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SPATIAL DATA INFRASTRUCTURE

DEVELOPING TRENDS AND CHALLENGES

SPATIAL DATA INFRASTRUCTURE
Developing Trends and Challenges

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Key words: NSDI, Spatial Information Management, Knowledge Management

ABSTRACT

Administrators and politicians are beginning to recognise spatial information as a national resource as well as a part of the basic infrastructure that needs to be efficiently co-ordinated and managed in the interest of the nation. It is very 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.*

The FIG Commission 3 has on the background of a number of Country Reports and presentations compiled a list of "Experiences and Visions" on Spatial Data Infrastructure. Even though the "Experiences and Visions" is not based on scientific work or investigations it contains valuable information on the developing trends and challenges.

1. INTRODUCTION

Mapping as a discipline is centuries old and rich in tradition. In contrast the spatial data and information business is immature but is developing very fast.

Many countries have had a nation-wide cadastre and topographic map-series in different scales for years. Some have during the last decade established digital solutions and additionally they have developed a market for digital spatial data and information.

Other countries are extending and consolidating their cadastral and cartographic institutions and services. At the same time they are facing the challenges to adapt to a market for spatial data and information.

The traditional paper map is static. Each map sheet represents a snapshot of selected objects at a given time, and "the owner" has an exclusive right to the map and the data the map is based on. In the "paper world" the users have to accept the maps as they are. It is difficult and in some cases almost impossible to change, manipulate and or combine the content of the available maps.

A digital map or better a collection of spatial data is dynamic with the time parameter being part of the individual data collection. In "the digital world" the available data will be used as well in public and private administration as in business. Data from different sources and data with different accuracy will be used in new combinations

To optimize and to rationalize the use of data national and regional users, public as well as private, will demand nationwide homogeneous and updated data sets. In a few years spatial data will be integrated in all kinds of information systems.

One precondition for successful implementation of spatial data in society is the establishment of a Spatial Data Infrastructure. Another is comprehensive knowledge on organizational structures, technological developments and data-collection methods.

2. 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. One reason for this is that the global society faces great problems with urbanisation and the influence of urbanisation on coastal zones and environmental conditions overall.

This is an additional argument for establishing a Spatial Data Infrastructure.

Because of the obvious global aspects it is appropriate to relate the development of National Spatial Infrastructures to the Global Spatial Infrastructure initiatives.

Spatial Data and Information is an indispensable part of the basic infrastructure in the individual country, and experiences from the rich countries shows that spatial information affects 80% of human decision making.

Spatial Information is a resource on a par with employees, funds etc. 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:

- Cadastre projects
- Land management
- Transportation infrastructure
- Health monitoring programmes
- Socio-economic issues
- Monitoring of environmental issues
- Environmental impact assessment
- Statistical analyses
- Conservation projects
- Natural resource management

The users have very different professional backgrounds. Therefore there will be a need for comprehensive instructions on the possibilities and limitations of data from the individual data collections and there is a need for user-friendly, efficient distribution systems /1/.

Management of Spatial Information and knowledge has to be recognized as a very important discipline in both developed and developing countries and in countries in transition.

3. SPATIAL DATA INFRASTRUCTURE

Spatial Data Infrastructure can be understood as an umbrella of policies, standards and procedures under which organisations and technologies interact to foster more efficient use, management and production of spatial data.

In 1997 the multi national Global Spatial Data Infrastructure (GSDI) Steering Group defined the Global Spatial Data Infrastructure as (/5/ page 148):

> "The policies, organizational remits, data, technologies, standards, delivery mechanisms and financial and human resources necessary to ensure that those working on the global and regional scale are not impeded in meeting their objectives."

In 2000 a technical working group of GDSI published version 1of the so-called SDI-Cookbook /5/ (www.gsdi.org). This Cookbook is valuable tool for all who work with Spatial Data Infrastructure.

