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Geoinformation, Geotechnology and Geoplanning in the 1990s

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Abstract

Over the last decade, there have been some significant changes in the geographic information available to support those involved in spatial planning and policy-making in different contexts. Moreover, developments have occurred apace in the technology with which to handle geoinformation. This paper provides an overview of trends during the 1990s in data provision, in the technology required to manipulate and analyse spatial information, and in the domain of planning where applications of computer technology in the processing of geodata are prominent. It draws largely on experience in western Europe, and in the UK and the Netherlands in particular, and suggests that there are a number of pressures for a strengthened role for geotechnology in geoplanning in the years ahead.

1 Introduction

The ‘geo’ prefix has become fashionable in the 1990s. A suite of new geo terms including geodata, geodemographics, geomarketing, geoinformatics and, most recently, geocomputation, now exist, bringing the geographical dimension into sharper focus in each case. In this paper, we consider some of the key developments that have taken place over the last decade in three related areas where the spatial component is of critical importance: geoinformation, geotechnology and geoplanning. The first of these terms derives from the fact that we are living in the 'information age'. Information has value because it can be used to extend knowledge, enhance wisdom and reduce uncertainty. It helps us to understand how the world works and assists us in making better decisions about developments that will affect our circumstances. The explosion of geographically referenced information or geoinformation over the last thirty years has been paralleled by huge advances in the capabilities of computer hardware technology that have facilitated the storage of massive amounts of data and reduced processing times to a fraction of what they were a decade ago. These developments have generated a demand for new software to allow potential users to handle the huge quantities of data of different types that have been captured in various ways. Geotechnology is the general term used to refer to the proprietary and customised geographical information systems (GIS) that are now available to support research and planning activities based on geoinformation.

Planning, in its broadest sense, is an activity that requires information about existing as well as future situations. Many types of planning have either implicit or explicit spatial dimensions whether they are distinguished by scale (e.g. global, national, regional, urban, local) or by sector (e.g. transport, energy, health, education). Much planning activity is therefore geoplanning and in situations where spatial decisions have to be made, the relative success or failure of the outcome depends on the accuracy and reliability of the geoinformation used to support the decision-making process and its expert interpretation. Geotechnology provides the decision support infrastructure within which geoinformation can be used to maximum advantage in the quest for better geoplanning.

This article aims to provide a overview of geoinformation, geotechnology and geoplanning in Europe as we approach the new millennium. Almost ten years ago, Scholten and Stillwell (1990) stated that *"GIS is playing a key role in a variety of urban and regional planning activities across the world. It is a dynamic technology with enormous potential for the future. However, this potential will only be realised if those in the planning profession in senior administrative and executive positions are prepared to meet the challenges which GIS adoption entails and are able to demonstrate the vision necessary to create a suitable environment for successful GIS implementation"* (Scholten and Stillwell 1990, p. 13). Now, at the end of the decade, it is appropriate to assess change, to consider what has been achieved, and to recognise where progress has been disappointing. These are amongst the aims of a recent volume edited by Stillwell, Geertman and Openshaw (1999) and this paper derives from a reworking and extension of its first chapter. Our discussion focuses respectively on trends in geoinformation (Section 2), in geotechnology (Section 3) and in geoplanning (Section 4). In Section 5, the state of the art with respect to the interrelationship between geoinformation, geotechnology and geoplanning will be dealt with. In conclusion(Section 6), we make some comments about the future use of geoinformation and geotechnology in geoplanning.

2 Trends in Geoinformation

The need for geoinformation as a basis for planning, development and control has grown rapidly. Likewise, the expansion of 'geoinformation business' (Frank 1997) in recent years has been rapid, with various agencies responding to the challenge of data acquisition and provision. National mapping agencies in most European countries have undertaken to produce national coverages of topographic maps in digital form that can be sold to customers. One example is the National Topographic Database (NTD) developed by Ordnance Survey (OS) during the 1990s which contains large-scale digital data for the whole of Great Britain (Masser, 1998). The NTD currently holds over 200 million features and intends to include all new features within six months of their completion. In addition, the OS has developed a National Height Database (NHD) derived from map contours converted into Digital Elevation Models (DTMs), as well as road centreline databases. Another group of data suppliers are those local authorities, central government departments and public utilities who frequently collect large scale and very detailed data for administrative purposes (e.g. the Office of National Statistics). In addition to these traditional geoinformation suppliers, new markets have developed for both geometric data and attribute information. One example is the creation of customer lifestyle databases, many of which are owned by private sector companies.

