14th CONGRESS OF THE INTERNATIONAL

SOCIETY FOR PHOTOGRAMMETRY

HAMBURG 1980

COMMISSION IV WORKING GROUP IV.5

INVITED PAPER

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SUMMARY

The work of the W.G. IV.5 is summarised including the present state of the art in orthophotomapping. Emphasis is given to special applications and special reproduction methods and the Report contains microfiche samples of orthophotomapping under a 24x reduction.

ORTHOPHOTOGRAPHY AND PHOTOMAPPING

REPORT ON WORKING GROUP IV.5

GENERAL.

Working Group IV.5 was created with the following aims:

> "To consider the problems of production relating to orthophotographic procedures (especially automated procedures), reproduction and the use of cartographic documents of all kinds".

As a result, the approach of the Working Group has been to contact organisations and/or people directly involved in practical orthophotography and photomapping and to prepare a group of statements for this Congress consistent with the spirit of the stated aims.

The work has been completed in three stages:

1. An Australian orthophoto and photomapping "user" survey.

2. The preparation and distribution of a World questionnaire designed to assess utilisation, production methods, and trends in photomapping generally.

3. The compilation on microfiche of a World collection of orthophotomaps and photomaps.

USER SURVEY.

It would be irresponsible to assume that a "user" survey carried out in Australia would reflect World user opinion in orthophoto, but several aspects of such a survey have been upheld by comments supplied in a World questionnaire supporting the third stage of this Report.

A World "user" survey was contemplated but subsequently discarded when the problems were fully appraised. It is conceivable that similar surveys have been undertaken in other countries and it may be in the interest of a future Working Group to seek, collate, and assess the results of any such surveys.

The Australian survey was organised through the Members of the National Mapping Council of Australia and by their kind assistance, through the various map sales outlets of the nation.

It was a short term project lasting three months, in which period more than 100 replies were received from orthophotomap (O.P.M.) users prepared to complete questionnaire forms proferred at the counters of the various sales outlets. This is not a large sample but it proved to be interesting and representative of a broad group of users. (It is of further interest to note that even now, some twelve months after the survey, completed questionnaires are still being received).

Of the samples originally analysed, some 59% were completed by State and Commonwealth Government Officers and a further 13% by Members of Local Government, yielding a national aggregate of 72% from Government sources.

On a national basis, private companies supplied 17% of the total sample and individuals representing a variety of activities provided an additional 11%.

TABLE 1 -
CATEGORIES OF USER EMPLOYMENT.

User Category	%
Civil Engineers	33
Town Planners	22
Land Surveyors	18
Architects	5
Other	22

TABLE 2 -
DISTRIBUTION OF USES.

	%
Planning	31
Design	26
Valuation	7
Environmental study	16
Recreation	6
Other	14

The Professional user is more often identified with Special Purpose (Project) type mapping. The need is invariably for data which is up to date and there will mostly be a time constraint upon its supply.

The interest of the Professional user is even more obvious when the Australian national production figures are compared with user demand in the various scales of mapping.

TABLE 3 -
COMPARISONS OF PRODUCTION AND DEMAND.

Scale	% Production	% Demand
1:500 - 1:2 500	35	39
1:4 000 - 1:5 000	33	30
1:10 000	15	27
1:25 000	5	2
1:50 000	1	-
1:100 000	11	2

It should be understood that in the Australian mapping environment only the National Mapping authorities are concerned with the 1:100 000 orthophoto compilation programme which assists a derived 1:250 000 map programme through the central, more arid regions of the Continent. The demand is therefore more specialised. Similarly it should be pointed out that the 1:50 000 topographic mapping programme is a limited programme at present. Maps are either compiled at such a scale to serve the 1:100 000 topographic series or to provide a basis for a particular State mapping need.

When orthophotomapping or photomapping is compiled in Series form it is naturally developed in scales and formats consistent with a Standard Map Series, thereby taking full advantage of the existing control data.

