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GIS/LIS: THE LATEST DEVELOPMENTS

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CARTOGRAPHIC SPECIAL APPLICATIONS:

LAND AND GEOGRAPHIC INFORMATION SYSTEMS

GIS/LIS: the latest developments *

(Submitted by United Nations Department of
Economic & Social Development (DESD))

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GIS/LIS LATEST DEVELOPMENTS

ABSTRACT

Significant achievements have taken place in Geographic/Land Information systems (GIS/LIS). An attempt is made to give an overview of the state of the art as well as vision of progress still to be accomplished. Key issues are discussed in various GIS/LIS activities. A generic analysis shows that most of the applications are environment oriented. The various GIS/LIS topical issues are discussed in the order of an ascending graph, including data capture, data structure and modelling, data quality and standards, institutions, ethics, education, visualization and interface, spatial decision support systems, and applications. Finally a brief assessment of the role and nature of GIS is made. It is noted, in particular, that there are great discrepencies in the spread and success of GIS/LIS at the international level. This is true between developed and developing countries, but the case can also be made between western industrialized countries. It is also observed that there is an increasing number of professions involved in GIS/LIS activities and that there is an increasing collaboration between those

professions. Finally, it is observed that GIS/LIS are used predominently as a tool to manage and keep records, although there are signs that GIS/LIS is also leading the way towards a new spatial science. This is only a 1992 "snap shot", however, and it is expected that many of the statements which follow have limited life and will need updating, considering the rapid changes in theory and technology.

INTRODUCTION

I will organize the discussion in three sections: 1) first I will briefly present the overall GIS/LIS generic activities, 2) second I will review the topical substance of GIS/LIS related activities and discuss the issues which have been recently raised, 3) third I will conclude by giving an international perspective to GIS/LIS recent developments.

We can distinguish between three types of generic activities: 1) Theory, 2) Technology, and 3) Application. The majority of the papers presented at GIS/LIS conferences usually deals with theoretical issues such as data modelling, data structure, and data quality; a minority of papers deals

with technological issues such as data capture (typically GPS) and communication hardware; the application papers are usually somewhere between those two poles. The ranked tuples combining any two of those three generic activities show that the tuple (Theory-Application) is the strongest combination followed by the tuple (Theory-Technology). Hence theoretical issues are the driving force and this reflects somewhat of a mature stage in the history of GIS/LIS, not the infancy where the majority of the issues would be technological, but not full maturity where most of our concerns would be applications.

It also appears that 20% or more of all papers presented at GIS conferences deal with Resource-Environment issues. Hence, there are a lot of GIS people concerned with the environment today, and this reflects an important fact: we are engaged in a world wide race between environmental threats (depletion of the ozone layer, deforestation, urban and industrial pollutions etc.) and technological-institutional solutions which would enable the removal of those threats. Spatial science and GIS will play a decisive role in promoting economically and socially feasible solutions to environment-related problems.

Another striking feature is the interdisciplinary character of the applications. Contrary to earlier days, where GIS was essentially the initiative of geographers and planners, GIS has become a common tool to many professionals

ranging from planners to telephone operators, freight transporters or real state vendors. The universality of GIS applications is rooted in its ability to 1) integrate spatial information coming from different sources, including satellite imagery, aerial photography, maps, ground surveys, statistical census etc., 2) integrate expert knowledge in focused areas and generic knowledge over a wide range of topics (thereby combining magnifying glasses to an encyclopedic perspective), and 3) offer to a variety of scientific and professional disciplines the opportunity to collaborate and exchange information within the framework of a common generic tool.

Furthermore, looking at the national and professional origin of participants at GIS/LIS conferences worldwide we observe that they remain overwhelmly either North American or European events. This fact can be expected but is not entirely desirable. More input should be coming from other continents, particularly from developing countries, at an age where global environmental problems and solutions are very much emphasized.

