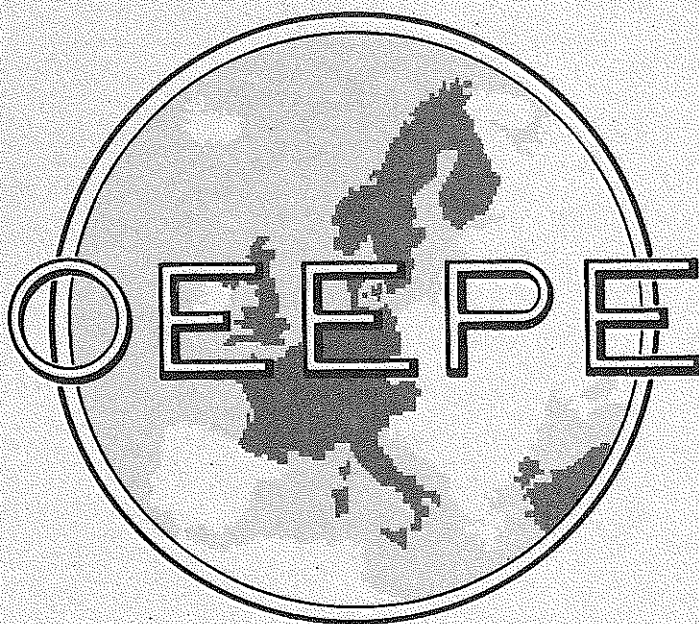


September 1992

EUROPEAN ORGANIZATION FOR EXPERIMENTAL PHOTOGRAMMETRIC RESEARCH

Proceedings of the
OEEPE — WORKSHOP
on
DATA QUALITY
IN LAND INFORMATION SYSTEMS
Apeldoorn, Netherlands
4–6 September 1991

Editors: L. A. Koen and O. Kölbl



Official Publication N° 28

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OEEPE

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Institut für Angewandte Geodäsie

Richard-Strauss-Allee 11

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September 1992

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Official Publication N° 28

ISSN 0257-0505

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DK 061.3.053.52
[332:347.235]:519.256

Proceedings of the
OEEPE — WORKSHOP
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DATA QUALITY
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(with 62 Figures, 14 Tables and 2 Appendices)

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PREFACE

On September 4-6, 1991, L.A. Koen (Cadastre and Public Registers Agency, Apeldoorn, the Netherlands) and O. Kölbl (EPFL, Lausanne, Switzerland) assembled and organized a "Workshop on Data Quality in Land Information Systems" in Apeldoorn. The workshop can be considered as a continuation of the OEEPE "Workshop on Cadastral Renovation" in Lausanne in 1987. Main aim of that workshop was to create a forum for an analysis of the problem of cadastral renovation in the various European countries. During the workshop in Lausanne common problems were made quite clear. However, it was also apparent that there were several and different solutions for equal problems and that a further analysis was needed. And so it was decided within OEEPE to organize another workshop and focuss attention on the functional aspects. 42 persons participated in the "Workshop on Data Quality in Land Information Systems" and in total 22 papers were presented.

The workshop comprised three parts :

1. Data structure
2. Data Quality
3. Data exchange and data standardisation

Almost all cadastral systems are developing from a single-purpose system towards a multi-purpose system. Mostly the development goes along the line fiscal cadastre-legal cadastre- land information system. One of the conclusions of the workshop was that Land Information Systems with a multi purpose character can only function properly if a set of functional standards is available. Pre-standardisation research, development, recognition, registration and publication of standards are key-words for our profession in the next decade.

A considerable part of the workshop has been devoted to discussions. For practical reasons the summary of these discussions will be published separately.

We hope, that the publication of the proceedings of this OEEPE workshop will stimulate the activities mentioned.

L.A. Koen	O. Kölbl
Apeldoorn	Lausanne

July 1992

WORKSHOP
DATA QUALITY IN LAND INFORMATION SYSTEMS
4-6 September 1991, Orpheus Congress Centre, Apeldoorn,
The Netherlands

PROGRAMME

Tuesday 3 September 1991

19.00 - 21.00 **Registration**
 Informal get-together

Wednesday 4 September 1991

08.30 - 09.15	Registration	
09.15 - 09.30	Welcome	de Smet(B)
09.30 - 10.00	General Introduction	Koen(NL)
10.00 - 10.15	Coffee break	
STRUCTURE OF DATA		
	Moderator	Koelbl(CH)
10.15 - 11.00	Keynote Considerations Structuring of Cadastral Data in GIS Systems Summary Presentation of simple and complex structures of geometric information in a land information system (node-line-region-object-complex object). Requirements of structuring of data for the various queries and other operations; introduction into stochastic aspects of data and the requirements for the improvement of the precision by continuous updating	Koelbl
11.00 - 11.20	Presentation of the inquiry on data organization and data structures in European countries Summary Short overview of common aspects of data organization in the different countries of OEEPE, according to the summary presented to the Steering Committee	Koelbl
11.20 - 12.10	On the Use of Commercial Database Technology in GIS Summary The presentation reviews the recent database technology The various logical data models - hierarchical, Codasyl relational and object oriented - are introduced. Differences between so-called "standard database applications" to "nonstandard database applications" such as GIS-problems or CAD-problems are shown. The	Bill(FRG)

necessity of special enhancements for dealing with spatial phenomena - currently in the research agenda of computer sciences - is derived and the forthcoming database technology described.

12.10 - 12.20 Discussion

12.20 - 13.30 Lunch

PRESENTATIONS FROM DIFFERENT COUNTRIES

13.30 - 14.10 A receiving structure and revision method to turn the napoleonic map into a digital land map
Summary Brixey (F)

This lecture gives an overview of the constitution of the computerized cadastral map and its management system; it enters in particular on the topological structure of the information system. Furthermore a working mode was chosen which allows a progressive improvement of the data quality.

14.10 - 14.15 Discussion

14.15 - 14.35 Cadastral Land Information System in the Netherlands
Summary van Osch(NL)

The presentation gives an update on the developments within the operational cadastral LIS in the Netherlands. The Dutch cadastral database is an integrated cartographic database containing both the national cadastral maps as well as the large scale topographic base-map. Special attention will be given to the following subjects:
- data structure and data quality
- geometric adjustment techniques
- external delivery of information

14.35 - 14.40 Discussion

14.40 - 15.00 Coherence and Validity of Geometric Data in Italian Cadastre
Summary Cannafoglia(It)

The paper describes geometrical data automation plan developed by the Italian Cadastre as well as the procedures of control to make valid geometrical cartographic data.
These data can be obtained by digitizing existing land cadastral maps, or by consulting the new up-dating surveys carried out using traditional or aerophotogrammetric techniques.
Attention is focussed on the ways to resolve the geometrical incongruities between what is represented in the maps and what is represented in the new surveys.

15.00 - 15.05 Discussion

15.05 - 15.25 Data Structures of Digital Cadastral Boundary Maps in National Land Survey of Finland (Tuhkanen (SF))

The presentation gives an overview concerning data structures for digital maps in Finland and the suitability of the present solution in meeting the corporative requirements of spatial data processing. Topics to be discussed include e.g. integration of data stores, version management, long transactions, seamless databases, simultaneous updating, access rights and distributed processing.

15.25 - 17.00 Break and Discussion

18.00 Departure for dinner

Thursday 5 September 1991

DATA QUALITY

Moderator

Koen

09.00 - 09.30 Keynote
Quality concepts in Land Information Systems
Summary Koen

In the paper a short review is given of the current evolution in thinking about quality within and beyond the area of our expertise. The increasing digital mapping activities not only ask for another way of handling the aspects precision and reliability but force us to consider other quality aspects as well. For large scale applications the exchangeability of information is essential. National and international standardisation is a necessity for both the metric quality aspects and the non-metric quality aspects.

09.30 - 10.00 Geometrical quality in a Land Information System
Summary Velsink(NL)

With the increasing implementation and use of computerized Land Information Systems different types of information that are geo-referenced are interrelated and analysed in an integrated manner. A consequence is that the geometrical fundament, i.e. the topographical map and the items that are surveyed in their geometrical relation to this topography, is becoming but a small part in the whole data processing complex. Aspects like good classification, completeness and rate of "updatedness" are often considered of far greater importance. There is a tendency to believe that quality management of the geometrical fundament is a well-understood and well-managed area of interest for the land surveyor.

Practice in the Netherland shows however that this is often not the case and that attention for the quality of the geometry tends to be forgotten because of the importance of aspects like classification, completeness and so on. In the environment of Land Information Systems it becomes vital for the geometrical quality of the information that the source and quality of information on form and position is well registered and used when necessary. It is likewise important that modern computing techniques of land surveyors are made suitable for the treatment of information on form and position like attributes to the objects in the LIS that can be manipulated according the problems and demands at hand. It is argued that modern measuring techniques and new computing techniques in relation to LIS can give a land surveyor a quite different position.

10.00 - 10.05 Discussion

10.05 - 10.35 Data Quality Summary

Dale (UK)

The paper lays emphasis on the nature of quality particularly from a users perspective. It addresses both topographical and topological accuracy and then examines data currency, accessibility, value and ownership, all of which are of crucial importance to the data user.

10.35 - 10.40 Discussion

10.40 - 10.55 Coffee break

PRESENTATIONS FROM DIFFERENT COUNTRIES

10.55 - 11.15 Accuracies of the digital danish cadastral map Hvidegaard (DK) Summary

In 1986 the national Survey and Cadastre of Denmark started a project to convert the old analogue cadastre maps to digital form. The project includes specifications, development of special software, education etc. The actual production has been going on now for a couple of years.

11.15 - 11.20 Discussion

11.20 - 11.40 Quality check up of spatial data in large scale information systems Stoeppler (FRG) Summary (pres. Bruggeman)

Digital spatial informations must be well defined in Geographic Information Systems (GIS). There is a strong need for quality check ups in data processing for storing in open data bases and for data exchange between different systems as well as for all kinds of official and private use. Therefore criteria are necessary to define the quality of these spatial informations (spatial objects).

The main criterion is the conformity of the internal digital objects with their external definition. Checking up these criteria mainly means general geometrically and special semantically object-checking. based on experiences with the "Automatisierte Liefenschafskarte ALK" necessary and possible object-checkings in large scale information systems are pointed.

11.40 - 11.45 Discussion

11.45 - 12.05 Data Quality Aspects in the Swiss Cadastral Surveying

Kaufmann(CH)

12.05 - 12.10 Discussion

12.10 - 13.30 Lunch

13.30 - 14.15 Discussion

14.15 - 14.45 Introduction to the excursion to the Headquarters of the Dutch Cadastre Summary

Polman(NL)

In a short lecture an introduction will be given of the tasks of the Dutch Cadastral Agency. Special attention will be given to the two map series of the Cadastre, e.g. the cadastral map and the large scale basic map. The policy of the Cadastre is to upgrade the quality of the cadastral map, using the large scale basic map and to build up an integrated database for both map series within a period of ten years.

14.45 - 15.10 Quality management in the photogrammetric department. introduction to the visit

Witmer(NL)

15.10 - 15.30 Transport to the head-quarters of the Dutch Cadastre

15.30 - 17.15 Demonstrations

Friday 6 September 1991

DATA STANDARDS AND DATA EXCHANGE Moderator

Bruggeman(F)

09.00 - 09.30 Keynote

Bruggeman)

Exchange of spatial data

-Current efforts to build an international standard-Summary

Two workshops in 1990 at Montreux and Brighton demonstrated in an impressive way the interest of all involved parties from governmental, industrial and academic institutions in the creation of a commonly accepted international transfer format for spatial data.

- Building of national and international spatial information systems is in fast progress, and frequent exchange of data between the users of these systems is to be expected. On the other hand, different approaches are being discussed and developed by national and international expert groups; some national and industrial standards are already established. Nevertheless there are good chances to come to an agreement on a European level during the next few years. The paper outlines the most important approach and describes the existing and planned activities in Europe. American developments are considered, too.
- 09.30 - 09.50 **Organizational chart for geographic data standards and its application to the CERCOC project MEGRIN** Salge(F)
Summary
 Several countries have developed with success transfer formats. Some professional sectors have also defined their own mechanisms. In order to facilitate the way towards European standards, an ad-hoc European group, from DRIVE, CNIG, CERCOC and AGI has developed an organizational chart of geographic standards showing that the exchange format is only one of the standards leading to a completely digital exchange mechanism at a national or international level. This paper outlines the most important aspects of this organizational chart and other outcomes of the ad-hoc group.
 CERCOC is developing the concept of MEGRIN (Multi Purpose European Ground-Related Information Network), which aims at networking the various topographic data bases that each European country is elaborating. This project will be lying on standards and European specifications. This paper will highlight the most important aspects of MEGRIN and will relate it to the organizational chart and geographic standards.
- 09.50 - 09.55 **Discussion**
- 09.55 - 10.15 **Data transfer, concepts and applications** Aalders (NL)
Summary
 Data transfer requires several interrelated definitions on (inter)national level. In several countries technical and functional standards are developed but on a European level there is no organisation for the development of functional standards in the field of LIS. The state of the art is presented in this article.
- 10.15 - 10.20 **Discussion**
- 10.20 - 10.35 **Coffee break**

PRESENTATIONS FROM DIFFERENT COUNTRIES

- 10.35 - 10.55 **Status of NTF - May 1991** Sowton(GB)
- 10.55 - 11.00 **Discussion**
- 11.00 - 11.20 **Standard exchange format for geographic information** van Oogen(NL)
Summary
 The papers gives first a rough sketch of the management situation within advises as the Standard Exchange Format version 2, are established. Then the place and the history of the format is given, followed by a short description of the exchange format on the hand of a diagram. Based on an evaluation of the format some adjustments are proposed so that the format is suitable for cable and pipeline information.
- 11.20 - 11.25 **Discussion**
- 11.25 - 11.45 **The German exchange standard "Einheitliche datenbankschnittstelle (EDBS)"** Stoeppler(FR)
 (pres.Brüggeman)
Summary
 The uniform database interface (EDBS) is the standard data format for the exchange of spatial data in the German Surveying and Mapping Administration. It is not only prepared to transfer the graphical part of land related objects but also their object structure. In addition it provides basic elements of a spatial data query language using a special operation code which allows the updating of existing databases and spatial data queries. The paper describes functions, structure and applications of this standard, especially considering large scale mapping.
- 11.45 - 11.50 **Discussion**
- 11.50 - 12.10 **The Italian digital cadastre data transfer system** Galetto(I)
Summary
 In the first part of the paper a short overview of the National Transfer System is given.
 In the second part the situation of the Italian Digital Cadastre is shortly presented and the reasons of choice of NTF level 2 for data exchange are explained; then a description of the data structure in the transfer file is given.
 In the third part an example of cadastral data transfer is proposed in detail.
- 12.10 - 12.15 **Discussion**

12.15 - 12.35	Towards a Swiss Standard for the Exchange of LIS/GIS-data	Kaufmann(CH)
12.35 - 12.40	Discussion	
12.40 - 13.45	Lunch	
13.45 - 14.30	Discussion	
14.30 - 15.30	FINAL DISCUSSION AND FOLLOW UP OF THE WORKSHOP Moderator	Koen
15.30	Closing of the workshop	

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WORKSHOP DATA QUALITY IN LAND INFORMATION SYSTEMS

Introduction to the workshop

ir. L.A. Koen

Introduction

I am very pleased to welcome you once again in the Netherlands and at Apeldoorn where you are to join our workshop on data quality in land information systems. I much appreciate the fact that you have registered for our workshop and I do so all the more because I am aware of the fact that you had a big choice as regards participating in workshops and symposia during this period of the year.

To begin with, I want to thank the president of the OEEPE, Mr. de Smet, not only for being present on this first day of the workshop, but also for his inspiring words. We all know that under the chairmanship of Mr. de Smet OEEPE is trying to find new ways to realise its tasks. It is my sincere wish that with this workshop we will be able to contribute to a new zeal of the OEEPE.

It is not quite a coincidence that we have chosen the Netherlands and Apeldoorn as our meetingplace. Holland was one of the founders of OEEPE and has a long photogrammetric tradition. Most of you will be familiar the ITC where a lot of foreign students are studying photogrammetry and other related specialities. Apeldoorn is the place where the Head-Quarters of the Dutch Cadastral Service are situated. The Dutch Cadastral Service is by far the largest surveying and mapping organisation in the Netherlands and has supported the organisation of this workshop in many ways. Tomorrow you will be able to get to know the Cadastral Service.

Objectives of the workshop

The theme of the workshop is data quality in land information systems. The terms data quality and land information system both represent a very wide range of aspects and so you can ask yourself why we have chosen the rather modest form of a workshop to discuss this theme. With that question I come to the objective of this workshop. It is the aim of every workshop to contribute to an intensive exchange of knowledge and of course this is also one of the main aims of this workshop. The form of a workshop is chosen in those cases that the subjects and the problems are of a complex nature and intensive discussions are necessary in order to define the problems and to outline the solutions. In my opinion this definitely applies to data quality in land information systems.

Besides the exchange of knowledge there is a second objective for our workshop and that is to contribute to the definition of research projects. As you may know OEEPE has so-called application commissions having as their main task to point out practical problems and make proposals for research projects. As president of Application Commission II of the OEEPE I must admit that I am being confronted with a lot of problems in realising this task. For this reason I request your cooperation during this workshop by making the problems more transparent by means of intensive discussions. And I should like to conclude this workshop next Friday with some clear common opinions or statements and

some points of reference for the research work that will have to be done in the future.

Theme

Let me give you a short explanation on the theme of the workshop. For this it is necessary to go back to the year 1987 and remind you of the workshop on cadastral renovation in Lausanne. Main aim of that workshop was to create a forum for an analysis of the problem of cadastral renovation in the different European countries. During that workshop we got a good idea on the conceptual, legal and technical problems concerning cadastral renovation. Moreover we got a picture of the realisation of the renovation. The most significant conclusions at the end of the workshop were:

- * Almost all cadastral systems are developing from a single-purpose towards a multi-purpose system. The development mostly goes along the line **fiscal cadastre-legal cadastre-land information system**
- * All countries are struggling with the conversion problem. In spite of the broad application of the relatively cheap photogrammetry the pace of the renovation remains low as a result of the labour intensive character of the conversion.
- * In many countries there is obviously a big contrast between the ambitious objectives of developing a multi-purpose cadastre or land information system with the corresponding specifications on the one hand and the always limited financial and personal means on the other.

During the workshop these common problems were made quite clear. However, it was also apparent that there were several and different solutions for equal problems. A first and general conclusion was that the differences in the solutions were caused by differences in culture, law and history. Nonetheless this explanation was not very satisfactory because we did not get a clear picture of the background of the different conceptions. So it was clear that we needed a further analysis and especially on the functional aspects in order to come to joint and accepted conceptual or practical solutions for equal problems. And so it was decided within OEEPE to organise another workshop and focuss attention on the functional aspects. It was decided **data quality in land information systems** was to be the theme of the workshop.

The very word **data** in the theme of the workshop implies that we will discuss in particular the functional aspects. It implies furthermore that computer-technical problems will not be discussed (although probably we cannot fully avoid that). Anyway the problems are complex. Today I won't dwell on the word **quality** as I should like to discuss this word more in detail during the session of tomorrow. Today I will limit myself to the remark that we will not only discuss the important aspects precision and reliability but other aspects as consistency and exchangeability as well. In this workshop we will discuss **quality** in the first place as a **measure for functionality**

The expression **land information systems** is used to indicate that we will not only discuss the quality of data in a purely legal or tax cadastre but data quality in multi purpose information systems as well. The limitation is that we will mainly discuss the large scale application field. I must admit that I intended not to use the word **scale** in this context but as you see I cannot avoid it. Anyway I expect that during this workshop we will have an opportunity to discuss the relation between scale or level of scale, field of application

and quality

The programme of the workshop

The programme of this workshop has been composed in a close cooperation between Commission C and Application Commission II of the OEEPE. To that end an ad hoc group of colleagues from several OEEPE countries has met in Apeldoorn, Lausanne and Paris successively. I am very grateful for the support we got on those occasions from our colleagues.

As was explained previously the main field of attention of this workshop is the **functional and conceptual aspects relevant for the building up of a land information system**.

First of all it is important to get an idea of existing conceptions concerning data structure. These conceptions are a translation of the mission and the ambitions of the services concerned. The complexity of the different data structures is of major importance for the feasibility of data standardisation. The first day of our workshop will be fully devoted to the data structure. On the second day of our workshop we will discuss the quality aspect more in detail. We will not only discuss quality criteria and the opportunities of modern instrumentation for quality control but we will also discuss the specific requirements which quality control demands of our organisation. The latter aspect will be explained during the excursion the the cadastral service at the end of the second day.

On the third day of our workshop we will discuss the important quality aspect of **exchangeability of data** and the corresponding **standardisation**.

With this programme of the workshop I expect that we not only will have a good basis for discussion but will get a clear view on existing problems and possible solutions at that.

Follow up of the workshop

There is an increasing interest in the data quality issue, and particularly in the corresponding issue of data standardisation. During the last year data exchange and data standardisation were discussed in several workshops and symposia. One of the problems is that a clear European action centre for the stimulation and coordination of research and development was missing up to now. Recently, however, CERCO initiated a professional and coordinated approach of the standardisation problem. Another promising initiative is the establishment of a special commission for digital data standardisation of the Comité Européen de Normalisation (CEN) in Brussels. This new commission will deal with the recognition, registration and publication of European standards.

Within OEEPE we had also a discussion on data standardisation and on the role OEEPE should or could play in pre-standardisation research. During the meeting of the Steering Committee of OEEPE in Copenhagen in May 1991, it was decided to investigate a possible cooperation with CERCO and other organisations. The Steering Committee has asked explicitly to discuss this problem during this workshop and report on this issue during the next OEEPE meeting in Bern in November 1991. So I would be most satisfied if next Friday this workshop concludes with some clear points of reference concerning pre-standardisation research on data quality in land information systems.

Now it only remains for me to wish you all a very good workshop, with thorough discussions on the data standardisation issue, which I expect to become one of the major issues of our profession in the next decade.

Considerations on Structuring of Cadastral Data in GIS Systems

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1. Introduction

Structuring of data for cadastral surveys in geo-information systems is necessary not only to permit the management of information but also to have a good flexibility available for the different operations. The most simple data structuring is limited to the definition of points, lines and attributes; for practical reasons, surfaces are also very often included.

In this case, however, the possible updating of data is not really taken into account. For further revisions, it will be necessary to eliminate or displace whole objects like houses or road sections and to replace them according to the new survey. Such operations require much more complex data structures, including the identification of whole objects. Further considerations lead to the incorporation of neighbourhood relations and to the construction of complex objects.

In all these considerations, it is assumed that the coordinates of an object, once determined, will keep invariant. Nevertheless, every correction of a border line may cause displacements which lead very often to constraints requiring the integration of stochastic characteristics. In addition, the incorporation of picture elements may need an improvement of the data structure. For various tasks in cadastral survey one was always inclined to use orthophotos; these orthophotos, as pictorial maps, will finally lead to a structuring of raster data similar to the definition of objects for line maps. A similar problem arises when defining a digital terrain model; of course, it can be assumed that this information layer is completely independent of the previous defined object but this would result in a loss of information and in numerous contradictions in the data set. The only way to avoid such contradictions is to establish interrelations between the different layers.

The problem of data structuring is very closely linked to the instrumental possibilities. For instance, considerable progress has now followed the development of database techniques, especially by the incorporation of object-oriented databases for the management of geometrical data. Many systems using various database concepts are being developed, whereas the structuring of raster data is still in its early stages. It seems beyond doubt that progress in automatic image restitution will considerably influence the incorporation of raster data. It is therefore useful to touch briefly the question of instrumental possibilities in automatic photogrammetric plotting in order to point out the requirements in the structuring of raster data.

Thereafter, it is first tried to describe the various aspects of data structuring for the symbolic presentation of information. The aspects of automation in photogrammetric plotting, from which are derived the possibilities of structuring of pictorial elements, are then discussed.

2. Data Structuring in CAD-Systems

In many of the information systems currently used, data are structured to meet the requirements of the graphical presentation. The structuring of data, in the most simple case, is limited to the definition of points, lines and attributes. With few limitations, this concept is sufficient for the automatic map drawing. However, a surface can only be determined as a derived quantity. This derivation can be achieved completely automatically, but includes the danger of failures in the operations, due to imprecisions. It is therefore logical to define the following elements as basic ones :

Points
Lines
Surfaces

By summarizing this information in well defined thematic layers, it is possible to achieve the same standard as the one of a graphical map. Most of the geo-information systems used nowadays have a structure limited to this concept, with few variations. In this context it is useful to mention some systems widely used in Switzerland such as ADALIN, GRADIS 2000 or INFOCAM.

3. Object-Oriented Data Structuring

The data structure indicated up to now leans itself only in a limited way to the updating of information. For the updating, it is usually necessary to eliminate or displace whole objects like houses, parcels or road sections. In this case, it is desirable to identify an object as a whole including all its elements and to eliminate or manipulate it in the one or the other way. In order to illustrate this aspect, it is referred to the classification system of the Swiss cadastral survey in which the outlines of buildings are stored in one layer whereas stairs and balconies are stored completely independently in another layer. If a building is to be eliminated, great care is then necessary to make sure that all balconies and external stairs also be eliminated.

This example shows that it would be extremely useful to consider a building as a whole with all its various elements. Of course, the requirement to define a building as a whole should be considered as an example, and the concept of forming objects or even gathering several objects in more complex ones will be a logical consequence of the previously mentioned concept. The Institute of Photogrammetry has developed such a concept, using the geo-information system 'SYSTEM 9' operating with a relational database. Several relations have been applied between the different elements considering the different possibilities of queries when using the information system (cf. fig.1). The TIGRIS System of Intergraph seems to offer similar possibilities.

4. Requirements in Cadastral Renovation

Surveyors are quite aware that the precision of measurements introduced in a geo-information systems is limited. This basic idea is to be taken into consideration when storing information about the point precision. All coordinates are considered as invariant, as when producing graphical maps. It is naturally not possible to modify a point once pricked on a sheet of paper or any other support. However, a digital set of data introduced into an information system can be modified rather easily. Such

data structure Neuchâtel / water

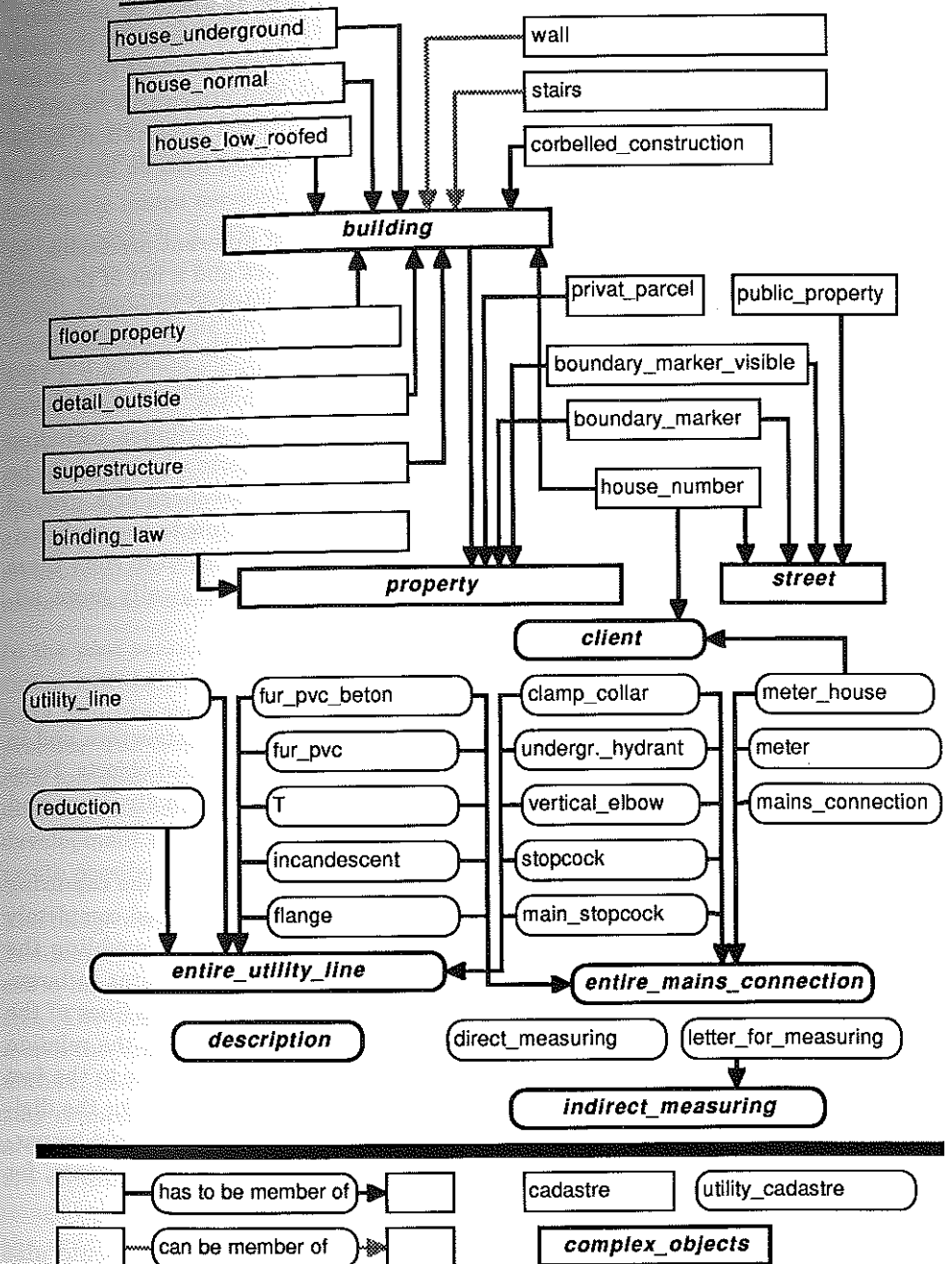


Fig. 1
Example of complex object structure developed within the context of a research project for utility mapping.

operations are necessary when changing the coordinates of the reference network or when improving the measurements by updating. In this case, it would be necessary to make sure that such transformations do not bring about contradictions in the data set. For example, it would be unfortunate that such a transformation lead to a situation in which the house, which was close to a border line, will afterwards be cut by this line. Such contradictions can be avoided by storing additional information, as for example the minimum distance to the border line, which should then be taken into consideration at the time of transformations.

A similar situation results from combinations of data sets of different precisions, as for example a combination between a net of cultural boundaries and a net of property boundaries, with a much higher precision. In this case, the cultural boundaries may come from photogrammetric measurements whereas the property boundaries come from terrestrial measurements. A similar situation can be faced when using a GPS in connection with older measurements made with a theodolite. All these cases would require objects to be stored with additional information as attributes, including the additional conditions. This concerns for example specific objects which have to be right-angled, the distance to neighbouring lines or the exclusiveness of a ground cover. As far as known, the currently available systems do not allow to use such conditions, with exception of the exclusiveness; it would however be useful to store these conditions already now in order to use them later with technologically more advanced information systems.

5. Reference to Height Data

A priori, it appears that height data also, like raster data, have no structure and in particular no reference to vector data describing the different cadastral objects. However, when looking closer, one can notice that all these data require a structure and should be related to each other.

Besides mass points, the elaboration of a digital terrain model requires the capturing of structure lines and dead areas. These elements are very often captured completely independently from all other data, which can lead to contradictions troubling the possible end-users of the data. Especially lines limiting roads or dam sites in large-scale works coincide completely with the normally determined structure lines of the digital terrain model. Consequently, it is logical to establish immediately the relation between these two kinds of lines and to draw the attention of the operator to the fact that the elements used for the planimetric presentation will also be used for the digital terrain model. The respect of the double function of these elements should be possible for photogrammetric plotting but also, as shown by different experiments, for tachymetric measurements.

A well defined reference between object data and height measurements should also allow to determine the height of various entities and to include them in further analyses. On the other hand, this concept would considerably facilitate the revision of digital terrain models as every planimetric updating would also establish the relation to the height information.

6. Automation of Data Acquisition

The technique of data acquisition has always had a great influence on the requirements and the data handling. The invention of the plane table led to the introduction of the cadastral survey as such and use of the cadastral maps. The precision of the cadastral survey increased with the introduction of digital survey methods and finally led to the development of the legal cadastre.

Automatic image correlation and automatic height measurements are other important elements in a new conception of photogrammetric image restitution. In these fields, developments are still going on. The first operational system for automatic height measurements and production of orthophotos was developed by Hobrough in the seventies. Some image correlators had already appeared on the market earlier, but their possible applications were very limited. Most of these early processors were based on analogical procedures which were not providing sufficient flexibility.

More favourable conditions are offered by the various digital procedures and most of the research in photogrammetry is currently concentrated in this field. Apparently, operational procedures might already be available for industrial applications. Interesting procedures are also available for small-scale plotting and automatic height measurements from satellite images. Large-scale mapping, however, entails much more difficult conditions.

In the past years, the Institute of Photogrammetry of the EPF-Lausanne, in collaboration with Leica Aarau & Co., has been working intensively on this problem and all tests indicate that the procedure being developed will satisfy the requirements in practice. The most important difficulties for the automatic derivation of a digital terrain model are the development of robust algorithms for image matching, the assurance that the measurements are effectively carried out on the natural terrain and the development of procedures allowing for thorough control of the results with appropriate possibilities for editing.

The image correlation elaborated at the Institute of Photogrammetry uses the Multi-Templet Matching, an algorithm developed from dynamic programming. This process is based on the computation of height parallaxes of image segments of varying size. The parallaxes are introduced into an adjustment algorithm which approximates the terrain with the help of finite elements. According to this terrain approximation, the aerial photographs are resampled and the height correlation is iteratively refined (cf. fig. 2). In order to accelerate the computations, all image operations are done on an array of Transputers. In a subsequent phase, the terrain obstacles are eliminated by a special filtering process and the data are finally controlled by image injection in an analytical plotter. Various tests have shown that a precision of the order of 0.1% of the flying height can be obtained, even with photographs of rather poor contrast and a terrain cover by houses or trees of up to 30% can be automatically eliminated. With the current technology, about 12 hours are still necessary for a model, but the new generation of Transputers or other parallel processors should considerably reduce the working time. This procedure would allow one to significantly reduce the cost of the establishment of digital terrain models but could also play a key-role for many other photogrammetric operations.

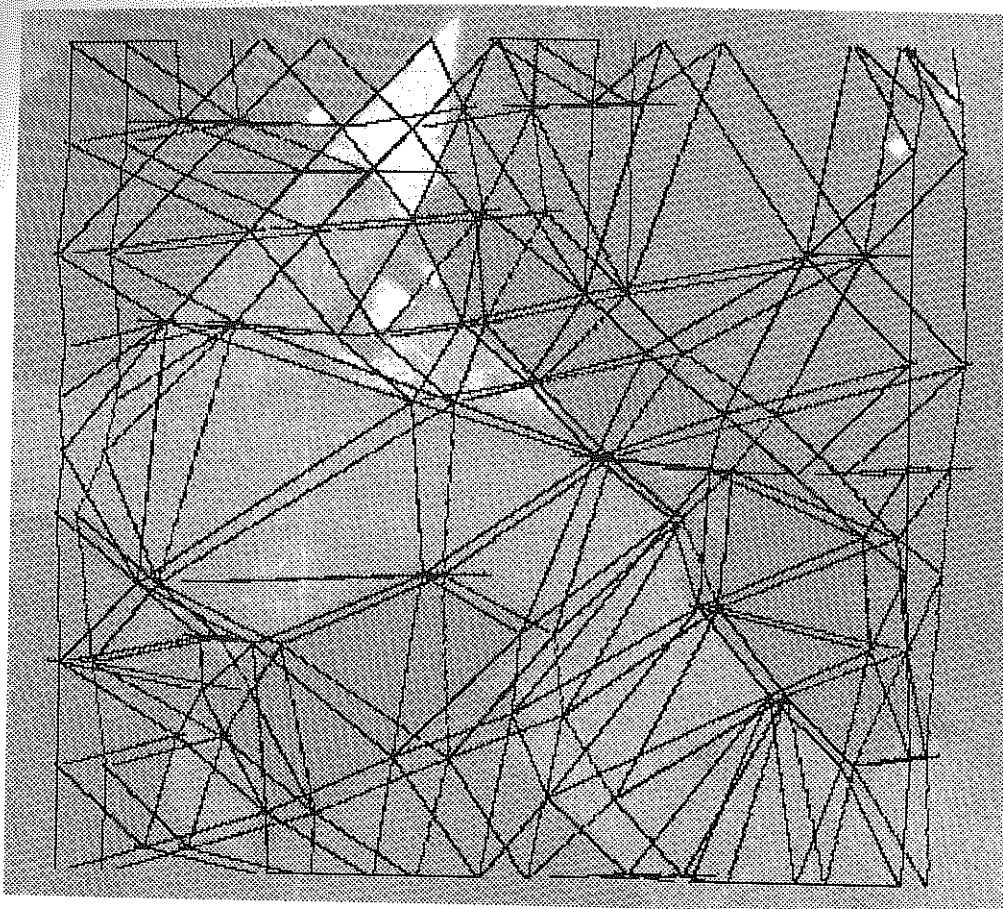


Fig. 2

Typical frame for multi-templet matching with terrain approximation by finite elements. The image section has been digitized for image matching and reproduced on a laser printer (512x480 pixels). The lines show the triangle surfaces of the finite elements and are used as reference for the representation of the height parallaxes. The size of the parallaxes is represented by the displaced lines; a displacement to the left indicates a lower terrain and a displacement to the right a terrain elevation. One notices that the lines extracted automatically describe perfectly the outlines of objects like houses.

7. Conception of Future Mapping Systems

The automation of stereo-measurements as it seems to come forward may cause a thorough modification in photogrammetric measurements and in the treatment of image information in general. The automation process could also be applied to other tasks like aerotriangulation. On the other hand, photogrammetric plotting could be limited to a sort of monoplottting, which could replace the highly specialised stereo-plotting. Most probably the greatest part of photogrammetric work will then be executed on geo-information systems with underlain digital aerial photographs.

Such a system could be composed of the following elements :

- **scanner** for the transformation of a photogrammetric analogical image into digital form
- **image processor** for the automatic derivation of a digital terrain model and the elaboration of orthophotos or landscape models, but also for tasks like automatic aerial triangulation
- **geographic information system with underlain aerial photographs** (monoplotter)
- **stereoscopic measuring instrument** (digital or analytical) with image injection for the verification of the results of the automatic plotting and for visual restitution
- **electrostatic plotter** for the production of half-tone images and line maps

This list may be incomplete, but it shows that the stereoscopic plotter will no longer play the central role it still assumes today. Numerous processes, such as image matching, might be done completely automatically, without supervision. For computations, efficient processors - most probably parallel processors - will be required, such as the Transputer array currently developed at the Institute of Photogrammetry for image correlation. Such processors could also be used for other computer-intensive operations like the management of a database for geographic information systems.

A more general use of dedicated processors, not only for photogrammetry but for other tasks of surveying or planning, could greatly facilitate the introduction of these procedures and might lead to a wide-scale use of these new working modes.

8. Structuring of Pictorial Data

Pictorial data play a certain role in cadastral surveys in conjunction with orthophotos. Orthophotos allow to reduce considerably the detail mapping and very expressive maps can be obtained. A disadvantage is however that orthophotos can only be interpreted visually; for example, the determination of the surface of a forest complex needs an abstraction and the definition of its surrounding polygon.

Consequently, it should be strived for that pictorial data be structured similarly to point and vector data; it is evident yet that pictorial data have mainly a surface structure and additionally a volumetric structure. The current activities in automatic extraction of border lines as well as in automatic derivation of digital terrain models clearly go in this direction.

These considerations might appear rather academic. It is however necessary to mention them if one thinks of the graphical styling of orthophotos. The combination of an orthophoto with a net of parcels lines already requires a geometric adaptation in order to avoid contradictions. The graphical accentuation of objects or line elements would be made much easier by the identification of objects in raster images. In this context, it is furthermore referred to the requirements of lettering.

The definition of volumetric objects would eventually facilitate the creation of synthetic views of either a landscape or a town and would allow to generate any arbitrary oblique view.

9. Conclusions

The structuring of data in information systems can take a great variety of aspects. Some of the aspects treated here may appear hypothetical or even unrealistic. However, the intention is to show with this key-note the great scope of this topic and to give an impulse to further developments. Some of the following lectures will deal with this topic in a much more concrete way and will point out structures which are realised today. It is absolutely necessary that practitioners proceed here very pragmatically and incorporate the possibilities of modern information systems in a realistic way. Without any doubt, the simple structures are still the most efficient and guarantee that a project for the computerisation of a cadastre can effectively be achieved. But when conceiving such a scheme, one should keep aware that great modifications are to be expected in this field within the immediate future. It is therefore wise to proceed very carefully for the structuring of data by leaving enough space for further refinements and enlargements.

Data Organization and Data Structures in European Countries

Summary of an inquiry done in January 1990

Data organization and data structures are key functions for an efficient data management in information systems. The organization and structuring depends to a great deal on the used land information system, but the historical development of the cadaster and the management of the previous graphical or numerical cadastre might also play an important role. In order to get an overview of the data organization and structuring in the different countries, it was decided to send a questionnaire to the national organizations. The questionnaire was sent out mid January and answers have been received from the following institutions :

Austria :	Bundesamt für Eich- und Vermessungswesen
Belgium :	Administration centrale du cadastre
France :	- Direction générale des impôts, Sous-direction des affaires foncières, cadastrales et domaniales, Paris - Ecole nationale du cadastre, Toulouse - IGN, Paris
Finland :	National Board of Survey, Helsinki
Germany :	Landesvermessungsamt Niedersachsen
Italy :	Ufficio Tecnico Erariale, Pesaro
Netherlands :	- Hoofddirectie van het Kadaster, Apeldoorn - Technical University of Delft
Switzerland :	Eidg. Vermessungsdirektion, Bern
United Kingdom :	- Her Majesty's Land Registry - Prof. P.F. Dale, Polytechnic of Great London.

Some Considerations on the received Questionnaires

These considerations are limited to Austria, Belgium, Finland, Germany, Italy, the Netherlands, Switzerland and the UK. France has not yet defined its concept for a computerized cadastre, but has developed a concept for a topographic database; reference is partly made to this concept.

1. Most countries have a legal cadastre, except for Belgium and Italy; these 2 countries have a tax cadastre (2.1a).
2. In most countries the computerized cadastre is not recognized as a basis of the legal cadastre, with the exception of Austria, Germany, the Netherlands and the UK (2.2b).
3. Data organization varies heavily from country to country (3.3).
A simple file structure is used in Belgium, which has 100% of its cadastre computerized, and in the Netherlands, with 10% computerized.
Currently, most countries use a hierarchical data structure; additionally, a relational database is used in Italy and in the UK for descriptive elements.
No country uses a relational database for storing the geometrical information with exception of France for the topographic database of the IGN.
4. Most countries dispose on a uniform data catalogue, except Austria, Belgium and the UK; the cadastre of the UK will adopt the structure of the Ordnance Survey (4a-4c).
5. The data structure seems in all countries very advanced; in all countries surfaces are used as elementary graphical elements beside Finland, but all countries define objects; no complex objects are used in Italy, in the Netherlands and in the UK. Finland, Germany and Switzerland also register neighbouring information (5.2.d) and the automatic interpretation of communication between elements is possible in Finland and Germany (5.1, 5.2).

Tables Summarizing the Working Progress and the Instruments in Use

Table 1. Overview of the working progress

Country	Surface already in the system	Expected year of completion	Way of data acquisition
Austria *	1.2% 1000 km ²	2000	digitizing and photogrammetry
Belgium	100% 30'500 km ² (since 1975)		
France (IGN)	0.2% 1000 km ²	2015	photogrammetry
Finland	10%	1997	digitizing and photogrammetry
Germany	4 pilot projects		digitizing
Italy	10%	2005	digit., resurvey, renov., photogramm.
Netherlands	15% 4000 km ²	2000	50% digitizing, 50% photogrammetry
Switzerland	start 1992	2030	digit., resurvey, renov., photogramm.
UK	0.1% 500 km ²		digit., resurvey, renov., photogramm.

* A computerized database for the cadastral register is existing for 90% of Austria and a database for point coordinates covers 60% of the territory.

Table 2. Overview of the used systems

Country	Admitted systems	Type of database
Austria	Autocad and others	IBM - IMS central
Belgium		DL/1 in future
France (IGN)	Tigris, Intergraph	and System 9
Finland	Fingis, own development	
Germany	ALB, ALK, own	Siemens - UDS
Italy	VAX / VMS	SYSSCAN
Netherlands	All	DBMS-II (DEC)
Switzerland	To be defined	
UK		DMRS (Intergraph), Informix

O. Kölbl

Lausanne, 5 March 1991

Zum Einsatz kommerzieller Datenbank-Technologie in Geo-Informationssystemen

RALF BILL, Stuttgart

Zusammenfassung

Der folgende Beitrag gibt einen Überblick über die heutige Datenbanktechnologie. Dabei werden die verschiedenen logischen Datenmodelle wie hierarchische, netzwerkartige, relationale und objektorientierte Datenmodelle angesprochen. Die Unterschiede von sogenannten 'Standard-Datenbankanwendungen' zu 'Nichtstandard-Datenbankanwendungen' werden aufgezeigt und daraus die Notwendigkeit spezieller Erweiterungen der Datenbanktechnik abgeleitet sowie durch aktuelle Forschungsarbeiten in der Informatik belegt.

Abstract

The following paper reviews the recent database technology. The various logical data models - hierarchical, Codasyl, relational and object-oriented - are introduced. Differences between so-called 'standard database applications' to 'nonstandard database applications' such as GIS-problems or CAD-problems are shown. The necessity of special enhancements for dealing with spatial phenomena - currently in the research agenda of computer sciences - is derived and the forthcoming database technology described.

1 Einführung

Datenbanken (im folgenden mit DB abgekürzt) kommt in Geo-Informationssystemen (GIS) eine zentrale Bedeutung zu. Denn es ist der Datenbestand und die Flexibilität der Datenverwaltung, die bereits nach kurzer Zeit für den Nutzer von raumbezogenen Informationen den größeren Wert (auch in finanzieller Hinsicht) darstellen als die schnelle Hard- und Software. Daher setzt sich der folgende Beitrag mit dem Thema Datenbanken auseinander. Neben der Erklärung der gängigen Datenbanktechnologie wird stets der Bezug zur speziellen Anwendung im GIS-Bereich aufgezeigt und die dort vertretenen Produkte aber auch die Probleme der heutigen Datenbanktechnik mit dem Arbeitsgebiet GIS genannt.

1.1 Grundbegriffe der Datenbanktechnik

Gegenüber der Dateienverwaltung der Vergangenheit, bei der Datenstrukturierung und Applikationsprogramm sehr eng miteinander verflochten waren, findet man - nicht nur im GIS-Bereich - zusehends Datenbanken als Speichermedien und Datenbank-Managementsysteme (DBMS) zur Manipulation der Daten. Zwei wichtige Anforderungen an ein Datenbanksystem sind zu nennen. Aus datenbanktechnischer Sicht sollte ein System nicht Datenbanksystem genannt werden, wenn es nicht über wesentliche der in Kapitel 3 genannten Techniken wie z.B. das Transaktionskonzept, den Recovery-Mechanismus, eine höherwertige Abfragesprache etc. verfügt. Aus Anwendersicht sollte eine Datenbank fähig sein, ENTITÄTEN (OBJEKTE) und deren BEZIEHUNGEN (RELATIONSHIPS) in einem allgemeinen Modell zu repräsentieren und eine dem Benutzer angemessene Sicht auf diese Daten bieten. Diese Modellierung sollte flexibel sein und möglichst wenig Einschränkungen unterliegen.

Eine Entität ist ein bedeutungsvolles Primitiv - im Datenbanksinn die kleinste informationstragende Einheit - der darzustellenden Miniwelt; es ist ein Oberbegriff für Subjekt, Objekt, Ereignis oder Begriff. Die einzelnen Entitäten werden in einer Entitätenmenge zusammengefasst, worin die Entitäten gleichartige Eigenschaften (auch Attribute genannt) besitzen. Eine Entität ist innerhalb der Entitätenmenge durch einen Schlüssel - ebenfalls eine Eigenschaft - eindeutig charakterisiert. Beziehungen (Relationships) drücken einen bedeutungsvollen Zusammenhang zwischen den Entitäten aus. Während in der Datenbankwelt unter den Begriffen Entität und Beziehung wirklich diese kleinsten Informationseinheiten und deren Zusammenhänge

zu verstehen sind, wird in der Anwendung GIS unter Entität (oder Objekt) schon ein in der realen Welt bedeutungsvolles Objekt (z.B. ein Haus) und unter dessen Beziehung z.B. der Zusammenhang zur Parzelle, auf der dieses Haus steht, verstanden. Diese Generalisierung ist datenbanktechnisch natürlich auf die dort verwaltbaren kleinsten Informationseinheiten zurückzuführen, welches zu Problemen der Datenbanken mit GIS Anwendungen führt, wie in den weiteren Ausführungen noch gezeigt wird.

Zwischen den Entitäten bzw. Objekten können folgende Beziehungen auftreten :

- die 1:1 Beziehung : Einem Objekt des Typs A ist umkehrbar eindeutig ein Objekt des Typs B zugeordnet.
- die 1:n (oder n:1) Beziehung : Einem Objekt des Typs A sind beliebig viele Objekte des Typs B zugeordnet (oder umgekehrt).
- die m:n Beziehung : Es besteht eine Zuordnung zwischen beliebig vielen Objekten des Typs A und Objekten des Typs B.

1.2 Datentypen in raumbezogenen Informationssystemen

Raumbezogene Informationssysteme verwalten die Datentypen Geometrie/Topologie, beschreibende Daten (Attribute) und Beschreibungen der graphischen Präsentation. In Zukunft werden vermutlich weitere Datenarten hinzukommen wie z.B. Volltexte, Bilder, Videosequenzen etc., wodurch sich das GIS zu einem Multimediasystem entwickeln wird. Bei den weiteren Betrachtungen wird aber - unter Berücksichtigung des gegenwärtigen Standes der Technik - überwiegend die Verwaltung der Geometrie und Topologie im Vordergrund stehen. Hinsichtlich der Geometrie/Topologie-Daten unterscheiden wir zwischen Vektor- und Rasterdaten. Mit Vektordaten ist die Verwaltung von Punkten, Linien und Flächen als Folge von 2D- oder 3D-Koordinaten bezeichnet, während unter Rasterdaten Matrizen von Bildelementen (Pixel) zu verstehen sind. Diese Pixel nehmen im einfachsten Fall nur zwei Zustände an : ein solches Binärbild könnte etwa eine mit einem Scanner erfaßte Katasterkarte oder ein Leitungsplan sein. Demgegenüber sind die Rasterdaten bei multispektralen Satellitenaufnahmen in die verschiedenen Spektralbereiche (Kanäle) zerlegte Matrizen von Bildelementen, wobei jedes Pixel bis zu 256 Graustufen annehmen kann und die Zuordnung der Kanäle über das Matrixelement erfolgt. Beschreibende Daten sind in ihren Eigenschaften den Datentypen sehr ähnlich, die mit Datenbanken üblicherweise verwaltet werden (wie z.B. Kontonummern, Kontostände, Kontobesitzer), so daß diese mit gängigen Datenbanktechniken weniger problematisch zu bearbeiten sind. Beschreibungen der graphischen Repräsentation von Objekten und Primitiven werden entweder analog zu Attributen behandelt oder extern neben dem DBMS in einfachen Tabellen verwaltet. Diese Form der Datenmodellierung findet man z.B. bei System 9 (Prime Wild GIS AG); alle Datentypen werden in einer kommerziellen relationalen Datenbank (siehe Kapitel 2) gemeinsam gespeichert.

Dieser Datenmodellierung steht eine andere Betrachtungsweise gegenüber, die häufig in raumbezogenen Informationssystemen anzutreffen ist. Hierbei wird zwischen Graphik- und Sachdatensätzen unterschieden. Der Graphikdatensatz orientiert sich an den graphischen Standards wie GKS (Graphisches Kernsystem), welche neben den obengenannten geometrischen Grundelementen Punkt, Linie und Fläche nun Text als weiteres graphisches Grundelement hinzunimmt. Die Beschreibung der Darstellung dieser vier graphischen Grundelemente ist ebenfalls Bestandteil des Graphikdatensatzes, der in einer netzwerkartigen Datenstruktur (vgl. Kapitel 2) verwaltet wird. Der Sachdatensatz entspricht dem nicht graphisch orientierten Teil der Attribute und wird in einem relationalen Datenmodell abgebildet.

Heutige GIS beruhen vorwiegend auf Vektordatenbasis. Ausschließlich auf Rasterdaten aufbauende GIS sind äußerst selten, während erst weniger als ein Viertel der Produkte hybride Systeme - Systeme, die beide Geometriedatentypen vereinigen - sind ([3]). Der Leistungsumfang hybrider Systeme ist auch sehr unterschiedlich. Dies reicht vom einfachen Hinterlegen eines Rasterbildes bis hin zu komplexen Bildverarbeitungs- oder Analyseoperationen im Rasterbereich.

Die GIS-Produkte bilden die reale Welt überwiegend zweidimensional ab. Die dritte Dimension kann eventuell als zusätzliche Koordinate - tlw. auch nur als Attribut - mitgeführt werden. Sie wird allerdings bei geometrisch-topologischen Operationen nur äußerst selten voll unterstützt, sondern eher als Datenbasis zur Ableitung digitaler Geländemodelle betrachtet.

2 Logische Datenmodelle und ihre Anwendung im GIS

Das logische Datenmodell beinhaltet die Festlegung von Datenstrukturen zur Verwaltung der Daten - oder der speziellen Sicht auf die Daten - und die zugehörigen erlaubten Operatoren auf diese Strukturen. Das logische Datenmodell ist die Basisinformation eines GIS, nicht die physikalische Datenspeicherung. Die Realwelt beschreiben wir im logischen Modell mit Objekten, den Beziehungen zwischen der Realwelt und den modellierten Objekten und den Beschreibungsregeln für beide. Die Datenstruktur für Objekttypen beinhaltet daher logische, technische, administrative und geographische Beziehungen.

Im folgenden Abschnitt sollen die wesentlichen Arten der logischen Datenmodellierung - wir unterscheiden hier zwischen hierarchisch, netzwerkartig, relational und objektorientiert - diskutiert werden ([7], [18]).

2.1 Das hierarchische Datenmodell

Hierarchische Datenmodelle sind die ältesten der logischen Modelle; sie setzen eine Hierarchie in den Beziehungen der Daten voraus und nutzen diese bei der Verwaltung aus. So sind z.B. baumartig organisierte Datenstrukturen (binär, quadtree ...) hierarchische Datenmodelle. Die Vater-Sohn Beziehungen werden von den Operatoren explizit genutzt. Operationen navigieren durch die Baumstruktur. Das hierarchische Datenmodell unterstützt relativ einfach die 1:n Beziehung, während m:n Beziehungen nur durch redundante Speicherung von Information modelliert werden kann. Jedes hierarchische Datenmodell erlaubt eine sehr rationelle Einreihung der Daten (sequentiell) und ist sehr effizient, wenn den Daten diese Eigenschaft zugrundeliegt.

Man spricht beim hierarchischen Modell von :

- ROOT - Stamm, Ausgangskriterium
- LEAVES - Blätter, Folgemerkmale

Hierarchische Modelle sind natürliche Modelle beim Versuch die Realwelt zu modellieren. Sie sind kompliziert zu handhaben, da Relationen durch eine beschränkte Anzahl von Links (Verknüpfungen zwischen Records) dargestellt sind. Man könnte sich das Verwalten der Daten in einfachen Listen oder sequentiellen Dateien vorstellen. Verfeinerungen sind geordnete Listen und indexsequentielle Dateien.

Ein Beispiel (nach [4], vgl. auch [15]) zeigt die Verwaltung von zwei Polygonen in einem hierarchischen Modell (Abbildung 1).

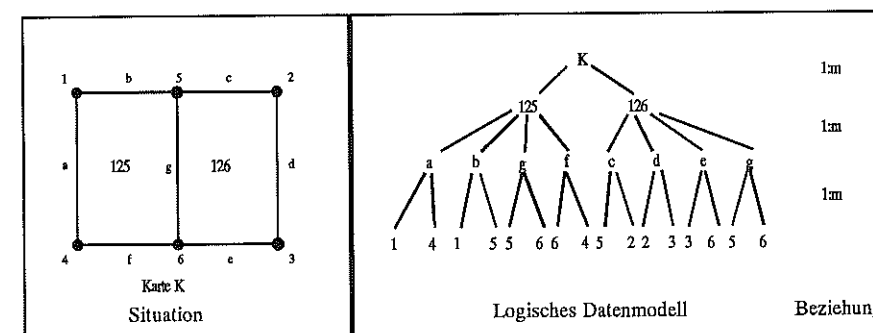


Abbildung 1 : Beispiel eines hierarchischen Datenmodells im GIS-Bereich.

Anwendungen von Hierarchien im GIS-Bereich finden sich z.B. im SICAD-System mit dem quadtree als Verwaltungs- und Zellteilungsstrategie der netzwerkartigen Geometrie-Modelldaten in der geographischen Datenbasis (SICAD-GDB). Auch die Verwaltung der Rasterdaten im SICAD-HYGRIS beruht auf einer hierarchischen Zellteilung; die Daten werden in einer eigenen Datenbank (RDB) abgelegt.

2.2 Das netzwerkartige Datenmodell

Der Begriff netzwerkartig reflektiert im wesentlichen den Beziehungsteil der Realwelt. Man kann es als verallgemeinerte Methode des hierarchischen Modells betrachten mit einer beliebigen Anzahl von Verknüpfungen. Das netzwerkartige Datenmodell ist durch den Data Base Task Group Vorschlag der CODASYL [5] standardisiert. Eine solche Datenbank wird auch CODASYL-Datenbank genannt, teilweise findet man auch die Bezeichnung Plexstrukturen.

Beim netzwerkartigen Modell spricht man direkt von

- RECORDS - den Objekten
- LINKS oder SETS - den Beziehungen

Es ist charakterisiert durch Owner-Member Beziehungen. Ein Owner Record Typ ist ein Objekt, dem andere Datenobjekte, Member Record Typen, über einen Set-Typ in fester Reihenfolge nachgeordnet sein können. Einem Owner können viele Member derselben Art, ein Member kann mehreren Ownern über jeweils ein Set zugeordnet sein. Jeder Set-Typ besitzt einen Owner- und einen Membertyp, womit indirekt auch m:n Beziehungen realisiert werden. Rekursive Strukturen sind schwer zu behandeln. Operationen in netzwerkartigen Modellen sind charakterisiert durch das Navigieren auf Set-Typen. Aus einem netzwerkartigen Datenmodell kann durch redundante Daten ein hierarchisches Modell erzeugt werden. Mit netzwerkartigen Modellen können Modelle großer Realitätsnähe erfaßt werden. Problematisch ist bei netzwerkartigen Modellen die Erweiterung des Modells. Kommerzielle netzwerkartige Datenbanken gibt es seit den 70er Jahren; zu nennen wären hier z.B. UDS-V2 auf Siemens BS1000/2000 Rechnern und AIM auf BS2000 Rechnern.

