14TH CONGRESS OF THE

INTERNATIONAL SOCIETY OF PHOTOGRAMMETRY

HAMBURG 1980

NO. OF COMMISSION: IV

NO. OF WORKING GROUP: IV/I

TYPE OF PAPER: Invited paper

NAME AND AFFILIATION OF AUTHOR: Eric J Fien, B. Surv (Qld)
Member of A.P.S.

ABSTRACT: More than ten years practical use in day to day photogrammetric practise has demonstrated the economic advantages of combining the power of digital data processing with the simplicity and economy of analogue restitution. This paper describes the existing equipment, its software system, application packages and current state of development and explores the present state of the art systems which are proposed for implementation in 1980.

In 1968 an evaluation of the existing commercially available means of extracting, storing and processing digital positional information from analogue stereoplotters, with particular attention to interactive data processing was commenced.

This study was necessary to enable our Company to acquire equipment to handle the increasing demand for volumetric computations and the time consuming tasks of relative orientation, absolute orientation and aerial triangulation.

None of the systems reviewed in January 1969 fulfilled all our requirements for adequate interaction with the operator and most used some form of deferred data processing.

A decision was made to implement a dedicated mini computer based system that would take the incremental X, Y and Z pulses from instrument mounted encoders and utilize real time interactive programs, organised in a user selectable suite to derive the required results. Data storage was limited to that of immediate interest only and featured a limited editing facility to permit the operator to delete the results of anomolous observations.

The selected hardware comprised a Honeywell H316 mini computer with 16 K, 16 bits words of core memory, two special stereoplotter interfaces and associated ASR33 teletypes. The initial operating system was written in-house using an assembler language interrupt driven executive and fortran application programs. It comprised three major application programs - viz. relative orientation, absolute orientation and volumetric computation. A service subroutine to display the status of the X, Y and Z counting registers was included in the main executive. This system became fully operational in 1970. See Figure 1.

A period of rapid expansion followed. Further application packages were developed and a disk system, magnetic tape drive, paper tape reader and punch and a high speed line printer were progressively added to the system. The system was re-organised in 1976 to run as a series of disk resident sub-routines.

Today some 34 individual programs and 26 utility routines largely written in fortran IV are operational and the system is in day to day use. Very few modifications have been required in the original application programs to keep them up to date. The system has provided many benefits to our Company and has resulted in an improved service to our clients including greatly reduced turn around times, decreased costs and the very high reliability that is attributable to the absence of hand manipulation of data. See Figure 2.

The hardware and the system have however been overtaken by technological change and rendered uneconomic by rising maintenance costs. In addition, more sophisticated products having more uniform cartographic standards are now available from some Government agencies in Australia and customers now expect private industry to match these standards. There are also major pressures to expand the range of application programs to cover new fields, not envisaged when the original system logic was written and which require quite different data handling techniques.

A program was implemented in 1979 to upgrade the present system in accordance with the following premises:-

1. Analogue stereoplotters will continue to provide for the majority of commercial photogrammetric mapping tasks for the foreseeable future.

2. The economics of replacing analogue instruments with fully analytical equipment cannot be demonstrated in the case of firms having a base load of less than 25,000 hours of machine work per annum and indeed the currently available instruments appear to be designed as "super fast, accurate triangulation tools", not economic commercially oriented production instruments.

3. An interactive graphic system should be provided to allow for editing and merging of the results to produce a final printing copy as the system output i.e. no cartography should be carried out manually.

4. The central processing capacity should cater for all existing and planned application programs.

5. The data base (if used) should be in a form suitable for transmission to a remote site for further processing or reproduction (i.e. some "standards" need to be adopted for the internal data formats).

6. The change over from the existing system should take account of current operator training and expectations. In this regard the new system must be easy to "drive", if it is to gain acceptance by photogrammetric staff as an aid to their daily work.

7. Maximum use should be made of existing time proven software and on the basis of past experience all the probable options should be included initially in the system and a second "final" system generated after 12 - 18 months use with unused options deleted.

8. As in the original system an "open ended" approach should be adopted in constructing the system executive to cater for expansion of both hardware and software.

   One of the greatest problems in considering hardware is the momentum of development of micro computer based technology which often renders todays soundly reasoned solution obsolete in a very short time, nevertheless, it is essential to take a position which reflects good judgement based on current availability and product history if the final system is to be successful and enduring.