I will now turn to the substance of GIS/LIS activities, by discussing the various issues which are presently dealt with.

TOPICAL REVIEWS

In order to grasp the essence of the GIS/LIS activities, one can organize the material into some sort of semantic hypergraph which shows the dependence relationships between the various generic themes which are dealt with (Figure 1).

The links in the graph are labeled by function names which associate topical activities. The conceptual dependencies may be many-to-one (i.e. various applications utilize Spatial Decision Support Systems, SDSSs), or one-to-many (i.e. Institutions influence Ethics, but also determine Quality Standards, and are responsable for providing Education). This formalism helps us to recognize which topics "act on" (i.e. visualization and interface help to support SDSSs) and which topics are "acted upon" (i.e. Digital Elevation Models -DEMs- are provided by Data Capture and Data Modelling). I will now review the various issues by attempting to follow a logical path which starts at the data acquisition level and which ends at the applications.

Data Capture and related Topics

Spatial data bases are made increasingly more available through modern data capture technology, including Global Positioning Systems (GPS), remote sensing with improved spectral, spatial and temporal resolutions (e.g. plans for SPOT new generation and Landsat 7), scan digitizing, automatic correlation, field computers, and, possibly in the near

future, numerical cameras. The ability to capture and manipulate massive amounts of data is related to the well known rapid developments in computer technology. The capacity of silicon RAM chip and silicon processing chip has continued to improve spectacularly and has transformed the computer industry. These developments have affected processing power, speed and cost. In term of costs, for instance, the price of one chip containing about 100 bits of memory in 1970 could buy about 10 000 000 bits of memory in 1989.

This new generation of data sources literally buries the scientific and professional community in bits of information. GPS, in particular, is receiving a lot of attention. GPS is accurate (although government restrictions have tried to limit public access to very high accuracy, Ashkenazi and Dodson, 1992). GPS is affordable and transportable, as much as to afford the application of GPS to street mapping by bicycle! We see a proliferation of organizations and individuals gathering GPS information for widely different programs. The question often asked is how do you provide the means of communication in order to avoid duplication of efforts and insure communality of standards and quality? Soft copy photogrammetry is another recent comer in data capture technology whose effect is to promote the incorporation of DEMs and digital topographic data bases in GIS data bases. What we increasingly see today in digital photogrammetric mapping is an integration of GPS, remotely sensed imagery (from aerial photos to SPOT imagery) and GIS processing,

providing "seamless" views covering large areas on work stations and PC platforms. One well known application of the interface between GIS data (usually vector) and image data (usually raster) is the production of image maps. This product is often considered a viable alternative for the mapping of third world countries. Updating of existing map series is another task which can be efficiently and economically resolved through the integration between a GIS and an imaging system. According to Morrison, by the year 2000 "most of our revisions will be on monoscopic imagery. A revision will involve someone sitting at a workstation with an ortho-rectified photograph or image and the current digital files from the national digital cartographic database," (Morrison, 1991).

As a result, the size of our data bases keep increasing. The vocabulary we use has changed by an order of magnitude: we speak of gigabytes today as easily as we spoke of megabytes yesterday. In France, for example, the new map series at 1/50000 scale will mobilize as much as 200 gigabytes. This is only for one scale and one country. At a more global level we would have to express data base sizes in terabytes. Some speak of establishing national GIS programmes, like did recently the National Cartographic Center in Iran. As a result, the data will extend both in the horizontal dimension (more space in finer resolution is being surveyed) and vertical dimension (more layers or more coverages of space are added to the GIS). And I have not spoken yet of the temporal dimension, another

future ingredient in GISs. The burgeoning of spatial data bases obviously trigers a sharp interest in data structure and modeling issues.