To keep geographic data up to date, more and more use is made of remote sensing techniques. During the last decade, the mapping of land cover at local and national scales has been hindered by the relatively coarse resolution of satellite images; e.g. the Landsat Thematic Mapper (LTM) images have a spatial resolution of thirty by thirty metres; SPOT multispectral images have a resolution of twenty by twenty metres. However, new commercially owned, very high resolution, digital earth-observing satellite systems sensors will increase the chances of being able to produce much better quality land use information (Donnay, 1999), although there are arguments that the accuracy of land cover classification may decline at the pixel level.

Problems of data inconsistency, both between and within organisations, have meant that the requirement for data standards has become increasingly important in the 1990s. Customer and establishment databases are notorious for being constructed in different ways. Instead of keeping data in different 'gazeteers', standards provide a framework for data to be collected and stored in a common format. Standards have enabled advances in data integration. Examples of this are the emerging national systems for property conveyances, which provide on-line integration and access to various property databases maintained by different organisations such as cadastral and mapping agencies, real estate and law firms, and local authorities. Such systems provide for much faster completion of conveyances, greater accuracy of information and easier transactions. As more data have been created in standard formats, initiatives have been developed to make the data more accessible. However, most European countries lack a general policy concerning geoinformation. The pricing of geodata is dependent on the market or on *ad hoc* agreements between data suppliers and customers. In the Netherlands, unlike the UK, charging commercial and non-commercial organizations different prices for governmental geodata is not permitted. The pricing of these geodata sets depends partly on the need for cost recovery. Moreover, adding value to geodata by Dutch governmental organizations is only allowed when this is part of their primary responsibility. The policy on copyright also differs between European countries. In the UK, Crown Copyright protects governmental geodata; in the Netherlands, copyright law does not protect most geodata because they are not considered to be original data. At the European level, directives are being formulated which will protect geodata created with substantial funding and maintain confidentiality restrictions. An EU Data Protection Directive will be implemented which will ensure that governments across Europe develop similar codes of practice with respect to data protection.

The explosion of data in recent years has been accompanied by a significant growth of interest in metadata and metadata services. Metadata refers to the standardised description of a data set or information about data. The purpose of a metadatabase is to give potential data users information about available databases, their contents, structure, format, *et cetera*. The most common forms of metadata are printed catalogues, map indexes, directories or data transfer specifications (Wood and Cassettari, 1997). The most practical amount of information required by a user is a simple classification of the main data objects, date of last update, completeness, coverage, resolution, GIS delivery format, GIS compatibility, map projection, indicative cost and supplier details. In 1996, a European standard (CEN/TC 287 GI metadata) emerged for geoinformation.

There is no doubt that the availability of and access to information of all types has been transformed by the development of the Internet, connecting millions of computers across the world. The World Wide Web is a service on the Internet, which was developed initially by researchers whose aim was to construct a common interface to both the different protocols existing on the Internet and the different data formats. The Web has become one of the most efficient channels for transferring information through the Internet due to its visual capabilities and its relatively advanced multimedia tools. One of the strengths of the Web is that any page (containing formatted text, images and multimedia) can 'hypertext link' to any other page on the Internet by simply referencing that page's address or Universal Resource Locator (URL). Perhaps the most important function of the Web for many users is the opportunity to access data sets and computer programs stored remotely. These data may be geographically referenced data and the programs may be GIS software. 'Gateways' have been developed to connect remote users to these resources. It is possible to construct a Common Gateways Interface (CGI) by translating the data in a hypertext markup language (html) page to the format required by Arc/Info's general query language, AML, for example. Such an interface would permit the user to identify objects on a map, zoom in on selected areas, select coverages and produce maps. Thus, several of the kinds of simple operations available locally can be performed remotely. Carver and Peckham (1999) identify several examples of Internet-based spatial decision support systems including the use of multi-criteria methods and GIS for site planning (e.g. exploring different potential sites for nuclear waste disposal).

