

# DISCUSSION OF GPS SUPPORTED AUTOMATIC TRIANGULATION BASE ON THE DMC IMAGES

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## WG IV/1-Spatial Data Infrastructure

**KEY WORDS:** Photogrammetry, ISAT, GPS\INS, IMU, DMC

### ABSTRACT:

With the development of modern aerophotogrammetry technology, GPS\INS(IMU) have been applied more and more widely. Data received by airborne GPS, can define the position of photography station. And the coordinates of photography station are very similar as the coordinates of control points in the field. We can do block adjustment by using of the coordinates of photography station to reduce a lot of ground control work. Aerotriangulation is a major procedure of aerophotogrammetry. This article, taking the Spanish project as an example, will introduce the methods and application of automated aerotriangulation by means of Intergraph ISAT software and GPS\INS(IMU) aid for the DMC images.

## 1. INTRODUCTION

ISAT(ImageStation Automatic Triangulation) is software developed by US Intergraph company. It is software that performs automated aerotriangulation from digital aerial images. Its function is to automate point transfer and tie-point measurement operations, reduce manual work and perator intervention, thereby increase work efficiency. For more convenient and efficient processing, ISAT can divide large projects into small blocks of photos. It can process whole blocks or logical groupings, of photos. Block processing has great flexibility. It can perform automatic triangulation on only one part of a larger project, or process parts of the project separately to more efficiently isolate and solve problems. At the end of ISAT workflow, you can merge all processed blocks measurement results into master project for the final adjustment step for all photos.

This article will take Spanish aerotriangulation project, GPS\INS(IMU) aid for the DMC images as an example. GPS means Global Positioning System, INS means Inertial Navigation System and IMU means Inertial Measurement Unit.

## 2. OPERATING ENVIRONMENT

**Hardware:** ISSK(ImageStation Stereo Softcopy Kit), from Intergraph Corporation.

**Software:** Intergraph ISAT.

Data materials: DMC digital aerial images supplied by Spanish company, camera calibration reports, photo center coordinates (GPS\INS(IMU) Extensive Orientation parameters), ground control points and technical specification.

When work with an ISAT project, The project photo images must be either all grayscale or all color; all images must have the same scan resolution (pixel size); every image file must contain a full set of overviews. Before start the ISAT workflow, the project must contain EO parameters, or approximate EO parameters created by Strip Wizard command, or from flight

plan or acquired other methods. In this way, the project will have enough information to define the approximate position of photos and ground control points, as can be confirmed by opening the Footprint Viewer (Tools menu) and observing their predicted locations.

## 3. WORK METHODS

### 3.1 ISAT Set Up the Project

Use the New Project(set up coordinate system and other parameters), Camera Wizard, Strip Wizard and Edit Control Point or Input Control Point command to set up the project for ISAT, input GPS\INS(IMU) EO parameters.

When using Strip Wizard to edit the flight line, we must define IDs(without strip IDs, the auto-matching not able to be executed), define photo IDs and image paths, and so on.

For DMC digital aerial images, there is no PPA(Principal Pt. of Auto collimation), no lens distortion correction, no need to do interior orientation. When using Camera Wizard command (setup camera file), For Camera Type menu, click Digital, then import Focal Length to Camera Data menu.

Use EO,GPS\INS,POSEO command(Translators menu, Import submenu) to input GPS\INS, select GPS\INS, then input the parameters into relevant column, If there is time parameters, set the column of it. For Std Dev, click and input figure according to the accuracy of this project(See Figure 1).

After set up the project of ISAT, use Footprint Viewer command(Tools menu) to check if the photo images overlap is correct or not, check the position of the first and end photo image. This step can also check the input EO(GPS\INS) parameters is correct or not.

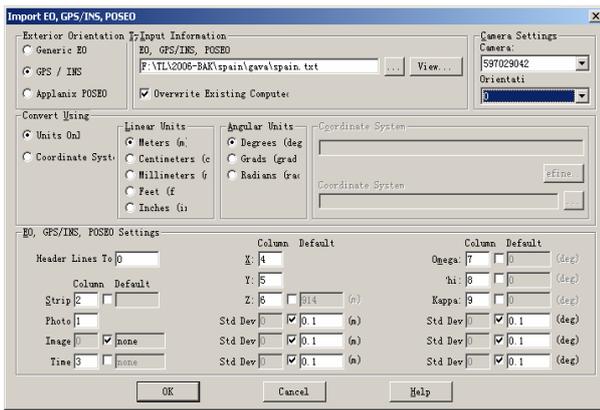


Figure 1

### 3.2 Prepare blocks

A block is a group of photos that have been organized into a logical subset of project photos. A block can be selected for input to the Photo Triangulation, Multiphoto Point Measurement, and ISAT point matching and bundle adjustment. We use the Block Preparation command (ISAT menu) to define a block by entering an ID and then by either selecting the photos from a list of project photos or by selecting them from a display of photo footprints. Blocks composed of parallel flight-line strips with side overlaps should have a one-strip overlap, that is, they should both include a common strip. When a strip is itself subdivided into different blocks, the blocks should have a two-photo overlap. Spanish project includes 500 photo images and is divided into upper and lower blocks. Block ID is A and B with a one-strip overlap.

