort should be the creation of a centralized spatial database for each community, state, region and municipality.

For those databases that are proprietary or controlled for security reasons, the effort should be to obtain advanced permissions and/or access codes to secure the information. That access could be in the form of a secure link with coded access.

This type of approach allows the creation of a secure, shareable, distributed database for spatial information that can make communities more resistant to attacks/disasters as well as more responsive to an actual event.

This network can be based on geographic network architecture, also for homeland security.

The value of building data warehouses for each community as well as obtaining permissions and access to invaluable proprietary data sets cannot be stressed enough.

Gathering data to create a GIS to meet potential emergencies requires an immediate and concentrated effort. It is far easier to accomplish this task before an attack or emergency than in its aftermath.

4.3 Geographic Information (GI) user: private and public

GIS technology is increasingly being used in spatial decision support systems.

In the past few years, GIS emerged as a powerful risk assessment tool and is being put to use to assess risk to property and life stemming from natural hazards such as earthquakes, hurricanes, cyclones and floods.

Manipulation, analysis, and graphic presentation of the risk and hazard data can be done within a GIS system, and because these data have associated location information which is also stored within the GIS, their spatial interrelationships can be determined and used in computer based risk assessment models. This assessment can be used by insurance companies to help them make decisions on their insurance policy rates, by land developers to make decisions on the feasibility of project sites, and by government planners for better disaster preparedness.

GIS plays a critical role also within the defence community, for instance in Defence mapping organizations, Base operations and facility management, Force protection and security, Environmental security and resource management, Intelligence, surveillance, and reconnaissance systems, Logistics, Mine clearance and mapping, Mission Planning, Peacekeeping operations, Terrain analysis, Visualization, Chemical, biological, radiological, nuclear, and high explosive incident planning and response.

The ‘reference’ of the Geographic Information (GI) user is generally more closely related to the real world.

It includes concrete themes, such as infrastructure – roads, railways, power-lines, settlements, etc, or physical features – terrain elevation, hydrography, etc. It includes also less tangible features that have nonetheless a significant role in human life: administrative boundaries, cadastral parcels, gazetteer, postal addresses, etc. All these features are keys that allow one to relate, to ‘refer’, external information to the real world, through the media of its GI representation. Therefore they may be considered as comprising a reference for the GI user -- the ‘reference data’.

The continued advances in remote sensing, mapping and geospatial technologies, including an increasing variety of data acquisition capabilities and low cost and more powerful computing capacity, coupled with the development of geographic information system technology, have enabled and increased the demand for geographic information.

As the importance of geographic information in addressing complex social, environmental, and economic issues facing communities around the globe is growing, the establishment of a Spatial Data Infrastructure to support the sharing and use of this data locally, nationally and transnationally makes increasing sense.

Trying to identify all possible exposures of all possible threat events across all critical components and forecasting all possible consequences is an impossible task.

The experience accumulated in the past few years suggests that having the right information, in the right format, at the right time in the hands of the right people significantly reduces the consequences of disasters and accelerates the recovery process

The set of Critical Infrastructures can be subdivided into individual infrastructural sectors, such as telecommunications or energy. These sectors can then be subdivided in turn, for example into industries (for example, in the case of transport, into aviation, shipping, road transport and rail transport), and into services (this breakdown is appropriate in, amongst other areas, telecommunications, or, quite generally, into products).

To be effective, risk assessment and management must continue to evolve from purely regulatory and scientific applications to techniques that capture and incorporate non-scientific, values-laden information in a quantitative manner.

In the field of Critical Infrastructure Protection GIS provides functionality to accurately determine the physical location of critical assets as well as identify and model potential risks and vulnerabilities associated with natural or man-made disasters.

GIS can generate models that predict the effects of damage or loss of a critical infrastructure on the continuity of various operations. For example, the user can create a GIS model to show

how the loss or damage of an electrical substation would affect other facilities dependent on that station for electricity.

Understanding the geographic relationship between vulnerabilities and potential risks or threats enables authorities to develop mitigation and protection strategies and plans such as expanding security buffer zones around vital areas or strategically deploying resources for increased protection

5. GIS - based decision supporting projects

5.1 The ECI GIS project

Project description

As mentioned in the previous paragraph, according to the proposal for a Directive COM(2006) 787, once approved, Member States will be obliged to identify the European Critical Infrastructures within their jurisdiction and to transmit a series of information associated to them to the European Commission.

In order to organize these transmission procedures in a rational and efficient manner, Member States could have the possibility to give the information required by the Directive, using a WEB GIS platform. This means that Member States' operator, instead of sending the documents via mail, increasing the amount and consume of paper and forcing the Commission to use other operators to entry the data, could simply accede to a specific web site and fill directly the information required, which will be automatically stored in a central database.

So, Member States operator would only have to recognize the ECI of its competence on the basis of a given map service, appositely created for this purpose, in a restricted web site.

ECI GIS project aims to show how could be easily achievable to create a similar instrument, using the most efficient GIS tools, adopting all the required security measures.

Prototype 2007 - working phases

A prototype of ECI GIS project has been developed using ArcGIS Server software, previously described. This product is available only in a restricted area within the SERAC Unit of IPSC, inside the JRC Ispra. Once the system will be implemented also outside the JRC, the license requirements related to the background database should be verified and planned again.

The main steps of the ECI GIS project development are the following:

- *Realization of the basic Spatial Data Infrastructure*

In order to create the background maps and dataset upon which locating the information related to ECI, a survey of existing and already available maps and database, consistent with the reference scale of representation has been done and, consequently, a Spatial Data Infrastructure related to ECI has been created.

In the prototype phase (internal use) the following maps have been used:

Basic maps

Satellite imagery (Landsat mosaic), Euroglobal Map. High resolution satellite imagery (IKONOS) could be acquired for specific analysis.

Thematic maps

GISCO database – GISCO is the Geographic Information System for the European Commission. Originally conceived as a prototype GIS cell that would serve a wide spectrum of users and uses, the GISCO project has developed a service-oriented dimension, namely in geographical database development, thematic mapping, desktop mapping and dissemination of data. Providing these types of services is directly related to key parts of the GISCO mandate.

ECI GIS project is mostly interested in the NUTS codes (Nomenclature of Territorial Units for statistics). The Nomenclature of Territorial Units for Statistics (NUTS) was established by Eurostat more than 25 years ago in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union. The NUTS is a three-level hierarchical classification. Since this is a hierarchical classification, the NUTS subdivides each Member State into a whole number of NUTS 1 regions, each of which is in turn subdivided into a whole number of NUTS 2 regions and so on.

At the regional level (without taking the municipalities into account), the administrative structure of the Member States generally comprises two main regional levels (Länder and Kreise in Germany, régions and départements in France, Comunidades autonomas and provincias in Spain, regioni and province in Italy, etc.). At a more detailed level, there are the districts and municipalities. These are called "Local Administrative Units" (LAU) and are not subject of the NUTS Regulation.

Teleatlas - **MultiNet** has the broadest coverage and highest accuracy of any map data-base in the world. Coverage in Europe amounts to 7.6 million mapped kilometers of roads with classifications and numbers, intersections and junctions, traffic flows and restrictions. Added features include street names and house numbers for millions of individual addresses and information on millions of points of interest (POIs).

