

SMALL OPERATIONAL SYSTEMS

DR. BOYLE: We change over now to the second part of the panel. Thank you, Major Broglie, Mr. Walko. We are going to talk about small systems. First of all, I am going to ask Efraim Arazi to tell you a little bit about editing in the raster mode. Christian Hoinkes, from Switzerland, is going to tell you a little about editing in the vector mode.

I think this is bringing us back to the present day. I think that this session right from yesterday morning has been rather like the Enterprise taking off on the back of the mother ship. We got to, I think, about maximum altitude and parted company with a sort of solid base of the 747 when Harry Heard came on, and since then we have been gradually coming back to earth, and we are going to slide to a stop in the future. Before we do, I want to ask Efraim to tell us a little about editing in the raster mode and as he sees how it must be useful in cartography, bearing in mind some of the things that were said by the group speaking about raster programming on Tuesday.

MR. EFRAIM ARAZI: In the first session today you saw the Sci-Tex movie. I apologise for the fact that it did not deal with cartographic material. The equipment is usually used for textile printing, packaging, decorative printing and the like. I want to take one minute to explain to you briefly the operation of this graphic design equipment that we have developed. Just to familiarize you with it, (because that movie was kind of running along), I would like to show you a couple of slides, just to acquaint you briefly with the equipment. Then we will show you how to use it. Now, this is a more formal picture. In the movie you saw the equipment in color, the scanning unit, the computer disc memory that goes with each editing station. This is the color television of the editing station.

Next slide please. Very quickly, there is not much to it. The editing stations are fairly independent, and many users have one scanner, one laser plotter, and several editing stations. You can increase your productivity fairly rapidly because one scanner and one laser plotter can support several interactive editing stations, about which we are going to amplify.

Next slide. This will give you a closer view. I am sorry I do not have good photographs of the screen itself. But let me drive home one point about the design philosophy behind this equipment. As I mentioned yesterday during the panel discussion on mass digitization, we are aware of the fact that scanned data -- including cartographic base data -- whether it is obtained from manuscripts or maps,

involve a lot of editing, inspection and revision, which may be due to mistakes or artifacts in the incoming art material or problems that have to do with automatic scanning. We have always paid tremendous attention to speeding up the man-machine interface of the people who operate the console.

Now, the update time of the television screen is a fraction of a second. By pressing buttons on this little function box over here we do what normally people might do when they select things from the menu in automatic drafting systems that operate in vector mode, those that are in the hardware display over there, except, notice the very important differences:

The person operating the equipment can run the stylus with his right hand and with his left hand he can very quickly decide what he is doing; assign colors, draw vectors, draw different colors, change the size of the drawing points, zoom in, zoom out, magnify, minify the picture, display on the screen the location where he is, zoom down to see the entire picture so he can go and work and zoom up on some detail. All together, the raster editing station is fairly optimized for man-machine interface.

The last two slides will be just a quick look at the laser plotter. This particular plotter is pushing the state of art in hardware in several respects. To the engineers among you I want to mention two interesting points. The heart of the plotter is this drum. The axis of the drum is going this way. The drum weighs 500 pounds. It is rotating 1,000 revolutions per minute. The surface is going at a hundred miles per hour, and the surface acceleration is 200G --i.e., 200 times the pull of gravity. A sheet of film which is lying on the surface of the plotter basically has to be held as if it was 200 layers of seven mil or four mil film. The film is held by vacuum from the inside. While the drum is turning, the laser light is coming out of this traversing head and is switched on and off at the rate of one million times per second. We now have developed a continuous tone modulator whereby we can also change the intensity of the light so that we can use continuous tone films.

Now, when you have the film turning with 200 G acceleration on the outside and vacuum on the inside, we obtain absolutely perfect films from the equipment. There are no pin holes if you plot negatives, for instance. So, one more advantage of plotting on a photo plotter of this kind of performance is that the users practically do not spend any time inspecting the film. The films are almost perfect. If something was right on the color television, the likelihood of getting it right on the film is great.

Computers have a way of either completely scrambling the data or you will have it right. The laser plotter is also doing electronic screens for those that print half tones, and you can assign different shapes, angles and percentage transmissions, if you wish. While the laser camera is rotating, we are generating the screen electronically.

Now, if we may have the lights back on, I will discuss for a moment the editing capabilities of this raster design system. Most cartographic problems have, by tradition or by complexity of the data, to do with having several layers of information which are superimposed on one another. If you spend enough time looking at the vector design systems, you will see that they have some intrinsic advantages, except that in terms of comprehending what is going on when you have several layers of lines lying on top of the other, you begin to have problems finding out who is doing what to whom.

Raster base systems are displaying areas. They are not displaying lines. We can very quickly assign a tint or color or shade to any polygon, or to any other zone, island or area in the picture. The raster systems are intrinsically capable of dealing with the more common cartographic material.

