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ORIPROGRAM

PROGRAM FOR MULTI-MODEL STEREO RESTITUTION

USERS MANUAL

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BRIEF DESCRIPTION

ORIPROGRAM supports the orientation of photographic images in the Kern DSR analytical plotter. Any combination of photographs from single images to stereoscopic models or blocks of small-frame photographs can be oriented. Orientation parameters are calculated using a bundle block adjustment of photogrammetric point measurements and various ground control information. The program is capable of self-calibrating adjustment and camera calibration as well. Therefore, photographs taken with any camera can be used.

The program was developed for the Kern DSR series of analytical plotters with a PDP11/53-RT11 plate processor and a MicroVAXII-VMS main processor. Executable modules of ORIPROGRAM (ORIP.EXE) and the necessary plate processor program (KDPP88.SAV) are available on request from the author at the Institute of Surveying and Photogrammetry, Technical University of Denmark, DK2800 Lyngby, Denmark.

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0. INTRODUCTION

ORIPROGRAM supports the orientation of photographic images in the Kern DSR analytical plotter. Any combination of photographs from single images to stereoscopic models or blocks of small-frame photographs can be oriented. Orientation parameters are calculated using a bundle block adjustment of photogrammetric point measurements and various ground control information. The program is capable of self-calibrating adjustment and camera calibration as well. Therefore, photographs taken with any camera can be used.

Chapter I of this manual gives a generalized outline of the program capabilities, chapter II describes which steps to go through in a typical orientation project, chapter III explains how to operate the program, and chapter IV gives detailed descriptions of all program modules organized according to the menu structure of the program. Chapter IV should be used as a reference rather than a comprehensive text.

First time users must read chapter I and II, other users can start with chapter III and use chapter IV as a reference for detailed information. Routine users may only need the help screens available in the program.

I. PROGRAM DESCRIPTION

Templates

The handling of small-frame photographs is facilitated by the use of templates which divide the interior orientation into two separate steps, template orientation and photo orientation. Multiple small-frame photographs are contact printed onto a single film sheet, called a template. Two templates with alternating left and right photographs are used in the orientation, one for each stage plate of the analytical plotter (fig. 1). The templates are provided with tick marks, one in each corner.

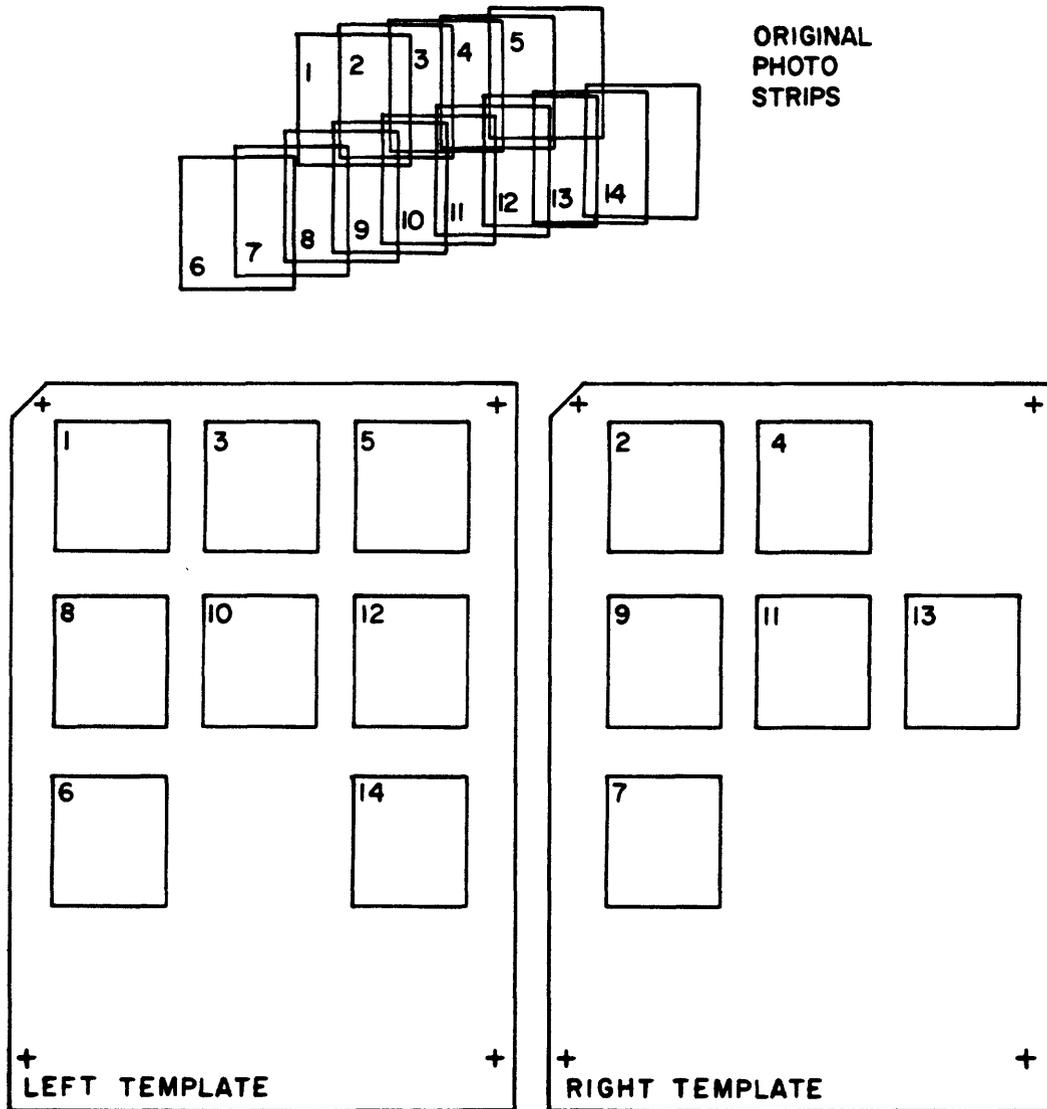


Figure 1. Sketch to exemplify how small-frame photographs are contact copied onto templates. The involved strips are shown at top, and the placement of the photographs on the two templates at bottom.

The templates are oriented on the plates of the analytical plotter by measuring the tick marks. The left and the right plate-to-template transformation matrices are established by least-squares adjustment.

Orientation of individual photographs is handled by measuring the fiducial marks, the reseau crosses, or the corners of each photograph, whichever is available. The measurements are transformed to template coordinates followed by a calculation of the template-to-photo transformation matrices by least-squares adjustment. The interior orientation transformation matrix for each individual photo is obtained by multiplying the plate-to-template orientation matrix and the template-to-photo orientation matrix.

This two step interior orientation will allow subsequent re-orientation of the whole template of photographs simply by only re-measuring the template tick marks.

Photo, camera, and template records are maintained by the program. Each photo record contains a pointer to a camera record where the fiducial mark coordinates (and other camera parameters) are stored. Similarly, each template record contains a pointer to a record (called temtick) where the template tick marks are stored.

The program is also capable of orienting single or multiple models without the use of templates.

The three coordinate systems used (stage plate, template, and photo coordinates) are shown in fig. 2.

Camera Data

Camera data records contain the camera constant, principal point corrections, distortion parameters, image frame sizes, and fiducial mark coordinates. The distortion parameters used by the program are the coefficients (A1, A3, A5, A7) of the polynomial:

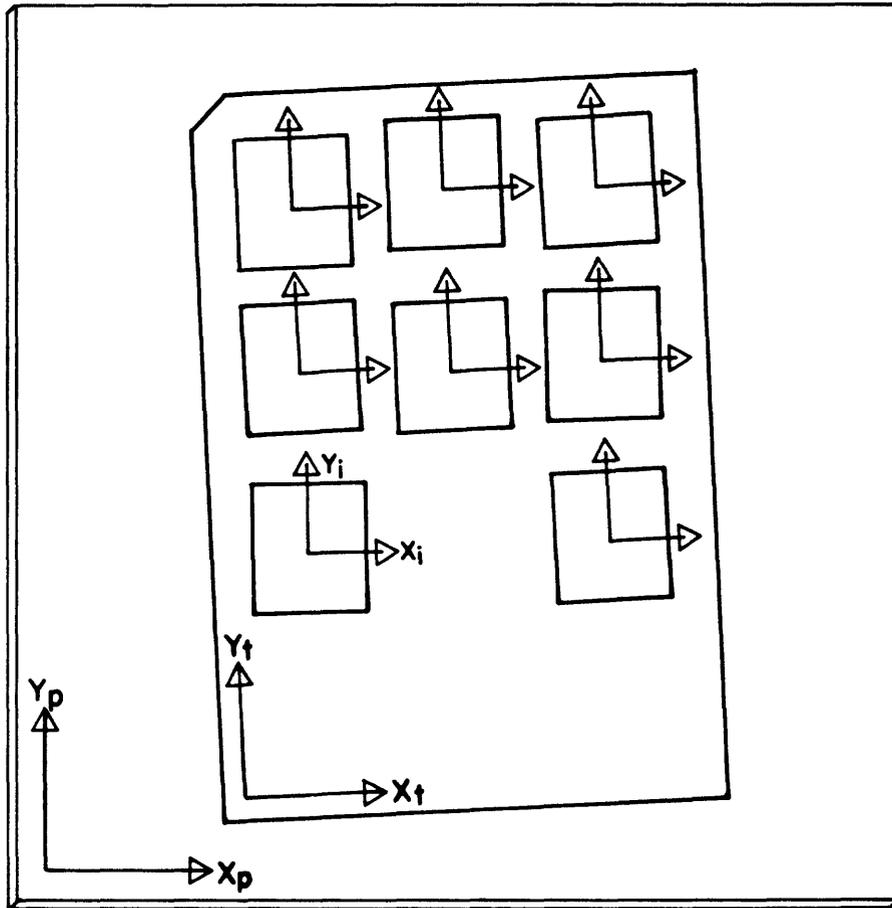
$$D = A1 \cdot R^{**1} + A3 \cdot R^{**3} + A5 \cdot R^{**5} + A7 \cdot R^{**7}$$

where D is the distortion at radial distance R from the principal point. However, the program also accepts the ISP-Regulation parameters (R0, A1, A2, A3) according to the formula:

$$D = R(A1(R^{**2} - R0^{**2}) + A2(R^{**4} - R0^{**4}) + A3(R^{**6} - R0^{**6}))$$

or a distortion curve described by any number of discrete points. The latter two forms are transformed into the polynomial parameters of the first form.

