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nAutiKa
A DIGITAL CHART INFORMATION SYSTEM

by the Swedish Hydrographic Department (*)

1. BACKGROUND

During 1983, discussions started at the Swedish Hydrographic Department about whether an Interactive Graphic System (IGS) would be a profitable investment or not. Since, during the same period, the Hydrographic Department (H.D.) started to receive requests from customers about the possibility of receiving chart information in digital form, a project, called nAutiKa, was started. The project was firstly aimed at defining the need for introducing such a system and writing a specification. A decision was later taken to purchase a system. It is now installed at the Hydrographic Department, and production lines are being set up.

'IGS' is not a totally suitable name for a system of this kind. It is preferable to call it a 'chart information system' since what is important is not the interactivity but the potential provided by the storage of chart and survey data in data bases. It is also important to realise that it is not 'automatic chart production' that is being discussed, but a new tool for the cartographers to use in the different stages of their work.

The advantages expected from the nAutiKa system are of several kinds. Storage and retrieval of all information in central data bases will give possibilities for improved and safer routines, since a great number of manual drawings and tabulations — often of the same information presented several times — will be avoided. The products will also be more uniform using digital methods, and it will be easier to produce new types of printed products. Another capability is the possibility to easily transform charts between different projections and geodetic datums, e.g. from the national Swedish datum to WGS 84.

Perhaps the most important capability that will be fulfilled with the new system is the possibility of providing chart information in digital form, as for example for ECDIS and for military applications.

No increase of productivity is expected for the first years of operation. On the contrary, much effort is being spent on training, testing of new working

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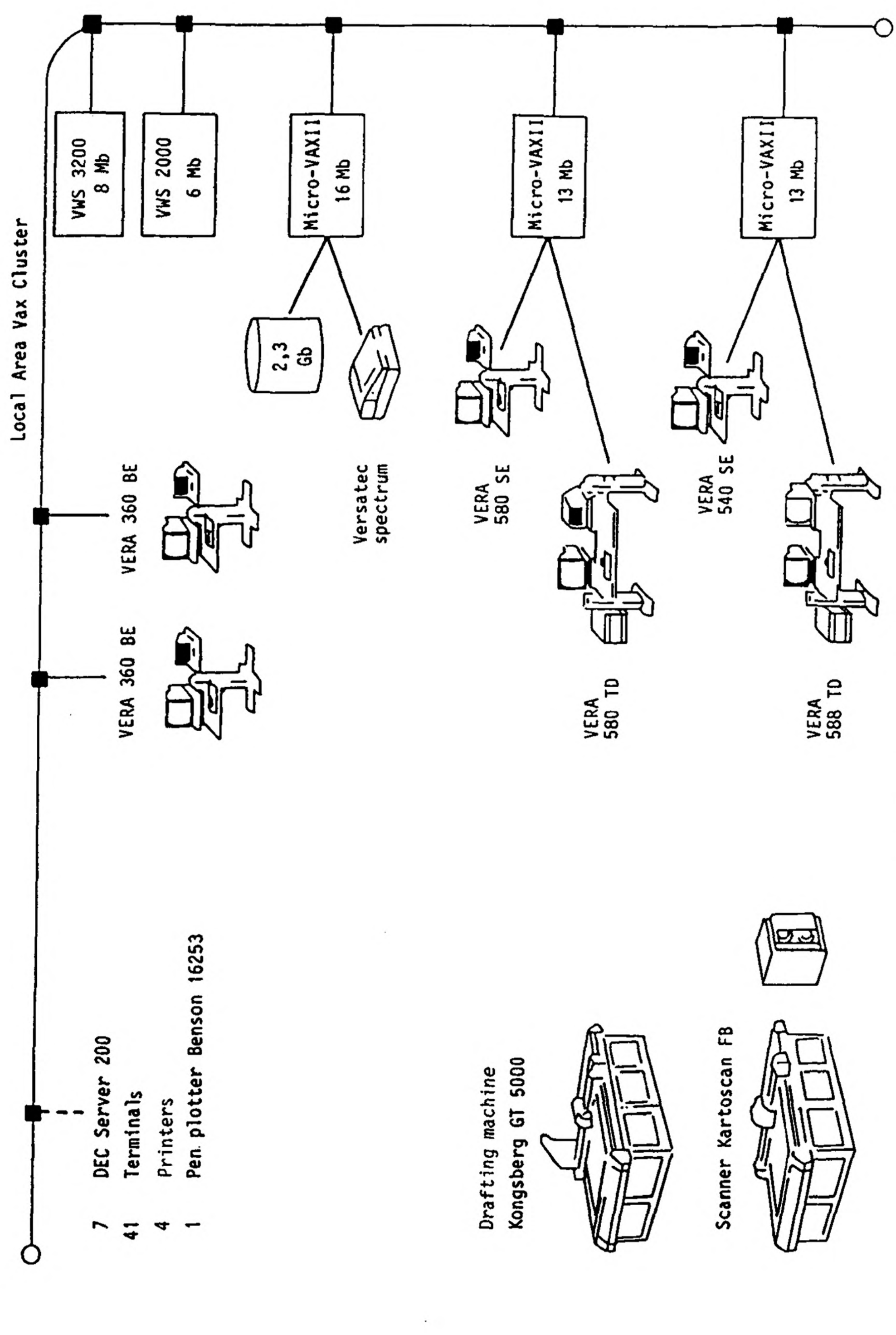