The vector systems, of course, have their backgrounds in two origins which should be remembered. Twenty years ago when they were being initially developed, one did not have the micro-electronic memories which are so essential to buffering and refreshing one screen worth of data, which is the heart of the whole raster display screen. Those memories did not exist. The only way then to display graphic data was by deflecting an electron beam on a CRT and addressing different places on the screen. These deflections were analog. I was involved at that time at MIT in the early stages of project MAC, which was one of the first graphic systems of this kind. Also, the plotting systems which were available at the time were Calcomp or Gerber or other flatbed or drum plotters, which are also by definition vector type systems. They have one pen which can go from one place to another.

Those were the technologies which were available for input and for display. The digitizers were also targeted toward manual driven "do some interpolation, of some thinking" as you scan. That is how the whole world of vector design equipment was developed.

This equipment is, of course, very efficient for mechanical design, for zoning, for tax applications, for two-dimensional overview of things, but they do not handle areas.

Handling areas is the thing we do so much better than those raster systems.

One last point. We now have scanned many cartographic source materials, and we are beginning to see that the amount of data which you need to store is definitely within the realm of currently available storage devices. Can you flash on the topographic map? What you see on the screen now is about 8 megabytes worth of data due to the specific encoding method we now employ. The system is now equipped with a 300 megabyte disc which can take care of an entire topographic quad map. Three hundred (300) megabyte is not like the mass storage that was spoken of yesterday. Those are mass produced discs which are available from IBM, and other manufacturers. By the way, I am talking about storing all the layers together. You can have a composite of the map. Can you put on a hydrographic map? This is a hydrographic map. It is a three-color map with all the tints in it. This is the black printer. Here we can show you a quick example of an editing operation. The map is a little bigger than what the overhead projector can handle. In dealing with other people's maps, you may have the requirement to delete some unwanted details, such as writing in it. You may want to change some of the symbols, so you want symbology. This is a patch that was later drafted into the main map. Basically, you can go up with your pen on your color television screen and wipe out the unrequired writing. Ian, you can now lift the different layers. Can you just move the film a little bit? As you can see, we are dealing with several layers of data.

A typical editing job can be to either correct graphics that are in the map or to change the symbols. You can very rapidly use your cursor to indicate a point and say, "Please lay over Symbol No. so-and-so, Angle so-and-so," and bingo, it is in. It pops up on the screen and you have verification. If you make a mistake, you can step back a couple of steps.

This is how in cartographic terms one sees those editing activities, some of which were shown in this jazzy movie that we played in the first part of the session. I think the best thing for me to do now is wait for the question period for any questions that may arise with regard to the matter of editing data. So, I will yield the microphone.

