MAP PRODUCTION AND REVISION WITH SATELLITE PHOTOGRAPHS TAKEN BY THE MKF-6 CAMERA AND BY THE CAMERAS KATE-140, KATE-200, AND KFA-1000

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In the practical work done so far with space photographs in our country has been proved that for many problems in principle the equipment and methods commonly used in photogrammetry can be employed. The methods are partial enlargement or rectification, graphic photogrammetric stereoplotting, and digital photogrammetric restitution. Photogrammetry and remote sensing viewed as related sciences very often provide a definitive photogrammetric or cartographic final-product. These are map products as photo maps or in vector format, thematic or topographic maps.

Thematic maps between 1 : 50,000 scale and 1 : 500,000 scale and smaller produced from space photographs are mainly used for special purposes such as geological exploration, for agriculture, forestry, ecological or local planning purposes.

Until recently, we had to consider the fact, that the resolution of satellite image data was inadequate for mapping or revision of topographic maps at a scale of 1 : 25,000. Since 1987 we now have got high resolution Soviet space photographs taken with the camera KFA-1000 which have been the subject of various theoretical and practical studies in photogrammetry.

Since 1976 we are producing photo maps from space photographs taken with the MKF-6 multispectral camera and taken with USSR-cameras made in the last years. Its technical data are:

Type of space vehicle	SOYUZ 22/ SALYUT	SALYUT	COSMOS (unmanned)	COSMOS (unmanned)
Camera	MKF-6 M	KATE-140	KATE-200	KFA-1000
Image format (mm)	55 x 81	180 x 180	180 x 180	300 x 300
Calibrated focal length (mm)	125	140	200	1,000
Spectral ranges, channels (nm)	6	1 black/white false colour	3	1 false colour
	460-520	500-700	500-600	570-670
	520-560		600-700	670-800
	580-620		700-900	
	640-680			
	700-740			
	790-900			

Photo scale 1:	2,500,000	1,500,000	1,000,000	270,000
Ground resolution (m)	10 to 15	50	15 to 30	5 to 10

We receive these space photographs from the Soviet Union in an acceptable period at acceptable costs for our user community.

The photographs from all these space cameras have a 100 per cent cloud-free coverage of the territory of our country.

Because of its geometrical properties the space photographs from the MKF-6 or KFA-1000 are especially suited for planimetric mapping and less for height representation. In previous missions for photogrammetric surveying the photographs were taken with about 60 per cent and more foreward overlap and adequate side overlap for areal coverage.

Since 1978 we have mainly produced photo maps between 1 : 50,000 and 1 : 500,000 scale from space photographs for an area of about 75,000 km^2. Photomaps have a high information content which can be geared to the varying needs of different users with elements known from the traditional line maps and with additional cartographic symbols. These maps are equipped with a grid, a map frame, and marginal data.

In a space photo map 1 : 200,000 scale just a part of the original photograph size of the space camera is used, for instance, to cover a map format 50 cm x 50 cm, an image part from a photograph taken with the MKF-6 camera of about 4 cm x 4 cm, or an image part from a photograph taken with the KATE-200 camera of about 10 cm x 10 cm is used.
For partial enlargement or rectification the RECTIMAT C rectifier has given evidence of its excellent performance; it is equipped with an additional device especially for the processing of MKF-6 photographs. The rectifier is an instrument of the new generation for colour and black-and-white photographs. High resolution and the wide range of magnification 0.85 ... 8.0 power or 3.0 ... 18.0 power allow processing of photographs taken with different photographic systems and a maximum photo-size of 30 cm x 30 cm. Its performance parameters satisfy the requirements of photogrammetry as well as those of remote sensing of the earth.

For differential rectification the TOPOCART D - ORTHOPHOT E has proved to be good. In addition to the rectification of black-and-white photographs, also colour photos can be rectified on colour film in the full magnification range without additional aids, the same applies to spectrozonal and infrared films.

