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Digitally Controlled Production of Orthophotos and Stereo-Orthophotos*

The computer programs are described, production procedures are reviewed, and results of accuracy tests of orthophotos and stereo-orthophotos are presented.

Abstract: *The Avioplan OR 1 digitally controlled rectifier was introduced by the Wild Company at the XIIIth Congress of the ISP. The corresponding software package* SORA *was presented to the Congress by the Institute of Photogrammetry of the Technical University of Vienna. Since the beginning of 1977 the Institute of Photogrammetry has produced several hundred orthophotos and stereo-orthophotos. In addition to black-and-white photographs, a growing number of color photographs have been rectified. The use of the software package* SORA *is analyzed. A multiplicity of data acquisition procedures, computational requirements, and production times for the rectification process are discussed. An empirical accuracy study of orthophotos and stereo-orthophotos has been performed on the basis of known coordinates of targeted points. In the closing section, the new version of the program for stereo-orthophotos,* SORA-OPS, *is described in detail. With it the production of all known types of stereo-orthophotos is possible.*

Introduction

By conversion to digital control an orthophoto printer can be used in conjunction with a general purpose computer. Furthermore, basing the projection control on photo coordinates rather than on model coordinates results in the relationship between the (digitized) stereo model and the photograph to be converted to an orthophoto being determined in the computer. Thus, the orthophoto printer becomes an off-line peripheral device connected to general purpose computers, and the implementation of various alternatives in orthophoto production becomes a programming task instead of a problem in precision hardware fabrication.

The Wild Company introduced at the XIIIth Congress of ISP in Helsinki the digitally controlled rectifier Avioplan OR 1 (see Stewardson, 1976). The corresponding SORA (Software for Offline Rectification with Avioplan) computer program was developed under a contract from the Wild Company by the Institute of Photogrammetry of the Technical University of Vienna. This paper describes this hardware and software.

The first part contains an interim report on the two years of production application of digitally controlled orthophoto printers. The second part describes the program for stereo-orthophoto production, available

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since the summer of 1978, and the experience with its first practical applications.

Computer Program for Orthophoto Production

The main purpose in program SORA-OP (*O*rtho*p*hoto) are as follows: (1) absolute orientation of the model or, when an orthophoto of an entire photograph is produced, of the double model; and (2) height interpolation of points in a square *XY* grid. The resulting points are known as the Digital Height Model (DHM). Either four or eight of the closest points in four quadrants are used for interpolation. The interpolated height is determined as a weighted mean with weights reciprocal to the quadrat of point distances (Otepka and Loitsch, 1976). The weighted mean procedure could be replaced, without much effort, by other interpolating algorithms (such as moving average, prediction, etc.).

Following the DHM interpolation, the exterior orientation of the photograph is determined by employing control point information. For non-metric cameras interior orientation is also determined. Thus, prerequisites for transforming the DHM into the photograph are present. Photo coordinates are then stored on magnetic tape for controlling the Avioplan OR 1.

Details, especially regarding optional data input and corresponding paths in data processing, are given by Kraus (1976) and Otepka and Loitsch (1976).

SORA-OP is written in standard FORTRAN and can be installed on computers with either 60-bit words (CDC, etc.), 32-bit words (IBM, UNIVAC, etc.), or 16-bit words (HP, NOVA, PDP, etc.). Such standard programming has the advantage that just one version of the program need be kept up to date. The price of this advantage is the need for a somewhat longer computing time on computers with 60 or 32 bit words as compared with programs written specially for these (large) systems.

By now, SORA-OP has been delivered to 19 customers. Table 1 contains data for different computers with regard to the core required by the program, and on CP and CPU time needed for a run in a typical production application. As reported by program users, computational costs amounted for this example to 250-1000 Austrian Shillings, corresponding to $17 to $70.

Because blunders were present in the data, especially in control points, some 25 percent of the computations had to be repeated applying corrected sets of data.

Computational costs constitute some 5 percent of the total cost of orthophoto production (flight, aerial triangulation, data acquisition, transformation on the OR 1). The economy of the process rises abruptly when applied to new aerial photography in an area where the DHM has been created and stored in previous tasks (Kraus, 1976; Otepka and Loitsch, 1976).