### 3.3 Perform matching

Click the ISAT Control Panel (Control Panel command, ISAT menu) to display the ISAT Control Panel, Select block A and B, select Auto Stretch Images, Reduce Shadow Points, Do Not Use GPS/INS on the right side and set up other parameters, then click submit, block A and B will be processed separately. We can submit the process to be run immediately or schedule it for a later time. (The Z/I Job-scheduling Service must be running on your computer at the scheduled time). ISAT will generate tie points between the photos, using its point-matching technique, and perform a bundle adjustment of the points. From the Control Panel, we can open the Job Controller or View Log File to view information about any running, scheduled ISAT processes or read informational messages generated by the process. ISAT can create a block project for a processed block in a subfolder of the current master project. The name of the project is the ID number of the Block. ISAT regenerates pass point IDs for each block based on its position in the list, that is, 1000001 for the first pass point in Block A, 2000001 for the first pass point in Block B.

### 3.4 Edit weak areas Block A and B, review results and adjust

After auto-matching, we can use Set Active Project (ISAT menu) or Open command (File menu) to make the Block project as current block project, a dialog box will come out to show the results of one or more weak areas. Use the Edit Weak Areas command, select a weak area from a list. The area on multiple overlapping photos, then click OK and the withheld placeholder point as positioned on each photo will be presented in a multi-photo point measurement environment. If there are an

adequate number of measured points in the vicinity for a good solution, we can delete the point. Otherwise, we should manually find and measure a nearby common reference feature in each of the photos to connect the multi photos. Continue to process with the same method till all weak areas are removed from the list. Point matching automatically measures a surface feature on multiple displayed photos when we measure it on one of the photos. The point matching is enabled by right-clicking in a view and then placing a check mark before Enabled on the Matching submenu. Clear the check mark whenever you want to disable point matching.

After edition of the weak areas, we will do compute. We can view the tie/pass points result in the window of Photo Triangulation Results. All the points will have the taxis with the  $V(xy)$  value. Delete the gross error points, Blunder points and one-ray points. Then use Multiphoto Orientation command, select six photos from two flight-line strips. to check if there are enough tie/pass points between photos. If necessary, input point label in Point ID column. In the area lack of tie/pass points, we can manually measure tie/pass points. After check, we will do relative orientation again. View the tie/pass points result of in the Photo Triangulation Results. If there are still big residual error points, we can run Multiphoto Orientation command again to adjust and re-compute. Repeat such procedure till the accuracy is meet. The accuracy of relative orientation for this project is  $RMS \leq 12\mu m$ .

### 3.5 Measure control points

This project has bundle adjustment data provided by GPS/INS, so ground control points are less and mainly locate around target points. Use Multiphoto Orientation command (Orientations mean), or Point Measurement command (ISAT menu), go into a multi-photo point measurement environment. Input the ground control point label in the Point ID column, use Photo (deselect and Find Photos commands to look for the photos which will be measured and measure the ground control points.

### 3.6 Merge the Block measurement results into the master project

Select the Set Active Project or Open command (File menu), select the master project (The Merge Block Measurements command is available only when the master project is active). Use Merge Block Measurements command (ISAT menu), open Merge Block Measurements dialog box, select two blocks separately which have been processed from Available Blocks list, then use Merge Select Block command to merge the generated tie/pass points with the master project.

### 3.7 Overall bundle adjustment; result evaluation and adjust control points

Select Triangulation command (Orientations menu, Photo Triangulation submenu), in Select Photos dialog box, we will select all the photos in the master project, click OK and open Photo Triangulation Results dialog box, click Options, select Absolute in Adjustment Mode, select Enable Precision Computation in Adjustment Parameters. Since this project has GPS/INS aid for bundle adjustment, in the Given EO/GPS/INS Settings parameters area of the Photo Triangulation Options dialog box, select the Enable Given EO/GPS check box (If you clear this check box, control point and tie point data alone will be used to compute the final exterior orientation parameters). And because this project has time parameters, we will select

GPS Shift/Drift Correction and INS Shift/Drift Correction check box(See Figure 2), then Click Ok, press Compute to do block adjustment, and, as desired, monitor the progress of the computation in the Solution Progress dialog box. If there is antenna height correction, we will also select Antenna Offsets, and input X, Y, Z correction parameters.