Auch hier sei wieder das Beispiel der Polygonverwaltung aufgezeigt (Abbildung 2).

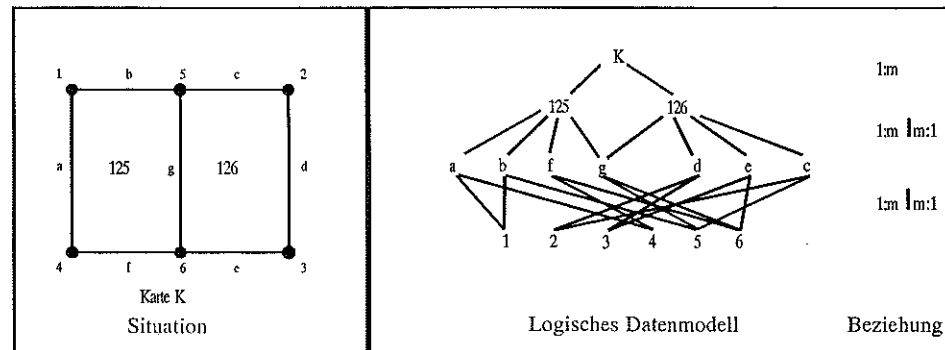


Abbildung 2: Beispiel eines netzwerkartigen Datenmodells im GIS-Bereich.

Netzwerkartige Datenmodelle findet man häufig in der Geometrie- und Graphikdatenverwaltung von GIS, z.B. bei SICAD für die Verwaltung von Punkten, Linien, Flächen, Texten und benutzerdefinierbaren Elementen.

2.3 Das relationale Datenmodell

Das relationale Modell überträgt die Ergebnisse der mathematischen Theorie der Relationen auf die Datenbankproblematik. Es ist ein tabellares Konzept, indem die Daten und Beziehungen zwischen den Daten verwaltet werden. Im Umfeld des relationalen Modells arbeitet man mit den Begriffen

- RELATION = Menge von Tupeln (Daten und Beziehungen zwischen Daten, deren Umsetzung in eine Tabelle mit Tabellename gleich Relation), die durch Angabe des Namens und der beteiligten Attribute festgelegt ist,
- TUPEL = geordneter Satz von Attributen, untereinander in zweidimensionalen Tabellen eingetragen, in Tabellensicht eine Zeile einer Tabelle mit einem eindeutigen Schlüssel auf das Tupel,

- ATTRIBUT = ein Eintrag zu einem bestimmten Merkmal (Entität oder Beziehung) einer Relation, also in Tabellensicht ein Spaltenwert,
- DOMÄNE = Wertebereich oder die Menge der verschiedenen Feldwerte eines Attributes,
- SCHLÜSSEL = ein Attribut (oder eine Kombination von Attributen) mit der Eigenschaft, daß in allen möglichen Ausprägungen der Relation jeder Wert nur einmal vorkommt. Man unterscheidet Primär- und Fremdschlüssel.

Aus der Sicht relationaler Datenmodelle bearbeitet man eine Datenbank mit den relationalen Operatoren:

- Projektion = Auswahl von Attributen aus einer Tabelle.
- Selektion = Auswahl von Tupeln, die einer bestimmten Bedingung genügen.
- Verknüpfung = das kartesische Produkt von Zeilenmengen.
- Produkt = das Produkt einer Spalte mit einer anderen.
- Vereinigung = die mengenmäßige Vereinigung zweier Teilmengen.
- Differenz = der Unterschied zwischen zwei Teilmengen.
- Durchschnitt = die Gemeinsamkeiten zweier Teilmengen.
- Dividieren = das Aufsplitten eines Produktes.

Dieses auf Codd [6] zurückzuführende Modell verdankt seine Verbreitung der klaren mathematischen Darstellung und dem am strengsten realisierten Entkoppeln der Datenbereitstellung von der Anwendung, d.h. die strikte Trennung von der physikalischen Speicherung und der logischen Modellierung. Die Tabelle ist die einzig gültige Datenstruktur. Den Objekten und Beziehungen werden Attribute zugeordnet, die als atomare (unstrukturierte) Einheiten betrachtet werden.

Bemerkenswert am relationalen Modell ist, daß Beziehungen zwischen Objekten ebenfalls als Werte in Tabellen, also wie die Objekte selbst verwaltet werden. Entitäten und Relationen werden in einer Weise repräsentiert. Außerdem ist die Tabellenform leicht zu verstehen und mit einem einfachen Operationsset bedienbar. Das relationale Modell ist allerdings schlecht für den räumlichen Zugriff geeignet. Unterhalb der logischen Modellierung im relationalen Modell kann die physikalische Umsetzung im Speicher der Rechner wiederum auf hierarchische oder netzwerkartige Strukturen aufbauen. Für den Entwurf eines relationalen Modells und dessen Umsetzung sind Normalformen anzustreben. Nicht normalisierte Relationen können Attribute besitzen, deren Werte wieder Relationen sein können. Man spricht von 1., 2., 3. usw. Normalform, je nachdem wie weit die Normalisierung der Entitäten und Relationships fortgeschritten ist. Die 1. Normalform ist erhalten, wenn eine Relation nur noch einfache Attribute enthält; d.h. in jeder Tabellenspalte steht nur noch ein Wert, ein Atom. In 2. Normalform ist eine Datenbank, wenn zusätzlich volle funktionale Abhängigkeit der Nichtschlüsselattribute von jedem Schlüsselkandidaten gegeben ist. In 3. Normalform gilt zusätzlich die wechselseitige (transitive) Unabhängigkeit der Nicht-Schlüsselattribute von jedem Schlüsselkandidaten. Eine andere Definition der Normalformen führt auf die sogenannte Boyce Codd Normalform (BCNF), bei der jedes Schlüssel- und Nichtschlüsselattribut voll funktional abhängig von jedem Schlüssel ist.

Kommerzielle Datenbanken aufbauend auf dem relationalen Modell sind heute in großer Vielzahl erhältlich. Dies reicht von relationalen Datenbanken auf Personalcomputern (Oracle, dBase IV usw.) über Workstations (Oracle, Ingres, Informix, Empress u.a.) bis zu Großrechnern (DB2, SQL/DS, DDB/4 u.a.).

Ein Problem der relationalen Datenbanken ist ihr Antwortzeitverhalten bei komplexeren Anfragen. Aus diesem Grund finden sie auch bisher nur in sehr wenigen GIS-Einsatz (Beispiel System 9) als Verwaltungssysteme für Geometriedaten; verstärkt sind sie allerdings vertreten bei der Verwaltung der beschreibenden Informationen, die eine hohe Ähnlichkeit mit denjenigen Daten besitzen, für die das relationale DBMS entworfen wurde. Hier werden vermehrt auch kommerzielle relationale Datenbank-Managementsysteme, die lauffähig vom PC bis zum Mainframe sind, eingesetzt wie z.B. Oracle.

Auch hier sei wieder das Beispiel der Polygonverwaltung aufgezeigt (Abbildung 3).

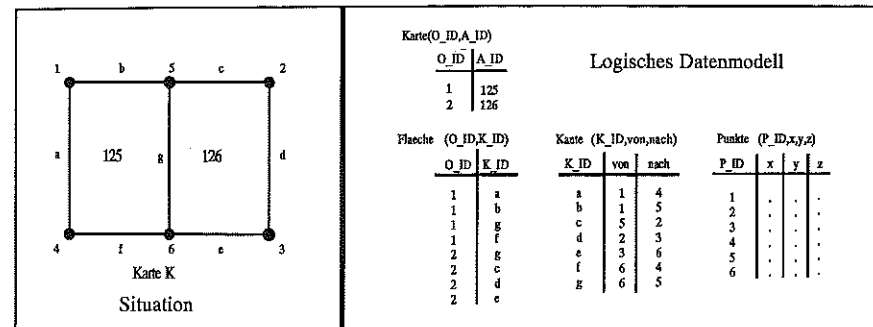


Abbildung 3 : Beispiel eines relationalen Datenmodells im GIS- Bereich.

2.4 Das objektorientierte Datenmodell

Derzeit sind in der Informatik Forschungen auf dem Gebiet der Erweiterung des relationalen Datenmodells zu objektorientierten Datenmodellen im Gange. Ziel ist hierbei die Unterstützung neuer Datentypen durch Aufgeben der ersten Normalform, die Unterstützung der dazugehörigen Operatoren und die Implementation raumbezogener Speicher- und Zugriffsmechanismen [22].

Hinsichtlich der objektorientierten Datenmodelle kann man drei Klassen unterscheiden [8] :

- Strukturell objektorientierte Datenmodelle.
- Verhaltensmäßig objektorientierte Datenmodelle.
- Voll objektorientierte Datenmodelle.

Diese unterscheiden sich hinsichtlich der Flexibilität. Strukturell objektorientierte Datenmodelle können komplexe Objekte als ein Atom in der Datenbank behandeln, wobei die Operatoren, die auf diese Objekte angewendet werden können, vordefiniert sind. Prototypen hierzu sind z.B. DASDBS oder DAMOKLES. Verhaltensmäßig objektorientierte Datenmodelle erlauben anwendungsspezifische Datentypen und Operatoren, abstrakte Datentypen und Integritätsbedingungen. Prototyp hierfür ist VBASE. Voll objektorientierte Datenmodelle sind strukturell und verhaltensmäßig objektorientiert. Hier wären zu nennen POSTGRES, eine Erweiterung von INGRES, ORION u.a. .

Zum Verständnis des objektorientierten Konzepts seien einige Begriffe erläutert [15]. Ein Objekt besteht aus einem Datensatz und einer Anzahl von Operationen (methods), die es ausführen kann. Ein Objekt kann über Kanäle (channels) mit anderen Objekten verbunden sein. Diese Verbindungen können vom Typ 1:1, 1:n oder m:n sein. Ein Objekt kann nur über einen seiner Kanäle mit einer Nachricht (message) angesprochen werden und zu einem Einsatz seiner Operationen veranlaßt werden. Der Benutzer sieht nur die Ausführung, nicht die interne Realisierung. Das Objekt ist eine kleine Welt für sich, weshalb man auch von der Einkapselung (encapsulation) spricht. Jedes Objekt gehört einer Objektklasse an, aus der es durch die Festlegung bestimmter Attribute entstanden ist. Erst bei Vorliegen aller Attribute wird es zu einem Individuum (instance). Durch Vererbung von Eigenschaften (inheritance) können neue Objektklassen gebildet werden. Die daraus gebildete Unterklasse erbt alle Funktionen und Daten dieser Oberklasse und es können Methoden umdefiniert und neue ergänzt werden. Die Vorteile des objektorientierten Ansatzes liegen klar auf der Hand. Das Objekt ist flexibel definierbar und änderbar als Abbild eines Bestandteils der realen Welt; es besitzt ein Eigenleben und verwaltet seine Daten selbständig. Der Nachteil ist allerdings neben der fehlenden bisherigen Verfügbarkeit solcher Datenbanken deren Antwortzeitverhalten und das rasche Anwachsen von Quellcode. Rechenaufwand und Speicherbedarf ist extrem. Dennoch wird dieses Modell in Zukunft bedeutend sein. Im GIS Bereich gibt es mindestens zwei Produkte (TIGRIS von Intergraph und Smallworld GIS von Smallworld), die als weitestgehend objektorientiert bezeichnet werden können.

Auch hier sei wieder das Beispiel der Polygonverwaltung aufgezeigt (Abbildung 4).

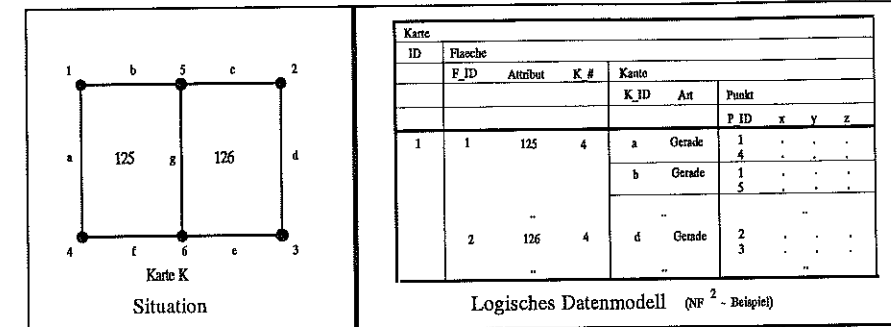


Abbildung 4 : Beispiel eines objektorientierten Datenmodells im GIS- Bereich.

2.5 Das HyperMedia Konzept

Als neue Entwicklung für den Bereich der Datenverwaltung ist das HyperText-Konzept anzusehen [23], welches auf dem Begriff des semantischen Netzes aufbaut. Semantische Netze sind frei definierte Graphen. Ein Graph besteht aus Knoten und Kanten, die Knoten untereinander verbinden. Die Knoten sind hierbei Träger von Objekten, die Kanten stehen für Beziehungen zwischen den Objekten. Bei HyperText sind die Objekte textuale Informations-elemente, während in der Verallgemeinerung, dann als HyperMedia bezeichnet, auch Komponenten wie Graphik, Sprache, Bilder, Musik und Animation als Objekte integriert sind. Die Bezeichnung 'Hyper' leitet sich davon ab, daß dieser Graph zur Darstellung von Beziehungen gegebenen Datenbeständen logisch gesehen übergestülpt wird. Die Beziehungen werden sowohl innerhalb eines Dokuments (im Falle von HyperText) als auch zwischen Dokumenten durch maschinen-unterstützte Verbindungen (links) realisiert. Somit lassen sich komplexe Datenbestände und deren Beziehungen separat erfassen. Zugriffsmöglichkeiten sind damit nicht nur über das Datenmaterial sondern auch über die zwischen ihnen festgelegten Beziehungen möglich. Erste Prototypen von Hypertext gibt es seit Ende der 60 er Jahre wie z.B. NLS, XANADU. HyperText-Umgebungen sind heute als Produkte verfügbar (HyperCard und GUIDE) für Apple Macintosh Computer. Eine Verschmelzung einer Oracle Datenbank mit einem HyperTalk-Programm auf dem Macintosh im Bereich GIS zeigt Gong [12]. Dieses Konzept wird in Zukunft besonders für ein Multimedia-GIS an Bedeutung gewinnen.

3 Technologien kommerzieller Datenbanken

In den folgenden Ausführungen werden einzelne Techniken der relationalen Datenbanken vorgestellt, da diese in der Praxis die größte Verbreitung gefunden haben. Diese Techniken finden sich aber auch zum Teil bei den anderen vorgestellten Datenmodellen.

3.1 Das Transaktionskonzept und der Recovery-Mechanismus im Mehr-Benutzerbetrieb

Die Datensicherheit in einem relationalen Datenbanksystem wird durch das Transaktionskonzept gewährleistet. Eine Transaktion ist eine ununterbrechbare Folge von Datenmanipulationsbefehlen, welche die Datenbank von einem logisch konsistenten Zustand in einen neuen logisch konsistenten Zustand überführt. Kann ein Eintrag in die Datenbank erfolgreich abgeschlossen werden, so hat sich der Zustand der DB geändert, kann er nicht erfolgreich erledigt werden, so wird der Ursprungszustand (ein logisch konsistenter Zustand) wieder eingesetzt. Damit erklärt sich die hohe Sicherheit der Daten in einem DBMS. Dies gilt für alle Grundoperationen Einfügen, Ändern, Löschen. Dem Transaktionsparadigma zugrunde liegt das ACID Prinzip (Atomicity, Consistency, Isolation, Durability), welches besagt, daß eine Transaktion auf atomarer Basis abläuft, konsistenten Datenbestand gewährleistet, isoliert von anderen Transaktionen nur auf die betroffene

nen Atome wirkt und nach Vollendung in der Auswirkung dauerhaft ist.

Zur Unterstützung des Transaktionsparadigmas bieten Datenbanken den Recovery Mechanismus (teilweises UNDO, REDO und globales UNDO, REDO), welcher für den Fehlerfall (nicht vollständig abschließbare Transaktion oder aber auch beim Systemabsturz) die Datenbank wieder in einen konsistenten Status versetzt. Hierzu werden Protokolle (log-Files) über die Transaktionen geführt.

Selbstverständlich gelten diese Konzepte auch für den Mehr-Benutzerbetrieb. Der gleichzeitige Zugriff auf Daten durch mehrere Benutzer wird durch Sperren zum Lesen und Schreiben sichergestellt.

3.2 Die Datenbanksprache

Die Kommunikation mit einer Datenbank aus Nutzersicht geschieht durch Applikationen oder mit einer Standarddatenbanksprache. Für relationale Datenbanken existieren standardisierte Abfragesprachen wie SQL, QBE, QUEL usw., von denen SQL die weiteste Verbreitung gefunden hat. SQL (Structured Query Language) ist eine standardisierte Datenbanksprache (ANSI X.3.135-1986, ISO/TC97/SC21/WG3N117) für relationale Datenbanken vom PC bis zum Mainframe [1]. SQL ist sowohl eine interaktive Abfragesprache als auch eine Datenbankprogrammiersprache; es beinhaltet eine

- DDL (Data Definition Language) zur Definition realer und virtueller Tabellen (Befehl : CREATE),
- DML (Data Manipulation Language) zum Dateneintrag, zur Abfrage und Veränderung von Daten (Befehle : INSERT, SELECT, UPDATE, DELETE),
- DCL (Data Control Language) zur Festlegung der Transaktionseinheiten und Sperren (Befehle : COMMIT, ROLLBACK),
- Einbindung in eine Programmiersprache wie Fortran, C, PASCAL (Befehle : EXEC SQL, DECLARE, OPEN, FETCH, EXECUTE, CLOSE),
- DBA (Data Base Administrator), der die Verteilung der Daten überwacht,
- DBMS (Data Base Management System), das den Zugriff auf die Daten kontrolliert und
- Standarddatentypen (Character, Integer, Float usw.).
- Built In Funktionen (Count, Minimum, Maximum, Average usw.).

Selbstverständlich bietet jedes Datenbanksystem auch sogenannte low level Interfaces zur Datenbank, die Funktionsaufrufen in der entsprechenden Programmiersprache entsprechen.

QBE (Query by example) ist eine graphisch orientierte Sprache, bei der der Benutzer ein Beispiel seines gewünschten Ergebnisses direkt interaktiv in den Tabellen am Bildschirm markiert. QUEL ist die Datenbanksprache von Ingres, die sich an einigen Stellen deutlich von SQL unterscheidet.

3.3 Der Systemkatalog

Jede relationale Datenbank beinhaltet einen Systemkatalog. Das ist eine Systemdatenbank mit detaillierten Informationen über alle Datenbankobjekte, also die Basistabellen, Sichten, Indizes, Benutzer, Authorisierungen usw. Dieser Systemkatalog wird vom DBMS selbst für die interne Verwaltung und vom Anwender verwendet, um Informationen zur Struktur der Datenbank zu erhalten. Der Systemkatalog besteht aus einer Menge von Tabellen, die mit den Standardbefehlen (z.B. SQL-Anweisungen) bedient werden. Änderungen der Tabellenstruktur des Systemkatalogs sind allerdings nicht erlaubt.

3.4 Zugriffsrechte und Datenintegrität

Im Systemkatalog werden auch die Zugriffsrechte (Lesen, Einfügen, Löschen und Verändern) auf die Datenbank (Tabellendefinition und Datenbestand) verwaltet. Im Gegensatz zu Dateisystemen sind bei relationalen Datenbanken eine Vielzahl von Zugriffsberechtigungen möglich, die vom globalen Lesen und Verändern bis hin zu sehr lokalen, d.h. Berechtigungen auf einzelne Attribute, Zugriffen reichen. Das DBMS kennt

verschiedene Kategorien von Benutzern, die vom Datenbankadministrator bis zu den individuellen Nutzern reichen, die jeweils auf ihren Datenbestand wiederum Rechte an andere weitergeben können.

Hinsichtlich der Datenintegrität differenzieren wir zwischen Entitäten- und Referenzintegrität. Entitätenintegrität wird durch die Forderung erreicht, daß Primärschlüssel nicht NULL sein dürfen. Referenzintegrität erreicht man dadurch, daß Fremdschlüssel entweder zu Primärschlüsseln passen oder NULL sein müssen.

3.5 Sichten auf ein DBMS

Die Basistabellen einer relationalen Datenbank sind physikalisch existent. Demgegenüber können Sichten (Views, virtuelle Tabellen) aus den Basisrelationen abgeleitet werden, die nicht explizit gespeichert, sondern mittels einer Berechnungsvorschrift im Systemkatalog definiert sind und beim Zugriff jeweils neu erzeugt wird. Dies erlaubt verschiedenen Benutzer sich von demselben Datenbestand eine der eigenen Problemstellung angepasste Sicht auf die Daten zu verschaffen, allerdings mit Leistungseinbußen. Auf diesen Sichten kann wiederum mit normalen DML- Befehlen (mit Einschränkungen bei Änderungen) gearbeitet werden.

3.6 Die Layerarchitektur eines DBMS

Ein Datenbanksystem gliedert sich in verschiedene Layer. Auf der obersten Ebene sieht man die logische Datenstruktur (die Relationen, Sichten und Tupel), die mit der Abfragesprache (SQL) bedient werden. Darunter liegen die logischen Zugriffspfade gefolgt von den Speicherstrukturen wie B*-Bäumen und Hashing-Tabellen. Speicherplatznah sind dann die Seiten- und Blockzuordnungsstrukturen. Zwischen physikalischem Permanentspeicherplatz und dem DBMS befindet sich oftmals noch ein Datenbankpuffer (Cache), in dem einmal von dem Speicher gelesene Information behalten wird. Die permanente Datenspeicherung geschieht irgendwann auch wieder in Files (Daten in Primärdateien, Index- oder Zugriffspfade in Sekundärdateien), bleibt aber vor dem Nutzer versteckt und ist nach DBMS-Kriterien strukturiert und von System zu System sehr verschieden. Diese Layerarchitektur unterscheidet DBMS wesentlich von der Dateienverwaltung, bei der Daten nach Applikations- oder Programmgesichtspunkten abgelegt sind und somit sämtliche Layer (und damit der Vorteil der Abschirmung und Datenunabhängigkeit) dazwischen entfallen.

3.7 Die Datenbankwerkzeuge

Datenbank-Managementsysteme bieten heute neben dem eigentlichen Datenverwaltungssystem eine Vielzahl von Werkzeugen, die den Datenbestand in die Arbeitsplatzumgebung integrieren sollen. Hierzu gehören - beispielhaft am Produkt Oracle gezeigt - Werkzeuge zur

- Erstellung von Menus und Masken für die Dateneingabe (SQL*Menus, SQL*Forms),
- Ermöglichung der Bürokommunikation (Oracle*Mail),
- Unterstützung der Softwareentwicklung (CASE*Dictionary),
- Integration in ein Netzwerk (SQL*Net)
- und andere (SQL*Graph, SQL*Report, SQL*Plus, EASY*SQL, SQL*QMX, SQL*CALC usw.)

4 Zur speziellen Problematik raumbezogener Daten

4.1 Standard- versus Nicht-Standardanwendungen von DBMS

Die Verwaltung raumbezogener Daten stellt aus der Sicht der Informatik eine Nichtstandard-Anwendung von Datenbankmanagementsystemen dar. In diesem Kapitel wird die Begründung für diese Aussage gegeben und Methoden aufgezeigt, wie sich mit Standard DBMS dennoch raumbezogene Daten verwalten lassen oder auf welche Methoden der Datenspeicherung und des Datenzugriffs die in Zukunft zu erwartenden DBMS für CAD- und GIS- Anwendungen aufbauen. Veranschaulichen wir uns einmal die wesentlichen Anwendungen und die Unterschiede zwischen Standard- (SA) und Nicht-Standard-Anwendungen (NSA) von DBMS.

Standardanwendungen von DBMS sind zu sehen in der Verwaltung administrativer Informationen (Personal-, Lohn- und Kundenwesen usw.), in der Materialbestellung und der Produktion (Stücklistenherstellung, Bestandskontrolle, Maschinenbelegungsverwaltung etc.), wohingegen als Nichtstandardanwendungen u.a. CAD und GIS betrachtet werden. Die wesentlichen Unterschiede sind

Standardanwendungen	Nichtstandardanwendungen
Feste Anzahl Attribute/Objekt	Variable Anzahl Attribute/Objekt
Einfach strukturierte Daten	Komplexe Datenstrukturen
Eindimensionale Schlüssel	Mehrdimensionale Schlüssel
Vorhersagbarkeit der Länge von Attributen und Tupeln	Variabilität der Länge von Attributen und Tupeln
Exakter Match	Unsicherer Match
Einige logische Verknüpfungen	Vielfache logische Verknüpfungen
Leichte Operatoren	Komplexe Operatoren
Kurze, unteilbare Transaktionen auf wenige Entitäten	Lange Transaktionen auf viele Entitäten
..	..

Diese Unterschiede seien etwas weiter ausgeführt.

Ein Objekt im Sinne des GIS ist ein Gebäude, eine Straße etc., das sich datenbanktechnisch aus einer Vielzahl von atomaren Einträgen zusammensetzt, bedeutungsvoll und logisch konsistent aber erst nach dem kompletten Eintrag aller Atome ist. Demgegenüber ist ein Objekt in der SA durch eine feste Anzahl von Attributen definiert wie z.B. eine Kontonummer oder der Kontostand. Damit ist auch die Struktur der Daten in Standardanwendungen wesentlich einfacher und kann direkt auf die vom DBMS unterstützten Datentypen abgebildet werden. Punkte, Linien und Polygone als GIS Objekte müssen dagegen erst in atomare Einträge aufgelöst werden. In Standardanwendungen basiert die Auswahl von Daten auf einem Schlüsselement (wie z.B. der Kontonummer). In raumbezogenen Informationssystemen geht der Schlüssel mindestens über zwei Größen, nämlich x und y, bei linien- oder flächenhaften Objekten über mehr als zwei. Jedes Record in Standardanwendungen hat eine feste Länge und Format, während dies für NSA nicht gilt. Eine Linie setzt sich aus mehreren Punkten zusammen, die z.T. abhängig von der Datenquelle unterschiedliche Auflösung der Koordinaten besitzen. Eine Anfrage in einem DBMS beruht auf dem exakten Match. In GIS Problemen ist wegen der Unsicherheit der Koordinaten der exakte Match nie gegeben. Eine Linie besteht aus einem Satz von Punkten, ein Polygon kann aus einer Vielzahl von Linien zusammengesetzt sein. Solche logischen Verknüpfungen führen durch die Normalformforderungen bei DBMS zur starken Aufspaltung in viele Tabellen. Die Konsistenz der logischen Verknüpfungen muß das GIS gewährleisten. Einfügen, Verändern und Löschen sind Standardoperationen in DBMS. Auf diesen aufbauend müssen für raumbezogene Daten eine Vielzahl wesentlich komplexerer Operationen aufsetzen (Clipping, Schneiden, Polygonbildung, Einschluß, Ausschluß). Eine typische Transaktion ist sehr kurz, z.B. wird nur der gegenwärtige Kontenstand geändert. Dagegen sind Transaktionen in GIS lang, da der Datenbestand (z.B. die Polygone) nach einer Aktion (Verändern, Löschen ..) wieder konsistent hergestellt werden muß. Es gibt noch weitere Unterschiede, auf die hier nicht eingegangen werden soll.

4.2 Forschungsarbeiten im Datenbankbereich

Aus obengenannten Gründen gibt es seit einiger Zeit Forschungen auf dem Gebiet der Computerwissenschaften zur Erweiterung der klassischen Konzepte für DBMS hinsichtlich den Erfordernissen von raumbezogenen Daten. Die Verwaltung dieser Daten ist auch für die Informatik interessant, da hier das große Gebiet CAD neben dem noch kleinen Gebiet GIS lockt. Diese Ansätze, die zum Teil bereits unter dem Stichwort objektorientierte Datenbanken angedeutet wurden, sollen nun detaillierter ausgeführt werden.

4.2.1 Komplexere Datentypen und Operationen

Relationale Datenbanken unterstützen zur Zeit nur wenige atomare Standarddatentypen. Bei der Verarbeitung geometrischer Zusammenhänge werden allerdings komplexere Datentypen benötigt; dies sind z.B. Punkte, Linien und Flächen. Ein bekannter Ansatz zur Realisierung solcher komplexer Datentypen ist das

NF²-Modell (non first normal form), bei dem das Atomaritätsprinzip aufgehoben ist, d.h. Attributeinträge können nun mehrere Werte (ein Punkt bestehend aus Identifikator, x, y und z) und sogar ganze, hierarchisch untergeordnete Relationen (ein Liniensegment bestehend aus zwei Punkten) sein. Für diese neuen Datentypen reichen aber die drei Grundoperationen relationaler Datenmodelle (Einfügen, Löschen und Verändern) nicht aus. Neu zu definierende Operatoren könnten neben den Einfüge-, Lösche- und Veränderungsoperationen für diese höherwertigen Operationen z.B. Abstandsberechnung (DISTANCE), Schnittpunktbildung (INTERSECT), Nachbarschaftsabfragen (NEXT_TO), Bereichsentscheidungen (CLIPPING) bis hin zu Flächenverschnidungen (OVERLAY) sein.

4.2.2 Raumbezogene Speicher- und Zugriffsmechanismen

Im Laufe der Nutzung von Datenbanksystemen für raumbezogene Daten haben sich verschiedene hierfür geeignete spezielle Speicher- und Zugriffsstrukturen entwickelt, die bisher allerdings noch nicht von den DBMS direkt unterstützt werden sondern noch vom raumbezogenen Informationssystem selbst zu lösen sind. Erste Bestrebungen der Integration in DBMS für GIS sind allerdings zur Zeit zu sehen [2]. Die Erweiterungen der eindimensionalen Schlüsselzugriffe haben zu vielen Lösungsvorschlägen geführt. Einen neueren Überblick gibt Günther [13].

Vielen Ansätzen gemeinsam ist die Vereinfachung der Geometrie der in der realen Welt vorkommenden Objekte nur für die Zwecke der Speicherung und des Zugriffs. Hat man anhand der vereinfachten Objekte eine Liste von Kandidaten für weitere Untersuchungen erhalten, so werden diese detailliert mit der tatsächlich abgespeicherten Objektgeometrie behandelt. Durch die Approximation vereinfacht sich die Suche nach komplizierten Objekten von der Dimension $n = 2^*m$ (mit m = Anzahl der Begrenzungspunkte) auf 2, 3 oder 4- dimensionale Zugriffsschlüssel. Im einfachsten Fall wird ein ausgedehntes Objekt durch einen Zentroidpunkt approximiert ($n=2$). Wird diesem noch ein Radius mitgegeben, der das ganze Objekt umschließt, so ist $n=3$. Das kleinste objektumschließende, achsparallele Rechteck ist eine 4- dimensionale Approximation eines Objektes. Höherdimensionale Approximationen sind durch Zellen möglich [14].

Verschiedene raumbezogene Zugriffsmechanismen sollen hier nur genannt werden. Dabei beschränkt sich die Auflistung auf solche, die auch im GIS-Bereich vertreten sind.

- Rasterzelleneinteilung, wie sie im System Phocus von Zeiss verwendet wird.
- Quad-trees (4 Nachfolger je Knoten), die in SICAD von Siemens Anwendung finden [21].
- Gridfile [19], der in Infocam von Kern genutzt wird.
- R-Baum [16], der in System 9 von Prime Wild GIS AG als Suchstrategie eingesetzt wird.

Gegenwärtige Datenbankforschung zur Unterstützung raumbezogener Zugriffs- und Speichermethoden konzentrieren sich im wesentlichen auf den Gridfile und den R-Baum.

4.2.3 Erweiterungen der Datenbanksprachen

Die Standard-Datenbanksprachen wie SQL und QBE haben ihre Schwierigkeiten mit räumlichen Daten. Sie arbeiten nur auf Atombasis mit Standarddatentypen; Punkt, Linie oder Polygon sind aus diesen atomaren Datentypen zusammenzusetzen. Räumliche Operationen und Beziehungen wie Abstandsberechnungen und Nachbarschaften sind unbekannt.

Von verschiedenen Seiten werden daher raumbezogene Erweiterungen von SQL gefordert und Konzepte hierfür erarbeitet. Zu nennen sind hier PSQL [20], KGIS SQL [17], TIGRIS SQL (die Datenbanksprache des Intergraph Produkts TIGRIS), SDQL/SEQL [10] u.v.a.. Gemeinsam ist diesen die Unterstützung raumbezogener Objekte (Punkte, Linien, Polygone, Fenster usw.), die Integration von räumlichen Operationen (Abstandsberechnungen, Schnittberechnung, Clipping, Overlay usw.). Jede SQL-Erweiterung hat allerdings die Problematik, die gewünschte Funktionalität innerhalb des generellen SQL Konzepts zu bieten.

Als Alternative zum erweiterten SQL gibt es auch Vorschläge für raumbezogene Abfragesprachen wie z.B. MAPQUERY [11], LOBSTER [9], die direkt auf die Problematik raumbezogener Daten zugeschnitten sind. Diesen fehlt allerdings die Unterstützung durch kommerzielle Datenbanksysteme.

5 Ausblick in die Zukunft

Die Anforderungen an die Leistungsfähigkeit von Datenbanken wachsen enorm. Zudem bewegen sich bestimmte aktuelle Forschungsgebiete gegenwärtig aufeinander zu, so daß in Zukunft Datenbanken erhöhte Bedeutung zukommt. Diese Datenbanken werden neben den in diesem Beitrag beschriebenen Daten auch noch Volltexte, Bilder, digitalisierte Tonbilder, Wissen, Methoden, Erklärungen und ähnliches verwalten und damit Komponenten von Expertensystemen werden. Datenbanken werden in Zukunft ihren Datenbestand verteilt verwalten. Die Daten werden auf mehrere Datenbanken aufgesplittet, die auf heterogenen Rechnern durch ein Netzwerk verbunden residieren.

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THE COMPUTERIZED CADASTRAL MAP

A RECEIVING STRUCTURE AND A REVISION METHOD TO TURN THE NAPOLEONIC MAP INTO A DIGITAL LAND MAP

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Abstract : The french Cadastre has launched an important cadastral map computerization plan which is called Computerized Cadastral Map (PCI in french). While this project started, local authorities and utility companies have locally already digitized cadastral maps for their own needs.

From the very beginning, those works have been monitored by the Direction générale des Impôts (DGI) to which the Cadastre belongs. For this purpose, a legal, technical and financial framework was designed to check and stamp the digital data capture in order to ensure the PCI supply.

In that way, two converging actions have already beginning: one , inside the DGI, aims to equip gradually its offices with a modern tool for cadastral map production and management, the other outside the DGI but tightly coordinated and controlled by it, intends to ensure an accurate information digital capture.

The main issue of data quality was discussed very often as many during the negotiations between the DGI and cadastral map users as through the reflections which contributed to the working out of the PCI project.

For the french Cadastre, the purpose is to avoid any alteration of the map accuracy caused by digital capture and to use for the best the new ressources of technology to improve its quality.

The computerized cadastral map

"A receiving structure and a revision method to turn the napoleonic map into a digital land map".

In France, the Cadastre is part of the "Direction générale des Impôts (DGI)" which belongs to the Ministry of Economy. Its main mission is to register land properties and to fix the rate value of plots and houses in order to calculate land taxes.

For this purpose, it has to manage a considerable amount of data.

In this way, regarding graphical data, the cartography of the French territory requires 560 000 cadastral maps describing 100 millions of plots distributed among 36 000 municipalities. The cadastre also manages 35 millions accounts of landowners and 36 millions of properties.

Today, the cadastral map has become one of the main data source for Land Information Systems (LIS). Thereby, the demand of digital data increased especially from local authorities and utility companies.

In other respects, since 1990, the management of alphanumeric cadastral data has been computerized all over the country. The system used is called MAJIC 2 (Mise A Jour des Informations Cadastreales).

These two factors led the DGI to modernize the management of the cadastral map.

The DGI undertakes two kinds of action :

- one external action aimed towards map users in order to meet their demand of digital data ;
- one internal action which aims to provide the DGI with a modern tool of map management.

Regarding the external action, the Cadastre alone can't bear the digital capture's cost, so, the DGI defined the principles related to the capture and the updating of graphical cadastral data integrated into local authorities' Land Information System (LIS).

The finality of such an approach is especially to allow the recuperation of cadastral data digitized by local authorities, as soon as the DGI will be equipped with its own management system.

Henceforward, any organization who wants to digitize cadastral maps has to sign with the DGI an agreement that lays down the legal and technical framework of data capture procedure. It is based on the following principles :

- any reproduction of the cadastral map, including digitizing, must be before hand allowed by the DGI, in virtue of the copyright of the French State on the cadastral documents ;
- the digitizing of the map must be in conformity with the norms of capture defined by the DGI ;
- the DGI receives a copy of the digital data files ;
- the updating of the map, just as the distribution of purely cadastral products are within the exclusive competence of the DGI.

Furthermore, a national agreement was signed on the third of june 1991 between the DGI and three big utility companies : Electricité de France(EDF), Gaz de France (GDF) and France Télécom. This agreement takes into account the specific needs of the utility companies.

The digitized background map these companies carry out is limited to some information of the cadastral map including essentially street segments and buildings.

The aim followed is to create a dynamic for the digitizing of the cadastral map. As a matter of fact, the constitution of files even incomplete is likely to encourage the exhaustive digitizing of the map either by other users or by the DGI.

This effort of the DGI to coordinate and supervise digitizing works is completed by national talks initiated by the DGI with all the organizations concerned by the computerization of the cadastral map.

The aim of this action is to reach an agreement on the general principles related to the digitizing of the maps (homogeneity and quality of the works, non dispersion of public money,...).

On the 6th of june 1991, the text of a protocol was agreed. It will be officially signed in the autumn of this year.

About the internal action, a parallel task has been started. It consists of :

- on the one hand, modernizing the output of new maps;
- on the other hand, providing the DGI with a management and distribution system for the cadastral map (the name of this project in French is PCI: Plan Cadastral Informatisé which means computerized cadastral map).

After this long preamble, I mean to set out the trends and the technical choices induced by this policy of modernisation.

Two fields must be distinguished : on one hand the constitution of the PCI on the other hand, its management.

I - THE CONSTITUTION OF THE PCI

The PCI to come will be mainly supplied by the digitizing of existing maps. However, processes and technics related to the remaking of the map must be necessarily adjusted to the new standard of output.

A - The digitizing of existing maps

It's a considerable work. As a matter of fact, the digital capture of 560 000 drawings requires a very important financial support and a long period of time. It can only be done on the grounds of a shared effort between the concerned organisations.

On a technical point of view, the digitizing of the cadastral map raises manifold problems. Among these, two have been particularly studied. Practical solutions have been found and deserve to be set out.

It concerns the assembling of cadastral sheets and the checking of digitizing works.

1. The assembling of cadastral sheets

The problem comes here from the lack of homogeneity among cadastral sheets.

The napoleonic map, created between 1807 and 1850 has been renovated on and after 1930. Different ways have been used to realize this process, according to the importance of the revision work.

The present maps resulting from this huge work are arranged in two categories :

- non regular cadastral maps renovated only by a simple revision of the napoleonic map;
- regular cadastral maps renovated by a new survey based on a cadastral triangulation.

The former (55 % of the whole sheets) have the particularity and the inconvenience not to be Lambert grid map (the Lambert projection is the French national system of projection).

The digitizing and assembling of these sheets require a sufficient number of points known in the Lambert system.

To carry out the adjustment of these sheets, one of the solutions is to survey by terrestrial or photogrammetric methods a set of points at the rate of at least five points per sheet. But such a method is extremely heavy to implement.

The procedure used by the French Cadastre doesn't need any field survey or aerial photography. It is based on the utilization of a block adjustment program.

Hence, the area covered by non system-related maps is treated as a photogrammetric block where each sheet is assimilated to a stereomodel. The control points are taken among the crosses of the system-related maps located around the block.

Tie points are identified and numbered on the limits of the sheets. Afterwards, they are digitized like the control points in an independant system for each sheet. The process of these data is done the same way than for an aerotriangulation work and so gives the possibility to obtain the Lambert coordinates of the tie points.

The method was tested all over a "departement" covered with 2 500 sheets which comprises 56 % of non system-related maps. The results were very satisfactory.

This technique presents four advantages :

- its cheapness if compared to the cost of methods based on ground survey techniques ;
- an homogeneous result for the whole block of sheets ;
- the use of an existing program which avoid any research and development for a specific tool;
- an adjustment of sheets' scale having original default.

It will be widely used when utility companies will begin digital capture on large areas.

The assembling of the sheets discloses the problem of the sheet-edges matching.

To resorb these differences, sheet limits must be redrawn. But such a modification can be done only if measured deviations are within a tolerance. If not, the two discordant boundaries remain unchanged until the area is resurveyed. However, the second instance should remain marginal. As a matter of fact, the sheet limits are more often center line of roads or rivers pertaining to the non surveyed property. In this case, the differences can be eliminated by modifying the shape of the non surveyed property without altering the limits of the parcels on the wayside.

In that way, it would be possible to ensure the geographical continuity of the computerized cadastral map from the very beginning of its constitution.

2. Checking of digital data capture

It is one of the main questions regarding digital data capture.

The checking aims to guarantee the conformity of digitized data with the original graphic map. It comprises two kind of operations :

- content checking ;
- accuracy checking.

The content checking is systematic.

Its purpose is to verify that all the map information is wholly captured. The procedure consists in comparing an output drawing generated at the end of the data capture with the original graphic map.

The precision checking is carried out on a random basis.

For each map, the verification begins with the checking of the results of the sheet adjustment to the Lambert reference system. It must be absolutely executed through a plane similarity transformation with overdetermination (the so-called Helmert adjustment) which doesn't warp the drawing geometry.

The determination of the transformation parameters requires a minimum of five control points per sheet. For each of them, the calculation provides a deviation which is compared to a tolerance.

If the adjustment is accurate, the supervisor digitizes a sample of hundred points homogeneously distributed on the sheet. For this purpose, the control points chosen for the first digital capture are taken again.

Coordinates provided by this digital capture allow an assessment of the accuracy of the initial digitizing. The position deviations of each point are compared to a tolerance as well as their root mean square error.

If the data capture norms are respected, a conformity label to the cadastral map is allotted to the checked product.

This procedure is widely used today to check data capture works realised by local authorities bound to the DGI by an agreement. The conversion into digital form is most often obtained by hand digitizing. So, human error is unavoidable and requires a strict checking of the results.

B - The output of new maps (rehandling)

Every year, the Cadastre remakes maps over about 1 000 square kms . In France, these works are called "remaniement" that means rehandling.

An important part of new maps also comes from rural regrouping that concerns 3000 square kms every year.

The DGI four photogrammetry shops, equipped with 13 analog stereoplotters and 3 analytical ones, yield on an average half of the rehandling production. The left part is coming from private companies.

To produce cadastral maps in digital form, the computerization of the production line is on the way.

A first step has been accomplished with the implementation of the computer aided restitution in all the shops during the first semester of 1991. In practice, the operation consisted in connecting each analog stereoplotter with a computer through an interface made by a private company. The Cadastre designed and developed the restitution software.

The new configuration provides an increase in productivity and more confort to the operators.

The second step concerns the editing stage. As a matter of fact, the product of restitution is only a rough draft of cadastral map. It must be completed with data coming from field measures.

The Cadastre will soon purchase a package adapted to the specificity of cadastral editing. It will be used to draw the final map by modifying the stereodraft on the screen through interactive process.

This tool would be install in the 44 local land brigades by the year of 1992 and would allow an output of digital data for the supply of the PCI.

II - THE PCI MANAGEMENT SYSTEM

The PCI plan has been studied since 1988. This year one has decided to start a consultation process in order to acquire a software that should be adapted to the management regulations of the French Cadastre.

The choice of a system has not yet been made. However, the basic trends of the project have been already done.

They take into account technology developments and would permit to improve the metric quality of the map.

The system is based on a decentralized architecture each one of the 314 Cadastre offices is equipped with an autonomous hardware configuration.

A - Organization and structure of data

The management and dissemination system must fulfill three main fonctions :

- the revision of the map from the documents established by civil servants of the Cadastre and private surveyors ;
- the dissemination of informations to the users by data consultation and production of files'copies ;
- the recuperation of structured data coming either from the digitizing of the existing cadastral maps or from the production of new maps.

An exchange format founded on the french norm EDIGEO will allow exchanges between the system and its environment.

The PCI management system is based on a topological structure.

The graphical objects of the cadastral map (municipalities, sections which are municipality divisions, plots, buildings and so on ...) are divided in three types of graphic objects : punctual, linear or zonal. The latter are described with topological primitives (node, string, face).

The choice of a topological structure allows a fine and coherent description of relations between objects.

According to this model of structuration, the limit shared by two parcels is recorded only one time. The absence of redundance leads to a reduction of the updating operations.

But such a choice results also from the necessity for the DGI to meet an increasing demand coming from local authorities.

As a matter of fact, the adoption of a less advanced structure, like the "spaghetti" one for example, would have inevitably generated difficulties for the updating of LIS with a topological structure.

As generally speaking, facing the evolution of the systems and the development of the topological model among them, the DGI had to modernize its management in a way compatible with its national role of geographical data producer.

Regarding the data logical organization, two points deserve to be underlined.

On one hand, the basic logical unit is the municipality. In France, the existence of 36 000 municipalities involves a very fine administrative cutting out of the territory.

Therefore, the adoption of the municipality as logical base within the computerized cadastral map allows a reduction of the consultation time and permits a coherent tie with the MAJIC 2 system which is used to manage the alphanumeric data. It also simplifies the management of municipality boundaries.

On the other hand, within each base, data are distributed among six levels :

Level 1 : "Cadastre".

It is the set formed with actual cadastral entities (municipalities, sections, plots, buildings, fiscal subdivisions) and triangulation points.

Level 2 : "road system".

Level 3 : "topographical details".

Level 4 : "verification".

It's a duplication of level 1 for the areas where updating must be done. It constitutes a temporary stage of the map until it is integrated into the level 1 through an interactive or automatic mode.

maps". Level 5 : "demarcation maps and land surveying

Level 6 : "temporary".

It receives the maps coming from the constitution system. This level takes the place of the cadastre level if existing :

- after validation of the rehandling or the regrouping within MAJIC 2 ;
- after processing of the discordances between MAJIC 2 and the PCI in any case.

The first three levels are the "receiving" levels of the graphical data coming from the cadastral map. It is necessary to know that the computerization of the map will not come with any enrichment of the managed informations.

The levels 4 and 6 are "transit" levels where data assigned to updating, revision or constitution of the PCI are checked.

The level 5 constitutes an innovation compared with the conventional hand management of the map.

Its finality is made clear in the following paragraph.

B - A system which allows an improvement of the metric quality of data

I already mentioned the unequal metric quality of the cadastral map and the important mass formed by non regular maps.

For the updating of these maps it's sometimes necessary to warp the surveying documents to get the change into the cadastral map. Awaiting for a complete rehandling of non regular cadastral maps, this practice remains the only acceptable procedure to update the map under the present hand management mode.

The computerization and the organisation of data into different levels offer a technical opportunity to preserve the metric integrity of accurate surveying documents and to update in the same time the cadastral map.

Surveying documents, which are established from either land surveying maps or demarcation maps are applied in the existing map to the level 1 by the implementation of adjustment algorithms, but their data are also recorded on the level 5 without the least metric alteration.

By this procedure, it becomes possible to constitute progressively by aggregation of updating informations a new cadastral map of better quality.

WORKSHOP ON DATA QUALITY IN LAND INFORMATION SYSTEMS

OEEPE (application commission II and C)

4-6 september 1991

paper: CADASTRAL LIS IN THE NETHERLANDS

by G.M. van Osch, manager LKI-systems, Dutch Cadastral Service

Apeldoorn, 4 september 1991

Ø. introduction

Contrary to my workshop presentation, which only deals with certain topics, this paper will give a more extensive overview on the cartographic activities and developments of the Dutch Cadastral Service.

The following subjects will be discussed:

1. Cadastral cartographic products
2. Cadastral map-renovation
3. LKI-system (automation in geodesy and cartography)
 - 3.1 definition and objectives
 - 3.2 processes and data flow
 - 3.3 data-structure
 - 3.4 storage structure
 - 3.5 attributes
4. Transport and exchange of cartographic data
5. Comments on the national standard data exchange format SUF2
6. Updating-process LKI and delivery of changes
7. Future development in data-exchange

The Dutch LKI-system (Cadastral LIS) became operational in 1988. Every year several parts of the system are improved, new applications are developed and software-releases are implemented.

The main goal of this LIS is to create a computerized environment for building up and maintaining a national cartographic database for both internal and external use.

Two large scale map-series with national coverage are digitally stored.

1. cadastral cartographic products

The most important cadastral target, of course, is the conversion of all cadastral maps into digital form (LKI-database).

In total we face an analogue-digital conversion of some 30 to 40 thousand maps, of which 50% is related to the national coordinate system (triangulation network), mostly in build-up areas and in areas where land consolidation projects were carried out.

The remaining maps are still in local reference systems.

All remaining local oriented maps also have to be renewed and geometrically improved [1].

This means that they have to be converted or transformed to the national triangulation network.

These activities are carried out within the LKI-environment instead of using existing analogue methods of map-renewal [2].

So far, about 7 to 10% of the cadastral map is converted to LKI.

The cadastral map is in a continuous updating process.

The geometrical quality of the map is 0.2 mm multiplied by the map scale, so in general this means 20 cm in build-up or urban areas and approximately 40 cm in rural or agricultural areas. We also maintain these quality-demands once the analogue maps are converted to the LKI-database.

During the constant updating of the digital map, the geometric accuracy will be improved by using automated adjustment techniques.

The second map which is stored in LKI, is the Large Scale Topographic Base-Map of the Netherlands (abbreviated in Dutch as GBKN).

Since 1988 the manufacturing of this map is a fully digital production-process (photogrammetry and field completion).

Currently approximately 40% of the Netherlands is covered, of which more than half is digitally available.

Once the GBKN is produced, the continuous activity of keeping the map up to date starts.

It is important to establish an adequate and lasting system for the maintenance and actualization of the GBKN; not only a technical problem but first and foremost an organizational and economical issue.

The need for high-quality and up-to-date topographic information is different for every user of the map.

How up-to-date the information should be, strongly depends on the individual needs and applications of each user.

For instance, a utility-company needs an extremely high topographic actuality in developing areas, because they have to plan a new or extended service network for the distribution of gas or electricity.

In fact, in this case the GBKN can never be up-to-date enough, because the new topography is still in a planning stage.

They need possibilities to convert topographic planning information into the GBKN, in order to connect their new pipe- and cable network to houses, yet to be build.

On the other hand other users have GIS-applications for which a 2 to 5 year update-level is more than sufficient.

Due to the discrepancy in these demands these kind of problems can never be solved completely.

Therefore the use of a national GBKN has more significance in the field of geometric co-ordination, and can be compared to the national triangulation network as a more detailed second level of co-ordination.

When all users use the same topographic base-information to connect with their own applications, it is understandable that the specific user-related information from different users is better tuned (identical reference).

At the very least, one can carry out physical terrain-activities more cost-effective and the chances for damages to pipes and cables can be diminished. Of course, it is necessary to have an organized environment, for instance an information centre for pipes and cables, to obtain this information.

The availability of a GBKN is of vital importance.

In the Netherlands such regional information centres are established.

They provide the necessary information about utility-companies, who in turn can deliver geometric information on their utility-networks.

2. cadastral map-renovation

The Dutch Cadastre is both producer and user of the GBKN.

The main benefit of the GBKN emanates from the coordination-function of the map.

Using the GBKN, the conversion or transformation of all the local cadastral maps to the national triangulation network will be carried out [1][2].

At the same time the geometric quality of the cadastral map is improved.

The process used, can best be described as a graphical renovation process.

There are a number of steps to be taken in the conversion process:

- first the cadastral map is re-scaled to the scale of the GBKN and placed in overlay on the GBKN;
- then the cadastral boundaries are geometrically compared with corresponding topographic objects (topological confrontation);
Decisions have to be made regarding the compatibility of a cadastral boundary and a topographic object. If so, they are declared identical in a geometrical sense, not in a judicial sense.
No data-collection or reconstruction in the terrain (survey) takes place to establish prove for this decision; that's too expensive.
Sometimes existing measurements or available survey documents are used for construction in an exceptional problematic situation.
- After this identification process the cadastral boundaries are digitized or copied in the map-database in case they co-incide with existing digital topographic objects.

In general the existing relative quality or geometrical precision of the cadastral map stays intact;

The overall improvement of the old cadastral maps lies in the confrontation between adjacent maps; the map-boundaries (the cadastral map is island-shaped) are compared and, when necessary, corrected.

When this process is completed, the result is a cartographic database with a seamless map-structure.

From that point on, the main cadastral task, the updating of the cadastral map, will be performed on the LKI-database in stead of the analogue map.

The Dutch Cadastre aims to complete this map renewal process together with the analogue/digital conversion of the maps in the national triangulation network within a period of 10 to 13 year.

3. LKI-system

In order to make the digital manufacturing and maintenance of the GBKN and the cadastral renewal process possible, the LKI-system was developed.

LKI stands for Geodetical and Cartographic Land Information System.

3.1. definition and objectives

The system deals with the capture, the processing, the storage and presentation of cadastral and topographic information.

The aim was to develop an instrument to create more efficiency in the production and use of digital map information.

Throughout the development of LKI the most important limiting condition is best described by the word "integration".

This conception needs further explanation:

- The first objective was to integrate all geodetic and cartographic work-processes, like the measuring and processing of field-data, the calculation of coordinates and the plotting and presentation of cartographic information.
The existing terrestrial measuring methods had to be improved, and new techniques were developed for digital data-collection from aerial photographs and the digitizing of analogue maps.
Some applications are build for data-processing and database-management.
Also different ways of presenting digital cartographic data (system-output) were designed.
Apart from the regular map-making the presentation of thematic and statistic information for management-purposes was introduced.
- The second objective was to design and implement an integrated cartographic database.
This means that the two map-series, the cadastral map and the GBKN, are logically and physically stored into one spatial database.
This was not a difficult decision, because there is much overlap of information on both maps, for instance, the main topography (buildings).
The reason for the presence of buildings on the cadastral map is simply because of a better map-orientation and as reference objects for cadastral terrestrial measurements.

Of course, these corresponding topographic objects on both maps, are stored only once in the database.

As stated earlier, the database has a map-independent storage-structure (seamless) with the range of a Dutch province.

A self-developed spatial database structure of 5 multi-indexed layers with different grid-size resolves the problem of physical storage of all cartographic objects.

For reasons of efficiency the editing and updating process for both maps is carried out in an integrated fashion. As much as possible, the capture of revised cadastral and topographic information is combined.

With the development of LKI, the Dutch Cadastre not only wanted to create a system for digital map-production.

From the beginning the target was to work slowly towards the development of an automated LIS, which is certainly more than just a simple tool for automated map-production.

One of the reasons is that LKI can play a significant role in the Netherlands as a coordination instrument within the field of all national land information activities.

In that respect, the general use of the GBKN for infrastructural planning and environmental issues was mentioned earlier.

Also the availability of digital cadastral information is important for the support of governmental and administrative tasks in the field of real estate activities.

3.2. processes and data flow

LKI offers automated tools for the cartographic activities which has to be performed by the Dutch Cadastre.

Based upon the cadastral core-activities and the LKI-objectives, a number of computer-assisted applications can be recognized.

The following activities are ment:

- production and editing/updating of the GBKN
- cadastral map-renewal
- editing/updating of the cadastral map

The simplified model below gives an indication on the possibilities of the LKI-system by showing the data flow.

input:

Massive data-collection takes place through the digitizing of aerial photos and existing cadastral and topographic maps.

Furthermore for updating activities the automated capture and processing of field measurements is foreseen.

Also existing digital information from internal as well as external sources can be handled. This is mostly external work done by contractors.

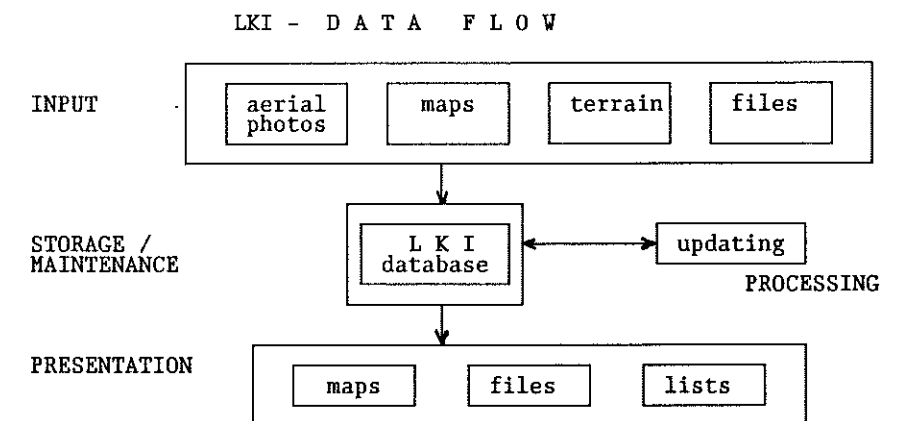
processing:

This application is used for all actions on the LKI-database in order to extract information, to edit and update cartographic information or to perform database management-facilities.

presentation:

On the output-side of LKI there is developed an application to present data from the database in various ways:

- maps: both standard and free products for in- and external use
- files: for external users who have a digital environment (GIS/LIS) and for internal transport between branch offices and LKI-subsystems
- lists: statistical information derived from the content of the LKI-database



3.3. data-structure

Map-analysis resulted in a translation of the map-model to a computer-model. These efforts showed the presence of 3 basic object-types:

point object:

- location bound
- symbol-presentation in accordance with object-classification

line object:

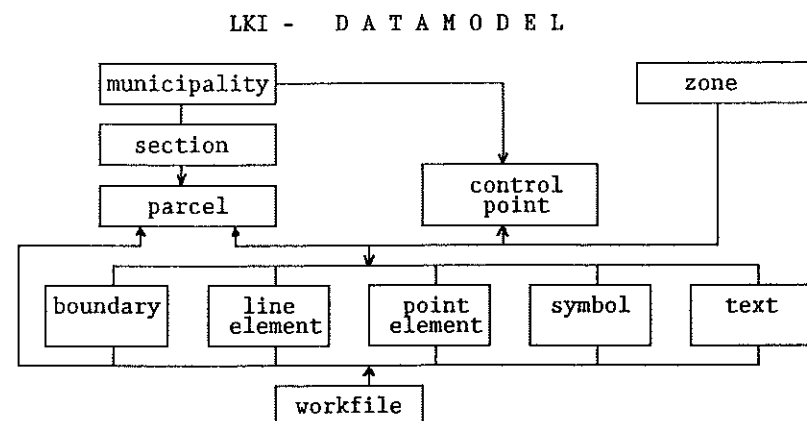
- location bound
- only straight lines in strings/chaines and arcs
- preset linestyle-library
- so called "splines" are not admitted.
- area object (parcel) represented by a set of lines (boundaries)

semantic object:

- weakly location bound
- preset symbol/text-library
- function is cartographic presentation

Looking at the simplified data-model, one recognizes 7 basic cartographic object-entities, which can be extracted from the object-types.