Platts is a provider of energy information around the world that has been in business in various forms for more than a century and is now a division of *The McGraw-Hill Companies*. Products include Platts Energy Economist, industry news and price benchmarks for the oil, natural gas, electricity, nuclear power, coal, petrochemical and metals markets. ECI GIS project will use data related to the European Electric Network: Generating Stations, Substations, Cross border sections, Transmission lines.

UCTE (**Union for the Co-ordination and Transmission of Electricity**) **data and publication –** consumption and production data, annual statistics at national or regional level; specific data related to cross border sections.

EUROSTAT tables – All sort of statistical data at every NUTS level, such as: general and regional statistics, population and social conditions, industry, trade and services, agriculture, forestry and fisheries, transport, environment and energy.

- *Planning data architecture – INSPIRE (Infrastructure for Spatial Information in the European Community) DIRECTIVE AND PRINCIPLES*

What is INSPIRE?

INSPIRE stands for "Infrastructure for Spatial Information in Europe". It is a Directive of the European Parliament and the Council, aiming to assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment. INSPIRE is based on the infrastructures for spatial information that are created by the Member States and that are made compatible with common implementing rules, supplemented with measures at Community level.

INSPIRE Principles

The key principles of INSPIRE are:

- that 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 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
- that spatial data needed for good governance should be available at conditions that are not restricting its extensive use,
- that it should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use.

What will INSPIRE do?

The Directive will improve the accessibility and interoperability of spatial data by laying down general rules applying to data and services held by or on behalf of public authorities and by private operators who choose to make their data available through the INSPIRE infrastructure. Spatial data and services will be accompanied by "metadata" making it easier to search them and assess their quality and potential use.

Detailed technical rules are under development for a wide range for spatial data themes in order to make it easier for different data sets to be combined. This involves standardisation of formats and nomenclatures so that the data sets can be combined seamlessly and without manual intervention, which greatly increases the range of uses that can be made of the data. Subject to certain exceptions, public authorities participating in the infrastructure will have to make their data publicly available and share it with other authorities.

Why INSPIRE? The need for the INSPIRE initiative

The general situation on spatial information in Europe is one of fragmentation of datasets and sources, gaps in availability, lack of harmonization between datasets at different geographical scales and duplication of information collection. These problems make it difficult to identify, access and use data that is available.

Fortunately, awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts

The INSPIRE initiative is therefore timely and relevant but also a major challenge given the general situation outlined above and the many stakeholder interests to be addressed.

INSPIRE is complementary to related policy initiatives, such as the Commission proposal for a Directive on the re-use and commercial exploitation of Public Sector Information.

The INSPIRE Concept

The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. The target users of INSPIRE include policy-makers, planners and managers at European, national and local level and the citizens and their organizations. Possible services are the visualization of information layers, overlay of information from different sources, spatial and temporal analysis, etc.

INSPIRE lays down the legal framework for the establishment and operation of an Infrastructure for Spatial Information in Europe. The purpose of such an infrastructure is to assist policy-making in relation to policies 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 are designed to ensure that spatial data are stored, made available and maintained at the most appropriate level; that it is possible to combine spatial data from different sources across the Community in a consistent way and share them between several users and applications; that it is possible for spatial data collected at one level of public authority to be shared between other public authorities; that spatial data are made available under conditions which do not unduly restrict their extensive use; that it is easy to discover available spatial data, to evaluate their suitability for the purpose and to know the conditions applicable to their use.

For these reasons, the Directive focuses in particular on five key areas: metadata, the interoperability and harmonisation of spatial data and services for selected themes (as described in Annexes I, II, III of the Directive); network services and technologies; measures on sharing spatial data and services; coordination and monitoring measures.

The Directive identifies what needs to be achieved, and Member States have two years following the date of entry into force of this Directive to bring into force national legislation, regulations, and administrative procedures that define how the agreed objectives will be met taking into account the specific situation of each Member State.

INSPIRE Community Geoportal

The INSPIRE Community Geoportal is Europe's Internet access point to a collection of geographic data and services within the framework of the infrastructure for Spatial Information in Europe (INSPIRE) Directive.

INSPIRE aims at making available relevant, harmonised and quality geographic information to support formulation, implementation, monitoring and evaluation of policies and activities which have a direct or indirect impact on the environment.

The geoportal does not store or maintain the data. It acts as a gateway to geographic data and services, distributed around Europe, allowing users to search, view or, subject to access restrictions, download geographic data or use available services to derive information (Figure 3).

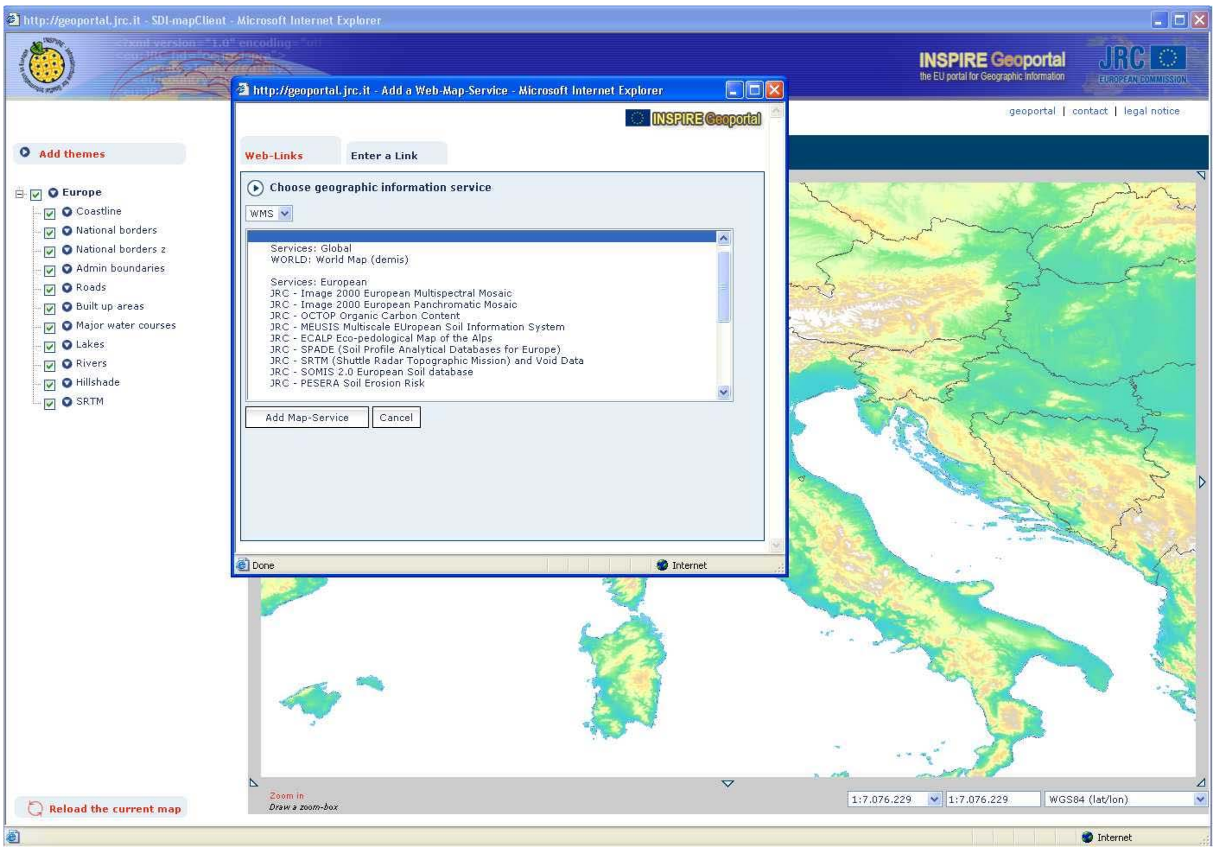

Fig. 3: The INSPIRE Geoportal, the EU portal for Geographic Information.

