GALILEO DIGICART 40:
AN ANALYTICAL INSTRUMENT BASED ON A PERSONAL COMPUTER

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ABSTRACT

A software has been developed that allows us to control the
analytical instrument DIGICART 40 with a personal computer.
The software was written in C language and FORTRAN 77 under
the XENIX Operating System in order to have a high level of
compatibility: the advantages of this approach are presented.
The system allows an interesting idea for the realization of
an inexpensive "superimposition" device.

INTRODUCTION

DIGICART 40 is a precise, flexible and easy to use fully
analytical photogrammetric instrument. Its hardware and
software solutions make available to the user all those
operating facilities that are nowadays essential for any
stereorestitution job.
Operations for model set-up are drastically simplified in the
DIGICART 40, at the same time a set of facilities for automatic
numerical or graphic mapping are implemented in order to
increase the system speed and productivity.
The use of a personal computer for the management of the
instrument, the choice of XENIX operating system and the C
language gives to the instrument a great flexibility and
guarantees us hardware and software compatibility with future
informatic products.
Other main features that had been kept in account during the
design of the DIGICART are the following:
. Planimetric exploration of the stereomodel by freehand
  guiding device with the possibility of selection of different
  speeds and fast positioning on the indicated point.
. Handwheel and/or thunbwheel for altimetric esploration.
. Footswitch for direct coordinate recording.
. Modular and interactive software to guide the operator in the
  use of the instrument.
. High reliability of harware and software.

All this make the DIGICART 40 an extremely potent answer to the
requirements of photogrammetrists.

MAIN HARDWARE COMPONENTS OF THE SYSTEM

The following basic parts can be distinguished:
. The stereoviewer that allows the stereoscopic observation of the photograms and the plate coordinates measurements.
. The computer that makes the calculation of orientation parameters and real time processing of model coordinates for updating the plate carriages position.
. The control electronic unit that manages the data interchanges between optical-mechanical part and the computer and drives the servomotors.
. Software for stereocompilation.
. Peripherical devices for on-line and off-line plotting like flat bed plotters, drum plotters and graphic screens.

In fig. 1 is a schematic diagram that shows the connection of the parts above mentioned; the all system is shown in fig. 2.
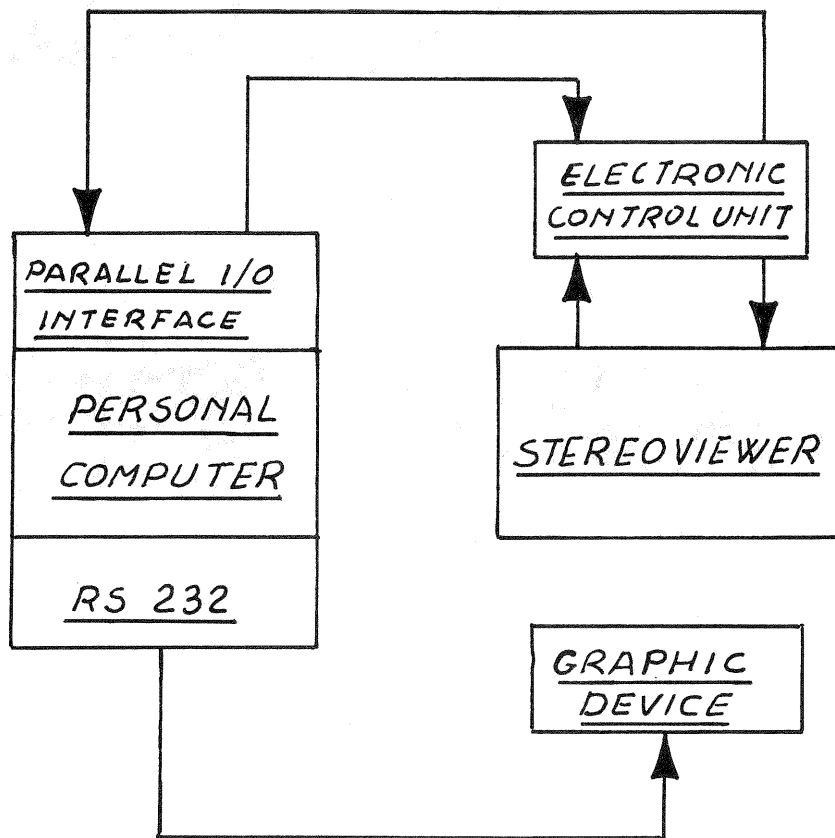

