7th United Nations Regional Cartographic Conference for the Americas
United Nations, New York, USA
22 – 26 January 2001

SPATIAL INFORMATION MANAGEMENT IN THE 21st CENTURY

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INTRODUCTION

In the paper "The Digital Earth", written by the American Vice President Al Gore states following:
"A new wave of technological innovation is allowing us to capture, store, process and display an unprecedented amount of information about our planet and a wide variety of environmental and cultural phenomena. Much of this information will be georeferenced. The hard part of taking advantage of this flood of geospatial information will be turning raw data into understandable information".

New technologies will give us new methods for data capture. Remote sensing will give us cheaper data. Real time positioning will revolutionise the traditional fieldwork, etc. The available data will be used as well in public and private administration as in business. Data from different sources and data with differing accuracies will be used in new combinations.
To optimize and rationalize the use of data national and regional users, as well public as private, will demand nationwide homogeneous data sets. In a few years no one will think of spatial data as something special. Spatial data will be integrated in all kinds of information systems.
Some of the preconditions for successful implementation of spatial data in society are the establishment of a Spatial Data Infrastructure and comprehensive knowledge on organizational structures, technological developments and data-collection methods.

SPATIAL INFORMATION AND SUSTAINABLE DEVELOPMENT

Agenda 21 and The Habitat II Global Plan of Action address the need for information, development of appropriate databases and exchange of information as conditions for creating the basis for sustainable development in all regions of the world. The global society faces great problems concerning urbanisation and the influence of urbanisation on coastal zones and environmental conditions overall. Ongoing development includes globalisation of both environmental problems and trades.

It is generally accepted that Spatial Information is an indispensable part of the basic infrastructure in the individual country. It is often stated that spatial information affects 80% of human decision-making.

Spatial Information is a resource on a par with personnel, funds and other resources. Use of spatial information produces a direct or indirect possibility of increased efficiency in all sectors of public administration, in the political decision-making process as well as in the private sector.

Regardless of the stage of development, there are innumerable applications for spatial information. The following are some examples of major, but also very different, areas of application:

- transportation infrastructure in a region,
- health monitoring programmes,
- cadastre projects,
- land management and spatial planning,
- socio-economic issues,
- monitoring of environmental issues
- environmental impact assessment
- conservation projects,
- natural resource management.

This variety of applications suggests that users will have very different backgrounds. There will be a need for comprehensible instructions on the possibilities and limitations of data from the individual data collections and there is a need for user-friendly, efficient distribution systems.

Spatial Information Management becomes an important discipline in both developed and developing countries and in countries in transition.

SPATIAL DATA INFRASTRUCTURE

Administrators and politicians are beginning to recognise spatial information as well as a national resource as a part of the basic infrastructure that needs to be efficiently co-ordinated and managed in the interest of the nation. It is important to develop policies for standardisation, legal aspects, pricing, distribution, etc.

Spatial Data Infrastructure is conceived to be: *an umbrella of policies, standards and procedures under which organisations and technologies interact to foster more efficient use, management and production of spatial data.*

FIG Commission 3 has, on the background of the recent developments, gathered the following experiences and visions on spatial data infrastructure.

Experiences

- National Spatial data Infrastructure (NSDI) is an asset for all nations in general. It should be considered as a key part of wider infrastructure assets such as roads, telecommunication networks etc.
- Establishing of a Spatial Information Infrastructure demands co-operation/partnership between the public and the private sectors and amongst the variety of professions involved.
- Given the complexity of existing institutional structures, one can expect conflicts when seeking co-operation in NSDI strategy formulation and implementation.
- NSDI can proceed even if a formal policy document (top down approach) does not exist. It is possible to proceed with certain operational level activities (bottom up approach)

while the policy is being formulated. These activities can themselves drive and encourage policy.

- Every NSDI will be different, depending on cultural needs, social evolution, economic reality and national ambitions. The environmental framework and the market demand will shape the most appropriate SDI.
- NSDI policy must be flexible to address rapidly changing needs and wishes of the users and adapt to changing technologies.
- Varied applications and services through a project-oriented approach will bring reality to a NSDI. An over-emphasis on data acquisition, without a market linked application, will not provide any momentum for further development.
- Visualisation, modelling and analysing activities will be the focus of value-added services in the years to come.

Visions

- Cadastral, topographic and thematic datasets should adopt the same overarching philosophy and data model to achieve multi-purpose data integration, both vertically and horizontally.
- To be able to integrate and share data we need to focus on research to understand and resolve semantic differences in data.
- To be able to offer the different users (institutional as well as private) the full potential of spatial information independent of space and time, the full range of spatial data, actual as well as historical, should be made accessible and available
- Alternative possibilities for the presentation and interpretations of spatial information, including integration of knowledge, should be considered.
- The commercial and contractual frameworks for co-operation and the associated business models will be key issues in the further development of NSDI.
- To be able to adapt to the e-market rethinking of pricing, rights and access to data is necessary.

ORGANISATIONAL ISSUES

For a long time, EDP was used primarily to automate known working processes. With the available information technology, it is now realistic to reassess working processes and co-operation models. Now it is possible to create models across the existing administrative borders, as well as across borders between the public and private sectors.