Precision of Orthophotos

Known accuracy studies of orthophotos (among others, see Blachut and van Wijk, 1976) assume that the profile spacing, *P*, in data acquisition is equal to the slit width, *S*, of differential image projection because classical orthophoto devices presuppose such equality. One of the special features of the technology based upon the program and the SORA program and the OR 1 is the total separation of data acquisition (digitizing the terrain surface) from the process of differential projection. Therefore, accuracy characteristics of orthophoto technologies have to be extended in the following two respects:

- data acquisition in the form of profiles, but

TABLE 1. CORE STORAGE FOR SORA-OP AND COMPUTING TIME FOR ONE ORTHOPHOTO (DOUBLE MODEL, FORMAT 60 BY 60 cm², 12 000 REGISTERED POINTS, 5 800 COMPUTED DHM POINTS, SLIT WIDTH IN ORTHOPHOTO 8 mm)

Computer	Core storage	CP resp. CPU-time (sec)
IBM 370/168	200 K bytes (8 bits)[1]	68
CDC CYBER 74	29 K words (60 bits)[1]	105
IBM 370/158	104 K bytes (8 bits)	135
UNIVAC 1100/22	23 K words (36 bits)	214
SEL 32/55	98 K bytes (8 bits) 24 K words (32 bits)	246
SIEMENS 7750	199 K words (8 bits)[1]	314
IBM 360/67	220 K bytes (8 bits)[1]	326
RANK XEROX 530	22 K words (16 bits)	—

[1] without overlaying.

with profile spacing smaller or larger than the slit width ($S \neq P$); and
- data acquisition in the form of contour lines.

DATA ACQUISITION IN THE FORM OF PROFILES

The well-controlled accuracy test "Hirschbach" was performed with the SORA-OP program and the OR 1 by Otepka and Duschanek (1978). There were 76 targeted points scattered in an irregular pattern over a double model. Maximum height differences were about 300 m and the mean slope angle of the terrain equalled 13^g. Along some straight lateral profiles there were, on the average, ten main inflection points (beside minor terrain formations). The number, T, of inflection points will be used to characterize the irregularity of terrain surface (in the Hirschbach case, $T = 10$). Aerial photography: Wild RC 8, $c = 153$ mm, photo scale 1:15 000. Compared with the Ripon test area (Blachut and van Wijk, 1976), characteristics of both the terrain and of the aerial photography are slightly more extreme.

For a profile spacing, P, at data acquisition and a slit width, S, in differential image projection equal to each other, accuracy characteristics have been derived as shown in Figure 1, based upon numerical information contained in Otepka and Duschanek (1978) and completed with supplementary tests, and upon some basic considerations.

The standard error $m_p = (m_x^2 + m_y^2)^{\frac{1}{2}}$, as given in Figure 1, depends on

- profile spacing, P, at the stage of data acquisition;
- the standard error, m_a, of data acquisition expressed as parts per thousand of the flying height or parts per thousand of the camera constant, c; and
- terrain surface irregularity, determined as the mean number of inflection points, T, within any of the lateral profiles of the double model.

The accuracy, m_a, of profiles can be determined by scanning some typical part of a profile in both directions. As rough estimates, the following extreme values of m_a can be applied as a function of the scanning spead (Marckwardt, 1978; Schneider, 1969) (expressed in mm/sec in the photo):

$m_a = 0.4$ ‰ c: flat open terrain (without woods and buildings), scanning speed 2-3 mm/sec; or steep open terrain, scanning speed about 1 mm/sec.

$m_a = 0.8$ ‰ c: Average, wooded terrain, buildings, scanning speed about 3 mm/sec; or steep, wooded terrain, buildings, scanning speed 1-2 mm/sec.

Examples: (1) Given aerial photographs with the following specifications: scale 1:30 000 for both data acquisition and orthophoto production, camera constant $c = 150$ mm; terrain with $T = 10$ inflection points; precise profiling of open terrain (without woods and buildings) with $m_a = 0.4$ ‰

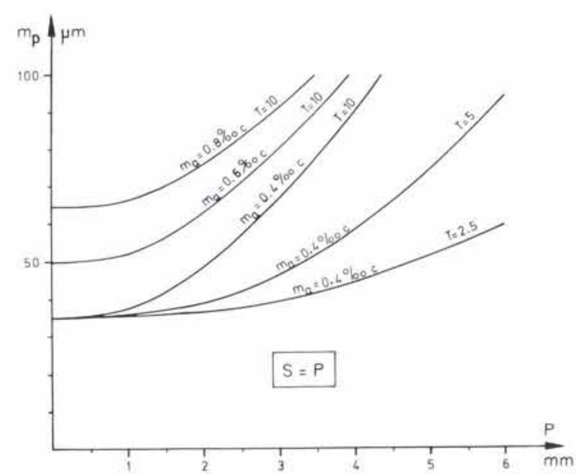

FIG. 1. Standard errors, m_p, of orthophotos as a function of profile spacing, P, slit width, $S(= P)$, terrain irregularity, T, and profiling error, m_a, where m_p, c, T, P, and S are expressed in the original photo used for data acquisition.

c; and with profile spacing of 2.67 mm in the photograph. Figure 1: $m_p = \pm 60\ \mu m$, corresponds to ± 0.18 mm in the 1:00 000 orthophoto.

