# A SUPER PRECISE TEST FIELD
# FOR CLOSE-RANGE PHOTOGRAMMETRIC APPLICATIONS*)

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ABSTRACT

A super-precise test field, which was established with the use of girder plates of a photogrammetric plotting instrument, consist of about 200 points. The coordinates of these test field points are derived with an accuracy of ±12μm and with a minimum afford of measure. This test field is photographed from three different camera stations with a metric camera, developed in IAGB, Stuttgart. The photographs are restituted on a Zeiss-PSK. For the computations, a computer program for a rigid bundle solution (multiple stations, convergent photographs) is used. From the differences of coordinates, conclusions of obtained accuracy are given with regard of control point number and the ratio of the depth of control point group to the mean object distance.

## INTRODUCTION

Photogrammetry or measuring with photographs is a measuring technique for reconstruction of spatial geometry of objects by means of photographs. With the aid of photogrammetric measuring methods one can determine single points with their three dimensional coordinate values or continous forms of the objects, such as contour lines, profiles or cross sections can be determined and represented. With these properties, the most frequent use of photogrammetry lies in the field of classical geodesy, thus in the field of map production. The use of photogrammetric methods is not limited to this field, it is to be understood generally as an indirect measuring technique to determine geometrical object data.

As in every planning, realisation and control steps of engineering problems, and in scientific resaerch and development, many problems are combined with measurements, photogrammetric techniques combined with modern data processing can be used in the above mentioned phases. The methods of point measurement on photographs with successive analytical treatment of obtained data have gained importance. In this way of data processing, the limitations cf focal length, format of the camera and configuration of camera stations don't play any importance.

In this context, in a photogrammetric measurement of an object, it is important for the users of photogrammetric methods, with which precision the photogrammetrically determined coordinates with the coordinates of the object space coincide. A simple method is to photcgraph precisely surveyed areas, which have practically points with precise coordinate values and tc compare these coordinate values with the photogrammetrically determined coordinates.

In aerial photogrammetry, test fields consisting of precisely signalised and surveyed points are flown and photographed. Similar to the aerial photogrammetry, with the arrangement of three dimensional located points (test fields reduced with a corresponding scale), one can proceed in close-range photogrammetry, too /1/, /2/.

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TEST FIELD

A test field, located in the measuring cellar 0034 of the Institute of Geodesy of the University of Stuttgart, is thought to serve the following purposes:

- It must allow to determine a maximum number of test field coordinates with a sufficient accuracy and a minimum afford of measure.

- The transport and installation of the test field at a different place must be done with no problem.

- During the use of computer programs, based on the method of "on-the-job calibration", test field must guarantee no restrictions concerning the camera situation and configuration.

For this reason the test field was constructed with two girder plates of the Autograph Wild A8, see Fig.1 and Fig.2. Each of the girder plate has as intersection of in horizontal and vertical direction engraved lines 100 points, whose coordinates were determined with an accuracy of ±0,5μm, absolutly to a point and axes system in the surface plane of each plate. In order to have a three dimensional extended test field, the girder plates are mounted on an aluminium plate forming an angle of approximately 160g between plate surfaces. An aluminium bar between the vertical edges of the plates serves as fixation in vertical direction.

After this preparatory works the test field is placed on a pillar in the cellar. In order to obtain precise coordinates of the test field points, angular (vertical and horizontal) and distance measurements were made.