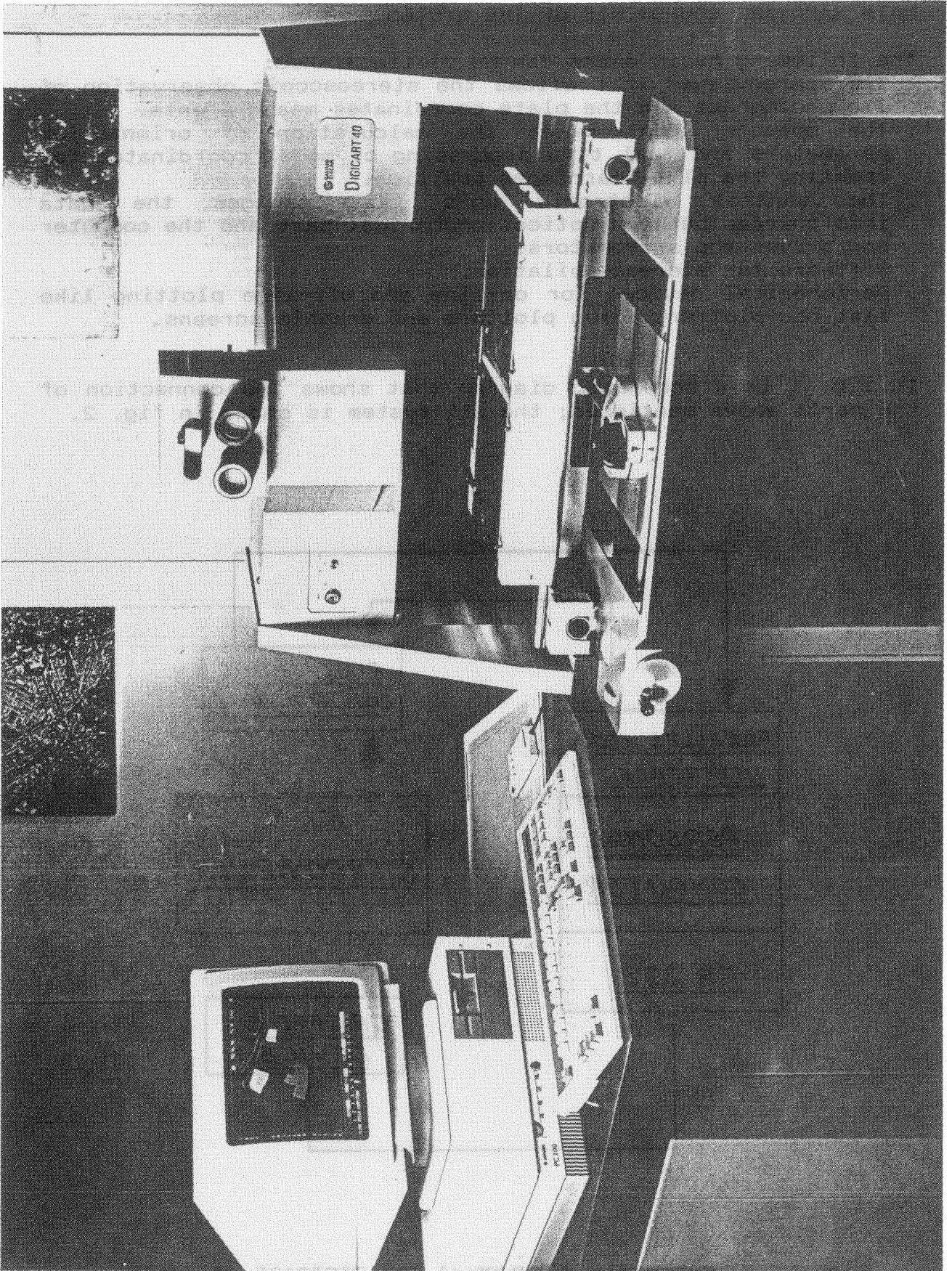Fig. 1 — Schematic diagram of the DIGICART 40 system

