'UNIVERSAL' GIS VERSUS NATIONAL LAND INFORMATION TRADITIONS: SOFTWARE IMPERIALISM OR ENDOGENOUS DEVELOPMENTS?

MICHAEL WEGENER and HARTWIG JUNIUS
Institute of Spatial Planning
University of Dortmund
Postfach 50 05 00
D-4600 Dortmund 50
Germany

ABSTRACT. There are large differences in the diffusion of geographical information systems in European countries. Whereas in some countries, notably in the United Kingdom and the Netherlands, GIS technology has already become standard practice in cartography, local land management and planning, other countries have been extremely slow in adopting the new technology. This paper suggests the hypothesis that national land information traditions determine the institutional environment and procedures into which the new technology needs to be integrated, and that this restricts the transfer of 'universal' GIS software developed in different national settings. The paper discusses approaches to deal with this problem and draws conclusions for a European GIS research agenda.

1. Introduction

Over the last two decades the rapid development of digital computers has brought increases in computing speed and memory size and reductions in hardware costs beyond all expectations. One of the many impacts of this explosive development is the ability to efficiently and economically handle large amounts of spatial data. The organization of these data in *geographical information systems* (GIS) has the potential to revolutionize all fields in which geographic data are handled such as mapping, land management and planning.

And indeed there is a veritable boom in GIS. What used to be an exclusive field of specialization of a small number of university experts has developed into a multimillion dollar market. International GIS conferences draw hundreds if not thousands of participants. There is a growing flood of GIS books and journals. And whereas a few years ago GIS software was a matter of two or three high-priced mainframe programmes, today there is a host of competing GIS packages of all levels of complexity and for a variety of hardware platforms including low-cost workstations or personal computers, and new entries appear on the market in rapid succession.

So it appears that the GIS revolution is part of the general trend towards the information society, and as that trend is produced by the revolution in computer hardware, one might expect that it would take place at about the same speed in all countries where computers are

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freely available. However, whereas office automation, computer-assisted manufacturing and advanced logistics are rapidly spreading across all countries with market-oriented economies, there are large and surprising differences in the diffusion of geographical information systems in European countries that cannot be explained by differences in affluence or technological advancement.

In some countries, notably in the United Kingdom and the Netherlands, GIS technology has already become standard practice in cartography, local land management and planning. These two countries have launched extensive national research programmes to promote the expertise in handling digital geographic data. In Britain, the Economic and Social Science Research Council allocated £2 million for funding eight Regional Research Laboratories over a five-year period. In the Netherlands, the Dutch Science Council spends 1.8 million guilders over a four-year period for a National Centre for Geographic Data Processing (Masser, 1988).

Not surprisingly, in both countries, the official base map systems have already to a large part been digitized across all map scales. In Britain, for example, the Ordnance Survey has used digital mapping techniques since 1972 and now digitizes some 5,000 of its 1:1,250 and 1:2,500 maps annually. It expects to have completed the digitising of all major urban areas by 1995 and all other warranted digital conversions within a further decade (Ordnance Survey, 1987). Ordnance Survey digital map data can be ordered by anybody for an individual charge or by subscription. On the basis of Ordnance Survey map data and the Post Office's Postcode Address File (PAF), which contains the postal addresses of 24 million locations in the UK, an immense commercial GIS industry has developed, of which *Pinpoint* is only the most spectacular example. *Pinpoint Analysis Ltd.* offers its customers a wide range of information services centred around the *Pinpoint Address Code* (PAC), a geographic reference attaching to every single address in Britain a twelve-digit *National Grid* reference and its precise geographical location.

In contrast to this, other European countries have been extremely slow in adopting the new GIS technology. In some of them this was obviously a consequence of insufficient public funds for research and development or of lack of skilled staff or hardware. In other countries this simple explanation does not hold because they belong to the more prosperous countries in Europe and yet have surprisingly failed to take full advantage of the immense technical potential of computerization for the handling of geographical data. Because the authors are most familiar with the situation in their own country, the following discussion focuses on the slow diffusion of GIS technology in Germany, which has made only regrettably slow progress in the adoption of GIS technology.

This paper discusses why this is so. The hypothesis is that national land information traditions determine the institutional environment and procedures into which GIS technology, if it is to be really successful, needs to be integrated, and that this restricts the transfer of 'universal' GIS software developed in different national settings. The paper discusses approaches to deal with this problem and draws conclusions for a European GIS research agenda.

2. Early GIS in Germany

The history of GIS in Germany is one of early enthusiasm, misconceptions, exaggerated hopes and great disillusions, many failures and few successes.

The first advances into the field were connected to the perceived needs of a particular kind of end users, the planners. Already in the 1960s, some information about the use of computerized 'planning information systems' in large cities of the US swept across the Atlantic. Stimulated by the USAC research programme of the US government to establish pilot information systems for urban planning, the West German government funded a pilot project for the development of an urban planning information system in the city of Cologne. Similar projects were launched by the cities of Munich and Berlin. However, inadequate computing power, batch processing, primitive mapping facilities and the lack of efficient software made these systems unattractive, so the planners returned to their traditional ways of information collection and processing. The Cologne project was completely abandoned during the 1970s, while the Munich system, though it still exists today, has never played an important part in the planning process.

