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RECENT TRENDS OF THE PRODUCTION OF
ORTHOPHOTOS AND STEREOORTHOPHOTOS

SUMMARY

International trends in production and application of orthophoto maps are systematized on the basis of trends in aerial photography in West Germany (increasing number of flights, predominance of scales larger than 1:20 000, growing application of color and color infrared photography, as well as of scanners). Trends in orthophotography are derived on the basis of the Austrian practice (application of two different image materials for data acquisition and for image projection, edition of the Aerial Photo Map 1:10 000, color infrared orthophotos as basis for an environmental cadastre, and so on). Experiences with stereo-orthophotos are treated in a special section. The STEREOGRAPH for compiling stereo-orthophotos has been described in the hope that it would facilitate the application of stereo-orthophotos in other disciplines. Finally, on producing large format orthophotos of scanner images is reported.

ZUSAMMENFASSUNG

Ausgehend von den gegenwärtigen Trends in der Luftaufnahme in der Bundesrepublik Deutschland (steigende Anzahl von Bildflügen, Dominanz der Bildmaßstäbe größer 1:20 000, steigende Verwendung von Farbfilmen und Farbinfrarotfilmen sowie von Scannern) werden die international gesammelten Erfahrungen mit Orthophotokarten mitgeteilt und daran anschließend die in Österreich erkennbaren Trends in der Orthophotographie (unterschiedliches Bildmaterial für die Datenerfassung und für die Umbildung, Herausgabe der Luftbildkarte 1:10 000, Farbinfrarot-Orthophotos als Basis eines "Umweltkatasters" etc.) zusammengefaßt. Den bisherigen Erfahrungen mit Stereoorthophotos ist ein eigenes Kapitel gewidmet. Zur Betrachtung und Auswertung der Stereoorthophotos wird der ROST-STEREOGRAPH in der Hoffnung vorgestellt, damit eine größere Verwendung der Stereoorthophotos bei anderen Disziplinen zu stimulieren. Abschließend wird auf die Herstellung von großformatigen Orthophotos aus Scanner-Aufnahmen eingegangen.

1. PRELIMINARY REMARKS

The production of orthophotos and stereo-orthophotos start with aerial photography. Therefore, it will be appropriate to consider first, recent trends of aerial photography, and to treat trends of the production of orthophotos and stereo-orthophotos afterwards.

2. TRENDS OF AERIAL PHOTOGRAPHY

As a gesture towards the host country of this 14th Congress, aerial photography in West Germany is analyzed here: trends derived from this example are representative for many other countries of the world.

Aerial photography in West Germany is systematically registered since 1954 by the Institut of Applied Geodesy (IFAG) in Frankfurt. Based on these records, and on private information from Prof. H. Schmidt-Falkenberg, the following trends can be derived:

- a) the area covered by aerial photography tends to be larger with each year. In each of the recent years, there has been covered an aerea of more than 100 000 km², corresponding to about 50% of the aerea of the entire country. The corresponding percentage in 1967 was 14, and in 1957 just 7.
- b) Large scale aerial photography is predominant: some 60% of the yearly coverage (about 60 000 km²) is flown in scales larger than 1:20 000.
- c) While black-and-white photography remains prevalent, there is a growing tendency toward the application of other photographic materials. Color aerial photography has been first applied in 1959, and color infrared photography in 1967. Today, about 10% of aerial photography projects (not of coverage) are using color films, and 3% are using color infrared materials.
- d) Only about 60% of aerial photographs are used for determining coordinates of points or for creating line maps. The remaining 40% are converted into orthophotos or applied in photo interpretation.
- e) Beside conventional aerial cameras, scanners are applied since 1972. In 1976, for example, an area of 4.290 km² has been covered by scanner images, and in 1979 - 1580 km².