A user survey is invariably answered in respect to products which are available rather than in products which might be contemplated. The Australian survey clearly demonstrated the demand in the larger scales and whereas there is an obvious imbalance in the 1:10 000 scale, the remainder of the scales were fairly well matched.

The programme in these larger scales is confined to the State authorities and to the private offices and whilst not all States are in agreement as to the most suitable scales the evidence suggests a common need in series orthophotomaps over urban communities at a scale of either 1:4 000 or 1:5 000 and the need for orthophoto or photomaps at 1:10 000 on a regional basis.

Criticism was directed to the sheet size of certain orthophoto products. The A1 size would seem to be the most popular product. Rarely was comment at variance with the quality of the imagery provided, except in small scales. Both this matter and the matter of a variable contour interval will be discussed in a later section of this Report.

THE WORLD QUESTIONNAIRE.

Questionnaires are the only practical means of gathering widely distributed data in a standard form. International questionnaires suffer mostly due to the various languages pertaining. A questionnaire framed in the language common to a recipient is far more likely to be answered in the same language than one requiring translation.

The questionnaire supporting Commission IV.5 was finally issued in English only after the logistics pertaining to its issue in various languages were fully investigated. The result yielded a 34% return following a written reminder to all concerned.

Although this may be considered a little disappointing the replies covered a broad World distribution of both Government and private office orthophoto producers and in the majority of cases were complete and well prepared.

The questionnaire was in three sections - A, B and C.

Section A was designed to support each sample of orthophoto or photomap supplied by a particular mapping organisation. These samples, with a copy of the completed questionnaire, are contained in the microfiche appended to the Report.

Section B was designed to gain further knowledge of orthophoto production methods at present in use by organisations.

Section C was designed to ascertain production statistics, research and general uses of orthophotos.

A reduced copy of Sections A and B is included as part of this Report.

Some interesting statistics consistent with the period 1976-1980 include:

Fifty-six percent (56%) of producers expanded their operations during the period and 26% of those, representing 15% of the total sample of producers, commenced O.P.M. production for the first time.

Sixteen percent (16%) of those who expanded their operations expected to increase their orthophoto production beyond that of their normal topographical map involvement.

The O.P.M. product, presented directly in diazo or photographic form, or indirectly by further cartographic processing, represents some 35% of the World's topographic mapping and production is seen to be increasing by some 58% of producers.

TABLE 4 -
SHOWING THE PERCENTAGE OF PRODUCERS COMPILING AT EACH OF SEVERAL SCALES.

O.P.M. scale	Percentage of Producers
1:500 - 1:1 000	22
1:2 000 - 1:2 500	51
1:4 000 - 1:5 000	55
1:10 000 - 1:12 000	55
1:20 000 - 1:25 000	32
1:50 000 - 1:100 000	18

The Australian survey indicated a similar trend of production but the World survey expresses greater activity in the 1:25 000 scale. Under scrutiny this increase can be qualified by the number of organisations which use orthophoto and photomaps as dedicated tools of management e.g. Forestry and Soils Sciences. In the majority of such uses, the medium scale products are composited with line or variable colour overlays.

Further to this there are organisations who utilise the medium scale product in series form as the basis of a total cadastral mapping system and others who use it as a companion series.

The best known use of the Orthophotomap as a General Purpose Topographic Series edition is that found in the United States Geological Service. This utilisation was reported upon at the Helsinki Congress and an update given to the Ottawa Symposium on Commission IV in 1978.

The system was initially designed as a means of providing map substitutes in unmapped areas of the United States of America and in servicing a multipurpose need in land use planning and natural resources inventories. Reproduction is in one of two forms - as black and white "orthophotoquads" in a 7.5 minute format with a geographic grid and with a few place names added; or as a full colour topographic map quadrangle using an orthophoto base. These particular maps which include about 10% of the total orthophoto production in the quadrangles are generally prepared when the conventional line maps cannot adequately portray the terrain e.g. extensive swamps or deserts.

