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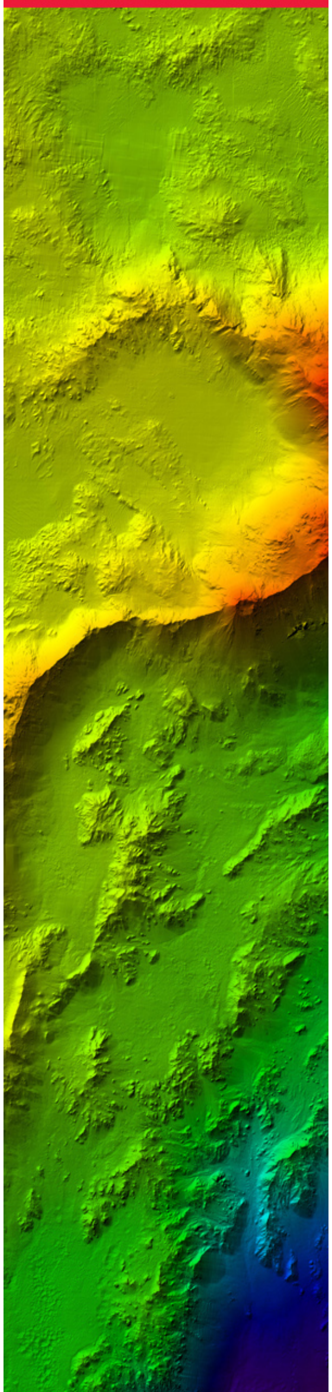
Astrogeology Research Program

BAE SYSTEMS



HiRISE

Stereo Processing of HiRISE Imagery Using SOCET SET®

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Preliminary Content

Please note that some information provided in this document may be preliminary in nature. This information is provided with the understanding that it is not guaranteed to be complete, and conclusions drawn from such information are the responsibility of the user.

1 Guest Facility Log On Procedure

1.1 SOCET SET (Windows) Workstation

1) Press and hold the keys Ctrl Alt Del. A login screen will appear.

2) Enter your Username: .\dpw-user#

   Where # is the last two digits of the igswzawg… number on each machine. See the ID label on the top of the Planar monitor associated with your workstation.

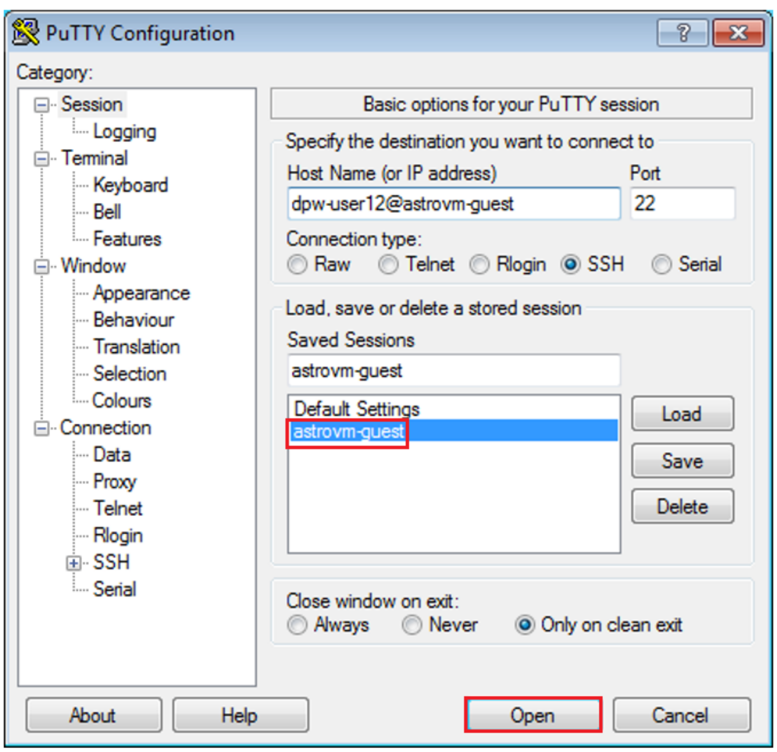
3) Enter your Password: We will provide you the password. You will use the same password for Windows and UNIX login.

1.2 ISIS (UNIX) Processing Machine: astrovm-guest

1) Open a PuTTY Session from the Windows Start Menu.

2) When the PuTTY Configuration window opens, select astrovm-guest under "Saved Sessions" to select it. Next, press "Open". Enter the password when prompted. The password is the same for Windows and UNIX Guest Facility accounts.

   Note that dpw-user#@astrovm-guest under "Host Name" will reflect the same two digits as at the end of the igswzawg…number on each machine.



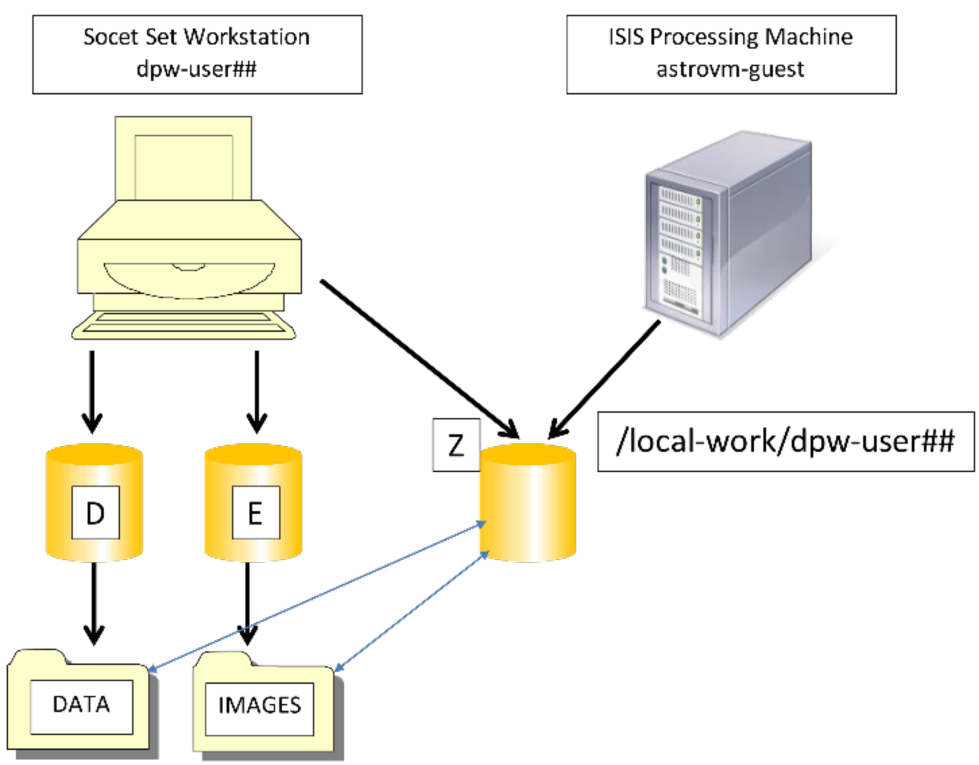
2 ISIS Machine and SOCET SET Workstation Interface for Guest Accounts

To transfer files between our ISIS processing machines and SOCET SET workstations, we use shared network drives. For our columnGuest Facility Users and participants of our training workshops, the shared network drive is named Z: on the SOCET SET Workstations. On ISIS machine astrovm-guest, this drive is accessed under /local_work.

Each Guest Facility account has access to localized folders and directories on the shared network drive based on the SOCET SET machine in use (these folders/directories are not accessible between SOCET SET workstations). When a Guest Facility user logs onto a SOCET SET machine or astrovm-guest, they will be *automatically* set to the root directory they have access to on the shared drive.

A SOCET SET project is divided into two folders: one to store data, the second to store images. The location of these folders is site dependent. At USGS Astrogeology, the project's data folder is stored under D:/DATA and the project's images folder is stored under E:/IMAGES. For any given project, SOCET SET will expect to find all data for the project in a folder path defined by D:\DATA\<ProjectName>, and all images in a folder path of E:\IMAGES\<ProjectName>.

Files will be transferred between the local D:\DATA\<ProjectName> and E:\IMAGES\<ProjectName> folders on the SOCET SET workstations, and the folders on the shared network drive Z:.



3 ISIS Pre-Processing Overview

In this section, we describe step-by-step procedures that are executed within ISIS as outlined in the Primer. This ISIS section focuses on ingestion of planetary image data and supporting geometric information for transfer to SOCET SET.

NOTE: Until ISIS has the calibration and "balancing" software to produce balanced cubes from PDS images, our procedure starts with the balanced cubes produced by the HiRISE Team. Note that balanced cubes are only available to HiRISE Team members.

For columnGuest Facility Users only, we will download the balanced cubes for your project before your arrival. Please contact us at PlanetaryPhotogrammetry@usgs.gov with the HiRISE stereo pairs you plan to process well in advance of your scheduled arrival date.

3.1 Create a working directory

Create a working directory on your ISIS machine for image processing. It is recommended that the working directory be named to represent the project/area you are working on. We will refer to the working directory as <ProjectName> from this point on in this tutorial. The UNIX command to create the directory is:

```
mkdir <ProjectName>
```

Note: The < and > characters surrounding ProjectName is syntax for a variable name and not part of the command.

3.2 Create image subdirectories

Under <ProjectName>, create separate directories for each image to process (<imgdir>). We suggest that <imgdir> be the image name, e.g., PSP_001714_1415. UNIX commands are:

```
cd <ProjectName>
mkdir <imgdir1>
mkdir <imgdir2>
```

3.3 Download the images

NOTE: This requires special permission and an account on PIRL.

Download the RED balanced cubes (*RED*.balance.cub) into each < ProjectName>/<imgdir> directory, as in the following examples.

cd <ProjectName>/<imgdir>

1) rsync balanced cubes as follows:

   rsync -rltvz hisync.lpl.arizona.edu::hirise_data/HiStitch/ESP/<ORB_dir>/<ESP_dir>/*RED*.cub .

2) rysnc color cubes as follows:

   rsync -rltvz
   hisync.lpl.arizona.edu::hirise_data/HiColorNorm/ESP/<ORB_dir>/<ESP_dir>/*COLOR*.cub .

3.4 Image Quality Evaluation

Use the ISIS program *qview* to display the cubes before processing, and examine their quality. This step is intended to make sure the images do not have any signal-to-noise/haze problems (see Figure 1) that will make them undesirable for automatic DEM extraction. Steps are:

1) Activate the graphics viewing utility for the UNIX environment. For the Guest Facility accounts, activate the Xming utility from the tool bar.

2) Initiate the current ISIS release as follows:

   setisis isis3

3) Then enter the qview command as follows:

   qview <image_id>.balance.cub

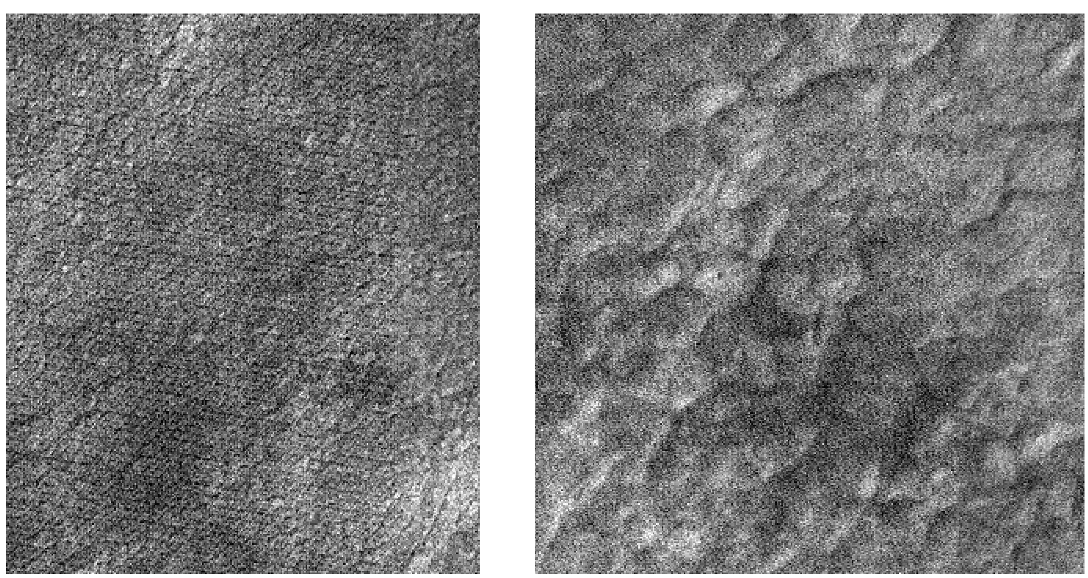


Figure 1. Examples of noise and haze that may cause matcher problems

3.5 High Frequency Jitter Evaluation

Until correcting for spacecraft jitter is part of the HiRISE processing pipeline at U of A, check for extreme spacecraft jitter before continuing on, by running ISIS program *hijitreg* on the RED4 and RED5 CCDs as follows:

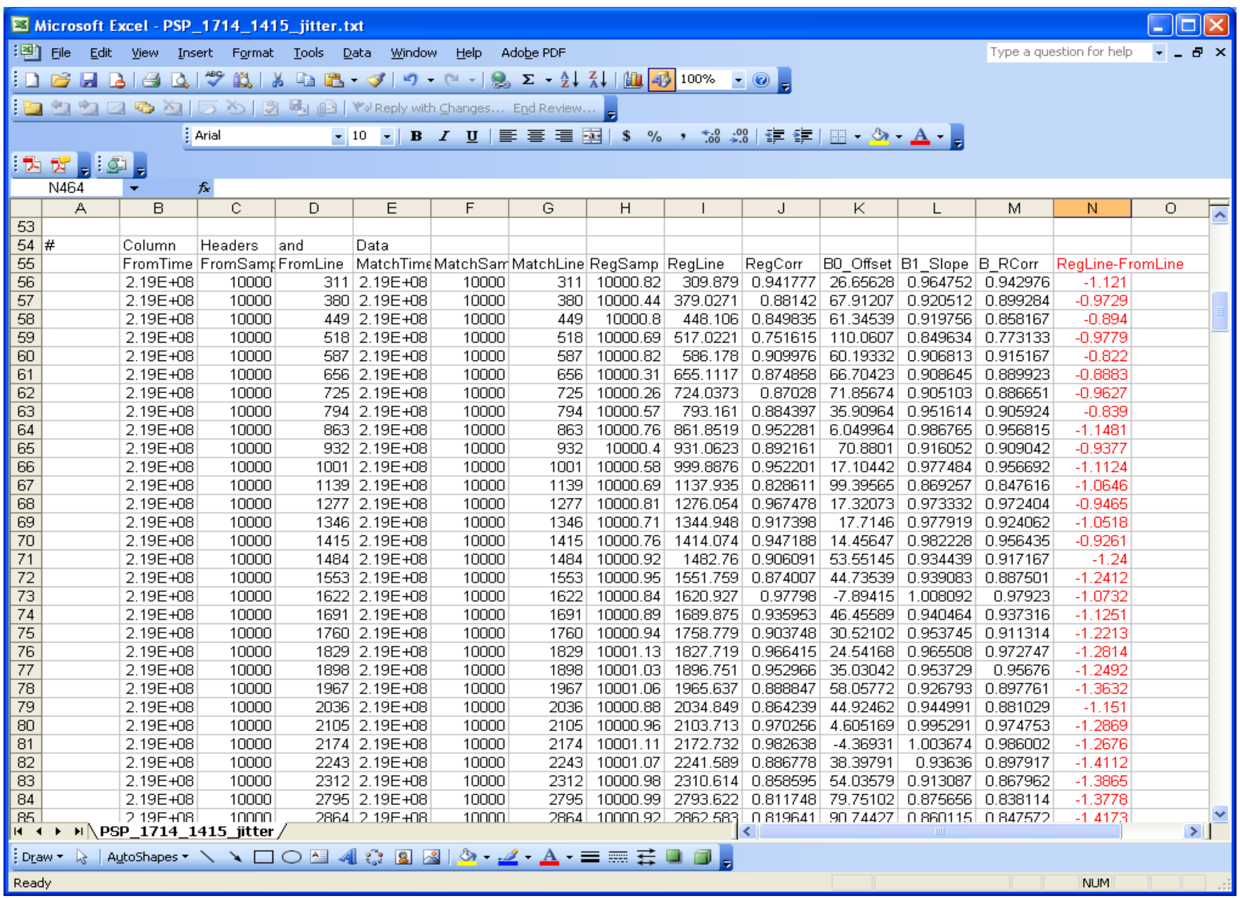
setisis isis3

hijitreg from= <RED4_balanced_cub> match=<RED5_balanced_cub> flatfile=<output_flat_file>

