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THE PRESENT SITUATION IN ORTHOPHOTOTECHNIQUE

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When Professor Ackermann invited me to give a lecture here on the present situation in orthophototechnique we decided that the main theme would be the discussion of the question:

"Has the photomap brought us what we expected?"

Asking this question one has first of all to define two points, namely

a) what is a photomap and

b) what did we expect?

What is a photomap?

For the purposes of this discussion we shall define a photomap as follows: A mathematical controlled aerial photographic imagery of a part of the Earth's surface. This photographic imagery can be converted by photomechanical techniques and/or enhanced by cartographic annotations. Such a photomap can be made in two ways

1. for flat terrain - with the use of exactly rectified aerial photographs and
2. for all types of terrain - with the use of orthophotos.

An orthophoto is a photographic image prepared from a perspective photograph in which the displacements of objects due to relief and tilts have been corrected.

By both methods the central projection photograph has been changed into an orthogonal projection image such as a map normally has.

For the photomap compilation it is often necessary to assemble a number of such (differentially) rectified photo images to cover the map area wanted.

Now that we know what goes under the heading photomap, we come to the other question which we put in the beginning. This was:

"What did we expect from the photomap?"

When in the middle of the 1950's, after the early start of orthophotomap production around 1930 by Lacmann and Ferber, Russel Bean in the USA breathed new life into the idea and when in the years 1960 - 1970 many photogrammetric instrument developments were carried out and resulted in the production of an orthophotodevice, the photomap as such got a big push forward.

Why was the photomap becoming so popular?

The reason was, as we all know, that the society in which we live demanded more maps and especially more up to date maps than we at that time could produce with the techniques available.

The conventional line map production being too time consuming in many cases could not challenge the needs of the map users.

The difference between the normal line map and the photomap without any annotation is in fact the photointerpretation and the data collected by field completion and I think that those who neglected the need of the map user for this information collected by interpretation and field completion, made a mistake.

Many of us, mapmakers, expected that the photoimagery as such could solve many of the problems of the map user. In my opinion we as photogrammetrists and mapmakers often make the mistake of thinking that our job is a purpose in itself and forget that in fact we only have a servicing task and perhaps in some cases an educating one. We have to make the maps that our customers need and if we can offer and introduce a new type of map we have to do it, but then we have also to accompany this. With the first production and introduction of photomaps the acceptance was quite different.

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It is interesting to read what Messrs Dagleish and Whitelegg of the Directorate of Overseas Surveys of the United Kingdom write |3| about their investigations into user requirements.

They divided the users into two groups:

a) the general users such as tourists, travellers and administrators who are interested in the overall picture and "feel" of the terrain and

b) the specialist users such as geologists, hydrologists etc, who use maps as tools in their work.

The first group favourably accepted the first series of DOS photomaps. This group was not familiar with the cartographic conventions of normal line maps. They had remarks on the choice of the colours used in the cartographic result.

The second more professional group, gave as comment that the colours, used in the DOS photomaps, did reduce the value of the map as base documents for superimposing of specialists information.

And also the enhancement of the photo imagery by the cartographer was not necessarily the one that they would prefer. And last but not least the chosen density slicing techniques to enhance areas of high vegetation sometimes produce unacceptable terrain anomalies which destroy the user's confidence in the product as compared with a normal photomap without cartographic or photomechanical enhancement.

So here we see that the appreciation turns in two directions: the general user likes the help of the cartographer and the professional user not.

On the other hand I think we have to consider that perhaps many of the map users and map makers are too traditional in their map appreciation. Change is always difficult for many people. If we compare the results now produced by automated cartography and the appreciation of it we see the same. Many non-professional map users do appreciate the new products but very often the professional and especially the cartographers themselves want to reproduce the old product that very often is not very suited to the automatic system.

Coming back to our question I think that those colleagues who expected that the photomap would totally replace the line map had too high expectations. However the ones who saw the phtomap as a good temporary map substitute and in many cases as a better solution than the line map were more realistic in their approach.

