European Spatial Data Research

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From OEEPE to EuroSDR: 50 years of European Spatial Data Research and beyond

Seminar of Honour

by Christian Heipke, Risto Kuittinen, and Günter Nagel (Eds.)

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(06100) ANKARA

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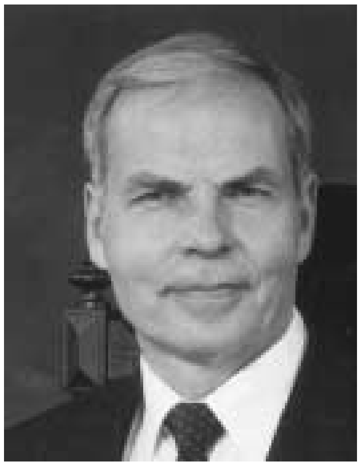
FOREWORD



In the late 1940's and early 1950's economic co-operation begun in Europe, with the aim of speeding up the development of industry and improving the welfare of people. At the same time, throughout Europe, there occurred an acceleration in the general migration of people from rural to urban locations, causing problems in planning residential development. For this reason new maps were urgently needed, since without maps no planning and construction was possible. At that time, photogrammetry seemed to offer the possibility of improving mapping, and consequently scientists and map-makers alike took pleasure in discussing and exchanging ideas on new methods and equipment.

Thus, on 12 October 1953 the ***Organisation Européenne d'Etudes Photogrammétriques Experimentales*** (OEEPE) was established, "... to increase the accuracy, quality and efficiency of aerial surveys by speeding up the development and improvement of photogrammetric methods ...", as is recorded in the first agreement concerning the formation of the European Organisation for Experimental Photogrammetric Research (OEEPE).

The research- and development work within the Organisation has covered all the relevant topics concerning photogrammetry during the past fifty years, including films and cameras, photogrammetric scanners, image co-ordinate measurement, aerial triangulation, digital terrain modelling as well as the manual and automated production and updating of topographic and orthophoto maps and databases. Thus the Organisation and its members have made a significant contribution to the production of topographic maps and databases in Europe. During the past twenty years the technology has developed rapidly, with new sensors and platforms as well as the development of digital data processing. The Organisation also widened its field of activity in the late 1990's so that it now covers, "… Research- and development of methods, systems and standards for the acquisition, processing, production, maintenance, storing, and dissemination of core geospatial data and information ...", as is recorded in the new Agreement on the Formation of the ***European Spatial Data Research*** (EuroSDR) in 2003.

In this Seminar of Honour we would like to look at the future of mapping technology and the demands which the unification of Europe places upon research and development work when, in the future, reference data will be produced and processed for Europe, its individual countries, and all its citizens.

I would like to thank all the contributors to this seminar: the guest speakers, the organizers and the editors of this publication; and I hope that this seminar will provide visions and ideas of how to continue the research- and development work needed for producing reference data.

Risto Kuittinen

President of EuroSDR

From OEEPE to EuroSDR:
50 years of European Spatial Data Research and beyond

Seminar of Honour

by Christian Heipke[1], Risto Kuittinen[2],
and Günter Nagel[3] (Eds.)

[1] Chair, Institute for Photogrammetry and GeoInformation
University of Hannover, Germany

[2] President of the Finnish Geodetic Institute, Masala, Finland

[3] President of the Bayerisches Landesvermessungsamt, Munich, Germany

From OEEPE to EuroSDR: 50 years of European Spatial Data Research and beyond

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WELCOME ADDRESS

of the Bavarian Minister for Financial Affairs
Prof. Dr. Kurt Faltlhauser

The sixteen states of the Federal Republic of Germany function independently in the fields of official surveying and mapping and the real estate cadastre. This is a characteristic of our federal system and encourages fertile competition. In order to support a common national geo data base and to provide uniform products, the German states co-operate in the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV).
The Bavarian Surveying Authority can proudly look back on a history of more than 200 years. Based on the ideas of the French Age of Enlightenment at the beginning of the 19th century, the later Kingdom of Bavaria created a farsighted system of surveying and mapping. It contained, even at that time, the fundamental ideas of today‘s geographic information systems: a common basis for topographic and cadastral maps, comprehensive maps in a homogeneous framework with the possibility of easy reproduction using simple printing techniques.
Both in the construction of survey instruments and in the development of techniques for calculation and map reproduction, pioneering work had to be done. Personalities such as Joseph von Fraunhofer, Georg von Reichenbach, Johann Georg von Soldner and Alois Senefelder have become well-known even beyond Bavaria’s borders.
The Bavarian Surveying Authority is a traditional service administration, seeing itself in today’s information society as a supplier of up-to-date, precise and multi-purpose core geospatial information.
In a period of global competition, the close cooperation of the German states across state boundaries in the field of surveying and the application of modern information and communication technologies is essential. The “Organisation Européenne d’Études Photogrammétriques Expérimentales” (OEEPE) –founded in 1953ī is one of the oldest scientific-technological organizations operating on a European level. It played a decisive role in helping to develop aerial imagery and remote sensing into standardised and highly efficient methods for acquisition, processing and updating of core geospatial information.
I therefore congratulate the OEEPE on its 50th anniversary. I am very pleased that you have chosen the State Mapping Agency in Munich as the venue for your 103rd meeting and as a setting for your celebrations.
In recent years the region of Munich has developed into one of the leading global locations for high-tech industries. Scientists and users in all fields benefit as a result. A vast number of workshops and professional meetings illustrates the growing demand for geo-data bases in our mobile society. The assumption that 80% of all data is linked with geospatial information does not seem to be too high an estimate. In the meantime the majority of our citizens consider precise geodata as an important element in positively shaping their future.
Successful action requires creativity, productivity and the willingness to innovate. The OEEPE has addressed today’s challenges by redefining its self-image as EuroSDR (“European Spatial Data Research”). Thus, by building on its fifty years of experience, EuroSDR continues to provide valuable contributions to administrations, commerce and all of our citizens.
I wish all participants of the 103rd meeting of the recently renamed EuroSDR very interesting and instructive lectures, a successful event and pleasant memories of their stay in Munich.

WELCOME ADDRESS

Prof. Günter Nagel,
President of BLVA

The BLVA (Bayerisches Landesvermessungsamt ī State Mapping Agency of Bavaria) is proud to host the 103rd Meeting and welcome the guests of the OEEPE, recently renamed EuroSDR. It is a great pleasure to provide the setting for its 50th anniversary.

The BLVA is subordinated to the Bavarian Ministry of Finance. With responsibility for 1/5 of the area of Germany (about 70.000 km²) it is the largest State Mapping Agency in Germany with about 600 staff members.

Charged with the production of geospatial data, which is used by numerous customers in governmental, administration, scientific and commercial sectors, the BLVA provides this data comprehensively and to a reliable accuracy. The main focus is in keeping the data base up-to-date while maintaining prices at a sufficiently low level to enable as many customers as possible to use it. All products satisfy the standards set up by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) making them homogeneous and compatible within the German boundaries.

Let me give you an idea of our main products.

Aerial imagery and digital orthophotos (DOP):
The BLVA houses an archive of more than 700,000 aerial images – both historical (going back as far as 1941) and up-to-date – for the entire state of Bavaria. In 1987 the BLVA commenced a statewide flight program (Bayernbefliegung 1:15,000) which has been continuously repeated in 5-year periods since that time. From 2002 on colour negative film has been used and in 2003 a systematic update over 3 years, with an image scale of 1:12,400 was initiated. Based on a statewide network of control points and a DTM, the images are rectified to produce digital orthophotos (DOP) which are sold as analogue orthophoto maps or as digital raster data with a ground resolution of 4 dm. Access to these data via the Internet is in preparation. Digital orthophotos resampled to a ground resolution of 2 m are already available statewide and free of charge to the public.

Digital terrain Models (DTM):
A state wide DTM is available at a grid spacing of 50 m and multiples of that. DTM data is already available for one third of the state of Bavaria with a much closer grid spacing and higher accuracy. At first photogrammetric compilation of grids or contours was used enhanced by morphological structure lines. Since 1996 airborne laser scanning has become the standard method for the generation of our high quality DTM.

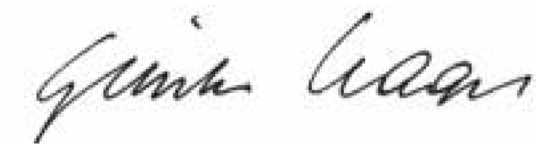
Digital topographic maps (DTK):
The DTK are raster data of the topographic maps, available at scales from 1:25,000 to 1:500,000. The data are composed of up to 23 layers for multiple and varied applications. The DTK25 is automatically derived from the ATKIS base DLM and additional cartographic data (e.g. labels, symbols, contour lines). DTK25 and DTK50 are updated in conjunction with the updating cycle of the ATKIS base DLM.

Digital landscape models (DLM)
The ATKIS digital landscape model (ATKIS base DLM) is the object oriented digital model of the earth’s surface. The modelling rules and the objects and attributes contained in the base DLM are described in the object feature catalogue (ATKIS-OK). The base DLM is available for the entire area of Bavaria for GIS users and can be obtained in different data formats. The very important updating of these data is now realised by local field surveyors who detect and survey feature changes. An updating cycle of better than one year is almost achieved for the priority objects such as roads, administrative boundaries and railway lines. New features such as georeferenced postal addresses are currently included in the base DLM.

GPS ī Satellite positioning service (SAPOS):
The BLVA operates 36 GPS reference stations for a differential GPS service within the German-wide SAtellite POSitioning service SAPOS. This service provides individual location-based ionosphere and troposphere correction data via mobile phone. Using only one GPS-receiver the customer can realise cm-accuracy in real time. For postprocessing applications the data from the reference stations are available via the Internet ten minutes later.

For further information about BLVA please visit us at http://www.blva.bayern.de.

For your stay in Munich I wish you interesting lectures, stimulating meetings and a pleasant time in our beautiful city.



Scientific Papers

SPATIAL DATA INFRASTRUCTURE - A TOOL FOR GROWTH AND SUSTAINABLE DEVELOPMENT IN EUROPE

Joakim Ollén
Director General of Lantmäteriet, Sweden
President of EuroGeographics

ABSTRACT

In order to create a more efficient handling of geographic information in Europe the spatial data infrastructure (SDI) must be developed. The INSPIRE initiative is of great importance not only for improvement of efficiency and effectiveness of governance, but also for the private sector. A fully fledged European SDI will increase markets through promoting harmonised pan-European reference data. It will support new business opportunities and also facilitate production and maintenance of fundamental geographic information.

To facilitate a more enhanced spatial data infrastructure it is necessary to seek involvement and support of decision-makers at the highest levels of business, government, and academia and to generate support to the local and regional levels as well as internationally. It is also of vital interest to make use of existing pan-European organisations, not at least EuroGeographics, as a vehicle for creating interoperable reference data, quality management systems, and metadata systems.

There is also a need to foster education and research activities that go beyond treatment of geographic data in solely a technical fashion. It is important that such activities include the creation of suitable tools in universities, government and the private sector to foster the use, demonstration, spread of good practice, and thoughtful application of results of this research.

It is necessary to make use of the existing (and soon coming) general standards as the foundation for technical implementation of the geographic data infrastructure and to develop efficient processes for creating technical specifications for the geographic information needed on the European level.

A lot of work remains before we have created a good European SDI – with easy access to interoperable geographic information. But, the pay-back from these investments in money and efforts will be significant.

AN INCREASING NEED FOR GEOSPATIAL DATA

Geospatial data, information, and technologies are becoming more important and more common tools throughout Europe (as well as in the rest of the world) because of their capacity to improve government and private sector decision making. Geospatial information is developed, used, maintained and shared in a range of application areas, including, environment, natural resources, agriculture, transportation, telecommunications, mapping, health, emergency services, research, and security. Sharing spatial data in such applications helps improve the management of public infrastructures and natural resources and produces numerous other benefits.

Geographic information is needed for formulation, implementation, monitoring and evaluation of European Community policy-making, especially within environmental, agricultural, regional and transport policies.[1]

[1] The Spatial Impact of European Union Policies (EUR 20121) by Massimo Craglia and Alessandro Annoni gives a good overview of directives, which claims for relevant, harmonised and quality geographic information.

Almost all themes of the environment policy (water, forestry, climate, soil, noise, sustainability, biodiversity, etc) have a spatial dimension.[2] Within the agriculture sector there are also a number of directives claiming for geographic information (rural development, information systems for agricultural policy, etc). Transport policy is also a crucial element of the integration of the European territory. One example of this is Article 129b of the 1994 Maastricht Treaty, which links the development of Trans-European Networks in the field of transport, energy, and communication to Article 7a (free movement of goods, persons, and capital in the single Market), and Article 130a (promotion of economic and social cohesion). The regional policy includes directives concerning urban policy, INTERREG, TERRA, ESPON, etc – all with a clear need for geographic information.

There is also a clear need for pan-European data in order to increase the market for products and services being build upon geographic information. Such an example is development of in-car transportation systems, intelligent transport systems, mobility management, and traffic management based on a pan-European road data solution. Many other examples can be found, e.g. applications to improve market analysis, to support tourism, or to facilitate the credit market.

FOCUS ON ESTABLISHING A SPATIAL DATA INFRASTRUCTURE

Initiatives to implement Spatial Data Infrastructures (SDI) are emerging at the national and regional level in industrialised as well as developing countries. A clear focus has been set on increased co-operation between authorities, municipalities and private sector companies, increased development and implementation of GI standards, re-structuring of the fundamental databases to object-oriented models, and to set up metadata services as well as Internet based services for easy access and distribution of maps, geographical databases, ortophotos, property information, etc.

A spatial data infrastructure must be based on a wide approach. It encompasses legislation and policies, organisational remits, geographic data resources, technologies, standards, delivery mechanisms, and financial and human resources. A well-functioning information infrastructure is a requirement for, amongst other things:

- Reduction of data collection and maintenance costs
- Improvement of data quality and consistency
- Added value through combinations of data from different sources
- Improved access to data

Policies must be defined and clear objectives must be set to achieve greater benefits from the geographic information resources and technology for the good of the whole society and to allow different parties involved to act in their own roles towards these objectives. Since the requirements of the society as well as the technical solutions change with the time, the objectives and policies must be revised in the course of time.

The geographic information infrastructure aims at making the geographic data resources and technology available to the society. This will mean a significant increase in the usage of the data sets, which could be achieved through improved information services and by insuring the usability and compatibility of the data sets. The improvements in the availability of the data sets would result in the decrease of overlapping data collection and maintenance.

The geographic information infrastructure should be looked upon as a set of basic components and services, which makes possible the exploitation of geographic information in the society for all kinds of official duties as well as in different business sectors.

[2] The Environmental Thematic Coordination Positions Paper within the INSPIRE initiative contains a detailed description of the needs for geographic information within the environmental sector.

Many nations and regions around Europe have been developing spatial data infrastructures (SDI) to help facilitate co-operative production, use and sharing of geospatial information. Experiences from these initiatives, which in some cases have been running for 10-20 years, must be used when a much more firm SDI is going to be established for Europe.

RISKS AND BARRIERS

The usage of geographic information and related technology are relatively new issues and the potential is not widely known. Geographic information (GI) technology requires greater resources than traditional administrative data processing because of the graphical interfaces and vast amounts of data to handle. It is less than fifteen years ago when hardware and software made it possible to support large-scale analysis and visualisations of geographic information at a cost, which was manageable for the end-users of information.

The collection and maintenance of geographic information has been slow and costly. The databases are often not adjusted for the new technology as they are still burdened with traditions of manual methods for map production. There are also still many themes for which nation-wide data coverage has not yet been reached. Many potential user-requirements have not been taken into account when specifications have been formulated for the collection of information. This has lead to situations where the imperfections in regards to the content and quality have been visible while applying the databases.

There is a lack of clear principles – or never ending discussion concerning the decided principles – for financing and pricing geographic information, as well as for handling questions concerning security, vulnerability, and personal integrity.

In short, the most significant barriers restricting the use of geographic information are:

- geographic information technology is not well known
- existing geographic databases are not known by potential users
- geographic databases are not structured in order to meet different user needs, which also implies that data cannot be combined in a reliable manner
- the coverage of fundamental geographic databases is not satisfactory
- data is out of date or of poor quality
- disputes concerning principles for pricing, copyright and privacy protection.

MAJOR COMPONENTS OF THE INFRASTRUCTURE

The major components of the infrastructure for geographic information are:

- organisations
- data resources
- information systems
- information networks and services
- regulation
- skills

The geographic information infrastructure sets a starting point and principles for the co-operation between the parties. The aim is to reduce and to avoid unnecessary or overlapping data collection. A further objective is to avoid uneconomical handling of data and erroneous decision making caused by incomplete preparation and lack of knowledge. Altogether, the aim would be to increase the economical competitiveness and cultural enrichment by wider exploitation of existing information.

Objectives must be set for each component of the infrastructure. These objectives are partly dependent of each other.

- Organisations: The roles and task of the parties are clear and the organisations are co-operating and thus avoiding overlapping work.
- Data resources: The areal and temporal coverage of geographic databases is satisfactory, the databases are compatible and meet the user requirements in terms of content and quality.
- Information systems: The information systems and applications of organisations are inter-operable allowing applications to exploit the data resources in different information systems.
- Information networks: The coverage of the networks and the available services guarantee an easy and safe implementation and access to geographic information services.
- Regulation: The division of work between the supply, distribution and use of geographic information works without any friction and the data resources are available to the parties without possible infringement of privacy protection or other rights, or endangering data security.
- Skills: The potential in geographic information and related technologies are widely known and in use.

Geographic information brings different disciplines together. The importance of commensurable data produced and used by different business sectors will increase in uniting and guiding the actions as a principle, when the regulation based control decreases and decision making becomes decentralised.

ORGANISATIONS AND CO-OPERATION

The users of geographic information and related techniques come from various business sectors and different tasks such as agriculture and forestry, preservation of game and fishing, mineral industry, land use planning, land administration and real estate services, soil and water construction, planning, construction and maintenance of utilities, transport planning, tourism, security service, surveillance, rescue service and national defence, protection of nature and environment, production of maps and statistics, and research and education.

Use of geographic information increases quickly as prices on hardware and software suitable for handling geographic information go down, the user friendliness of applications increases, and the Internet makes it possible to distribute data as well as applications to many new users. The market for geographic information should be regarded as broad, varied and constantly developing.

The users come from governmental bodies, municipalities, private companies and citizens. Not least the introduction of GIS applications on the Internet means that the citizens also will be more advanced users of geographic information.

The geographic information infrastructure must take into account the different situations, needs and possibilities of different types of parties as well as co-operation between them.

The roles of the parties for which the geographic information infrastructure is important can be such as:

- collection and maintenance of data
- processing data and deriving products from it

- data distribution and sale
- hardware production and sale
- software production and sale
- production and sale of data transfer services
- methods development and research
- education
- consultation
- co-ordination

An individual party may have several roles at the same time. However, the functionality of the geographic information infrastructure requires that there are some parties in the society for each role.

The co-operation between different parties is a fundamental part of the geographic information infrastructure. Traditionally co-ordination in public administration has been the responsibility of each ministry in their field of administration. Geographic information provides an interdisciplinary perspective. However, it is such an enormous issue that it would be very difficult, if not impossible, to administrate it centrally by norms. The needs and capabilities of each party should form the basis for the co-ordination and integration of actions. The parties themselves must become aware of the possibilities to be gained through co-operation. Co-operation must be based, as far as possible, on consensus. However, it is obvious that there is a need to regulate the framework of action and to encourage the parties to co-operate. The networking of the parties also requires efficient information activities and data directory services.

The national mapping agencies have in most European countries developed from being a map producer to be the national SDI co-ordinator. Focus has been moved from being a “map factory” with a few, well-known products to be a custom-oriented co-ordinator striving towards satisfying the needs for geographic information in society. This includes increased co-operation with authorities, municipalities and private sector companies, contracting out parts of the production, increased development and implementation of GI standards, restructuring of the fundamental databases to object-oriented models, and to set up metadata services and Internet based services for easy access and distribution of geographic information.

On the European level the EuroGeographics, the co-operation body for the European mapping and cadastre agencies, has developed to be and important SDI actor. The EuroSpec initiative is one example on how EuroGeographics makes a significant contribution to the establishment of interoperable pan-European geographic data.

DATA RESOURCES AND COMPATIBILITY

The geographic databases form an essential part of the infrastructure. Focus must be set on the fundamental databases, which are of interest to many users and have a significant potential for efficiency gaining in the society.

Overlapping data collection and maintenance is today unnecessary because data can be transmitted to a user in real time through the information network from original databases. From the national economy point of view, overlapping data collection is not sensible, even if it were privately funded. To reach a shared use of geographic data is it necessary:

- to improve knowledge about which GI-data that is available and encourage easier access to it;
- to enable easier integration of GI through the use of standards and guidelines;

- to provide users with assurance that the information is consistent and of defined quality;
- to provide advice to governmental organisations on geographic information.

INFORMATION SYSTEMS AND INTER-OPERABILITY

GIS's are based on software, which support data administration, analysis and visualisation based on location and geometric structures. The software packages have been relatively independent and separate, thus the data has been captured by tools provided in the packages or imported from other systems as export files. Nowadays, data management is more often object-oriented and based on separate commercial data management systems (often using relational databases), and systems are divided into more specialised but inter-operable units. Today, there is also an extensive development in the use of the Internet, not only for distribution of data, but also for access to different kinds of applications.

The geographic information perspective and map interfaces have also been integrated into conventional spreadsheet software packages and as multimedia is becoming more common, the functionality can be found in both factual and fictional applications. The availability of geographic information is important for the development of different applications and services.

The inter-operability of information systems and applications requires that service interfaces and the representation of geographic information in data transfer are standardised. There is an abundant number of formats for geographic information, especially for digital maps. Almost all the major software packages have their own formats and there are many national and international recommendations for certain business sectors. However, a new set of standards for geographic information has been developed. Some of them are have already been decided as final standards and the rest will be finalised within a year from now.

ISO 19100 Geographic Information forms the basis for inter-operability between geographic databases and systems. These standards are complimented by the OGC (Open GIS Consortium) industry standards, which will make it much easier to use different kinds of GIS software for different applications.

INFORMATION NETWORKS AND SERVICES

Geographic databases in general and image datasets in particular are large, and like multi-media applications, require a lot of capacity from the networks to transfer them in real time. Many of the applications using geographic information, e.g. in transport and fieldwork require cordless data transfer.

The available services on the net are required for the implementation of geographic information services. Sometimes, there are needs for special solutions in terms of data transfer technology or administrative services, such as user verification, electronic signatures and payments. The data security requirements vary according to the content. Therefore, the basic services should include proper encryption methods etc for the use, when needed. The directory services for geographic information require specific solutions, which are supported by map interfaces.

The information network is mainly needed for the transmission and distribution of geographic data to make processes more efficient, and to allow one to avoid slow manual phases. The network also plays a central part in decentralising information systems, and in avoiding overlapping data collection. The development of data transfer technologies brings the separate work phases closer and emphasises the need to redefine the processes.

REGULATION

A variety of data can be regarded as geographic information. Some of the data saved in attribute databases are related to individuals and even of delicate nature. Personal data can be regarded as geographic information if, for example, an attribute database contains the co-ordinates, and thus allows location of individuals by e.g. residential buildings. The development of information networks and information systems opens new possibilities in use and line of actions, which often have not been foreseen in the legislation concerning privacy protection, security or vulnerability. The regulations should follow the development and give guidelines for proper culture of using data so that rights of individuals, the national security or other vital interests not are endangered.

SKILLS

Ability to manage and benefit from geographic information technology is based on education and experience. Education in this field is given at several levels and among different educational programmes. Up to now too much focus has been set on education and training in specific software and too less on database development, standardisation, and other more fundamental questions.

TOWARDS A SDI FOR EUROPE: AN OVERVIEW AND AREAS FOR RESEARCH AND INVESTIGATION

Alessandro Annoni

Joint Research Centre, European Commission
Institute for Environment and Sustainability

ABSTRACT

Good policy is dependant on reliable information and informed public participation. The increasing complexity and inter-connection of the cumulative impacts of different policies affecting the quality of life is more and more recognised by the policy-makers and influences the way new policies are being prepared today and the way to monitor and evaluate their impact. All new policies now emphasise the need to be based on sound knowledge and participation, principles that will influence the decisions for the next decade. As the need for better monitoring and evaluation is recognized, so are the current deficiencies in access harmonized, consistent datasets at the appropriate geographic scale and time series. Presently, relevant spatial information is sometimes available at local and regional level, but it is difficult to exploit in a broader context for a variety of reasons (unsatisfactory or undefined data quality, use of incompatible proprietary GIS, lack of accessibility to the public or other users at local, regional, national and international level). The concept of 'Spatial Data Infrastructure' has been introduced to indicate the set of policies, institutional arrangements, technologies, data, and people that should be fulfilled to allow for the full deployment of the GI-potential in a society perspective. In Europe, most countries are in the process of developing SDIs at national and/or regional/local levels. There are variations that are partly a function of the cultural, institutional and economic heterogeneity of Europe. As Europe becomes economically and socially more integrated, there is a growing recognition that these processes need to be addressed at a European level. With this in mind, the European Commission launched several initiatives to unlock the potential of GI. One of these in particular is the Infrastructure for Spatial Information in Europe (INSPIRE) that intends to trigger the creation of a European Spatial Data Infrastructure (ESDI) which delivers to the users integrated spatial information services. The increasing demand of interoperable SDI across Europe is a new challenge for research and technical development.