The Web also provides an environment for meta-metadata services that offer an efficient gateway for moving between different metadata sites. The ‘clearinghouse’ concept is directly related to this kind of service. At the national level, almost every country is involved in setting up a national clearinghouse service for geoinformation. At the European level, the ESMI-project is aimed at linking together the diversity of national clearinghouses. Services are now becoming available on the Internet, which are essentially 'one stop shops' for users requiring either map-based information or other information from private or public data providers.

Trends in the provision, distribution, consistency and integration of geographical data have been accompanied by efforts at national and supranational levels to promote and encourage the use of data resources. The National Geospatial Data Framework (NGDF) is the

UK spatial data infrastructure whose aim is to facilitate the unlocking of geospatial information through provision of better awareness of data availability, improved access to the data, and better data through encouraging the use of standards. In most other European countries, similar national agencies have been set up to perform the same type of promotional activities (e.g. CNIG in Portugal).

In summary, the 1990s have been a decade in which the problem of obtaining data to populate geotechnology has been the focus of attention of planners throughout Europe. Huge advances have been made in data availability, standards, integration and access, although problems in each of these areas still persist and many of the principal barriers remaining are relating to cost, copyright and ownership. The handling of computerised data has had to be regulated and in the UK: the 1984 Data Protection Act has meant that data users have had to register with the Data Protection Registrar and comply with a set of principles and provisions for different types of data. Some of the measures to provide protection for information carry penalties in terms of costs and inconvenience but, despite constraints of this type, the geoinformation business has flourished.

3 Trends in Geotechnology and its Use

GIS is now a technology widely accepted by organizations involved in planning at different spatial scales and in different sectors. According to Campbell and Masser (1995), the adoption of GIS in local government in the UK was quite widespread by the early 1990s and local authority planning departments were seen to be taking a lead role in GIS implementation. In the Netherlands, studies by Grothe *et al.* (1994) and Grothe and Scholten (1996) showed that GIS use had been highest in central and provincial government and water boards, with the municipalities lagging behind and there too planning departments fulfilled an important role in their implementation.

Traditionally, large organisations with widely distributed assets required geotechnology to capture, store, manage and display very large amounts of geoinformation. Either mainframe or dedicated workstations were used as the platforms for building the GIS. Companies in the GIS industry developed their own UNIX-based proprietary systems, their own user interfaces and their own developmental languages. This meant that GIS had to run on expensive hardware and needed highly trained operators to exploit the technology for each application. GIS, like many CAD systems, became 'islands of automation' with no links with other systems (graphics, models, other GIS).

During the 1990s, geotechnology has filtered down from organisations with large and dispersed assets (e.g. utilities and local authorities) to smaller organisations for whom GIS is a useful tool to enable particular tasks to be undertaken more effectively. Due primarily to the introduction in the mid-1990s of PCs with Intel processors delivering the power required to drive the geotechnology, 'desktop' systems started to become the dominant environment for working on the PC. An industry once tied to servers and workstations was liberated with the result that there has been a proliferation of GIS desktop solutions offered on the market in recent years. GIS is now affordable and accessible to a wide range of users. Nowadays, new users of GIS tend to look for simplicity rather than sophistication in the use of GIS in a PC environment, no longer wanting to have to employ dedicated specialists to undertake analyses for them. Desktop mapping packages have been developed (e.g. MapInfo or ArcView) which are often used entirely as presentation tools to provide a backdrop for business statistics. Desktop GIS are taking an increasing share of the overall GIS market. However, once attracted to these systems, the user soon becomes aware of the limitations of the software and a migration occurs from cheaper mapping systems to more sophisticated GIS tools. Vendors of major GIS systems have recognised this change in customer preference and have responded to it in the introduction of cheaper standalone packages.