FIG. 1.— Hardware configuration of the nAutiKa system.

methods, etc. After some time, when the data bases have been established, the productivity will increase, e.g. for the correction of charts. The possibilities of extending the system with a photo-plotter to produce printing originals — or even printing plates — directly from the data bases with a minimum of manual intervention will be studied. This has the potential of increasing considerably the productivity.

2. SYSTEM DESCRIPTION

In February 1987, a contract was signed with the Norwegian company SysScan A/S. The contract includes delivery of a complete system, development of certain functions, maintenance, training and support. The latter included one specialist from the vendor assigned to the Hydrographic Department (H.D.) for eight months.

nAutiKa is a complete system for collecting, storing — both in vector-, raster- and alphanumerical form — editing, retrieval and output of digital chart information. The hardware configuration is shown in Figure 1. The system is based on DEC-VAX computers connected via an Ethernet in a Local Area Vax Cluster (LAVC). This makes the individual computers invisible to the user, who, when logging onto the system, is automatically connected to the computer which at the moment has the lowest load. This solution is very flexible and it is easy to connect additional CPU-power and new peripherals when they are needed. The disc capacity is at present 2 500 Mb and is expected to grow rapidly when production starts.

Since the major part of the information that is to be stored in nAutiKa is classified, very high requirements have been put on the security functions of the system. Except for the normal access control functions built into the system, special care has been taken in the physical layout of the installation. One example is that the Ethernet cable has been installed to be fully visible, and consequently open to inspection throughout its full length. Special measurements of detectable radiation from the installation are to be made. The system is completely locked inside the H.D. and no external connections are allowed.

3. LINE OF PRODUCTION

3.1 Data collection

The two major sources of data input to the system will now be discussed: data from modern surveys and from existing maps and charts.

3.1.1 Surveying

The biggest and most resource-consuming source of input data for chart production is, of course, the surveys. These are accomplished using modern echo sounding methods and a very accurate positioning method (± 5 m). Up to now the surveys have been recorded on analogue echograms which have been sent to the office for manual digitizing. The experienced operator then has to choose significant points along the depth profile. He can also decide relatively simply which echo signal really is the bottom and not a disturbance, a shoal of fish or a false echo caused by the density structure of the water.

The analysis of these difficulties has been carefully considered in a project to evaluate digital surveying methods, in which a processor in real time has to decide which depths are to be recorded. The number of depths recorded automatically is much larger than by manually digitized means. Therefore, data reduction must be introduced, in several steps in the process leading to the final contour map, which is the result of the surveying.

As an example, the number of stored depths in the different production stages can be as follows: for an area of 18 × 20 km, about 26 million depths are recorded by the echo sounders. On the magnetic tape, produced on board the surveying ship, about 1/10 of these, i.e. 2.6 million depth values, are stored together with the corresponding positions. The depths are stored with a resolution of 1 dm and the positions with a resolution of 1 m. At the office, a digital terrain model of the area is produced consisting of about 500,000 points. From the model, a depth figure map at a scale of 1:10,000 is drawn containing about 4,000 depths. Finally, in the chart at a scale 1:50,000, the area is represented by approximately 500 depth figures. That gives a reduction factor of 50,000 from the surveying to the finished chart.