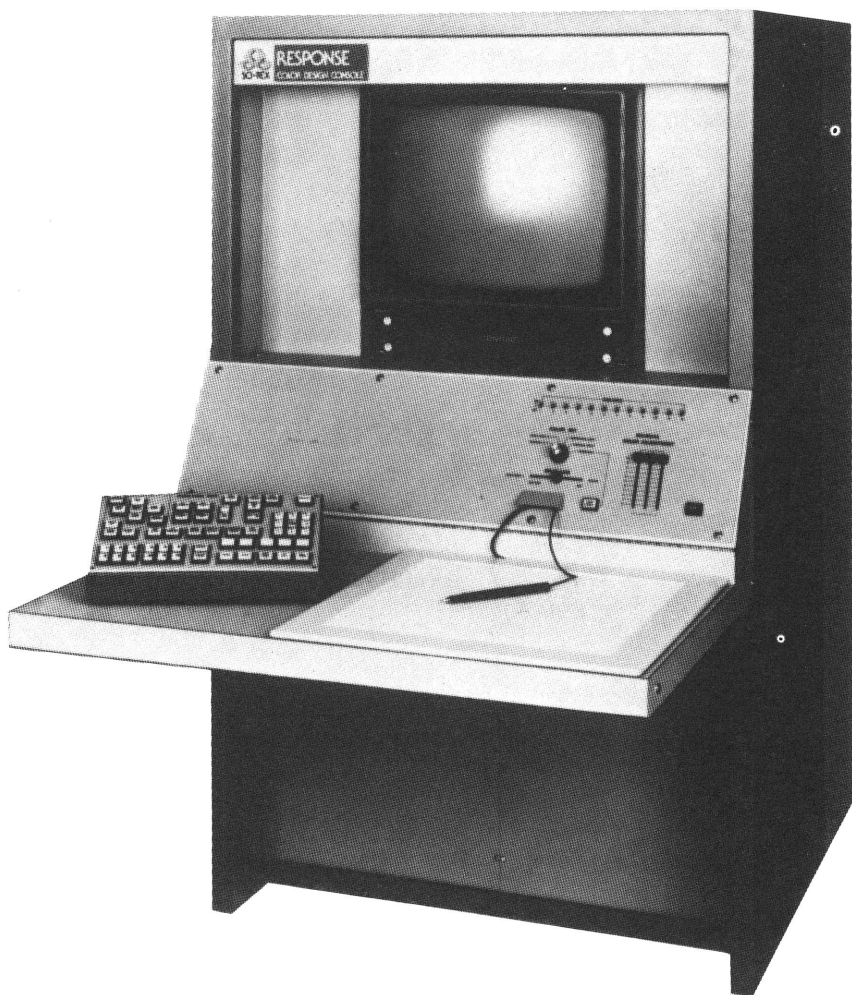


Fig. 2 The SCI-TEX RESPONSE Raster Editing Station

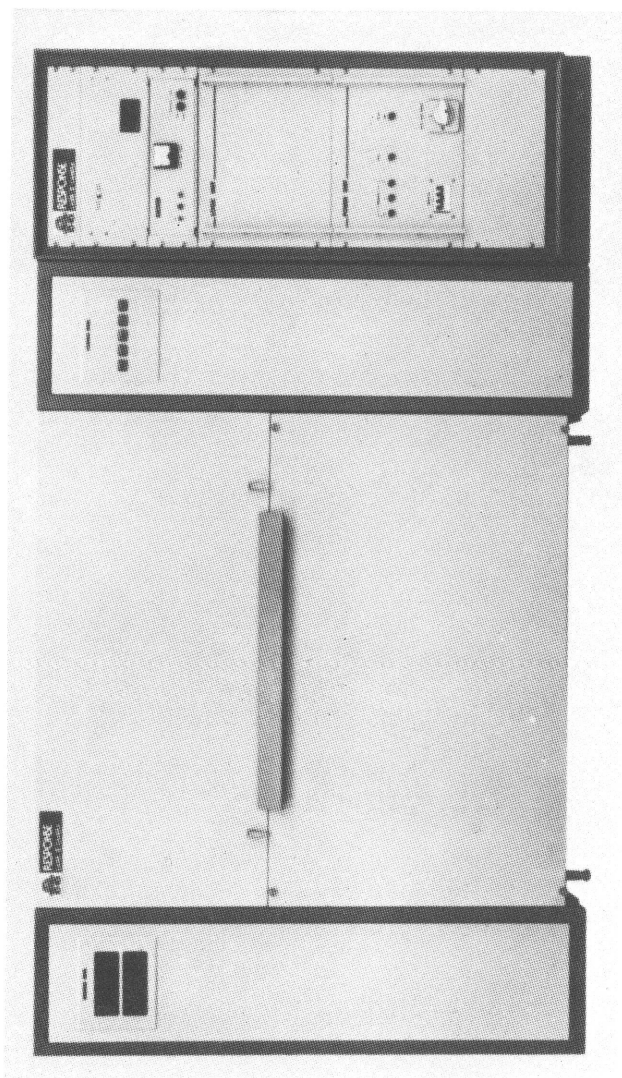


Fig. 3 The SCI-TEX Electronic Laser Plotter

DR. BOYLE: Thank you very much. (Applause). Christian Hoinkes is at the ETH at Zurich in Switzerland, and has come over to tell us about some of his work that he has been doing over there.

MR. CHRISTIAN HOINKES: Thank you for the invitation to come here. It is a pleasure for me to talk about something that we have done for the last couple of years. I will try to fulfill my role at the end of this hardware session, to land you smoothly down on earth again, so nobody will be knocked over by a car when coming out of the building and figuring out what ten to the 16th really is, or getting afraid of talking computers, and so on. We have nothing of this kind, rather something we can call "smallware" or even "oldware", because all the technology used is five to ten or even more years old. Also, we think in terms of classical map production. It has been our main aim to produce something on the plotter that can be printed in maps the standard way. In Switzerland we have a big challenge there because of the high graphic quality of the maps, and the intensive use of maps too. People walk around with them and read them. I think we have to continue to produce something like that.

To go back to the beginning, briefly. It was about 1971 when we started our computer project, with something like half a million dollars endowment, to spend on something like digitizing and precision plotting. It was our task then to get a system together for this amount of money and try to do something useful with it. We first had to find out what was existing then, and how this fit into our aims and objectives. What we actually did was something mentioned earlier during this week, we tried to take cartographic thinking to the manufacturers. We wrote out specifications and talked to them on our needs.

