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Digital Large Scale Restitution and Map Compilation

Abstract:

The development of a procedure for digital restitution started as early as 1969. The stage has been reached now, that the digital mapping method is operational for the major part of the large scale map production of the Department. Some 25 photogrammetric plotters are equiped with digitisers, a HRD1 Laser Display is available for interactive editing and a Cal Comp 745 plotting machine is used for drawing the maps.
The paper describes the development over het past 10 years, discussing hardware, software, procedures and human aspects.

Digital Large Scale Restitution and Map Compilation

Early history

The development of the system for digital mapping was initiated as a logical extension to another automation project.
The introduction of radiolocation systems by the Rijkswaterstaat (1958) required the preparation of a large number of map sheets with hyperbolic grids, and the performance of the required calculations using manual calculating machines, with subsequent preparation of the drawings, was a tedious task.
Around 1960 the manual calculating work was taken over by a computer, the Stantec ZEBRA, a primitive model by present standards. Shortly after this an automatic coordinatograph was brought into use, which led to a great saving in time and man-hours.
After a simple automatic drumplotter had become available, it was possible to speak of an automated process for the preparation of grids and lattices.
The availability of the computer, and developments in the field of aerial triangulation adjustment, supplied a reason for coupling simple electronic recording equipment to photogrammetric instruments. By recording on paper tape, the previously unavoidable errors of reading and writing were eliminated and the process of calculation was accelerated.
The graphical photogrammetric method and the subsequent fairdrawing of the product by draftsmen to give a definitive map was very labourintensive. A certain amount of effort was duplicated.
The shortage of trained personnel that was a consequence of the boom in the sixties led to the first step on the path to digital mapping.

The chronological development took place as follows.

1969-1970 Test period

Preparation of a map compiled from several photogrammetric models, including annotations and symbols.
Apparatus: Slow output recording apparatus for the stereoplotters (Wild EK5), a Stantec ZEBRA computer with a CalComp 563 drum plotter and an Electrologica X-1 computer with a CalComp 663 drum plotter.

1970-1972 First practical period

Practical experience was obtained with 4 stereoplotters and rapid registration devices (Wild EK8) that had been procured in the meantime.
The many problems with drawing on stable base materials on the drum plotter and the wish to be able to scribe led to the acquisition of a CalComp 745 flatbed drafting machine.

1972-1974 Study period

On the basis of the results and analyses obtained up to that time it was concluded that the method of digital mapping would be developed further and that the system would have to be expanded into an interactive system. It was decided to procure a Laser Display from the British company Laser Scan Laboratories. The software had to be developed according to our own specifications.
In the meantime, production continued as in the preceding years.

1974-1976 Implementation

A large number of registration devices of various makes were procured, but the procedures remained unchanged. Specifications were drawn up and programs for the interactive system were written. The Laser Display was ordered.

1976-1978 Second practical period

The Laser Display was installed. The inevitable troubles in the hardware were overcome and the likewise inevitable modifications to the software were made. The existing procedures were improved, inter alia by the addition of a so-called HP (Hewlett Packard) station. Thus, a stage was reached that can truly be described as digital mapping.

Description of the present-day system (Fig. 1)

The whole process comprises the following phase:
- data acquisition
- pre-processing
- processing.

Data acquisition

Of the 35 photogrammetric instruments available to the Meetkundige Dienst, 24 are at present equipped with digital recording apparatus. A keyboard and tape-punch are coupled to each device. The photogrammetrist records his observations on paper tape and, via the keyboard, adds a numerical code by which the type of line, the text, or the symbol that is to be drawn is