On page 7 in the Cookbook /5/ the working group has the following initial description:

> "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. The applications that run "on" such an infrastructure are not specified in detail in this document. But, like roads and wires, an SDI facilitates the conveyance of virtually unlimited packages of geographic information.
>
> An SDI must be more than a single data set or database; *an SDI includes geographic data and attributes, sufficient documentation (metadata), a means to discover, visualize, and evaluate the data, 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 organizational agreements needed to coordinate and adminster it on a local, regional, national, and or trans-national scale.*
>
> 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."

3.1 Fundamental parts of every Spatial Data Infrastructure.

An important and fundamental part of any National Spatial Infrastructure (NSDI) is the spatial referencing system that ensures all positions conform to well defined horizontal and vertical datums and to a known quality. The spatial referencing part of the NSDI includes geodetic reference marks, supplemented to an appropriate degree with GPS base stations. As well as horizontal datum improvements, this includes the need for appropriate geoid models to enable accurate height measurement using satellite positioning.

4. EXPERIENCIES AND VISIONS

Against a background of a large number of presentations in FIG Commission 3 seminars and workshops and the belonging debates the following "Experiences and Visions" concerning establishment and implementation of Spatial Data Infrastructure and expectations to the future developments has been formulated.

On the one hand this is not a scientific conclusion based on uniform data, on the other hand there has been so many similarities in the different statements that the "Experiences and Visions" is normative for the necessary developments in the years to come, at least in the more wealthy countries and the countries in transition.

In its basic form "Experiences and Visions" consist of a number of statements. On the one hand the statements are independent on the other interdependent.

In the following the individual statement is complemented with some clarifying examples.

4.1 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.

Administrators and politicians have to recognise spatial information as a national resource that needs to be efficiently co-ordinated, maintained, updated and managed in the interest of the nation.

Establishing of a Spatial Data Infrastructure demands co-operation/partnership between the public and the private sectors and amongst the variety of professions involved.

Some would equate National Spatial Data Infrastructure with the National Mapping Agency (NMA). The NMA of course is a one of the interested parties together with regional and local mapping authorities, cadastral agencies, mapping companies, and possible users from all parts of the public and private sector such as administrative bodies, environmental agencies, the health sector, the statistical agencies and so on.

Given the complexity of existing institutional structures, conflicts are to be expected when seeking co-operation in NSDI strategy formulation and implementation.

Co-operation on NSDI demands access to people with managerial experience. Sustainable development and implementation of a NSDI demands understanding on how organizations works and develops, knowledge on inter-organizational processes, political understanding, knowledge on human nature and on information management in general.

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.

In some cases the NMA has or takes on the role as coordinator. Through projects, or other kind of involvement they manage to activate and involve the main partners.

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.

The development of a NSDI has to be adapted to the general stage of development in the country. It is not only a question of the economically possibilities. It is necessary to respect and accept the limitations and possibilities in the general infrastructure including the propagation of the Internet, in capacity building etc, and to take in account the risk for brain drain.

NSDI policy must be flexible to address rapidly changing needs and wishes of the users and must adapt to changing technologies.

Because it is a process of long duration to establish and maintain spatial data for a certain area, it is a big challenge for the national, regional or local mapping agencies to build robust and stable basic systems with flexible output facilities, including the possibilities for outsourcing of the distribution of data.

Varied applications and services through a project oriented approach will bring reality to the NSDI (GSDI). An overemphasis on data acquisition, without a market linked application, will not provide any momentum for further development.

Instead of forcing through a specific development for instance copying the development in a neighbour country or region, cooperation on projects with possible partners and users has to be recommended.

The potential values and benefits have to be demonstrated through large scale projects to encourage further investment.

Often it is difficult to convince potential new users and/or partners of the value of new applications. Normally they forget that 80% of all information contains a spatial component. If you want to convince a possible partner on the value of co-investments in spatial data, for instance the health sector or the statistician, you must find projects relevant either for the partners everyday needs or a specific task. You must focus on "need to have instead of nice to have". It is to be recommended to include visualization of data and information in the projects.

Currently, it is often difficult, or even impossible, for users to sensibly combine data from different sources.

Common methods and standards for data modelling are almost a condition of harmonizing and combining data from different databases. Concerning standards for spatial data it is valuable to utilize the ISO TC211 standards and the Open GIS Consortium (OGIS) developments.

