Creating Orthorectified Aerial Photography Without A Camera Calibration Report

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Introduction

To make precisely orthorectified aerial photographs using IMAGINE OrthoBASE, generally you need the camera calibration report to identify the interior parameters such as focal length, principal points and fiducial marks of the frame camera used to capture your photography. However, there are times when you may not be able to get the report. Even in such cases, some of the parameters can be derived from your photography and used in your ortho-rectification process.

Of course, the non-metric model or digital camera model that doesn't need fiducial marks are also useful in this case, but using the frame camera model and estimating the interior orientation information will give more accurate results.

Input Data

- Aerial photography
- Ground control points (GCPs) with x, y, z coordinates
- DEMs

* Assumption: Camera calibration report is *not* available

How to Get Camera Information?

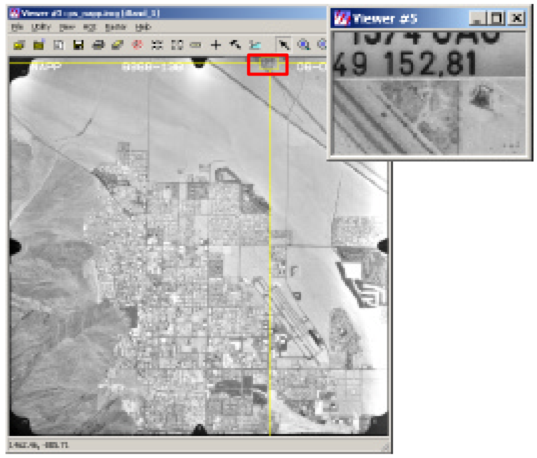
To define the frame camera model, we have to input, at a minimum, the following three kinds of information – principal point, focal length and the coordinates of the fiducial marks. In case you don't have the camera calibration report, you need to get these parameters from somewhere else. This information can be derived from your photography.

<u>1. Principal Point</u>

The principal point is mathematically defined as the intersection of the perpendicular line through the perspective center of the image plane. If the optical system of camera has some distortion, this point will be slightly different from the center of photography. Thinking inversely, this point corresponds to the center of photography when an ideal camera is assumed. Under this assumption, you can use value **x, y = 0, 0** as the principal point coordinate.

<u>2. Focal Length</u>

In typical aerial photography, you can find the value of the focal length captured in the data strip. Below is an example of NAPP (National Aerial Photography Program)

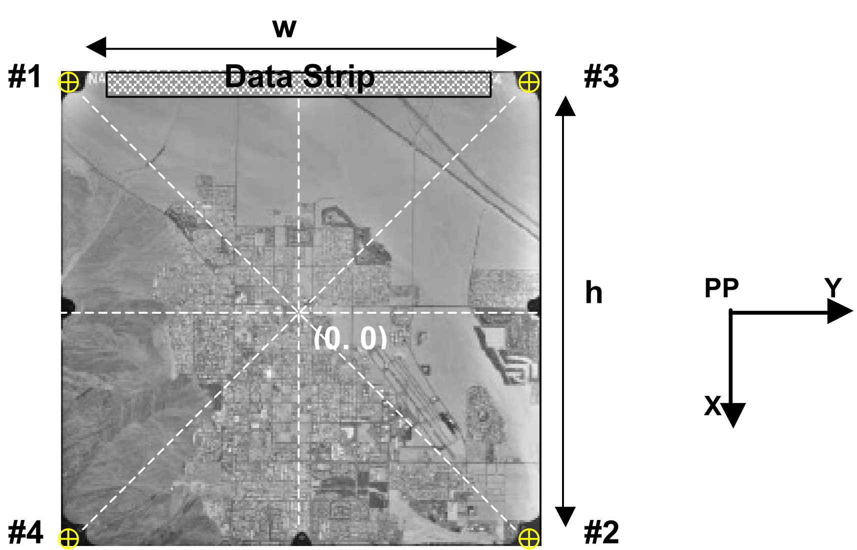


photography captured by a Wild camera. The focal length can be identified as 152.81mm.