ACKNOWLEDGEMENT

This paper is part of the celebration of EuroSDR's 50 years of collaborative research. Its membership of mapping agency technical experts/researchers and universities has accomplished much over that timescale which itself is a commendable example of European collaboration. This paper proposes research topics that look to the future and can provide material that will take us all forward well into the next 50 years.

For the compilation of this paper the author has taken advantage of previous and ongoing work related to the status of SDI in Europe (in particular the work of the GINIE project, the Spatial Applications Division K.U. Leuven Research & Development, and the INSPIRE working groups). "Informal inputs came from a number of people and organisations who are gratefully acknowledged."
The list is too long to be reported here; it includes the members of the INSPIRE experts group, the European and International Associations acting in this field (Eurogi, EuroGeographics, AGILE, EuroGeosurveys, EuroSDR, GSDI, UNGIWG, WPLA, FIG, ...), and also those organisations acting in GI standardisation (ISO TC 211, and the OpenGIS Consortium and its members). Special acknowledgement is for Prof. Max Craglia of the Sheffield University, co-author of several studies, for Prof. Ian Masser who, first, explained to me long time ago what a SDI is, and for my colleague Paul Smits who is coordinating the work related to INSPIRE architecture and standards.

PREFACE

Despite the increasing awareness of the potential of GIS-technology to improve decision making on spatial planning and territorial management, and the power of the GIS technology considerably increasing in the last 2 decades, with costs that actually can not be considered an obstacle for the users. These systems are still not as widely used as they should be.

Introduction of the technology in the organizations, which traditionally produce, manage and distribute GI and maps, is an important step. This however, does not allow to remove the lack of technical interoperability nor the organizational obstacles to data exchange, and hence to support the creation of real added value to be removed.

To really increase the market and unlock the potential of GI , the GIS systems originally designed in the 70's to support the production of digital cartography (from paper to map) should now be replaced by IT technology. This is required in order to query and access via web large amounts of well structured and distributed spatially referenced information. More and more users are in fact not interested in obtaining copies of the data but want to query it and obtain quick answers to their needs.

For this reason the focus is now increasingly shifting to the interoperability of data and systems, and to the services that should be built on top of them. So the emphasis is on building a Spatial Data Infrastructure (SDI) that can be considered as a general strategy or framework to manage and integrate the different data sources for the benefit of the overall user community. A SDI delivers integrated spatial information services to the users, allowing them to easily identify and access GI from a wide range of sources in an interoperable way and for a wide variety of uses.

A good definition of SDI can be found in the GSDI Cookbook:

"*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. Beyond this are additional services or software to support applications of the 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.

The creation of specific organisations or programs for developing or overseeing the development of SDI, particularly by government at various scales can be seen as the logical extension of the long practice of co-ordinating the building of other infrastructures necessary for ongoing development, such as transportation or telecommunication networks."

The following chapters will address the emerging concept of the European SDI, and the opportunities for future research and investigation.

1 THE EUROPEAN INITIATIVES

The European Commission's active involvement in GI policy development has sprung out of the IMPACT (89-94) and INFO2000 (96-99) programmes to support the European information and multimedia industry respectively. The projects in these programmes faced major difficulties in getting access to the geographic information they needed. This led the Commission to consider organise GI in Europe to improve availability and access.

In fact Europe has very extensive and comprehensive collections of national GI but it is often difficult to find and to access. In addition, there is very little seamless homogenised pan-European data available. Such information is scarce and difficult to obtain because national data was created in accordance with 15 different traditions and standards that do not fit easily together. This effectively stops a healthy European market for applications from developing, and is a big problem for many cross-border projects. The combination of the national data into European data is a highly complex and important task.

1.1 European Commission initiatives

To address these problems a communication (GI2000) from the Commission to the Council and Parliament was drafted to launch a debate at the political level. The GI2000 document has been the subject of numerous consultation meetings over the last years with interested parties both within and outside the Commission. It suggested action under the headings: Leadership & vision, European GI infrastructure, and Realising the potential and Global rules.

On 8 December 1999 the new Commission launched an initiative entitled "eEurope - An Information Society for All" which proposes ambitious targets to bring the benefits of the Information Society within reach of all Europeans. eEurope is a political initiative to ensure the European Union full benefits for generations to come from the changes the Information Society is bringing.

The issue of access to public information in general has been debated several times by the European Parliament. In 1999 the Green Paper on Public Sector Information (PSI) pointed out that "*the European Treaty has conferred a number of fundamental freedoms on EU citizens, but that considerable practical difficulties can prevent people from exercising those rights . These difficulties result primarily from a lack of information for citizens, employers and administrations at all levels*."

Geographic information is considered a relevant component of PSI.Only when the Directorate General of Environment became proactive, was the discussion about the setting-up of a European SDI really raised within the European Commission. The environment sector is traditionally highly conscious of the importance of data access in particular to monitor the status of the environment. Access to environmental information was the subject of the 1998 Aarhus Convention that was seen as a big step forward for both the environment and democracy as it improves the public's rights in the making and implementation of environmental policy.

The Aarhus Convention has now been implemented through the Directive 2003/4/EC on public access to environmental information that defines "environmental information" very broadly. This definition, however, shows how closely the environment is linked to activities in other sectors.

The Sixth Environment Action Programme and the European Sustainable Development Strategy advocate a knowledge-based approach to policy making that requires quality information on the state of the local and global environment to be readily available.

This was the reason given for the INSPIRE (Infrastructure for Spatial Information in Europe) initiative in the Memorandum of Understanding between Commissioners Wallstróm, Solbes, and Busquin on 11 April 2002 to provide a basis for continued co-operation between the Commission services DG Environment, EUROSTAT and the Joint Research Centre for developing the INSPIRE initiative.

1.2 INSPIRE - Infrastructure for Spatial Information in Europe

INSPIRE will result in an EU legal framework addressing the challenges to achieving the widespread use of spatial information needed to support European governance. INSPIRE is being developed by the Commission services in conjunction with officials and experts in Member States and accession countries from the national, regional and local levels. It is to be implemented throughout the European Union (EU) from 2006/7 onwards with different types of geographical information gradually harmonised and integrated, resulting in a European Spatial Data Infrastructure.

The content of the framework has been initially provided by separate position papers published in 2002 by six working groups: 1) Common Reference Data & Metadata, 2) Data, 3) Data Policy and Legal Aspects, 4) Architecture and Standards, 5) Funding & Implementation Structures, 6) Impact Analysis. Currently new working groups are actively focusing on the impact assessment and on implementation strategies.

There is a major difference between the concept of SDI foreseen in INSPIRE and the definition given in the GSDI cookbook. Both are multi-sectors but the INSPIRE - ESDI is user driven starting with the environmental policies first (other policies will be addressed in the future). For this reason all environmental policies are carefully analysed in order to define precise data requirement for both reference and thematic data. The current emphasis on environment should not be considered as an obstacle but as a challenge for future sectors.

INSPIRE is ambitious because the framework will not only cover core or framework data as some traditional SDIs, but will concern all spatial data needed for good governance. The framework will also address technical issues involving standardisation, organisations and co-ordination, data policy issues and with the data itself.

INSPIRE is governed by the following principles:

- Data should be collected once and maintained at the level where this can be done most effectively.
- It must be possible to combine seamlessly spatial data from different sources across the EU and share it between many users and applications.
- It must be possible for spatial data collected at one level of government to be shared between all levels of government.
- Spatial data needed for good governance should be available on conditions that are not restricting its extensive use.
- It should be easy to discover which spatial data is available, evaluate its suitability and know what conditions of use apply to it.

The INSPIRE – ESDI will be built on the top of existing and future National SDI. For this reason the implementation of these principles is not a simple task and requires further investigation and research on how to harmonise access to scattered and heterogeneous spatial data.

2 THE STATE OF PLAY IN EUROPE

Whilst INSPIRE aims at developing a legal framework to underpin the creation of an ESDI, it is clearly important to evaluate the extent of progress of SDIs in Europe, and identify key issues that need addressing to ensure conformity between European and national/regional developments. This chapter mainly analyses and summarises the results of two specific studies carried out by the GINIE project and by the Spatial Applications Division of the University of Leuven.

As addressed in the GSDI cookbook it is important to differentiate between “real” SDI initiatives and GIS projects. In fact an “ideal” SDI must

- be more than a single data set or database;
- host geographic data and attributes, sufficient documentation (metadata),
- provide a means to discover, visualize, and evaluate the data and some method to provide access to the geographic data
- include the organisational agreements needed to coordinate and administer it on a local, regional, national, and or trans-national scale.

The experiences of implementing SDIs in Europe clearly show that different models and approaches emerge as a result of the different cultural and institutional circumstances. Some countries spend a longer time in the planning stage, developing a coherent conceptual model of the SDI and its components before starting implementation. Others are more pragmatic and start with whatever is already available and develop as they proceed. In some countries (e.g. Belgium and Switzerland) it is observed that special emphasis is given to multilingual aspects. Obviously one model does not fit all.

True theoretical and optimal SDI -compliant with the above definition and having all components in place- are scarce in Europe. Only Portugal, Finland and the Netherlands are close to this model, although each has taken a different approach to develop its SDI.

However, as addressed in the two previously mentioned reports, there are a lot of initiatives in Europe that are construction elements of SDI. It should be noted that the creation of an SDI could be an evolutionary process not strictly following a top-down or a bottom-up approach.

Different types of SDIs are possible. Each country has a specific socio-economic, technological and political context. The implementation of an SDI is a process that sometimes proceeds in unanticipated way.

2.1 What are the features of a successful SDI?

As underlined by GINIE, a SDI is successful

- When it is developed, used, and maintained by several agencies responsible for key data resources including socio-economic, environmental, land and property, and reference data,
- When it is ready to answer to real needs,
- When its framework data conform to common specifications, are maintained up-to-date, and are easy to find and access,
- When it is multi-level from local to regional and national levels,
- When there is functional homogeneity in the framework across levels of jurisdiction,
- When there is clear authority in managing the framework,
- When it supports sufficient economy to justify itself.

2.2 Technical aspects of SDIs

The existing experiences in Europe in relation to developing seamless data indicate that significant harmonization work is needed, and that for each theme a specific working group or organisation need to be appointed with the task of undertaking this work.

The major technical issues relate to data aspects and not necessarily to technology. There is a common perception that technology is ready to provide the needed infrastructure, but there is a lack of awareness and knowledge on the obstacles related to the absence of data standardisation.

However, some technological problems still need to be addressed as identified by the first Regional SDI workshop organised in Ispra in January 2003 with the participation of several Regional Authorities. The workshop identified some major technical issues in connecting SDI:

- Different standards are used at National and Local level. In order to improve interoperability the adoption or compatibility of common standards should be foreseen,
- Even when common standards are used (e.g. OGC, ISO) there are remaining problems of interoperability related to the ambiguity in the development (e.g. difference between different releases), to the inconsistency or high complexity of some of them (e.g. standards for catalogue services), and to the specific software implementation by the system vendors.
- It is also crucial to be able to support a common geodetic reference system covering horizontal and vertical references (at present two systems are proposed ETRS89/EVRS2000 and WGS84). Countries not being able to directly provide data referenced to the common system have, first, to precisely describe their reference systems, and secondly to publish the transformation parameters to the common system at the appropriate accuracy.
- It is a priority to launch projects on cross-border areas to better identify and address the problems related to the setting-up of the future ESDI.

3 TOWARD ESDI IMPLEMENTATION

When building national and European SDIs, action is needed both top down (policy frameworks, coordination), and bottom up, integrating what already exists. Crucially however, the services implemented need to work together i.e. be interoperable.

Implementing ESDI specifically needs consideration of a series of issues including identification and selection of who will be in charge of establishing harmonised models and further eventually harmonizing the national data layers.

The INSPIRE Implementation Strategy Working Group (IMS) is specifically working on defining the technical elements to set-up ESDI.

This group identifies two types of interoperability necessary for efficient sharing of spatial information:

- Technical interoperability refers to the ability of different geoprocessing software systems to communicate and interact through shared interfaces.
- Semantic interoperability refers to standards that support the ability of people and software systems to find and use spatial data produced at different times by different people for different purposes, in which geographic features may be represented using different naming schemes and "geometries." Semantic interoperability depends largely on data producers adhering to standard feature naming schemes and metadata schemes.

Referring primarily to the European Union, Accession Countries and EFTA, the current situation concerning generic GI interoperability can be characterised as follows:

- Within the GI community at large, there is a strong awareness of the importance of interoperability.

- There is a limited level of GI "interoperability" in existing propriety software packages, and mainly at the level of data exchange by support of vendor-specific import and export possibilities.
- Technical standards and specifications for geographic information and geomatics are being developed in support of GI interoperability.
- The critical mass of vendors supporting international standards and specifications has not yet been reached.
- There is no support for GI process interoperability in mainstream IT.
- Interoperability is highly developed in some thematic communities, and awareness of its importance is growing in others.
- Sometimes highly developed thematic interoperability is based on ad-hoc standards, and not on international standards.

3.1 Data requirements

The INSPIRE IMS Working Group is also analysing data related issues in order to propose a common terminology for different categories of data, as well as to define a set of general requirements linked to all data to be part of the ESDI, and describe a set of general guiding principles for development of ESDI.

Harmonised data models for GI are the very core to interoperability of geographic information. In this context a distinction must be made between data models for common reference data and those for thematic data. If done properly, the former should be part and parcel of the latter. Migration plans for existing data models and production processes should be defined in order to minimise the impact of the adaptation to the future data models encapsulated in a European Standard.

The current work takes in consideration that a pragmatic approach is needed. In fact, if the logical starting point for an ESDI is firstly to set up the conceptual data model for features, components, themes, standards, specifications, architectures and processes, at European level this only can be the long-term vision. A two track approach has thus been proposed in order to start simultaneously the development of a conceptual data model, and the provision of intermediate data sets at small to medium scale.

Specific working groups are needed to develop the conceptual model for the spatial data being part of the ESDI and to carry out complementary studies to identify the resolution (horizontal, vertical, time) requirements for data that may vary according to feature/component and geographic areas. The definition of common thesauri is also needed.

Other complex additionally identified requirements concern the depiction and position of common features along shared borders with other Member States (edge matching); the interoperability between different data components and between different levels (e.g. generalisation of large scale data); the adoption of common standards for metadata for discovery and use, in conformity with the ISO INSPIRE profile (metadata should be maintained in the national language in respect of the cultural differences but tools should be provided to guarantee the multilingual access and understanding).

3.2 Architecture and Standards

The Position Paper of the INSPIRE Architecture and Standards Working Group expressed a set of recommendations about the future ESDI architecture (the term architecture is understood by them as the models, standards, technologies, specifications, and procedures used to represent, transform and generally accommodate the integration, maintenance and use of information in digital format):

- *INSPIRE will define requirements for a European spatial data infrastructure that national or regional spatial data infrastructures will be able to comply with, either directly or by the use of appropriate tools that guarantee compliance.*
- *It is the responsibility of each participating country to install and operate a national spatial data infrastructure which will comprise metadata, reference data and thematic data. This data will be made accessible electronically via a catalogue and viewing services.*
- *The implementation of the infrastructure shall follow the specifications and guidelines issued and maintained by an INSPIRE-CEN Workshop Agreement. The guidelines shall contain specifications for the reference system, metadata, catalogue and viewing services, etc. They shall be based on the ISO 19100 series of standards for geographic information, and where necessary and appropriate, results of other standardisation initiatives will be included (e.g., the ETRS89 reference system, specifications issued by the OpenGIS Consortium Ltd., the Dublin Core Metadata Initiative). A responsible technical body at EU level will assist the Member States in the implementation of INSPIRE.*
- *At EU level a geo-portal will be in place 6 months after the adoption of the legislative framework, and will link to the catalogue services of the Member States.*
- *INSPIRE Procurement Guidelines shall be developed, possibly as an integral part of e-government initiatives, assisting public administrations in making choices when dealing with issues that touch information technology and geographic information. In line with this, the INSPIRE common principles should be followed in EU and national funded projects: development of data and technology specifications should be considered in parallel to enable delivery of a specific service.*

3.3 Other considerations

A common European reference grid is also needed. Despite their many advantages, one or more reference grids have not been agreed upon because of political decisions. One of the basic problems to be solved is the lack of harmonisation between the various grid systems used by researchers or data producers.

Access to information in INSPIRE will be guaranteed by the EU portal and the underlying EU clearinghouse. In US a similar initiative is running for the definition of the OneStop GeoPortal. The EU Clearing house is considered to be part of the EU Portal. INSPIRE will be based on National Spatial Data Infrastructures that will link together local and regional data infrastructures. It is important to start to populate the EU Clearinghouse network with volunteer nodes to develop pilot demonstrators providing data to be accessed through the EU portal. The EU GeoPortal needs to be multi-lingual to act as a European entry point to available services, and provide links to national portals based on service registers. To achieve this, existing catalogues in different countries need to be extended by building software interfaces.

The value of such a GeoPortal is to show what can already be achieved by making public sector data more visible and accessible, provide services that respond to user needs, and identify priority areas for improvements and gaps to be filled. It also has the value of showing that something is happening, and a measure of SDI development progress through indicators such as the number of services and catalogues available over time, and measures of user feedback.

INSPIRE should make use of a common Glossary. It will be important to have at least the Glossary and the Thesaurus developed in parallel with the development of the INSPIRE EU Portal. These components together with a Multilingual Gazetteer will make it possible to search different data sets, across different regions in Europe using a common language. Most of this information is available but scattered across different sectors.

Pilot projects are needed to investigate the feasibility of the proposed approach. They should focus in cross-border areas in which different data providers are connected through web feature and web mapping servers. The pilots should study the data models of the required data sets, and create for each data set a common data model for visualization purposes, and implement the common data models in the prototypes to demonstrate interoperability.

More precisely INSPIRE interoperability demonstrators should include:

- Support to development of metadata profiles (the work comprises the creation of Dublin Core / ISO 19115-based profiles, guidelines, and XML schemes for discovery, evaluation and use of data).
- Software tools for metadata editing and sharing.
- Support to common data model definition and interoperability of existing national/regional data models for visualization and analysis.
- Support to development of Glossaries and Thesauri (it comprises the collection and harmonization of existing information, and the creation of a multilingual prototype, to be integrated into the INSPIRE EU Portal).
- Support to development of Catalogue Services (the aim of the work is to connect a limited number of existing catalogues, both at European and national levels, implemented according to different models (distributed and centralized), thus creating a prototype Clearinghouse Network).

3.4 INSPIRE stepwise approach to implementation

As described in the INSPIRE Consultation paper, the INSPIRE implementation will follow a step-wise approach, starting with unlocking the potential of existing spatial data and spatial data infrastructures and then gradually harmonising data and information services.

The first step will focus on the harmonisation of documenting existing datasets (metadata) and on the implementation of basic query, view and access mechanisms. Portals will be established at EU, national and regional levels and will provide the opportunity to access and query spatial datasets. This will be a gradual process where first the "core datasets" will be documented and accessible and, later on, the other datasets…

The second step will focus on the harmonisation of existing spatial datasets. A better knowledge of the existing datasets achieved through the first step, and the establishment of co-ordination mechanisms, will allow the key stakeholders to contribute to the definition of common ways to define and characterise spatial objects, such as transport networks, forests, etc. Once these common specifications are adopted, data providers will start to build interfaces between their datasets that will, to a large extent, remain in their original formats and common specifications. These interfaces will, to a certain extent, "hide" from the user differences between datasets from various sources. It will be the start of a harmonised spatial data infrastructure that will combine information from various sources to support more advanced analysis work…

The third step will push the harmonisation one stage further. Even if the above measures significantly increase the ability to combine data from different sources, the use of existing data will, at a certain stage, start to show its limitations. This will be particularly discomforting for core spatial datasets to which many others will refer to for linking information to specific places and spaces. Separate legal initiatives will therefore be taken to ensure that, for these datasets, the limitation of existing data in terms of measurement methods, quality, immediacy and geographical coverage will be overcome…

The fourth and last step will build upon the previous steps and concentrate on completing the common models and on providing the services to fully integrate data from various sources and various levels *into coherent seamless datasets supporting the same standards and protocols. This will allow real time access to up-to-date data across the whole of Europe. Furthermore, by this stage, INSPIRE will have developed an open framework of interest to other sectors to join, complementing the cross-sectoral and environmental information with details on agriculture, transport, energy etc. This will support cross-sectoral policy co-ordination and facilitate the integration of environmental, social and economic concern in support of sustainable development…*

This approach is illustrated in Figure 1

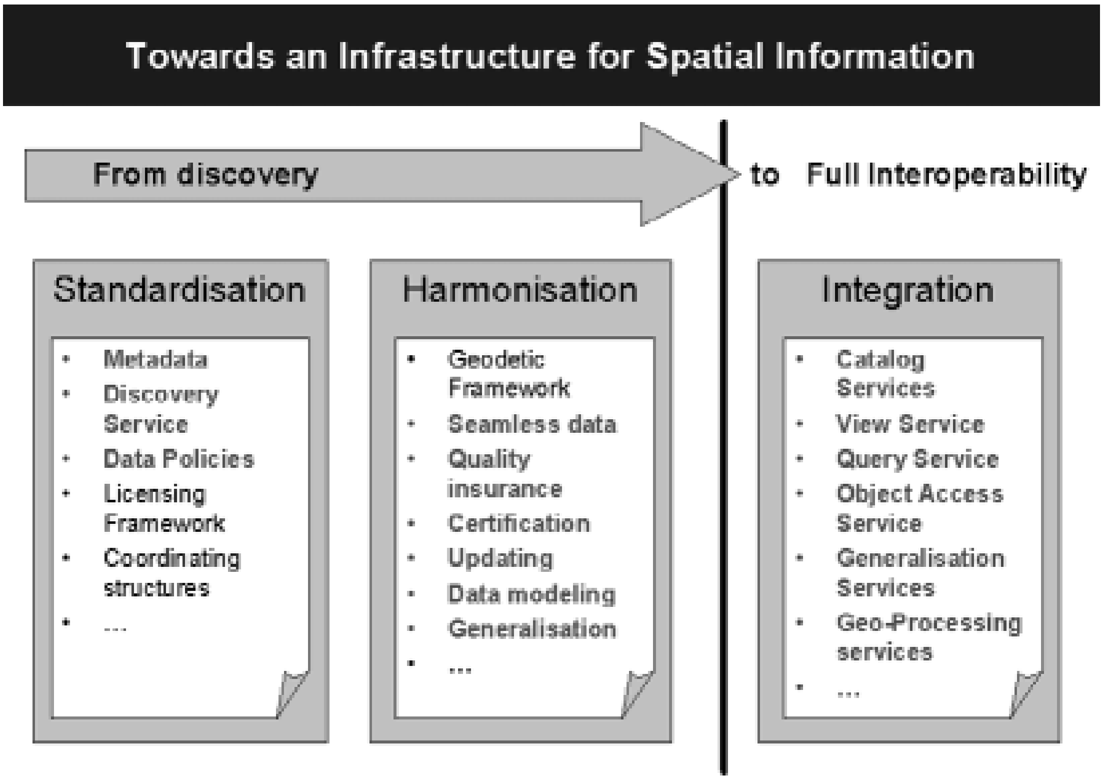


Figure 1 – Towards ESDI (research areas are in grey).

PRACTICAL CONCLUSIONS

The very ambitious vision of setting up ESDI according to the INSPIRE principles implies further investigation and research.

Some INSPIRE principles require addressing very complex issues. How to “combine” “seamlessly” spatial data from “different sources” across the EU and “share” it between “many users” and “applications”? How to “discover” which spatial data is available, to “evaluate its fitness for purpose”? How to make possible that data “collected at one” level of government be shared between “all the different levels”?

Every word in quotations is a potential area of further research. In fact Standardisation is not enough because it implies a lot of work in data conversion. In order to implement decreased costs and speed-up the process new intelligent methods and tools need to be realised.