Environmental protection is the major direct or indirect course for growing activities in aerial photography, and for recent trends toward methods yielding more rigorous and complex characteristics of the natural and cultural environment. Elementary needs of the population have been satisfied by the great technical and social achievements of modern industrial civilisation, and now there is a spreading consciousness of the need for man to be a partner rather than a tyrant of nature. This ecologically motivated point of view is widely expressed by demanding

- all engineering to go along with environmental protection
- a more general resource management and control
- the state of environment, and all changes in it to be regularly monitored.

All these demands are hardly managable without the modern techniques of aerial photography and photogrammetric compilation.

3. ORTHOPHOTO MAP AND/OR LINEMAP

The production of orthophotos, or of orthophotos with cartographic elements added (especially of contour lines) - in other words the production of orthophoto maps - can be considered as one of the photogrammetric compilation techniques. This techniques has been made more appealing by considerable advancements of recent years concerning both the equipment and the methods applied. The chairman of the working group IV-5, Mr. D. I. Glendinning, has shown on the basis of his inquiry via questionnaires, that 56% of orthophoto manufacturers have expanded their orthophoto equipment during the years 1976 to 1980. Of these manufacturers, 26% are private or governmental organizations that started orthophoto production for the first time. Some of the other results of the inquiry mentioned show that most orthophotos and orthophoto maps are produced in scales 1:2000 to 1:12 000.

To the question how far orthophoto maps are accepted in our days, let me quote some authors from the Proceedings of the International Symposium of the Commission IV in Ottawa, 1978:

R. R. CHAMARD, U.S. Forest Service (p.54): The orthophoto is a layer of the Primary Base. It is an important layer, especially so, for the various National Forest management specialists. To have a photographic image of the land cover is better than any line map by itself. Combining various layers or plates of the line map with orthophotos is very useful and of high demand.

K. J. LESTER, South African Survey (p.252): It is perhaps appropriate to pose the question: Why use an orthophoto to revise a line map? Should the orthophoto not in fact replace the line map? Many cogent reasons could be stated in favour of either series. ... Serious consideration is being given to publishing the orthophoto in monochrome on the reverse side of the line map.

G. E. BELLING, Photosurveys Ltd., South Africa (p.282): These orthophoto maps 1:2 000 - enhanced with cadastral and contour information - provided the basic data for rout examination, evaluation and selection and in the opinion of the user engineers were far more suitable than the previously used line mapping. Orthophoto strip mapping has since become standard procedure for almost all projects relating to railroad planning and desing in South Africa.

P.A. BATES-BROWNSWORD, Australian Army (p.513): The enhanced orthophoto map has been well received by the user.

S. DEQUAL, Professor of Surveying in Torino (Italy) (p.525): There are numerous reasons for the slowness in the production of traditional cartography. In this situation the Marche region has decided to use the orthophoto technique for its cartography, taking care, moreover, that each phase of the productive process is automated to the maximum.

R. B. SOUTHARD, U. S. Geological Survey (p.601): Orthophotoquads have proved useful as map substitutes in unmapped areas, as important time-saving aids in photorevision and stereocompilation, and as multipurpose cartographic bases for Federal, State, and private agencies concerned with land-use planning and natural-resource inventories. Developments in orthophoto instrumentation, improved quality, and digital data applications have led the U.S. Geological Survey to make orthophotomapping and digital terrain data acquisition a significant part of the National Mapping Program.

I. F. G. WHITTINGTON, Royal Australian Survey (p.629): The urban orthophoto map provides an economical large scale topographic map in areas where no other suitable mapping exists.

On the other hand, one finds similarly striking opinions in favour of line maps. Line maps, especially in smaller scales, are renowned products of our profession. There should and will not be changed anything in this respect. For the future, I expect orthophoto maps and line maps both to be applied, each there where it suits the specific purpose better. In critical cases, however, orthophoto maps will more often be the choice, they being manifold cheaper than line maps are (see, e.g.) W. H. Young and D. M. Isbell, p.348 of the mentioned Proceedings of Commission IV, Ottawa 1978).