So, what are these main demands of cartography? First of all, we looked for a high quality output, as I mentioned earlier, which should come at least close to what human cartographers can scribe. In Switzerland, at least, that is so good that I have not yet seen any automated output that is really as good. It may come close, but I have not seen anything quite as good as a manually scribed line. So that was quite a task already. Then secondly, we looked for precision digitizing, because we thought we would have a cartographer sitting there, and his hand movement should be digitized, and we still trusted in that because all the maps so far are produced that way, one to one with printing scale. So we did not think there was any trembling or shaking in the hand. We wanted the precise movement of him to be digitized. Then, certainly some other digital inputs were necessary, because one main problem we

were facing generally was the fact that digital data had to be mapped, so that had to be one of the main functions of such a system. In those two cases, digitizing and digital input for a map, we felt a very strong need for immediate graphic verification and feedback to the operator. He should see what he does graphically and not work blind. Then, after this sort of quick verification, we thought he needed some good hard copy output also, because from the traditional technology we knew that it is really necessary to look at the various parts which are generated for a printed map in close detail, to determine whether it is all right, and to mark corrections, and so on.

Finally we always pointed out to the manufacturers the importance of human engineering factors, because we wanted the cartographer to be the most important part of the system, and he should not be bored or be bothered by the computer, he should be assisted. With these ideas in mind we evaluated things about two years or so. And in late 1973 we were ready to place an order. We had about one year delivery time, since we also ordered some special hardware and software. The system went into operation in 1975. So, from then on we have worked now for three years, roughly.

The first Vu-Graph (Figure 1) will show you roughly what we got. The system basically fell apart into two halves. First, an interactive graphic system, including the digitizing work station, editing, and verification plotting. Off-line from this a precision plotting system, a Ferranti master plotter with light spot projector. We were looking for a photo plotter from the very beginning, besides other possibilities like scribing and cut and peel work and even pen and ink. But we felt the light spot projector had certain advantages. Coming back to this part, the system you see there consists of several work stations on-line on one mini-computer, and quite a bit of storage, nearly 50 megabytes, which was not small then, but it seems to be very small now. We had quite some trouble to convince manufacturers that we needed that much storage on such a small system. However, the amount of data worked with interactively is certainly only a small fraction of this. One drawing that is to be edited may contain up to maybe one megabyte, not more than that.

This operation of several stations on one mini-computer and interactive work called for a lot of software, which we were in no position to develop ourselves. So, the main thing was to find a software company doing this for us, or having done most of it already. So, although we are on a hardware panel, I shall show you something of the software in the next Vu-Graph (Figure 2). AGS, by the way,