Since the aim of European Geoportal is to represent an access point for European map services, the integration of ECI GIS will represent a way for ECI GIS to have a certain visibility, even in its prototype steps.

- ***Choice of Web GIS technology***

ArcGIS Server Technology

After having analyzed the technologies already available at JRC, the choice of the appropriate one in order to develop the ECI GIS project, went to ArcGIS Sever (ESRI).

ArcGIS Server is a complete and integrated server-based geographic information system (GIS), coming with out-of-the-box, end user applications and services for spatial data management, visualization, and spatial analysis.

ArcGIS Server offers open access to extensive GIS capabilities that enable organizations to publish and share geographic data, maps, analyses, models, and more. With the ArcGIS Server rich standards-based platform, centrally managed, high-performance GIS applications and services can be accessed using browser-based, desktop, or mobile clients.

ArcGIS Server offers the following advantages:

• Browser-based access to GIS makes applications readily available both internally and externally. ArcGIS Server comes with browser-based Web applications for viewing and editing.

• Lower cost of ownership through centrally managed, focused GIS applications that are

easy to use and can scale to support many users. Centrally managed data, models, tools, maps, and applications can be created once and reused, leading to greater organizational efficiency.

• Integration with other enterprise systems such as customer relationship management (CRM) or enterprise resource planning (ERP) systems using industry-standard software.

As a result, the organization can gain new value from existing information, which, in turn, improves the decision-making process and increases return on investment.

• Support for interoperability standards in both the GIS domain as well as the broader information technology (IT) domain.

Supported standards include ISO, ANSI, and Open Geospatial Consortium, Inc.

• Ability to create custom applications and services for browser, desktop, mobile, Smart Client, and enterprise deployments using .NET or Java™.

ArcGIS Server offers server-based analysis and geoprocessing. This includes vector, raster, 3D, and network analytics; models, scripts, and tools; desktop authoring; and synchronous processing. ArcGIS Server includes both workgroup- and enterprise-level geodata management based on the ArcGIS geodatabase model. Geodata services allow administrators to publish geographic data for extraction, checkout/check-in, and replication.

ArcGIS Server offers Web mapping services that support 2D dynamic and cached maps as well as 3D globes. GIS analysts can configure rich browser-based Web mapping applications that consume these services with point-and-click ease.

ArcGIS Server is an open, flexible, and scalable technology that runs on industry-standard IT infrastructure and supports geospatial service-oriented architecture (SOA) initiatives. ArcGIS Desktop software complements ArcGIS Server by acting as a means of authoring, configuring, and maintaining data, models, and applications. This authored content can be published via ArcGIS Server, which provides the technology foundation for organizations to build and implement GIS-based Web services. With the addition of an integration platform, GIS services, such as mapping, geocoding, geoprocessing, and data management, can be fused with other shared services of complementary enterprise systems (e.g., CRM or ERP). Because ArcGIS Server supports industry standards, these services can be consumed by a variety of client applications, workflows, and processes to provide a more complete business picture (Figure 4).

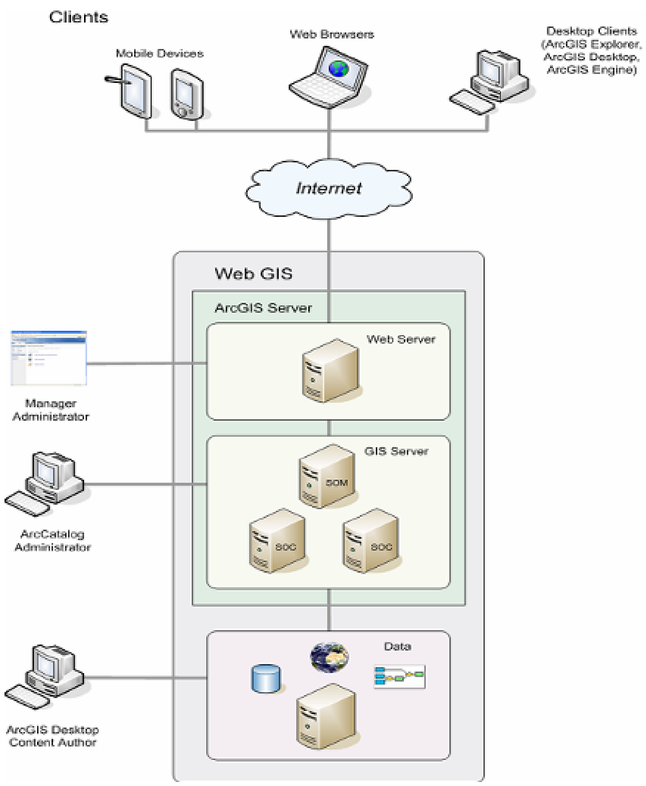

Fig. 4: The ArcGIS Server system architecture.

Overview of ArcGIS Architecture

An ArcGIS Server system may consist of the following components:

GIS server:

The GIS server hosts the GIS resources, such as maps, globes, and address locators, and exposes them as services to client applications. The GIS server is composed of two distinct parts: the server object manager and the server object container (SOC). The SOM manages the services running on the server. When a client application requests the use of a particular service, the SOM assigns the request to an available server object. There is only one SOM per GIS server. The SOM connects to one or more SOCs. The SOC machines—also referred to as container machines—contain, or host, the services that the SOM manages.

Web server:

The Web server hosts Web applications and Web services that use the resources running on the GIS server. Interfaces for clients include:

Web Service End Point—SOAP/HTTP Web service access;

Tile Handler Interface—Allows clients to directly access cache files stored in a Web server virtual directory;

Web Application Development Framework—Out-of-the-box Web mapping application functionality.

Clients:

Client applications are Web, mobile, and desktop applications that connect over HTTP to ArcGIS Server Web services or ArcGIS Server local services over a LAN or WAN.

Data server:

The data server contains the GIS resources that have been published as services on the GIS server. These resources can be map documents, address locators, globe documents, geodatabases, and toolboxes.

Manager and ArcCatalog administrators:

- ArcGIS Server administrators can use either Server Manager or ArcCatalog to publish their GIS resources as services.
- Server Manager is a Web application that supports publishing services, administering the GIS server, creating Web applications, and publishing ArcGIS Explorer maps on the server.
- ArcCatalog includes a GIS server node that can be used to add connections to GIS servers for either general server usage or administration of a server's properties and services.

ArcGIS Desktop content authors:

- To author the GIS resources, such as maps, geoprocessing tools, and globes, that will be published to the server, it will be necessary to use ArcGIS Desktop applications such as ArcMap, ArcCatalog, and ArcGlobe. Additionally, in order to create 2D map or 3D globe caches to increase rendering performance, it will be necessary to use ArcCatalog to create the cache.