The fiducial mark coordinates may be entered by hand from a calibration report or they may be digitized from the DSR analytical plotter.



(X_p, Y_p) : PLATE COORDINATE SYSTEM

(X_t, Y_t) : TEMPLATE COORDINATE SYSTEM

(X_i, Y_i) : PHOTO (IMAGE) COORDINATE SYSTEM

Figure 2. The three measurement coordinate systems: plate, template, and photo coordinates.

Ground Control

Ground control information is entered as observations along with an a-priori error estimate. In the bundle adjustment the observations are weighted by the inverse square of their a-priori error. If the a-priori error is given as zero the entered observation value is considered constant, if it is negative the observation is disregarded.

Ground control is stored in text (ASCII) files. The files can be updated and edited with a standard VAX/VMS editor or by use of ORIPROGRAM procedures. The program is designed so that any ground control situation can be readily accommodated by an application programmer. The ground control types implemented so far are listed below:

Control Point Coordinates: All combinations of point coordinates can be used as ground control (XYZ, XY, YZ, ZX, X, Y, Z).

Control Elements: Observations of the following adjustment unknowns can be used as control: camera constant, camera principal point, camera distortion parameters, photo projection center coordinates, photo rotations, point coordinates, theodolite zero direction.

Control Distances: Coordinate differences in X, Y, or Z, distances in the XY, YZ, or ZX planes, and spatial distances can be used.

Measurements

The measurement of tie points and control points can be done monoscopically or stereoscopically. Monoscopic measurement is feasible for targeted tie and control points. The program automatically handles the template and photo orientation transformations necessary to compute the photo coordinates for each measured point.

The stereoscopic measurement of tie points and control points features computer guided stereoscopic point transfer. Because the photos that constitute a block of models are mounted together on templates in the analytical plotter, tie points are measured using stereoscopic point transfer between models as well as between strips. A point that has been measured in one photo is transferred to an adjacent photo as follows: one of the plates is locked keeping the measuring mark positioned on the previously digitized coordinates. The point is measured in the new photo by removing the parallaxes relative to the locked photo.

Stereoscopic point transfer is used whenever a tie point that has been selected and named by the operator is found by the program in a previously measured photo. Point transfer between photos in the same strip is done by simply locking the left or the right photo of the current model dependent on where the old point measurement is found. Transfer from a previously measured strip to the current model is done in two steps. First, the point is transferred from a

photo in the adjacent strip to one of the photos in the current model. Next, it is transferred from the newly measured photo to the second photo of the current model. A true stereoscopic model of the side lap is obtained by rotating the left and the right optical prisms of the DSR analytical plotter 90 degrees.

The program initially guides the operator through the measurements, model by model. In the subsequent remeasuring mode the measurements are performed point by point. A point is visited and/or remeasured in all photos where it was previously measured before the program proceeds to the next point.

Preliminary Values

Normally, preliminary values are a big obstacle in photogrammetry when using blocks of oblique, terrestrial photographs. ORIPROGRAM includes a module for calculation of preliminary values. The calculations may be based on as little as three ground control points for an entire block. Based on these points, the preliminary values for all involved photo transformation parameters and photogrammetrically measured points are computed.

Bundle Adjustment

The bundle adjustment module performs a weighted adjustment where all observations are weighted by the inverse square of the a-priori error.

The adjustment includes automatic identification of blunders and reduction of weight on involved observations by means of the Danish Method (Krarup et al. 1980). The program computes standard residuals for all observations after each adjustment iteration. The standard residual will be around 1 if the observation's residual matches the a-priori error estimate. If the standard residual exceed 3 there is a 99.7% chance of a blunder. The user defines a maximum standard residual value above which the involved observation will be given a reduced weight in the next iteration. The weight factors are updated after each iteration so that a down weighted observation from an earlier iteration may be reinserted into the adjustment during a later iteration.

In addition to the automatic identification of blunders the program locates and removes unknowns that cannot be computed due to the observation configuration (singularities). For example, in a model with only two control points one of the rotations, omega or phi cannot be computed. The location of such unknowns is done by monitoring normal-equation columns (Poder 1982) for the number of digits lost during reduction of the diagonal element. If the number of lost digits approaches the calculation precision of the computer, results become meaningless and an arithmetic error may occur. To avoid this, the normal-equation

column is removed from the adjustment before too many digits have been lost. The maximum number of lost digits allowed is defined by the user.

Convergence stop criterion are also set by the operator. The program uses the exponent of numerical precision (ENP) (Krarup 1982) as a convergence measure. The ENP increases with the degree of convergence and reasonable results are normally obtained if the iterations are stopped at an ENP between 3 and 5.

Critical parameters such as the number of down-weighted points, the number of singular columns, the ENP, and the standard error unit weight are displayed after each iteration. The adjustment may be stopped by the operator at any point between iterations.

Multi_Model Drive

After the bundle adjustment the orientation parameters for all involved photos are down loaded and simultaneously stored in the plate processor. Special plate processor modules enable the operator to move freely between the oriented models during interpretation and mapping. Models change automatically when the measuring mark is moved from one frame to another, moving to the same ground coordinate in the neighbor model. Thus, data collection and plotting can be performed continuously across model boundaries.

II. TYPICAL ORIENTATION PROJECT

An orientation project must follow five steps outlined by the main modules of the program, and described in brief below. First however, a note on the coordinate systems and units applied by the program.

Right hand coordinate systems are used throughout the program. The rotations: ω around the X-axis, ϕ around Y, and κ around Z are all right hand rotations in units of degrees. Camera data are entered in units of millimeters. Ground coordinates in units of meters. Any other unit can be used for ground coordinates. In this case, however, the calculated scale factors describe the transformation between photo units of meters and the chosen ground units.

1) Initialize Project:

Enter users name; project name; and name, open, and check various data files.

The camera file holds records of camera parameters and fiducial mark coordinates. Each file can store any number of camera records.

The temtick file holds records of template tick mark coordinates. Each file can store any number of records.

The project files are three files for storing of template orientation parameters, photo orientation parame-

ters, and exterior orientation parameters. Each file may store any number of records. The project files all get the same name entered by the operator, but different extensions provided by the program. The extensions are 'TEM' for templates, '.PHO' for photos, and '.EXT' for exterior orientation data (bundle adjustment data).

The camera, temtick, and project files that contain data records are binary and therefore cannot be edited or printed outside ORIPROGRAM.

The ground files are text (ASCII) files that hold ground control information, one file for each type of control. The files all get the same name entered by the operator, but different extensions provided by the program. The available control files are: '.PNT' for control points, '.ELE' for control elements, and '.LEN' for control distances. The ground files can be updated and edited with a standard VAX/VMS editor or by use of ORIPROGRAM procedures.

Finally, the 'Initialize Project' menu contains a function to move the stage plates of the DSR analytical plotter to the front of the machine for photo (template) loading.

2) Enter Control:

Ground control information is entered and edited by the ORIPROGRAM module 'Enter Control', or a VAX/VMS editor outside the program. Different ground control types are stored in different files. For an orientation project, these files must all have the same name and reside in the same directory with the extensions described under initialize project above.

The a-priori error estimate needed for all observations can be guessed if no experience is available. The value influences the balance between observations in the adjustment. A small a-priori error means high weight to the involved observation.

Preliminary coordinates for the adjustment can be entered and/or edited by another function in the 'Enter Control' menu.

3) Define Project:

Under this menu camera and temtick records can be created, updated, and edited. Fiducial and tick mark coordinates may be entered by hand or digitized from the DSR analytical plotter. In the case of camera records, the camera constant, principal point coordinates, and distortion parameters are entered as well. Individual camera parameters can be defined as constants or unknowns in the adjustment.

Photo records are defined by giving the name of the photo, the name of the camera used, and the name of the

template on which the photo is printed. If the photo is not printed on a template (single photo or single model setup), the template name is left blank. Preliminary values for exterior orientation parameters (projection center coordinates and photo rotations) may also be entered. These are, however, also calculated in the preliminary values module (see page 10). Individual photo parameters can be defined as constants or unknowns in the adjustment. Only unknown parameters are updated by the preliminary values module.

Template records are defined by naming the template and specifying the temtick record used to store the tick mark coordinates. The photos on the template are listed and cross checks are performed with the entered photo records.