Appicon Graphik System 700 / Version ETH

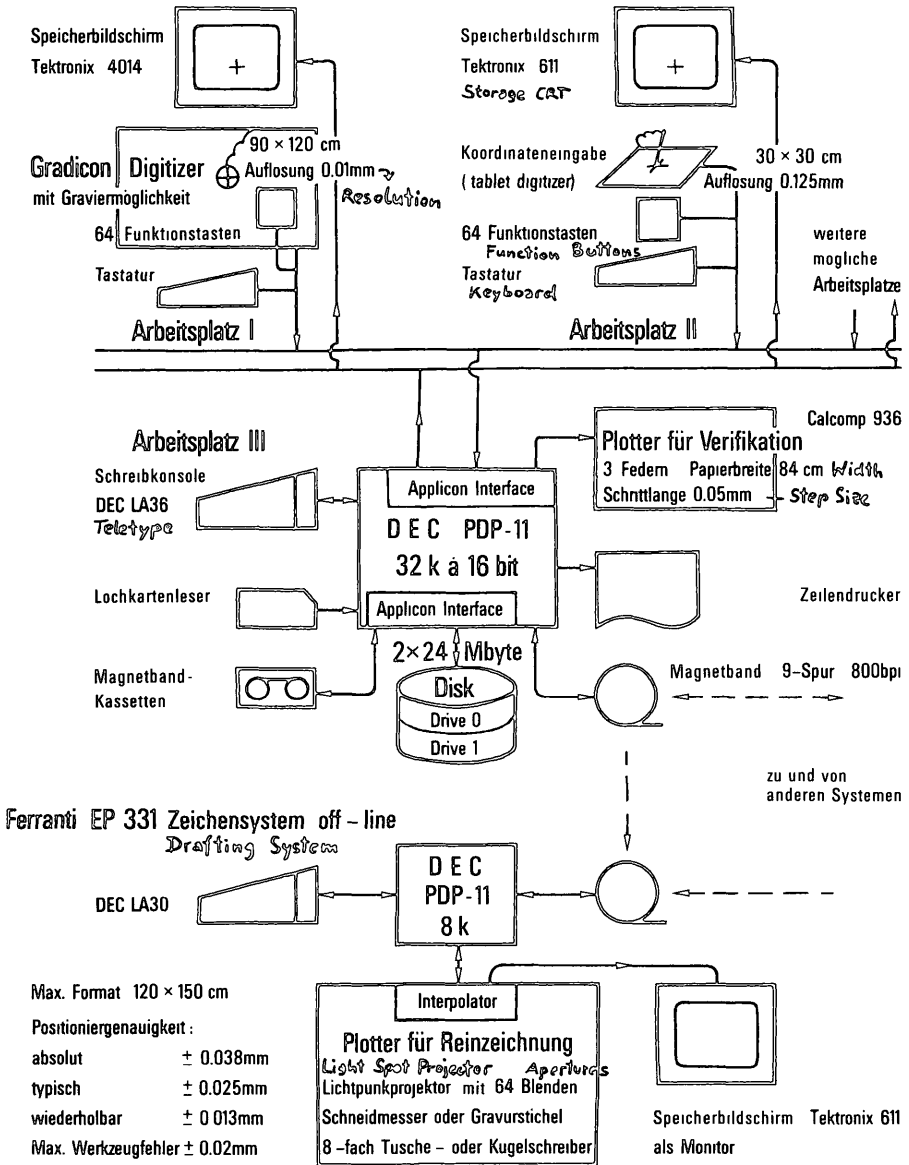


Figure 1 ETH Zurich Computer Assisted Cartographic Design and Drafting Unit (CACADU), Hardware Configuration

AGS/ETH SOFTWARE

- REAL-TIME MULTI-USER OPERATING SYSTEM FOR UP TO 5 WORK STATIONS
- SPECIALIZED GRAPHIC DATA BASE MANAGEMENT SYSTEM FOR DATA DESCRIPTION AND MANIPULATION BY MEANS OF A COMPREHENSIVE COMMAND LANGUAGE, WHICH INCLUDES:
 - GRAPHIC SYMBOL RECOGNITION FOR COMMAND INPUT FROM TABLET
 - MENU AND FUNCTION BUTTON DEFINITION AND DECODING
 - FILE MANAGEMENT WITH ACCESS CONTROL AND ACCOUNTING
 - INTERFACE SOFTWARE TO THE DATA BASE SYSTEM FOR MACRO ASSEMBLER AND FORTRAN
- STANDARD DOS/BATCH SOFTWARE FROM DEC FOR SINGLE USER PROGRAM DEVELOPMENT
- ETH CUSTOM SOFTWARE PACKAGE FOR CARTOGRAPHIC APPLICATIONS
- LIBRARY OF ETH-PROGRAMMED "USER COMMANDS", WHICH IS GROWING CONSTANTLY ACCORDING TO PRODUCTION REQUIREMENTS

ALL SOFTWARE STRICTLY SYSTEM DEPENDENT, I.E. USEFUL ONLY FOR OTHER AGS 700 INSTALLATIONS

Figure 2 Applicon Graphic System Software Summary

means Applicon Graphics System. It contains a whole lot of software. I had difficulty to get it down on one Vu-Graph, and it still could be done in much more detail. First of all, there is a real time multiuser operating system which was developed by Applicon, not using DEC's, because that did not exist in the late '60's and '70's when they developed their system. It has a data base management system, but not a general one, a very highly specialized one. But this allows, by means of a command language, to manipulate the data.

It also includes certain nice things like graphic symbol recognition on the tablet. That is something very handy to input commands graphically, like define a window just by a graphic symbol, nothing typed, no buttons pushed at all. Also menu and function button decoding, so these techniques can be used. We use much more the functions buttons, you will see later, than the menu. A file management system. This is in contrast to data base management. While we work interactively, the data of a file reside within the data base system. After manipulation the changed data are taken out again by a store manipulation and stored as a file, but filed with access control and accounting information, et cetera. This is meant by "file management". So, for this file storage we use a lot of disk space, which allows us to keep quite a lot of data on-line. Archival storage is then off-line on mag tape.

Then, very important, too, the system has a software interface for data base input-output operations. So, by Assembler and even FORTRAN programs we were able to expand the systems capabilities. Such programs are developed with the standard DOS/BATCH software from DEC in a single user mode.

This facility to access the data base was quite an important criterion for the decision of what to buy. However, it is important to realize that all this software is hardware dependent, and this is mainly because of the speed that is the main issue in interactive editing. So, the system makes use of special hardware for interfacing displays and digitizers. Thus the software is not only PDP 11 dependent, it is really system-dependent.

There is no code for the operating system and the data base management system available, but we were not really interested in that. We were just interested in learning basically how it works, and we succeeded in that. But I think the code would not have been much help to us. Important is this data base interface. Since we have this we can access the data base and do anything to the data in an interactive mode. Now, I show this in such length on

the hardware panel because I got the feeling here during the last week that the software going with the various available interactive graphic systems off the shelf is somewhat underestimated. There is such a lot in our system that I would think no university department could develop that on its own, not even in years. So, why not take advantage of what these companies did? Although, as I said, it needs some modification to be used in cartography. All these systems are developed for quite different purposes, for which they are used economically, and that is why you can buy the software together with the hardware so cheaply. These systems are sold by the hundreds for layout of integrated circuits, and things like that. I think we will have to ride on the back of others in this case.

