TOPOGRAPHIC MAPPING FROM SPACE BORNE METRIC CAMERA IMAGERY

H. Engel, G. Konecny, P. Lohmann and W. Schuhr
Institute For Photogrammetry, University Of Hannover
Federal Republic of Germany

1. INTRODUCTION

The purpose of Spacelab 1 Metric Camera imagery is to provide world wide medium scale mapping coverage (scale ranges from 1 : 50 000 to 1 : 100 000) for the benefit of

- planning of human activities,
- environmental observation,
- transportation organization and
- natural ressource management.

For the original Metric Camera images are of analog nature, analog projection techniques, so far experimentially have been applied very successfully for some testareas by Zeiss Orthocomp Z2 (see ENGEL, 1984). This paper deals with first results of the futural contribution of complete digital image processing techniques for Metric Camera imagery evaluation.
Digital image processing techniques offer special advantages outside of those already known for digital ground control point adjustment procedures. They permit the extension of the digital treatment of photogrammetry to differential image elements. The advantages of automatic or semi-automatic digital image processing techniques are of concern to many disciplins; such as

- optimal enhancement of contrast contained in the emulsion with respect to the human viewing,
- edgeenhancement for quasiline map-production,
- application of classification approaches and
- geometric image processing.

2. APPLIED TECHNIQUE

In order to avoid measurements within the digitized image, comparator coordinates for ground control preferably have been measured in the original Metric Camera image. If the digitized image part does not contain the viducial marks, 4 (artificial) transfer points are necessary to be used as identic points for the transformation of original into digitized image coordinates.
As far as Metric Camera imagery is concerned, a part of a four times enlarged image of the Munic area has been used for digitization (see figure 1). The digitized image only has been used for measuring 4 transfer points and the 4 image edges.
So after a Helmert transformation of comparator coordinates into metric image coordinates (index 1)

$$x_1' = x_s' + a \cdot x'_{PSK} - o \cdot y'_{PSK}$$

$$y_1' = a_s' + a \cdot y'_{PSK} + 0 \cdot a'_{PSK}$$

for calculating row- and column values of the ground control-points, a two time affintransformation approach of metric image coordinates into the

row- and column-system is applied, including the pixel shapeand the image skew.
For the 4 transfer points the metric image coordinates in the original image (index 1) and the mashine coordinates in the digitized image (index 2) are known:

$$x'_{PSK2} = a_o + a_1\, x'_1 + a_2 y_1'$$

$$y'_{PSK2} = b_o + b_1\, x_1' + b_2 a_1'$$

The row- and column-values (record address x' and y') for the ground control points in the digitized image result by another equalization of an affin-transformation based upon the imageedges, which comparator coordinates and row- and column-values are known:

$$x' = (a_o) + (a_1)\, x'_{PSK2} + (a_2)\, y'_{PSK2}$$

$$y' = (b_o) + (b_1)\, x'_{PSK2} + (b_2)\, a'_{PSK2}$$

This approach at least allows to determine record addresses for every output pixel position by applying the exterior orientation values via the collinearity approach.

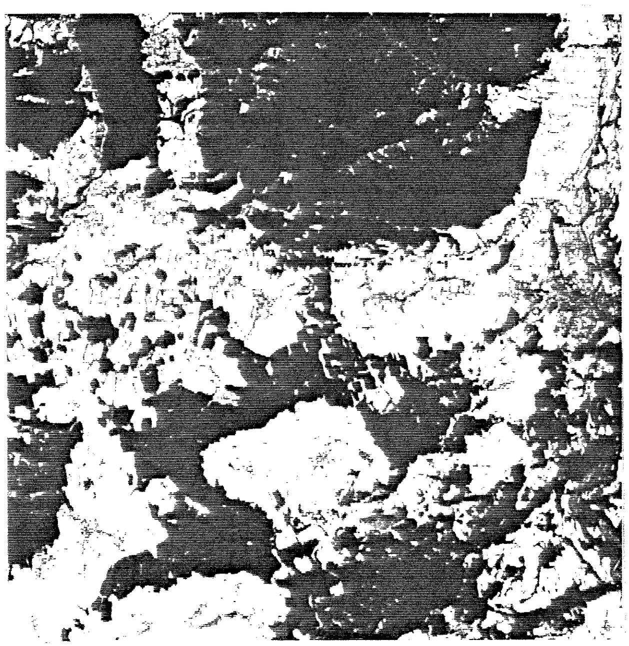

Fig.1 Four times enlarged part of a Metric Camera Image of the Alpsregion, used for digitization

3. DIGITAL RECTIFICATION

Digital rectification is required for tape images of digital sensors such as Thematic Mapper etc., but it can also be applied to photographic images if they have been digitized for instance on the Optronics P1700 device.