3. Fiducial Marks

The coordinates of fiducial marks can be measured directly using a ruler on the hardcopy photography. Take the origin of coordinates at the point where the diagonal lines connecting fiducial marks meet. At least four fiducial marks must be measured in millimeter units.

The coordinate system should be defined according to the location of the data strip, i.e., you should take the Y-axis in the direction along which the data strip lies. The order of marks is typically defined as shown in following diagram.



Once you have measured the distance between fiducial marks both horizontally (w) and vertically (h), the coordinates are easily defined, as in the following table according to the origin and orientation of coordinate system mentioned above.

	X	Y
#1	- h/2	- w/2
#2	h/2	w/2
#3	- h/2	w/2
#4	h/2	- w/2

Table 1. Coordinate values of fiducial marks (Units; mm)

If you have digitized photography but know in what resolution it was scanned, you can measure the length with the Measurement Tool of the IMAGINE Viewer and divide it by the scanning resolution. For example, if the scanning resolution is 300 dpi (dots per inch) and the length (w) measured in the Viewer is 2500 pixels, the mm length can be easily calculated as,

$$w = (2500 / 300) \times 25.4 = 211.67 \text{ mm.}$$

In case your photography doesn't have the focal length information captured, if you do know the flight height (H) and photo scale (1/S), you can calculate the rough value from the following simple expression. Of course, the flight height must be converted to *meter* units.

$$\text{Focal length} \approx H / S$$

You may also find a rough value from photogrammetry manuals if you have information on what model of camera was used for the photography.

Self-calibrating Bundle Adjustment (SCBA)

IMAGINE OrthoBASE can automatically correct these rough camera parameters in the triangulation process by the method called SCBA. Accuracy should be reasonably sufficient with the focal length in the data strip. But for those applications where greater accuracy is required or only rough focal length is available, SCBA may be worthwhile. It is advisable to obtain a reasonable RMSE without SCBA first prior to selecting to use an SCBA because it requires more GCPs than usual due to the additional unknowns of the focal length, etc. Also, it is recommended to use only two to three images in order to find the adjusted focal length before applying it to a whole block of more images.

IMAGINE OrthoBASE Workflow

The following steps can be used to orthorectify aerial photography without a calibration report. In this case, we ortho-rectify using the following data, which are included in the "examples" directory of ERDAS IMAGINE.

- Aerial Photograph (Input Data): **ps_napp.img**
- DEM: **ps_dem.img**

- GCPs: **ps_camera.gcc**

NOTE: Although we process only one photograph in this example, this method also can be applied to multiple images.

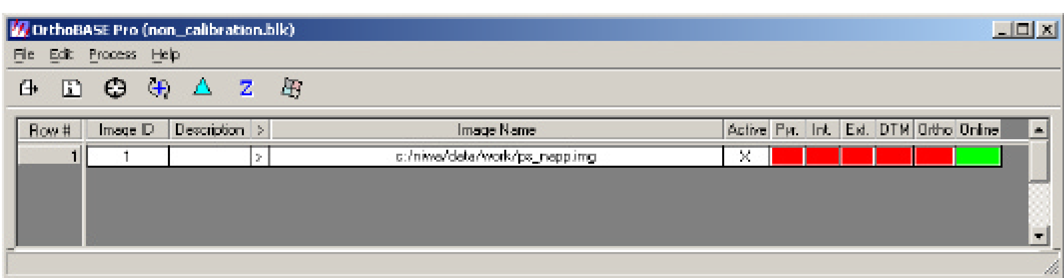
Step 1. Define the IMAGINE OrthoBASE Block File

Input the following information to define the IMAGINE OrthoBASE project:

- The IMAGINE OrthoBASE Block file name. The block file is a binary file that contains all of the information associated with a project. This includes the number of images processed, GCPs used, image coordinate information, projection, units, etc.
- Select the **Frame Camera** geometric model.
- Projection, spheroid and datum should be same as DEM and GCPs. In this case,
  - Projection: **UTM Zone 11**
  - Spheroid: **Clarke 1866**
  - Datum: **NAD27**
- Horizontal, vertical and angular units are **Meter**, **Meter** and **Degree**.
- Type of rotation used to define the orientation of the camera as it existed at the time of exposure. In this case, the **Omega, Phi and Kappa** rotation systems are used.
- Type of photography/imagery used (including aerial or terrestrial). If aerial photography/imagery is used, the photographic direction is the Z-Axis. In this case, the **Z-Axis** option is selected.
- Average flying height of the camera. The average flying height of the aircraft is not required for this case.