These object-entities were derived after a thorough map-inventory.



Together, "Municipality", "Section" and "Parcel" form the cadastral parcel identification, which is an entry-key on the LKI-database.

The entity "Zone" has to do with the physical storage structure.

The entity "Workfile" functions as a sort of pointer to prevent double updating in the same area.

3.4. storage structure

The physical organization of the national, map-independent, LKI-database needs further explanation.

The database has continuous horizontal 'seamless' coverage, because it contains no arbitrary partitioning according to map-sheet forms like the rectangular GBKN and the island-shaped cadastral map.

In this way the database model has no broken or clipped objects because there are no arbitrary area boundaries.

As was stated above, the LKI-database is a self-developed spatial database of a network structure.

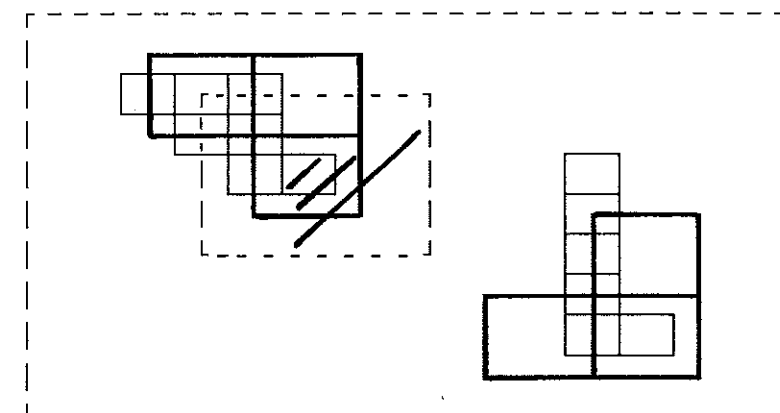
The performance is maintained through the use of a so-called multi-dimensional index, containing 5 overlapping layers of spatial grids (or "zones").

The variation in gridsizes is:

- E-zone: 100 by 100 meters
- T-zone: 200 by 200 meters
- V-Zone: 400 by 400 meters
- A-zone: 800 by 800 meters
- Z-zone: 1600 by 1600 meters

None of the grid-borders co-incide with others.

In this way every cartographic object fits completely in the smallest possible grid; no clipping is necessary.



In the example above only some of the E-zones (100*100), T-zones (200*200) and V-zones (400*400) are shown. The storage of the 3 illustrated objects is self-evident.

The necessary 'zones' will be physically allocated at the moment data needs to be stored. On the other hand when there are no longer zone-related objects a zone will be deleted.

DBMS takes care of handling all cartographic and attribute information.

Database-retrieval by giving up a rectangle in coordinates results in a fast selection of a number of corresponding grids ("zones").

Also the cadastral parcel identification is an access to the LKI-database; it may be just one parcelnumber or a complete section or municipality.

It is not allowed to edit or update the database directly or interactively, only by way of selecting an adequate portion of data from the database, which is called a workfile (database-copy).

Workfiles are selected in this way for purposes of consulting, processing, updating and presenting of the data.

After selection, a workfile is transferred to a graphic workstation and the content is edited.

Then the updated workfile is transferred back to the LKI-database.

A separate updating-process takes care of the factual replacing in the database (batch-operation).

3.5. attributes

It is imaginable that it is necessary that the LKI-database contains more information about cadastral and topographic objects than just geometric location and plot-information.

One of the reasons is that faster and more adequate selection of LKI-database information is possible, so that the delivery of cartographic products is better tuned on the demands of the customers.

An extensive set of attributes, containing technical and administrative information is connected to the objects.

Every object-entity is related to a different group of attributes. The more important attributes are shown in the table.

ATTRIBUTE	OBJECT-ENTITY			
	line/boundary	control/point	parcel	symbol/text
<u>explicit</u>				
classification	*	*	*	*
selection-code	*	*	*	*
quality-label	*	*		
date of storage	*	*		
source identification	*	*		
number (id)		*	*	
<u>implicit</u>				
parcel area			*	
left/right id.	*			
object-range	*			
coordinates	*	*	*	*
line-interpolation	*			

The content of the 'implicit' attributes is generated within the various applications and processes where the objects come into being.

'Explicit' attributes are filled during the process of data-collection either with defaults (preset values) or by interactive input.

The object "cadastral boundary" is directly related to the adjacent parcel-numbers, so that a topological structure can be established ("left/right parcelnumber identification").

Furthermore, the parcel-area, which is automatically calculated, is connected directly to the objecttype "parcelnumber".

One of the technical attributes is a geometric quality label, which is connected to all location-bound objects.

It contains information about the measuring-precision, the object-idealization and the cartographic reliability.

This information is necessary for the users to get an impression about the overall geometric quality (accuracy) of the digital cartographic data.

A highly skilled draughtsman can look at an analogue map and quickly give an estimation about the general map-quality (state of the map, scale, visible physical consequences of earlier updates etc.) and act accordingly during his work of map-revision and updating.

In a digital environment, one is more or less deprived of that knowledge. Staring at coordinates won't help a bit!

A second reason for creating such a quality-attribute is that the content of the LKI-database is allowed to have a graphic precision or map-quality, as a result of digitizing existing maps or using photogrammetric data.

In combination with more precise terrestrial survey data, the normal method used for updating, it can be expected that in time the accuracy of spatial related objects will deteriorate in a relative sense.

When this quality-attribute is filled in correctly, it is possible to make automatic quality-adjustments on larger areas in the cartographic database. Software is and will be developed to perform extensive geometric transformations taking into account the differences in accuracy of the cartographic objects or areas.

4. transport and exchange of cartographic data

Within LKI the output, presentation or exchange of digital information is one of the major applications.

Especially this aspect is most relevant for the discussion about standardization and data-quality in our field.

A special application (subsystem) was designed to deal with data-exchange and transport. 'Exchange' and 'Transport' are not meant to be synonymous.

There are two ways to look at the problem of data-exchange.

On one hand, what is the target or function of data-exchange and on the other hand, where does it physically take place.

The functional distinction can be visualized in the sense that there are two recognizable phases, a production-phase and a delivery-phase.

The last one can be characterized as an information-flow in one direction, like plotting a map or composing a magnetic tape with cartographic information for external use.

The production-phase is much more complicated; it's a two-way street.

In this case higher quality standards and more strict regulations have to be enforced in order to guarantee a successful data-exchange.

For instance, it is of the utmost importance, that the geometric object-information together with the attribute-information is not distorted during transport.

The receiving party must convert the information to their own system and data-format, perform the necessary activities, and convert back to the general exchange format without loss of attribute-information.

The importance of the mentioned procedure became evident when the Dutch Cadastre several years ago started to work with external contractors for geodetic and cartographic activities.

Whatever type of data-exchange is needed, it's important to develop an adequate data-format.

Because of the way our internal workprocesses within LKI were organized, we needed a very compact data-transfer-format, in order to send and receive extensive cartographic datafiles on-line to and from head-office to all our 15 regional offices.

The Dutch Cadastre created such a format in 1983 and called it DUF, which simply stands for data-exchange-format.

The design of DUF is quite simple: there are 7 cartographic recordtypes with variable length and one header-record, containing specific file-information. The two line-records 'topographic linestring' and 'cadastral boundary' are followed by one or more subrecords, which contain the co-ordinates.

Every recordtype has a different length, because of the different set of object-related attributes.

All records are sequentially placed in a file.

In this way the size of a data-file is kept to a minimum.

Of course, this is not a good solution if you want to design a true exchange format, but that wasn't the objective at that time: we just needed a quick transfer-format.

Due to the early stage in time, there was no suitable standard in the Netherlands for exchanging cartographic data between different organizations.

So, when the Cadastre was able to deliver digital cartographic information to external users, it was to be expected that the DUF-format moved up from an internal transfer format to more or less a 'standard' data exchange format.

From that moment on, we were confronted with one of the negative consequences of creating a standard.

It will be practically impossible to adjust the data format or even to perform minor corrections, because for obvious reasons external users trust you not to change the format. That's no way to treat a "standard". Together with the fact that this internal data-exchange-format is not an ideal standard-exchange-format, it is self-evident that the Dutch Cadastre was a big promotor of the development of a national standard data exchange format.

5. comments on the national standard data exchange format SUF2

Therefore, The Dutch Cadastre gladly adopted the second version of such a format, called SUF2, which was drawn up by the national advisory council for landinformation (RAVI) [3].

In 1988 we formally chose that format for the exchange of cadastral and topographic data with external users.

If everyone uses a standard format, the problems with data conversions are equally shared. And it guarantees total freedom for all users in further development of their LIS- or GIS-applications.

SUF2 is a reasonable simple format for exchanging cartographic data.

It is more than just an exchange-format for plots, but it is not designed to exchange object-related information and non-graphic information.

The best characterization can be given by placing this Dutch national exchange format between level 2 and 3 of the 4 dynamic levels which are distinguished in the British National Transfer Format (NTF) [5].

The best way, in my opinion, to analyze the quality of a standard exchange format like SUF2 is when you have to draw up the specifications for the conversion from an internal data-structure to a standard format.

In the case of SUF2 it turned out that the format-structure itself was no problem [4][6].

More attention had to be given to the technical attributes, which are connected to the cartographic objects.

Within the design of SUF2 a large number of them are recognized and documented.

In theory, attribute-information (content description) should be explained in only one way.

But, when the data-conversion software was written, some LKI-attributes could not be transferred on a one-to-one basis.

Either, they didn't exist in SUF2 or they were multi-interpretable.

Several decisions and choices had to be made in order to complete the conversion program.

The result is that several SUF2-subrecords had to be re-interpreted so all LKI-attribute information could be exchanged.

Two examples illustrate some of the problems we encountered.

The first one is the geometric quality-label, which gives an indication of the precision, idealization and reliability by which each terrain-object is captured or measured.

In the subrecord (9 positions) 'quality' 3 positions are reserved for the measurement-precision in "cm" standard deviation.

Since several years the Cadastre has defined the domain of this attribute by a scale from 1 to 9, which represents a climbing standard deviation in cm.

An additional problem is that we only use one position and there are 3 positions at your disposal, so a special conversion table is necessary.

The domain of the attribute "reliability" (3 positions) is not uniquely defined.

It is suggested that the input may be a percentage or a classification table.

In this case, the Cadastre also devised a class definition of 0 to 9, representing the controllability of the data-collection.

Conclusion is that standard input is not possible.

Another example, and in this case there is no subrecord designed in SUF2, is the way a geodetic control point is represented in the terrain; for instance as a 'stone' or 'iron tube'.

This attribute information is added to an attribute in another subrecord.

Of course, external users have to know these specific defects and deal with it accordingly.

On the other hand, the question still remains if all of the attribute-information should be exchanged or not.

In general, the conclusion is that part of the standardization potential of a format like SUF2 is diminished.

In order to contribute to these standardization efforts the Dutch Cadastre published its format-conversion activities, so that other users know what to expect when they receive digital cartographic information from us. A better solution, however, is to set up a more detailed specification of all possibly needed cartographic attributes, so that there will be no misunderstanding about how to convert information from one's own internal data-structure to a general exchange format-structure.

Related to these physical problems of data-exchange-formats is an aspect of standardization which is equally important, namely the object-attribute "classification" of cartographic elements.

The prefix 'carto' is premeditated because topographic as well as thematic, semantic or symbolic information is meant; in short, everything that is presented on a map apart from location-bound objects.

In the early 80's in the Netherlands the geodetic community agreed upon a national classification of topographic objects; at this very moment a third version of this classification-set is being prepared for publishing.

One of the major problems is to reach a balance in the distinction of all features that should be a part of the classification-set.

In my view a hierarchical classification with several levels/classes of details is in order to get the utmost general use of a national cartographic object-classification.

At least on the higher levels agreement is necessary between all users; the lower levels can be used for more user-related classification, for which standardization is less important.

Recently, attempts are made to set up a national classification of map-presentation features, such as symbols, texts and linestyles.

Of course they are only necessary in the field of analogue map-production (typical plotfile-information).

Later on, they will be an integrated part or a separate level in the national cartographic object-classification.

6. updating-process LKI and delivery of changes

Another subject I want to discuss is extremely actual nowadays. Next to the question how to exchange digital cartographic information, it is also important "what" information should be exchanged. All companies and institutions in the Netherlands with applications, needing digital cadastral and topographic information, are in a different stage of the development or implementation of LIS-systems. Some users of digital cadastral and topographic information now have a full copy of the cartographic database within their own service-district and are applying that information for their own purposes. They have reached a point in time where they don't want to get completely updated digital maps anymore, but only want to receive the cadastral and topographic changes in order to update their database.

As producer, responsible for maintenance and updating of both the cadastral map and the GBKN, the Cadastre needs to provide a solution for this problem. The objective for the delivery of update-files is clear; they are small and the customer doesn't need to replace large and complete sections of his database.

So there is less chance of distorting possible relations between topographic objects and the thematic applications of the customer.

The customer can process these update-files in his database either manually or in an automated fashion.

Automatic processing demands that the customer does not alter the received basic cartographic information in any way, otherwise automatic recognition of deleted objects is not possible.

Another factor, which create a complex situation, is that several users of the GBKN (mostly municipalities) participate in the spotting and capturing of topographic changes. Consequently these changes will be delivered to the Cadastre, processed in the LKI-database and distributed to all users through update-files.

It is imaginable, that users are not always satisfied with receiving cartographic information from the Cadastre which was originally delivered by them, often as a half-finished product.

The problem is under study and the possible solution will be simultaneously developed with an overall improvement (new release) of the main LKI-application, the update-process of the LKI-database.

A serious question is how to define an "update"?

Only two types of object-updates are distinguished: "new" and "deleted" elements.

Even an attribute-change results in a new and a deleted element.

Furthermore the number of attributes is extended with two extra features, an update-code and a date of capture or deletion.

The date-attribute makes it possible to perform a flexible database-query over a certain period of time in order to select for instance all the changes in the last 6 months or so. Any other time-period is allowed.

The update-code, however, needs more explanation.

The Cadastre has defined the term 'update' as any change in geometric and technical attributes of a cartographic object.

However, many of our customers have a problem with this definition and will only regard a geometrical change (coordinates) as an object-update.

For instance, they don't see the improvement of the attribute 'quality' as an update, which should be exchanged.

To solve this problem, we intend to create two levels in selecting update-files.

Each customer can state if he wants all changes or just the geometrical changes. Of course, when he chooses the last option, his database may become slightly inconsistent for future processing of updates (problem with automatic recognition of similar objects).

If that is acceptable depends on the use of digital cartographic information in connection with his own thematic applications.

In order to select update-files efficiently, the LKI-database keeps record of all the changes during a large period of time (f.i. two or more years).

The updated information itself is kept within the cartographic database on several different layers, so that the selection process is minimal.

We expect to implement this new software-release in 1992.

7. future development in data-exchange

The best solution to deal with the future delivery of update-information is, of course, the 'on-line'-data exchange.

All major receivers of digital cartographic information should be able to be directly connected with the LKI-database through a nationwide external computer-network.

The first results of a research-project on this subject show that this solution is feasible within a few years.

There are no real technical restraints but it is commercially not ready for implementation.

It requires a highly sophisticated computer-network and a good data-communication-infrastructure, which is not yet available.

In particular smaller users need more time to establish this level of technology.

The ultimate consequence however is, that when the time is there, all our problems of delivering update-files by tape, floppy or even map-sheets, belong to the past.

A second benefit is that external customers do not need to maintain all the digital basic cartographic information in their GIS-databases.

Of course they have to rely on constant availability of the most actual cartographic information from LKI.

To achieve such a goal we probably will be in the next century.

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COHERENCE AND VALIDITY OF GEOMETRIC DATA IN ITALIAN CADASTRE

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SUMMARY The paper describes geometrical data automation plan developed by Italian Cadastre as well as the procedures of controle to make valid geometrical cartograph data. These data can be obtained by digitizing existing land cadastral maps, or by consulting the new up-dating surveys carried out using traditional or aerophotogrammetric techniques. Attention is focused on the ways to resolve the geometrical incongruities between what is represented in the maps and what is represented in the new surveys.

1. Introduction

Italian Cadastre, as for its rural section, was set up by the law n.3682 in 01.03.1886, while its urban section was set up by the law n.1249 in 11.08.1939. The aim was to equalize real estate tax all over national territory.

In order to succeed in this aim, it was necessary to inventory all the real estate immovables existing in the national territory and to establish methods for managing subsequent changes.

Considering the fact that the utility of an inventory depends on its up-dating and considering too that in the recent years land is subjected to substantial changes, Italian Cadastre has adopted systems for up-dating files so as to keep the page with the dynamic evolution of real estate property.

In Italian Cadastre immovables are represented by two types of document:

a) parcel map: a technical cartographic and geometric representation of cadastral parcels (rural and building parcels, rivers, toponymies, symbols, etc.).

This representation is made in closed-perimeter sheet on large scale (1:1000 for urban areas, 1:2000 for areas out urban centres, 1:4000 for mountainous areas or for regions of low-economic interest).

Cadastral cartography has the following limits;

- first: it represents only land planimetry;

- second: it uses Cassini-Soldner representation system which refers to Bessel's ellipsoid and which has many local origins throughout the national territory.

However, cadastral map represent a considerable cartographic patrimony (about 300,000 map sheets, 80% of which on the scale of 1:2000) with omogeneous and standard characteristics all over the Nation (except for 1.5 million of hectares in some Northern Italy areas still represented using "Maria Teresa" open-perimeter cadastral sheets).

Cadastral cartography with the law n.68 in 1960, thanks to its technical characteristics of topographic precision and to its homogeneity of representation, became official cartography of the State.

- b) administrative papers; files of owners and real estate data needed to describe the administrative and taxable aspects of the immovables contained in the parcel map.
Each file permits to access to the cadastral data base using different input data.

In 1969, an automated information system was introduced on an experimental basis, in the administrative-rural section. While the cartographic and the building section were automated in 1974 and in 1983 respectively. After a pilot experiment carried out by the cadastral office in Florence, automation started in massive form in 92 remaining Italian provincial areas. The adopted technical solutions were the following:

- each provincial cadastral office was provided with local processing system with storage capacity and terminals necessary to manage local cadastral files;
- a central processing system, connected to 93 provincial processing systems, was set up in the central main office in Rome.

The targets were the following:

- 1) performing hardware and software checks (remote diagnostic);
 - 2) inserting all the files produced by the local cadastral offices in the central processing system data base;
 - 3) guaranteeing the saving of the files;
 - 4) making nationwide statistics;
- three separate files were created as for the rural, cartographic and building sections, considering that they made to be worked out in different periods. These files, even if they are separated, form three strictly-connected data base. It is possible to retrieve these data using univocal keys of identification of owners and immovables.

By 1992, all processing systems, necessary to handle the administrative data, as for the rural and the building sections, will start in all 93 provincial cadastral offices. However, by the same date, only 23 offices with about 90.000 numerical map sheets, will be provided with processing units operating in the cartographic section.

A ten-year activity plan is setting up to complete the cartographic numerical files of the 70 remaining cadastral offices.

In order to complete these files it is necessary to digitize 180.000 existing map sheets and to make new surveys on 3.000.000 hectares not coherently represented in existing map sheets.

The cost to complete this plan amounts to one thousand billion Italian lira.

2. Picture of cadastral cartographic data base

Map sheets numerical data are contained in a single geometric file. The enlargement of a section map is considered a new map itself and has its own geometric file. The whole of geometric files, forms the cartographic data base.

A geometric file is formed by graphic and logical data, by well-structured logical levels and by a special group of general data contained in the main logical level.

Graphic data are fundamental primitive elements (points, lines, symbols, texts), while logical data are compounded primitive elements which represent real cadastral objects (parcels, buildings, roads, waterstreams, sheet boundary).

Each significant object is identified in the geometric file thanks to the user's identification code, like for instance, the parcel number.

The main role of logic levels structure is to assign each data base element, graphic or significant objects, its task within the map. Consequently, all the graphic object representing parcels' boundaries, belong to the "parcel level".

The access to any logical level permits to represent all the graphic objects contained in the level itself.

It is possible to make an inquiry using the parcel number or the building code thanks to the data base type (structured on significant object).

Moreover, this data base type permits to correlate objects and administrative data in a logical and bi-directional way.

Here follows a simplified list of map sheets' cadastral logical levels:

- sheet boundary
- parcels
- buildings
- waterstreams
- roads
- symbols
- parameters of coordinate system grid
- orientation control points
- others (all graphic elements necessary to complete the land representation).

Numerical cadastral cartography has been organized in a way to serve public efficiently, both as for cartographic authentication and as for cartographic updating.

3. Remarks about digitizing process

In order to obtain a numerical cartography with well-operating processing techniques, two main conditions are needed:

a) a "FM" (facilities management) cartography with appropriate data base type is necessary;

b) numerical data must be carefully verified.

However, we should express some useful remarks about the massive production of numerical cadastral cartography.

Nowadays, cadastral cartography annual production, by digitizing process, regards more than 20.000 map sheets.

Consequently, map production for month amounts to 2.000 map sheets representing 200.000 hectares of territory. 500.000 cadastral parcels, standing for 15 million graphic data, are verified monthly.

These figures demonstrate that to achieve these targets, high-quality information system is needed in cadastral cartography.

4. Cartographic quality check

4.1 Map updating

Before being digitized, the map sheet is updated on the basis of the documented variations existing in cadastral office but not yet treated.

In this stage a manual check is carried out by cadastral operators. The main target is to verify that all variations have been produced according to cadastral code. Not less than 10% of the updated maps are carefully controlled.

4.2 Numerical digitization of the map

The updated map is manually digitized in order to create a numerical cartographic file.

The control process is divided into two stages.

In the first completely automated stage, which is carried out for all created files, the coherence of the produced data base is carefully controlled.

The main automated verifications regard:

- congruency and structure of all the produced files;
- congruency between map sheet and its eventual map sections enlarged;
- control of the map sheet's orientation process. It is necessary to verify the computability of the obtained results with the limits given in cadastral code;
- control of topologic assignments of the geometric file elements and verification of physical and logical end of polygonal lines;
- control that the total area, within the sheet boundary, is equal to the sum of separate areas belonging to the logical data (like parcels, waters and roads) represented within the map;
- control that each graphic object is organized in its logical level and is given its identification code;
- control that map sheets boundaries are exactly positioned in order to orientate them correctly near adjacent sheets;
- control that all parcels and surfaces data are completed with administrative data.

Procedures can estimate and identify the number and type of errors in each sheet.

The number of automated checks varies according to the complexity of the map, and can be thousands in each sheet.

On average the processing time needed to verify the cartographic data base of a standard district (40 map sheets) is 1.5 h.

In the second stage, which is carried out manually, the updated map is superimposed on the automatically plotted map, after the manual digitizing process, in order to compare them.

After these two stages, a final test is made.

5% of map sheets, are selected and submitted to a new digitizing process, so it's possible to automatically analyze the two cartographic data bases of the same map, to check:

- sheets' correct orientation;
- the respect of tolerance limits admitted for areas of cadastral interest and for the coordinates of each processed point;
- the correct interpretation of cadastral objects.

In case of a standard district's files with a few errors, less than tolerance limit number, this stage takes, on average, an hour to be carried out.

5. Acceptance batch processing procedures

The procedures described in the preceding paragraph, has been worked out from a kernel program which has been developed in the course of years on the base of experience made.

The incongruences present in a produced map file have been divided into three main categories.

a) Serious errors

Here follows a list of the most frequent serious errors:

- unreadable map: in some cases the file representing the map is not physically or formally readable;
- wrong sum of surfaces: in a map sheet, the sum of the surfaces of parcels, waterstreams, roads and enlargements must be equal to the surface within the sheet boundaries; incorrect topology: it is necessary that all polygonal lines bordering the areas, really close them; incorrect figures of areas: figures of areas are calculated again. They must be equal to those registered in the data base;
- incorrect rototranslation process: the mathematical operation used to orientate the map in the territory is a rototranslation with isotropic stretching. The sum of the squared differences between the orientation control points calculated coordinates and their given coordinates must be a minimum;
- incorrect matching of maps; all the maps of a district are matched together. In this stage it is necessary that at least 70% of vertexes forming the boundary of each map has a corresponding point in the boundary of the adjacent map with a tolerated difference of 10 metres.

b) Mediocre errors

These errors are due to a wrong coding of graphic element for significant cadastral objects such as waterstreams, roads, parcels, buildings, enlargements and boundaries. Mediocre errors are also the incorrect positioning of toponymies within areas.

c) Slight errors

Errors caused by wrong coding of geometrical objects characteristics.

The automated procedure classifies errors and produces a list of all the maps which must be corrected

If there are some serious errors or a considerable number of mediocre errors, map sheets must be digitized again.

On average 5% of maps need to be reprocessed.

6. Test stage

In this third stage, some maps are selected and digitized again by an operator who did not make the first digitization.

The comparisons between the two files allow to verify not only the respect of tolerance limits admitted for the coordinates of vertexes and for the areas, but also the correct interpretation of cadastral objects carried out by operators.

The test is considered positive if the number of the comparison errors do not exceed the limits of 0,5% of the totality of controlled objects.

It has taken 13 years per man to elaborate the acceptance and test

procedures.

7. Processing of the new updating surveys

Besides the map digitization process and land surveys to produce new maps interesting some large areas (1.5 million of hectares), Cadastre Management has revised geometrical updating procedures in order to put the updating surveys in the numerical cartographic data base.

The updating surveys interest the parcel geometry or the insertion of new buildings.

In this context, a net of cartographic points of reference (fiducial points) has been selected. Fiducial points are chosen among the material objects (i.e. building corners) which can easily be individuated in the territory. The net sides are 250-300 metres long.

The updating acts are compiled by qualified technicians not depending on Cadastre, after the control of the mutual position of the fiducial points chosen and used to orientate the updating survey.

During surveying operations, topographic measures are taken to detect the new updating lines starting from fiducial points which act as local references to convert measures in coordinates.

Owing to the approximated coordinates of fiducial points, the calculated coordinates of vertexes of updating lines are approximated too. However, the coordinates of fiducial points are useful to orientate the new geometry in the existing cartographic structure.

The final result is an approximate but updated representation of the territory in the numerical cadastral map.

In a second stage, after having linked fiducial points to the geodetic net, the data obtained from the new updating surveys are retrieved in order to adjust all measures and to produce a coherent cartographic representation of all these data.

It takes a long time to carry out the whole process, however, the obtained results which have already been verified for some areas, prove the validity of the theoretic and technical bases of advanced adopted methodology.

It must be considered that this process of "cartographic reconstruction" carried out using the fiducial points and the measures obtained from the new updating surveys, is fast for those map sheets which are subjected to a great number of geometric variations.

Consequently, even if it takes a long time to carry out the entire process, cartographic reconstruction will be rapidly executed in areas subjected to geometric variations, that is to say in territories particularly interesting from a cadastral point of view.

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WORKSHOP ON DATA QUALITY IN LAND INFORMATION SYSTEMS
APELDOORN, The Netherlands,
4-6 September 1991

DATA STRUCTURES OF DIGITAL CADASTRAL BOUNDARY MAPS IN NATIONAL LAND SURVEY OF FINLAND

Summary

The presentation gives an overview concerning data structures for digital cadastral boundary maps in Finland and the suitability of the present solution in meeting the corporative requirements of spatial data processing. Topics to be discussed include e.g. integration of data stores, version management, long transactions, seamless databases, simultaneous updating, access rights and distributed processing.

Real Estate System

Owing to historical development, Finland does not have a uniform real estate system. Instead, several state and municipal registers and catalogues contain information on land, buildings and rights to them.

Our real estate system is built upon the parcel based cadastre. The cadastre defines the real estate units, areas and permanent rights. There have been two types of cadastres: the rural Land Register and the urban Lot Book.

The Land Register is maintained by the 11 Provincial Survey Offices. At the end of 1990 the total number of registered real estates was about 1.850.000. During the last five years about 24.000 - 34.000 new real estates have been registered annually. At the moment 75% of the Land Register units have been stored into the computerized real estate register.

The Land Register contains attribute data. The geometry of the real estates is depicted on the boundary maps.

At the moment about 20% of the geometric presentation of the real estates is in digital form. Geometric depiction of land rights and restrictions and some other administrative records are maintained manually on the maps in the Provincial Survey Offices.

The computerized Land Register and the Digital Cadastral Map systems have been implemented on different computer platforms: HP MPE3000 equipment is used in the Land Register system while the Digital Cadastral Map system is running on DEC VAX/VMS computers. A more detailed discussion of the Real Estate Information System is given by Parviainen in /4/.

Digital Cadastral Boundary Map

The geometric description of real estate parcels is digitized in different ways depending on district and production methods.

The establishment of Digital Cadastral Boundary Map is based on:

- a. The base map 1:5000 methodology consisting pre-marking of the corner marks of the properties, aerotriangulation and compilation of a digital boundary map.
- b. Digitization of existing graphical boundary maps in the scale of 1:10000 and 1:2000. If there are computed coordinates of boundary corners those will be used.

Updating of Digital Cadastral Boundary Map is based on:

- a. Digital survey plans consisting of computed coordinates and boundaries.
- b. Field notes on a survey plan using coordinate geometry.
- c. Digitization of graphical survey plan.

Data Contents of Digital Cadastral Boundary Maps are as follows:

The Parcel Identifier

- Identifier consists of four numerical fields, for example 858-401-1-17, where:
858 - municipality number
401 - village number
1 - block number
17 - real estate unit number
- Appearance code
- size, font

Parcel Boundaries

- Feature codes
 - state, region, municipality, village, real estate unit or general road
 - certain or uncertain (surveyed or non-surveyed) boundary
 - interpolation code
 - etc

Parcel Corners

- Feature codes
 - boundary monument type
- Position accuracy code
- Survey (definition) method code
- Boundary monument versus earth surface code
- Number of boundary monument
- Location in the National Grid Coordinate System

Auxiliary Texts

- Appearance code
 - size, font

Spatial Data Structures

Spatial data is stored in the spatial database and maintained using a spatial information management system developed in the National Board of Survey. The software is called MAAGIS, Multi Application Architecture Geographical Information System. MAAGIS is the kernel of the several digital production systems in the Land Survey of Finland.

The spatial database system has been generated using an indexed sequential file system where records are stored in a specified order and accessed by primary key value.

The data model of spatial data in MAAGIS is outlined in Appendix 1 using Entity Relationship diagramming technique.

The entities of the data model are:

POINT is a one-dimensional spatial object with coordinates (x,y,z). Sub-entities are:

- Polygon identifier point
- Symbolic point
- Special symbolic point with text
- Non-symbolic point
- Text

LINE is a sequence of ordered points, which may be symbolic, special or non-symbolic points. The beginning of the line has a special start node, and the end a special end

node. The pointer of the first intermediate point and the number of intermediate points are stored in a line record.

LINE/LINE tells the pointers to the right and left lines in a junction point or endpoint of one or more lines.

There is no POLYGON entity (consists of one outer and zero or more inner rings) stored in the database. Polygons are computed automatically by means of geometric access. The polygon identifier is a point consisting of coordinates anywhere inside the polygon and polygon attributes.

COVERAGE LAYER consists of spatial objects of one type describing one theme.

COVERAGE SET consists of a number of coverage layers.

A regular GRID is the position index system. Each SQUARE has an associated list of the entities which are contained in or pass through the region of space covered by the square. There is one grid for all the points and one grid for each line layer.

SPATIAL DOMAIN is a geographic area of interest consisting of a number of coverage sets. The geographic area of interest, SPATIAL DOMAIN, is managed using the directory structure and the DCL command language of VAX/VMS system and lists OF POLYGON IDENTIFIERS.

Corporate Requirements

In the Land Survey of Finland there have been serious efforts to establish an information-based cadastral system. The data entry of the Land Register was started in the seventies and it has continued to this day. The computerization of the Cadastral Boundary Maps was started in the beginning of the eighties. By the 1980's the pressure for uniform information had grown to such an extent that the principle decisions were made by the government (1984, 1987) to establish the Real Estate Information System by the year 1995.

The integration of attribute and spatial datasets has become vital necessity in a multipurpose cadastre which must produce information that satisfies users' needs. Large data volumes with geographical data makes the process of dataset integration very demanding. We have started to develop a next generation solution for the Land Register using the IE (Information Engineering) methodology developed by Martin and Finkelstein /1/. The Information Strategy Planning and the Business Area Analysis phases have been completed during 1990-1991. It has been estimated that the development of the

system will take 3-5 years.

In the following, the present Digital Cadastral Boundary Map system is considered from a corporate point of view.

Data integrity

One of the main problems in a GIS is maintaining data integrity at all times. There are a number of things that can, and frequently do, go wrong. A feature consists of a geometric description and related alphanumeric information. In the Land Register the two types of data are held in different data structures. The only way to ensure integrity is by laboriously cross-checking and editing data holdings in the attribute database and in the Digital Cadastral Boundary Mapbase. Even to enquire the geometric description and the related attributes of the real estate simultaneously is impossible because of separate systems running on different computer platforms.

Seamless Mapbases

Modern GIS systems must be able to handle very large databases, accessed by many concurrent users. Typically such databases have been partitioned so that individual pieces can be accessed by only one user at a time, thereby avoiding update conflicts. Partitioned databases cause a number of problems which are well known, e.g.

- difficulties in maintaining topology across sheet boundaries
- ad hoc solutions to maintain the illusion of continuity on display screens
- difficulties in providing simultaneous access to parts of the database by more than one user.

We have constructed our Digital Cadastral Boundary Mapbases by partitioning data conventionally to approximately 15.000 map sheets. The scales of the map sheets are 1:2000, 1:5000, 1:10000 or 1:20000 depending on the density of the cadastral structure on the area. On the average, there are about 250 registered units per one map sheet.

The continuity across sheet boundaries is handled by the data management of MAAGIS so that it is possible to work with several map sheets simultaneously. Anyway, geometric objects must be cut to pieces on a map edge which complicates the handling of identifiers and geometric objects.

Long transactions

A GIS transaction can be very long, possibly days or even weeks. Usually an updating transaction of the Digital Cadastral Boundary Mapbase takes from a few minutes to hours or days depending on the nature of surveys.

Long transactions combined with seamless mapbase approach require special solutions to manage simultaneous users updating the database. For example, Newell and Easterfield /3/ propose a solution based on version management to solve the long transaction problem.

The update of the real estate information in our Digital Cadastral Boundary Map system has been organized so that the related map sheets are copied and the original map sheets are locked to read only state. The updated map sheets will be restored into the Digital Cadastral Boundary Mapbase as a separate batch processing activity.

Distributed databases

A distributed database is a database that is not stored entirely at a single physical location, but rather spread across a network of locations which are geographically dispersed and connected via communication links.

Ted Codd and his partner Chris Date have developed an unofficial set of 12 rules (commandments) governing the specifications for a DBMS to be certified as 'truly Distributed'. An overview of the rules is given in Appendix 2 (for a more detailed discussion of distributed GIS see /2/).

The Digital Cadastral Boundary Mapbase is more decentralized than distributed. All the Provincial Survey Offices have their own mapbase concerning the area of one province. The modifications of the common province boundaries will be updated separately to all related provincial databases.

Replication of the cadastral boundary data is needed for real estate surveys. The Digital Cadastral Boundary System does not provide 'replication transparency' facilities to be managed automatically by the distributed data management system. The conflicts caused by replicated data are handled manually by the user who is responsible for the update of the Digital Cadastral Boundary Mapbase.

Conclusion

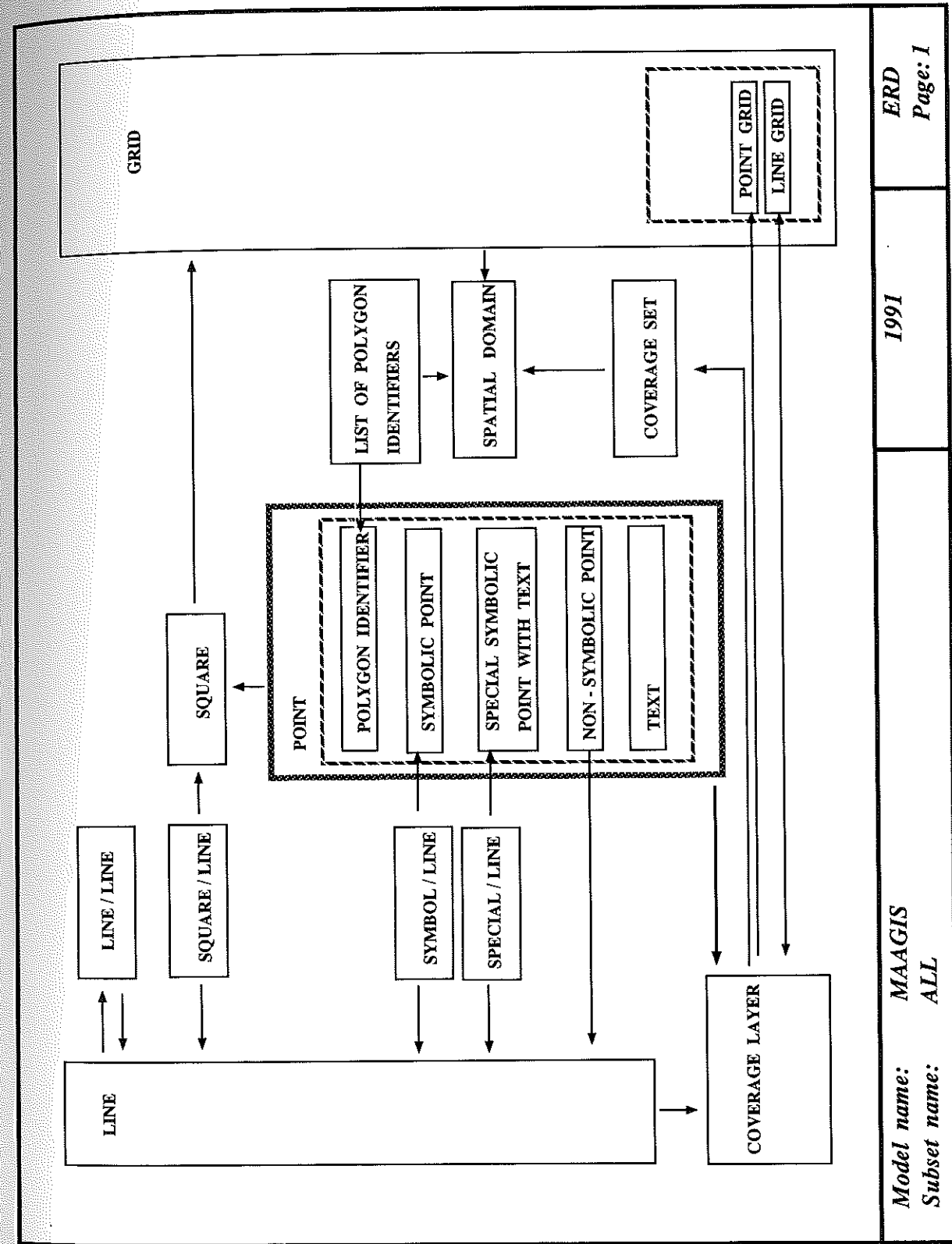
Our current Digital Cadastral Boundary Map system achieves partially the corporative requirements by providing facilities to establish Digital Cadastral Boundary Mapbases, enquire real estate units, copy objects to another system and update database. Our current solution is the first stage in creating the geometric description of the real estate network in Finland. However, the digital cadastral boundary data must be an integral part of the Real Estate Information System so that it is possible to produce information that satisfies users' needs also from a spatial point of view.

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Appendix 1

The Data Model



Appendix 2

An overview of 'Codd's Rules'; an unofficial set of 12 rules governing the specification for a DBMS to be certified as 'truly Distributed':

1. Locally owned, i.e. without central control system;
2. No site need rely on another for an activity/skill;
3. The system should never shut down;
4. Users are unaware of the physical location of the data accessed;
5. Logical data structures may include data from different machines;
6. Replicated data should be handled automatically by the Distributed DMS;
7. Query processing should be optimised through the DBMS in two phases;
8. Transaction management has to be distributed;
9. The database must be hardware independent for all machines involved;
10. It must be operating system independent;
11. It must be independent of all network software;
12. It must be independent of all the individual DBMSs in the network.

Quality concepts in Land Information Systems

ir. L.A. Koen

SUMMARY

In this paper a short presentation is given on the current evolution in thinking about quality within and beyond the area of our expertise. The increasing digital mapping activities not only ask for a different way of handling the aspects precision and reliability but force us to consider other quality aspects as well. For large scale applications the exchangeability of information is essential. National and international standardisation is a necessity for both the metric quality aspects and the non-metric quality aspects.

INTRODUCTION

In this paper quality concepts in Land Information Systems will be discussed. The word quality and the term LIS require some further explanation. There are several and different definitions for both terms which may lead to confusion when used in combination.

Quality is a subjective idea. The meaning of the word quality strongly depends on the different specialities in which the word is used (and those are all specialities). In fact there is a variety of ideas on quality and on the way quality has to be dealt with in an organisation.

Some examples of such different quality approaches are:

- * Quality is confirmation to specifications
This is especially a technical approach
Product and production process are main points for quality assurance
- * Quality is fitness for use
This is a practical and market oriented approach
In this case it is for the customer to determine the quality
- * Quality implies a judgement of the organisation
This is a management-oriented definition
All aspects of the enterprise determine the quality.

In recent years there has been an enormous development in thinking about quality in western countries and especially in industry. In the beginning the quality of the final product was emphasized and so were checks and corrections. Later the whole production process became involved in the quality assurance activities and more attention was paid to preventive actions. In recent years we have seen a still broader approach with Total Quality Control. In this situation not only the product and the process, but the whole organisation is involved in the process of quality improvement. An illustration of this

approach is the ISO-9000 series. These ISO-9000 standards are generic standards, developed by ISO and accepted by most of the national standardisation institutes. They can be of great help for the development of quality systems in many different kinds of organisations.

In the European surveying world this development is not yet to be seen. Only in some countries such as the UK and to some extent in the Netherlands we see a beginning of a more business-like approach of building up Land Information Systems with relevant systems for Total Quality Control. In most of the countries major attention is still paid to the quality of the processes and the quality of the final product. As for those aspects a lot of work has to be done anyway. In this workshop on data quality we will therefore focuss our attention mainly on the product (data) in the large scale application field (LIS). The reason for this limitation is clear. The data and the corresponding quality standards are a direct translation of the objectives and the functions of a Land Information System and so of paramount importance. The process of data acquisition is a derivative and an aid. Moreover this aid is subject to many quick changes as a result of technological developments. Our objectives are not changing so fast and so the data level is a more stable field of attention. In spite of this limitation though, data quality in Land Information Systems is a complex and very wide field of attention.

A general definition of quality, relevant for our purposes, is given in ISO-standard 8402:

"the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs"

The stated or implied needs might be called quality-functions and can e.g. refer to:

- performance
- public necessities
- presentation
- characteristics
- exchangeability

The different quality approaches depend on the emphasis that is put on each of those quality-functions. It is clear that the quality functions and so the view on quality can change in the course of time as a result of the developments in the organisations concerned or in society.

Within our profession these developments are evident. The need for thoughtful and careful land management has led to a re-evaluation of the need for systematically provided land information. This development is highly stimulated by the advances in information technology. In Western Europe there is a tradition of centuries for collecting, storing and presenting land information. Examples are of course the cadastral systems in most of the European countries and the topographical map series. Originally these information systems were single purpose systems. With the increasing complexity of society and with the intensification of land use these systems evolved or are evolving into multi-purpose systems. To my mind in many cases our view on the quality of products and services in our surveying profession does not keep pace with the developments mentioned before. Our approach of quality is still strongly based on the long tradition of the trade of surveying and mapping and on the old connections and organisations within which the information was acquired and updated.

In the scheme below the major quality aspects in our surveying and mapping profession are presented:

metric quality	precision reliability
non-metric quality	exchangeability logical consistency presentation lineage completeness

Of old, the first group of metric quality aspects has got most of the attention of the surveyors. However, in a digital approach the second group of quality aspects is important as well. Because of the large number of users and producers of large scale information especially the exchangeability deserves more attention. For this reason the theme of the last day of our workshop is exchangeability and standardisation as a logical consequence.

The term Land Information System requires some further explanation. In my introduction to this workshop the term LIS was used mainly in the sense of multi-purpose cadastral system. A LIS can also be considered as a special kind of a Geographic Information System. (GIS). Land Information System and Geographic Information System have a partly overlapping meaning. For practical reasons I will not try to define both terms but for the purpose of this workshop it is useful to point out some differences. Mostly a LIS concerns detailed digital information resulting in large scale maps if presented in an analogue form. This workshop will be focussed on this large scale application field where cadastral services, local authorities, public utilities and increasingly private firms are active as producers or users of geographic or land information.

It is true that a digital approach provides a possibility of a certain independence of scale. In practice, however, it is useful to distinguish between some levels of scale, corresponding with different methods of data acquisition and/or with different application fields and it is useful to discuss the relation between the various levels of scale in this workshop. Especially the differences and similarities concerning quality aspects and the consequences for standardisation should be considered.

Anyway, better arrangements should be made on terms and definitions as mentioned above. These terms and definitions should comprise all keywords for digital data handling and should, like all standards, result in formal recognition by the national and international standard institutes.

DATA QUALITY. PRESENT SITUATION

The present situation in Europe concerning large scale mapping and in general concerning the building up of Land Information Systems is amorphous. This applies both to the information itself and the corresponding quality aspect. This situation can not only be explained from the nature of the information concerned but also from the great differences in geography, culture, legislation and level of development in various European countries and even inside a certain country. Furthermore it is important that most of the data in land information systems are collected and processed decentrally by a great number of different organisations.

In most of the countries the systematic collecting, renovation and updating of

land information leave much to be desired. Examples are the cadastral systems created in many European countries in the last century. There is almost no country having a realistic planning for the renovation of the old cadastral maps of the whole country and so for the building up of a multi-functional data base. On a national level a Land Information System is still more a conception than a reality in most of the European countries. As a result of this lack of prospects many local or regional mapmakers and map-users continue with the production of maps or detailed digital information for their own and often limited purposes. These individual purposes are corresponding with individual and different standards for definition, quality and presentation of the data concerned. Moreover, systematic updating varies from application to application and from region to region.

There is no reliable estimation of the yearly amount of expenses for large scale mapping activities in Europe. When taking the estimated situation in my country as a reference and extrapolating this situation to all other OEEPE countries it leads to an amount of 10 billion Dutch guilders or 4 billion ECU (and this is a very conservative estimation at that). When confronting this enormous sum with the present poor output, and with the lack of prospects for a systematic renovation, a first impression is that a better coordination could lead to much better results. However, it is a general experience that coordination is a difficult and lengthy process. The administrative and legal instruments for a better coordination are scarce. The most effective instrument to come to a more optimal situation is standardisation.

Compared to other technical professions, European surveyors and mapmakers are hesitant as to formal standardisation. The reason might be the tradition of individual craftsmanship and the corresponding lack of a clear stressing of the distinctive features of our profession. Initiatives for standardisation come mainly from the small scale application field or the sector of the Geographic Information Systems. It is open to discussion whether the large scale applications in such a situation get the attention they deserve. This is one of the key-questions that are to be discussed during this workshop:

Can we develop a (system of) application-independent generic standards for an effective and efficient exchange of digital cartographic information?

In order to answer this question a detailed analysis of the various quality aspects relevant for the various applications is needed. This workshop might contribute to the solution of this problem by helping to define the problem. However, for the solution of the problem, more and full-time professional research is necessary.

METRIC QUALITY. INQUIRY.

The foregoing might have created the impression that less attention should be paid to the conventional quality aspects precision and reliability. This is not correct. New applications certainly demand attention for new or for other quality aspects. This does not alter the fact that the location of the objects is the most important aspect of most of the large scale data and so the corresponding quality aspects precision and reliability remain of the utmost importance. However, it is certainly useful to have a critical look at the existing metric quality criteria and in general at the existing quality system if a digital database is to be built up. Especially the effectiveness and the

userfriendliness of the existing system should be considered.

In order to get an impression of the present approach concerning metric quality in land information systems, Application Commission II (Cadastral Mapping) carried out an inquiry among the OEEPE countries. Main aims of the inquiry were:

- to get an inventory of the existing approaches concerning metric quality representing the general situation in the OEEPE countries
- to analyse the differences and resemblances
- to prepare proposals for common research

Eight out of the twelve OEEPE countries responded to the inquiry. As could be expected the situation proved to be very complex. Moreover the relevant and voluminous documentation was difficult to get access to. So for the moment only a global analysis has been carried out. Proposals for common research have not yet been made.

In most of the countries the existing standards and guidelines for metric quality proved to be based on statistical models. In general the quality aspects precision and reliability were distinguished very well. In only one country we found an approach based on tolerances. However it is not clear in how far the good standards and guidelines are used in daily practice. In other words: we do not have a good perception of the effectiveness of the existing standards. It seems likely that there are great differences in the way people use the standards. An example might be an important activity such as the cadastral updating which often has to be carried out on the basis of a very inhomogeneous technical situation.

Generally the precision is consistently approached in a numerical way by means of the standard deviation. This does not exclude the use of certain classes. In most of the cases the reliability is recorded on a more limited and not always numerical way. For instance a system of classes, corresponding with the methods of data acquisition or the source of the data, is being used. This is especially the case for systems with graphical applications.

A first and general conclusion of the inquiry is that the development of common models or common generic standards for metric quality could be a feasible OEEPE activity. One of the conditions for such an activity is that there is a clearness on the terms and definitions to be used. This could be a separate standardisation activity

QUALITY SYSTEM PRINCIPLES

In order to develop quality standards for our products or processes, or to develop a quality system for our organisation, the attention must be focussed on some important developments. The most important trends in our society which are relevant for our profession as well, are computerization, market-orientation and internationalization.

-computerization

Basically many services have the means for a digital approach at their disposal nowadays. One of the major problems when establishing a consistent digital database is the inconsistency of existing data. Especially the cadastral services are confronted with enormous quality problems when trying to

convert their data. In most of the cases the establishment of a digital data base is therefore combined with an improvement of the metric quality. The improvement of the quality however is very labour-intensive so that the pace of renovation is low.

If we want to develop a realistic quality policy, we will have to accept the fact that the financial and personal budgets are limited now and will remain so in the future. One of the characteristics of such a realistic quality policy must be the fact that we accept that our quality criteria depend on place and time and that we consequently accept certain differences in quality. This is not necessarily a drawback, provided we have the disposal of quality standards enabling us to record the differences and to operate with the differences in quality in a user-friendly way. This means that we will have to develop a generic or conceptual quality standard that enables us to operate on different quality levels. In such an approach not the improvement of quality but the control of quality comes first. The quality standards to be developed must be simple. Existing quality standards often are too sophisticated and only workable for surveyors with an academic education.

In my opinion OEEPE will have to contribute to common research in order to develop the simple and userfriendly quality standards as mentioned above.

-market-orientation

In almost all OEEPE countries we see the governments stepping back and consequently notice a trend to privatisation. Many old services are examined critically on their objectives and their management. The aim for a more businesslike management implies the development of a more businesslike quality policy. The higher extent of contracting our activities requires transparent quality systems for private enterprises and for governmental services as well. Standardisation is one of the major instruments to get to this situation.

-internationalization

The above market orientation will be intensified by the much easier communication and the disappearing frontiers in Europe after 1992. This means among other things that the standardisation has to be viewed not only on a national level but on an international level as well. Furthermore standardisation will stimulate the exchange of knowledge and will be of special importance for countries with technical disadvantages.

CONCLUSION

The key-word in this paper on quality is standardisation. In my opinion national and international standardisation has to be one of the major fields of attention for our profession in the years to come. Standardisation is a long and often laborious proces. This is especially the case for international standardisation. Twenty years ago, during the FIG congress in Wiesbaden, a resolution was accepted calling for standardisation. Particularly the existing metric quality standards should be collected, analysed and reconciled to a common standard. In spite of many efforts and the good intentions of a lot of people the aim has not been achieved.

From this experience it must be concluded that the complex problem of

international standardisation can only be solved by a professional and bussiness-like approach. For a good result the international standardisation process should proceed in phases:

1. Awareness (present phase)
2. Feasibility study (scope, priorities, alternatives, budget, timetable)
3. Research agenda (definition of projects)
4. Execution of projects
5. Recognition, registration and publication by CEN or ISO

In conclusion I should like to repeat my opinion that OEEPE ought participate in pre-standardisation research and initiate feasibility studies, together with other professional organisations like CERCO, FIG and ICA.

On Geometrical Quality in a Land Information System*

ir. H. Velsink

Abstract

With the increasing implementation and use of computerized Land Information Systems different types of information that are geo-referenced are interrelated and analyzed in an integrated manner. A consequence is that the geometrical fundament, i.e. the topographical map and the items that are surveyed in their geometrical relation to this topography, is becoming but a small part in the whole data processing complex. Aspects like good classification, completeness and frequency of revision are often considered of far greater importance.

There is a tendency to believe that quality management of the geometrical fundament is a well-understood and well-managed area of interest for the land surveyor. Practice in the Netherlands shows however that this is often not the case and that attention for the quality of the geometry tends to be forgotten because of the importance of aspects like classification, completeness and frequency of revision.

In the environment of Land Information Systems it becomes vital for the geometrical quality of the information that the source and quality are well registered. It is likewise important that modern computing techniques of the land surveyor are made suitable for the treatment of geometrical information like attributes to the objects in the LIS that can be manipulated according to the problems and demands at hand.

1. LIS and the Land Surveyor

The origin of Land Information Systems is map making, especially the making of large scale vector maps. In the context of map making a land surveyor has a clearly defined task. He should provide the observations to map the relevant topographic information and related themes. To fulfil this task a land surveyor traditionally starts by using a national control survey network. Within this national geometric fundament he effectuates a dependant control survey and using the thus realized geodetic control he performs his topographic and cadastral surveying.

It is the expertise of the land surveyor that guarantees the quality of the information on the map as far as position and form of mapped objects is concerned. Of old the land surveyor has extended his area of interest to related topics. This extension goes two ways, firstly he often registers much more than just geometrical information, secondly he may go very far in the application of the registered information for nearby and remote purposes.

But in essence the determination of position, size and shape of geo-referenced information has stayed the kernel of the profession.

In performing his task in the map making process the land surveyor traditionally aims at a geometric precision of the mapped information that is as high as is necessary to prevent any user from noticing any lack in accuracy. As a result of this general aim for many purposes the geometric precision of mapped objects is much too high for the purpose at hand. Besides in

* Presentation held at the Workshop on Data Quality in Land Information Systems of the OEEPE in Apeldoorn, 4-6 September 1991

earlier years computing and information storing tools and theoretical knowledge were not so advanced as to make determination of acquired geometrical quality of every mapped object possible. So a land surveyor had the tendency to work better than would be needed for many users of the map.

2. New Developments

Recent years have shown new developments that give a new look at the position of the land surveyor in his work.

First of all there is the evolvement of Land Information Systems that are replacing maps as a storing device and an analysis tool of geo-referenced information. A characteristic of Land Information Systems (hereafter called LIS) is the ability to attach to the basic geometric, topographic information an overwhelming quantity of other data that is certainly geo-referenced but is traditionally not seen as such. The effect for the land surveyor is that he has to deal more and more with information from other disciplines and that he has to operate in multi-disciplinary teams.

Secondly measuring technology in land surveying has developed extremely rapidly and many new possibilities are available. The revolution for example that the Global Positioning System (GPS) has caused is very intriguing. It furnishes the interesting question what to do if a small survey of a certain area is done via GPS with a higher level of accuracy than the control survey network to which it is to be adjusted.

The new measuring techniques that have arisen in the last decades have also resulted in concepts like integrated geodesy, that is the necessity to integrate several types of observations into one mathematical model. Thus for instance observations from GPS, photogrammetry, levelling, electronic distance measurement equipment and theodolites should be combined to fill a LIS with its topographic fundament.

In the Netherlands it had become more or less practice that surveying activities were mostly performed by government institutes that controlled these activities by precisely prescribing the actions to be performed. In the last decade however many activities have been tendered to the private sector. This, combined with the proliferation of new technologies has been the cause of a demand for better standards and criteria. Then how to compare the results of different measurements stemming from different measuring techniques performed by different surveying firms?

It is important to notice here that demands for better standards and criteria should often be interpreted as demands for better procedures to derive standards and criteria. For instance one could ask what is the precision of a geodetically determined point field. It is the land surveyor who should firstly point out that precision of coordinates is always defined with reference to a geodetic datum and that only point standard ellipses are not sufficient but that a complete covariance matrix should be given. In practice however even land surveyors do not go beyond defining a standard deviation for each point, often without mentioning any geodetic datum. To what extent is this acceptable and when do problems occur?

3. An Object Oriented Approach

Many of the developments mentioned above can be handled better by looking in another way at the task of the land surveyor. To describe this other way use will be made hereafter of the approach known as object oriented programming, which has been adopted in software development (a good introduction gives [Korson, McGregor, 1990]). In the object oriented reasoning of software development the whole of reality which is the subject of interest is modeled by way of objects. An object is what also a layman would understand as an object, for example a house, a street, but also a block of houses, a district, a collection of trees that belong to the same administrative domain, etcetera. An object is not only an entity that is concretely visible or describable, but it also consists of actions that the object can perform or that can be performed with the object. The object so to say 'knows' what can be done with it. Suppose we are talking about objects in a LIS. A house for example can be an object in a LIS, of which is known what its value is, how many floors it contains, what its status of maintenance is, etcetera. But also known is how it should be represented on a large scale map. Such a house 'knows' what can be done with it. That means that it knows as well what can be done with its graphical presentation, its geometrical projection on the map. It can be imagined that the house knows that it may be placed parallel to the road on that it knows as well that it may not be moved to the opposite side of the road.

The fact that within one object many properties and processes are described is generally known as 'encapsulation'. The fact that not every user needs to know all properties and processes that are hidden within the object and how those processes work is known as 'data abstraction'.