In conclusion, INSPIRE is a big challenge for researchers acting on the following areas:

a) *Data production (reference and environmental data)* - Data and process uncertainty (including Spatial uncertainty), Data quality and Procedures for data quality check, Data integration and Data Fusion, Data modelling (including cross-thematic interoperability of reference and thematic data), Fuzzy objects management, Automatic feature extraction, Change detection and database updating, Spatial-temporal management and modelling, Metadata profiles, thesauri and glossaries, 3D/4D modelling and management, Database technology including Deductive and Object oriented spatial databases, …

b) *Interoperability and Access* - Semantic and technical interoperability, Semantic web and federated databases, Ontology, Object modelling and Generalisation (cartographic and object), Spatial data mining, Registries and Catalogs, Interoperable services (gazetteer, coordinate transformation services, …) and service chaining. Multilingual aspects, International standardization (ISO, CEN, OGIS), Map projection and coordinate transformation, …

c) *Visualization of GI* - Web mapping, 3D/4D visualization, Dynamic visualization, web mapping, Augmented and virtual reality, Usability (including graphics user interfaces and collaborative user environments) , …

d) Training and Education

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THE KNOWLEDGE ECONOMY:
BUILDING THE FRAMEWORK FOR BETTER DECISION MAKING

Vanessa Lawrence
Director General of Ordnance Survey, Southampton, United Kingdom

ABSTRACT

Information is important to all of us. In our daily lives or in our business, information helps us make informed decisions. This only works if the information is fit for purpose, sufficiently accurate, up to date and easy to use. Geography is now moving beyond its electronic infancy where "data" has been made available and we are now starting to develop services based on "information". New government services at the local, regional, central government, European levels combined with commercial demand for applications such as in-car navigation and location based services are stimulating this transition.

This is introducing demanding new levels of capability from the geographic information industry, not only "better information" but industrial strength data management and service delivery. The model of the spatial data infrastructure needs to evolve to support this model as a way of enabling the use of geographic information but which also provides better connectivity and robustness in critical business situations.

In Great Britain Ordnance Survey is building a framework for geographic information through the development of OS MasterMap and its underlying principles of the Digital National Framework. OS MasterMap is a layered database of reference data, designed for universal use but increasingly as a base for explicit georeferencing through features which are referenced by unique identifiers (TOIDs). Several collaborative projects are also active in terms of extending the infrastructure and joining up key national datasets such as land and property, coastal zone information. In addition to this collaborative work with sister organisations in Ireland and thereon further in Europe is aimed at supporting customers who expect seamless information across national borders.

This is supported by a business model where the mainstream users pay for the information but which also enables the citizen to use the information eg viewing planning information of their local community on the web. It is clear that the National Mapping Agency of the future will be very different from today both in terms of what they deliver and how they do it. Their role in delivering a key part of the national information infrastructure will be more important than ever in the knowledge economy.

ACKNOWLEDGEMENTS

In preparing this paper I am grateful to have had the input and resources of Ordnance Survey colleagues.

I would also like to take this opportunity to congratulate EuroSDR on 50 years of European collaboration. The United Kingdom through Ordnance Survey, Ordnance Survey of Northern Ireland and many other public and private sector players have been actively involved for most of those years. I am pleased to say that we have all benefited through collaborative projects and workshops over that time.

PREFACE: THE KNOWLEDGE ECONOMY - EXPANDING THE HORIZON FOR INFORMATION

Information for better decision making.

Information is essential to us all. We need information whether we are planning a vacation, looking for a new job, a new home, or when we are looking to improve our local community in some way or we may have to manage a crisis such as damage to our property or encounter an accident of some kind.

What kind of information is required? what do we expect. Generally the information needs to be::

- Accessible
  - Services needs to be accessible by all kinds of users, whether this is a pay as you use service by a telecoms operator or a government website describing the local community.
- Easy to use
  - Users will range from the young to the elderly, from the active to the infirm, from the citizen to senior politicians.
- Reliable
  - Decisions need reliable information, gaps, errors or lack of currency can all adversely affect the outcome, users will become disenchanted with services that let them down at important moments.
  - Industrial level service reliability is also essential to ensure that information is available when it is required and where it is required.
- Consistent
  - Users' expectations will rise with usage, there will always be an expectation for the service to do more than it does, and this is a positive driver.
- Inter-connected
  - Isolated information silos are of little use to anyone and are no more than "data silos". Differences in information from silos can damage credibility. However when connected information quality improves immediately and the components then start to become part of a "chain of information"
- Specific
  - Users will need different information at different times, depending on their immediate task and their situation.
  - While information maybe reused (behind the scenes) the service needs to be tailored to service the specific needs of the user at that moment.
  - One size does not fit all.

LEADING THE DEMAND FOR BETTER INFORMATION

Not only is better information essential in our daily lives but extends to good governance and for all kinds of national and global needs where decision making is essential. This in turn affects all us as citizens. This can be illustrated in the following three examples.

Flooding – the need for different organisations to work together (central, regional, local government, the utilities and insurance companies etc) to plan flood prevention schemes and to work together when flooding crises inevitably occur – whatever their role.

Figure 1 - Indicative floodplain maps available on the web in England and Wales.
Images courtesy of the Environment Agency
(http://www.environment-agency.gov.uk/subjects/flood)

Neighbourhood renewal – the need to identify where social deprivation or social exclusion is occurring and address the cause of the problem through better services, investments, education etc. and to measure whether the problem areas are responding to investment and new resources.

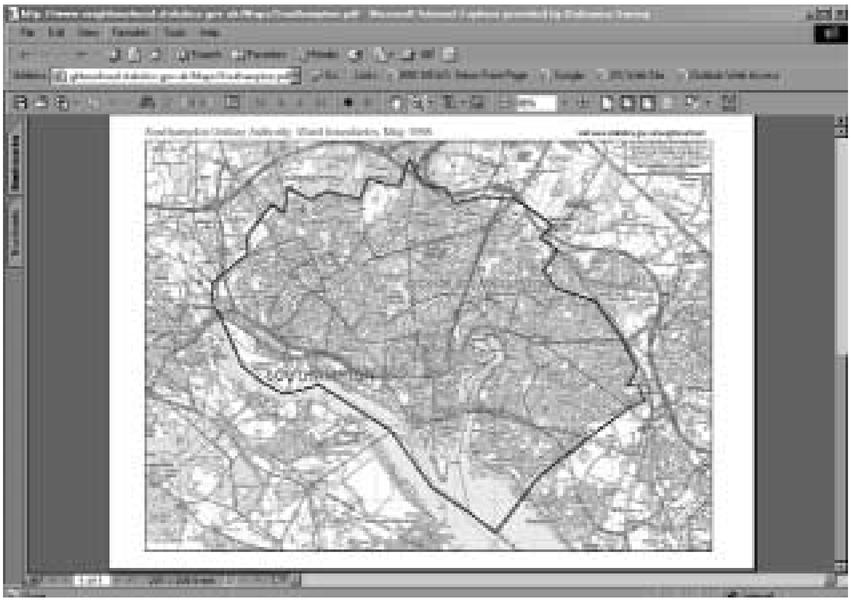

Figure 2 - Neighbourhood information based on local boundary information available on the web.
Images courtesy of the Office for National Statistics
(http://www.neighbourhood.statistics.gov.uk/Maps)

Location Based Services – as society goes mobile, better connected and needs information fast, LBS can provide the answer to where is my nearest ?….How do I get to?

Figure 3 - Three examples of current 3G LBS services available in Great Britain using Ordnance Survey information.
Images courtesy of '3' (http://www.three.co.uk/explore/services3/detailLocate.omp)

These are just three examples taken from hundreds which need better information to provide improved services to customers. There is a general need to:

- Geolocate their information (assets, events, etc)
- Link their information with that of other 3rd parties (service providers eg restaurants, dental practices with web addresses, opening times etc)
- Exchange information with 3rd parties (in planning or execution of services)

In this way they will often independently refer to a common geographic feature eg a building, road, land parcel etc therefore:

*…….all these services require **a consistent framework for geographic information.***

1 BUILDING A FRAMEWORK FOR GEOGRAPHIC INFORMATION

1.1 Impact of New Technology

New technology is opening up many new opportunities, so much that the previously ordered world of mapping is now turned upside down. Today all kinds of organisations collect all kinds of data and information using GPS, aerial and satellite imagery, new sources of data from LIDAR to SAR. The Internet and low cost desk top systems has brought capability to the reach of many.

In reality, as many of the dot com companies discovered to their cost, business logic stays much the same. National databases cost € millions to establish and € millions to maintain. Some one has to pay for this and that can only be done if there is a broad need, efficient management and exploitation of the information. Even then, valuable information is worth little if it is not fit for purpose. What was yesterday's backdrop mapping may meet few demands today when the user needs to know who owns which buildings, the floor area and what materials they are built from.

1.2 Spatial Data Infrastructures

The concept of the spatial data infrastructure has been with us for over a decade, yet it is accepted that few can agree what they mean by the term. To the technologist it is the web servers and software interoperability, to others it is a better set of online services and to some it is simply about getting data accessible and out of the dusty cupboards and hidden away on computers in government agencies. Indeed an SDI can be all these things, but have we not moved on from this today? The lack of awareness and failure to recognise that information hidden away had value was widely evident in the mid 1990's. This is less so today and the SDI we perhaps recognised 10 years ago, is now increasingly evident albeit at very unsophisticated levels of operation as simple overlays.

1.3 Framework for Geographic Information

The greater adoption of geography in applications, aided by new technologies, is fuelling the need for "information" with easy to display, process and use services now abundant. The geographic industry is therefore moving inexorably towards the wider information society and greater integration with mainstream information systems. This is not to say that it will be wholly swallowed up by that industry, it will not. Geographic information, by its very nature cannot be held in a simple database table and processed as we may perform with a client contact database. We need specialists to manage the collection, assembly and integration of geographic information into applications, but information providers need to adopt common standards and consistent approaches consistent with the Information Systems industry.

Therefore we need to move forward in our thinking beyond the earlier notions of "SDI's" to evolving frameworks that support richer and better integrated sources of geographic information. What does this mean?

The reply from a very successful and existing market is "standardisation." At the first EuroGeographics General Assembly in Dublin in 2000, we heard from one of the world's telecoms giants that the geographic information providers could learn from their experience by establishing common standards. The speaker gave an illustration of a lesson learnt by the telecomm industry in the 1990's. The adoption of GSM (Global System for Mobile Communications) as an agreed industry standard paved the way for interoperable service development and thereon massive growth. All of a sudden consumers had a flexible handset at an affordable price which allowed them to do things they were until then unable to do (international roaming, text messaging etc). Today, GSM technology is in use by more than one in ten of the world's population and it is estimated that at the end of 2002 there were 787 million GSM subscribers across the 190 countries of the world.

1.4 Geographic Information – setting new standards of operation

What then are the essential characteristics of a framework for geographic information?

- **high quality geographic information**, fit for purpose reference information and that information georeferenced to this base by a wide variety of users.
- **maintained information** to a level of currency to meet users needs.
- **richer attribution of features.**
- **connected information** and is ease to georeference, link and is effectively plug & play increasingly meeting the needs of mainstream information systems integrators.
- **adheres to practical standards** and principles.
- is **inclusive to all those who collect information** and need to link it to or analyse their environment.
- supported by a **rigorous systems infrastructure** with clear and consistent licensing and business models to sustain all of this.

2 MEETING PAN-EUROPEAN NEEDS

When we consider the pan-European needs we need to identify those characteristics that are essential in extending such a framework. Clearly the **need for cross border information is the primary differential at European level**. This will be common factor in the growing number of applications as diverse as in-car navigation and the EC Water Framework Directive. The simple requirement, for cross border connectivity introduces the need to balance national priorities, where the need will always be the greatest, against the wider European need. We must work within these parameters and manage collaborative datasets across Europe. This is already demanding new levels of co-operation and interoperability in three key areas:

- Information and data – greater consistency through common standards
- Commercial arrangements – Intellectual Property Rights, Licenses to use the information in given circumstances etc
- Legal jurisdiction under which the information is published - eg Competition Law, Copyright Law etc

While much of the legal framework now exists under European legislation, more work on best practice is required to ensure that the national positions are maintained while supporting pan-European needs at the information and commercial levels.

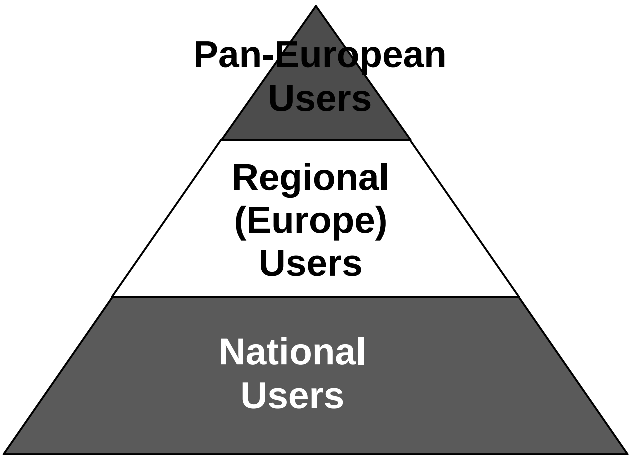

Figure 4 - Serving customers at the National, Regional and European levels. Balancing needs and priorities of these levels will be an ongoing challenge for the foreseeable future.

3 THE FRAMEWORK FOR GI IN GREAT BRITAIN

Turning now to the national position in Great Britain. The last 3-4 years has witnessed major changes in the growth of the geographic information industry in Great Britain. We have seen new users adopt geographic information, new applications develop and new initiatives develop where GI plays a central role. These are exciting days in the development of the geographic information infrastructure and to support these new demands and needs Ordnance Survey is in the process of building and re-engineering the national datasets to provide a robust framework for georeferencing and geographic information. This is most visible in the form of OS MasterMap™.

3.1 OS MasterMap

OS MasterMap is a seamless, national and layered database of reference information and provides the framework for geographic information in Great Britain. OS MasterMap also incorporates the supporting customer selection and delivery service. It will in time and along with other developments, supersede all existing detailed datasets developed by Ordnance Survey over the past 15 or more years. From the core database (National Geospatial Database) all products such as OS MasterMap and other multi-resolution products will eventually be derived, as far as possible by full automation.

Each "layer" of OS MasterMap is broken into "themes". The customer or partner can then select the geographic area and just those themes they require for their application. Following initial delivery, update is provided on a change only basis and all vector or text information is supplied in Geography Mark-up Language (GML) and GML only.

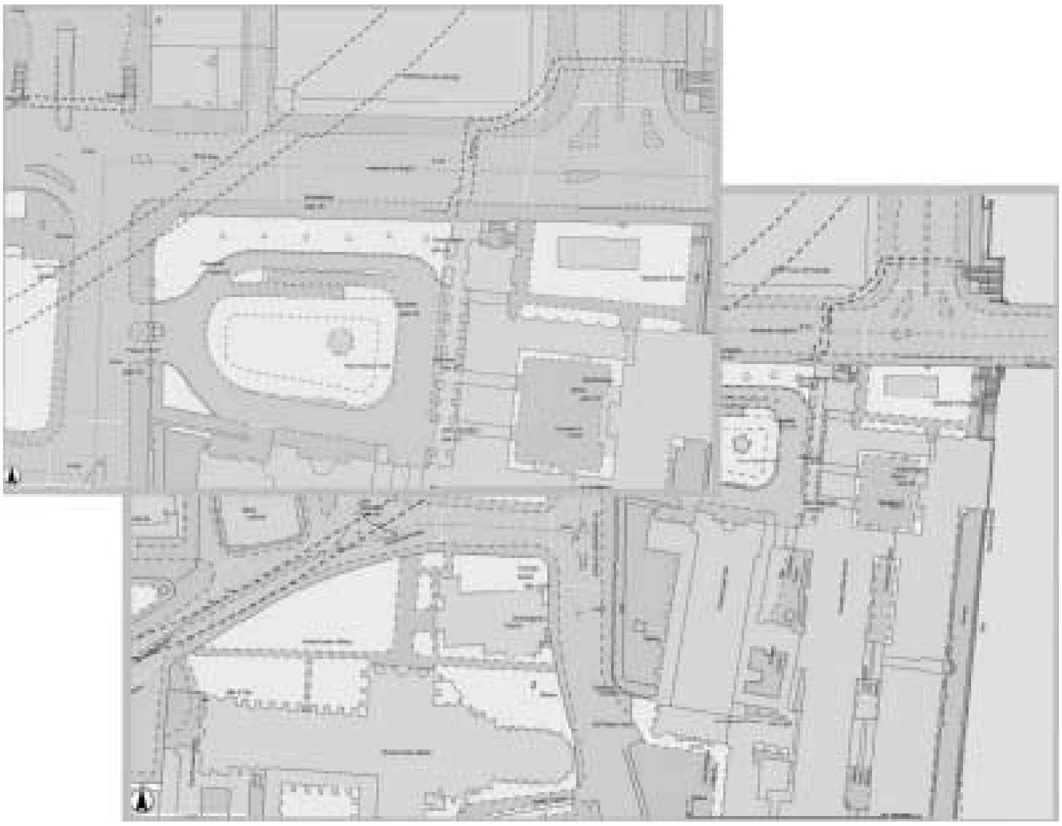

Figure 5 - OS MasterMap. Topographic Layer of Westminster, London. Each feature has a unique identifier and in turn can be used as a component to form features representing the user's view of the world eg land occupancy, land use etc.

3.2 Role of OS MasterMap.

The primary role of OS MasterMap is to provide the geographic information framework for Great Britain and the underpinning georeferencing base for location based information inside and outside government. With OS MasterMap, users have a robust, assured, maintained and integrated foundation on which users can establish their own thematic information such as environmental records, crop types and statistics, crime records, property information and so on. Providing georeferencing to this base is performed consistently by the wide variety and growing number of users, the potential to integrate information and perform reliable analysis will be very significant. The objective is to create virtual “joined-up geography” at the national level and exploit this information in supporting the development of the national economy[1].

The first release included several themes of Topographic information [Buildings, Land, and Water etc]. As the most detailed and universal data layer it was appropriate that this information was developed first and other layers then engineered to fit this common base. The Topographic layer contains over 430 million separately referenced real world features such as buildings, land parcels, roads, paths, streams and rivers, etc.

Since November 2001 a further three layers have been added to OS MasterMap

- the national georeferenced database of 26 million postal addresses was brought into the environment. Each address is referenced to the corresponding building object.
- a initial theme of the Integrated Transport Network (ITN) layer, including highways and drive restriction information, and
- a 25cm colour orthoimagery layer. .

The address and imagery layers have respectively been developed in collaboration with Royal Mail and private sector imagery companies.

Further datasets are also being prepared for migration or inclusion in the future, including: height, administrative, electoral and statistical geography boundaries, land use etc. Many of these are being developed again in conjunction with other agencies through collaborative partnerships. In meeting demanding government e-business targets the data can be ordered on-line via a map interface and delivered on-line or via media. Change only information at feature level is supplied on-line after the initial supply (OS MasterMap website, http://www.ordnancesurvey.gov.uk/os_mastermap/home/fr_index.htm?/os_mastermap/home/home.htm).

4 DIGITAL NATIONAL FRAMEWORK

4.1 The Concept of the Digital National Framework

The concept underlying this “joined up” approach is an initiative called the Digital National Framework (DNF) which was established in1999-2000 in consultation with the GI community in Great Britain. Some elements of the DNF are being developed in partnership with other mapping agencies and the concept is gradually being evolved in conjunction with users in the government, utility and private sectors. It was recognised that there was an absence of a formal documented approach to support a national georeferencing infrastructure and it is the aim of Digital National Framework to fill that gap:

“DNF is a set of enabling principles and operational rules that underpin and facilitate the integration of geo-referenced information from multiple sources.”

4.2 Scope of DNF

Within the overall DNF model features (such as buildings, land parcels, roads etc) are *each* referenced by a unique feature identifier known as a (TOID) to enable georeferencing and data linking and to support unambiguous user/thematic data exchange. The scope of DNF documentation includes the national coordinate system and its relationships with Global Positioning System (GPS) and other datum’s such as the hydrographic chart datum. A key part of the documentation, currently under development, encompasses the relationship of “reference data” and the data created by users and the

[1] See OXERA report: “The economic contribution of Ordnance Survey GB” which showed that something in the order of €160 billion of the UK GDP is underpinned by Ordnance Survey information in some way.

inter-relationship of these various datasets. There will also be material to support data quality, terminology and other data related issues.

"DNF is primarily concerned with geospatial information and its relationship to other data and information."

4.3 DNF Principles

Fundamental principles and drivers within the DNF concept necessitate reuse of information (capture once and use that source many times) and the ability to use common methods in publishing combinations of the reference data and user data for publication at smaller scales (Lilley 2003),. This will enable flexible rendering and visualisation to support the needs of users to adopting similar practises in collecting information at the highest resolution and publishing this in several ways and for all kinds from printed documents to web services. The DNF principles include:

1. *"The operational rules shall be driven by the strategic needs of the wider GI community. This will always be to the ultimate benefit of the user/customer in the knowledge economy, be they a business organisation or an end consumer*
2. *Data should be collected only once and then re-used.*
3. *Reference information/data should be captured at the highest resolution. It may then, where appropriate, subsequently be used to meet multi-resolution publishing requirements*
4. *DNF will incorporate and adopt existing de facto and de jure standards wherever they are proven and robust."*

The benefits of DNF are seen to be:

1. *"Reduced data collection and maintenance costs*
2. *Reduced data integration costs and times*
3. *Easier and greater reliability in information/data interoperability.*
4. *Easier user data exchange and sharing*
5. *Greater reuse of information and thereby higher value of that information.*
6. *Improved intra and inter-business communication*
7. *Reduced data duplication*
8. *A stronger knowledge economy"*

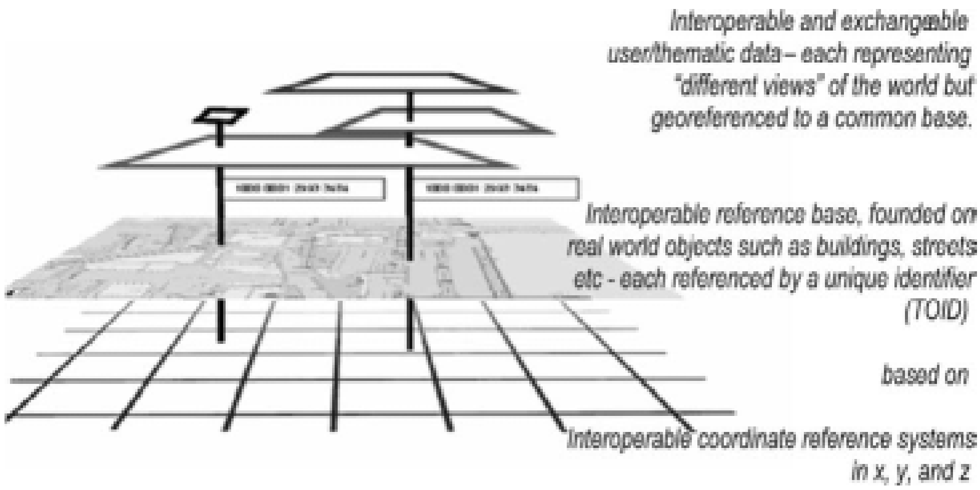

Figure 6 - The framework for geographic information using DNF principles to support widespread information interoperability through the entire infrastructure.

5 DEVELOPING THE FRAMEWORK

5.1 Collaboration

Unlike 50 years ago in the world of paper mapping, no organisation in the information age can assemble entire national databases alone. While some information collection may always be the domain of the NMA eg geodetic infrastructure and topographic information, other information can only be properly developed through collaboration eg georeferenced address information. Thus no one organisation holds all the information for the framework and this will demand cooperation and prioritisation. Hence interoperability needs to be applied at all levels, it is not simply a technical issue (*Murray & Mahoney*, 2003).

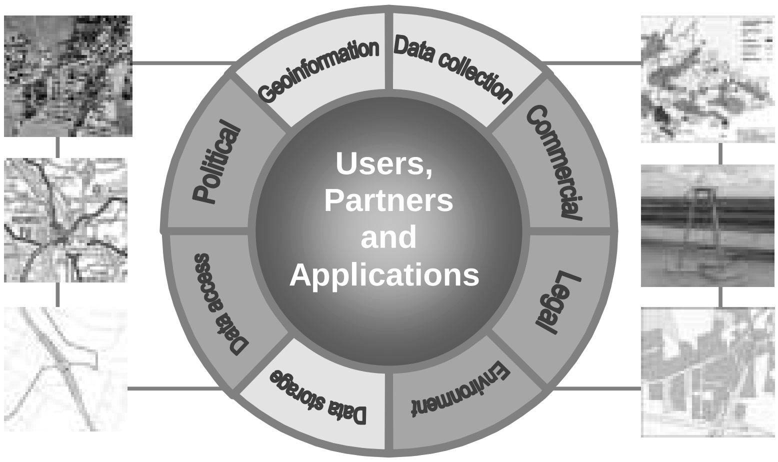

Figure 7 - The information economy is composed of several different aspects which all need to be interoperable. Note: The Digital National Framework is primarily concerned with the Data and Information aspects (collection, storage and geoinformation processes)]

In Great Britain there are several active initiatives aimed at joining up geographic information to provide a more complete and consistent geographic information infrastructure.