Fig. 2 - The DIGICART 40 system

THE STEREOVIEWER

The optical mechanical unit is basically a high precision stereocomparator. Pictures are mounted in a main carriage movable on orthogonal guide system that materialize the reference axis for instrument coordinates.
The right optical channel can be moved along the above mentioned axis, allowing the horizontal and vertical parallaxes elimination.
Main carriage and optical carriage are moved by four computer controlled servomotors.
During model set-up movements can be manually controlled using a special free-hand device (pantograph) and thumbwheels; software selectable speeds are available.
After interior, relative and absolute orientation, motors are controlled by the computer. It reads model coordinates, transforms them in plate coordinates using collinearity equations and sends the up-dating positions to servomotors through electronic control unit.

THE OPTICAL SYSTEM

The fig. 3 shows the collimation optics. Observed field is received by a first lens that form an image on the focusing plane of the measuring mark.
Photo image and measuring mark are received by a second lens that outputs a parallel-rays image allowing a part of the optical system to be movable.
Following prisms and lenses group are suitable to transport the image on the focal plane of the eye-piece .
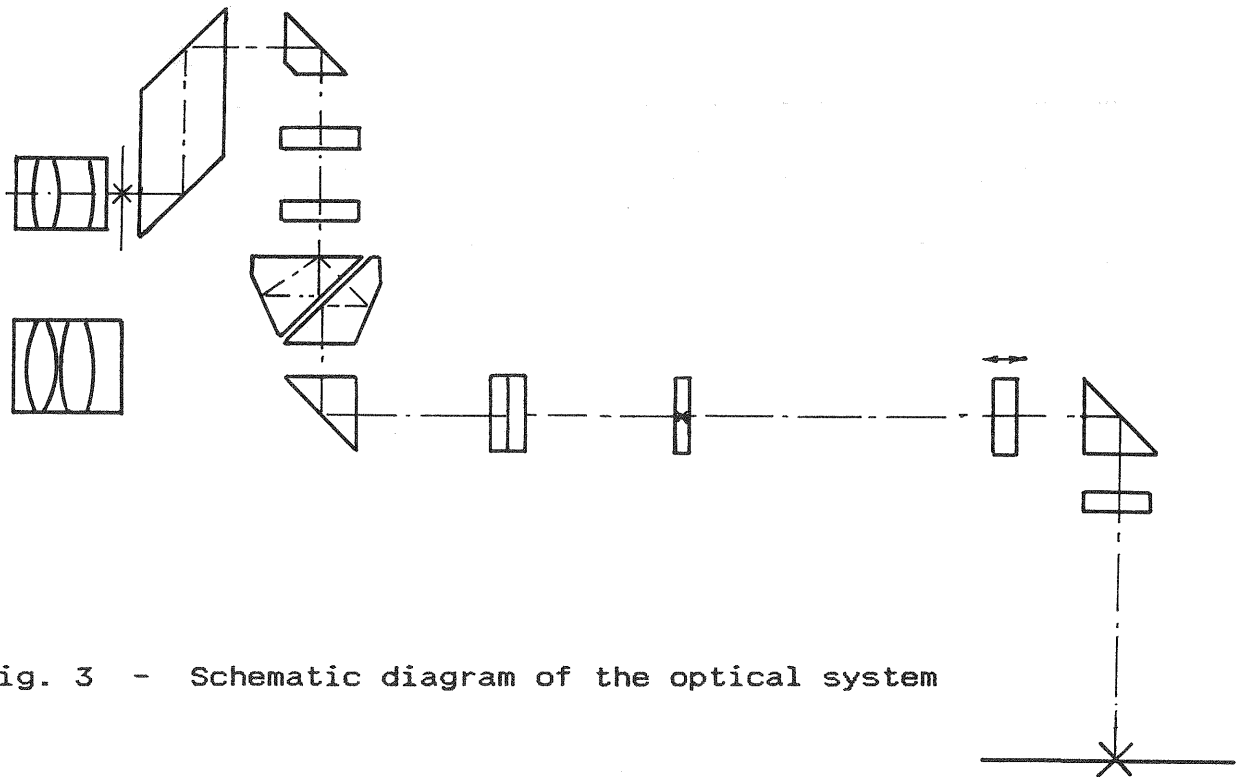Changing eye-pieces we can have two enlargement 8x and 12x.