A land surveyor may look now in the following way to the filling of a LIS with objects. Each object has many properties and many actions that can be performed with it. The geometrical representation is one of the properties and a limited number of actions exists that can be performed with that geometrical representation. It is in the furnishing of information for the geometrical representation and in the definition of allowed actions that the land surveyor shows his expertise.

4. Local Structures

Geodetic computing techniques have developed with rapid strides in recent years, because of especially the application of computers. It has made it easier in common surveying work to compute the results of new measurements by first calculating internally with those measurements checking for correctness and consistency. Only afterwards the measurements are confronted with already available measurements and existing map information. The internal computation gives coordinates and quality information in a local reference system. Let us define a local reference system together with the objects that have been measured with reference to that system as a 'local structure'. Such a structure can be considered an object in itself.

To a local structure with its coordinates belongs a geometric quality description. What parameters should be used for such a description depends on the mathematical model that is used. The theory introduced by prof. Baarda (see e.g. [LGR, 1982]) from the Delft University of Technology for the description of precision and reliability of geodetic measurements is very suited for this aim.

If the local structure is considered an object then one should also define which actions can be performed on that object. An allowed action is for instance the fitting in of the local structure into a large scale map. But when is a fitting in still justified and when are the discrepancies too big? It depends on the geometric quality description of the local structure and on the quality description of the map. If those descriptions have been modeled well mathematically such a judgement can be automated to a reasonable extent. By application of the geometric quality description methodology of the Delft School it becomes possible to let a geometric object judge by itself if it fits to another geometric object, where a geometric object may be one house, one street, but also a large scale map.

A geometric object is in general a part of one or even more local structures. A LIS needs the geometrical quality description of this or these local structures to give the mentioned judgements.

Local structures can be a powerful tool for a LIS, especially when one considers updating of a LIS. The strength of a local structure lies in the fact that it may be seen as a representation of the original information from the measurements although these measurements have been translated to coordinates and other parameters according to the mathematical model used.

In a lecture the author held two years ago, see [Velsink, 1990], a comparison was made between the concept of local structures and the pieces of a jig-saw puzzle. A jig-saw is produced by having a complete picture on cardboard that is cut into pieces. You could also try to make each piece separately by cutting it according to its prescribed form. But then you would end up with a collection of pieces that do not fit together to form a complete picture. The reason is that each piece has minor deviations from its ideal form and neighbouring pieces will generally not have exactly the same deviations at their common boundary.

It is this same reason why land surveyors always start with a national control survey network and then work down to the local survey. In this way he can for example make maps on paper that do not show major distortions at the common map sheet boundaries.

But in a LIS the final product is not a map on paper but is a collection of coordinates that may be stored like local structures.

With modern geodetic computing techniques it is possible to first create the pieces, that is the local structures, and only afterwards compute them together to form the big picture, that is for example a complete map data base. This is possible because local structures are not as stiff as jig-saw pieces. Talking in terms of computing technique you could say that a jig-saw piece can only be translated along the x- and y-axes and rotated around the origin. In other words it can only perform a similarity transformation.

With the help of modern geodetic computing techniques however one has less problems to postprocess the similarity transformation of a local structure with a least squares adjustment and thus getting a much more smooth result. To perform the least squares adjustment one needs a stochastic model and therefore a good geometrical quality description.

This does not mean that one may forget to aim at a good internal geometric quality of the local structures, judging by the geometric quality description criteria developed by the faculty of Geodesy of the Delft University of Technology.

Having measured a local structure it is no problem to change the coordinates afterwards to make them fit to other local structures. This is quite a difference from the concept of maps on paper which have to be put together and then show differences at the map sheet boundaries.

As one of the main advantages of the object oriented approach in software development is considered the possibility of re-use of once written software. In the same way it is important that once surveyed information can be re-used whenever that may be useful, eventually in an adapted or corrected form. It is then important that information on source and quality of the information is available. Nowadays it is however quite common that information in a LIS is stored as one great heap from which one cannot derive what was the source and quality of individual pieces of information.

Surveying information can be available in many forms. Not only many measuring techniques exist but also many types of measurement. Surveying information may come from the original field sketches the land surveyor made in the field. Experience in the Netherlands shows that there is a great demand for the field sketches even though it is in a rather unpolished form. Often information is available on planned building activities via building specifications. It may even be possible to use information from small scale maps as a coarse basis for applications with large scale maps.

Each of these sources of surveying information has its own quality and application possibilities. It is therefore advisable to store this information by way of local structures so that it can be used when the moment is right.

It should be noted here that a large scale map can be seen as a collection of local structures that have been joined together. Of each local structure geometric quality information is available.

In this view much less necessity exists to demand from a large scale map that it be of a homogeneous and high quality. Surveyed information is collected from different sources and stored together and it is used with a specific purpose in mind. Later use can be made of it, but it is then adapted and extended according to the special purpose of that moment.

5. An Example of Local Structures

To illustrate the use of local structures let us consider the map data base of a cadastral service. When creating such a data base for the first time they may not be felt any need to differentiate in local structures or to register accurately the sources and quality of the input. But when such a map data base has to be updated a land surveyor produces a field sketch and he tries to fit his measurements into the map data base at the office. One advantage of having used local structures is that it is very useful to know the quality of the information the data base contains to be able to judge appearing discrepancies.

Moreover a general concept like a local structure can make the updating process of the map data base more standardized and more automated, because the coordinates and their geometric quality description are in a standardized format. Therefore fitting in the coordinates and judging discrepancies may be done with extensive support by the software of the LIS.

And let us now consider the case that a measured boundary has to be reconstructed in the field after some years. Then it is very useful to have the possibility to use the original information that is stored in the local structures. In that case the land surveyor might even want to connect several local structures that have been measured in the course of many years. Such a connection can be done via similarity transformations. The resulting coordinates of the combined local structures can be used to generate the information that is needed to stake out the old boundary.

If the updating measurements are stored together with the map data base in a LIS by way of local structures also outdoor users of the cadastral data base are able to use more accurate information than is contained in the map data base itself.

6. Graphical Editing

The phenomenon LIS has grown from the thought that map production should be automated. In this line of thought a land surveyor determines the positions of points whereafter those points are connected to form lines. Discrepancies result for example from the fact that points do not coincide where they should or that lines are not parallel where they ought to be.

In an object oriented approach however not two lines should be parallel, but a house should be parallel to a road. This means that one looks at a LIS as a collection of objects that have to be handled. The concepts of encapsulation and data abstraction make it easier for a user to handle the objects because much information on the attributes of the objects and of allowed actions on the object is contained in the object definition. Using that information the LIS can decide itself in many cases where otherwise it should first consult the user.

In case a LIS must decide if certain geometric discrepancies are acceptable it should consult the information contained in the objects. These objects are part of one or more local structures. Using the reference to the geometric quality descriptions of these local structures the LIS can judge if existing discrepancies are acceptable.

Returning to the example of the house that should be parallel to a road, the LIS must be able to control the change of the geometrical representation of the house in such a way that the house is in its right position. The operator gives for instance the command: MOVE house PARALLEL TO road. The LIS must now be able to judge if this is justified by means of the geometric quality descriptions of these objects and of the local structures to which they belong. So it is not any more the operator in front of his graphics terminal who picks up a line and moves it to a better position and judges if this is justified with the help of his land surveying expertise.

The well-known commands to manipulate graphical elements on a graphics terminal should therefore disappear or their use should at least be minimized in favour of manipulation commands of geometric objects that are controlled by geodetic computing techniques and criteria.

7. Conclusions

The emergence of Land Information Systems in combination with the coming of many new instrumentation and surveying technologies has given rise to the question if the quality of the geometric information of large scale maps can still be controlled by the land surveyor. It is argued that it will be necessary to store with the information in a LIS also information on the geometric quality. Parameters on precision and reliability as they have been developed by the faculty of Geodesy of the Delft University of Technology are very appropriate for this purpose and could especially be applied to local structures as they are defined in this presentation. In this context it is specifically the geodetic computing technique of joining coordinate point fields by way of similarity and analogous transformations that will become of great importance.

Storing information on geometric quality is not enough to ensure geometric quality control of a LIS. Maintenance and editing of geometrical information in a LIS has to be seen as handling the geometrical representations of objects. In the definition of these objects information must be contained on the editing actions that one may perform on the objects.

When advanced geodetic computing techniques are to be applied in Land Information Systems it is important that they are automated as much as possible so that the land surveyor can concentrate on the application of these techniques rather than on using them in bothersome calculations by hand. These techniques ought to be an integrated part of the object definitions in the LIS.

When such advanced techniques will have come in common use the demand for criteria and standards for geometric information can be more easily answered by reference to the hand books of the software.

A national standard could then confine itself to mentioning existing software and how it can be used to define criteria for a specific project.

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Data Quality

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Introduction

The function of all data management systems is to produce information in support of decision making. The growth of geographic information system technology and the many and varied applications of land and geographic information systems have opened up new opportunities. They have also created new risks since the quality of the decisions made can be strongly influenced by the quality of the data upon which they are based. With bad information there is a high probability of making bad decisions while with good information there is a significant reduction in the risk that wrong decisions will occur. Risk can only be reduced if the quality of the information that is offered to the decision maker is suitable for the purpose for which it is being used.

Data quality is an issue of management. Throughout all sectors of professional and commercial practice there is growing pressure to demonstrate total quality management and the adoption of quality assurance procedures. The European Community, for example, is pressing for quality assurance from all those tendering in the procurement of goods and services. Land information systems will not be exempt from this directive and although information is unlike other goods, it too can be subject to quality control. The British Standard BS 5750, the UK equivalent of ISO 9000, regards "quality" as being "fitness for purpose" or "safe in use" and is "the totality of features and characteristics of a product or service that bear on its ability to satisfy a given need".

Quality assurance encompasses a number of activities from quality audit ("the independent examination of quality to provide information") through quality control and quality procedures to quality systems. The latter is defined in British Standard BS 4778 as "the organization structure, responsibilities, activities, resources and events that together provide organized procedures and methods of implementation to ensure the capability of the organization to meet quality requirements". The whole process of ensuring quality is essentially a matter of management, the term 'Total Quality Management' (TQM) reflecting accurately what is involved. The International Federation of Surveyors (FIG) is currently undertaking a review of TQM throughout its members in an attempt to determine what legislation is currently available and to what extent countries are already insisting on quality assurance and quality control in the procurement of goods and services. This paper examines some of the characteristics of spatial data that need to be considered by those responsible for their management.

Categories of spatial data.

Data within a land information system consists of objects and attributes, the latter including locational information. The United Kingdom National Transfer Format (NTF, 1989) defines an object as

"A collection of entities which form a higher entity within a specific data model. For example a group of entities defining a drainage system".

An entity is defined as

"something about which data are stored in a data bank or data base. For example, building, tree. The data may consist of relationships, attributes, positional and shape information etc. Often synonymous with 'feature'".

An attribute is defined as

"a property of an entity, usually used to refer to a non-spatial qualification of a spatially referenced entity. For example, a descriptive code indicating what an entity represents, or how it should be portrayed".

In this definition, a coordinate is not considered as an attribute. Other authors include coordinates within the definition of an attribute.

Objects may be classified in many different ways - one example being into nominal, ordinal, interval and ratio. Nominal data are in distinct classes such as in the periodic table where elements can be precisely categorised or natural species placed in a taxonomy based on specific criteria. For spatial data however there is no single agreed taxonomy and items can be classified in many different ways. With ordinal data there is an hierarchy so that data can be ranked in some order of precedence though with no precision of measurement. For instance when generalizing map features such as a road beside a railway beside a river, there has to be some priority as to which feature is displaced most when compiling the data at smaller scale. The nominal data 'road', 'railway' and 'river' must be ranked in order to guide the cartographer.

Interval data can be measured on a scale that quantifies this ranking while ratio data are based on scales that have an absolute zero. Thus centigrade is an interval scale since it measures the difference in temperature between two objects. It is not however a ratio scale since 20 degrees C is not twice as hot as 10 degrees C as would be the case if measurements were taken from absolute zero.

Data may also be categorised as primary or secondary depending on whether they come from direct observation or from secondary sources. The origin or lineage of data will influence their overall quality, the Second Law of Thermodynamics governing the way that entropy increases; hence random errors degrade the quality of data unless additional information is provided. Primary data are

not however necessarily those nearest to the truth - theoretically at least, the adjusted values of survey observations are more nearly correct than the raw data. In land surveying, which is essentially a primary data gathering activity, much effort is placed on analyzing and reducing errors in positional measurement. Less attention is paid to data classification.

Ambiguities in the definition of terms are only now becoming apparent as data are exchanged electronically. The distinction between a river and a stream may be of little importance to a cartographer drawing a single blue line on a map but when the data are classified and stored in a data base, the differences in their meaning become significant. In many jurisdictions, the area of land defined by rights of ownership may differ from the area that is in practice used by the occupier, and from that which is taxed by the fiscal authority. The lawyer will be concerned with the areas of ownership, the planner with areas of use and the tax officer with areas for assessment. Depending on the application, a different type of land parcel will be identified. In like manner, a statistic such as floor or office space may be taken to include only usable space or the whole curtilage of a building; the rent charged could be significantly different depending on how the statistic is derived.

Recent research (Land, 1991) has suggested that so complex and controversial are the issues in data classification that the only way to proceed is through a thesaurus, laying down definitions, broader terms and narrower terms. Each user can then operate an independent system for internal applications while when exchanging data reference should be made to the thesaurus. Even then ambiguities can remain, for instance the distinction between an object and an attribute depends on the user. Soil may be an attribute of a land parcel for the planner but may be the object of study for a soil scientist.

Data Accuracy

The accuracy of spatial data may be a matter of geometry, a matter of semantics or a combination of both. A line on a map that marks the edge of a wood may be incorrect because of the quality of the survey (geometry) or because of ambiguities in the definition of what constitutes a wood (semantics) - rarely is there a clearly defined line on the ground or on an aerial photograph that marks the boundary of a wooded area. Woodland and its neighbouring territory (for instance grazing land for cattle) represent fuzzy sets and however precise the survey, the line between them may be fuzzy and hence in geometric terms relatively inaccurate. Spatial data base management systems have to deal with such fuzzy sets, fuzziness being an inherent quality of much spatial data. Various attempts are being made to assess the overall accuracy of spatial data bases (see for example Goodchild and Gupta, 1989) but many of the issues remain unresolved.

While uncertainty in meaning is difficult to quantify, positional accuracy has been regarded as being measurable. Nonetheless there is growing confusion. The normal methods for describing the accuracy of a land survey are either in terms of proportional measurement (1 part in 10,000 of the distance) or in terms of the absolute positional error as defined by the size of an 'error ellipse'. The latter refers to the locational accuracy of a point. Some have extended this idea to an 'epsilon band' giving a thickness to a line within which the true position of a boundary lies. Whereas the proportional method is satisfactory for a single distance measurement, since it is a one dimensional quantity expressing an error in a one dimensional linear measurement, it is less satisfactory when related to vector rather than undirected distance measurement. It also, normally, only represents accumulated error, for instance at the end of a traverse. The effectiveness of the description of locational error as a ratio is also range dependent, it being inappropriate over very short distances where it may unrealistic while becoming misleading over very long distances. The parameter can, of course, be modified to the form "1 part in 10,000 of the distance plus or minus 100 mm" but this ceases to be meaningful over long ranges.

Definitions of accuracy in terms of error ellipses are similarly misleading since they imply error in relation to the origin of the system. A coordinate that is accurate to say, plus or minus one centimetre is only that accurate relative to nearby points; it cannot be that accurate in relation to points hundreds of kilometres away. There is however a further dilemma. Given two points A and B and a third point C midway between them, each with an error ellipse of defined size, the tolerance may allow C to be one side or the other of the precise line from A to B. Yet in much work in land and geographic information systems, topology is of great importance and which side of the line AB that the point C lies is more significant than its error ellipse. There are no parameters for measuring topology. The well known London Underground map shows stations in their correct topological positions. Can any one version of such a map be said to be better than any other, in terms of 'accuracy'?

A similar problem arises with map generalization. There are many algorithms available that can take large scale map data and redraw them at smaller scale. What constitutes accuracy in generalized spatial data? Likewise, what constitutes the best measure of accuracy of a three dimensional digital elevation model of the surface of the earth? The root mean square error of the residuals at points of known height is a very weak indicator of the overall qualities of the surface that has been modelled. Many algorithms exist to interpolate the surface from a number of primary observations and there are of course national standards of map accuracy for assessing the reliability of contour lines (such as their position must be accurate to within a standard error of one third of the contour interval). Given the fact that no two

algorithms will create the same surface, which algorithm is the better? When faced with two versions of a contoured surface derived from exactly the same source data, how can the user tell which is the more accurate?

Data are often dynamic, that is they change over time. Maps soon get out of date and are, at best, only accurate at a particular instant which is normally well before the date of publication. Most maps are of varying accuracy and reliability. In many countries, maps are only revised when they are so out of date as to be no longer useful. How does one measure the quality of 'out-of-datedness' of a map? Does it matter on a large scale urban map if some minor extensions to buildings have not been added to the map? At what point has the data quality become so degraded that it becomes necessary to incorporate change? Some data bases, for instance those containing aerial photographs, contain archival material, representing information at a particular moment. Such data bases can be 'date stamped' and retained for future historical research. For many maps, however, the data they contain should always be kept up to date.

Data currency and completeness are related, an out of date data set and an incomplete data set being equally as dangerous to the decision maker. Whereas it is possible to evaluate the quality of those data that are present on a map or in a data base, it is more difficult to know what has been omitted or what has changed. Some data will be omitted by accident, others on purpose, either for reasons of cost or prioritization or for what may loosely be described as political reasons. Thus some strategic information may be deliberately withheld or data of a confidential nature concealed. All decisions as to what to include and what to exclude affect the quality of the data as perceived by the user. The criteria for such decisions are in general not recorded in the history of the data base.

Data Access

The quality of data is however not just a matter of position and attributes, nor of completeness and currency. The accessibility of the data is of crucial importance. Control of access to data may be necessary for social or political reasons, for instance to protect privacy, or to prevent data degradation through computer viruses or the deliberate removal or alteration of data within a data base. Confidentiality of data is difficult to define since it may relate to information that if released would cause grave harm to an individual or even society at large; or that the information would give competitive advantage to another organization; or that its disclosure would cause political embarrassment if it fell into the wrong hands. Confidentiality may change with time - thus a list of the tenders placed for a particular job would be confidential until the closing date after which the information may move into the public domain, even though on its own it has not changed. Hence the context within which the data are viewed are as much a characteristic of

data quality as their meaning and location. Sometimes data that are aggregated to conceal individual items - such as census data - can become disaggregated when combined with other data sets. The intersection of two data sets can occasionally reveal information of a confidential nature that was not apparent when the sets were held separately. There can be inherent characteristics in data of which the data base manager may not even be aware.

An important quality of data is their price. Given the high cost of data acquisition - estimates have suggested that 70% - 80% of the up-front costs in setting up a land or geographic information system can come from data capture - then it is logical to look for ways to share data and minimise the expense of data conversion. Much is heard about the need to avoid 'reinventing wheels' yet much time and effort is spent on converting the same raw data into digital form. When data are shared, as through a wide area network, it is not unreasonable for the user to contribute towards the costs of the data producer. Too high a price will discourage the user and result either in a failure to use valuable information or else in duplication of effort through the user carrying out his or her own data conversion. Too low a price will discourage data producers from offering their data to the network. The market for spatial data is already distorted since many governments have by tradition offered map based products at highly subsidised rates. Few countries have market-oriented policies for trading in government held spatial information and hence the private sector has difficulty in getting a fair return for surveying and mapping products, other than in a mass market such as the sale of atlases. There are exceptions - such as the on-line access to the Swedish Real Estate Data Base where inquirers are automatically billed for the information that they request. In general, however, wide area network access is growing only very slowly.

Some countries have a Freedom of Information Act that allows the public access to all but the most sensitive material, often at no more than the cost of making a copy. Others have no such Act - in the United Kingdom, for example, in spite of four years activity by a Tradeable Information Initiative Working Group, only now is 'information about information' being compiled so that a list of over 400 data bases held by government departments will be put into the public domain. Whereas the existence of these data sets will become public knowledge, access to them may still be restricted.

All data have an intellectual quality. Like other items of property, data are owned by someone or some organization. Intellectual property rights may be protected through copyright law. The UK Copyright, Designs and Patents Act, 1988 extends protection to all literary works. These are taken to mean any works, other than dramatic or musical works (which are separately protected) that are written, spoken or sung and accordingly include (a) tables or compilations, and (b) computer programs. Graphic works, such as paintings,

drawings, diagrams, maps, charts and plans are specifically included. The extent to which copyright exists in derived data remains somewhat obscure. It is clear that digital map data, for example, are protected and that if they were transformed, for instance through a change of projection, the copyright would still be vested in the originator - just as an author retains the copyright in a book that is translated into a different language.

If, however, new data are produced that do not exist as such in the original, for example the coordinates of the centre line of a road calculated from the digital outline of the road casing or a digital terrain model derived from a set of spot heights taken from a map, who then owns the copyright? The UK Act defines copying as including the storing of a work in any medium by electronic means and that copying of work includes the making of copies which are transient or are incidental to some other use of the work. Hence every time that a digital map is shown on a screen this is making a copy and may be an infringement of copyright. Every time that a user looks at a paper print of a map, this does not constitute making a copy and is not a breach of copyright. Digital data thus have qualities that differ from those of traditional manual based systems.

Data may have a legal status. Thus in many land registration systems, the correctness of the data is paramount and compensation may be payable if errors occur. The information held on land ownership may be subject to a State backed guarantee, the register providing the definitive statement about who owns what piece of land. To protect the data, access may be restricted. - in England and Wales, until the end of 1990, data on land ownership were treated as secret by Her Majesty's Land Registry although today access to ownership information (though not the price paid for property) is now allowed on payment of an appropriate fee.

In other circumstances, spatial information may not be guaranteed - thus the Guidelines issued by the Department of Trade and Industry (DTI, 1990) recommend that Government Departments should issue a disclaimer to the effect that "No warranty is given by the Data Provider or Controller as to the accuracy or comprehensiveness of the Data". This is consistent with the principle of 'caveat emptor', or 'let the buyer beware'. It is contrary to much consumer legislation which states that the producer or vendor will be held liable for defective products until such time as the purchaser can be proved to be the cause of any defect. There have been suggestions within the European Community that information and data should be put on the same footing as other products and services that are consumed by the public and that the doctrine of 'caveat emptor' should be reversed. The data producer can be protected against charges of negligence through professional indemnity insurance and the public can be paid fair compensation if the data that they use are incorrect and give rise to loss.

The problem is that what is necessary and sufficient for one user may be inadequate for another. Those responsible for managing the data cannot know and accommodate all the uses to which the data will be put. Within one organization, those responsible for operational control will require accurate, detailed and up to date information to meet well defined objectives. Those concerned with strategic planning within the same organization may need less accurate, more generalized and aggregated data, often of an historical nature to meet ill-defined and broad objectives. Each type of manager will need very different types and qualities of data.

Conclusions

This paper has attempted to explore a number of issues that are associated with data quality. Some of these depend as much upon the user of the data as upon the producer. Data need to be to an acceptable quality level. Reasonable standards are needed for the positional and attribute accuracy of the data and for the completeness of data sets. The data must at least be logically consistent. In addition to technical criteria, there is a range of institutional issues that also need to be considered, such as copyright, confidentiality and price all of which affect the usefulness of the data and their suitability for the purposes for which they are to be used.

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Accuracies of the digital Danish cadastral map

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1. Introduction.

In 1986 the National Survey and Cadastre of Denmark started a project to convert the old analogue cadastral maps to digital form.

The project included specifications, choice of hardware and software, development of special software, education etc. The actual production has been going on now for a couple of years.

To day the digital map is the official cadastral map in 12 municipalities.

By the end of this year approx. 10 % of the country will be covered by digital cadastral maps.

The economy, to go on in the rest of the country, has not been settled yet. If the suggestions are agreed upon, it should be possible to finish the rest of the country before the turn of the century, possibly by giving out some of the work in private enterprise.

2. Principles for building up the digital cadastral map.

The ideas behind the creation of a digital cadastral map, have been described earlier, also in OEEPE connections [1].

The following is only ment as a brief introduction, to give sufficient background for the discussion on the accuracy obtained.

The elements used for building up the map are:

1. renovated/recalculated control points
2. measurements to the boundaries from the archives
3. the analogue cadastral map
4. information from the field (orthophotos/topographic maps)
5. cadastral know how

When building up the map, you start with the control points, of which we have approx. 330.000 in the whole country.

On top of them you construct the measurements to the boundaries. Not all the measurements are used. We estimate that there are 1 mio. measurement sheets in the archives.

The rest of the map is digitized from the analogue maps, of which approx. 90% are island maps. The whole country is covered by analogue maps. We have approx. 15.000 map sheets, most of them in scale 1:4000.

The digitized parts are transformed into the map using the constructed "skeleton map". Also the field informations, from the orthofotos or topographic maps, are used in this process.

Finally the outer boundaries of the island maps are adjusted to each other using measurements and - mainly - the map informations from the field.

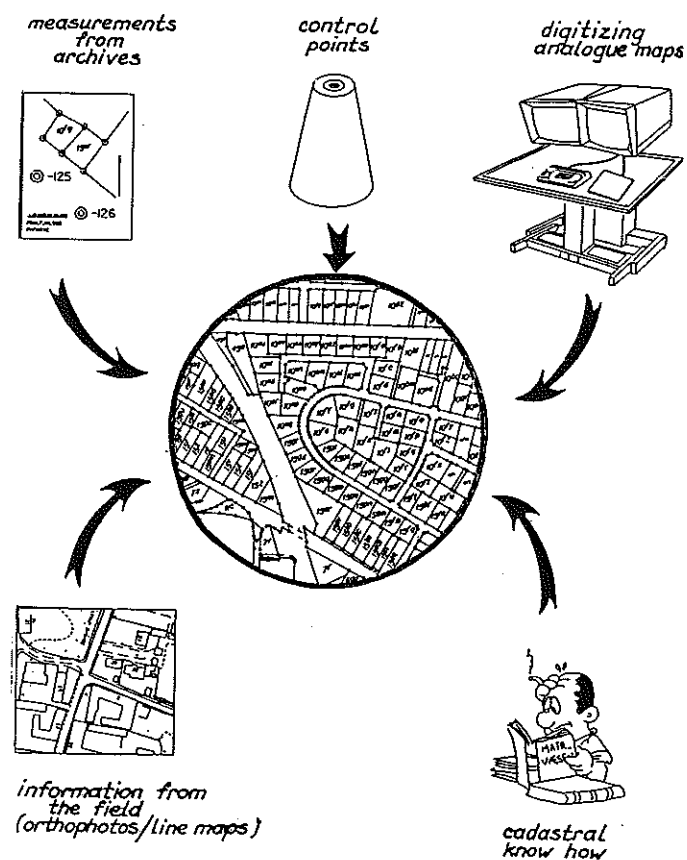


Fig. 1: Elements used in building up the map.

3. Sources of errors.

The gross errors are not considered in this connection, although of course they do occur. They have to be found and corrected in the production routines.

The accuracy of the final map is determined by the elements mentioned above, the equipment used and the persons doing the work.

The control points have been recalculated and have an accuracy which, in this connection, is very high.

When using measurements you also get a very high accuracy in the map. You could say that you use the scale 1:1.

When digitizing of course the accuracy is much lower. The digitizing table, the person using it and the accuracy of the old analogue map all influence the result. It is very difficult to give an exact figure, but the resulting rms of a digitized point will probably be between $\frac{1}{2}$ and 1 m in the field for maps in 1:4000 using high precision digitizing tables.

In the end this means that you get a digital map with a very inhomogeneous accuracy.

4. User information - classes of accuracy.

To use an inhomogeneous map of course is a challenge! It has therefore been a request from some of the users, to have the rms for each point available as associated data to the graphic presentation.

We did not feel, that it was possible to fulfil that wish, so instead we decided to register informations on how the actual point was put into the new map. To do so we created 8 classes of origin. The number of the actual class is tied to each point during the conversion of the map.

The classes depend on 3 things:

1. is the point digitized or measured in the field?
2. which points are used as paspoints for the transformation?
3. is the analogue map of a special high quality (recently reconstructed maps)?

The classes range from 0 (control points) to 8 (points digitized from old maps).

A special class is class no. 5, which includes "natural" points, chosen from the orthophoto or the topographic map. The points are chosen either by digitizing or, in case the map is digital, by pointing out the "natural" point.

The computersystem is designed to attach the right class number to the points, in connection with the transformation procedure.

The person doing the conversion do not have to think about the classes at all.

The logic is quite simple in fact, as can be seen from fig.2 below.

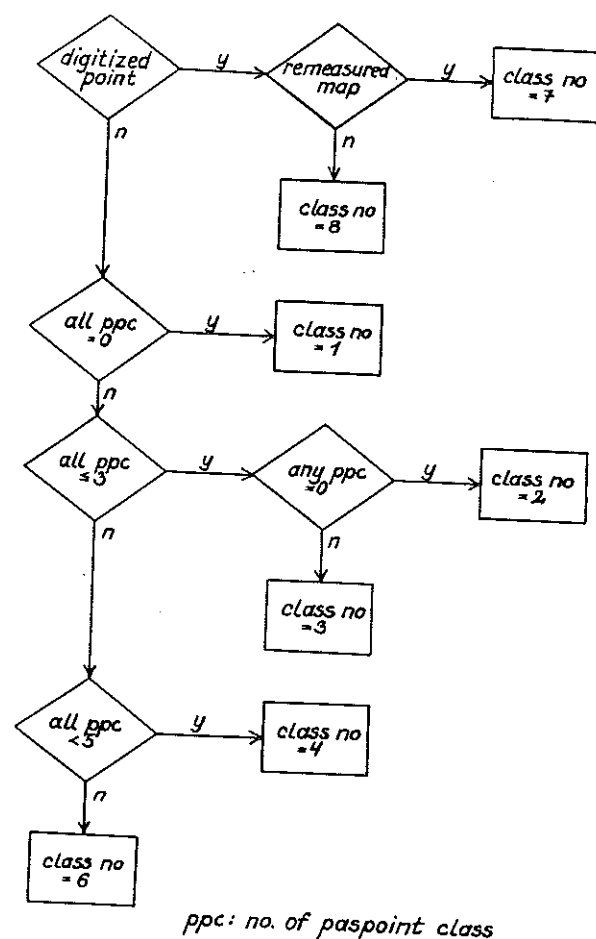


Fig. 2: Diagram for appointing classes

5. An approximate value of the rms.

Although we stick to the classes as user information, we have tried to get a measure for the accuracy of the points within the individual classes.

Each transformation provide us with a rms, and by adding up these values for each class, you get an expression in cm in the field, saying something about the accuracy.

From a theoretical point of view you may argue, that you do not get a proper rms in that way. For most of the transformations

the paspoints are not error-free, and you will get correlations, which are not taken into considerations.

The classes were never designed with the rms in mind, and you can get a lot of discussion on, what the figures really means and stand for.

Never the less I risk to use these results to get an idea, more than an accurate expression, of the accuracy of the points in the final map.

For Helmert transformations, only transformations on 4 points and more are included in the report below. For affine transformations at least 5 points have been demanded.

Table of rms values

class no.	1	2	3	4	6	7	8
rms (m)	0.09	0.25	0.42	1.13	1.71	0.84	4.62
no. of points	22.167	2.074	852	273	231	4.482	42.392
redundances	15.599	1.485	561	193	150	3.855	32.630
transf. points	measured					digitized from maps < new > < old >	
paspoints	control points incl.		transformed points < nat. pts. >				

6. Conclusions

As expected you get a large variation in accuracy going from one class to another.

With the exception of class no.7, the order of classes reflects the same order in accuracy.

Compared to the results you get when using measurement, it seems justified to digitize only, where new reconstructed analogue cadastral maps are available.

On the other hand you get a low accuracy digitizing old maps.

In the discussions concerning a digital cadastral map, economy plays a still more important role, at least in Denmark.

There is no doubt, that it is easier and quicker to digitize

the existing maps than it is to include measurements, even if you have the measurements in house.

Therefore the most important factor when talking accuracy is money. Which accuracy can we afford?

The loss of accuracy when moving down through the classes, clearly indicates that you do not get more than you pay for.

Copenhagen, August 1991

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Jonna Hvidegaard
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Lausanne 9-11 September 1987

Zur Qualitätsprüfung graphischer Daten in großmaßstäbigen raumbezogenen Informationssystemen

Quality check up of spatial data in large scale information systems

v. H.W. Stöppler, Bonn

Manuskript zum Vortrag beim FIG-Symposium in Innsbruck, 30.9.1991

Zusammenfassung: Die Verarbeitung von Daten in raumbezogenen großmaßstäbigen Informationssystemen und insbesondere der Datenaustausch erfordern Qualitätskriterien für die Richtigkeit der Daten. Die Einhaltung der Kriterien ist durch Prüfungen sicherzustellen. Als Grundsatz gilt, daß die digitalen Daten mit ihrer fachlichen Definition übereinstimmen müssen. Die Prüfung dieser Übereinstimmung erfordert hauptsächlich allgemeine geometrische Prüfungen und fachlich-semantiche Prüfungen. Notwendiger und möglicher Prüfungsumfang werden auf der Grundlage praktischer Erfahrungen am Prüfungskonzept der Automatisierten Liegenschaftskarte (ALK) aufgezeigt.

Summary: Digital spatial informations must be well defined in geographic information systems (GIS). There is a strong need for quality check ups in data processing, for storing in open data bases and for data exchange between different systems as well as for all kinds of official and private use. Therefore criteria are necessary to define the quality of these spatial informations (spatial objects). The main criterion is the conformity of the internal digital objects with their external definition. Checking up these criteria mainly means general geometrically and special semantically object-checking. Based on experiences with the 'Automatisierte Liegenschaftskarte (ALK)' necessary and possible object-checkings in large scale information systems are pointed out.

1 Prüfungsgrundsätze

Raumbezogene Datenbestände, die einer Vielzahl von Nutzern für unterschiedliche Zwecke zur Verfügung stehen (Basisdatenbestände), werden heute in Datenbanken vorgehalten, mit Datenbankverwaltungssystemen verwaltet sowie mehr und mehr über Datennetze mit Serverkonzepten den verschiedenen Nutzern zur Verfügung gestellt. Für die Beschreibung und für die Mitteilung über die Qualität der vorgehaltenen und auszutauschenden Informationen (und dies ist mehr als nur die Frage der Genauigkeit) gibt es bisher keine allgemeinen Kriterien.

Ein Problem der Definition von solchen Kriterien liegt sicherlich darin, daß Datenbestände über Verarbeitungsketten entstehen und Ergebnisse sich wiederum als Folge von Arbeitsketten präsentieren. Es liegt nahe, daß sich bei diesen komplexen Arbeitsabläufen im Fehlerfalle Verantwortlichkeiten gegenseitig zugeschoben werden ('Keiner will es gewesen sein'). Unter diesem Gesichtspunkt liegt es auch wiederum nahe, zumindest eine Stelle festzulegen, bei der die Daten aufgrund bekannter Kriterien abschließend geprüft sind. Diese Stelle kann nur bei den Datenverwaltungs- und Datenverarbeitungsprogrammen des Datenbestandes bzw. Datennachweises selbst liegen. Die Prüfung setzt fachliche und organisatorische Regelungen voraus, die die Übereinstimmung der digitalen Informationen mit der Realwelt und Modellwelt weitgehend sichern.

Zum Prüfungsumfeld

Ein Datenbestand ist richtig, wenn er mit allen seinen fachlichen Definitionen und dv-technischen Festlegungen übereinstimmt. Dieser Qualitätsansatz zeigt bereits auf, daß die Richtigkeit eines Datenbestandes nicht durch eine Prüfung allein, sondern nur durch eine abgestimmte Summe von Prüfungen erreichbar ist. Den inneren Kern dieser Prüfungen bilden diejenigen Maßnahmen, die den Datennachweis selbst auf Übereinstimmung mit seinen externen Festlegungen und auf Widerspruchsfreiheit prüfen.

Art und Umfang der Prüfungen hängen sicherlich vom Inhalt und von der Struktur des jeweiligen Informationssystems ab. Als Beispiel für ein raumbezogenes Informationssystem und seine Qualitätsprüfungen sei die Automatisierte Liegenschaftskarte (ALK) herangezogen. Sie ist ein Basisinformationssystem für großmaßstäbige Grundrißinformationen auf der Grundlage des Liegenschaftskatasters. Die ALK besteht aus dem Datenbankteil, dem Verarbeitungsteil und einer vermittelnden Schnittstelle.

Im Datenbankteil werden Punktinformationen (Punktdatei) und Grundrißinformationen (Grundrißdatei) mit Hilfe eines Datenbankverwaltungssystems verwaltet. Die Einrichtung, Fortführung und Benutzung dieser Dateien, einschließlich der dabei erforderlichen Qualitätsprüfungen, werden mit speziellen Anwendungsprogrammen (Datenbankverarbeitung) durchgeführt.

Die Grundrißinformationen sind als Grundrißobjekte (objektorientierter Ansatz) strukturiert, wobei ein Objekt jeweils eine fachlich zusammengehörige Menge von raumbezogenen Informationen ist (z. Bsp. ein Flurstück, ein Gebäude, eine Leitung). Grundrißobjekte können mit Sachdaten über Verknüpfungselemente verknüpft sein. Die Grundrißobjekte sind fachlich definiert in einem Objektabbildungskatalog (OBAB). Die Gesamtheit der Grundrißobjekte bildet den Grundrißnachweis.

Der Verarbeitungsteil besteht aus fachlichen Funktionsbereichen mit Programm- und Datenbereichen für geodätische Berechnungen, graphisch-interaktives Arbeiten (ALK-GIAP), Offline-Digitalisierung und Antragsverwaltungsfunktionen. Der Verarbeitungsteil führt die Kommunikation mit dem Sachbearbeiter am Arbeitsplatz durch.

Verarbeitungsteil und Datenbankteil kommunizieren miteinander über Aufträge, die in dem Format der Einheitlichen Datenbank-Schnittstelle (EDBS) ausgetauscht werden. Die EDBS ist daher eine Daten- und Funktionsschnittstelle.

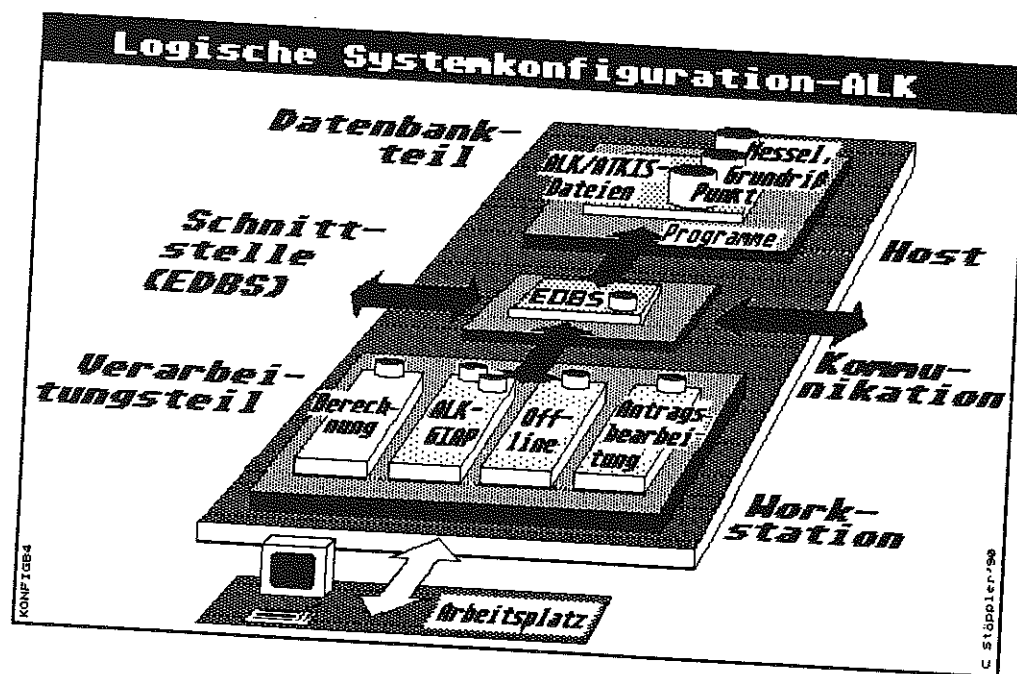


Abb. 1: Systemkonzeption der Automatisierten Liegenschaftskarte (ALK)

In dieser ALK-Systemkonfiguration werden die beschreibenden Daten (Sachdaten wie z. Bsp. Daten des Liegenschaftsbuches) von der jeweils zuständigen Stelle mit eigenständigen Programmsystemen geführt. Qualitätsprüfungen, die auf dem Grundrißnachweis im Datenbankteil aufsetzen, lassen sich gruppieren in

- die Berechtigungsprüfung: Sie prüft formal, inhaltlich und räumlich ab, ob nur die dafür berechtigten Personen bzw. Stellen Grundrißdaten eintragen, fortführen oder benutzen.
- die Objektprüfung: Sie prüft ab, ob das einzelne Grundrißobjekt mit seinen fachlichen Definitionen übereinstimmt.
- die Simulationsprüfung: Sie prüft durch verfahrenstechnische Maßnahmen ab, ob eine fachlich zusammengehörige Menge von Grundrißobjekten in ihrem Kontext vollständig und richtig fortgeführt wird.
- die Integrationsprüfung: Sie prüft durch verfahrens- und programmtechnische Maßnahmen ab, ob eine fachlich zusammengehörige Menge von Grundrißobjekten und Sachdaten in ihrem Kontext vollständig und richtig fortgeführt wird.

Weitere Prüfungen im Umfeld des Grundrißnachweises sind Prüfungen im Verarbeitungsteil (Vorverarbeitung), Prüfungen durch Schnittstellenumsetzer beim Datenaustausch und Sachbearbeiterprüfungen.

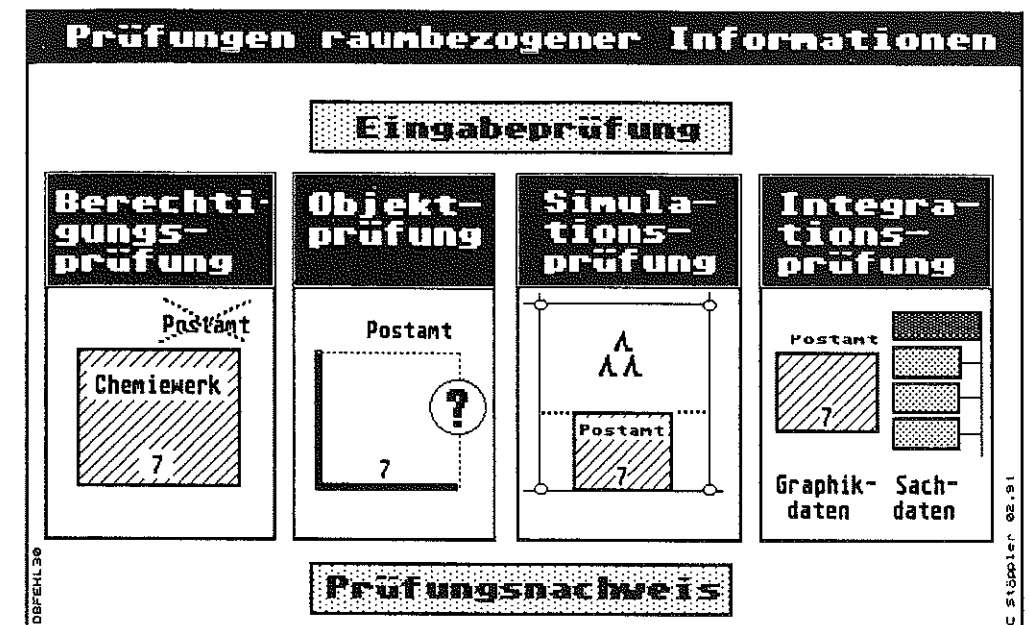


Abb. 2: Allgemeine Prüfungsbereiche in raumbezogenen Informationssystemen

Im Rahmen der für dieses Referat zur Verfügung stehenden Präsentationszeit von 15 Minuten und in anbetracht der Komplexität des Stoffes ruht der Schwerpunkt meiner Darstellung auf dem Bereich der Objektprüfung der großmaßstäbigen Grundrißinformationen im Grundrißnachweis. Die anderen Qualitäts- und Prüfungsanforderungen werden nur angerissen.

2 Objektprüfung

Ziel der Objektprüfung ist es, den Datenbestand des Grundrißnachweises bei der Ersteinrichtung

und bei jeder weiteren Fortführung zu überprüfen auf die Übereinstimmung mit den im Objektabbildungskatalog fachlich definierten Grundrißobjekten. Diese Zielsetzung erfordert eine Reihe aufeinander abgestimmter Einzelprüfungen. Die Objektprüfung besteht daher aus anwendungsunabhängigen Überprüfungen der Objektdefinitionen durch Geometrieprüfungen und aus anwendungsabhängigen Überprüfungen der fachlichen Inhalte der Objektdefinitionen durch Datenelementprüfungen (Fortführungsarten).

OBAB - LiegKat											Folie 081 Flurstücke
Funktion des Objekts				Besondere Information zum Objekt						F-L1	
0- Art	Bezeichnung	0- TY	0- KO	0- IN	K- TY	0- Art	Text d. Inform. bzw. Hinweise	K/M	AG	0- Art	Am.
1	2	3	4	5	6	7	8	9	10	11	12
0233	Flurstück	F	P	13	KX	0233 oder 0234	Kennung FL-Datei und Flurstücks- kennzeichen	M	51	0233 0235 0245 0248	13
DARSTELLUNGSMUSTER											
				31	KX	0291	Zugehörigkeitsh.	K	53		
				31	KX	0292	Zuordnungspfeil	K	11 15		
1) Ein Standardaggregat je Kartenzeichen											

Abb. 3: Fachliche Objektdefinition im Objektabbildungskatalog (OBAB)

2.1 Geometrieprüfungen

Die geometrischen Prüfungen der Datenbankverarbeitung sind anwendungsunabhängige Überprüfungen der geometrischen Konsistenz des Grundrißnachweises bei der Ersteinrichtung und bei jeder Veränderung: 1. die Integrationsprüfung Punkt- und Grundrißdatei, 2. die Geometriebehandlung, 3. die Objektprüfung entsprechend dem Objekttyp und 4. die Prüfung auf Flächendeckung bei Folien mit flächendeckendem Nachweis.

2.1.1 Integration Punkt- und Grundrißdatei

Die Punktdati kann aufgrund ihrer Attributinformationen im Gegensatz zu einer reinen 'Koordinatendati' als herausgehobene Fach- bzw. Sachdati zur Grundrißdati aufgefaßt werden. Ein Punkt kann außerdem mit mehreren Lagekoordinaten geführt werden (z. Bsp. aufgrund von Erneuerungen im Trigonometrischen Festpunktfeld). Damit stellen sich besondere Integrationsanforderungen. Die geometrische Integration von Punkt- und Grundrißdati erfordert somit die ständige definierte Koordinatenidentität zwischen bestimmten Lagekoordinaten eines Punktes der Punktdati und ihrem Nachweis in der Grundrißdati. Typische Fehlersituationen sind:

a) **Formeller und materieller Integrationsfehler:** Die Punktnummer (Punktkennzeichen) in der Punktdati stimmt nicht mit ihrem Nachweis in der Grundrißdati überein (formeller Integrationsfehler); die Vermarkungsart eines Punktes der Punktdati stimmt nicht mit dem Schlüssel der Vermarkungssignatur in der Grundrißdati überein (materieller Integrationsfehler).

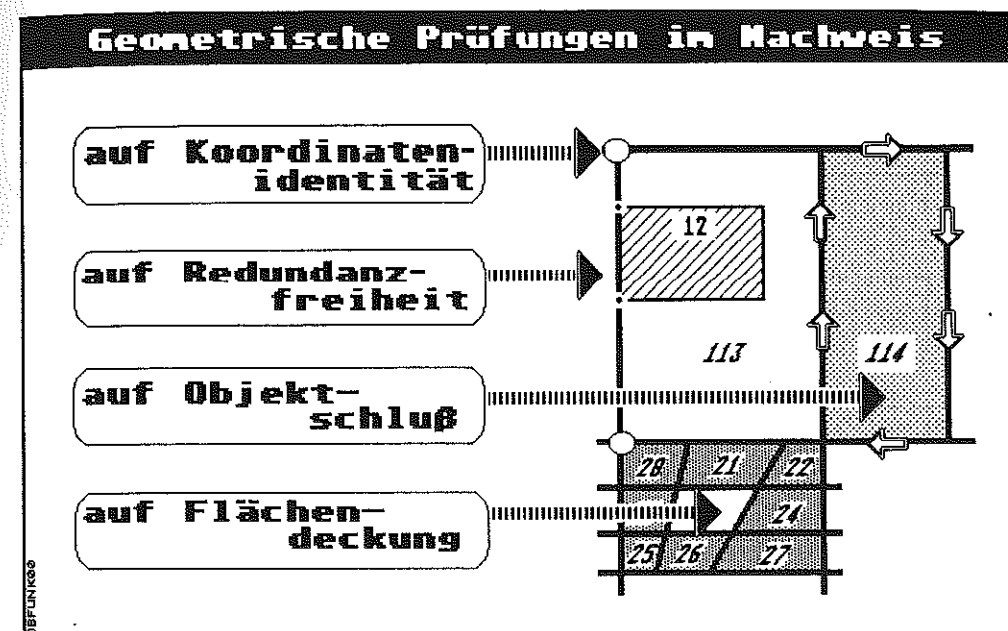


Abb. 4: Geometrische Prüfungen auf den Grundrißnachweis

b) **Koordinatenidentitätsfehler:** Durch den Entstehungsprozeß der Koordinaten und durch ihre ständigen Erneuerungen bzw. Genauigkeitssteigerungen werden bei einem Punkt mehrere Koordinatenpaare nachgewiesen. Dies können z. Bsp. gleichzeitig digitalisierte Koordinaten, Koordinaten in einem älteren Festpunktfeld, vorläufige und/oder amtlich festgesetzte Koordinaten in einem neueren Festpunktfeld, verbesserte (homogenisierte Koordinaten) in demselben Festpunktfeld sowie Punkt- und Koordinatenidentitäten von Grenzpunkten, die gleichzeitig Gebäudepunkt sind, sein. Koordinatenidentitätsfehler treten dann auf, wenn die fachlich festgelegte Identität zwischen der den Grundriß definierenden Koordinate und ihrem Abbild im Grundrißnachweis gestört ist.

Die ALK erfüllt diese Qualitätsanforderung mit der 'Sekundärverarbeitung'. Mit der Sekundärverarbeitung wird jeder Punkt, der in die Punktdati eingetragen wird, gleichzeitig programmgesteuert in die korrespondierende Folie der Grundrißdati als punktförmiges Elementarobjekt aufgrund einer von der Katasterbehörde vorgegebenen Rangfolge des Lagestatus, der die fachliche Bezugsgrundlage der Koordinaten definiert, eingetragen. Ein Direkteintrag in den Grundrißnachweis wird abgewiesen.

2.1.2 Geometriebehandlung

Ein wesentlicher Grundsatz für raumbezogene Informationssysteme sollte sein, die vollständig oder teilweise identische Geometrie verschiedener Grundrißobjekte redundanzfrei zu führen. Dies gilt unverzichtbar für raumbezogene Basisinformationssysteme. Die Objektgeometrie ist daher einer Geometriebehandlung zu unterziehen. Typische Fehlersituationen sind:

a) **Punktidentitätsfehler:** Punktobjekte verschiedener Objektart, die geometrisch identisch sind, wie z. Bsp. ein Grenzpunkt, der gleichzeitig Gebäudepunkt ist, haben unterschiedliche Koordinaten im Grundrißnachweis und werden doppelt abgebildet (Punkt-zu-Punkt Beziehung).

b) **Linienidentitätsfehler:** Definitionsgeometrie verschiedener oder gleicher Objektarten, die

geometrisch partiell oder vollständig identisch ist, wie z. Bsp. eine Grenzhecke oder Gebäudeseite auf einer Flurstücksgrenze, wird im Grundrißnachweis mehrfach abgebildet (Linie-zu-Linie Beziehung).

c) **Bedingungsfehler:** Anfangs- oder Endpunkt einer Definitionsgeometrie (oder ein Punktobjekt), wie z. Bsp. der einer Nutzungsartengrenze, liegt nicht geometrisch genau auf der entsprechenden Bezugsgeometrie wie z. Bsp. einer Flurstücksgrenze (Punkt-zu-Linie Beziehung).

d) **Kooperationsfehler:** Kooperationsfehler können auftreten, wenn sich mehrere Fachbereiche auf einen gemeinsamen Grundrißnachweis beziehen (z. Bsp. Liegenschaftskataster, Planungsamt, Grünflächenamt). In diesen Fällen muß die Geometriebehandlung fachübergreifend aufgrund von Kooperationsvereinbarungen auch dann wirken, wenn die verschiedenen Fachbereiche unabhängig voneinander mit demselben Grundrißnachweis redundanzfrei arbeiten wollen. Diese Arbeitsweise erfordert einen funktionierenden Benachrichtigungsmechanismus zwischen den Disziplinen. Fehlerhafte sowie unterbliebene Benachrichtigungen und fehlerhafte sowie unterbliebene Geometriebehandlungen sind Kooperationsfehler.

Mit der Geometriebehandlung der ALK werden die Grundrißobjekte geprüft auf Redundanzfreiheit der Definitionsgeometrie durch die systeminterne Splitting vorhandener Definitionsgeometrie aufgrund neu einzutragender Geometrieidentitäten. Die Geometriebehandlung der ALK führt des weiteren eine programmgesteuerte Angleichung neuer Grundrißinformationen an vorhandene Definitionsgeometrie durch sowie eine Benachrichtigung, wenn eine Angleichung eines Altbestandes an den Neubestand möglich ist. Die Geometriebehandlung wird folienabhängig nach Folienprioritäten und aufgrund von Abstandsmaßen (Toleranzbereich) durchgeführt.

2.1.3 Objekttypprüfung

Bei der Objekttypprüfung sind die Objekte des Grundrißnachweises auf Übereinstimmung mit dem festgelegten Objekttyp zu prüfen. Typische Fehlersituationen sind:

a) **Primäre Objekttypfehler:** Objektinformationen enthalten keine Objektkoordinate (geometrischer Objektrepräsentant); bei flächenförmigen Objekten liegt die Objektkoordinate fehlerhaft außerhalb des Objektrings; Objektinformationen desselben Objekts liegen fehlerhaft in verschiedenen Folien (Ebenen usw.); das Objekt hat falsche oder fehlende Referenzen auf andere Objekte.

b) **Formfehler:** Flächenförmige Objekte bilden keinen Flächenschluß; fehlender oder falscher Schluß einer Linienkette bei linienförmigen Objekten; punktförmige Objekte weisen fehlerhaft Definitionsgeometrien auf; Enklaven oder Exklaven bei flächenförmigen Objekten sind nicht bzw. fehlerhaft gebildet.

c) **Unzulässigkeitsfehler:** Objekte weisen unzulässige Objektformen auf wie z. Bsp. kreuzende Linien bei einer Umringsdefinition oder flächenförmige Objektteile sind über unzulässige 'Einpunktidentität' verknüpft; Objekte enthalten unzulässige Anzahl von Informationen z. Bsp. Mengenfehler aufgrund zu großer Anzahl der Stützpunkte eines Splines.

d) **Geometriedefinitionsfehler:** Geometrieparameter sind fehlerhaft gegenüber dem definitionsgemäß vorgegebenen Aufbau, z. Bsp. beim Kreisbogen, beim geschlossenen Polygonzug oder beim Spline; die Definitionsgeometrie enthält nicht oder noch nicht vereinbarte Geometriearten wie z. Bsp. eine Klothoidenparallele.

e) **Unschärfefehler:** Ein flächenförmiges Objekt wird differentiell von anderer Definitionsgeometrie geschnitten; Geometrien weichen durch Umrechnungen voneinander ab, z. Bsp. aufgrund unterschiedlicher Definition eines Kreisbogens im Grundrißnachweis und im Verarbeitungssystem.

Ein weiterer Fehler- bzw. Diskrepanzbereich sind 'Programmentwicklungsdiskrepanzen': Diese Diskrepanzen sind nur mittelbar der Objekttypprüfung zuzurechnen, sie gehen über in den Bereich der Datenaustausch- bzw. Präsentationsfehler. Programmentwicklungsdiskrepanzen liegen in dem unterschiedlichen Leistungsvermögen der verschiedenen graphischen Systeme bzw. deren unterschiedlichem Entwicklungsstand zum gleichen Zeitpunkt begründet. Dies ist insgesamt ein umfangreicher Bereich. Als typische Fehlersituationen seien genannt:

- eine fachlich vorgegebene Präsentation einer Böschungsschraffendarstellung kann aus den funktionalen Mindestinformationen im Grundrißnachweis nicht von allen anderen Graphiksystemen nachvollzogen werden (Objektproduktionsdiskrepanz);

- eine im Grundrißnachweis implizit vorhandene Präsentation aufgabe kann von anderen Systemen nicht nachvollzogen werden, wie z. Bsp. die flurstücksgrenzenübergreifende Präsentation einer Grenzeinrichtung oder die durch Prioritätensteuerung zu unterdrückende Böschungsdarstellung unter einer Brücke (topologische Entwicklungsdiskrepanz).

In der ALK finden diese geometrischen Qualitätsprüfungen (Objekttypprüfungen) bei der Ersteinrichtung und bei jeder Fortführung statt.

2.1.4 Prüfung auf Flächendeckung

Für flächenförmige Objekte, die Teil eines flächendeckenden Nachweises sind (z. Bsp. Flurstücke, Nutzungsarten), ist durch programmtechnische Qualitätsprüfungen sicherzustellen, daß bei der Ersteinrichtung dieser Nachweise und bei jeder Fortführung stets die Flächendeckung gewährleistet ist und bleibt. Typische Fehlersituationen dieses Qualitätsbereiches sind:

a) **Überlagerungsfehler:** Ein Objekt eines flächendeckenden Nachweises wird teilweise oder vollständig von einem anderen Objekt überlagert. Ein Objekt kann auch durch sich selbst überlagert werden (Dopplungsfehler) mit gleicher, anderer oder abweichender Objektbezeichnung.

b) **Aussparungsfehler:** Der Flächennachweis enthält Lücken (Aussparungen) aufgrund fehlender Objekte, fehlender flächenförmiger Objektteile oder aufgrund einer fehlerhaften Umringsdefinition.

c) **Anfelderungsfehler:** Bei der naturgemäß sukzessiven Einrichtung flächendeckender Nachweise entstehen Problemzonen an den Nahtstellen der Einrichtungsbereiche. Flächendeckungsprüfung setzt an diesen Stellen geometrische Identität der Bereichsgrenzen voraus. Dies erfordert besondere Sorgfalt innerhalb des Grundrißnachweises eines Zuständigkeitsbereiches (z. Bsp. eines Katasteramtsbezirks) und weitere exakte Koordinierung an den Bereichsgrenzen verschiedener örtlicher Zuständigkeiten.

