

# MAINTENANCE OF URBAN INFORMATION SYSTEMS USING PHOTOGRAMMETRIC SUPERIMPOSITION TECHNIQUE

by

Anders Östman  
Intergraph (Scandinavia) AB  
Box 2146  
S-183 02 Täby  
SWEDEN

Matti Tujunen  
City of Helsinki  
Viipurinkatu 2  
SF-00510 Helsinki  
FINLAND

## ABSTRACT

During the last decade, the city of Helsinki has put much effort into obtaining better co-operation among different authorities within the city. This work has, among other things, resulted in a large spatial database for different urban applications.

Photogrammetric methods based on superimposition are used for the updating of the database. This paper describes and discusses different questions associated with this process, such as 2D-to-3D conversion and maintenance of ground control.

## INTRODUCTION

The city of Helsinki, with its 485,000 inhabitants, is the capital of Finland. The main part of the area is classified as urban area, but a significant part also consists of forests, argicultural areas and water areas.

The city survey department is responsible for the production and maintenance of the large scale base map. This map is produced in the scale of 1:500 using photogrammetric methods. Other versions, in the scales of 1:1000 and 1:2000, are then produced using reprographic methods. Currently, a complete coverage of the city exists in graphical form. The 1:500 base map consists of approximately 2000 sheets and the content is fairly up-to-date.

The city survey department is also responsible for the maintenance of the combined utility map. The corresponding measurements are though performed by the three utility departments of the city and the telephone company themselves. All of these maps are very important for different authorities within the city. They are used for many activities such as city planning in different levels, street planning and construction, decision making etc.

In the early 80's, the city acquired an Intergraph information system, first for combined utility purposes , but shortly afterwards also for the acquisition, storage, retrieval and analysis of spatial information in general. Since 1983, the utility and base maps have gradually been converted into digital form and stored in a large spatial database. So far, about 30% of the base map and 50% of the utility map have been converted, a work which is planned to be finished in about 1992-93. Graphical workstations have been used in this work. Graphic data processing is gradually becoming a tool for many different types of mapping and engineering operations. The main advantages of using computerized urban information system techniques are

1. Increased production and improved maintenance of the information.
2. Improved co-operation and communication among the authorities within the city, leading to reduced number of redundant (doubled) operations.
3. Ability to perform new operations, such as presentation of proposed construction works using 3D surface models and computer generated perspective images in colour.

The buildings, the real estate boundaries and the network points are measured using geodetic field survey. All other information on the base map has mainly been obtained using photogrammetric techniques. In the beginning of the 80's, an analytical plotter with plottingtable was acquired for this task. It was acquired before the Intergraph system and only minor efforts were made to interface the equipments with each other.

Although the work with the base map information is very essential for the surveying department, other maps and information themes are produced upon specification. Different planners need information concerning the environment, forest, vegetation etc. Another important application is photogrammetric data acquisition for Digital Terrain Models (DTM's) for planning purposes in general and street planning in particular. The information produced on request for other departments is not maintained by the surveying department. The volume per year of photogrammetric work at the city of Helsinki has been as follows:

- Updating the base map (1:500): 2400 hectares (200 mapsheets).
- Forest, vegetation and environment maps (1:500 - 1:2000): 700 hectares.
- DTM data collection and cross sections: 500 hectares.

In addition to this, some non-topographic stereomodels have also been evaluated.

When moving from graphical mapping to computer-based maintenance of spatial information, several problems are encountered.

a) Interfacing computer equipment from different manufacturers turned out to be associated with some problems. For instance, data transfer and translation from the analytical plotter to the Intergraph system was performed using self-made programs. This process was time-consuming and the information transferred was not always correct. Some promising efforts were made to improve the process, but because of the amount of post-editing work needed, this approach was given up.