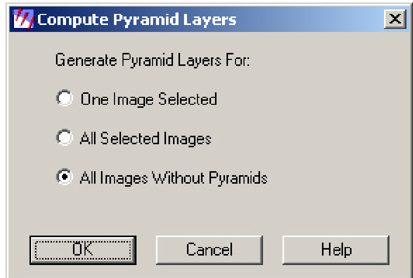
Step 2. Add imagery to the project

To add images to the block, select the **Add Images** icon  or **Edit | Add Frame...** option from menu. Within the Image File Name chooser, identify and select the image to be added. In this case, select **ps_napp.img** from examples directory.



Step 3. Create Pyramid Layers

Once the images have been input and defined, the pyramid layers associated with the image can be created. Selecting one of the red cell elements contained within the **Pyr** column will open the Compute Pyramid Layers dialog.



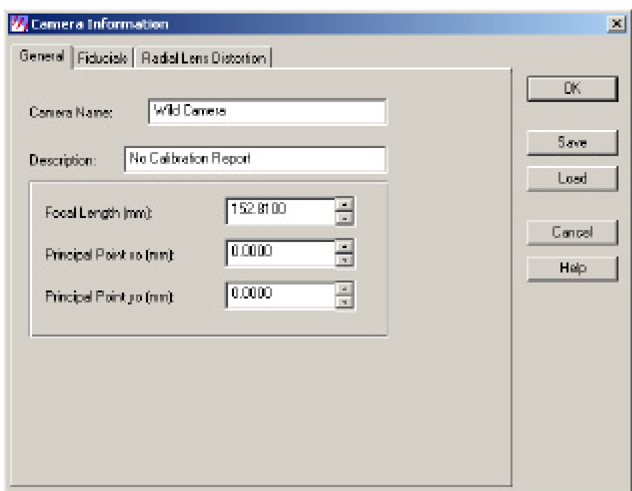
Selecting the **All Images Without Pyramids** option will consecutively create pyramid layers for each image in the block project. Once the pyramid layers have been created, the **Pyr** cell elements will change to green. The pyramid layers optimize image handling during display, as well as the performance of automatic tie point collection.

Step 4. Input camera parameters

Start the Frame Editor by selecting the **Show and Edit Frame Properties** icon  or **Edit | Frame Editor...** Then press the **New...** button in the **Sensor** tab. You may then input camera parameters we discussed above.

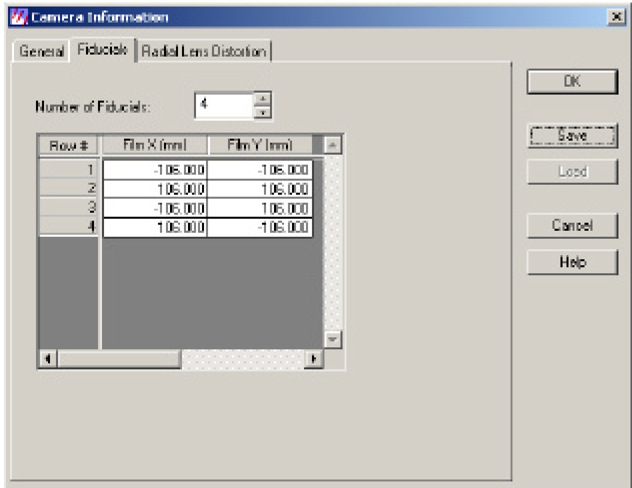
4-1. General Tab

You can input **Focal Length** and **Principal Point** here. With regard to the focal length, you can find the value at the top of the **ps_napp.img**. (Open the file in a Viewer and check it.)



