Short information about program system BLUH

Program System

BLUH

Bundle block adjustment
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The program system BLUH is subdivided into programs to ensure a flexible handling. It includes a high number of programs for pre and post processing.

Preparation

1 BLPRE preparation of photo coordinates
2 BLTRA transformation of ground coordinates or image orientations to different map projections

bundle block adjustment

3 BLOR approximate photo orientations, first data check
4 BLAPP sorting of photo coordinates
5 BLIM input of control data for BLUH
6 BLUH bundle block adjustment
7 BLAN analysis of results, plot

post processing

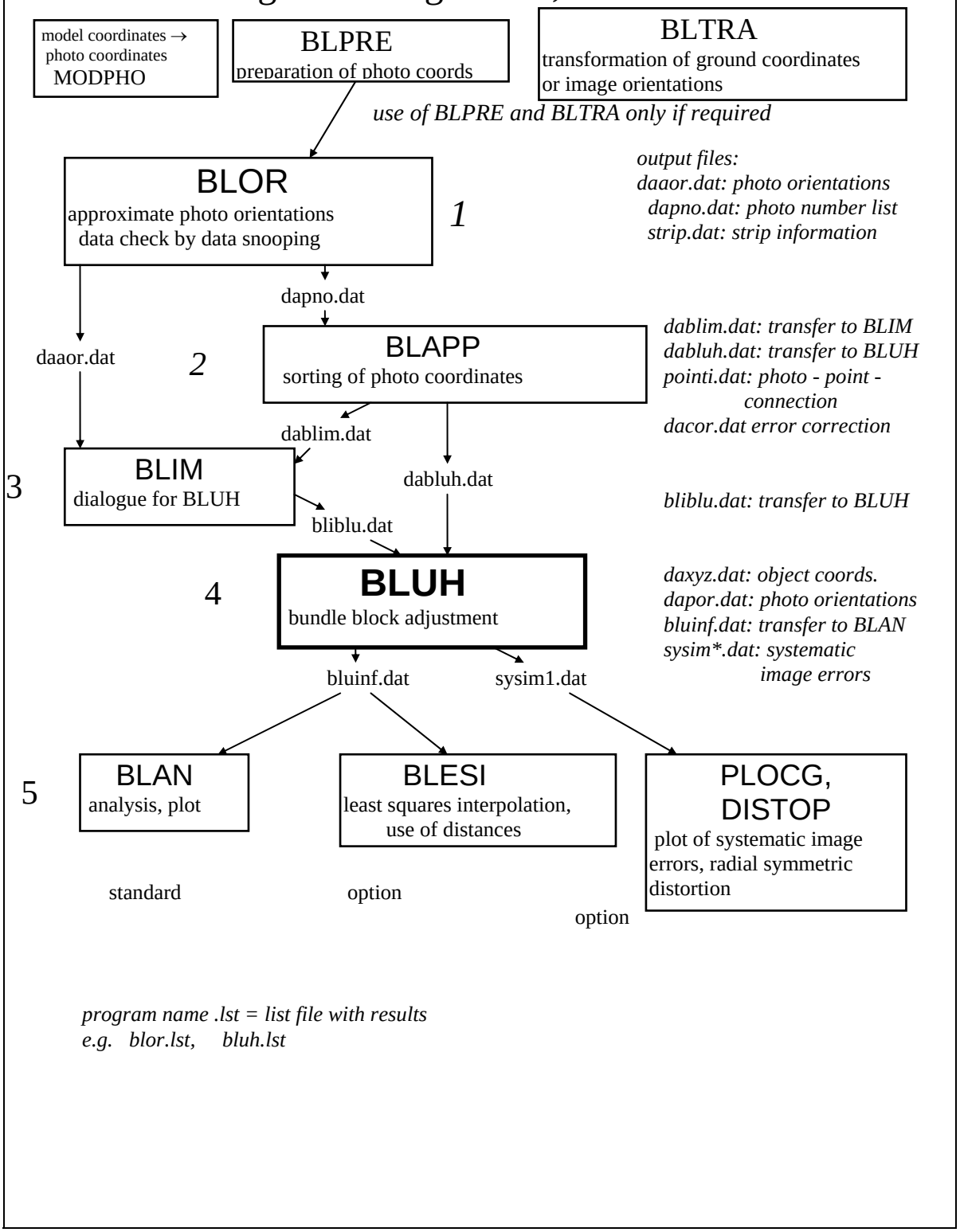
8 BLESI least squares interpolation, check and/or improvement of ground coordinates by distances, plot