Apart from these and some well-known utilisations in Series form, such as the General Land Use (Economic) Map of Sweden, the questionnaire has unearthed a variety of "Series" type applications not all General Purpose in character but mostly including some form of cadastral composite.

Upon reflection, this grouping is a natural development, for in land areas of little cultural development, the cadastral fabric and the pictorial map presentation of the ground have a strong interdependency - one map enhances the value of the other. The "Jessiman" method of line enhancement on orthophotomaps maximises the thematic effectiveness of the union. Additional advantage is taken in colour printing.

In land areas of increasing cultural development there is a lesser interdependency. As "planning purposes" provide the principal reasons for large scale orthophotos, this relationship with the cadastral fabric is a matter to aid the planning rather than enhance the value of the orthophoto.

Large scale orthophotos have the added value of greater resolution in ground detail and suffer the fate of most large scale mapping in that they are more quickly out of date. It is not uncommon to find the cadastral/orthophoto union achieved by separate transparent overlays. Reproduction is most likely to be by diazo process.

In a paper to the Ottawa Symposium on Commission IV in 1968, P.B. Stewardson outlined the three basic links in the process of preparing an orthophotomap. They were:

1. The original photographic image.
2. The geometric data serving as the basis of the photographic transformation and
3. The transformation itself.

His paper traced important quality constraints in each of the links and as such it is an important document for those seeking to advance the greater utilisation of the orthophoto product.

Only about 50% of the respondents to the questionnaire were prepared to answer questions relating to image specifications and in the majority of such answers there was little uniformity.

Compared to the constraints outlined by Stewardson, most producers obtain excessive density ranges in the final generation O.P.M. negative. He suggests developing the O.P.M. negative to a density ranging from .2 to .3 above fog through a range of .7 when considering diazo reproduction and a lesser range for photographic reproduction. Production values of .4 to 1.6 were not uncommon from the survey.

This fact indicates that some producers are seeking a "special purpose" impact by building a product of aesthetic quality, servicing a particular need and whilst this in itself is praiseworthy, it should be retained for special purpose applications only.

AUTOMATED AND DIGITAL PROCEDURES.

Image Correlation Techniques have not been reported to be widely used for routine O.P.M. production except in the U.S.G.S. and seemingly is restricted to medium and small scale programmes.

The Institute Geographica Augustin Codazzi (I.G.A.C.) Bogata, Columbia, have recently installed a Gestalt Photomapper II (G.P.M.II) to produce stereo-orthophotos as part of an integrated cadastral mapping system (Cadastre Latin America). The general technique is that described by Blachut (1976).

Digital Control Techniques are associated with producers who have entered into orthophoto production in the past four years and to the one or two other producers who have added digital modifications to existing analogue control systems.

The technology and software allowing compilation of a desired contour from digital elevation data does not appear to be routine production. Exceptions are to be found in the U.S.G.S., the Geodetic Institute of Denmark and the National Land Survey of Sweden. In the case of the last named, contour information is extracted from a Land Data Bank.

Digital control techniques which include automated correlation have been reported as being in practical operation by 36% of respondents to the World questionnaire.

REPRODUCTION METHODS.

Continuous tone photographic systems and half tone diazo or offset reproduction techniques are the basic procedures available to the producer. Both are well tried and find favour according to the manner and scale of the map sought. Large scale productions are more likely to utilise photographic or half tone diazo processes whereas the medium and small scales are likely to be created from half tone offset methods.

Random Dot (R.D.) - attempts to compromise the problems of poor image particularly in the medium and smaller scales. The technique "manufactures" a screen for each image and creates a random dot unique for the particular image to be reproduced rather than creating a regular dot screen. The screen is manufactured by over-exposing the O.P.M. negative to a UV light source and passing the resultant positive latent image through a fixing bath only.

The action of the UV light on the film emulsion partially develops the silver crystals and with further processing forms an R.D. screen to breakup dense image detail in the printing down process.

In effect, when the R.D. screen is printed down with the O.P.M. negative, the resultant positive image is a combination of continuous tone and R.D. tone in the highlights and shadows of the total image.