The exterior orientation (bundle block adjustment) is initially defined by giving an adjustment name. Automatically an observation file with the given name and an extension of '.EXO' is created in the same directory as the project files. This file is used to store the photogrammetric photo observations. The following parameter values which control the bundle adjustment are entered: measurement precision, the exponent of numerical precision at which the iterations are to be stopped (ENP-Stop), the maximum number of iterations allowed in case of divergence, the iteration number at which automatic weight reduction is started, the standard residual above which weight reduction is performed, and the allowed number of lost decimal digits before a unknown is removed from the adjustment. Finally, the models of the exterior orientation block are listed by naming each model, the photos involved, and defining the block row and column numbers of the models (fig. 3).

4) Measure Orientation:

This menu includes functions for photo and template orientations as well as photo measurements for the bundle adjustment.

The photo and template orientations are menu driven with functions to add, insert, edit, delete, remeasure, disregard, or include points. Affine, conform, or conform-no-scale transformation adjustments are available. The adjustment is updated after each measurement. The plates of the DSR-11 are driven to the most recently computed position of the next point to be measured.

As described in chapter I, photo measurements for the bundle adjustment (measurement of tie points and control points) can be done either monoscopically or stereoscopically. The point measurement functions include editing facilities as described above under the photo and template orientations. The photo measurements are done relative to the template measurements, so that subsequent re-orientations only involves new measurements of the template fiducial marks.

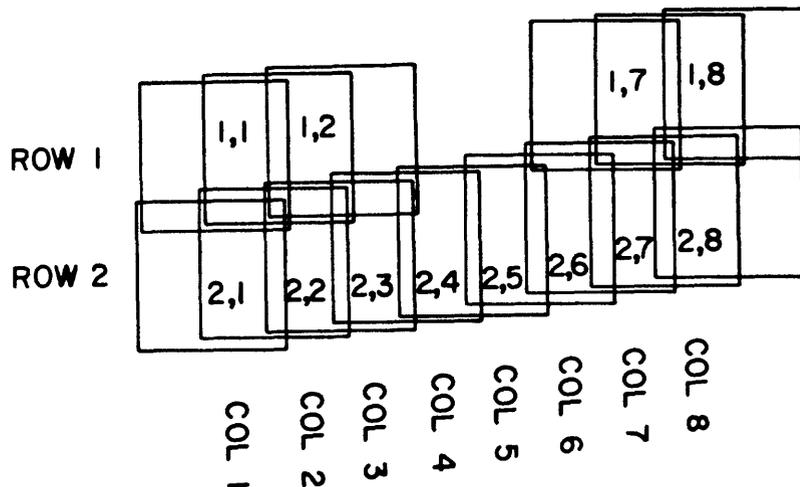


Figure 3. Sketch to illustrate row and column numbering of models. The models are numbered according to a matrix system. The column numbers of missing models are skipped.

5) Compute Bundle Adjustment:

Preliminary values for the photogrammetrically measured points and for photo parameters can be calculated through: 1) relative orientation of all models, 2) model bridging using spatial similarity transformation, 3) strip connection using spatial similarity transformation, and 4) absolute orientation of the computed block using at least 3 ground control points. The absolute orientation does not need initial values for translations and rotation angles. The calculations are semi automatic. The operator starts a relative orientation of all models. The standard error unit weight (average residual) is listed for each model. If one model has too high of a standard error unit weight, then this model may be re-computed individually in order to locate the blunder(s). A similar procedure is used for model bridging and strip connection. Finally the absolute orientation is performed. If the results are satisfactory the preliminary values for the photo transformation parameters and all the photogrammetrically measured points are updated.

The bundle adjustment is started by the function 'Solve Bundle'. The adjustment elements (unknowns and constants), and the photo and control observations of the project are read and tested, and the iterations are started. Result from each iteration are displayed so that the opera-

tor can follow the developments in the exponent of numerical precision (ENP), the number of observations that have been given reduced weight, the number of located singular elements, and the standard error unit weight. The adjustment can be manually stopped after each iteration if the operator judges the iterations to have converged, or if the solution diverges.

Finally the 'Compute Bundle' menu has a function to automatically download the oriented models to the plate processor for multi-model driving.

III. OPERATING THE PROGRAM

Environment

The program runs on a MicroVAX computer using the VMS operating system, and it controls the Kern DSR series of analytical plotters.

The plate processor program needed for the PDP11/53 computer integrated in the DSR is a modified version of Kerns's original software. It is called KDPP88.SAV (Keld Dueholm Plate Processor, 1988). The source code is located on logical disk DUE.DSK.

Start the Program

ORIPROGRAM is located in directory \$DISK3:[KERN.DSR] under user 'KERN'. Type 'RORI' and wait for the main menu to appear. Follow prompts and select menus and functions according to the guidelines described below.

Menus

The program is menu driven. The menu items are displayed in a four by four highlighted matrix (fig. 4) symbolizing the keypad of the DSR. The operator selects program functions by depressing the appropriate key on the keypad.

The menus are arranged in a hierarchy. The <ENTER> key returns to the previous menu, or stops the program from the main menu.

Help

All menus include on-screen help texts. Press the 'Help' function and then the function key for which to display help text. The text is displayed in the scroll area (fig. 4). Use the arrow keys (up and down) on the terminal keyboard to scroll through the text. Press the <ENTER> key to return to menu selection mode. For general information on the entire displayed menu press the 'Help' key twice.

Enter commands and text

The bottom line of the display is the command line (fig. 4). The program prompts for input in this line. Num-

bers can be entered from the DSR keypad or the terminal keyboard. Letters and special symbols must be entered from the keyboard.

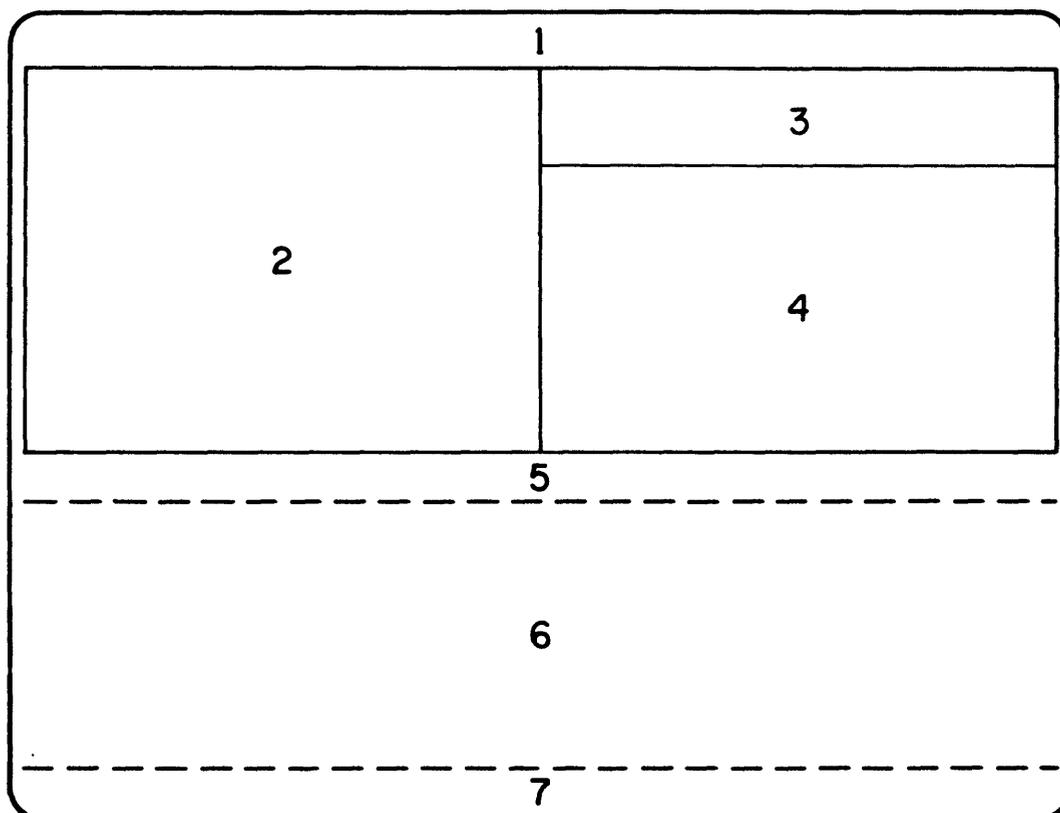


Figure 4. The ORIPROGRAM display is divided into 7 areas:

- 1) The 'project' line at the top of the screen, showing the program name, the current menu, and the project name.
- 2) The 'menu' area, showing the currently active menu functions.
- 3) The 'status' area, showing DSR stage plate coordinates.
- 4) The 'result' area where calculation results are displayed.
- 5) The 'legend' line in which headings for the scroll area are written.
- 6) The 'scroll' area with 8 scrolling lines for general program output.
- 7) The 'command' line at the bottom of the screen.

IV PROGRAM MODULES

This chapter gives detailed descriptions of program functions organized according to the program menu structure. Functions that are repeated in many menus are described below and will not reappear under the individual menu descriptions.

Help

Gives information on the keys for the menu currently displayed. After pressing 'Help', then press the key for which you need information.

Main Menu

This key has two functions. In "Select Function" mode the key returns you to the main menu. When entering numbers or characters from the keyboard it acts as the <ENTER> key.

Return

This key has two functions. In "Select Function" mode the key returns you to the previous menu. When entering numbers or characters from the keyboard it acts as the <ENTER> key.

DSR11

Changing the DSR guiding system as follows:

- 1) Upper : Move only upper plate in the plate coordinate system.
- 2) Lower : Move only lower plate in the plate coordinate system.
- 3) Both : Move both plates in the plate coordinate system.
- 4) Model : Move in the model coordinate system with Z in and out of the model.
- 5) Object: Move in the object (ground) coordinate system.
Select by number or by the first letter of the keyword.