Once we have the flatfile in place, the following steps can be executed to check for jitter:

- *Bring <output_flat_file> into MS EXCEL*
- *Calculate the difference of RegLine-FromLine*
- *Make a plot of the differences.*

The relative oscillation of the RegLine-FromLine difference gives an indication of the jitter in pixels, as shown in Figure 2.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
53														
54	#	Column	Headers	and	Data									
55		FromTime	FromSamp	FromLine	MatchTime	MatchSam	MatchLine	RegSamp	RegLine	RegCorr	B0_Offset	B1_Slope	B_RCorr	RegLine-FromLine
56		2.19E+08	10000	311	2.19E+08	10000	311	10000.82	309.879	0.941777	26.65628	0.964752	0.942976	-1.121
57		2.19E+08	10000	380	2.19E+08	10000	380	10000.44	379.0271	0.88142	67.91207	0.920512	0.899284	-0.9729
58		2.19E+08	10000	449	2.19E+08	10000	449	10000.8	448.106	0.849835	61.34539	0.919756	0.858167	-0.894
59		2.19E+08	10000	518	2.19E+08	10000	518	10000.69	517.0221	0.751615	110.0607	0.849634	0.773133	-0.9779
60		2.19E+08	10000	587	2.19E+08	10000	587	10000.82	586.178	0.909976	60.19332	0.906813	0.915167	-0.822
61		2.19E+08	10000	656	2.19E+08	10000	656	10000.31	655.1117	0.874858	66.70423	0.908645	0.889923	-0.8883
62		2.19E+08	10000	725	2.19E+08	10000	725	10000.26	724.0373	0.87028	71.85674	0.905103	0.886651	-0.9627
63		2.19E+08	10000	794	2.19E+08	10000	794	10000.57	793.161	0.884397	35.90964	0.951614	0.905924	-0.839
64		2.19E+08	10000	863	2.19E+08	10000	863	10000.76	861.8519	0.952281	6.049964	0.986765	0.956815	-1.1481
65		2.19E+08	10000	932	2.19E+08	10000	932	10000.4	931.0623	0.892161	70.8801	0.916052	0.909042	-0.9377
66		2.19E+08	10000	1001	2.19E+08	10000	1001	10000.58	999.8876	0.952201	17.10442	0.977484	0.956692	-1.1124
67		2.19E+08	10000	1139	2.19E+08	10000	1139	10000.69	1137.935	0.828611	99.39565	0.869257	0.847616	-1.0646
68		2.19E+08	10000	1277	2.19E+08	10000	1277	10000.81	1276.054	0.967478	17.32073	0.973332	0.972404	-0.9465
69		2.19E+08	10000	1346	2.19E+08	10000	1346	10000.71	1344.948	0.917398	17.7146	0.977919	0.924062	-1.0518
70		2.19E+08	10000	1415	2.19E+08	10000	1415	10000.76	1414.074	0.947188	14.45647	0.982228	0.956435	-0.9261
71		2.19E+08	10000	1484	2.19E+08	10000	1484	10000.92	1482.76	0.906091	53.55145	0.934439	0.917167	-1.24
72		2.19E+08	10000	1553	2.19E+08	10000	1553	10000.95	1551.759	0.874007	44.73539	0.939083	0.887501	-1.2412
73		2.19E+08	10000	1622	2.19E+08	10000	1622	10000.84	1620.927	0.97798	-7.89415	1.008092	0.97923	-1.0732
74		2.19E+08	10000	1691	2.19E+08	10000	1691	10000.89	1689.875	0.935953	46.45589	0.940464	0.937316	-1.1251
75		2.19E+08	10000	1760	2.19E+08	10000	1760	10000.94	1758.779	0.903748	30.52102	0.953745	0.911314	-1.2213
76		2.19E+08	10000	1829	2.19E+08	10000	1829	10001.13	1827.719	0.966415	24.54168	0.965508	0.972747	-1.2814
77		2.19E+08	10000	1898	2.19E+08	10000	1898	10001.03	1896.751	0.952966	35.03042	0.953729	0.95676	-1.2492
78		2.19E+08	10000	1967	2.19E+08	10000	1967	10001.06	1965.637	0.888847	58.05772	0.926793	0.897761	-1.3632
79		2.19E+08	10000	2036	2.19E+08	10000	2036	10000.88	2034.849	0.864239	44.92462	0.944991	0.881029	-1.151
80		2.19E+08	10000	2105	2.19E+08	10000	2105	10000.96	2103.713	0.970256	4.605169	0.995291	0.974753	-1.2869
81		2.19E+08	10000	2174	2.19E+08	10000	2174	10001.11	2172.732	0.982638	-4.36931	1.003674	0.986002	-1.2676
82		2.19E+08	10000	2243	2.19E+08	10000	2243	10001.07	2241.589	0.886778	38.39791	0.93636	0.897917	-1.4112
83		2.19E+08	10000	2312	2.19E+08	10000	2312	10000.98	2310.614	0.858595	54.03579	0.913087	0.867962	-1.3865
84		2.19E+08	10000	2795	2.19E+08	10000	2795	10000.99	2793.622	0.811748	79.75102	0.875656	0.838114	-1.3778
85		2.19E+08	10000	2864	2.19E+08	10000	2864	10000.92	2862.583	0.819641	90.74427	0.860115	0.847572	-1.4173

Figure 2. hijitreg flat file imported into excel, and Regline -Fromline calculated (see the red field)

Evaluate the relative magnitude of the plot– not the absolute value of RegLine-FromLine, to determine the amount of jitter. Jitter that is less than 2 pixels is very workable, as in the example show in Figure 3.

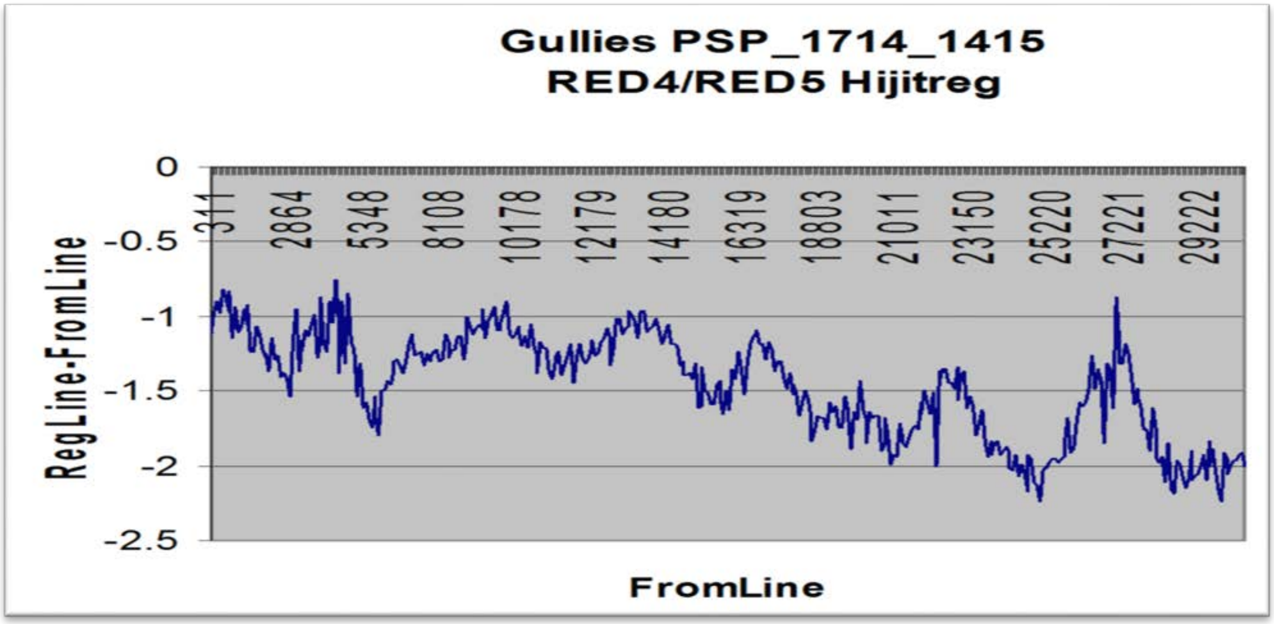


Figure 3. Example plot of acceptable jitter.

If the overall jitter is between 2 - 3 pixels, you *may* have problems. At 4 pixels, you will *definitely* have problems.

If the jitter and image quality are acceptable, create a listing of *RED*.balance.cub files in <ProjectName>/<imgdir> and then run hi4socet.pl (details below). hi4socet.pl performs ISIS3 processing on HiRISE RED CCDs to generate a *.raw and a *_keywords.lis file for transfer to your SOCET SET workstation. Specifically, hi4socet.pl:

1) creates a 32-bit noproj'ed mosaic of the CCDs
2) converts the 32-bit mosaic to 8-bit and reports the stretch pairs used for the conversion to *_STRETCH_PAIRS.lis
3) converts the 8-bit image to a raw file (*.raw)
4) creates a list file of the SOCET SET USGSAstroLineScanner sensor model's keywords and values (*_keywords.lis)

Tip: Please try to organize your time as running hi4socet.pl may take hours to run.

3.6 Create image import list

hi4socet.pl requires the image cub list as input. Commands to generate this list are:

cd <ProjectName>/<imgdir>

ls *.cub > cube_list

3.7 Process images for import

Commands to run hi4socet.pl are:

setisis isis3

hi4socet.pl cube_list

3.8 Collect stereo statistics, MOLA DTM and MOLA track points

For HiRISE stereo processing in SOCET SET, we work in the Geographic Coordinate system. For input parameters to a project in geographic coordinates, you will need a planetographic latitude and positive east longitude reference point, and an estimated elevation range expected in the map area. Additionally, to control a stereo pair to MOLA, you will need the portion of the MOLA gridded data and MOLA Track data that cover the project area. These datasets must also be in the planetoographic latitude and positive East longitude system.

Based on the stereo coverage on a HiRISE (or MRO CTX) stereo pair, PERL script *hidata4socet.pl* will run ISIS3 and PEDR programs to generate the needed MOLA DEM and MOLA track files, along with a statistics files needed for the creation of <ProjectName> in SOCET SET. Simply run *hidata4socet.pl* within working directory <ProjectName> as follows:

cd <ProjectName>

hidata4socet.pl <ProjectName> <imgdir1>/<noproj_img1> <imgdir2>/<noproj_img2>

Where: ProjectName = Name of the SOCET SET project

<imgdir1>/<noproj_img1> = First noproj'ed image of a stereo pair

<imgdir2>/<noproj_img2> = Second noproj'ed image of a stereo pair

The output products of hidata4socetl.pl are as follows:

1) A MOLA DEM as an ISIS3 cube and an ascii ARC Grid. The MOLA DEM will be stored in <ProjectName>/MOLA_DEM and named <ProjectName>_mola.cub and <ProjectName>_mola.asc.

2) The MOLA track data as a Shapefile and a table file. The track data will be stored in <ProjectName>/MOLA_TRACKS. Shapefile will be named <ProjectName>Z.shp. The table file will be named <ProjectName>.tab. (Other miscellaneous files will also be stored in <ProjectName>/MOLA_TRACKS, but are not directly used in the stereo processing.)

3) A file listing the geographic reference point coordinate and elevation range of the stereo-overlap area. This file will be named <ProjectName>_SS_statistics.lis, and located in <ProjectName>.

4 SOCET SET Workstation setup

4.1 SOCET SET root paths

There are three primary paths defined in the SOCET SET default configuration. These paths are site dependent, and are:

<install_path> = The path for executables and system level support files in the SOCET SET application suite. At the Astrogeology Guest Facility, this path is C:\SOCET_SET_5.6.0.

<data_path> = The default root path to the various project folders and project files (*.prj). At the Astrogeology Guest Facility, this path is D:\DATA.

<image_path> = The default root path to imagery for various project folders. At the Astrogeology Guest Facility, this path is E:\IMAGE.

In the case of a project named <ProjectName>, SOCET SET will expect to find all images in a folder path of <image_path>\<ProjectName> (e.g., E:\IMAGES\<ProjectName>), and all data for the project in a folder path defined by <data_path>\<ProjectName> (e.g., D:\DATA\<ProjectName>).

4.2 Planer Stereo Display Calibration

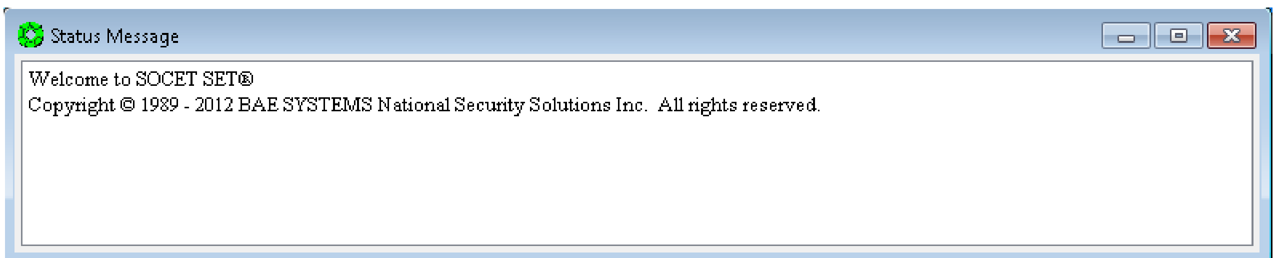
In order to see 3D (stereo) correctly, it is important to have the two screens meet the beam splitter display device at sympathetic angles; this is accomplished by adjusting the beam splitter set screws to change the orientation of the beam splitter relative to the two display monitors. If the display appears "de-focused" it is necessary to make these adjustments before the measurement process is begun, in order to reduce the eye strain associated with the stereo viewing process.

4.3 Starting SOCET SET

The very first step is to locate the following icon on the Windows Desktop. Double click on this icon to start SOCET SET, and wait until all components are activated.

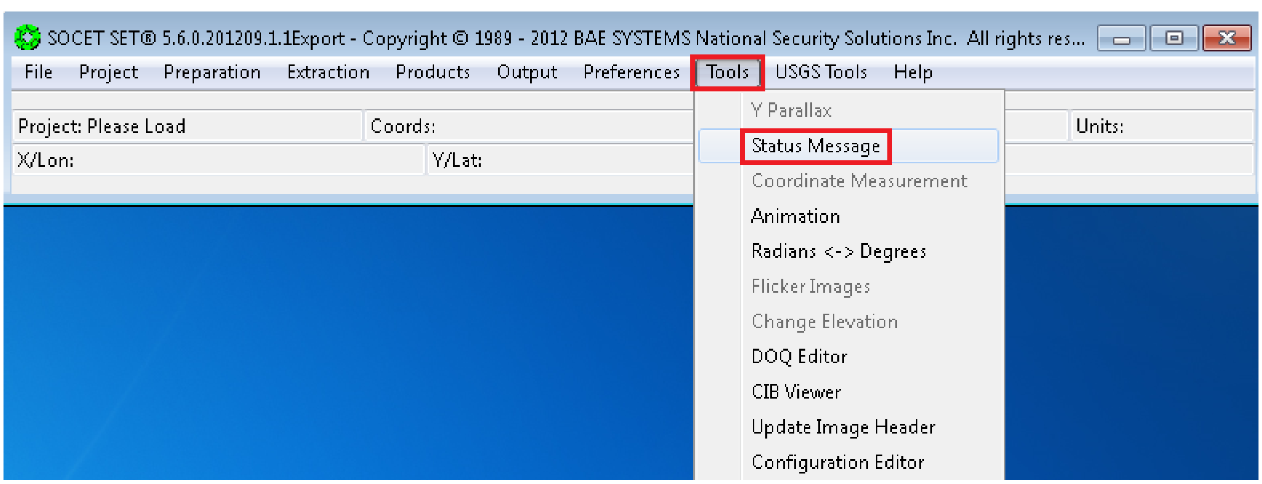
4.4 Status Message Window

The Status Message Window should come up automatically (usually in the lower left corner of the console monitor.) This window captures status messages and error messages issued by SOCET SET, and is helpful to have open at all times.



If the Status Message window did not come up, do the following:

From the SOCET SET menu bar, select “Tools” > “Status Message”.