To test the applicability of digital rectification to Metric Camera imagery, a first generation photograph at the scale 1 : 800 000 was 4 times linear enlarged and digitized on the Optronics at 50 µm pixel size. This image data was transferred to the disk storage of the CDC Cyber 73/76 computer available in Hannover.

A regular output grid is immediately obtained in the indirect method of digital rectification. There the application of collinearity equations results in pixel locations for the transfer of densities.

In order to speed up calculation, the strict geometrical solution is applied to anchor points of output blocks 150 by 20 pixels only, see figure 2. This serves two purposes:

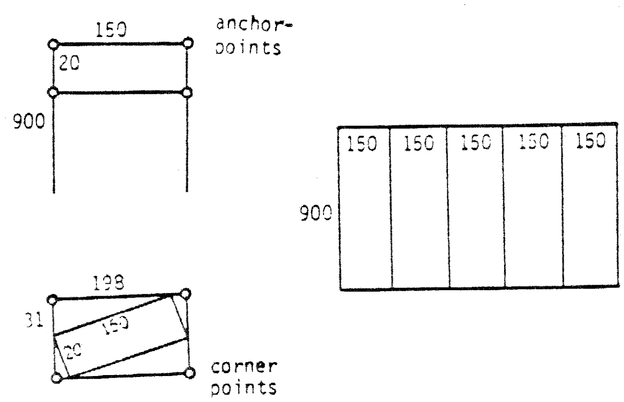

Fig.2 Example for the principal pixel data organization

First, the computing speed; second, to determine the maximum storage requirement in core to be used for the indirect rectification of each image block.
An existing 1 : 50 000 map of the area has been used to interpolate DTM information. This information is stored in a rectangular grid.
The DTM is originally stored for the whole image in the form of a rectangular grid. The grid must be so dense that elevation interpolation is possible by a first order polynomial.
This interpolated height is then used for the anchor point solution; the image of the small 150 by 20 block is transferred by hyperbolic interpolation. Based on this an orthophoto at the scale 1 : 100 000 was produced. This orthophoto may also be generated with a digitally determined coordinate grid and edge enhancement procedures may be utilized to generate a quasi line map. In figure 3 is shown the first result of an overlay of an existing 1 : 100 000 line map and a part of a rectified Metric Camera quasi line map image.