Application of photomaps

We now will follow a number of applications and then discuss also if for the photomap application alternatives were available.

One of the most impressive applications we find in Nordrhein-Westfalen in Germany |9|. Here the programme, started after 1945, for 1:5000 "Grundkarte" mapping, had in 1968 only 14 % completely available and 52 % in preliminary edition with planimetry without spot heights. The production of photomaps was decided on since this opened the only possibility of fulfilling the needs of the many users.

Cartographic editing of these photomaps is reduced to a minimum to avoid further loss of detail. Only white lettering and black contours are shown. (contours derived from drop lines in the beginning but these giving too inaccurate results and being not efficient enough have now been abandoned and replaced by conventionally produced ones.

The Nordrhein-Westfalen production is about 4 times faster and 3.4 times cheaper than the comparable line map production. But we have to remember that no photo interpretation nor cartographic enhancement and field completion has been done for them and these factors influence the total cost for line mapping by at least 70 %.

The photomaps are used for local planning mainly and even where the line map is available often the photomap is preferred. Also forest services use the photomap for determination of boundaries of areas and so extensive field work can be saved.

A use of photomaps for cadastral purposes in Nordrhein-Westfalen even when the scale is larger than 1:5000 is not acceptable because of the very high property values there.

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Another German application of orthophotos is described by Kersting |6|. In forest inventory he applies orthophotos at 1:5000 scale and concludes that for this work no alternatives are available! Orthophotos are the only answer to his problems.

A huge task is in execution with the mapping of Saudi Arabia. There the only solution in fact for the topographic mapping at the scale 1:50 000 is again the production of annotated photomaps. For such a type of terrain photomapping is the only obtainable alternative |21|. Big parts are in execution. Later in this lecture some repro problems related to the Saudi Arabia project will be touched upon.

As we all know photomapping has a very large application in the USA. There the US Geological Survey produces a large number of orthophotomaps at the scale 1:24 000. In |17| and |13| Pumpelly and Mullen describe the first experiments and the later real productions of a type of map what we could call a pictomap also. The word pictomap means, as you may know, photographic image conversion by tonal masking procedures and the photographic image conversion is used with these orthophotomaps. With the negative made of the mounted photomap imagery and a 70 % positive mask of that, registered back to back, a high contrast transparency is exposed on Dupont Cronar Ortho S film material. The result after development gives a printable so called random dot image tone right reading positive. More other random dot pattern separation sheets are produced which are printed in different tints together with cartographically prepared separations for blue (water) and red (roads).

This image conversion is intended to help the map user with the interpretation. It can be of some help but in my opinion this technique influences the map imagery so strongly that for a multipurpose map like this 1:24 000 topographic orthophotomap cartographically enhanced screen printed result could be more recommendable.

Mullen describes |13| that the problem of tone matching in an orthophoto montage now is overcome with the use of high altitude photography. With the 15 cm lens camera at 12 000 meters flying height 1:80 000 pictures are taken that avoid the photoassembling because one image covers one map sheet so it avoids the problem of tone matching.

USGS makes also photomaps 1:7 200 (from photographs taken with an aerial camera of 30 cm focal length) for urban studies and 1:125 000 orthophotomaps for region planning studies (from 1:80 000 scale photos).

In South Africa there was a great need for detailed maps for future planning development. Here again the orthophotomap was the only possible solution to get maps prior to the development. The scale chosen is 1:10 000 with 5 m contour intervals |11|. Here the drop lines are also not considered acceptable.

In highly developed areas in South Africa however the photomap does not fulfill the needs, but in spite of these limitations the orthophotomapping method offers the only opportunity to produce up to date maps with much information at relatively low costs.

As a matter of fact we have also to mention the important work for urban mapping in France executed under the direction of Mr. Dubuisson. He promoted the photomap with very good results.

The oldest application is the well known Economic Swedish photomap 1:10 000 |5|. This map, originally made for agricultural and forestry planning purposes, is now also applied in architecture, survey and for registration of properties of subdivided parcels. For the last purpose the photomap is even continuously revised!