1: Main Menu

Initialize Project

Define project parameters (project name and users name), and define (open) files for template and camera definitions, measurements and orientation data, and ground control.

Define Project

Enter template, camera, photo, and adjustment parameters for the orientation. Define template tick marks (tem-tick), camera fiducial marks, and the model configuration.

Enter Control

Enter ground control information. Presently, control point coordinates, element observations, and distance observations are implemented.

Enter and/or edit of preliminary coordinate values (note that an automatic calculation of preliminary values exist in the 'Compute Bundle Adjustment' menu).

Measure Orientation

Perform template and photo interior orientations. Measure photo coordinates for the exterior orientation (the bundle adjustment).

Compute Bundle Adjustment

Calculate preliminary values, compute the exterior orientation by bundle adjustment, inspect resulting camera and photo parameters, and down load models to the plate processor.

Test Menu

Undocumented test programs. Display ground coordinates. Move DSR stage plates forward. Move the DSR floating mark to a point given by entered ground coordinates.

Print Results

Print results to Ascii files or the system printer. Currently, no functions are implemented under this menu.

Stop Program

Ending the orientation program and return to VMS. Current program parameter settings are saved and the program will restart in the same mode(s) as it was left in. However, because restarting takes time you will be prompted to confirm this action.

1.1: Initialize Project Menu

Define project parameters (project name and users name), and define (open) files for template and camera definitions (temtick and camera file), measurements and orientation data (project files), and ground control (control files).

Camera File

Enter the name (directory path, name, and extension) of the camera definition file (30 characters or less). Each camera file can hold an unlimited number of cameras.

Temtick File

Enter the name (directory path, name, and extension) of the template tick mark definition file (30 characters or

less). The file contains the 'calibrated' coordinates of the template fiducial marks (tick marks).

The temtick-template relationship is similar to the camera-photo relationship. Temtick records holds definitions of template characteristics (the tick mark coordinates) to be used in subsequent orientations of templates. Each temtick file can hold an unlimited number of template tick mark definitions.

Project Files

Enter the name (directory path, and name) of the measurement and orientation files (26 characters or less). Do not enter the extension. The program automatically assigns extensions to the name as follows:

Photos:	.PHO,	Templates:	.TEM
Exterior:	.EXT		

Project files are binary and cannot be read or edited from outside the ORIPROGRAM. To print the content of the files use the 'Print Menu'.

Control Files

Enter the name (directory path, and name) of the ground control files (26 characters or less). Do not enter the extension. The program automatically assigns extensions to the name as follows:

Control Points:	.PNT,	Control Elements:	.ELE
Control Distances:	.LEN		

Control files are Ascii files and may be written and/or edited outside ORIPROGRAM by means of the VAX/VMS editor, or they may be created by use of the functions in the 'Enter Control' menu. Files written by VMS editors must have the above described extensions in order to be used by ORIPROGRAM. If more than one control file is used in a project the individual files must have the same name.

Project Name

Enter the project name (20 characters or less). The name will be displayed on the first line of every menu screen, and printed to all output.

Users Name

Enter the name of the operator (20 characters or less). The name will be displayed in the display result area during program startup, and printed to all output.

Plates Forward

Moves the stage plates of the DSR to the front of the machine for photo (template) loading.

1.2: Print Results Menu

Print results to text (Ascii) files or the system printer. Currently, no functions are implemented under this menu.

1.3: Enter Control Menu

Enter ground control information. Presently, control point coordinates, element observations, and distance observations are implemented.

Enter and/or edit of preliminary coordinate values (note that an automatic calculation of preliminary values exist in the 'Compute Bundle Adjustment' menu).

Control Points

Enter/edit ground control point coordinates and their a-priori errors. Any combination of X, Y, Z coordinates can be used as control.

Control Elements

Enter/edit observed values for unknowns in the adjustment. All unknowns can be controlled by entering an observed value and an a-priori error.

Example: Camera projection center coordinates are unknown in the adjustment. Field measurements of the projection center coordinates are entered under the 'Control Elements' menu.

Control Distances

Enter/edit ground control distances. Coordinate, plane, and spatial distances can be entered to control the adjustment.

Preliminary Values

Enter/edit preliminary ground coordinates for points in the adjustment.

Preliminary coordinates for photogrammetrically measured points are calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle Adjustment' menu. The coordinates are stored in a file with the name of the bundle adjustment and an extension of 'PRE', located in the same directory as the project files. The calculated preliminary coordinates may be inspected, edited, and/or supplemented under this menu.

1.3.1: Control Point Coordinates Menu

Enter/edit ground control point coordinates and their a-priori errors. Any combination of X, Y, Z coordinates can be used as control.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize. Enter the a-priori errors (aX, aY, aZ).

A coordinate will be considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the coordinate will not be included in the adjustment.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize. Enter the a-priori errors (aX, aY, aZ).

A coordinate will be considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the coordinate will not be included in the adjustment.

Edit Point

Edit the current point (at >). Enter or digitize values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted to confirm this action.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

1.3.2: Control Elements Menu

Enter/edit observed values for unknowns in the adjustment. All unknowns can be controlled by entering an observed value and an a-priori error.

Example: Camera projection center coordinates are unknown in the adjustment. Field measurements of the projection center coordinates are entered under the 'Control Elements' menu.

Insert Element

Inserts a new element observation before the current element (at >). Enter the element name from keyboard or keypad. Enter the element group and kind (chosed from the list below), the value, and the a-priori error.

Group	Kind
CAMERA	: C (camera constant) DX, DY (principal point corrections) A1, A3, A5, A7 (distortion parameters)
PHOTO	: X0, Y0, Z0 (projection center coordinates) OMEGA, PHI, KAPPA (rotations)
POINT	: X, Y, Z (coordinates)
THEODOLITE:	R (zero direction)

An element will be considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the element will not join the adjustment.

Add Element

Adds a new element observation at the end of the current list. Enter the element name from keyboard or keypad. Enter the element group and kind name (chosed from list below), the value, and the a-priori error.

Group	Kind
CAMERA	: C (camera constant) DX, DY (principal point corrections) A1, A3, A5, A7 (distortion parameters)
PHOTO	: X0, Y0, Z0 (projection center coordinates) OMEGA, PHI, KAPPA (rotations)
POINT	: X, Y, Z (coordinates)
THEODOLITE:	R (zero direction)

An element will be considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the element will not join the adjustment.

Edit Element

Edit the current element (at >). Enter values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Element

Deletes the current element (at >). You will be prompted to confirm this action.

Kill All

Deletes all elements in the list (start all over). You will be prompted to confirm this action.

1.3.3: Control Distances Menu

Enter/edit ground control distances. Coordinate, plane, and spatial distances can be entered to control the adjustment.

Insert Distance

Inserts a new distance observation before the current distance (at >). Enter the distance name from keyboard or keypad. Enter the names of the two end points, the code (chose from the list below), the distance, and the a-priori error.

Code

X : X-coordinate distance
 Y : Y-coordinate distance
 Z : Z-coordinate distance
 XY : Distance in the XY plane
 YZ : Distance in the YZ plane
 ZX : Distance in the ZX plane
 XYZ: Spatial distance

A distance is considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the distance will not join the adjustment.

Add Distance

Adds a new distance observation at the end of the current list. Enter the distance name from keyboard or keypad. Enter the names of the two end points, the code (chose from list below), the distance, and the a-priori error.

Code

X : X-coordinate distance
 Y : Y-coordinate distance
 Z : Z-coordinate distance
 XY : Distance in the XY plane
 YZ : Distance in the YZ plane
 ZX : Distance in the ZX plane
 XYZ: Spatial distance

A distance is considered constant in the bundle adjustment if the a-priori error is 0.00. If the a-priori error is negative the distance will not join the adjustment.

Edit Distance

Edit the current distance (at >). Enter values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Distance

Deletes the current distance (at >). You will be prompted to confirm this action.

Kill All

Deletes all Distances in the list (start all over). You will be prompted to confirm this action.

1.3.4: Preliminary Coordinates Menu

Enter/edit preliminary ground coordinates for points in the adjustment.

Preliminary coordinates for photogrammetrically measured points are calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle Adjustment' menu. The coordinates are stored in a file with the name of the bundle adjustment and an extension of 'PRE', located in the same directory as the project files. The calculated preliminary coordinates may be inspected, edited, and/or supplemented under this menu.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

The standard deviations (sX, sY, sZ) do not need to be entered. Points with the standard deviations attached originate from the automatic calculation of preliminary coordinates. Here (sX, sY, sZ) reflect the bridging or the strip connection precession.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

The standard deviations (sX, sY, sZ) do not need to be entered. Points with the standard deviations attached originate from the automatic calculation of preliminary coordinates. Here (sX, sY, sZ) reflect the bridging or the strip connection precession.

Edit Point

Edit the current point (at >). Enter or digitize values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted to confirm this action.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

1.4: Define Project Menu

Define template tick marks (temtick data), and camera parameters and fiducial marks (camera data). Enter photo parameters (define photo), and list the photos on individual templates (define template). Enter parameters to control the adjustment and list the model configuration (define bundle).

Camera Data

Enter/edit camera parameters (camera name, camera constant, principal point, distortion, frame size, and fiducial coordinates) or preliminary values for unknown parameters. Inspect the camera file.

Temtick Data

Enter/edit template fiducial coordinates (tick marks). Inspect the temtick file.