The basic misconception underlying these systems was that, understandably, they started from the users' end but neglected the basic processes of data collection and updating. The Munich system, for instance, did its own large-scale digitization of the whole city area but had to find out that the task of keeping up with the constant flow of alterations made necessary by explosive city growth in the early 1970s was far beyond the capacity of even the most enthusiastic planning department. The same applied to the nongraphical data associated with (in the Munich case) individual addresses. As it turned out, only the most rudimentary population data could be routinely updated using periodical excerpts from the city's population register. However, as public sensitivity for the privacy issues brought up by computerization grew, even that became infeasible for political reasons. More interesting information, e.g. about household composition or the distribution of workplaces, either proved too costly to be periodically collected or increasingly became off-limits for the same privacy reasons that eventually toppled the 1980 West German census.

The importance of privacy issues for the slow progress in GIS applications in planning in West Germany cannot be overestimated. In effect they turned out to be a serious restriction for any advancements in two ways:

- For once, through excesses of data collection and surveillance revealed during the anti-terrorism campaigns of the 1970s, the West German public became more sensitive in this respect than probably in any other country in Europe. Even well-intended proposals for the utilization of personal data for public service provision or planning became stigmatized as potentially dangerous and open for misuse.
- Second, exactly for that reason, new planning information systems were not established, and existing ones were not updated and hence quickly became outdated and void of any meaning, and this erosion of the significance of the information provided by the systems made it difficult if not impossible even for their most ardent defenders to demonstrate their usefulness.

Today the situation comes close to the absurd. When the census originally scheduled for 1980, after severe legal disputes and only with strict privacy safeguards, was finally conducted in 1987 (seventeen years after the previous census of 1970), the results were not published except in highly aggregate form and not made available to researchers. Even worse, the census revealed that the local population registers and the employment statistics maintained by the Federal Labor Agency, which the opponents of the census had claimed made a census unnecessary, were widely unreliable - if the census is considered reliable, which itself is questionable given the large number of responses that had to be enforced by court decisions or to be substituted by assumptions. The city of Dortmund, for instance, learned by way of the census that it had 11,000 more inhabitants and 30,000 more jobs than the population register and employment statistics contained, whereas other municipalities discovered they had less. To complete the folly, the census law expressly prohibited local governments to update their population registers using census data thus perpetuating the inconsistency between the two types of information.

However, even if the early planning GIS had succeeded in overcoming the privacy problems associated with disaggregate planning data by appropriate safeguards, the failure to be firmly linked to the digital base map system of the city or country would have been sufficient to kill them. In this respect, only a close cooperation with the institutions responsible for surveying and mapping could have helped (cf. Junius, 1988). This cooperation, however, did not work because the surveying people played their own cards.

3. Land Information in Germany

To understand this, it is necessary to briefly review the history and main characteristics of the land information system in Germany and compare them with those of other European countries. Some significant differences appear.

The first written documents on land in Germany are treaties between territorial rulers about border lines dating back to the 16th century (Kloos, 1990). As land taxes were the principle source of income of these princes, some of the larger territories developed land registers in which individual lots were listed by area, soil quality and owner. Later the land registers also contained information on titles such as mortgages. However, the first systematic inventory of all properties in the form of a cadastral register and maps based on surveying property boundaries was only introduced in the 19th century after the Napoleonic wars and the consolidation of the great number of small territories to larger states such as Prussia. Now the installation and maintenance of the cadastre was assigned as a permanent task to specialist surveying departments.

With the decreasing role of land taxes as government income and the growing importance of land as an economic asset, the principal function of land information became the registration of property rights. For this the cadastre (which essentially was a map) was complemented by a written land register containing information on land ownership that could not conveniently be placed on a map and was liable to frequent changes.

This led to the dual mode of land information existing in Germany today. There are two registers belonging to this system: the cadastre (*Liegenschaftskataster*) and the land register (*Grundbuch*). The cadastre contains information on the physical characteristics of properties such as size, inclination and location by geometric coordinates. The land register, on the other hand, contains information on the ownership of properties and all property rights, especially mortgages. The two registers are linked by a common referencing system based on a hierarchical numerical code for each property, and each change in one of them may affect the other. This makes updating procedures cumbersome and slow but guarantees a high level of reliability of the cadastre as it participates in the official status of the land register. Liegenschaftskataster and Grundbuch might, directly or indirectly, be linked to the files of the local population register, planning and budgeting departments and the commission for land value assessment. Figure 1 visualizes this complex set of relations.