support programs

9 COVER HP-GL-plot of area covered by photos – for close range and also based on IMU-data
10 BLCON conversion of ground coordinates, window functions, reduction to equal distributed points
11 BLSET settings for analog instruments
12 BLECO correction of photo coordinates based on error correction list
13 BLIST creation of photo number list based on sub-blocks
14 BLSORT sorting of ground coordinates by point names and/or location, plot of points
15 BLDIR search of neighbored and identical points
16 BLINT / BLINTS computation of ground coordinates by photo coordinates and orientations
17 APROX computation of photo coordinates by ground coordinates and orientations
18 PHOPO print plot of location of photos and/or ground points
19 PHOMOD computation of model coordinates
20 MODPHO conversion of model to photo coordinates
21 MOSTE rearrangement of mono photo file to stereo arrangement
22 MANI manipulation of ground coordinates
23 PLOCG plot correction grid (SYSIMn.DAT)
24 ROTOR rotation of orientations and/or ground coordinates
25 TRAN3D 3-D (or 2-D) transformation or shift with data snooping
26 RESEC resection (computation of photo orientation)
27 BLUREX creation of a PHOREX-file (orientation interchange format)
28 BLUHEV creation of orientation file for LHS or TopoSurf (PAT)
29 IMPLO plot of point distribution in specified images
30 DIPHO analysis of differences of multiple photo measurements, plot
31 SINPHO computation of object coordinates based on single photo
32 GPSTRA plot of GPS-flight trace
32 GPSPL plot and analysis of differences between projection centers and GPS-positions and/or IMU-data
32 GPSINT interpolation of projection centers based on kinematic GPS-positions
32 GPSHIF shift of GPS-projection centers strip by strip
33 HPGDXF conversion of HP/GL-files from BLUH to DXF-files
34 CSORT sorting of ASCII file in ascending sequence or corresponding to a sort-file
35 FIDUCI computation of fiducial mark positions based on points located on a line
36 DBLANK delete and add blanks to a file and selected output
37 PHOCON analysis of photo connection and distribution of points in the photos
38 BLUOMAX creation of orientation file for OrthoMax
39 EXPHO exclude photos out of the photo number list
40 PIDENT point renaming by identical points (names from one file, coordinates from other)
41 DISTOP plot of radial symmetric distortion determined by self calibration
42 ORATA transformation of orientations from aerial to terrestrial and reverse
43 BLUIAO creation of Intergraph AO-file and Exterior-file
44 OMAXBLU photo coordinates from OrthoMax ASCII-dump
45 PHOSORT sorting of photo coordinate file, arrangement of all separate parts together
46 BLUDSR creation of orientation information for the DSR
47 PCIBLU extraction of photo coordinates from a PCI-output file
48 BLUHBC update of BC-3-orientation files
49 IMUPRE preparation of orientation data from an inertial measurement unit
50 PHORED reduction of number of photo points in an input file
51 OB2BLU / BLU2OB extraction of photo coordinates from an ERDAS Imaging OrthoBASE-file, preparation of import of orientations to OrthoBASE
52 A8PRJ computation of model projection centers based on A8-measurements (on request)
53 TRI2BLU extraction of photo coordinates and control points from Image Station Match-AT
55 LPSBLU extracting photo coords and other data from LPS block adjustment / conversion of image files
56 DEMCOR correction of a DEM by model deformation caused by not respected systematic image errors

Optional programs for handling of satellite images, DEM generation and analysis : - see separate paper

Program configuration, data flow



program name .lst = list file with results
e.g. blor.lst, bluh.lst

Program System BLUH
BundLe Block Adjustment Leibniz University Hannover

General

The bundle block adjustment is the most rigorous and flexible method of a block adjustment. The computation with self calibration by additional parameters leads to the most accurate results of any type of block adjustment.
With coordinates of the projection centers determined by kinematic GPS-positioning, the number of control points can be minimized. The misalignment of a direct sensor orientation package (GPS + inertial system) can be computed. A combined adjustment of direct sensor orientation together with image coordinates is possible.
The program system BLUH is optimized for aerial triangulation but not limited to this. Even close range photos taken from all directions (with exception of omega = 80 - 120 grads) can be handled (terrestrial orientations can be handled only by RESEC, BLINT and ORATA). A camera calibration for close range applications is possible even with special optics like Fisheye.
Special possibilities for the supported elimination of a higher number of blunders like in the case of data acquisition with automatic aerial triangulation are included.
Also panoramic photos can be handled in the adjustment.