A prototype system for complete digital management of surveys is now being evaluated. It is planned to be used for all surveys during 1989.

The digital terrain model mentioned above is used for producing contour maps of the surveyed area as well as perspective views. These can be useful, for example, when discussing new fairways, and for volume calculations for dredgings, etc. (see Fig. 2).

3.1.2 Input of existing maps

For the input of existing maps, nAutiKa relies heavily on automated digitizing. This subsystem consists of a flat bed raster scanner, with an area of 1.2 m × 1.6 m and a highest resolution of 25 microns, together with software for vectorising, automatic structuring and symbol recognition. The scanner is shown in Figure 3. Data from the scanner can be used directly as a raster background to the vector map shown at the interactive work station. This function is very useful for proof reading and for interactive screen digitizing, since the raster map is so good that it can be considered as a copy of the original map. Before storing in a structured data base format, the raster information is converted to lines (vectors), points (symbols) and text-information. Also areas can be defined if it is considered necessary. The structuring of information using manually interactive methods is very time consuming and contains risks of introducing errors in the data base. How useful a scanning system can be for digitizing maps and charts for a data base is very much dependent on how much interactive editing of the result is required.

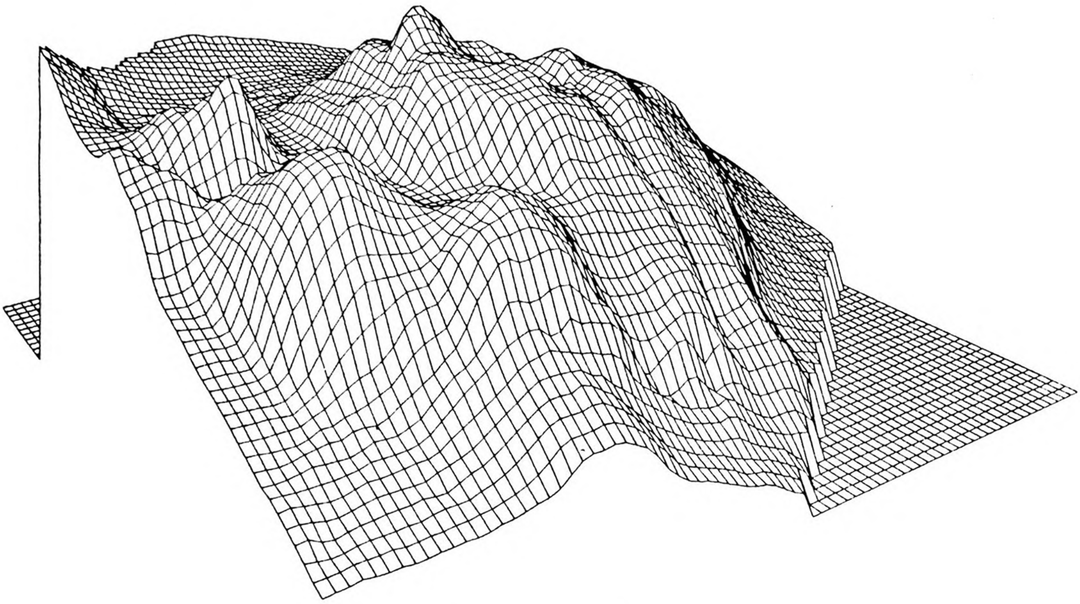

FIG. 2.— Perspective view produced using the digital terrain model.