Experimental work and practical experience has been reported upon from both the U.S.G.S. and Australia.

Analogue Edge Enhancement (PICTOMAP) has been reported upon from Great Britain, Israel and Australia.

The technique creates a hard black line along the edges of images of contrasting density by superimposing an edge enhancement overlay during the printing down process. This overlay is created from an image processed as a false negative made from a composite of the original continuous tone negative and a continuous tone positive transparency. This composite is demanding of the misregister of the continuous tone positive transparency in terms of the continuous tone negative in the direction of the fall of the shadow detail. This misregister creates a small negative window which when printed down to a positive, forms a black edge line overlay. This overlay is then finally printed down with the original tone positive transparency to a contact negative or positive depending upon the type of reproduction to be used (ie offset or diazo).

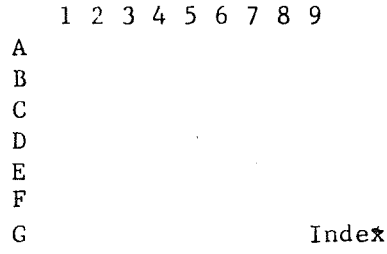
Density "Dodging" Techniques. This allows mosaicing to take place from a variety of negatives with greatly improved join quality using the "montage" method. The equipment includes 236, 7.5 watt bulbs which illumimate a 24" x 30" exposing surface. Each bulb is on a reostat which can raise, lower or extinguish the intensity of light. From the example given (Microfiche F7) the results are impressive.

Automated Optical Scanning systems with associated playback has been reported from Canada (Alberta Transportation), but little further information is known.

THE MICROFICHE SAMPLES.

The original intention of the Working Group was to produce two microfiche each of some 56 samples, one in colour and one in black and white. Unfortunately only 16 colour samples were received plus an additional 50 samples in black and white.

A total of 62 samples have finally been combined in COSATI format to form a single microfiche in black and white, containing 7 columns of 7 samples, plus 1 column of 6 samples, plus an index in the bottom right hand corner.



The samples have been grouped according to scale, ranging from 1:500 (3 samples) to a 1:500 000 sample of a coloured Landsat image.

The original supplied copies have been reduced by a factor of 24. All original samples were 24cms x 24cms and attached to the right-hand side of each was a completed questionnaire outlining the manner of its compilation. The overall size of each original copy was therefore 36cms x 24 cms and the reduced size on microfiche is 1.5cms x 1 cm.

Every endeavour has been made to ensure the quality of the reduced images and each of the 2000 copies provided. To further support this aspect of Working Group IV.5, the original samples have been grouped and displayed in the display area of the Congress and colour microfiche and reader made available.

Photomapping is particularly a function of pictorial quality and cartographic enhancement. Such an enhancement lifts an image out of the ordinary and projects it in support of a theme. The many themes provided by the samples can only be understood by careful examination of the products. Unfortunately the lack of colour in the microfiche does much to lessen the thematic impact.

SUMMARY.

Modern cartography implies the graphical, pictorial or digital treatment of basic and/or derived map information data.

Photomapping using either aerial photography or satellite imagery can claim to be the principal means of pictorial cartographic treatment.

Orthophotomapping derived as a result of differential rectification of the basic aerial photography has claim to being a total mapping system, for the source data readily provides the third dimensional measurement and unlike satellite imagery is operative through all scales of present day mapping.

Further to this, it binds itself to virtually any thematic or special purpose work including non-topographic applications. Its role is further enhanced by the development in stereo-orthographic systems and equipment.

The research has shown:

1. Rarely is the manufacture of an orthophotomap considered to be a special cartographic application, demanding of specially skilled operators working in a team environment responsible for the full range of planning and production tasks demanded.

   ie - From the design of the aerial photography specifications to quality acceptance of the aerial negative; from the manufacture of the diapositive to the quality acceptance of the diapositive; from the photogrammetric creation of the orthophoto product and its subsequent production and cartographic enhancement, to quality acceptance of the finally printed product.