(2) Making 1:5 000 orthophotos from 1:15 000 photographs ($c = 150$ mm) and applying the same data and a slit width (16 mm) in the orthophoto, one gets the accuracy ± 0.36 mm in the 1:5 000 orthophoto (gained as 60μm from figure 1 with $T = 10$, $m_a = 0.4$ ‰ c, and $P = 2.67$ mm, times 6 being the magnification from the photo used for data acquisition to the orthophoto).

(3) If the 1:15 000 photographs are taken with $c = 300$ mm instead of $c = 150$ mm, the accuracy improves to ± 0.18 mm (= 0.36 × 150/300) in the 1:5 000 orthophoto.

A considerable improvement in the accuracy can be achieved by choosing the slit width, *S*, of the differential projection as half of the profile spacing, *P*, at the stage of data acquisition. This can be seen when comparing the curves in Figures 1 and 2. The price of this improvement is the additional computing time and the longer time required to operate the OR 1.

(4) Making orthophotos with slit width $S = 8$ mm (in the 1:5 000 orthophoto) from a 1:15 000 photograph ($c = 300$ mm) and applying the data of the above example (with the known specifications: 1:30 000 photograph with $c = 150$ mm, profile spacing $P = 2.67$ mm in the 1:30 000 photograph, $T = 10$, $m_a = 0.4$ ‰ c), one gets an accuracy of ± 0.14 mm in the 1:5 000 orthophoto (obtained as 48 μm from Figure 2 with $T = 10$, $m_a = 0.4$ ‰ c, and $P = 2.67$ mm, times 6 being the magnification from the photo used for data acquisition to the orthophoto, times 150/300).

Finally, the accuracy of orthophotos can be determined in Figure 3 for the case when the slit width of differential projection is chosen to be twice as large as the profile spacing at data acquisition. This case occurs in practice when the data acquisition has been performed earlier on the basis of large-scale photographs, and orthophotos have to be produced from smaller scale photographs for more general purposes.

In using Figures 1 to 3, one should make sure that the camera constant, *c*, the number of inflection points, *T*, the profile spacing, *P*, the slit width, *S*, and the accuracy of the orthophoto, m_p, are all related to the photograph used in data acquisition.

DATA ACQUISITION IN FORM OF CONTOUR LINES

The "Hirschbach" test area was compiled with different contour intervals and, on this

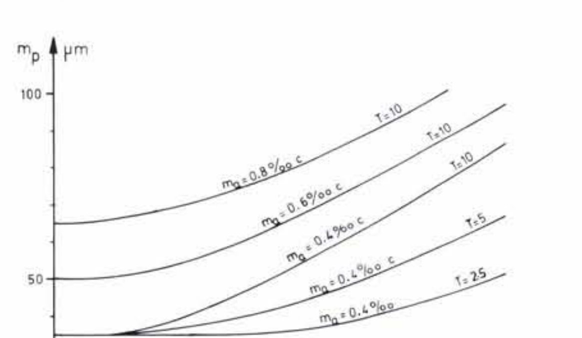

FIG. 2. Standard errors, m_p, of orthophotos as a function of profile spacing, *P*, slit width, $S(= P/2)$, terrain irregularity, *T*, and profiling error, m_a, where m_p, *c*, *T*, *P*, and *S* are expressed in the original photo used for data acquisition.

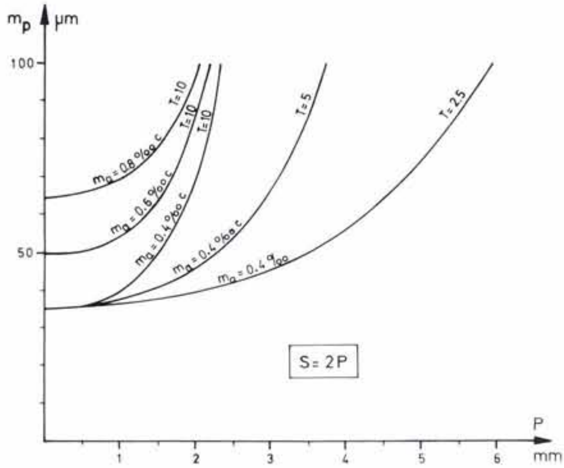

FIG. 3. Standard errors, m_p, of orthophotos as a function of profile spacing, P, slit width, $S(= 2P)$, terrain irregularity, T, and profiling error, m_a, where m_p, c, T, P, and S are expressed in the original photo used for data acquisition.