Functions of the program system

The program system is subdivided into several program modules to ensure a flexible handling. For computation of a bundle block adjustment only the modules BLOR, BLAPP, BLIM and BLUH are necessary, they can be handled as one unique set or separately. Even a batch handling of this group is possible or in can be included into a shell because the control data can be introduced not only by dialogue, it is also possible to introduce it by support files. The other modules can be used for special conditions, for analysis of the data and for other support of the data handling.

preparation of image coordinates

non standard input data can be prepared for the adjustment, e.g. photo coordinates from other analytical of digital plotters, mono and stereo comparators;
- transformation of pixel positions to image coordinates
- transformation of photo carrier to photo coordinates by similarity, affine or perspective transformation
- reseau correction - correction of lens distortion, refraction, earth curvature
- rearrangement of data sets into different format, sequence and orientation
- geometric changes of photo coordinates (shift, scale, transformation of photos ...)
- determination of boresite misalignment for IMU (INS) and GPS to camera, boresite misalignment of multiple camera systems

conversion of photo coordinates

photo coordinates or pixel addresses in other arrangements can be converted e.g. with LPSBLU, TRI2BLU, OB2BLU, PCIBLU, PMAXBLU

transformation of ground coordinates and image orientations

transformation of UTM, transversal Mercator (Gauss-Krueger) and Lambert, oblique Mercator (Hotine) and US state plane coordinates to geographic, geocentric coordinates and tangential plane coordinate system to the ellipsoid and back, datum transformation – the same can be done with image orientation, transformation of IMU-orientation (roll, pitch, yaw) to image orientation, conversion of different image orientation

computation of approximate photo orientations and first data check

by combined strip computations with first data check by means of data snooping; also handling of photos which do not allow a relative orientation, e.g. photos with very small view angle or panoramic photos - automatic elimination of blunders, automatic detection of optimal sequence of data for block adjustment

bundle block adjustment

- with self calibration by additional parameters and possibility of automatic reduction of set of additional parameters to optimal set, special parameters for DMC and UltraCam
- camera and/or strip and/or block invariant additional parameters

- statistical analysis of additional parameters and remaining systematic image errors, automatic reduction of the set of additional parameters to the required set
- camera calibration and determination of IMU-misalignment (=boresight misalignment)
- blunder detection by robust estimators
- high number of plausibility checks and error messages
- also handling of panoramic photos
- combined adjustment with GPS projection center coordinates, direct sensor orientation with IMU + GPS
- determination of the misalignment of an inertial measurement unit
- adjustment with possibility of individual weight for control points and with different weight groups for photo coordinates
- combined intersection based on image orientation determined by GPS + IMU

analysis of results

- detection of points with approximate same position (errors in point names)
- computation of differences between different data sets
- covariance analysis, computation of relative accuracy
- printed graphical representation of results
- creation of HP/GL-plot files (also conversion program to DXF-format)

post processing

- fitting of ground coordinates to support points by least squares interpolation
- correction of ground coordinates by means of measured distances

GENERAL POSSIBILITIES

- input data in ASCII-files with any format - even mixed formats in a file are accepted
- the photo coordinates can be arranged in the sequence of models (analytical plotters or stereo comparators) and/or photos (mono comparators), different arrangements are accepted
- the data for a photo do not have to be contiguous; later on new measurements of the same photo can be added at the end of the file
- there is no restriction to the type of photographs, totally different cameras can be handled together in one adjustment
- panoramic photographs (no perspective geometry) can be handled as well as extremely high oblique photos with very small view angle (caused by such a special geometry a relative orientation cannot be computed)
- handling of satellite line scanner images (IKONOS, QuickBird, SPOT, IRS...) possible with optional modules
- input of control data mainly by menu supported by default values of the preceding program run; immediate plausibility check of control values but also batch process possible
- combined adjustment with GPS-positions for the projection centers (in this case only few or no control points are necessary) or supported by inertial measurement unit (IMU)

blunder detection

The automatic blunder detection by data snooping during the combined strip computation in BLOR and robust estimators in bundle adjustment is very powerful, even blocks with a high number of blunders can be handled fast and easy. The program system can also be handled by slightly trained staff.

available program versions

The standard program system is available for Windows systems.

