DEVELOPMENTS IN ORTHOPHOTO MAPPING

Paper presented by Australia[1]

Introduction

In 1966 a federal programme was commenced for the coverage of Australia with maps at a scale of 1:100,000 having a contour interval of 20 m. For the coastal fringe, consisting of approximately 3,000,000 km², the maps will be published in traditional form at 1:100,000 but for the central region of approximately 5,000,000 km² manuscript maps will be compiled at 1:100,000 but maps will be published at 1:250,000 only.

The programme is, for the most part, being carried out by the two federal agencies engaged in mapping, the Department of National Development (Division of National Mapping) and the Department of the Army (Royal Australian Survey Corps). The State Lands Departments participate in varying degrees with the Federal Department of National Development reimbursing the cost. One State (Tasmania) is mapping the whole of its territory at 1:100,000.

Introduction of orthophoto techniques into the programme

Orthophoto maps have many advantages for geoscientists and for those engaged in the exploitation, administration and preservation of the Earth's natural resources, in that this particular type of map readily permits the plotting of the correct map position of data that has been identified on air photographs.

From the map production viewpoint, orthophotos have the advantage that identification and plotting of detail can be carried out with the aid of simple stereoscopic plotting equipment by personnel with reasonable interpretative and drafting ability. Where a mapping programme is scheduled for completion within a set time-frame, this particular aspect is of significance to management in that, first, it provides for a more flexible use of field staff who, on completion of control surveys, can be used not only for accuracy check surveys but also for the field and/or office identification of map detail and for the simple plotting of this detail; secondly, it opens up a much wider field for contract support from moderately equipped survey and drafting offices throughout the country.

Early experience in various organizations throughout the world has shown that orthophoto mapping techniques have obvious time-saving advantages over traditional techniques where the orthophoto and contour overlay in themselves provide all the necessary data. Furthermore, if orthophoto maps can be obtained as a by-product in the production of traditional "line" maps, without loss of specified map accuracy and without very materially increasing production costs, then it will certainly be very worth while to adopt this form of production, particularly for medium- and small-scale national mapping programmes.

Another possible benefit from orthophoto mapping techniques can be obtained by the simultaneous recording of digital terrain data. Whether it is worth while doing this in every case is unknown at this stage, but future user experience may justify such a course of action.

When the 1:100,000 mapping programme commenced, test models were forwarded to various manufacturers for processing into orthophotographs, but little was known of the economics of orthophoto mapping techniques, and for the coastal perimeter of the country where publication is intended at the basic scale, it was decided to rely primarily on traditional "line" mapping procedures, but to include some orthophoto mapping techniques, as appropriate, and almost certainly to use them in the course of future revision of areas of intensive new development. Within the central area where compilation is required at 1:100,000 for publication at 1:250,000 and where the terrain is for the most part extremely flat and sparsely vegetated, orthophoto mapping techniques were an obvious choice.

Much of this orthophoto mapping can be accomplished by simple rectification supplemented by contouring in stereoplotting equipment. In fact about 20 per cent of the area is so flat that contours can be directly interpolated from airborne profiles.

(It should be explained that the sand ridges which cover a great part of central Australia are fairly stable, and, in most areas, lightly vegetated. They are usually roughly parallel at varying distances apart with a flat area between them. In sand-ridge terrain it is the intention to contour the flat areas only, and include a general note as to the height of sand ridges.)

Present application and plans for use in Australia

While topographic mapping is generally continuing along traditional lines, the regular production of orthophoto maps has now commenced in the Division of National Mapping, and other agencies are now starting to introduce the technique.

The Division of National Mapping will convert 1:84,000 superwide-angle photography into 1:80,000 orthophoto maps on 1:50,000 series sheet lines with a separate contour overlay at the same scale. When viewed with the original photography, the orthophoto map at this scale will enable simple semi-stereoscopic examination and annotation of the detail on the orthophoto map to form a basis for the production of standard 1:100,000 and 1:250,000 line maps in certain areas. The 1:80,000 orthophoto maps will also be made available to users in various disciplines where the advantages outlined above will prove a valuable aid to field investigations.

