

# COMPUTER-ASSISTED GENERALIZATION - AN IMPORTANT SOFTWARE-TOOL IN GIS

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The present expansion of GIS has also a grand effect on computer-assisted cartography. Nowadays there is a great demand for special software-tools and applications. GIS-users do need algorithms and computer-solutions for the main items of generalization and visualization. At the Institute of Cartography (IfK) at Hannover University it is a long tradition to work on research projects in the field of computer-assisted generalization. The main emphasis is put on the development of practical computer solutions. The actual repertoire of the IfK's generalization software called CHANGE consists of a lot of program moduls and algorithms for the automatic map design of large scale maps.

At the IfK individual products for cartographic preparation of the traffic network and the buildings have been developed. A lot of difficult problems of cartographic generalization and creation of digital cartographic models (DCM) have yet been solved (eg. smothing, elimination, simplification, symbolization, selection, classification, exaggeration, combination etc).

**KEY WORDS:** Generalization, Visualization, GIS-software

## 1. INTRODUCTION

The current boom in the field of geographical information systems (GIS) and the rapid development in graphic data processing have many consequences concerning computer cartography. Mainly for visualization and graphic output of spatial GIS-data suitable software solutions are necessary. These software modules are indispensable components in GIS as alongside of data aquisition, data storage and data management etc. varied and flexible possibilities for graphic presentation of spatial information have to be provided. This brings new chances and challenges for computer cartography and familiar science disciplines.

Cartographic generalization is an imperative means in the visualization of spatial GIS-data. The generalization or visualization process can be divided in single elementary steps as selection, simplification, symbolization, displacement etc. apart from the necessary data preprocessing and data structuring. At present the automation of generalization for large scale applications is a subject of intensive research. Computer-assisted procedural solutions of particular generalization tasks refering to selected feature classes are nowadays available (e.g. generalization-software of Institute of Cartography (IfK) at Hannover University called CHANGE). The aim is to construct a modular program system in the frame of GIS through the link of independent software modules that also takes into account the interactions between single processes and thus is able to support effectively the visualization of spatial information and of course the graphic production of modern maps.

## 2. HISTORY

For many years several research projects at the Institute of Cartography (IfK) at Hannover University have contained problems and tasks from the field of computer-assisted generalization (Powitz, 1990). In the seventies the prior endeavours of IfK research were definitions, theoretical basis and methodical analysis in cartographic generalization. The eighties were the decade of program developments and realisation of different computer-assisted generalization procedures. The current tasks and research projects of the nineties are the provision of efficient robust software-modules, the arranging of complex system-components as powerful software tools in GIS, the practical tests of generalization programs and above all the use of modern computer technologies as for example object-oriented or rule-based methods and procedures.

## 3. SOFTWARE-CONCEPT AT THE IFK FOR COMPUTER-ASSISTED GENERALIZATION

For a constructive graphic presentation of spatial GIS-data several software modules for modelling, generalization and visualization are necessary. These cartographically demanding components have to be integrated in GIS as powerful tools. Flexible graphical output in various scales and an efficient use of GIS-information are above all solutions in computer-assisted cartographic generalization. Cartographic generalization is absolutely necessary where for faultless legibility and good interpretation of graphic representation in smaller scales on one side given minimum dimensions have to be kept

and on the other side the local information density has to be reduced (Powitz, 1991).

'traffic roads' and 'buildings' (see figure 1 and figure 2).

In the following paragraphs several software tools for model processing and of course for cartographic generalization developed at the IfK called CHANGE will be introduced. Here first computer solutions apply to digital landscape model-objects (DLM-objects) acquired with high resolution or digitized in large scale for the feature classes

#### 4. CONDITIONS FOR GENERALIZATION AND DLM-DATA

As a digital cartographic database for graphic presentation either direct in the original scale or in a smaller scale every spatial GIS-data of a digital landscape model in vector format

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### Generalization-Software CHANGE