PROGRAM CAPACITY

The capacity is depending upon the available core. The program system BLUH does not need a large size for scratch files and is very fast in the execution. The program capacity corresponds to the requirements for block adjustments based on data acquisition with automatic triangulation.

standard capacity:
4000 photos , 200 000 ground points, 50 photos/ground point, 3000 points/photo
500 additional parameters, 500 cameras / strips for combined adjustment with GPS-data
point names up to 15 characters, photo numbers up to 9 digits
an extension of the program capacity on request can be done within hours

order number difference: 160 (see BLAPP / BLUH) – for stronger image connections the extended version **BLUHT** handling up to 6000 photos with an order number difference up to 260 has to be used

Handling of control points in BLUH

In program BLUH it is possible to handle the control points with the weight indefinitely (error free control points – specification in BLIM) or with specified standard deviations of the ground coordinates of the control points. In both cases, the corresponding weights of the control points are used for the computation of the bundle block adjustment. For error free control points the discrepancies at the ground coordinates of the control points are 0.0 and for the computation with the specified weights, the discrepancies are directly depending upon such weights.
In the case of an operational data handling, this includes the danger of a manipulation of the results of a bundle block adjustment and the problem that real problems are not obviously. Most bundle block adjustments are handling the listing in this manner – this looks better, but it is very dangerous. Even statistic analysis methods (e.g. variance component analysis) do have here some problems. By this reason, the listing of BLUH will show the following: The adjustment will be done with the specified weights; this will lead to the correct image orientations. Based on the image orientations and is used, also the additional parameters, the ground coordinates of the control points are determined by a combined intersection. The discrepancies of these ground coordinates against the input values of the control points are listed – so also in the case of a handling with error free control points, discrepancies are shown at the ground coordinates of the control points. This method shows the real problems of the control points and the discrepancies are not hidden like in the case of other programs. By this reason, the root mean square errors of the control points are showing in the case of a sufficient density of the control points the quality of the block and a good estimation of the reached quality of the ground coordinates of tie points.
For an independent comparison of different bundle block adjustment programs in no case the listed discrepancies and computed standard deviations should be used because very often they are manipulated and show only the internal accuracy figures. An independent comparison only can be made with independent check points (points with known ground coordinates, which have not been used as control points).

Handling of Panoramic Photos

Panoramic photos do not have a perspective geometry. Theoretically the distance from the projection center to the film is the same for x'=const. In addition the aircraft is changing its position while the surface is scanned from one side to the other. That means we do not have one projection center in the object space, there is a line of projection.