basis, orthophotos were made using various slit widths. These results, although relatively few in number, made it possible to derive the curves in Figures 4 and 5 describing the accuracy of orthophotos as function of contour interval, I, of slit width, S, of the number of inflection points, T, along some profile, and in addition, of the new parameter, m_h, the accuracy of contour line compilation. This last parameter can be determined by compiling in both directions a characteristic part of a contour line. The difference in the position of the two lines multiplied by tan α(α being the slope angle of the terrain) yields the height accuracy, m_h.

As a rule of thumb the height accuracy, m_h, can be determined from

$$m_h(‰\, c) = 0.25 + \frac{100}{c} \tan \bar{\alpha} \qquad (1)$$

where $\bar{\alpha}$ corresponds to the average terrain slope within the stereo model, and c denotes the camera constant in mm.

The height accuracy, m_h, is influenced by the terrain slope, but also by the open or closed character of the terrain (woods, buildings, etc.) which is not expressed in the above rule of thumb.

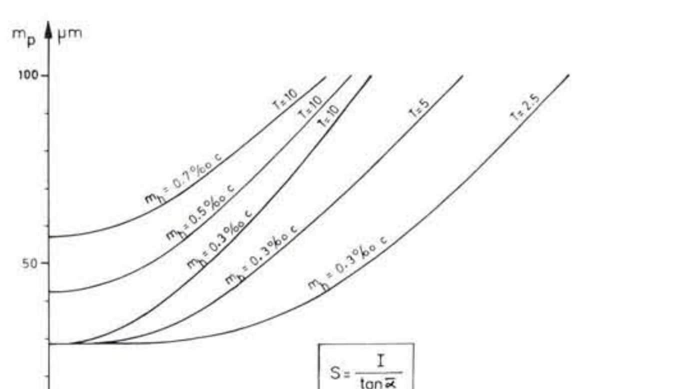

FIG. 4. Standard errors, m_p, of orthophotos as a function of contour line interval, I, slit width, $S(= I/\tan \bar{\alpha})$, terrain irregularity, T, and contouring error, m_h, where m_p, c, T, I, and S are expressed in the original photo used for data acquisition ($\bar{\alpha}$ is the average slope angle of the terrain).

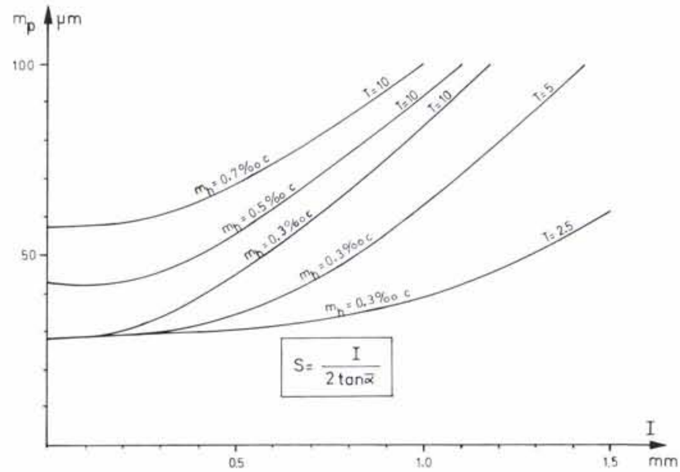

FIG. 5. Standard errors, m_p, of orthophotos as function of contour line interval, I, slit width, $S(= I/(2\tan\bar{\alpha}))$, terrain irregularity, T, and contouring error, m_h, where m_p, c, T, I, and S are expressed in the original photo used for data acquisition ($\bar{\alpha}$ is the average slope angle of the terrain).

DESCRIPTION OF ORTHOPHOTOS PRODUCED

The Institute of Photogrammetry of the Technical University of Vienna has produced some 400 orthophotos during the last few years by employing the SORA-OP program and the OR 1 orthophoto printer. These orthophotos consist of individual cases or of very small series of orthophotos covering an unusually wide field of application. The following information is related to this background.