In addition it is to be recommended to cooperate on establishing national core dataset with a limited content but nationwide in order to fulfil the minimum needs for as many users as possible.

Furthermore it is worth to consider the establishment of a clearinghouse and to involve service providers in combining data from different sources.

It is essential that the users is involved in defining and testing the associated products and services.

If the Mapping Agencies forget or omit to involve the users in the specification of data and products, they may experience that the users will adapt rival "products" even if the quality is lower. For a NMA quality is closely related to accuracy whereas the user is more focused on the degree of update and coverage.

Visualization, modelling and analyzing activities will be the focus of value added services in the years to come.

Visualization of data from different sources and visualization of the results from modelling and analysing projects is very essential in the dissemination of information to politicians as well as citizens.

By visualization it is possible to make complex information available and understandable even for people with limited reading skills. In this way you create transparency in the decision making processes and supporting the democratic processes.

4.2 Visions.

Based on the experiences from the ongoing organizational and technological developments in the various countries and the predictable developments, extension and distribution of the electronic and communication infrastructure the following visions could be added to the experiences.

Cadastral, topographic and thematic datasets should adopt the same overarching philosophy and datamodel to achieve multi-purpose data integration, both vertically and horizontally.

Planning, management and monitoring at regional and national level requires access to spatial data from the underlying political and administrative levels. It is of greatest importance that data created "locally" is standardized so that it can be used "globally". Some talk about establishing "vertical highways" for data and information.

For several reasons this is a real challenge because as a minimum it implies interorganizational agreements on data models, model generalisation, cartographic generalisation and so on.

To be able to integrate and share data we need to focus on research to understand and resolve different semantics in data.

It is necessary on cross-institutional level or better on national level to start to discuss and decide on the *semantics* in spatial data. To do so we have to bring people with different professional background together to elaborate common definitions on objects with a spatial reference.

For example people from the cadastre, the property registers, the topographic agencies, the planning departments, the statistical agencies etc. has to harmonize their individual definitions of buildings, properties, administrative boarders and districts, addresses etc..... in order to be able to share data and information without loose of information.

This part of the process may imply extensive consequences for the involved parties. Start with a few objects and evaluate the consequences of and the realism in possible harmoniszing activities.

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

This is a challenge from a technical as well as from a resource point of view. In addition to this there are legal as well as institutional barriers to overcome.

Alternative possibilities for the presentation and interpretations of spatial information, including integration of knowledge, should be considered.

Many users only have limited or no experience in use and interpretation of spatially based information. Therefore it is necessary to develop alternative possibilities for presentation and interpretations of spatial information.

The results has to be presented in such a way that it is intelligible to non professionals. To support this knowledge and experiences will be integrated in the different applications in the years to come. Knowledge management becomes a part of a NSDI.

The commercial and contractual frameworks for co-operation and the associated business models will be key issues in the further development of NSDI.

There is general trend towards establishing partnership and strategic alliances between public agencies as well as between the public and the private sector in order to share resources, knowledge and experiences and to create synergism.

To be able to adapt to the e-market rethinking of pricing, rights and access to data is necessary.

At the moment the marked for spatial data and information undergo major changes, with Internet and E-commerce as business drivers.

Depending of the maturity of NSDI in the individual country it is recommendable to have special focus on legal aspects, access to data and pricing. It is very urgent to relate the different topics to the Internet as a mean of communication and to e-commerce.

4.3 Additional remarks on experiences and visions.

Establishing of a National or Regional Spatial Infrastructure includes a lot of technical topics, but it is essential to remember that creating a successful development and implementation implies comprehensive organizational activities and changes.

As soon as it becomes possible to have access to different sources with spatial data and knowledge it is time for reengineering of the way we arrange duties, workflow and decision making process inside the individual organisation as well as across boarders between different organisations.

Finally we all have to be aware of the need for education and training. 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. Also there are demands for employees with new qualifications such as standards, data models, meta data, access to data, infrastructure architecture, intellectual property right, copyright, prizing of data and organizational and managerial developments. In addition there is a need for knowledge on analysis, modelling, visualization, visual communication etc.