Now, let me show you some slides to bring this a little bit to life. The first one gives you an overall impression of the interactive system without the precision plotter, which is off-line. Here, the PDP 11. One graphic work station has a 611 Tektronix with a digitizing tablet, the other one the 4014, and the GRADICON digitizer (See Figure 3). In the foreground here, the disk drive, one at that time, we ordered a second one a little later. The Calcomp 936 drum plotter for verification, which we find does a very good job very cheaply. It is our sort of hard copy device, by a software program, certainly, but it allows us to verify map data full size. In the background, mainly for programming, also a printer. Here, a card reader. This, a little bit more closely, the two graphic work stations. From the software point of view they are pretty much alike. They both have a digital tablet input, this one small, this one big, for precise work, and a CRT output.



Figure 3

View of the Two Graphic Work Stations, Large Tektronix 4014 with Digitizer in Background, Smaller Tablet Station with Card Reader and Cassette Tape in Foreground

The next slide shows the digitizing station in more detail. We use two types of cursor, cross-hair with magnification or a scribing cursor. Quite important is this device here, a function button array. It is made up that way, so you can easily write in here to specify what the buttons are defined to mean, and that is user definable, certainly. You can take this sheet out and use it as a menu in digitizing, but we found that very, very impractical as compared to this way of operation, pushing the button with the finger and keeping the cursor in place, maybe with the other hand; you do not have to move the cursor back and forth all the time.

Next slide. This shows something on CRT (Figure 4). It is quite a good example for a practical application. It is an aeronautical chart overlay done for real production purposes. It is printed, and it will go to the second print now, and will be updated every year and reprinted every year -- on top of a topographic map that is still manually produced. The next shows the windowing, or zooming-in capability, which is very fast. I cannot really show the editing here without having a film to show, because otherwise you do not get the impression of time. But you have seen something like that--I hope--in the exhibition, so you can imagine. It is important that these things work pretty fast, in a matter of seconds, because an operator waiting there really wastes his time if he has to wait for minutes just to look at another section of the map, which he could do in a manual process very, very quickly. But, at least with sort of a limited amount of data we have here, although there are continuously digitized lines with thousands of points (but not more than, say, 50 000), this works very well.

Pressing one function button we get the same display on the plotter, but certainly at defined scale, with one of three pens, and, also, if we like, full symbolization. For verification that is quite important. That was stressed earlier today. This shows one of these plots. One important thing for verification is also that we use output sort of "sliced" by feature, so we plot only one kind of feature at a time, and then another and another, or maybe three different colors on top of each other, so three, then the next three, so that the feature code assignment can also be verified. After verification a tape is made and this goes to this photo plotter, or light spot projector, as it is called, very accurately I would say, by Ferranti, with a disk of 64 apertures, of which we have two. This is purely used to play back what is on the tape. Not even scale changes are possible, although a computer is used to control it, but this has to control other things, like speed, light intensity along the path, and so on.