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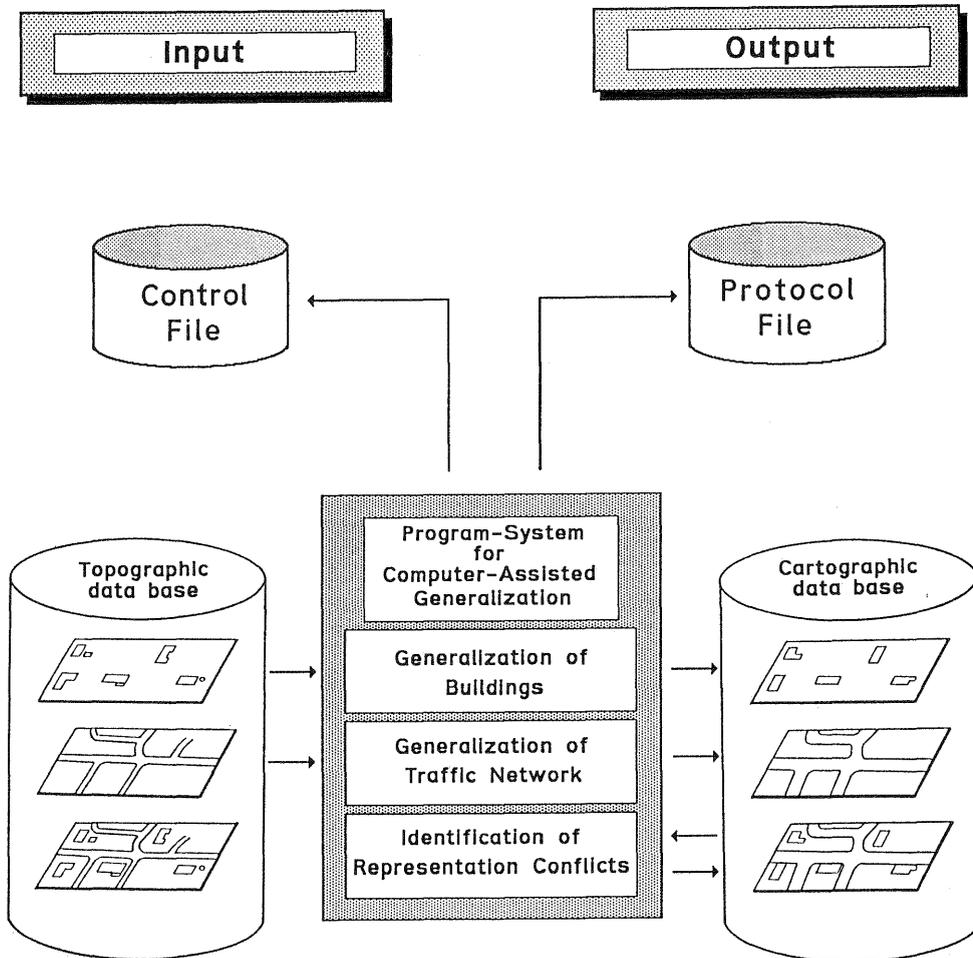


Figure 1: Software-Concept for Computer-Assisted Generalisation with CHANGE

can be considered for the generalization software of the IfK. These digital information can result directly from terrestrial surveying, photogrammetry, digitization of analogous maps (with digitizer or scanner plus raster-vector-conversion and structuring), from available strange digital data or from a lot of other sources.

After the selection or respectively supply of data first the modelling of independent objects with their geometry and the belonging descriptive attributes is necessary. In addition definitions as the degree of generalization, the output scale, the sequence of processing, quite a few threshold values and many more as well as the kind of symbolization are to be selected by the user. Mainly the question "What should be presented how in the derived digital cartographic model (DCM)?" have to be answered. These predefinitions and parameters for the generalization process, which play a substantial role in DCM-derivation in all phases, can be individually specified by the GIS-user for different applications by editing a simple control file (Powitz, Schmidt, 1991).

## 5. GENERALIZATION OF TRAFFIC NETWORK

For a scale-dependent graphic presentation of GIS-objects from the feature class 'traffic roads' several computation steps are necessary in generalization processing. The process includes firstly the data modelling and after that follows the cartographic generalization with the symbolization. The modules of IfK out of the generalization software CHANGE for the processing of the traffic roads are named CHANGE\_Roads.

The first step of computer-assisted pre-processing includes an extensive control of plausibility as incorrect or illogical data have to be changed constructively. These insufficiencies can be caused by errors in digitization or by the inconsistency of different data sources etc. These data checks are concerning geometric as well as geometric-conceptual terms. For example unwelcome line intersections, futile loops or wrong attributes are tracked down and automatically removed.