Die Flächendeckungsprüfung muß dabei erfüllt sein sowohl für einzelne vollständig flächendeckende Nachweise (wie z. Bsp. Flurstücke), für partiell flächendeckende Nachweise (wie z. Bsp. die Flächen der Bodenschätzung) sowie für jede fachlich bestimmte Stufe der allmählichen Ersteinrichtung dieser Nachweise.

Der ALK-Datenbankteil führt die Flächendeckungsprüfung bei der Ersteinrichtung sowie bei jeder Fortführung flächendeckender Grundrißobjekte in vom Anwender frei zu definierenden Bereichen, in standardisierten Bereichen (Numerierungsbezirke) oder objektweise in den Änderungsbereichen durch.

2.2 Prüfung auf Zulässigkeit, fachliche Wertebereiche und Vollständigkeit

Aufbau und Inhalt des Grundrißnachweises des Liegenschaftskatasters in Nordrhein-Westfalen sind im Objektabbildungskatalog-Liegenschaftskataster (OBAL-LiegKat NRW) fachlich festgelegt. Aufgabe der Fortführungsarten für die Grundrißdatei ist es, die den Festlegungen des OBAL-LiegKat NRW entsprechenden fachlichen Prüfungen zur Sicherung der Konsistenz des Datenbestandes der Grundrißdatei, der nach der Ersteinrichtung und nach jeder Fortführung entstehen soll, durchzuführen. Dazu wird bei jedem Fortführungsauftrag an die ALK-Datenbank eine Fortführungsart mit ihrem Namen angegeben, der den Umfang der von der Datenbankverarbeitung durchzuführenden Prüfungen beschreibt. Die Prüfung durch Fortführungsarten ergänzt die geometrischen Prüfungen um die fachlichen Inhalte der Grundrißobjekte.

In jeder Fortführungsart sind Festlegungen getroffen über Zulässigkeit, Operationsumfang, Vollständigkeit und Werteeinschränkung der Datenelemente. Die Datenbankverarbeitung führt die Plausibilitätsprüfungen zu diesen Festlegungen durch.

Prüfungen der Fortführungsart							
Auszug aus FUGOBINN: Fortführung von aktuellen Flurstücken							
Datenelement	Kann Muß	E	OP-Umfang			Ket- ten	Werteeinschränkung
			Neu	Änd	Lö	Pos	
DL08							
-Objektcoordinate-							
0001 Numerierungsbezirk	M		N			P	
0002 Coordinate	M		N			P	
0003 Prüfzeichen	M		N			P	
-Endpunkt d. Linie-							
1001 Numerierungsbezirk	K		N			A	
1002 Coordinate	K		N			F	
1003 Art der Geometrie	K	E	N			F	11, 15, 21, 22
-Funktion der Linie-							
1101 Folie	K	E	N			A	
1102 Objektart	K	E	N			F	001 0233, 0235, 0239, 0242 0245, 0248
1103 Objektnummer 1(R)	K		N				
-Parameter-							
1201 Parameter	K		N				
...							

Abb. 5: Prüfungsumfang mit Fortführungsarten

- Zulässigkeitsprüfung:** Sie plausibilisiert, ob Datenelemente bei einer Fortführung vorkommen müssen oder können oder nicht vorkommen dürfen. So muß z. Bsp. bei Flurstücken das Datenelement 'Objektart' in 'Funktion der Linie' vorkommen.
- Wertepfung:** Sie prüft, ob das Datenelement mit einem zulässigen Wert belegt ist. So kann z. Bsp. das Datenelement 'Objektart' in 'Funktion der Linie' bei Flurstücken eingeschränkt werden auf den Schlüssel 0233 (Flurstück allgemein); Straßenflurstücke (Schlüssel 0239) werden damit abgewiesen.
- Operationsprüfung:** Sie prüft, ob die mit dem Datenelement vorgesehene Operation (Neueintragen, Ändern, Löschen, Positionieren) bei dieser Fortführung überhaupt zulässig ist. Damit können Fortführungsarten definiert werden, die z. Bsp. nur ein Neueintragen, aber kein Löschen zulassen.
- Vollständigkeitsprüfung:** Sie ergänzt die Zulässigkeitsprüfung um fachliche Abhängigkeiten bzw. Bedingungen zwischen einzelnen Datenelementen. Dazu können logische Kettenbeziehungen

beschrieben werden (wenn ein Datenelement belegt ist, dann müssen bestimmte weitere auch belegt sein).

In der ALK wird der Prüfungsumfang und die Prüfungsmöglichkeit umso geringer, je allgemeiner die Fortführungsarten definiert werden. Derzeit werden die Fortführungsarten in Nordrhein-Westfalen auf der Grundlage von Grundrißeinheiten der Objekte und nicht auf Objektebene definiert.

3 Weitere Qualitätsprüfungen

Weitere Qualitätsprüfungen auf die Grundrißinformationen seien an dieser Stelle nur im Überblick aufgezeigt. Der Überblick soll verdeutlichen, daß verlässliche Datenqualität nur durch eine Vielzahl verschiedener Prüfungen gewährleistet werden kann, die einerseits notwendig und andererseits zweckmäßig sind. Diese Prüfungen seien unter den Stichworten Berechtigungsprüfung, Simulationsprüfung, Integrationsprüfung, Vorverarbeitungsprüfung, Prüfung durch Schnittstellenumschalter und Sachbearbeiterprüfung angedeutet:

a) **Berechtigungsprüfung:** Berechtigungsprüfungen sichern den Grundrißnachweis vor unberechtigtem Eintragen, Ändern, Löschen oder Benutzen von Grundrißdaten. Die Berechtigungsprüfung im Grundrißnachweis umfaßt die Eingabeberechtigungsprüfung für den Fortführungs- bzw. Benutzungsauftrag und die Zugriffsberechtigungsprüfung für die fachliche Veränderung oder Benutzung des Grundrißnachweises. Die Berechtigungsprüfung findet unabhängig von entsprechenden Berechtigungsprüfungen im Verarbeitungsteil und unabhängig von sonstigen organisatorischen und dv-technischen Datenschutz- und Datensicherheitsmaßnahmen statt.

b) **Simulationsprüfung:** Im Gegensatz zur alphanumerischen Datenverarbeitung ist es ein Charakteristikum der graphischen Datenverarbeitung, daß ihre Daten a priori untereinander vernetzt sind. Die Fortführung von Grundrißdaten kann daher nicht elementar zerlegt werden sondern ist als Fortführungseinheit zu behandeln.

So zeigt z. Bsp. die in Abb. 2 skizzierte Gebäudeeinmessung auf, daß die Fortführung des Grundrißnachweises erst dann richtig abgeschlossen ist, wenn gleichzeitig das Gebäude mit allen seinen Informationen eingetragen ist, die gesplittete Flurstücksgrenze fortgeführt worden ist, die Nutzungsartengrenzen und -signaturen eingetragen sind und ggf. die Position der Flurstücksnummer verschoben worden ist ('Fachliche' Transaktion).

Bei dieser Fortführung muß u.a. auch geprüft werden, ob die Veränderung des Grundrißnachweises auf einem fachlich gewollten Altszustand aufsetzt (Aktualitätsprüfung) und ob die Veränderung nicht mit anderen gleichzeitig bzw. parallel stattfindenden Fortführungen kollidiert (Konkurrenzprüfung). Fehlerhafte Eintragungen, Programm- oder Systemabstürze können darüber hinaus zu inkonsistenten Datenbeständen führen (Konsistenzfehler).

In der ALK werden daher Fortführungen zuerst in einer 'Hintergrunddatenbank' simuliert und die Dateiveränderung wird anschließend in einer 'fachlichen Transaktion' vorgenommen.

c) **Integrationsprüfung:** Der Umfang der dv-technischen Integrationsprüfung (gleichzeitige Fortführung von Grundriß- und Sachdaten) muß abdecken: die Übereinstimmung der Verknüpfungselemente (formale Integrationsprüfung), die Übereinstimmung der korrespondierenden Dateninhalte (materielle Integrationsprüfung), die Abstimmung beider fachlichen Fortführungslogiken untereinander (Fallverarbeitungsprüfung) und beider dv-technischen Fortführungslogiken untereinander (integrierte Simulationsverarbeitung entsprechend Buchstabe b)).

d) **Vorverarbeitungsprüfungen:** Diese Prüfungen sind dvtechnische Prüfungen im Verarbeitungsteil

auf die Objektdefinitionen und die Integrationsanforderungen. Sie sind im Regelfall als Vorprüfungen zu den Prüfungen des Datenbankteils zu verstehen. Bei den Vorarbeiten für die ALK sollen diese Prüfungen möglichst umfassend durchgeführt werden.

e) Prüfungen durch Schnittstellenumsetzer: Bei der Umsetzung finden in Abhängigkeit vom graphischen System statt: eine Umsetzung von Datenstrukturen (Objekttransformationen), eine Umsetzung von Datenelementen (Feldtransformationen), eine programmgesteuerte Ergänzung von Datenelementen und eine Prüfung und Plausibilisierung der Auftragsdaten.

Schnittstellenumsetzer (EDBS-Umsetzer) müssen programmgesteuert insbesondere die Fortführungsprüfungen durchführen, die die inhaltlich und fachlich korrekte Umsetzung der Grundrißobjekte gewährleisten und insbesondere solche Prüfungen, die nicht vom eingesetzten graphischen System des Verarbeitungsteils durchgeführt werden können.

f) Sachbearbeiterprüfungen: Prüfungen durch den Sachbearbeiter sind grundsätzlich durchzuführen auf Übereinstimmung der Fortführungsunterlagen mit den im Verarbeitungsteil erzeugten Fortführungsdaten, auf den korrekten Ablauf der Fortführungsverarbeitung und der Integrationsverarbeitung mit dem Liegenschaftsbuch.

4 Zusammenfassung

- es muß ein fachlicher Konsens über die Qualitätsanforderungen an die Objekte in raumbezogenen Informationen bestehen,
- Qualitätskriterien müssen in ihr anwendungsneutrales und in ihr anwendungsspezifisches Spektrum gesplittet werden,
- es ist ein funktionales Qualitätsmodell für das Datenmodell zu definieren (eine unabdingbare Forderung im Hinblick auf objektorientierte Datenbanken),
- Qualitätskriterien müssen in die Praxis umgesetzt werden und ihre Realisierung muss Prüfverfahren unterliegen,
- Datenbestände, die als Datenaustausch über Schnittstellenformate an Nutzer abgegeben werden, müssen Qualitätsinformationen enthalten,
- elementargeometrische Qualitätsaspekte sollten in raumbezogenen Informationssystemen nicht vernachlässigt werden.

Es sei angemerkt, daß die Definition und Durchsetzung von Qualitätskriterien in raumbezogenen Informationssystemen wohl längere und breitere Diskussionen erfordert. Außerdem mag die Anzahl der Prüfungen zunächst verwirren. Sie wird jedoch verständlich, wenn man berücksichtigt, daß die Fülle der bisher bei herkömmlichen Arbeitsmethoden nicht bewußt vom Menschen wahrgenommenen oder versteckten Prüftätigkeiten für die Datenverarbeitung formalisiert werden muß und daß digitale Daten neue Prüfungsarten erfordern. Letzlich ist beruhigend, daß die menschliche Urteilskraft und Prüfkraft auch durch noch so ausgefeilte Programme nicht ersetzt werden kann.

Anschrift des Verfassers: Regierungsvermessungsdirektor Dipl.-Ing. H. W. Stöppler, beim Landesvermessungsamt Nordrhein-Westfalen, Muffendorfer Str. 19-21, D - 5300 Bonn 2

NORMEN UND STANDARDS FÜR GEODATEN - Stand und Perspektiven der nationalen und internationalen Entwicklung -¹

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1. Vorbemerkung

In verschiedenen Beiträgen, zuletzt im Heft 4/90 der Zeitschrift GIS (Brüggemann 90), hat der Autor über Stand und Perspektiven der Entwicklung nationaler und internationaler Standards für Geodaten berichtet. Einen umfassenden Überblick über Standards für den Austausch raumbezogener Daten gibt (Moellering 91). Der vorliegende Beitrag beschränkt sich deshalb auf einen kurzen Abriß der derzeitigen Situation, ohne Anspruch auf Vollständigkeit, anknüpfend an eine Kernfeststellung aus dem zitierten GIS-Beitrag: "Die Chancen einer Einigung auf einen gemeinsamen europäischen Standard sind gut, wenn es gelingt, die Partikularinteressen zurückzustellen und kurzfristig eine Lösung zu finden, bevor sich nationale Standards im praktischen Einsatz etabliert haben."

Im gleichen Jahr haben zwei Diskussionsforen die europäische Szene des Austauschs von Geodaten beleuchtet, der von AM/FM ausgerichtete Workshop "Towards a Common International AM/FM Transfer Format" in Montreux und wenig später der im Rahmen des IMPACT-Programms der EG-Kommission veranstaltete Workshop "GIS - A European Initiative".

Die Ergebnisse des AM/FM-Workshops, an dem etwa 100 Experten aus 15 europäischen Ländern, den USA, Südafrika und Saudi-Arabien teilnahmen, sind in vier Empfehlungen zusammengefaßt:

1. Es ist anzuerkennen, daß nationale Standards für den Austausch raumbezogener Daten in Europa existieren. Sie sind gerade entwickelt worden und müssen in den nächsten Jahren landesintern eingesetzt werden.
2. International sollte ein allgemein anerkanntes Referenzmodell für den Austausch raumbezogener Daten entwickelt und eine gemeinsame Terminologie eingeführt werden.
3. Ein einheitlicher Ansatz zur Beschreibung der realen Welt unter Einsatz eines gemeinsamen konzeptuellen Datenmodells sollte entwickelt werden.

¹ Beitrag zum BLAK-UIS-FAW-Werkstattgespräch "UGIS 1992" November 1992 in Ulm
Aktualisierte Fassung des Workshop-Beitrags
"Exchange Formats for Topographic-Cartographic Data"

4. Ein Projekt sollte geschaffen werden, in das die wesentlichen Nutzer auf europäischer Ebene eingebunden sind. Eine gute Möglichkeit wäre z.B. ein DRIVE-II-Projekt als Folgeprojekt des recht erfolg-reichen DRIVE-I-Projekts "Task Force European Digital Road Map". Partner könnten sein

- CERCO mit einigen interessierten Ländern,
- die Auto- und Elektronikindustrie,
- Consultants,
- die EG-Kommission.

Das Projekt könnte durch CERCO-Working Groups auf der Grundlage bereits ausgearbeiteter Vorschläge Frankreichs durchgeführt werden. Die Grundidee ist die Einrichtung eines europäischen Informationsnetzes, das nationale raumbezogene Datenbestände verknüpft und Nutzern den Zugriff von jedem Netzknoten ermöglicht. Das Projekt wäre ein ausgezeichnete Integrationsfaktor für künftigen europaweiten Datenaustausch nach einem einheitlichen "European Transfer Format (ETF)". Das Projekt könnte nach einer Vorbereitungsphase im Jahre 1991 starten und im Jahre 1992 durchgeführt werden."

Der EG-Workshop in Brighton führte zu der Empfehlung, im Rahmen des IMPACT-Programms eine europäische Dachorganisation für die Vermarktung von Geodaten zu gründen.

Wenn auch nicht alle Empfehlungen aus den Workshops des Jahres 1990 bis heute in praktische Ergebnisse umgesetzt werden konnten, so haben sie doch zumindest entsprechende Aktivitäten maßgeblich mitinitiiert. In der Tat markiert dieses Jahr 1990 den Beginn einer neuen Periode für den europäischen Geoinformationsmarkt, geprägt durch den immer deutlicher werdenden Bedarf nach grenzüberschreitendem Datenaustausch in Europa und weltweit.

2. Nationale Entwicklungen nach 1990 (Beispiele)

2.1 Deutschland

Sieht man von firmenspezifischen Austauschformaten für Geodaten und trivialen Lösungen ab, so ist weiterhin der einzige nennenswerte deutsche Standard die Einheitliche Datenbankschnittstelle (EDBS) der amtlichen Landesvermessung. Es liegen nunmehr deaillierte Spezifikationen für den Austausch von ALK- und ATKIS-Daten vor, die zu einer Reihe von Implementierungen geführt haben. Für die ALK und für ATKIS ist Datenaustausch zum Tagesgeschäft geworden. Dabei bieten ALK- und ATKIS-EDBS bekanntlich Möglichkeiten der Versorgung von Sekundärdatenbanken mit Änderungsdaten nach inhaltlichen und zeitlichen Vereinbarungen. Diese Fähigkeiten, die über entsprechende Kontrollkomponenten der ALK/ ATKIS-Datenbank gestützt werden, bietet derzeit kein anderes Austauschformat.

Die EDBS-Lösung für ALK- und ATKIS-Daten ist strikt produktorientiert. Sie erhebt nicht den Anspruch der Allgemeingültigkeit für den Austausch beliebiger Geodaten zwischen beliebigen Partnern. Die Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) setzt dazu auf eine europäische

Lösung.

ALK- und ATKIS-EDBS werden zur Zeit über Verwaltungsvorschriften verbindlich in den Bundesländern eingeführt. Insbesondere die ATKIS-EDBS ist die Grundlage einer Vereinbarung zwischen Bund und Ländern für die Bereitstellung von ATKIS-Daten für Aufgaben von Bundesinstitutionen.

2.2 Frankreich

In Frankreich ist EDIGÉO als nationaler ziviler Standard eingeführt worden. Es wurde der Conseil National de l'Information Géographique (CNIG) mit Sitz beim IGN in Paris gegründet, dem neben behördlichen auch privatwirtschaftliche Institutionen, die mit der Produktion und Nutzung von Geodaten befaßt sind, sowie das französische Normungsinstitut AFNOR angehören. Auf die Initiative von CNIG geht die Gründung des Technical Comité 287 "Geoinformation" zurück (siehe dazu Abschnitt 3.4).

EDIGÉO ist eine zivile Weiterentwicklung des DGIWG-Standards DIGEST (siehe 3.2). Sein Datenmodell ist zudem sehr verwandt mit ATKIS, dem amerikanischen Produktstandard DLG-E und dem britischen Standard NTF und war mit dem Rahmenkonzept des Standards eine entscheidende Grundlage für die Weiterentwicklung des GDF-Standards der Auto- und Elektronikindustrie (siehe 3.3) von der Version 1.0 zur Version 2.0.

2.3 Großbritannien

Der britische Standard NTF ist wesentlich weiterentwickelt und dabei an grundlegende Konzepte aus der internationalen Diskussion angepaßt worden. So ist nunmehr das Datenmodell, das dem NTF zugrundeliegt, explizit beschrieben, auch ist die ISO 8211 integriert.

Wie in Frankreich, so wurde auch in Großbritannien mit der Association for Geographic Information (AGI) eine Anwenderorganisation gegründet, die die Entstehung eines Geoinformationsmarkts begleitet und insbesondere die Standardisierung von Geodaten und ihres Austauschs fördert. AGI ist es gelungen, NTF zur nationalen BSI-Norm zu machen.

2.4 USA

In den USA wurde die Arbeit am Spatial Data Transfer Standard (SDTS) durch das Federal Geographic Data Committee (FGDC) abgeschlossen; kürzlich wurde SDTS als NIST-Standard anerkannt. Damit liegt für die Vereinigten Staaten eine allgemeine Norm für den Austausch beliebiger Geodaten vor. Es liegt in der Natur eines sehr allgemeinen Standards, daß ihr praktischer Einsatz zusätzliche Absprachen im Sinne von Einschränkungen sinnvoll macht. Der SDTS kann deshalb über "Profiles" auf abgegrenzte Klassen von Übertragungsfällen beschränkt werden, um die Entwicklung von Schnittstellensoftware zu vereinfachen.

Die Defense Mapping Agency (DMA) hat gemeinsam mit den Firmen ESRI und INTERGRAPH das Produkt Digital Chart of the World (DCW) entwickelt, das weltweit auf der Basis des DIGEST-Subsets VPF (Vector Product Format) über den U.S. Geological Survey vermarktet wird.

Interessant ist, daß in diesem Projekt Geo-Basisdaten auf der Grundlage eines von den Partnern vereinbarten Formats gemeinsam mit Software für den Umgang mit den Daten kostengünstig (200 \$) vermarktet werden, ein Vorgang, der Maßstäbe setzen kann für die Verbreitung von de-facto-Standards für Geodaten unter den Nutzern.

3. Internationale Gemeinschaftsentwicklungen

3.1 CERCO

Das "Comité Européen des Responsables de la Cartographie Officielle (CERCO)" ist jahrelang bemüht gewesen, den Austausch von Geodaten in Europa zu harmonisieren. Wertvolle Grundlagenarbeit wurde in den Working Groups V "European Territorial Database" und VII "European Road Database" geleistet. So geht die Idee für einen europäischen Felddatentest gemeinsam mit der europäischen Auto- und Elektronikindustrie auf den CERCO-Generalsekretär Joe Mousset zurück und wurde von den Projektpartnern der EUREKA-Projekte DEMETER, CARMINAT und PROMETHEUS aufgegriffen und gemeinsam mit CERCO und Repräsentanten der Straßenbauverwaltung im DRIVE-Vorhaben "Task Force European Digital Road Map" in die Tat umgesetzt (siehe Abschnitt 3.3).

Experten aus den CERCO Working Groups haben auch maßgeblich die eingangs erwähnten Workshops mitgestaltet, die den Boden bereiten haben für die für die europäische Standardisierung wichtigsten Ereignisse des Jahres 1991, den Beginn der Arbeiten an dem Projekt "Multi-purpose European Ground-Related Information Network (MEGRIN)" durch die CERCO-PTG (Permanent Technical Group) und die Gründung des CEN-TC 287 (Geographical Information) auf Antrag des französischen Normungsinstituts AFNOR. Außerdem ist CERCO beteiligt bei den Vorarbeiten zur Gründung einer "European Umbrella Organisation for Geographical Information (EUOGI)" im Rahmen des IMPACT-Vorhabens der EG-Kommission.

CERCO hat beim CEN die Anerkennung als "associated body" beantragt.

3.2 DGIWG

Die "Digital Geographic Information Working Group (DGIWG)" ist eine multinationale Interessensgruppe bestehend aus Fachleuten auf dem Gebiet des Geoinformationswesens von militärischen Institutionen in Europa, den Vereinigten Staaten und Kanada. Die Gruppe bemüht sich um die Entwicklung und Förderung des DIGEST als internationaler Standard. Auf seiner Grundlage sind bereits mehrere Produkte für militärische Anwendungen entwickelt worden. Ein DIGEST-Subset ist das VPF, das der DCW zugrunde liegt.

Die DGIWG hat ebenfalls beim CEN die Anerkennung als "associated body" beantragt.

3.3 DRIVE Project "Task Force European Digital Road Map"

Im DRIVE I-Vorhaben Task Force EDRM ist der GDF-Standard im praktischen Einsatz erprobt worden. In der Schlußphase dieses Projektes wurde die "Geographic Standardisation Working Group" mit Experten aus der Auto- und Elektronikindustrie, von CNIG, CERCO, DGIWG und der Straßenbauverwaltung eingerichtet.

Als Ergebnis dieser Kooperation liegen mehrere wichtige Standardentwürfe auf dem Ge-biet der Geoinformation vor:

- Das Referenzmodell einer Familie von Standards für Geodaten.
- Das Conceptual Data Model.
- Das Quality Model.

Auf der Grundlage dieser Entwürfe wurde der GDF 1.0 zum GDF 2.0 fortentwickelt. Diese Version ist der Basisstandard für die laufenden DRIVE II - Projekte.

3.4 CEN

Die Ergebnisse der Arbeit der Geographic Standardisation Working Group sind wichtige Grundlagen für die laufende Arbeit sowohl des CEN TC 278 "Road Transport Telematics" als auch des TC 287 "Geographical Information". Beide Technical Committees sind 1991 von CEN eingerichtet worden. Während sich die Aktivitäten des TC 278 auf das Anwendungsfeld Straßenverkehr konzentrieren, muß der TC 287 zwangsläufig allgemeinere Standards auf dem Gebiet des Geoinformationswesens entwickeln.

Innerhalb des TC 278 beschäftigt sich die Working Group 7 "Geographic and Road Database (GRDB)" mit Straßendaten auf der Grundlage des GDF. Die Arbeit wird in vier Untergruppen geleistet: "Conceptual Model", "GDF", "Location References", "Dynamic Data". Eine Liaison zum TC 287 ist eingerichtet.

Das Sekretariat für das TC 287 hat AFNOR übernommen; der Präsident ist Francois Salgé, CERCO-PTG. Die Aufgabe des TC 287 ist wie folgt festgelegt:

"Normung auf dem Gebiet der digitalen Geoinformation umfaßt die Schaffung eines Normenwerks, das Verfahren zur Definition, Beschreibung und zum Austausch von Modellen der realen Welt bereitstellt. Es soll das Verständnis und den Gebrauch von digitalen Informationen ermöglichen, die sich auf alle ortsgebundenen Gegenstände und Sachverhalte der realen Welt beziehen. Ziel ist es, den Umgang mit diesen digitalen Informationen durch den Einsatz der gesamten Informationstechnologie zu erleichtern. Das Normenwerk wird die Entwicklungen im Bereich der Informationstechnologie sowohl beeinflussen als auch von diesen beeinflusst werden.

Anmerkung 1:

Die "Ortsgebundenheit" von Objekten (Location) kann durch Koordinaten, textliche Beschreibungen oder kodierte Namen repräsentiert werden." Das TC 287 hat vier Working Groups eingerichtet:

- WG 1: Arbeitsrahmen und Referenzmodell (Norwegen)
- WG 2: Modelle und Sprachen (Frankreich)
- WG 3: Übertragung von Geoinformation (Vereinigtes Königreich)
- WG 4: Referenzsysteme für Geoinformation (Deutschland)

3.5 ICA

Seit der ICA-Konferenz in Bournemouth im September 1991 ist aus der "ICA Working Group on Digital Cartographic Database Transfer Standards" die "ICA Commission on Standards for the Transfer of Spatial Data" unter Leitung von Harold Moellering, USA geworden. Zwanzig Staaten und die wichtigsten internationalen wissenschaftlichen Vereinigungen auf dem Gebiet des Geoinformationswesens sind in dieser Kommission vertreten. Die Zielsetzung dieser Gruppe ist die Entwicklung wissenschaftlich fundierter Vergleichskriterien für Austauschstandards für raumbezogene Daten. Ein großes Problem ist die unterschiedliche Terminologie, die sich international in den letzten Jahren entwickelt hat.

Es ist beabsichtigt, die Vergleichskriterien bis zum International Cartographic Congress (ICC) in Köln 1993 im Schreibtischtest an existierenden Standards zu erproben und die Ergebnisse bis zur ICA-Konferenz 1995 in Barcelona zu veröffentlichen.

4. Schlußbemerkung

Der kurze Abriß über Standardisierungs- und Normungsaktivitäten seit 1990 kann nicht vollständig sein; er gibt nur einen gekürzten Einblick in das Geschehen. Gleichwohl ist deutlich geworden, inwieweit die Ergebnisse der Workshops in Montoux und Brighton in praktische Arbeiten umgesetzt werden konnten.

Nur im Falle des GDF ist es gelungen, einen europäischen Standardentwurf kurzfristig für den praktischen Einsatz aufzubereiten und gleichzeitig zielstrebig den europäischen Normungsprozeß einzuleiten. Bereits heute ist der GDF ein de-facto-Standard, der international auch außerhalb Europas Beachtung findet. Die GDF-Entwicklung konnte erfolgreich sein, weil sie unter massivem Anwenderdruck zustande kam, und weil sie sich auf ein klar umrissenes Anwendungsfeld beschränkte.

Die Entwicklung allgemeinerer Standards für die Übertragung raumbezogener Daten vollzieht sich erheblich langsamer. Für die Arbeit im CEN TC 287 wird deutlich, daß mit steigender Zahl beteiligter nationaler Normungsinstitute auch der Konsensbedarf wächst, was langwierige Verhandlungen nach sich zieht. Außerdem ist die Situation wenig hilfreich, daß verschiedene Länder gerade nationale Standards und Normen eingeführt haben und nun möglichst viele ihrer Ideen in einer europäischen Norm umgesetzt sehen wollen.

Der einzige Weg zu einem pragmatischen Vorgehen und zur Beschleunigung des Normungsprozesses wird der zunehmende Anwendungsdruck sein. Das CERCO-Vorhaben MEGRIN könnte eine hervorragende Basis bilden, mit der Entwicklung von CEN-Normen auch ihre Implementierung zu betreiben und in praktischen Feldversuchen zu erproben.

Abkürzungen

AFNOR
Association Française de Normalisation
AGI
Association for Geographic Information
ALK
Automatisierte Liegenschaftskarte
AM/FM
Automated Mapping / Facilities Management
ATKIS
Amtliches Topographisch-Kartographisches Informationssystem
BSI
British Standards Institution
CARMINAT
(EUREKA project)
CEN
Comité Européen de Normalisation
CERCO
Comité Européen des Responsables de la Cartographie Officielle
CNIG
Conseil National de l'Information Géographique
DCW
Digital Chart of the World
DEMETER
(EUREKA project)
DGIWG
Digital Geographic Information Working Group
DIGEST
Digital Geographic Exchange Standard
DIN
Deutsches Institut für Normung
DLG-E
Digital Line Graph - Enhanced
DMA
Defense Mapping Agency
DRIVE
(European road traffic research program)
EDBS
Einheitliche Datenbankschnittstelle
EDIGÉO
Echange de Données Informatisées Géographiques
EG
Europäische Gemeinschaften
ETF
European Transfer Format
EUOGI
European Umbrella Organisation for Geographical Information
EUREKA
(European research initiative)
FGDC
Federal Geographic Data Committee
FIPS
Federal Information Processing Standard
GDF
Geographic Data Files

GIS

- a) Geographical Information System
- b) GeoInformations-Systeme (Zeitschrift)

ICA

International Cartographic Association

ICC

International Cartographic Conference

IGN

Institut Géographique National

IMPACT

Information Market Policy Action

MEGRIN

Multi-purpose European Ground-Related Information Network

NIST

National Institute of Standards and Technology

NTF

National Transfer Format

PROMETHEUS

(EUREKA project)

PTG

Permanent Technical Group

SDTS

Spatial Data Transfer Standard

TC

Technical Committee

USGS

U.S. Geological Survey

VPF

Vector Product Format

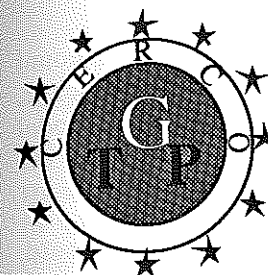
Referenzen

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SALGE 1992: Interchange of Geographical Information in Europe. Paper presented at AM/FM European division 1992 conference, Montreux Switzerland



C.E.R.C.O

**Groupe Technique Permanent
Permanent Technical Group**

objet:

OEEPE workshop on Data Quality in LIS

Apeldorn (NL)

4-6 September 1991

**Organizational chart of geographic data standards,
its application to the CERCO project MEGRIN**

**Organizational chart for
geographic data standards**

1. Paper Objective

The organisational chart for geographic standards groups together and defines the standards which should be set up within the field of digital geographic information. Here the term "digital geographic information" is a generic one used to represent all the information which are needed for the knowledge of the geographic environment.

2. Organizational Chart

The organizational chart is split into three levels: concepts, languages, implementation

2.1. Conceptual level

The conceptual level is the most abstracted view of information. It consists of a collection of models defined in a formal way which leads to "paper-views" of information.

2.1.1. Information

Existing methods can help to model general information. Some of them are suitable for modelling the World in a geographical way. It is not of the paper concern to define new ones.

2.1.2. Geographical information

Geographic information are specific for their ability to deal with location on the Earth. Three models are then necessary.

2.1.2.1. Conceptual Data Model

The Conceptual Data Model (see annex 1) defines all the entity types which let it possible to describe and locate phenomena and which raise the knowledge of the geographic environment. (see annex 2 for an example of a CDM)

2.1.2.2. Quality Model

The Quality Model describes the parameters to be taken into account for characterising the quality of any data set or data base (origin, lineage, accuracy, completeness, consistency, up-to-dateness...); The quality model is a consistent definition of those parameters in conjunction with the Conceptual Data Model

2.1.2.3. Positioning References

Any data set must be referenced to the Earth: projection, ellipsoid, datum, height reference... The positioning references let it possible to identify the geographic references of the data set, and some transformation formulas to other referencing systems

2.1.3. Specific geographic information

For a given technical domain, specific geographic information may exist

2.1.3.1. Conceptual Data Schemas

The Conceptual Data Schema describes the logical organisation of the data set. (see the example of annex 4). It is the description of the "drawers" where the data are arranged according to the Conceptual Data Model.

Several Conceptual Data Schemas are to be standardized: for each basic level and each referencing scale (basic data), and for each technical domain (road management, road navigation, facility management, statistics, local government, environment, geology, soil,...).

Within the Conceptual Data Schemas are defined the data content definition, the data quality specification, the feature representation rules the coding schema, the cartographic specifications (paper-map and soft copy display).

While the reality is splitted into domains, the domain-specific Conceptual Data Models may overlap: some objects are identical but are differently perceived (different functions for an object), other are identical and similarly perceived. A CDS synthesis is then needed and have to show the discrepancies and similarities.

2.1.3.2. Spatial Reference

The ultimate goal is to set-up a spatial reference which will be common, homogeneous, European and independant from the national boundaries. It is then necessary to adopt: 1) an European referencin g system, 2) a network of geodetic control points, 3) a recomputation of existing networks, 4) a European cartographic projection (for small scales).

2.1.4. Application dependant schéma

For a given use, the previous CDS must be specialized: digital cartographic models (external view of the CDS combined with cartographic symbols and generalization spécifications), feature representation rules (external view of the CDS combined with a set of rules for modelling the geometry).

2.2. Language level

2.2.1. Languages

This level is often called the logical level. Languages mean tools to represent concepts in a particular environment.

2.2.2. Geographic languages

When the previously defined geographic concepts will be set up, it is natural to formalize computer geographic languages which help GIS use.

2.2.2.1. Data Base Definition Language

For a specific application one can design own data-base. The Data Base Definition Language aims to describe how the data base is organized in a computer readable form. This language is based on the previously defined model concepts and let it possible to speak "data base structure" to the computer.

2.2.2.2. Query Language

Exchanging data between systems dealing with digital geographic information, supposes for the receiver to express his objects of interest to the sender data base. Linked with the Data Base Definition Language, the Query Language let it possible for a user to express his needs in a computer compatible form .

2.2.2.3. General Exchange Mechanism

The general exchange mechanism allows to define a digital geographic exchange standard which is independant from the sender and receiver systems, the physical media, and the precise definition of the exchanged data. It corresponds to the geographical layer and lies on the transmission layer (see annexe 3)

The Conceptual Transmission Model is the guiding philisophy for the exchange of information between systems. It identifies the constituent necessary for any exchange [exchange identifiers, describing parameters (referencing system, geographic extent, data structure and schema, quality), the data themselves]

2.2.3. Specialized Exchange Mechanism

The Specialized Exchange Mecanism takes into account the General Exchange Mechanism and a specialized Conceptual Data Schema. It is an exchange format and is dedicated to technical domain but follows the rules of the General Exchange Mecanism. For its own interface to a specialized exchange mecanism, the user, coming from an other technical domain, has to take into account the domain conceptual data model, set up the content cross-reference, and reset its own interface.

2.3. Implementation level

This level is the programmer's world. It defines the way of implementing the previous abstractions (concepts and languages)

2.3.1. Transmission mechanism

According to the rules of software engineering and the layers defined in the general exchange mechanism, there is a need for choosing existing computer sciences standards (ISO 8211...)

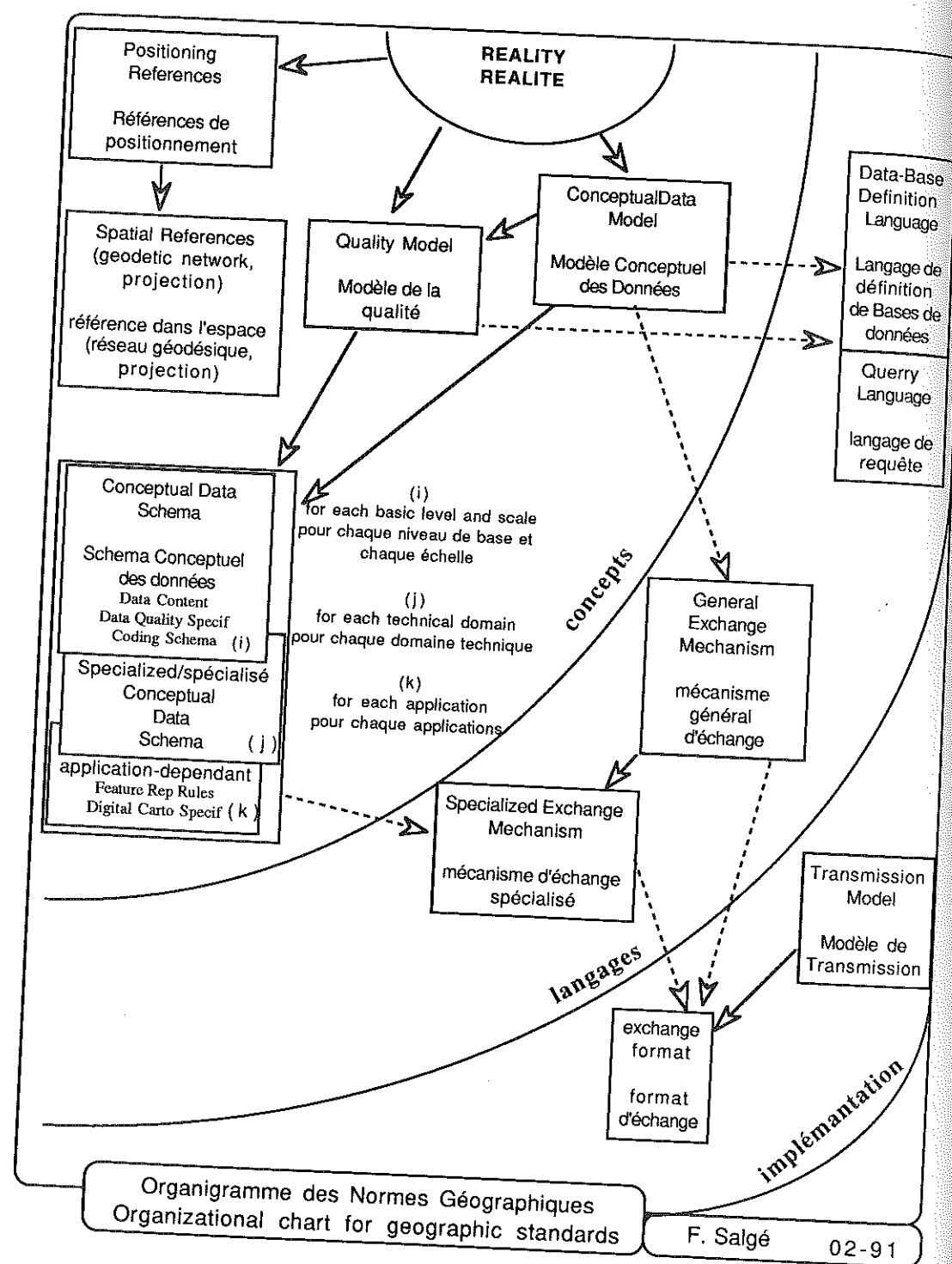
2.3.2. Exchange format

An exchange format is the physical description of the format of the data to be exchanged. As such it is general exchange mechanism adapted into the transmission

2.4. Organizational chart

The following is a graphical representation of the organizational chart for geographic information where each box is one of the previously

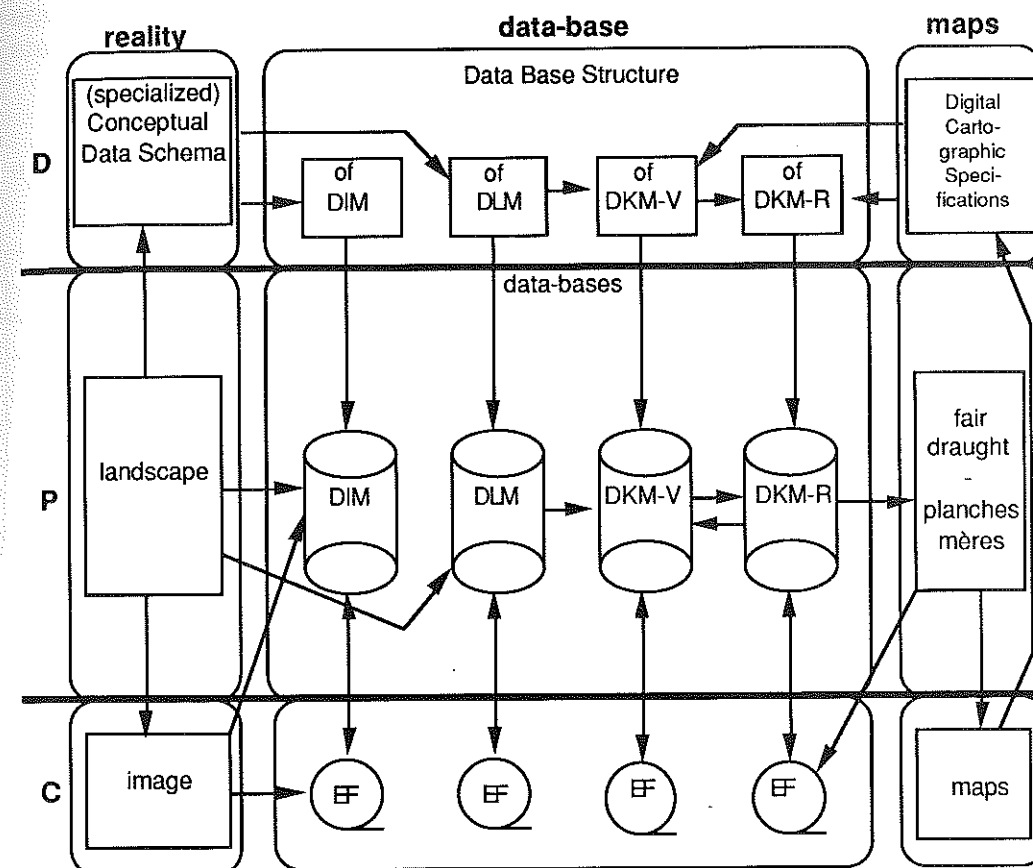
defined standard. They are distributed according to the three levels. The arrows intend to show their logical dependencies.



3. Use of geographic standards in a G/LIS environment

The "G/LIS production environment" shown in the next figure explains data definition aspects (D), data exchange related to a G/LIS environment. Data definition aspects (D), data production aspects (P) and data communication aspects (C) are separated by different layers. Processes are marked by arrows.

G/LIS production environment



3.1. Definition aspects

The Conceptual Data schema is the definition of the reality for a given domain. The data base structure is its implementation in a specific data base environment. The Digital Cartographic Specifications define the design of maps.

3.2. Production aspects

The production is based on different types of reality. The Landscape reality leads either to Digital Image Model (DIM) by remote sensing or to Digital Land Model (DLM) by field measurements or by digitizing large scale maps or orthophoto maps instead of the landscape. Image reality leads to a DIM by scanning. Derivation of a DLM from a DIM is done by image processing and pattern recognition technics. The vector form of the Digital Cartographic Model (DKM-V) is derived from a DLM by cartographic generalization. Assigning symbols to the DKM-V objects and rasterizing leads to the raster form of a DKM: the DKM-R.

A special type of reality is the map. On the one hand, a map is the analogue result of the cartographic production process, on the other hand the map reality leads to a special CDS realized in the DKM database described by a symbol catalogue.

3.3. Communication aspects

In the described G/LIS production system, different types of user relevant data arise, which have to be exchanged by suitable exchange formats. Users are willing to exchange image data (DIM), geographic data (DLM) and cartographic data (DKM-V, DKM-R).

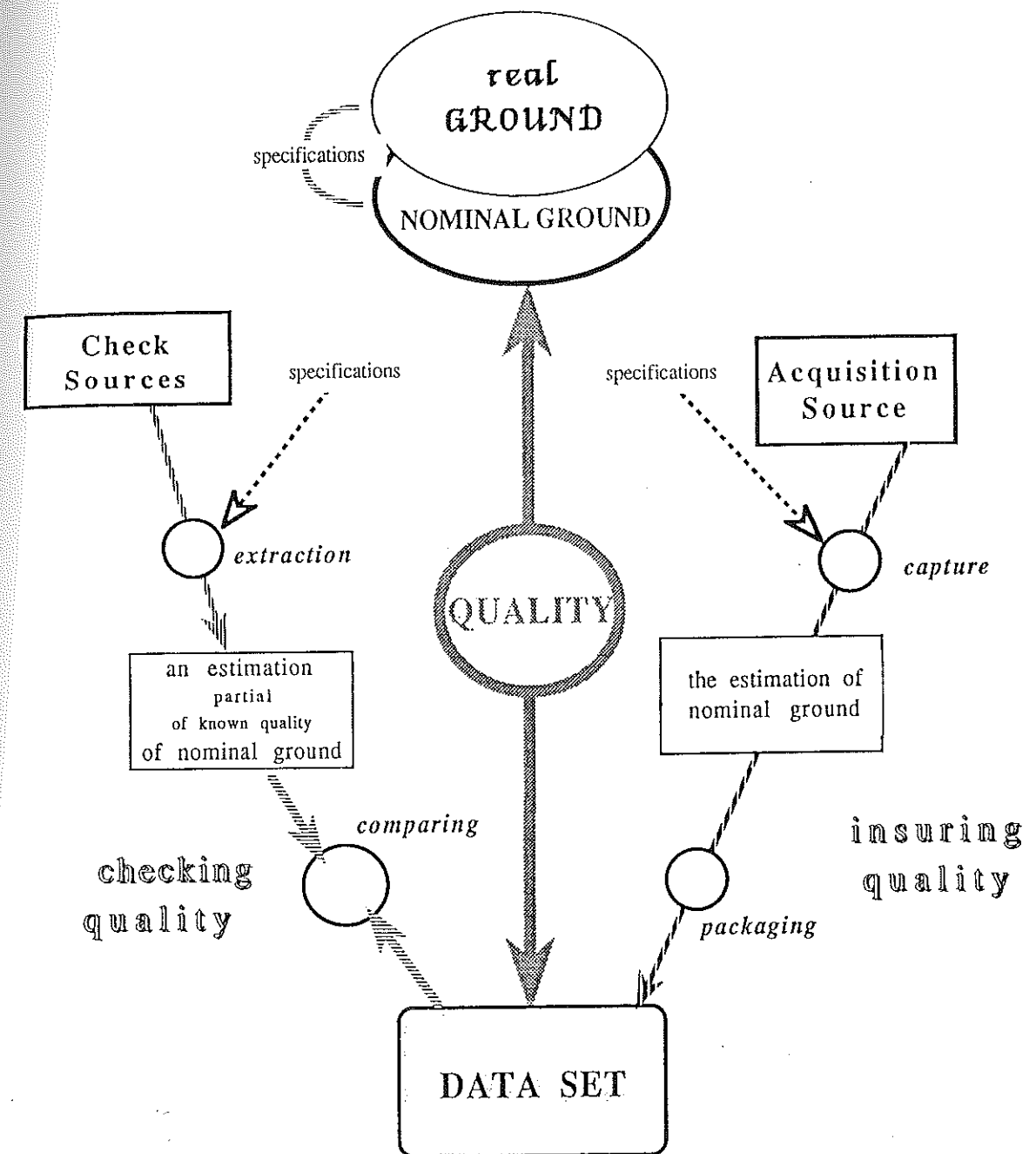
4. Start-up

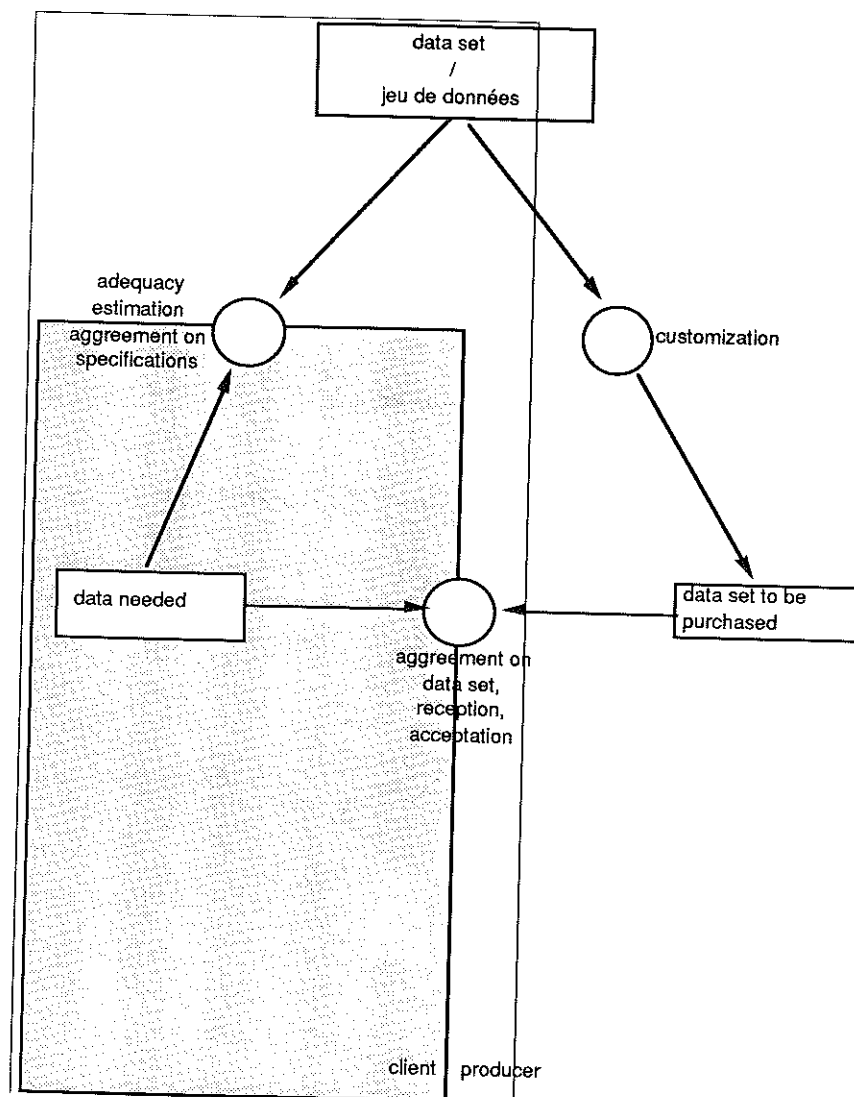
Proposals to be taken into account for the standards setting-up are listed in the following table.

norme - standards	proposals
Positioning references	EDIGéO - FEIV - DIGEST
spatial references	EUREF
conceptual data model	CNIG - DIGEST - ATKIS - SDTS - Demeter - BDCarto/BDTopo - ETDB
quality model	SDTS - BDCarto - DIGEST - DEMETER
conceptual data schemas	ATKIS - GDF/SA - BDCarto/BDTopo - EDIGéO - FACC - ETDB - ...
database definition language	REMO - ETDB - Joint use of GIS
query language	Joint use of GIS
general exchange mechanism	EDIGéO - DIGEST - SDTS - NTF
specialized exchange mechanism	GDF/EF - DIGEST - ...
transmission model	ISO 8211 - EDIFACT - ...
exchange format	EDIGéO - DIGEST - SDTS - NTF - EDIFACT

Quality Model

The work done by the ad-hoc group is summed up by two diagrams. It also defines the terminology and definitions of quality criteria.





MEGRIN

1. MEGRIN idea

1.1. Current situation

It is the traditional role of the Surveying and Mapping Agencies in Europe to provide basic spatial data for a lot of different users and applications. Until now, they have been producing maps on a national level based on national standards. Only for military purposes and for a few special projects covering parts of more than one European country have common map standards been developed and introduced. So far, maps 'symbolize' the old European situation: independent European countries having their own histories, languages and traditions are producing maps with quite different layouts. Usually official maps have not been used as an integrating factor for Europe.

This situation is valid not only for the traditional analogue mapping process, but also for the introduction of spatial databases by the responsible national mapping organizations. Workshops on spatial data standards in Montreux and Brighton in 1990 demonstrated in an impressive way the existence of nearly as many standards as participating European nations and international organizations like CERCO, NATO and the car industry. Large spatial databases are being built by European nations based on these national standards like ATKIS and EDBS in Germany, BDTopo, BDCarto and EDIGéO in France, NTF in Great Britain. NATO is using DIGEST, and the car and electronic industry uses GDF.

In parallel, user groups are developing their own application-oriented, partly project-specific spatial data standards, and the GIS industry their own system-based standards.

1.2. Future needs

Now, this non-uniform European mapping situation comes into conflict with the needs expressed by large user communities interested in basic spatial data like the European Environmental Agency (EEA), EUROSTAT and the car and electronic industry. They have an urgent demand for data covering large European regions traditionally provided by the national Surveying and Mapping Agencies in Europe. They have already declared their willingness to capture such data by themselves, founding special Europe-wide companies, if the official authorities should not be able to do the work. On the other hand, these companies will be adding some thematic information which in turn can be used by mapping agencies to improve their own data-bases. Users of geo-data will be in some case producers of geo-data which may serve for updating purposes. In the future consumers will be also producers and vice-versa.

These user needs meet with the interests of the European Community in preparing a Europe without frontiers after 1993. Therefore the Commission supports activities which lead to European spatial data standards and to open access to spatial databases being maintained by official authorities.

Within this effort of European integration, which is reinforced by more close relationships with EFTA countries and Central & Oriental Europe, a geographic information integration for Europe should be included.

1.3. Work of CERCO

It is the role of CERCO as the responsible European body coordinating the interests of the official national Surveying and Mapping Agencies to give an answer to these questions and demands.

According to basic spatial data, the goals to be fulfilled by the European Surveying and Mapping Agencies can be summarized as follows :

- Define and agree on common data specifications and technical data exchange standards as soon as possible.
- Allow uniform access to distributed national and regional spatial databases.
- Clarify and harmonize the legal prerequisites like ownership, copyright and licensing of spatial data, to simplify access to these data and form a common "market" for geodata.
- Support the combination of data of different owners to meet user needs.

The CERCO concept, to meet the above mentioned requirements, is the "Multi-purpose European Ground-Related Information Network (MEGRIN)". WG 10 was set up to realise that concept with the following terms of reference:

- Development of the basic technical MEGRIN concept.
- Development of possible realization procedures ; identification of suitable project involvement.
- Coordination of the work of Working Groups 2, 5, 7 and 9 to ensure that the work of the working groups are integrated and not duplicated.
- Definition of tasks for the Working groups to allow the MEGRIN concept to be achieved.
- Finding ways of financial and other support.

2. MEGRIN concepts

This paragraph deals with an overview of the main concepts underlying MEGRIN. There is first a technical explanation of the Multi-purpose European Ground-Related Information Network. Then is described the involvement of CERCO in defining the standards necessary for MEGRIN.

MEGRIN is a logical network of nation-wide data-bases which makes it possible to formulate same answer to users wherever they be in Europe. Nations are free to have their own systems.

2.1 Technical description

2.1.1 Principle diagram

The following diagram is a graphical representation of MEGRIN. Basically MEGRIN is the kernel of a network which makes it possible to exchange geographic data between CERCO nations. These exchanges may be extended to potential technical users¹, or other similar networks and for other kinds of data than topographic data.

MEGRIN provides a system able to transfer data at the European level. The following paragraphs describe MEGRIN.

Directory of conceptual data schemas

This directory aims at describing the data bases which are connected to MEGRIN. Within this directory there are specific Conceptual Data Schemas CDS (i.e. definition of content, objects, attributes, links, definition of quality specifications and coding system...) which describe commonly agreed data sets (European Territorial Data Base, European Road DB...). An extension to non-connected data bases may also be available. The conceptual data schemas of national data bases are also described. Also included is information about progress in developing national data bases. and who is responsible for providing data.

Dispatcher

Suppose there is a user wishing to obtain a set of geographic information which suits his requirements. He will describe the information needed to the DISPATCHER. The DISPATCHER compares the information demanded with the content of the directory. While analyzing the query, the DISPATCHER determines which national data bases are involved (which will deliver elements of the response) and what elementary information is to be asked off these data bases. The DISPATCHER then sends elementary queries to each relevant national system .