- **Realization of a prototype and creation of a mock-up for a case study**

A prototype application of the system has been realized using ArcGIS Server 9.2 and, at the moment, is available in a restricted area inside JRC network.

The realization of the mock up aims at showing not only the usefulness and the potentiality of the entire system, but also identifying other requirements and gaps that could be fulfilled in the final version.

With the purpose of giving a better idea of the definitive product, a case study infrastructure, together with a specific related dataset, has been identified in order to simulate the functioning of the entire system.

This prototype has been developed using GIS technologies and maps already available at JRC and it simulates the implementation and the functioning of the real system.

The general idea is that each member state's/infrastructure operator representative will insert the dataset related to its own ECI/system, including the position and all other information defined according to the Directive, once approved (Figure 5).

The system so created will permit the managing of all ECI-GIS data in an integrated and rational way, fostering the possibility of making spatial elaborations.

So, the main steps are:

1. identification of the basic <u>background</u> maps:

GISCO: NUTS code for administrative boundary

EUROGLOBAL MAP: geographic and territorial information

2. creation of a specific geodatabase SDE based upon maps and dataset <u>to be edited by the user</u>:

PLATTS (energy infrastructures): cross border lines and substations.

Definition of the attribute table to be edited in the web application.

3. creation of the web application on the basis of an ArcGIS Desktop map, defining SEARCH and EDITING tools.

The final result is that each MS operator, when filling the form created in the web site ECIGIS related to the ECI of its competence, will also fill and complete the central database which manage all the information entered in the system.

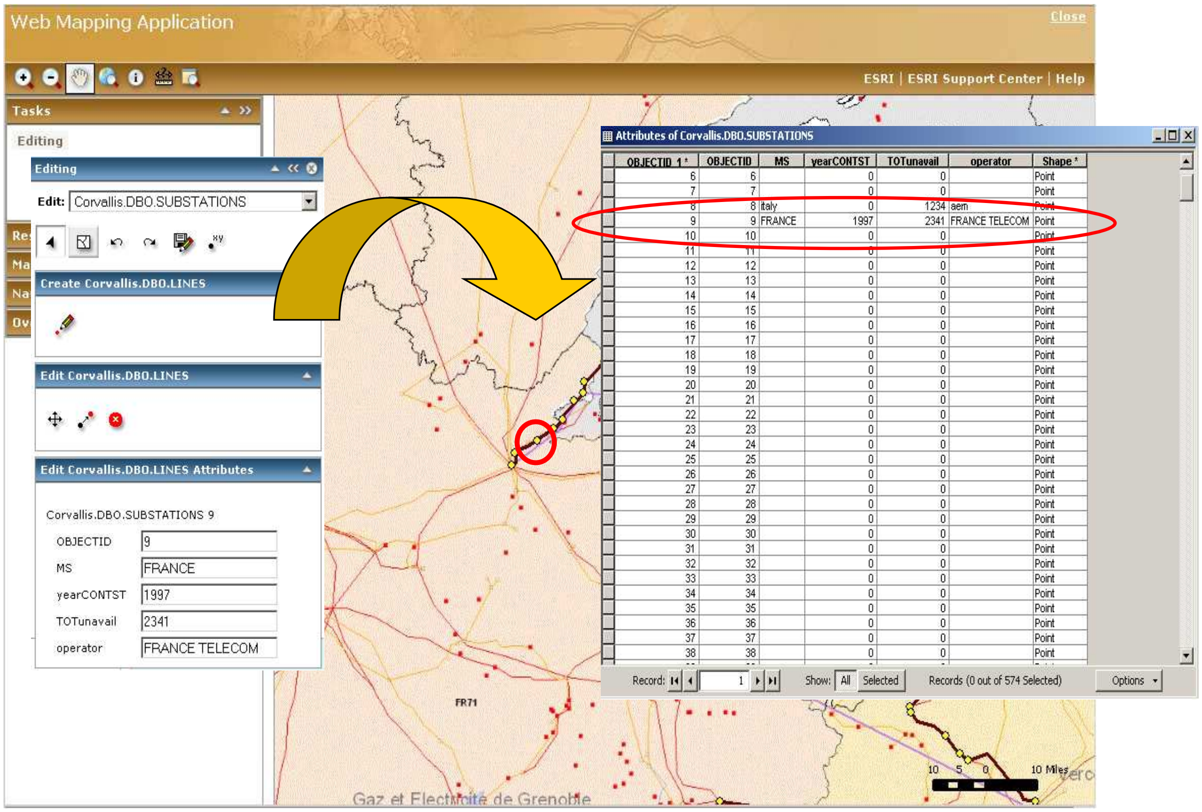

Fig. 5: Realization of a ECI-GIS prototype system using the electrical network as case study-infrastructure, with the aim to simulate the implementation (data entry, validation, update) and the functioning of the system.

Future Developments

As already mentioned, the objective for 2007 is to start with the realization of a prototype of ECI-GIS, consisting of a web application, based upon map services created using the spatial data infrastructure already described. This prototype will be available in a restricted area, among IPSC Institute of JRC.

The prototype has been developed using ArcGIS Server technology, as illustrated in the previous paragraphs, using the electric network as case study infrastructure.

Starting from 2008 the ECI GIS will be implemented, improved and detailed. It will incorporate other basic maps, which will be used as a support for SEARCH TOOLS. Moreover, it will include the spatial representation of mathematic models for security-related analysis (i.e. interdependencies, vulnerability.) of ECI, and other complex elaborations (e.g. what if scenarios, decision support). For these purposes the system will define realistic case studies and will require relevant data.

Once identified the cartographic basis, the structure scheme and the dataset associated to ECI, the entire production process will be defined, including the data entry modalities, the validation and the updating procedures.

Moreover the system will be tested also outside the JRC, in collaboration with a specific Institution or Authority interested in implementing the above mentioned procedures in advance.

5.2 The MEDI project (Mapping the European Defence Industry)

Defence related products are considered “materials and products of a potentially hazardous nature that are required to produce important economic goods and also to protect our state”. They are a fundamental component of the hazardous materials infrastructure. It is therefore of critical importance that these goods and materials are not only protected against misuse but also that they can be used in a controlled manner as well. This includes the transportation of these goods and materials to the places where they are used, processed or held in depots.

Considering the global US approach of Defence Critical Infrastructure Protection: Through a deliberative process we first answer the question “What is critical?”...followed by “Is it vulnerable?”...then finally “What can be done about it? The “critical” designation is directly tied to the mission that asset supports coupled with the time and scenario the asset is utilized. DCI can be viewed in three different categories; those owned by Department of Defence (DoD), those influenced by DoD and those of interest to DoD. Protection responsibilities for those assets owned by DoD (i.e. military facilities) clearly fall upon DoD and more specifically the installation commander. Defence Critical Infrastructure is composed of functional sectors that provide the operational and technical capabilities essential to mobilize, deploy, and sustain military operations in peacetime and war.

MEDI stands for Mapping of the European Defence Industry and has as its prime objective to develop a better understanding of the European defence-related industries in terms of their economic strengths, their technical and technological capabilities and their overall competitiveness.