The biggest problems appeared when making corrections of the old information, matching of old and new information and matching of two or more mapsheets (graphical files). These procedures were carried out more or less blindly, resulting in unreliable data sets.

b) The increased amount of hardware, software and information implies an increasing amount of consultant work for other departments within the city. This is of course very positive as such, but the significant increase in work load also causes problems in the short run.

c) Different sources and methods are used for data input. In some cases, the numerical representation of the graphical elements have to match each other as smoothly as possible. This requires close co-operation and procedures for the specification of data quality.

d) To obtain optimum economy, organisational changes are needed. The borders between cartography, photogrammetry and even geodesy are slowly disappearing. The increased demands on more rapid maintenance of information also leads to organisational changes.

e) The analytical stereoplotter with plotting unit was a very good solution at the time it was acquired. But due to the demands of larger capacity and quicker maintenance of the detailed information in the base maps, photogrammetric technique based on direct connection to the Intergraph system and colour superimposition is needed.

To solve some of these problems, an InterMap Analytic stereoinstrument from Intergraph has been acquired. The purpose of this paper is to present and discuss some problems, considerations and possibilities this new photogrammetric technique may offer concerning the problem of maintenance of spatial information.

## THE INTERMAP ANALYTIC

The photogrammetric stereoinstrument currently used in the city of Helsinki is an InterMap Analytic from Intergraph (figure 1). The instrument works like any other work station within the information system. It is connected to a central VAX computer through an Ethernet communication link.

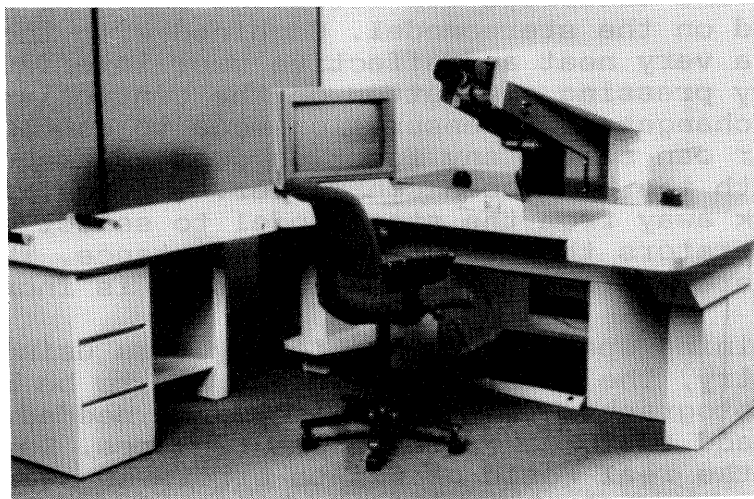


Figure 1. InterMap Analytic.

The hardware part of the instrument consists of a stereoviewer (optics, stage movements etc), a graphical terminal, an additional superimposition monitor, a hand-held controller for positional movements, a sensitized menu surface, processors etc. During the design of the instrument, Intergraph has paid very much attention to ergonomic features. The instrument is engineered to accommodate a wide range of operator variables and is adjustable for height, leg length, torso length etc. These features are of great importance in a productional environment such as in the city of Helsinki, where several stereo-operators use the instrument.

The superimposition technique and the hand-held controller are two ergonomical features which here are of special interest. The hand-held controller has two thumb-controlled switches for movement in X, Y and Z. It also contains ten additional buttons for invoking different commands. This means that the operator has in his hand full control of the X, Y and Z movements as well as all the commands given to the work station.

The colour superimposition monitor is placed on the back of the instrument and injected into the optical train of the left eye-piece, so that the graphics can be viewed superimposed on the stereomodel. The monitor displays information from the graphical database as well as menus

and tutorials (screen menus). The information from the graphical database is transformed to the image co-ordinate system using a strict perspective transformation. This means that if the database is represented in three dimensions, all graphical features coincide with the corresponding features in the image.

Also menus and tutorials for different commands are superimposed on the stereomodel. Combined with the hand-held controller a very neat and effective user interface is achieved. By pressing one button on the controller, the instrument changes from mensuration mode to command mode and the operator can select any function from the menu, just by pointing with the hand-held controller. The operator doesn't have to look away from the stereomodel to select commands. For many operators this is of great importance. The working conditions are improved and the production is increased.