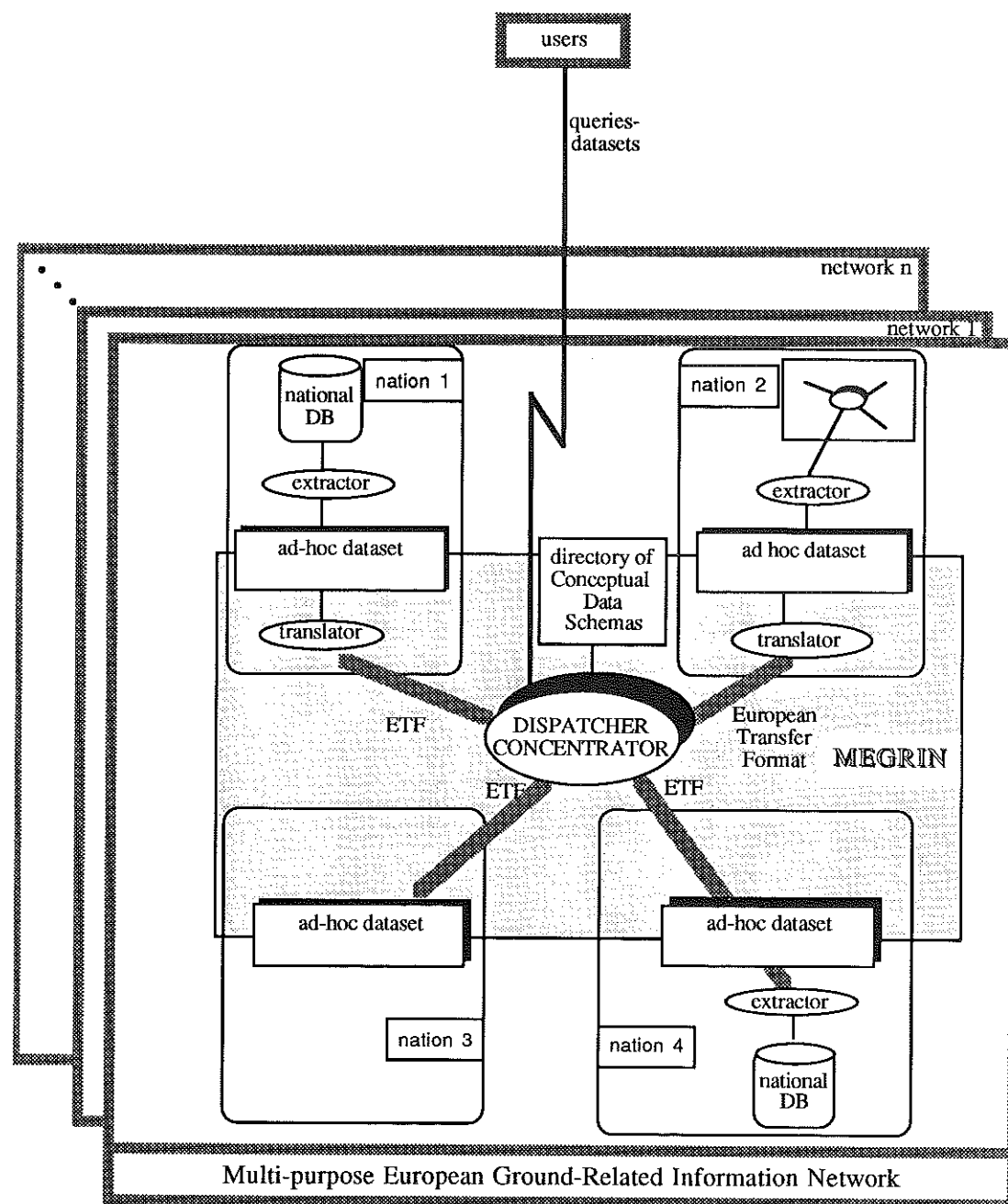
Translator

The TRANSLATOR is an interface between a national data system and MEGRIN, and transforms the elementary query into a format which suits the requirements of the national system. The latter then elaborates a response to that query by means of an "ad-hoc data set". The TRANSLATOR converts the dataset into the European Transfer Format (ETF) and sends it to the CONCENTRATOR.

Concentrator

Having received all the "ad-hoc-datasets" required under the ETF specifications, the CONCENTRATOR elaborates the complete answer to the user's query and sends it to him.

¹ such as road administration, municipalities...as opposed to general public



2.1.2. Minimum informative content

In the long term, MEGRIN will make the data produced by CERCO organizations homogeneous. MEGRIN will not define a unique data-base, design but will make it possible to provide datasets according to commonly agreed specifications. The Minimum Informative Content (MIC) of the European Territorial Data Base (ETDB) is an example of such common specifications. Among the geographic information usage, the needs for

environmental studies have been addressed. ETDB was designed primarily to meet the topographic information requirements of this kind of activity.

In the MEGRIN context, the ETDB documentation intends to specify the topographic information which can be interpreted from every map produced by the CERCO organizations.

This ETDB documentation will be the first MEGRIN specification. It aims at:

- specifying a minimum structure and content (MIC) for topographic data bases which defines the content of "European" data-sets produced by CERCO members
- specifying a first proposal for a conceptual data model to which any mapping agency may refer
- giving guidelines for a European Transfer Format able to convey data-sets under the ETDB specifications.

2.1.3. Nation responsibility

Each nation may choose or not ETF as a national transfer format and to follow or not the MIC specification for their own data base.

The national arrangement may be based or not on similar network structure.

The only mandatory action for each nation is to provide a description of the national context (directory of conceptual data schema, ...) and to make it possible for any user to get data with the agreed specifications.

Thus it will be possible to organize at a European level commonly agreed geographic information datasets which may serve as basic references.

2.2. Specification for MEGRIN

The organizational chart for geographic standards (see annex) groups together and defines the standards which should be set up within the field of digital geographic information. Here the term "digital geographic information" is a generic one used to represent all the information which is needed for the knowledge of the geographic environment.

In the context of MEGRIN it is necessary to split those standards into three categories: those which belong to CERCO responsibility, those which have to be re-used without changing anything, those which need to be elaborated within the geographic user community. Please refer to the annex to find the exact definition of the terms.

2.2.1. Specification of CERCO responsibility

Basically, those specifications which define common products offered by CERCO members must fall under CERCO responsibility and need to be validated by user enquiries:

- CERCO conceptual data schemas CDS (e.g. definition of MIC)
- CERCO specialized exchange mechanism profiled according to CERCO CSDs
- existing national database description
- operating use of MEGRIN
- spatial references (WG 8)

2.2.2. Standards to be re-used

As MEGRIN is based on informatics it is necessary to build it as much as possible on existing standards such as:

transmission model (for files e.g. ISO 8211, for messages e.g. EDIFACT...)

network organization and related techniques.

2.2.3. Standards to be elaborated with or proposed to the geographic user community

The CERCO community is one of the components of the geographic community. CERCO, as an expert body, is able to propose or to comment on draft standards. Among them can be selected:

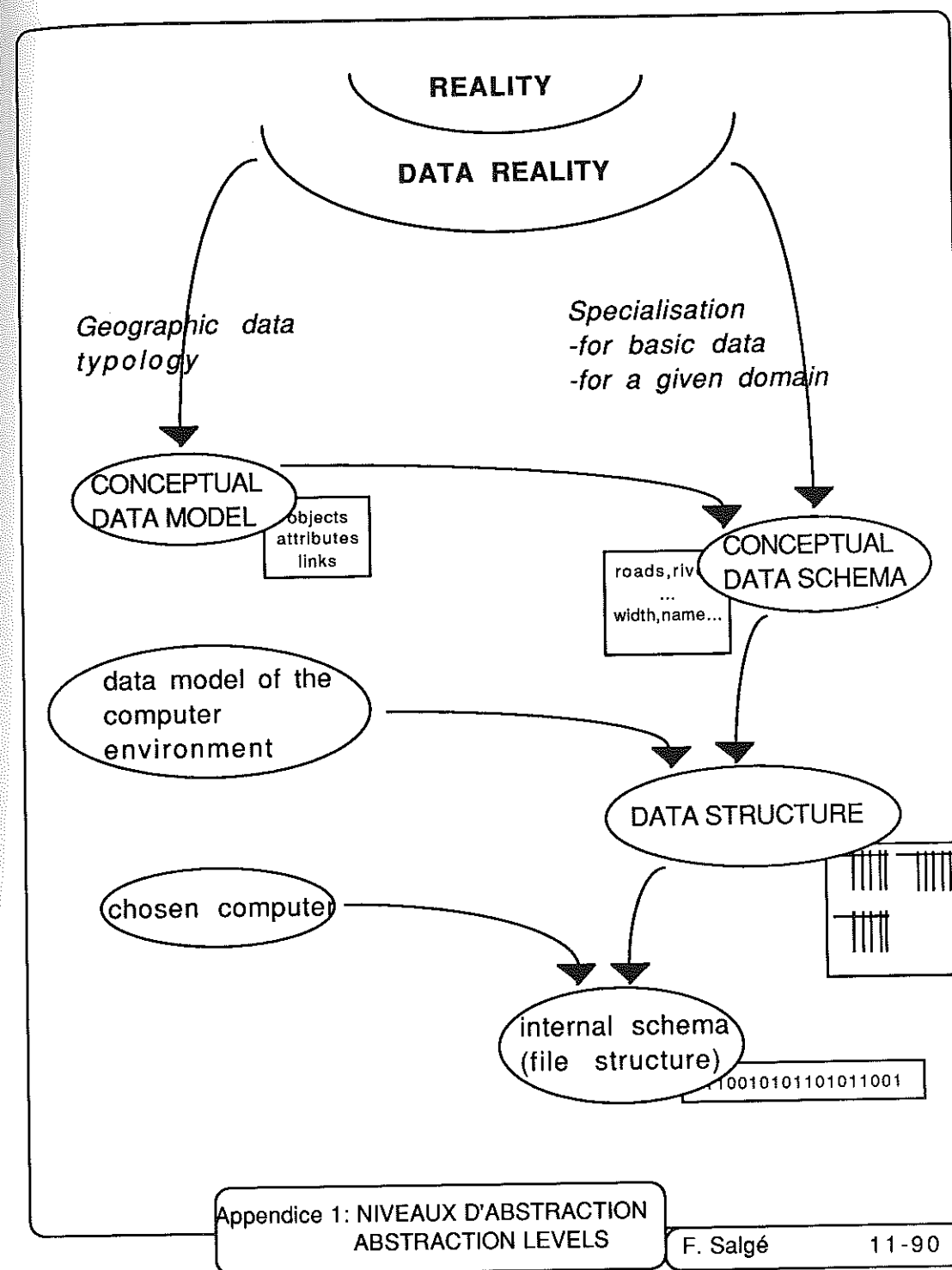
- conceptual data model
- quality model
- general exchange mechanism
- data-base definition language and query language
- specialized exchange mechanism
- exchange formats...

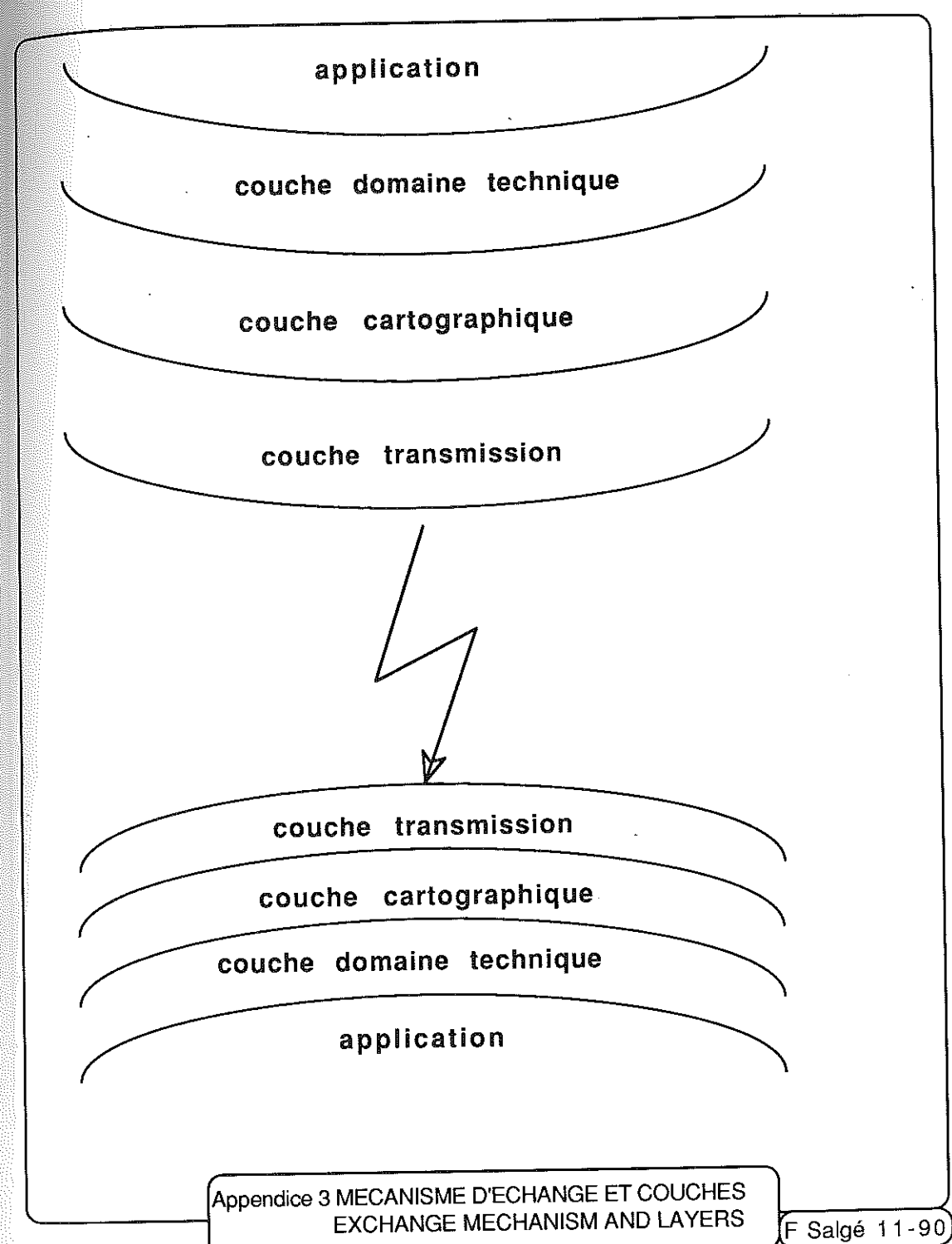
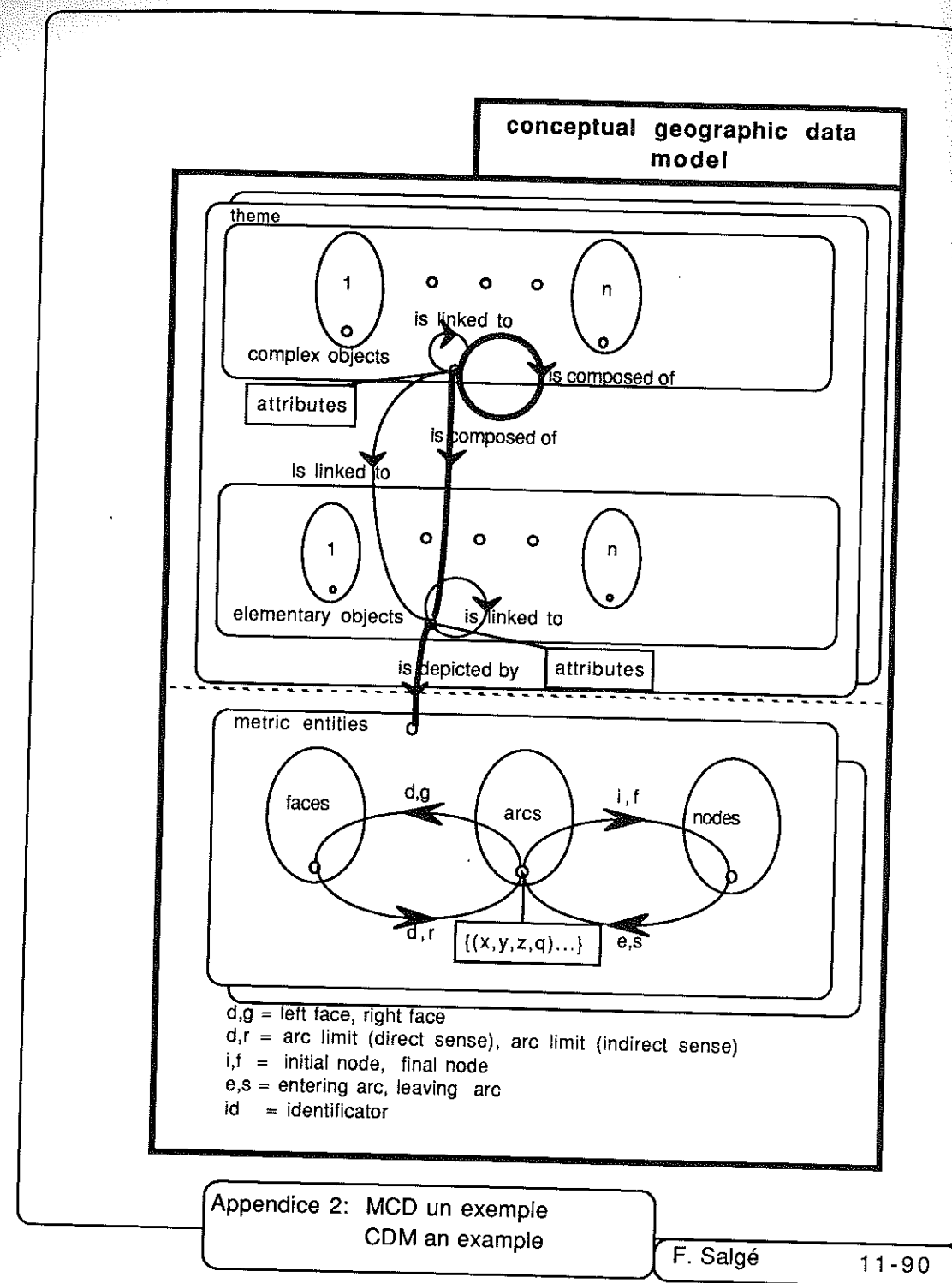
3. conclusions

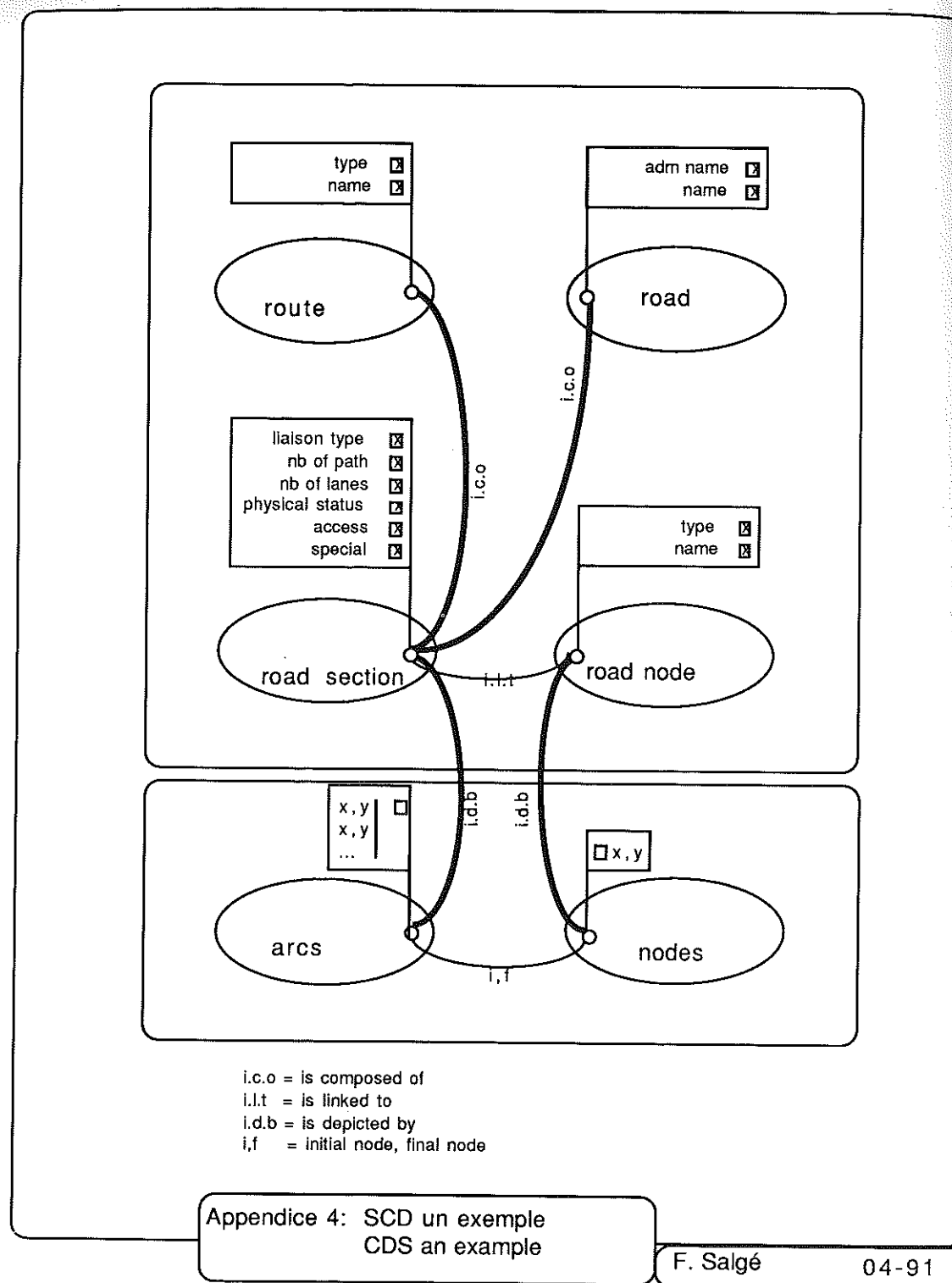
The implementation of MEGRIN may be seen as a first step toward a more general service: "European Network of Geographic Information in the context of the single act".

MEGRIN as a prototype will make it possible to derive the R&D topics necessary to be undertaken for this essential interconexion of information networks.

Digital Geography as an integrating factor will be then a more powerfull tool.







Data transfer, concepts and applications

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Summary

Data transfer requires several interrelated definitions on (inter-)national level. In many countries technical and functional standards are developed but on a European level there is no responsible organization for the development of functional standards in the field of LIS. The state of the art is presented.

Introduction

In the communication between people signs and gestures, and later the language, were the first standards ever. In language, especially the applied grammar forms a standard, since they are used to speak or write a language correctly. It is an agreement with complete consensus between users which is freely accepted and these are the two main characteristics of standards:

- full consensus;
- free acceptance.

However language is not only an object for standardization, but also an important mean: the classification of objects (topographic objects in LIS) uses language for the syntactic definition.

For centuries a handy standard for the unit of length has been an important topic of debate, and not only to land-surveyors. The word handy may be literally understood, for parts of the human body were often used as unit of length as Dutch ell, foot, step, inch, etc. The replacement of the very many different units of length by the meter was a great success for the standardization process. But also the introduction of the cadastre by Napoleon and the industrial revolution of the last century contributed immensely to the standardization process.

Aims and definitions

In general the aim of standardization is to enable easy and efficient transfer. This comprises:

- quality improvement. Often existing LIS-data is very different in quality. Improvement of quality is possible by setting a well defined general applicable quality concept (the conceptual standard) and quality registration according to this concept in each of the LIS's concerned;

- quality control. Especially in a digital environment of LIS it becomes possible to control the quality of each object separately. This enables contractors to perform measurements with a quality for every object as desired by principals;
- cost savings. Since better exchange of data will be possible by using standards, not only the process of data exchange will become cheaper also the use of each other data saves the costs of multiple data capture;
- knowledge transfer. Since the LIS community is very much decentralized due to its different types of applications as utility, cadastre and different types of governments many different concepts exist. General accepted standards contribute to the understanding of the different applications and the LIS-science in general;
- data integrity. General standards and definitions avoid loss of information during the exchange process which can occur due to different understanding or definitions of objects by users;
- user protection. Increasing privatization and co-operation make users more dependant of each other and the private sector. Well defined standards are a means to protect the users' interest in the data.

Phases of standardization

The terms normalization, standardization, unification and harmonization are often used in synonymous context. However some scientists do distinct:

- **normalization**, to be understood as the drafting and application of a set of rules by all parties involved, to create unity and so tuning the concepts while
- the actual application of specifications and rules could be called **standardization**. Though the term standardization is more often preferred for both concepts (normalization and standardization);
- **harmonization** is often used for the process of agreement in legislation. But it also involves the planning of the different phases of the standardization process, the clarification of terminology and the design of generic conceptual standards. Above all, harmonization enables the standardization process and promotes to the transfer of knowledge;
- **unification** is an extreme type of standardization and results in the use of the same type of system(s) by all users, i.e. the same conceptual, logical and physical model and the same hard- and software.

Standardization institutes

In the beginning of this century standardization became more widespread accepted in Europe, e.g. the foundation of the British Standards Institute (1901), the Netherlands Electronic Committee (NEC, 1911) and the Netherlands Normalization Institute (NNI, 1916) and in many more European countries.

The CEN (Comité Européen de Normalisation) in Brussels co-ordinates on European level as the ISO (International Standards Organization) in Genève does on a global level. Apart from the standardization for general applications the electrotechnical community has its own organization on different levels.

The decision 87/95/EC of the EC council, taken in 1986, about the agreement of all member-countries to accept all standards effected on a European level, is an important milestone. It shows that the EC stimulates the standardization process very

strongly. In the ESPRIT and RACE programmes large amounts of money is invested for telecommunication. The ESPRIT programme is mainly directed towards the development of standards, while the RACE programme is devoted towards telecommunication.

Standards developed under co-ordination of ISO and CEN are mainly **technical standards**, enabling the physical transfer of data. On a international level there are no standards developed for the **functional aspects**. However during congresses of ICA, ISPRS, FIG and AM/FM standardization becomes more and more important and some of these associations have initiated working committees. The Comité Européen des Responsables de la Cartographie Officielle (CERCO) has started to develop a standard for the exchange of data (but mainly for so-called 'small scale applications').

The transfer process

Since the use of standards is a free choice of the users concerned, it is not the purpose of standardization to force each user to implement uniform standards in their own system. Moreover, existing GIS/LIS's apply different data structures, successfully exactly meeting the users' requirements. And surely, in the future new structures will be developed for new applications. So, exchanging common data of mutual interest requires a freely accepted agreement of both users.

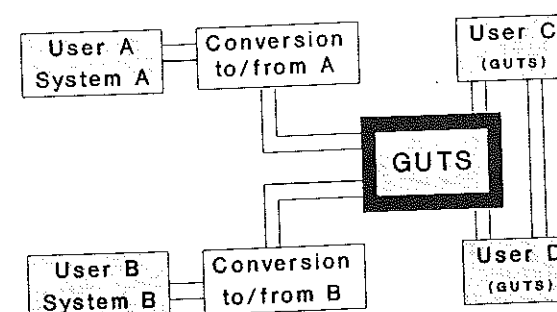


Fig.1. The general situation for data transfer.

However, standardization aims at the multiple access of data from different data bases with different structures transferring data from one system into another (by 'translating' the data, assuming the possibility of the translation). This involves the development of a Geographic Uniform Transfer Standard (GUTS) which is flexible enough to all systems in consideration (fig. 1). This should not require to convert data definitions (existing and new ones) of different GIS/LIS's into that newly developed standard but a conversion into the standard should made be possible in order to communicate amongst each other.

Required standards for data transfer

Prior to the definition of a general applicable GUTS for data transfer, several different standards are to be developed:

- definition of terminology as features, entities, objects, attributes, value, domain, occurrence, relations, graphic primitives, data base, file, data base structure, etc. Definitions can be taken over from the science of informatics;
- definition of objects (DDS, Data Definition System); it recognizes and names terrain features and its characteristics but is mostly called classification. From theoretical point of view classification is the ordering of objects into classes according to specific characteristics (for quick data access). Characteristics are stored as attributes in a data base.

Also the domain definition of attributes is part of the data definition;

- definition of the quality characteristics and concepts as units for the metric quality, up-to-dateness, availability, completeness, lineage, security-, validation-, verification- and quality control procedures, etc.;
- definition of spatial aspects, as the co-ordinate reference system and its units, metric structure, etc.;
- definition of models for Data Base Management System (DBMS) and (geometric) data structures;
- hard- and software standards, as transfer medium (e.g. tape, optical or floppy disc), the logical and physical structure of the data transfer file, its labelling, the communication system (ISO standards), etc.

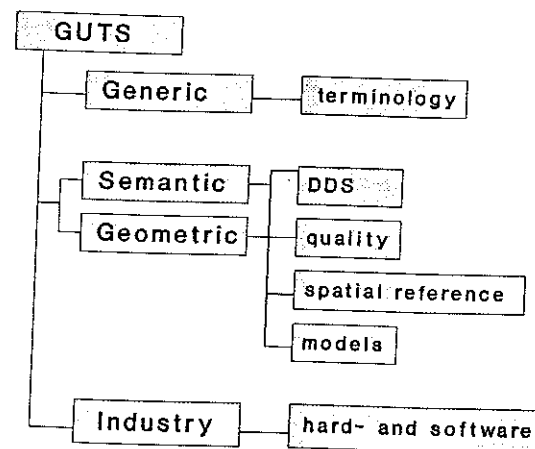


Fig.2. The mutual relation between the different standards required for data transfer.

Levels of data transfer

Data transfer may be on three levels:

- transfer of **digital drawings**, transferring only the (carto-)graphic objects with their (carto-)graphic characteristics (attributes). This type of data transfer only exchanges drawing instructions in order to make plots on different media as plotter, screen, etc. The ISO (International Standard Organization) already issued standards for this

type of transfer: GKS (Graphic Kernel System) and PHIGS (Programmer's Hierarchical Interactive Graphic System), which is used by many manufactures to transfer data from one devices to another within one IGS system;

- transfer of occurrences of for example topographic objects and their attributes, but not their mutual relations. This type of data transfer is developed because often the relations between objects are too application dependent making the relations obsolete for the data receiver;
- transfer of digital spatial data bases including the objects as well as their mutual relations, i.e. the data model and structure, as well grid as vector structures including topology. The ISO standard developed for this type of data transfer is IGES (Initial Graphics Exchange Specification).

Horizontal and vertical data transfer

Data are transferred because another user may be interested to use the same data for his application. His application may require an exact copy of the same data adding his own data e.g. for research purposes of the geographical area of interest or a thematic selection of the received data will be used. One may call this a horizontal data transfer.

Data may also be used on a different scale of aggregation as is applied for data to be represented on a different map scale. For these applications the received data has to be processed through a generalization programme before any use. If appropriate generalization programmes are available the whole range of map scale can be derived from the original basic data; this may be called a vertical data transfer.

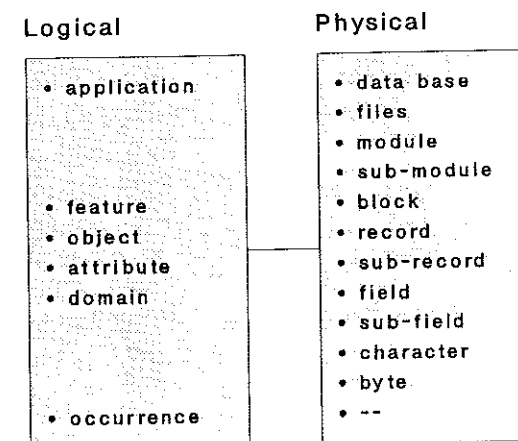


Fig. 3. The conversion of the logical model into physical hierarchy.

Models used for data transfer

The different models used for data transfer stem from the informatics science and contain a:

- conceptual model including a data model for transfer abstracting entities and data classification, coding and quality description;

- logical model describing the entities' mutual relations resulting in a generic and spatial data structure;
- physical model defining physical hierarchy between data base (sub-)sets, (sub-)modules, (sub-)records, fields, items and positions and their definitions.

The conceptual model recognizes objects and attributes to be stored and logical relations (with their characteristics) between objects. This requires for data transfer the definition of record to contain occurrences of objects and relations. Each occurrence contains all characteristics (of the object or the relation) preceded by a description of the type of occurrence and the type of attributes in every occurrence.

International standards

From technical point of view, ISO has defined two generic standards for data transfer: ISO 8211 and EDIFACT (ISO 9375).

ISO 8211

ISO 8211 is originally developed by the ANSI (American National Standard Institute) in 1985. The aim of this standard is to deliver data from one user to another in a way that the receiver can convert the data into his data base structure without changing the contents and remaining the relations as received.

The ISO 8211 allows:

- to define a general data structure between data of features, as vectors and images, and its hierarchy;
- to transfer different types of data as ASCII, EBCDIC, 7 bits, binary, etc. and different types of data structures as sequential, hierarchic, relational or indexed; grid structured data sets require pre- and post processes;
- means to recognize the type and organization of the transferred information;
- three levels of complexity about the nature and functions of the data to be transferred:
 - . level 1: fields with data about simple non-structured chains;
 - . level 2: level 1 but also fields containing different types of data for transfer;
 - . level 3: level 2 including hierarchical data structures.

With ISO 8211 one or more descriptive records are transferred. Each record contains respectively:

- logical definition of records: RDR, Record Descriptive Records, describing the semantics of following records;
- description of the data itself: DDR, Data Descriptive Record;
- the data itself in Data Records (DR).

EDIFACT

EDIFACT (Electronic Data Interchange For Administration, Commerce and Transport) is developed in 1985 by the Economic Commission of the European Community (WP.4 of the CEE/EC), which is accepted by the ISO in 1987 (ISO 9735).

The aim of EDIFACT is to supply:

- procedures for international trade;
- reduction of costs and avoid delays in data transfer;
- error free transfer of administrative and commercial data;
- system independent interactive data transfer.

An EDIFACT transfer is considered to be a set of records in hierarchical layers being transfer layers, functional layers and messages. There exists single and multiple records in EDIFACT.

The EDIFACT structure is a concatenation of characters called CONNECTION, indicating one or more data transfers (see fig.4).

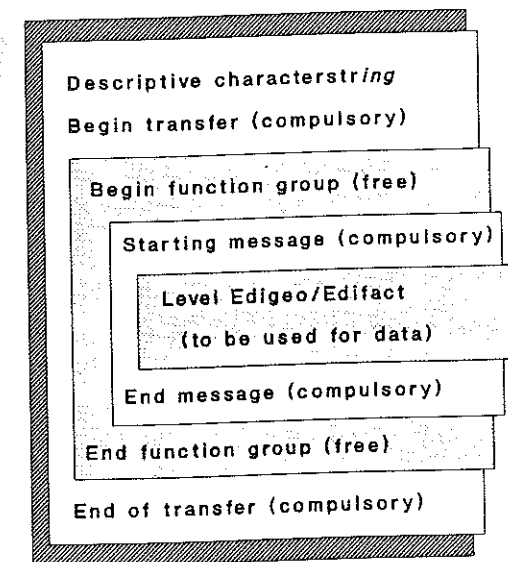


Fig.4. The communication protocol in EDIFACT.

Functional aspects of data transfer

Functional aspects in data transfer are:

- the structure and hierarchy in the conceptual model as type of geometric data structure, i.e. topological, node/link, polygonal, grid cell or raster, network or relational, etc. as well as the relation between different thematic data subsets (CAD levels/layers or overlays);
- data validation using a data definition (DDS, Data Definition System) for objects and attributes and their spatial and non-spatial domain;

- security aspects as:
 - secrecy classification;
 - type of use (view or view and edit, including senders' permission of the type of editing as possible in object-oriented data structures through messages);
- spatial reference as:
 - internal geometry, defining the permitted types of transformations;
 - the data sets' co-ordinate range;
 - external co-ordinate reference system and units;
 - reference points to adjust the internal geometry to an external reference system.

Existing transfer standards

The development of GUTS started in the seventies in Germany [1] directly followed (still in the same decade) by a development in The Netherlands [2].

Subsequently different standards are defined:

- USA with SDTS, Spatial Data Transfer Standard;
- UK with NTF, National Transfer Format;
- starting with some European NATO countries followed by others, now united in DGWIG, the Digital Geographic Information Working Group including the cooperation of Belgium, Canada, Denmark, France, Germany, Norway, The Netherlands, United Kingdom and USA defining DIGEST, Digital Geographic Information Exchange Standard;
- Germany with EBDS, Einheitliche Daten-Bank Schnittstelle, based on the ALK/ATKIS model of the German Landesvermessungämter;
- Finland with VHS 1040 en 1041 based on the EDIFACT norm.

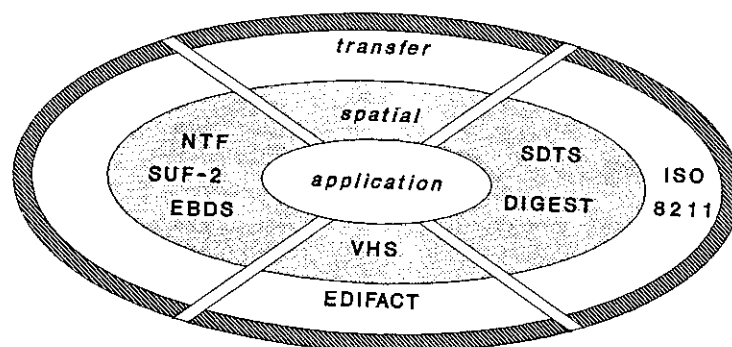


Fig. 5. The technical choice between ISO 8211 en EDIFACT as it is used for the different existing standards.

SDTS

SDTS [5] and [10] is developed through an extensive study of the federal government and academic party in the USA. The standard comprises three parts (to provide a transfer system of digital spatial information between parties using dissimilar computer systems, preserving the meaning of the information and reducing the need for external information during transfer):

- logical specifications, including a conceptual model of spatial data and definitions and terminology; this section contains the definition of a set of spatial primitives for vector-, raster-, grid-, attribute-, and other data;
- transfer specification, defining the logical file and geometric data structure, data quality requirements, that specify the true value labelling of object's attributes as lineage, positional precision and reliability, attribute accuracy, up-to-dateness, completeness, logical consistency;
- spatial features, defining a standard for spatial, topographic and hydrographic objects and attributes, attribute values, relationships as well as a specification for a cross reference list to convert user definitions into standard definitions.

ISO implementation is applied in the development of SDTS, using as much as possible existing FIPS, ANSI, or other accepted standards.

The standard was submitted to the NIST (National Institute for Standards and Technology) in July 1990 after extensive testing and reviewing and in future might be submitted to the American National Standards Institute, Inc., for promotion as an ANSI standard.

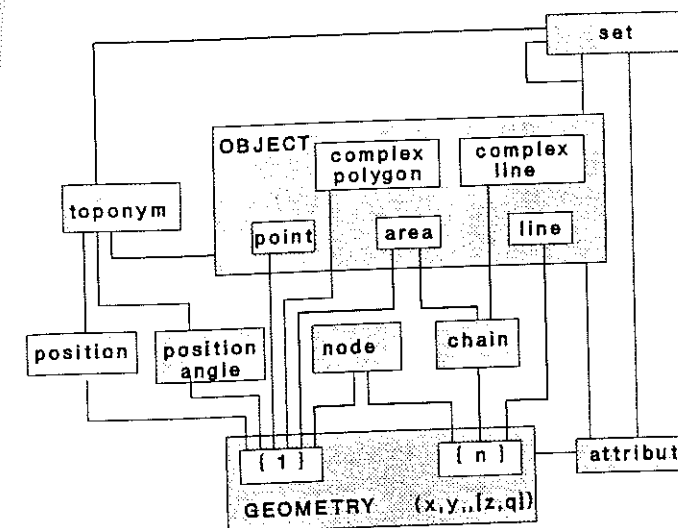


Fig. 6. The conceptual model of NTF data structure.

NTF

The development (1985-1986) of the British standard NTF (National Transfer Format) [9] is mainly based on early definitions of SDTS. The conceptual model of NTF is displayed in fig. 6. NTF enables to transfer data:

- on geometric level (only co-ordinates);
- occurrences of objects in a 'spaghetti' structure for point-, line- and circumferences of area objects as well as composed objects, symbols and text;
- with a topological data structure being nodes and their connections defining chains and area objects.

The NTF standard contains a data definition table (DDS) including all attributes per object with their domains. At present NTF is considered to be adapted into the ISO 8211 standard.

DIGEST

The conceptual model of DIGEST is shown in fig. 7 and allows the transfer of a topological structure including the indicated mutual relations between objects:

- entity - objects, elementary and composed entities;
- entity - primitives: nodes, chains and areas;
- mutual between primitives, as: node/chain, chain/area, node/area.

DIGEST is based on the ISO 8211 standard and allows the transfer of both raster and vector data. The DDS has a hierarchical classification of superclasses, classes and subclasses. The quality is defined in three levels: transmission quality, spatial quality and non-spatial quality. At present the standard for raster data transfer is completely defined, while the definition for vector data is under development.

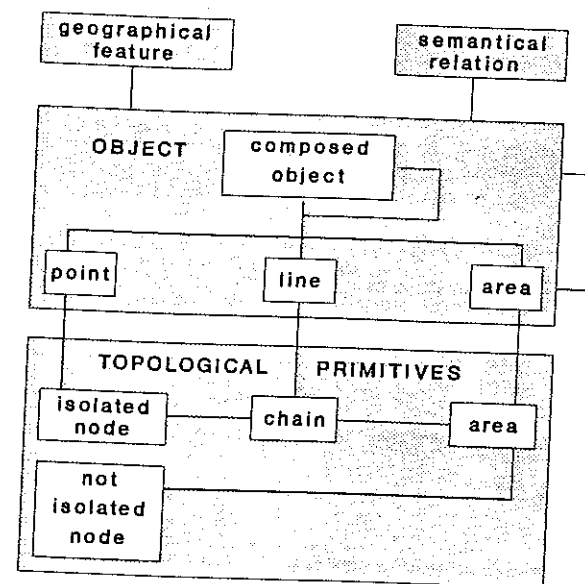


Fig. 7. The conceptual model of DIGEST

EBDS

The EBDS model is based on the ATKIS/ALK data models DLM (Digital Landscape Model) and DKM (Digital Cartographic Model) [7]. EBDS has a hierarchical structure between database units related by relation tables.

The EBDS system is meant for the transfer of:

- data input in DLM and DKM;
- updating in DLM and DKM;
- definition of selection criteria;
- processing and preparation of selected data.

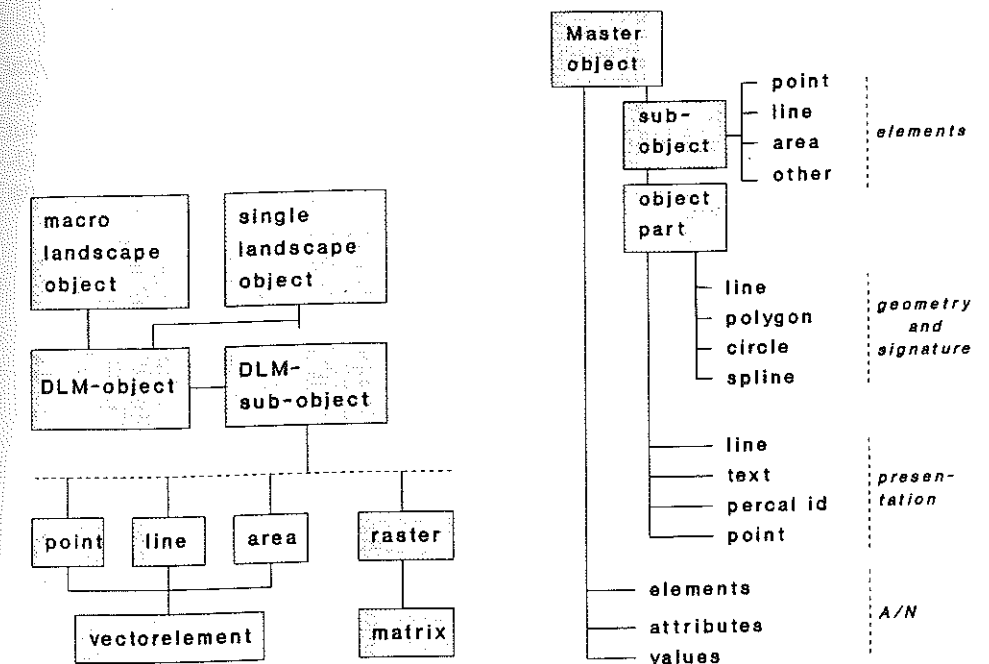


Fig. 8. Data model and transfer model of ATKIS/ALK.

VHS 1040 and 1041

The national data transfer standards for geographic data (VHS 1040) and messages data (VHS 1041) is developed in Finland as part of a national GIS-programme. These standards form the basic model to define and exchange data. The geographic standard contains:

- co-ordinate reference system;
- geometric quality classification;

- geometric object definition and representation rules:
 - * points, lines and areas. Areas are represented as single or complex polygons or as a set of boundaries. Topological relations only exist for vector models in this standard;
 - * grids and gridcells with boundaries only parallel to the co-ordinate system geometrical reference system;
- representation rules for non-spatial attributes;
- reference to the message standard;
- geographical Data Definition (Data Dictionary, DDS), in which for every user the object definition, attribute definition and the spatial domain of every database are determined.

SUF-2

The conceptual model of SUF-2 is described in [8]. It is designed having a topological data definition and possibilities for multicoding in mind, to enable data transfer with unlimited multiple semantical attributing. The standard does not include a DDS but allows the application of a user defined DDS, although the use of the BOCO-classification system, issue 1985 (a classification system for LIS objects of the Netherlands Council of Landinformation, RAVI) is advised to be used.

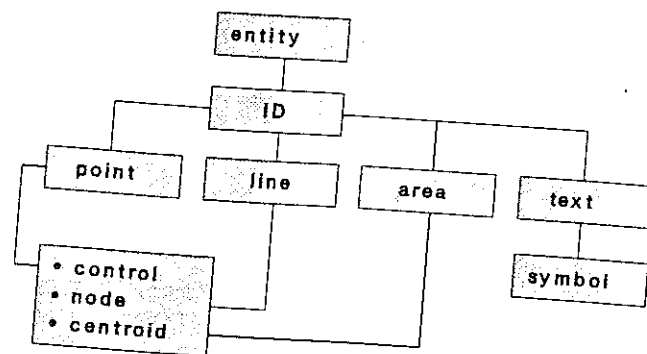


Fig.9. The data model of SUF-2.

In SUF-2 objects are transferred through the record types 3 and 4 (records for the actual data base objects) and record types 5 en 6 (for graphical objects as symbols and text).
SUF-2 is defined by a working party of the RAVI and is now presented to the Netherlands Normalization Institute (NNI) which at present holds an open criticism session

Conclusions

In many countries one is aware of the immediate need for a GUTS fulfilling the structure and requirements of the different users. It results in the development of new standards or the application of existing ones. Modern standards for geographical data transfer are based on the ISO standards 8211 or 9375 (EDIFACT) and have a conceptual model and structure allowing the exchange of data and their relations. However, mostly received data is stripped from its relations leaving only the actual data as subject for transfer; this requires a subsequent restructuring of the received data into the database structure of the receiver. At present, users of data transfer seem to prefer this procedure over the acceptance of data and relations.

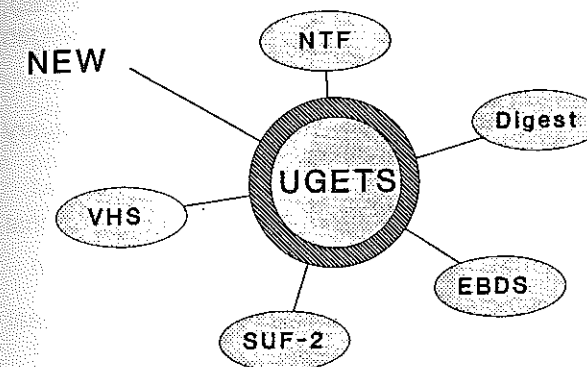


Fig. 10. Structure of a "Uniform Geometric European Transfer Standard".

In (inter-)national forums one often debates about the difference between LIS and GIS. Although these concepts are partly overlapping, the difference yields to a difference in level of detail and so to different applications and scale-levels. (Besides the LIS's are often "parcel-based".) For the process of standardization on European level, especially for the functional aspects, the lack of an European organization is felt very strongly. A workshop of the AM/FM conference, held in October 1990, suffering from the same, did not conclude to the development for Uniform Geometric European Transfer Standards, although the need was felt strongly. Such a standard should be structured so that other standards or data bases can be linked to it (fig. 12).

Literature

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ASSOCIATION FOR GEOGRAPHIC INFORMATION

STATUS OF NTF - MAY 1991

M SOWTON

CHAIRMAN NTF STEERING COMMITTEE

INTRODUCTION

Recent modifications to the National Transfer Format (NTF) have made it possible to make NTF compatible with DIGEST while retaining the flexibility which was built into NTF from its early development in 1985. NTF is now a format in general use in the United Kingdom and for specific applications in Europe. It conforms to recently agreed conceptual data transfer models (see later) and with the development of an ISO 8211 compatible version now in hand it will be possible to transfer any data model (using Level 5) provided it can be described by means of a Data Dictionary.

BACKGROUND

Since 1985 the "National Working Party to produce Standards for the Transfer of Digital Map Data" has been developing NTF initially as a means to transfer map data. However from the outset it was recognised that attribute data and topology would also need to be exchanged and that the term map should include any spatial diagram such as thematic maps and utility plant layouts.

In 1986 the original draft standard was issued and this was implemented in January 1987. This was improved in stages until January 1989 when version 1.1, which was a complete revision, was issued.

Although Ordnance Survey was the driving force behind the project, all the UK government mapping agencies participated and the utilities through the National Joint Utilities Group supported the development. In 1989 the Association for Geographic Information (AGI) undertook responsibility for NTF and the NTF Steering Group which then became a sub-committee of the AGI Standards Committee was renamed the NTF Steering Committee.

CURRENT STATUS OF NTF

As a result of work being carried out in Europe through the agency of CERCO (The European Committee of the Heads of the Official Mapping Agencies), NTF became a candidate for an interim European transfer format (ETF). A condition for this to happen was that NTF should be compatible with ISO 8211. Consequently AGI agreed to have the necessary work carried out by consultancy in June 1990. However, before the necessary changes could be written and the documentation produced, there were indications of a growing attraction to the DIGEST specification which was

created by a group of NATO nations through the Digital Geographic Information Working Group (DGIWG). In order to determine the differences between NTF and DIGEST, a consultancy was arranged by the British Military Survey on behalf of AGI. This study indicated that the two formats were not far apart and that with few changes to NTF levels 1, 2 and 3 and the introduction of a new level 4 for full topological data, NTF and DIGEST could be made compatible.

As a consequence a version of NTF (version 1.2) has been produced which meets all the requirements for compatibility with DIGEST, ie there is no significant loss of data integrity when transferring data in either direction. Once version 1.2 has been accepted by the working party evaluating the new documentation, work will be put in hand to produce the ISO 8211 compatible version 2.0. When this has been done NTF will have achieved the requirements set for its adoption for testing as an interim European transfer format by CERCO.

NEW MODELS IN NTF

In order to achieve compatibility with DIGEST it has been necessary to introduce an additional data model into NTF and modify some of the existing models. As a result there will be five levels, (level 0 raster to level 4 full topological) which conform to models in the DIGEST format with in addition level 5 for special data sets. The NTF data models conform to the Conceptual Data Transfer Model created by an ad hoc group in Paris (members were drawn from DRIVE (EDRM), CNIG, CERCO - OS participated).

- level 0 Raster data. Being re-developed to conform to the DIGEST raster/matrix model. The existing level 0 will be retained until the ISO 8211 version is issued.
- level 1 Simple spaghetti data model. See figure 1. This model would only be useful where only one attribute exists per feature.
- level 2 Spaghetti model with multiple attributes. See figure 2. Level 2 conforms to the DIGEST spaghetti model but has the added advantage of being able to handle cartographic text as an object.
- level 3 Partial topology. This level handles a variety of models, including partial topology, (figure 3a), link and node (figure 3b) and spaghetti with closed areas (figure 3c). The link and node model can conform to the DIGEST chain-node model.
- level 4 Full Topological Model. See figure 4. The model has been introduced to conform to the DIGEST Topological model. The concept of faces has been introduced but unlike DIGEST it is not essential to provide a complete

and consistent topological representation if that does not exist in the data being transferred. Polygon seeds are allowed.

- Level 5 This is the old NTF level 4 which allows any special dataset to be transferred by using a data dictionary which is mandatory at this level. This level becomes more simple to use with the introduction of ISO 8211.

As a result of the changes to the data model it is now possible to transfer data between NTF and DIGEST without significant loss of data and all the earlier requirements have been fulfilled. It must be remembered that NTF is a live format in use in a significant number of applications in Europe. However, it is anticipated that these changes can be introduced to the existing user community without disruption.

CHANGES TO RECORD STRUCTURE

As well as the new record structure in level 4, levels 3 and 4 have had new facilities for handling text and additional attributes added. Levels 0, 1 and 2 are unchanged. Many existing users are therefore largely unaffected. Those that are affected are generally those who have sought the amendments.

TIMETABLE

The new non-ISO documentation (version 1.2) is now ready and is being evaluated by the Technical Standing Working Group. It is expected that the documentation for the ISO 8211 version of NTF (version 2.0) will be written by the end of July and this will be put out for comment so that by the end of the year version 2 could be in use. It is anticipated that version 2.0 and version 1.2 will be used side by side for some time because not all users will need the benefits of ISO 8211 immediately. This proposal will also allow other versions of NTF such as an EDIFACT version to be created from version 1.2. The ISO 8211/DIGEST compatible level 0 will be introduced as part of version 2.0.

UK TESTING PROGRAMME

The NTF Steering Committee has set up a Working Group drawn from the major system suppliers and data providers in UK to determine the acceptability of the version 2.0 format. The results of this assessment will be taken into account and a final version 2.0 will be issued towards the end of September. Meanwhile it is expected that version 1.2 will be taken into use very soon.

EUROPEAN TESTING PROGRAMME

The models which are the basis for version 1.2 and version 2.0 are now available and it is now possible to carry out the initial evaluation of NTF as a format for use as an interim ETF. In October it will be possible to transfer data using version 2.0 as a central exchange mechanism and tests of the feasibility of carrying out exchanges in this way should be performed. It will be necessary to establish a testing programme to evaluate the

feasibility of using NTF in this way.

BRITISH STANDARDS INSTITUTION

The AGI has decided to prepare NTF as a British Standard and the documentation has been written to conform to BS requirements in BS(0) format. Version 1.2 will be presented to BSI as a draft for comment in June.

CONCLUSION

NTF uses the conceptual data models for data exchange which have been developed in Europe and should be compatible with all formats using these models. NTF is unique in offering the facility to transfer data through a data dictionary and ISO 8211 makes this facility easier to use.

NTF remains one of the few exchange formats in active use. It has recently been modified to make it compatible with DIGEST and work is in hand to create a version 2.0 which will incorporate ISO 8211. Whilst NTF is compatible with DIGEST data models it is much more flexible in the sense that it allows different models to be transmitted in the same file.

When these changes have been completed NTF will be an extremely powerful tool for the exchange of spatially referenced data and associated data files. Meanwhile Version 1.2 is being prepared for circulation by BSI as a draft for comment prior to NTF becoming a British Standard.