These include:

Joined-up Coastal Zone Information

The report by *Lord Chorley* in 1988 regarding Geographic Information (DoE, 1988) identified several national objectives, one of which was the need to provide better joined up information in the coastal zone. A paper trial map in the mid 1990's by Ordnance Survey and the UK Hydrographic Office proved not to be cost effective and was therefore abandoned. In 1999-2000 the demand for joined up coastal zone information was again raised by several key players who need to georeference information and operate in the coastal zone. At that time this proved difficult because they could not easily combine the hydrographic chart data and the national mapping. A project to integrate these two datasets and the data from the British Geological Survey has addressed this issue. It is not the intention to create a new map, but more simply to ensure that the data "fit" seamlessly, ie interoperable, horizontally and vertically.

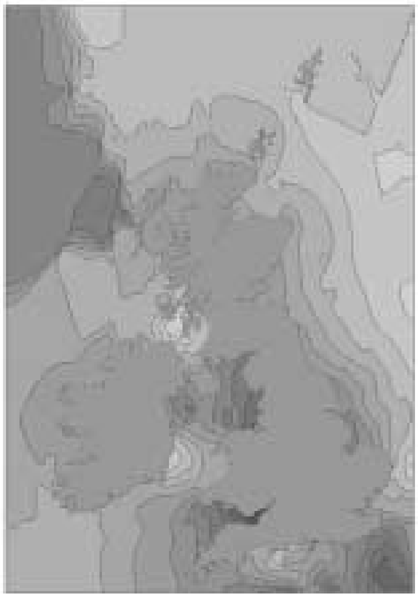

Figure 8 - Transformation between Ordnance Survey Height Datum and UK Hydrographic Office Chart Datum (mean sea level) for the United Kingdom.
Image courtesy of UK Hydrographic Office.

This project has included a short GPS campaign to ensure the integrity of a new transformation between the land vertical datum (based on *Newlyn* but linked to ETRS89) and Chart Datum based on Mean Sea Level around the coast. This is currently being developed as part of the three-way collaboration (*Whitfield and Pepper*, 2003).

Land and Property Information

Several organisations have a role in servicing land and property needs in the UK. The chief players, the land registries base their information on Ordnance Survey topographic mapping. Since we have all moved into the information systems age, many of the existing methods and approaches have been carried forward but have been driven by separate organisational drivers over the years. A collaborative project is currently attempting to try and consolidate and improve the information managed by the six principal organisations involved in land and property information. These are the Royal Mail, Valuation Office, HM Land Registry, Registers of Scotland, the Local Authorities and Ordnance Survey.

Britain and Ireland

In the world of the global market it is not surprising that many users are extending their services across adjacent national boundaries. There has been a growth in operational roll out of services across the UK (e.g. telecoms), involving Great Britain and Northern Ireland. Similarly there is a need for common services across both parts of Ireland. Users expect to be able to obtain data from any of these geographic and political areas and simply use it in an application. However, the geodetic and mapping responsibilities for Britain and Ireland fall to three separate mapping organisations: Ordnance Survey Ireland, Ordnance Survey of Northern Ireland and Ordnance Survey (of Great Britain). In 2000 we agreed to a programme to make it easier for customers who require geographic information across these boundaries, in terms of access to information and technical consistency. So far we have established a joint website (Joint Ordnance Survey website: www.osmaps.org) to help users navigate between current datasets. We are now working together on developing components of our respective georeferencing frameworks, such as the feature structure and the use of unique identifiers (TOIDs) (*Murray* et al 2001).

European Geographic Information

Britain and Ireland form an active region of western Europe. In recent years the concept of developing a harmonised European geospatial data infrastructure has been debated. Over the past 18 months, activity has been stimulated by the European Commission (EC) via a Memorandum of Understanding signed by Environment, EuroStat and Research Commissioners to support a European Spatial Data Infrastructure (ESDI). The project is known as "INSPIRE". The aim is to provide interoperable reference data, seamlessly supporting the thematic data collected and used for various European directives and applications such as Environment, Agriculture and Transport.

INSPIRE has already been successful in triggering the European mapping agencies body, EuroGeographics, (EuroGeographics website, 2003) to start work on a strategy to develop the reference layers (known as EuroSpec) which will not only underpin an ESDI for the EC but also support commercial and other users. The integration with the Galileo GPS programme currently under development (Galileo website, 2003) and scheduled for operation in 2008 will also be important.

Ordnance Survey and the United Kingdom are playing a major role in supporting both of these initiatives.

5.2 Maintaining the Investment

Business Model

The GI industry in the UK is very active and well developed. There is less emphasis on low level data processing as there is in some parts of the world. There is more focus on the development of industrial strength solutions which have been developing for some years through the private sector. More recently there has also been significant activity in establishing Government services on-line to meet e-Government targets for 2005. Across all these activities there are a wide variety of business models and processes to support different parts of the national economy

Ordnance Survey licenses data and information to its customers and partners and fully recovers its costs. This ensures that products are customer focused and there are funds to provide the level of service and continuing further enhancements now expected by users. Service level agreements play a major role such as the Pan Government Agreement which from April 2003 provides access to key national datasets for nearly 600 government agencies. Over 100 government organisations initiated new GI developments in the back of the pilot agreement raising usage from 40 at the start to over 140 government bodies by the end of the 12 month pilot in March 2003.

The user pays model of funding means that Ordnance Survey's income depends on users who pay for the information we provide, and customers therefore drive the content - ensuring that it is fit for purpose and prioritised to meet their needs.

Exploitation of the Asset

The Ordnance Survey data provides a robust platform for users of all kinds to build and develop solutions and services. Our customers and partners products range from reports on land contamination, where the user pays a fee; to a growing number of citizen based services which provide information on local developments eg local planning. Many of the central, regional and local government services offer information, including mapping, free of charge to the citizen.

Other download examples are the Get a Map service on the Ordnance Survey website offering small scale map extracts along with other data eg historical mapping. Recently all school children starting secondary education (750,000 11 year old children in 2002) were given a free 1:25,000 paper map of their home area. Thus the commercial business model, contrary to popular belief, is not necessarily restrictive, indeed it is possible to demonstrate a thriving and active market with information reaching more users today than ever before.

Figure 9 - Example of information accessible to the citizen: - Get-a-map^{TM} from Ordnance Survey.

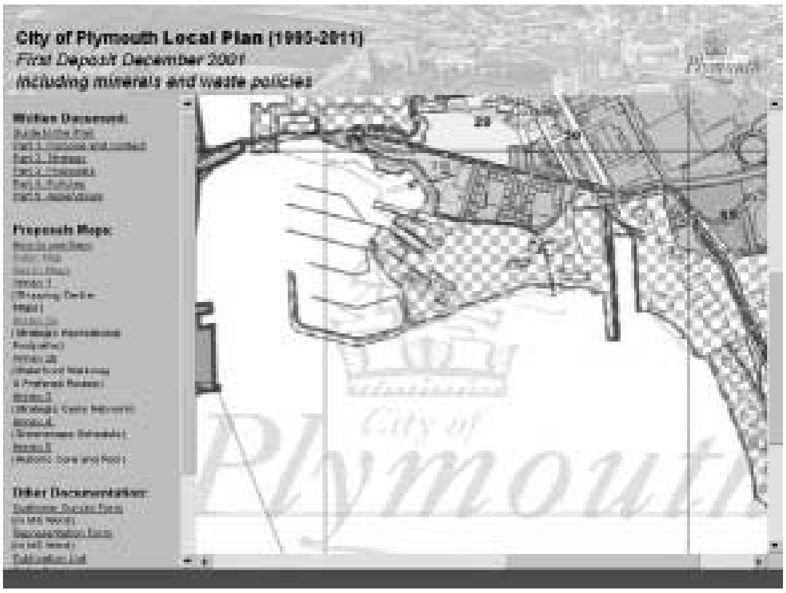

Figure 10 - Example of local authority information accessible to the citizen: City of Plymouth showing the Local Plan, based on Ordnance Survey data.
Image courtesy of City of Plymouth.

Protecting the Asset

A significant proportion of the annual income is dedicated to data maintenance where approximately one million changes are made to the base information in the National Geospatial Database per annum. Of this approximately 45% is surveyed directly by anyone of our network of 400 field surveyors located across Great Britain using pen PCs and real time kinematic GPS, 45% by photogrammetry either in-house or by contractors (largely rural update) and an increasing proportion is now sourced through design plans which allows us to publish "PreBuild" information – eg planned residential developments for the use of utilities to design their networks prior to construction.

The database itself and supporting edit and delivery systems requires ongoing investment to ensure that it maintains industrial strength capability and continues to meet the significant growth demands year on year.

5.3 Role of the National Mapping Agency in the 21st century

The NMA, like any other business today, needs to be fit to perform in the modern economy. We have to focus on the key outputs, how we maximise those outputs while critically assessing and controlling costs. The organisations that will survive will be lean, fit and agile. A substantial part of Ordnance Survey's revenue is invested in its human resource. We have been particularly active in bringing in new skills, new approaches and new attitudes into the business. Retraining and staff initiatives are also key developments. Part of this included an event in late 2001 called the "OS Experience". This brought all members of the organisation to Head Office over the course of a week for a half day to engage directly in the change process that had just started – this has had a very positive impact on staff in obtaining buy-in and commitment to the new challenges that lie ahead and is now just part of the way we work together as an organisational team.

The figures speak for themselves, over the past 20 years costs have remained reasonably steady at ca € 160 m pa, revenue has trebled to a similar figure providing a small surplus (a minimum surplus is required by HM Treasury) and staff numbers have reduced from 3,500 to just over 1,500.

Within Europe we need strong mapping organisations, there is much to do and bigger challenges ahead. Together, with a common vision, we can help reshape the European GI scene to meet those challenges successfully and sustainably.

6 CONCLUSIONS

Geographic information is critical for a modern information/knowledge economy. From this paper we can conclude that:

1. users and their role in defining needs and expectations are more important than they have ever been – this ranges from the citizen through to commercial providers to government at all levels including Europe
2. we need to develop practical standards and consistency through robust, maintained geographic information frameworks that will underpin GI and the exchange of thematic information in applications and processes of the future.
3. the user pays funding model has been shown to work successfully by combining a high quality maintained framework with careful licensing to ensure that the use of the information is maximised, widely adopted and used by all sections of society
4. there will always be a need to research new ways of working and scenarios to try to ensure we meet the needs of the future before we arrive there
5. finally, no one organisation is an island and while we all have individual and demanding responsibilities we must recognise that partnerships (at all levels – data collection, information collaboration and in extending the reach to all corners of the market) are essential to be successful in the knowledge economy.

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GEOGRAPHIC INFORMATION AND INFORMATION SOCIETY

Dieter Fritsch
Institute for Photogrammetry, Rector of Stuttgart University, Geschwister-Scholl-Str. 24D, D-70174 Stuttgart

ABSTRACT

Geographic Information has become an influential driving force especially when making spatial decisions. No matter who is using spatial data – all people relying on positioning and orientation of spatial objects value geometric and thematic information in two-, three- or even higher dimensions. This is independent of business, public or private applications. The tremendous progress of communication and computing technologies provides today geographic information anytime, anywhere and anyplace.

The paper addresses key issues to highlight today's computing infrastructures for geographic information delivery. Main emphasis is put on client/server computing, and mobility. As a result of spatial data refinement virtual reality maps are defined being used on any computing or communication device. The future of geographic information seems to be brilliant and without any limits – streaming delivery of outdoor and indoor data will even boost added value to daily life applications and habits providing extra cash flows for spatial data providers.

Standards of geographic information as data regulation and exchange rules have become more and more important. With the definitions of ISO and OGC it seems appropriate to cover the difficulties of his process. Standardized data are the "fuel" of spatial data infrastructures which could also worldwide implemented during the last years. The internet with its markup languages offers the backbone of these infrastructures. Digital geographic data hubs as "market places" and distribution nodes will hopefully provide more public awareness in future.

With the unlimited availability of geographic information one further point will be stressed: data quality. It is out of question that geographic data quality has to be considered within most spatial analysis and decision processes. No matter which application is carried out – quality figures should "render" the final result. Therefore geographic data quality penetrates today the whole workflow providing geographic information: data modeling, data collection, management, analysis and output. Few examples of sustainable land use planning will demonstrate the importance of spatial data homogenization and quality.

Finally, some theses are defined to summarize the paper. The future will show, whether geographic information providers will make the progress expected by the public delivering geographic data any time and any place. It is on us, the EuroSDR and other international and national communities to stimulate and influence geographic data research, developments and deliveries. Best wishes for the last 50 years of European Geographic Information Experimental Research. Hopefully, EuroSDR will become the driving force we need to boost further developments in this important area.

NEW PERSPECTIVES IN GIS DATABASES

Robert LAURINI, Sylvie SERVIGNE
LIRIS / INSA de Lyon
F-69621 Villeurbanne

ABSTRACT

Due to the evolution of social needs, together with new potentialities in information and communication technology, new considerations are emerging, so the goal of this paper will be to emphasize the new directions of databases for GIS.

The use of GPS, together with mobility leads to new location-based services (LBS). In database terms, this means that the information must be pervasive, i.e. accessible everywhere by means of antennas and special server architecture. Among the critical issues, let us mention mobile queries and transactions which imply the design of high performance caching systems.

Another evolution regards real time GIS, not only for LBS, but also for risks and disaster management. The key-points are the existence of myriads of sensors regularly sending measures to some monitoring centre. Here the technological barriers are essentially the performances of existing spatio-temporal databases systems which cannot correctly handled real time data. The design of real time GIS is clearly a new technological barriers.

Applications such as meteorology deal with data coming from continuous phenomena, known as field oriented databases. Presently, no marketed database systems allow a continuous vision of the reality from a user's point of view.

Cadastral applications, maintenance and geology implies the necessity of having real 3D GIS, and as a consequence database systems able to store query and visualize 3D objects.

NICT implies also the reorganization of the processes, especially for urban and environmental planning. So, new functionalities must be integrated allowing cooperation (groupware) between actors and participation of the citizens.

Moreover, since decision-making procedures are more and more backed on computers and database contents, spatial analyses techniques must be based on data with a very high quality level. So, geographic databases must encompass efficient quality control mechanisms in order to reduce errors in decision making.

The importance of Internet is pushing the design of GIS able to work not only at server level, but also at client level. The consequence is not only geographic data structure, but also the existence of cartographic tools at client level.

Finally, another important evolution is the use of XML, not only for storing geographic data, but also metadata.

1 EMERGING APPLICATIONS / NEW SOCIAL NEEDS / NEW FUNCTIONALITIES

In the domain of GIS, from the 70'ies we have gradually passed from automated cartography to geoprocessing through GIS. And now, new information and communication technologies in conjunction with new emerging geographic applications and services have led to new paradigms such as telegeoprocessing and telegeomonitoring.

In this introductory paragraph, we will successively examine those new classes of services, and overall emphasize the new database functionalities they require. Let us considerate a few new issues such as:

- location-based services (LBS)
- real time GIS (RTGIS)
- 3D databases
- field oriented GIS
- new decision-support systems
- GIS for public participation (PPGIS)
- Interoperability
- Web GIS.

1.1 LBS

New technologies in mobile systems and communications have influenced the development of mobile applications and mobile geographic applications. These new technologies based on mobile communication systems, GPS (Global Positioning Systems), mobile and on-board computers have led to new types of services i.e. Location Based Services (LBS).

Location-based Services are an important development in the area of geographic information applications: navigation systems, traffic systems, transport systems, emergency services, military applications, risk management… A LBS has to be distributed to clients according to their spatial position and profile by an Information Provider through the Internet and telecommunication network (*Brinkhoff*, 2003). Information concerning spatial objects into an area of influence around the client location is sent to clients. For example, when an accident occurs on a motorway, it would be interesting to know the nearest exits and hospitals, and to see their location on a map.

1.2 RTGIS

Consider the monitoring of a disaster, for instance floods or volcano; sensors are regularly sending measures to some control center. These kinds of geographic information applications and also LBS applications enhance another aspect of new GIS which have to include real time functionalities. Information concerning spatial objects (location, information…) has to be transmitted and stored in real time and then exploited and visualized in real time. The big issue is performance. Indeed, actual GIS products cannot deal with huge flows of information arriving in real time from sensors. Due to these characteristics, new architecture of real time spatio-temporal databases must be defined and implemented, and their crucial point is to design new data access methods matching the time constraints.

1.3 3D DBMS

At the inception of GIS, the dominant application was 2D cartography. But more and more 3D applications are emerging. For instance in some cities, cadastres must be 3-dimensional. Another domain is geology. This implies the design of 3D data structures relevant for GIS. In the domains of mechanical CADCAM, and even in computer-image generation, for decades 3D structures have been proposed. The challenge here is not the design of 3D data structures, but the management of millions of 3D objects in urban databases, such as buildings.

1.4 FO-GIS

Field oriented GIS must model continuous phenomena. Of course, even if the user’s vision is continuous, everything is discrete at physical level. The scientific barriers are twofold, first proposing a continuous vision (language, queries, etc.), second an architecture and data access method based on the storage of data samplings, and powerful interpolation procedures. As a consequence, new indexing schemes must be provided.

Let us say that FO GIS are a special case of temporal GIS.

1.5 DSS

Another goal of GIS and spatial database is to help user during a decision process. So, spatio-temporal decision support systems are needed. One difficulty concerns spatial data quality. To make a decision concerning for example urban planning or emergency procedures based on spatio-temporal data, it is necessary to know some information about spatial data quality. When had spatial data been acquired? with what kind of tool? were they regularly updated? what was the scale of acquisition? And so on.

This information is useful to evaluate the uncertainty of data during a decision process. This information has to be communicated to users, perhaps by using new techniques for visualizing quality.

1.6 PPGIS

While many planners use computers, they use them primarily for general-purpose office functions [VON 03]. The adoption and use of geo tools (GIS and spatial modelling systems) is far from being effectively integrated into the planning process [STI 99]. However, GIS is an interesting tool to support planning and moreover will help to support participatory planning. One of current stake is to easy public participation in environmental planning which is now possible thanks to web architecture.

Apparently, the only implications on GIS database are the connection with Internet, and the necessity to link databases with discussion forums and virtual reality. We can also add the management of versions (alternative plans) due to groupware.

1.7 Interoperability

Even if the OpenGIS consortium (http://www.opengis.org/) has made a nice work in order to facilitate interoperability of spatial data, especially at geometric and topological levels, a lot of things have to be done to ensure real interoperability at semantic level. An emerging solution is based on ontologies. By ontology, one means a formal vocabulary, or a sort of semantic network encompassing all concepts for a precise domain. Then relationships are made between data definitions, and so allowing the transformation of data by means of mediators. More and more the ontologies are described with extensions of XML.

1.8 Web GIS

By WebGIS, one means the connections of GIS database with Internet. In other words, the mapping functionality must be possible at client level. Thanks to SVG (W3C 2001), GML (*Lake* 2000), etc. the data structure allows the transfer from the server side to the client side.

Those cases were given only to give a fresh idea of the new concerns for spatial databases. Now, let us examine the new research directions in this domain.

2 NEW RESEARCH DIRECTIONS IN GIS DATABASES FUNCTIONALITIES

The new applications as described earlier imply the design and the prototyping of new software components in the nearby future. Let us examine few of them.

2.1 Spatio-temporal data warehousing and data mining

In the past, zillions of geographic data have been acquired and stored. By data warehouse, we mean a repository storing all ancient and archived data as they were acquired in the past, that is to say, with their own data structures. By data mining, we mean any tool for analyzing data stored in databases or datawarehouses, in order to discover regular patterns.

A datawarehouse is a collection of data stored in an orderly and accessible way. Facts and related data are used in a datawarehouse for better analyses and decision support. The basic characteristics of data in a datawarehouse are; consistent, subject-oriented, integrated, time-variant, non-volatile (*Van Berkel*, 1997). Typical for datawarehouse systems is:

- **Separate**. The datawarehouse is separate from the operational systems in the company. It gets its data out of these legacy systems.

- **Available**. The task of a datawarehouse is to make data accessible for the user.
- **Integrated**. The basis of this integration is the standard company model
- **Historical**. Questions have to be answered; trends and correlations have to be discovered. They are time stamped and associated with defined periods of time.
- **Subject oriented**. Most of the time oriented on the subject customer.
- **Not dynamic**. When the data is updated, it is done only periodical, but not as on individual basis.
- **Aggregation performance**. The data which is requested by the user has to perform well on all scales of aggregation.
- **Consistency**. Structural contents of the data are very important and can only be guaranteed by the use of metadata: this is independent from the source and collection date of the data.
- **Iterative development**: A datawarehouse starts small and grows bigger and bigger. Starting point is a subject area. Implementation is done in an iterative process. Iterations are clearly defined projects, which are added to the datawarehouse. The big challenge in an iterative process is to guarantee the structural and contents consistency of the data, it makes the datawarehouse live or die.

One of the roles of datawarehouse is to allow datamining, i.e. the searching of regular patterns such as rules or thematic mappings. For instance *Koperski* et al. (1997) distinguish:

> **RULES:** Various kinds of rules can be discovered from databases in general. For example, characteristic rules, discriminant rules, association rules, or deviation and evolution rules can be mined. A spatial characteristic rule is a general description of spatial data. For example, a rule describing the general price range of houses in various geographic regions in a city is a spatial characteristic rule. A spatial discriminant rule is a general description of the features discriminating or contrasting a class of spatial data from other class(es) like the comparison of price ranges of houses in different geographical regions. Finally, a spatial association rule is a rule which describes the implication of one or a set of features by another set of features in spatial databases. For example, a rule associating the price range of the houses with nearby spatial features, like beaches, is a spatial association rule.
>
> **THEMATIC MAPS:** Thematic maps present the spatial distribution of a single or a few attributes. This differs from general or reference maps where the main objective is to present the position of objects in relation to other spatial objects. **Thematic maps may be used for discovering different rules**. For example, we may want to look at temperature thematic map while analyzing the general weather pattern of a geographic region. There are two ways to represent thematic maps: raster and vector. In the raster image form thematic maps have pixels associated with the attribute values. For example, a map may have the altitude of the spatial objects coded as the intensity of the pixel (or the color). In the vector representation, a spatial object is represented by its geometry, most commonly being the boundary representation along with the thematic attributes. For example, a census tract may be represented by the boundary points and corresponding population value.

Simple query and retrieval function of GIS cannot be satisfied with need of geographers and other scientists. On-Line Analytical Processing (OLAP) occurs to facilitate the decision-maker to gain insight from large treasury of data, instead of drowning in the sea of unmeaning data. We believe that OLAP and GIS should be integrated so that we can make the most of the geographic data.

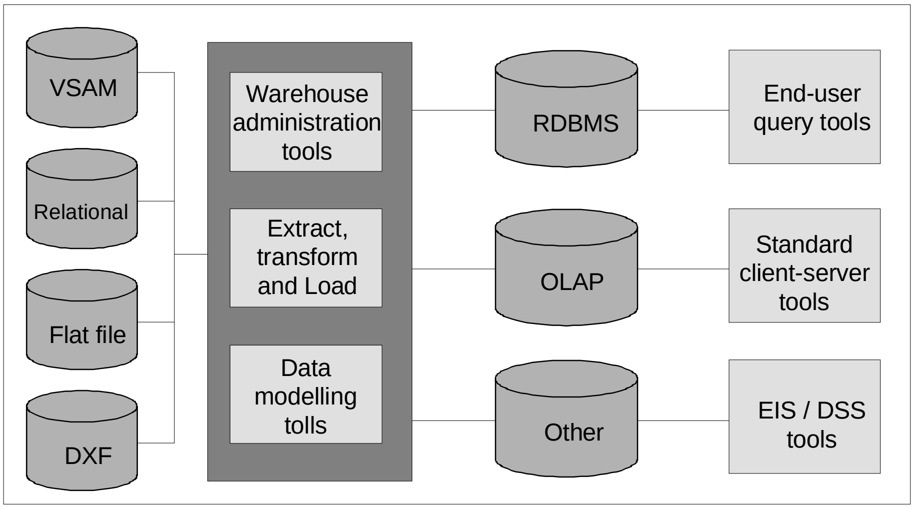

Figure 1 - Components of a datawarehousing architecture system (after *Barquin* and *Edelstein*, 1997 with modifications).