Given the Community’s task of ensuring the conditions for competitiveness of industry (Art. 130 TEC), the Union would need access to the relevant data concerning the different industrial sectors and, more specifically in the context of COM(2003) 113 Final, to the relevant data concerning defence-related industry in order to allow benchmarking and to contribute to the development of relevant policies in the sector.

MEDI collects and collates data in three different fields:

• Economic data:

MEDI measures the economic importance of the defence-related industry through the collection of raw economic and financial data, such as turnover, number of employees, exports, etc. and assesses these data to draw conclusions on the competitiveness of the European defence-related industry on the global market.

• Technical and technological data:

MEDI addresses the need to understand the importance of the defence-related industry in terms of its overall technical and industrial competences. This qualitative analysis will map the overall competences of the European defence-related industry in order to draw conclusions on the strengths and weaknesses, national champions and European centres of excellence, and gaps where strong research investment is required, etc.

• Defence budgets data:

MEDI covers the analysis of the national defence budgets. The end of the Cold War has led to a decrease in defence budgets and to a reorientation of military priorities and related requirements. The objective of the budgetary data collection is to analyse these changing defence budgets and their related priorities.

MEDI makes maximum use of data that are publicly available. Some data are available through publications, reports, national analyses and assessments, etc. MEDI analyses these available data and eventually complements them by targeted questionnaires and direct requests for information to achieve a homogeneous and comparable set for consolidation.

In order to maximise the output of the different types of data and to build on relevant existing on-going national and international analyses, a data collection network was set up of national and international data collection institutes and organizations.

In order to harmonise and consolidate the data and allow analysis of specific topics of the Defence Technological and Industrial Base (DTIB), MEDI structures the data in a comprehensive database. The approach to this task is pragmatic, relying on best practices and taking account of relevant ongoing or recent activities.

For the strengthening of its CFSP (Common Foreign and Security Policy) competences, structures and infrastructures, Europe can rely on strong in-house technological and industrial competences. These competences are covering a very wide range of research, technology, development, manufacturing and service expertise, including very specific detailed areas, such as biotechnology and biosensors as well as very generic domains, such as technology and systems integration, interoperable communications, C4ISR, etc. In addition, the technological and industrial landscape displays a large variety and geometry, covering SMEs as well as large multi-nationals, basic research in technical universities as well as in service support companies, regional/national expertise as well as more established integrated European networks of excellence, etc. The objective of the technical and technological data collection is to map the competences of the European DTIB, covering all relevant technology, system and service areas, all types of technical and industrial players and all European Union Member States. Such a mapping will allow the identification of the strengths and weaknesses of the DTIB and will support the policy makers in defining the research, technology and development priorities for the EU, strengthening its technological capacity, and developing new competences where deemed necessary for the CFSP interests of the EU and the Member States.

In order to achieve such a competence mapping, the MEDI project has used the SeNTRE technology taxonomy as a basis for the structuring of the core technological and industrial capabilities. The MEDI team has updated the structure whilst analysing the company details. The SeNTRE taxonomy has been developed in the context of the PASR-2004 Supporting Activity SeNTRE and builds on the UK and WEAG technology taxonomies.
All companies are featured according to their specific technological competences. In addition, the MEDI project uses a product codification to structure the company outputs at the level of product categories rather than detailed specific technologies.

Such a codification enables specific reporting, tailored to specific product categories, such as communications, sensor technology, air platforms, etc. This product codification builds on the Common Military List of the EU (Equipment covered by the European Union Code of Conduct on Arms Export).

Within this context GIS (Geographic Information System) tools allow to integrate, at European level, economic and technological data with geographic information's into the European geographic standard GISCO.

Furthermore a GIS pilot project of the defence related industries of the Letter of Intent (LoI) countries that represent 90% of the technological and industrial competences of defence in Europe has been established (Figure 6).

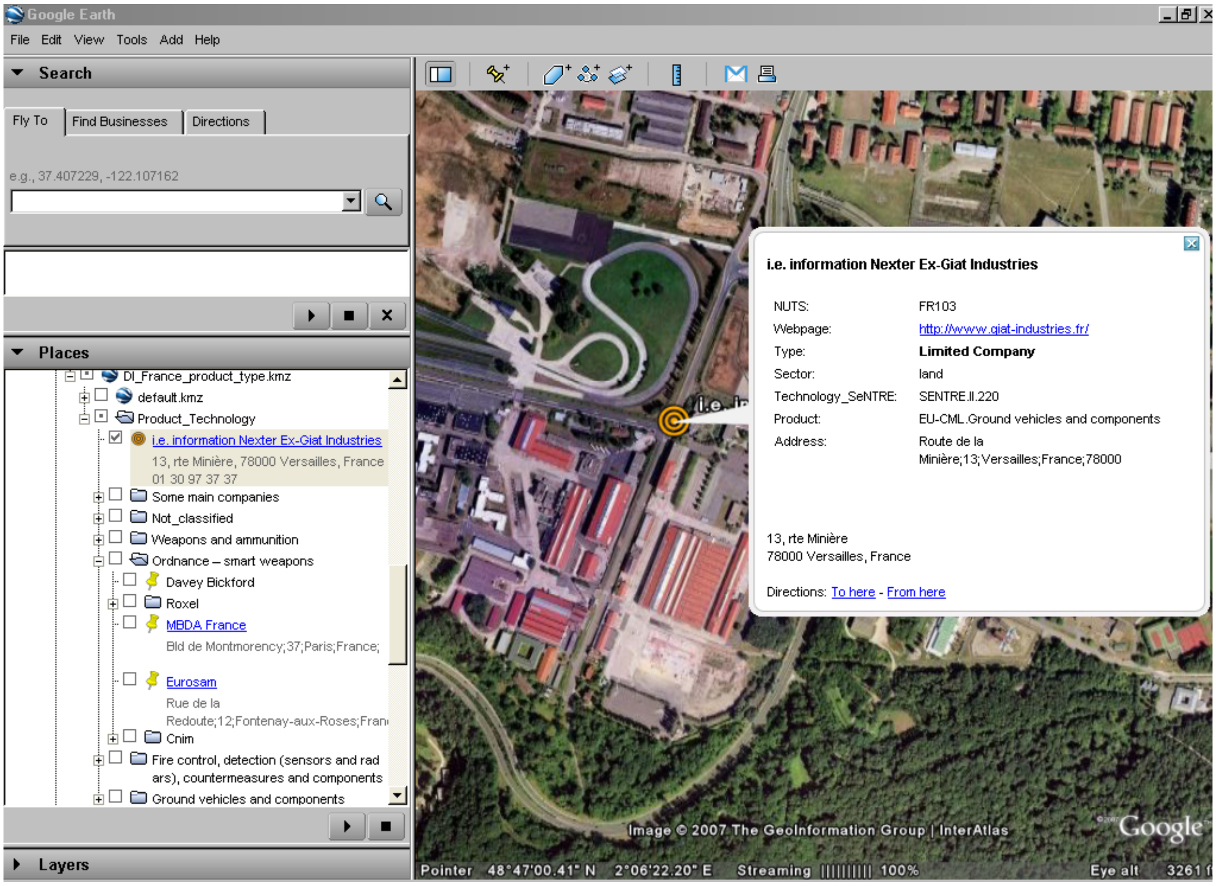

Fig. 6: Database of defense industries in the 5 LoI countries (France, Germany, Italy, Sweden, United Kingdom) using Google Earth, the query returns a French company and its geographical location with information on the technologies.