Information technology makes it possible to separate authority from administration. It is possible to outsource parts of the public administration, and to involve the private sector in the establishment, operation and updating of the basic geographic and alphanumeric data collections.

Introducing information technology is so crucial to an organisation that the responsibility for the implementation has to be deeply rooted in the top management.

Unlike other resources, spatial information does not suffer any wear from repeated use. Different investigations show that the real benefit of investments in spatial data increases dramatically with the multiple use of data.

Multiple use demands co-operation between the primary user and other possible users on common data models. Object definitions, common identification, keys, even agreements between agencies will be required.

With the modelling, analysis and visualisation possibilities inherent in even cheap GIS solutions, it is now possible to present plans, solution proposals, etc. in a form which does not require great reading skills. It is becoming possible to involve citizens even if they lack the requisite educational background.

The use of spatial information creates transparency in the decision-making. At the same time this implies better service for politicians, NGOs and citizens, and efficient support for the democratic process.

Information technology offers many possibilities for establishing efficient communication and distribution of information. This also applies in those parts of the world where the general communications infrastructure is developed only to a limited extent.

With Internet technology and by using the world wide web, it is possible, at the same time, to create cheaper solutions at national level and to open up existing data collections to the outside world.

THE EDUCATIONAL CHALLENGE

Developing countries as well as countries in transition are facing problems such as capacity building and the lack of a developed private surveying community. Often they experience an intensive brain-drain.

In this way the individual country becomes very dependent on international consultancies and contractors, and it is nearly impossible for surveyors to establish the basis for sustainable business.

Education is a problem. It is urgent to establish sufficient possibilities for education and training on all professional levels.

Hitherto it has been necessary to send key employees on training and education stays in donor countries, at international training centres, for instance.

The new technology offers completely new possibilities for training and education. Distance learning and distance training are becoming important strategic parameters in developing countries. It is now possible to offer training and education on site at all levels with whichever specialists might be required. This will minimise implementation time. At the same time, it will be possible to be less dependent on key persons because it will not be costly to involve more employees in the training and education. The individual country should be very much aware of the distance learning activities e.g. in some of the former eastern European countries.

The traditional employee with a medium or high level education in geo-related issues does have a comprehensive knowledge on IT and informatics, cartography, photogrammetry and surveying.

At the same time there is a need for employees with new qualifications such as management, standards, data models, meta data, access to data, infrastructure architecture, intellectual property right, copyright, prizing of data and organizational developments. There is a need also for knowledge on analyzis, modelling, visualization and visual communication.

TECHNOLOGICAL DEVELOPMENTS

Information technology plays a very important role as a tool for use and integration of data both at local and national levels. It is used to create a model of a part of the world which in turn is used for manipulation, analyzis and visualization purposes.

For a long time cost-intensive technology has been a barrier to effective utilisation of information technology. Today the tools are cheap mass-produced hardware and standard software like databases and spreadsheets.

This trend towards cheaper, simpler solutions is continuing. With Internet and intranet technology it is possible to make data and information available inexpensively to both traditional users and new groups of users, including individual citizens. Internet technology makes it possible to open up traditional archives to interested users. Web-GIS in which the users handle geographic information using standard Web browsers is a reality.

SPATIAL DATA AND SPATIAL INFORMATION

High costs are involved in the establishment and maintenance of the necessary spatial data; many people are endeavouring to utilise alternative methods for collecting data and to use other data types.

To facilitate and minimise costs in connection with changes in technology it is essential to use robust data models and as far as possible it is best to base developments on internationally approved or de facto industry standards, data-exchange formats, and so on.

The costs are dependent on the level of ambition. On account of both the high initial costs and the long implementation periods, in a preliminary phase it is an idea to divide the future use of spatial data and spatial information into three groups: planning, administration and projects.

For planning purposes, low-cost and short production time is more important than accuracy and completeness. For administration, the focus is on the completeness of specific themes or objects and on the possibilities for updating. Project data is normally characterised by high demands on accuracy and the content of specific details. In contrast to administrative data, planning and project data has a limited lifetime.

SPATIAL INTEGRATION

The capabilities of data collection technologies along with the demands of GIS and the extension of SDI concepts will require high levels of spatial integration. However, it is difficult to predict what other data a user may want to integrate. Therefore, data itself must be as “integratable” as possible by being in a common reference system and to a known quality.

INTEGRATION OF TECHNOLOGIES

The digital nature of the technologies will enable them to be integrated to mitigate each other’s shortcomings. This can already be seen at several levels. At the international level we see collocation of various complementary observation techniques such as very long baseline interferometry, satellite laser ranging, absolute gravimetry, high precision tide gauges and satellite positioning. So called mobile mapping systems are bringing imaging and scanning technologies together with satellite and inertial positioning (in airborne, marine and vehicle platforms). At the level of the survey party we see integration of total stations and real time satellite positioning. As well as physical integration in the field, there is also much effort going into integration at the data processing level, under headings such as data fusion.