Origin of initial data:

- 50% profiling only relatively oriented photographs (often without special means for profiling in analog instruments).
- 30% recording contour lines in analog instruments and—in a smaller amount—in analytical plotters.
- 10% recording single points distributed in an irregular pattern (city area, very flat terrain) in photogrammetric analog instruments or in stereocomparators during the aerial triangulation process.
- 8% digitizing existing contour lines.
- 2% field surveying.

For profiling or for compiling contour lines, (older) wide-angle photographs are often used. Orthophotos are then made on the basis of normal-angle photographs at twice the scale. The scale of orthophotos is then about three times the scale of the newer photographs. Using the same photographs for both data acquisition and orthophoto production, a scale factor of 1:4 between photo and orthophoto scales is generally applied. In some extreme cases it was necessary to use a factor of 1:8.

Slit width varies between 3 mm (high mountains) and 16 mm (digitizing in the form of single points in city areas and in flat terrain). In the case of data acquisition in the form of profiles, the slit width is chosen somewhat smaller than the profile spacing and, in case of contour lines, considerably smaller than the average distance between contour lines ($= I/\tan\bar{\alpha}$).

The OR 1 cannot cope with discontinuities; therefore, digitized terrain points should describe an ideal continuous surface. Such a surface can be achieved by ignoring small terrain formations and artificial objects when digitizing the terrain surface. Thus, the continuity of geometrical details (street sides, railroad tracks, etc.) will not be disturbed in the orthophotos.

Among the 400 orthophotos produced, some 150 were in natural or false color. Multispectral photographs taken with Hasselblad cameras also have been converted to orthophotos. Naturally, the Hasselblad photographs have not been used for data acquisition.

One makes frequent use of the way of determining control data by utilizing DHM data created earlier. In one case, seven orthophotos of the same region have been made this way. This possibility contributes to the growing importance of archives of aerial photographs.

About half of the orthophoto negatives

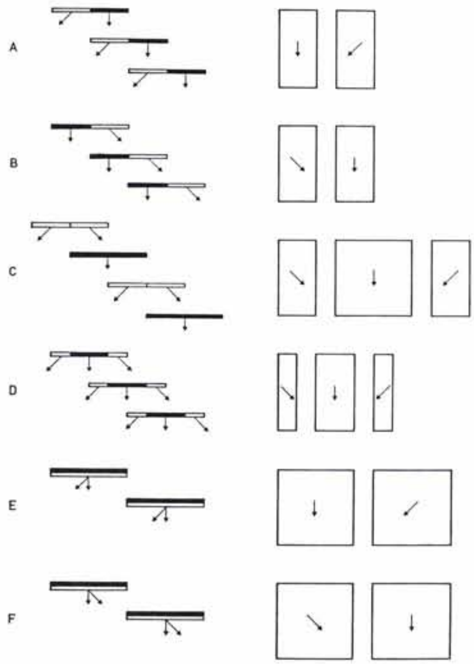

FIG. 6. Arrangements of orthophotos and stereomates.

were processed typographically into photographic maps, or screen processed to allow blue-printing. The other half of the negatives were duplicated in small numbers by photographic contact copying. Before copying, the state coordinate grid and some names were scribed on both black-and-white and color negatives.

STEREO-ORTHOPHOTOS

PROGRAM DESCRIPTION

Without additional data acquisition, stereomates can be compiled for orthophotos in the Avioplan OR 1 using in their preparatory computation the DHM determined for the corresponding orthophoto. The computer program for both orthophotos and their corresponding stereomates is called SORA-OPS.

When employing SORA-OPS, various arrangements of orthophotos and stereomates can be computed as shown in Figure 6. To the left in Figure 6 schemes of (usually overlapping) aerial photographs are shown, and to the right their stereomates are represented by the signs: ↓ = orthophoto, ↘ = left side stereomate, ↙ = right side stereomate. Version C is the one most often applied in practice. Version D was suggested by Ducher (1978), and yields the most accurate stereo-orthophotos.

The following two ways of projection have been realized:

- oblique parallel projection (linear projection) yielding a horizontal parallax

$$p_x = k \cdot h \quad (2)$$

where h is the terrain height, and k is an optional factor usually chosen to be equal to the ratio of the basis, B, to the flying height $\bar{H}$, related to the ground surface.

- the logarithmic projection suggested by Collins (1970) and adapted to the Avioplan OR 1 (see Kraus, 1976) yielding a horizontal parallax

$$p_x = B \cdot \ln \frac{H}{H - h} \quad (3)$$

where H is the flying height above sea level.