For cadastral work the photomap also has several applications, in Thailand at scales 1:2000 and 1:4000 and in Central America (Costa Rica and El Salvador 1:5000 and 1:10 000). In Canada cadastral photomaps 1:1000, 1:2000 and 1:5000 are in production for the larger towns. In South-Australia photomaps are produced at scale 1:2500 simultaneously with the line map of the same area.

In the Netherlands a large number of photomaps has been produced for reallotment purposes. Here the user wants a combination of line map and photomap. The scales used are 1:5000 and smaller and the photomap is especially used for interpretation and addition of extra interpretated lines into the existing line map 1:10 000. Such lines are the subdivisions of parcels and not mapped very small details like footpaths, very small electricity lines etc.

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Dr. Schmidt Falkenberg of the German Institut für angewandte Geodäsie |19| did some very interesting research on the production of 1:25 000 photomaps with a lot of cartographic enhancement photomechanically and manually done. The map made from aerial photos 1:65 000 (focal length of camera 15 cm) had special separations for forest, field structure, valley structure, roads, water, contours, hill shading, names and the marginal information. In 24 days work he achieved a complete map 1:25 000. The choice of colours is still under consideration and I am sure that even better results can be obtained with the existing separation sheets.

An impressive application of orthophotomapping is to be found in Japan. By mid 1974 already 22 orthophoto instruments were in use |15|. The photomaps are applied for cadastral work, forest survey, agriculture, electricity transmission etc. and also for 1:50 000 and 1:100 000 scale mapping. Mr. Oshima writes in his report, above mentioned, that in total 143109 km^2 were mapped with orthophotos in 1972 and 1973. His opinion is in agreement in fact with remarks I made earlier for example the need of education of the map user and the need for guidance of the map user, but he puts forward also the problem of proving the higher accuracy of orthophotomaps in comparison with the formerly often used semi-controlled mosaics.

Many map users are spoiled with these because they do not know that there is quite a difference between the two in accuracy. Well, it is not difficult to continue this long list of applications but I may refer to the list of literature shown at the end of this paper. I will conclude the list of applications now with one described by van Twembeke |20|. He reports on his work in land consolidation and says that the map is no longer only a metric base for economic purposes but also an information source for ecological means. The photomap 1:1000 and 1:2000 proved to be a very good base for that if it shows the following elements: rural areas (agricultural and zones with social functions), roads classified following a predetermined system, forest areas for inventory, pedological soil classification and height information. All other informations can be obtained by the user himself by photo interpretation.

The map user can be offered:

a) a continuous tone negative of the photomap

b) a diapositive with permanent map elements like map neatlines, contours, spot heights, limits of pedological zones and the marginal information

c) a diapositive with variable map elements like limits of property parcels, limits of exploitation parcels, infrastructure, real limits of wood etc.

We all know that the importance of the ecological informations is increasing because we have to make the most of our surface we live on and I agree totally with van Twembeke's approach that photomaps can help us in this respect. Many elements important for a good planning of the maximum use we can make of our terrain are only obtainable from photomaps.

Is a photomap cheaper than a line map?

This question can not be answered with one answer. The costs in mapping are highly depending on the amount of time used for photo interpretation, field completion and cartographic work and last but not least on the density of the area to be mapped.

As I mentioned already the German Nordrhein-Westfalen example having only very little extra information on the map is 3 1/2 times cheaper than the line map of dense areas.

However the USGS applications with their extensive extra work for maps of national parks, swampy areas etc. have, as I am told, about the same costs as the line mapping. But there, as in many other cases, the photomapping is preferred because of the extra amount of map detail shown at the photo imagery.

In the most cases photomapping will give a cheaper result but, and this is often more important, also a quicker one.

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Can we use a photomap for line production?

Apart from elevation the photomap offers very good possibilities for line map production |13|, |21|. By putting the photomap imagery on a presensitized scribe coat material, one has a guide available for the scribing of planimetry. If the cartographer has also a preinterpreted photo of this same area at his disposal he can produce in a quick way the line map. The advantage of this system in comparison with stereoplotting is that one orthophoto instrument can feed many more draftsmen than one stereoplotter can do.