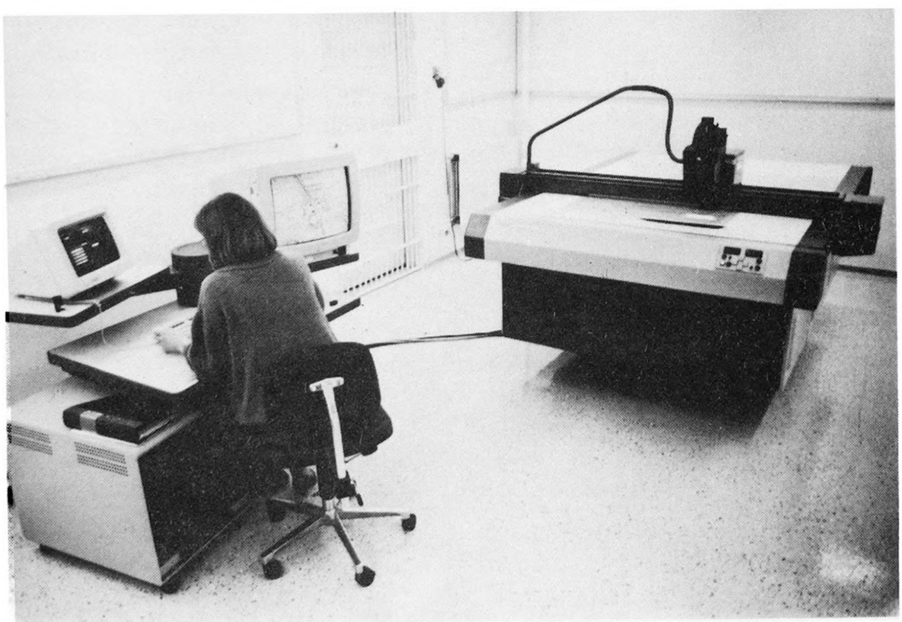

FIG. 3.— Flat bed raster scanner.

Georec is a software package for the automatic structuring of map information and the recognition of text and symbols. The program is developed partly with nautical charts as a basis, and the tests that have been performed so far show that it is a promising aid for the structuring of chart information. The program is 'taught' how to handle different types of maps by setting up a set of rules on how, in the beginning, unstructured vector information should be analysed and divided into classified objects. The program is also trained to recognize different kinds of texts and symbols. This training is at present going on in the Swedish Hydrographic Department and the goal is now that up to 80% of the chart information can be recognized and structured automatically. The manual checking and editing that has to be done is preferably done interactively, with the raster map as a background. It is worth noting that, since the scanning system was put into operation, manual digitizing has been used only for minor parts of the map material in the Swedish H.D.

3.2 Storing

Figure 4 shows in a simplified form how a digital chart production can be realised. The nAutiKa-system will be based on three primary data bases, where information with the highest resolution and accuracy that is needed is stored.

The 'point bank' contains coordinates and administrative data for point objects used in chart production, such as geodetic points, lighthouses, marks, etc.

The 'depth map bank' contains the contours and depth figure maps stored as a continuous data base over Swedish waters together with information about the different surveys.

The 'coast bank' contains the Swedish coastline and possibly some additional cultural information. It will probably be built up in two different scales.

When a new chart is to be produced, relevant information is selected from the three primary data bases, compiled, generalised, completed with other information needed and stored in a chart data base. From this data base, printing originals are to be output as well as data for electronic chart systems.

Before the primary data bases are established, a great part of the chart production will be done manually. For example, it is possible that chart manuscripts will be hand drawn and then scanned into the data base.

The H.D. has a map archive containing about 15,000 maps, parts of which are very old. In order to save these valuable maps from destruction, since they are still used, they are to be scanned and saved in raster form on video cassettes or optical discs. In this way, the maps can be used in the digital chart production. Since many of the old maps contain colours, a development project has been started, aiming at scanning, storing, displaying and plotting colour raster maps.

A very important question, when establishing digital map data bases, is how the quality tagging of the information is to be done. The information in a nautical chart is very heterogeneous. The depth information is compiled from a number of different sources with very variable quality. It is desired that each single object in the chart data base could be derived to its origin and quality. This will lead to major practical difficulties, especially regarding the line information which often is a generalization from many different sources. Much discussion is still needed in this area. In Sweden, a standardization study is going on regarding quality annotation of geographical data.