Define Photo

Enter/edit photo parameters (photo name, camera name, template name, projection center, rotations) or preliminary values for unknown parameters. Inspect the photo file.

Define Template

Enter/edit template parameters (template name, temtick name) and list the name of the photos on the individual templates. Inspect the template file.

Photo parameters can also be entered under this menu. The photo file will be updated with the photos and the photo parameters defined.

Define Bundle

Enter/edit bundle adjustment parameters (bundle adjustment name, default measurement precision, ENP-stop, maximum iterations, start down weight, maximum standard residual, maximum lost digits, observation file name) and list the individual models of the adjustment by naming the two photos of each model. Inspect the exterior orientation file.

1.4.1: Camera Data Menu

Enter/edit camera parameters (camera name, camera constant, principal point, distortion, frame size, and fiducial coordinates) or preliminary values for unknown parameters.

The ISP-regulation distortion parameters can be entered and transformed to polynomial parameters by the 'Distortion ISP-Parameters' function.

Discrete points on the distortion curve can be transformed to polynomial parameters by the 'Distortion Curve' function.

Inspect, rename, copy, and delete the records of the camera file using the 'Inspect File' function.

Inspect File

Shows the content of the camera file and allows for rename, copy, and delete of camera records.

Camera Record Name

Enter the name of the camera record to be created or edited (capital letters without spaces).

Camera Constant (C)

Enter the camera constant (calibrated focal length) in units of millimeters.

Principal Point (X, Y)

Enter the coordinates of the principal point in units of millimeters and in the coordinate system defined by the fiducial mark, reseau cross, or the photo corner coordinates, whatever is available.

Distortion, A1

Enter coefficient A1 of the distortion polynomial. The formula used is:

$$D = A1 \cdot R^{**1} + A3 \cdot R^{**3} + A5 \cdot R^{**5} + A7 \cdot R^{**7}$$

where D is the distortion and R the radial distance from the principal point.

Distortion, A3

Enter coefficient A3 of the distortion polynomial. The formula used is:

$$D = A1 \cdot R^{**1} + A3 \cdot R^{**3} + A5 \cdot R^{**5} + A7 \cdot R^{**7}$$

where D is the distortion and R the radial distance from the principal point.

Distortion, A5

Enter coefficient A5 of the distortion polynomial. The formula used is:

$$D = A1 \cdot R^{**1} + A3 \cdot R^{**3} + A5 \cdot R^{**5} + A7 \cdot R^{**7}$$

where D is the distortion and R the radial distance from the principal point.

Distortion, A7

Enter coefficient A7 of the distortion polynomial. The formula used is:

$$D = A1 \cdot R^{**1} + A3 \cdot R^{**3} + A5 \cdot R^{**5} + A7 \cdot R^{**7}$$

where D is the distortion and R the radial distance from the principal point.

Frame size in X and Y

Enter the frame sizes in units of millimeters. The frame sizes is used by the multi-model driving. Whenever the floating mark crosses a frame boundary it jumps to the neighboring model. Therefore, a good choice for the position of frame lines is in the middle of the model overlap areas.

Fiducial Marks

Enter fiducial coordinates in units of millimeters. The coordinates may be entered manually or by digitizing the fiducial marks, reseau crosses, or photo corners in the DSR11.

Constant/Unknown

Defines whether the camera parameters (camera constant, principal point, and distortion) are constant (C) or unknown (U) in the bundle adjustment. The unknown camera parameters will be adjusted if the observation geometry allows.

Distortion Curve

Enter the distortion curve point by point. For each point on the curve enter the point name, the radial distance from the principal point in millimeters, and the distortion in millimeters. 16 points are a suitable amount. Enter at least 4 points. The polynomial parameters (A1, A3, A5, A7) will be calculated from the entered points.

Distortion ISP Parameters

Enter distortion parameters (R0, A1, A2, A3) according to the ISP-Regulations, using the formula:

$$D = R(A_1(R^{**2} - R_0^{**2}) + A_2(R^{**4} - R_0^{**4}) + A_3(R^{**6} - R_0^{**6}))$$

where D is the distortion and R the radial distance to the principal point. The polynomial parameters (A1, A3, A5, A7) will be calculated from the entered parameters.

Down Load Distortion

Down load the distortion parameters to the plate processor. This function is used in conjunction with the Kern orientation software. The function is obsolete, and not to be used with ORIPROGRAM set-ups.

1.4.1.1: Fiducial Marks Menu

Enter fiducial coordinates in units of millimeters. The coordinates may be entered manually or by digitizing the fiducial marks, reseau crosses, or photo corners in the DSR11. The coordinates are digitized in the plate coordinate system. Since fiducial coordinates has the origin at the

"photo center", the digitized coordinates need to be transformed using the 'Transform Coordinates' function.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

Edit Point

Edit the current point (at >). Enter or digitize values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted for confirmation.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Transform Coordinates

If the fiducial coordinates are digitized in the DSR this function is used to transform the coordinates from plate to fiducial coordinates. Four points one in each photo corner or one in the middle of each photo frame line is needed for the transformation.

The fiducial system has the origin at the mean coordinates of the digitized points. The system is rotated so that the x-axis goes through the two fiducial marks closest to the plate x-direction.

1.4.1.2: ISP-Distortion Parameters Menu

Enter distortion parameters (R0, A1, A2, A3) according to the ISP regulations, using the formula:

$$D = R(A1(R^{**2}-R0^{**2}) + A2(R^{**4}-R0^{**4}) + A3(R^{**6}-R0^{**6}))$$

where D is the distortion and R the radial distance to the principal point. The polynomial parameters (A1, A3, A5, A7) will be calculated from the entered parameters by the function 'Compute Parmeters'

Distortion, R0

Enter coefficient R0 of the ISP distortion polynomial. The formula used is:

$D = R(A_1(R^{**2} - R_0^{**2}) + A_2(R^{**4} - R_0^{**4}) + A_3(R^{**6} - R_0^{**6}))$
 where D is the distortion and R the radial distance from the principal point.

Distortion, A1

Enter coefficient A1 of the ISP distortion polynomial.
 The formula used is:

$D = R(A_1(R^{**2} - R_0^{**2}) + A_2(R^{**4} - R_0^{**4}) + A_3(R^{**6} - R_0^{**6}))$
 where D is the distortion and R the radial distance from the principal point.

Distortion, A2

Enter coefficient A2 of the ISP distortion polynomial.
 The formula used is:

$D = R(A_1(R^{**2} - R_0^{**2}) + A_2(R^{**4} - R_0^{**4}) + A_3(R^{**6} - R_0^{**6}))$
 where D is the distortion and R the radial distance from the principal point.

Distortion, A3

Enter coefficient A3 of the ISP distortion polynomial.
 The formula used is:

$D = R(A_1(R^{**2} - R_0^{**2}) + A_2(R^{**4} - R_0^{**4}) + A_3(R^{**6} - R_0^{**6}))$
 where D is the distortion and R the radial distance from the principal point.

Compute Parameters

Compute polynomial parameters (A1, A3, A5, A7) from the entered ISP distortion curve parameters. The results will be shown in the display result area, and the distortion parameters in the 'Camera Data' menu will be updated.

1.4.1.3: Distortion Curve Points Menu

Enter the distortion curve point by point. For each point on the curve enter the point name, the radial distance from the principal point in millimeters, and the distortion in millimeters. 16 points are a suitable amount. Enter at least 4 points.

The polynomial parameters (A1, A3, A5, A7) will be calculated from the entered points by the function 'Compute Parameters'. A curve fitting by least-squares adjustment are used for the calculation.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter the radial distance from the principal point and the distortion in units of millimeters.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter the radial distance from the principal point and the distortion in units of millimeters.

Edit Point

Edit the current point (at >). Enter values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted for confirmation.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Compute Parameters

Compute polynomial parameters (A1, A3, A5, A7) from the entered distortion curve points. The results will be shown in the display result field, and the distortion parameters in the 'Camera Data' menu will be updated.

1.4.2: Temticks Menu

Enter/edit template fiducial coordinates (tick marks). Inspect, rename, copy, and delete the records of the temtick file using the 'Inspect File' function.

Temtick Record Name

Enter the name of the template tick mark record to be created or edited (capital letters without spaces).

Tick Marks

Enter coordinates of the template tick marks in units of millimeters. The coordinates may be entered manually or by digitizing the tick marks in the DSR11.

Inspect File

Shows the content of the template tick mark file and allows for rename, copy, and delete of records.

1.4.2.1: Tick Marks Menu

Enter tick mark coordinates in units of millimeters. The coordinates may be entered manually or by digitizing the tick marks in the DSR11.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter or digitize the coordinates. Use the right DSR foot switch to digitize.

Edit Point

Edit the current point (at >). Enter or digitize values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted for confirmation.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

1.4.3: Define Photo Menu

Enter/edit photo parameters (photo name, camera name, template name, projection center, rotations) or preliminary values for unknown parameters.

Inspect, rename, copy, and delete records in the photo file.

Photo Record Name

Enter the name of the photo record to be created or edited (capital letters without spaces).

Camera Name

Enter the name of the camera (record) used for the photography (capital letters without spaces).

Template Name

Enter the name of the template on which the photo is printed or mounted (capital letters without spaces). Leave this name blank if the photo is not on a template.

Projection Center, X0

Enter the X ground coordinate of the projection center. This value can also be calculated in the 'Compute Preliminary Values.' menu under the 'Compute Bundle' menu.

If this is desired enter any value and define the parameter as 'unknown'.