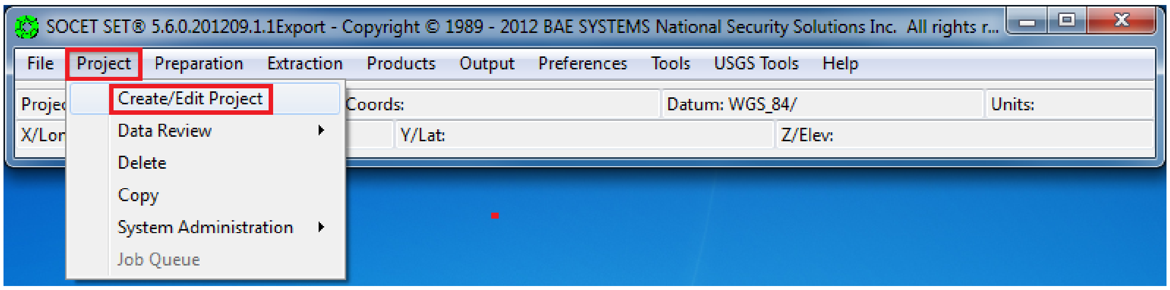


5 Create a SOCET SET Project

For HiRISE stereo processing, create a project in Geographic Coordinates, using Mars2000 as the datum. (Note that SOCET SET also allows a project in a map projection. This would generally be needed only if the project is (a) polar and (b) spans a large range of latitudes.)

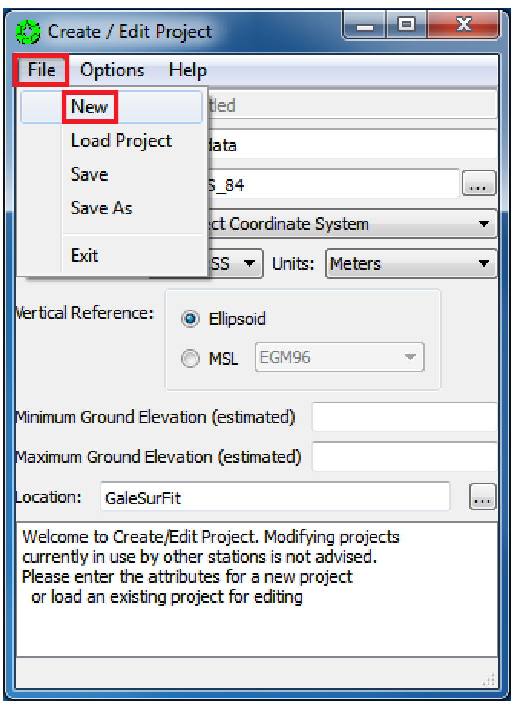
5.1 Launch the Project Editor

From the SOCET SET menu bar, select “Project” > “Create/Edit Project”.



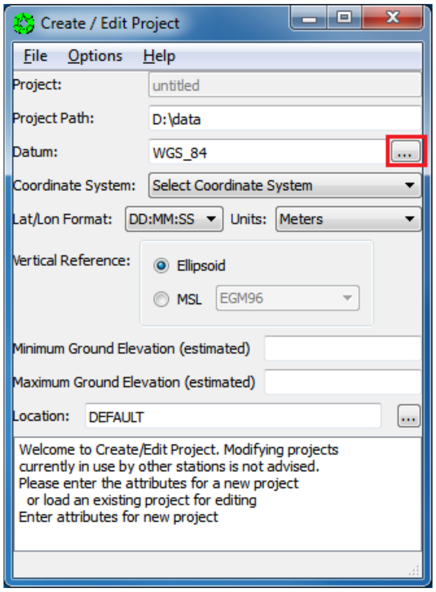
5.2 Create a new project

Select “File” > “New”

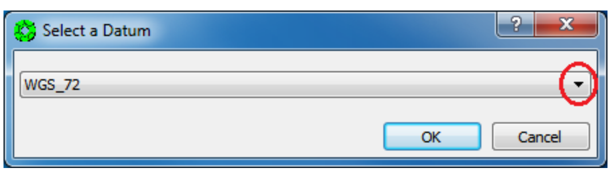


5.3 Set the Datum

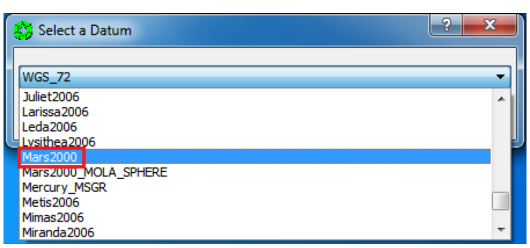
1) Press the box next to the datum field to bring up the "Select a Datum" window.

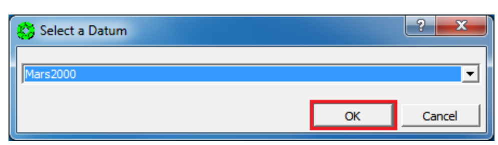


2) Right-Click on the down arrow in the selection window to display drop-down box of options.



3) Scroll about 90% down the list, *or* press the letter M to skip down the list to the datums starting with the letter M. Select "Mars2000" and then press "OK".



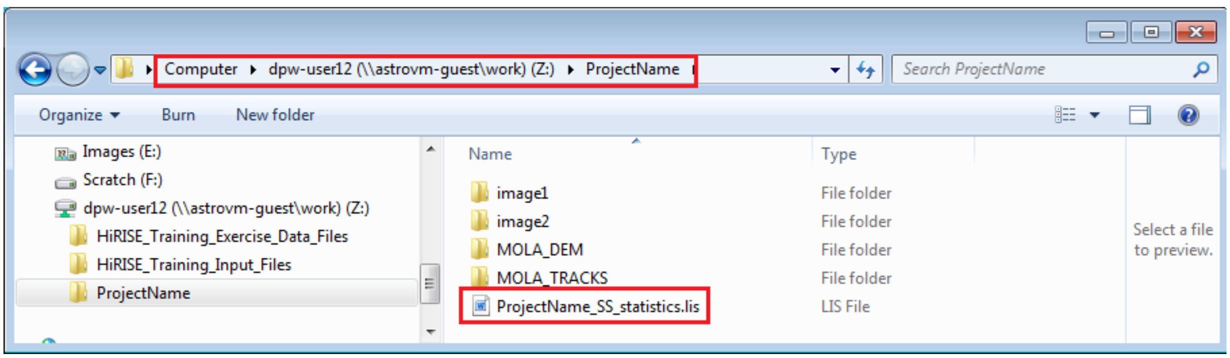


5.4 Set the Coordinate System

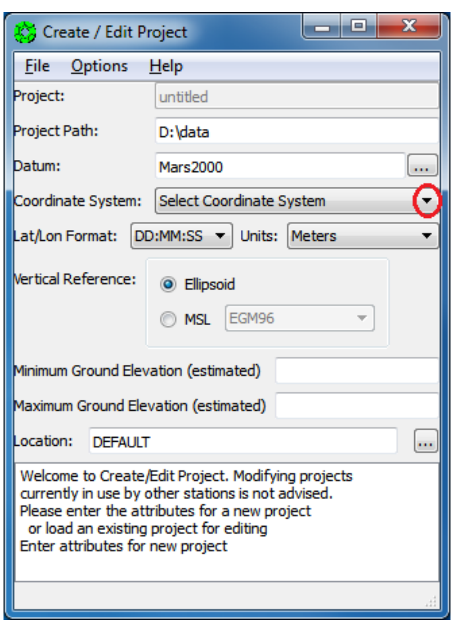
For SOCET SET projects in Geographic Coordinates, you must enter a reference latitude and longitude coordinate (this is equivalent to the center longitude and center latitude of the equi-rectangular map projection.)

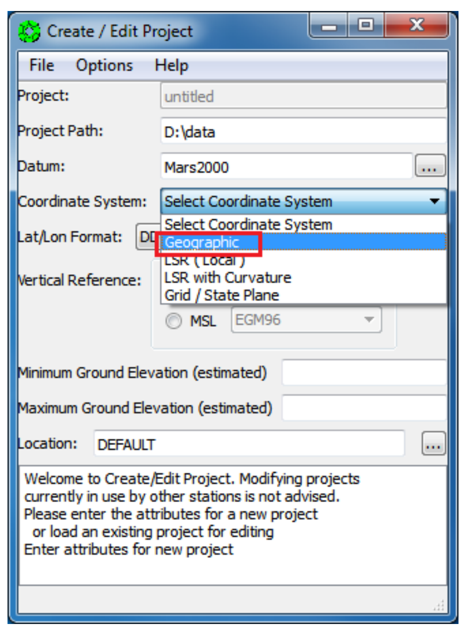
The reference latitude and longitude coordinates can be found in the SOCET SET project statistics file, generated by *hidata4socet.pl*.

1) Use a text editor to open <ProjectName>_SS_statistics.lis. For columnGuest Facility Users, this file is located in Z:\<ProjectName> and named <ProjectName>_SS_statistics.lis.

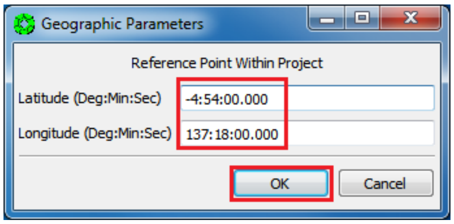


2) On the Create/Edit Project window, Left-Click on the down arrow next to Coordinate System name to display drop-down box of options and select Geographic.





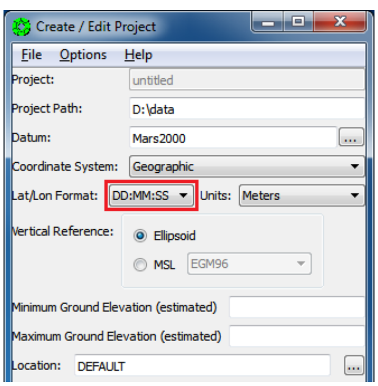
3) You will be prompted to enter a reference point within the project in Degrees Minutes Seconds (DMS) format. Enter the coordinate listed in <ProjectName>_SS_statistics.lis file generated by hidata4socet.pl. Then press “OK”.



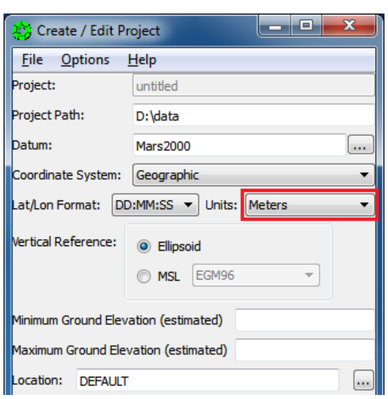
4) Do not close <ProjectName>_SS_statistics.lis yet. It is needed again, below.

5) Keep the default Lat/Lon Format definition: DD:MM:SS

Note: We’ve tried using a lat/lon format of decimal degrees, but found in some cases the lat/lon format is in DMS regardless. So we are sticking with DMS throughout SOCET SET processing.

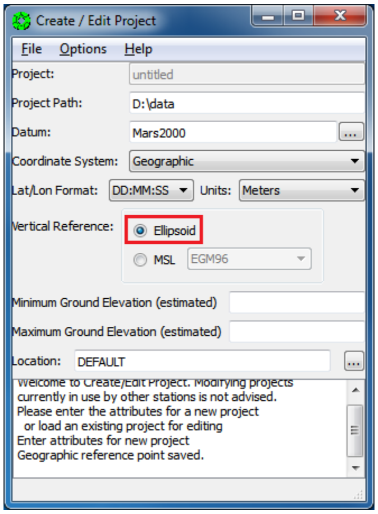


6) Keep the default Units definition: Meters



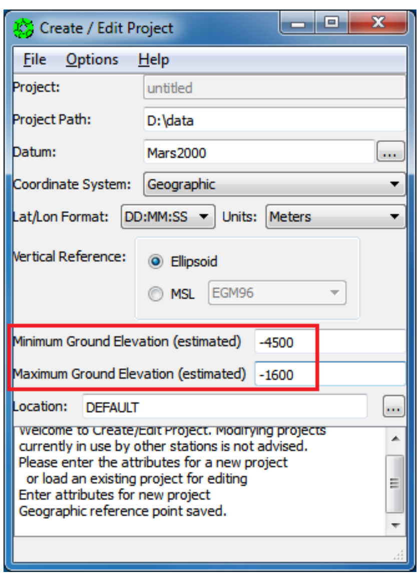
5.5 Select a vertical reference

1) Press the “Ellipsoid” radio button (this should be the default).



2) For the Min and Max Ground Elevations, enter the minimum and maximum elevations listed in the project statistics file generated by hidata4socet.pl <ProjectName>_SS_statistics.lis.

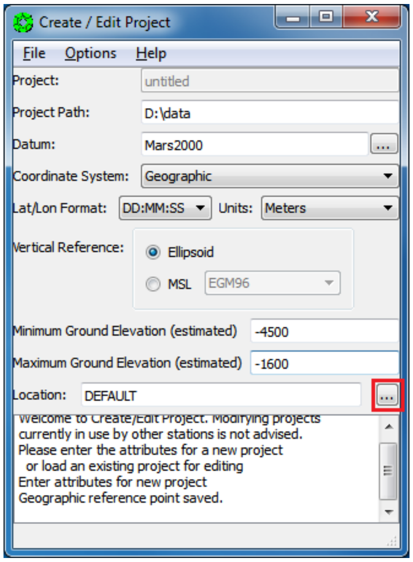
Note: A rough estimate of the expected elevation range over the project area is all that is needed.



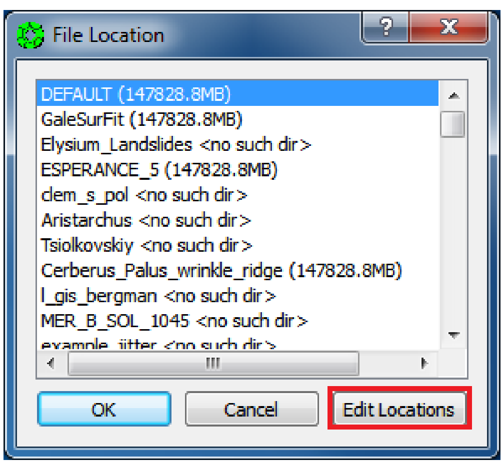
3) Now close <ProjectName>_SS_statistics.lis.

5.6 Define the location of the images folder/directory

1) Press the box next to the Location field to bring up a selection window.

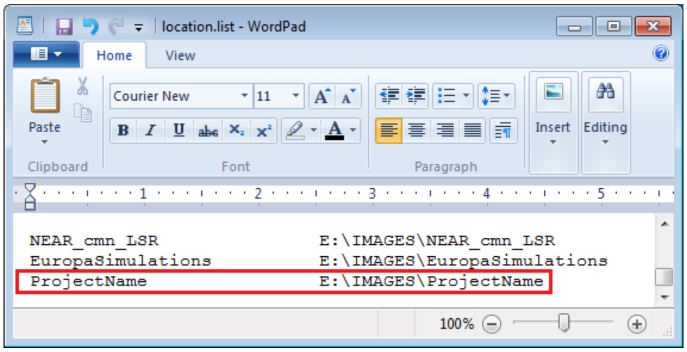


2) Press “Edit Locations” to add a directory/folder to the File Location list.



3) The WordPad editor will be initiated. **Scroll to the bottom of the file.** Enter your desired location/folder name following the format of the location.list file, then save and exit from WordPad.

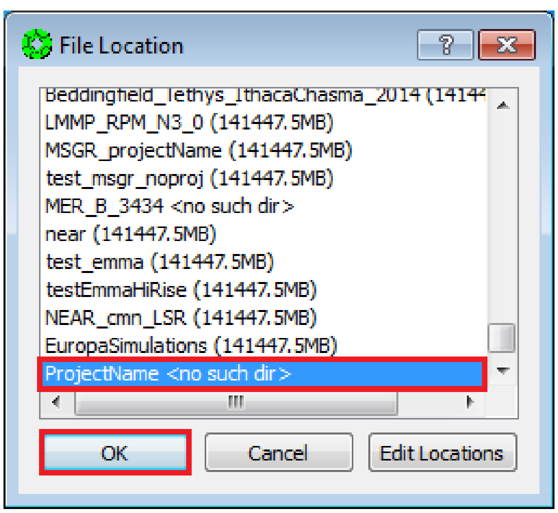
Note: (1) Do not use tab in editing the File locations information as it will lead to errors in intrepretation by SOCET SET. **(2) We scroll to the bottom of the list because the top three lines define a default images folder, and the default should not be changed.**



4) From the File Location window (it remained open while editing the location.list file), you can now scroll to the bottom of the list and select your location/folder for the project to store and create images in.