When maintaining spatial information systems using photogrammetry, the existing data base has to be compared with the photographs. The editing commands needed are usually to add features or to delete features. Due to changes in the real world or due to errors in stored data, features also have to be modified. Data are often acquired using many different methods such as photogrammetric methods, field surveys or digitalisation of existing maps. In some cases, data may also be acquired from other organisations. The experience obtained so far, shows that the main part of the errors in data consists of erroneous feature coding. Stereo-operators or field surveyors seldom make large errors in the measurements. If so, they usually correct them immediately. Erroneous coding of features are more common, as well regarding photogrammetric data acquisition, geodetic field surveys as data transfer between different systems.

To check the coding of the features, they have to be displayed differently. For this, different line patterns, line weights or colours may be used. Since humans are very sensitive to colours in the visible range, the use of colours is very useful for the detection of erroneous feature codes. In addition, the use of colours are far more convenient for an operator than black/white graphics. For an operator working at the instrument the whole day, the use of soft colours improves the working conditions.

The software of the InterMap Analytic (IMA) is based on the IGDS/DMRS basic software from Intergraph. IGDS is the basic graphic package while DMRS is the database managing system, mainly for handling non-graphical data. These two software packages are well integrated with each other, forming a basic unit. On this unit, other application software are built, such as DTM packages, geodetic network analysis and software for the analytical stereo-instrument. The latter software module consists of programs for data acquisition

for DTM's, feature coding, alignment and cross-sectioning, aerial triangulation, calibration of the instrument, orientation and project management.

## 2D - 3D CONVERSION

In 1983, the city of Helsinki started the process of converting graphical maps into digital information. Using mainly manual digitizing methods, the database being established is only represented in two dimensions. But the need for 3D-information is continuously growing. A couple of years ago, a part of the inner city was modelled in 3D. The purpose here was to evaluate different architectural plans using 3D surface modelling (figure 2).

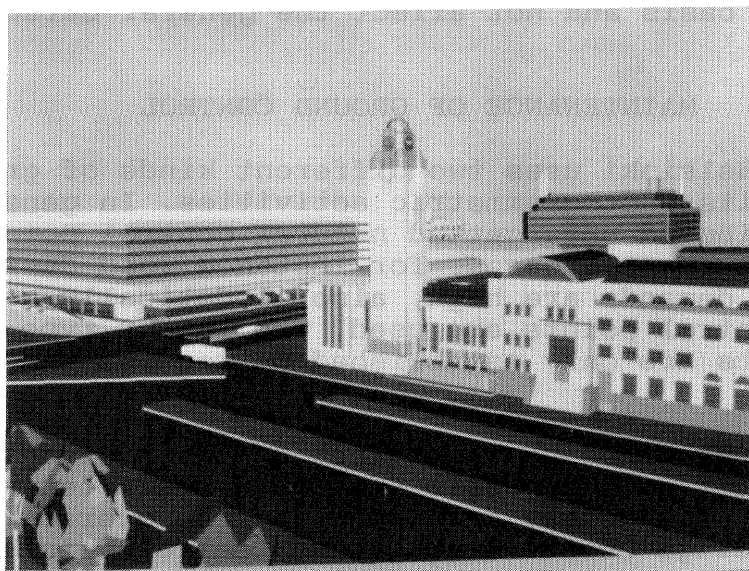


Figure 2. 3D model of a part of Helsinki.

During this evaluation, the city gained experience regarding both technique and economy. From a pure technical point of view, the project was a success, but it also turned out to be fairly expensive. A complete 3D surface modelling coverage of the city was at that time not economically justified, at least not for architectural purposes alone.

In 1987, the decision was made that a photogrammetric technique based on superimposition was to be used for the maintenance of the spatial information system. While evaluating this technique, the question of 2D or 3D information was raised again. The questions to be answered was whether superimposition of 2D-information is sufficient for the maintenance of the existing database or should the database be converted into 3D? If the database is two-dimensional, the elevation of the measuring mark is used in the perspective transformation of the graphics.

A theoretical analysis shows that the use of 2D-information is sufficient for superimposition purposes. The mismatch between image and superimposed graphics is only depending on the terrain variations within the field of view. The theoretical analysis shows that the average mismatch is about 4-7 pixels, depending on the zoom factor.

