

INTERACTIVE GRAPHICS IN STEREO DIGITIZING AT MEDIUM SCALE MAPPING

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ABSTRACT

This paper describes the adaptation of an interactive graphics system in the Department of Photogrammetry of the Spanish I.G.N. The need for interactive graphics at the photogrammetric workstations, the reasons for 3D data files, the problems with their management and the results of the system applied to a test work are discussed together with some of the editing functions and automatic generalization processes developed.

INTRODUCTION

The main task of the IGN is cartographic production at the scales of 1:200000 and 1:50000, currently finished and under updating, and 1:25000, in phase of photogrammetric compilation.

In 1986 it was decided to introduce stereodigitizing in the process and a public contest for the acquisition of three photogrammetric and one editing workstations (with interactive graphic capabilities in all of them) was announced. After an analysis of the different possibilities, an Intergraph system was chosen. Although this is not a purely cartographic system, but rather a multipurpose one, it seemed to be the most suitable for our job when the choice was made.

This paper deals with the adaptation of the system to the specific requirements of 1:25000 stereoplotting at the IGN.

REASONS FOR INTERACTIVE-GRAPHICS AT PHOTOGRAMMETRIC WORKSTATIONS

1:25000 is a very critical mapping scale, because some features are represented true to scale, while others must be symbolized. In fact, some details, like roads, are represented true to scale in one of their dimensions (length) and symbolically in the other (width), so the symbol may overlap the position of other details and these have to be shifted.

Moreover, a certain amount of cartographic generalization has to be carried out over the photographed details in areas with a high density of man-made features, where a careful choice of data is to be done; in irrigated agricultural lands, for instance, a representative hierarchy of waterlines has to be established. Another case is that of urban areas, specially the oldest parts of the towns, where narrow streets

cannot be represented true to scale, and cannot be widened either, because the blocks of buildings inside them should then disappear. Thereby, not all streets are to be represented, but only those which configure a well-representative structure of the town.

This generalization is usually done by trial and error, i.e., an area is plotted with pre-defined criteria, then the results are analyzed and the criteria are modified according to the results if these are not satisfactory. Many of these manipulations of plotting data should be done at the time of plotting, when the model is still set, so as to check them with the model image, for the results of such a manipulation could fall out of reality otherwise. Interactive graphics in digital plotting play the same role as erasing rubbers and square rules do in graphical plotting.

REASONS FOR 3D FILES

Besides the production of 1:25000 maps, photogrammetric data will feed a cartographic data base, under development at the moment, which will require 3D definition of the position of the cartographic features.

Intergraph advises to use 2D data files. The reasons for this advice could be the use of smaller files (about one 33%) and the fact that many cartographic application products, like the polygon processor, work only in 2D files. 2D files are enough for mapping purposes, but not for feeding a 3D data base. A possibility should be to store elevations as an attribute of level contours and to use these for the generation of a DTM.

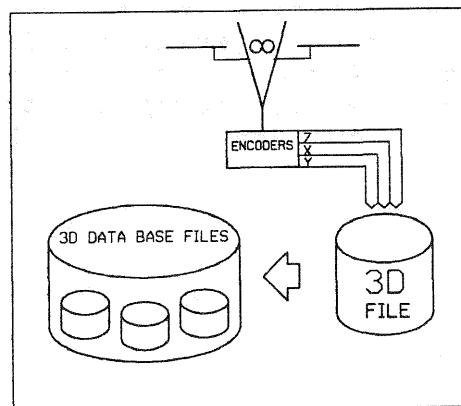
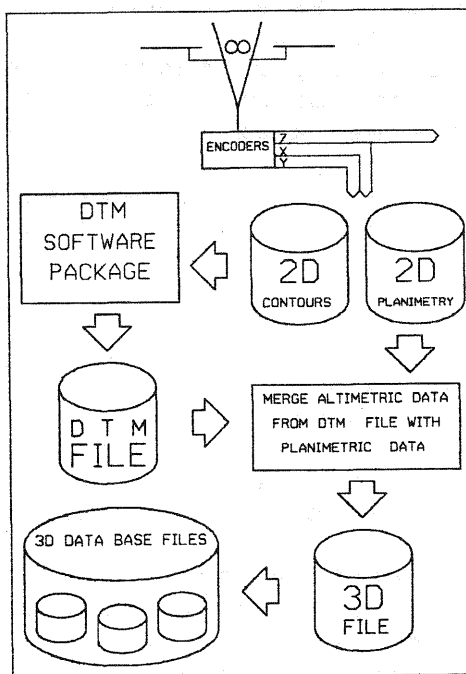


FIG 1. REASONS FOR 3D FILES

SHOULD A PROCESS LIKE THE ONE ON THE LEFT BE USED INSTEAD OF PUTTING Z COORDINATES DIRECTLY INTO A 3D FILE ?