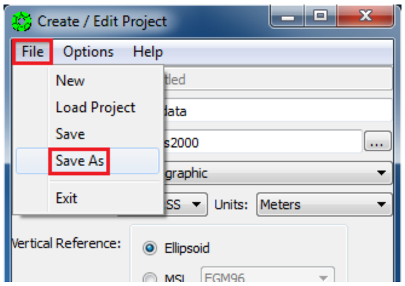
Note: If your folder name is not listed, press "cancel" and reopen the file (by pressing the box next to Location field) to see your folder name.

Note: Upon data entry the window may report that there is "no such directory", it is safe to ignore this prompt and continue. (The directory will be created for you once project creation is complete.)

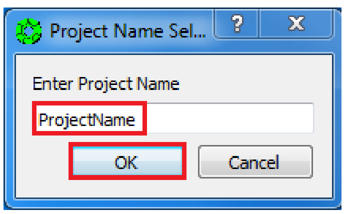


5.7 Create the Project Files and Folders

1) Select “File” > “Save As”.

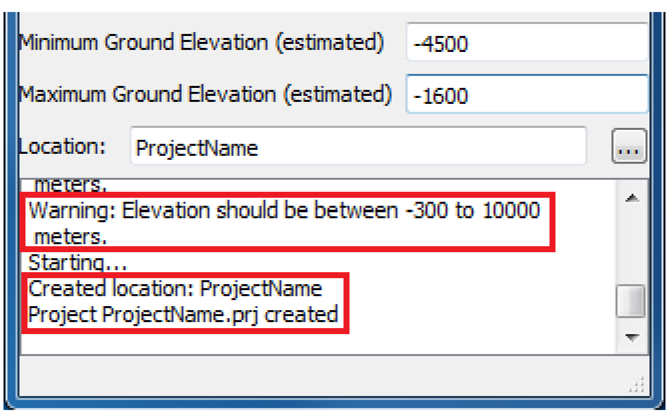


2) Enter the name of the project in the pop-up window, then press “OK”.

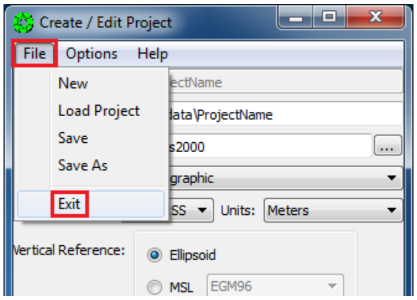


If the images folder did not previously exist (set in the previous section), SOCET SET will now create it, along with the data folder.

For an elevation range below -300 meters, or greater than 10000 meters, you will get a warning message. This warning can be ignored for non-Earth projects.

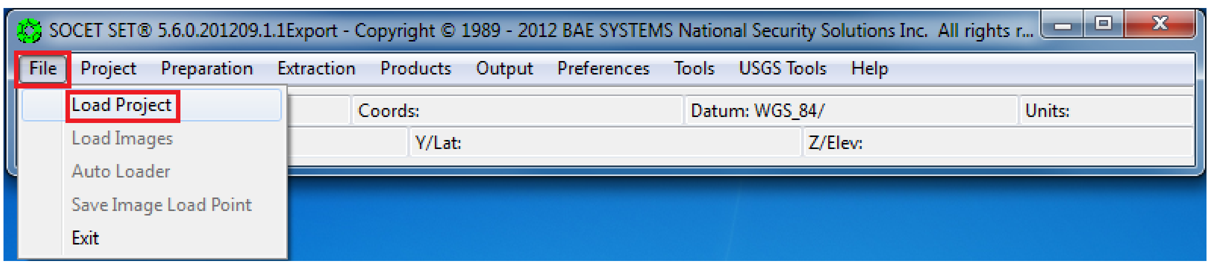


3) Select “File” > “Exit”.

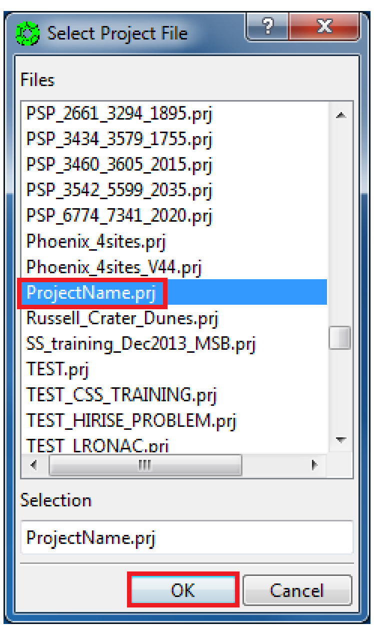


6 Load Project

1) From the SOCET SET menu bar, select “File” > “Load Project”.



2) From the pop-up window, scroll to find your project (the list of projects is in alphabetical order), select it and press “OK”.



7 Transfer Files to SOCET SET Workstation

From the ISIS processing machine, we need the following files generated by the *hi4socet.pl* and *hidata4socet.pl* scripts for each image in the ISIS pre-processing stage:

1) <ProjectName>/<imgdir>/<noproj_img>/*.raw: The distortion corrected images in 8-bit raw format,
2) <ProjectName>/<imgdir>/<noproj_img>/*_keywords.lis: The associated SOCET SET USGSAstroLineScanner keywords files, and
3) <ProjectName>/<imgdir>/<noproj_img>/campt*.prt: The campt report associated with the image.

If your plans are to control the stereo pair to MOLA, you will also need the following files generated by the *hidata4socet.pl* script in the ISIS pre-processing stage:

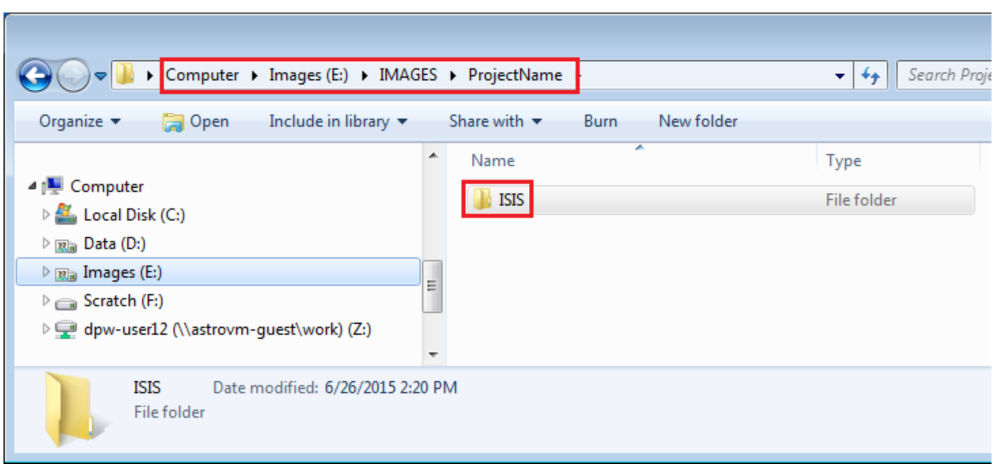
4) <ProjectName>/MOLA_DTM/*.asc: The MOLA DTM as an ARC Grid.
5) <ProjectName>/MOLA_TRACKS: The entire MOLA Tracks directory which contains the files associated with the Shape file.

It is strongly recommended that the *.raw, *keywords.lis and campt*.prt files (items 1, 2 and 3 from the above list) be copied into a subfolder named ISIS in the project's images folder on the SOCET SET machine (e.g., E:\IMAGES\<ProjectName>\ISIS), and the MOLA data files (items 4 and 5, above) be copied into the project's data folder (e.g., D:\DATA\<ProjectName>).

7.1 File Transfer for Guest Facility Users

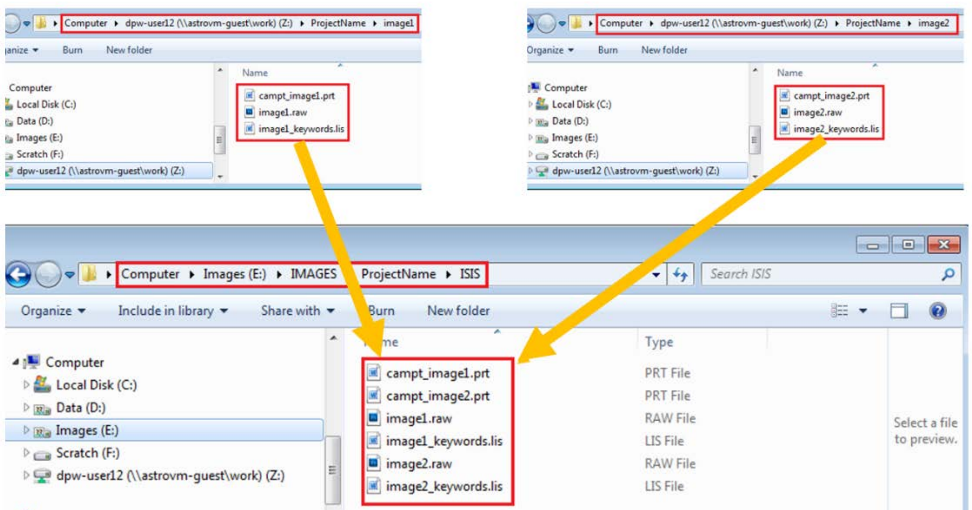
7.1.1 Create ISIS subfolder under E:\IMAGES\<ProjectName>

1) Bring up Windows Explorer and navigate to E:\IMAGES\<ProjectName>.
2) Create a folder in E:\IMAGES\<ProjectName>and name it ISIS.



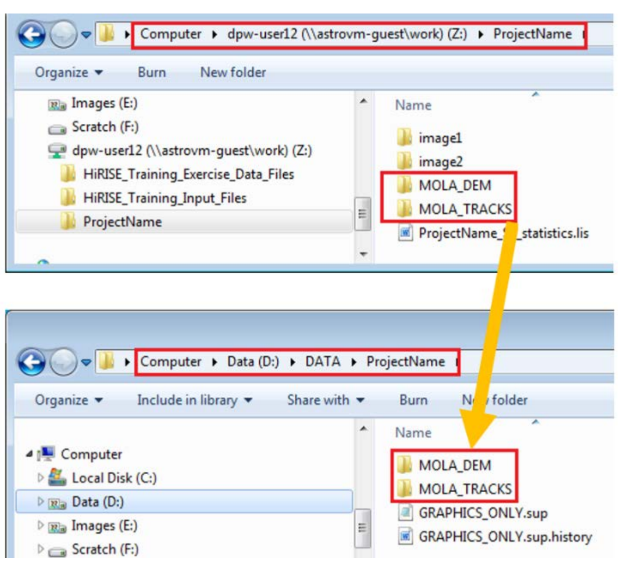
7.1.2 Transfer Images and Keywords files into E:\IMAGES\<ProjectName>\ISIS

1) Navigate into E:\IMAGES\<ProjectName>\ISIS.
2) Open a second Windows Explorer window, and navigate into Z:\<ProjectName>\<image>.
3) Copy the campt_<image>.prt, <image>.raw and <image>_keywords.lis files into E:\<ProjectName>\ISIS. Repeat for all images processed in Z:\<ProjectName>.
4) Note that there are no subfolders under E:\<ProjectName>\ISIS.



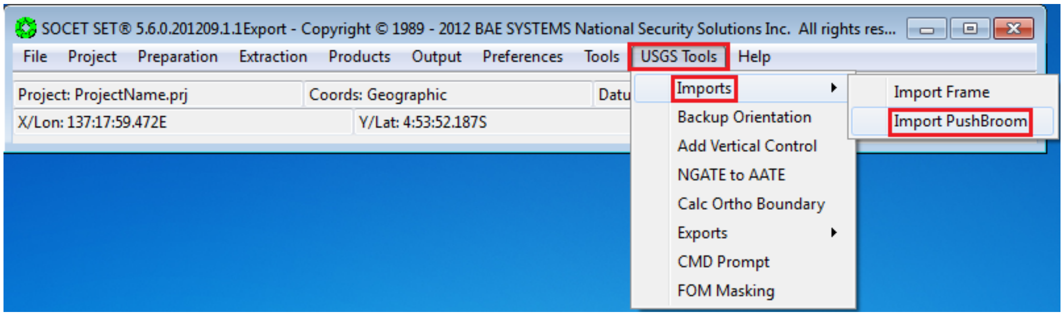
7.1.3 Transfer MOLA Data

1) Navigate into D:\DATA\<ProjectName>.
2) Open a second Windows Explorer window, and navigate into Z:\<ProjectName>.
3) Copy the MOLA_DEM and MOLA_TRACKS folders from Z:\<ProjectName> into D:\DATA\<ProjectName>.

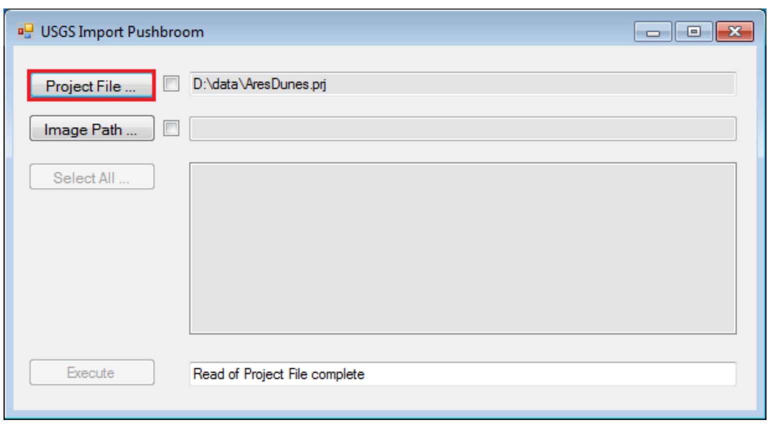


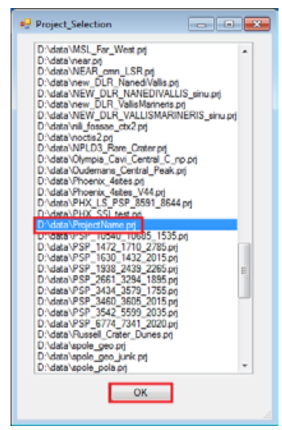
8 Import Pushbroom/Linescanner Images

1) Select “USGS Tools” > “Imports” > “Import Pushbroom”.



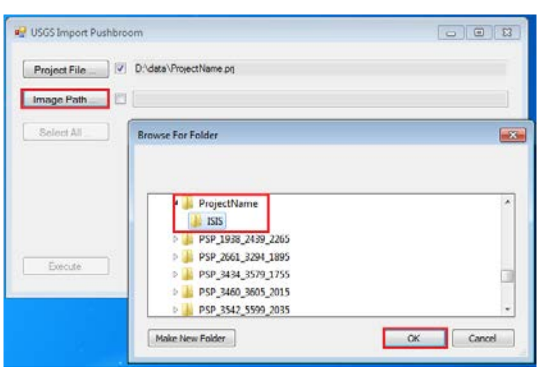
2) From the USGS Import Pushbroom window, if the project listed is your current project confirm the Project by clicking the “Project File” checkbox. Otherwise press “Project File…” to bring up the Project_Selection window, select the current project, and press “OK”.



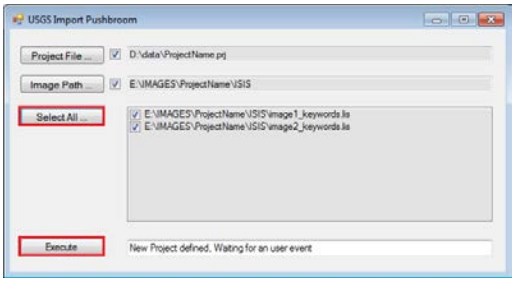


3) Press “Image Path…” and navigate to the project’s E:\IMAGES/<ProjectName>/ISIS folder. Then press “OK”.

Note: The ISIS folder MUST contain the <image>_keyword.lis and <image>.raw files.



4) Either select Individually the images required for the project or use the “Select All” button to import all the images in the list.



5) Press “Execute”, and the utility will populate then execute program *import_pushbroom* to build the required images and project support files.

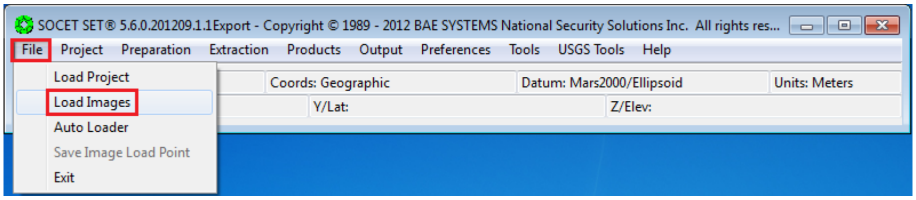
Note: This utility expects that the image name and the keywords file are in agreement with each other, with “_keyword” appended to the base file name. For example, An Image file named “Image_123.raw” should have an associated keywords file of “Image_123_keyword.lis”.