Following on is the design of an orderly topological network of the streets and ways. If the outlines limiting both sides of the roads are provided as original geometric information for middle axis in the sense of centre lines of these band shaped objects will be calculated automatically. Afterwards gaps and line crossings (over- and under-cuts) of the centre lines especially at road intersections and junctions are eliminated. The result is a topological network of the roads with explicit nodes and edges (see figure 3).

The important simplification of the traffic road representations is carried out on the basis of the computed topological network taking

into account the predefined generalization parameters. Through variation and combination of nodes as well as through smoothing of edges unimportant small forms have to be eliminated whereas clear-cut forms are modified.

The next step in processing is the raw symbolization. Raw symbolization means that corridors or areas for the road symbols are reserved in the presentation level. These corridors are formed on both sides of the edges or centre lines by orthogonal widening according to the individual object attributes. The wideness depends on the space needed by each object in its full graphic display in the DCM.

Finally an optimization of the raw symbolization has to ensue as in intersections and junctions the derived corridor's symbol sectors are overlapping. To remove the overlapping parts a computer-assisted cleaning process is implemented. The result of the actions described is a pre-DCM which supplies the final graphic presentation wanted in combination with the graphic layout elements. This pre-DCM exclusively contains the objects of the feature class 'traffic roads' (see figure 4).

## 6. GENERALIZATION OF BUILDINGS

Similar to the process described for the feature class 'traffic roads' the computer-assisted transfer of the objects from the feature class 'buildings' into the DCM is carried out in several steps by IfK's software modules called CHANGE\_Buildings.

As geometric information digital outlines of single buildings are provided (see figure 5). In processing of buildings the first step also is an extensive plausibility control. These difficult checks already include on one hand the tracking down and on the other hand the automatic correction of unplausible building outlines. After thus optimizing the digital GIS-data the actual steps of cartographic generalization start off.

The necessary simplification of building outlines is an important aspect of cartographic generalization for large scale applications (Staufenbiel, 1973, Meyer, 1987). Based on the given thresholds for minimal dimensions specific to scale (thresholds of graphic minima sizes for single building sides and area parts) insignificant small forms are eliminated and important ones are emphasized. The algorithms are based on the treatment of small forms that can consist of separated building points, small sides and parts of building areas. Nevertheless the original characteristics of the buildings should be consistent during and of course after the simplification process.

Another generalization step contains the combination of neighbouring buildings while

preserving the local relations. The combination gets necessary when the distance between two buildings is smaller than the given threshold and according to the scale the original gap should no longer be presented in the derived DCM.

Two variants are implemented in the software module for the combination of buildings: a relatively small building is moved towards a larger building and two objects are joined if both buildings are to be kept placed according to the ground plan because of their considerable spatial extension.

As a result from these computation steps you get the buildings for the final DCM (see figure 6).

## 7. RECOGNITION OF CARTOGRAPHICAL CONFLICTS

The preceding descriptions explained the standalone processing of the single feature classes 'traffic roads' and 'buildings'. Furthermore graphical conflicts in presentation of the generalized and symbolized objects have to be recognized and subsequently removed. The local interactions among different feature classes have to be considered in the way that objects of low priority must be adjusted to all other neighbouring objects of higher hierarchy. Displacement and homogenization, two important steps in generalization come to fruition here.

The symbolization especially of the roads brings about a widened representation for the DCM and the displacement of buildings gets absolutely necessary. Objects from the feature class 'buildings' of lower priority have to be moved or aligned to the traffic road symbols. The IfK's generalization software offers a special component for automatic recognition of graphical conflicts that have to be modified. The following removal of conflicts has to be carried out interactively by the GIS-user in charge. The resulting DCM can be presented as soft- or hardcopy after the final graphic layout.

## 8. CONCLUSIONS

The aim of developments at the Institute of Cartography (IfK) at Hannover University is to provide robust computer-assisted software tools for generalization and to force the integration of these modules into complex GIS-mainframes. The request for appropriate visualization tools in GIS is expected to grow extremely in future as a versatile and flexible use of spatial GIS-data is desirable.