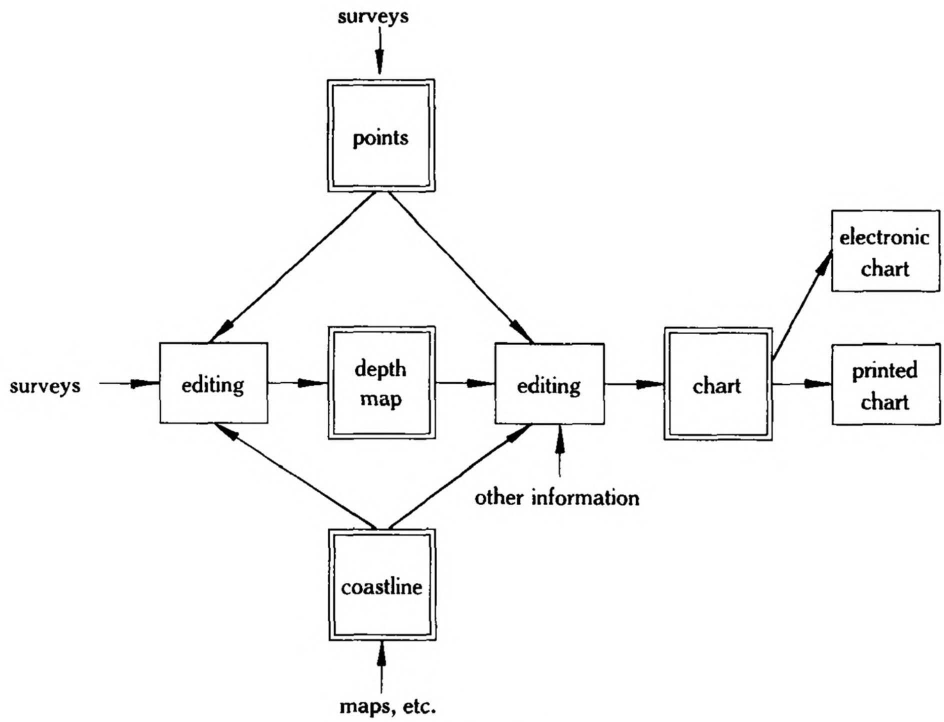

FIG. 4.— Digital chart production using the nAutiKa system.

3.2.1 Data base systems

A graphical file, e.g. part of a nautical chart, is built up of graphical elements-lines (vectors), text or point symbols. It is also possible to define a higher order of geometry — called objects — which consists of an arbitrary number of graphical elements of any type and of other objects. One example of this is a sector light where the lighthouse symbol, the sectors with their different colours and the name and characteristics of the light have been defined and stored as an object. In this way, each sector line 'knows' to which lighthouse it belongs.

The defined objects are given an identity code, e.g. the lighthouse number from the List of Lights. This code can be used as a search key in one or more alphanumerical data bases containing attribute data or administrative information. The relational data base system VMS/Rdb is used, for example for storing the List of Lights and information of chart updates.

The link between the graphical and alphanumerical data bases is bi-directional, i.e. you can perform a search in one data base type and retrieve information from the other.

The vectors are stored in a chain node structure, i.e. the system contains some topological information and has the possibility of defining areas, e.g. for color fill. The geometry is divided into a number of logical blocks — levels — arranged in a hierarchical structure. A graphic element can belong to several levels. Within each level, the information can be coded further, e.g. with type of line, colour, symbol number, etc.

To handle the vast amount of different maps, a map management system is used, which makes the graphical data bases virtually continuous for the user. It is intended to store all the different types of maps and charts in this system. They can then be stored as 'layers' on top of each other, making it possible for the user to choose which map types he wants to work with in each session. He can, for example when a new depth contour map has been produced, display this behind the existing chart and make the necessary updates of the chart.

3.2.2 Point bank

The point bank is an alphanumerical data base containing information about all point objects that are used in the chart production. It will contain about 10,000 geodetic points, 3,000 lighthouses, 9,000 marks of different kinds, military marks, etc. At present, only the part with the geodetic points has been started. A problem to be faced is that Sweden soon will be converting to a new nation-wide coordinate system.

3.2.3 Coast bank

The coastline is used in a number of different places in the production lines of the H.D. Today the same part of the coastline is drawn manually several times. A nation-wide bank of coastline would allow considerable savings. The coastline is taken mainly from the Swedish economical map series (scale 1:10,000), complemented with information from aerial photographs, harbour and local authorities and so on. The bank will be established for at least two different scale areas.

3.2.4 Depth map bank

To establish a nation-wide data base with detailed depth information is a complex project that will probably go on for decades. An enormous amount of work will be put into the compiling and editing of old and new surveys and maps into one final product. One complication is that, due to the isostatic land rise, the depth information has to be modified, approximately every 10 years. Depth reduction has to be made on the survey data and new contours must be generated. Unfortunately, there is today no automatic process that can cope with these requirements.