Types of equipment installed in Australia

Wild B8 stereomat

The B8 stereomat consists of two basic components which are intimately tied together to make one efficiently operating instrument. The optical-mechanical part of the photogrammetric instrument is derived from the Wild B8 aviograph. It retains the ability of the B8 to accommodate wide-angle photography of the prevailing focal lengths 100 mm, 115 mm, 152 mm (6 inch), as well as the superwide-angle photography of 88 mm focal length. The electronic part of the instrument is an ingenious combination of scanners, detectors, correlators and servomotors, which to a large extent replace the functions of the human

[1] The original text of this paper, submitted under items 9 (*a*) and 9 (*b*), appeared as document E/CONF.57/L.63.

operator. The Division of National Mapping has three B8 stereomats installed and two are equipped with digitizing facilities.

Zeiss topocart—orthophot—orograph

This system consists of three interconnected units: the topocart, which can function as a normal stereoplotting instrument; the orthophot, which is a differential optical rectifier; and the orograph, which is a special contour drop line drawing-head attached to the topocart drawing table. The Division of National Mapping has two complete systems installed.

Zeiss GZ-1 orthoprojector

This equipment is of the optical projection type incorporating multiple stage rectification. The required vertical information is supplied either directly or via a storage unit.

For direct operation the GZ-1 is set up in a dark room adjacent to the stereoplotter. The interconnection is by synchro drives, the X and Y motion being under full automatic control by the GZ-1 with the Z motion controlled at the stereo plotter by a handwheel.

For operation via storage the vertical profile and control point registration marks are scribed on storage plates in a unit connected directly to the stereoplotter. This storage plate is inserted into a scanning unit, the profiles are scanned by photo cells and the resultant data is fed into the GZ-1 to control the rectification process. An advantage of the indirect method is that interpolation procedures may be used and it is not necessary to scan every profile in the stereoplotter.

The Department of Lands and Survey, Western Australia, and the Department of Lands, South Australia each have a GZ-1 installed, connected to a Zeiss planimat stereoplotter.

Operational notes—Wild B8 stereomat

The first Wild B8 stereomat was delivered to the Division of National Mapping in January 1968 and finally accepted in September of that year. The second such machine was delivered in October 1969 and finally accepted in March 1970. A third machine was in process of installation during October 1970. Since acceptance, the first two machines have been in continuous operation except, in the case of the first machine, for periods of maintenance. In the first year this consisted of 36 days for electronic maintenance and 7 days of mechanical maintenance, which included early delays due to non-availability of spares. In recent operations there has been a 5 per cent "down time" for adjustment and maintenance of equipment and an additional 5 per cent while awaiting servicing.

The two stereomats, in operational production by the Division, require a team of two personnel per machine/shift and this team attends to preparatory activities, machine operation, editing of contours, preparation of photomap and preparation of contour overlay.

For the last fifty models processed on the two machines the average "set-up time" was 1 hour per model with an average variation of ± 5 minutes; this included placing the diapositives in the machine, relative and absolute orientation and the loading and unloading of cassettes. The average time for production of an orthophoto plus digital output and/or contour segments was 2 hours with an average variation of ± 15 minutes. Additionally, a commercial contractor both develops the orthophoto negative and produces the corresponding colour separated prints at the rate of eight models per day.

From the above figures and the earlier figures quoted for traditional stereocompilation, it will be seen that the machine time and manpower required for production of an orthophoto map and contour overlay via the stereomat equipment is about one-third of the time required to produce a manuscript compilation in traditional form. The additional inspection and annotation of the orthophoto map, using simple stereoscopic equipment, should certainly not extend this over-all time to more than that required for traditional stereoplotting.

Provided the photographic image possesses good detail, the stereomat does not appear to be worried either by the ruggedness or the flatness of the terrain. In light to medium timber the floating mark appears to move over the ground surface, and in dense timber it appears to travel slightly below the treetops.

The orthophoto produced by the stereomat is at 1:40,000 and when reduced to 1:80,000 or 1:100,000 it is of quite good quality considering the production process. A work flow diagram is shown in figure I.

Operational notes—Zeiss topocart—orthophot—orograph

The Division of National Mapping has installed two topocart equipments. About twenty test and experimental models have been produced up to October 1970, and on the basis of this limited experience a preliminary assessment of the equipment has been made.