4. NOTICABLE TRENDS IN AUSTRIA

Austrian orthophoto manufacturers are among those 26% of Mr. Glendinning's inquiry who first introduced orthophoto production in or past 1976 (with the exception of some small contracts for foreign firms). An Avioplan OR 1 /13/ is used for orthophoto projection. Data recorded on some 10 stereocompiling instruments is processed by the program package SORA-OP /9, 10/. Trends of these four years of production will be representative in the first line for countries similar to Austria. First technical trends will be treated, and then those of application.

- a) Most frequently, there is used one aerial photography for the projection, and another one for data acquisition.

	photography for the purpose of	
	data acquisition	projection
date	some existing coverage from the archives	fresh photography flown shortly before projection time
film sort	black-and-white	corresponding to the purpose of orthophotos (e.g. color infrared)
optics	wide angle	focal length as long as possible
overlap	60%	if there is certainty that this photography will not be stereoscopically compiled: 20%
photo scale	a) 1:30 000 b) 1:15 000	a) 1:30 000 to 1:15 000 for orthophotos 1:10 000 to 1: 5 000 b) 1:15 000 to 1: 8 000 for orthophotos 1: 5 000 to 1: 2 000

- b) If there is freedom of choice in this respect, there is a tendency of choosing larger formats of orthophotos than that of the line map of the same scale. E.g. the state Steiermark is producing orthophoto maps 1:5 000 of format 60 x 60 cm², out of a photography 1:20 000 /8/.
- c) As opposed to their importance in West Germany, color photographs do not play any remarkable role in Austria. On the other hand, there is produced a relatively large amount of color infrared orthophotos. Their share is expected to grow still considerably larger in the coming years.
- d) Are contour lines to be shown on the orthophoto map, they are in general digitized directly in stereocompiling instruments. There is, however, a growing readiness to accept contour lines derived by programs (e.g. by SCOP /1/) from digitized profiles and break lines, with computational costs becoming lower, and the quality of results growing higher.
- e) There is considerable demand for orthophoto maps with lines of equal terrain slopes shown on them. Such lines can be derived from the digital height model.
- f) Repeated application of the data digitized once, made it necessary to develop a special software for archiving terrain height information. This same software controls the archiving of aerial photography, and that of orthophotos as well. This software is entitled TOPIAS (Topographic Information and Archiving Software). Detailed information on it is to be found in presented paper /5/.
- g) Orthophoto production within the frame of program TOPIAS, SORA-OP and SCOP is a topographic information system. In Austria, this system is more and more regarded not only as a technically advanced one, but as one feasible in respects of economy and of time. In this topographic information system horizontal terrain information is represented by the photographic image; it can be automatically compiled applying the archived digital height model. Information on heights, in the form of contour lines or lines of equal slope, can be derived by computation from these same data.

The following trends can be derived concerning application of orthophoto maps:

- h) At the Federal Department of Standards and Surveys, orthophotos of scale 1:10 000 are produced for the purpose of updating line maps 1:50 000. These same orthophotos are edited as the independent map system "Aerial Photo Map 1:10 000" (At this time without contour lines). For this purpose, about one quarter of the territory of Austria has already been digitized in profiles of a density 30 to 160 m. For the half of the digitized area, orthophotos have been produced. There is considerable demand for the completed sheets of this map.
- i) Private forester companies are gradually changing from line maps to orthophoto maps. They generally prefer orthophotos in scale 1:5 000, partly with contour lines added.
- j) State governments prefer for their purposes - mainly for regional planning - orthophoto maps 1:5 000.

- k) With the financial help of the Federal Ministry of Health and Environmental Protection, some larger cities are preparing color infrared orthophotos 1:2 000 or 1:2 500.
- l) Designing highways and hydro-electric plants has been accomplished a couple of times using orthophoto maps. These having been successes, one can expect such applications to become a clear trend in the future.
- m) Finally, agriculture, glaciology, and archeology should be mentioned as areas where orthophotos have been - and probably will be - successfully applied.