3.2.5 Chart data base

As mentioned already, there is at present no automatic method linking the whole chain from surveying to the final chart. The very time consuming work of producing and updating the nautical chart is today done mainly manually. The work contains several re-drawings of the same map information, e.g. the coastline, and a number of comprehensive compilations of information from different sources. The chart data base is planned to be established as a number of continuous data bases — one for each scale interval. That the charts will not have to be handled sheet by sheet will greatly simplify the updating process. Instead, procedures must be defined which, when a chart is to be reprinted, retrieve the relevant information from the data base, edit information near the edge of the sheet and put on the frame, frame text, graticule, etc.

It is planned to use the same data base to produce both printed charts and digital charts for ECDIS. In order to do this, all areas that are to be colour filled must be surrounded by closed polygons. As examples of alphanumerical data bases that are to be linked with the chart data base, the Swedish List of Lights and Notices to Mariners can be mentioned.

Methods of updating the chart data base are to be defined. This task is quite complex, since much information is stored several times, sometimes with different generalization, in the different data bases mentioned here.

3.2.6 Publications

For the production of the different nautical publications, an electronic publishing system is to be introduced at the H.D. Work stations connected to the Ethernet will be used for retrieval of data from the central data bases, e.g. the point bank, and compiling of the information to the desired publication, e.g. the List of Lights.

3.3 Output

3.3.1 Printed products

For output from the system, vector oriented devices will be mostly used in the beginning, namely a Benson pen plotter and a Kongsberg drafting machine. These are complemented with a colour raster plotter/hard copy device in A3 format. At the beginning of 1989, a large format (A0) colour raster plotter has to be bought. It will be used for verification plots before printing and for plotting of different colour maps from the digital terrain model. It is very desirable that a large format photo-plotter for direct output of printing originals can be included in the system. It is also possible that, in the future, the printing plates can be produced directly from the system.

3.3.2 Digital products

One of the most important reasons for introducing a system, such as has been described, into the chart production process, is the rapidly growing use of digital map information in our society. This puts demands on the H.D. to deliver charts and other products with depth information in digital form. In this matter, the standardization of Electronic Chart Data Base contents and of transfer formats for digital chart information is of great importance. It is very desirable that these standards can be established as soon as possible. Today, agreement with each individual customer of digital chart information on data content and transfer format must be reached, and this is time consuming and costly. Such discussions are however useful contributions to discussions of the future standards.

4. EXPERIENCES

Since nAutiKa is not yet in full scale production, the experiences of the Swedish H.D. come from the tests and trials that have been completed. It has been mentioned earlier that as many as possible of the working steps that have to be added to the production line, because of the new technique, should be performed automatically. This is important so that the operators do not regard some steps as 'unnecessary' work and so that it is possible to minimize the time for interactive editing on the display. This is a tiresome work that should be limited in time.

Scanning existing maps is necessary for building up the planned data bases. The time it takes to make the structuring rules for the Georec program is quite long. This is a one-time-job for each type of map, but it must always be considered if it is worth doing for small map series.

One of the most important prerequisites, perhaps the most important one, for introducing a system line nAutiKa into an organization is that the staff be well informed, has a positive view and is trained properly. In the nAutiKa project, the user groups have taken part in the work and have had the opportunity to influence the plans from the beginning of the project. The work with the specification of requirements was carried out in small working groups, one for each application field, consisting of both users and technical specialists. The training that was carried out during the first year comprises about 5,600 man hours.

Training has been adapted for different categories such as: management at different levels, operators, systems personnel and application programmers. The largest group, the operators, consists of about 15 persons who, during the first year, have gone through a thorough training on the system and are now taking part in the different pilot projects that are being started in order to suggest and test working methods, data base design and so on. These persons will later take part in the training of the other personnel. The operators are taken from existing groups of cartographers and draftsmen. Most of them have no earlier experiences with computer work. One problem has been — and still is — that the operators still have to manage their ordinary duties — the charts still have to be updated and printed during the training and design periods of the new system. Since this work often has the highest priority, this has made the nAutiKa project difficult to plan and often has led to successive delays in introducing the system.

So far the project has gone according to the plans, and the Swedish H.D. has high expectations for the system in the future.