The described generalization modules for generalization are nowadays still available with the IfK's generalization software CHANGE for large scale applications of commercial GIS-users. The IfK's solutions for displacement exist in several prototype

programs and are an important part of the actual research in the field of computer-assisted generalization at the IfK. Furthermore modern computer technologies as for example the use of exclusively object-oriented or rule-based methods and procedures have to be established in computer-assisted generalization in future (Grünreich, Powitz, Schmidt, 1992).

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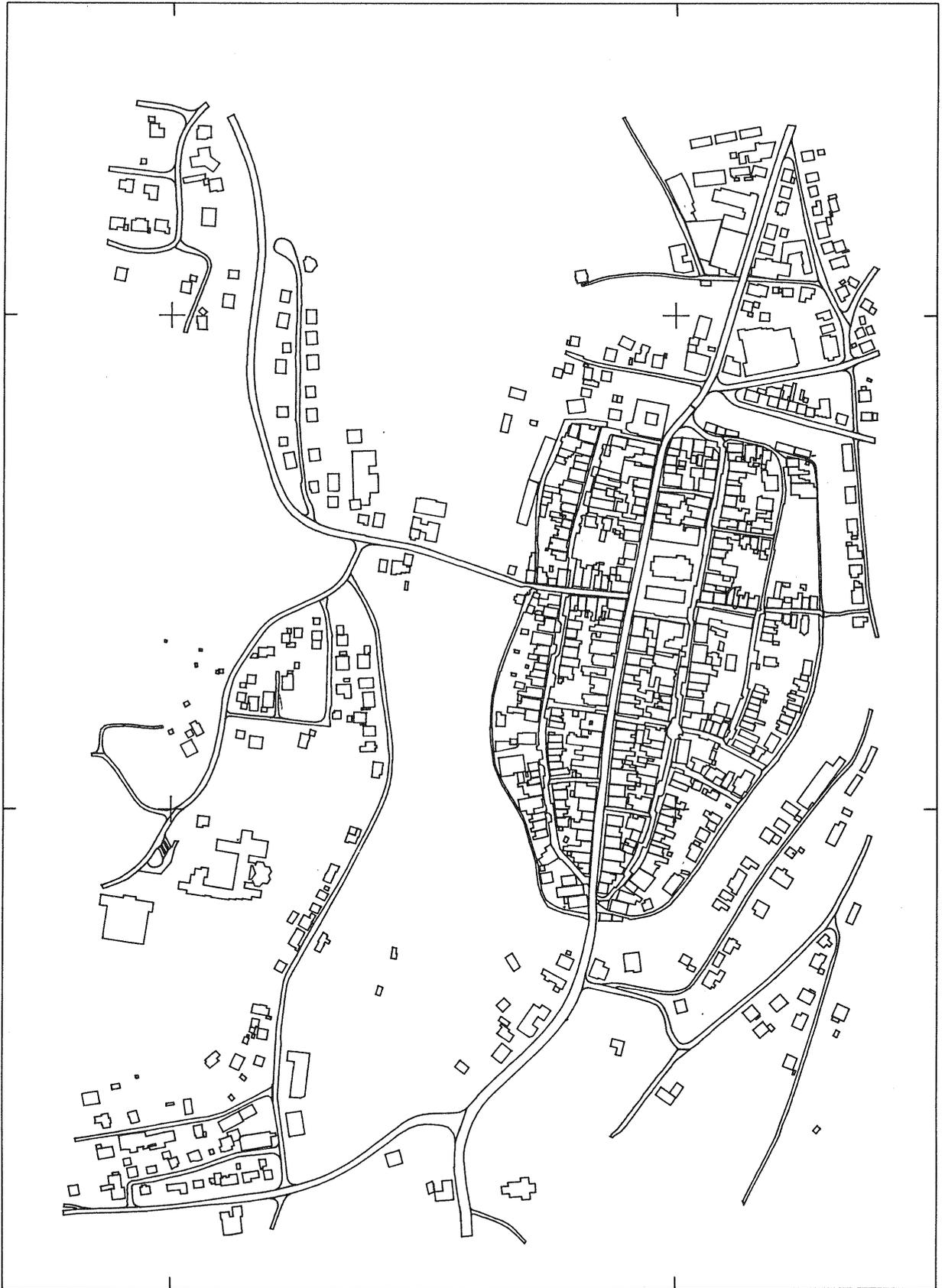