Projection Center, Y0

Enter the Y ground coordinate of the projection center. This value can also be calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle' menu. If this is desired any value and define the parameter as 'unknown'.

Projection Center, Z0

Enter the Z ground coordinate of the projection center. This value can also be calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle' menu. If this is desired any value and define the parameter as 'unknown'.

Rotation, Omega

Enter the photo omega rotation in degrees (around the ground X axes). This value can also be calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle' menu. If this is desired any value and define the parameter as 'unknown'.

Rotation, Phi

Enter the photo phi rotation in degrees (around the ground Y axes). This value can also be calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle' menu. If this is desired any value and define the parameter as 'unknown'.

Rotation, Kappa

Enter the photo kappa rotation in degrees (around the ground Z axes). This value can also be calculated in the 'Compute Preliminary Values' menu under the 'Compute Bundle' menu. If this is desired any value and define the parameter as 'unknown'.

Constant/Unknown

Defines whether the photo parameters (projection center and rotations) are constant (C) or unknown (U) in the bundle adjustment. The unknown photo parameters will be adjusted if the observation geometry allows.

Inspect File

Shows the content of the photo file (Project_Name.PHO) and allows for rename, copy, and delete of photo records.

1.4.4: Define Template Menu

Enter/edit template parameters (template name, temtick name) and list the name of the photos on the individual templates. Inspect, rename, copy, and delete records in the template file.

Template Record Name

Enter the name of the template record to be created or edited (capital letters without spaces).

Temtick Name

Enter the name of the template tick marks record used for the template.

List Photos

Enter the names of the photos on the template. Photo parameters can also be entered under this menu. The photo file will be updated with the photos and the photo parameters defined.

Inspect File

Shows the content of the template file (Project_Name.TEM) and allows for rename, copy, and delete of template records.

1.4.4.1: List Photos Menu

Enter the names of the photos on the template. For each photo enter the photo parameters: camera name, projection center coordinates, and rotations. The values defaults to whatever has been entered in the photo definition menu. The photo file will be updated with the photos and the photo parameters defined.

Insert Photo

Inserts a new photo before the current photo (at >). Enter the photo name from keyboard or keypad. Enter the camera used for photography, the ground coordinates of the projection center, and the photo rotations in degrees.

If the photo has already been defined under the 'Photo Data' menu the defined camera name, projection center coordinates, and photo rotations will be shown as default. Get the default value by pressing <ENTER>, without having changed the value.

The projection center and the rotations can also be calculated under the 'Compute Preliminary Values' menu in the 'Compute Bundle' menu.

Add Photo

Adds a new photo at the end of the current list. Enter the photo name from keyboard or keypad. Enter the camera used for photography, the ground coordinates of the projection center, and the photo rotations in degrees.

If the photo has already been defined under the 'Photo Data' menu the defined camera name, projection center coordinates, and photo rotations will be shown as default. Get the default value by pressing <ENTER>, without having changed the value.

The projection center and the rotations can also be calculated under the 'Compute Preliminary Values' menu in the 'Compute Bundle' menu.

Edit Photo

Edit the current photo (at >). Enter values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Photo

Deletes the current photo (at >). You will be prompted for confirmation.

Kill All

Deletes all photos in the list (start all over). You will be prompted to confirm this action.

1.4.5: Define Bundle Adjustment Menu

Enter/edit bundle adjustment parameters (bundle adjustment name, default measurement precision, ENP-stop, maximum iterations, start down weight, maximum standard residual, maximum lost digits, observation file name) and list the individual models of the adjustment by naming the left and right photo of each model. Inspect, rename, copy, and delete records the exterior orientation file.

Bundle Adjustment Name

Enter the name of the exterior orientation record to be created or edited (capital letters without spaces).

Observation File Name

The photo observations will be stored in a separate file. The name defaults to the name of the bundle adjustment with an extension of 'EXO', with the file located in the same directory as the project files. The user cannot change this name!

Measurement Precision

Enter the photo measurement precision in millimeters (the a-priori photo measurement error). The value should

reflect the instrument precision (DSR: 0.001 to 0.003 millimeters), the operator repetition precision (about 0.002 millimeters), and the residual errors from the camera calibration (depends on the camera). A typical measurement precision is between 0.004 and 0.006 millimeters.

ENP-Stop

ENP is the exponent of numerical precision that is used to describe the state of convergence of the adjustment. The higher the ENP the closer the adjustment is to convergence. Normally, the iterations are stopped at an ENP value between 3 and 5.

Maximum Number of Iterations

Enter the maximum number of iterations that you will allow the adjustment to run in case it does not converge. With automatic search and down weight of blunders you should allow for at least 20 iterations.

Start Down Weight

Enter the iteration number at which the automatic search for blunders and down weight of observations start. Enter a number higher than 1. Typically the down weight function should start at iteration number 2. To cancel the automatic down weight enter a number equal to 'Max Number of Iterations'.

Maximum Standard Residual

Enter the standard residual above which weight reduction is applied. Normally a value between 3 and 5 gives good results. If you are in doubt start with 5 and decrease towards 3 if too many blunders escape. Typically, a standard residual higher than 3 indicate a possible blunder.

Maximum Number of Lost Digits

If an unknown cannot be calculated for some reason this will normally result in excessive loss of digits in the involved normal equation diagonal element. If nothing is done the adjustment might break down because of an arithmetic error.

Enter the number of digits that will be acceptable for a diagonal element to lose before the corresponding unknown is removed from the adjustment. 12 seems to work well for the MicroVAX computer.

List Models

Enter the names of the models included in the adjustment. For each model, name the left and right photo and enter the row and column number of the model in the block.

Row and column numbers are used for the calculation of preliminary values, and for the multi-model driving in the

DSR plate processor. Start in the upper left corner with row 1 and column 1. Skip row and column numbers for missing models.

Inspect File

Shows the content of the exterior orientation file (Project_Name.EXT) and allows for rename, copy, and delete of records.

1.4.5.1: List Models Menu

Enter the names of the models included in the adjustment. For each model, name the left and right photo and enter the row and column number of the model in the block.

Row and column numbers are used for the calculation of preliminary values, and for the multi-model driving in the DSR plate processor. Start in the upper left corner with row 1 and column 1. Skip row and column numbers for missing models.

Insert Model

Inserts a new model before the current model (at >). Enter the model name from keyboard or keypad. Enter the name of the left and right photo, and the row and column number of the model.

For row and column number start in the upper left corner of the block and number the model positions according to their 'matrix' position in the adjustment block.

Add Model

Adds a new model at the end of the current list. Enter the model name from keyboard or keypad. Enter the name of the left and right photo, and the row and column number of the model.

For row and column number start in the upper left corner of the block and number the model positions according to their 'matrix' position in the adjustment block.

Edit Model

Edit the current model (at >). Enter values. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Model

Deletes the current model (at >). You will be prompted for confirmation.

Kill All

Deletes all models in the list (start all over). You will be prompted to confirm this action.

1.5: Measure Orientation Menu

Perform template and photo (interior) orientations. Measure photo coordinates for the exterior orientation (the bundle adjustment).

Template Orientation

Measure the template tick marks and transform to the coordinates defined under the 'Temtick Data' menu. A no scale, conform, or affine transformation adjustment is performed. The orientation parameters are down loaded to the Plate Processor.

Both the upper and lower template can be measured.

Photo Orientation

Measure the photo (interior) orientation for single photos (on or not on) a template. Photo fiducial marks, reseau crosses, or corners are measured and transformed to the coordinates defined under the 'Camera Data' menu. A no scale, conform, or affine transformation adjustment is performed.

Template Photos

Measure the photo (interior) orientation for all photos on one template. The photo orientation menu appears for each photo in sequential order. Photo fiducial marks, reseau crosses, or corners are measured and transformed to the coordinates defined under the 'Camera Data' menu. A no scale, conform, or affine transformation adjustment is performed.

Bundle Mono

Measure photo coordinates for the bundle adjustment by monoscopic (one eye) viewing.

Bundle Stereo

Measure photo coordinates for the bundle adjustment. All points are measured with computer assisted stereoscopic (model) point transfer.

The measurements are guided according to the model definitions entered under the 'Bundle Data' menu.

1.5.1: Template Orientation Menu

Measure the template tick marks and transform to the coordinates defined under the 'Temtick Data' menu. A no scale, conform, or affine transformation adjustment is performed. The orientation parameters are down loaded to the DSR plate processor.

The following is written to the display scroll area: the point name (point name), template tick mark coordinates (X-template, Y-template), DSR plate coordinates (X-plate, Y-plate), residuals from the transformation adjustment (VX, VY).

Adjustment results, shown in the display result area are:

x0, y0: translations (offsets)
 ro, sk: rotation and axes skew
 sx, sy: x-axes and y-axes scales

Re-Measure Point

Re-measure the current point (at >). The DSR stage plate will drive to the formerly digitized coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point (delete the old measurement), and <ENTER> or any other function key to keep the old measurement.

Re-Measure All

Re-measure all points. The DSR stage plate will drive to all formerly digitized coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point (delete the old measurement), <ENTER> to keep the old measurement, and any other function key to escape from the 'Re-measure All' function.

Measure All

Measure all points. The DSR stage plate will drive to the the tick mark coordinates, transformed to template coordinates by using the currently available transformation. Use the DSR right foot switch to digitize, left foot switch to skip the point, <ENTER> to keep the old measurement, and any other function key to escape from the 'Measure All' function.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter the tick mark coordinates (X-template, Y-template) and digitize the plate coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point, and <ENTER> or any other function key to keep the old measurement.