Interpretable superimposed colour photographs may be produced with the multispectral projector MSP-4 C from photographs taken with the multispectral camera MKF-6 M. The MSP-4 C is a four-channel colour synthesizer for the interpretation of multispectral black-and-white photographs with a maximal picture size

of 70 mm to 91 mm using a constant 5.0 times magnification. Superimposed colour photographs from the multispectral photographs taken with the MKF-6 and the multispectral camera KATE-200 with an image format of 18 cm x 18 cm can also be produced by a special method on the rectifier RECTIMAT C in the full magnification range on colour film.

From the 6 spectral ranges of the space camera MKF-6 M it was channel 4 (from 640 ... 680 nm) and channel 6 (from 790 ... 900 nm) which proved to be most suitable for interpretation in most object categories of complex thematic mapping at the scale 1 : 200,000. Mainly larger villages, settlements and important single buildings are clearly visible with regard to their boundaries and inner structures. Industrial plants, airports, dumps of building material, lignite opencuts etc. can be well recognized. The road network with highways, motorways, and communication roads can be compiled in more detail than it is represented in the general map 1 : 200,000 scale. The road net, the network of railway communications, rivers and ponds, canals, inland lakes, and coastal lines can be identified and well demarcated by the contrast of the contiguous different vegetation covers or built-up areas in the multispectral photographs. Many possibilities are obtained especially for the special, detailed interpretation of forests and agricultural areas and for the determination of different classes of growth with simultaneous measurement of their sizes and positions for planning and controlling the foodstuff production in agriculture and for territorial planning with the aid of colour mixture and pseudo-colouring.

The graphic photogrammetric stereoplotting of the photographs from the space cameras MKF-6 or type KATE of the scales 1 : 1,000,000, 1 : 2,000,000, or 1 : 2,500,000 for the map scale 1 : 100,000 and 1 : 200,000 can be carried out on the STEREOMETROGRAPH G precision stereoplotter. This precision stereoplotter with a range of calibrated focal length from 85 mm to 310 mm and 7 times viewing magnification allows the restitution of cosmis image material. Supplementaries such as recorders, tilt calculator or model corrector for the graphical plotting with correction of distorsion, earth curvature, and refraction can be connected electrically via selsyns. The MKF-6 photographs can be placed into the machine either in their original size or magnified by 2.4 times in the precision enlarger. The absolute orientation of the image model is made partially by means of map control points. The stereoscopic compilation of the map elements to be represented is performed in partial sections and by line-by-line engraving on an engraving foil directly on the computer-aided digital plotting system DZT 90 x 120. With this technique it is possible to compare the photogrammetrically restituted photograph directly with the existing maps and to represent quite different map elements on separate engraving foils.

In the last time we have got high resolution space photographs taken with the camera KFA-1000 during the years 1985, 1986, and 1987 from the territory of our country. The photographs have a photoscale 1 : 270,000, a calibrated focal length of 1,000 mm, a resolution of 5 to 10 m, an image format of 30 cm x 30 cm, also more than 60 per cent foreward overlap whereby the positive

film material is false colour film. The photogrammetrists and cartographers would like to have a cosmic sensor resolution of about 5 m. In the GDR, for example, topographic maps must meet state map accuracy standard which requires about 66 per cent of well defined points, such as road intersections, to be within ± 0.35 mm of the correct photogrammetric map location. These are ± 8.75 m in nature for the topographic map 1 : 25,000 scale. Many customers require topical topographic data and, increasingly, the ability to generate them in a short time. The major problem we have encountered with high resolution space photographs and the present topographic map 1 : 25,000 scale is the "shortened updating".

First experiences have shown that the high resolution space photographs taken with the camera KFA-1000 can be used for the revision of topographic map products 1 : 25,000 scale using conventional photogrammetric techniques such as the map revision system KARTOFLEX (Fig. 1), the precision stereoplotter STEREOMETROGRAPH or the instrument system TOPOCART D (Fig. 2).

