MAP REVISION WITH STEREO-ORTHOPHOTOS [1)]

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Zusammenfassung

Das Orthophoto hat sich für die Kartenfortführung vor allem wegen der fehlenden stereoskopischen Betrachtung nicht in dem Maße wie ursprünglich erwartet durchgesetzt. Die wirtschaftliche Herstellung der Stereopartner zum Orthophoto mit Hilfe der digital gesteuerten Differentialumbildung beseitigt diesen Nachteil. In dem vorliegenden Aufsatz wird die Kartenfortführung nach verschiedenen Methoden eines Gebietes von 80 km^2 im Arbeitsmaßstab 1:25 000 für die österreichische topographische Karte 1:50 000 beschrieben. Die eine Methode verwendet ein Spiegelstereoskop, wobei unter den einen Spiegel ein Orthophoto und unter den anderen das Duplikat dieses Orthophotos gemeinsam mit einer Folie, die den veralteten Kartenbestand enthält, gelegt werden. Eine andere Methode verwendet anstelle eines Spiegelstereoskopes den Stereographen und zusätzlich zum Orthophoto die Stereopartner. Bei der zweiten Methode erkannte man etwa 50 % mehr Details; die Anzahl der ermittelten Veränderungen je Stunde betrug bei der ersten Methode 19 und bei der zweiten Methode 39.

Summary

Application of orthophotos in map revision is less successful than originally expected due in the first line to lack of stereoscopy in viewing them. This obstacle can be removed in producing stereomates to orthophotos by the economically feasible method of differential rectification controlled digitally. In this comparative study, map revision of an area of 80 km^2 has been performed using different methods. A working scale of 1:25 000 has been employed to update sheets of the Austrian Topographic Map 1:50 000. In one of the methods applied, two identical orthophotos, one overlayed by a transparent copy of the old map, have been prospected under mirror stereoscope. In a second method, the stereoscope has been replaced by the Stereograph, and one of the identical orthophotos by a stereomate. In this second method, some 50% more alterations have been recognized; the average number of alterations found in an hour increased from 19 for the first method to 39 for the second one.

Résumé

L'orthophoto n'a pas été utilisée pour la mise à jour des cartes comme on pouvait l'imaginé car il lui manquait la vision stéréoscopique. La confection économique des stéréo-orthophotos n'est plus un obstacle grâce aux appareils de projection différentielle numériques. Les differentes méthodes de la mise à jour des cartes sont présentées ici pour une zone de 80 km^2 à l'échelle de travail de 1:25 000 pour la carte topographique 1:50 000 de l'Autriche. La première methode consiste en l'utilisation d'un stéréoscope à miroir sous lequel on place l'orthophoto avec un calque de la situation topographique en superposition et le duplicata de l'orthophoto. La deuxième methode fait appel ou "Stéréographe" qui accepte l'orthophoto et son stéréopartenaire. 50% plus de details ont été discernés grâce au "stéréographe". 19 changements ont été trouvés par la première methode et 39 par la deuxième.

1) A german version of this paper is published in "Bildmessung und Luftbildwesen", Heft 5, 1983, Herbert Wichmann Verlag, Karlsruhe

1. Preliminary remarks

In advanced countries, map revision rather then mapping itself is the major task of photogrammetry and cartography. One is often far from keeping pace with the ideal cycle of the revision which varies between three and ten years depending upon the amount of changes.

Before the appearance of orthophotos, revision of topographic maps was performed nearly exclusively in using photogrammetric stereo compiling instruments preferably of the cheaper price category. In the meantime, a significant portion of maps has been revised by orthophotos /2, 6, 7/. However, the method is not unquestioned, mainly because of the lack of stereoscopy /9/.

The economically feasible production of stereomates to orthophotos (of "stereo-orthophotos", /4/) yields new opportunities for map revision. This technological opportunity has been studied on an extensive example, within the frame of a diploma thesis /8/ to be partially reviewed here. In order to prove the efficiency of the method in relative terms, map revision of the research area has been performed additionally by two methods applying just orthophotos without stereo-mates.

Comparison has been dismissed with the simplest method applying a transparent copy of the map to be revised. This copy is laid over the orthophoto, and changes are drawn directly on it. Elements of the map are so much disturbing that a satisfactory interpretation of orthophoto contents is not really possible.