Disregard Point

Disregards the current point (at >) from the adjustment without deleting the coordinates.

Residuals will be calculated for the disregarded point, although the point does not influence the adjustment result.

Include Point

Includes a disregarded point in the adjustment calculations.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter the tick mark coordinates (X-template, Y-template) and digitize the plate coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point, and <ENTER> or any other function key to keep the old measurement.

Edit Point

Edit the current point (at >). Enter values and digitize coordinates. Keep the old value by pressing 'ENTER, without having changed the former value.

Kill Point

Deletes the current point (at >). You will be prompted for confirmation.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Transformation

Select which transformation to use in the adjustment calculations. A: affine transformation (two scales, rotation, axes skew, and two translations), C: conform transformation (scale, rotation and two translations), and W: conform transformation without scale.

After every point measurement the adjustment results will be shown in the display result area. The following are displayed:

x0, y0: translations (offsets)
 ro, sk: rotation and axes skew
 sx, sy: x-axes and y-axes scales

1.5.2: Photo Orientation Menu

Measure the photo (interior) orientation for single photos (on or not on) a template. Photo fiducial marks, reseau crosses, or corners are measured and transformed to the coordinates defined under the 'Camera Data' menu. A no scale, conform, or affine transformation adjustment is performed.

The following is written to the display scroll area: (point name) the point name, (X-image, Y-image) camera fiducial coordinates, (X-plate, Y-plate) DSR plate (template) coordinates, (VX, VY) residuals from the transformation ad-

justment. Adjustment results shown in the display result area are:

x0, y0: translations (offsets)
 ro, sk: rotation and axes skew
 sx, sy: x-axes and y-axes scales

Re-Measure Point

Re-measure the current point (at >). The DSR stage plate will drive to the formerly digitized coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point (delete the old measurement), and <ENTER> or any other function key to keep the old measurement.

Re-Measure All

Re-measure all points. The DSR stage plate will drive to all formerly digitized coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point (delete the old measurement), <ENTER> to keep the old measurement, and any other function key to escape from the 'Re-measure All' function.

Measure All

Measure all points. The DSR stage plate will drive to of the fiducial mark coordinates, transformed to photo coordinates by using the currently available transformation. Use the DSR right foot switch to digitize, left foot switch to skip the point, <ENTER> to keep the old measurement, and any other function key to escape from the 'Measure All' function.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Enter the fiducial mark coordinates (X-photo, Y-photo) and digitize the plate (for single photo not on a template) or template (for photos on a template) coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point, and <ENTER> or any other function key to keep the old measurement.

Disregard Point

Disregards the current point (at >) from the adjustment without deleting the coordinates.

Residuals will be calculated for the disregarded point, although the point does not influence the adjustment result.

Include Point

Includes a disregarded point in the adjustment calculations.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Enter the fiducial mark coordinates (X-photo, Y-photo) and digitize the plate (for a single photo not on a template) or template (for photos on a template) coordinates. Use the DSR right foot switch to digitize, left foot switch to skip the point, and <ENTER> or any other function key to keep the old measurement.

Edit Point

Edit the current point (at >). Enter values and digitize coordinates. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >).

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Transformation

Select which transformation to use in the adjustment calculations. A: affine transformation (two scales, rotation, axes skew, and two translations), C: conform transformation (scale, rotation and two translations), and W: conform transformation without scale.

After every point measurement the adjustment results will be shown in the display result area. The following are displayed:

x0, y0: translations (offsets)
 ro, sk: rotation and axes skew
 sx, sy: x-axes and y-axes scales

1.5.3: Measure Bundle, Mono Menu

Measure photo coordinates for the bundle adjustment by monoscopic (one eye) viewing.

The following will be written to the display scroll area: point name (name), photo name, measured coordinates (X-template, Y-template), a-priori error on X and Y (WX, WY), residuals from the bundle adjustment (X_residual, Y_residual), standard deviation on X and Y calculated by the bundle adjustment (SD X, SD Y), and weight factors used for down weighting in the automatic removal of blunders (X WF, Y WF).

Re-Measure Point

Re-measure the current point (at >). The DSR stage plate will drive to the formerly digitized coordinates. Use

the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point (delete the old measurement), and <ENTER> or any other function key to keep the old measurement.

Re-Measure All

Re-measure all points. The DSR stage plate will drive to all formerly digitized coordinates. Use the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point (delete the old measurement), <ENTER> to keep the old measurement, and any other function key to escape from the 'Re-measure All' function.

Measure All

Measure all previously named points. Manually drive the DSR stage plate to the current point. Use the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point, and any other function key to escape from the 'Measure All' function.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. Digitize the plate coordinates. Use the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point, and <ENTER> or any other function key to keep the old measurement.

Disregard Point

Disregards the current point (at >) from the adjustment without deleting the digitized coordinates. Residuals will be calculated for the disregarded point, although the point does not influence the adjustment.

Include Point

Includes a disregarded point in the adjustment calculations.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. Digitize the plate coordinates. Use the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point, and <ENTER> or any other function key to keep the old measurement.

Edit Point

Edit the current point (at >). Enter values and digitize coordinates. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >).

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Re-Measure Down Weighted

Re-measure the points that have been down weighted by the bundle adjustment (possible blunders). The DSR stage plates will drive to the points one by one. Use the DSR right foot switch (RFS) to digitize, left foot switch (LFS) to skip the point (delete the old measurement), <ENTER> to keep the old measurement, and any other function key to escape from the 'Re-Measure Down Weighted' function.

1.5.4: Measure Bundle, Stereo Menu

Measure photo coordinates for the bundle adjustment. All points are measured with computer assisted stereoscopic (model) point transfer. The measurements are guided according to the model definitions entered under the 'Bundle Data' menu.

The following will be written to the display scroll area: point name (name), photo name, measured coordinates (X-template, Y-template), a-priori error on X and Y (WX, WY), residuals from the bundle adjustment (X_residual, Y_residual), standard deviation on X and Y calculated by the bundle adjustment (SD X, SD Y), and weight factors used for down weight in the automatic removal of blunders (X WF, Y WF).

Re-Measure Point

Re-measure the current point (at >). The program will find a stereo partner for the point and drive the DSR stage plates to the former digitized coordinates. One measuring mark will be locked on the coordinates of the stereo partner. Use the DSR right foot switch (RFS) to digitize, and <ENTER> to escape while keeping the old measurement.

Re-Measure All

Re-measure all points from the top of the list or from the current pointer position (point at >). Answer 'P' or 'T' to the prompt "Start at Pointer or Top? (P/T)". The program will lead you through a re-measurement of the desired points. However, rather than measuring the points in the listed order, the program will finish the measurement of each individual point in all photos, before going to the next point.

For each point the program first finds a stereo partner, drives the plates to the previously measured coordinates and allows for stereoscopic measurement in the two

photos. Then the program searches for, drives to, and allows for measurement of all equally named points in other photos. One measuring mark will be locked for stereoscopic point transfer. Try it!

Use the DSR right foot switch (RFS) to digitize, the left foot switch (LFS) to lock and unlock the left photo, <ENTER> to keep the old measurement, and <ZERO> to escape the 'Re-measure All' function.

Measure Point All

Re-measures a point in all photos where it has previously been measured. Enter the name of the point to be re-measured. The default is the current point (at >). If the current point is selected, the program finds a stereo partner, drives to the previously measured coordinates and allows for stereoscopic measurement of the point in the two photos. If another point (other than the current point) is chosen the program selects the first stereo partners of the point in the list.

After having measured the first stereo pair the program searches for, drives to, and allows for measurement of all equally named points in other photos. One measuring mark will be locked for stereoscopic point transfer. Try it!

Use the DSR right foot switch (RFS) to digitize, the left foot switch (LFS) to lock and unlock the left photo, <ENTER> to keep the old measurement, and <ZERO> to escape the 'Re-measure Point All' function.

Insert Point

Inserts a new point before the current point (at >). Enter the point name from keyboard or keypad. If the point has not been measured in other photos, the program allows for stereoscopic measurement in the two photos of the current model. If the point has been measured in another photo, one measuring mark is locked on the previously measured coordinates. Measure the point in the new photo by removing x and y parallaxes.

Use the DSR right foot switch (RFS) to digitize, the left foot switch (LFS) to lock and unlock the left photo, and <ZERO> to escape the 'Insert Point' function.

Disregard Point

Disregards the current point (at >) from the bundle adjustment without deleting the digitized coordinates. Residuals will be calculated for the disregarded point, although the point does not influence the adjustment.

Include Point

Includes a disregarded point in the adjustment calculations.

Add Point

Adds a new point at the end of the current list. Enter the point name from keyboard or keypad. If the point has not been measured in other photos, the program allows for stereoscopic measurement in the two photos of the current model. If the point has been measured in another photo, one measuring mark is locked on the previously measured coordinates. Measure the point in the new photo by removing x and y parallaxes.

Use the DSR right foot switch (RFS) to digitize, the left foot switch (LFS) to lock and unlock the left photo, and <ZERO> to escape the 'Add Point' function.

Edit Point

Edit the current point (at >). Enter values and digitize coordinates. Keep the old value by pressing <ENTER>, without having changed the former value.

Kill Point

Deletes the current point (at >). If deleting a point in one photo leaves a point in another photo without a stereo partner, be sure to delete this point also.

Kill All

Deletes all points in the list (start all over). You will be prompted to confirm this action.