The map revision instrument KARTOFLEX is universally applicable to the updating of maps of any scales, interpretation, and calculation of areas with fast operating mode. The original documents are predominantly aerial photo pairs and space photographs irrespective of the exposure focal length with maximum format size of 30 cm x 30 cm. The extended version of the instrument is equipped to solve the following problems:
- Correction of affine and perspective distortions occuring between original photograph and map can be activated through the microcomputer;
- Fast correlating of photo and map by an orientation programm;
- Digitizing of map points and image points with coordinate output via standard interface.

The viewing magnification on the KARTOFLEX is continuously variable for photographs from 2.4 to 12 times and for the map from 0.8 to 4 times. The viewing modes to be changed over:
- Stereoscopic viewing of photos with superimposed map in the left or right eyepiece;
- Binocular viewing of one of the two photos with superimposing map;
- Binocular superimposed viewing of multispectral photos in three channels.

The main field of application of KARTOFLEX with space photographs are the production of thematic maps of any scales and the "shortened updating" of topographic maps 1 : 50,000 or 1 : 25,000 scale. For instance, the correlation of the space photo model from the camera KFA-1000 with an image format of 30 cm x 30 cm with the existing topographic map 1 : 25,000 scale is made partially by means of 3 to 5 map control points. The interpretation of the new map elements to be represented is performed in partial sections with maximum area of about 5 to 8 cm^2 in the map 1 : 25,000 scale. This corresponds to an area of 4 to 7 mm^2 in the original image of 1 : 270,000 scale.

For large areas, for instance new housing areas, of about 100 cm^2 in the map 1 : 25,000 scale the photogrammetric stereoplotting from high resolution space photographs of the scale 1 : 270,000 can be carried out effectively on the STEREOMETROGRAPH G precision stereoplotting machine with model corrector. The absolute orientation of the image model is made partially by means of 6 map control points. The affine stereoscopic compilation of the new map elements to be represented is performed in partial sections and by line-by-line engraving on an engraving foil directly on the computer-aided stereoplotting system.

The combination of photogrammetric mapping with the KARTOFLEX and with the STEREOMETROGRAPH G from the high resolution space photographs may be utilized now with other source information for the "shortened updating". The only one year old, new topographic information from the space photographs on the combination foil may be coloured imprinted in the existing topographic map 1 : 25,000 scale. This is an effective method. (Fig. 3.1. ... 3.3.)

For the digital photogrammetric restitution of the space photographs can be made use of the STECOMETER C precision stereocomparator. It allows the point-by-point restitution of the cosmic photographic material inan image format of 23 cm x 23 cm with a total magnification of 6 to 18 times. The photo coordinates of single points measured in digital photogrammetric restitution are recorded in machine readable form and subsequently processed in a computer with the block triangulation program SAMT. Here, too, map control points from existing topographic maps of the scale 1 : 25,000 or 1 : 10,000 are introduced, with street crossings being well suited as map control points. In the computer program consideration of influences of the earth's curvature and refraction can be satisfied. For the STECOMETER measurement for one photo pair from the space camera MKF-6 M for instance a mean position error of $\pm$ 32.5 m or $\pm$ 16 µm in the original image yielded. The results are represented cartographically in the usual form in off-line operation on the DZT 90 x 120 Digital Drawing Table.

It is a fact that for many problems in the production of thematic maps and in the revision of topographic maps with space photographs the photogrammetric equipments and systems from VEB Carl Zeiss JENA in our mapping and plotting centre can be employed.

The photogrammetric and cartographic methods as we practise them with aerial photographs and the analogue and analytical plotting instruments can also be used for space photogrammetry in the next time.