If your import fails then please verify that the naming convention is correct.

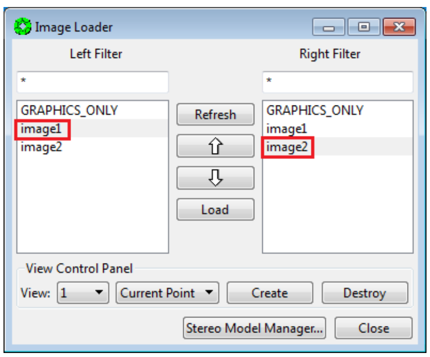
6) Close the Command Prompt Window when import is complete for all images selected.

9 Load Images

1) From the SOCET SET menu bar, select “File” > “Load Images”.



2) Select a Left and Right Image to display in the stereo monitor by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)

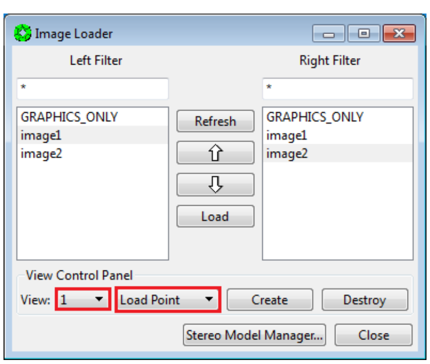


Note:

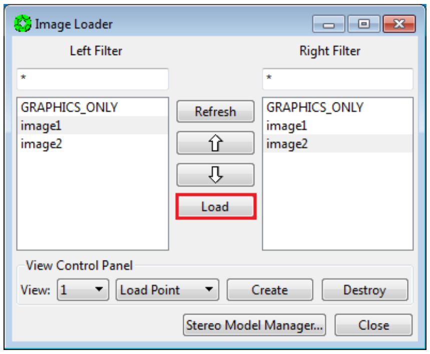
1) For image display, it does not matter which image you choose for the left or right “eye”. SOCET SET will align the images for best stereo viewing regardless of the order selected, however, you will notice a 180 degree rotation of the stereo pair depending on the order you select the images.

2) The Refresh button only refreshes the list of images, it does not actually reload images. Press the “Refresh” button if there are newly created images not showing up on the list.

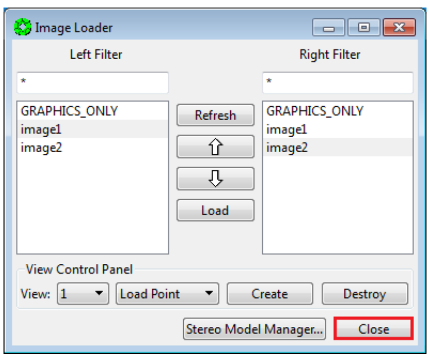
3) Under “View Control Panel” settings: Ensure that View = 1 and that “Load Point” is selected.



4) Press “Load”.



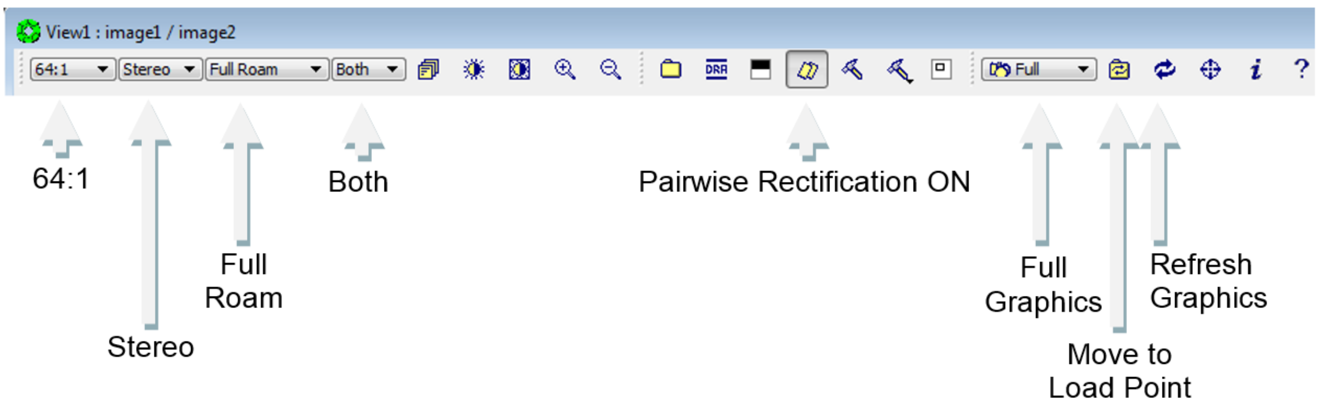
5) Press “Close"



10Establish Stereo Display Settings

10.1 View 1 Window Settings

Below is an example of the settings typically used for View 1, and may vary depending on system and data uniqueness. These settings are to be established on the View 1 window (the stereo display monitor).

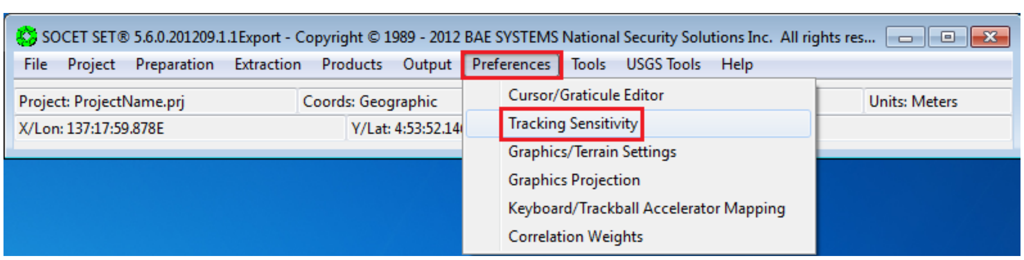


10.2 Tracking Sensitivity

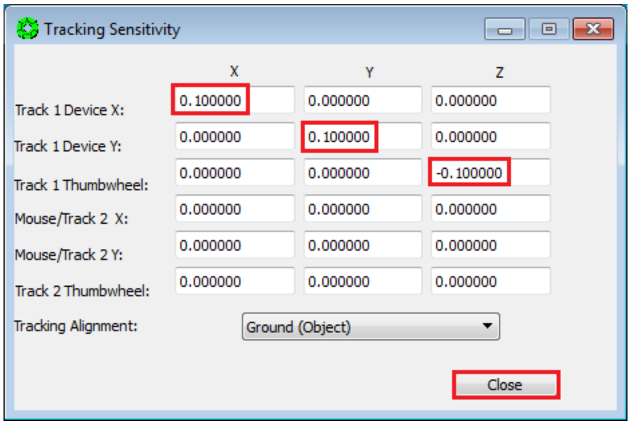
Tracking sensitivity controls the movement and speed of the TopoMouse (i.e., extraction cursor.) Before proceeding, please check that the **tracking sensitivity** is correct for the TopoMouse (details below.)

Also, if SOCET SET crashes, the tracking sensitivity values are typically lost, and the TopoMouse behaves poorly. When this happens, you must reset the values.

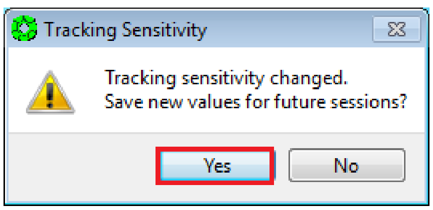
1) From the SOCET SET menu bar, select "Preferences" > "Tracking Sensitivity".



2) In the diagonal of the upper matrix, enter 0.1, 0.1, **-**0.1 for X, Y and Z motion, respectively, and zeros everywhere else. Then press “Close”. *Note that the Z motion is a negative value.*

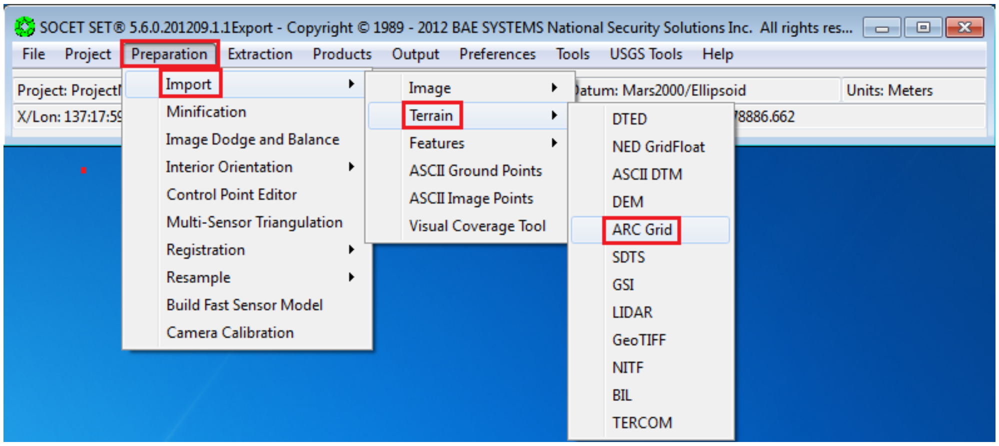


3) Press “Yes” on the pop-up window to save the new values for future sessions.

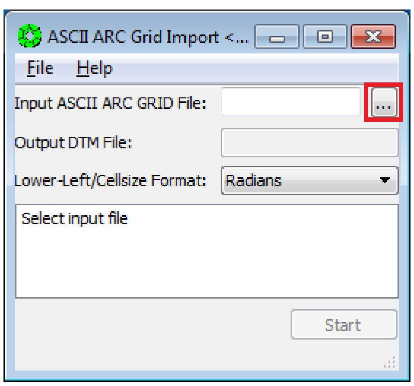


11Import MOLA ArcGrid DTM

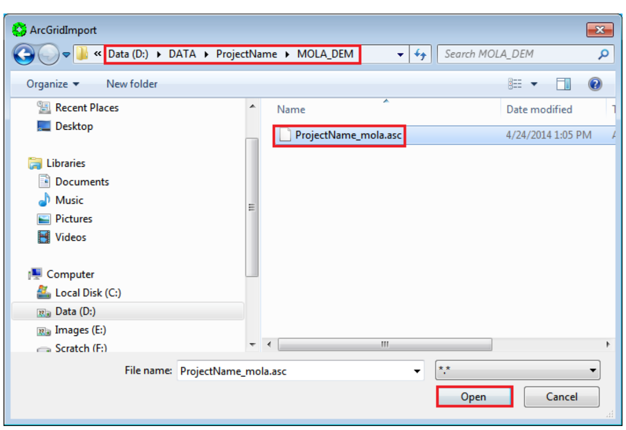
1) From the SOCET SET menu bar, select “Preparation” > “Import” > “Terrain” > “ArcGrid”.



2) Press the button next to the “Input ASCII ARC GRID File” field to bring up a file selection window.

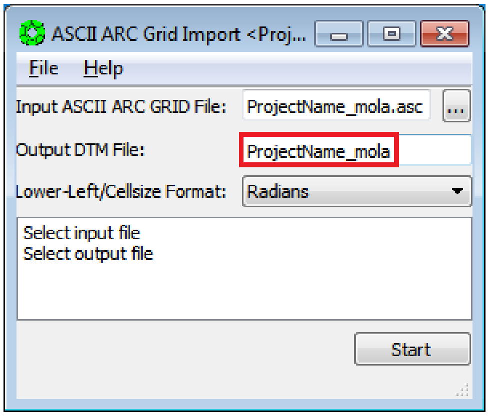


3) Navigate to D:\DATA\<ProjectName>\MOLA_DEM. Select <ProjectName>_mola.asc, and press “Open”.

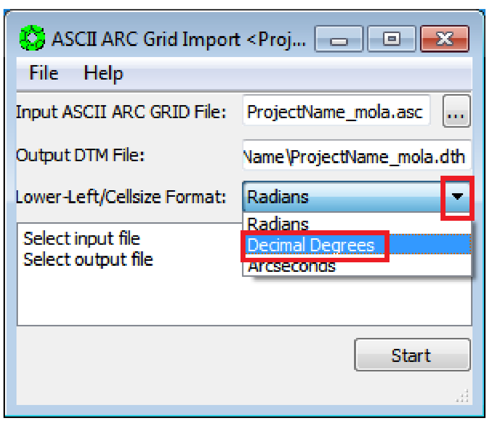


4) Enter output DTM File name.

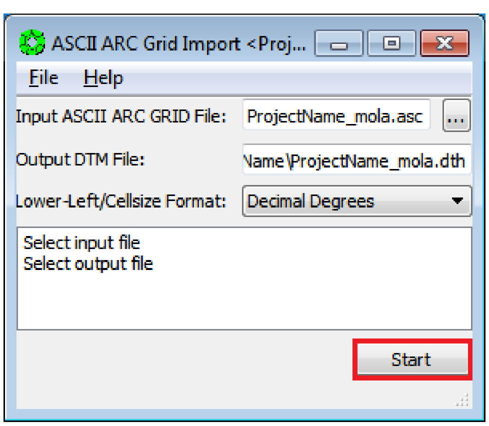
The easiest way is to copy/paste the input name without the .asc extension.
Then press the return key and SOCET SET will automatically add the path and dth extension.



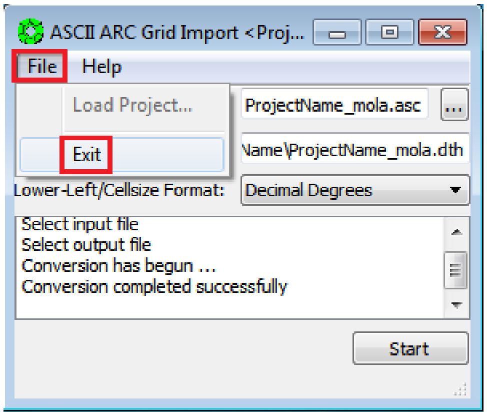
5) Set the Cell size Format to Decimal Degrees. Right-Click on down arrow to display drop-down box of options and select Decimal Degrees.



6) Press "Start" to import the MOLA ARC Grid.



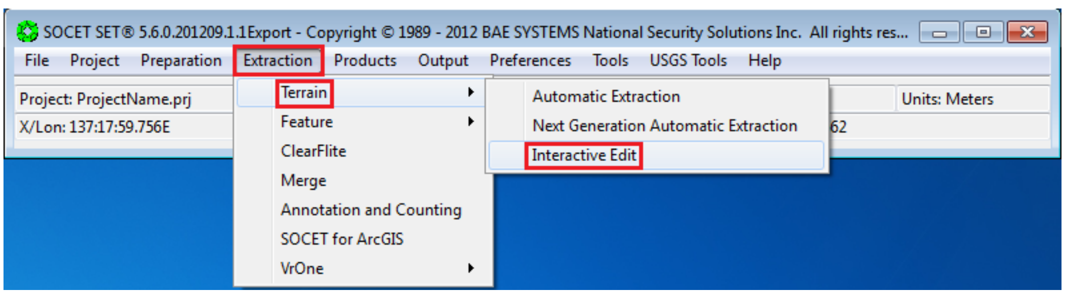
7) Select “File” > “Exit” when import is finished.



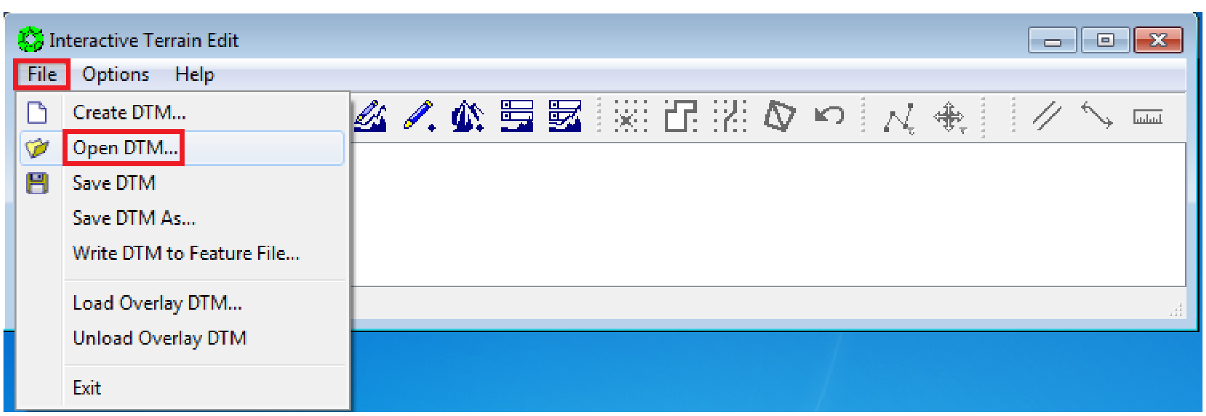
11.1 Verify MOLA DTM Import

Display the MOLA DTM as contours using Interactive Terrain Edit (ITE) to verify the import.

