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Cologne: A GIS Solution for Integrated Traffic Management and Strategic Planning

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By Dr-Ing. Peter Ladstätter, Manager R&D, GIS Division, Strässle Technische Informationssysteme

Traffic congestion, air and noise pollution are common features of our modern way of life. The traffic volume is increasing rapidly with no sign of any slow down. The German states of the former GDR are experiencing a real traffic 'explosion'. Current estimates for Germany forecast an eighty per cent increase in the amount of private traffic and a forty per cent increase in the traffic volume in the road transport industry over the next twenty years. The only definite statement that can be made about these traffic and related problems is that the current traffic management methods are no longer able to cope.

The traffic problems are the most extreme in the large cities and built-up areas. This has lead to a number of initiatives and co-operations emerging from these areas, with the aim of finding solutions to these problems. One of these initiatives is the project SCOPE that started in early 1992. The members of the project are the cities of Southampton, Cologne and Piraeus and a number of industrial partners (the project name is an acronym derived from the names of the three cities). The SCOPE project aims to develop and test new technologies in the field of integrated traffic management. The project is supported by the European Community as part of its Advanced Transport Telematics (ATT) Programme.

The aims of integrated traffic management are not only the optimisation of traffic flow but also changing peoples attitudes toward transport in general. An example is the use of public transport in the cities. The fields of city planning and environmental protection are therefore as equally important as measures of co-ordinating and directing the flow of traffic.

Measures aimed at influencing the traffic problems are highly interdependent. New technologies are therefore required to integrate the systems for planning, directing and controlling traffic and its associated problems. The contribution from the city of Cologne toward the SCOPE project emphasises particularly this integration.

The Strategic Information System

The central aim of this Cologne project is the creation of a Strategic Information System (SIS) through further development of the existing Statistical Information System (STATIS). STATIS was developed by a consortium of German cities and states, headed by the City of Cologne. Although originally designed to the needs of departments of statistics, STATIS can be considered as a general purpose information system. It serves to set up and process information for planning, decision support and strategic controlling.

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STATIS loads, describes and converts raw data from operational systems. Typical raw data comes from public registrations and other events such as elections, polls and census. The preprocessed data can be selected and aggregated to 'information packages' tailored to meet specific user needs. These information packages, which can be regarded as multi-dimensional tables, can be further processed to create reports or to input into specialised application programs. One major task of the Cologne project was the integration of a GIS with STATIS. The main objectives of this integration are to provide users with

* a general and extendable data model for urban infrastructure and traffic related information
* information retrieval functions based on attributes, time periods and geographical locations, with any of these aspects combined

Addresses and Some Elements of the Spatial Reference System, Orthophoto As Background Information

* GIS functions for data capture, spatial analysis and thematic mapping

The SIS project group consisted of members of the Department of Statistics and Urban Affairs in Cologne, the Software AG and strässle Informationssysteme GmbH, which provided the GIS software. strässle Informationssysteme is a German software company with about 500 employees that specialises in technical information systems.

Spatial Reference Systems

Nearly all traffic related data contains a locational reference. If data from different sources has to be combined, aggregated and analysed, locational referencing using a GIS is a powerful tool for data integration. Locational referencing initially requires the establishment of a unique spatial reference system covering the complete area of interest. Availability and quality of digital map data have to be considered and evaluated. Although a considerable amount of digital maps are available today, it is still a critical task to find digital maps suitable for integrated traffic management. Topologic information – necessary for most traffic management purposes – is not available in most cases.