Fig. 3 - Schematic diagram of the optical system

THE CONTROL ELECTRONIC UNIT

Main purposes of electronic interface are the management of data interchange between the stereoviewer and the computer, plus control of the four servomotors which move the plate carriages.

The interface was designed according to the latest up-to-date digital techniques using microprocessors and a modular structure in order to have a rapid and easy maintenance.

We can distinguish four functional parts in the electronic interface:

. The main board that contains a high speed CPU, the EPROM with the program, the RAM for data and a set of parallel I/O ports for data transmission.

. Four control-axis boards, which are microprocessor based, containing the counters of transducers of photocarriages position and the servomotor drivers.

. The power supply section providing the voltages for logic, transducers and servomotors.

. The parallel I/O interface is a specially designed board, that can be added on the bus of the personal computer in order to obtain a very high speed in transfering data from and to the central memory of the personal.

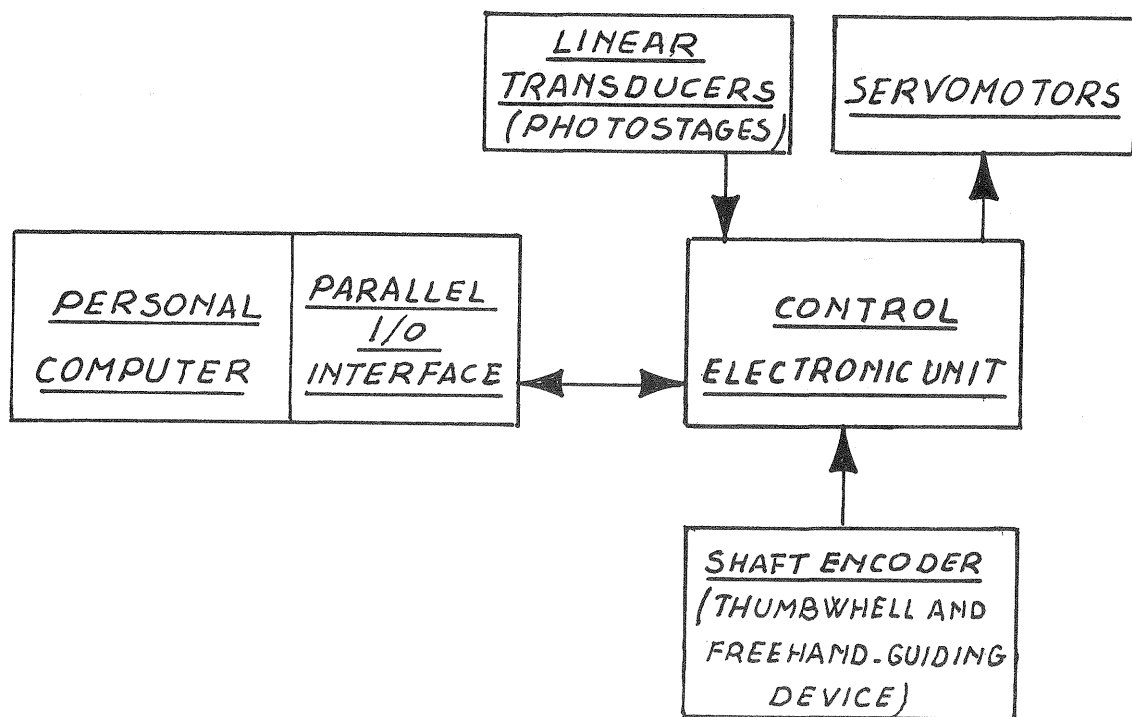The following block diagram (fig. 4) shows the logic functions of control interface.