New concepts like 'open systems' and 'interoperability' appeared during the 1990s. The purpose of open systems is to make it possible for computers to communicate with one another. The tendency for GIS to remain 'islands of information' (Aybet, 1996) is due in part to their complexity but also because vendors have felt it necessary to preserve their own identity in their proprietary products. However, it is recognised that departments of the same GIS user organisation may require different systems to undertake various applications but that the systems should not be isolated from one another. This necessitates a common platform on which geodata can be shared and used by these departments and better facilities for accessing data. Communications and distributed database systems are now available that allow open GIS to be achieved and there are new standards such as Object Linking and Embedding (OLE), Common Object Model (COM) and Spatial Data Transfer Standard (SDTS) which allow users to run GIS applications in a single computing environment. Interoperability refers to the freedom and ability of users to access local or remote geoprocessing environments that may use various GIS and contain multiple format data sets. Furthermore, one of the key dimensions of desktop systems now is seamless software environments in which word processing, spreadsheets, business graphics, document management, mapping and GIS functions are all available in the same application (e.g. Geomedia). However, increasingly the global domination of PC and workstation markets by Microsoft via Windows 2000 (formerly NT5) will trivialise many of these interoperability issues by having a global *de facto* standard. This, combined with exponential growth of Java, will ensure that soon hardware and platform dependency will become purely a historical artefact.

The application of geotechnology in geoplanning has been widely reported in the literature in the 1990s (see, for example, Scholten and Stillwell, 1990; Worrall, 1990, 1991; Huxhold, 1991; Rideout, 1992; Longley and Clarke, 1995; Rumor *et al*., 1996; Hodgson *et al*., 1997). Most recently, Stillwell *et al.* (1999) provides an overview of European-based GIS applications in planning. It is possible to distinguish at least four trends: the evolution from CAD-GIS to virtual reality (VR); the change from maps to multimedia; the transition form data-management and presentation to analysis and modelling; and the development from simple GIS operations to geocomputation.

The representation of urban and rural environments on the computer was initially through the use of Computer Aided Design (CAD) packages. Most of this software was developed specifically for the design and visualisation of graphic elements in two dimensional (2D) or three dimensional (3D) ways with very limited facilities for handling the spatial concepts. The integration of the 3D modelling capabilities of CAD technology with the 2D spatial analysis functions of GIS has therefore provided opportunities for planners to develop more realistic visualisations of city and rural landscapes. However, the integration of CAD and GIS in planning practise has been mainly limited to the translation of 2D graphics files between the two software environments and the development of enhanced database facilities in CAD so they are more GIS-like (Mayal *et al*., 1994). The last decade has seen the development of VR as a way of overcoming the inability of CAD-GIS to reflect reality and its dynamics. VR is the concept of advanced 3D and interactive computer simulation in which users, using movement and position tracers, move around an artificial environment. VR technology has now become available on low-end workstations and high performance PCs and is increasingly being used in urban planning and design to provide a more sophisticated form of communication between the planners themselves in visualising alternative designs, to provide non-professionals with information concerning difficult design and planning concepts and to enable new buildings or environments to be perceived by potential users more effectively (Batty *et al.*, 1999).

In parallel with development of VR, the 1990s have also witnessed the emerging use of multimedia systems with components (photographic images, animations, video and sound) that are much more complex than the text and vector data associated with traditional GIS, require special tools for data capture and involve huge quantities of information. The integration of multimedia and GIS has changed the conventionally limited representation forms of static figures and tables to various other forms of visualisation, and interactive multimedia has enabled multidimensional exploration of data and processes, which may reveal new and previously unknown patterns. Gouveia and Câmara (1999) have reviewed different forms of multimedia technology and their use in different planning contexts (e.g. traffic monitoring, education and tourism, radioactive waste site selection and environmental impact assessment). As hardware speeds improve, as gigabyte networks proliferate and as disk storage costs fall, so there will be an explosion in multimedia because it is suddenly easy and economic alongside its other innate attractions.