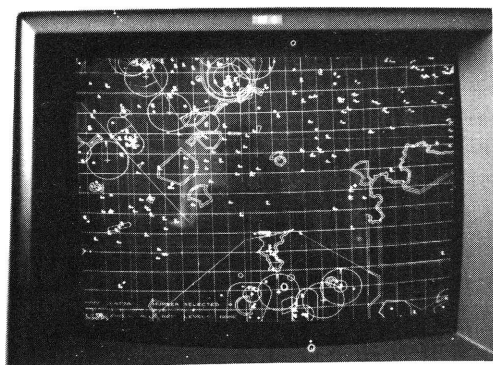


Figure 4
A Section of the ICAO Chart 1 : 500 000
on Display during Editing

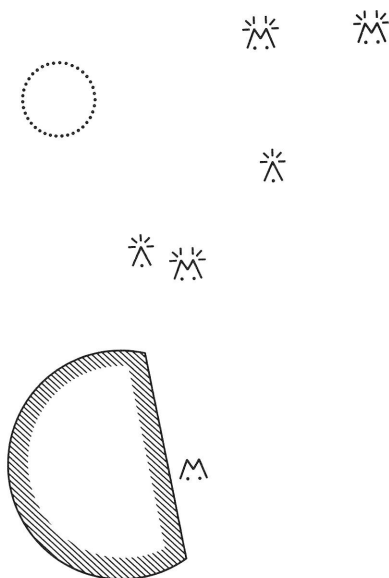
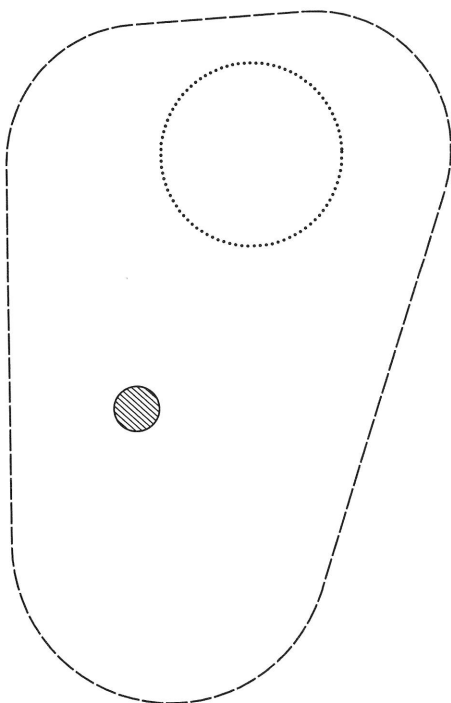
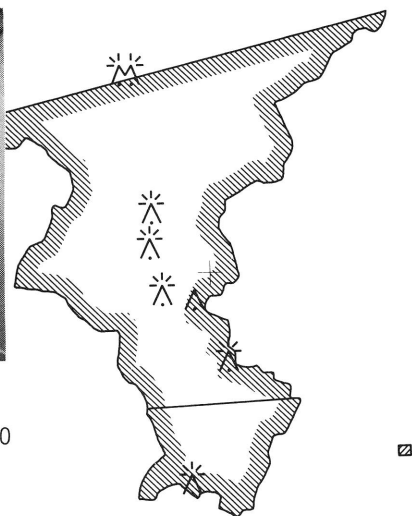


Figure 5 A Section of the Printing Masters for the ICAO Chart
without any Manual Touch-up

Now, this is the output we get on the film, for example, after development (Figure 5). You see also these continuous lines, which consist of short straight segments, about three points a millimeter, come out rather nicely, constant line width, depending on the aperture. And we have practically all necessary apertures to compete with everything that is scribed manually. Even these line symbolizations are generated automatically by flashing dots along the line or making breaks at regular intervals. Also, the cross-hatching is done automatically. However, for this, we prefer to cut masks and copy this in manually, like a standard screen is copied in, but the lines themselves were produced by the plotter on a big sheet to generate exactly that kind of screen which was required for this map.

This procedure illustrates one important thing. We always felt that these plotting capabilities are one additional capability to all the other, the reproduction and manual techniques, and that they should fit together. In this case they do. For example, as I mentioned earlier, the base map for this map, all the topography, is done manually in the National Topographic Mapping Center on glass plates, absolutely accurate and stable in dimension. The plotted overlay sheets have to fit these plates precisely, and they did, even though the map is more than a meter wide.

Here you see dashed and dotted lines, cross hatching and even some symbols, like these obstacles, which were plotted at printing scale, and the result is satisfactory for even the most critical Swiss cartographers.

Now, this is another example of an area we are going into, thematic maps for the "Atlas of Switzerland". This is a simple example where we used the standard system capabilities, just placing various sized symbols at centers of villages, at Zurich, for example (see Figure 6). We are now working on additional software (called DIAMANT) to process directly the statistical data, like population counts, and generate things like pie diagrams and other kinds of diagram maps at the interactive system. The output should be film masters directly for printing, but there may still be some other lines on the map (e.g. topographic base) which have been generated manually. Also the lettering we leave out because we did not find the capabilities of a light spot projector good enough to generate cartographic style lettering. Some experimental work is also done in the field of topographic mapping. We are digitizing sample areas, but are experiencing the limits of such an interactive system there. To find these was one of the objectives of our research, to show what can be done and what cannot yet be done.

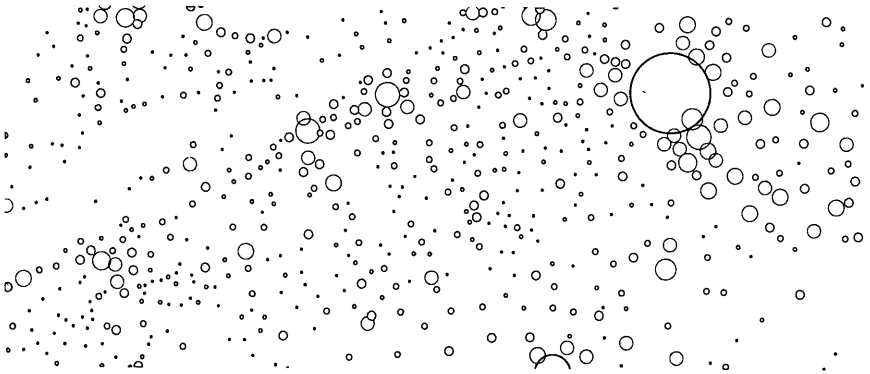


Figure 6 Section of a Light Spot Projector Plot as Used for Printing of the "Atlas of Switzerland"