ADVANTAGES OF THIS LAST METHOD :

- SIMPLICITY IN THE PROCESS
- DIRECTLY RECORDED Z'S ARE BETTER THAN INTERPOLATED ONES

Level contours do not supply data enough to generate a good DTM, specially in flat areas, so spot heights and breaklines should be also digitized. Another possibility should be the capture of specific altimetric data, such as a grid of points, spot heights and breaklines for the generation of both, DTM and contours. But then one of the main advantages of Photogrammetry should be lost, i.e., the fact of being lines, rather than points, the units of the survey.

Furthermore, a stream of Z coordinates is generated at the time of data capture, and it seems to be faster, cheaper, and more accurate to use these Z coordinates, captured together with the planimetric position of the features, than to reject them and get altimetric data from a later on interpolated DTM, linking these calculated Z's with the directly recorded XY's. So, it was decided to work with 3D files, although a certain amount of programming had to be carried out to overcome the difficulties in their use.

PROBLEMS WITH 3D FILES MANAGEMENT

Some of the interactive graphic editing functions, like linear patterning, copying a line parallel to itself and adjusting close or open traverses, don't work properly or don't work at all with non planar lines. The two former cases have been solved by projecting the original geometry of the line onto a horizontal plane, and patterning or copying parallel this projected line, for display and symbolization purposes only; the original geometry is always stored and used to feed the Data Base. For the later case, a program has been developed. The development of these programs has been carried out under the Intergraph environment using the so-called "user commands", i.e., sequences of frequently used instructions stored in files and started from menus.

When modifying the geometry of an element, points are to be given to set the new position of the element or of its points, or of its segments. These data points are given on the graphic screen, and there is no problem with 2D files, but when managing 3D files, things are different. XY coordinates of the point are defined on the screen, but Z coordinate is defined by means of a parameter, the "active Z of the screen", which must be set by the user. So, when moving an element or a point, the Z of the new position will be the active Z, and this Z displacement will usually not be desired, but only a planimetric shift. To avoid this, user commands have been developed for modifying elements geometrically, storing the Z of located points and setting it as the active Z before the element is modified.

LIMITATION OF THE NUMBER OF POINTS

Linear elements cannot be geometrically defined by more than 101 points, and, whenever a line needs more, each 101 points section of the line is written to disk as a single element, and all the sections of the line are connected by writting a common header which links all the segments together. Thus, a complex element is generated, so as to manipulate it as a whole.

Again , not all interactive-graphics capabilities work with these complex elements . In fact , connected strings are not located by the system when some options are selected . This happens with geometrical modifications which vary, or may vary, the number of points of the line, like adding points , deleting points or moving segments. Some user commands have been written and incorporated to our menu which make possible to perform these modifications on complex elements .

Partial delete is possible , but it results in deleted connecting headers without any element following them to appear in the file ; even deleted , these "empty" connecting headers may occasionally result in difficulties with the management of the file.

Moreover, the way a complex element is created is by marking each single element in it as deleted and writing all of them together behind the header at the end of the file . This means that in photogrammetric tasks , where lines do often have more than 101 points , each element is frequently written twice to the file, and this is disk-consuming. A periodical compression of the file should be performed , getting rid of deleted elements , for it would be soon filled up otherwise.

SOFTWARE DEVELOPED AT THE IGN

The general purpose software supplied with the system can be used directly in any application , but it is advisable to tailor it so as to meet the specific requirements of each task. So, an effort has been made to get , as far as possible , the system adapted to IGN's methodology , and not vice-versa , the basic idea being to do the same or similar work in each step of the job as it was done before the introduction of the system (i.e. , the polyester sheet with control and geodetic points is conserved in a new manner , a graphic file where control and geodetic points have been incorporated together with a strip of cartographic data belonging to adjacent existing sheets ; each model file is merged to this when finished).