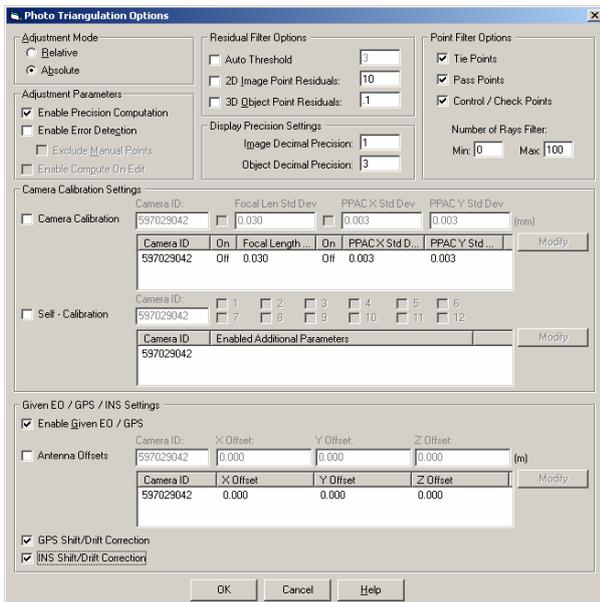


Figure 2

When computation completes, we can analyze the triangulation results, view the summary statistics to check whether the solution is satisfactory or not. Check sigma value, Root Mean Squares(RMS) errors of control and check points, maximum control point residuals, and mean standard deviation values of the object point coordinates and EO parameters, and check if the drift value between exterior orientation and input GPS/INS is within accuracy. If there are still big residual error ground control points, we can written down the point label and use Point Measurement command(ISAT menu) or Multiphot command(Orientations menu) to re-measure the points in stereo. After we adjust the ground control points, we can re-do bundle adjustment till the result reaches the accuracy requirement. This step will Commit the bundle adjustment results to the project files by clicking OK on the Photo Triangulation Results dialog box. This writes the computed EO parameters to the Photo file and the adjusted tie/pass points coordinates to the project Triang file. The absolute orientation accuracy for this project is Max Rms  $X, Y \leq 0.1m$ ;  $Z \leq 0.1m$ .

### 3.8 Submission of final result

After the relative orientation and absolute orientation meet the accuracy requirement, we can click Reports in Photo Triangulation Results dialog box, a PhotoT Reports will come out, See Figure 3. The computed EO parameters has been written into Photo file when we do block adjustment; Select the Densify command(Orientations menu, Photo Triangulation submenu) to open the Densification dialog box, click OK to densify control procedure and this process writes the calculated ground coordinates of the tie/pass points from the Triang file to the Control file. Select the Bulk Orientation command (Orientations menu, Photo Triangulation submenut) to open the Bulk Orientation dialog box. At a minimum, select the Relative Orientation and Absolute Orientation check boxes. Select photos and models to perform relative orientation and absolute

orientation on the models, by block ID, or by model ID. Click Compute, and review the results when they are displayed. Finally, we use Export command in Translators menu to export PATB、EO and Control reports.

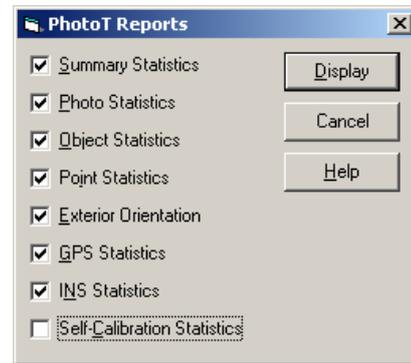


Figure 3

## 4. CONCLUSION

Through the aerotriangulation of Spanish project, we are more skillful with ISAT software. We think it has good reliability, quality and function. It can work for large projects more conveniently and effectively. Its points matching can reduce a lot of manual points selection work. With GPS/INS aid, we need less ground control points, so the field work has been reduced a lot too. Furthermore, DMC images do not need to be scanned, it also increase the efficiency of aerotriangulation.

In high-speed developing information society, satellite navigation system has been widely used and it can provide high precision service. GPS has the function of navigation, positioning, timing, and measuring etc. Besides, with the development of aerophotography technology, there will be more and more DMC digital images with air-borne GPS and INS which can takes place of aerophotograph films and scanners. We believe ISAT will be used more and more widely.

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