Data Structure and Modeling

Much recent developments dealing with data base structure and modeling are refering to object oriented data bases. Hence object orientation increasingly fascinates experts in this field. There seems to be a wide recognition that the present "layers of maps" metaphor is not ideal, and some vendors of GISs today claim to be moving towards a combination of feature and georelational approaches. The debate over the object view versus the field view of reality is likely to continue, however, because it is not only a matter related to object programming; it also has philosophical underpinnings. The object perspective may be relevant for cadastral or utility information systems, but not so useful for natural resource or cultural geography information systems where objects are difficult to recognize and relationships difficult to describe (Burrough 1992). Nevertheless, plans of the United States Geological Survey (USGS) to implement DLG-E, which is feature oriented, are going forwards (Chappell and al, 1992). Rather disapointing is the fact that data modeling for temporal GIS does not attract a wider attention. Although everybody recognizes the urgency of implementing the temporal dimension

issue. One hopes that the case will be different in future. Different time periods are presently stored on different maps as snap shots. Hence GIS users need to call up individual maps to compare time related data. A more efficient method would be to handle changes related to time as an attribute and treat each collection of spatial/temporal maps as a single temporal map set object. Noteworthy is also the increasing scarcety of research efforts in algorithm developments. This seems to reflect the maturity of our existing tools as well as the fact that further research on improved algorithmic efficiency does not appear to be a priority, perhaps because the performance of less than optimal solutions in computational geometry is now largely compensated by improvement in processing speed.

Climbing our hypergraph (Figure 1), we now turn our attention to data quality, which is affected by a multiplicity of factors, including the way we structure and model the data, the policy of institutions and the prevalent ethics.

Data Quality and Standards

Boundary uncertainties in categorical maps such as soil or vegetation maps still raise a lot of interest. Very few GISs, if any, offer facilities for tracking and visualizing this kind of error. We need capabilities to analyze and communicate errors due to the integration of heterogeneous

data coming from different sources with variable resolutions, scales and inaccuracies. Although computer technology has provided the means to increased precision (by adding significant figures to our calculations), this increase of precision is often not justified in view of the inaccuracies derived from poor performance in modelling and sampling strategies.

Giving a measure of positional or classification accuracy is not very useful, however, unless a level of confidence is specified with it. What is becoming clear is that it is the accuracy of the data base, not the accuracy of the map, which is most relevant. On the other hand, it is less clear what will be the impact of the idea of uncertainty in data bases on production methods, GISs and map representations. It is not clear whether the user is prepared to pay for the cost of added data analysis capability for error tracking and display. The lack of enthousiasm expressed by the vendor community to add data quality control facilities to their systems is certainly a reflection of low market demand. Much of the interest for quality control in GIS is still limited to academic circles and has not reached commercial organizations. Documentation is another component of data quality. As mentionned by Ferber (1992), documentation is an undervalued task in many GIS projects. Typically, all the money is spent to create the data product, and no money is left for documenting the product creation!

The development of Spatial Data Transfer Standards (SDTS) is another pressing issue. In a top-down approach, the USGS has taken the initiative to involve the spatial data community in various activities to support the acceptance of standards, to insure the reduction of information loss, to avoid duplication of data acquisition, and to increase the quality and integrity of spatial data among state and local authorities, private sectors and research organisations.

Institutions such as the USGS can play a decisive role not only in the setting of quality standards but in the use of GIS by providing the necessary high-quality, comprehensive national data base to serve as the geometric framework to which specialized data sets can be registered. This brings us to the issue of institutions.

Institutions

Institution related research efforts are now playing a major role in GIS/LIS. This seems to confirm the prediction by some that the next challenge of GIS/LIS is not technical, but lies in the organizational ability to maximize the potential of GIS through management and planing. If the 1980s focused on technological questions, the 1990s instead will focuse on management and applications. This shift in interest comes from a realization that success in GIS applications depends on the