The master piece of the developed software has been a stereoplotting menu , which has been built to cover all the needs for data capture in a usual photogrammetric process, leaving aside those special tasks for the final cartographic edition . The menu has about 225 function boxes divided into four main categories :

- Stereodigitizer interface.
- Element creation, with special procedures for urban areas.
- Element edition.
- Miscellaneous options to establish screen scale , search criteria, etc.

The stereodigitizing interface provides functions such as define origin , model orientation , and so on . These functions are directly supplied by the manufacturer and no modification has been done on them except the one of translating the messages into spanish.

The function of the other groups have been entirely developed at the IGN in some cases, while others are system commands more or less modified, the minimum modification being to translate messages into spanish. Intergraph's user-command language and, in a few cases, Fortran, have been used to develop all the software.

ELEMENT CREATION

Each cartographic element corresponding to 1:25000 scale map has been given a box in the menu. When selecting one of these boxes, all the parameters concerning to digitizing mode (point by point, stream mode, etc.) and symbolization (line style, weight, colour and linear pattern, if any) are automatically established for the element.

The colour code has been used as object code, a colour table providing the correspondence between logical colour and physical colour. Elements are clasified into different logical layers, the so-called "levels", each level corresponding to a specific theme in the cartographic clasification: Relief, Hidrography, Communications, Buildings and Land use. Some auxiliary levels are used for model frame, temporary annotations of contour altitudes at the end of each model, and storage of original geometries.

Once the digitizing mode and the symbology have been set up, a common basic routine is invoked for all the elements (except

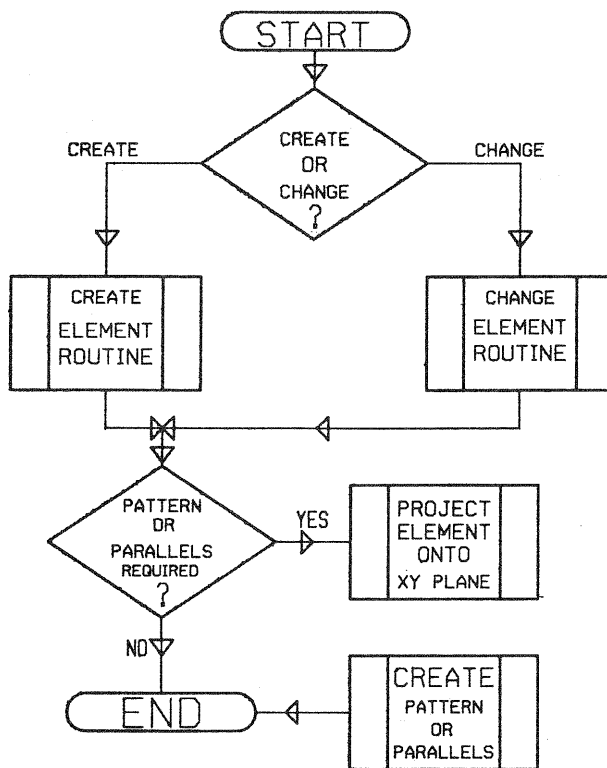


FIG. 2 OVERALL FLOWCHART OF THE BASIC USER-COMMAND FOR ELEMENT CREATION

point elements). This routine has two entry points , depending on the status of a flag : if this is set to 0, new elements are created ; if it is set to 1 , which is the case when the box CHANGE ELEMENT TYPE is activated, a previously selected element is re-written onto the disk with the code and the symbology of the selected box.

The basic routine also projects onto a horizontal plane those elements which are to be symbolized by means of a linear pattern or two parallel lines, and creates the pattern or the parallel lines. The original geometry of the elements is not deleted, but retained in a different level ; this original geometry , its projection , the pattern and/or the parallel lines remain vinculated one another as members of a so-called " graphic group " , so certain manipulations can be done simultaneously on all of them.

A complex element is generated by the system whenever an element requires more than 101 points for its geometrical definition , as it has been mentioned above . For software compatibility reasons, single elements are forced to be complex (i.e. , a complex header is written before the element) as they are created.