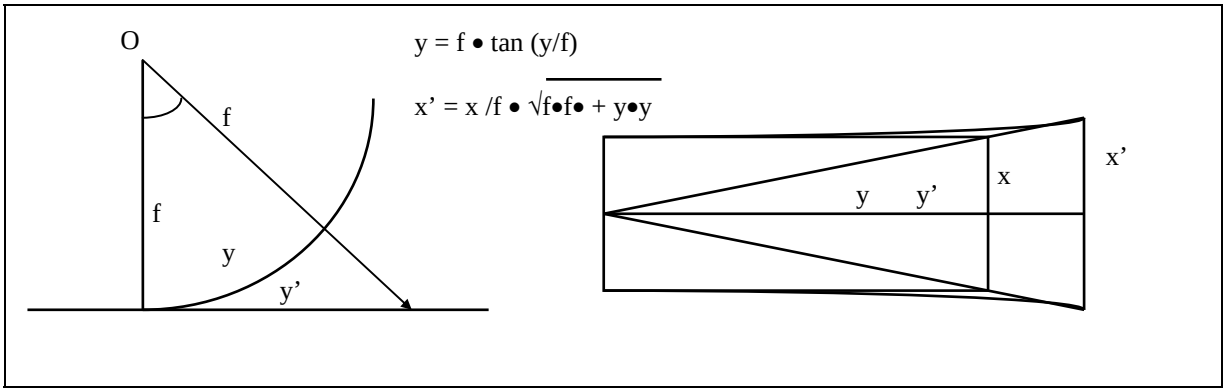


Fig. 1 transformation of panoramic photos to a tangential plane

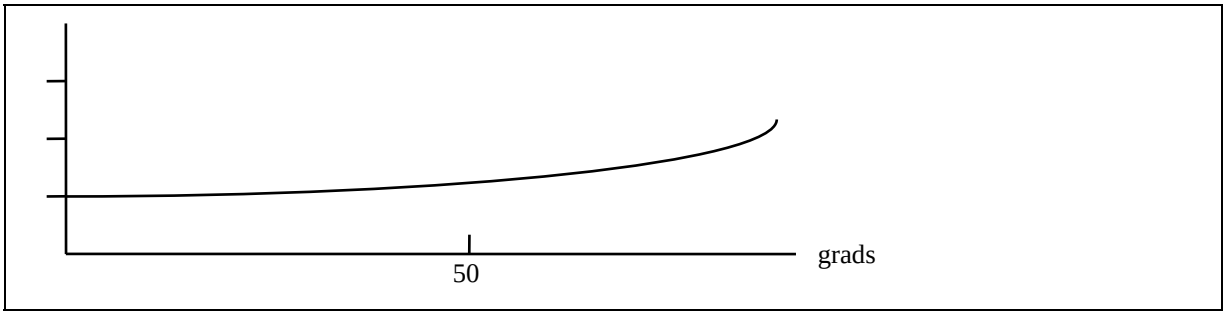


Fig. 2 scale number of panoramic photos as function of the nadir angle before transformation
(1 / cos t)

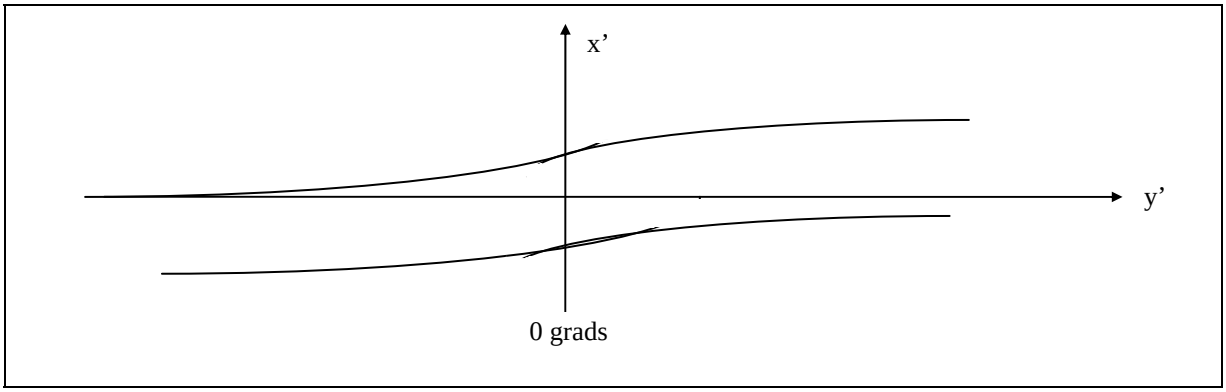


Fig. 3 projection of the photo center line to the ground upper line: neighbored panoramic photo

Panoramic photos can be handled by program system BLUH. The panoramic geometry has to be transformed into perspective geometry. This can be done in BLPRE, BLOR and BLAPP. But if it has been done in BLPRE, it should not be done again in BLOR and BLAPP.
The dynamic effects can be compensated with the special additional parameters 19 - 23. Highly oblique parts of panoramic photos should be handled in BLOR as oblique photos.

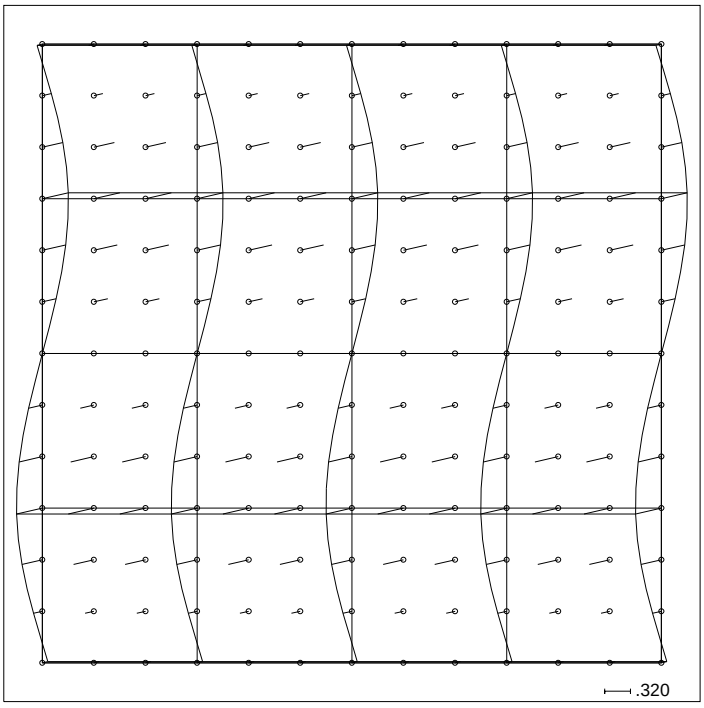


Fig. 4: dynamic effect of panoramic images, compensated by additional parameters

systematic image errors determined by additional parameters in BLUH, creation of plot file by PLOCG