ability to integrate multiple sources of information, which, in turn, requires the cooperation and communication between multiple partners from governments and private industry. For instance, the USGS has entered into cooperative agreements with local agencies, public utilities and private industry to expedize the development of the DGL data and the National Digital Cartographic Data Base (NDCDB). The idea of a national spatial data infrastructure, from which the NDCDB is a subset, is not far away from the concept of a national GIS. This concept is becoming popular both in developed and developing countries: in Germany where the federal states are coordinating their efforts to build a national topographical cartographical information system called ATKIS (Brueggemann 1990), in Iran where the National Cartographic Center (NCC) is discussing the idea of a national GIS to be implemented in a ten year period (Sharifi, 1992). Obviously, in both cases, institutions are the driving forces behind the coordinated efforts towards the implementation of integrated national spatial information systems. National institutions, in particular, seem to have taken the lead in exploiting the available technology, such as high speed communication links, client-server architecture, distributed data bases, distributed computer environment, for promoting the cooperation between geographically or administratively dispersed organizations. Such integration, however, requires a minimum common denominator of development among the partners of society. This is one of the difficulties faced by many developing countries where you have enormous disparities in levels of development among national agencies, where high

technology is only available in a few departments with no forseable integration at the national level. My own experience both in Africa and India confirmed this: you were travelling a few hundred years of technological development by moving from one agency, say the ministery of agriculture, to another agency like the cadaster.

Another issue which must be raised regarding national GISs is the different public notions of access to spatial information. The USA, for instance, consider spatial information as a public good which should be made available for a nominal charge to every citizen. England, on the contrary, regards spatial information as a commercial commodity whose access should be regulated by the market forces of supply and demand. France is not clear in that respect, and tends to follow the tradition of the Roman Empire: spatial information is centralized and monopolized by the government for control and development of the territory! The impact that those various notions will have on the spread and application of GIS technology is difficult to predict.

The saying that information is power is also true for GIS. Institutions or individuals who exercise GISs and therefore have control over the production and interpretation of geoinformation can exercize substantial power and therefore bear ethical responsabilities. Privacy rights may be violated, spatial information may be manipulated and distorted. This

brings us to the next issue in our GIS/LIS hypergraph, which is ethics.

Ethics

In recent discussions addressed to ethical issues come often the questions: Who is liable for erroneous information produced in a GIS? Does a call for certification of GIS/LIS practice makes sense? Should we have a code of ethic and if so what should this code entail? We have so far concentrated on system performance. We need to concentrate more on system reliance and information quality.

More general ethical issues which must be addressed in the future refer to the technocratical aspects of GIS and their inpacts on societies. For instance, GIS is still a privilege in the hands of a few who can exercize tremendous influence on the political decision making process. The money used to buy technology and GIS expertise can also be used to protect the interest of institutions or poweful lobbies who pay for the technology. Including or excluding certain type of information automatically affects the kind of questions which can be asked. There is no technology which is economically or socially "neutral". This also true for education which is the next topic of our agenda.

Education

Education is fundamental for shaping the identity of a discipline. Since GIS is up for grab, all disciplines which deal with spatial information attempt to incorporate GIS in their curriculum in order to strenghten their profile and competitive skills. As a result, there is much discussion as to where GIS belongs. Beyond the concerns of corporate interests, it is indeed an interesting question to ask which discipline, which professional society or which government agency offer the best education and training to foster GIS science and technology. This question has been specifically addressed during special sessions at GIS/LIS related conferences (Konecny, 1992). I personally do not think that the question is too relevant, because GIS requires multidisciplinary work and therefore cannot be the monopole of any single profession. I know this goes against the way our educational system works. We are trained to think and work within discipline boundaries (such as surveying, civil engineering, geodesy, cartography, geography etc.). As a result, there is a tendency to work from a specific disciplinary angle, in depth rather than in breath, and to ignore the global aspects of geoinformation sciences. However, if you want to make a map simulating the world's carbon dioxide emission from fossil-fuel combustion in the year 2000 (to take an example of Nigel Calder, 1991), you are doing GIS in a global sense and you are going to have to involve all kinds of people coming from all sorts of directions, such as

earth scientists, physicists and mathematicians. This is why words like geomatics or geoinformatics have poped up and are being used at some universities to emphasize the integration of knowledge coming from various disciplines (Groot, 1987).