This system |21| has proved to be a very successful one. In the USA one got the same conclusions as Mullen reports |13|. The colour separated scribings of culture, woodland and drainage are directly scribed from the orthophotomap guide. No planimetric detail has to be mapped in the stereoplotters and more time is available for contour compilation. To my opinion this direct scribing technique could be used much more than is done up till now, apart from a much quicker result also the reduction in costs has to be considered. This is in fact highly influenced by the costs of instrument hours.

Can we use the orthophotomap for automated cartography?

When it is possible to scribe a line map with the orthophotomap as guide, the step to the use of the orthophotomap base for digitizing is a very small one.

In the Netherlands at the Topographic Service and the ITC we did a research in digitizing an orthophotomap for the base map production at the scale 1:12 500 |26|. The orthophotomap of an area of 62 1/2 km^2 was assembled at the scale 1:6250 and at the scale 1:12 500 and both were digitized with an Instronics Gradicon digitizer. The cartographer executing the digitizing had a preinterpreted set of photographs at his disposal. The photomap imagery was exposed on Contone scribe coat of Keuffel and Esser (USA).

For digitizing of the photo image at the scale 1:6250 of a normal density 154 hours were needed. Some of the most difficult objects to digitize on an orthophotomap, are the houses, Out of the total of 154 hours, about 30 % is used to digitize the houses. On such a sheet about 3500 houses have to be recorded. The digitizing of a sheet of this surface area and density was carried out using 1,369,193 characters. This number of characters needs, inclusive the interrecord gaps, on 800bpi magnetic tape 94,4 metres length. A normal tape has a length of 800 metres, so about 9 of these sheets could be stored on one tape. At the scale of 1:12 500 the time needed for digitizing of 62 1/2 km^2 was 139 hours. The reason for this must be the shorter line lengths. The digitizing itself was considered to be easier at the scale of 1:6250. The smaller objects such as houses took more time at the smaller scale. However, in comparison with the time needed for conventional line scribing (412 hours), digitizing gives a considerable reduction, even when an editing percentage of 30 % is included.

Thus we see:

Scale 1: 6 250 digitizing ..... 200 hours needed (about 50 % of the time needed for scribing)

Scale 1:12 500 digitizing ..... 181 hours (about 44 % of time needed for scribing)

The engraving with the Kongsberg 1215/DC 300 took, working on 30 % of the maximum speed, for the scale 1:12 500 sheet ..... 310 minutes and for the scale 1:6250 sheet ..... 375 minutes.

In Canada also digitizing from orthophotomaps is done and there the digitizing of an area takes about 35 % of the time necessary for normal conventional scribing |7|.

The mapping system for automation in cartography in Nordrhein-Westfalen Germany is also partly based on digitizing from the 1:5000 orthophotomaps.

Last but not least I may mention the study of Mr. Gordon Petrie |16| on this point. He discusses the data compiled from orthophotomaps by the different digitizing systems.

To my opinion the orthophotomap enables very good the data collection for mapping by automated means. Here again the technique here mentioned reduces very much the time needed for digitizing of planimetry with stereoplotting instruments. Mr. Kersting |6| executes the digitizing on orthophotomaps with the digimeter (measurement of polar coordinates) and the plotting is done with the Calcomp 745 high accuracy plotter.

The orthophotomap combined with automation in cartography enables what many mapusers prefer e.g. the possibility of the production of special purpose maps. The multipurpose topographic or thematic map many times shows too much information. The mapuser wants to select himself the elements on the map before plotting. The automation techniques enable this because the elements can be selected by their code before the special purpose plotting is started.

The orthophotomap in fact is a databank that includes all map elements.

Can we use the photomaps for map revision?

A top problem in topographic mapping now is the revision or up dating existing line maps. Many countries now have already completed series 1:50 000 or larger and have to revise them.

There also the orthophotomap can play an important role.

In the literature we find that in the USA |13| orthophotos are used for that.