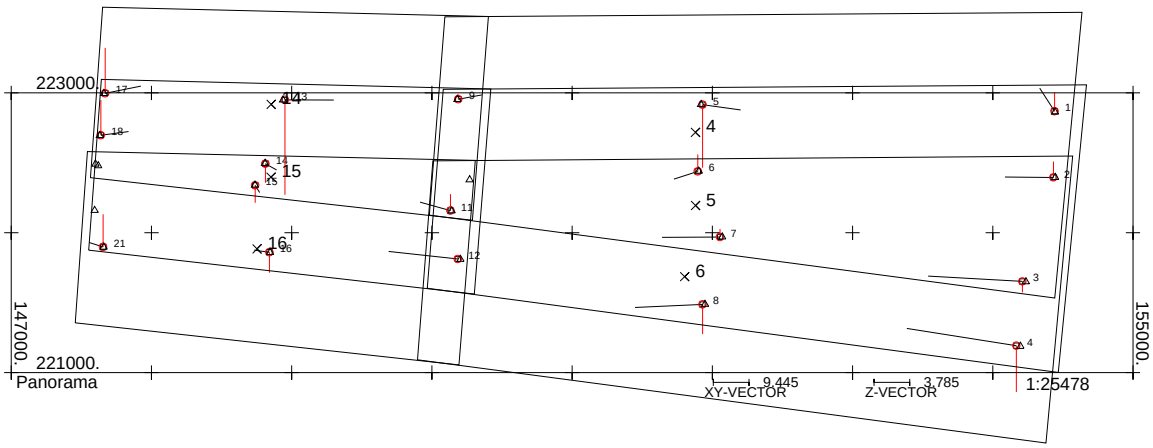


Fig. 5 block adjustment with panoramic images - location of images created by BLAN

Support of Program User

The use of the program system is simplified by the dialogue including, if useful, menus. Intensive user support by default values exists. The default values are defined by the programs and/or the last use of the programs. File names are transferred by the program system, so the file names only have to be specified once in the program system. The default values are stored in the files *program name.dat.* Most programs are prepared for batch handling based on a control file, so the programs can be imbedded into others.

References

Passini, R., Jacobsen, K., 2008: Geometric Analysis on Digital Photogrammetric Cameras, ASPRS 2008 + , http://www.ipi.uni-hannover.de/

Jacobsen, K., 2007: Geometric Handling of Large Size Digital Airborne Frame Camera Images, Optical 3D Measurement Techniques VIII, Zürich 2007, pp 164 -171

Jacobsen, Digital Height Models by Cartosat-1, ISPRS Hannover Workshop 2007, http://www.ipi.uni-hannover.de/

Jacobsen, K.: Orientation of high resolution optical space images, ASPRS annual conference, Tampa 2007

Baz, I., Jacobsen, K., Büyüksalih, G.: Analysis of a bundle block adjustment with UltraCamD images over Istanbul, Turkish-German Geodetic Days, Berlin 2006

Madani, M..,Dörstel, C., Heipke, C.,Jacobsen, K., 2004: DMC Practical Experience and Accuracy Assessment, ISPRS Congress, Istanbul 2004 IntArchPhRS. Vol XXXV, B2. pp 396-401

Passini, R., Jewell, D., Jacobsen, K.: An Accuracy Study on a large Airborne GPS Aero Triangulation Block, ASPRS annual convention, Washington 2002

Jacobsen, K., Wegmann, H.: Dependency and Problems of Direct Sensor Orientation, OEEPE-Workshop Integrated Sensor Orientation, Hannover Sept. 2001

Jacobsen, K.: Selection of additional parameters by program, ISPRS Com III, Helsinki 1982

Jacobsen, K.: Operational use of combined bundle block adjustment with GPS-data of the projection centers, ASPRS Baltimore 1996

Jacobsen, K.: Handling of panoramic and extreme high oblique photographs in analytical plotters, ISPRS Kyoto 1988

Jacobsen, K.: Vorschläge zur Konzeption und zur Bearbeitung von Bündelblockausgleichungen, doctor thesis, University of Hannover 1980