5. STEREO-ORTHOPHOTOS

Although the first stereo-orthophotos have been produced by the National Research Council in Ottawa as much as 13 years ago, no break through towards wider applications has yet been achieved, as to my knowledge. At that time, economically feasible methods and instruments were missing. Nowadays, extremely precise stereo-orthophotos can be produced much cheaper, applying digitally controlled orthophoto projectors /9/, or instruments of the type Gestalt Photo Mapper II /14/.

To a certain extent, these new capabilities have already gained practical application. At the Institute of Photogrammetry of the Technical University of Vienna, some hundreds of stereo-orthophotos have yet been produced for Austrian, but in the first line for foreign contractors. The program SORA-OPS /9/ to determine control data for the production of orthophotos and their stereo-mates, has been sold to 5 organizations.

There are some positive reactions available. The IGN in Paris organized a special symposium on applications of stereo-orthophotos. From the reports published, that of E. Gros /4/ should be mentioned; he is reporting on the application of stereo-orthophotos in designing highways. R. Finsterwalder /3/ advocates the production of topographic maps with a technology based on stereo-orthophotos. The Federal Department of Standards and Surveys in Vienna is experimenting with the application of stereo-orthophotos in updating line maps.

Users of stereo-orthophotos are complaining about the missing of corresponding devices for the compilation of stereo-orthophotos of large formats. Similar problems are reported by Ducher /2/ in France. One can state, that a provision of any break-through in stereo-orthophotos applications is the availability of a corresponding instrument to compile them.

In cooperation with the ROST Co., Vienna, the Institute of Photogrammetry of the Technical University of Vienna developed the STEREOGRAPH (fig. 1) for the purpose of viewing and compiling stereo-orthophotos. On the desc of the STEREOGRAPH, there is place for an orthophoto of the maximal format $65 \times 65 \text{ cm}^2$, and for the corresponding stereomates on both sides. With a stereoscope rolling on parallel rails, and setting a viewing base of 38 cm, one can view stereoscopically the entire $65 \times 65 \text{ cm}^2$ large model in a convenient manner. Transparent films can be illuminated through the base.

Setting the viewing base of the stereoscope to 65 cm, and working with just the orthophoto and one of its stereomates, it becomes possible to place between them a sheet of paper or another copy of the orthophoto itself (fig. 2).