DIAGRAM OF PROCEDURE FOR RESTITUTION AND MAP COMPILATION

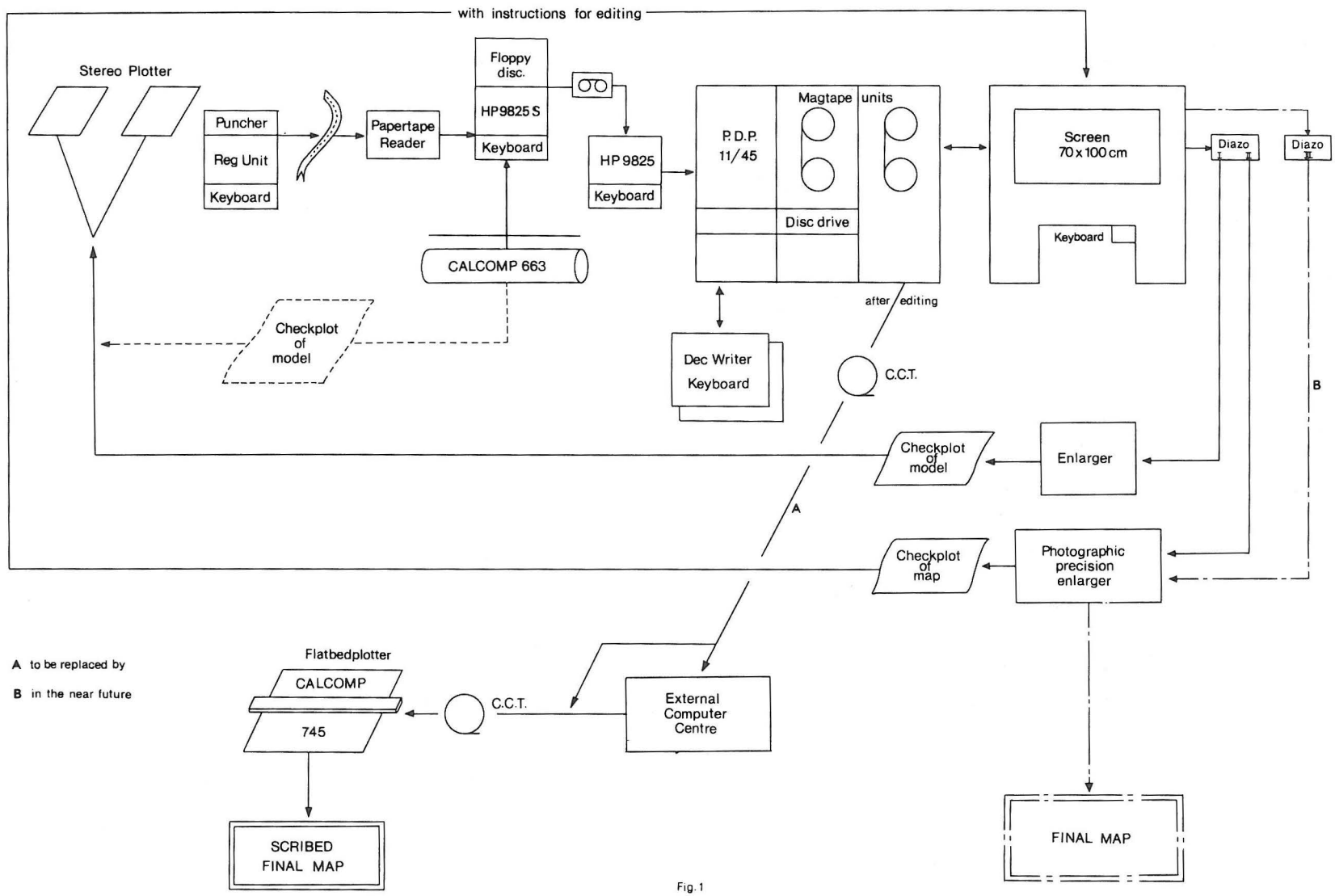

Fig. 1

defined.
After the completion of the measurement of the model, this passes to the HP station for the preprocessing phase.