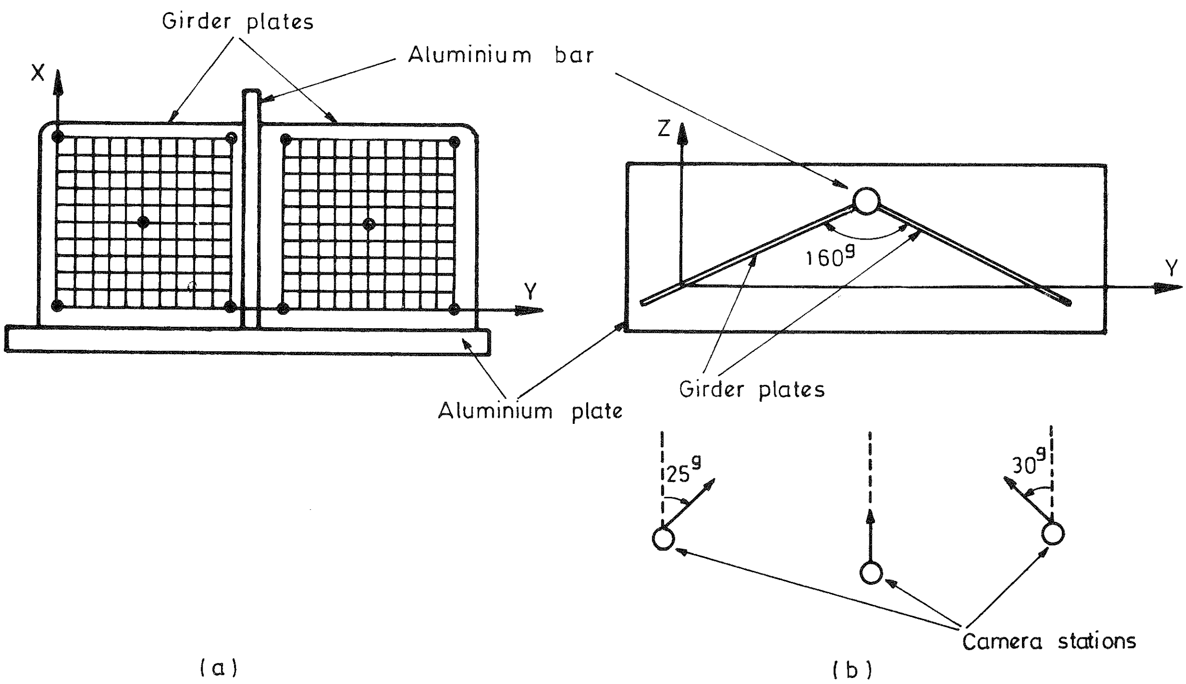


Figure 1 - Design of the test field with camera stations and exposure directions, (a) view, (b) plane

From two theodolite stations, the vertical and horizontal directions to the points, which are at the corners and in the middle of the girder plates (in Fig.1(a) points marked with a circle) and to the other theodolite are measured. These angles and the distances calculated from the coordinate differences of the diagonal corner points of each girder plate, combined with adequate weights are handled with a rigorous three dimensional geodetic net adjustment program /3/. One of the outputs of this program is the coordinates of this 10 points in the ground coordinate system shown in

Fig.1(b). The mean square point error $m_p$ of this coordinates are ±12μm. Afterwards the coordinates of the remaining test field points are determined with an uniform subdivision of coordinate differences of the corner points. Thus, with the determination of coordinates of 10 points, one gets the coordinates of 200 points with the same accuracy.

## PHOTOGRAMMETRIC SURVEY

This test field is photographed from three different camera stations, with a mean object distance of about 60 cm. (Fig.1(b)). The camera used in this survey is developed at IAGB (University of Stuttgart) and it has a focal length of 114.7 mm. For further details of the camera, see /4/. During the photographing process, for a sharp image of the girder points on the image plane,which are the intersection of very thin engraved lines, some improvisation experiments were necessary. After some tests, an indirect illumination of the test field from back, seen also in Fig.2 has given the best result. Therefore two illumination spots are directed to the wall behind the test field. The reflected light rays meet on their way back to a brigt spanned paper just behind the test field.