The new technology offers completely new possibilities. Distance learning and training are becoming important strategic issues. It is now possible to offer training and education on site at all levels with whichever specialists might be required. This will minimise the implementation time /4/. But we must not forget the success of distance learning and training is totally dependent on the available electric and electronic infrastructure.

5. EPILOG

In the paper "The Digital Earth: Understanding our Planet in the 21st Century", written by the former American Vice President Al Gore you can find the 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 "geo-referenced" – that is, it will refer to some specific place on the Earth's surface. The hard part of taking advantage of this flood of geospatial information will be making sense of it, -turning raw data into understandable information" /7/.

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 data and information. However, this is not solely a question of data and information. On the one hand there is a strong need for developing and maintaining a Spatial Data Infrastructure, on the other hand there is a very significant management element. Spatial Information and Knowledge Management is becoming a major area in public and private administration throughout the world.

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SPATIAL INFORMATION MANAGEMENT
A Multidiscipline Approach

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Key words: Infrastructure, Information Management, education, training.

ABSTRACT
The paper will give an introduction to the various elements of spatial information management. It will by examples illustrate the ongoing developments and the coherence between the stage of organizational developments and the need for different professional qualifications and skills.

1. INTRODUCTION

The technological development offers the users possibilities for access to information and services that was unforeseeable a few years ago, and this is a continuing process. The new technologies cause new methods for data capture. Remote sensing will give us cheaper data. GPS and real time positioning will revolutionise the traditional fieldwork, etc.

In the years to come Location Based Information Systems will be available for many of us. With online access to information-systems with geographic references it will become possible to offer individualized information and services.

In time with the integration of spatial information in the various information systems, there will be a strong need for people who can manage the technical and organisational aspects of combining data and in turning raw data into understandable information. Aspects comprising disciplines as semantics in data, common standards, common data models, models for spatial information infrastructures, visualization, etc. We need Spatial Information Managers.

2. PREDICTABLE DEVELOPMENTS

In the near future spatial data will be integrated in all kinds of information systems. Sometimes they will be visible. In other cases they will be invisible, but indispensable because they are the real prerequisite for the actual information system.

The geographic based information systems will influence the way the public administrations are organized. With access to different sources with data and knowledge it will become possible at to decentralize decision competence and to break down traditional bureaucratic barriers even barriers between the private and the public sector. Spatial information will be one of the catalysts in reengineering of many administrations.

Systems like this demand common references and common "keys" between different data sets, seamless databases, common standards, nationwide datasets etc.

The users will take it for granted that it is possible to combine data from different sources. To handle this situation the geo information business has to be reorganized. We will see new business units based on partnership and strategic alliances, involving as well the private and the public sector. Some of these business units will be global. Internet and E-commerce is some of the catalysts in this process.

3. HANDLING SPATIAL INFORMATION, MANAGEMENT OR TECHNIQUE.

The predictable technical possibilities imply a comprehensive development of and cooperation between the involved organisations. Traditionally the individual organisation has been responsible for all parts of the mapping process from data-capture to the final print of the individual map sheet. This as well will change in the future.

If the organisation responsible for collections of spatial data has the necessary resources, technical equipment and skilled people it will establish digital systems for maintenance and further development of their data collections. Normally they simply convert their analogous base material to digital form, and in this way they create isolated solutions – "data islands".