Preprocessing

An HP station consists of an HP 9825S table computer (24 Kb) provided with a standard floppy disc unit (512 Kb), a built-in cassette recorder, and a paper tape reader with which the results of measurement can be input.
The insertion of this preprocessing phase is intended to take pressure of the Laser Display.
The software consists of four parts:
- A program that offers various possibilities of transformation and that also provides a means of control over the relative orientation.
- A syntax control program that, in particular, checks faults in the coding and to a limited extent, the model coordinates.
  Files of the validated data are created on a floppy disc.
  Discarded recordings are printed out and after re-measurement the corrected information can be added to the file.
- A conversion program that converts information on the floppy disc into the internal coding of the interactive system.
  Where this is desired, the rectangularity of buildings is checked and, if necessary, corrected.
- An editing program by means of which items of data can be located and delected or, to a limited extent, amended.

The whole process takes about 15 minutes for an average model.
Since the photogrammetrist digitizes "blind", a facility for rapidly producing a check plot of a digitized model is necessary.
This check plot is made on the Laser Display from the information checked and corrected in the pre-processing phase.

Processing

The check plot is made on a diazo film. An enlarged copy of the diazo film is made on a printer; the copy is passed to the photogrammetrist. He checks his own work and, if necessary, adds non-digital information to this check plot. Eventually he completes his digitized model.
In the case of breakdown or during the maintenance of the interactive system, the check plot of the model is prepared on a CalComp 663 drum plotter which can be coupled to the HP 9825S used in the pre-processing phase.
By providing this facility, the operator can always obtain a checkplot, so that interruption of the data acquisition work is avoided.
In a processing phase the preparation of a check plot of a model takes about 2 minutes, on the reserve facility CalComp 663, this takes 20 minutes.
A provisional map of the relevant models is made on diazo film by means of the Laser Display by simple combination. The diazo is enlarged photographically to the approximate scale of the map.
In this map, a cartographer enters the required corrections and additions, partly based on the notes on the check plots of the individual models.
The operator of the Laser Display corrects and completes the digital data already present on the basis of the provisional map with annotations. The result is written onto a Computer Compatible Tape which, if no other information has to be added, is used to generate a scribed map as the end-product via the CalComp 745. If other than photogrammetric information has to be added, extra numerical processes are necessary, which are taken care of by the central computer of the Rijkswaterstaat.
The editing of the definitive map requires about 90 minutes and the prepara-

tion of a diazo 2 minutes.
The net capacity of the Laser Display configuration is 5 maps per day.

Within a forseeable time, it will be possible to prepare the definitive map photographically in the form of a positive film by enlarging the diazo film produced by the Laser Display.

The interactive system

The main requirements that the interactive system had to satisfy at the time of the selection (1974) were:
- the graphical representation of the digitized information had to be possible with a resolution adequate for cartographic purposes;
- lines, symbols, and inscriptions had to be eliminable, insertable, or movable;
- it had to be possible to make a hard copy;
- the speed of the system had to be such that the planned production could be achieved;
- the screen had to be large enough for a single model and, preferably, a whole map sheet to be displayed without loss of information.

The choice fell on the Laser Display of Laser Scan Laboratories, which best satisfied the requirements given above. Other systems then available were mostly based on the Tektronix 4014 cathode-ray tube and in each case failed to satisfy the last of the requirements given above.
The interactive program developed by Laser Scan Laboratories in 1975 largely satisfied the requirements set by the Meetkundige Dienst. Further adaptation of the editing program took place in close cooperation with them.
The scheme of the SOftware of the LAser DIsplay (SOLADI) is shown in Fig. 2.