URBAN AREAS

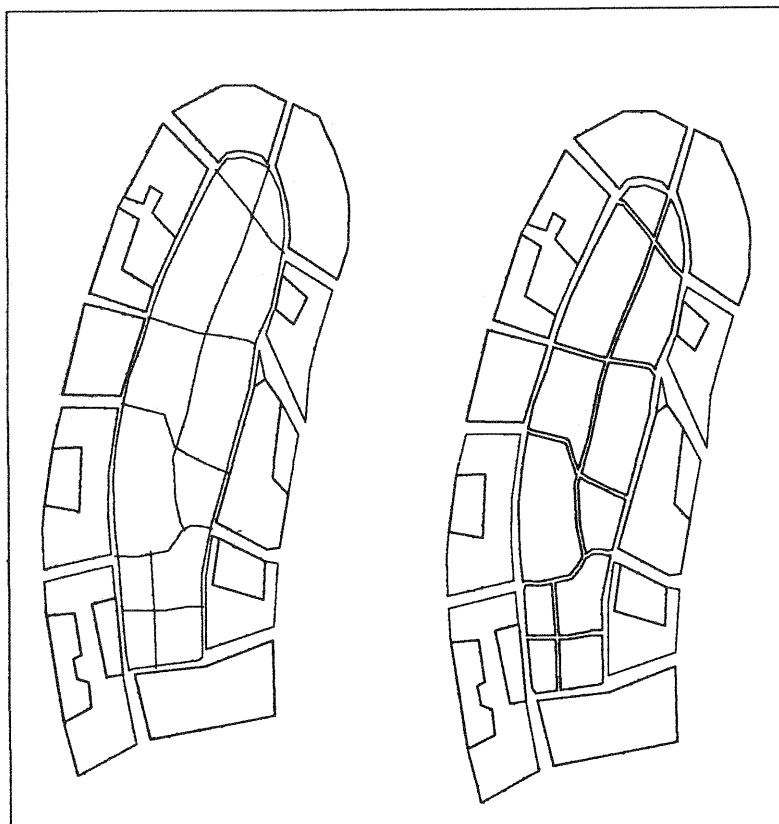


FIG.3 PROCEDURE FOR DIFFICULT URBAN AREAS

Single lines (left, center) are digitized. The process draws parallel lines and cleans intersections . No modification , is made on directly digitized data.

When plotting urban areas many problems arise , specially in the oldest parts of cities , where streets are narrow and their width has no graphic representation at the working scale . If this width is exaggerated,entire blocks of houses may disappear, so a careful selection of streets to be represented must be done. If a symbolic width is to be used , the way of plotting should be to follow the axes of the selected streets , and draw parallel lines . A time-consuming cleaning of the intersections of all these lines had then to be done.

A procedure to make this operation easy has been developed. The operator draws the skeleton of lines defining the structure of the town, or the part of the town where blocks of houses can not be digitized individually. Then he uses system capabilities to create a separated file containing those skeleton lines, and a batch procedure is started to create automatically the parallel lines and to clean the intersections. The operator may go on with his task meanwhile ; when the batch procedure is finished , he is reported and then he may merge the file containing the results of the batch job with the active file.

ELEMENT EDITION

This group includes all the basic functions to manipulate elements , such as delete , geometrical or symbollogical modifications , change of element type , and so on.

All of these functions include a routine for element identifying, i.e., whenever an element is selected for edition, a message tells the operator which class of element has be located in the file , so as to confirm or reject the choice before the edition . This routine can be invoked separately via an independent box, providing the operator with a good help to identify the nature of elements onto a B&W screen without the risk of undesired modifications . The lack of a function like this in the standard menu forces to use any of the editing keys to identify level and type (not class or object code) of an element when this standard menu is used.

Element manipulations are done through a 2D screen display. Whenever a point or an element is shifted from its original position or new points are inserted into the element , a value for Z coordinate is taken from the element and assigned to the new position of the point or to the new point, so as to avoid undesired elevation displacements or geometric inconsistencies inside the element , for the active screen Z should have been assigned otherwise.

The system does not allow modifications resulting in a different number of points for a complex element. Thus, the IGN commands performing this kind of functions first break the complex element into single elements,then modify the appropriate single element , the complex one being re-built at the end of the operation.

The supplied command for adjusting open or close traverses does not work in 3D files. There's a need for this function, so the corresponding user-command had to be written.