The decision made in the city of Helsinki is to use the 2D information. It is not economically justified to convert data into 3D just for superimposition purposes. But there are also other applications within the city which have an interest in 3D modelling of the city, such as architectural, planning etc. If a 2D - 3D conversion is to be performed in the future, it has to be of good quality so as not to worsen the superimposition. Otherwise, it should only be performed on a project basis and not affect the general database.

#### MAINTENANCE OF GROUND CONTROL

The city of Helsinki uses two different kinds of ground control for its photogrammetric activities. In general, densely distributed untargetted natural control points are used. In some special cases, for instance road design where the accuracy demands are high, also geodetically measured targetted control points are used. The latter type of control points are only established on request and are not maintained.

The ground control being maintained consists of untargetted natural points, such as roofs and other characteristic details. They are densely patterned and one stereo-model covers in average about 10-15 ground control points. Their accuracy varies, depending on factors such as measuring method (geodetic field survey, aerial triangulation etc) and type of feature (roof, manhole etc). For each control point an accuracy class is tagged. The corresponding standard deviations are then used in the least squares adjustment for the orientation of the stereomodels. The ability of assigning and using different weights of the control points is essential for the use of natural untargetted control points.

For the updating of the urban information system, the city is photographed regularly. Each year, a third of the city area, about 8 - 9000 hectares, is photographed from an altitude of 600 meters. In addition to this, the whole city is also photographed in scale of 1:10,000 using false coloured IR film or conventional colour film. These images are used for environmental observations but also in some cases for stereo mapping of vegetation, forest etc. Only a minor part of the images are evaluated in the stereoinstruments, but the approach gives the possibility to make maps for urgent needs almost anywhere in the city the whole year. In this way, the city survey department can

improve the maintenance of the base map and other mapping services for special purposes.

Currently, about 70 % of the city area has a coverage of ground control points. They are maintained through a 5 - 10 year revision cycle. The ground control is then updated using mainly aerial triangulation. So far this approach has worked well and if urgent needs occur, geodetic point densification is performed.

#### FUTURE PLANS

Several areas of study are being planned for the future. One area consists of improving the current routines, the organisation and the knowledge level. In a dynamic field like this, all these three ingredients need to be improved continuously. The photogrammetric work has up to now been carried out fairly isolated. As a consequence, present information transfer between stereo-operators on the one hand and cartographers, planners etc on the other is not sufficient. By forming project groups, incorporating the photogrammetrists, it is assumed that this problem will be reduced.

One very significant and developing work will be DTM data collection and DTM modelling for special purposes. At the moment, there is a special project going on to investigate these matters. Is there a large need for 3D information? Is there a need for a DTM covering the whole city or should the DTM's be produced on request? During the next 1 - 2 years, these questions have to be answered. They concern several departments in the city with different accuracy demands, such as civil engineering department, geotechnical department, water and sewage department, city planning department, energy works and city survey department. Other questions to be answered during the coming years are concerning the methods to be used for data acquisition, organisation and maintenance of the database and last, but not least, the economical questions.

Another area which draws much attention is the evaluation of new technical inventions. Some of these seem not yet to be practically realised, for instance digital orthophotos, while others such as raster-scanning and combining vector- and raster-information may be useful in the very near future.

A fourth area of study for the future consists of the evaluation of the information system as such. This evaluation consists of both economical and informational considerations. The economical analysis performed by the joint nordic KVANTIF work (Kylén 1987, Bernhardsen & Tveitdal 1986) is here of great value. Another strategic decision concerns the quality specification of data.



Currently, the quality is specified on the map, but in the future this information is to be handled by the spatial information system.

#### CONCLUSIONS

The main conclusions to be drawn from this paper may be summarised as.

- 1.) There is at the moment no urgent need for 3D-information in the information system in the city of Helsinki. For the superimposition of graphics, 2D-information is sufficient.
- 2.) The maintenance of ground control is simplified by just using natural control points. The ability of weighting each control point individually in the orientation is here essential.
- 3.) Photogrammetric technique is very useful for an organisation like the surveying department in the city of Helsinki. But there is also a continuous need for further enhancement of the process and a close study of the development is desired.

#### REFERENCES

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