The over-all operating procedures should present no difficulty to an experienced stereoplotter operator. Some care is required in performing the relative and absolute orientations. No X or Y movements of the picture carriages are permissible when the ω and φ clamps are in the release position since the clamp levers are connected to the clamps with rather fragile wires and any large carriage movement will break them. A warning alarm has been fitted but is only operative if the orthophot unit has been switched on.

The manual operation of the Z column control during scanning has, predictably, proved rather monotonous. It is possible that this could be performed by assistant technician type staff, either male or female, with supervision by senior staff. Within limits, the basic scanning speed does not appear to greatly affect the quality of the orthophoto image. However, the reliability of the contour drop lines is affected if fast scanning speeds are used and alternate and opposite displacement along the scan direction can occur due possibly to a combination of mechanical and operator response delay. The variable scan speed facility is very useful and no exposure variations were detected throughout models where full use had been made of it.

The drop line scribing head would only function on coated glass plates and could not produce satisfactory lines on coated film. A unit incorporating "microdraft" ball-point pens was designed and satisfactory drop line charts have been produced on conventional drafting film bases.

The orthophoto quality in relation to image resolution and absence of scan join lines is considered very satisfactory, but insufficient production work has been done at this stage to assess the over-all electronic and mechanical reliability of the equipment. A work flow diagram is shown in figure II.

Operational notes—GZ-1—Department of Lands, Western Australia

The Department of Lands, Western Australia, undertook initial testing with the following equipment in September 1970: Gigas-Zeiss orthoprojector GZ-1; planimat D2; relay unit LG1; and storage unit SG1.

The objectives of these tests were to produce orthophotomaps at 1:10,000, 1:5,000, 1:2,500 and 1:1,200.

1:10,000 test

Aerial photography at 1:30,000 enabled three stereomodels to give complete coverage of the map sheet. The total processing time to produce the required orthophoto negatives was 15 hours, or 5 hours per model.

The negatives were cut and fitted together to form the map sheet. The drop line chart was interpreted and nomenclature and contour overlays produced for combination with the negative to obtain bromide or stable-base prints.

1:5,000 and 1:2,500 test

Basic photography at 1:13,700 required two full photographs for complete map sheet coverage. The utilization of north–south photography runs flown at 6,835 ft so as to