An easy CHANGE ELEMENT TYPE function has been implemented. After the choice of this option , the desired element is selected. When it is highlighted and identified, the operator is asked to enter the new type for the element; this entry is via the corresponding menu box of the creation group and, when done, the geometry of the element is retained and linked to the new object code and symbology.

MISCELLANEOUS COMMANDS

This group includes the necessary commands to control both , scale of the representation and items to be represented; to establish search criteria (i.e., to restrict elements in search to those in a certain level), to set up the screen mode (point search , line search) , and to handle reference files, so as to adjust the present model to preceeding works . The most relevant incorporated functions in this group are :

- Set screen scale to 1:25000 : during the job , windows and zooms make the operator to lose the idea of what the original scale was . By selecting this box , a 1:25000 scale window is displayed onto the screen , centered in any desired point which must be entered.

- Write remarks concerning elements : whenever the operator wishes to write a remark concerning an element , because he doubts about its identification in the photographie or whatever the reason , this command allows to write the remark in a file and to draw a symbol on the affected element with the number of the remark . Texts are entered and displayed via the screen menus , which also allow to review , modificate or delete the remarks.

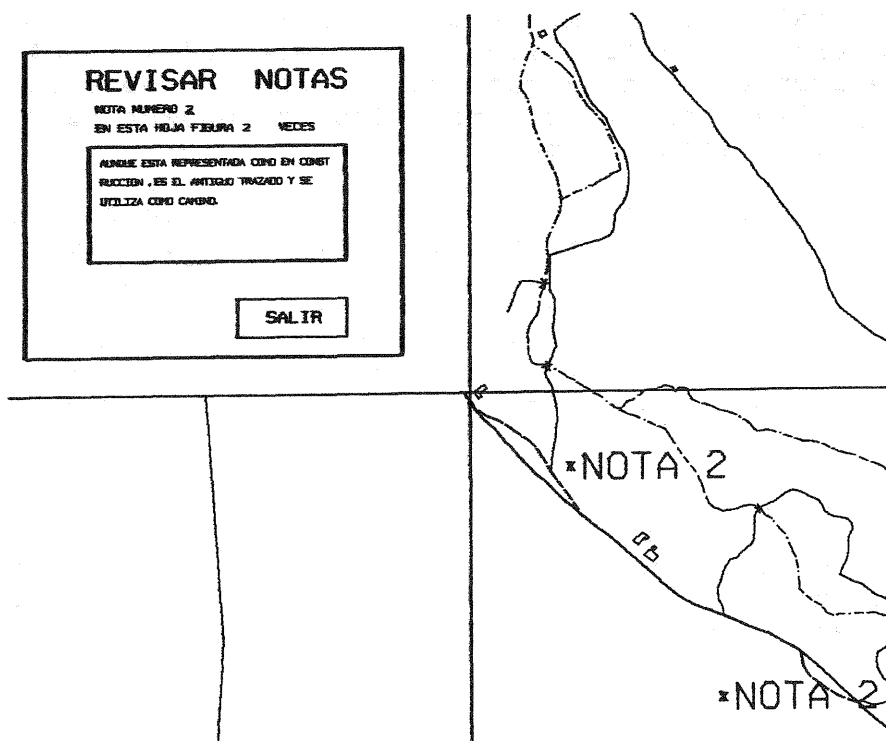


FIG.4 Remarks are entered, reviewed, modified and deleted through tutorials (screen menus) like this

TEST WORK

The first experience was carried out over one of the sheets of the spanish 1:25000 map, chosen under the following criteria:

- A previously plotted sheet should be used, for comparison.
- It should cover an area with a wide variety of topographic features.
- It should comprise a certain amount of information to be stored.

The chosen sheet was Nr. 639 NE , VIVER , situated in the SE of Spain. The photogrammetric data of the work were :

Camera WILD RC10
Focal length 153.26 mm
Photo scale 1:40000
Model scale 1:25000
Stereoplotter WILD B8
Number of models of the sheet ... 10 (not complete)