5.3 Pilot project: SDI for Risk Analysis

The spatial data infrastructure support to risk analysis pilot project has as its prime objective to develop a better understanding of the risks and vulnerabilities a critical infrastructure (CI) could be exposed (Figure 8).

A first approach will be to get at international, EU, national or even regional level a better overview of the security policies and legislations that cover this challenge (see the proposal for a Directive COM(2006) 787.

Furthermore a specific CI type (i.e. Electric power plant) has been used to demonstrate the eventual circumstances. All available information's (administrative, geographic, territorial data) of the CI are collected and saved in a local geodatabase.

- Administrative/technical dataset:

  Name/owner/year of construction, surface, number employees, production type, extension, web- site, contact person, address, etc (Figure 7).
- Geographical dataset:

  Geographic coordinates/country/region/province/elevation.
- Territorial dataset:

  Urbanisation/geo location (coastal, rural, airports, roads and railroads, water bodies and populated places, transport infrastructure, drainage, main cities, populated places, inland waters, forests vicinity, etc.)

  A territorial analysis of the possible hazards, natural disasters, risks (active and/or passive), potential threats, constraints and necessaries countermeasures are revealed and have to be combined with the characteristics of the CI.

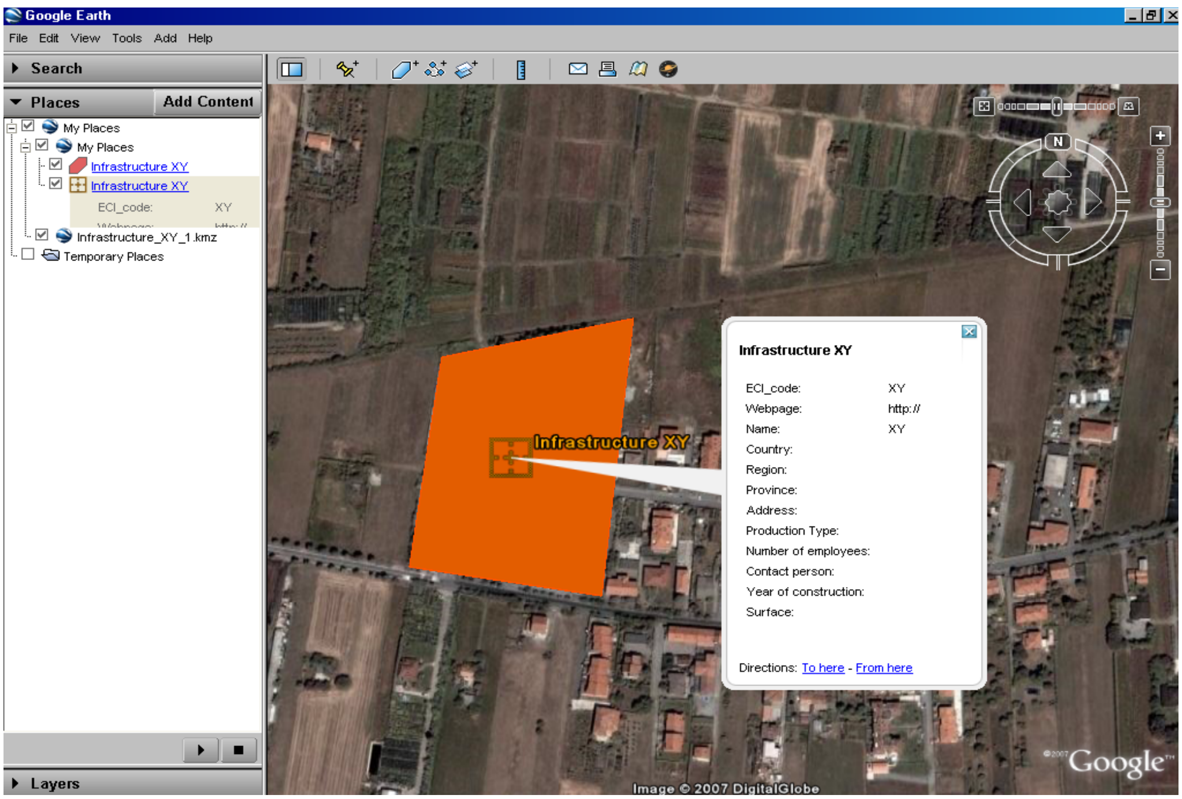

Fig. 7: Example of the Critical Infrastructure dataset of a fictive XY installation with the related information's using the Google Earth tool.