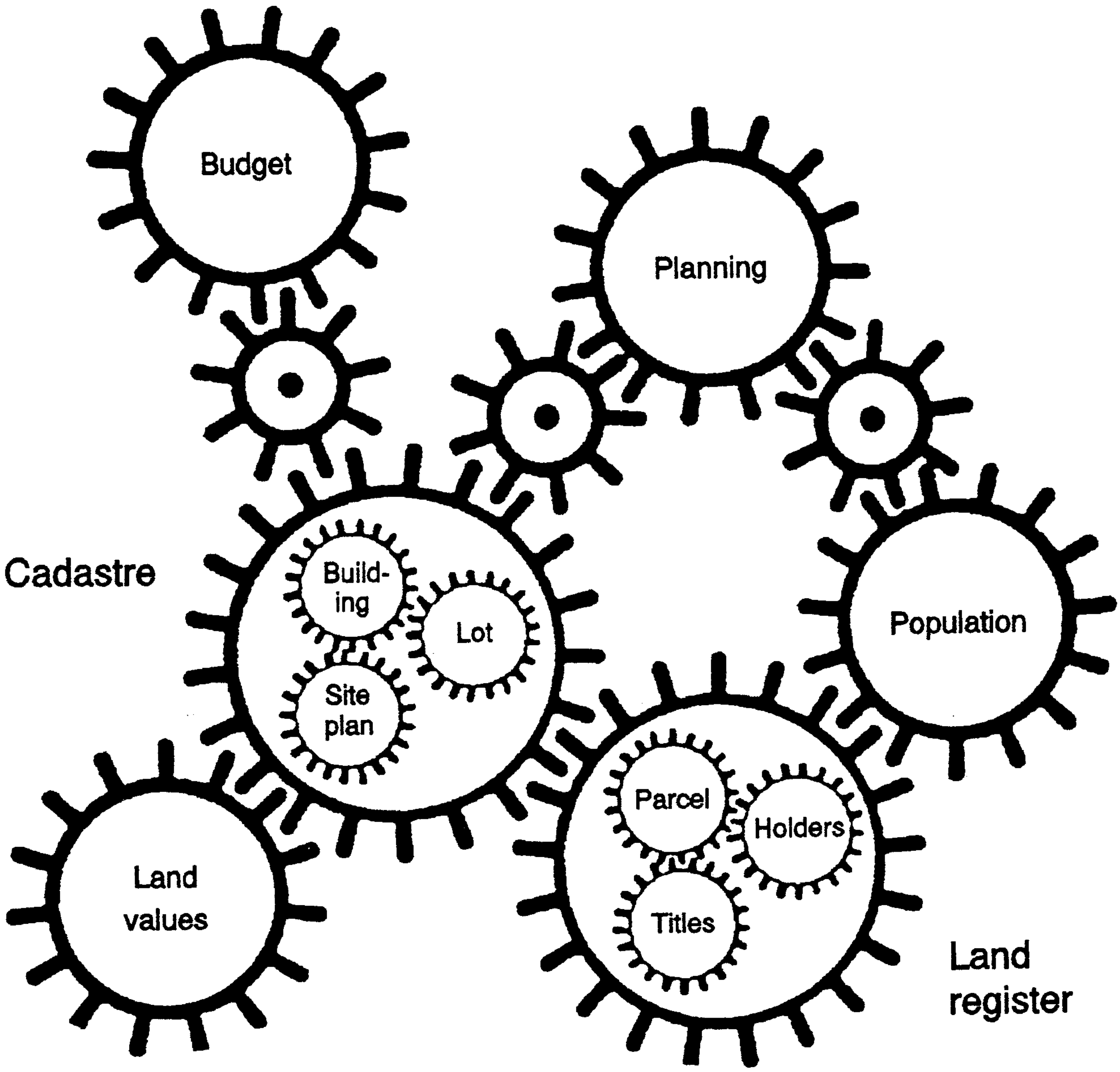

Figure 1. Cadastre and land register and the network of local government files (adapted from Stöppler, 1983). The dual mode of land information in Germany consists of two registers: the cadastre (Liegenschaftskataster0 and the land register (Grundbuch). They may be linked to the files of the local population register, planning and budgeting departments and the commission for land value assessment.

The German land information system (which is also representative for the Austrian and Swiss systems) differs from those in most English- and French-speaking coun'ries in that it registers *titles*, i.e property rights belonging to a specific parcel, whereas in France, most of the US and parts of Canada and Australia traditional land information systems register *deeds*, i.e. documents on land transactions. In other words, the German land information system is organized by parcel, whereas the traditional British land information system is organized by *owner* (cf. Kloos, 1990). It is easy to see that the German system is much closer to the structure of GIS which by definition are organized by location.

While this affinity between the logical structure of land information in Germany and a relational GIS database should have facilitated the introduction of GIS technology, the decentralized institutional setup and distributed responsibility for land information made it more difficult.

Unlike Britain, West Germany has no central surveying and mapping institution. Rather, for historical reasons, surveying and mapping in Germany is highly decentralized or, more precisely, fragmented, reflecting the federal organization of government in the country. Local or county government surveying departments are in charge of 1:1,000 *city maps*; medium-scale maps, such as the 1:5,000 German Base Map (*Deutsche Grundkarte*) and 1:25,000, 1:50,000 and 1:100,000 topographical maps are prepared by the surveying departments (*Landesvermessungsämter*) of the states (*Länder*), and the 1:200,000 and 1:1,000,000 maps by the Institute of Applied Geodesy (*Institut für Angewandte Geodäsie*), a Federal agency in Frankfurt and Berlin.

In addition, several Federal and state agencies such as the Federal Railways or the state highway departments are involved in specific tasks of surveying and mapping. To make things worse, in some states medium-level regional planning authorities are in charge of maintaining a special set of registers and maps, the Regional Planning Inventory (*Raumordnungskataster*). In line with this setup, the cadastre is maintained by the local government, i.e. municipal or county, surveying departments (in some states by the state surveying agencies). The land register, however, is administered by special authorities at courts of law (*Grundbuchämter*), but in some cases by local governments.

To make this multi-level system work, a complicated set of procedures is necessary which guarantee that queries and updates performed by a multitude of users in a wide range of agencies and institutions are processed according to defined rules with access control and data integrity being maintained. In short, if such a system is to be computerized, it requires a multi-user, multi-agency database management system.