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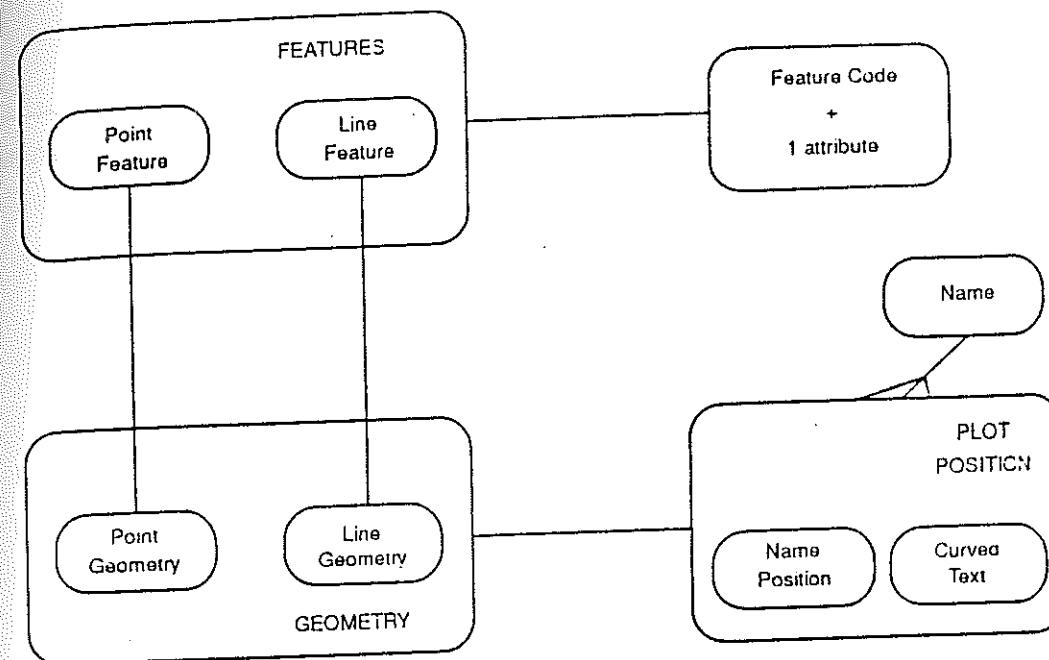


Fig. 1 Data Model for Simple Spaghetti

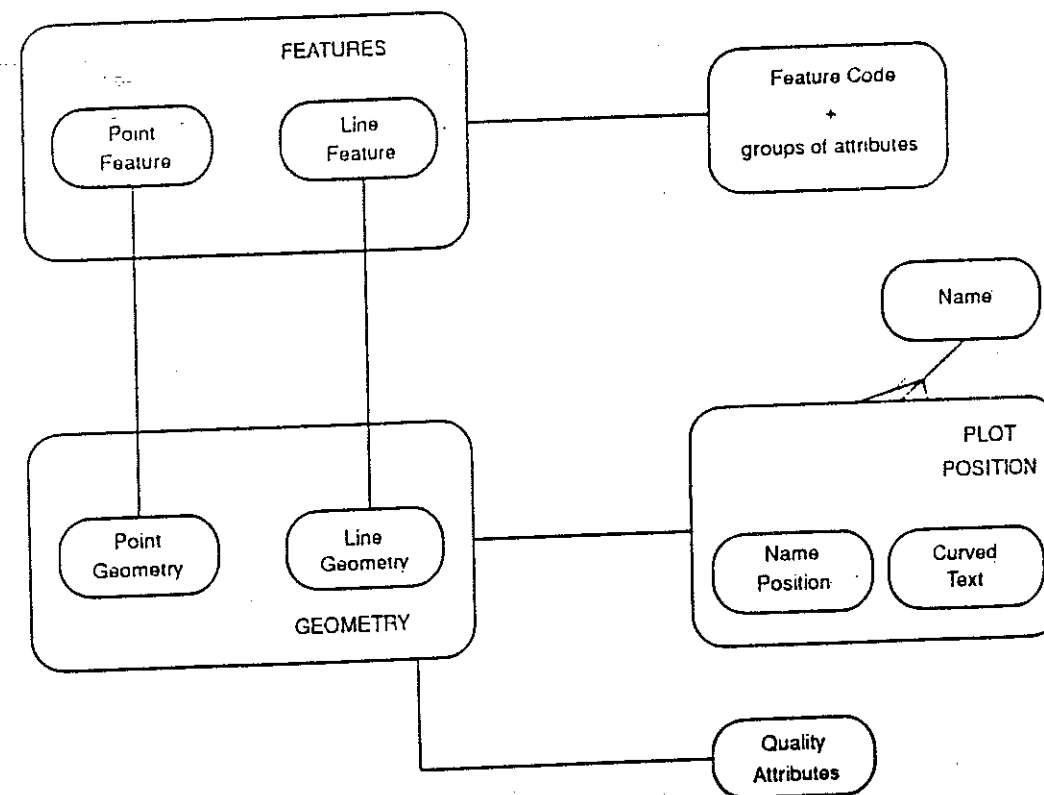


Fig. 2 Data Model for Simple Spaghetti with Multiple Attributes

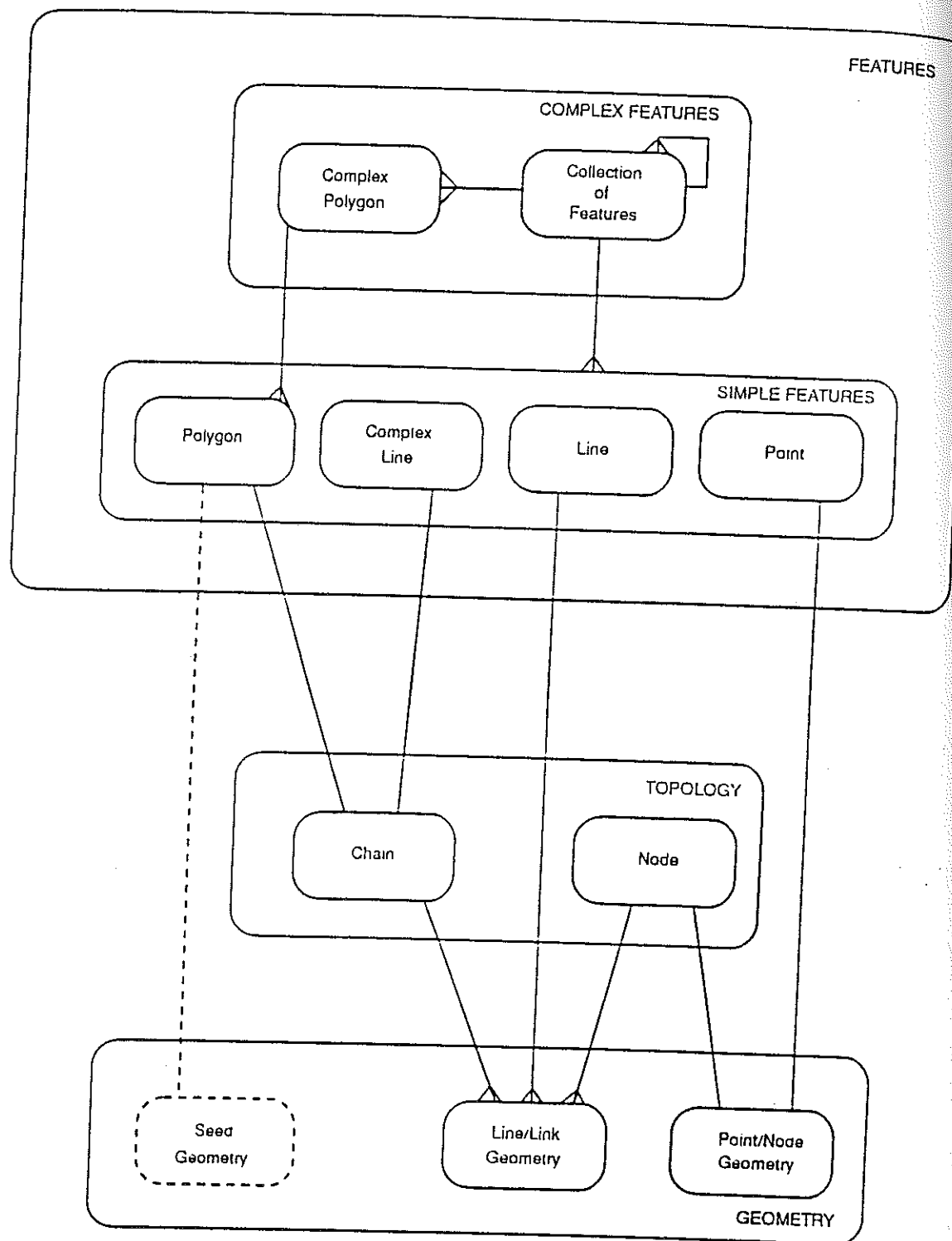


Fig. 3a Example of Partial Topology (Level 3)

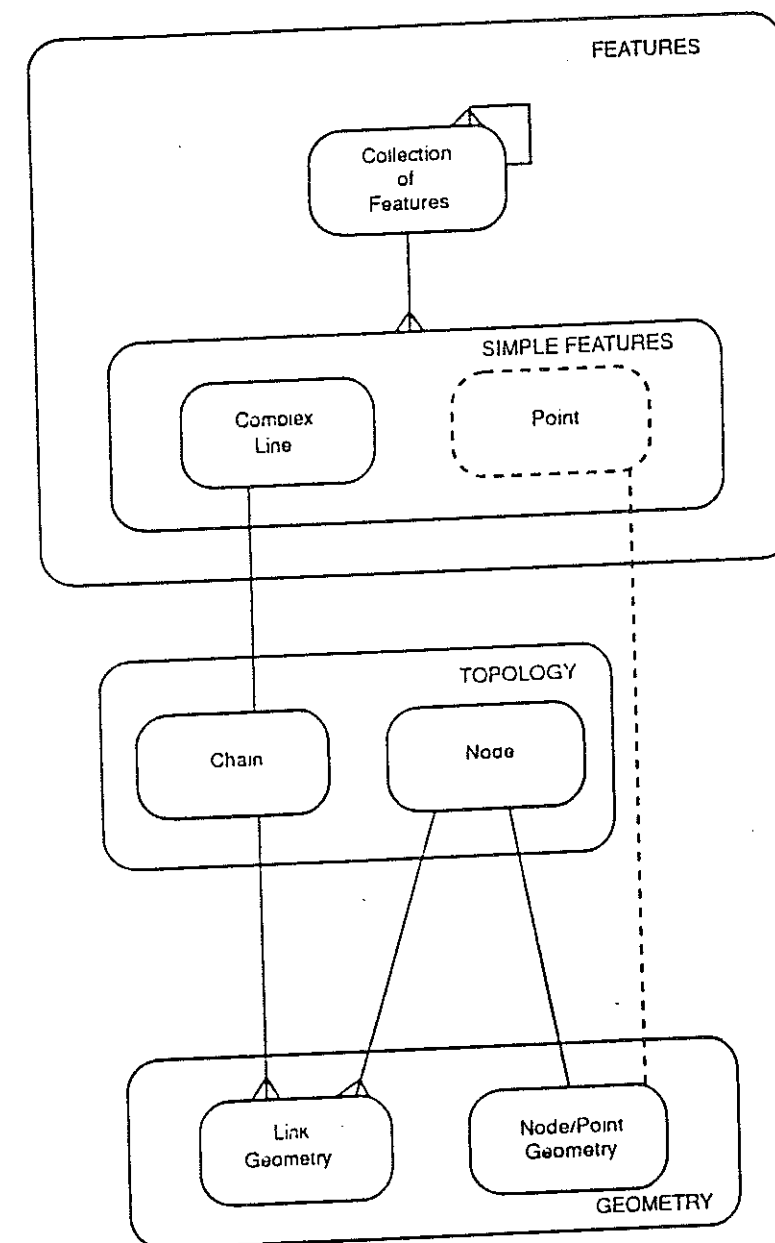


Fig. 3b Link and Node Model (Level 3)

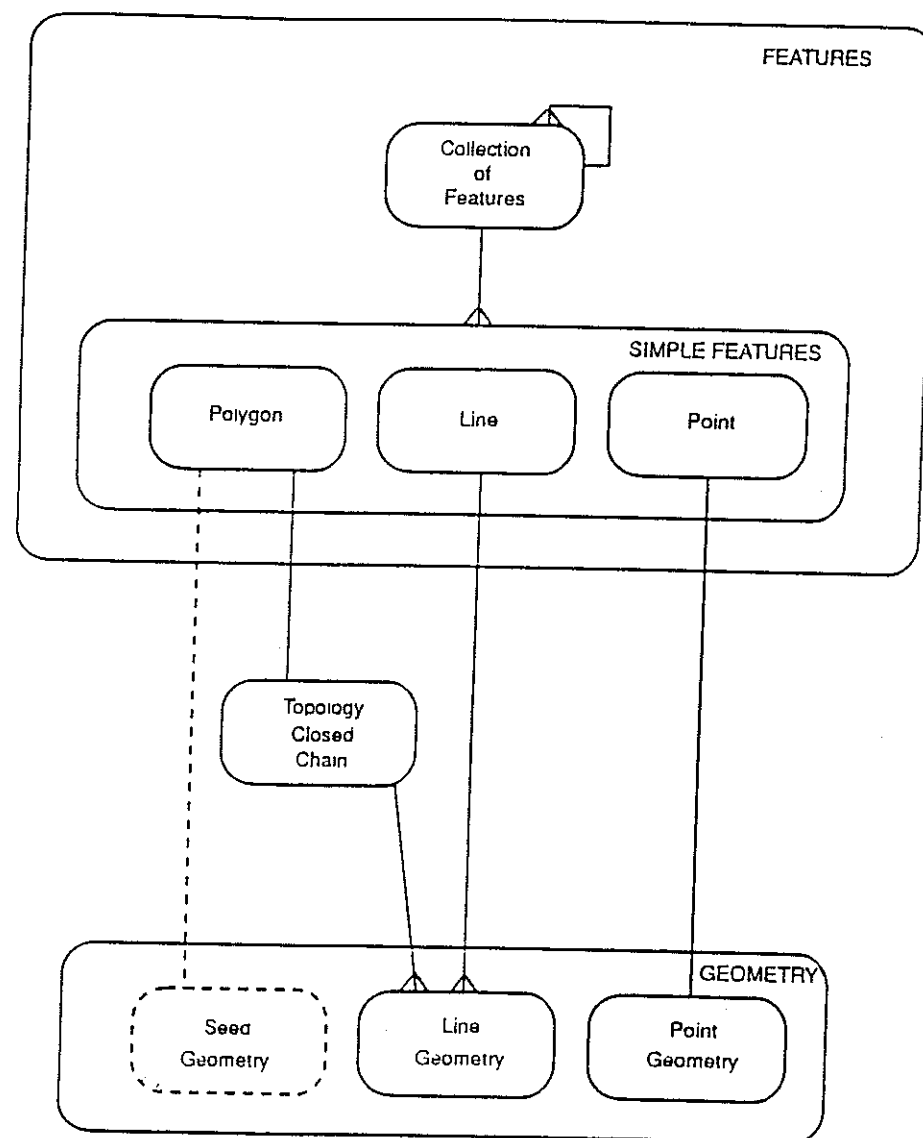


Fig. 3c Complex Spaghetti (Level 3)

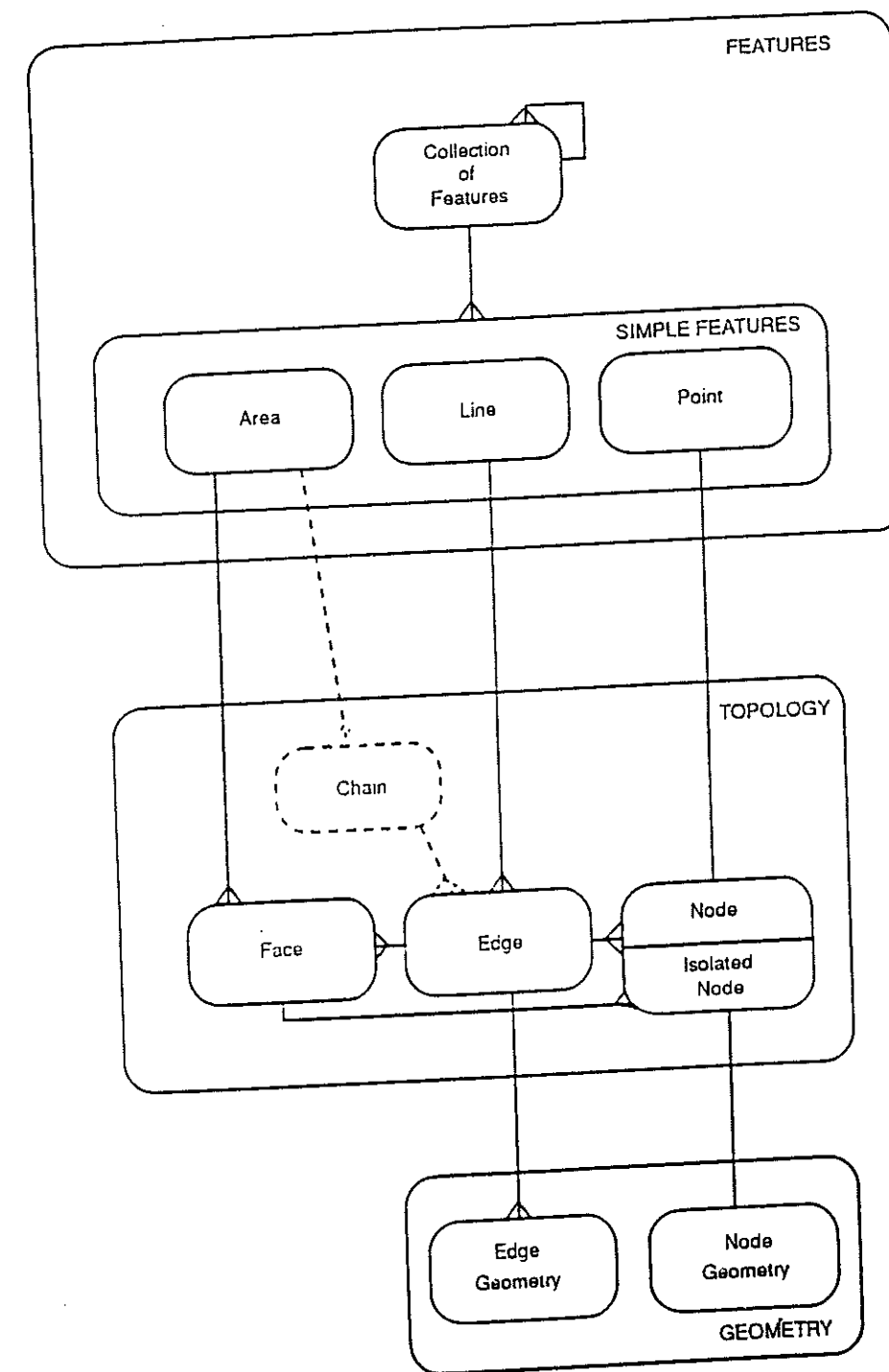


Fig. 4 Full Topological Model (Level 4)

STANDARD EXCHANGE FORMAT FOR GEOGRAPHIC INFORMATION

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Summary The paper gives first a rough sketch of the management situation within advices as the Standard Exchange Format version 2 are established. Then the place and the history of the format is given. Followed by a short description of the exchange format on the hand of a diagram. Based on an evaluation of the format some adjustments are proposed so that the format is suitable for cable and pipeline data. At the end of the paper the following question:

"Is it, in the light of the developments to come to a European standard for the exchange of topographic databases, still necessary or desired to keep up a national standard until the introduction of the European standard and if so, with which effort?".

Before I start dealing with the subject of my lecture, I would first like to give you a rough sketch of the management situation within the sorts of advice such as the Standard Exchange Format version 2 are established.

In 1975 the Minister of Home Affairs, as co-ordinating member of the cabinet for the information supply in the government, established the Management Consultation Committee for Governmental Automation as the formal body of consultation of the central government, provinces and municipalities. This committee may advise relevant bodies in the public and semi-public sector. The aim of this is to improve the efficiency and accuracy of the information supply in the government and semi-government by way of co-ordination of the activities in the field of automation.

In 1984, on the basis of an advice supplied by this committee, the Council for Land Information was established as an advisory organ for the Minister of Housing, Physical Planning and Environmental Affairs in order to support his co-ordinating task in the field of land information supply.

At the start the Council consists of thirteen representatives of ministries, provinces, municipalities, public utility companies, polder boards and notaries. The Council has an independent chairman and the Director General of the Cadastre initially was the secretary. In 1992 the activities of the Council will be laid down in a new law. In this new law it will also be settled that the Council gets an independent secretary. On January 1, 1990, in anticipation of the law becoming effective, the secretary and thus the secretariat of the Council received a position which is formally independent of the Cadastre. At the same time the Council received a wider and better balanced composition. New members of the Council represent social organizations or are experts in the field of land information. The Council may advise the co-ordinating minister both on invitation and un-invited. The advices to-be-given are prepared by committees, which are established by the Council.

One of them is the Committee Topographic Basic Registrations. This committee is engaged in the cartographic field of the land information supply and, among others, prepared the advice to come to the Standard Exchange Format version 2.

Before I explain how this exchange format has been elaborated, I will first tell you for which level of exchange this format is meant. Exchange of data can take place on three levels:

- 1 Supply of the data and their mutual relations.
In a database the data of objects are recorded. These object data have mutual relations. Besides the supply of data, also the supply of the mutual relations is important. For this purpose the ISO, the International Organization for Standardization, defined the Initial Graphics Exchange Specification (IGES).
- 2 Supply of the data without their mutual relations.
In this case the object data are supplied and not the data of the relations between the objects. In many cases the relations in the large-scale applications are so depending on the application, that it is useful to exchange on this level. Since no international standard exists, activities have been started in the Netherlands to create a standard.
- 3 Supply of digitized drawings with drawing instructions.
In practice the Graphic Kernel System (GKS) and the Programmer's Hierarchical Interactive Graphic System (PHIGS), which are adopted by the ISO, are defined for this purpose. However, these standards do not enable us to supply the topographical significance of objects, so that the topographical characteristics are lost.

For the second level of exchange a standard exchange format, which was defined by the Contact Group Automation in the Cartography, has been used since 1980. This format was derived from the German standard. The most important difference from the German standard is in the space which is reserved in the various types of records for the x- and y-co-ordinates. In the German format they were recorded with a resolution of 1 metre (5 positions), whereas in the Dutch format space is reserved for a resolution of 0.01 metre (8 positions). The length of the records, 48 against 72, and the number of types of records, 8 against 7, also differ.

A number of organizations - the Cadastre, KLM Aerocarto, Topographic Survey - have gained experience with this exchange format. Here it became clear that some records, needed for the data supply, were not defined well enough and because of this much additional information has to be added. This especially holds good for the characteristics of topographical objects - this was caused by the lack of a standard for classification of topographical elements - and for the supply of texts and symbols and of characteristics of point objects.

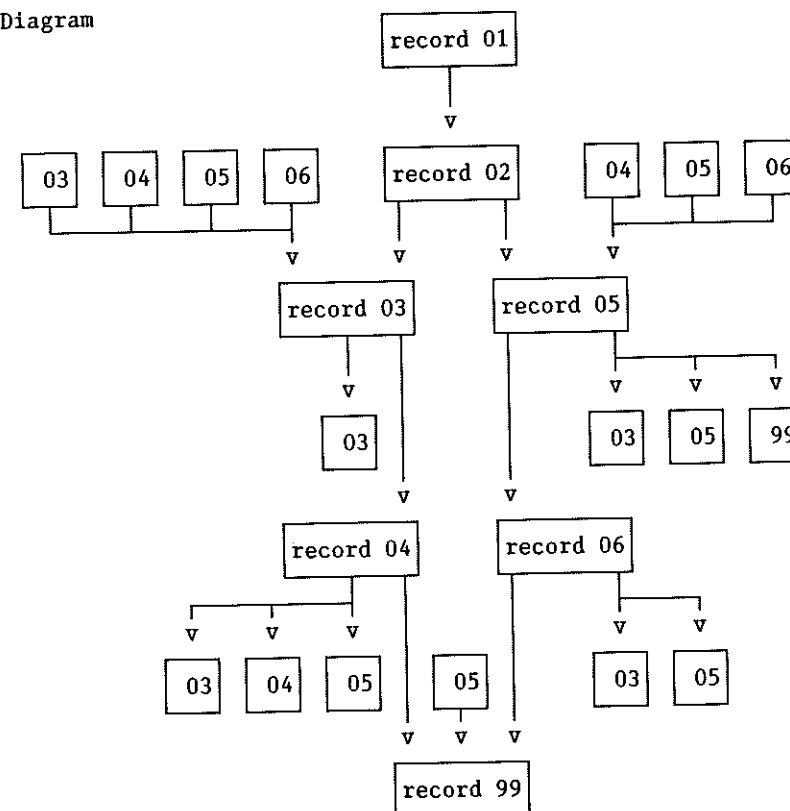
These bottlenecks were the immediate cause to come to an adjusted exchange format and a classification table for topographical elements. In 1983 the Management Consultation Committee for Government Automation published a first draft of this classification. This classification is up-dated by the Cadastre. At present a third edition is being prepared.

In 1987 it was observed that the increasing use of digital land information required agreements on a number of aspects, in order to simplify the mutual exchange of data between various users. In view of the bottlenecks established in the first version of the exchange format it was necessary to adjust the format, since a good exchange standard prevents the need of specific programmes for each exchange, in order to be able to convert from one format to another. In this way it is possible to cut the cost if one exchange format can be obtained. Then each organization participating in the data exchange only has to develop the programmes for the conversion of its own format to the standard format and vice versa. So the adjustment of the exchange format was picked up by the Committee Topographic Basic Registrations in 1987.

The requirements which a standard exchange format has to meet are:

- 1 The standard must have such a documentation, that the receiver of the data must be able to process the data with a minimum of guiding explanations.
- 2 A description of all the object types to-be-supplied has to be defined.
- 3 Supply of data has to be possible independent from equipment or media.
- 4 It should be possible to supply several files at a time, that is on a physical medium or in a transmission session.
- 5 In case of mutations it should be possible to supply the mutations only.

Diagram



Based on the diagram I would now like to give you a short description of the exchange format. An exchange file consists of a sequence of records of 64 characters each. The first two positions of each record indicate the type of record. There are 7 types of records. The types 01, 02 and 99 can be found only once in the file and are defined as follows:

- record type 01 contains data of a general nature, which are valid for the entire file, such as identification of the file, total revision or not;
- record type 02 contains metric data, which are also valid for the entire file, such as systems of co-ordinates, adding and multiplication constants;
- record type 99 indicates the end of the file.

The record types 03 and 04 are complementary and together they define the topographical information. They are defined as follows:

- record type 03 contains the non-geometrical characteristics, such as classification code, way of representation, recording date;
- record type 04 contains the geometrical characteristics, such as co-ordinates, geometrical quality, height.

The record types 05 and 06 are also complementary and together they define the semantic information. They are defined as follows:

- record type 05 contains the place and sort of the text or the symbol;
- record type 06 contains the text to-be-placed.

At the record types 03, 04 and 05 the data are placed in the fields of ten positions by way of 1-character codes. So per record a maximum of 6 fields exists. In case a specific data needs more than 6 fields a new record of the same type will be used.

From the diagram also the compulsory order of the records becomes clear.

When the Council gave the advice concerning version 2 of the Standard Exchange Format, the Council advised to proclaim the form to a national standard. For this purpose the co-ordinating minister asked the "Nederlands Normalisatie Instituut" (the Dutch Institute for Normalisation) to take steps which will lead to an NEN-standard on the basis of the advice. Because of this the up-date of the exchange format is also arranged.

In the use of the exchange format described before, a number of bottlenecks have been observed, especially by public utility companies, since not all data of cables and pipelines can be brought into the format. The classification table for topographic elements does not meet with the requirements for cables and pipelines either.

In 1990 the Council advised the co-ordinating minister for land information in relation to a new classification for cable and pipeline data. This classification contains the minimum data required in order to be able to locate the cables and pipelines of third parties in a responsible manner. It was also observed that the exchange format, described by me, with some adjustments, is suitable for the exchange of entities and attributes which are defined in the classification for cable and pipeline data. Last month the co-ordinating minister was advised to adjust the exchange format on these points and to have the adjustments proposed recorded in the NEN-1878 (the title of the Dutch standard). The adjustments are:

- explicit reference to the "NAP" (Normal Amsterdam Level);
- adding of record type 07 in which the data of the manager(s) are recorded, this record is placed between the record type 02 and the record types 03 and 05 (see scheme);
- recording of a field in which the depth of a point in relation to the ground level can be recorded;
- recording of a field in which the space a cable or pipeline takes can be observed, especially necessary for trenches.

As far as the description of the exchange format is concerned, I would like to stop here. However, I do want to give you one consideration:

"Is it, in the light of the developments to come to a European standard for the exchange of topographic databases, still necessary or desired to keep up a national standard until the introduction of the European standard and if so, with which effort?"

THE ITALIAN DIGITAL CADASTRE DATA TRANSFER SYSTEM

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1. THE WORKINGS OF A TRANSFER STANDARD. THE NTF STANDARD.

The need to define standards is due to the fact that information contained in digital maps is produced or processed with differing instruments and are developed generally using different logical structures according to the hardware or software used.

To allow the data contained in digital cartographic data to be used by the greatest number of users possible, the transfer of the information contained in the different processing systems on the market and held by various bodies must be guaranteed.

The transfer of data between any two processing systems let us say; A and B, is possible:

- if the data contained in A organized in a manner functional to the structure of system A can be converted according to standard formats so as to allow their use from outside, that is, by systems based on different logical structures;
- if the digital cartography processing system B is capable of

collecting data according to the standard formats which it is fed with and is able to translate this data into its own processing architecture, thus allowing the processing of the information they contain according to its own optimized procedures;
- and vice-versa.

The standards sought, therefore are not aimed at being general processing standards, defined according to user logic, but are more simply transfer rules. These must be defined to make the the transport of data from one system to another possible, if necessary filtering the information contained during the transfer by applying the criteria of usefulness and convenience.

However, it is not easy to define the standards which already must not conflict with the conceptual lay out criteria of the main cartographic data-base systems on the market and which must also be open to the possible even substantial innovations which future needs may sanction.

At the Ordnance Survey of Southampton (UK) a NTF (National Transfer Format)

system has been developed and is being perfected (Ordinance Survey 1987,1989).

This system has been quickly dedicated to the transfer of cartographic data, and being developed recently it has been able to take into account similar activities undertaken in other countries. Initially announced as temporary, the NTF is now the official system used in the United Kingdom for the transfer of data of relevant digital cartographic trials.

In a set, or volume of NTF transfers, cartographic data which has been realized by different types of techniques can be transferred. Each map is a data base. In the context of each of these data bases, and therefore of every map the contents of different maps are transferred. They are referred to as sections.

This transfer is accomplished along specific lines, according to the sequence of records. In table 1. we show the development of records according to how the NTF makes a transfer. Some records must always be transferred, while others are optional: these are transferred or not according to a system of default criteria. For example if during the transfer of a data base, i.e. a map, de finition records of a coded system are not transferred, then we must infer that the data is coded according to the standard recommended by the NTF.

Records are subdivided into fields of interest.

In the first field there is always a descriptive numerical code of the type of record. On the basis of the value of the descriptive code it is possible to guide the interpretation of the other fields according to the format established for the records of this code.

For example the descriptive code of

the first record of an entire volume is, by default 01. For this reason when the sequence of records is followed, one reads 01 in the first field of the record, and we can see :

- that the record in question is the title record of a volume;
- that the content of the other fields must be read according to the NTF instructions.

The relation between the various descriptive codes of the records and the various possible subdivisions of the records in fields is defined by the *data base dictionary* which is not defined as is commonly meant but rather as a body of homogeneous data regarding the same work.

Each data base is characterized by its own heading record, by a record which describes the type of data base and by records within which the dictionary of number codes and the classification of the contents can be redefined.

Within the data base the data is gathered into sections. Each section has a heading record and a general description of the type of section involved. Following the sequence of the general section records, the data is transferred.

The information contained by the data in one section may be more or less detailed depending on the possibility of relating the information within it. The NTF transfers data over 5 levels of growing characterized information. To level 0 are transferred *raster* type data, to levels 1-4 the data already structured in vectors are transferred.

Totally disaggregated data is transferred to *level 0*. These are of raster type and do not possess any qualities. They are generally remotely censured or they come from scanners.

TABLE 1

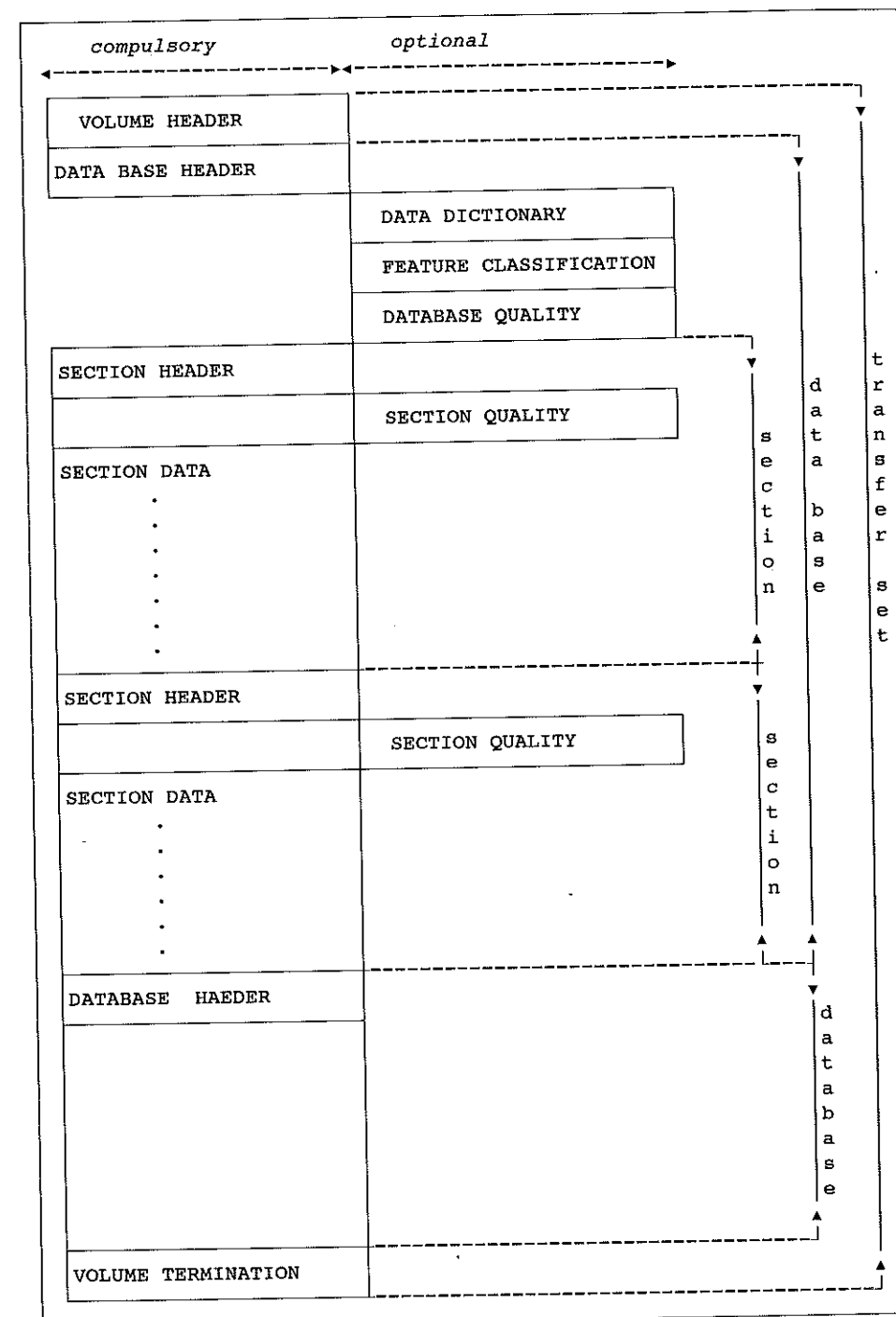


TABLE 2.1

NTF* Code	Record's Name	Function	Content
<i>General Definition Record</i>			
01	VOLHDREC	General definition record volume heading record	record code(01) general transfer data (NTF level, record format, etc.)
02	DBHREC	data base heading record	record code (02), general information on the data ba- se (name, name of the fun- ction dictionary, quality relation name etc.)
40	ATTDESC	definition record of a simple attribute	record code (40), 2 mnemonic characters which define the simple attribute, the number of the columns taken up by the value of the attribute, attribute read format, clearly shown name of the attribute, in- sertion value for void at- tribute, the minimum and maximum values that the at- tribute can assume.
41	ATTCOM	definition record of a composite attribute	record code(40), 2 mnemonic characters which define the composite attribute, number of the simple attributes which define the composite attribute, all the mnemonic acronyms of the above men- tioned simple attributes.
07	SECHREC	section heading record	record code (07), general section data, sheet name, coordinate system, section origin coordinates, in- scription rectangle coordi- nates for the whole sec- tion, planimetric preci- sion, altimetric preci- sion, date of survey, date of the last update, quality control name, date of qua- lity control.

* NTF default code. At level 4 they may also be redefined by the client.

TABLE 2.2

NTF Code	Record's Name	Function	Content
<i>Section Data Record</i>			
14	ATTREC	attribute record	record code(14), mnemonic code which identifies the type of attribute, the value assumed by the attri- bute (if the mnemonic code refers to a simple attribu- te only one value is to be given, if it refers to a composite attribute as many values are to be given as are specified by the compo- site attribute itself)
15	POINTREC	point descriptive record	record code (15), point identification number.
23	LINEREC	line descriptive record	record code (23), line identification number
21	GEOMETRY1	two dimensional geometry	record code (21), record i- dentity, number of the memo- rised points, for all the memorised points x,y and a quality code for the piece of information. If the data relative to all the points do not fit onto the record one or more continuation records are made to follow with the same content.
22	GEOMETRY2	three dimensional geometry record	record code (22), code iden- tification record, number of the memorised points for all the memorised points, x,y, z and a quality code for the piece of informa- tion. If the data relative to all the points do not fit onto the record one or more continuation records are made to follow with the same content.
00	CONTREC	continuation record	record code (00), it is the logical follow up to the preceding record, and it has the same contents as the following record.
90	COMMENT	comment record	record code (90), comment with free text
99	VOLTERM	end of volume record	code of record (99), final transfer record, free text.

* NTF default code. At level 4 they may also be redefined by the client.

Non structured data transferred to **level 1** where a descriptive attribute is given which is chosen from a restricted number of possible attributes.

The data which is transferred to **level 2**, is not structured but defines entities with which many attributes must be associated. At this level, documentation can be furnished by each piece of information, thus it is possible to have information regarding its origin and any subsequent modifications.

Data is transferred to **level 3**, which has topological contents which allows the identification of complex structures.

Data is transferred to **level 4** which can only be transferred by reference to particular purposely redefined data base dictionary functions.

The use of levels for the transfer of data allows information made according to the NTF standard to be processed on growing power systems.

Even a P.C. can run small quantities of data organized according to 0 or 1 transfer levels. A powerful calculator can on the other hand run large amounts of structured data and run those qualitative and topological correlations which pertain to the higher levels of the standard.

The general structure of the transfer set is always laid out as can be seen in the scheme in figure one. What changes with the level is the content of the data in each section.

In the heading record of the volume the transfer level is indicated: the data contained in the following sections shown are to be interpreted and run according to the level they are allotted to.

In table 2.1 and table 2.2 the records needed to perform data

transfer at levels 1 and 2 are given. A general description is also given of the contents. For more details see (Ordnance Survey, 1987,1989).

2. THE SOGEI PROJECT FOR DATA TRANSFER OF THE ITALIAN DIGITAL GEOMETRIC CADASTRE.

2.1 The Italian Geometric Digital Cadastre.

The process of digitalization of cadastral cartography has been started by the Central Cadastral Body with aim of setting up a readily updatable data base open to many users.

The data base containing the digitalized cadastral maps is called **Digital Geometric Cadastre**.

It is necessary to point out that the name **Digital Geometric Cadastre** by which the data base in which the cadastral maps are stored is called, may create a misunderstanding. In fact the word **Geometric** has the general meaning of *provided by coordinates* and has nothing to do with the meaning of *geometric* as something different from *topological*.

The Digital Geometric Cadastre is being created in two different stages:

- the updating of cadastral maps
- the transposition of the updated cadastral maps into a numerical form through manual digitalization.

Italy's territory is mapped on 300.000 cadastral sheets.

Up to now 45.000 of these have been digitalized and make up the present Digital Geometric Cadastre.

The Digital Geometric Cadaster is a data base in which each entity of a

traditional cadastral map is represented by means of cartographic objects which have geometric and topological meaning (chains, nodes, and so on).

The main function of the topological contents is to allow the reconstruction of the perimeter of five types of surfaces which are called **surfaces of cadastral interest**. The perimeter of each surface is reconstructed as a ring created by chains which are topologically interrelated.

The five types of surface of cadastral interest are the following:

- surface of cadastral parcels
- surface of buildings
- surface of sheets of water
- surface of roads
- surface of cadastral maps.

2.2 The Digital Geometric Cadastre as the basis for GIS and LIS.

Presently Digital Cadastral Cartographic data is often seen, by the local land governing bodies, as a possible cartographic basis for GIS and LIS avoiding the compilation of specific numerical cartographies, which is not only expensive but also substantially slows down the creation of an information system. Furthermore cadastral data holds great interest for local government bodies because they are an important information gathering tool essential for the carrying out of tasks, for example in the case of local councils it can help with the issue of building permits etc.

For these reasons the General Management of the Italian Cadastre decided to organize a special service having the aim of transferring the data of the Digital Geometric Cadastre to other public Bodies.

On the other hand the digital cartographies produced by local land governing bodies such as regional, provincial and municipal governments are cartographies which reproduce traditional cartographic lay outs in their contents, without topological information. However digital cadastral data is an extremely interesting product for the above mentioned governing bodies.

The problem of establishing how the Italian Cadastre can transfer information from its data base to those of local governing bodies has therefore arisen. There is also the opposite problem of recovering locally produced digital cartographies which are considered worthwhile as a base to insert cadastral information in order to obtain updated cadastral digital maps.

Thought has been given to the need to manage a double flow of information such as:

- topologically organized data, for a user who needs simpler information;
- simplified data to be inserted into complex structures.

The choice of the transfer system was made therefore in such a way as to fill this double need.

2.3 Reasons for the choice of the NTF standard level 2.

Since Italy does not possess universally accepted or nationally certified codified transfer systems, the system within the ambit of SOGEI which was seen to satisfy best these general requirements and the most suitable for the transfer of cadastral cartography was the NTF system (National Transfer Format).

The transfer system we studied is valid both when the governing body which the data is transferred to does

not have a sufficiently developed informatics background. Sometimes, for example what is needed is a purely representative management of cartographic information. On other occasions the governing body is more articulated and uses cartographic data as a basis for a fully fledged information system running on specific software to process information about territory.

In the first place it is not only useful but necessary for the data to be given in a geometric structure and not a topological one so that it is easier to manage.

Nevertheless for cases where data must be transferred from a well developed user it may be useful to convert the structure of the data to a simpler form. It is not at all to be assumed that the information needed to define topologies in a system can be recovered for the same purposes in other systems. A transfer of topologically organized data could then force the user receiving information to go from a topological structure to a topographic one so as to allow the reconstruction of data in a topological sense which then can be interpreted by the user's system.

The choice of a descriptive and geometric organization represented by the NTF level 2 appears today to be reasonable and useful.

Despite the fact that in the transfer file the cartographic objects are not topological, the thematic information associated as attributes to them, guarantees the maintenance of a large part of the contents of the Digital Geometric Cadastre.

The choice of the NTF level 2 does not however exclude any future option for a higher level standard because of the need for few modifications. This in the case where innovations are introduced in information managing systems or if new needs are

expressed by governing bodies which use numeric cartographies.

2.4 The conceptual transfer model.

As we said before the Digital Geometric Cadastre has a topological structure which allows one to draw cadastral maps and to connect cartographic objects (chains) stored in the data base in order to reconstruct the perimeter of each surface of cadastral interest (see above).

The General Management of the Italian Cadastre has decided not to transfer the topological contents of the data base, and to transfer only the geometry of the cartographic objects which are necessary in order to draw the cadastral maps.

All the entities stored in the Digital Geometric Cadastre are transferred by means of two types only of cartographic objects, both belonging to the *geometry only* classe:

- strings
- points.

In the transfer file the strings have the same geometry of the corresponding chains in the Digital Geometric Cadastre.

The points stored in the transfer file are of tree types:

- *area point*, that is a point within an area carrying attribute information, about the area; this kind of point is used for the transfer of information concerning surfaces of cadastral interest;
- *label point*, that is a point used for displaying parcel numbers, place names, map text and so on;
- *symbol point*, that is a point use for displaying cadastral symbols or

any other type of symbol needed for drawing the map.

In order to transfer some of any information lost owing to missing topology, certain attributes are associated with each cartographic object (strings or points) in the transfer file.

Altogether twelve simple attributes have been singled out as necessary; they are as follows:

- LV the level the entity appears at in a digital cadastral map;
- PN the pen to be used to draw the entity;
- TR the type of line pattern to draw the entity with;
- TX the text that accompanies the entity;
- AL the height of the text;
- OR the text's orientation angle;
- CA the orientation of the hatching with which buildings are drawn on the map;
- SU the surface area;
- DX movement along the axis of the x coordinates (offset in x) of a piece of text or symbol in respect of the x coordinate which it is associated with;
- DY movement along the axis of the y coordinates (offset in y) of a piece of text or symbol in respect of the y coordinate which it is associated with;
- SN the code of the symbol to give the entity;
- FN the type of font to give the text.

The attributes associated with the cartographic objects are the following:

- for strings:
 - . level;
 - . pen;
 - . type of line pattern used to draw the line;
- for symbol points:
 - . level;
 - . symbol;
 - . text orientation;

. pen;

- for area points :
 - . level;
 - . text;
 - . pen;
 - . font size;
 - . text orientation;
 - . orientation of hatching lines;
 - . surface area;
 - . offset in x;
 - . offset in y;
- for label points:
 - . level;
 - . text;
 - . pen;
 - . height;
 - . text orientation;
 - . font;

The four groups of the simple attributes that are significant for the four categories of entities will be referred to in the following as complex attributes.

The Cadastre is organized into levels.

Each object contained in the transfer file is associated with the levels to which it belongs in the Cadastral Registry.

Generally the objects, which are points, are placed at only one level, whereas the strings can be placed at more than one level and precisely from one to four. The structure of the digital cadastral data is indeed topological, therefore the same polyline, seen as primitive geometry, can be used to describe more than one entity.

In the transfer file the levels are indicated with the letters of the alphabet in capitals.

The strings can be placed at one or more of the following levels:

- F, geometry of the sheet edge;
- L, geometry of the property boundary;

- M, geometry of the building perimeters;
- O, geometry of the perimeters of bodies of water;
- R, geometry of the road perimeters;
- V, geometry of the graphic elements which while present on the map, have no importance from the point of view of the administrative land register.

The symbol points are placed at one of the following levels:

- U, Cadastral symbols,
- I, reference crosses of the parameter;
- J, Cadastral control points.

The area points are placed at one of the following levels:

- D, surface covered by buildings;
- G, surface covered by the map sheet or by map sheet flaps;
- K, Cadastral parcel dimensions;
- P, water surface;
- S, road surface.

The label points are placed at one of the following levels:

- E, piece of text which indicate the map sheet;

- H, cartographic coordinates of the sheet parameters;
- N, the names of the bodies of water;
- Q, the names of the roads;
- T, pieces of text belonging to symbols (i.e. the elevation of the data points).

By using the records listed in table 2.1 all the transfer file self documenting data is transferred, including twelve ATTDSC type records describing the twelve simple attributes as in the table 3.

After these records follow another four of ATTCOM type which describe the four types of composite attributes listed in the table 4.

The composite attributes are associated to the cartographic objects in the transfer file as follows:

LN to the strings,
SN to the symbol points,
AR to the area points,
TP to the label points.

Once the general definition information of the data base is carried out the data contained in the

TABLE 3

	record code	ATTDESC mnemonic code	size	inter	information
1	40	LV	4	A4	level
2	40	PN	2	I2	pen
3	40	TR	2	I2	linear pattern
4	40	TX	*	A*	text
5	40	AL	3	I3	text height
6	40	OR	3	I3	text orientation
7	40	CA	3	I3	pattern orientation
8	40	SU	12	R12.2	surface
9	40	DX	7	R7.3	offset x
10	40	DY	7	R7.3	offset y
11	40	SN	2	I2	symbol code
12	40	FN	2	I2	font

single sections, that is, the data contained in the digital maps of the Digital Geometric Cadastre are transferred according to the sequences listed below.

The strings are transferred with the following record sequences:

.
LINEREC
GEOMETRY 1
any record continuation records
GEOMETRY 1
ATTREC

.
LINEREC
GEOMETRY1
any record continuation records
GEOMETRY 1
ATTREC

For the strings, the GEOMETRY 1 type records can be followed by continuation records. The number of these records depends on the number of points which make up the polyline which is transferred.

The ATTREC record is of an ATTCOM type and is the same for all the strings. It is made up of as indicated at the first code 41 record listed in table 4.

The point type objects are transferred with the following record sequences:

.
POINTREC
GEOMETRY1
ATTREC

.
POINTREC
GEOMETRY1
ATTREC

The structure of the POINTREC and GEOMETRY 1 records is given in table 2.2. For the point type objects there is only one GEOMETRY1 record because only one couple of coordinates must always be transferred for each point.

The ATTREC record is of a ATTCOM type and may have different structures according to whether the point is a symbol point, an area point or a labelpoint. These structures are described in the preceding second, third and fourth record of code 41 in table 4.

It is important to note that to transfer label point the same, POINTREC, GEOMETRY 1 and ATTREC architectures are used instead of the NTF records regarding names (NAMEREC,

TABLE 4

	record code	ATTCOM mnemonic code	N.simple attributes	simple attributes mnemonic codes	description
1	41	LN	3	LV, PN, TR	string
2	41	SB	4	LV,SN,OR,PN	symbol point
3	41	AR	9	LV,TX,PN,AL,OR	area point
4	41	TP	6	CA,SU,DX,DY LV,TX,PN,AL OR, FN	label point

NAMPSTN and GEOMETRY).

We have preferred to keep the transfer methods consistent by treating the place name as a special type of attribute to associate with a point.

3. AN EXAMPLE OF THE TRANSFER OF DATA OF THE DIGITAL GEOMETRIC CADASTRE

In figure 1 there is a part of a cadastral map in which we see:

- the parcel n. 134;
- a building which belongs to the parcel 134; in the Geometric Cadastre such a kind of building has the same number of the parcel following by a hyphenated sequence number;
- a symbol which denotes that the building is associated with the parcel 134 (a 'clip' or backward 's');
- the hatching of the building;
- a section of a road with its name Via Nuova.
- the place name Via Nuova, which is the name of the road.

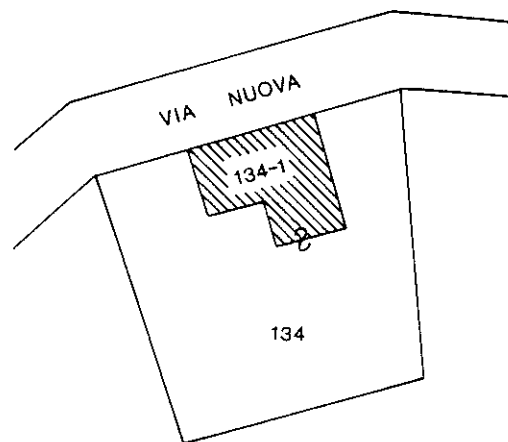


figure 1

In figure 2, the various parts of the drawing are shown separated: they correspond to the cartographic objects by which the drawn is transferred at NTF level 2. In table 5 they are listed from 1 to 12.

The listings in tables 6 and 7 represent the read out of the Level 2 transfer files which is based on the Sogei project of what is shown in figure 1.

The records from 1 to 22 are the initial definitions of the transfer records which have the following meanings.

The first record, which is the title section of the volume, contains:

- the record code 01 (the NTF Default code for the title record of the volume)
- the name of the organisation which is transferring the data, i.e. UTE FIRENZE
- the transfer date i.e. 19890401
- Volume Number, 01
- NTF level used, 2

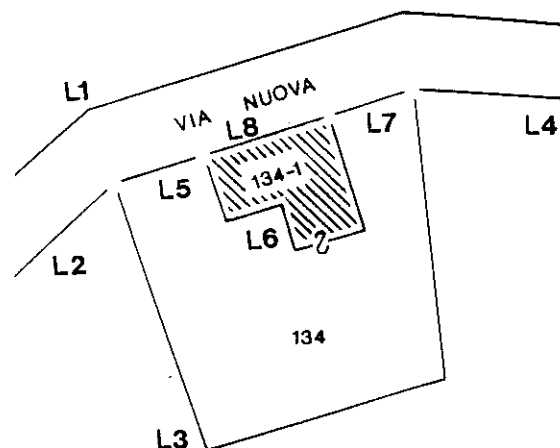


figure 2

TABLE 5

row number in this table	entity	type of object in the transfer file	level *
1	L1	string	R
2	L2	string	R
3	L3	string	L
4	L4	string	R
5	L5	string	L,R
6	L6	string	M
7	L7	string	L,R
8	L8	string	L,M,R
9	134	area point	K
10	134-1	area point	D
11	Via Nuova	label point	Q
12	'clip'	symbol point	T

*) in the Italian Digital Geometric Cadastre

- the NTF release number used, 0110
- a 'V' which indicates that the records must be read with a variable format,
- an 'O' which indicates that the record is finished.
- the date of the latest version of the dictionary; 19890401
- unused areas

Record number 2 is the title record of the data base. According to the NTF syntax, the record can contain a lot of information so that provision has been made for a supplementary record. (Record 3) Only certain areas are used in this transfer, while the unused ones contain 0's or blank characters according to the NTF guide-lines. In the case of the supplementary record, Record N.3 which can include type relationship data, only contains zeros.

The data transferred from record 2 as the title of the data base (and its supplement) are the following:

- record code 02 (the NTF Default code for the title record of the data base)
- the name of the data base which is CATASTO
- the name of the functions dictionary which is SOGEI DICTIONARY

Records from 4 to 15 which begin with code 40 are ATTDSC type records. They describe simple attributes (see table 3). Records from 16 to 19 which begin with code 41 are ATTCOM type records. These describe the composite attributes (see table 4).

Record 20 which is the title record for the section contains:

- record code 07 (NTF Default code for the section title record)
- the section reference title, D61200100
- a 2 which according to NTF conventions indicates that the coordinates being transferred are cartesian
- a 1 which according to NTF conventions, indicates that the structure of the data being transferred is done by vectors
- 0010 which indicates that for coordinates 'x' and 'y' 10 numbers are memorised
- a 2 which according to NTF conventions indicates that the coordinates are given in metres

TABLE 6

1234567890123456789012345678901234567890123456789012345678901234567890									
1	01UTE FIRENZE								
2	02CATASTO	DIZIONARIO_SOGEI	1989040100010120110V \0						
3	00	00000000	19890401					000000001	
4	40LV004A4	LIVELLI\LIVELLI DI APPARTENENZA		000000000					
5	40PN00212	PENNA\PENNA USATA IN RIPRODUZIONE							
6	40TRO0212	TRATTO\TRATTO USATO IN RIPRODUZIONE							
7	40SN00212	SNR\NUMERO DEL SIMBOLO							
8	40OR00313	ORIENTAMENTO\ORIENTAMENTO							
9	40TX***A*	TESTO\TESTO GENERIC							
10	40AL00313	ALTESTO\ALTEZZA DEL TESTO							
11	40CA00313	ORCAMP\ORIENTAMENTO DELLA CAMPITURAO							
12	40SU012R12,2	SUPERFICIE\SUPERFICIE							
13	40DX007R7,3	DELTAX\SCOSTAMENTO IN XO							
14	40DY007R7,3	DELTAY\SCOSTAMENTO IN YO							
15	40FN00212	FONTE\FONTE DEL TESTO							
16	41LN003LVPNTRO								
17	41SB004LVSNORPNO								
18	41AR009LVTPNALORCASUDXDYO								
19	41TP006LVTPNALORFNO								
20	07D6120010021000102000000000100000		0000001000	000020189	000053980				1
21	00	000020410	000054184						
22	00	000000000050020000013400001210	1989030319890303000000001						

- 0000000001 which indicates that the values of the 'x' and 'y' coordinates must be multiplied by 0.001 according to quota conventions
- empty areas which describe the quota conventions and which are used when tri-dimensional data is being transferred.
- the large transfers to be add up at coordinates, 000020189, 000053980
- a '1' which shows that the record is not finished, but which will be subsequently added to.

Record No. 21, a continuation of the previous one which contains:

- the code for record 00 (i.e. the NFT Default code for the supplementary record)
- two unused areas, where the blanks are shown
- the coordinates Xmax and Ymax at points 000020410, 000054184
- the date of the point 19890303
- the date of the last supplement 19890303

- an unused field 00000000 (which can be used for the copyright)
- a '1' which shows that the record is not finished but which will subsequently be added to.

Record No. 22, which a continuation of the preceding one contains data about the relationship between items. Up to character 30 it is in the form layed out by NFT conventions. After character 30, it has been used for the transfer of cadastral information given that it was free from this point to do so.

Record 22 data includes:

- the code of record 00 (i.e. the NFT Default code for the supplementary record).
- unused areas which according to convention could contain data about the relationship between items.
- areas redefined for the transfer of cadastral related data.
- 00500 which is the scale of the plot

- a value '2' which shows that projection used is the Cassinis Soldner one (the value being '1' for the Gauss-Boaga projection)
- 000 which is the number of reference points in the section
- 00134 which is the highest particle number in the section
- 00001 which is the number of particles in the section
- a value '2' which shows that the supporting material which was used to obtain the map is a matrix on a flexible transparency. (1-> indicates that it is a map sheet on stiff paper, a 3-> a copy of the sheet)
- a value '1', which shows that the acquisition method used was manual digitalization (2-> indicating from a scanner, 3-> from numerical photographic relief, 4-> from topographic relief)
- a value '0' which shows that the record is completed.

Fields of the title record of the section which do not contain any information also have no data as layed down by the NTF system.

In particular the areas which are set aside for information about heights are left empty.

From this we can see that a two-dimensional geometry has been transferred and so the GEOMETRY* type record should be more properly known as the GEOMETRY1 type record (i.e. without heights).

The transferral of the real data which describes the particle of the map begins from record 23 (Table 7).

In the transfer file the two types of cartographic objects, that is strings and points, are listed as belonging to four categories of objects. One category is that of the strings. The other three are those of area points, label points, and symbol points.

In the transfer file a number is

associated to each object; this number has a sequential value in each one of the four categories listed above, and in that follows it will be called sequential number.

Together the sequence of records 23, 24 and 25 describes entity No. 10 from table 5; i.e. a sequence of the NTF records POINTREC, GEOMETRY1 and ATTREC.

Record 23 contains

- the code of record 15 which shows that the record is a POINTREC one and transfers a point entity; it shows that it is transferring a point, that its coordinates are contained in the following GEOMETRY1 record and that its attributes are containing in the following ATTREC record.

- a number 000001 which is sequential number in the category.
- a value '0' which shows that the record is finished.

Record 24 contains:

- the record 21 code which shows that it is a GEOMETRY1 type.
- a number 000001 which is sequential number in the category.
- a '1' which shows that the record contains a single point.
- 0001 which is the number of the memorised points
- the coordinates of the point (which are the coordinates of the beginning point of the written numbers 134-1)
- a value '0' which shows that the record is finished.

Record 25 contains;

- the record 14 code which shows that the record is an ATTREC one,
- the number 000001 which is sequential number in the category,
- the initials AR, if we look the initials dictionary record and referring to tables 1 and 2 we can see that the these initials come from the composite type ARea;

TABLE 7

12345678901234567890123456789012345678901234567890123456789012345678901234567890									
23	15000001	0							
24	2100000110001	000105278	000126467	0					
25	14000001ARD	134-1\01018015135	76247	0000	00000				
26	15000002	0							
27	2100000210001	000119566	000088443	0					
28	14000002ARK	134\01018000000	490160	0000	00000				
29	23000001	0							
30	21000001200021								
31	00 000068099	000125938	000089468	000131999	0				
32	14000001LNL	01000							
33	23000002	0							
34	21000002200021								
35	00 000089468	000131999	000120702	000140974	0				
36	14000002LNL	01000							
37	23000003	0							
38	21000003200021								
39	00 000120702	000140974	000142732	000146899	0				
40	14000003LNL	01000							
41	23000004	0							
42	21000004200041								
43	00 000068099	000125938	000087966	000058742	000147443	0000744969	1		
44	00 000142732	000146899	0						
45	14000004LNL	01000							
46	23000005	0							
47	21000005200061								
48	00 000089468	000131999	000095212	000115651	000108072	000119447	1		
49	00 000111756	000108348	000128637	000112414	000120702	000140974	0		
50	14000005LNL	01000							
51	15000001	0							
52	2100000110001	000098611	000143293	0					
53	14000001TPQ	Via Nuova \01025015000							
54	23000006	0							
55	21000006200021								
56	00 000142732	000146899	000191590	000143076	0				
57	14000006LNL	01000							
58	23000007	0							
59	21000007200021								
60	00 000034928	000097396	000068099	000125938	0				
61	14000007LNL	01000							
62	23000008	0							
63	21000008200041								
64	00 000024902	000113693	000060938	000144517	000139169	000165985	1		
65	00 000192179	000161051	0						
66	14000008LNL	01000							
67	15000001	0							
68	2100000110001	000121168	000110541	0					
69	14000001SBU	09283010							
70	99 0								

record 18 describes how this composite area (AR) is made up, which allows us to interpret the remaining parts of the record. Indeed the contents of the following areas show;

- that the level (LV) associated with the entity is D (a building); the entity can be seen to be at level D only because the other three spaces reserved for other possibilities are empty.
- that the text (TX) associated with the entity is 134-1
- that the pen (PN) with which the code 134-1 must be written and with which the cross-hatching must be drawn is the pen 01.
- that the height of the characters of code 134-1 is 018 tenths of a millimetre.
- that the angle of the writing (OR) is 015 degrees.
- that the inclination of the cross-hatching (CA) of the building is 135 degrees
- that the area of the building (SU) is 76.247 square meters.
- that the writing 134-1 has no offset.

Record No. 25 also ends with a 0 to show that the record is finished. The three following records 26, 27 and 28 describe the particle 134, which is entity No. 9 of table 3; the three records should be read in the same way as the three previous ones; we can see that the composite attribute is still part of the area category (AR), but that this time the entity is given the level K, which means that it is a surface of a particle of the map (see the previous note 2.2).

The four records after this (from 29 to 32) contain transfer data for entity No. 5 from table 3. The records 33 to 36 contain transfer data for entity No. 8 from table 5. Let us consider how data for this entity is transferred. Here we are talking about a *separated line* needed to describe the geometry of a

road, of the border of a particle of the map and the border of a building. These are transferred using a sequence of NTF records LINEREC, GEOMETRY1 (with an up-dating record), and ATREC.