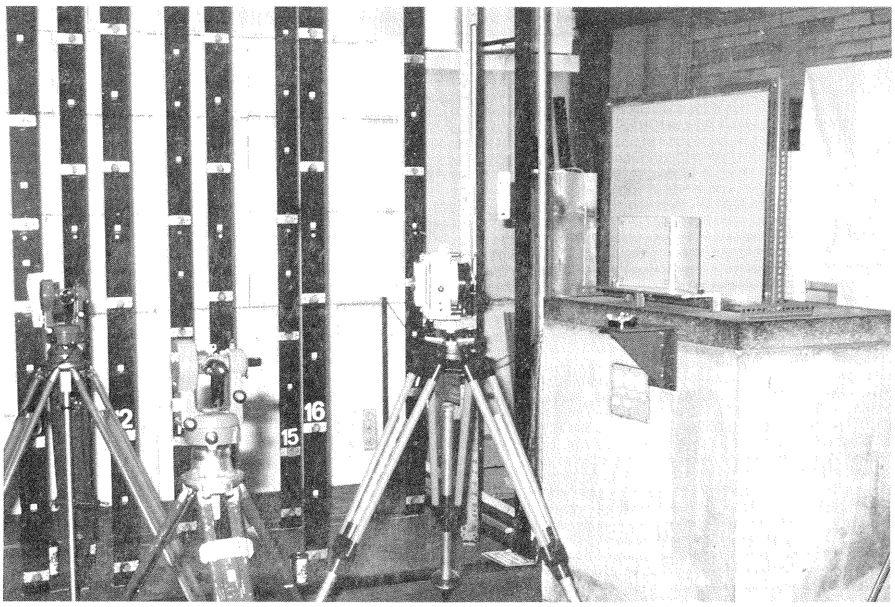


Figure 2 - Test field, camera used in this survey and the measurement of angles

The image coordinates of the girder points are measured in a Zeiss Stereocomparator, treating each photograph seperately. For the computations a computer program for a rigid bundle solution was used /4/, /5/. The approximate coordinates of the test field points and camera stations, other elements of exterior and interior orientation elements are given as initial data to the program. The adjusted coordinates of the test field points are achieved in the ground coordinate system, shown in Fig.1(a).

The base for further investigations are the 3-dimensional coordinates of all test field points, which result on one hand from the rigid bunde solution and on the other hand the coordinates of these points achieved by means of geodetic measurements. For the presentation of the results, the differences of the coordinates of all points, which are represented by the mean values, are considered :