In the 1990s geotechnology has been widely applied in planning for activities like database management and map presentation, but much less for more analytical and modelling purposes (Geertman, 1999). Some examples of applications of modelling and/or GIS techniques to support planning in different contexts are presented in Longley and Batty

(1996). The use of multicriteria analysis (MCA) techniques for an environmental impact assessment of wind farming in Wales (Kidner *et al.,* 1999) provides another example. Cellular automata (CA) models coupled to a GIS have been used to simulate spatial developments for the generation of spatial future scenarios by Engelen *et al.* (1999). In socio-economic planning too a diversity of analytical GIS applications have been built and used to assist in solving planning problems (Martin 1999). Many applications in planning require more analytical and modelling functionality than existing proprietary GIS are able to provide. As a consequence, analysis and modelling usually occurs independently. It was clear that, in the 1980s, the two sub-disciplines of GIS and quantitative modelling remained apart (Birkin *et al.,* 1987), despite repeated calls for the 'missing link' (e.g. Scholten and Padding, 1990) to be introduced through the embedding of modelling functions within GIS and *vice versa*. The concept of an 'intelligent GIS' is one in which analytical and modelling capabilities are developed in close association with database management and display tools for a particular client who is likely to have a unique strategic problem to solve (Birkin *et al.*, 1996).

However, intelligent GIS should not be confused with what is referred to as 'intelligent GIA' (Geographical Information Analysis), that is associated with the term geocomputation. Intelligent GIA involves a range of techniques, usually mathematical or statistical, that have computational adaptivity and which are not constrained by the computational limitations of more conventional methods of spatial analysis (Fischer, 1999). The computation of geoinformation or geocomputation is not new but the last ten years have seen a very significant change in the size, speed and costs of high performance computing (HPC) whilst the emergence of parallel computing hardware has broadened the range of applications requiring a geocomputational approach (Openshaw and Abrahart, 1996). Artificial

Intelligence (AI) has become one of the most recent areas of interest in GIS with particular emphasis on expert systems, knowledge-based techniques, fuzzy logic models and neural nets (Openshaw and Openshaw 1997).

In summary it is clear from the discussion in this section that the technology for handling multiple forms of geoinformation has continued to develop (VR; multimedia; intelligent GIS; intelligent GIA). There has also been a parallel trend towards the development of simpler, more user-friendly systems that can be used by those with lower skill levels to support their research and planning activities. In fact this last development has resulted in a widespread explosion of users and applications of geotechnology.

4 Trends in Geoplanning

In this section of the paper, we turn our attention to the main trends in geoplanning over the last ten years which have exerted an influence on geoinformation and geotechnology. After a period of time when priority was given to environmental planning, physical planning has returned to the forefront of public and political attention in many European countries and the sustainability of the environment has become one of the key dimensions underpinning many initiatives. The recent acknowledgement of the interconnectedness of land use and transport planning, for example, has resulted in greater awareness of the need to develop sustainable patterns of development. Transport is no longer regarded as an end in itself but as a means for developing sustainable transport policies which balance the freedom to travel with the need for a healthy environment, support for a competitive economy and which assist urban and regional regeneration. Most of the problems with indicators of sustainability have been in defining them, in measuring them, and in trying to attach weights signifying the relative importance of features as diverse as the transfer of commuters from private cars to public transport and the use of greenfield sites for new residential development.

Integrated land use and transport planning is one expression of a wider trend towards more integrated planning in general. Traditional boundaries between different types of planning are being redefined so that the process of area planning is becoming more holistic in nature. The Dutch term *'gebiedsgericht beleid'* means 'region-oriented policy' and implies that, within the boundaries of a region or locality, different kinds of spatial related policy are formulated and implemented together. This leads to the idea of 'community plans' complementing 'development plans' and to new approaches for creating 'mixed developments' where land in one locality is used for residential and commercial uses as well as for shopping and leisure activities. This is a far cry from the traditional view of land being zoned for one particular land use that was the norm ten years ago. The process of integration is not just restricted to plan design, but applies to the overall planning process: the specification of goals, programs, financial arrangements, implementation, monitoring and evaluation. Appropriate monitoring and effective evaluation following plan or policy implementation have become crucial and it is important to recognise that monitoring and evaluation require different geoinformation and geotechnology tools than those that support plan design and policy formulation.

Greater integration has meant that public and private agencies now collaborate in development planning projects and policy initiatives. Public-private partnerships (PPPs) have become the *modus operandi* for many development schemes and there are no better examples of partnership in action than the arrangements that exist whereby government or private sector funds are required to match funds from Europe. One corollary of the trends towards integration and partnership has been the change of emphasis towards a more strategic programme approach and away from an approach that focuses on smaller projects independently. There are many instances of increased collaboration between stakeholders who are directly involved in and/or affected by the plan-making process. In this way, planning is no longer exclusively a task of government agencies; it has become an organizational/financial/responsive agreement between the public and private partners involved and satisfactory plan implementation depends on successful co-operation between all parties concerned.