The trade off between machine independence (by writing the application programs in standardised languages) and software development costs (by utilizing some sophisticated dedicated software packages) is difficult to evaluate, however, I believe that experience to date has shown the value of writing application programs in machine independent code and this procedure will be adopted.

In considering any computer aided stereoplotting system, the effectiveness of the system demands careful consideration and the range of program options to meet changing market demands must be carefully evaluated.

Our decision is based on a mini computer of 256 K, 16 bits words, with full hardware floating point arithmetic (with D.P. functions) with an advanced operating system executive capable of dynamically allocating both central memory and peripheral devices, with digital interfaces to the stereoplotters, terminals, magnetic tapes, disks, printer and external RS232C compatible sub-systems. A dedicated pair of channels will be employed to interface the high precision flat bed plotter sub-system and the 3D interactive graphics. Secondary considerations are our requirements for interfacing the following equipment:-

1. An X, Y digitizer.

2. An existing computer controlled data acquisition system and its associated plotter.

3. A proposed analytical stereoplotter for terrestrial industrial photogrammetry and non topographic applications.

4. A high speed memory access channel for direct computer to computer communications.

An unusual consideration possibly peculiar to our Company's varied operations is the desirability of acquiring job costing, accounting, inventory and historical information directly from the operating positions and integrating this with input from terminals associated with the aerial photography and photographic laboratory sections of our operation. The resultant saving in manual costing controls and increase in reliability of the data will offset the initial costs of implementation.

So far I have said little about the applications software, yet this often overlooked item is as important to the success of any computerisation of photogrammetry as the selection of the proper hardware. I believe that to be successful in this area the software must include the following features:-

1. Convenience - the dialogue between the operators and programs must be in a form that the operator comprehends and be in familiar text. Changes of format between programs must be avoided if possible and error recovery routines written to reject erroneous data and prompt the

operator for a valid response should be included. An option that permits the editing of entered data where an error is detected during subsequent processing (or before commencing processing) without the need to re-enter all other valid data is necessary.

2. The results must be mathematically correct for all valid combinations of input data and operator selected options. Any shortcomings in this area renders the whole system open to suspicion. Rounding errors in matrix solutions in particular must be carefully monitored to ensure system confidence.

3. Wherever possible the photogrammetric operator should be able to proceed uninterrupted with his data gathering task, at his own rate (i.e. there should be no unnecessary prompting or requests requiring operator intervention).

   On time consuming work adequate provision for interruptions to the input flow must be provided e.g. a visual display of current status should be available on the terminal and a review facility to re-examine data already recorded should be implemented.

These requirements must, of necessity, be an economically viable proposition and be capable of implementation without compromising the overall effectiveness of the system. Considering each of these requirements in turn we have found after some 10 years experience with the existing system that:-

1. The value of adequate program/operator dialogue cannot be overstated. This feature can quite readily be provided on most hardware, written either in basic or fortran without too much trouble, although the storage of alphanumeric data strings and references to them in format statements tends to consume significant memory and a machine with compatible cobol would appear to be advantageous.

2. The error handling for invalid formats (which could not be provided in our original software) was included in our revised disk based BOS210C and BOS220 executives, permitting format error detection at run time. Adequate recovery procedures can be easily implemented.

3. Re-computation after data editing is fairly readily handled although this necessitates the inclusion of file manipulation code into the application programs and secondary entry points in many sub-sections of the programs.

4. The accuracy of results from data employing ground values (of the order of 106) can only be maintained by the use of 48 bit operations (double precision floating point arithmetic) unless recourse is made to offsetting techniques. Generally these methods are not popular, although the advantages of using library routines for

matrix arithmetic must be carefully considered. To date very few matrix routines have appeared in double precision arithmetic and accordingly we propose to continue using discrete direct methods of solution for the unknowns.

5. Once the data acquisition proper has commenced (whether in running cross sections or a DTM grid), it is highly desirable to program so that the work continues without the operator having to attend to a keyboard except for editing or program option selection. All existing software use these techniques.

On large tasks a VDU display of current status is a very valuable aid to show in simplified graphical form the progress to date. The option of temporary saving an incomplete file and then restoring and adding to that file at a later date is a necessity.