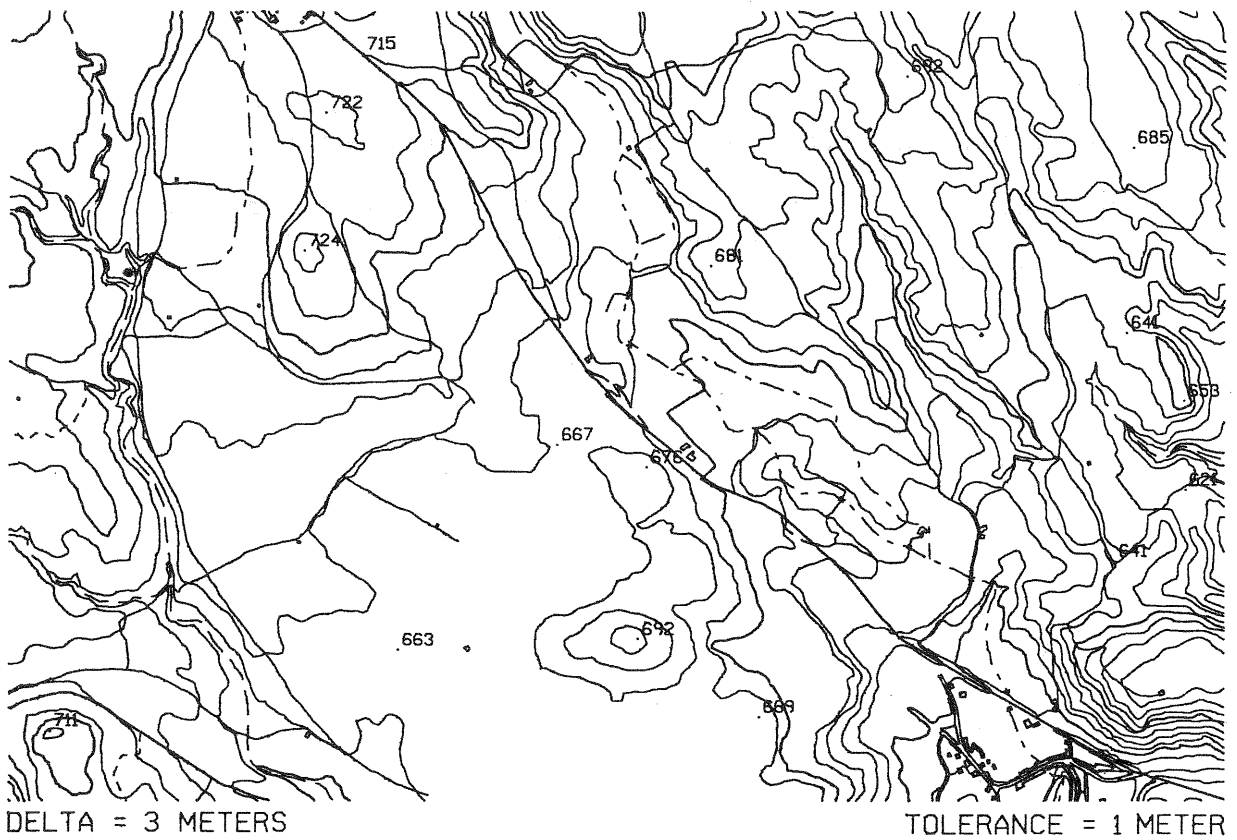
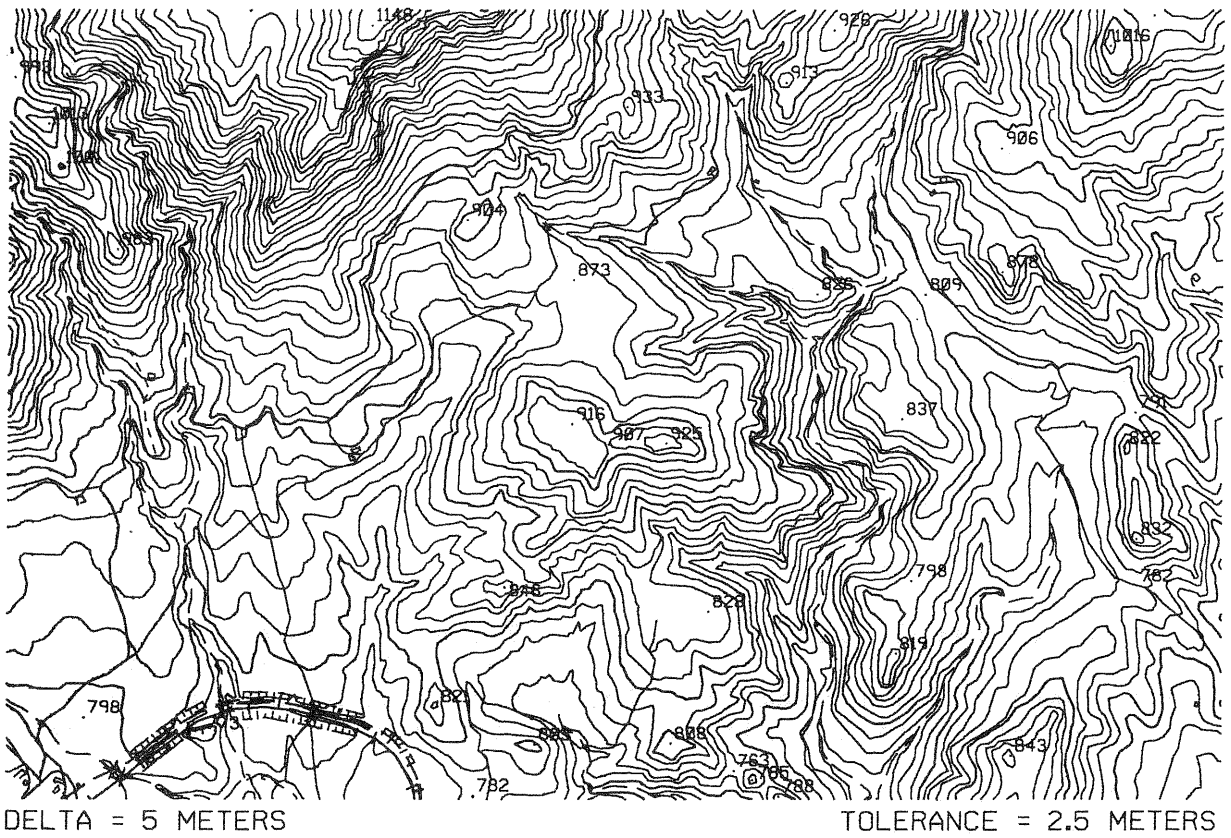
The graphic file features were :