2. Experience with three different methods

As research area, the south-east quarter has been chosen of sheet No.33 of the Austrian Map 1:50 000, "Steyregg". This sheet has been compiled in 1958/59, and revised in 1972; some details have been added in 1978. In recent years, much has been changed in this area. In the south, there is a large alluvial riverside meadow always in change. In other areas woods have been partially cleared, and for this purpose new roads created. On the other hand, some agricultural parcels have been afforested. Closer to the city of Linz there has been much building activity and road construction.

For revision of the Austrian Map 1:50 000 a working scale 1:25 000 is used. In this scale we obtained from the Federal Department of Standards and Surveys (Bundesamt für Eich- und Vermessungswesen):
- prints on paper (situation, waterlines, and text in dark blue; contour lines in light blue; and wooded areas in light green), and
- prints on a transparent foil (situation, waterlines, and text in blue).

We have been provided furthermore by the Federal Mapping Agency with orthophotos and stereomates. [1] The aerial photographs have been taken in 1979 for the Austrian Aerial Photo Map 1:10 000, i.e. of image scale 1:30 000 for orthophotos covering 5 x 5 km^2 /1/, corresponding to the working scale of 1:25 000 to only 20 x 20 cm^2. The test area is covered by four orthophotos with eight stereomates, some on glossy and others on frosted paper.

1) We should like to thank gentlemen of the Federal Department of Standards and Surveys for their readiness to cooperate.

2.1 Orthophoto, and mirror stereoscope

In this first method there have been used a simple mirror stereoscope (in our case a WILD ST4), the orthophotos, and the prints on drafting foils (fig. 1). On the left side a glossy orthophoto is placed, and on the right side an orthophoto with frosted surface overlayed by the drafting foil with the contents of the old map. On this last one, changes are noted by free hand using a red pen.

The drafting foil being not quite transparent, it makes contents of the right side orthophoto less brilliant. In viewing stereoscopically this orthophoto and contents of the old map on the right side, and the glossy orthophoto on the left, a mixed image results. The right side orthophoto has in this process the single task of better supporting the parallelism of the eye axis, especially in regions of numerous changes. Notwithstanding this, viewing is quite strenuous. After a while, one sees the photographic image only. Closing the left eye for a moment map lines will be noticed again. Working time has lasted for some four hours daily. Finally it has to be noted that using the oculars with a "3-times" magnification (diameter of viewing field 71 mm) was much more convenient that using those with an "8-time" magnification.

2.2 Orthophoto, and Stereograph

In order to eliminate some of the problems of the first method, map revision with orthophotos has been repeated with the stereoscope replaced by the Stereograph of the firm R + A Rost, Vienna.

The Stereograph (a view of which is contained in /4/) consists basically of a mirror stereoscope with a viewing base of 65 cm, mounted on a carriage with parallel guidance. On the arm of this guidance with the stereoscope, measuring marks are mounted equipped with a micrometer, and with a drawing penholder immediately in front of the operator. The operator moves this entire equipment with a ring including the drawing pen, above the stationary orthophoto (or some other drafting base). Breaks with adjustable strength are countering this drawing movement providing for continuous unshaky lines.

On the Stereograph, the glossy orthophoto is placed at the left side, a print with old map contents on the right side, and a further print of these contents on paper in the middle under the drawing pen (fig. 2). This results again in a mixed image of the glossy orthophoto with the old map. Parallel "guidance" of the eye axis is provided in this case by the measuring marks. Marking of changes is performed with the drawing pen.

In the course of this study, the Stereograph has been improved in two ways. The operator missed the possibility of shutting down for short periods of time the optical channel to the map, and he was disturbed by the difference in brightness of the orthophoto and of the map. Both these problems have been solved by the mechanism shown on fig.3. It can be installed on a lens in both the left or the right optical branch. A flop diaphragm can be operated from the guiding ring with a rope control, and with a disc the intensity of a polarisation filter can be adjusted continuously.

The economy in time of compilation using the Stereograph versus using a simple mirror stereoscope is quantified in section 2.4. This economy is the result in the first line of the parallel guidance of the mirror stereoscope allowing the compilation of long lines in one step. It is important to state, furthermore, that the better convenience of work with the Stereograph enables six hours of work with it daily as compared with four hours using the simple mirror stereoscope. The magnification of 1,8 x of the optics(diameter of the viewing field 119 mm) has been felt by the operator as more convenient than the magnification of 3 x of the mirror stereoscope.