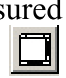
4-2. Fiducials Tab

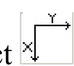
Here, you can input fiducial coordinates that are summarized in Table 1. Set the **Number of Fiducials** to the same number as the fiducial marks on your photography, in this case **4**, and type the coordinate values you measured in the **Film X** and **Film Y** columns.



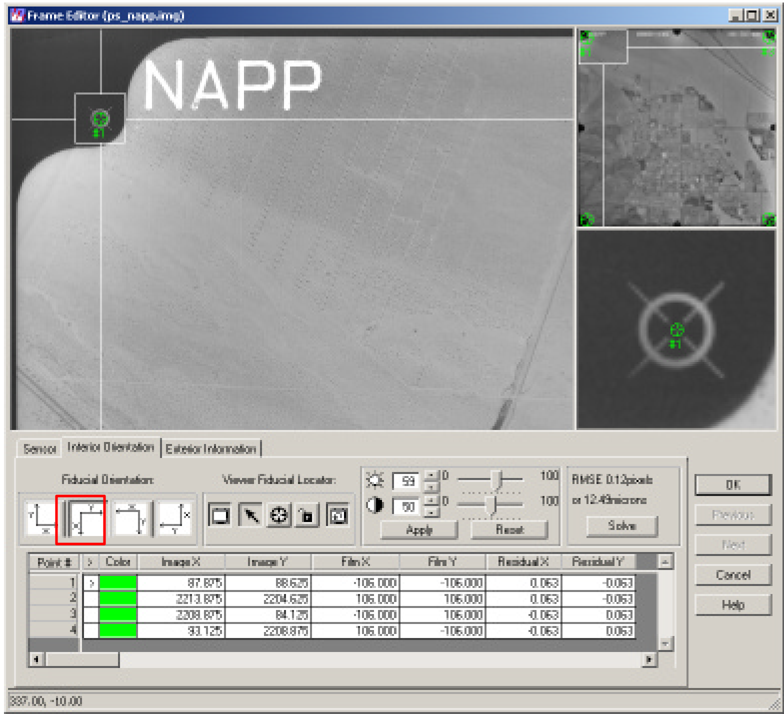
You can save these parameters with the **Save** button. Pressing **OK** will apply this setting and close the dialog. By defining the camera within the Camera Information dialog, the information will be applied to each image in the block project.

<u>4-3. Fiducial Measurement</u>

Click the **Interior Orientation** Tab of the Frame Editor. You can see the fiducial mark coordinates in the CellArray. The fiducial mark positions on the image coordinate system can be measured within this dialog. Clicking the **Open viewer for image fiducial measurement** icon  will show three embedded viewers in which you can select the point with mouse cursor. Before selecting the point, make sure that you are selecting appropriate **Fiducial Orientations**.

In this example, you should select 

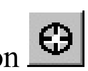
icon because the Y-axis of ps_napp.img can be identified as right from the location of the data strip of the photograph.

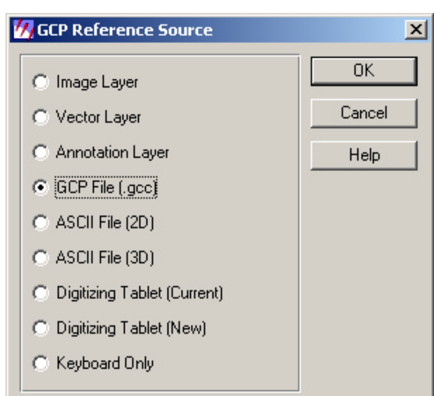


When all of Fiducials are measured, click **OK** button and close this dialog.

<u>Step 5. GCP Collection</u>

In this step, we define ground control points (GCPs). Since we process only one image in this example, we should collect as many GCPs as possible. There is a GCP file named ps_camera.gcc in the examples directory that can be used.