Figure 2: Traffic-Roads and Buildings (Scale 1:5.000)

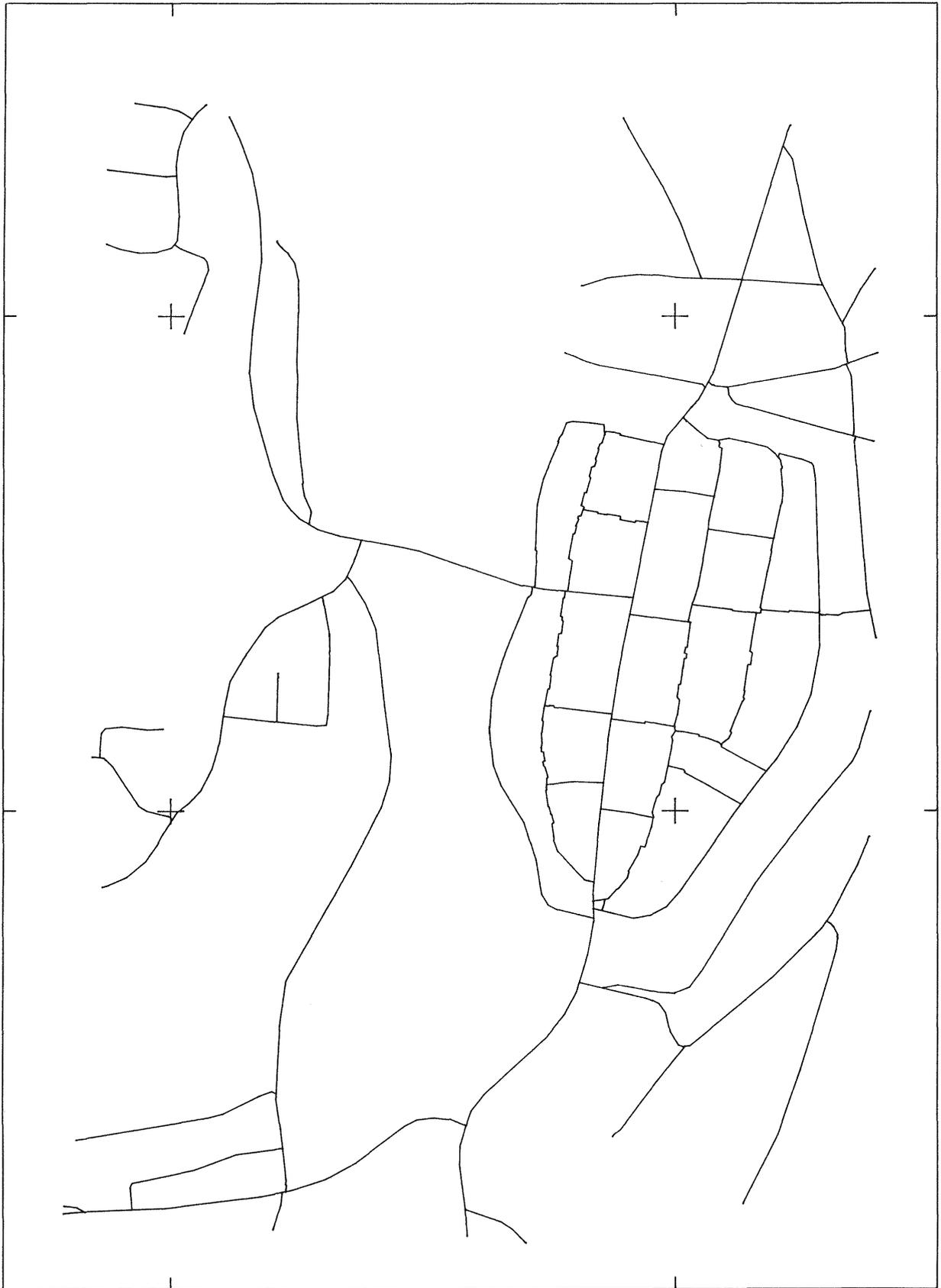


Figure 3: Network of Traffic Roads



Figure 4: Result of CHANGE\_Roads: Generalized Traffic Roads (Scale 1:25.000)