4. Endogenous GIS: the German LIS

In order to develop such a system, already in 1971 a working party with representatives of state surveying departments submitted a proposal for automating both registers. The first project started was the Automated Cadastral Register (*Automatisiertes Liegenschaftsbuch*), in short ALB, designed as a standard database management system (DBMS). The second project, started in 1976, is the Automated Cadastral Map (*Automatisiertes Liegenschaftskarte*), or ALK. That the two projects were conducted separately was due to the fact that data structures to efficiently link attribute and geometry data as in today's GIS were simply not available at that time. As DBMS technology became available, work on the register was started earlier, whereas map automation was a byproduct of surveying. Today, however, both systems together form the integrated land information system (LIS), which includes a complex set of procedures and administrative processes for generating and updating land information in a multi-user, multi-agency environment. This system is characterized by a strict separation of the users from the database management system through a standardized interface or data transfer format, the EDBS (*'Einheitliche Datenbankschnittstelle'*).

The implementation of the EDBS is very similar to a graphics metafile format consisting of records identified by a record identifier, a header, and any number of data fields. Figure 2 illustrates how a typical ALK object is coded into the EDBS format and decoded at the user's application. In the ALK terminology, an object is a collection of attribute and geometry data. Attribute data of a building object, for instance, are its label, shading, or all sorts of annotations, while geometry data are its label coordinate and the coordinates of, say, its perimeter: in other words, object primitives such as line objects can be nested within more complex objects.

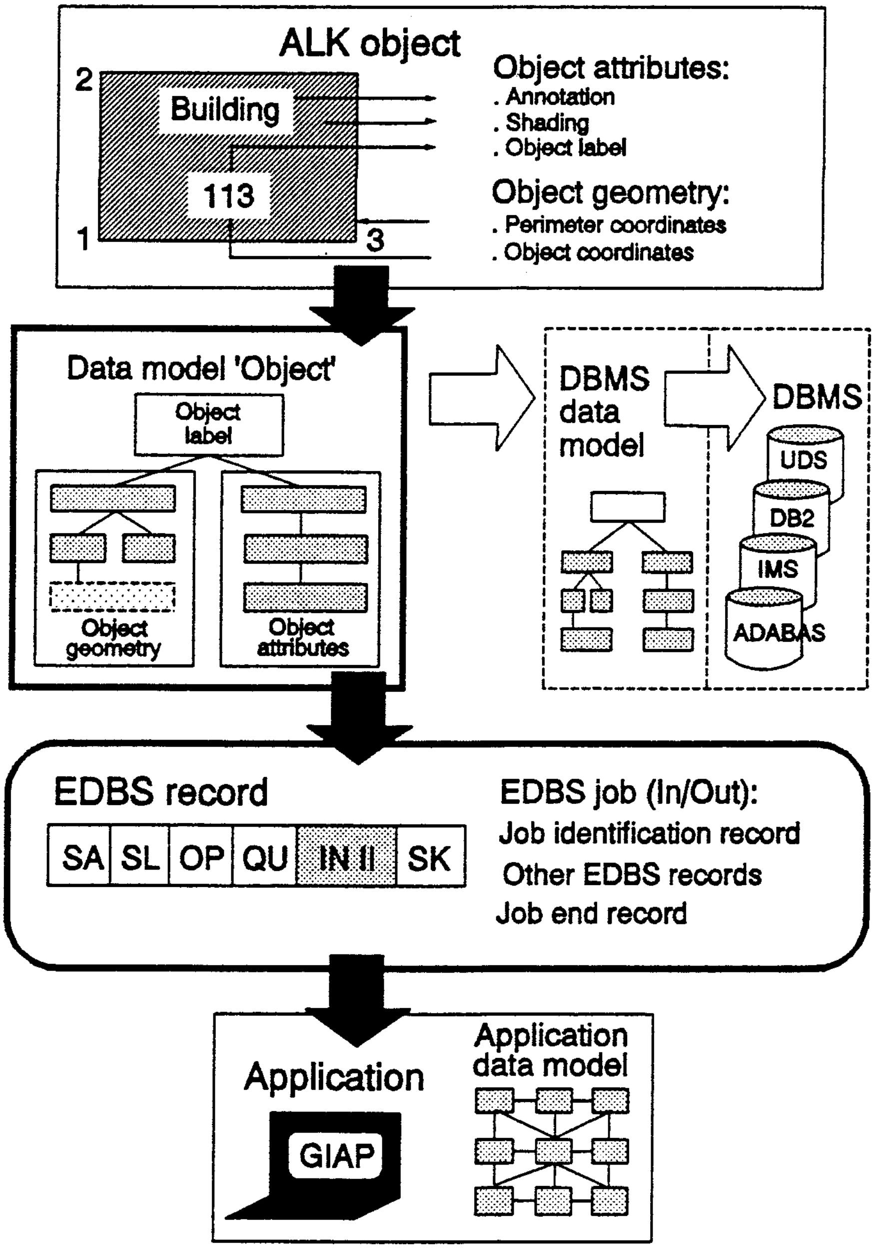

Figure 2. ALK objects and data models (adapted from Stöppler, 1989). ALK objects are collections of attribute and geometry data. Object primitives such as line objects can be nested within more complex objects. The figure illustrates how the object 'building' is mapped to the logical data model of the DBMS but also to the data transfer format of the EDBS and decoded at the user's application.