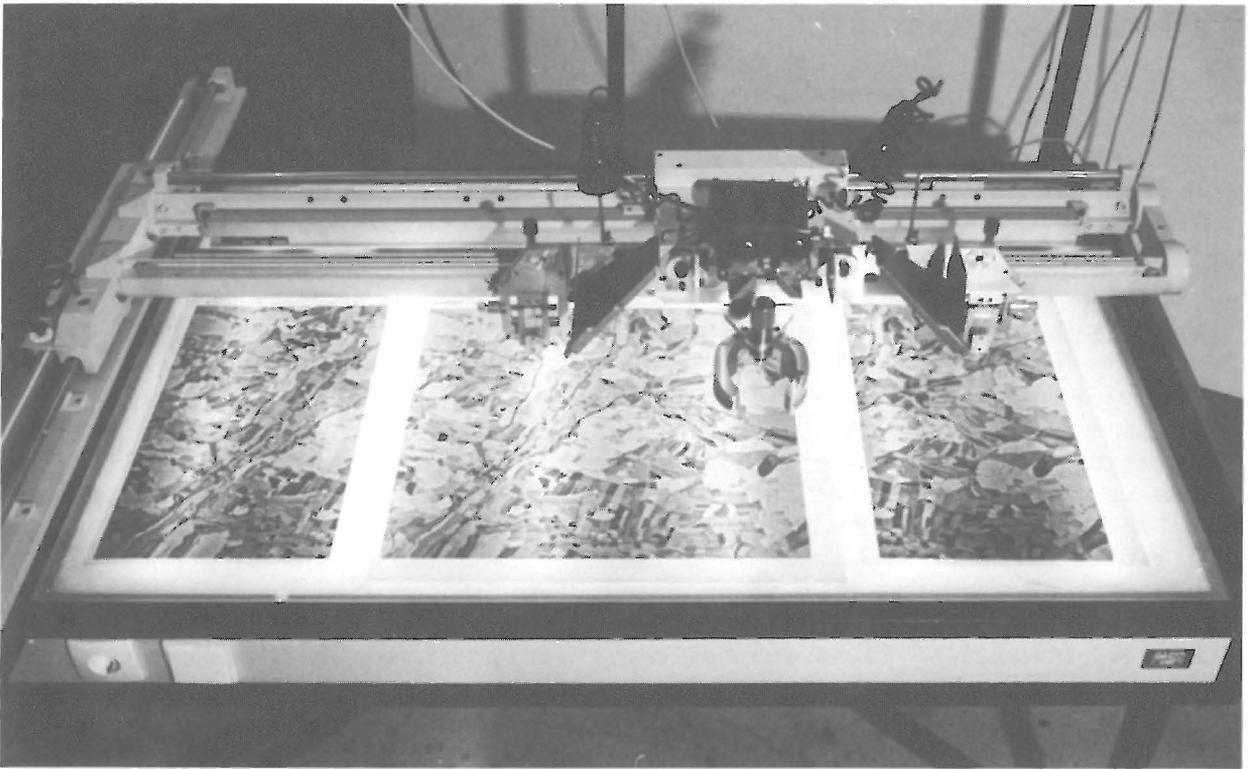


Fig. 1: STEREOGRAPH when observing stereo-orthophotos

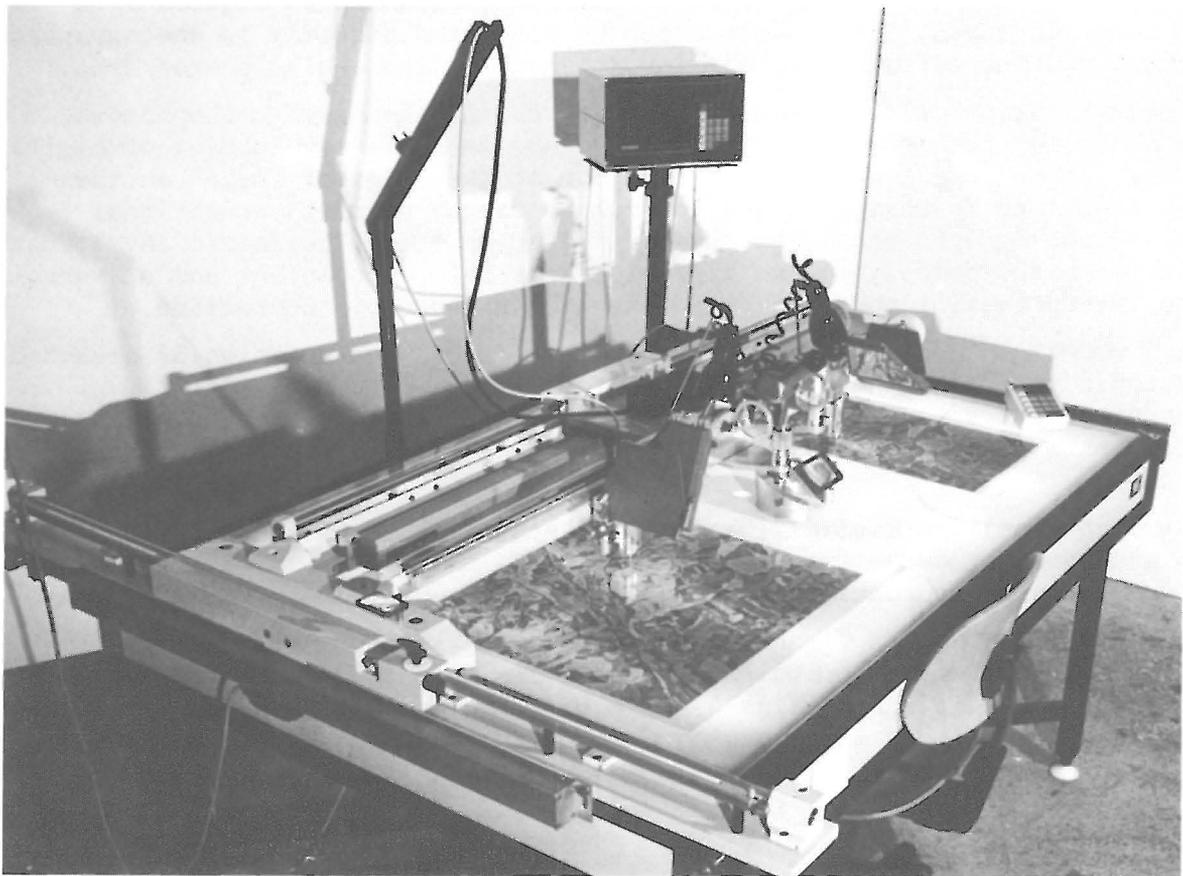


Fig. 2: STEREOGRAPH when compiling stereo-orthophotos

To compile just horizontal contents, one measuring mark can be used on the side of the orthophoto. Its movements can be graphically recorded with the drafting device (pencil, ink etc.) on the sheet on the desc in front of the operator. The version STEREOGRAPH-D 1 of the instrument is provided with impulse generators for digitally recording the movements of the measuring mark on some standard electronic recording equipment. For compilation of heights, a second measuring mark can be used, and moved along the X-axis via a micrometer.

In my opinion simple compilation of cheap orthophotos will be done, in most cases, not by photogrammetrists but by photo interpreters of other special lines. They are, as mentioned in section 2, the main initiators of many projects in aerial photography. It seems natural to them, that the negative image has to be photographically developed first. This chemical process is, however, just half of the development: the second half being a geometric process consisting itself of two major tasks. The first of these is the conversion of the distorted image into a geometrically correct one (the orthophoto) showing geometric qualities of a map. And the second task of this geometric development is the conversion of the same photographic image into another one (the stereomate), for the purpose of stereoscopic viewing and measurements. Both these tasks of the "geometric development" are major provisions for a secure, convenient, and universal application of information contained in aerial photographs.

6. RECTIFYING SCANNER IMAGES

A paper dealing with next future would hardly be complete without treating scanner images. They make up a couple of percents already, as mentioned in section 2. This percentage will probably grow larger in coming years.

Information gathered by scanners is generally recorded in digital form on magnetic tapes. These records can be converted directly to photographic images showing deformations similar to those of the aerial photographs.