- Unit of resolution 0.1 m (minimum length to be considered)
- Parameters of stream digitizing mode (they were modified after evaluating a plotter output in the middle of the job) :
 - Stream delta 5 m (3 m)
 - Stream tolerance 2.5 m (1 m)
- File size 2.5 Mbytes

A unique sheet gives no enough experience to obtain general concluding remarks . However , some facts can be already expressed after the first evaluation of the system :

- Whenever the operator wants to know the Z coordinate of a point , he must run a user-command and give a data point; there is no possibility of getting a continuous display of Z value on the screen , so the glass scale must still be used to set the altitude of contour lines . This lack is hardly understandable , for less sophisticated systems allow continuous Z display.
- Edge matching with pre-existing manuscript sheets must be made by table digitizing at the Interact 32 workstation; the lack of a magnifying glass and the free-hand guidance of the cursor result in a different accuracy between data captured this way and those obtained via stereoplotting. Obviously , only 2D information is captured for matching elements.
- The resolution of the screen does not allow a display of file contents at map scale , because close details would be difficult to distinguish , so a larger display scale must be used. Generalization is then more difficult , for the operator may lose the idea of how much detail to include at the actual mapping scale . Furthermore,

FIG. 5 TWO DIFFERENT PARTS OF THE TEST SHEET WITH DIFFERENT STREAM DIGITIZING PARAMETERS. MAP SCALE 1:25000



geometric adjustment of elements may be extended beyond the needs of this map scale.

- It would be convenient to set up the limits on using interactive graphic edition. In fact, users of these powerful systems may sometimes forget that they are representating an object and that this representation must be as true as possible. Ease in the use of modifying element commands, together with a misunderstood wish of geometrical perfection could make the user modify the true features beyond their real shapes.

These latter remarks should not be understood as weak points in the system, but just as warnings for a proper operation. The advantages of an entirely open system, where the user may introduce his own functions without restrictions, and the friendly operator interface, wich allows an easy handling via screen and tablet menus, requiring a short training time, must also be underlined here.

All the job described has been carried out by a team composed of the authors and two additional people, Luis Domingo and Jesus Fernandez.

Finally, we wish to thank to Manuel Aguinaga, who helped us with the outline of the developed functions, and to Manuel Esteban and Francisco Casado, all of them from Intergraph Spain, for their assistance.