This data model 'object' is mapped to the logical data model of the respective DBMS but also to the data transfer format of the EDBS. At the application end, the data are decoded and translated into the representation required by the specific application. It is assumed that the application consists of an interactive session at the GIAP (*Graphischer Interaktiver Arbeitsplatz*), the graphical workstation functionality defined by the ALK system (which may be implemented on any kind of real workstation). Each query or update request by the user is translated into the EDBS by the EDBS interpreter and put into the job queue of the ALK-DBMS. After processing, the response or acknowledgment is sent back to the EDBS interpreter which reconverts it into the format required by the application.

The ALK system as it has been sketched out above, is supposed to be the basic GIS standard not only for the local cadastre and associated base map system, but, in a bottom-up fashion, also for the middle-scale topographical maps of the state surveying agencies under the acronym ATKIS (*Amtliches Topographisch-Kartographisches Informationssystem*).

Today, two decades after the initiation of the project, only first steps have been made towards implementation of the ALK system. Only three of the twelve Federal states of the former Federal Republic (Hessen, Niedersachsen and Nordrhein-Westfalen) have actually started to implement the data collection component of ALK (digitising of existing analog maps or converting existing non-compatible digital map formats). A few other Federal states are preparing themselves to join the ALK system. Some Federal states have already decided not to join. Needless to say that the five new Federal states (the former GDR), where a different, much more centralized surveying system had developed since the war, present new unforeseen problems.

Understandably, the system components implemented so far concentrate on the primary functions necessary for data collection, updating, map editing and data communication between the subsystems. More complex GIS functions such as union or intersection of coverages, buffering, digital terrain models or network analysis are still under development. More specialized applications for statistical analysis, thematic mapping or land use planning are still far away in the future.

Also on the state level only first experiences with the ATKIS mapping standard have been made. Only two states, Niedersachsen and Nordrhein-Westfalen, started actual map production before 1991 (Grünreich, 1990). The original plan to generate ATKIS maps by generalization from ALK base maps has been abandoned in most states yet digitization from existing analog maps takes longer than expected. The idea that one could order any scale digital map from the *Landesvermessungsamt*, as it is common practice in Britain, would appear quite inconceivable here. Also the data exchange between the different agencies and institutions of the ALK system with the EDBS data transfer format, although in principle it is designed to be interactive, to date is used only off-line, i.e. via batch processing; more far-reaching interface problems such as, for instance, the exchange of geographical data between mapping systems in different European countries or between European institutions, have hardly been taken into view. Most importantly, the whole system is totally under control of the surveying departments without broad consultation let alone participation of other potential users.

5. 'Universal' GIS?

Considering the small progress made in the introduction of the ALK so far, one might ask why the responsible actors decided to go through all the pains of developing their own 'endogenous' GIS instead of buying a commercial GIS software product off-the-shelf. This strategy has, for instance, been adopted by the Hong Kong government, which after an international competition between major vendors of GIS selected ARC/INFO of ESRI Environmental Systems Research Institute, Redlands, California, USA for its surveying/mapping and planning information system. A comparison between Hong Kong and Germany reveals the main reasons why in Germany a different decision was made.

- *Language*. Because the most commercially available GIS (ARC/INFO) is of US origin, all its command language, user interfaces, manuals etc. are in English. This presents no problems as long as either the country is English-speaking (as Hong Kong), or the users are multilingual academics. For the average officer in a municipal surveying department in Germany the foreign language presents a serious barrier.
- *Data models*. The cadastre system in Germany suggests complex object types such as the 'building' object used as an example in Figure 2, which themselves contain geometrical primitives as objects, such as the perimeter line object. Such a data object can only be emulated with, say, ARC/INFO, which only knows point, line and polygon objects.
- *Algorithms*. There are significant differences in the measurement techniques and algorithms used in surveying in Germany and in the US which make American surveying programmes "practically useless as components of land information systems" (Kloos, 1990, 131.)
- *Map projection*. The German base map system uses the Gauß-Krüger transversal Mercator projection similar but not identical to the UTM projection used for NATO and civil aviation maps (see Figure 3). Neither ARC/INFO nor any other US-based GIS support this projection.
- *Networking capability*. The multi-level and multi-user organization of surveying and mapping and the associated cadastre and land register require more elaborate support for access control, data communication and data integrity than a single client or a centrally organized city state such as Hong Kong. Presently only few commercial GIS take account of this need.
- *Data interface standards*. The decentralized system of map production and maintenance requires standards for the exchange of cartographic and non-cartographic data. Most commercial GIS use their own proprietary data formats and allow data exchange with other software only by way of the lowest common denominator, i.e. ASCII files. Needless to say that the German EDBS is not directly supported but requires special conversion programmes.
- *Cost*. Commercial GIS software is expensive to buy and to maintain. In contrast, the true costs of developing an endogenous GIS such as the ALK system are hidden in general administrative budgets. Once existing, endogenous solutions have to be used. For instance, in Nordrhein-Westfalen the municipalities get the ALK software free which means that they simply no longer have the option to choose an expensive external system.