A rectification of such images, i.e. converting them into orthophotos is naturally possible. However, with regard to rapid development of digital image processing, a direct rectification of the "digital image" on the magnetic tape is better suited for future usage. Just as conventional aerial photographs should be interpreted after their "geometric development" (stereo-orthophotos), so are digital images safe, convenient and universal for interpretation purposes only after their geometric correction.

Such geometric correction of digital images means the creation of a second magnetic tape with the pixels of the first tape rearranged. This rearrangement yields a constant scale, and a reference to the geodetic coordinate system. Generally, such rectified digital images have meridional sides.

Although rectified digital images are further processed in computers, there is a demand for converting them into (color) photographic images. In this, large formats and round scales are generally requested.

The AUSTROPLAN Co. in Vienna succeeded in creating an instrument capable of fulfilling the above demands /6/. The device handles formats up to $1 \times 1 \text{ m}^2$ and any requested scale (fig. 3). The software needed for controlling this process is described in presented paper /7/.



*Fig. 3: Device to output digital images,
of the AUSTROPLAN Co., Vienna.*

In the yet most extensive project, the rectified image (orthophoto) has been composed of 7 somewhat overlapping strips of thermal imagery.

7. CLOSING REMARKS

Research in optics, physics, television and electronics is continuously yielding new systems for image recording. Periodically, the chemical industry succeeds in improving photographic materials. It is the task of photogrammetrists to bridge the gap between image recording methods, on the one hand, and interdisciplinary applications of these digital or photographic images. In this, a major part is the transfer of originally digital and photographic images with a distorted geometry impractical for applications, into digital and photographic images with a geometry that makes them convenient to use.

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