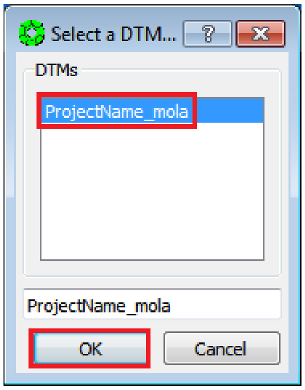
1) From the SOCET SET menu bar, select “Extraction” > “Terrain” > “Interactive Edit”.



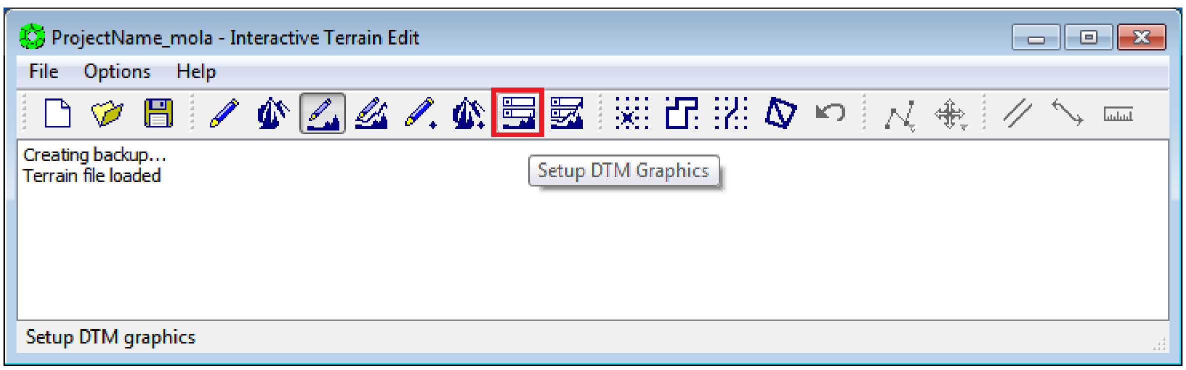
2) Select “File” > “Open DTM…” on the ITE window.



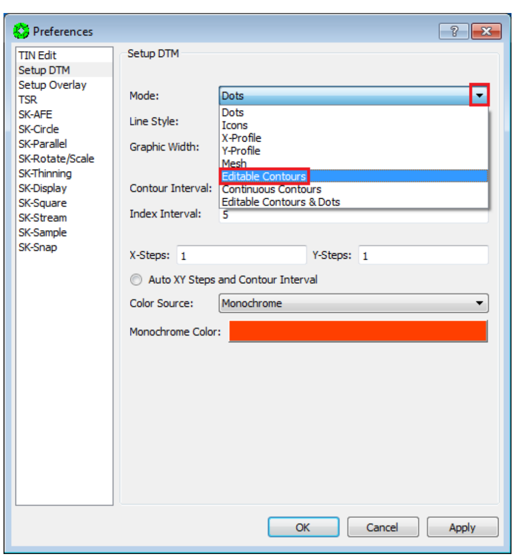
3) Select <ProjectName>_mola and press “OK”.



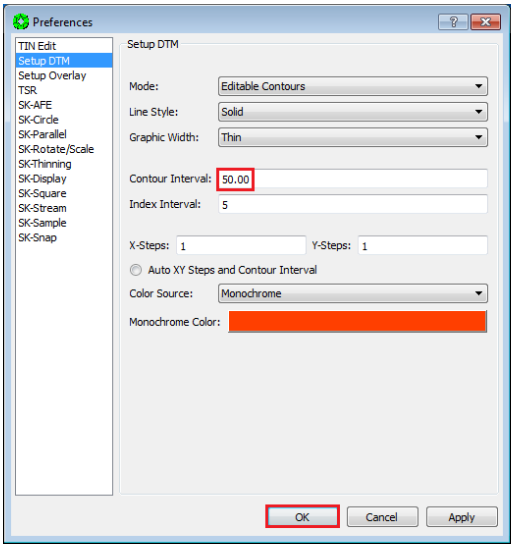
4) Press the “Setup DTM Graphics” icon on the ITE window.



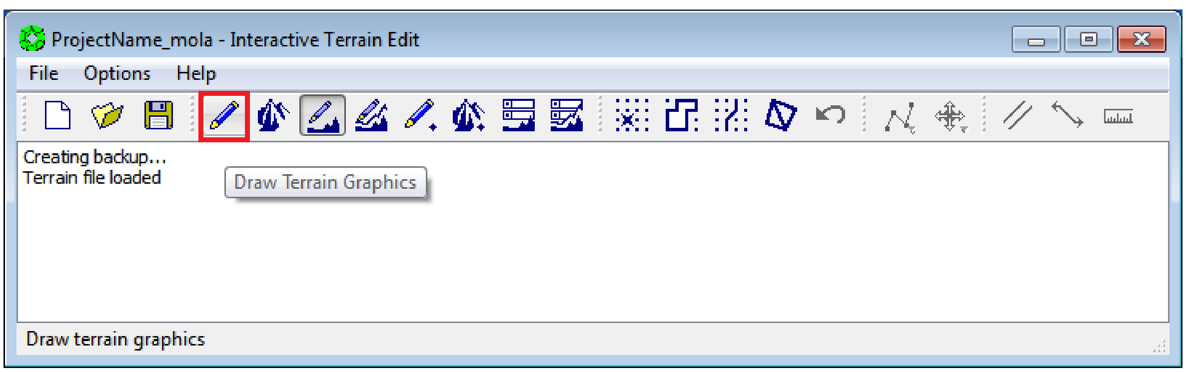
5) On the Preferences window, Left-Click on down arrow next to the Mode field to display drop-down box of options, and select Editable Contours.



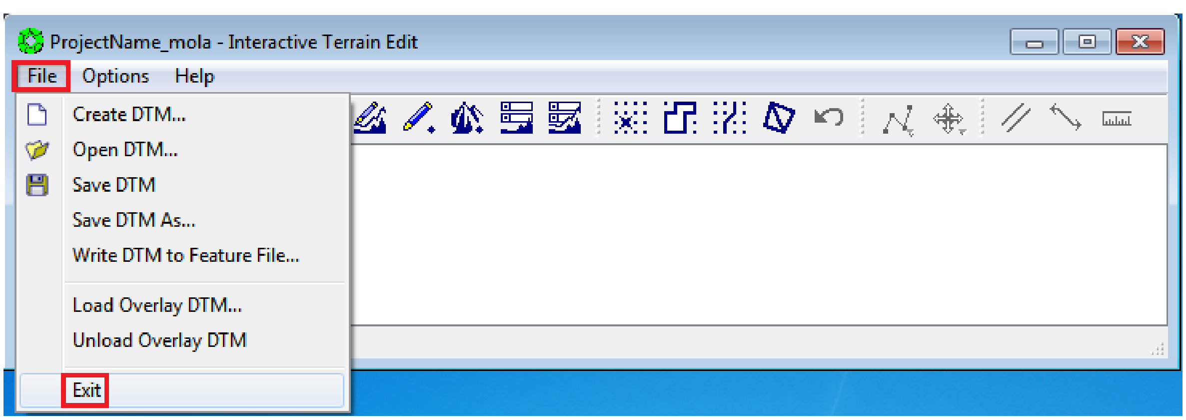
6) Set the Contour Interval field to 50.0, and press “OK”.



7) Press the “Draw Terrain Graphics” icon on the ITE window. The MOLA contours will be drawn on the View 1 (stereo display).

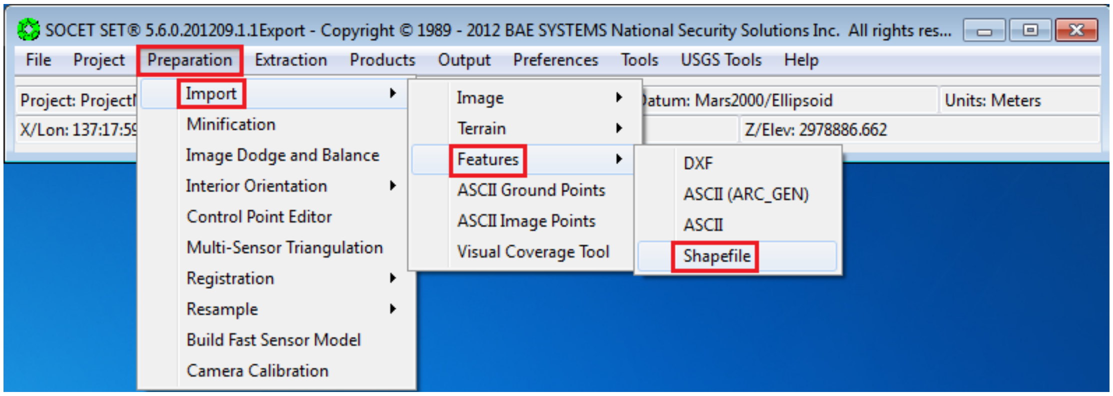


8) When the MOLA Grid import is verified, select “File” > “Exit” on the ITE window.

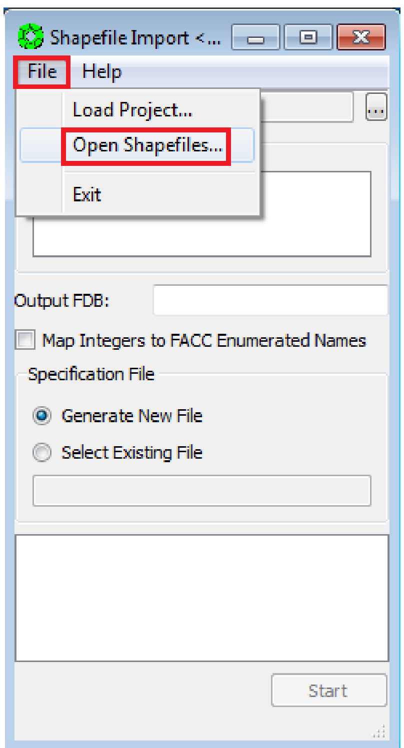


12Import MOLA TRACKS Shapefile:

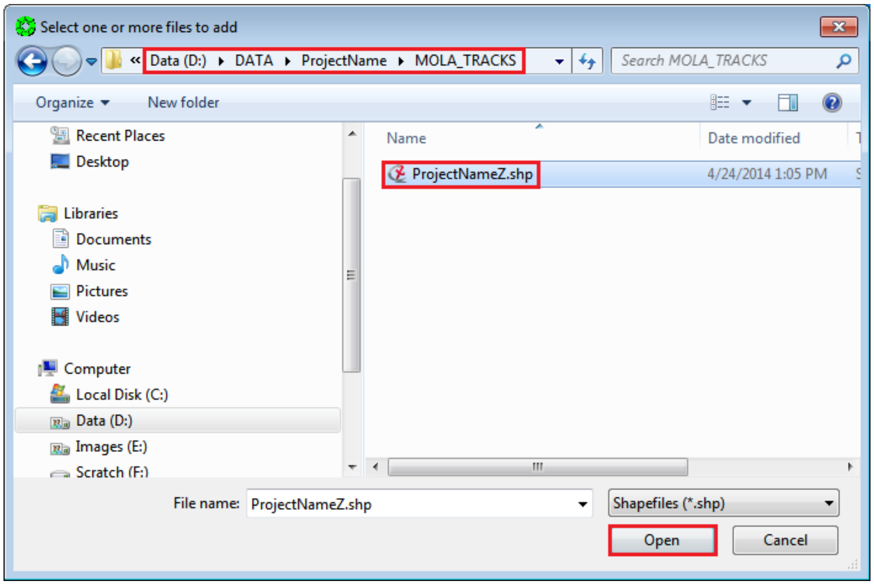
1) From the SOCET SET menu bar, select “Preparation” > “Import” > “Features” > “Shapefile”.



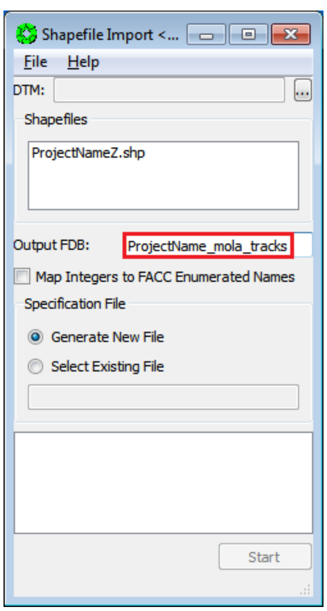
2) Select “File” > “Open Shapefiles…” in the Shapefile Import window.



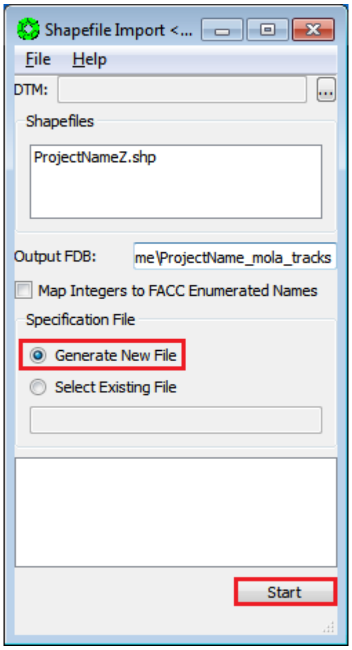
3) Navigate to D:\DATA\<ProjectName>\MOLA_TRACKS. Select <ProjectName>Z.shp, and press "Open".



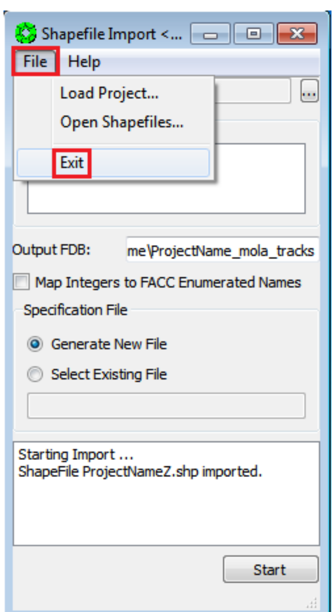
4) Enter the Output FDB name without an extension. Then press the enter key and SOCET SET will add the project data path and file extension.



5) Turn on radio button for “Generate New File”, and press “Start” to import the MOLA Track Points.



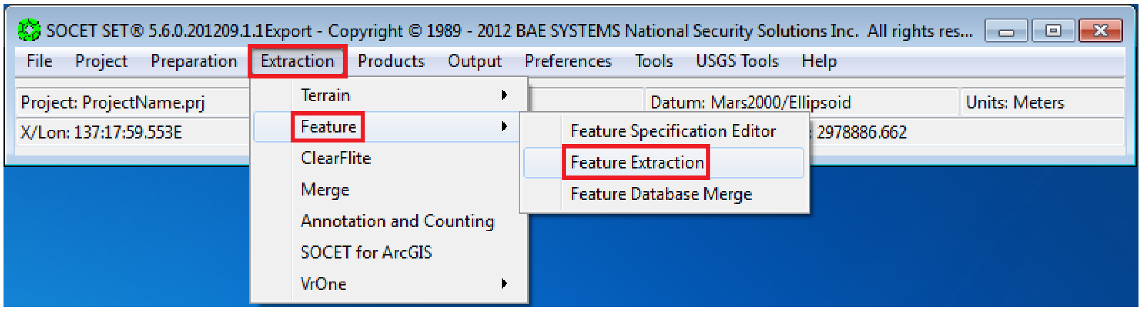
6) Select “File”> “Exit” when import is finished.



12.1 Verify MOLA Track Import

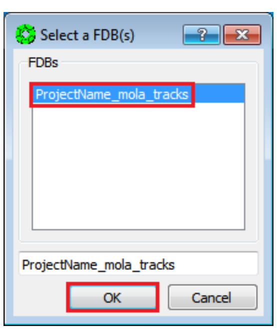
Display the MOLA Track points using Feature Extraction (FE) to verify the import.