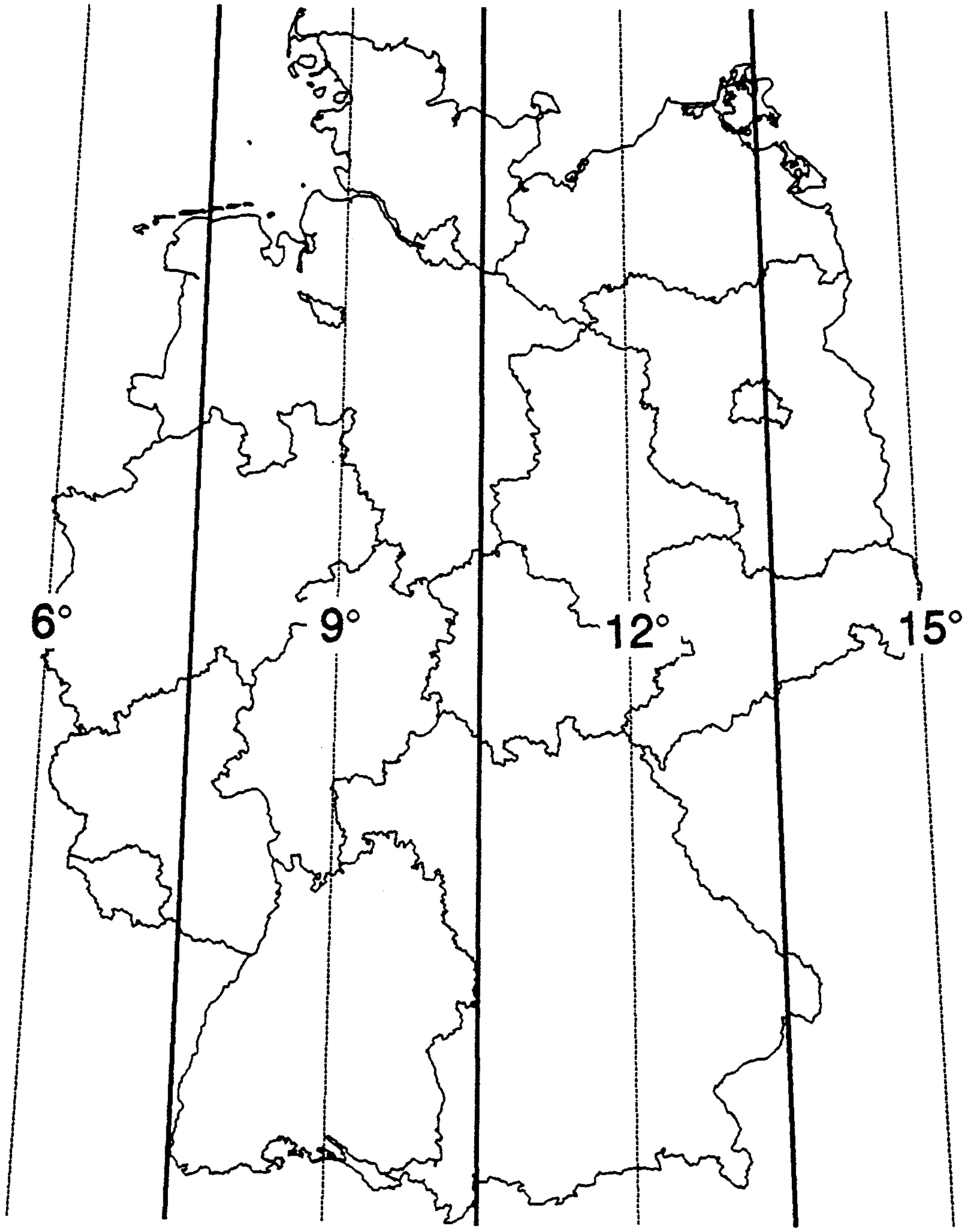

Figure 3. The Gauß-Krüger map system. The transversal Mercator projection of German basemaps uses 3°-wide bands centred on the 6°, 9°, 12° and 15° meridians. Neither ARC/INFO nor other US-based GIS support this projection.

As a result of these considerations, the GIS scene in Germany is divided into two worlds. Public surveying and mapping, and hence most native GIS developments, are committed to the endogenous development of ALK and ATKIS, whereas universities and other public and private research institutions are linked to the international world of 'universal' GIS. This has serious consequences for the diffusion and acceptance of GIS technology and for GIS research and education.

6. Alternative Solutions

To be sure, Germany because of its size is a large GIS market, and there is no reason to assume that private companies in Germany should be less interested in using GIS technology for truck routing, real estate management or market research than firms in other countries. However, the diffusion of GIS technology in Germany might have been much more successful if the ALK/ATKIS system had been implemented on schedule and as universally as originally intended and if it had been made publicly available as a national standard to software producers and GIS research and education. However, as it was delayed beyond all expectations, even states and Federal agencies that originally were sympathetic to its objectives turned away to look for alternative solutions.

One example is the *Institut für angewandte Geodäsie* which recently chose ARC/INFO as GIS for the preparation of its 1:250,000 and 1:1,000,000 maps, which obviously creates problems of data exchange with the larger-scale maps produced at the state surveying departments. A second example is the 'Statistical Information System on Land Use' (STABIS) launched by the Statistisches Bundesamt (Federal Statistical Office). Although ATKIS, when it eventually is implemented, will provide more land use information than required by STABIS, the Bundesamt has started its own digitization of land coverage from aerial photographs and intends to update it every five years, although for a later stage utilization of ATKIS data is intended (Rademacher, 1990). Remarkably, the Office has never developed a publicly available georeferencing system for census information like the US TIGER files, be it because of privacy concerns or because of lack of demand or both. Other Federal and state agencies such as the Federal Railways or the state highway departments face the problem of integrating their digital databases with the ALK/ATKIS system.