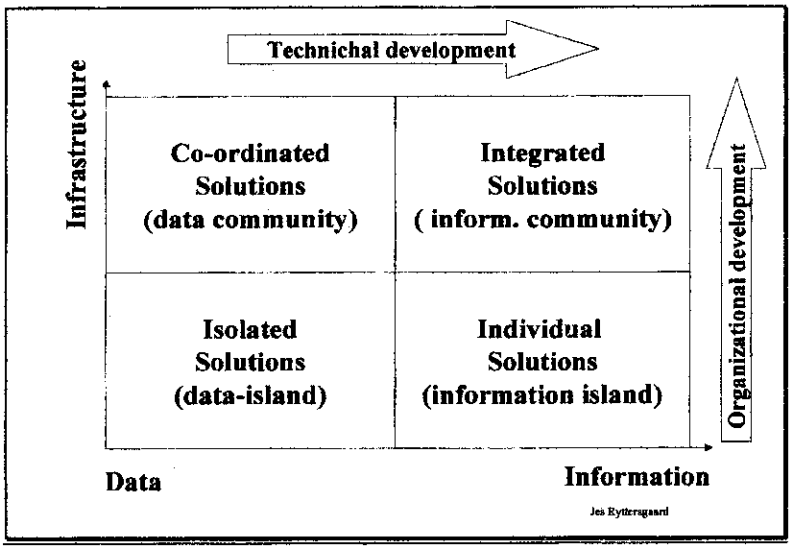

Figure 1.

Normally the base material has been produced and maintained in order to fulfil and support the core business of the responsible body. Therefore it is immediate practicable to create an individual solution that fulfil the need for access to and dissemination of information within the organization itself and the primary users – "an information island". There are also examples on information systems for limited dedicated projects created as individual solutions.

If an organisation wants to combine its own data with data from other organisations, it is necessary to harmonise the involved data. This process requires agreements on semantics of the data, common standards, data models, exchange formats, upgrading of content and accuracy of data, common keys, prizing, copyright, etc. With other words there is a need

for establishing a spatial data infrastructure. When the necessary infrastructure is a reality it is possible to create co-ordinated solutions – "data communities".

The final goal is to create integrated solutions – "information communities". Different organisations have tried to establish general integrated solutions without the necessary infrastructure. In most cases the result is limited solutions lacking the possibility for further enlargements.

Of course there is technique involved in the different processes, but the demands for organizational and managerial skills are obvious and even increasing. With reference to figure 1 one could argue that a horizontal movement from left to right represents the technical developments whereas a vertical movement from bottom to top represents the organisational developments.

4. NECESSARY PROFESSIONAL SKILLS

Normally surveyors or cartographers are responsible for establishing and maintaining the basic collections of data. It is professionals with a technical approach. These persons often go for immediate solutions that fulfil the immediate needs of their own organisation.

If you want to establish "data and information communities" you must have access to people with managerial experience. Sustainable development of a spatial data infrastructure demands understanding on how organisations works and develops, knowledge on inter-organizational processes, political understanding, knowledge on human nature and on information management in general.

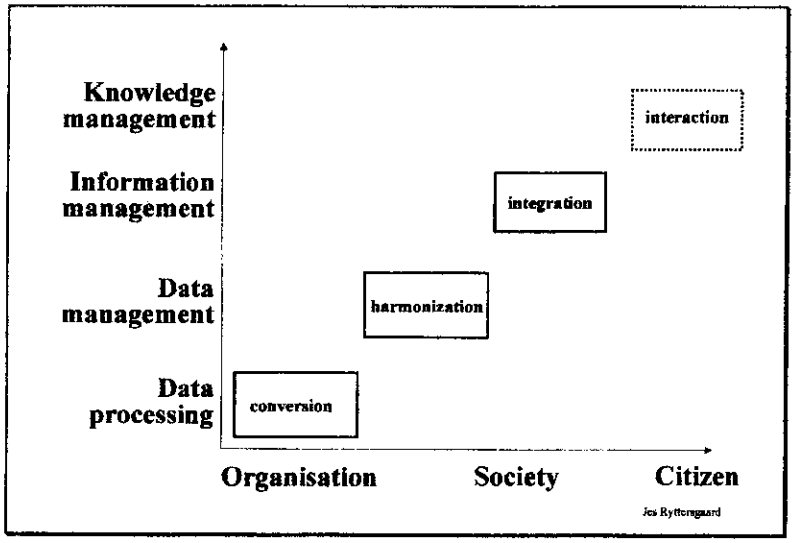

Figure 2.

The demands for managerial and organizational skills depend on where on the development ladder the organisation is (se figure 2).