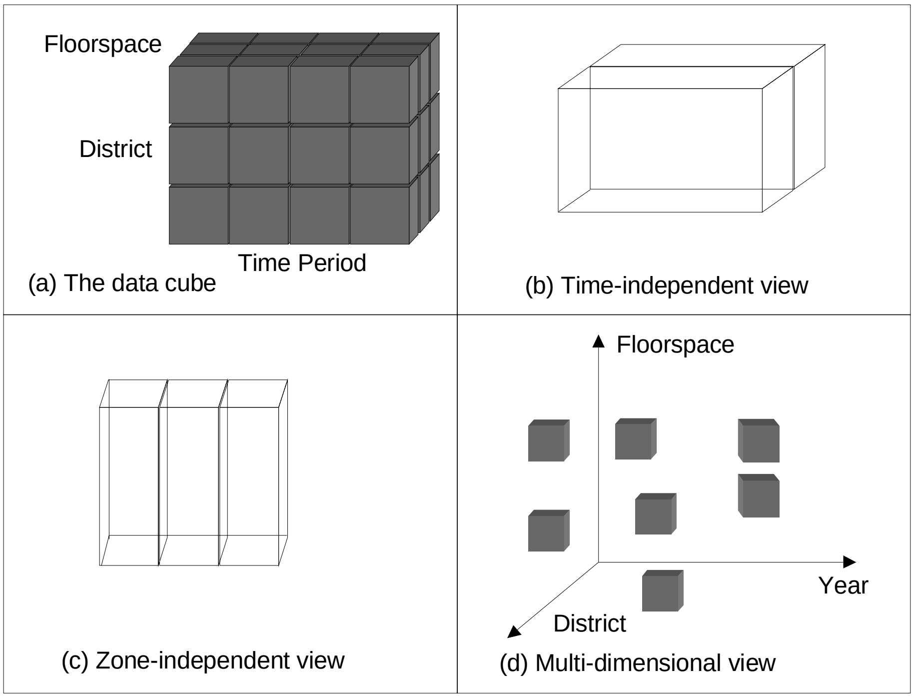

Figure 2 - Example of a datacube for accessing a datawarehouse for floorspace analysis. (a) the data-cube. (b) A time-independent view. (c) A Zone-independent view. (d) The multi-dimensional view.

Even if datawarehousing and datamining are not precisely DBMS, they are connected concepts, because:

- spatial data must be organized in order to find any kind of regularity among data,
- mining is based on spatial queries and spatial analysis
- any new future GIS DBMS must allow datamining as a core functionality.

2.2 FO GIS

Conventional GIS do not support spatio-temporal continuous data: they are only dedicated to discrete geometric data. But the modeling and storing of data derived from continuous fields such temperature, pressure, etc. imply the design of DBMS with the functionality of dealing with continuous fields (*Gordillo*, 2001).

The main characteristics are as follows:

- the user vision must be continuous; in other words it means that the modelling tools, the operators, the description and the manipulation languages must integrate continuity;
- even if at physical level everything is discrete, transparency must be provided to the user;
- fields are 3D and time oriented;
- spatial indexing must be designed and prototyped.

Figure 3 shows the two visions and their mapping, whereas Figure 4 schematizes the architecture of a FO GIS with different repositories.

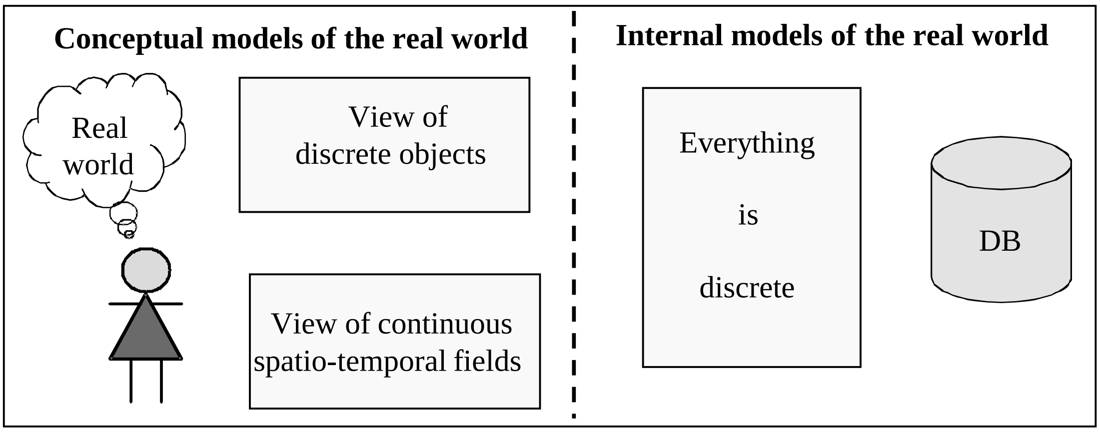

Figure 3 - The two visions for field oriented DBMS, continuous at user's level, and discrete at physical level.

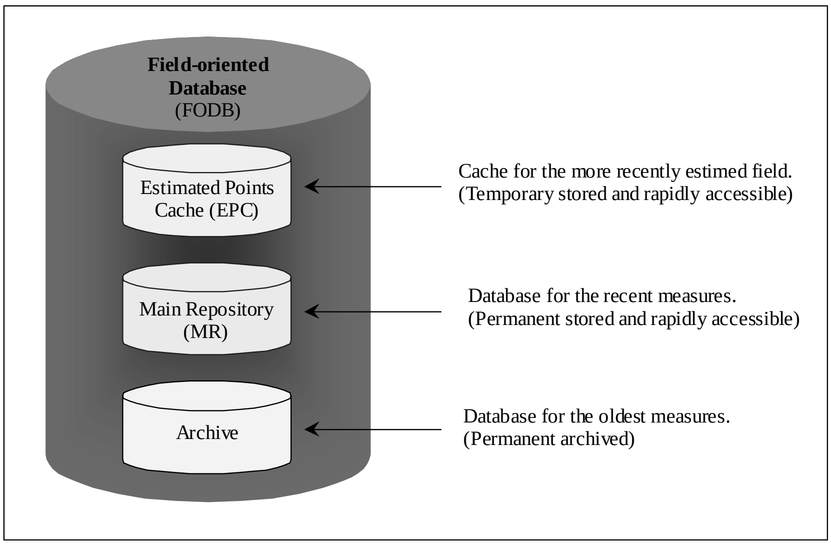

Figure 4 - Structuring continuous field data

2.3 3D DBMS

Key aspects in 3D GIS and DBMS are buildings and terrain modeling. In 3D cadastres, we do not want to model the complete buildings, but only to have a schematized shape: in other words, models made CAD architects are too much detailed for us. A special issue of CEUS review (July 2003) is devoted to 3D cadastre (*Lemmen-van Oosterom* 2003).

If 3D modelling is effective, many problems arise with efficient 3D indexing.

2.4 Real time GIS

Many applications, especially for disaster monitoring and location based services imply the design of real time GIS. Here, by real time GIS, we do not mean hard real time as found in military applications with very critical constraints, but rather soft real time. Anyway, in the foreseen geomonitoring applications, human or group decision-making procedures must be launched, for instance such as people evacuation (Figure 5).

Existing data structures give more emphasis to older data than to newer data: in other words, response times are lower for older data and higher for recent data. So, data structures giving lower responses to recent data must be designed (*Laurini* 2001). A second problem is that, during a crisis, since the sensors are sending more and more information, the system must not face database saturation, or crash. The idea is regularly to flush data to another repository, for instance into a datawarehouse. Figure 6 gives a structure with two computers.

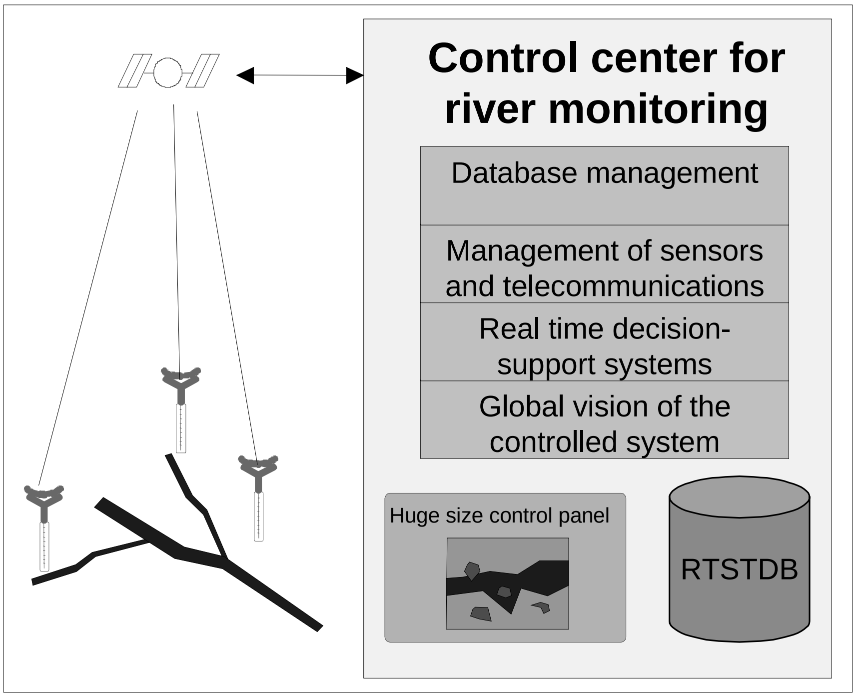

Figure 5 - Architecture for river monitoring

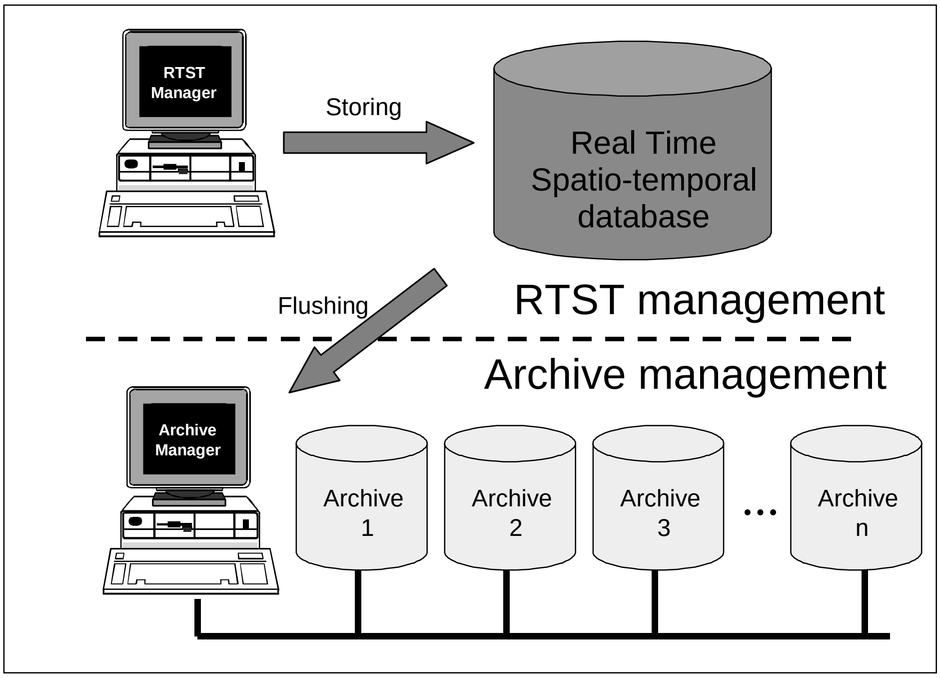

Figure 6 - Structure of a Realtime spatio-temporal database (RTST) management system with regular flushing of data into archive.

2.5 Data quality

Data quality is not exactly a database issue; however well known mechanisms such as tools to ensure or check integrity constraints are classical components of DBMS. For our concerns, new spatio-temporal database systems must integrate tools for spatial integrity constraints. Huge quality control experiments can be done during three moments, creation of the database (loading data), updating (at each update/delete/modify transaction), and when necessary.

Standards for quality control are generally integrated into metadata, such as in FGDC (1998) or ISO 19115 (2003); but they only concern quality from a data producer point of view. But daily or regular decision-making procedures demand high level quality; in other words, tools for assessing quality control from a user point of view are demanded.

Assume one has a geographic database with few errors (for instance let say 0.01%): what kind of confidence level can one confer to a result, if any? is one sure that some transactions will not crash due to errors? So, as a consequence, is it possible to provide the database mechanisms for ensuring quality?

In the domain of spatial databases, several levels of integrity constraints can be enforced:

- existential and referential quality constraints which are usually enforced in marketed DBMS and GIS,
- spatial integrity constraints (geometric and topological) which are not usually enforced in marketed spatiotemporal DBMS (*Servigne* 2000).

We think that more research must be carried out in order to fully integrate the checking of spatial integrity constraints in future GIS database systems.

2.6 XML and alikes

Extensible Markup Language, abbreviated XML (W3C 2000), describes a class of data objects called XML documents and partially describes the behavior of computer programs which process them. XML is an application profile or restricted form of SGML, the Standard Generalized Markup Language. By construction, XML documents are conforming SGML documents.

For instance, the structure of the description of a parcel will be:

```
<parcel>
      <parcel_number> 457 LM 89 </parcel_number>
      . . . .
</parcel>
```

XML documents are made up of storage units called entities, which contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data, and some of which form markup. Markup encodes a description of the document's storage layout and logical structure. XML provides a mechanism to impose constraints on the storage layout and logical structure.

The design goals for XML are:

- XML shall be straightforwardly usable over the Internet.
- XML shall support a wide variety of applications.
- XML shall be compatible with SGML.
- It shall be easy to write programs which process XML documents.
- The number of optional features in XML is to be kept to the absolute minimum, ideally zero.
- XML documents should be human-legible and reasonably clear.
- The XML design should be prepared quickly.
- The design of XML shall be formal and concise.
- XML documents shall be easy to create.
- Terseness in XML markup is of minimal importance.

XML and its extensions are more and more used for databases. The main advantages are as follows:

1 – human-legible contents; due to markups any contents and structure of a database can be understood.

2 – unstructured contents; some attributes, or structure subset can be missing or irregular. In the relational model, missing attribute values may be treated by “NULL”, but with difficulties, and extra attributes were not allowed. By “unstructured contents”, more flexibility is conferred to database contents.

3 – possibility of mixing data and metadata; this aspect will ease sharing and interoperability between different systems.

But the drawbacks are:

1 – very long description; since everything is textually described, it is very time-consuming to find something;

2 – absence of indexing; since no indexing is provided, performances are very low for querying;

3 – difficulties of using this kind of encoding for very large geographic databases.

Many extensions have been designed in order to store any kind of data. Considering geographic data, three extensions are existing, namely SVG, GML, and LandXML.

SVG

Scalable Vector Graphics (SVG) is a language for describing two-dimensional graphics in XML (W3C 2001). SVG allows for three types of graphic objects: vector graphic shapes (e.g., paths consisting of straight lines and curves), images and text. Graphical objects can be grouped, styled, transformed and composed into previously rendered objects.

SVG drawings can be interactive and dynamic. Animations can be defined and triggered either declaratively (i.e., by embedding SVG animation elements in SVG content) or via scripting.

SVG is a language for rich graphical content. For accessibility reasons, if there is an original source document containing higher-level structure and semantics, it is recommended that the higher-level information be made available somehow, either by making the original source document available, or making an alternative version available in an alternative format which conveys the higher-level information, or by using SVG's facilities to include the higher-level information within the SVG content.

GML

GML (*Lake*, 2000) or Geography Markup Language is an XML based encoding standard for geographic information developed by the OpenGIS Consortium (OGC).

GML is concerned with the representation of the geographic data content. Of course we can also use GML to make maps. This might be accomplished by developing a rendering tool to interpret GML data, however, this would go against the GML approach to standardization, and to the separation of content and presentation. To make a map from GML we need only to style the GML elements into a form which can be interpreted for graphical display in a web browser. Potential graphical display formats include W3C Scalable Vector Graphics (SVG), the Microsoft Vector Markup Language (VML), and the X3D. A map styler is thus used to locate GML elements and interpret them using particular graphical styles.

LandXML

The LandXML schema facilitates the exchange of data create during the Land Planning, Civil Engineering and Land Survey process. Land development professionals can use LandXML to make the data they create more readily accessible and available to anyone involved with a project. With LandXML, project data is independent of the authoring software, thus overcoming the interoperability problems that have plagued the land development industry. Not only does LandXML provide interoperability between different application software, but also between varying versions of software. As a result, data can be archived and accessed more readily on future projects. Additionally, other web-based tools can be used to view, edit, and report LandXML data.

XMI

XMI (XML Metadata Interchange) is a widely used interchange format for sharing objects using XML. XMI defines many of the important aspects involved in describing objects in XML:

- The representation of objects in terms of XML elements and attributes is the foundation.
- Since objects are typically interconnected, XMI includes standard mechanisms to link objects within the same file or across files.
- Object identity allows objects to be referenced from other objects in terms of identifiers.
- The versioning of objects and their definitions is handled by the XMI model.

2.7 Ontologies

In order to make interoperability possible between several systems, opinions are converging to the use of ontologies. From the computer science point of view, an ontology is defined as a formal vocabulary (a set of concepts, a set of objects, and a set of relationships) collected for a given discipline. Ontologies are especially used within the framework of the interoperability of databases, and the conceptual co-operative systems (Groupware). According to *Gruniger* et al. (2002)2, ontologies can provide the following:

- Communication between humans and machines,
- Structuring and organizing the virtual libraries, and the receptacles of the plans,
- Reasoning by inference, particularly in very large databases (Google is undoubtedly very well known example using reasoning services).

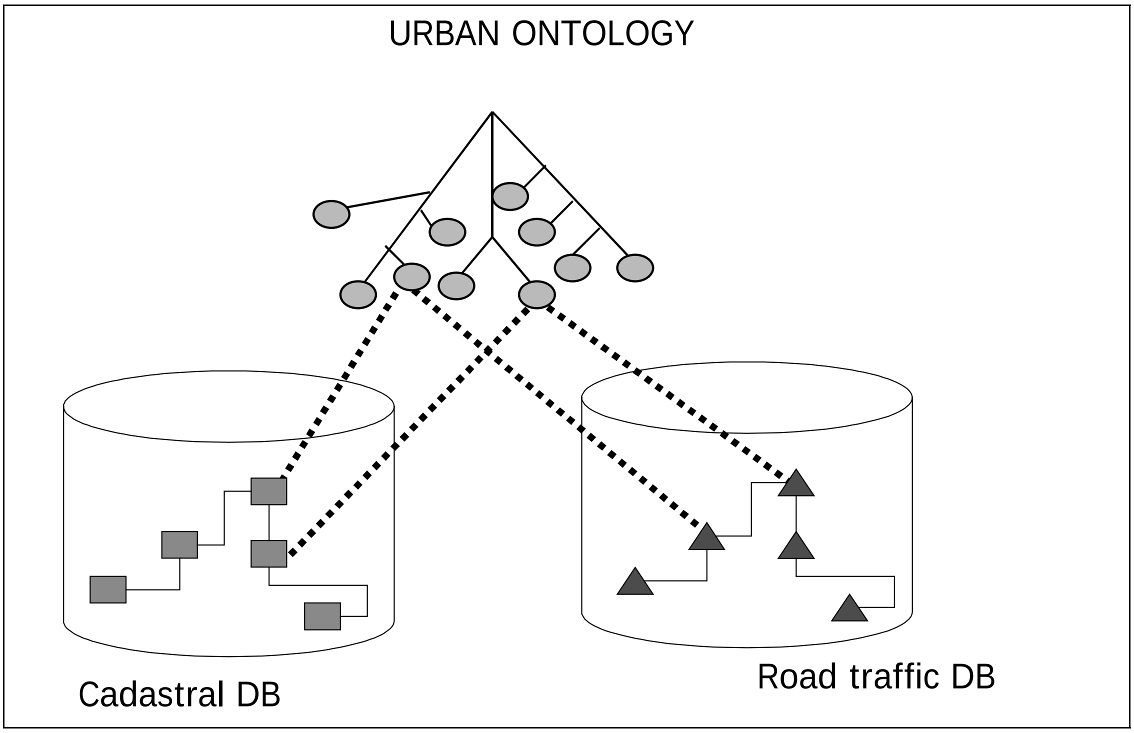

Figure 7 - Interoperability between two databases by means of an ontology

Figure 7 describes the way two databases can cooperate trough ontologies. Each database has its own ontology (or conceptual model), and concepts are matched to concept of a larger ontology, named “Urban Ontology” in Figure 7.

Due to the absence of real ontologies in urban planning, we have decided to launch a project named “Towntology” for designing an ontology for cities and planning affairs. To date, only street planning is done with around 700 concepts in French language.

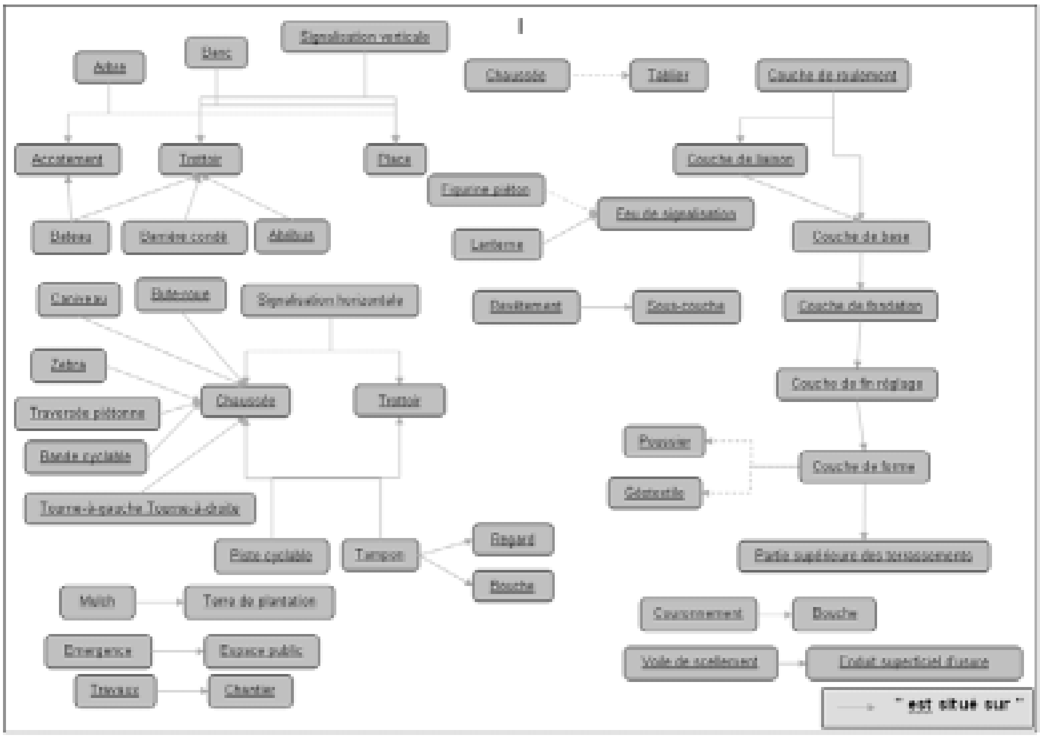

Figure 8 - Excerpt of a street planning ontology (Towntology Project)

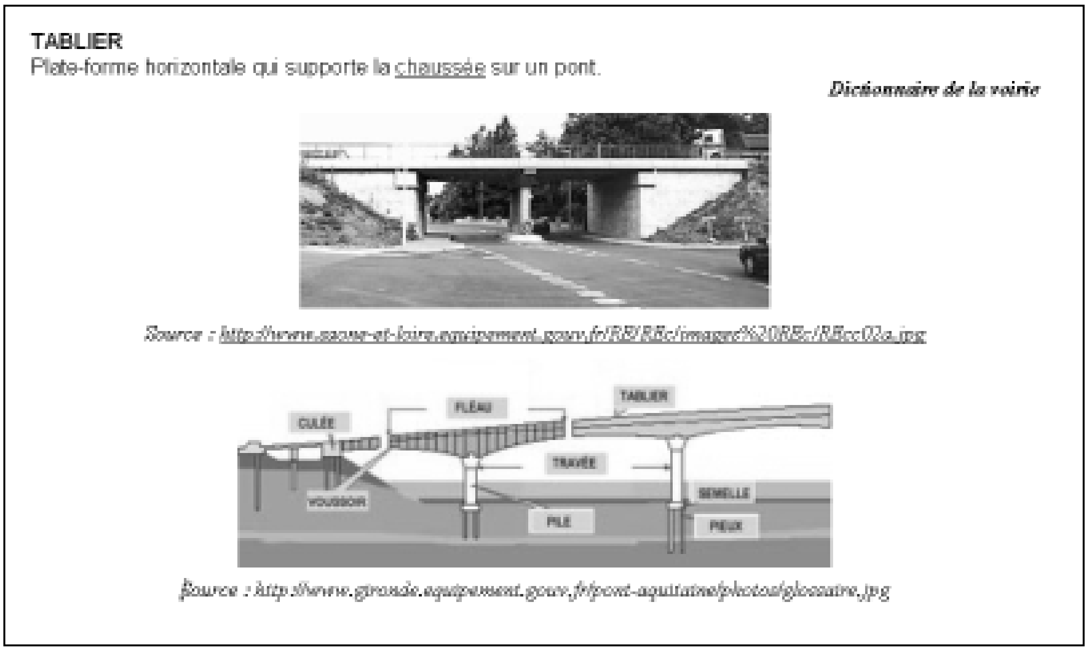

Figure 9 - Definition of concepts in Towntology

2.8 Mobile queries and transactions

By mobile queries or transactions, we mean queries and transactions whose results depend on the user's location; for instance when a pedestrian is asking for the nearest restaurant, or taxi. Or a vehicle can ask for the five nearest gas stations. For LBS, this is a crucial functionality.