Fig. 4 - Schematic logic functions of electronic units

MODERN PERSONAL COMPUTER: THEIR CHARACTERISTICS

When choosing a computer for an analytical stereoplotter one must have well present in mind two important facts:

a) real time functions necessary in a stereoplotter control require a very high computational power

b) the operator's job must be as easy as possible.

In other words one must never forget the operator friendliness of the machine.

A very high development of VLSI technologies have made available in a short period of time microprocessors working with 32 bits and 20 MHz clock. At the same time the personal computers, which are small, inexpensive and able to carry out bookkeeping of a little firm, increased their calculating power to the point that they can substitute in several applications the old minicomputers.

The high level of compatibility played a fundamental role in the large diffusion of the personal computers also for hobby purpose, so people that are familiar with a personal computer are getting more and more numerous.

What we call a "personal computer" is nowadays a machine with 16 or 32 bit processor, floating point coprocessor, 640 Kb of core memory, 20 or 40 Mbytes hard disk, graphic options (special boards and monitors) that transform the personal in a work station; all this at a very low price.

The possibility of using a personal as a stereoplotter control computer was valued and found achievable.

Following advantages appeared evident:

. Economics: the prices of personal computers are decreasing.

. Compatibility: we are not tied down any more to just one machine but to a class of machines. Passing from one to another is a simple process.

. Modularity: as already stated a personal computer can be transformed into a graphic work station allowing display and graphic processing of data.

. Easy to operate.

THE OPERATING SYSTEM

Talking about personal computers means remembering the MS-DOS operating system. This is in fact the system more frequently used up to now for its power and simplicity; it put itself in the middle between the old CP/M and UNIX.

When the PC AT computers, based on I80286 microprocessor, appeared on the market, a new operating system named XENIX also appeared.

XENIX can be regarded as a UNIX modification just to fit hardware characteristics of the personal computers; it keeps the same commands format, the possibility of multitasking and multiuser.

Having to choose the operating system for our DIGICART software it was clear that some limits would be put from the MS-DOS,

like the limitated memory access and the possibility of a
flexible use of the modern hard disks.
In addition, we can keep in account that MS-DOS was born for
8086/88 microprocessors so, it uses the more powerful 80286/386
in a limitated mode.
Considering all this, we decided on using the XENIX operating
system for software development. The choice had been valid and
the main advantages we found are detailed below:
. Programming tools are very efficient and powerful;
  multitasking and multiscreen mode offer to the programmer a
  good environment for software development.
. There are pratically no limits to the extension of memory and
  number of peripheral devices.
. One can read and write DOS disks so, a file created under
  XENIX, can be processed under DOS without any problem. In
  addition we can have on the same hard disk both the operating
  systems and pass from one to another just rebooting the
  computer.
. The complete compatibility with UNIX allows us to look at
  workstations or big systems as future implementation of the
  Stereoplotting instrument.
The last thing we want to say is that the XENIX software
development is more complex, but it is limited at the drivers
for external devices and in any case at the starting phase of
the programming work. User interface can be very simple and
friendliness can be reach by a good user.

SOFTWARE ORGANIZATION

Two functional layers can be distinguished in the DIGICART 40
software structure. The first one is the real time software; it
implements the basic algorithm to up-date the picture-carriages
systems after the reading of input coordinates from the
phisical devices.
The second layer is the software that performs model
orientation, interpretation of commands, printout of results
and other application programs.
FORTRAN 77 and C are the languages used to develop software:
the FORTRAN 77 gives us the opportunity to use certain
subroutines already working in the previous instruments, the C
language is the natural language of XENIX environment.
Tests and benchmark carried out during the preliminary phases
of system design gave the following results: C is faster than
FORTRAN for I/O applications and drivers building; FORTRAN is
faster in floating point calculations.
Subroutines written in different languages are used in order to
get the best solution regarding speed and I/O management.