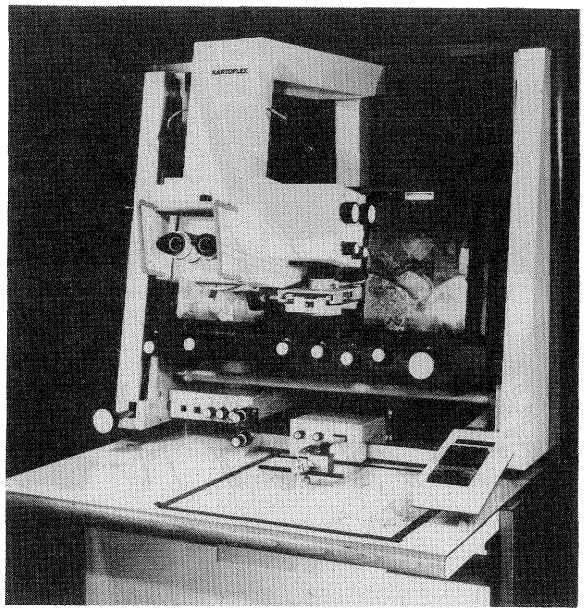

Figure 1: Map Revision Instrument KARTOFLEX

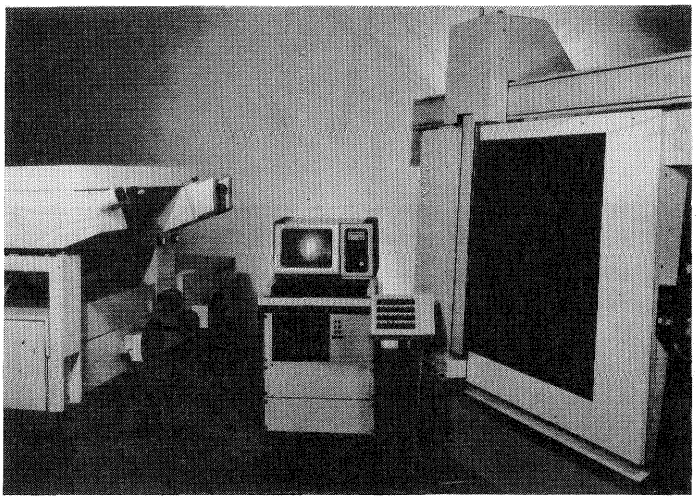

Figure 2: Stereoplotter TOPOCART D with connection of a computer-aided plotting system DZT 90 x 120 / RGS

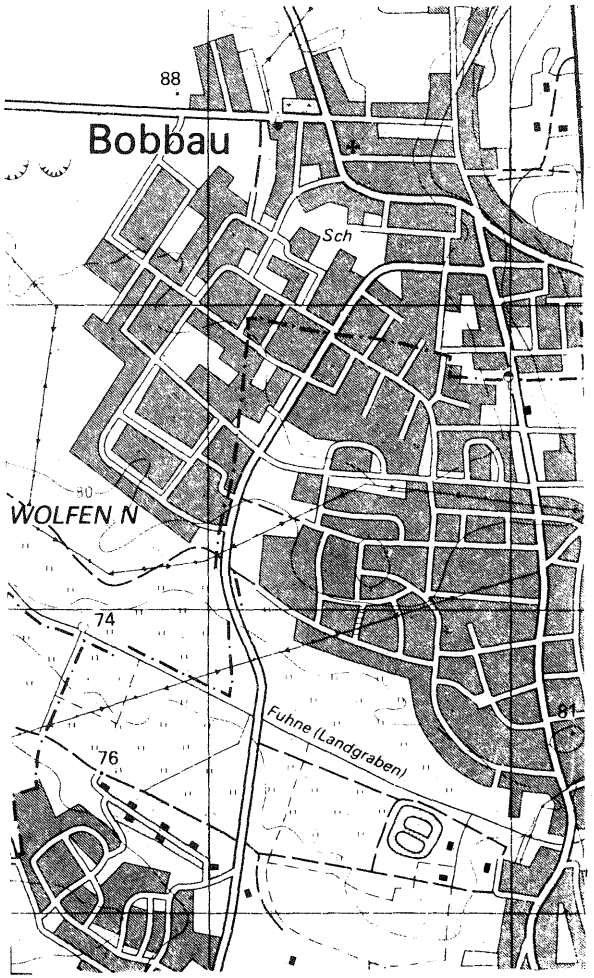

Fig. 3.1.:
Existing topographic map (1980)

Stand der Unterlagen
1980

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Topographische Karte 1 : 25 000