Other GIS projects have simply ignored the problems of integration with the ALK/ATKIS system and prepared their own digital database. There is the large category of environmental projects which typically use a combination of satellite data, aerial photographs, digitized existing analog maps and special measurement or data collection programmes (cf. Ashwood and Schaller, 1990). Obviously, as in these projects the users tend to be the researchers themselves, problems of language and user-friendliness are less relevant, so in many of them commercial GIS such as ARC/INFO or ERDAS are used. However, there is at least one local government environmental department (Dortmund) which has purchased ARC/INFO for implementing an environmental information system. Although some of these projects aim at long-term environmental monitoring, none of them seems to have addressed the problem of updating their base maps.

In local government, GIS technology has proved indispensable for planning and maintaining utility networks. Pioneered by private utility companies, in most cities the cadastre of utility networks is more advanced than the digitization of the cadastre, which will produce serious integration problems in the future, although there are some recent examples of cooperationa between utility companies and the cadastre. Many of utility GIS, if they do not use custom-tailored software, are based on SICAD, a CAD package by Siemens Nixdorf, for which modules for cartography, network documentation, etc. have been developed. Because of its popularity, SICAD file formats have become a de-facto standard in this field. In addition, SICAD supports the EDBS and so is a serious contender for the ALK-GIAP.

GIS applications for local planning, after the negative experience of the early predecessors, are practically nonexistent. One notable exception is the Greater Frankfurt Area Association of Local Governments (UVF) which has since 1977 developed a sophisticated planning information system for preparing a joint land use plan for 43 municipalities (Rautenstrauch, 1989). The digital base maps for this system were extracted from aerial photographs and have since been updated three times. There is no link to the ALK/ATKIS system. The software used is ARC/INFO.

The example of the UVF seems to suggest that 'universal' GIS can be effectively applied in local planning. However, as the UVP is unique by its large staff of academics and its showcase position in Germany, its example cannot be generalized to small and medium-sized cities with less sophisticated staff.

One alternative is to custom-tailor a German-language user interface shell around the original GIS software. In a project conducted at the University of Dortmund two simple evaluation tasks were selected for a prototype of a planning information system for small cities (Altenhoff et al., 1991). The first evaluates local street design alternatives with respect to criteria such as cycling lanes, pedestrian crossings, traffic noise, landscaping, activities spaces, car parking and access for delivery. The second evaluates land use alternatives with respect to accessibility, provision of services and environmental constraints. Both applications make use of topological information such as adjacency, distance or domain. The prototype system was implemented using pcARC/INFO combined with a menu-driven user interface in German.

The user interface was written in FORTRAN with additional assembler routines for operating system and display management functions. It consists of a hierarchy of character-based windows, dialogue and alert boxes. Figure 4 shows the hierarchy of windows. The interface shields the user from all operating-system and English-language ARC/INFO commands. It has been programmed in a way that makes user errors as unlikely as possible without restricting the freedom of choosing any reasonable sequence of operations.

7. GIS Research and Education

The division of the GIS diffusion in Germany into two separate streams, the endogenous GIS centred around the ALK/ATKIS system and the 'universal' GIS linked to the international GIS world, puts GIS research and education into a dilemma.

In research, to develop GIS applications exclusively for the domestic standard would probably make it easier to get research contracts from local clients but also entail the risk to be separated from the international state of the art. The slow progress made by the ALK/ATKIS project and the lack of interest on the side of the participating agencies to publicize their standards and interface conventions have contributed to make this alternative less than attractive. Conversely, to entirely ignore the standards set by the domestic market would mean to have no access to it and hence no access to data and no clients for one's products.

In education, the choice is not easier. On the one hand, state-of-the-art GIS such as ARC/INFO are the natural choice for introductory GIS courses. On the other hand, students would be poorly prepared for the GIS environment they are likely to encounter in their future practice in public agencies if they would not get exposed to the ALK/ATKIS system at all. This, however, would make it necessary for universities to install an ALK implementation on the campus, something to date only few surveying departments and no planning schools at German universities have yet achieved. A survey among German-speaking universities revealed that ARC/INFO is by far the most frequent GIS software used for teaching (Bill, forthcoming).