SOME SPECIFIC TECHNOLOGICAL DEVELOPMENTS

Specific technologies must reach a certain level of maturity before integration can be considered. In parallel with integration developments then, it is also important to watch the development of individual technologies. That enables one to keep technological developments in perspective and select the appropriate data collection technology for a given task and a given budget.

With that in mind and looking to future technologies, an overriding trend will be continued development of space based technologies. A new generation of imaging satellites is coming that will cover a range of spectral and spatial resolutions, including metre level resolution. A spectacular example is the recent Shuttle Radar Topography Mission that produced global topographic data and a global DEM over 80% of Earth's land mass (between 60°N and 56°S) during an 11-day flight.

Satellite positioning will continue to have a profound effect on data collection techniques. The Global Positioning System (GPS) will continue to hold centre stage for some time but influences beyond GPS alone will begin to have impact under the more generic term, Global Navigation Satellite Systems (GNSS). Developments we are already seeing include the growing importance of the Russian GLONASS system, the development of augmentations systems (ground and/or space based) and the European community’s desire for more influence through its Galileo program.

Within GPS itself, a major milestone has been the removal of selective availability (SA) leading to major improvements in the accuracy available for point positioning using inexpensive handheld receivers. This is just the first in many improvements planned for GPS. Developments under the heading of GPS modernisation, include adding a second civil frequency and eventually a third frequency; improvements that will bring increased accuracy and reliability for all users.

These changes will not bring a significant increase in the accuracy of GPS surveying, already at the centimetre accuracy end of the market, but the additional frequencies will improve reliability. The major influence on GPS surveying in coming years will be the continuing trend to the so-called real time kinematic technique (RTK). Networks of permanent stations supporting real time and post processed GPS surveying will be increasingly important parts of the Spatial Data Infrastructure.

As well as these newer technologies, traditional data collection technologies like total stations and levels will continue to improve. Like everything else, these technologies will become increasingly digital and allow for easier integration of the data sets gathered. Improvements to the supporting software will assist in this regard with tighter integration of GIS and surveying software.

ASPECTS OF SDI TO SUPPORT DATA COLLECTION

It will be important for Spatial Data Infrastructure to recognise and support these developments in data collection. At the softer end of the infrastructure, work is required to ensure that the appropriate technical standards and specifications are in place. Any data collection can then be carried out to these standards and specifications and according to processes that enable compliance.

Another important part of any SDI is the spatial referencing system that ensures all positions conform to well defined horizontal and vertical datums and to a known quality. As outlined earlier, this ensures data is as “integratable” as possible. The spatial referencing part of the SDI includes geodetic reference marks, supplemented to an appropriate degree with GPS base stations. The system also includes databases and mechanisms for accessing the required spatial referencing information. A major task for spatial referencing is making local datums more compatible with the International Terrestrial Reference Frame and thus with WGS84 as used in GPS. As well as horizontal datum improvements, this includes the need for appropriate geoid models to enable accurate height measurement using satellite positioning. Looking further into the future, countries such as Japan and New Zealand, where crustal deformation is an issue, are realising that the fourth dimension of time will be increasingly important in their spatial referencing system.

SENSITIVITY TO CULTURAL HERITAGE AND ENVIRONMENTAL ISSUES

Moving on from the SDI into applications, there is increasing demand for data collection processes that are sensitive to cultural heritage and environmental issues. On a global scale, geodetic knowledge is combining with many other disciplines to help understand global processes. Satellite radar altimetry is being used to measure sea surface height and temperature; vital to understanding climate variation. Satellite geodesy is monitoring the stability of high precision tide gauges that are measuring sea level variations linked to global warming.

On local and regional scales, non-invasive remote sensing technologies like photogrammetry and spectral and laser scanning are already in use in applications ranging from archaeological sites to assessing tree canopy cover to finding routes through culturally or environmentally sensitive areas. These technologies may be deployed on land and marine vehicles, in aircraft or satellite based.

AREAS OF CONFLICT

Such non-invasive technologies also have utility in areas where security of personnel is an issue and direct data collection techniques may be logistically difficult or even dangerous. This would include areas of current conflict or areas of past conflict that may have the unwelcome legacy of land mines.

CONCLUSIONS

It is our duty to promote sustainable development. This requires us to be unprejudiced and to have an overview. We create the overview by, among other things, monitoring developments and continuously analysing results. Information technology is indispensable, but data and information are a prerequisite. There is a great need for spatial information. However, this is not solely a question of information. There is a very significant management element. Spatial Information Management is becoming a major area of work for surveyors throughout the world.

The FIG working on the issues raised in this paper and on their application at the local, regional and international level. The specialist commissions of FIG are well placed to develop practical and appropriate best practices in spatial information management. The member organizations of FIG can be strong advocates of those best practices in their countries of interest. FIG also recognises the need to act at the regional and international level through cooperation with allied professions and with agencies of the UN and through its forums like the regional cartographic conferences and the permanent committees on GIS infrastructure. These actions demonstrate that the surveying profession is committed to spatial information management in support of the sustainable development of our "Digital Earth".

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