One educational impediment is the belief still widely popular that school and university trainings are once in a life time investment. The question has often been raised of measuring the lifespan of hardware and software for cost/benefit purposes. The same question should be raised about the lifespan of brainware. The need for knowledge update or retraining is becoming more frequent with the rapid technological changes within by the practice of geosciences. The feeling of one individual becoming professionally obsolete is not an uncommon experience, but it is not universally recognized to a point where the employers include a budget for reschooling as corporate practice. Furthermore, the management component of GIS education has been too much and for too long neglected. Technologic and scientific know-how are necessary but not sufficient conditions for the successful achievement of a production goal. One should also be able to exercise leadership and motivate the personal involved in geoinformation production. This ability is sometimes called the human factor which is particularly decisive in suboptimal working conditions, like in developing countries where production sectors using high technology lack the general support of the economical and social fabric in the surrounding society.

Another pressing question is the GIS training of people coming from developing countries. We do it at ITC, my own institution in the Netherlands, and I have to tell you how much of a pleasure it is to see the reactions of students coming from countries like Ghana or Kenia. They seem to be surprised that space and time could be managed in a formalised, logical and socially ethical fashion with the help of a GIS, instead of having, as usual, a decision making process essentially based on particular political and corporate interests. One difficulty we are facing, however, is that GIS trained people in the third world access higher management ranks where they do not use their technical skills, or they leave for more developed countries with higher standards of living, which is of course a loss for the development of their own country.

A technology which can greatly enhance education is visualization, which is the next topic in our GIS/LIS agenda.

Visualization / Interface

Visualization can be considered as the window of GIS, and therefore is part of the interface between the system and the ... ... more and more attention

According to some, "major changes are likely to take place in the visualization aspects of GIS in the 1990s" (Velden and Lingen, 1990). Technology is responsable for this new interest. High resolution display and printing devices (color ink jet, thermo-printing, laser printing) are becoming affordable. There are also new impressive three dimensional and animation visualization capabilities (e.g. liquid crystal shutter technology, ray-tracing techniques) coupled with the increasing speed and power of microcomputers and workstations (although the difference between those two platforms is becoming blurred). Animation programs using various metaphors (interpolated frames, color cycling, see Gersmhel, 1992) can be purchased for minimum prices. Multimedia, a technology of data integration and presentation including graphics, text, high quality color imagery, animation, and video, is also a new comer which is already implemented in some GIS/user interfaces. An integration of multimedia technology with coordinate-based spatially referenced information leads to the notion of hypermap. Public access to GIS can greatly benefit from the application of multimedia, as was recently demontrated by the GIS tutorial package developed at Birkbeck College (Raper and Green, 1992).

Colour is discovered once again as a visual variable to convey the idea of quality in combination with quantitative data. The advantage of colour is in its multidimensionality. One can play with the Hue/Saturation/Value (HSV) colour model to represent levels of quality (good, bad, mediocre) attached

to quantitative data like terrain elevation. Visualization relies on specific techniques like pull down menus, icon language, graphical user interface, asynchronous dialogue, all parts of the desk-top metaphor. But there is a long way to go before we master those tools for effective communication. Many people still complain about the lack of user friendliness of GISs. Moreover, we have done too little to exploit the power of visualization for spatial analysis, as we keep thinking of visualization-equal- presentation-equal-communication. But visualization takes another dimension when it is used as an aid to explore spatial/temporal data stored in a GIS. For example, multiple representations of the same data set with various levels of details and resolutions, various types of classification and combination within or between different coverages provide added power to analysis (Egbert and Slocum, 1992). Recent developments in computer programming including the notions of objects, frames and parallelism offer new promisses in multiple representations by storing knowledge about objects, relationships, and the so-called contextual information which is so difficult to encode in traditional computer architectures.