Mr. van Wijk of the National Research Council of Canada |23| promotes with Mr. Blachut |2| the advantage of the stereoorthophotography for map revision.

In France map revision with orthophotos is in research |1|. In the Federal Republic of Germany |10| and in the German Democratic Republic |22| the revision with orthophotos has been described, but I want to mention here especially the excellent work done by the Landesvermessungsamt Baden-Württemberg (FRG) and described by Mr. König |8|. Here the orthophoto image is directly used for the revision of the 1:25 000 and 1:50 000 topographic map. The original map separations 1:25 000 are enlarged to 1:10 000 and on blue guides on astralon the changes are drawn in black and red directly from the orthophoto that is fitted under the astralon. The new elements are after this brought in the originals by coping techniques.

As a matter of fact a quick fieldcompletion has to be done before the actual drawing starts. In using this method the revision cyclus of the 1:25 000 scale maps could be reduced from 30 years to 10 years and the 1:50 000 scale revision cyclus from 15 years into 5 years.

In the above mentioned report an interesting result is given of tests with colour, infrared and black-white orthophotos at various scales to study the improvements in photo interpretation for the map revision. It is worthwhile to mention a few of the conclusions.

For the identification of the most important elements like big buildings gives the black-white photography the best results (better resolution, influence of colour decreases with flying height, infrared film often too much contrast). A larger scale 1:7500 instead of 1:10 000 scale does not give remarkable advantages. Stereoscopic interpretation improves the results.

From my own experience I may report that in the Netherlands since 1962 the photomaps are in use for map revision with very good results. On a new photomap imagery 1:12 500 on stabilene (yellow with diazocoating) the old unchanged lines of the map are etched and the new elements can be scribed in direct connection with the old lines. This avoids fitting problems of the combination of old and new lines. The gain in times depends a lot of the amount of elements to be changed of course but reductions in cartographic work up to 50 % and more are quite common.

The time reduction in map revision is influenced highly by the degree of detail that is included in the revision philosophy of the institute concerned, but with good quality orthophoto images map revision can be speeded up considerably.

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Does the man in practice of photomapping still has wishes?

Yes! Talking about the main portion of the orthophoto devices in use, so the non-automatic ones, we know that the operator has problems in the profile-following in not open terrain.

I think there is a great need for a system that makes it possible to drive the floating mark in the scanning profile automatically with digital data as input.

As we have seen the droplines are not accurate enough for many map users. So, often they construct the contours needed for the photomap on the conventional way.

Then also a digital output of these contours can easily be obtained. The next step is the use of a computer program for calculation of the profile-values needed for the orthophotoscanning. This would improve the scanning procedure and make the operator's task much easier.

Another wish I have in mind concerns the tone matching. A big problem in photo-map making is the tone matching and the necessary retouche we have to do.

The USGS was already very happy to fly high altitude to get one photo on one map sheet |13| but in many cases the flying heights necessary for such a photo-graphy are too large in many countries in relation to the atmospheric circum-stances and the number of chances for good aerial photography.

The map user in fact directly bases his appreciation on the quality of photo imagery. Big steps in density and bad tone matching decrease the appreciation of it.
Therefore I would like to stress the need for possibilities for good tone matching of an orthophoto with its neighbours.

I think that in the orthophotoinstruments the operator must have easy possibilities for influencing the tone based on density measurements he has to do before the actual scanning starts. I could imagine that along the edges of an orthophoto different tone ranges could be obtained by of a change of itensity or by the use of filters.

I know this is not an easy question but the time needed for good retouche now is often so considerable that this influences the efficiency of the appli-cation of photomaps.

What can be improved?

Apart from the two wishes mentioned above I am of the opinion that much can be improved in the use of orthophotomaps by the development of better reproduction results.

The image we offer the client must be the best we can make. His results are directly depending on the interpretability of the photo image so on the quality of it.