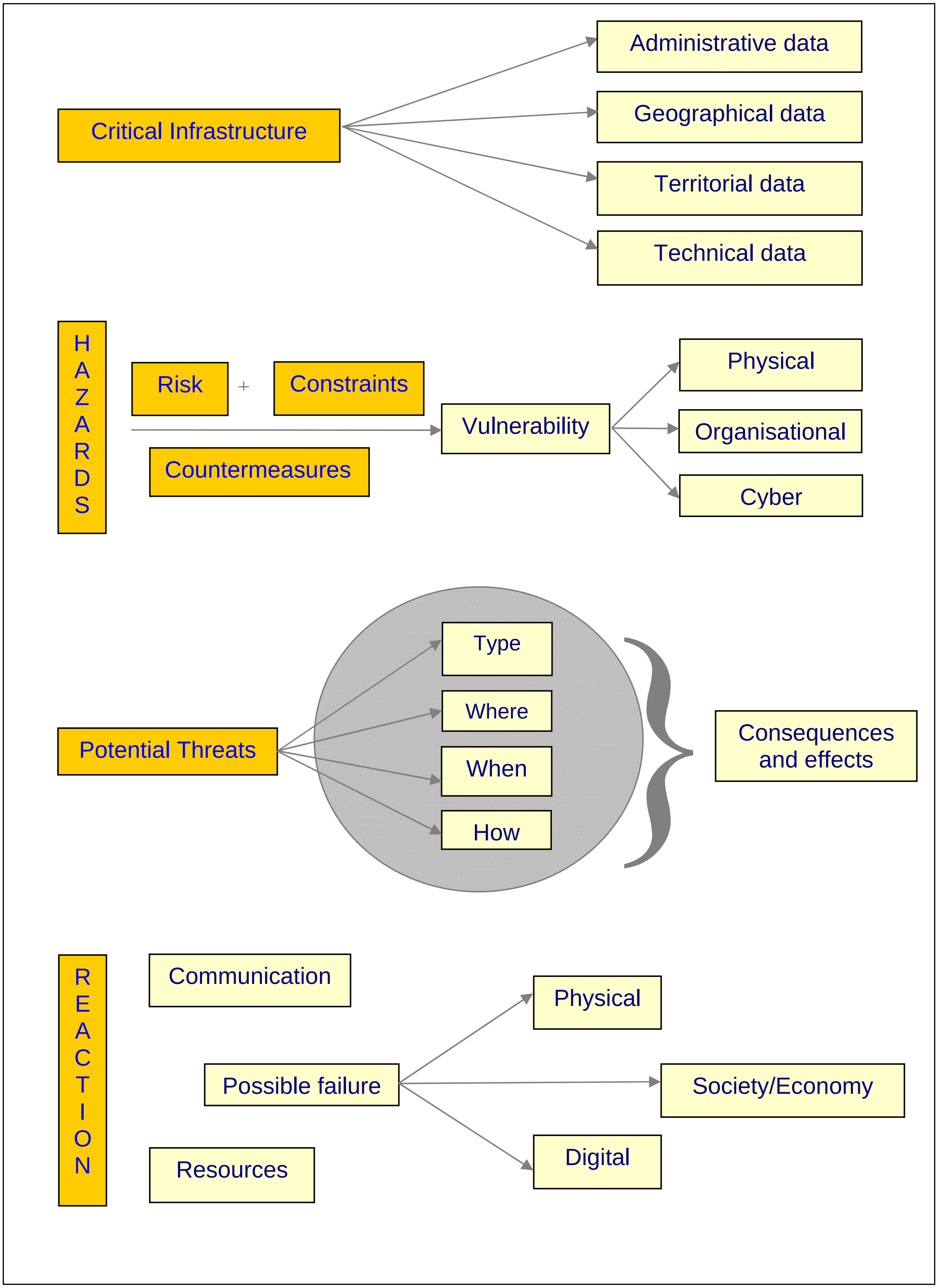

Fig. 8: Risks and vulnerabilities a critical infrastructure (CI) could be exposed.

What is a European Critical Infrastructure? A proposal for the European Commission

As already described in the previous paragraphs, the proposal for the Directive COM(2006) 787 will provide for a definition of ECI. At the moment the only definition mentioned in the document is that a ECI is a critical infrastructure which involves two or more MS.

In order to find a more detailed definition which not only could be useful for Member States to identify the ECI under its competence but also could be presented as an official proposal to the Commission, the project will create a methodology, based on a system of attributing score, for the

characterization of the meaning of European Critical Infrastructure.

The information and the database already described could be applied to the Electric Network, chosen as case study infrastructure, with the aim of creating a ‘classification of criticism’ connected to transmission lines, substations and plants.

The purpose is to identify the ‘crucial’ elements, that if subjected to an accident or a dysfunction will create more problems than other element, and for this reason, should be considered as 'Critical'.

The basic idea is that the European level of a critical infrastructure is a result of a combination of three main factors:

- Territorial Analysis
- Technical Component
- Socio-Economic Evaluation

Territorial Analysis

The territorial analysis could be surely realised in raison of the great availability of specific database at a detailed scale.

The principle is that the position of an infrastructure among the territory influences its criticality. In fact, an infrastructure located in a urbanised area could be more critical than another in an isolated area. In the same way an infrastructure located near a sensible (school, hospital,...) element is more critical. To all these aspect should be given a score. The higher the score, the higher the criticality.

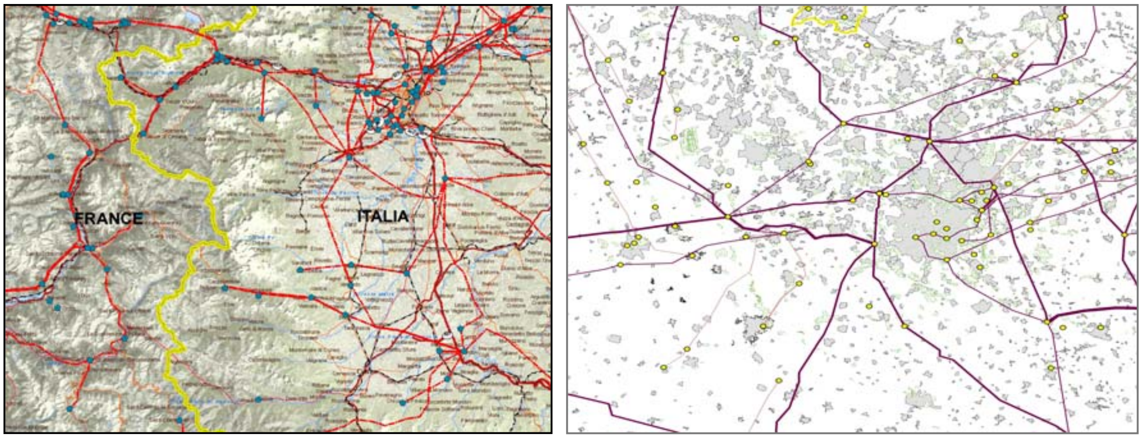

Fig. 9: Territorial analysis: all the spatial elements in the available database should be considered Technical Component.

Under a technical point of view, the criticality of an infrastructure could be determined by its position within the network. So a cross border line or substation (involving two MS) or a substation directly connected to a plant, should be considered more critical. In the same way, the higher the score, the higher the criticality.

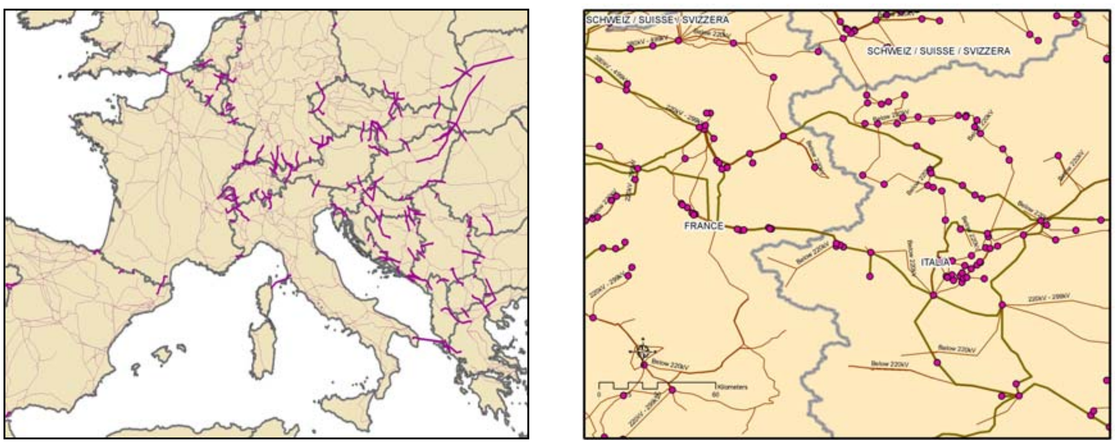

Fig. 10: Technical component: PLATTS database - EU cross border lines and electric network.

Not only the position within the network is an important aspect, also its reliability should be considered.

Using, for instance, UCTE data, it is possible to build a map of the major loss of power, in order to establish which infrastructure had the most relevant problems related to its functionality. This is another element for determining the criticality.

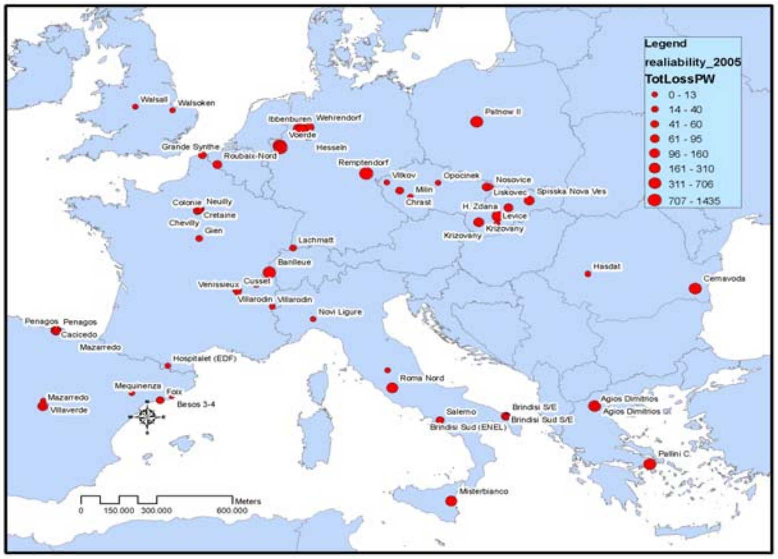

Fig. 11: Technical component: UCTE - Total Loss of Power 2005.