Horizontal parallaxes, p_x, measured in stereo-orthophotos can be converted to terrain heights

- for linear stereo-orthophotos:

$$h = \frac{p_x}{k} \quad (4)$$

- for logarithmic stereo-orthophotos:

$$h = H(1 - e^{-\frac{p_x}{B}}) \quad (5)$$

Linear stereo-orthophotos (Equation 4) are only suited for determining heights on the terrain surface. Details such as buildings, trees, and accidental small terrain formations correspond to a different form of projection. In logarithmic stereo-orthophotos, both these details and large terrain formations can be handled equally by Equation 5.

At present, interpretation for special purposes is the major application area of stereo-orthophotos. Correspondingly, most stereo-orthophotos are produced with the economic linear projection, applying—especially for flat terrain—a great exaggeration of heights.

As to scanning direction in the OR 1, SORA-OPS contains both cases indicated in Figures 7 and 8. Case 1 corresponds to a minimum in data input. In this case profiles are longer and therefore the total scanning time in the OR 1 is shorter than in case 2. On the other hand, scanning in the X-direction in the OR 1 yields stereo-orthophotos considerably improved in precision (when applying the same slit width in both cases 1 and 2). This aspect will be considered later.

At this time SORA-OPS has been delivered to four customers. Table 2 lists the core

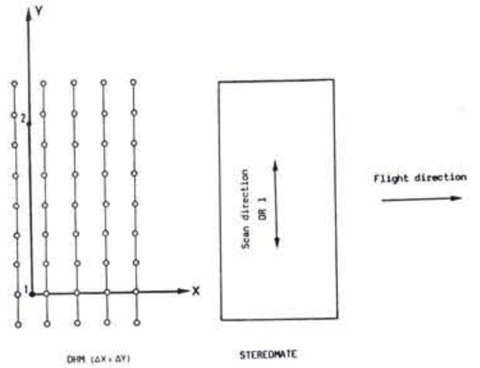

FIG. 7. Stereomate scanned in the Y-direction.

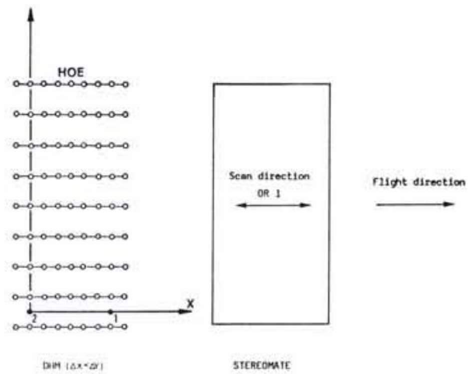

FIG. 8. Stereomate scanned in the X-direction.

needed by the program and the CP or CPU time, for one run for two different computers, required to compute a typical example of producing an orthophoto and both of its stereomates. A comparison with computing times for the orthophotos alone (Table 1) demonstrates the economy of producing stereomates by this new system. So far about 100 stereomates (both in color and in black and white) have been produced by the Institute of Photogrammetry of the Technical University Vienna. In Plate 1 a stereo-orthophoto of the mountain Grossglockner in the Austrian Alps is reproduced (made for Austrian Academy of Sciences; orthophoto scale 1:10 000, slit width 5 mm, linear projection with $k = 0.5$).

PRECISION

Theoretical studies by Blachut and van Wijk (1970), Collins (1970), and Ducher (1973) indicate that stereo-orthophotos should have a relatively good height precision. For linear stereo-orthophotos produced with the modified SFOM orthophotocartograph, numerical precision characteristics have been published by Collins and van Wijk (1976).

No accuracy studies on logarithmic stereo-orthophotos are known to these authors. It can be stated with safety that no accuracy characteristics are available on any types of stereo-orthophotos made with the SORA-OPS program and the OR 1.