2. Many Government agencies are seen to be creating a General Purpose "Series" product for a Special Purpose need and the product is proving to be inadequate, often out-of-date and a poor base for additional thematic enhancement.

3. Whilst digital storage techniques offer the most practical and economical methods to store and retrieve a data profile record, this capability is available to less than 50% of present-day producers.

4. The intention to revise existing maps has been indicated by 43% of producers but 10% of this category have no facility to retrieve a profile record. This time span for revision ranges from 3-15 years and is seen as being "scale dependent".

5. The general user prefers a symbolised perceptive presentation whereas the professional user is more concerned with current information provided in the speediest and most practical way.

6. It suggests a need for a two tiered mapping system founded upon digital recording and profiling systems adequately designed to service special purpose and general purpose applications.

7. It suggests that ideally the role of the orthophoto producer should emerge as that of a provider of up-to-date map information data in digital or picture form sufficiently flexible for use in a wide variety of cartographic applications.

8. It suggests that such flexibility will not be achieved until topographic data bases are readily available for all producers, but as an interim measure it requires producers to acknowledge the weakness of the present analogue systems and to be innovative in developing present digital technology to benefit the orthophoto process.

9. It suggests that much is to be learnt from systems at present operative in the processing of satellite imagery.

10. That, aided by the simple equipment now under development, stereo-orthophoto systems will complete the full potential of ortho-mapping to vie as a total mapping system. Such equipment will allow the professional user to manipulate interpreted map data, including height to the maximum advantage of a particular study.

The following Authorities have indicated current research:

Authority	Subject
United States Geological Survey	Dual camera systems for false colour reproduction.
Alberta Transportation, Canada	Automatic optical scanning and playback for improving the quality of poor imagery.
National Research Council,Canada	Stereo-O.P.M. presentation specification for image quality.
North West Survey Corporation, Int., Canada.	Blockout - bleed mask line enhancement technique.
Survey of Israel	O.P.M. applications to geology.

Authority	Subject
International Institute for Aerial Survey and Earth Sciences, Netherlands.	Developing software for non-standard processor - controller for Wild ORl, to input any form of D.H.M., G.C.P. and camera data.
Institute Geographic Nationale, France.	Exploitation of the stereomate for civil engineering purposes. Development of the Ortoster simple stereo compiler for viewing and measurement of stereo-orthophotos.
Fairey Surveys Ltd., Great Britain	Has developed a complex production control system.

The following Authorities have indicated a willingness to undertake further research:

United States Geological Survey
National Research Council, Canada
Penas, Indonesia
National Land Survey, Sweden
Geodetic Institute, Copenhagen, Denmark
Institute Geographic Nationale (I.G.N.) France
Technical University, Austria.

RECOMMENDATIONS

The Working Group offers the following guidelines for further research on Working Group activity.

1. The development of specifications guiding image quality at the source (aerial negative) and for reproduced imagery from both analogue and digital *(M.S.S., C.C.D.) format.

   Such specifications should consider the general "falling off" of image resolution through the various stages of production and provide guidelines for processed density ranges in -

   (a) Photographic reproduction.
   (b) Diazo reproduction.
   (c) Screen Printing methods.

2. Investigate the general compliance of computer derived contours from D.E.M.'s with present map accuracy standards including -

   (a) Digital profile scanning.
   (b) Digital "string" recording of contours.
   (c) Stereo-orthophoto compilation.

3. Establish specifications for image enhancement using researched methods of: Random Dot plus analogue and digital techniques.

* Multi Spectral Scanner, Charge Couple Device.

ACKNOWLEDGEMENT.

The Working Group has included a local Committee of three - Messrs. P. Boniface, P. Byrne and J. Szorenyi plus Secretary and Chairman. It has a debt to a variety of people and organisations including the instrument manufacturers but most particularly it has relied upon the energies and interest of its Secretary, Mr. R. Fieldgate, who has been responsible for much of the preparation and analysis of data now presented in Report form.

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