Visualization should help spatial decision support systems (SDSS) to work more efficiently and SDSSs are one important issue also debated in GIS/LIS circles.

SDSS

Capturing spatial digital data has been a key focus during the 1980s. A key focus for the 1990s will be the development of intelligent systems to support spatial decisions and resolve problems. SDSSs are relatively new products. The difficulty in developing SDSSs is the fact that in order to be efficient they have to be taylorised and therefore lack the potential support of a wide cliental. At least in their first phase, we will see a development with a customized orientation.

Some people argue for the introduction of expert system technology to support the intuition and experience of the human expert who naturally integrate all kinds of information such as geographical context and administrative regulations in order to reach a decision. An example is given of the integration of a GIS (ARC/INFO) with an expert system tool (CLIPS) and multimedia to produce a knowledge based SDSS (In. and Healey, 1992). When the rules are difficult to formalize, or when the knowledge is too difficult to acquire and to represent, some suggest the application of neural networks. The debate of pro and contra neural networks versus expert systems is not only confined in computer science but is also taking place in GIS circles. But the potential impact of neural computing technology on the further development of SDSSs and GIS remains to be seen.

Applications

I now turn to the subject of applications, which is after all the purpose and "raison d'etre" of GISs. As mentionned earlier, a good third of GIS/LIS research related efforts are devoted to application, which is far more than technology. This speaks for the maturity of the field. There are new interesting examples of GIS applications, such as fighting fires, assessing damages caused by naturally occuring desasters, identifying high risk areas or coordinating rebuilding efforts. The three main areas of GIS/LIS applications are either related to environment, to transportation, or to land cadastre. Hence one could summarize by saying that GIS is for the most part used as a geographical, operational and legal tool. But the overwhelming interest for the environment is striking. It is a sign of our time that the environment is becoming one of our highest concern. Typical environmental applications are the monitoring of seasonal flood events, the estimation of ozone emission, the management of oil spills, the preservation of biodiversity, the management of waste water etc., to cite a few.

Interesting applications in transportation are the dispatch of telephone maintenance crews, the management of traffic congestions and the optimal location of school facilities. It is also interesting to note that marketing is

catching up on GIS: a typical example is real estate where GIS can be used by the prospecting house buyer to locate a residence of his choice according to a set of multiple criteria.

I conclude by providing some evaluation of recent GIS/LIS activities, as well as giving an international perspective to GIS events.

SOME EVALUATIONS

Will the GIS/LIS conferences survive? Some may argue that GIS is victime of its own success, that GIS is spreading out so much that general GIS meetings like GIS/LIS or EGIS will be less useful in the future than specific, specialized meetings (Goodchild, 1992). We will probably need both, as demonstrated by the success of other more focused gatherings like the Spatial Data Handling Symposium series.

Some big items are usually not well represented GIS/LIS recent developments, such as vehicle navigation, computer graphic animation, automated feature extraction from scan

digitizing, soft copy photogrammetry or more general issues like GIS technology transfer to developing countries. This is not a criticism, however, since GIS/LIS activities are not supposed to cover all topics which fall in the juridiction of every single contributing discipline. One could expect more contributions in some other priority areas, however. Those include three dimensional GIS and temporal GIS, as well as education and ethical issues. It is interesting to note that some buzz words are fading away (like fractals or quadtrees) and are replaced by some others (like object, open system and multimedia).

Everybody seems to agree that future efforts in the development of GIS should try to answer the four following requirements:

1) necessity to add the third dimension in GIS modelling. Our present systems reflect the two dimensional paradigm of the paper map and the two dimensions of the computer screen. They do not provide sufficient tools for landscape analysis, geological structure analysis, and other types of analysis requiring the third dimension such as sky vehicle navigation control.