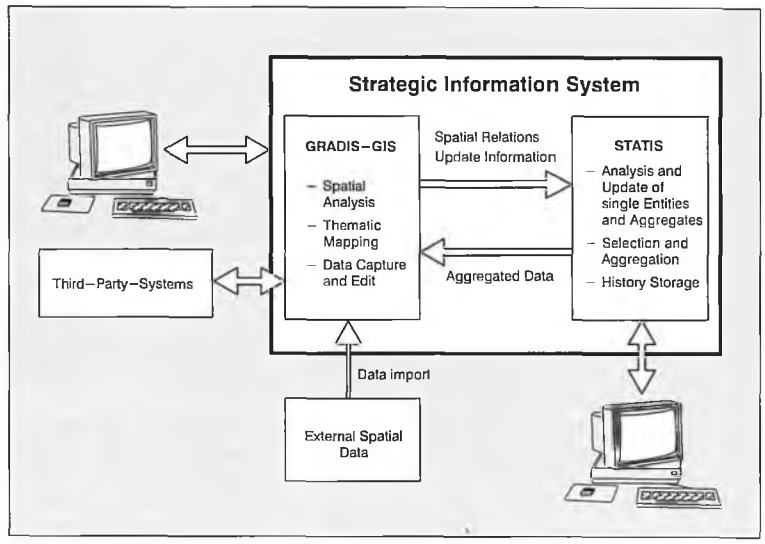
Fortunately, a spatial reference system covering the complete city area of Cologne and its surroundings is provided in digital form by the Department of Statistics and Urban Affairs. The spatial reference system is based on recommendations from the 'Deutscher Städtetag' for administrative purposes in German cities. It is basically a subdivision and ordering scheme for regions and cities, containing hierarchies of administrative areas. The smallest elements of this subdivision are street segments, intersections, building blocks and associated addresses.

This spatial reference system is widely used to index and to aggregate data on a geographic base without having to know geographic coordinates. Locational referencing is very easy to achieve, since in most cases either addresses or named/numbered spatial subdivision here can be used. The hierarchical structure of subdivisions also forms the basis for aggregation purposes and the integration of data with different levels of spatial resolution.

In Cologne, as in other German cities, the statistical spatial reference is stored together with the associated coordinates according to the GEOCODE approach. The reference system therefore forms a fully topologically organised and seamless base map, containing planar networks in different levels of resolution.

The spatial reference system of Cologne holds about 140,000 addresses, 15,000 street segments and 10,000 building blocks at the highest level of resolution.

One of the project tasks was to convert and import the spatial reference data into the Strategic Information System. The limitations of the GEOCODE model should thereby be overcome, e.g. in the treatment of areas crossing the boundaries of administrative subdivisions. The costs to maintain the spatial reference system should also be significantly reduced.



Components of the Strategic Information System

GIS Integration

GRADIS-GIS, a software package supplied by Strässle Informationssysteme, was chosen for the GIS component of the Strategic Information System. GRADIS-GIS is built as an open system, especially suited for the integration into existing information system environments.

GRADIS-GIS is different from most GIS software packages in that it is a completely database oriented system. All spatial objects including their geometric and topologic properties and their attributes are stored in one single commercial database. In this way the well-known problems of maintaining consistency between geometry and attributes are avoided. The user does not have to deal with different storage and data management schemes for geometry and attributes.

Features of GRADIS-GIS that lead to its selection include:

* object-oriented and topologic data structures
* built-in data structures and functions to handle planar networks and node-edge topology
* seamless database storage
* multi-user capability and data security features
* powerful tools for customisation and database integration
* customisable OSF/Motif User Interface
* open system standards like UNIX, SQL, X11, CGM and TCP/IP

Data Modelling

The first step in the integration was the specification of an unified logical data model covering all spatial entities. The data model is divided into several application areas, enabling the extension of the model to new applications. In the data modelling stage, the SIS project group took advantage of the use of CASE tools. This approach has until now been rarely used in the GIS area. The experience from the GIS integration shows that formal data modelling and the use of CASE tools could significantly speed up the data modelling stage.

A central part of the data model are the spatial subdivisions that already exist in the statistical reference system. The subdivisions describe the spatial reference and provide the links to demographic and administrative data. The spatial base for private and public transportation planning is modelled close to the GDF-format.