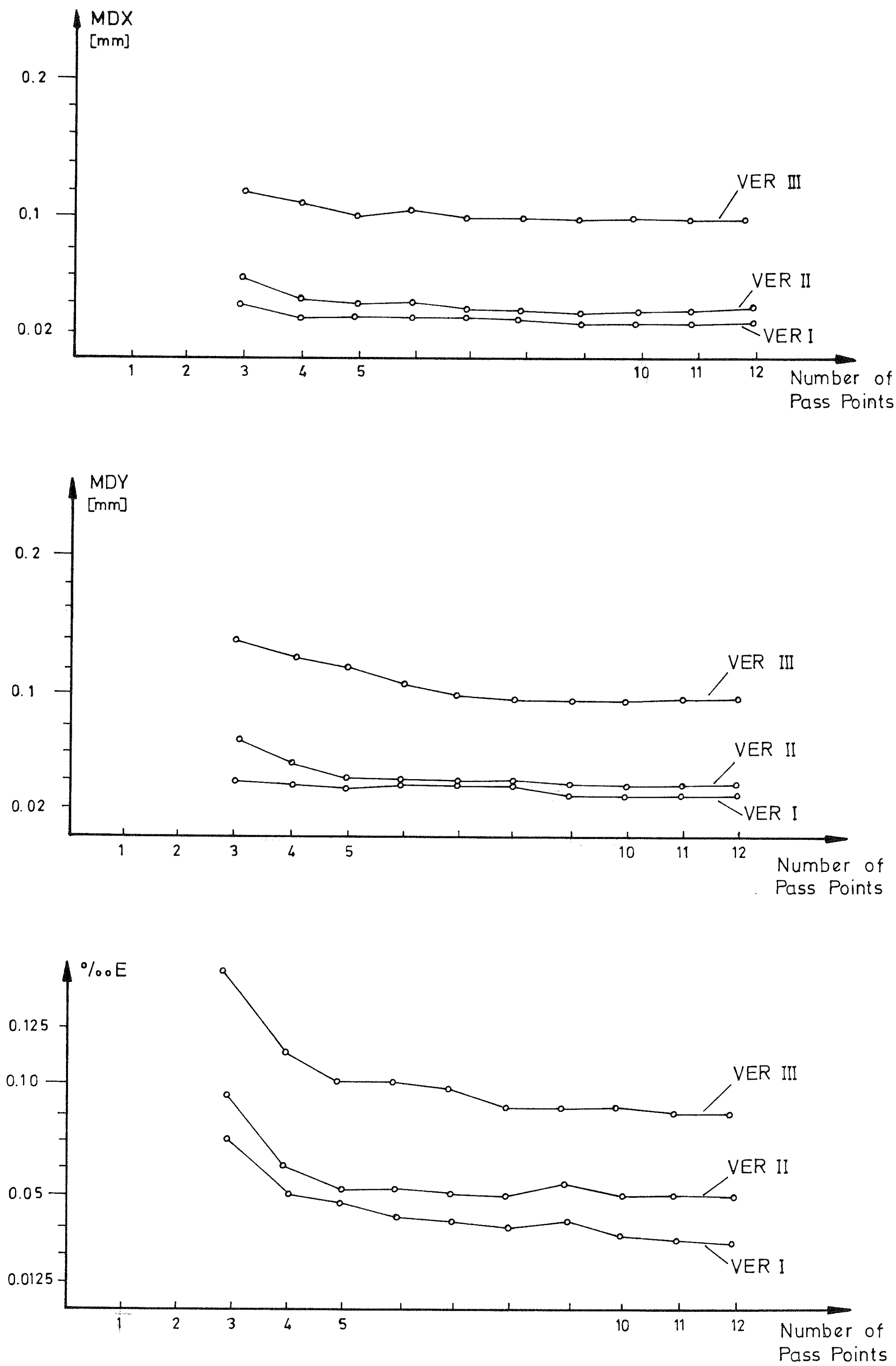


Fig.3 - Variation of MDX, MDY and the ratio of MDZ to mean object distance.

$$MDX = \frac{1}{n} \Sigma |DX|$$

$$MDY = \frac{1}{n} \Sigma |DY|$$

$$MDZ = \frac{1}{n} \Sigma |DZ|$$

with DX, DY, DZ differences of the coordinates

n number of points in the comparison

For a better representation of results the calculated values of MDX, MDY and the ratio of MDZ to a mean object distance about 60 cm in per mille are given as drawings in Fig.3. These results are computed for three different ratios of mean object distance to the depth of pass points as three different versions. The first version (VER I) is computed for the maximum extend of control point depth (6,2 cm) and the ratio of this value to the mean object distance (60 cm) is 9.7, Other versions (VER II) and (VER III) are computed for a depth of 10 cm and 5 cm of the pass point extend. In each version the values are given for different number of pass points, beginning from 3 pass points.

From the course of curve for the Version I, the version with longest depth of pass points, one can conclude, that this version gives the most precise results, in comparison to other version. This is an expected result from different studies /6/, /7/. In each direction an increase of the number of pass points up 6 doesn't bring any improvement in the accuracy. Only the enlargment of the ratio of mean object distance to the pass point extension causes in every direction from VER III to VER II an improvement of 60 and 40 % and from VER II to VER I an improvement of 20 and 5 %, according to the number of pass points.

## CONCLUSIONS

In this work, it is tried to establish a precise test field with a minimum afford of surveying work. This aim was achieved with the use of girder plates of an autograph. The determination of totaly 10 points of two girder plates permits to achieve 200 points with an accuracy of $\pm 12 \mu m$. The possibility of variation of the pass points allows to investigate the influence of the depth field of pass points to the results. As the establishment of the test field doesn't make any problem, it can be used in many close range problems, just in the problems where the object size allows to photograph a minimum number of pass points with the object. It can specially in the applications, where "on-the-job calibration" method must be used, very helpful.

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