1) From the SOCET SET menu bar, select “Extraction” > “Feature” > “Feature Extraction”.

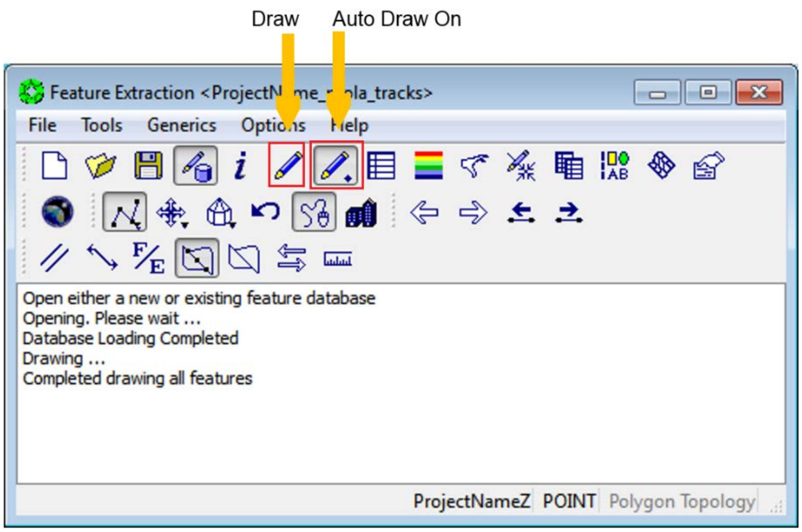


2) Select “File” > “Open FDB…” in the FE window.

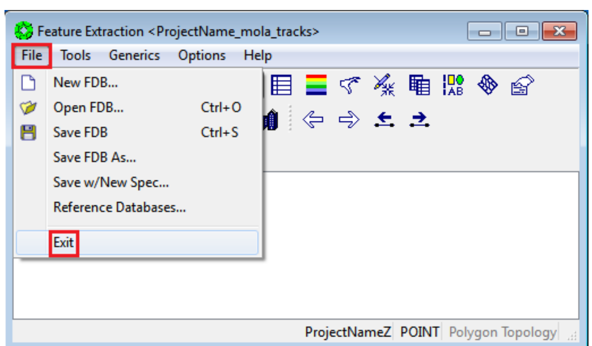
3) Select <ProjectName>_mola_tracks, then press “OK”.



4) The Feature Extraction tool should have defaulted to “Auto Draw” On, and the Tracks should be drawn on View 1. If not, press the “Draw” icon to draw the Tracks.



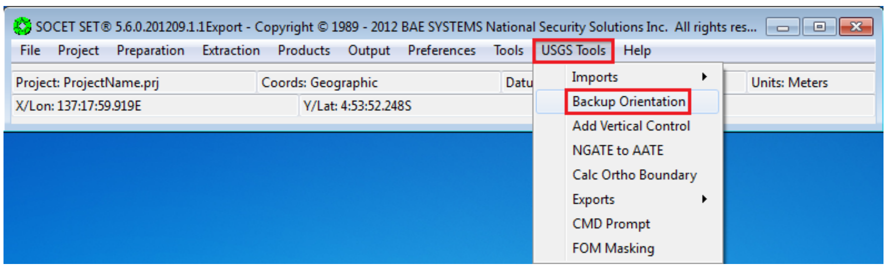
5) When the MOLA Track import is verified, select “File” > “Exit” on the FE window.



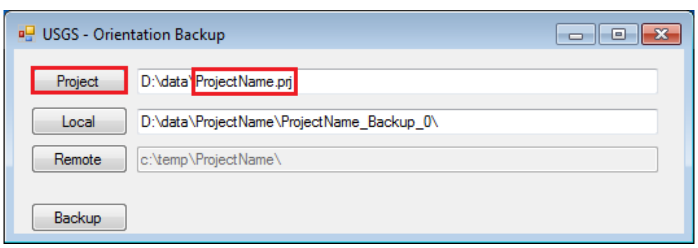
13Backup Original Image Support Files

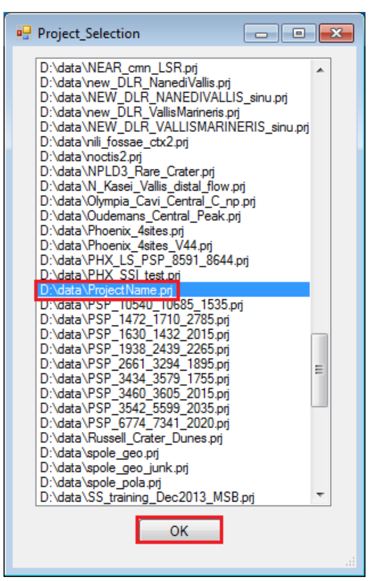
Before beginning the image control procedure, store a copy of the original (a-priori) support files in a subfolder of the project's data folder named <ProjectName>_Original. Throughout the control procedure, we will copy the contents of this subfolder back into the project's data folder for a clean adjustment, or to reset the support files if an adjustment diverges.

1) From the SOCET SET menu bar, select "USGS Tools" > "Backup Orientation".

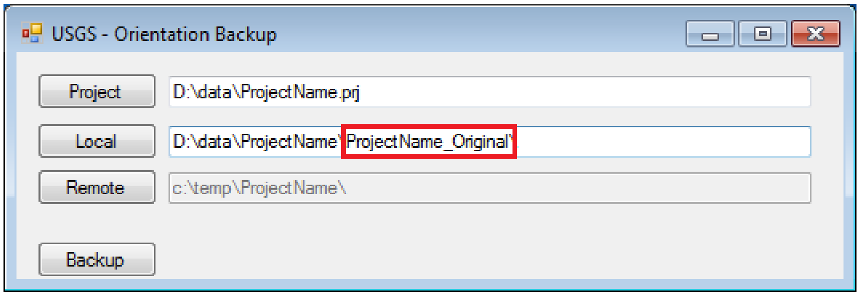


2) **Make sure the current project name is listed in the Project field. If not, press "Project" to select the current project, then press "OK".** (Otherwise the backup will be made in, and for, the wrong project!)

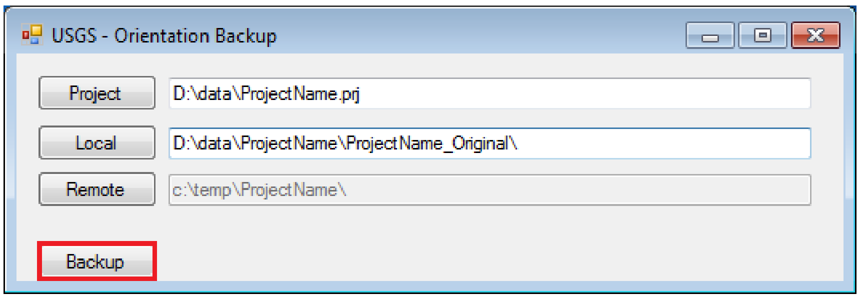




3) Replace **Backup_0** with **_Original** in the Local folder name field.



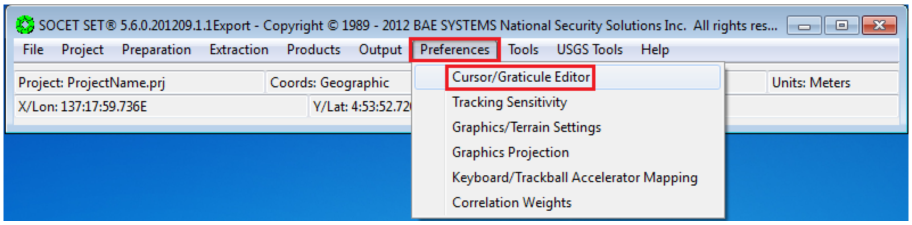
4) Press “Backup”.



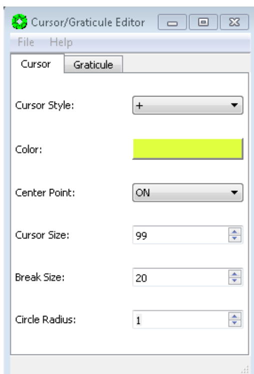
14Setup of Extraction Cursor for Beginners

Experienced operators will normally use a very small dot for their extraction cursor (also known as a floating mark), but this type of floating mark will usually prove to cause eye fatigue and pointing errors for novice operators. The following is a recommendation only and not crucial to stereo processing.

1) From the SOCET SET menu bar, select “Preferences” > “Cursor/Graticle Editor”.

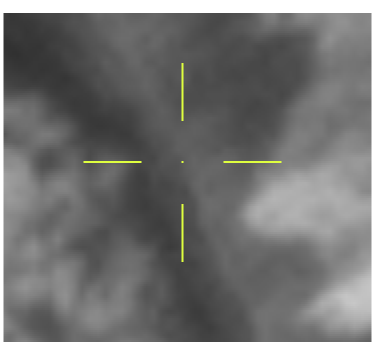


2) The following window will become active.



3) The following recommended settings will yield the cursor shown below:

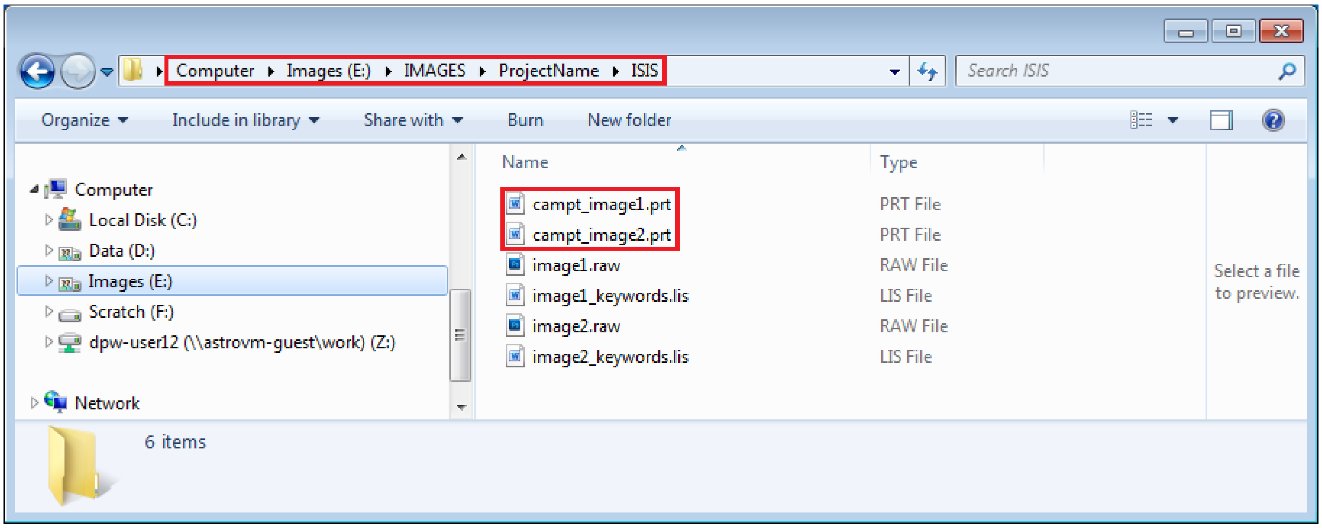
Cursor Style	Cross
Color	Yellow, or a Color Highly Visible on BW image
Center Point	On
Cursor size	99
Break size	20
Circle radius	1



4) Select “File” > “Exit” on the Cursor/Graticule Editor window.

15Determine Nadir-Most image for Image Control

During the Relative Orientation and Vertical Adjustment to MOLA image control stages, we will hold the nadir-most image. To determine which is the nadir most, use a text editor to open the campt_<image>.prt files in E:/IMAGES/<ProjectName>/ISIS, and make note of the image with the smallest Emission Angle.



16Image Control Overview and Naming Convention

Controlling HiRISE images to MOLA Tracks is a three-stage approach. Stage 1 is a Relative Orientation to remove y-parallax between the images of the stereo pair which aids stereo viewing. Stage 2 is Vertical Adjustment of the stereo model to align it in height (elevation) to the MOLA surface; which aids viewing the MOLA DTM or MOLA Tracks superimposed over the stereo pair. Stage 3 is an Absolute Orientation to align the stereo model with the MOLA Tracks, if-and-only-if there are sufficient MOLA Track data to accomplish the orientation. Depending on the analyst's desired level of accuracy, the Image Control process can stop at any of the three stages.

We ask that all users follow the same naming convention for triangulation file names and backup folder names (listed below). Following the same convention allows for ease of transition with multiple users accessing a project.

Triangulation files (*.atf) will be named as follows:

1) **<ProjectName>_Relative.atf** – Relative Orientation

2) **<ProjectName>_Rel_VertCtrl.atf** – Vertical Adjustment using relative orientation image parameters and vertical (Z) control points.

3) **<ProjectName>_Abs_XYZ_Ctrl.atf** – Absolute Orientation using absolute orientation image parameters, and XYZ Control.

Project Backup Folders will be named as follows:

1) **<ProjectName>_Original** – Stores the original (a-priori) image support files.

2) **<ProjectName>_Relative** – Stores the result of the Relative Orientation

3) **<ProjectName>_Relative_VerticalControl** – Stores the result of the Vertical Adjustment

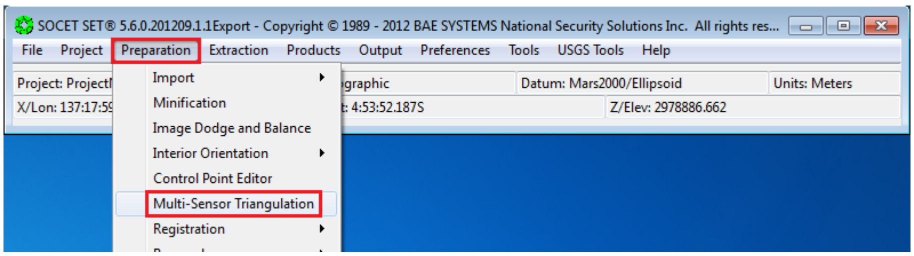
4) **<ProjectName>_ Absolute_XYZ_Control** – Stores the result of the Absolute Orientation

17Image Control Stage 1: Relative Orientation

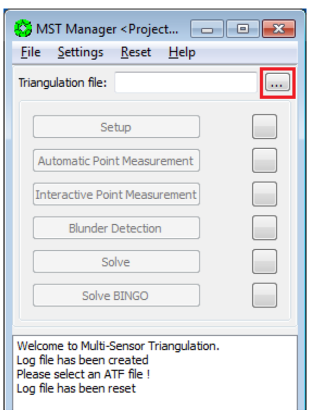
In the Relative Orientation stage we will remove the Y-parallax between the stereo images. Y-parallax is separation of the stereo images in the Y (up-and-down) direction.

17.1 Multi-Sensor Triangulation Setup

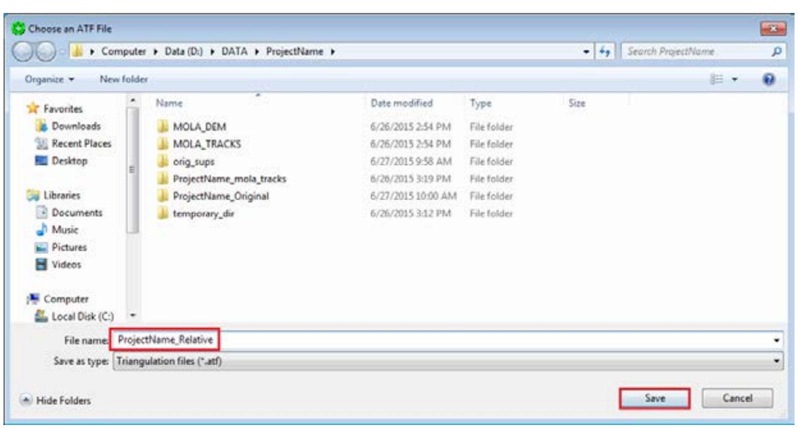
1) From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



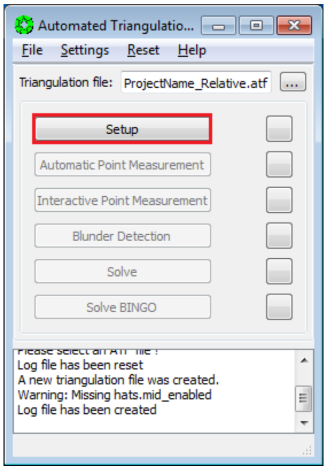
2) Press the box next to the “Triangulation file” field to bring up a file selection window.