If the primary goal is to serve the organisation itself the demands are limited compared to a situation where the organisation will involve users without specific knowledge on the actual data. Systems that allow the citizens to interact with the systems demand even "knowledge management".

5. THE EDUCATIONAL CHALLENGE

To day the mapping companies, the National Mapping Agencies and the mapping department at the different authorities and agencies employ as well people with an university degree in surveying or cartography with extensive theoretical knowledge on surveying, photogrammetry, data processing and cartography as technicians skilled in surveying, mapping and cartography.

As mentioned in part three and four the future development of the necessary sustainable spatial data infrastructure on the one hand demands new skills. From a technical perspective we need people with theoretical and/or practical knowledge on issues like semantics of data, object identifiers, data models, exchange formats, development of databases, model and cartographic generalisation, visualization, standards, prizing, copyright, etc. At the same time there is a strong need for people with understanding on how organisations works and develops, knowledge on interorganizational processes, political understanding, knowledge on human nature and on information management in general.

Over the last decade new techniques such as digital photogrammetry, remote sensing, laser mapping, GPS and other black box solutions have changed the data-capture methods and procedures. These changes have had great impacts on the employment of the traditional surveyor. To day the surveyor on the one hand as operator of the data-capture systems is too expensive and on the other hand his/ hers theoretical knowledge in general is too limited in respect of the new methods. There are new players in the data-capture arena, such as mathematicians, statistician, physicist and geo-physicist.

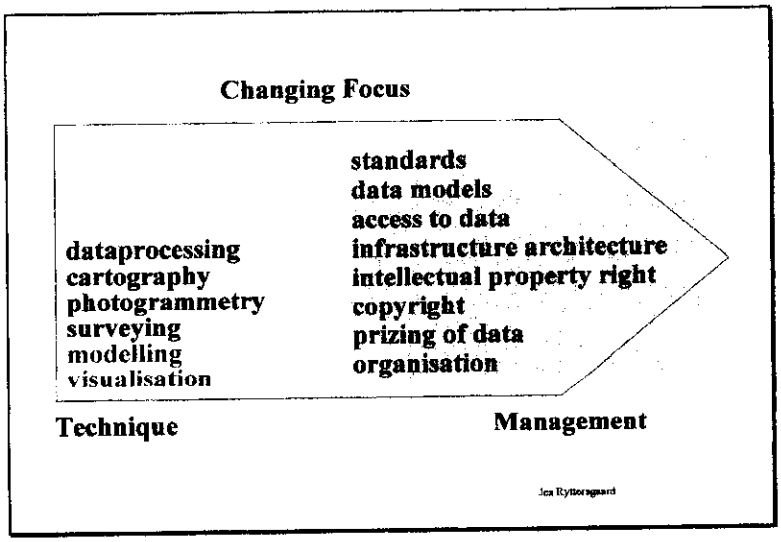

Figure 3.

It is an enormous challenge for universities and technical high schools to adapt their curriculum to the needs and demands already recognised. Because of the traditional enertia of and reluctance in the educational system at universities and technical schools it is a necessity to establish postgraduate training programs, master programs.

The future concept is lifelong learning, continuous professional development (CPD) etc. If the necessary technical infrastructure like the internet is available time ready for to utilizing the possibilities in distance learning and/or e-learning.

If the educational institutions are able to attract and produce candidates who understand and are able to handle the topics related to spatial data/information infrastructure, harmonisation and integration of data there exist enormous possibilities for employment.

Some universities have meet with situations with too few students. But it is possible to break through this vicious circle. Over the last years the Aalborg University in Denmark has had an increasing intake of new students.

6. CONCLUSION.

As previously mentioned other professionals than surveyors are and will be involved in data-capture process. On the other hand there is recognition of the need for professionals who are able to take the responsibility for establishment of the necessary spatial data/information infrastructures.

As soon as the infrastructure activities are in place we will experience demands for people who can take the lead in modelling, analysing and visualization of data and information.

Spatial Information Managers or even more correct Spatial Information and Knowledge Managers can look forward for a busy future.

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BIOGRAPHICAL NOTES

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