Another category of queries is continuous queries. A continuous query is defined as a query compiled once, and executed several times. For instance, the flow of data coming from sensors can be continuously queried for checking data validity, or filtering.

The query regarding the five nearest gas stations can be considered as mobile and as continuously if the vehicle's driver wants to know always this situation. In this case, answers can be presented by animated cartography. See Figure 10.

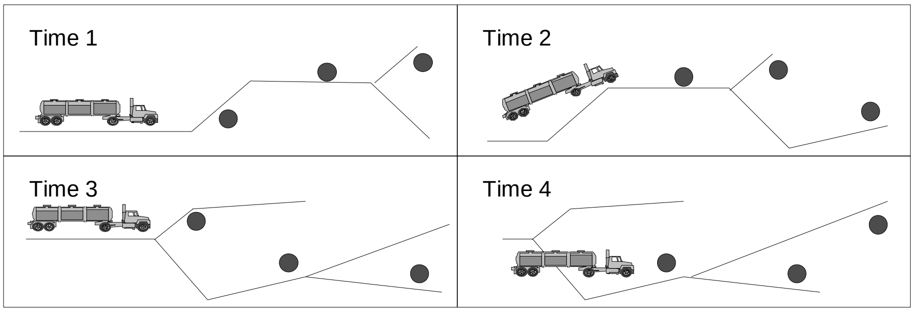

Figure 10 - Example of mobile query "A running lorry is continuously asking for the three nearest gas stations".

3 FINAL REMARKS

In this paper, we have listed functionalities which must be integrated in the GIS databases of the future.

In early days of GIS, due to the specificities of geography data, proprietary spatial DBMS were designed and implemented. Since the inception of ORACLE SDI, some GIS vendors have decided to offer their customers the possibility of storing geographic data with ORACLE, instead of using the proprietary system.

Another aspect is the importance of XML which pushes to use XML extensions for storing geographic data, but the temporal performances are still very low.

Now, due the emergence of new specificities such as field oriented data, real time GIS, 3D for which performances are a very crucial point, our feeling is that new generations of GIS proprietary systems will be designed to meet the required performances.

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THE RESEARCH GOALS AND THE RESEARCH STRATEGY OF THE EuroSDR

Martien Molenaar
Vice President of EuroSDR

International Institute for geo-Information Science and Earth Observation (ITC)
Enschede, The Netherlands

ABSTRACT

The rapid development of the modern Information Society and within that of GSDIs has important consequences for the role of NMAs and geoinformation providers in general. In the past the activities of OEEPE concentrated on the development of procedures and methods for spatial data acquisition through photogrammetry and other (digital) imagery. The organization decided recently to change her name into EuroSDR and to redefine here objectives and strategies and broaden her scope to do research on the technology and methods related to all different stages of geo-spatial core data provision processes. This means that research will now deal with data acquisition, data storage and retrieval, data processing and presentation and dissemination and integration with other data. This presentation will explain the consideration leading to these new research goals and strategies.

1 INTRODUCTION

Today we celebrate the 50^{th} anniversary of an organisation that was called OEEPE but that starts the next fifty years of its existence under name EuroSDR. The change of name was considered relevant because the scope of the organisation has widened. In the first fifty years the emphasis was on photogrammetry; the founding fathers of OEEPE had a clear vision that this technology, which was rather new at that time, could play an important role in the timely production of map data. They were even able to convince their governments that these data were of great importance for the development of the countries of Europe so that an agreement between their governments was arranged with the purpose to do experimental studies to explore and improve the potentials of photogrammetry. Looking back we see that this was an exceptional feat, never repeated ever after.

In the fifty years of its existence OEEPE was instrumental in the emancipation of photogrammetry as a tool for mapping. OEEPE projects proved that this technology could significantly speed up mapping processes and that it enabled the production of maps with an accuracy level comparable to the traditional surveying techniques. The mid seventies the time of the Oberschwaben tests were the high days of OEEPE because their accuracy results meant the definite breakthrough of photogrammetry as full-grown mapping instrument. Many other projects demonstrated the possibilities of photogrammetry for the production of topographic data and contour lines. Other projects demonstrated the usefulness of new products like orthophotos and digital height models and a logical next step in the development was the production digital terrain models instead of paper maps. At that moment the first step was made in the direction of digital spatial databases. That was in the early eighties but it took almost twenty years before the full impact of this (gradual) breakthrough was properly understood so that the organisation could draw the consequences of this development.

In the mean time we have seen the advent of remote sensing, digital image processing and GIS or rather geo-informatics. With the development of digital spatial databases came the need for data exchange. The role of the traditional maps was now in the context of visualisation rather than dissemination. Digital data exchange means generally data integration and that requires standards but also a framework, which can be provided by geodetic reference systems and core topographic data. With that we see the role of topographic information changing it is no longer the production that is the key problem for national mapping agencies but the delivery of these data and derived products and services in a geo-spatial data infrastructure. This development was the reason why OEEPE had to redefine its role for the spatial information community and see how we could best support new developments in this field. This new role should be embedded in our tradition of experimental studies in projects where academia and organisations involved in spatial information production and dissemination cooperate and the focus should be on the provision of core data. The definition of this new role went though three stages:

- The formulation of a New Long-term Strategy 2000 document, approved at the 95th Steering Committee meeting in Paris, France, November 1999.
- The formulation of a New Mission and Strategies statement, approved at the 96th Steering Committee meeting in Longyearbyen, Norway, June 2000.
- Implementation of the new Mission and Strategies in the Rolling Research Plan 2001-2003, which defines the framework within which the research of the organisation is performed. This rolling plan has been approved at the 97th Steering Committee meeting in Ankara, Turkey, November 2000. (*EuroSDR, 2000*)

Finally amendments to the 1953 agreement have been formulated and the organisation decided to modernise the name to the present EuroSDR.

2 EUROSDR VISION AND MISSION

In these documents EuroSDR formulated the vision that it wants…

> *….to be the European research platform for National Mapping Agencies (NMAs), Academic Institutes, Private Sector, Industry and User's Groups, on issues related to the implementation of technology developments in view of optimising the provision (collection, processing, storage, maintenance, visualisation, dissemination and use) of core data (data serving as a spatial framework for organisations involved in monitoring, management and development) in a Geoinformation Infrastructure (GII) context.*

This vision clearly states that the organisation wants to address an audience wider than the present NMAs and academia. The world of geo-spatial core data provision is changing rapidly with new relationships developing between the players in this field. This is due to several reasons like the revolutionary development of technology, the changing role of government, the globalisation of markets, the liberalisation of markets, etc.

Certainly the last twenty years governments are outsourcing many tasks especially production tasks. In this line many NMAs have outsourced activities like data acquisition and map data production and a new industry develops for the provision of geodata based services and added value products.

At a European level EUROGEOGRAPHICS is developing interesting projects the create pan European datasets, to tackle cross boundary issues and harmonise the production of geo-spatial core data. These are product and result oriented initiatives. It is quite obvious, however, that realisation of these projects will meet many technical and other problems that need to be solved. Many of these problems will require (experimental) research to find strategic solutions.

Furthermore we see that users of geodata and thus of core data are required to pay for these data and services and this of course implies that they want to have a say in the specification of the products. This means a more intensive interaction between the different parties involved in geoinformation infrastructures. We see a rapid transformation from a supply driven to demand driven market.

We see also a rapid transformation of the professional groups involved in this market. There were the professional mapmakers, i.e. geodesists, cartographers, surveyors and photogrammetrists. Then in the seventies and eighties a remote sensing and GIS community evolved which consisted in the early days of interested experts from other fields and pioneering amateurs who obtained their skills by training and through experience. Nowadays the gi-community consists increasingly of highly educated professionals. These professionals can be divided in three major groups:

1. Experts in the field of spatial information handling (or specialists in certain aspects of this field),
2. Users of geo-information and
3. Professionals and policy makers, who are aware of the importance of geo-information for Civil Society.

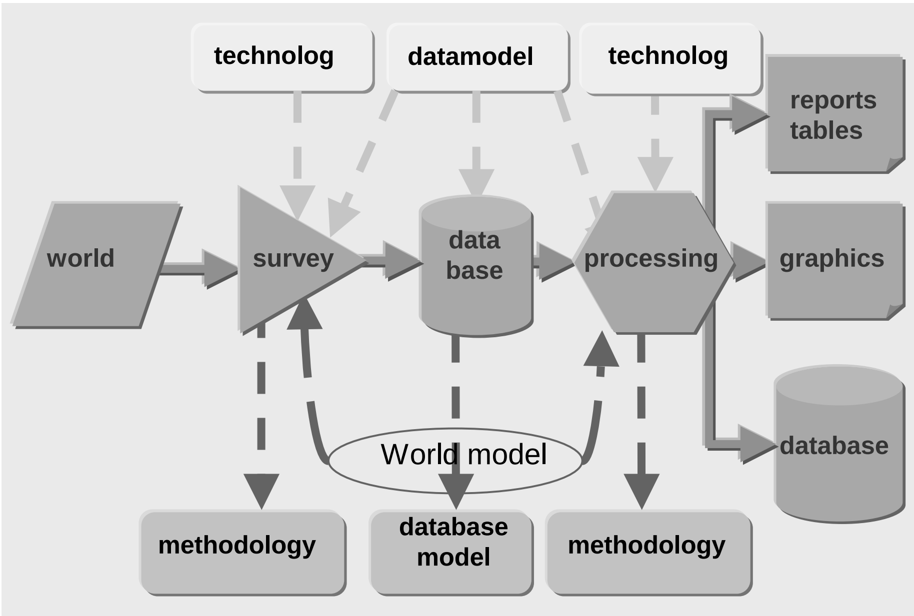

Figure 1 - The structure of geo-information production processes.

These three types of professionals each play their own role in processes for geo-information provision and these processes should be seen from two angles:

a) *The structure of processes* for geo-information production with the stages of data acquisition, storage and retrieval, processing and presentation and dissemination and use. See Figure 1.

b) These processes can be seen in *different contexts.* EuroSDR traditionally looks at it in the context of the applied technology with the aspects of sensor systems for data acquisition, the systems and methods for information extraction from images and the systems and methods for information storage and retrieval and dissemination. But these information production processes can also be seen in the context of the application domains. These cover a wide variety of fields, such as land registration and administration, natural resources management, disaster mitigation, etc. Other contexts are the information flow management with its organisational aspects and also the institutional and policy issues.

Figure 2 shows how these different viewpoints relate. This figure also shows that the activities of EuroSDR traditionally paid most attention to the technological issues of data acquisition and processing and presentation and less to data storage and dissemination.

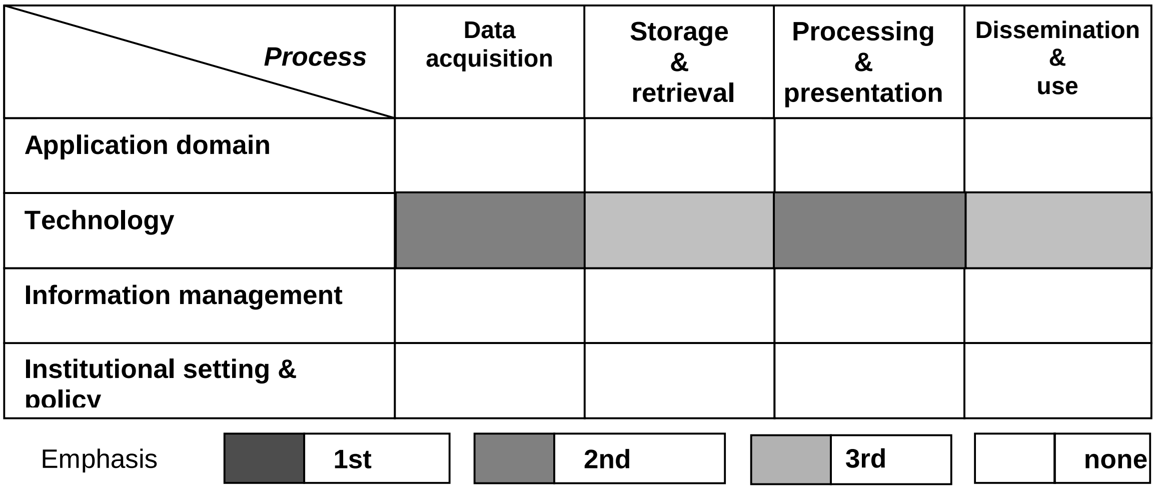

Figure 2 - aspects of spatial information handling processes and the context of these processes and the emphasis of OEEPE in the past.

Other contexts then technology were hardly dealt with. Experts or organisations involved in this field are generally active in only a few blocks of this diagram. Within this environment EuroSDR reformulated its objectives and strategy. The scope has been widened, the mission of EuroSDR is now to

- *Develop and improve methods, systems and standards for the acquisition, processing, production, maintenance and dissemination of core geo-spatial information and to promote applications of all such data. Special emphasis is put on the further development of airborne and space borne methods for data acquisition, on methods for information extraction from these sources and on the integration of this information with information from other sources.*
- *Encourage interaction between research organisations and the public and private sector to exchange ideas about relevant research problems and to transfer research results obtained to geoinformation production organisations.*

The emphasis is still on the technological aspects but now all stages of the information production process will be addressed including also database issues and delivery mechanisms. The organisation still focuses on core and framework data, but this will be seen more in the context of their use.

3 EUROSDR RESEARCH PERSPECTIVE AND TARGETS

3.1 The Research Perspective

The mission statement specifies the field of activity of EuroSDR, but this is still a "mer a boire" so that priorities are required for the actual research program and a clear research perspective should be given. As EuroSDR is an agreement between governments we should first of all support our governments an their organizations, like NMAs, to develop their strategies in this respect.

With the present developments of technology for data collection, representation and management and dissemination NMAs but also other organizations involved in processes of spatial information production, dissemination and use will have to anticipate on their position and role in this field in the coming ten years. The new opportunities offered by the modern technology, the new concepts of the role of government and the evolving new (global) economy will have an impact on the development of (national) geo-data infrastructures.

What should be the role of governments? Do they have a regulatory role or should they be providers of information or should they only provide the infrastructure through which geo-information is provided? How should the core data for such an NSDI be defined, who will be the prime users and who should produce it? At which aggregation levels should GSDI be provided, national, provincial and or local?

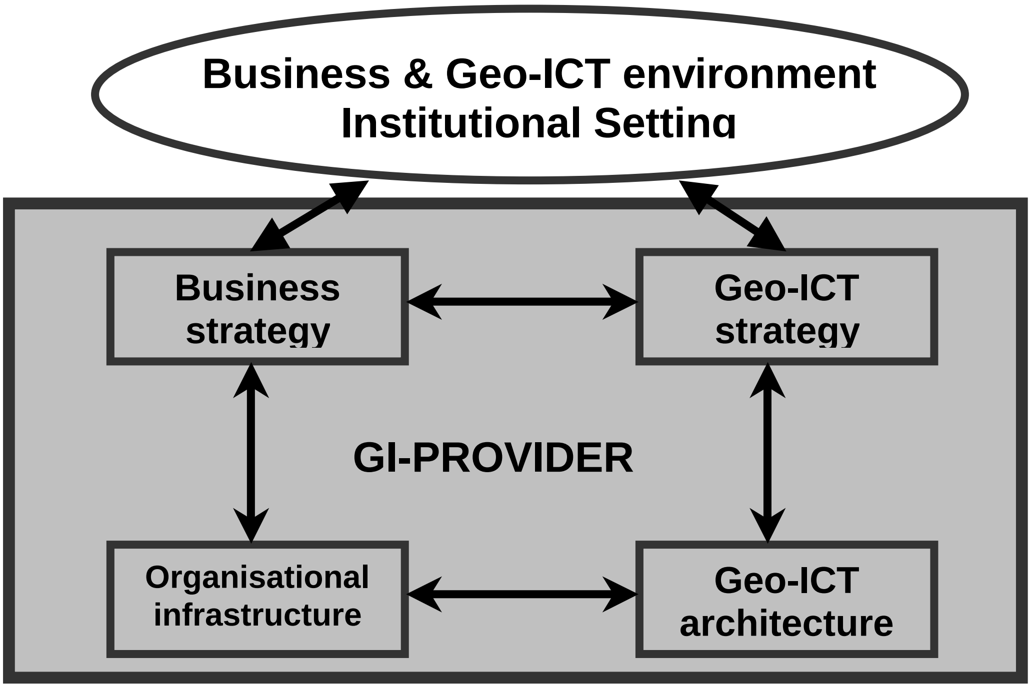

Figure 3 - GI-Providers have to adjust their strategies, organizational structure and ICT architectures to meet the modern challenges of their Business and Geo-ICT environment (Courtesy of Dr *Geogiadou,*, ITC)

GI-providers, and NMAs among them have to answer these questions to establish their roles in the modern evolving information society. Within this society a new business end Geo-ICT environment is emerging which forces GI-providers to develop new business strategies. Consequently they have to adjust their Geo-ICT strategies and develop new Geo-ICT architectures and adjust their organizational structure. This has been illustrated in Figure 3. EuroSDR has the expertise to anticipate on the new opportunities offered by the new technology and to elaborate scenarios for the development new GDIs with respect to the definition core or reference data, and the new products and services that should be provided and the technological infrastructure required. Therefore the contribution of the Organization will mainly be in the support of the development on new Geo-ICT strategies and architectures.

Following from these considerations the following criteria have been formulated for the EuroSDR research perspective (*EuroSDR, 2000*):

- *The EuroSDR research should serve the whole European Geoinformatics Community, deal with problems of more than local significance, and be carried out by means of international co-operation.*

- *EuroSDR should broaden its field of activities, yet keeping relevance to data acquisition. On the other hand there are too many applications to address all of them; therefore choices should be made.*
- *Core geo-spatial databases should take a central position in EuroSDR activities; this includes geo-spatial data modelling, maintenance, integration, delivery and access mechanisms*
- *EuroSDR should profile itself as a technology exchange platform (professional and commercially neutral platform) to provide services to the European GI community*
- *Collaboration with other organisations and use of new data modelling paradigms should be encouraged.*
- *Private sector and industry should be involved.*
- *EuroSDR results should be timely available (short project phases with intermediate deliverables).*

3.2 The Research Targets

It is quite clear that the development of GDIs will provide a major context for the research agenda of EuroSDR. The information components of the GDIs that are generally still based on the traditional map paradigm. But within this paradigm we see the development of nw products and services. That is that the old concept of maps evolved into digital maps and from there into seamless databases and presently we see scaleless databases emerging, slowly but surely. The line map is more and more replaced by object-structured representations. The dimensionality evolves from 2D to 2.5D and users have access to data and services that allow them to create rectified or draped high-resolution images according to their own needs. Core data are also provided through new delivery mechanisms that support the present fast development location based services and mobile GIS.

But we see also new development lines that are no longer embedded in the traditional map paradigm. Object structured approaches allow other spatial representation that go beyond those contained in this paradigm. The development of the dimensionality of spatial data bases from 2D to 2.5D and beyond to 3D and 4D will allow new types of representation of dynamic spatial complexes where we can travel through space and through objects. Based on the integration of images with these 3D and 4D data base models VR and augmented reality representations have been developed in the form of e.g. city models, street models and buildings. First developments have been shown on the combination of GIS and CAD techniques where city models zoom in to individual buildings, which can be entered to inspect the interior of these buildings.

It is very likely that planners and engineers developing physical (urban) infrastructures etc. will require such presentations with object information at multi-resolution levels rather then the traditional map data. Professional users will see spatial data as one component of an integrated set of information with also administrative, management and planning data. Organizations involved in future spatial data management should anticipate the technical issues they will have to face.

EuroSDR has a clear role to play in this field and has accepted some twelve main research subjects where it intends to contribute. These are without any priority arrangement (*EuroSDR, 2000)*:

1. *Sensor systems (including calibration aspects)*
2. *Geometric data acquisition issues (geo-referencing, DEM)*
3. *Semantic data acquisition issues (information extraction, contents, automation)*
4. *3-D core data; emphasis on spatial modelling, information extraction and tools for 3-D*
5. *Integrated problem solution from industry (systems manufacturers should become more database centric)*
6. *Process modelling and interfaces (product diversity/servicing)*

7. *Core geo-spatial databases (data modelling, currency/maintenance, unique ID, metadata, changes only)*
8. *Data integration (integrating core data with other data)*
9. *Generalisation in terms of up-scaling/down-scaling*
10. *Harmonisation requirements on core data (cross-border issues; e.g. river basins, transportation networks)*
11. *Delivery mechanisms and access to data (internet and standards)*
12. *Geo-spatial data quality*

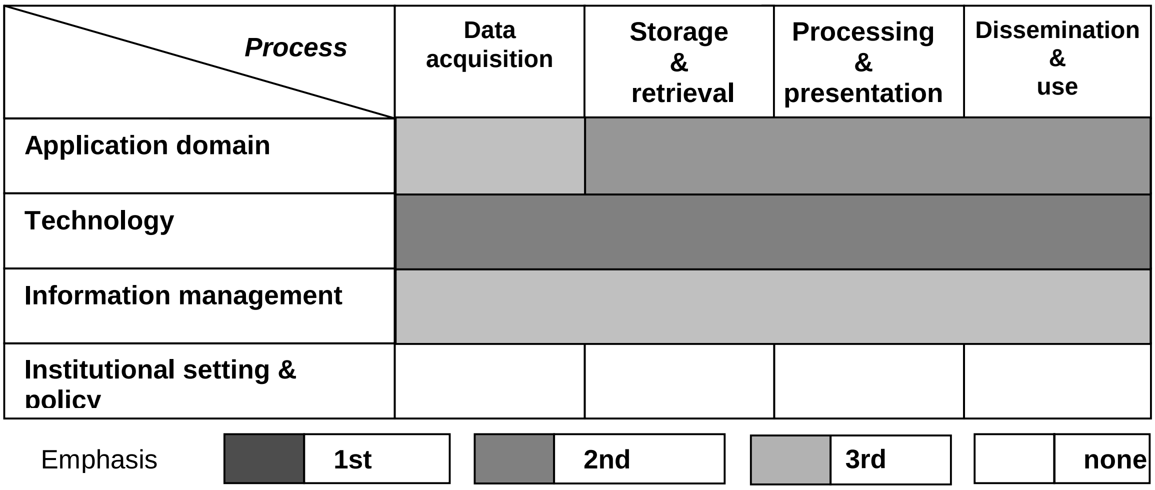

Figure 4 - EuroSDR new research priorities

Figure 4 shows how the EuroSDR research interest has widened compares to the earlier situation. Technological issues of the whole geo-information production flow are covered now. The prime field of interest is still the production of core data, i.e. large and medium scale topographic data; but this is now dealt with in the setting of GSDI. This means that the link has to be made to the different types of application domains where this information is used. This is certainly true when we see the shift from map structured data products to object structured approaches. These imply a higher semantic content of the data, which requires a better integration with user environments to provide relevant semantics. The GSDI setting also implies that information management issues have to be dealt with to provide for timely data delivery and to facilitate the integration of geo-spatial core data with other (geo-spatial) data.

3.3 The research structure

The five Commissions of the Organization will implement the new research strategy. Their main task is to initiate projects and publish their results. The Commissions should also stimulate interaction between the different parties playing in the field of core data provision and its use. The commissions are (*EuroSDR, 2000*):

Commission 1: Sensors, Primary data acquisition and Georeferencing
Its mission is to to explore, demonstrate, and further develop

- airborne and spaceborne sensors for data collection
- calibration aspects of such sensors
- methods and instruments for georeferencing of such data

- reliability, since new systems allow for a very low number of ground control
- geometric quality of spatial data acquisition
- DEM quality

and to encourage transfer of research results obtained in this field from academia to the public and private sector.

Commission 2: Image Analysis and Information Extraction
Its mission is to explore, demonstrate, and further develop the applicability of image analysis methods for automatically extracting and updating geo-spatial data from images and collateral information with special emphasis on:

- Information content of multi-spectral, multi-sensor, multi-resolution, and multi-temporal imagery;
- Methods and algorithms for automated acquisition of geo-spatial data and the description of data quality;
- Methodology for the integrated acquisition and update of geo-spatial data from imagery and collateral information.

Commission 3: Production Systems and Processes
Its mission is to evaluate, demonstrate and further develop production systems and processes for handling geo-spatial information by closely incorporating private industries in these OEEPE activities.