Planning for the system implementation depicted in Figure 3 is at an advanced stage and the system should be operational early in 1981. It will include several radical features, the most notable being the memory mapping controller. This device will keep a copy of selected memory locations (normally a graphics "page") which may be displayed on a VDU as a composite image, or retransmitted via the RC232C sub-controller to the flat bed plotter as a plot file. It will be possible to carry out a keyboard based edit on the VDU using the terminals own 8 page memory (i.e. off-line to the system) and in turn modify the memory mapping storage. Alternatively, the two storages can be searched to determine differences (as in terrain modelling) and the main system can perform computations between the storages. The dynamic memory allocation feature of the CPU will permit either same size, expanded or condensed copies to be generated in the CPU.

The adopted protocol for all application programs will be to use ground units and a series of user written sub-routines to permit the plotting of standardised data by single CPU sub-routine calls. The dynamic time sharing and micro computer based RS232 sub-controller permits simultaneous plotting of one task and the computation, data gathering and file management of other tasks.

A detailed listing of the hardware and software is given in Table 1.

The revised system, at a cost less than an analytical plotter system of the same capacity, has many features not found in currently marketed systems not the least of which is the utilization of existing analogue stereoplotters in conventional roles i.e. they are not rendered ineffective by central processor or peripheral failures.

The integration of data streams in a modern highly sophisticated mini computer system makes more sense in a practical situation than powerful analytical systems on a one per instrument basis.

A great deal of pioneering work on integrating multiple users in a commercially viable situation has also been carried out by the Hunting Surveys Group in England over the past three years and although those developments are along different lines, the systems approach is common.

By early 1981 the system described will be operational and a further report will be published in 1982 detailing in particular the industrial terrestrial applications of the system.

TABLE 1

Hardware

CPU Honeywell H316, 16 K core DMC controller
7 track 200/556/800 BPI magnetic tape sub-system (4021)
Dual 756 K cartridge disk sub-system (4760)
8 channel paper tape reader and punch
Two current loop interfaces - 300 baud
Two stereoplotter interface options - 2 channel, 3 axis
300 LPM 132 character/line buffered line printer
Stereoplotter encoding 3 x 200 P.P.R. Trump Ross incremental encoders.

Software

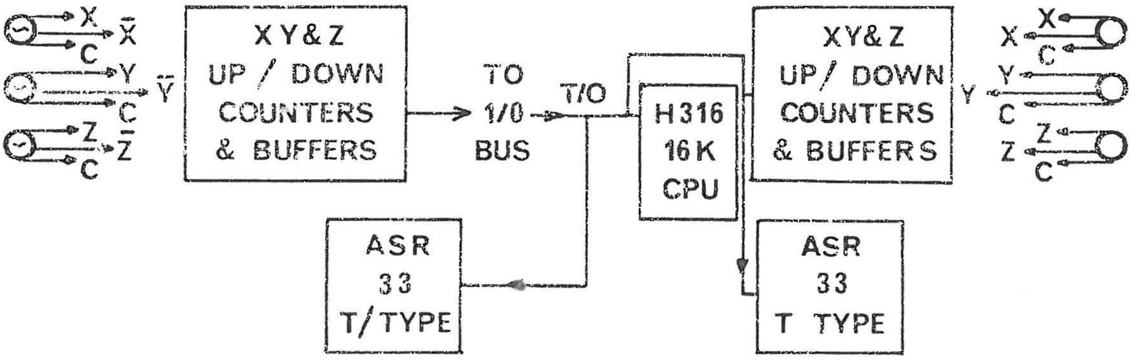
Main operating system - interrupt driven assembly language executive with fortran sub-system application programs. Volume, relative and absolute orientation. System is stand-alone.

Application packages - batch operating system fortran/assembly language sub-systems:-

"Camera" calibration by intersection
Independent model triangulation - 4 sub-systems terminating in sheet coordinates and model set-up data
Areas of features - 1 program
Road design, including cut, fill, batter pegs, mass diagram - dynamic design. Suite of 14 sub-programs from stereoplotter digitization to final mass diagram printout and layout detail sheets. Included are vertical and horizontal curves, tangent and intersection point coordination and centre line chainages.
Digital terrain modelling - 7 interactive programs for acquisition analysis and plotting of digital information in ground coordinates.
Dam wall and impounded water volumes/areas - 7 interactive programs for volume, cut, sections of dam walls, volume (s) of impounded water and area inundated.