ON LINE MAPPING AND DATA BASE ORGANIZATION

MAPPING OPERATIONS

Several software packages are one of the most important
components of DIGICART 40. The following main photogrammetric
applications can be considered:
. Stereomodel set-up
. Graphic and numeric stereocompilation
. Close-range application
. Aerotriangulation
Principal functions of this software are summarized in the
points below listed:
. Interior, relative and absolute orientation of paranadiral
  or tilted stereopairs.
. Numerical stereocompilation supported by graphic
  rappresentation on the screen; formats used in data
  collection are selected by the user. Data can be collected
  according to different modalities: point by point or stream
  mode (fixed time, space intervals and vector).
. Profiling and cross sections facility along a straight or
  circular line. These applications, extremely useful in civil
  engineering mapping, can be activated by two different modes.
  The first one has the scanning of every single profile guided
  by the computer, the speed is software selectable; the
  operator only controls the elevation movement.
  In the second mode the operator directly follows the profile
  using the special freehand guiding device; this allows the
  operator to work with continously changing speed, including
  the possibility to stop on particular points.
. Digital terrain modeling (D.T.M.) with regular grid and
  "visit point" facility.
. Remote control of the principal functions. This very
  interesting feature offers the possibility to activate the
  above listed functions (D.T.M., profiling, visit points) by a
  remote computer which is processing (for instance) project
  data or triangulation block adjustment.
. Aerotriangulation facilities including model observations and
  independent model block adjustment.

PHOTOGRAMMETRIC DATA BASE AND GRAPHIC FUNCTIONS

DIGICART 40 system is a photogrammetric work station that gives
to the user a powerful tool for production of numerical maps.
A graphic support is offered to the operator for two main
purposes:
. To help him in the work of data collection
. To make available a powerful graphic interactive editing for
  on line corrections directly occurring at restitution time.
Data stored on the disk can be subdivided into three groups of
elements: single points, open and closed polygonals.
During data collection, information is recorded in a file
called "restitution file"; this file contains only codes and

coordinates, but in order to be able to have the graphic representation of the restitution file, some other information are needed so the system automatically creates an auxiliary file to record this extra information.

This auxiliary file called "drawing file" contains information about alfanumeric code associated to an element, number of points for each element, pointer to the coordinate file, color to be selected when the element is displayed on the screen.

Other configuration files, built at the beginning of the work, are useful to give general instructions to the system like codes which are normally used, definition of symbols, color-pen association when the plotter is used, and so on.

With the above described data organization, good performances in speed as well as in flexibility and reliability are obtained.

We would like to spend, at this point, just a few words to describe the graphic possibilities of the system; four classes of functions are available:

. Graphic representation on graphic screen or plotter
. Numerical and graphic editing
. Tests for consistency of data and codes
. Data base integration with data coming from surveying or map digitizing.

Graphic functions give the possibility to zoom, to work by levels (display only the requested elements) and to output the numerical map on the plotter.

The graphic editing is a package for first correction of restitution errors; for this purpose it includes functiones like total or partial deleting, rotation or traslation of elements, squaring. All the graphic possibilities can be activated on or off-line.

Consistency of collected data is always tested according to special procedures: geometrical and codifying problems are detected and pointed out.

The last possibility we want to talk about is the data base integration with data coming from map digitizing, survey instruments and of course using the computer keyboard.

Integration obtained from digitizing is supported by a rototraslation algorithm that allows the real time transformation of digitizing coordinates in ground coordinates. Digitized points can be processed immediately like all the other elements of data base.

CONCLUSIONS

An analytical stereoplotter based on a personal computer, an unimaginable thing just a few years ago, offers photogrammetrists a system of valuable features.

It's enough to think of the instrument semplicity, of the easily maintenance and not last of the possibility to have a low price photogrammetric work station.

The presence of personal computer makes possible the access of photogrammetric equipment in the world of small systems: that means an enormous quantity of already developed applications, interfaces and image processing cards ready to be assembled in

the computer.
Talking about image processing it could be very interesting to point out an application, at the moment under development in our laboratory, that will make available a very simple and functional superimposition device.
Cards, fully compatible with personal computer data bus, can be used for displaying on high resolution monitor photography and, superimposed, the photogrammetric restitution.
This superimposition device, that will allow us scaling operations, "panning" of the image and windowing, could be advantageously used also for mapping updating and maintenance.