Special points of interest are:

- Evaluating and when applicable testing problem solutions from industry for Integrated (geometric/semantic) data provision processes, with special emphasis on 3D core data, data base integration, data quality and performance (time, cost, flexibility) of integrated data provision systems/processes.
- Encouraging private industries to contribute to OEEPE activities with mutual benefits like:
- Supporting the standardization for data exchange of sensor data, geometric data and semantic data

Commission 4: Core Geospatial Databases
Its mission is to investigate, evaluate and document the development of geospatial databases for storing and maintaining national core/framework data. This includes related data management research topics in extending the capability of such databases such as:

- developing 3D data models and datasets
- linking 3rd party data,
- developing the temporal component of spatial data models and
- deriving smaller scale datasets/products from the definitive database.

Commission 5: Integration and Delivery of Data and Services
Its mission is to investigate, evaluate and document developments in the technologies for the integration and delivery of all forms of geospatial information, including information derived from imagery. Major themes are the impact of the Internet and related technologies such as XML, the shift to service-based architectures and the use of object models for information.

Special points of interest are

- Methods and mechanisms for integrating core (framework) data with other geospatial and business (or value-added) data.
- Harmonisation requirements on core data, including cross-jurisdiction issues.
- The adoption of new Delivery mechanisms, specifically the Internet and mobile communications, and their effect on the business models and practices of NMA's
- Methods and mechanisms for delivery of metadata with emphasis on data quality information
- Applications of visualisation technology to geospatial information

4 CONCLUSIONS

EuroSDR developed its research goals and strategy to meet the requirements of the modern geo-spatial information community. The main objective is to initiate and do research to improve the present practices and to develop new methods for the provision of core data. The domain of the Organization expanded from data acquisition and information extraction from image data to all the aspects of information provision processes. That means that the Organization also deals with technological and methodical aspects of data base issues, delivery mechanisms, data processing, integration and presentation etc.

Because core data provision will be in the context of GSDI the field of interest also expanded to cover issues of information management. Data integration is one of the important aspects of data exchange. This implies that more attention is required to deal with the users aspects of geo-spatial core data.

To keep a research orientation focused on the needs of a wider geo-spatial data community EuroSDR encourages interaction between research organisations and the public and private sector to exchange ideas about relevant research problems and to transfer research results obtained to geoinformation production organisations.

REFERENCE:

EuroSDR, 2000: *Rolling Research Plan 2001-2003*, European Organisation For Experimental Photogrammetric Research OEEPE

EUROSDR INVESTIGATIONS OF MODERN PHOTOGRAMMETRIC TECHNIQUES

Olaf Hellwich
Technical University Berlin, Germany

FOREWORD

This contribution exemplarily shows how an application-oriented investigation is conducted under the auspices of EuroSDR. At the beginning frequently stands the observation that common practise in the field of photogrammetry and GIS is about to change due to the transformation of research results into practical procedures. At this point in time, a new technique is available, yet the chances and risks of use are not known to a wider audience. This situation often lets practitioners in administration and engineering companies hesitate to use the novelties. It is EuroSDR's ambition to clarify chances and risks, and – consequently – to motivate practitioners to use the new methods themselves, and apply them to different tasks.

Here, a closer look is taken to the "EuroSDR Sensor and Data Fusion Contest: Information for Mapping from SAR and Optical Imagery". The article presented in part I of this contribution has previously been published in the proceedings of the ISPRS Commission III Symposium 2002 in Graz. It explains the goals of the test and the potential of the data provided to test participants.

During the preparation of a EuroSDR project, besides clarifying goals and procedures, usually the test data is collected and participants of the test are solicited. Before the beginning of the actual test, the optimum way of participation of each interested party is inquired – e.g. by a questionnaire as the one shown in part II.

The sensor and data fusion contest described is still under way, and further participants are welcome to join in.

Part I

SENSOR AND DATA FUSION CONTEST: TEST IMAGERY TO COMPARE AND COMBINE AIRBORNE SAR AND OPTICAL SENSORS FOR MAPPING[1]

Olaf HELLWICH, Andreas REIGBER, Hartmut LEHMANN

Technical University Berlin, D-10623 Berlin, Germany
Department for Photogrammetry and Cartography
Phone: +49-30-31422796, Fax: +49-30-31421104
E-mail: hellwich@fpk.tu-berlin.de

Working Group III/6

KEY WORDS: Data fusion, Multi-spectral data, Radar, SAR, Multi-temporal, Object recognition

ABSTRACT

Presently, a data fusion contest is conducted to compare the potential of airborne SAR with optical sensors for mapping applications. The goal of the test is to answer two questions: (1) Can state-of-the-art airborne SAR compete with optical sensors in the mapping domain? (2) What can be gained when SAR and optical images are used in combination, i.e., when methods for information fusion are

[1] published in the International Archives of Photogrammetry, Remote Sensing and the Spatial Information Sciences, Vol. 34, part 3b, pp. 75-78, Graz 2002.

applied? The test is organized in the framework of the IEEE GRSS data fusion technical committee (DFC), ISPRS working group III/6 “Multi-Source Vision”, which both have strong relations with scientists, active in research on sensor fusion and automation in mapping, and – as the provider of the main organizational framework – the European Organization for Experimental Photogrammetric Research (OEEPE), which is the European research platform of national mapping agencies and other institutions, regarding technology developments to optimize the use of core data in a geoinformation infrastructure context. In the preparatory phase of the test, which has been started on the occasion of IGARSS 2001, test data has been collected and the scope of object extraction for mapping has been defined. The outcome of this phase, i.e. the test imagery to be used in the contest and its potential for mapping is presented in this paper.

1 DATA

A data fusion contest, titled “Information for Mapping from Airborne SAR and Optical Imagery”, is organized under the umbrella of OEEPE, IEEE GRSS DFC, and ISPRS WG III/6 and will be started in summer 2002. The contest has been announced on the occasion of the International Geoscience and Remote Sensing Symposium 2001 in Sydney [1]. In the mean time, existing test imagery from three test sites has been collected and the object types to be extracted from the imagery have been defined based on an intensive discussion with parties interested in the investigation.

In order to be able to map objects, relevant for map scales of about 1:25,000, with sufficient correctness, completeness, accuracy, and robustness, it is advisable to use optical imagery with a resolution of 1 m, when automatic image analysis methods are to be applied. The reason for the use of such a high resolution (1 m in a scale of 1:25,000 corresponds to only 0.04 mm) is that it is difficult to interpret airborne imagery, when objects in complex environments are to be extracted. Another reason is that topographic maps often contain linear objects, which have a width of only 3 to 5 m.

When SAR imagery is to be used instead of optical imagery, speckle should be eliminated at least partially. Therefore, the SAR imagery should have a nominally higher resolution than the optical imagery. This is why it is planned to use for the mapping contest only SAR imagery of the worlds highest resolving airborne SAR systems presently publicly available.

In order to also account for the large variety of modern SAR systems, different frequencies as well as polarimetric data were selected. Certainly, there are more parameters strongly influencing the appearance of topographic objects in SAR imagery – such as incidence angle and direction. In spite of their importance regarding object appearance, these parameters could not be considered for the selection of appropriate data, as the high demands of the contest, regarding resolution and other more practical matters, such as data costs and copyright, are already quite restricting. Nevertheless, the authors are convinced that the image data will provide a very good opportunity to investigate the applicability of SAR for mapping purposes.

The test areas to be investigated were selected neither to be of a too complex nor to be of a too simple structure. For instance, very densely built-up urban regions can hardly be found in the test data. They certainly would have posed a hard challenge for SAR imaging, so that it seems appropriate not to investigate them intensively at this stage of the test. Therefore, the test areas selected mainly include agricultural and forested rural areas as well as industrial areas with large flat buildings.

They are located in Central Europe and Scandinavia.

The objects to be extracted from the imagery are roads, built-up areas, forests, agricultural fields, lakes, rivers, and railroads. Forests and agricultural fields should be subdivided into different types. The results of object extraction will be evaluated on the basis of different national mapping standards.

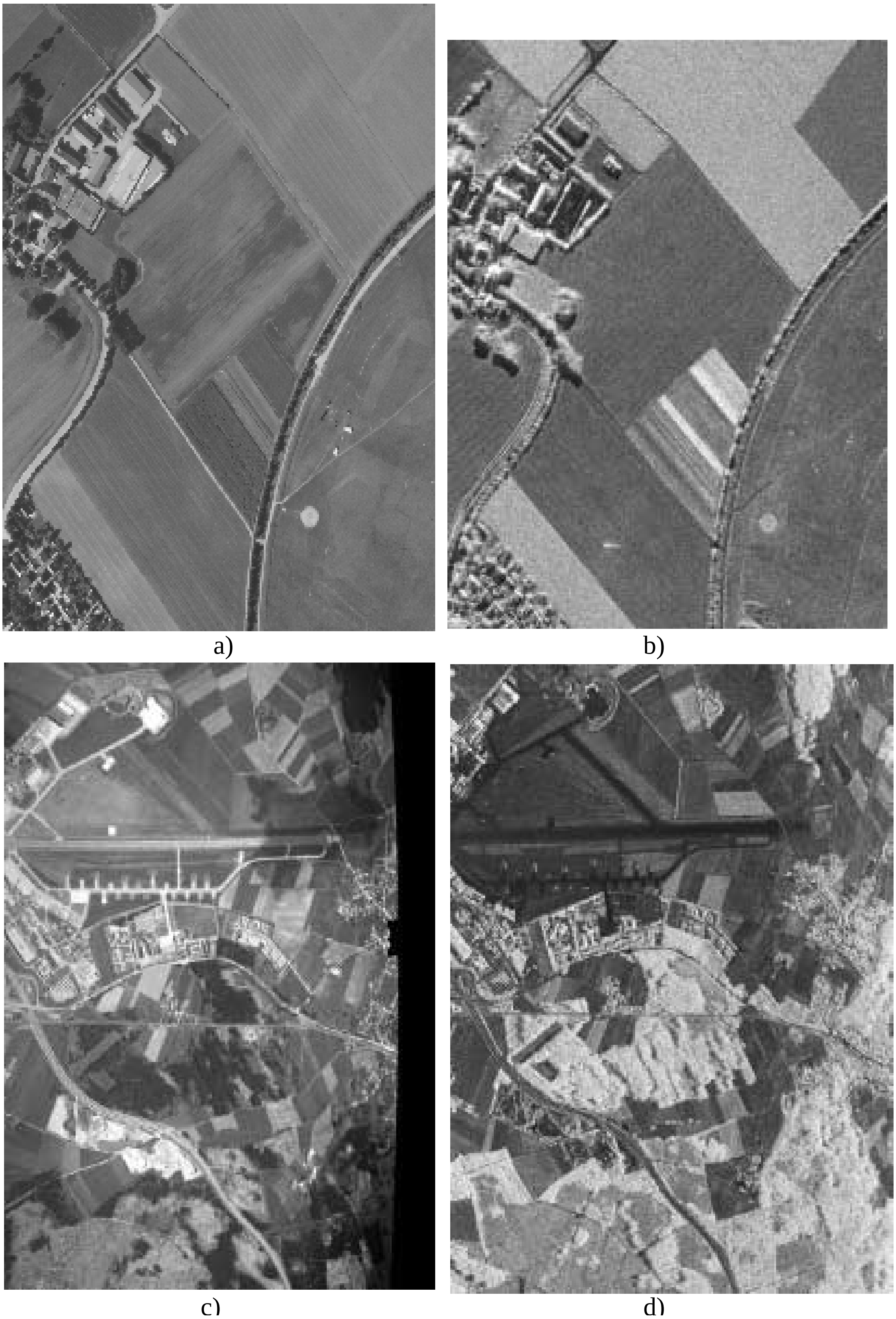

Figure 1 - Example of data sets used in the contest: a) high-resolution optical image (part of testsite Trudering), b) high-resolution X-band SAR image (part of testsite Trudering), c) airborne optical image (testsite Oberpfaffenhofen), d) L-band polarimetric SAR image (testsite Oberpfaffenhofen).

2 EXAMPLES

Figure 1 shows examples of data samples, which are going to be used in the contest. They give an impression of the mapping potential of optical and SAR data, both in a competitive as well as a complementary sense. Fig. 1 a) shows high-resolution optical data, acquired by an airborne sensor at a resolution of 0.4m. For comparison, in Fig. 1 b), SAR intensity data of the testsite of Trudering/Germany, acquired by the commercial airborne X-band sensor AeS-1 [2], is shown. This sensor reaches a resolution of about 40cm and is, therefore, very well suited for mapping purposes. It demonstrates very well the high image quality that can be obtained with modern SAR sensors. Due to the high resolution, speckle effects are relatively small in this data, nevertheless it is clearly visible when looking at distributed targets like the agricultural fields. It can be expected, that the speckle problem in SAR imagery becomes much less important when reducing the resolution by multilooking techniques. With very high resolution systems, strong multilooking can be applied while still preserving an acceptable resolution.

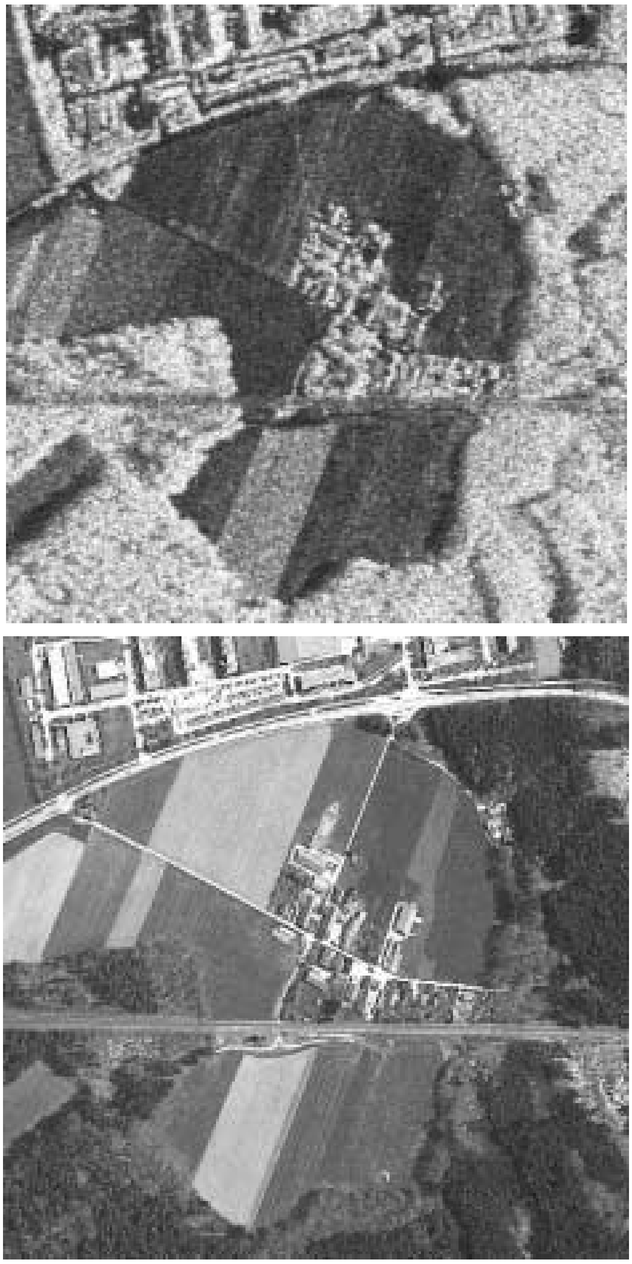

Figure 2 - Speckled polarimetric SAR image (top) and smooth panchromatic optical image (bottom), testsite Oberpfaffenhofen/Germany

In Fig. 1 d) a polarimetric SAR image of the testsite of Oberpfaffenhofen/ Germany is shown, acquired by the E-SAR sensor of DLR [3]. Here, the resolution is much lower (approx. 2x2m), but the polarimetric system allows the generation of color images. Color coding often leads to a better mapping results, as the additional information helps in interpreting areas which are ambiguous in simple amplitude images. Finally, in Fig. 1 c) a panchromatic optical image of the testsite of Oberpfaffenhofen can be found. Clearly visible are the differences to the SAR image. Many areas appear more clear than in the SAR image, but other, like for example forested areas, are less differentiated in the optical image. Additionally, atmospheric artefacts become a problem, too.

Fig. 2 shows details of the polarimetric and the panchromatic image of Oberpfaffenhofen. The speckle problem in the SAR image becomes clearly visible at this magnification, but on the other hand on the manmade structures it can be observed that the true resolution of the SAR system is almost the same than the one of the optical image. One question to be answered in the contest is whether the bad visual impression of SAR data is only a subjective effect, or if the information content at the same resolution is really lower.

In Fig. 3, two other SAR data sets are shown, acquired by the Danish EMISAR sensor in C-band. Both data set are fully polarimetric and represent two very special areas: An rural area around Fjordhundra in

Sweden and the urban area of the city centre of Copenhagen. This SAR data has a medium resolution of 1.5 meters, which should be enough for rural structures but which might be to bad to resolve adequately the finer urban structures, especially when applying multilooking for reducing the speckle effect. It should be shown by this contest which is appropriate resolutions for SAR and optical sensors, depending on the applications and scene type under investigation.

At the moment another testsite in Finland is under investigation, which might replace the Fjordhundra testsite. The Finland testsite has very well documented ground truth. Additionally, SAR and optical data of this site are easily accessible.

3 PHASES OF THE CONTEST

The test will be conducted in three phases. In phase 1, the participants will derive a visual interpretation of the data. The results will show the information content of the data independent of the performance of specific automatic object extraction methods and software. The data will be prepared at different resolution levels and distributed to the participants. It is planned not to distribute SAR and optical data to the same parties in order to avoid undesired 'crosstalk' between the two data sets of a scene. A list of features to be extracted will be delivered together with the data sets. In this phase, mapping authorities, commonly active in state- or country-wide mapping projects, can give valuable contributions. Phase 1 will be started in autumn 2002.

In phase 2, automatic object extraction procedures will be applied to each sensor's data separately. Regarding data fusion, the results will be reference data for the performance of object extraction without use of multi-sensor data. They will, at the same time, represent the outcome of a competition of sensors. Probably, the question can be answered whether SAR is already an alternative means of data acquisition in mapping projects, compared

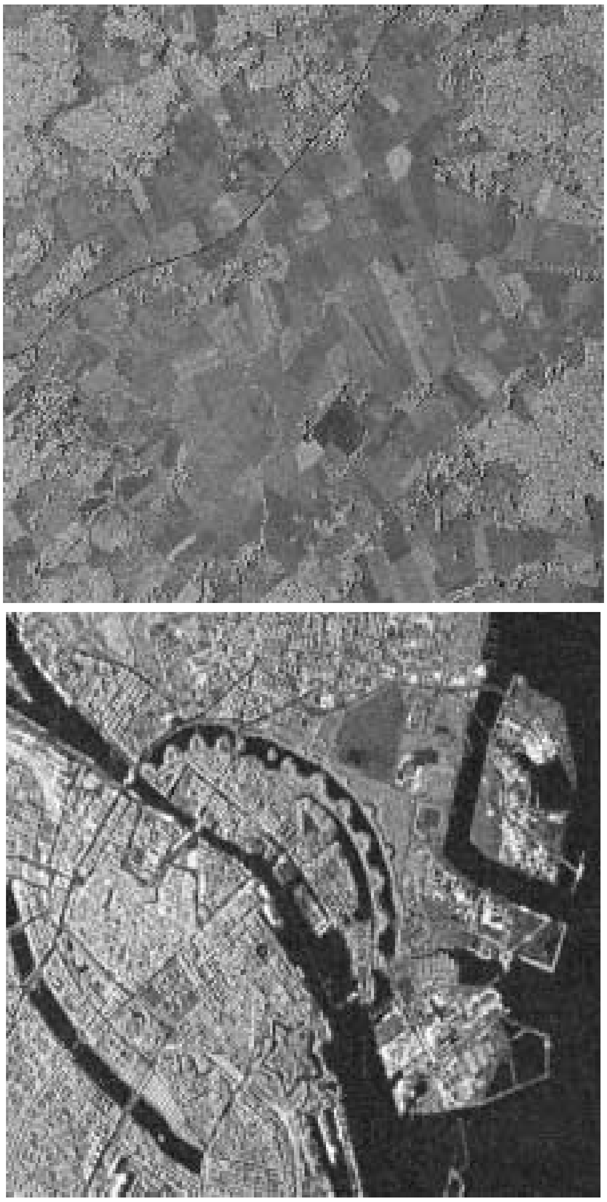

Figure 3 - Polarimetric SAR images of testsite Fjordhundra/Sweden (top) and city centre of Copenhagen (bottom).

with optical sensors, or whether it even outperforms optical sensors. In this phase, the alternative use of only partial data of one or both of the sensors may be requested from the participants. Object extraction results will be analyzed by comparison with the digital reference maps. In phase 2, any party (private company, governmental authority, university or research institute) can compete successfully by presentation of results, reflecting its specific expertise, e.g. in automatic extraction of a specific class of objects, or in compilation of maps fulfilling specific official requirements. Phase 2 will be started in spring 2003.

In phase 3, mapping will be conducted based on data of both sensors, i.e. by multi-sensor data fusion. This phase will give any participant, interested in research on data fusion, a chance to prove how valuable multi-sensor data fusion is, by demonstrating the degree of improvement in accuracy, correctness, completeness, robustness, or scope of object extraction. Phase 3 will be started in fall 2003.

ACKNOWLEDGEMENTS

The authors have to thank several authorities for providing data for the contest, namely the IHR/DLR (E-SAR data), Aerosensing GmbH (AeS-1 data) as well as the DDRE (EmiSAR data).

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Part II

Questionnaire 1

EuroSDR sensor and data fusion contest
Information for mapping from SAR and optical imagery

This questionnaire addresses you as a participant to the sensor fusion contest.
Please return it by e-mail, fax or mail to

Technical University Berlin
Photogrammetry and Cartography
Sekr. EB 9
Str. des 17. Juni 135

Fax: +49 30 314 21104
e-mail: dennert@fpk.tu-berlin.de

before **May 15, 2003**.

The questionnaire intents to find out your personal way of participation.

Its goal is
1. to optimally integrate your expertise, and
2. to secure an objective result of the comparison of sensors.

To which phase(s) of the contest would you like to participate?

- o A. Visual interpretation and map compilation
- o B. Automatic object extraction
- o C. Sensor fusion

For phases A and B you have to decide whether you want to investigate SAR or optical imagery, in order to avoid unintentional correlations between the mapping results. If you decide to use a sensor´s data in phase A, you have to use the same sensor´s data in phase B.

Which sensors data would you like to investigate?

- o I. SAR
- o II. Optical

Which object types would you like to address in your investigations?

- o linear objects
  - o roads
  - o railways
  - o rivers and other waterways
- o areal objects/landuse
  - o agricultural
  - o forest
  - o built-up
    - o residential
    - o urban
  - o lakes and other waterbodies

At the end of each phase of the contest digital map data in the geometry of the image has to be delivered to the organizer. The format of the map data should be GeoTiff or a common raster data format.

Thank you for your interest in participating to the contest. Participants to phase A will receive data and additional information until **June 30, 2003**. Evaluation results will be expected until **December 31, 2003**.

EVOLUTION OF PHOTOGRAMMETRY AND THE WORK OF THE OEEPE IN THE PAST 50 YEARS

C.M. Paresi
Secretary-General of EuroSDR (formerly OEEPE)

ABSTRACT

The author first reviews changes in the provision and use of spatial data during the past five decades, in terms of technology developments, changes in approach to problem solving and changes in policies, market and (inter) organisational structures. He then reflects on the OEEPE/EuroSDR response to these changes in terms of the evolution of the organisation's aim, structure, research perspective/approach and outputs. He finally discusses some ideas on the future role of EuroSDR in the framework of spatial information for the European Information Society.

1 INTRODUCTION

The way ahead for the information society has be summarized by the following statement [*M. Bangemann*, 1994] "Throughout the world, information and communication technologies are generating a new industrial revolution already as significant and far-reaching as those in the past." and "This revolution adds huge new capacities to human intelligence and ... changes the way we work together and the way we live together."

This revolution also applies to the spatial data provision community that has rapidly changed during the past 50 years, from (analogue) data collection and processing to (digital) storage of structured data and geo-information dissemination. This being due to a series of factors ranging from technology developments to changes in (government) policies and (business) management practices, from new customer requirements to new actors (users and producers) on the spatial data market and to new approaches to problem solving and thus to research and knowledge transfer.

The OEEPE/EuroSDR, as an organisation aiming at facilitating spatial data provision organisations technological developments by means of multinational experimental research had to deal with the above mentioned changes too. It is therefore appropriate, on the occasion of the 50th anniversary of the OEEPE/EuroSDR to reflect on these changes and the way the organisation managed them during its 50 years of existence.