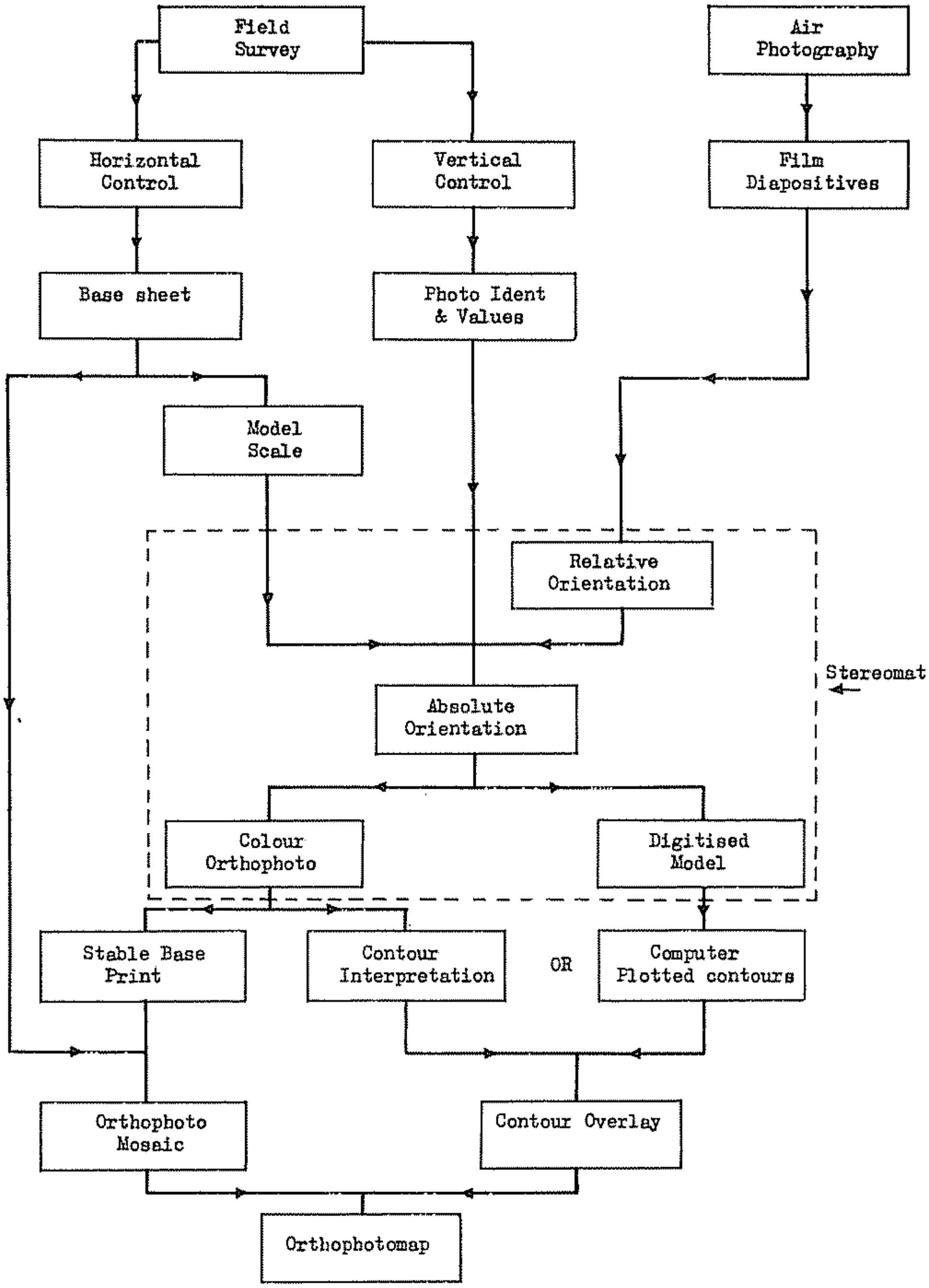

Figure 1. Work flow diagram: Orthophoto map production: B8 stereomat

give a complete 1:2,500 map sheet from every model was considered possible, and 1:5,000 map sheet coverage could be obtained by joining together two full plates.

Photography flown from 4,400 ft at 1:8,800 required three models to give 1:2,500 map sheet coverage. Interpolation procedures were used to improve the drop line chart, and the total instrument time to process the three models was 20 hours.

1:1,200 test

This test was designed to assess the large-scale capability of the GZ-1. Basic photography scale was 1:3,600 and the drop line contour interval was 2 ft, and, again interpolation procedures were used.

SUMMARY

The test based, of necessity, on limited practical experience suggested that: (*a*) the placement of air photo exposures will enable minimum negative joining and if 80 per cent forward overlay is obtained a single exposure overlap will be available for every map sheet; (*b*) the orthophoto map will require to be produced on a stable medium; and (*c*) the cost of orthophoto mapping will be quite competitive in relation to normal instrument compilation