Data Conversion

The spatial reference data could be converted and imported into GRADIS-GIS by means of relatively simple conversion programs. Besides the GEOCODE data, a number of different files were used to retrieve the necessary information. This mainly automatic data import was followed by two further steps. First the city blocks were further divided into smaller subdivisions. Secondly, some relations between objects, which were not maintained in the existing files, had to be defined and entered. Conventional manual digitising was used to refine the block subdivisions.

Additional experiences have been made with the usage of orthophotos (scale 1:5,000), that were scanned and displayed as graphical background in GRADIS-GIS. This allowed a very fast on-screen digitising. It also turned out that the orthophoto as background data can serve as an important help in understanding and interpreting the results of many queries and analyses.

System Integration Functions

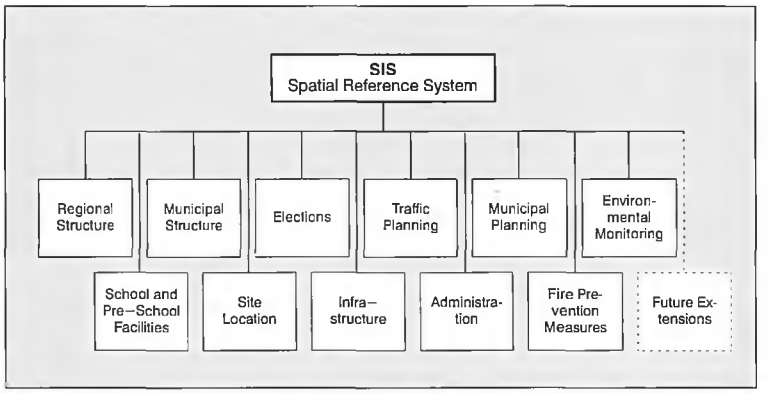
Methods based on the data model are specified and implemented enabling both system components – STATIS and GRADIS-GIS – to access data from each other. The basic integration functions are

* spatial selection of attribute data, using geometric or topologic operators
* selection and visualisation of geographic properties to given attribute data
* creation and update of spatial relations (neighbourhood, connectivity etc.)

The spatial selection is one of the most important tools used to integrate traffic relevant data from different sources, e.g. traffic flow and air pollution along a designated road. The integration of STATIS and GRADIS-GIS provides two general ways to perform spatial queries. The user can start with a geometric/topologic query and then retrieve the associated attributes or information packages. Conversely, the user can start with a selection on attribute data and then retrieve spatial entities. Both methods can be combined in a sequential manner. The results of spatial queries can be used to build information packages in STATIS for further processing. In many cases an (additional) visualisation in form of a thematic display or map allows a very intuitive and comprehensive presentation.
A special feature of the integration is the use of heterogeneous hardware. Since STATIS is designed for very large amounts of data and the use of many terminals its first release runs on mainframes. GRADIS-GIS runs on UNIX workstations. The two systems are connected by a network so that STATIS can be accessed on the workstation. A new release of STATIS is also available on UNIX.

Summary

Local government authorities as well as many larger private companies hold vast amounts of data which are spatially referenced by addresses, by administrative areas or other references. The integration of a Geographic Information System with a Statistical Information System in Cologne shows how the spatial aspect of information can be accessed and used. Modern GIS technology can serve as an important tool for data integration and for strategic decision support.



SIS Data Model Subdivisions

Biography of the Author

Dr-Ing. Peter Ladstätter graduated in Geodesy and Photogrammetry from the Technical University Berlin in 1981. From 1981 to 1986 he worked as Research Assistent at the Institute for Photogrammetry and Cartography at the Technical University Braunschweig. In 1986 he received a Ph.D. on a theme on photogrammetric deformation measurement. He subsequently joined Wild Heerbrugg in Switzerland, where he worked in the areas of Digital Terrain Models and Geographic Information Systems. In 1988 he joined Strässle Technical Information Systems, Zürich as Manager of Research and Development of the GIS division.

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