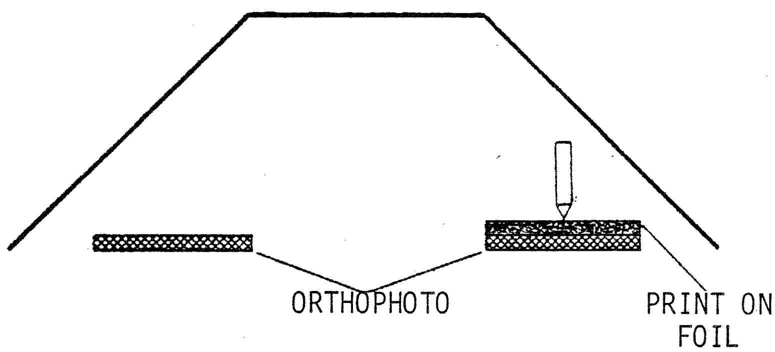


Fig. 1 Orthophoto and mirror stereoscope

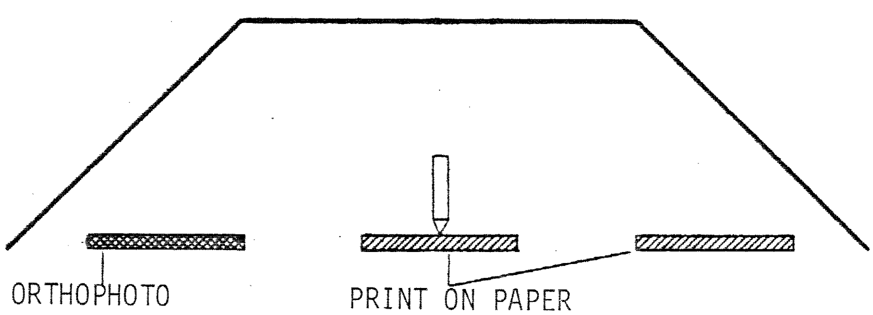
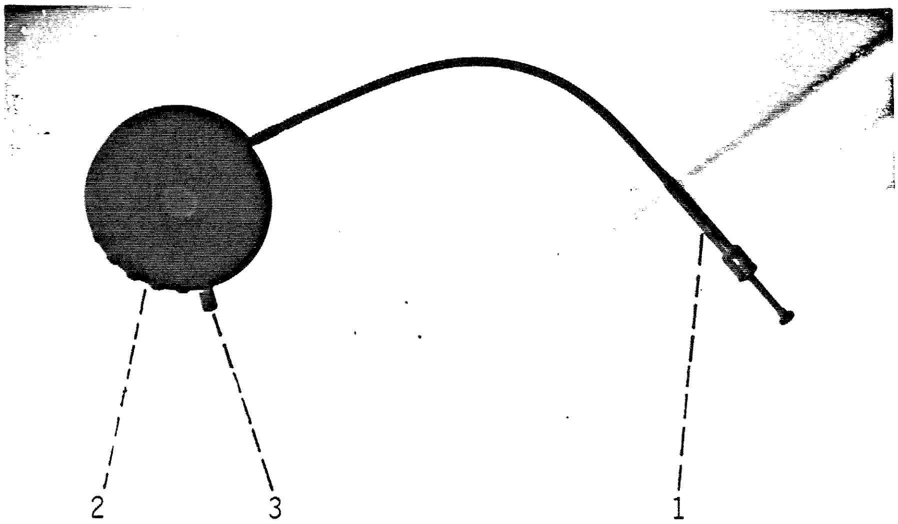


Fig. 2 Orthophoto and Stereograph

2.3 Stereo-orthophoto and Stereograph

In the third method, as shown on fig. 4, a stereo-mate has been added on the Stereograph. It has been laid over the print of the old map in such a way that by flipping it aside the contents of the old map could have been prospected. This enables the operator of chosing between a spatial photographic image, and the mixed image of the orthophoto with the map print. Whereas the spatial image facilitates interpretation greatly, prospecting the mixed image enables the detection of changes.