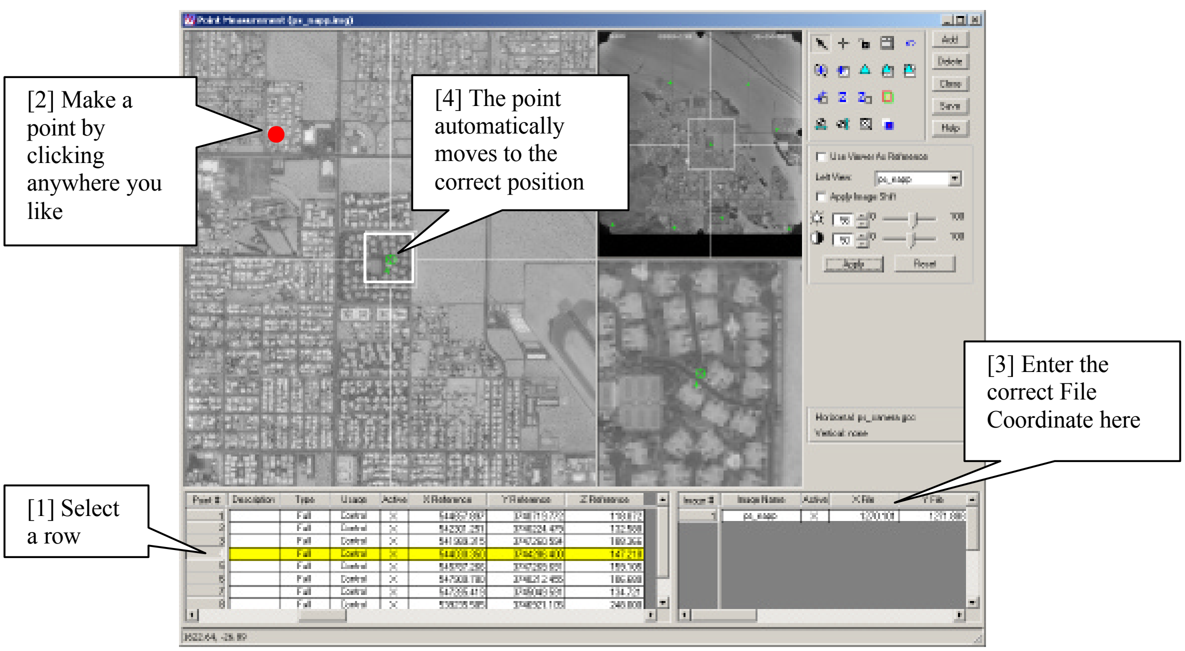
Selecting the **Start point measurement tool** icon  will open a window that has three embedded viewers. First, load the GCP file **ps_camera.gcc** with the **Reset horizontal reference source** icon.



Second, enter the file coordinates in the right CellArray. Coordinates corresponding to each reference coordinates are shown in following table. Notice that you have to create a row in the table (and a point) by clicking somewhere you like in the viewer using **Create Point** tool before enter file coordinates. Once a row is created, you can enter the correct coordinate values into the column **X File** and **Y File**. The point will automatically move to the correct position.

No.	X File	Y File	X Reference	Y Reference
1	1401.178	2101.549716	544657.8972	3740719.772
2	850.1665	2214.532185	542301.2512	3740224.479
3	808.0213	571.7258523	541989.3150	3747260.594
4	1270.101	1271.887784	544030.3503	3744286.400
5	1687.295	590.5027834	545787.2657	3747269.691
6	2146.066	2223.599887	547900.7802	3740212.455
7	2019.663	1107.192155	547285.4195	3745049.591
8	150.7457	630.5894886	539235.5851	3746921.105
9	165.4252	1525.152586	539516.8989	3743200.150
10	163.5571	2181.081535	539801.9035	3740804.110

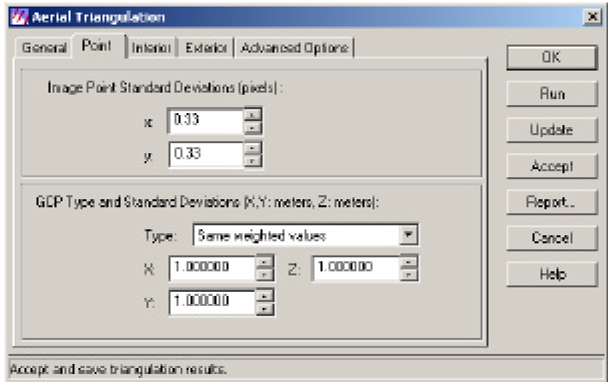
Table 2. File and Reference Coordinates of GCPs (ps_camera.gcc)