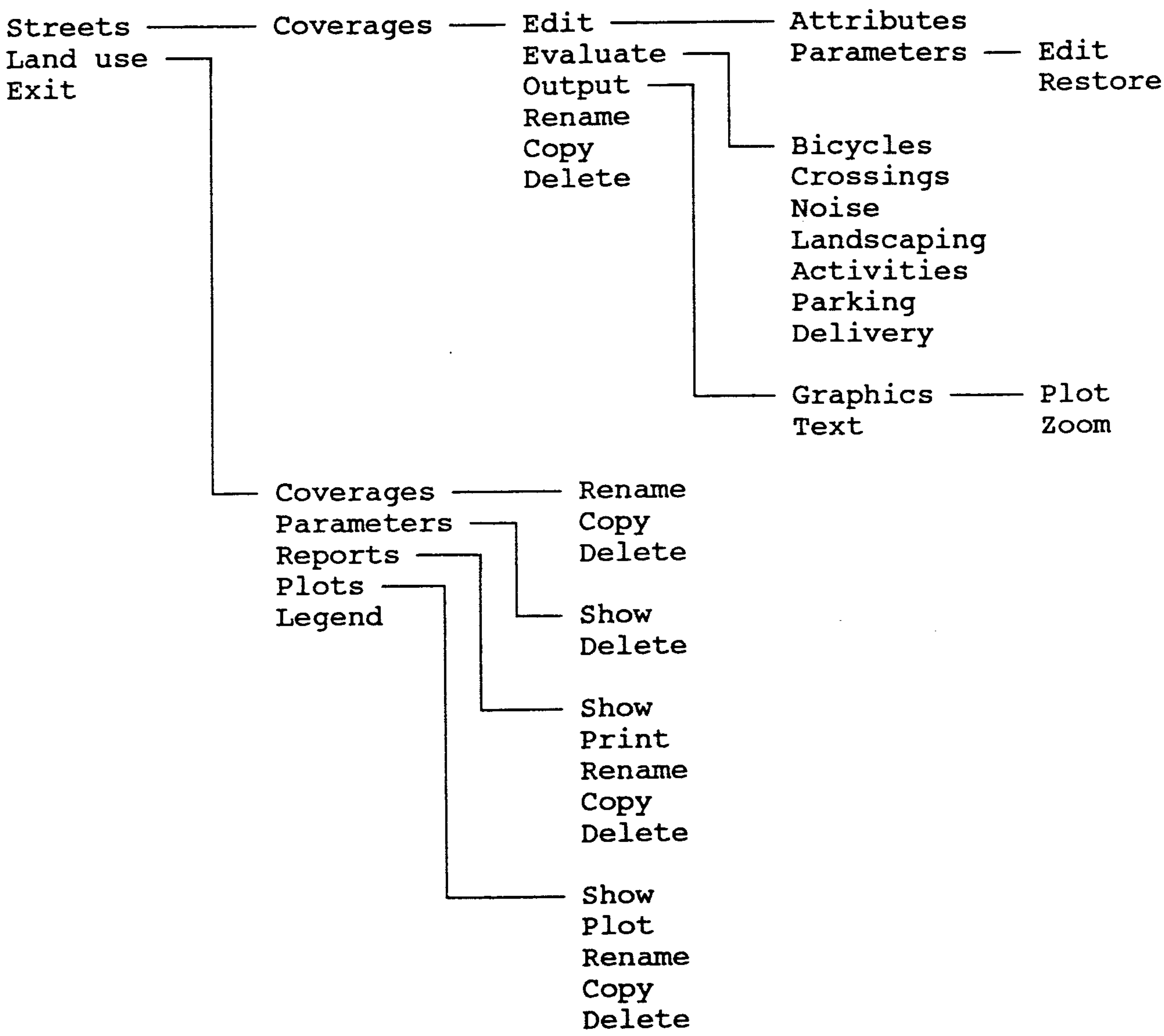

Figure 4. Hierarchy of windows of user interface for pcARC/INFO. The interface shields the user from all operating-system and English-language ARC/INFO commands. It has been programmed in a way that makes user errors as unlikely as possible without restricting the freedom of choosing any reasonable sequence of operations.

8. Conclusions

The answer to the initial question: 'Universal' GIS or endogenous developments? can therefore only be: both. In non-English-speaking countries with a decentralized system of surveying and mapping like Germany custom-tailored endogenous solutions combining software *and* procedures seem indispensable. At the same time in the research field 'universal' GIS reflecting the international state of the art allowing for a variety of possible approaches and giving room for innovation and experimentation are likely to be the more appropriate choice.

From a research point of view, three areas seem to have been neglected in the past and to deserve particular attention:

The first addresses the question of better user interfaces reflecting the needs of local users including native-language shells. If the GIS market continues to expand as it has in the recent past, part of this can be expected to come from the software suppliers themselves, just as word processors appear in different languages. If not, at least the vendors should provide adequate documentation of their file formats and programming conventions to aid developers of such interfaces. The past policy of ESRI has been regrettably deficient in this respect, although the multi-language user shell of ARCVIEW is a first step in the right direction.

The second field regards implementation issues. The problems discussed in this paper suggest more emphasis on the organizational and institutional environment of GIS in the land information field taking account of the different traditions and restrictions of each particular country. Many of the issues discussed after the failure of the first attempts to establish planning information systems in the 1960s and 1970s, such as the information needs of planners and the way planners use information, are equally relevant today yet tend to be forgotten over the enthusiasm of the new GIS boom (see, for instance, Wegener, 1983; 1987; 1988).

The third neglected research area concerns data exchange between different GIS systems within and between countries. With the Single European Market coming closer and further advances in European integration in sight, the problems arising from the integration of incompatible geographical data bases between European countries or between European institutions deserve increased attention. Although significant progress in the harmonization of data exchange standards have been made (cf. Brüggemann, 1990), the multitude of incompatible data formats used by different countries, European agencies, industry groups or NATO is still staggering and makes isolated national efforts towards standardization, such as the EDBS, questionable.

GIS education in non-English-speaking countries will become more difficult. Except for the most basic concepts, the unmodified transfer of foreign teaching material and software will not be sufficient if the claim of practice-orientation of the course is taken seriously. Planning schools in Germany, for that matter, will have to install at least one implementation of the ALK-GIAP in their GIS teaching laboratory, even though the maintenance of more than one complex GIS systems may put a heavy strain on their financial and staff resources.

9. Endnote

This chapter is in part based on a contribution by the authors to the European Science Foundation Workshop on European Research in Geographic Information Systems held in Davos, Switzerland, 24-26 January 1991 (Junius and Wegener, 1991).

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