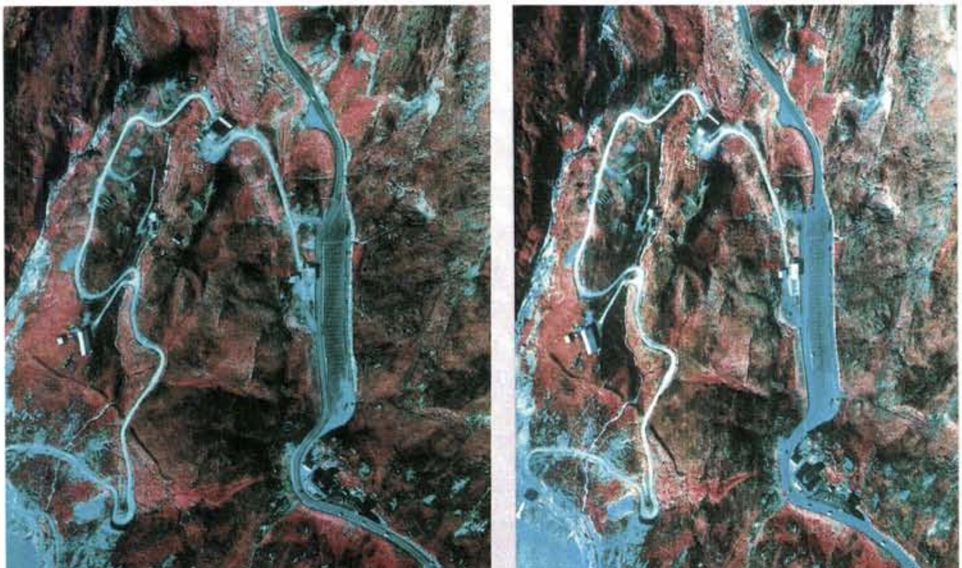

PLATE 1. A color orthophoto of the Grossglockner (right) and its stereomate (left).

TABLE 2. CORE STORAGE FOR SORA-OPS AND COMPUTING TIME FOR ONE ORTHOPHOTO (FORMAT 60 BY 60 cm^2, DHM 8 BY 8 mm^2) AND FOR THE LEFT AND RIGHT STEREOMATES (VARIANT C OF FIGURE 6; LINEAR PROJECTION)

Computer	Core storage	CP resp. CPU-time (sec)
CDC CYBER 74	29 K words (60 bits)[1]	134
SEL 32/55	98 K bytes (8 bits) 24 K words (32 bits)	390

[1] without overlaying.

The following accuracy study is based on the same "Hirschbach" test area with 76 targeted check points. Table 3 contains the standard errors in two orthophotos made with the OR 1, the first by scanning in the Y-direction and the second in the X-direction. The slit width was in both cases 8 mm in the 1:5 000 orthophoto (=2.7 mm in the original photograph). In the second case DHM interpolation was performed with a point distance equal to half of the profile spacing of data acquisition. This way an accuracy of $\pm$ 29 μm was achieved. This accuracy, and all other accuracy characteristics, are in full accordance with Figures 1 and 2.

First, the accuracy of linear stereo-orthophotos was determined with k = equal to the base-height ratio ($B/\bar{H}$) related to the ground surface ((a) in Table 4). The height accuracy m_z expressed in the photograph equals 0.26 ‰ c. The height accuracy of logarithmic stereomates has been shown to be the same ((b) in Table 4).

Thus, stereo-orthophotos show an excellent height accuracy. A comparison with horizontal accuracy (m_p of Table 3 compared with m_z of Table 4) yields the interesting conclusion that stereo-orthophotos possess a considerably better accuracy in heights than in planimetry.

To demonstrate the capability of stereo-orthophotos to compensate height errors of the DHM, the height accuracy of the DHM itself has to be determined. For this purpose, heights of check points have been interpolated in the DHM and compared with geodetic heights. The standard height accuracy, m_z, of the DHM was found to be $\pm$ 0.78 ‰ c for $\Delta X = \Delta Y$ = 2.7 mm (in the original photograph) (Otepka and Duschanek, 1978).

Thus, stereo-orthophotos show a height accuracy three times better than of the DHM used in creating the stereo-orthophotos. This is an effect of compensation which can be explained by the equal direction of errors in orthophoto and stereomate (for detailed explanation, see Blachut and van Wijk, 1970; Collins, 1970; Ducher, 1978). This compensatory effect can be seen in comparing columns 8 and 9 in Table 4. Column 9 contains the standard error m_{p_x} of parallaxes *actually measured* in the stereo-orthophoto. Column 8 contains the corresponding *theoretical* standard error $m_{p_x} = (m_{xo}^2 + m_{xs}^2)^{\frac{1}{2}}$ derived on the basis of standard error m_{xo} of the x-coordinates of the orthophoto (Table 3) and standard error m_{xs} of the x-coordinates of the stereomate (Table 4) by applying the law of distribution of variances (but with systematic errors neglected).

CONCLUDING REMARKS

There is already a considerable international spread of orthophoto and stereo-orthophoto production controlled digitally in off-line processing and based upon three-dimensional coordinates of the terrain. The major advantages of this method are—

- decentralized data acquisition with a wide range of different instruments.