2) necessity to develop temporal GIS. The required facilities imply motion. But computer graphic animation is not enough. We need data base management systems which incorporate causal behaviour and temporal topology.

3) necessity to provide simulation facilities in order to support scenario studies where questions like "what if" are answered.

4) necessity to provide reasoning capabilities with advanced analytical tools taking advantage of theoretical developments in spatial statistics and spatial interactive modelling. Spatial reasoning tools require the cross-fertilization of various disciplines such as artificial intelligence, spatial and cognitive sciences, and linguistics. I think this is an important issue since spatial reasoning is a reflection of culture and does influence the way GISs are built. The functions and the interface of a GIS produced in a country like Zambia would probably be different from a GIS produced in Alabama or California. Depending on the system we use, we are forced to reason in terms which may not always agree with our way of thinking or reason about space. We all have experience the difficulty (and frustration) of channeling our thoughts to

the narrow paths of a user's manual! In fact, one could argue that user's manuals as we conceive them today (a stack of thick volumes) are the major impediment to widespread GIS. No matter the application, whether it is truck dispatch nation wide or spatial strategies for retail sale and service of a franchise product, you need an expert to translate GIS to the user. This prevent general public access. Although some predict one million GIS users by the year 2000 (Dangermond, 1992), this figure could become even bigger if the general public was given access to GIS at home (e.g. through Minitel, a video telephone device in France) or in public places (like public libraries). This would presuppose a much more friendly entrance to GIS than presently afforded by the tedious and laborious user's manual approach, however. To put it in a somewhat exaggerated fashion, someone will have to invent a dum bell simple GIS for all! The Macintosh success story, in spite of the well established DOS cliental, is a point in case.

Compared to advances in data capture, data storage and data base management, one observes that progress in data analysis is not so spectacular. As mentionned earlier, very few GISs are able to analyze spatial/temporal data. The lack of data analysis capabilities in GIS/LIS can be traced back in the applications, which are still very much oriented towards facilities management and record keeping. It also relates to the lack of theories in spatial science, a discipline which is

not yet firmly established.

INTERNATIONAL PERSPECTIVES

There is great discrepancy in the spread and success of GIS/LIS at the international level. First we note the scarcity of third world participants at international GIS events. But there is also disparity among western countries. Except for Great Britain, Scandinavia and the Benelux, Europe is generally behind the US and Canada in GIS applications. It is true that a replica to GIS/LIS has been invented in Europe: it is called EGIS. But with mixed success if we look at the limited contribution of participants coming from Germany, France, Italy, Spain and Eastern Europe. So there is still much to be achieved for those countries to become clearly visible in the GIS arena.

That there is a slower pace for some countries to rally the GIS band wagon may be due to the difficulty faced by some more than others to break up the boundary of well established disciplines. Note that there is no international GIS professional society like there is for photogrammetry, surveying, geodesy or hydrography. The question whether this

should come is subject to debate. Although we have a good idea of what GIS does there are still epistemological and ontological arguments regarding the existence of GIS. Is GIS merely a tool, or can we refer to GIS as a science? I personnaly do not favor casuistical discussions on this subject but we do have to recognize that there is a source of confusion raised by the dichotomic function of GIS. There are two kinds of activities in GIS/LIS: 1) those which use GIS as a tool to manage resources for concrete purposes in order to provide specific services, and 2) the second kind of activities which present GIS as a mean to learn to know and analyze scientific problems. The goal in the second case is to discover some general laws in order to explain and to predict. To take a rather simplistic analogy, one group of professionals are concerned with the question of when and where is the apple going to fall, whereas the other group is concerned with the more fondamental question of why is the apple falling in the first place. I think the difference between tool and science lies at the boundary separating those two groups. My opinion is that we should strive for science in GIS and not rely on the technology alone for the advancement of GIS concepts and theories.

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FIGURE CAPTIONS

Figure 1. Various GIS/LIS Topics and their Dependence Relationships.

Gis/Lis '92 Panorama