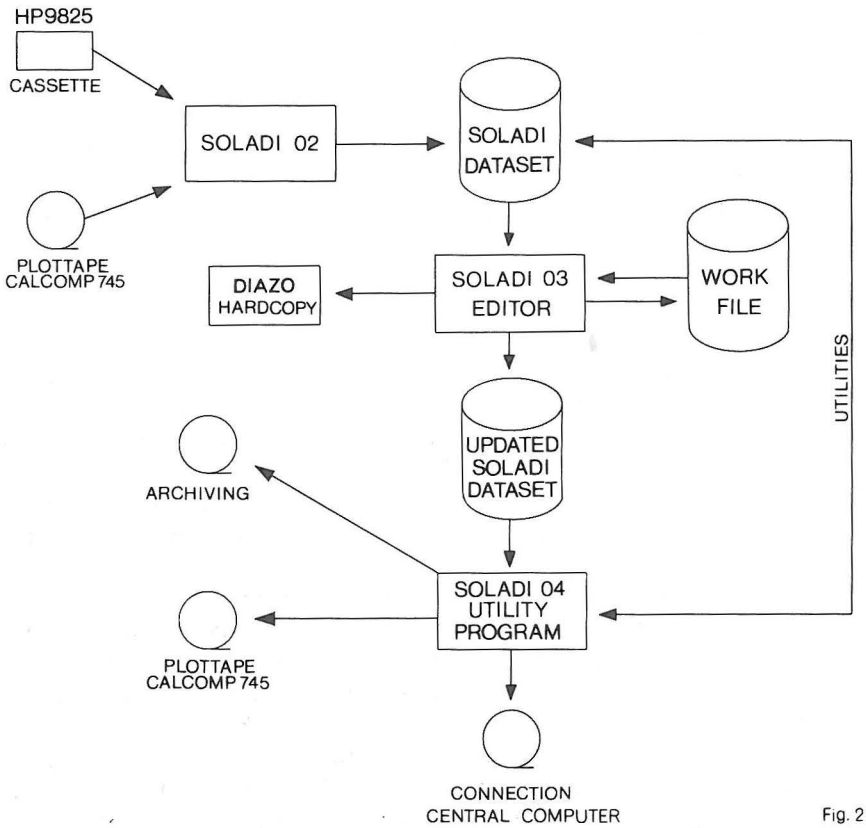

Fig. 2

SOLADI 02 is a program for conversion of the input, HP 9825S cassette tape, to a standard format and it also takes care of transformation of the digitized information to the national grid system.

SOLADI 03 is an interactive program which makes the following processes possible:
- drawing on the screen of the data set;
- deletion, modification, and addition of lines, text, symbols, etc.;
- modifications necessary in order to satisfy certain conditions such as rectangularity, parallelism, and circularity;
- drawing on a diazo film.

SOLADI 04 provides for:
- merging of several data sets (models) into one data set covering a specified map sheet;
- windowing of the combined data set to the map sheet frame;
- printing of statistical information concerning a SOLADI data set;
- rotation of the coordinates of a data set so that the frame of the map sheet becomes parallel to the edges of the screen, thus enabling the drawing surface to be used in the optimum way.

SOLADI 04 has three possible types of output:
- an archive tape for the storage of information that has not yet reached a processing phase;
- a tape for the central Rijkswaterstaat computer, which is made if other than photogrammetric information is still to be added to an edited sheet;
- a drafting tape for the CalComp 745, which is made if an edited sheet requires no supplementary information.

Operations

After the installation of the interactive system in 1976 came the period of inevitable teething troubles in relation both to the hardware and to the software. After these had been put right little by little, it was found that the specifications originally set had to be supplemented and modified, which again required further software development.
It also appeared to be advantageous to add a second keyboard to the Laser Display and to expand the memory of the PDP 11/45 control computer by 32K words. This made it possible for editing work and program development to take place in parallel.
Procedures also had to be modified throughout.
It is true that maps could be produced, but still many manual corrections were required. For the above mentioned reasons, and partly because of lack of experience in operating, work not infrequently had to be repeated.
An important question was what qualities the operator of the interactive system should have? Should he be a photogrammetrist or a cartographer, or even a specially trained operator working under the direction of photogrammetrists and cartographers?
A test period with three volunteers, experienced respectively in cartography, geodetic computing, and computer operating, led to the conclusion that the cartographic division must remain responsible for the endproduct but that the operator of the system need not have photogrammetric or cartographic training. He prepares the check plots and edits them on the basis of the photogrammetric and cartographic instructions subsequently added. In practice, this arrangement is extremely satisfactory.