TABLE 3. STANDARD ERRORS m_{xo}, m_{yo}, AND m_p OF THE ORTHOPHOTO, WHERE ΔX, ΔY, AND THE STANDARD ERRORS ARE EXPRESSED IN THE ORIGINAL PHOTO 1:15 000

No. of reg. pts. in Y-profiles ΔX = 2.7 mm	No. of comp. DHM pts.	DHM ΔX mm	DHM ΔY mm	OR 1 scanning in	No. of check pts.	m_{xo} μm	m_{yo} μm	m_p μm
5730	4970	2.7	2.7	Y	71	40	42	58
5730	9727	1.3	2.7	X	70	29	46	54

TABLE 4. STANDARD ERRORS m_z OF STEREO-ORTHOPHOTOS (VARIANT C OF FIGURE 6), WHERE ΔX, ΔY, AND THE STANDARD ERRORS ARE EXPRESSED IN THE ORIGINAL PHOTO 1:15 000

DHM ΔX mm	DHM ΔY mm	OR 1 scanning in	No. of Mates	No. of check pts.	m_x µm	m_y µm	$(m_{xo}^2 + m_{xs}^2)^{1/2}$ µm	m_{px} µm	m_z µm	m_z ‰c
(a) Linear Stereomates with $k = B/\bar{H} = 0.6$										
2.7	2.7	Y	1	32	35	41	53	25	40	0.26
1.3	2.7	X	1	31	31	37	42	24	40	0.26
(b) Logarithmic Stereomates with B = 1122m, H = 2752m										
2.7	2.7	Y	2	68	33	43	52	25	46	0.30
1.3	2.7	X	2	69	29	40	41	21	39	0.25

- total separation of data acquisition and rectification, and
- control of the differential rectification by software of high flexibility within a general purpose computer.

In this paper accuracy laws have been derived depending upon various parameters of orthophoto production and to be applied in planning. It is most surprising that stereo-orthophotos can be easily produced with a height accuracy of 0.25 parts per thousand of the flying height. Future instruments for compiling heights from stereo-orthophotos should be capable of realizing this excellent precision.

REFERENCES

Blachut, T., and M. van Wijk, 1970. 3-D Information from Orthophotos, *Photogrammetric Engineering* (365-374).

———, 1976. Results of the international Orthophoto Experiment 1972-76, *Photogrammetric Engineering* (1483-1498).

Collins, S., 1970. The Ideal Mechanical Parallax for Stereoorthophotos, *Canadian Surveyor* (561-568).

Collins, S., and M. van Wijk, 1976. Production and Accuracy of Simultaneously Scanned Stereo-Orthophotos, *Photogrammetric Engineering* (1521-1528).

Ducher, G., 1978. Aperçu sur les caracteristiques de réalisation des stéréo-orthophotos et les appareils stéréo-orthophotographiques, *Bulletin*, No. 70 (25-49) Société Francaise de Photogrammétrie.

Kraus, K., 1976. *Applications of a Digitally-Controlled Orthophoto Instrument*, Presented Paper, XIII. ISP-Congress.

Marckwardt, W., 1978. Digital Filtering of Profile Data, *Photogrammetria* (111-117).

Otepka, G., and J. Loitsch, 1976. *A Computer Program for Digitally-Controlled Production of Orthophotos*, Presented Paper, XIII. ISP-Congress.

Otepka, G., and E. Duschanek, 1978. Empirische Genauigkeits-untersuchung von Orthophotos, *Geowissenschaftliche Mitteilungen Vienna Technical University*, copy 13 (125-150).

Schneider, H., 1969. Experimentelle Untersuchungen über den Abtastfehler bei der Orthoprojektion, *Bildmessung und Luftbildwesen* (209-218).

Stewardson, P., 1976. *The Wild Avioplan OR 1 Orthophoto System*, Presented Paper, XIII. ISP-Congress.

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Forthcoming Articles

John R. Jensen, Ph.D., Fred A. Ennerson, and *Earl J. Hajic*, An Interactive Image Processing System for Remote Sensing Education.

John R. Jensen, Ph.D., Computer Graphic Feature Analysis and Selection.

Roy A. Mead, Occupational Preparation in Remote Sensing.

James M. Sharp, Demonstrating the Value of Landsat Data: A Case for Lowered Expectations.

Philip N. Slater, A Re-Examination of the Landsat MSS.

Fawwaz T. Ulaby and *J. E. Bare*, Look Direction Modulation Function of the Radar Backscattering Coefficient of Agricultural Fields.

Papers from the 1979 ASP/ACSM Convention Joint Plenary Session, "A Century of Progress in USGS Mapping."