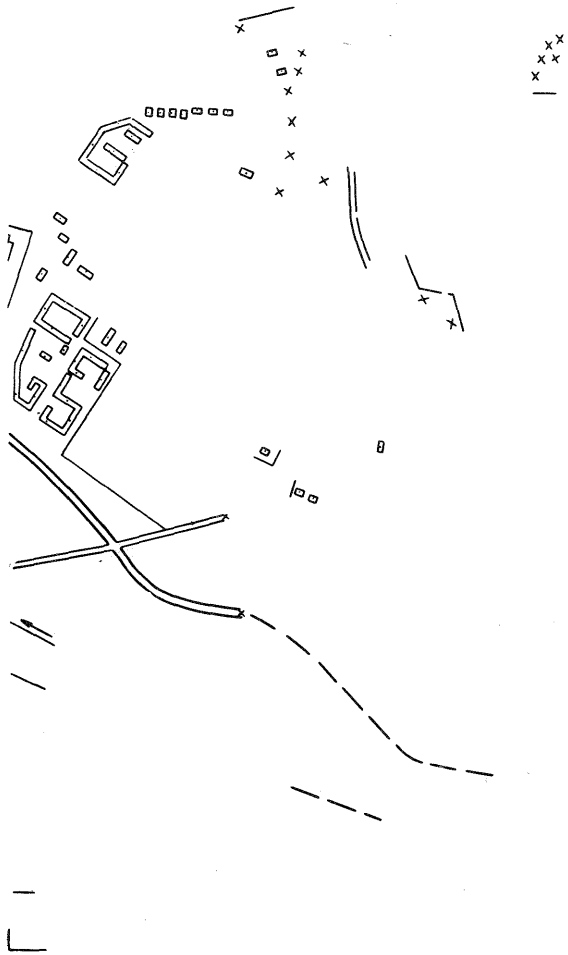

Fig. 3.2.:
New topographic information
from the high resolution space
photographs (1986)

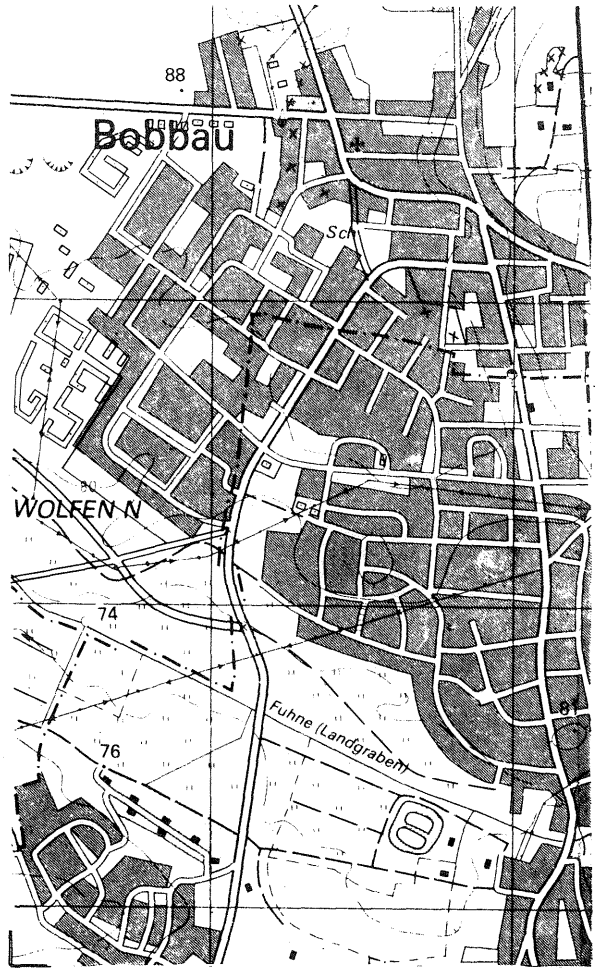

Fig. 3.3.: "Shortened updating"
(combination 3.1. and 3.2.)

1

Stand der Unterlagen:
1 : 1980

Ergänzt mit Kosmischen Aufnahmen
vom August 1986

LFB 12/88