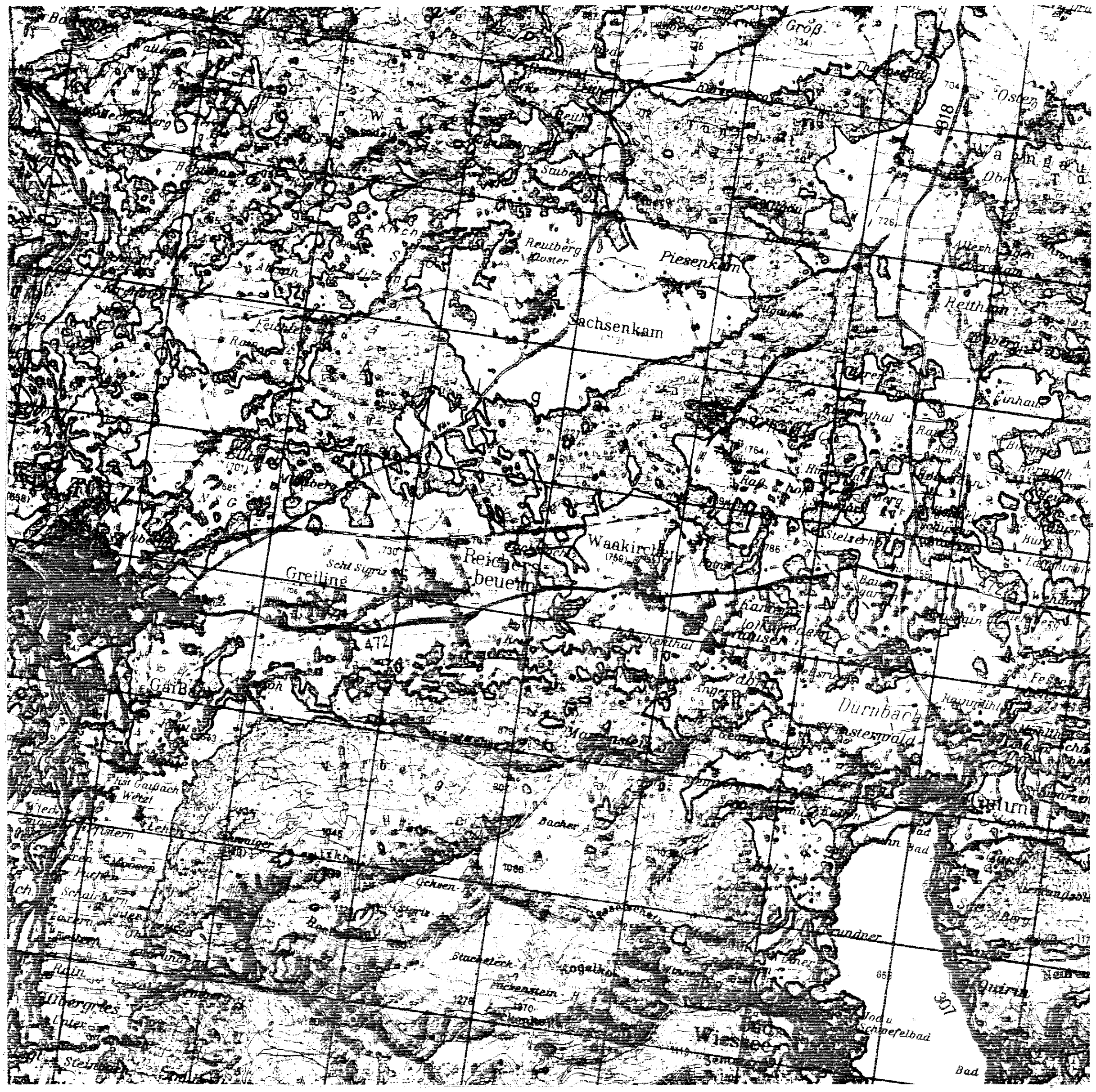

Fig. 3 First result of a combination of a digital rectified edgeenhanced Metric Camera image part with an existing line map (scale 1:100 000)

3. CONCLUSIONS

The examples demonstrate that it is technically feasible to generate digital orthophotos from Metric Camera photography.
The generation of digital orthophotos may be of particular advantage for the production of color orthophotomaps. Photolithography only requires a low resolution input of three color separations. These should, however, be image processed to allow for the proper balance of color. Such control could best be executed by digital means. Off-line image processing for photolithography is therefore a potential tool today.
If the digital rectification is to be applied to images of the highest resolution, as is required for visual analysis at high magnification, a pixel size of 12.5 µm is necessary, and the amount of data rises to $3 \cdot 10^9$ bits.

Currently there exist various economic and technical limitations for the digital processing of such images. The first limitation is the read-write speed for the input and output of images. Only fast drums offer a satisfactory input-output rate for high resolution.
The next limitations are transfer rates within the computing system and its peripherals, as well as the storage requirements.
With respect to storage devices currently available, only high digital density tapes offer sufficient storage capability and sufficient transfer speed.
Devices, such as a fast scanning and printing drum and the high digital density tape intermediate storage, are extremely expensive. They would be worthwhile only if processing of images, geometric and otherwise, could be carried out in a data stream, that is, on-line. For on-line processing another limitation is imposed by the maximum core storage requirement for the input-image in the indirect rectification process. It is determined by the size of expected image deformations, unless anchor points are priviously determined in an off-line manner.
Finally a limitation exists in computing the collinearity equation in real time. Digital hardware is currently capable of solving the total of 14 arithmetic operations at 1/3 MHz rates if they are performed in parallel. U. Helava in Hannover designed such a processor, which he calls the digital projector. Such a perspective processor design may be applied several times. A number of these processors may be arranged in a pipeline mode. Six processors operating at 1/3 MHz rate could increase the total flow rate to 3 MHz. Such a perspective processor system could be integrated with an output and an input drum. The image on the input drum can be addressed in real time by an acousto-optical laser deflector. A suggestion to that effect was presented at the conference on the use of digital components in photogrammetry in Hannover in February, 1978 (Konecny, 1978; Luetjen, 1978). The result would be a digital image processing system capable of producing high quality digital orthophotos at very high speeds and at low unit cost.

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