One recent development that has made a huge impact on the process of planning and its associated information requirements and technology support is the rise of 'interactive' or 'participatory' plan-making. The traditional approach has been that planners have generated ideas for consultation and that citizens and persons affected by the outcome of the plan-making procedure are consulted through public inquiries or hearings. In the new era of interactive planning, all interested parties (including children) are invited to participate in the plan-making process right from the beginning through participatory workshops. As with the new demands for efficient monitoring, so this kind of 'planning for real' process demands quite different functions/tools that require support by geotechnology. Increasingly the Internet is being used as a mechanism for improving public participation in a variety of planning contexts (Carver and Peckham, 1999). Although connected to several other planning trends, 'collaborative groupware planning' has become distinctive by using computer-based systems to support partners achieve the task of attaining a set of predefined goals. Communication, collaboration and co-ordination are the requirements for stakeholders working together in the same place or in different places simultaneously or at different times. A variety of different geotechnology support tools have been developed to support this process such as group decision rooms (e.g. Computer Supported Co-operative Work (CSCW)) and group decision support systems. Another way to increase participation in planning and facilitate the process of making difficult and frequently unpopular decisions, is to ask different kinds of experts from industry, business, academia and research institutes, to participate at certain stages (through brainstorming; expert meetings). The information technology support in this context may be offered to facilitate the experts in expressing and translating their knowledge and ideas for a wider audience or the contribution of the experts can be incorporated as encoded expert knowledge within a (spatial) decision support system.

Throughout Europe, encouraged by supranational organisations like the European Commission, there has been a trend to encourage planning at a regional level. This is partly a recognition of the fact that many planning problems cannot be solved at the national level or at the local level, and partly a pragmatic response across Europe to the requirement to formulate submissions for funds that have a regional dimension. The regional tier of administration and planning in most European states has increased in importance over the 1990s. Even in the UK, where regionalism has been resisted strongly by Conservative governments, the last two years under Labour have seen considerable progress and legislation for new regional governance. Scotland and Wales have their own assemblies and Regional Development Agencies have been established in each English region since April 1999. From an information technology perspective, this implies an increase in regional data sets and planning support tools at the regional level (Stillwell and Winnett, 1999) so that new strategies for regional economic development, innovation, integrated transport and land use, sustainable environments, and enhanced quality of life can be formulated and implemented.

Finally, during the last ten years, it has become common practice within planning to consider the future by defining different spatial and aspatial scenarios. Typical examples might include the formulation of scenarios about specific development projects such as the construction of a new airport or the siting of a new industrial estate, whose impacts on the physical environment, land use, jobs and traffic may be very substantial. Scenario planning becomes more complex when plans relate to a combination of objectives, which may result in a diverse set of outcomes. Spatial scenario planning offers different views on the future based on different assumptions or underlying trends and on what might be the optimum spatial outcome. The uncertainty associated with a particular planning context may mean that an orientation toward the optimum solution would not be expedient. Scenario planning strongly emphasizes map representation and the analytical 'what-if' functions of GIS and spatial modelling. It is closely connected to the view that planning should offer inspired visions of the future, a function which forms the foundation for the implementation of spatial policy. Scenario planning can be seen as a reaction against the more procedural and instrumental orientations that characterised planning during the seventies and early eighties.

Thus, over the last ten years, planning has become more integrated, more partnership-oriented, more holistic, more strategic, more interactive, more regional and more scenario-oriented. These changes have far-reaching consequences for geoinformation provision and analysis as well as for the skill requirements of planners in the profession. Whilst the immediate availability and easy exchange of data between participating agencies has become vital, in some circumstances, problems of information overload have been encountered. As planners have been required to respond to more and more consultations, time horizons have reduced and time pressures have increased. Technology has helped facilitate the process in many cases but information technology skills have not yet been fully adopted by the planning community in many regions of Europe. However, during the last few years, planners have become more open-minded towards the use of computer technology and the application of GIS and models, following a long period of adamant rejection of more quantitative approaches.