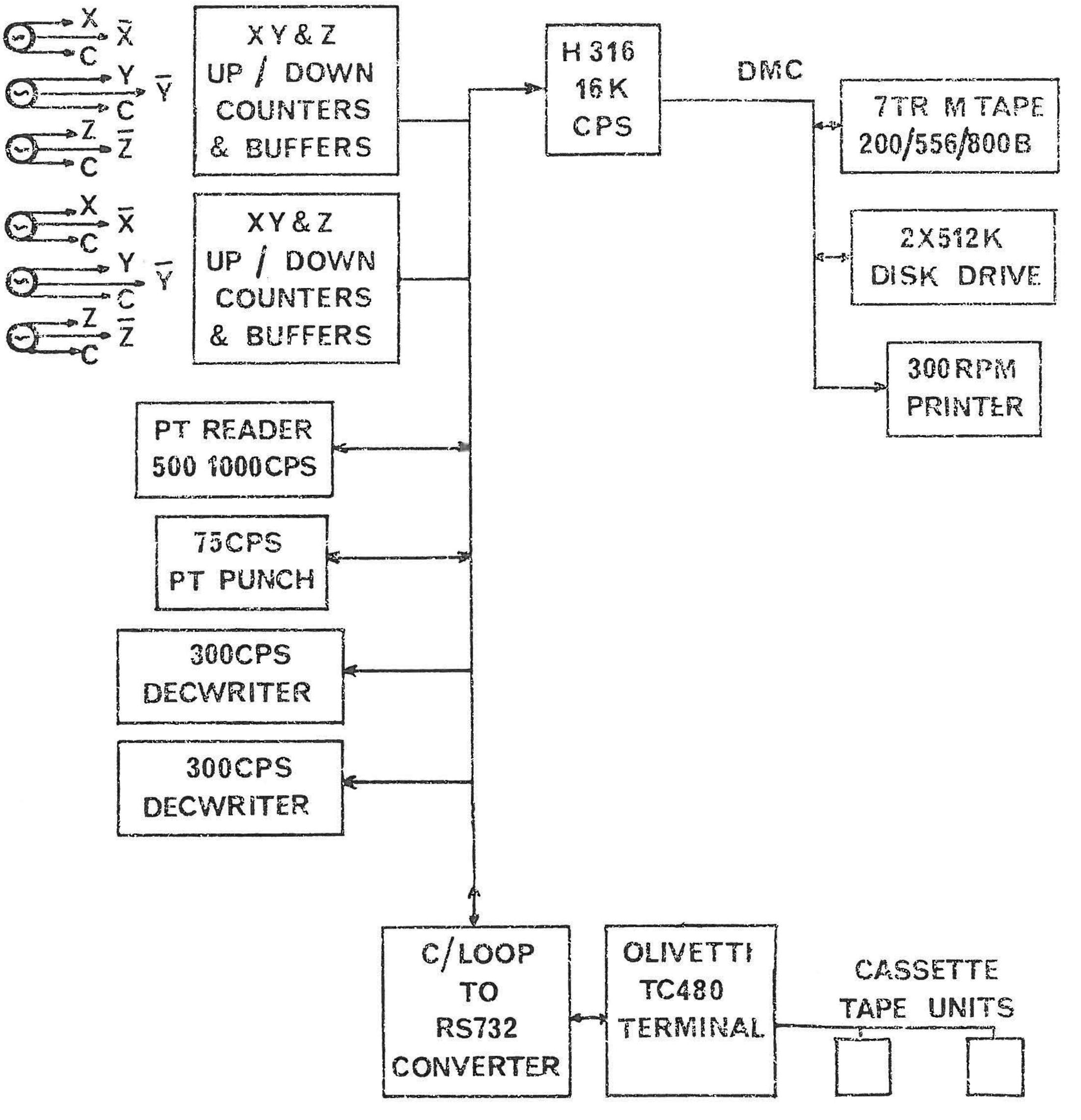
Miscellaneous programs for power line design, shallow water depth determinations and allied routines make up remaining applications packages.