This brings me to the end of my presentation. I just want to say something more about the economic aspects. Although our main interest is research and education, (also for visitors, not only for our students, so you are welcome to do the same as many others did before, if you have a chance to visit us we will be glad to show you the system), we have tried to use the system also - part-time - for production, in applications as you have just seen. Although being part of a university, we will try to run something like a service for automated plotting, especially for other government agencies, but also for private companies. So we have to figure out quite well the cost of our work, because these people actually pay. The aeronautical chart office paid our effort in full and found it actually cheaper than what they would have had to pay to do this manually, and it was faster. So, we arrived at cost figures per system hour. This means one hour on one of the two interactive terminals, which can be used simultaneously, or one plot hour. So, on the whole, there are three things that can go on together, and each of them costs anywhere between \$ 30 and \$ 50 an hour. It depends mainly on how many productive hours you count. We found this figure quite low. It comes close to the cost for manual labor hours which in Switzerland is about \$ 25. So, we found that cost-effective applications can be found for such a system already now, if there would be enough volume of work. That is one problem in Switzerland, where just one sheet like this aeronautical chart covers the whole country. It is only a part-time job for us to do that, but I would think in your country that there are very good application areas for systems like that in cartography. Thank you. (Applause).

HARDWARE SUMMARY

DR. BOYLE: Thank you very much, Christian. I am afraid we are running rather late, and there will not be time for any questions at this point.

I would now like to recapitulate what we have tried to do in this session.

On this Enterprise operation, we have now skidded to a halt. We have brought together for you some of the best people that are available in the world. I think that much of this will only come through when you read it again in the report, which, I hope, can be made available as soon as possible. I believe it will be a very valuable document of the state of the art in hardware, which, as I said at the beginning of this period, may be at a peak in its development. From now on we shall be getting to much more straightforward engineering.

I think you may be getting worried in case this juggernaut of technical advance is really a juggernaut. And believe me, it is. North America has chosen to go to advancing technology and, it is moving very, very quickly. You, in cartography, are at the convergent point of a number of juggernauts coming down the roads towards you. If you are not careful you might become just part of the graphics art operation, and, along with design of dress fabric, cartography might be an auxiliary art.

I have had great fun over the last few years riding, on a little white horse, ahead of the juggernauts and beckoning to them and pretending I am doing a bit of leading. In fact, it is not that at all. As I get older and more experienced I know which wheels will speed up and which ones will slow down. I am able to see which way they are going to turn, and can pretend I am guiding them. I am not, of course, from my position, and just purely as an individual.

However, you have to be prepared to learn to get into the driving seat of these juggernauts and you have to do a lot of work to get to this stage. If you do not, you will get -- I was going to say a "dumb engineer" sitting in the seat, driving along, because, if he does not, he will get a parking ticket from some office of budget or finance. He has to move on, and you are going to be taken along in the wash. I do strongly suggest that you get into the driving seat.

This raises the problem of education. How are you going to get education? The universities have a part to play. They are not going to do it unless they get some financial support from your

government organizations. I believe one way might be to give a contract to an appropriate university near a large organization, to do some research in methods of teaching advanced cartography, automated cartography, and so on.

I would also like to see the aspect of service bureaus advanced. In my opinion there has been too much of the large government departments keeping the black boxes to themselves; it is then very difficult for anyone outside to get in and use them. I would much prefer to see the departments now supplying some support money, some bread and butter money, to operations outside, so that these operations gain some background, knowing that they are going to get so much a month to do certain basic work; not impossible work, but just straightforward work. They can get some of their jam and cake doing work for other people.

I would like to see this approach in the area of mass digitizing. I would like to see it in precision drafting. I would also like to see it in the area of mass storage recording. I think that most people will want somebody else to do their recording as it will be an infrequent operation. Even a large amount of digitizing would only require that one of these optical disks be made once every six months or maybe once a year.

These are all philosophies, and maybe we will have a little time to talk about them this afternoon in the overall wrap-up session. However, I wanted to bring them to you because they are part of hardware and part of hardware development.

I have had the opportunity of working with Dean this summer to sort out the people we wanted to invite. We chose people who were not only leaders but could confer their knowledge in plain English to you. Believe me, most of these people could have spoken to you in a language, which, without going back to a university for a number of years, you would not have been able to understand. But they were all people who could translate into, I believe, a language that you understand. You have had a packed session and you have had a lot of information. I have been very thrilled with the quality of the information and I think that it will make an excellent report when it appears.

Would you like to finish off, Dean, with any final announcements? (Applause).

MR. EDSON: I would like to thank Ray for all that he has done in bringing this hardware session to us. We had to bring him in from somewhere on the other side of the world, and we are going to be returning him, I believe, to someplace on the other side of the world. It certainly is inconvenient for him, but it was great for us. Thank you, Ray.