1 ROPE TO CONTROL THE DIAPHRAGM
2 DISC TO ADJUST FILTER INTENSITY CONTINUOUSLY
3 FIXING SCREW

Fig. 3 Mechanism with filter and diaphragm

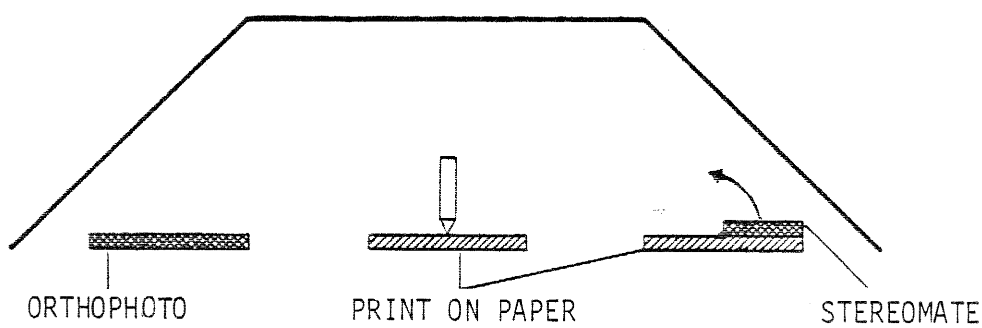


Fig. 4 Stereo-Orthophoto and Stereograph

The measuring mark on the side of the stereo-mate is superfluous and even disturbing when compiling lines of the situation for in this case its position would have to be changed depending upon terrain elevation. One of the major advantages of using stereo-orthophotos for compiling situation lines is just this need for a single measuring mark over the orthophoto. On the other hand, the second measuring mark is missing when prospecting the mixed image to guide both eyes to look at points corresponding to each other on the orthophoto and on the map print. This circumstance has not been disturbing compilation however, for the mixed image is only necessary to detect changes, not to compile them. Of the three described methods, working with stereo-orthophotos on the Stereograph has been the most convenient for the operator.

It seems to be possible to solve the problem mentioned above of the "missing" second measuring mark for prospecting mixed images by adding a simple control mechanism to the Stereograph. Mr. Rabenstein, of the Federal Department of Standards and Surveys, has made a further suggestion as to another arrangement of materials on the Stereograph: on the one side the orthophoto covered by a transparent copy of the old map, in the middle a print on paper of the old map, and the stereo-mate on the other side. In this case, contents of the old map can be permanently seen against the background of the spatial photographic image. Using two diaphragms as described in 2.2 (fig. 3), any of the two image branches could be prospected separately.

2.4 Comparing the three methods

Changes in map contents as detected by the third method (stereo-orthophotos, Stereograph) are represented in fig. 5. Table 1 contains comparative data as to the changes detected by the methods studied.

Table 1 Changes detected by the three methods

Changes in	Orthophoto		Stereo-orthophoto
	Mirror stereoscope	Stereograph	
Traffic lines			
length up to 150 m	144	109	206
150 - 500 m	160	158	247
over 500 m	21	22	35
Woods	349	366	479
Still waters	16	21	33
Sand and rubble mines	8	4	14
Houses	96	133	173
Other	24	16	24
All together	818	829	1211

Results speak for themselves. It has to be stressed that stereoscopic as compared to monoscopic interpretation yields some 50% more details detected.

Let us turn to time consumption of the methods. Data are summarized in table 2, for image orientation and for interpretation separately. Rates of changes detected per hour are the most impressive comparative characteristics (last row in table 2). These rates are counted by dividing the number of changes detected (last row in table 1) by the total time consumed - including that for image orientation.

Gaines attained by the stereo-orthophoto method prove to be quite important when measured by economy in field work following photogrammetric compilation. A further effect results from the fact that in addition to the improvement of 50% in the number of changes detected, the number of misinterpretations has been substantially diminished by using stereo-orthophotos. - On the other hand, additional costs for producing stereo-mates have to be taken into account. These costs can be hold down by applying a data bank of terrain elevations to produce orthophotos and stereo-mates /1, 3/. Stereo-orthophotos so created may be applied then for many different interpretation purposes, as well.

Table 2 Time consumption of the three methods

	Orthophoto		Stereo-orthophoto
	Mirror stereoscope	Stereograph	
Orientation Interpretation	2 42	3 23	6^h 25^h
All together	44	26	31^h
Resulting rate changes/hour	19	32	39

3. Additional considerations

Giving careful consideration to the production of topographic maps by computer aided processes, the importance of technologies for map revision compatible with such systems cannot be overseen. The Stereograph being equipped with linear pulse generators, and with a data recording unit /4/, changes detected and compiled on the Stereograph can be recorded and further processed by digital methods.