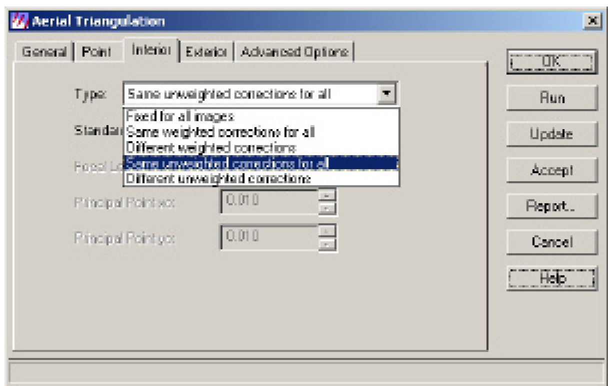
NOTE: Before going to next step, select GCP and click **Active** column and make it inactive (dismiss X mark) because it's a bad GCP.

<u>Step 6. Perform Block Triangulation</u>

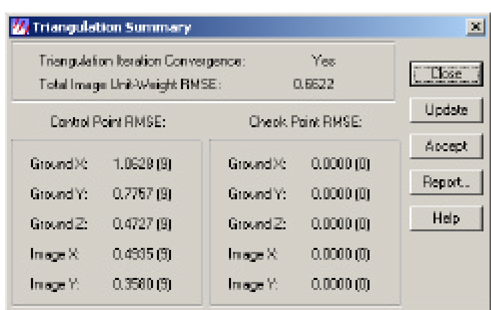
Click the **Triangulation Property** icon  on the Point Measurement Tool and edit Triangulation Property. Open the **Point** tab and set the **Type** field to **Same weighted values**.



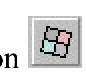
In case you are using rough focal length, self-calibration capability will correct this automatically while following the triangulation process. It is available if you select **Same unweighted correction for all** in the **Interior** tab.



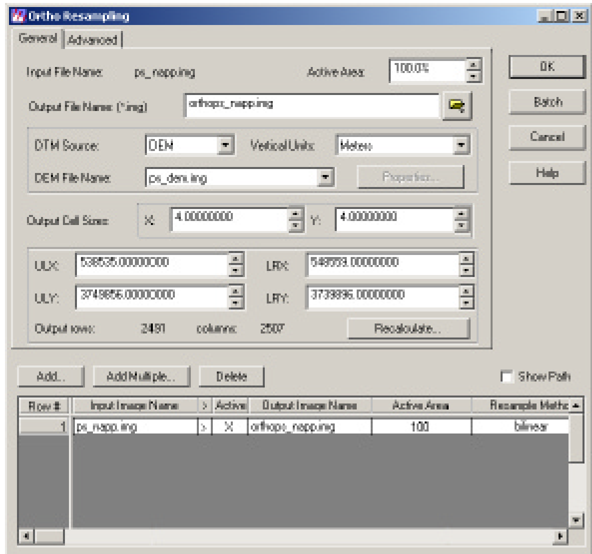
Selecting the **Run** button will execute triangulation. The resulting accuracy of the triangulation can be checked in the Triangulation Summary dialog or report. Then press **Update** button to reflect the triangulation results to Exterior Orientation Parameters. (You can see this in the Frame Editor.) **Close** the Triangulation Summary and Point Measurement Tool and go to next step.



Step 7. Rectify the Images

Selecting the **Start ortho resampling process** icon  will display the Ortho Resampling dialog. Set the output file name as you like and select **ps_dem.img** as the

DEM. Output Cell Size, Output Extent and Resampling Method, etc., also can be specified here.



Step 8. Check the result

Open the output file on the Viewer and overlay other GIS data.