5 Geoinformation, Geotechnology and Geoplanning: The State of the Art

Several conclusions can be drawn concerning the state of the art in the interrelationship between geoinformation, geotechnology and geoplanning. Firstly, it appears that within current planning activity there is a substantial and ever growing need for planning support. Two interconnected developments contribute to this need: the increased role of communication in planning and its increased complexity. At one time, planning was seen primarily as the task of a selected group of experts. Within the current tradition of participatory planning, each of us is considered to be an expert and it is necessary to 'plan with' the public instead of to 'plan for' the public Klosterman (1999b). In such circumstances, proper communication of information in an overall comprehensive way is of tremendous importance, particularly when using vague planning concepts like 'sustainability'. Likewise, complexity has increased substantially, not at least because of the interconnectedness of issues and the frequently conflicting interests and goals of planning that is integrated and holistic. As a consequence, there is a substantial need for instruments that can assist in handling this complexity. In general, geographical information and communication technology is expected to contribute to the proper handling of this complexity (e.g. insightful procedures) and communication (e.g. graphical outlook).

However, despite the need for decision support in planning, this role of geotechnology is still primarily restricted to the management and presentation of geoinformation (Geertman, 1996; Wegener, 1998) and those experiences in practice show quite a mixed pattern of success and failure (Nedovic-Budic, 1998). In the literature, a wide diversity of arguments can be found for this deficiency, like the lack of sufficient geographical data and/or of their availability or the lack of investment in geotechnology within planning departments. The lack of knowledge and/or acquaintance with the potential of geotechnology is another frequently mentioned reason that explains the predominant position of qualitative methods in past and present planning practice as well as the distrust of and resistance to more quantitative planning methods (Harris 1998; 1999). The lack of training in the handling of more advanced geotechnology tools within higher education can be considered a main reason for this lack of knowledge and distrust (Wegener, 1998; Castells, 1999). As a consequence, the more analytical and modelling potential of geotechnology remains little used within present planning practice and scant progress in the development of analytical tools for planning purposes has been achieved beyond the stage of prototyping (Klosterman 1998). This neglect, which was recognised by Goodchild (1991) at the beginning of the nineties, has persisted.

However, despite the limitations, ignorance, insufficient training and distrust, it is necessary to recognize a recent explosive growth in the use of geotechnology within planning practice. An important reason for this is that, besides the tremendous growth in accessible and affordable geodata, the developments in geotechnology have moved from being primarily technology-driven to being more user-driven (Geertman, 1999). Geotechnology is becoming more accessible with the emergence of relatively cheap and easy to handle windows-based (eg. ArcView) and WWW-based (e.g. Geomedia; MapObjects) geotechnology tools, which do not expect the new user to invest several weeks or even months in training, which was the case ten years ago. Besides this improved accessibility, the first tentative steps in the direction of dedicated and more integrated Planning Support Systems (PSS) can be detected, generally comprised of the components of information, models and visualisation (Klosterman 1999a; 1999b). As an illustration, a PSS can combine ‘sketching’ – the rapid and partial description of alternatives – with state of the art modelling of the implications of these alternatives (Hopkins 1998). Alternatively, a PSS may assist in the design of different regional scenarios with the help of spatial simulation tools based on Cellular Automata, in their evaluation with the help of MCA-tools integrated in a GIS, and in their communication with the help of WWW-technology and VR-techniques. In general, it must be concluded that the Internet increasingly fulfils a more stimulating role by offering visualisation, spatial analysis and modelling tools and/or possibilities (e.g. remote modelling) for handling geoinformation at marginal costs. We are at the beginning of an era in which a whole suite of new potentials of the WWW-technology will drastically change the interrelationship between geoinformation, geotechnology and geoplanning.

6 Geoinformation, Geotechnology and Geoplanning in the Future

In concluding this paper, we offer some ideas about the future use of geoinformation and geotechnology within geoplanning that emerge from the review of trends and the state of the art discused previously.