2 THE PARALLEL DEVELOPMENTS OF PROVISION AND USE OF SPATIAL DATA AND OEEPE/EUROSDR RESEARCH

2.1 Changes in Spatial data provision and use

2.1.1 Technology developments

In his keynote address to the XVIII Congress of the ISPRS (1996), G. Konecny reviewed the "Paradigm changes in ISPRS from the first to the eighteenth Congress in Vienna" [*G. Konecny*, 1996]. OEEPE/EuroSDR has experienced technology changes in parallel with the ISPRS.

The first 25 years of existence of the OEEPE (1953/1978) were fully focussed on analogue/analytical photogrammetry and photo-interpretation; although the first Landsat satellite was launched in 1972, opening the way to remote sensing on a global scale, analogue aerial cameras were still mostly used for primary data acquisition; analogue photogrammetric plotters and mirror stereoscopes were the only operational equipments permitting to map (topographic/thematic mapping) the empty portions of the world and to assess natural resources exploitation. Analytical developments had more to do with computing techniques like aerial triangulation block adjustment and digital terrain modelling, as the inventions of the photogrammetric analytical plotter (*Helava*, 1957) and of the image correlator (*Hobrough,* 1958) were not yet accepted in operational mapping practices.

The end of the seventies/early eighties brought the first critical change in technology that OEEPE had to face; Landsat imagery being widely available, and computer and communication technologies improved, digital image processing started to be applied; further, the photogrammetric industry had almost exclusively switched over to analytical plotters. Visual interpretation started to change into image analysis, and the map manuscript to be replaced by digital databases.

The eighties brought the second radical change in technology; developments in satellite (launch of SPOT-1 in 1984) and computer (PC-based platforms) technologies, image processing, databases, navigation and positioning systems, expert systems and system integration changed the tools available to the geoinformation scientists and professionals. Geoinformation Systems (GIS) software packages became available and offered new capabilities for the analysis of the spatial relationships existing between objects and/or phenomena on earth. Those new integrating tools and techniques have been complementing and/or replacing established technologies in spatial data production, but either way they have been revolutionizing spatial data production processes through their impact on the traditional disciplines involved and on how the information needs of the user community can best be served.

The nineties have brought the third big change for the spatial data provision technology. As stated by G. Konecny, "The capabilities of high resolution and hyperspectral imaging, of radar imaging and interferometry, and of laser profiling from satellites or aircraft are increasing, and the distribution of images through Internet or Intranet is at the doorsteps" [*G. Konecny*, 1996]. On the other hand, advances in communications technology, development of powerful desktop workstations, extreme high costs of data acquisition, and increased customer's demand for diverse products and services, and for transparent and cost effective access to existing information, regardless of the hosts on which it resides, have rapidly changed information management from a traditional centralized perspective to a distributed one. This demanded for inter-operability among heterogeneous hosts, operating systems, data sources, and data structures [*C.M. Paresi/M.M. Radwan*, 1996]. Indeed, the operationalisation of new sensors (e.g. digital cameras, Ikonos), integrated systems for spatial data acquisition and production, computer vision and e-commerce, and critical advances in database management systems and Spatial Data Infrastructures have tremendously impacted on the way to acquire, handle, store, analyse, disseminate and use spatial data.

2.1.2 Changes in approach to problem solving

The above described technology changes, combined with radical changes of the needs from the information society have drastically modified the geoinformation approach to problem solving in the last five decades.

The conventional approach to descriptive (topographic/thematic) mapping through non-selective surveys of territories and standard/linear production lines which has been heavily used till the eighties could not anymore be responsive to the increasingly complex and diversified requirements from planners and decision makers on geoinformation. This approach was too much technology driven (technology developments were only used to improve efficiency of the mapping process), too much based on a mono-disciplinary approach (even so-called multi-diciplinary projects were just an aggregation of different survey techniques without conceptual integration models), and too much supply driven (the mission of the geoinformation production organization was predominant, not user requirements) [*K.J. Beek, C.M. Paresi*, 1998].

The integrating and customizing impact of information technology came only into practice in the eighties; developments are nowadays towards the design of flexible geoinformation systems/ decision support systems of evolutionary nature, to support decision making for sustainable development. Those systems are developed based on user/society requirements (demand driven), and fully consider social, cultural and economic factors in addition to the technological ones. Multi-disciplinary teams are using those systems in a problem driven perspective [*K.J. Beek, C.M. Paresi*, 1998].

It is interesting to realize that the development of information systems in other industries (eg. banking, insurance companies) took a parallel approach to mapping; the first developed systems were too much application and/or project dependent, offering limited operational support to the users; only since the eighties, integrated and flexible information systems were developed which offer operational, tactical and strategic support [*A. Wanders*, 1989].

2.1.3 Changes in policies, market and (inter) organisational structures

Integration, decentralization and customization are the most fundamental characteristics of information technology; those characteristics have major impacts on organizations, their functions and how they relate to other organizations.

Integration: The integration of the information puts a radically different perspective on the work process. Spatial data provision organisations now need to question how the information will be used and to what end in order to explicitly capture the relationships of map elements in the database. This requires an information perspective as opposed to a map perspective. This in turn affects the tasks within the organization and also creates new ones. [*R. Groot,* 1992].

Decentralization: As already stated, the change from a traditional centralized to a distributed information management perspective requires inter-operability among heterogeneous hosts, operating systems, data sources and data structures. This implies the need for the development of models, methods and techniques that support the comprehensive planning, construction, integration and use of a Spatial Data Infrastructure in a federated perspective; indeed, a Spatial Data Infrastructure is needed to improve access, sharing, integration and use of geoinformation to support decision making at different levels (horizontally: across different thematic databases; vertically: from local to global levels). [*C.M. Paresi/M.M. Radwan*, 1996].

Customization: Information technology promotes customization of products at relatively low costs. The trend is towards responsiveness to niche markets and low-volume production lines, as opposed to high-volume standard products (eg. topographic base maps). Once a database is in place, the derived custom-made products can be produced for a marginal cost. [*R. Groot*, 1992].

2.2 OEEPE/EuroSDR response to the changes

Analysing the evolution of OEEPE/EuroSDR during the last five decades, one can identify three main periods, fairly well corresponding to the changes in spatial data provision and use, as outlined above: the first 25 years; the eighties/early nineties and then the late nineties/entering the 21st Century. The main characteristics of these periods are highlighted below.

The first 25 years (1953/1978):

The OEEPE was established on 12 October 1953 in Paris, in accordance with a recommendation passed by the Council of the Organisation for European Economic Co-operation (OECD) in 1952. The five founding fathers of OEEPE were Karl Neumaier from Austria, Urbain Panier from Belgium, Erwin Gigas from Germany, Alfredo Parodi from Italy and Willem Schermerhorn from The Netherlands.

The aim of the Organisation was then to increase the accuracy, quality and efficiency of aerial surveys by speeding up the development and improvement of photogrammetric methods, in particular by arranging and carrying out, in mutual cooperation, a joint programme of experimental photogrammetric research [Agreement concerning the formation of the OEEPE, 1953].

The OEEPE mission was realised through mutual cooperation of scientists and practitioners from different countries, in accordance with the needs and priorities of current practice, through five Commissions. Commission A focussed on the accuracy of aerial triangulation for medium- and small-scale photography whilst Commission B was involved with the accuracy of aerial triangulation for large-scale photography. Commission C dealt with all aspects of the accuracy of large-scale restitution. Commission D devoted its investigations to the quality and economy of mapping procedures as a whole, including cartographic aspects. Commission E was charged, in the beginning, with the study of problems related to photogrammetric mapping at small-scales; later on it moved to studies of the semantic performance of aerial images. Finally, Commission F devoted its activities to the study of fundamental problems, identified in the first works of Commissions A and B [*R. Verlaine*, 1979]

The activities of the OEEPE during the first 25 years of its existence were mainly test-based. Results obtained have largely contributed to enhance the efficiency of the photogrammetric mapping process but have also stimulated theoretical studies in several academic institutions. Any photogrammetrist will remember the tests Reichenbach [OEEPE Publication No 4, 1968], Oberschwaben [OEEPE Publication No 8, 1973] and Oberriet [OEEPE Publication No 10, 1975], to name but a few.

In the meantime, the OEEPE had grown from five member countries in 1953 to ten member countries in 1978 (Denmark, Finland, Norway, Sweden and Switzerland joined the organisation), demonstrating the success of the OEEPE cooperative and experimental approach to spatial data research.

The eighties and early nineties (1978/1995)

Following technology developments and changes in problem solving from the late seventies and early eighties, the OEEPE recognised the need to extend its research efforts to other than purely photogrammetric (sub-) processes, thus also to work on issues related to the establishment of Digital Elevation Models and of digital topographic databases, to the cartographic process and to the use of remote sensing and digital image processing systems. Additionally, the experimental research projects approach was also extended to development research, when of common interest for the member's countries [OEEPE Organisation and Procedures, 2nd Edition, 1985]

Consequently, the tasks of the Scientific Commissions was re-organised in a matrix structure, creating on the one hand, a number of Application Commissions responsible for specific production processes [Commission I – Topographic Mapping, Commission II – Cadastral Mapping, Commission III – Engineering Surveys, Commission IV – Environmental/Thematic Surveys and Commission V – Land Information Systems] and on the other hand, a number of Scientific Commissions, each being responsible for a specific technical/scientific area [Commission A – Aerotriangulation; Commission B – Digital Elevation Models; Commission C – Large scale restitution; Commission D – Photogrammetry and Cartography; Commission E – Topographic interpretation; Commission F – Fundamental problems of Photogrammetry]. Towards the end of the eighties and to ensure the development and execution of a coherent research plan, the OEEPE Science Committee was created; the Science Committee included all Commission's Presidents [OEEPE Strategic and Action Plans, 1990]

These developments leaded towards the mid-nineties to a re-definition of the OEEPE mission, as follows: "The aim of the Organisation is to improve and promote methods, performance and application of photogrammetry by carrying out in mutual co-operation, investigations and research, in particular of experimental and application oriented nature.

Experimental research is understood to include, whenever necessary, theoretical and methodological preparation, as well as scientific analysis of the results.
The photogrammetric research can extend, as necessary, into related fields in which an interaction takes place, such as sensor technology, data processing, information systems, automation, cartography and geodetic methods. It is to include in particular the integration of data from different origins and their combination to higher-level systems of wide scope" [Supplementary Protocol amending the Agreement; 1994].

The type of research projects executed by the OEEPE during this period also reflects the evolution of the research scope of the organisation. Next to tests in traditional photogrammetic fields [Test "Dordrecht", OEEPE Publication No 13; Test of "Steinwedel", OEEPE Publication No 15], new projects were launched on the usability of satellite data [OEEPE Publications No 19, 24 and 26] and on Land Information Systems [OEEPE Publications No 20 and 28], to name but a few.

It is also important to mention that, during this period, France, Turkey and the United Kingdom joined the OEEPE, bringing the number of member countries to 13.

The late nineties/entering the 21st Century (1995/to date)

The process of changes tremendously accelerated in the second half of the nineties and culminated at the change of centuries. During this period, the spatial data provision profession changed rapidly and definitively, from data collection and processing to storage of structured data and information dissemination. The role of National Mapping Agencies changed to become providers of core data in a Spatial Data Infrastructure context, to serve as a framework for spatial referencing for the mapping activities of many disciplines involved in spatial monitoring, management and development; this implied a shift from the production stage to the dissemination stage of the information flow; this also implied a need for integration of core data with other spatial data. Also, the role of governmental organisations changed, retreating from many traditional tasks and especially production-oriented tasks being outsourced; this posed the problem of quality assurance/control for sub-contracting (especially on the semantic contents of the data). Finally, technological developments accelerated in terms of new types of source data being available for mapping; these were based on new technologies such as GPS, high-resolution satellite images, laser scanning and radar interferometry; these new technologies were able to take care of mapping tasks that were traditionally performed by photogrammetry. Web-cartography technology and e-commerce developed at extreme high speed too.

All these developments, and many more that are out of the scope of this paper, leaded the OEEPE to revisit its vision as well as the mechanisms to achieve its mission. In 2000, a new OEEPE Long-term Strategy was developed, with the following mission, vision and key focuses:

<u>Aim:</u> "The aim of the Organisation is:

- Research and development of methods, systems and standards for the acquisition, processing, production, maintenance, storing and dissemination of core geospatial data and information, and the integration of this data and information with information from other sources, and the promotion of applications of all such data and information.
- To stimulate interaction and cooperation between research organisations and the public and private sector, to exchange ideas about relevant research problems and to transfer research results obtained to geoinformation production organisations".

<u>Vision:</u> "To be the European research platform for National Mapping Agencies (NMA's), Academic Institutes, Private Sector, Industry and User's Groups, on issues related to the implementation of technology developments in view of optimising the provision (collection, processing, storage, maintenance, visualisation, dissemination and use) of core data (data serving as a spatial framework for organisations involved in monitoring, management and development) in a Geoinformation Infrastructure (GII) context".

<u>Strategies:</u>

- Widen the research field of OEEPE to cover technology developments related to collection, processing, storage, maintenance, visualisation, dissemination and use of spatially referenced core data
- Widen the OEEPE research platform to Private Sector, Industry and User's Groups involved in Geoinformation
- Improve efficiency

The Commissions were re-organised to support the above mentioned mission, vision and strategies [Commission 1 - Sensors, primary data acquisition and georeferencing; Commission 2 - Image analysis and information extraction; Commission 3 - Production systems and processes; Commission 4 - Core geospatial databases; Commission 5 - Integration and delivery of data and services]

The type of research projects executed during this period reflect the change of focus of the OEEPE, ranging from Geocoding ERS-1 SAR data [OEEPE Publication No 32] to Automatic Generalisation [OEEPE Publication No 39], through Automation in Digital Photogrammetric Production [OEEPE Publication No 37], Structural Approach to the Management and Optimization of Geoinformation Processes [OEEPE Publication No 41] and Use of XML/GML [OEEPE Publication No 42], again, to name but a few. New project started recently like Automatic building extraction, Automatic road extraction, Test of digital cameras, Interoperability of Digital Photogrammetric Workstations, but also more integrating projects like EuroSpec.

More Workshops were organised; Workshops as facilitator for organisations (National Mapping Agencies, Academic Institutes, Private Sector, Industry and User's Groups) to delineate common problems and prepare/execute projects, but also Workshops as knowledge transfer platform [OEEPE Publications No 33, 37, 38, 40, 42 and 43].

A new activity was created in the field of knowledge transfer: the OEEPE Education Service, using Internet based distance learning and results of OEEPE research projects [OEEPE Newsletters 2002-1 and 2002-2].

The visibility of the Organisation was enhanced during this period too, through the creation of a website (www.eurosdr.org) and the dissemination of a bi-annual Newsletter.

Also, during this period, five countries joined the Organisation (Spain, Poland, Cyprus, Ireland and Portugal), bringing the number of member's countries to eighteen.

All these changes leaded to a need for changing the name of the Organisation, to better reflect its mission and activities: EuroSDR was born by fall 2002. Therefore the Agreement concerning the Formation of the OEEPE had to be amended in 2003, for the third time in the 50 years of existence of the Organisation. Finally and to better support the diverse activities of EuroSDR, a full-time Secretariat was established in 2003 too.

2.3 The future of EuroSDR; Spatial information and the European Information Society

Technology but also societal developments are continuously changing the way business is done; the only constant in to-day's business is change. This applies also to the spatial data provision and use business, as it has been confirmed by different speakers during this Seminar of Honour. How then should EuroSDR react to the challenges of the coming decades?

Spatial data provision is not an aim in itself; it is meant to support higher societal objectives like sustainable development, multi-use of space, environmental management and risk management. EuroSDR should learn more from these higher-level objectives to focus on spatial data research that will deliver results relevant for society as a whole. Ensuring that the map is ready before the aircraft lands back from its data acquisition mission is a nice aim but what if the map is not used by the customers? EuroSDR should recognize that nothing it does or produces is an end in itself; it only has value to the extent that it genuinely meets user needs.

Also, EuroSDR cannot achieve these higher objectives alone; it needs to extend its network and cooperate more with other pan-European organisations like JRC, EUROGEOGRAPHICS, AGILE and EARSeL in particular, but also with totally new partners from other disciplines.

Finally, what EuroSDR should not change is the old (1953) principle of the creation of the OEEPE, namely the integral and cost-effective approach to problem solving by means of multi-national research on common problems in different European countries, supported by organisations (National Mapping Agencies, Academic Institutes, Private Sector, Industry and User's Groups) having different views on the problem and different research capabilities and experiences; the whole being greater than the sum of the parts.

3 CONCLUSION

OEEPE has now effectively moved into EuroSDR; this means new spatial data research perspectives but with the same spirit as in the past: networked science and technology developments as a mean to improve spatial data services for the European Information Society. OEEPE/EuroSDR is a very good example of an "old" but very dynamic "young" organisation, working towards the future without forgetting its past.

A lot of challenges will continue coming on the way of EuroSDR but this is the essence of science, challenging the challenges. And, finally, EuroSDR should never forget the words of late OEEPE President Ø. Andersen "It's fun to be good; let's have a lot of fun", to which I would like to add: "but first define what is good".

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R. Groot, 1992; Management aspects of the introduction of spatial information technology in mapping organizations; ITC Journal 1992-4

A. Wanders, 1989; Systeemontwikkelingsmethoden; Academic Service

R. Verlaine, 1979; 25 years of OEEPE; OEEPE Official Publication No 11; June 1979

OEEPE Publications series

OEEPE/EuroSDR Strategic Plans, Research Plans and amendments to the Agreement concerning the Formation of the OEEPE.

Appendix

LIST OF PRESIDENTS, SECRETARY-GENERALS AND CHAIRMEN SCIENCE COMMITTEE OF OEEPE/EUROSDR

OEEPE Presidents

1953-1956	Colonel Panier	Belgium
1956-1959	Colonel Duckaert	Belgium
1959-1961	Prof. Solaini (†)	Italy
1961-1963	Prof. Gigas (†)	Germany
1963-1965	Prof. Neumaier (†)	Austria
1965-1967	Prof. Trombetti (†)	Italy
1967-1969	Colonel Simonet	Belgium
1969-1971	Prof. Knorr (†)	Germany
1971-1973	Präsident Eidherr	Austria
1973-1975	Prof. Solaini (†)	Italy
1975-1977	Prof. Bachmann (†)	Switzerland
1977-1979	Director Dahle (†)	Norway
1979-1981	Director General Härmälä	Finland
1981-1982	Director General Verberckt	Belgium
1982-1984	Prof. Ackermann	Germany
1984-1985	Director General Smith	United Kingdom
1985-1986	Director General McMaster	United Kingdom
1986-1988	Directeur Ducher	France
1988-1990	Prof. Talts	Sweden
1990-1992	Administrateur Général De Smet (†)	Belgium
1992-1994	Prof. Ackermann	Germany
1994-1996	Dipl.-Ing. Kilga	Austria
1996-1998	Prof. Galetto	Italy
1998-2000	Prof. Kölbl	Switzerland
2000-2002	Prof. Andersen (†)	Norway
2002-date	Prof. Kuittinen	Finland

OEEPE Secretary-Generals

1953-1975	Ing. Verlaine (†) (Honorary Secretary-General)	Belgium
1975-1985	Prof. Visser (†)	The Netherlands
1985-1992	Mr. Kure (†) (Honorary Secretary-General)	The Netherlands
1992-date	Mr. Paresi	The Netherlands

OEEPE Chairmen Science Committee

1989-1996	Prof Dowman	United Kingdom
1996-2000	Prof Torlegård	Sweden
2000-date	Prof. Molenaar	The Netherlands

LIST OF OEEPE/EuroSDR OFFICIAL PUBLICATIONS

State – August 2003

1 *Trombetti, C.:* „Activité de la Commission A de l'OEEPE de 1960 à 1964" – *Cunietti, M.:* „Activité de la Commission B de l'OEEPE pendant la période septembre 1960 –j anvier 1964" – *Förstner, R.:* „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960–1964)" – *Neumaier, K.:* „Rapport de la Commission E pour Lisbonne" – *Weele, A. J. v. d.:* „Report of Commission F." – Frankfurt a. M. 1964, 50 pages with 7 tables and 9 annexes.

2 *Neumaier, K.:* „Essais d'interprétation de »Bedford« et de »Waterbury«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" – „The Interpretation Tests of »Bedford« and »Waterbury«. Common Report Established by all Participating Centres of Commission E of OEEPE" – „Essais de restitution »Bloc Suisse«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" – „Test »Schweizer Block«. Joint Report of all Centres of Commission E of OEEPE." – Frankfurt a. M. 1966, 60 pages with 44 annexes.

3 *Cunietti, M.:* „Emploi des blocs de bandes pour la cartographie à grande échelle – Résultats des recherches expérimentales organisées par la Commission B de l'O.E.E.P.E. au cours de la période 1959–1966" – „Use of Strips Connected to Blocks for Large Scale Mapping – Results of Experimental Research Organized by Commission B of the O.E.E.P.E. from 1959 through 1966." – Frankfurt a. M. 1968, 157 pages with 50 figures and 24 tables.

4 *Förstner, R.:* „Sur la précision de mesures photogrammétriques de coordonnées en terrain montagneux. Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE" – „The Accuracy of Photogrammetric Co-ordinate Measurements in Mountainous Terrain. Report on the Results of the Reichenbach Test Commission C of the OEEPE." – Frankfurt a. M. 1968, Part I: 145 pages with 9 figures; Part II: 23 pages with 65 tables.

5 *Trombetti, C.:* „Les recherches expérimentales exécutées sur de longues bandes par la Commission A de l'OEEPE." – Frankfurt a. M. 1972, 41 pages with 1 figure, 2 tables, 96 annexes and 19 plates.

6 *Neumaier, K.:* „Essai d'interprétation. Rapports des Centres de la Commission E de l'OEEPE." – Frankfurt a. M. 1972, 38 pages with 12 tables and 5 annexes.

7 *Wiser, P.:* „Etude expérimentale de l'aérotiangulation semi-analytique. Rapport sur l'essai »Gramastetten«." – Frankfurt a. M. 1972, 36 pages with 6 figures and 8 tables.

8 „Proceedings of the OEEPE Symposium on Experimental Research on Accuracy of Aerial Triangulation (Results of Oberschwaben Tests)" *Ackermann, F.:* „On Statistical Investigation into the Accuracy of Aerial Triangulation. The Test Project Oberschwaben" – „Recherches statistiques sur la précision de l'aérotriangulation. Le champ d'essai Oberschwaben" – *Belzner, H.:* „The Planning. Establishing and Flying of the Test Field Oberschwaben" – *Stark, E.:* Testblock Oberschwaben, Programme I. Results of Strip Adjustments" – *Ackermann, F.:* „Testblock Oberschwaben, Program I. Results of Block-Adjustment by Independent Models" – *Ebner, H.:* Comparison of Different Methods of Block Adjustment" – *Wiser, P.:* „Propositions pour le traitement des erreurs non-accidentelles" – *Camps, F.:* „Résultats obtenus dans le cadre du project Oberschwaben 2A" – *Cunietti, M.; Vanossi, A.:* „Etude statistique expérimentale des erreurs d'enchaînement des photogrammes" – *Kupfer, G.:* „Image Geometry as Obtained from Rheidt Test Area Photography" – *Förstner, R.:* „The Signal-Field of Baustetten. A Short Report" – *Visser, J.; Leberl, F.; Kure, J.:* „OEEPE Oberschwaben Reseau Investigations" – *Bauer, H.:* „Compensation of Systematic Errors by Analytical Block Adjustment with Common Image Deformation Parameters." – Frankfurt a. M. 1973, 350 pages with 119 figures, 68 tables and 1 annex.

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10 „Résultats complémentaires de l'essai d'«Oberriet» of the Commission C de l'OEEPE – Further Results of the Photogrammetric Tests of «Oberriet» of the Commission C of the OEEPE"

Hárry, H.: „Mesure de points de terrain non signalisés dans le champ d'essai d'«Oberriet» – Measurements of Non-Signalized Points in the Test Field «Oberriet» (Abstract)" – *Stickler, A.; Waldhäusl, P.:* „Restitution graphique des points et des lignes non signalisés et leur comparaison avec des résultats de mesures sur le terrain dans le champ d'essai d'«Oberriet» – Graphical Plotting of Non-Signalized Points and Lines, and Comparison with Terrestrial Surveys in the Test Field «Oberriet»" – *Förstner, R.:* „Résultats complémentaires des transformations de coordonnées de l'essai d'«Oberriet» de la Commission C de l'OEEPE – Further Results from Co-ordinate Transformations of the Test «Oberriet» of Commission C of the OEEPE" – *Schürer, K.:* „Comparaison des distances d'«Oberriet» – Comparison of Distances of «Oberriet» (Abstract)." – Frankfurt a. M. 1975, 158 pages with 22 figures and 26 tables.

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