The bromide picture still gives the best interpretation possibilities. For larger amount of copies diazo or offset techniques have to be applied and the screening of the photoimagery is needed then. The use of the modern positive and negative magenta or grey screens |25| and the applicable maximum and minimum density percentages in the result is of utmost importance.
In the OEEPE commission E this problem will be studied intensively during the next years.
Also the dodging techniques did open a wide field of improvement. However the dodging has not always such good results. On hand of a simulation model built up of 9 density levels a number of steps, the same as we have to do in the production of orthophotomaps, are executed by colleagues of the ITC and the Topographic Service in the Netherlands and the first results do show already remarkable results which perhaps will be published at another time.

The advantage of the use of a simulation model is that we have the possibility to compare our results always with the original itself. In aerial photography we first of all have to accept what the air photographer presents us, the photo-graphic image of the original. So we are always a step behind.

To conclude I put again the question: "Have photomaps brought us what we expected?" forward and I think, after having shown the many applications done, that the answer can be: "Yes".

For a lot of mappings the photomap offers the only acceptable (time and costs) solution.
The photomap is not the remedie for all diseases but I would say it is the anti-biotic for many mapping problems!

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Abstract

After a very short introduction the following questions will be discussed on hand of applications.

Did the photomap bring us what we expected?
Did not we expect too much or are we perhaps too traditional in our map appreciation?
Are we satisfied with the orthophoto instruments?
What has to be done in research for improvement?
Does one have for certain types better alternatives?
Is a photomap cheaper than a line map? Can we use a photomap as a start for line map production?
Is a photomap a possible base for map revision?
Is a photomap a possible base for automated map production?

During the lecture some cartographic and reproduction problems will be touched.

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Résumé

Après une courte introduction, les questions suivantes sont abordées à la lumière d'exemples d'application pratiques:

La photocarte a-t-elle rempli nos espérances?
N'avons-nous pas peut-être exagéré nos espérances ou notre attitude vis-à-vis de la photocarte n'est-elle pas trop traditionnelle?
Nos appareils orthophotographiques nous donnent-ils satisfaction?
Dans quel sens les recherches ont-elles été entreprises pour obtenir des améliorations?
La photocarte est-elle meilleur marché que la carte dessinée au trait?
Pouvons-nous utiliser une photocarte comme document de base pour la confection des cartes dessinées au trait?
La photocarte peut-elle servir de base pour la mise à jour des cartes?
La photocarte constitute-t-elle une base valable pour la production automatique des cartes?

L'exposé se penche également sur quelques problèmes inhérents à la cartographie et à la reproduction.

Resumen

Después de una introducción muy breve se plantean las siguientes cuestiones mediante ejemplos tomados de la práctica:

Ha satisfecho el mapa fotográfico nuestras esperanzas?
No hemos esperado demasiado o somos tal vez demasiado tradicionales en nuestra postura respecto al mapa?
Estamos satisfechos con nuestros equipos ortofotoscópicos?
Qué se ha hecho en la búsquedad de nuevas mejoras?
Es más económico un mapa fotográfico que uno de trazos? Podemos emplear un mapa fotográfico como base para la confección de mapas de trazo?
Puede servir el mapa fotográfico como base para la actualización?
Puede servir el mapa fotográfico como base para la confección automática de mapas?

En el curso de la conferencia se tratan algunos problemas cartográficos y de reproducción.

Zusammenfassung

Nach einer sehr kurzen Einleitung werden die folgenden Fragen an Hand praktischer Anwendungsbeispiele erörtert:

Hat die Photokarte unsere Erwartungen erfüllt?
Haben wir nicht vielleicht zu viel erwartet oder sind wir vielleicht zu traditionsgebunden in unserer Einstellung zur Karte?
Sind wir mit unseren Orthophotogeräten zufrieden?
Was ist auf der Suche nach weiteren Verbesserungen getan worden?
Ist eine Photokarte billiger als eine Strichkarte? Können wir eine Photokarte als Grundlage für die Herstellung von Strichkarten verwenden?
Ist die Photokarte eine mögliche Grundlage für die Kartennachführung?
Ist die Photokarte eine mögliche Grundlage für die automatische Kartenherstellung?

Im Laufe des Vortrags werden einige kartographische und Reproduktionsprobleme gestreift.