Re-Measure Down Weighted

Re-measure the points that have been down weighted by the bundle adjustment (possible blunders). The program will drive to the points one by one and find a stereo partner for each point. One measuring mark will be locked on the coordinates of the stereo partner. Use the DSR right foot switch (RFS) to digitize, <ENTER> to keep the old measurement, and <ZERO> to escape the 'Re-measure Down Weighted' function.

Next Model

The next model is the model with the sequentially higher column number than the current model. If such model don't exist the first model of the next row is selected. 'Next Model' loads the parameters for the next model into memory.

Change Model

Changes the model residing in memory. Enter the name of the model to be loaded.

1.6: Compute Bundle Menu

Calculate preliminary values, compute the exterior orientation by bundle adjustment 'Solve Bundle', inspect

resulting camera and photo parameters, and down load templates and models to the plate processor.

Solve Bundle

Performs the bundle adjustment calculations. During the processing of observations and unknowns (elements), warnings and errors will be written to the display scroll area. Errors will stop the computations, warnings will not. Study the warnings carefully, but do not panic, most warnings can be ignored. For instance, if you have more control points listed in the control file than used by the current block of photos, warnings will be issued for each surplus point.

The pass results of every iteration is written to the display result area. Follow the developments in ENP, singularities, and errors (number of down weighted points). IF the ENP constantly decreases or if the number of errors and singularities constantly increases the adjustment is diverging. Stop the adjustment and check photo observations, control information, and preliminary values.

If when finished the standard error unit weight is approximately 1 the adjustment has succeeded. A higher standard error unit weight indicates that a group of observations have higher residuals than their a-priori error. Check the a-priori error values or the observations for blunders.

The results of the adjustment are written to Ascii files. BUNDLE_ERROR.OUT holds the warnings and errors issued. BUNDLE_RESULT.OUT holds the adjusted values and standard deviations.

Stop Solve

Stops the adjustment after the next completed iteration. Initially nothing happens when 'Stop Solve' is pressed, however, when the ongoing iteration is completed the adjustment is halted, and you will be prompted to confirm that you want the adjustment stopped.

Camera Results

Displays the camera parameters calculated by the bundle adjustment, and update preliminary values.

Photo Results

Displays the photo parameters calculated by the bundle adjustment, and update preliminary values.

Point Results

Displays the point coordinates calculated by the bundle adjustment, and update preliminary coordinates.

Compute Preliminary Values

Calculates preliminary coordinates for photogrammetrically measured points and preliminary values for photo parameters (projection center coordinates and rotations).

Preliminary values are calculated through relative orientation, model bridging, strip connection, and absolute orientation of the whole block of photos.

The menu can be used, as well, for individual relative orientations, model bridgings, and strip connections. This is useful for the isolation of blunders. Use the 'Measure Orientation' menu to edit, delete, re-measure, disregard, or include points.

Down Load Models

Down loads the entire block of photos (models) to the DSR plate processor. Parameters calculated by the last bundle adjustment are down loaded.

1.6.1: Camera Results Menu

The parameter values displayed are the results of the most recent bundle adjustment. The calculated standard deviations are shown in brackets.

The values shown in this menu are not written to the camera data record unless the 'Update Preliminary Values' function is used.

Camera Name

Enter the name of the camera record to be inspected. The parameter values displayed are the results of the most recent bundle adjustment. The calculated standard deviations are shown in brackets.

Update Preliminary Values

Update the preliminary values entered under the 'Camera Data' menu. Only the values for the displayed camera and only values with status 'unknown' are updated.

1.6.2: Photo Results Menu

The parameter values displayed are the results of the most recent bundle adjustment. The calculated standard deviations are shown in brackets.

The values shown in this menu are not written to the photo record unless the 'Update Preliminary Values' function is used.

Photo Name

Enter the name of the photo record to be inspected. The parameter values displayed are the results of the most

recent bundle adjustment. The calculated standard deviations are shown in brackets.

Update Preliminary Values

Update the preliminary values entered under the 'Define Photo' menu. Only the values for the displayed photo and only values with status 'unknown' are updated.

1.6.3: Point Results Menu

The coordinates displayed are the results of the most recent bundle adjustment. The calculated standard deviations are shown for each coordinate.

The values shown in this menu are not written to the preliminary coordinate file unless the 'Update Preliminary Values' function is used.

Update Preliminary Values

Update the values in the file for preliminary coordinate. Existing values in the file will be deleted.

1.6.4 Compute Preliminary Values Menu

Calculates preliminary coordinates for photogrammetrically measured points and preliminary values for photo parameters (projection center coordinates and rotations).

Preliminary values are calculated through relative orientation 'Relative Orientation All', model bridging 'Bridge All', strip connection 'Connect All', and absolute orientation 'Absolute Orientation' of the whole block of photos.

The menu can be used, as well, for individual relative orientations 'Relative Orientation Model', model bridgings 'Bridge Models', and strip connections 'Connect Strips'. This is useful for the isolation of blunders. Use the 'Measure Orient' menu to edit, delete, re-measure, disregard, or include points.

Relative Orientation Model

Performs a relative orientation adjustment of the model currently in memory. Use 'Next Model' or 'Change Model' to load another model.

The model coordinate list will not be updated by this function so bridging, strip connection, and absolute orientation is not possible. Use 'Relative Orientation All' to update the list.

After the adjustment, results will be shown in the display scroll and result areas.

A list of relative orientation points are displayed in the scroll area, showing the point name, the names of the

left and right photo, the photo coordinates (left X, left Y, right X, right Y), the residual parallax (py), and the standard deviation on the parallax (spy).

The orientation parameters are displayed in the result area, showing the model row and column numbers (row, col), the base components (by, bz) with calculated standard deviations (mby, mbz), and the rotations of the right photograph (om, phi, kp) with calculated standard deviations (mo, mf, mk).

Bridge Models

Performs a spatial similarity transformation adjustment of common points between the model currently in memory and the next model. Use 'Next Model' or 'Change Model' to load another model to memory. Use the 'Relative Orientation All' function first to calculate model coordinates.

The model coordinate list will not be updated by the 'Bridge Model' function so strip connection, and absolute orientation is not possible. Use 'Bridge All' to update the list.

After the adjustment, results will be shown in the display scroll and result areas.

A list of the bridging points are displayed in the scroll area, showing the point name, the name of the photo appearing in both models, the model coordinates (X, Y, Z), and the residuals (sX, sY, sZ).

The orientation parameters are displayed in the result area, showing the names of the two models, number of points (pnt), the number of iterations (its), the standard error unit weight (s0), and the scale, shifts, and rotations with standard deviations in brackets.

Connect Strips

Performs a spatial similarity transformation adjustment of common points between strips of models. Enter the row numbers for the strips to connect. Use the 'Bridge All' function first to calculate strip coordinates.

The model coordinate list will not be updated by the 'Connect Strips' function so absolute orientation is not possible. Use 'Connect All' to update the list.

After the adjustment, results will be shown in the display scroll and result areas.

A list of the connect points are displayed in the scroll area, showing the point name, the model coordinates (X, Y, Z), and the residuals (sX, sY, sZ).

The orientation parameters are displayed in the result area, showing the names of the first model in each strip, number of points (pnt), the number of iterations (its), the standard error unit weight (s0), and the scale, shifts, and rotations with standard deviations in brackets.

Relative Orientation All

Performs relative orientation adjustments of all models in the block and updates the model coordinate list. The results are shown in the display scroll area: the model name, the names of the left and right photo, the number of points (npts), the number of iterations (its), the standard error unit weight (seuw), and the maximum residual (mres).

Bridge All

Performs spatial similarity transformation adjustment between all models in all strips and updates the model coordinate list. The results are shown in the display scroll area: the names of the left and right model, the names of the photos that appear in each model, the number of points (npts), the number of iterations (its), the standard error unit weight (seuw), and the maximum residual (mres).

Connect All

Performs spatial similarity transformation adjustment between all strips and updates the model coordinate list. The results are shown in the display scroll area: the name of the first model in each strip the number of points (npts), the number of iterations (its), the standard error unit weight (seuw), and the maximum residual (mres).

Absolute Orientation

Performs a spatial similarity transformation adjustment of common points between the block of models and the control point file. Use the 'Relative Orientation All', 'Bridge All', and/or the 'Connect All' function first to calculate block coordinates.

After the adjustment, results will be shown in the display scroll and result areas.

A list of the control points are displayed in the scroll area, showing the point name, the ground coordinates (X, Y, Z), and the residuals (sX, sY, sZ).

The orientation parameters are displayed in the result area, showing the number of points (pnt), the number of iterations (its), the standard error unit weight (s0), and the scale, shifts, and rotations with standard deviations in brackets.

Print Results

Prints the resulting preliminary photo parameters and point coordinates to a file called 'PRELIM_RESULT.OUT'.

Update Values

Updates the preliminary photo parameter values and coordinates to be used in the bundle block adjustment. The coordinates are stored in a file with the name of the bundle adjustment and an extension of 'PRE', located in the same directory as the project files.

Use 'Relative Orientation All', 'Bridge All', and/or the 'Connect All', and 'Absolute Orientation' before using the 'Update Values' function.

Model Coordinates

Writes to the display scroll area a list of the current model coordinates as calculated by 'Relative Orientation All', 'Bridge All', 'Connect All', or 'Absolute Orientation'.

Next Model

Next model is the model with the sequentially higher column number than the current model. If such model does not exist the first model of the next row is selected. 'Next Model' loads the parameters for the next model into computer memory.

Change Model

Changes the model residing in memory. Enter the name of the model to be loaded.

V. REFERENCES

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