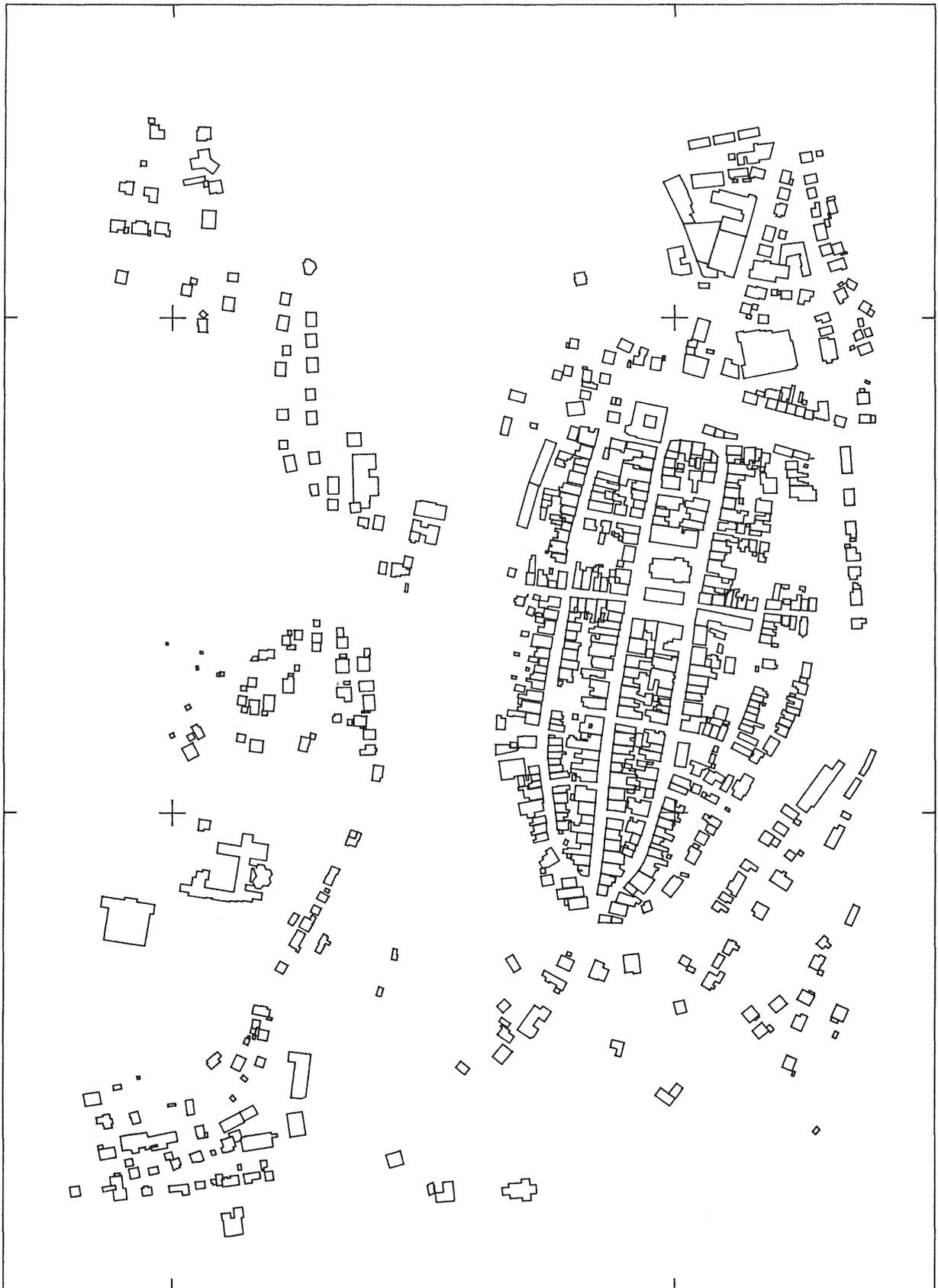


Figure 5: Buildings (Scale 1:5.000)



Figure 6: Result of CHANGE\_Buildings: Generalized Buildings (Scale 1:25.000)