It has been assumed by this study that, with the time passing, terrain elevations do not change substantially. Only if this is true can precise stereo-orthophotos be produced using (old) data banks of terrain elevations. Although major changes in elevations are seldom, it is advisable to check on this before producing stereoorthophotos with data banks of elevations, and to correct them if necessary. As to this problem, some solutions have been suggested but no experience is yet present. The suggestion of Masry /5/ seems to be the most promising one. According to it a digital terrain model (e.g. in form of a grid) has to be projected centrally in both the left and the right photo of a stereo pair. The resulting grid patterns have to be plotted on transparent foils and laid over the photographs. Prospecting these last ones stereoscopically it becomes possible to detect major changes in elevations as deviations between the terrain and the stereo model. Areas of change have to be then recompiled, and the data bank of terrain elevations updated before it would be used for the production of stereo-orthophotos.

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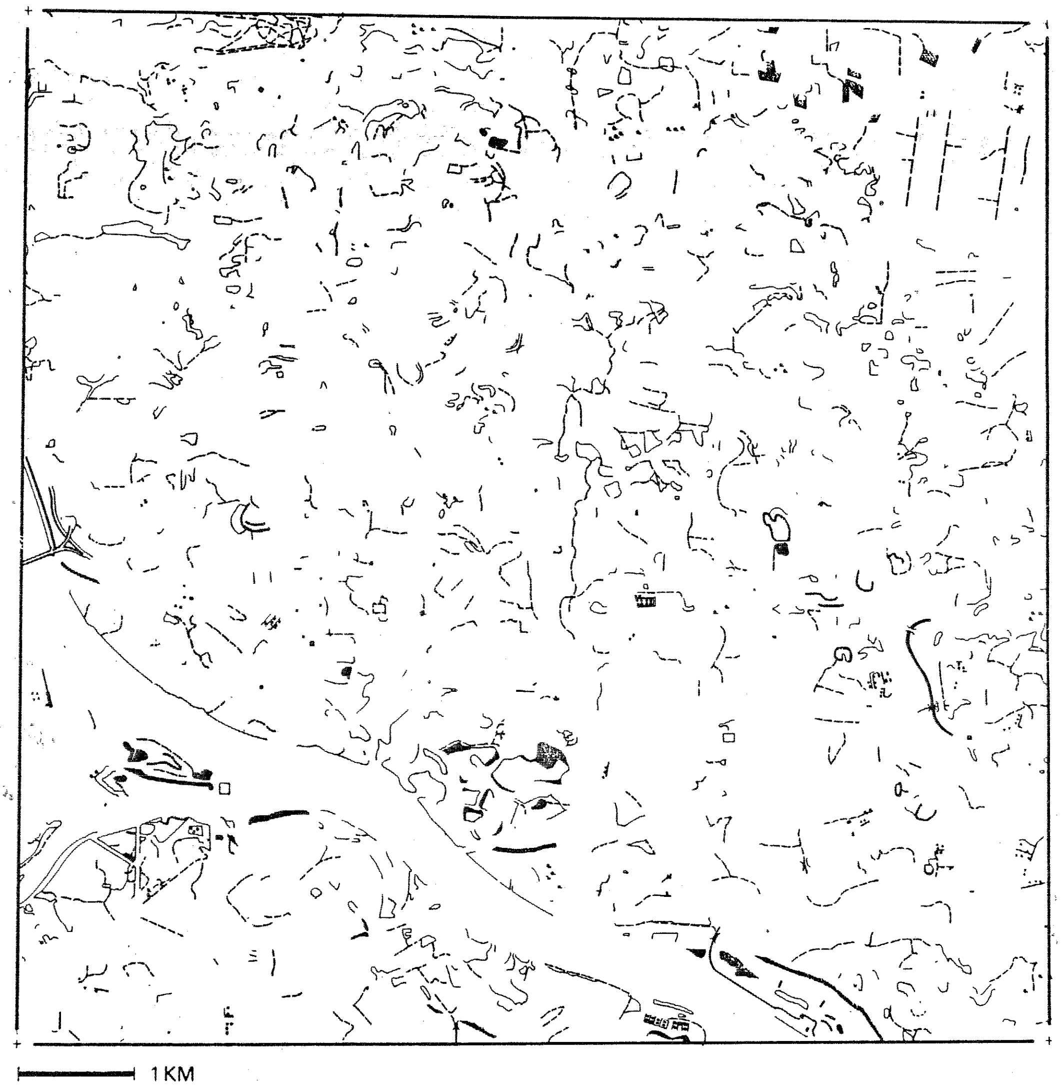

Fig. 5 Map changes as detected using stereo-orthophotos and Stereograph