Here is another representation related to the functioning of the network, showing the total unavailability of the Italian cross border lines.

This elaboration has been obtained joining UCTE and Platts database: each line represents the total time of unavailability (reasons: maintenance, repair, weather, natural disaster..), giving an idea of the more critical situations (on the basis of the general functioning during the whole year), to keep under constant monitoring.

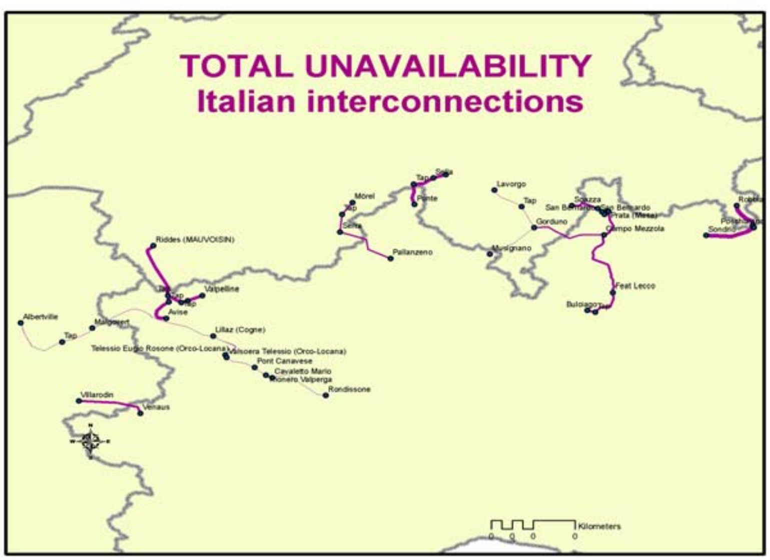

Fig. 12: Technical component: UCTE data Total unavailability values.

So, all these data could be combined in order to obtain a value which gives an idea of the ECI functionality.

Socio-Economic Evaluation

The last component to be considered is the social and economic impact of a possible disfunctioning occurring to an infrastructure. An accident to an infrastructure involving a great number of users or causing great economic loss is to take into account.

To establish that an infrastructure is critical at a European level means give attention to that infrastructure, also in terms of economic resources.

This final component ‘filters’ the previous ones and its meaning is that an investment on that infrastructure protection must be worthy also under a social point of view.

6. Conclusions

Infrastructures are critical because they provide services that are vital to one or more broad governmental or societal functions or attributes. They are systems and assets, both physical and cyber, so vital to society that their impairment or destruction would have a debilitating impact on national security, and/or national public health and safety.

Critical infrastructures are endangered. This is no different today than in earlier times. What has changed, however, is the type of threat as well as its relevance. Interruptions and shutdowns occurred rarely in the past. As a result of the limited extent of networking and limited interdependencies, there was only little consequential damage.

National borderlines and classical means of protection have, for the most part, become irrelevant. IT-related threats may originate anywhere in the world and affect our critical, national infrastructures.

There are several risk categories: i.e. force majeure, organisational deficiencies, human error, technical failure, deliberate acts

The security and economy of the European Union as well as the well-being of its citizens depends on certain infrastructure and the services they provide. The destruction or disruption of infrastructure providing key services could entail the loss of lives, the loss of property, a collapse of public confidence and moral in the EU.

The European Program for Critical Infrastructure Protection (EPCIP) has been requested and promoted by the European Council, in order to counteract potential vulnerabilities.

In general, even if it is clear that the protection of critical infrastructures is first and foremost a national responsibility, all stakeholders acknowledge that due to interdependencies and the general nature of today's economy, there exists in the EU a certain number of critical infrastructures which if disrupted or destroyed would have a serious impact on the entire Community or on a number of Member States.

As part of the EPCIP framework dealing specifically with European Critical Infrastructures, a proposal for a Directive of the Council on *the identification and designation of European Critical Infrastructure and the assessment of the need to improve their protection* plays an important role.

Yet it is clear that risk assessments have an important spatial component. One challenge for the effective spatial presentation of risk is the juxtaposition of multiple variables within a recognizable spatial context. The same multidimensionality that is difficult to present can, when couched in the right spatial context, effectively communicate nuances about the risk evaluation process and lead to insights for making decisions.

A Geographic Information System (GIS) is mapping software that provides spatial information by linking locations with information about that location. It provides the functions and tools needed to efficiently capture, store, manipulate, analyse, and display the information about places and things.

GIS is a very important tool for the policy maker. It can show as little or as much detail as needed in a form most people can understand. With its ability to be easily understood, GIS enables policy makers to take the information to the public. This allows the public the opportunity not only to understand what is going on, but enables the public to be able to offer informed feedback, which is as important to the policy politician as it is to the policy analyst.

When GIS data and functionality are made available over the Internet, the system is referred to as a "Web GIS". With Web GIS, users do not need to purchase and install expensive GIS software in order to access and work with maps and databases.

Spatial data, spatial technologies and spatial models are needed to understand and respond to any disaster.

A GIS based risk analysis procedure, can be synthesized by the following steps: Planning, Mitigation, Preparedness, Response and Recovery.

The value of building data warehouses for each community as well as obtaining permissions and access to invaluable proprietary data sets cannot be stressed enough.

Gathering data to create a GIS to meet potential emergencies requires an immediate and concentrated effort. It is far easier to accomplish this task before an attack or emergency than in its aftermath.

GIS can deliver not only data on hazards in the region information on building, lifelines, and critical facilities, but can also contain built in risk assessment programmes that allow the planner to simulate disaster scenarios and graphically view the potential damages and affected areas as well as plan rescue operations.

Fortunately, awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts. The INSPIRE initiative is therefore timely and relevant but also a major challenge given the general situation outlined above and the many stakeholder interests to be addressed.

The SERAC Unit of the JRC acts in several EU-GIS - based decision supporting projects.

The ECI GIS project, MEDI and the spatial data infrastructure support to risk analysis.

Having the right information, in the right format, at the right time in the hands of the right people significantly reduces the consequences of disasters and accelerates the recovery process.

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Abstract

This report presents projects developed by the Unit IPSC/SERAC regarding the use of Geographic Information Systems (GIS) for supporting the study of critical infrastructures and the security/defence industry. It also discusses how risk assessment can benefit from geographical representations. Risk assessments have an important spatial component and GIS can be central to risk identification, quantification, and evaluation. Furthermore it presents a wide-ranging description of different GIS techniques and web-technologies, and its potential application to supporting the European Program for Critical Infrastructure Protection, and the mapping of the European Defence Industry.

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