Record 33 contains;

- the code for record 23 which shows that it is a LINEREC one and which is transferring a separated line; this shows us that we are transferring a separated line whose coordinates are contained in the following GEOMETRY1 record (continually supplemented) and whose attributes are contained in the following ATTREC record
- the number 000002 which is sequential number in the category
- a value '0' which shows that the record is finished.

Record 34 contains:

- the record 21 code which shows that the record is a GEOMETRY1 one.
- the number 000002, which is sequential number in the category
- a '2' which shows that the record contains the points of a separated line.
- 0002 which is the number of the memorised points
- a '1' which indicates that the record is not completed, but a supplementary record must be read.

Record 35 contains:

- the 00 record code (the supplementary record code)
- two pairs of coordinates
- a value 0 which indicates that the

Record 36 contains:

- Record code 14 which shows that the record is an ATTREC one.
- the number 000002, which shows that the entity is a line, part of the transferral of the entire section.
- the initials LN, going through the initials dictionary record and referring to tables 1 and 2 we can see that the initials LN is that of the composite attribute LINE (LN), which allows us to interpret the

rest of the record. Indeed the contents of the following areas show

- that there are three levels associated with the entity which are L, M, and R which show respectively the geometry of the border of the particle, the geometry of the border of the building and the geometry of the course of the road
- that the pen (PN) that must be used to draw the separated line is pen 01
- that the graphic line is 00
- record 36 also ends with a 0 to show that the record is finished

The sequence of the subsequent records transfers the other lines in the same way.

It should be noted that in the sequence of records 46 to 50, which refer to entity 6 of table 5, that in order to transfer the coordinates of all the points, two supplementary GEOMETRY records were needed.

Records 51, 52 and 53 transfer the place-name *Via Nuova* by means of a sequence of NTF records POINTREC, GEOMETRY1 and ATTREC. Records 51 and 52 are interpreted according to the means already shown of the records POINTREC and GEOMETRY.

However, let us consider in detail how the information of the place-name is transferred as a composite attribute and in particular let us have a look at record No. 53.

Record 53 contains:

- Code record 14 which shows that the record is an ATTREC one.
- the number 000001, which is sequential number in the category label points,
- the initials TP; again looking through the initials dictionary record and referring to table 1 and 2, we can see that the initials TP is that which is given to the composite attribute PLACE-NAMES (TOPONOMASTICA, TP), which allows us to interpret the rest of the record.

Indeed the contents of the following areas show

- that the point entity is at level Q which corresponds to road place names
- that the text (TX) associated with the entity is *Via Nuova*
- that the pen (PN) with which it must be written is pen 01
- that the height of the characters is 025 tenths of a millimetre
- that the orientation of the writing (OR) is 015 degrees;
- that the character font is 000.
- Record 53 also ends with a 0 to show that it is finished.

Let us now consider how a symbol point entity such as the 'clip' shown in the example drawing is transferred. It is transferred in records 67, 68 and 69 by a sequence of NTF records POINTRE, GEOMETRY1 and ATTREC.

Here again we will look in detail at only record No. 69. This contains:

- record code 14 which shows that it is an ATTREC record.
- a number 000001, which is sequential number in the category of symbol points
- the initials SB; again looking through the initials dictionary record and referring to table 1 and 2, we can see that the initials SB is that which is given to the composite attribute SYMBOL. Record 17 which describes how the composite attribute of the mnemonic initials SB, allows us to interpret the rest of the record.

Indeed the contents of the following areas show

- that the point entity is at level U which is that of cadastral symbols
- that the reference number of the symbol (SN) is 09
- that the orientation of the writing (OR) is 283 degrees;
- that the pen (PN) which must be used to write it is the pen 01.
- record 69 also finishes with a 0 to show that the record is complete.

Record 70 is the NTF end of volume

record. It contains the NTF Default code for the end of volume which is 99 and the usual 0 shows that the record is finished.

4. EXPERIENCES FOLLOWING IMPLEMENTATION

The first important trials in the transposition of Land Registry maps from the systems used in the Surveyors' Land Registry onto other territorial data management systems present on the market were carried out.

The transfer format was the one delineated by the NTF level 2.

This process involves converting the data organized according to the system in use at the Italian Cadastre into an intermediate exchange format (NTF).

The data thus converted can easily be interpreted and re-converted according to the receiving system's structures.

At the UTE (Ufficio Tecnico Erariale = Cadastral Provincial Office) in Milan the data from the numerization of the digital cadastral maps were converted according to the NTF standard following the above mentioned procedures. They were then transferred to the WILD-PRIME System 9 data base run on a SUN station.

This trial showed that the geometric and logical contents of the original digital cadastral maps were neither lost during conversion to the standard transfer system nor during the following transfer according to the internal format of the WILD-PRIME System 9.

The trial also showed that it was possible to ask for and to integrate the cadastral information coming from the Land Registry with other information about the territory

coming from other sources.

The conversion procedures took little time and did not give rise to any particular technical problems.

Another important trial is being carried out at the Municipality of Modena where the conversion interfaces from the NTF standard to its system are available.

A agreement between the UTE and the Municipality both of Florence brought about the construction of a new municipal base cartography.

This cartography was created using the cadastral maps. The maps were digitalised and updated by the cadastral. The data they contained after they were memorised in files which corresponded to the Land Registry's sheets underwent all the processing necessary to satisfy the requirements asked for by the municipality. Coordinate transpositions together with the linking and cutting of cadastral sheets according to the municipality's cartographic procedures were then carried out.

Each of the 79 sheets which make up the map covering the whole of the Municipality of Florence was made both in a traditional form on a transparent and alterproof backing and in a numerical form according to the original in the Cadastre. The original files which correspond to the digital cadastral map were done according to its own format and that of the NTF level 2 format.

An agreement is being reached between the Cadastre's general Management and the AGAC (Gas and Water Consortium) which represents the 45 municipalities of the province of Reggio Emilia. The agreement concerns providing digital cadastral maps for all of these municipalities to be used in drafting plans for the construction of new gas pipelines.

As an experiment all the maps covering the territory of Reggio Emilia have already been provided. The transfer of data from the NTF

level 2 format to that of the AGAC consortium is being carried out.

A tentative agreement has also been made between the Cadastre's general Management and the Friuli Venezia Giulia region on the basis of which the UTE of the provinces of this region will be able to provide the region with the digital cadastral maps elaborated according to the NTF standard.

The problem of opening up the heritage of digital cadastral data is very complex given the huge amount of data to be processed and from a legal point of view.

New regulations to make the exchange of data between the UTE and local governing bodies and/or the public service more efficient are presently being considered. For municipalities in particular, the legal process is fairly simple since legal norms that traditionally govern the transfer of the Land Registry's cartography already exist and it is possible to use them when transferring numeric data.

All the trials mentioned above concerned examples of cartography made and digitalised by the cadastre which have been transferred by the cadastre itself to other bodies.

Standardised procedures now being drafted and which are nearly complete will allow the cadastre to receive cartographic data according to the standard format as well as to supply it.

The transfer of these cartographies will be carried out using the very same NTF level 2 standard that has

been described in this paper and which has been used up to now to transfer cartography in the opposite direction, that is, from the cadastre to different users.

These procedures of standard acquisition are in use in all branches of cadastre by 1990.

Acknowledgements

The authors wish to express great thanks to Ordnance Survey and mostly to Mr. Peter Haywood, Chairman of the Working Group for NTF, for his valuable suggestions.

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Towards a swiss standard for the exchange of LIS/GIS-data

Jürg Kaufmann, chartered surveyor, Member of the Project management board of the project 'Reform of the national cadastral surveying'.

1. Introduction

The project 'Reform of the national cadastral surveying' (RAV) shall be implemented in 1992. As it foresees that cadastral data shall be the basis for land information systems (LIS) there must be created a solution for the exchange of cadastral data between surveyors and the users.

1985 a proposition was made that there should be 2 levels of data exchanges. One level was defined as a problem oriented data exchange, which respects the data structure of the LIS and it was called 'official surveying Interface' (AVS). For the exchange of purely graphic data an existing standard (as GKS, DXF) shall be used. (figure 1)

The project management board agreed to this proposition and in 1986 the problem was studied by an expert. He presented a concept as follows:

The official surveying data interface has 3 levels.

- The data definition level with a data definition language.
- The transfer specification level with the transfer identification and the format specifications.
- The hardware level with the connection protocol and the physical connection.

The hardware level is based on available de facto standards, the data definition language and the transfer specification had to be developed.

The project management board did also agree to these propositions. In a further step one found it useful to define a data definition language which could be used not only for surveying data but also for Land information System data. This language is now called INTERLIS. (figure 2) The description of the official surveying data is now called AVS.

2. Data Definition language INTERLIS

The idea of INTERLIS is that different systems with different data models are able to exchange data by a common format, which is derived from a common data model. INTERLIS is the mechanism which allows to describe the common data model. (figure 3)

The language INTERLIS consists of basic symbols, as names, numbers, reserved words and special characters.

Examples are shown in figure 4

The structure elements of the language are:

- the transfer definition
- the value definition
- the data model definition
- the topic definition
- the table definition
- the attribute definition.

For the description of attributes INTERLIS makes available type definitions as follows:

- basic types (figure 5)
- line type (figure 6)
- surface and partition (figure 7)

With this elements it is possible to describe data models.

3. Official surveying Interface (AVS)

The AVS is the application of INTERLIS on the data model of the official cadastral surveying (figure 8). According to the topic-oriented model of RAV, the transfer model is described in topics. This description of the data model (figure 9) is absolutely precise and without contradiction. Examples of the description are given in figures 10-14.

As the project RAV is in some sort in a take-off phase one must be aware that during a long period we have to live with incomplete data sets. It is a big advantage of the INTERLIS/AVS approach that also incomplete models may be described so that the sender and the receiver of surveying data can find a clear agreement on the exchanged data.

4. The INTERLIS-Compiler

The project management board did also order an INTERLIS-Compiler which can be used to check the correctness of data description and to create format definitions. This compiler is available on PC's at minimum costs, so that everyone who is interested in data exchange can easily work with it. In the moment there are no activities to develop the compiler in direction of automatic data conversion.

An example of the compiler output can be found in figures 15-18.

5. State of the INTERLIS/AVS project

The INTERLIS-definition paper has been approved by the RAV project management and also by the system manufacturers. It is now translated to French and Italian. It will be put into force next month.

Some small changes have to be done on the AVS description and then also this paper can be put into force.

Because the idea and also the language and the procedures are new for the professionals there must be done some education work in this field. First experiences show that people who are confronted with these problems are learning quickly and are finally convinced to have a good mechanism to define and realize the exchange of their data.

6. Relation to the international efforts for standardization

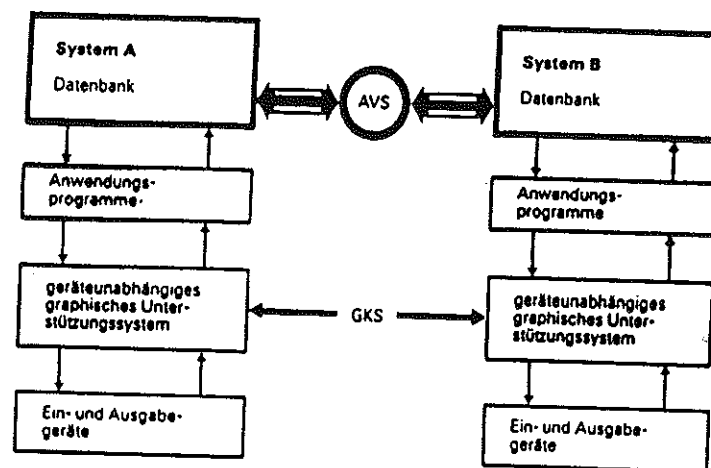
Because of the time-table of the RAV-project Switzerland can not wait for international standardization. We must have a practical solution. But we are aware that the ideas of the European standardization projects go into a same direction, so we are very interested in this work and we think that it would be worthwhile to take part in this work - so that finally LIS/GIS data can be exchanged internationally.

FIG/Hollvor1/JK/3.9.91

Schnittstellen

Bereits innerhalb eines Systems sind Schnittstellen vorhanden, die den Datenverkehr zwischen dem Computer und den angeschlossenen Peripheriegeräten einerseits und zwischen den eingesetzten Programmen andererseits bewerkstelligen. Besondere Problemkreise sind, im Zusammenhang 'Graphik' und 'interaktive Arbeitsweise' zu sehen. Der Datenaustausch unter solchen Systemen ist insofern komplexer in dem zwischen den Systemen Datenmodelle ausgetauscht werden müssen. In unserem Falle das Datenmodell der aV. Die Normierungsbestrebungen spielen sich also auf verschiedenen funktionalen Ebenen ab.

Grundsatz:



Für die Schnittstellen der aV und für die Entwicklung künftiger Systeme sind Standards auf zwei Ebenen zu berücksichtigen:

- höhere anwendungsorientierte, auf die EDV-Basisstruktur der aV ausgerichtete Schnittstelle (nach Grundsätzen 1 - 16)
- amtliche Vermessung Schnittstelle (AVS)
- tiefere graphikorientierte Standardschnittstelle internationaler Norm (ISO IS7942 GKS)

Fig. 1

INTERLIS

MECANISME D'ECHANGE DE DONNEES

POUR

SYSTEMES D'INFORMATION DU TERRITOIRE

Fig. 2

JUIN 1990

1. Überblick

Die Grundidee von INTERLIS besteht darin, dass ein Austausch der Informationen eines Landinformationssystems nur möglich ist, wenn die am Austausch beteiligten Stellen eine genaue und einheitliche Vorstellung über die Art der auszutauschenden Daten haben. INTERLIS befasst sich deshalb zunächst mit der genauen Beschreibung des Datenmodells und erst in einem zweiten Schritt mit der Festlegung des Austauschformates.

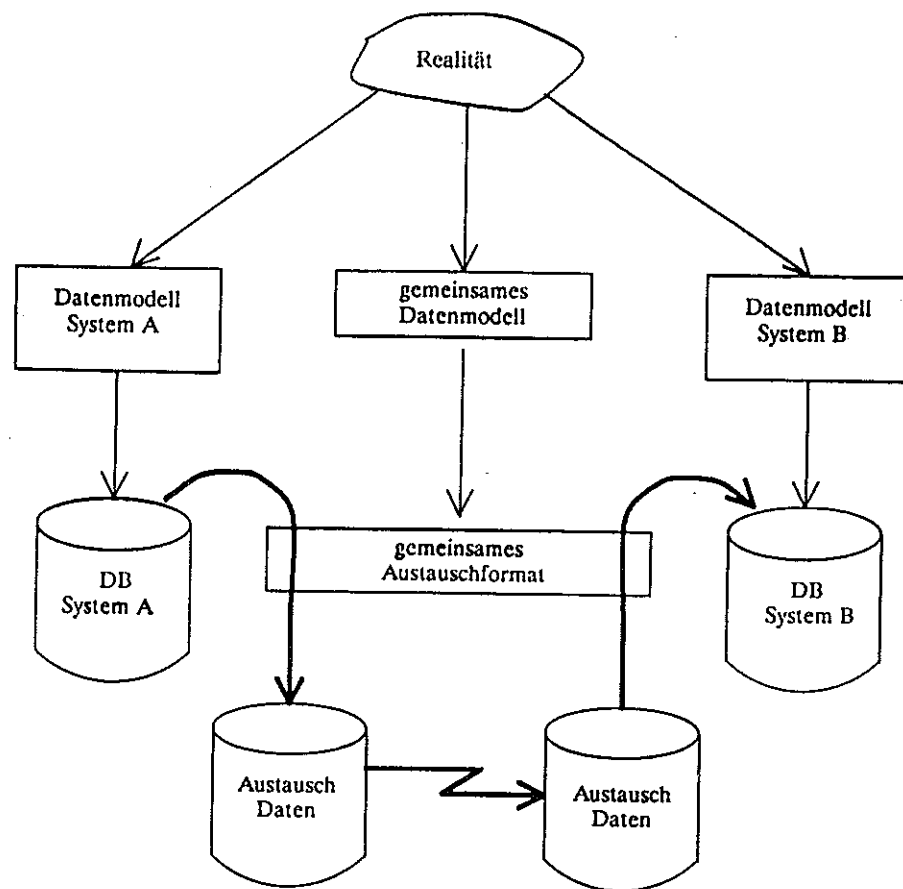


Fig. 3

Bei der Beschreibung des Datenmodells wird nicht von einer bestimmten Anwendung ausgegangen. Vielmehr kann das Modell einer konkreten Anwendung mittels einer Beschreibungssprache definiert werden (vgl. Kapitel 2). Damit steht INTERLIS für die ganze Menge der Anwendungen zur Verfügung, die mit den vorgesehenen Grundelementen beschrieben werden können.

2.2.1.2 Zahlen

Zahlen kommen im Zusammenhang mit der Definition von Wertebereichen und bei der Festlegung des Codes eines bestimmten Zeichens vor. Im zweiten Fall ist es angenehm, wenn dafür auch die hexadezimale Darstellung zur Verfügung steht.

$\text{PosZahl} = (* \text{Ziffer} *)$.

$\text{Zahl} = ['+' | '-'] \text{PosZahl}$.

$\text{Dez} = \text{Zahl} ['.' \text{PosZahl}] [\text{Skalierung}]$.

$\text{Skalierung} = 'S' \text{Zahl}$.

$\text{Code} = (\text{PosZahl} | \text{Hexzahl})$.

$\text{Hexziffer} = (\text{Ziffer} | 'A' | 'B' | 'C' | 'D' | 'E' | 'F' | 'a' | 'b' | 'c' | 'd' | 'e' | 'f')$.

$\text{Hexzahl} = '0' ('x' | 'X') (* \text{Hexziffer} *)$.

Beispiele:

- PosZahl: 5134523 1 23
- Zahl: 123 -435 +5769
- Dez: 123.456 123.456S4 123.456S-2
- Code: 1234 0XA2

Mit der Skalierung wird bei Dez erreicht, dass die Wertangabe in einem sinnigen Bereich, ohne überflüssige Nullen erfolgen kann. 123.456S4 bedeutet z.B. $123.456 \cdot 10^{+4}$ also 1234560.

2.2.1.3 Sonderzeichen und reservierte Worte

Sonderzeichen und reservierte Worte sind in den Syntax Regeln der Sprache immer zwischen Apostrophen geschrieben, z.B. ';' oder 'MODEL'. Die reservierten Worte werden grundsätzlich mit Grossbuchstaben geschrieben. Verwendet man für die Namen nicht ausschliesslich Grossbuchstaben können Konflikte auf einfache Art vermieden werden.

Es werden folgende reservierten Worte verwendet:

ANY	ARCS	AREA	BASE
BLANK	CIRCLES	CODE	CONTINUE
CONTOUR	COORD2	COORD3	DATE
DEFAULT	DEGREES	DERIVATIVES	DIM1
DIM2	DOMAIN	END	FIX

Fig. 4

Tabelle und damit zu welchen Objekten die Beziehung besteht. Damit aber die Unabhängigkeit der Ebenen gewahrt bleibt, sind BeziehungsAttribute nur für Beziehungen innerhalb des gleichen Themas zulässig.

BezAttribut = '->' Tabellen-Name .

2.2.4. Basistypen

Basistyp = (Koord2

| Koord3

| Länge

| Flächenmass

| Winkel

| Bereich

| Text

| Datum

| Aufzählung

| HorizAlignment

| VertAlignment) .

Koordinaten, Längen und Flächenmasse bauen alle auf dem Längenmass auf. Damit über die Bedeutung der transferierten Daten Klarheit herrscht, soll für diese Typen eine einheitliche Grundeinheit (in der Regel der Meter) festgelegt werden. Alle Angaben über Längen, Flächen und Koordinaten sollen dann in dieser Einheit erfolgen.

Die Angabe von Minimum und Maximum bei den verschiedenen Typen definiert nebst den Grenzen auch die Stellenzahl. Dezimalstellen und Skallierung müssen bei Minimum und Maximum übereinstimmen. Will man zum Beispiel einen Längentyp mit einer Obergrenze von einem Kilometer definieren und den Millimeter dabei darstellen können, schreibt man:

DIM1 0.000 1000.000

Fig. 5

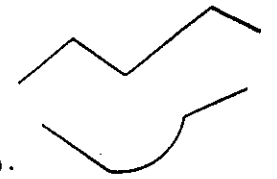
2.2.5. Linientyp

Unter dem Begriff Linie wird eine ununterbrochene Folge von Linienstücken, ein Linienzug verstanden. Nähere Beschreibungen werden für die Form des Linienzuges (welche Verbindungsgeometrien sind zulässig?) und Angaben über die Eigenschaften der Stützpunkte verlangt.

Einzellinie = 'POLYLINE' Form Stützpunkte .

Form = 'WITH' (' Formtyp { ' ' Formtyp } ') .

Formtyp = ('STRAIGHTS' | 'ARCS' | 'CIRCLES' | Erläuterung) .



Es können also Kombinationen von Geraden, Kreisbogen und speziellen Formen als zulässige Verbindungsgeometrien erklärt werden. Zudem kann die Linie auch aus einem Vollkreis bestehen. Die Kreisbogen werden auf dem TransferFile mittels einem Zwischenpunkt in Bogenmitte dargestellt. Bogen mit sehr grossem Zentriwinkel (nahezu Vollkreise) werden dabei numerisch instabil. Sie sind also zu vermeiden.

Kompliziertere Verbindungsgeometrien werden durch INTERLIS nicht fixiert. Damit aber dennoch die Möglichkeit zur Beschreibung und Übertragung besteht, können Spezialfälle als Erläuterung angegeben werden (zum Beispiel für Interpolationskurven). Die Art der Beschreibung und der Codierung auf dem Transfer-File ist dabei Sache der am Transfer Beteiligten.

Stützpunkte = 'VERTEX'

(Koord2 | Koord3 | Koordtyp-Name) ['BASE' Erläuterung] .

Primär wird der Wertebereich der Koordinaten definiert. Mittels einer Erläuterung besteht die Möglichkeit zusätzliche Bedingungen zu beschreiben. So kann zum Beispiel gefordert werden, dass die Koordinaten nicht beliebig sein dürfen, sondern denjenigen der Punkte einer bestimmten Tabelle entsprechen müssen.

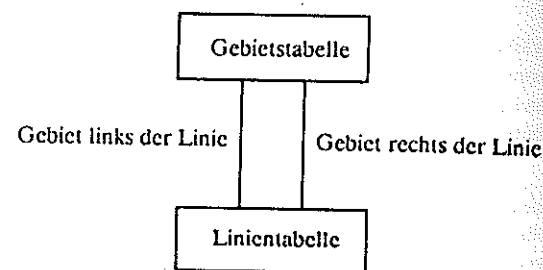
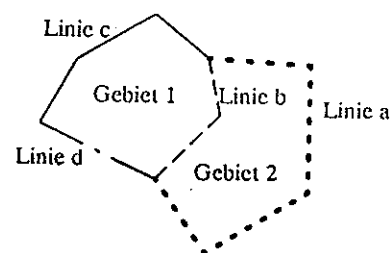
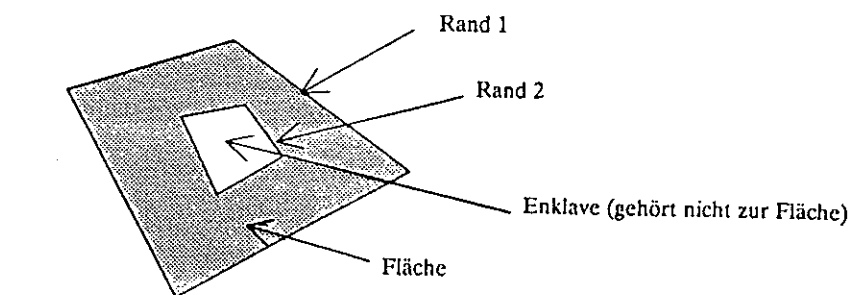
2.2.6. Fläche und Gebiet

Unter einer Fläche wird ein durch Linienzüge oder Vollkreise berandeter, zusammenhängender Bereich verstanden. Üblicherweise weist eine Fläche einen Rand auf, die äussere Begrenzung. Gehört jedoch nicht der ganze Bereich innerhalb der äusseren Begrenzung zur Fläche, werden mit weiteren Rändern der Fläche die ausgesparten Bereiche, die Enklaven bezeichnet. Es kann definiert werden, ob sich die Flächen verschiedener Objekte der Tabelle überlappen dürfen oder nicht.

Als spezielle Form der überlappungsfreien Flächen sind die Gebiete definiert. Dabei wird die Oberfläche vollständig durch Flächen abgedeckt. Jedes Gebiet ist dabei genau einem Objekt der Tabelle zugeordnet. Pro Tabelle kann deshalb nur ein Attribut als Gebiet bezeichnet werden.

Im Unterschied zu allen anderen Attributtypen wird bei Flächen und Gebieten implizit eine weitere Tabelle (als Tabellen-Name wird < Haupt-Tab-Name > _ < Attribut-Name > genommen) gebildet. Sie enthält Ob-

Fig. 6



jekte mit (in dieser Reihenfolge) einer Beziehung zur zugehörigen Fläche (Attributname = P_Objekt) bzw. je einer Beziehung zum den Gebieten links (L_Objekt) und rechts (R_Objekt) der Linie, dem Linienzug (Linie) und weiteren, frei definierbaren Attributen (Linattrdef). Die Definition der zulässigen Form der Verbindungen und die Beschreibung der Stützpunkte erfolgt wie bei den Linien. Die Aufteilung der Ränder in einzelne Linienzüge ist bei Flächen beliebig, bei Gebieten dürfen sie nicht über einen Knotenpunkt (mehr als zwei zusammentreffende Linien) hinausgehen. Für die Linienzüge können bei Bedarf auch Attribute festgelegt werden (Linattrdef). Es dürfen dabei aber keine Flächentypen vorkommen.

Flächentyp = ('SURFACE' ['OVERLAPPING'] | 'AREA') Form Stützpunkte [Linattrdef] .

Linattrdef = 'LINATTR' Attribute { Identifikationen } 'END' .

2.2.7 Auswertungen

Auswertungen = 'DERIVATIVES' Modell-Name ; 'Globale-Wertebereichdef (* Thema *)' .
'END' ;

Auswertungen sind von der Struktur gleich aufgebaut wie das Modell. Sie definieren jedoch keine neuen Daten. Die einzelnen Attributwerte sind Auswertungen, Funktionen der Modelldaten.

Fig. 7

AVS

Beschreibung des Grunddatensatzes

in INTERLIS

Fig. 8

1. INHALT

1.1 Grunddatensatz

Der vorgeschlagene Informationsgehalt der zukünftigen amtlichen Vermessung lässt sich als benutzerorientiertes funktionales Denkmodell in folgende Ebenen gliedern:

FIXPUNKTE
BODENBEDECKUNG
EINZELOBJEKTE/LINIENELEMENTE
HOEHEN
NOMENKLATUR
GRUNDEIGENTUM
RAUMPLANUNG
BODENNUTZUNG
DIENSTBARKEITEN
LEITUNGEN
ADMINISTRATIVE EINGTEILUNG

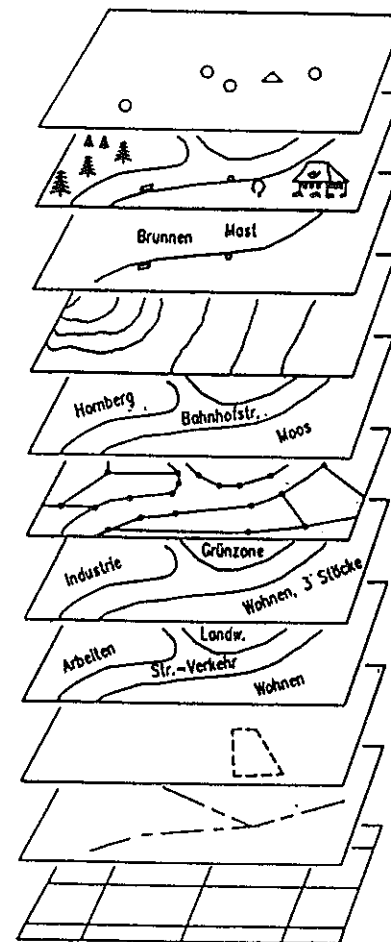


Fig. 9

TRANSFER Datenkatalog;

MODEL Grunddatensatz

DOMAIN

```
LKoord = COORD2 480000.000 60000.000
          850000.000 320000.000;
HKoord = COORD3 480000.000 60000.000 0.000
          850000.000 320000.000 5000.000;
Höhe = DIM1 0.000 5000.000;
Genauigkeit = 0.0 1.0;
Zuverlässigkeit = 0.0 1.0;
SchriftOri = GRADS 0.0 400.0;
```

TOPIC Fixpunkte =

TABLE FPNummer =

```
Nummer: TEXT*12;
NumPos: LKoord;
NumOri: SchriftOri;
NumHAl: OPTIONAL HALIGNMENT; !! Default: Links
!! VAlignment fix: auf Schriftlinie
```

IDENT

```
- Nummer
END FPNummer;
```

TABLE LFP1 =

```
Nummer: -> FPNummer;
Geometrie: HKoord;
LageGen: Genauigkeit;
LageZuv: Zuverlässigkeit;
HöheGen: Genauigkeit;
HöheZuv: Zuverlässigkeit;
TechDossier: TEXT*12;
Date: DATE;
Fixpunktzeichen: Text*12;
Begehbarkeit: Text*1;
```

IDENT

```
- Nummer
END LFP1;
```

Fig. 10

TOPIC Bodenbedeckung =

```

DOMAIN
  BBArt = (Gebäude,
           befestigt (Strassenverkehr,
                     Bahn,
                     Flugplatz,
                     Wasserbecken,
                     übrige_befestigte),
           humusiert (Acker_Wiese_Weide,
                     Intensivkultur,
                     Gartenanlage,
                     Hoch_oder_Flachmoor,
                     übrige_humusiert),
           Gewässer (offenes,
                     Schilfgürtel),
           bestockt (geschlossener Wald,
                     übrige_bestockte),
           vegetationslos (Fels,
                           Gletscher_Firn,
                           Geröll_Sand,
                           Abbau_Deponie));

```

```

TABLE BBProjekt =
  Identifikator: TEXT*12;
  Beschreibung: TEXT*30;
  Perimeter: SURFACE WITH (STRAIGHTS, ARCS) VERTEX LKoord;
  Beginn: DATE;
  Abschluss: OPTIONAL DATE;

```

```

IDENT
  - Identifikator
END BBProjekt;

```

```

TABLE Projektfläche =
  Geometrie: SURFACE WITH (STRAIGHTS, ARCS, CIRCLES) VERTEX LKoord;
  Qualität: OPTIONAL (Text*60);
  TechDossier: -> BBProjekt;
  Art: BBArt;
NO IDENT
END Projektfläche;

```

```

TABLE BoFläche =
  Identifikator: OPTIONAL (TEXT*12); !! Angabe nur bei kant. Vergabe
  Geometrie: AREA WITH (STRAIGHTS, ARCS, CIRCLES) VERTEX LKoord;
  Qualität: OPTIONAL (Text*60); !! falls nicht im TOPIC Qualität
  TechDossier: Text*12;
  Date: OPTIONAL DATE; !! falls nicht im TOPIC NF_Stand
  Art: BBArt;
NO IDENT
END BoFläche;

```

Fig. 11

```

TABLE Objektname =
  Objekt: -> BoFläche;
  Name: TEXT*30;
  NamPos: LKoord // Position in der Regel innerhalb der Fläche //;
  NamOri: SchriftOri;
  NamHali: OPTIONAL HALIGNMENT; !! Default: Links
                                     !! VAlignment fix: auf Schriftlinie

```

```

NO IDENT
END Objektname;

```

```

TABLE Gebäude =
  Nummer: TEXT*12;
  NumPos: LKoord // Position in der Regel innerhalb der Fläche //;
  NumOri: SchriftOri;
  NumHali: OPTIONAL HALIGNMENT; !! Default: Mitte
                                     !! VAlignment fix: auf Schriftlinie
  Geometrie: -> BoFläche // Art = Gebäude //;

```

```

IDENT
  - Nummer
  - Geometrie
END Gebäude;

```

END Bodenbedeckung.

```

OPTIONAL TABLE SpezLinien = !! evt. für Auswertung der Dachkanten
  Linie: -> BoFläche Form;
  Definition: OPTIONAL (am_Boden, Dachkante);
IDENT
  - Linie
END SpezLinien;

```

Fig. 12

TOPIC Grundeigentum

```
TABLE Grenzpunkte =  
  Geometrie: LKoord;  
  LageGen: Genauigkeit  
  LageZuv: Zuverlässigkeit  
  Punktzeichen: TEXT*12;
```

```
IDENT  
  - Geometrie  
END Grenzpunkte;
```

```
TABLE Mutation =  
  Nummer: TEXT*12;  
  Beschreibung: TEXT*30;  
  Beginn: DATE;  
  TechAbschluss: OPTIONAL DATE;  
  Abschluss: OPTIONAL DATE;  
  Gültigkeit: Projektiert;  
  Perimeter: SURFACE WITH (STRAIGHTS, ARCS) VERTEX LKoord;
```

```
IDENT  
  - Nummer  
END Mutation;
```

```
TABLE MutParz =  
  Nummer: TEXT*12;  
  Geometrie: SURFACE WITH (STRAIGHTS, ARCS) VERTEX LKoord;  
  NumPos: LKoord // Position in der Regel innerhalb der Fläche //;  
  NumOri: OPTIONAL SchriftOri; !! undef heisst gegen Norden  
                                     !! Alignment fix: links,  
                                     !! auf Schriftlinie
```

```
  Art: (Parzelle, SelbstRecht (Baurecht, Quellenrecht));  
  Projekt: -> Mutation;
```

```
IDENT  
  - Projekt  
  - Art  
  - Nummer
```

```
END MutParz;
```

```
TABLE Parzelle =  
  Nummer: TEXT*12;  
  Geometrie: AREA WITH (STRAIGHTS, ARCS)  
                                     VERTEX: -> Grenzpunkte;  
  Gültigkeit: (rechtskräftig, streitig);  
  TechDossier: Text*12;  
  Date: DATE;  
  Flächenmass: DIM2 1 999999999;  
  NumPos: LKoord // Position in der Regel innerhalb der Fläche //;  
  NumOri: OPTIONAL SchriftOri; !! undef heisst gegen Norden  
                                     !! Alignment fix: links,  
                                     !! auf Schriftlinie
```

```
  Entstehung: -> Mutation;
```

```
IDENT  
  - Nummer  
END Parzelle;
```

Fig. 13

```
TABLE SelbstRecht =  
  Nummer: TEXT*12;  
  Geometrie: SURFACE WITH (STRAIGHTS, ARCS)  
                                     VERTEX: -> Grenzpunkte;  
  Gültigkeit: (rechtskräftig, streitig);  
  TechDossier: Text*12;  
  Date: DATE;  
  Flächenmass: DIM2 1 999999999;  
  NumPos: LKoord // Position in der Regel innerhalb der Fläche //;  
  NumOri: OPTIONAL SchriftOri; !! undef heisst gegen Norden  
                                     !! Alignment fix: links,  
                                     !! auf Schriftlinie
```

```
  Art: (Baurecht, Quellenrecht);  
  Entstehung: -> Mutation;
```

```
IDENT  
  - Nummer  
END SelbstRecht;
```

```
END Grundeigentum.
```

Fig. 14

LIST OF THE OEEPE PUBLICATIONS

State — September 1992

A. Official publications

- 1 *Trombetti, C.*: „Activité de la Commission A de l'OEEPE de 1960 à 1964“ — *Cunietti, M.*: „Activité de la Commission B de l'OEEPE pendant la période septembre 1960—janvier 1964“ — *Förstner, R.*: „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960—1964)“ — *Neumaier, K.*: „Rapport de la Commission E pour Lisbonne“ — *Weele, A.J. v. d.*: „Report of Commission F.“ — Frankfurt a.M. 1964, 50 pages with 7 tables and 9 annexes.
- 2 *Neumaier, K.*: „Essais d'interprétation de »Bedford« et de »Waterbury«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests“ — „The Interpretation Tests of »Bedford« and »Waterbury«. Common Report Established by all Participating Centres of Commission E of OEEPE“ — „Essais de restitution »Bloc Suisse«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests“ — „Test »Schweizer Block«. Joint Report of all Centres of Commission E of OEEPE.“ — Frankfurt a.M. 1966, 60 pages with 44 annexes.
- 3 *Cunietti, M.*: „Emploi des blocs de bandes pour la cartographie à grande échelle — Résultats des recherches expérimentales organisées par la Commission B de l'O.E.E.P.E. au cours de la période 1959—1966“ — „Use of Strips Connected to Blocks for Large Scale Mapping — Results of Experimental Research Organized by Commission B of the O.E.E.P.E. from 1959 through 1966.“ — Frankfurt a.M. 1968, 157 pages with 50 figures and 24 tables.
- 4 *Förstner, R.*: „Sur la précision de mesures photogrammétriques de coordonnées en terrain montagneux. Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE“ — „The Accuracy of Photogrammetric Co-ordinate Measurements in Mountainous Terrain. Report on the Results of the Reichenbach Test Commission C of the OEEPE.“ — Frankfurt a.M. 1968, Part I: 145 pages with 9 figures; Part II: 23 pages with 65 tables.
- 5 *Trombetti, C.*: „Les recherches expérimentales exécutées sur de longues bandes par la Commission A de l'OEEPE.“ — Frankfurt a.M. 1972, 41 pages with 1 figure, 2 tables, 96 annexes and 19 plates.
- 6 *Neumaier, K.*: „Essai d'interprétation. Rapports des Centres de la Commission E de l'OEEPE.“ — Frankfurt a.M. 1972, 38 pages with 12 tables and 5 annexes.
- 7 *Wiser, P.*: „Etude expérimentale de l'aérottriangulation semi-analytique. Rapport sur l'essai »Gramastetten.“ — Frankfurt a.M. 1972, 36 pages with 6 figures and 8 tables.

- 8 „Proceedings of the OEEPE Symposium on Experimental Research on Accuracy of Aerial Triangulation (Results of Oberschwaben Tests)“
Ackermann, F.: „On Statistical Investigation into the Accuracy of Aerial Triangulation. The Test Project Oberschwaben“ — „Recherches statistiques sur la précision de l'aérottriangulation. Le champ d'essai Oberschwaben“ — Belzner, H.: „The Planning, Establishing and Flying of the Test Field Oberschwaben“ — Stark, E.: „Testblock Oberschwaben, Programme I. Results of Strip Adjustments“ — Ackermann, F.: „Testblock Oberschwaben, Program I. Results of Block-Adjustment by Independent Models“ — Ebner, H.: „Comparison of Different Methods of Block Adjustment“ — Wiser, P.: „Propositions pour le traitement des erreurs non-accidentelles“ — Camps, F.: „Résultats obtenus dans le cadre du projet Oberschwaben 2A“ — Cunietti, M.; Vanossi, A.: „Etude statistique expérimentale des erreurs d'enchaînement des photographies“ — Kupfer, G.: „Image Geometry as Obtained from Rheidt Test Area Photography“ — Förstner, R.: „The Signal-Field of Baustetten. A Short Report“ — Visser, J.; Leberl, F.; Kure, J.: „OEEPE Oberschwaben Réseau Investigations“ — Bauer, H.: „Compensation of Systematic Errors by Analytical Block Adjustment with Common Image Deformation Parameters.“ — Frankfurt a. M. 1973, 350 pages with 119 figures, 68 tables and 1 annex.
- 9 Beck, W.: „The Production of Topographic Maps at 1:10,000 by Photogrammetric Methods. — With statistical evaluations, reproductions, style sheet and sample fragments by Landesvermessungsamt Baden-Württemberg, Stuttgart.“ — Frankfurt a. M. 1976, 89 pages with 10 figures, 20 tables and 20 annexes.
- 10 „Résultats complémentaires de l'essai d'Oberriet de la Commission C de l'OEEPE — Further Results of the Photogrammetric Tests of Oberriet of the Commission C of the OEEPE“
Harry, H.: „Mesure de points de terrain non signalisés dans le champ d'essai d'Oberriet“ — Measurements of Non-Signalized Points in the Test Field Oberriet (Abstract) — Stickler, A.; Waldhäusl, P.: „Restitution graphique des points et des lignes non signalisés et leur comparaison avec des résultats de mesures sur le terrain dans le champ d'essai d'Oberriet“ — Graphical Plotting of Non-Signalized Points and Lines, and Comparison with Terrestrial Surveys in the Test Field Oberriet — Förstner, R.: „Résultats complémentaires des transformations de coordonnées de l'essai d'Oberriet de la Commission C de l'OEEPE — Further Results from Co-ordinate Transformations of the Test Oberriet of Commission C of the OEEPE“ — Schürer, K.: „Comparaison des distances d'Oberriet — Comparison of Distances of Oberriet (Abstract).“ — Frankfurt a. M. 1975, 158 pages with 22 figures and 26 tables.
- 11 „25 années de l'OEEPE“
Verlaine, R.: „25 années d'activité de l'OEEPE“ — „25 Years of OEEPE (Summary)“ — Baarda, W.: „Mathematical Models.“ — Frankfurt a. M. 1979, 104 pages with 22 figures.
- 12 Spiess, E.: „Revision of 1:25,000 Topographic Maps by Photogrammetric Methods.“ — Frankfurt a. M. 1985, 228 pages with 102 figures and 30 tables.
- 13 Timmerman, J.; Roos, P. A.; Schürer, K.; Förstner, R.: On the Accuracy of Photogrammetric Measurements of Buildings — Report on the Results of the Test „Dordrecht“, Carried out by Commission C of the OEEPE. — Frankfurt a. M. 1982, 144 pages with 14 figures and 36 tables.
- 14 Thompson, C. N.: Test of Digitising Methods. — Frankfurt a. M. 1984, 120 pages with 38 figures and 18 tables.
- 15 Jaakkola, M.; Brindöpke, W.; Kölbl, O.; Noukka, P.: Optimal Emulsions for Large-Scale Mapping — Test of „Steinwedel“ — Commission C of the OEEPE 1981–84. — Frankfurt a. M. 1985, 102 pages with 53 figures.
- 16 Waldhäusl, P.: Results of the Vienna Test of OEEPE Commission C. — Kölbl, O.: Photogrammetric Versus Terrestrial Town Survey. — Frankfurt a. M. 1986, 57 pages with 16 figures, 10 tables and 7 annexes.
- 17 Commission E of the OEEPE: Influences of Reproduction Techniques on the Identification of Topographic Details on Orthophotomaps. — Frankfurt a. M. 1986, 138 pages with 51 figures, 25 tables and 6 appendices.
- 18 Förstner, W.: Final Report on the Joint Test on Gross Error Detection of OEEPE and ISP WG III/1. — Frankfurt a. M. 1986, 97 pages with 27 tables and 20 figures.
- 19 Dowman, I. J.; Ducher, G.: Spacelab Metric Camera Experiment — Test of Image Accuracy. — Frankfurt a. M. 1987, 112 pages with 13 figures, 25 tables and 7 appendices.
- 20 Eichhorn, G.: Summary of Replies to Questionnaire on Land Information Systems — Commission V — Land Information Systems. — Frankfurt a. M. 1988, 129 pages with 49 tables and 1 annex.
- 21 Kölbl, O.: Proceedings of the Workshop on Cadastral Renovation — Ecole polytechnique fédérale, Lausanne, 9–11 September, 1987. — Frankfurt a. M. 1988, 337 pages with figures, tables and appendices.
- 22 Rollin, J.; Dowman, I. J.: Map Compilation and Revision in Developing Areas — Test of Large Format Camera Imagery. — Frankfurt a. M. 1988, 35 pages with 3 figures, 9 tables and 3 appendices.
- 23 Drummond, J. (ed.): Automatic Digitizing — A Report Submitted by a Working Group of Commission D (Photogrammetry and Cartography). — Frankfurt a. M. 1990, 224 pages with 85 figures, 6 tables and 6 appendices.
- 24 Ahokas, E.; Jaakkola, J.; Sothas, P.: Interpretability of SPOT data for General Mapping. — Frankfurt a. M. 1990, 120 pages with 11 figures, 7 tables and 10 appendices.
- 25 Ducher, G.: Test on Orthophoto and Stereo-Orthophoto Accuracy. — Frankfurt a. M. 1991, 227 pages with 16 figures and 44 tables.
- 26 Dowman, I. J. (ed.): Test of Triangulation of SPOT Data — Frankfurt a. M. 1991, 206 pages with 67 figures, 52 tables and 3 appendices.
- 27 Newby, P. R. T.; Thompson, C. N. (ed.): Proceedings of the ISPRS and OEEPE Joint Workshop on Updating Digital Data by Photogrammetric Methods. — Frankfurt a. M. 1992, 278 pages with 79 figures, 10 tables and 2 appendices.

B. Special publications

— Special Publications O.E.E.P.E. — Number I

Solaini, L.; Trombetti, C.: Relation sur les travaux préliminaires de la Commission A (Triangulation aérienne aux petites et aux moyennes échelles) de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.). I^{ère} Partie: Programme et organisation du travail. — *Solaini, L.; Belfiore, P.*: Travaux préliminaires de la Commission B de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.) (Triangulations aériennes aux grandes échelles). — *Solaini, L.; Trombetti, C.; Belfiore, P.*: Rapport sur les travaux expérimentaux de triangulation aérienne exécutés par l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (Commission A et B). — *Lehmann, G.*: Compte rendu des travaux de la Commission C de l'O.E.E.P.E. effectués jusqu'à présent. — *Gotthardt, E.*: O.E.E.P.E. Commission C. Compte-rendu de la restitution à la Technischen Hochschule, Stuttgart, des vols d'essai du groupe I du terrain d'Oberriet. — *Brucklacher, W.*: Compte-rendu du centre «Zeiss-Aerotopograph» sur les restitutions pour la Commission C de l'O.E.E.P.E. (Restitution de la bande de vol, groupe I, vol. No. 5). — *Förstner, R.*: O.E.E.P.E. Commission C. Rapport sur la restitution effectuée dans l'Institut für Angewandte Geodäsie, Frankfurt sur le Main. Terrain d'essai d'Oberriet les vols No. 1 et 3 (groupe I). — I.T.C., Delft: Commission C, O.E.E.P.E. Déroulement chronologique des observations. — *Photogrammetria* XII (1955–1956) 3, Amsterdam 1956, pp. 79–199 with 12 figures and 11 tables.

— Publications spéciales de l'O.E.E.P.E. — Numéro II

Solaini, L.; Trombetti, C.: Relations sur les travaux préliminaires de la Commission A (Triangulation aérienne aux petites et aux moyennes échelles) de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.). 2^e partie. Prises de vues et points de contrôle. — *Gotthardt, E.*: Rapport sur les premiers résultats de l'essai d'Oberriet de la Commission C de l'O.E.E.P.E. — *Photogrammetria* XV (1958–1959) 3, Amsterdam 1959, pp. 77–148 with 15 figures and 12 tables.

— *Trombetti, C.*: Travaux de prises de vues et préparation sur le terrain effectuées dans le 1958 sur le nouveau polygone italien pour la Commission A de l'OEEPE. — Florence 1959, 16 pages with 109 tables.

— *Trombetti, C.; Fondelli, M.*: Aérotiangulation analogique solaire. — Firenze 1961, 111 pages, with 14 figures and 43 tables.

— Publications spéciales de l'O.E.E.P.E. — Numéro III

Solaini, L.; Trombetti, C.: Rapport sur les résultats des travaux d'enchaînement et de compensation exécutés pour la Commission A de l'O.E.E.P.E. jusqu'au mois de Janvier 1960. Tome 1: Tableaux et texte. Tome 2: Atlas. — *Photogrammetria* XVII (1960–1961) 4, Amsterdam 1961, pp. 119–326 with 69 figures and 18 tables.

— „OEEPE — Sonderveröffentlichung Nr. 1“

Gigas, E.: „Beitrag zur Geschichte der Europäischen Organisation für photogrammetrische experimentelle Untersuchungen“ — *N.N.*: „Vereinbarung über die Gründung einer Europäischen Organisation für photogrammetrische experimentelle Untersuchungen“ — „Zusatzprotokoll“ — *Gigas, E.*: „Der Sechserausschuß“ — *Brucklacher, W.*: „Kurzbericht über die Arbeiten in der Kommission A der OEEPE“ — *Cunietti, M.*: „Kurzbericht des Präsidenten der Kommission B über die gegenwärtigen Versuche und Untersuchungen“ — *Förstner, R.*: „Kurzbericht über die Arbeiten in der Kommission B der OEEPE“ — „Kurzbericht über die Arbeiten in der Kommission C der OEEPE“ — *Belzner, H.*: „Kurzbericht über die Arbeiten in der Kommission E der OEEPE“ — *Schwidersky, K.*: „Kurzbericht über die Tätigkeit in der Kommission F der OEEPE“ — *Meier, H.-K.*: „Kurzbericht über die Tätigkeit der Untergruppe „Numerische Verfahren“ in der Kommission F der OEEPE“ — *Belzner, H.*: „Versuchsfelder für internationale Versuchs- und Forschungsarbeiten.“ — *Nachr. Kt.- u. Vermess.-wes.*, R. V, Nr. 2, Frankfurt a. M. 1962, 41 pages with 3 tables and 7 annexes.

— *Rinner, K.*: Analytisch-photogrammetrische Triangulation eines Teststreifens der OEEPE. — *Österr. Z. Vermess.-wes.*, OEEPE-Sonderveröff. Nr. 1, Wien 1962, 31 pages.

— *Neumaier, K.; Kasper, H.*: Untersuchungen zur Aerotriangulation von Überweitwinkelaufnahmen. — *Österr. Z. Vermess.-wes.*, OEEPE-Sonderveröff. Nr. 2, Wien 1965, 4 pages with 4 annexes.

— „OEEPE — Sonderveröffentlichung Nr. 2“

Gotthardt, E.: „Erfahrungen mit analytischer Einpassung von Bildstreifen.“ — *Nachr. Kt.- u. Vermess.-wes.*, R. V, Nr. 12, Frankfurt a. M. 1965, 14 pages with 2 figures and 7 tables.

— „OEEPE — Sonderveröffentlichung Nr. 3“

Neumaier, K.: „Versuch »Bedford« und »Waterbury«. Gemeinsamer Bericht aller Zentren der Kommission E der OEEPE“ — „Versuch »Schweizer Block«. Gemeinsamer Bericht aller Zentren der Kommission E der OEEPE.“ — *Nachr. Kt.- u. Vermess.-wes.*, R. V, Nr. 13, Frankfurt a. M. 1966, 30 pages with 44 annexes.

— *Stickler, A.; Waldhäusl, P.*: Interpretation der vorläufigen Ergebnisse der Versuche der Kommission C der OEEPE aus der Sicht des Zentrums Wien. — *Österr. Z. Vermess.-wes.*, OEEPE-Sonderveröff. (Publ. Spéc.) Nr. 3, Wien 1967, 4 pages with 2 figures and 9 tables.

— „OEEPE — Sonderveröffentlichung Nr. 4“

Schürer, K.: „Die Höhenmeßgenauigkeit einfacher photogrammetrischer Kartiergeräte. Bemerkungen zum Versuch »Schweizer Block« der Kommission E der OEEPE.“ — *Nachr. Kt.- u. Vermess.-wes.*, Sonderhefte, Frankfurt a. M., 1968, 25 pages with 7 figures and 3 tables.

- „OEEPE — Sonderveröffentlichung Nr. 5“
Förstner, R.: „Über die Genauigkeit der photogrammetrischen Koordinatenmessung in bergigem Gelände. Bericht über die Ergebnisse des Versuchs Reichenbach der Kommission C der OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1969, Part I: 74 pages with 9 figures; Part II: 65 tables.
- „OEEPE — Sonderveröffentlichung Nr. 6“
Knorr, H.: „Die Europäische Organisation für experimentelle photogrammetrische Untersuchungen — OEEPE — in den Jahren 1962 bis 1970.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1971, 44 pages with 1 figure and 3 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-7“
Förstner, R.: „Das Versuchsfeld Reichenbach der OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1972, 191 pages with 49 figures and 38 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-8“
Neumaier, K.: „Interpretationsversuch. Berichte der Zentren der Kommission E der OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1972, 33 pages with 12 tables and 5 annexes.
- „OEEPE — Sonderveröffentlichung Nr. D-9“
Beck, W.: „Herstellung topographischer Karten 1:10 000 auf photogrammetrischem Weg. Mit statistischen Auswertungen, Reproduktionen, Musterblatt und Kartenmustern des Landesvermessungsamts Baden-Württemberg, Stuttgart.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1976, 65 pages with 10 figures, 20 tables and 20 annexes.
- „OEEPE — Sonderveröffentlichung Nr. D-10“
 Weitere Ergebnisse des Meßversuchs „Oberriet“ der Kommission C der OEEPE.
Harry, H.: „Messungen an nicht signalisierten Geländepunkten im Versuchsfeld „Oberriet““ — *Stickler, A.; Waldhäusl, P.:* „Graphische Auswertung nicht signalisierter Punkte und Linien und deren Vergleich mit Feldmessungsergebnissen im Versuchsfeld „Oberriet““ — *Förstner, R.:* „Weitere Ergebnisse aus Koordinatentransformationen des Versuchs „Oberriet“ der Kommission C der OEEPE“ — *Schürer, K.:* „Streckenvergleich „Oberriet“.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1975, 116 pages with 22 figures and 26 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-11“
Schulz, B.-S.: „Vorschlag einer Methode zur analytischen Behandlung von Reseauaufnahmen.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1976, 34 pages with 16 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-12“
Verlaine, R.: „25 Jahre OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1980, 53 pages.
- „OEEPE — Sonderveröffentlichung Nr. D-13“
Haug, G.: „Bestimmung und Korrektur systematischer Bild- und Modelldeformationen in der Aerotriangulation am Beispiel des Testfeldes „Oberschwaben.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1980, 136 pages with 25 figures and 51 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-14“
Spiess, E.: „Fortführung der Topographischen Karte 1:25 000 mittels Photogrammetrie“ (not published, see English version in OEEPE official publication No. 12)
- „OEEPE — Sonderveröffentlichung Nr. D-15“
Timmerman, J.; Roos, P. A.; Schürer, K.; Förstner, R.: „Über die Genauigkeit der photogrammetrischen Gebäudevermessung. Bericht über die Ergebnisse des Versuchs Dordrecht der Kommission C der OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1983, 131 pages with 14 figures and 36 tables.
- „OEEPE — Sonderveröffentlichung Nr. D-16“
Kommission E der OEEPE: „Einflüsse der Reproduktionstechnik auf die Erkennbarkeit von Details in Orthophotokarten.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1986, 130 pages with 51 figures, 25 tables and 6 annexes.
- „OEEPE — Sonderveröffentlichung Nr. D-17“
Schürer, K.: „Über die Genauigkeit der Koordinaten signalisierter Punkte bei großen Bildmaßstäben. Ergebnisse des Versuchs „Wien“ der Kommission C der OEEPE.“ — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1987, 84 pages with 3 figures, 10 tables and 42 annexes.

C. Congress reports and publications in scientific reviews

- *Stickler, A.*: Interpretation of the Results of the O.E.E.P.E. Commission C. — Photogrammetria XVI (1959–1960) 1, pp. 8–12, 3 figures, 1 annexe (en langue allemande: pp. 12–16).
- *Solaini, L.; Trombetti, C.*: Results of Bridging and Adjustment Works of the Commission A of the O.E.E.P.E. from 1956 to 1959. — Photogrammetria XVI (1959–1960) 4 (Spec. Congr.-No. C), pp. 340–345, 2 tables.
- *N. N.*: Report on the Work Carried out by Commission B of the O.E.E.P.E. During the Period of September 1956–August 1960. — Photogrammetria XVI (1959–1960) 4 (Spec. Congr.-No. C), pp. 346–351, 2 tables.
- *Förstner, R.*: Bericht über die Tätigkeit und Ergebnisse der Kommission C der O.E.E.P.E. (1956–1960). — Photogrammetria XVI (1959–1960) 4 (Spec. Congr.-No. C), pp. 352–357, 1 table.
- *Bachmann, W. K.*: Essais sur la précision de la mesure des parallaxes verticales dans les appareils de restitution du 1^{er} ordre. — Photogrammetria XVI (1959–1960) 4 (Spec. Congr.-No. C), pp. 358–360.
- *Wiser, P.*: Sur la reproductibilité des erreurs du cheminement aérien. — Bull. Soc. Belge Photogramm., No. 60, Juin 1960, pp. 3–11, 2 figures, 2 tables.
- *Cunietti, M.*: L'erreur de mesure des parallaxes transversales dans les appareils de restitution. — Bull. Trimestr. Soc. Belge Photogramm., No. 66, Décembre 1961, pp. 3–50, 12 figures, 22 tables.
- „OEEPE — Arbeitsberichte 1960/64 der Kommissionen A, B, C, E, F“
Trombetti, C.: „Activité de la Commission A de l'OEEPE de 1960 à 1964“ —
Cunietti, M.: „Activité de la Commission B de l'OEEPE pendant la période septembre 1960–janvier 1964“ —
Förstner, R.: „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960–1964)“ —
Neumaier, K.: „Rapport de la Commission E pour Lisbonne“ —
Weele, A. J. van der.: „Report of Commission F.“ — Nachr. Kt.- u. Vermess.-wes., R. V. Nr. 11, Frankfurt a. M. 1964, 50 pages with 7 tables and 9 annexes.
- *Cunietti, M.; Inghilleri, G.; Puliti, M.; Togliatti, G.*: Participation aux recherches sur les blocs de bandes pour la cartographie à grande échelle organisées par la Commission B de l'OEEPE. Milano, Centre CASF du Politecnico. — Boll. Geod. e Sc. affini (XXVI) 1, Firenze 1967, 104 pages.
- *Gotthardt E.*: Die Tätigkeit der Kommission B der OEEPE. — Bildmess. u. Luftbildwes. 36 (1968) 1, pp. 35–37.
- *Cunietti, M.*: Résultats des recherches expérimentales organisées par la Commission B de l'OEEPE au cours de la période 1959–1966. Résumé du Rapport final. — Présenté à l'XI^e Congrès International de Photogrammétrie, Lausanne 1968, Comm. III (en langues française et anglaise), 9 pages.
- *Förstner, R.*: Résumé du Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE. — Présenté à l'XI^e Congrès International de Photogrammétrie, Lausanne 1968, Comm. IV (en langues française, anglaise et allemande), 28 pages, 2 figures, 2 tables.
- *Timmerman, J.*: Proef „OEEPE-Dordrecht“. — ngt 74, 4.Jg., Nr. 6, Juni 1974, S. 143–154 (Kurzfassung: Versuch „OEEPE-Dordrecht“. Genauigkeit photogrammetrischer Gebäudevermessung. Vorgelegt auf dem Symposium der Kommission IV der I.G.P., Paris, 24.–26. September 1974).
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