Firstly, the next decade will see geodata and geoinformation become available in ever-larger quantities and better qualities, at lower cost, and more accessible to a wider diversity of customers. In such a data rich environment, tools for geocomputational processing of huge quantities of geodata will become essential to extract knowledge from the mass of information in an efficient way. Moreover, the Internet will provide us with fairly cheap and easy to handle tools for use in these geodata rich environments.

Secondly, the use of geoinformation and its supporting geotechnology will become much more common within our lives in general and within planning in particular. Geotechnology will enable a more exciting representation of reality through 2D maps, 3D scale models, (photo)VR animations or even 4D time/spatial simulations. Microsoft will offer some of these representation capabilities (2D maps) in its Office software package. Our new cars will be provided with built-in navigation systems that make use of maps and GPS. Many towns already have ‘information pillars’, which provide printed maps of an area and give directions to a required destination. We will get more and more accustomed to using geoinformation in both our private and working lives. Geotechnology will lose its isolated status and become a more integral part of a society built upon open information and communication technology (Open ICT). Within geoplanning it will contribute to each stage of the planning process and in each of these, its functions will be attuned to the needs of users. In general, the main functions of geotechnology within these stages will be twofold. On the one hand, as part of the Open ICT, it will take care of the input, storage, management, processing, analysing, presentation and exchange of geoinformation. Standardisation, pricing, accessibility, privacy, data quality and meta-information will be essential factors in such an ICT environment. On the other hand, the geotechnology will assist in performing specific tasks within the planning environment for which it is especially well equipped (e.g. environmental impact assessment; optimal routing; spatial modelling and visualisation). This will also result in specific geoinformation instruments, which can assist in performing specific planning tasks (e.g. traffic monitoring systems).

A third issue concerns the developments within geoplanning and their impacts on geotechnology. The more geoplanning will become a participatory process, the more the need will arise for geotechnological support to attain accessible and understandable forms of geoinformation. Undoubtedly the Internet will play an important role in this, because of its technological potential (e.g. multimedia presentation; two-way communication) and of its direct and continuous accessibility. Moreover, monitoring of (spatial) development projects or policies and their modification will become equally as important as their initial formulation and the consideration of alternatives. As a consequence, better instruments for remote sensing and global positioning will be needed to capture the geodata to monitor change more effectively. Further, trends towards more integrated planning can be considered as an extra stimulus for open and interoperable systems. The necessary exchange of geodata and geoinformation between involved parties may no longer be frustrated by non-compatible technologies and differing data formats. Besides, if strategic planning in which there is a close connection between a vision for the long-term future and a short-term program of measurements is to be successful, new and more advanced tools for geosimulation modelling will be needed to provide clear and plausible visions of the future ('what-if' scenarios). This opens the way to a kind of planning that is much better equipped to anticipate a diversity of potential futures and occasions (robustness).

Fourthly, an important issue for geotechnology relates to the scale at which geoplanning is undertaken. In Western Europe, the regional scale has become an increasingly important focus of policy. It follows that while the strategic decisions and directions will be formulated at a supranational scale, the application and elaboration of policies will focus at the regional scale. These developments will result in increased collaboration between regions and will offer extra stimuli to Europe-wide standardisation in geodata and geotechnology with respect to pricing, formats, privacy law, accessibility, et cetera (e.g. GI2000). At the regional scale, this will also result in an intensified collaboration between public and private parties to perform increasingly complex integrated planning tasks, and supported by ICT in general (e.g. Internet communication) and geotechnology in particular (e.g. the attunement of separate economic, environmental and spatial and sectoral plans).

Finally, the 1990s has witnessed an array of new applications of geotechnology and GIS is increasingly playing a part in planning activity. A number of trends suggests the demand for geotechnology remains undiminished: more complex planning tasks require better geoinformation and improved decision support mechanisms; more integrated and collaborative geoplanning requires better geoinformation accessibility and exchange arrangements; a focus on regional planning makes new demands for data and analysis at this level; the need for better monitoring and evaluation has implications for data collection and processing; and the desire to make better judgements about the future requires improved modelling and forecasting methods. Thus, there are several reasons to sustain our hopes that a greater synthesis of geoinformation and geotechnology with geoplanning will occur in the coming years.

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