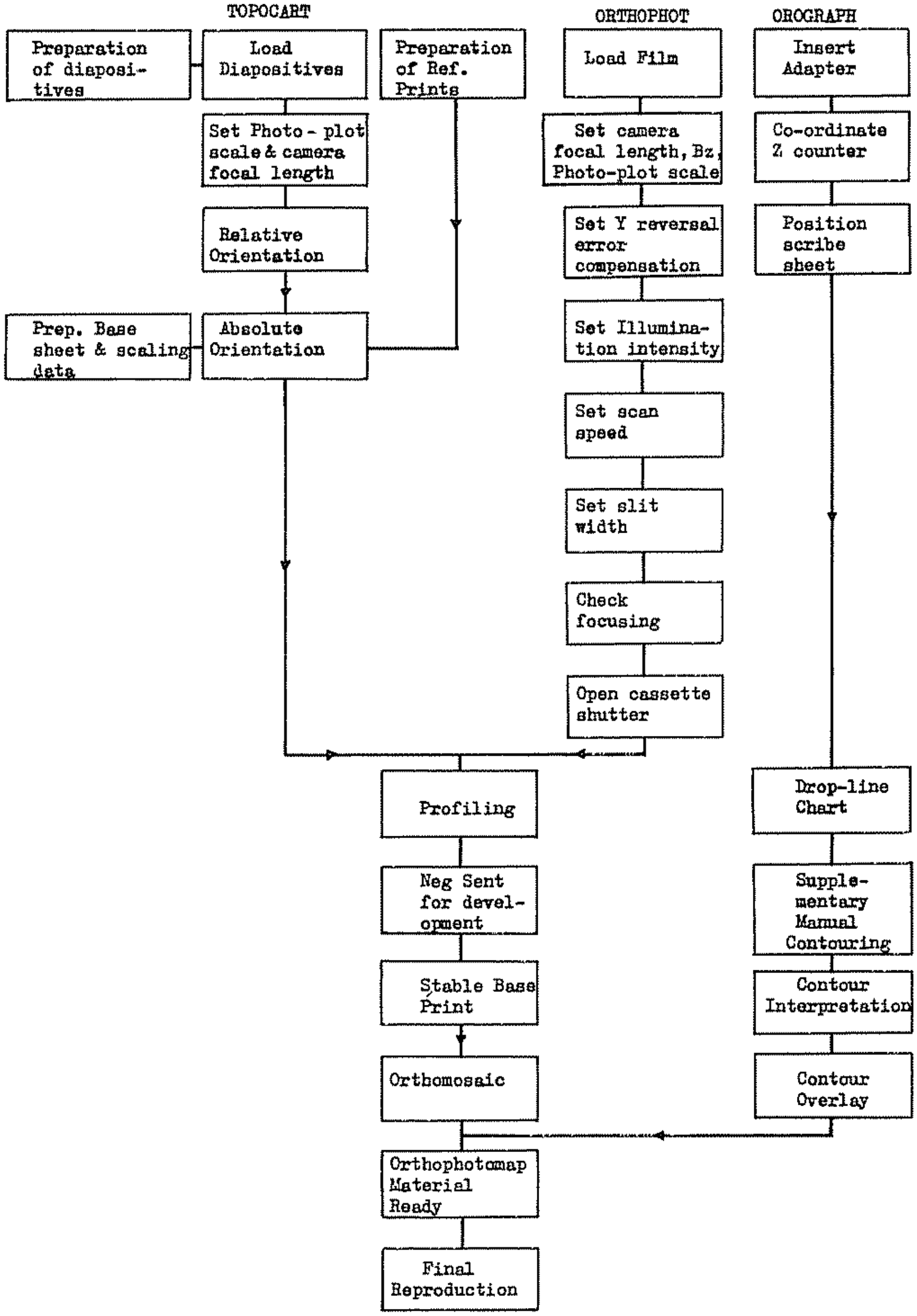

Figure II. Work flow diagram: Orthophoto map production: Zeiss topocart provided it is pursued to the orthophoto map stage, i.e. with grid values and format information.

FUTURE DEVELOPMENTS

It is almost certain that the production of coloured orthophoto maps will become a routine production operation within the next few years. To the technical expert they provide much more visual information than a line map and therefore provide a very useful base for delineating the map position of topographic and scientific detail that has been identified on air photographs or by field investigation.

It seems most likely that the future requirements of technically oriented maps users will be met by a basic coverage of orthophoto maps, possibly coloured, and supplemented by special-purpose transport overlays that will be plotted, on demand, from computer storage.

Orthophoto maps have the advantage that they can be produced quickly and can therefore readily provide an answer to the map revision problem. However, it should not be necessary to stereoscopically scan models for revision purposes. Some practical technique will need to be evolved whereby the photo limits and scanning lines are set out on a contoured map and the contour information are converted into a form that can be used to automatically drive a differential rectifier.

It is extremely difficult to assess the likely trend in the use of digitally recorded evaluation data. Air photographs plus identified survey control in themselves constitute a data bank from which digital terrain data can be extracted. However, the Division of National Mapping is already producing contour plots from digital terrain data obtained from the stereomat and, with refinements to the processing, this approach will be used particularly in areas where difficulty is experienced in extracting contour information by other methods. Other users have shown an interest in digital terrain data obtained in this way, but the potential for its use is yet to be fully realized.

In the light of these trends, critical management decisions will be necessary from time to time on the extent of production of normal line maps, lithographically printed copies of orthophoto maps and/or contact orthophoto map prints supplemented by computer stored information. In the meantime, the 1:80,000 orthophoto maps to be produced by the Division of National Mapping will afford a valuable aid to users in the various disciplines concerned.