FIG 1



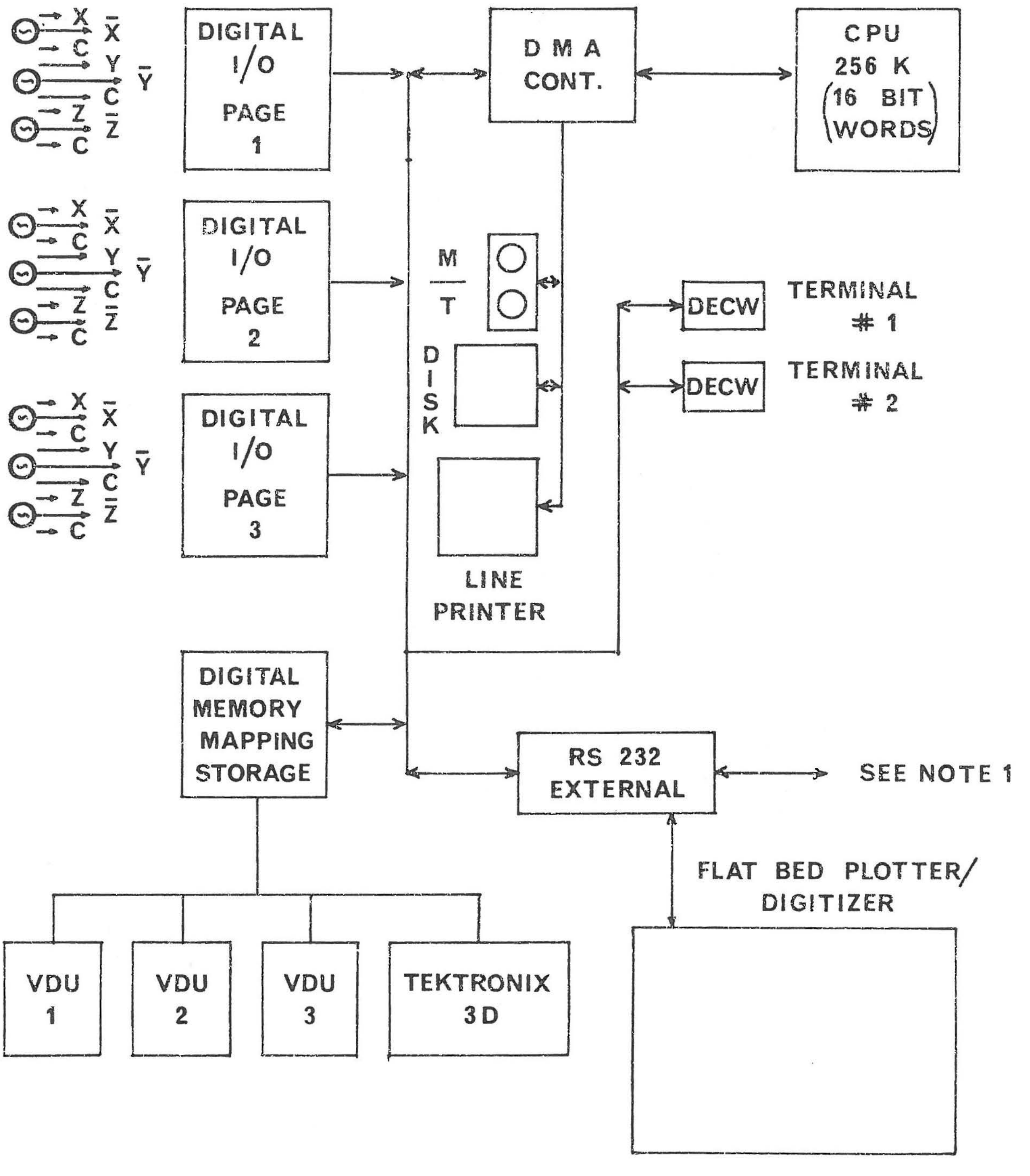
SOFTWARE:- 12.6 K CORE RESIDENT

FIG 2



SOFTWARE:- DISK RESIDENT - CORE EXECUTABLE
(TOTAL:- 370 K)
(PLUS DATA FILES)

FIG 3



NOTE 1: 9600 BAND TO FLATBED PLOTTER
9600 BAND TO WILD TA TABLE/PRI1 CONT.
9600 BAND TO ANALYTICAL PLOTTER
1200 BAND TO TELECOM/TRANSIT LINES
300 BAND TO OLIVETTI TC480 AND/OR CASSETTES