The operational stage was reached at the beginning of 1979. The whole system and the procedures now work properly. The average daily production of the Laser Display currently amounts to 5 edited sheets for the definitive

maps and the preparation of 15 check plots.
This means there is an approximate overcapacity left of 15% of the present-day digital throughput.

At present an adaption of the software is in preparation which will make it possible to prepare a qualitatively satisfactory diazo of the definitive map. This can then be photographically enlarged to give a positive film on a prescribed scale. Thus, in addition to flatbed scribing, a second technique will be available for the preparation of the definitive map sheets.

Although the digital mapping is operational, the system will always continue to demand special attention in addition to the normal maintenance. Technological developments will continue to improve the potential for measurements in both aerial photography and in the field, and for digital processing. Specifications will have to be continually revised.

The inclusion of a central registration unit in the system, with the possibility of giving a visual presentation to the photogrammetrist via display screens has, of course, been under consideration. This idea was abandoned since, in the period in which the decision had to be made, the number of photogrammetric instruments was already too large for such a system and the costs were relatively high.
Furthermore the disadvantage of such a system is that in case of a break-down of the central computer, production would come to a complete standstill.

It has also been found that the photogrammetrists are satisfied with the less vulnerable and cheaper solution finally selected, involving separate recording apparatus, and have little need for display screens whose response times, moreover, are regarded as annoyingly long; the general picture and the resolution they produce is also inadequate.

Some production figures

To evaluate the digital mapping procedure a calculation was made of the production of a number of map sheets. The first column gives the results for graphical restitution in 1973, the second one for digital restitution in the same year. The last one gives those for digital restitution in 1979.
The figures are indicative, not absolute.

man hours per sheet (planimetry only)	1973 graphical	1973 digital	1979 digital
photogrammetric restitution	35	38	29
fair drawing etc.	75	39	0
map editing	0	0	6
computer and drawing machine	0	3	1
Laser Display	-	-	1.5

Personnel aspects

Four groups of personnel are involved in the conventional graphical preparation of maps, with the respective tasks of fieldwork, photogrammetry, calculations, and cartography.

The decision taken in 1969 to proceed with the development and gradual introduction of digital map compilation caused different reactions in the four groups.
Field personnel adopted a fairly indifferent attitude, since their work would scarcely be affected by digital mapping. The photogrammetrists saw a possibility of acquiring more influence in the whole process of map compilation and were therefore enthusiastic.
The calculators had no problems, since to them automation was already a natural concept.
Great uncertainty and disquiet gradually arose among the cartographers who, not without reason, felt their position threatened.
Although the first automation of their work, the setting out and drawing of hyperbolic networks for the purposes of radiolocation, was welcomed as a deliverance from a soul-destroying task, the situation was different with digital mapping. In order to reduce the stresses and uncertainties that had arisen, it was decided in 1977 to bring cartography and photogrammetry into a single division.
All the mapping activities are gradually being integrated.
All new personnel are required to have good stereoscopic vision. Lower demands are being made on skill in drawing than previously. The younger cartographers are being retrained in photogrammetry, provided that they can see stereoscopically.
For those cartographers who will not or cannot take part in retraining, there still remain many years of usefull work of a non-photogrammetric nature.

The Meetkundige Dienst has found by experience that an organisation that needs (or wants) to develop by itself an advanced digital mapping system must devote attention to quite a few problems and risks, among others:
- large investments in money and manpower are necessary;
- analyses of cost effectiveness are very difficult to draw up and the capacity and reliability of new technically complicated peripherals are difficult to determine in advance;
- social problems will arise both with individual workers and with groups;
- reorganizations of service departments and the revision of procedures may be necessary;
- temporary losses in production are unavoidable;
- training and retraining programmes must be modified.

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