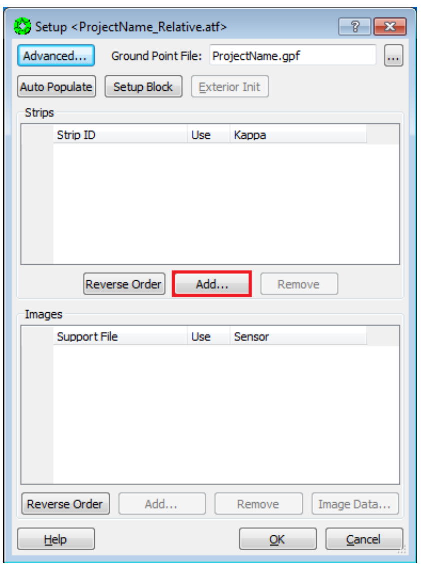
3) Enter **<ProjectName>_Relative** as the name of triangulation file and press “Save”.



4) Press “Setup”.

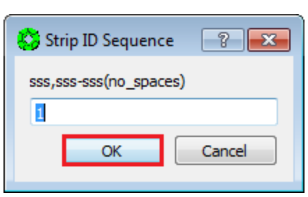


5) In the Setup window, press “Add”.

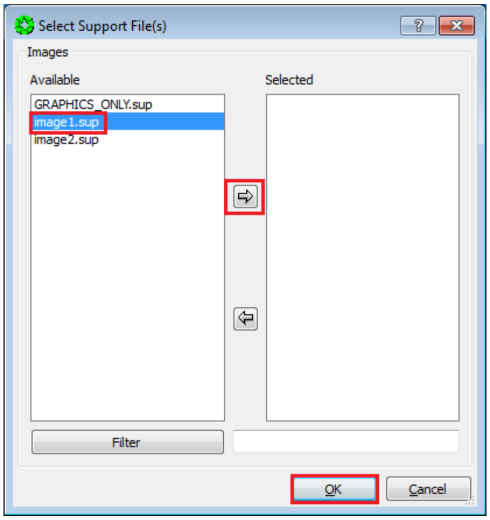


Note that in the Setup Window, the Ground Point File: (to be created) will automatically be named after the project name.

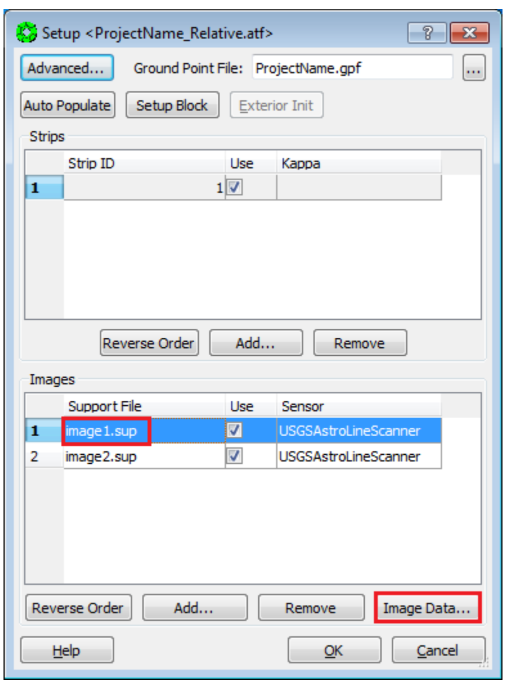
6) In the Strip ID Sequence box, use the default value of 1, and press “OK”.



7) You will be prompted to Select Support Files. Do this by highlighting each image in the "Available" list and moving them to "Selected" list via the arrow buttons. Press "OK" when done.



8) The selected images are now listed in the Setup window. Select the nadir-most image, and press "Image Data…".



9) In the Image Data window:

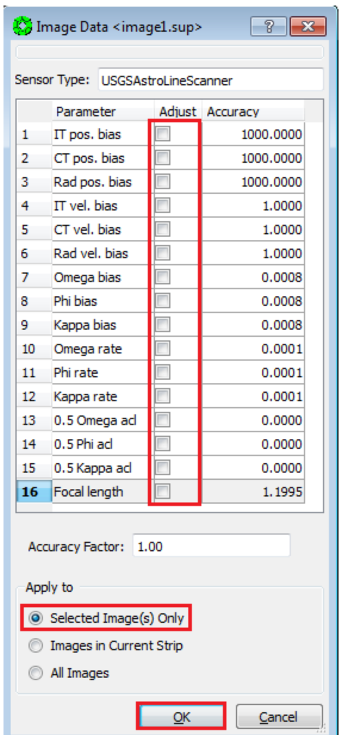
   a. make sure no check boxes are checked in the Adjust field.

   b. Turn on radio button “Selected Image(s) Only” in the “Apply To” section.

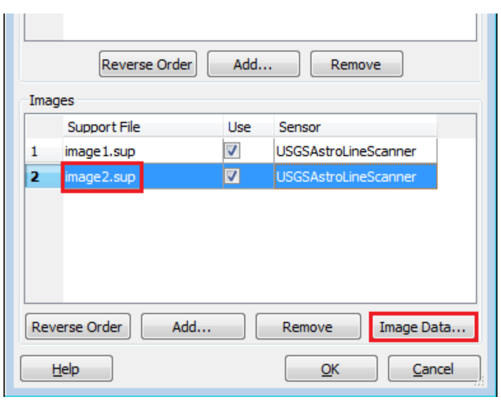
   c. Press “OK”.

   Note: 1) Not allowing any parameters to adjust holds this image to it’s a-priori position and pointing.

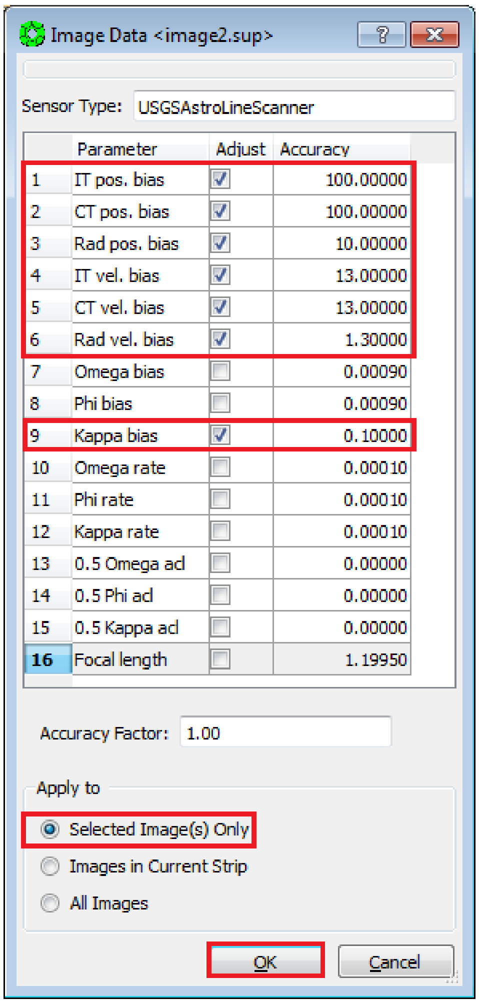
   2) Please ignore the values listed in the Accuracy field, as they may not be applicable to the setup in certain cases



10) Go back to the Setup window. Select the Support file of the other image, and press “Image Data…”.

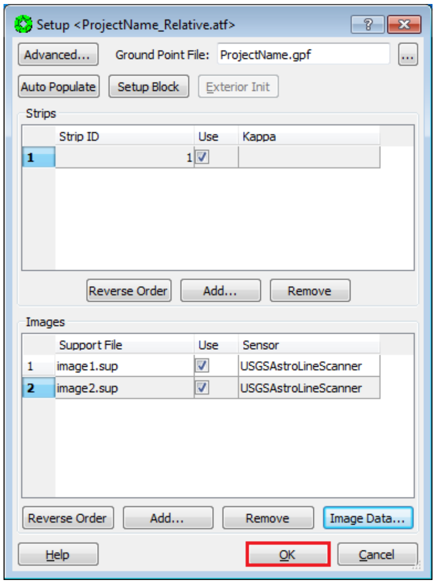


11) In the Image Data window:
    a. Turn on the check boxes for the parameters listed below, and enter the corresponding accuracy values. (All other parameters are off. If a parameter is checked, it will be allowed to adjust. If it is not checked, it will remain unchanged when the triangulation is run.)
    b. Turn on radio button “Selected Image(s) Only” in the “Apply To” section.
    c. Press “OK”.

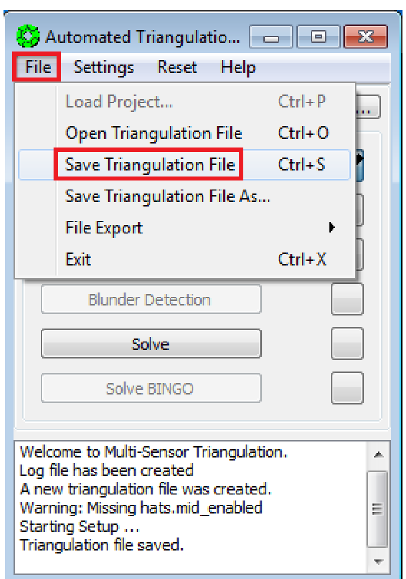


<u>Parameter</u>	<u>Accuracy</u>
IT pos. bias	100 m
CT pos. bias	100 m
Radial pos. bias	10 m
IT vel. bias	13 m/s
CT vel. bias	13 m/s
Radial vel. bias	1.3 m/s
Kappa bias	0.1 degree

12) Press “OK” in the Setup window.



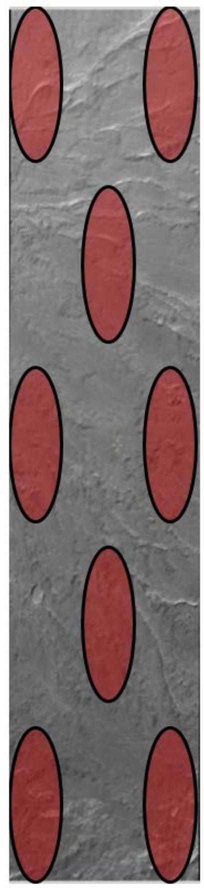
13) Select “File” > “Save Triangulation File” in the Automated Triangulation window.



17.2 Tie Point Distribution

Using Interactive Point Measurement (details below), we will measure **two** "tie points" per region, as distributed in 8 regions shown here, for a minimum of 16 points. This point distribution is called "Buddy Points", and aids in highlighting poor image measurements when solving a bundle adjustment.

NOTE: We want to convert as many of these tie-points to z-only control in the Vertical Adjustment to MOLA stage, **so when possible avoid steep slopes areas.**

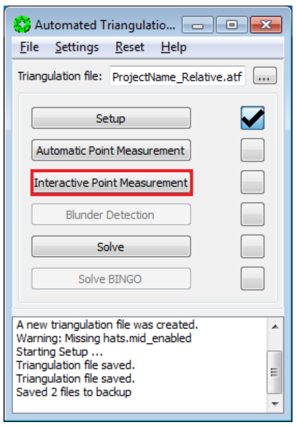


17.3 Interactive Point Measurement Setup

1) Ensure that the “View 1” window in the stereo display is set for stereo mode.

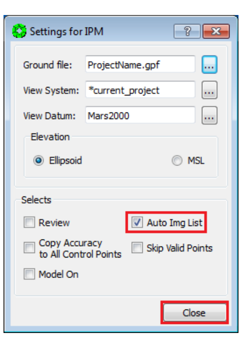
2) Be seated squarely in front of the stereo display (with stereo viewing glasses).

3) Press “Interactive Point Measurement” from the Automated Triangulation window.



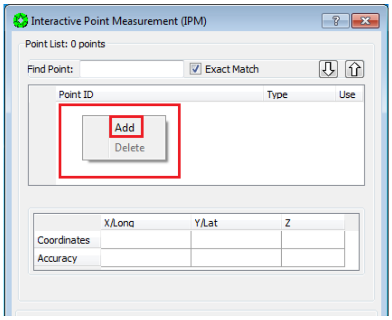
4) Press “Settings” in the Interactive Point Measurement (IPM) window.

5) In the Settings for IPM window, check the “Auto Img List” box, then press “Close”.

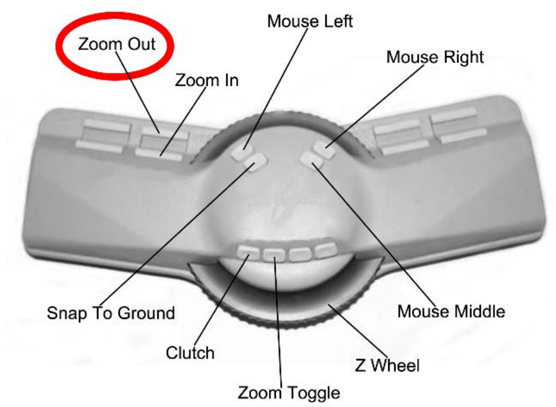


17.4 Manual Tie Point Measurement

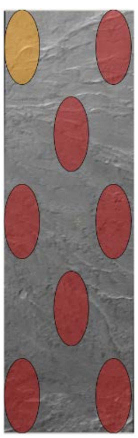
1) In the IPM window:
   a. Right Click in the Point ID field.
   b. Select "Add" in the pop-up window.



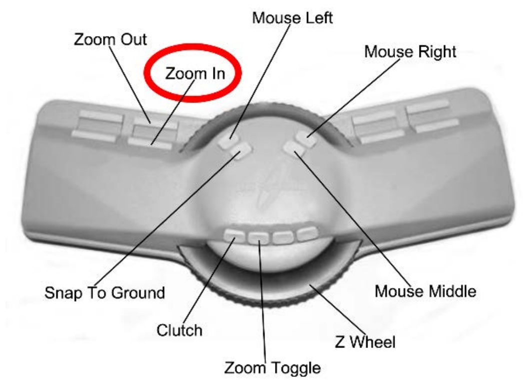
2) On the TopoMouse, use the zoom out button (repeatedly), to view full extents of the stereo model.



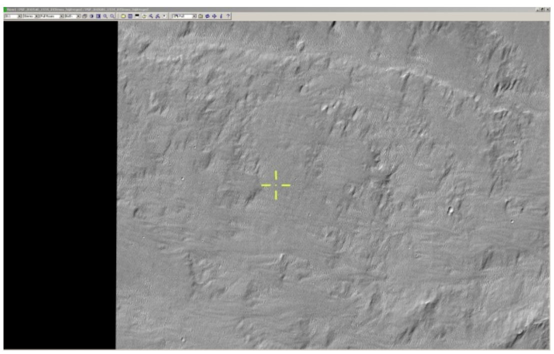
3) Move cursor to first (or next) region for tie point measurement.



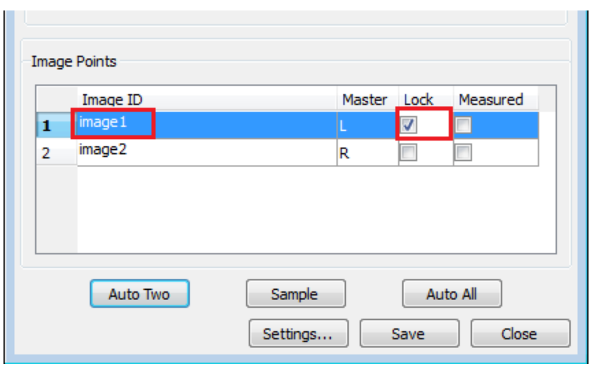
4) Use TopoMouse “Zoom in” button (repeatedly) to set view to approximately 8:1 ratio.



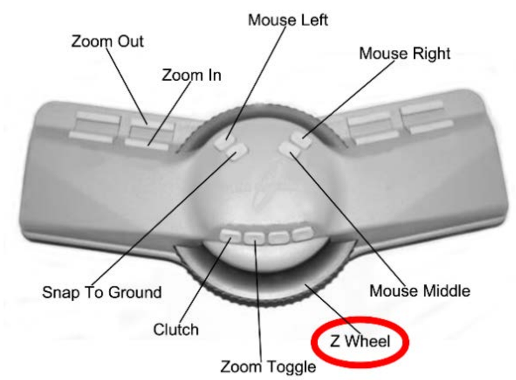
5) Locate an area where terrain is relatively continuous with minimal slope, and move extraction cursor to that location.



6) In the IPM window, lock the Left image by checking its Lock box.

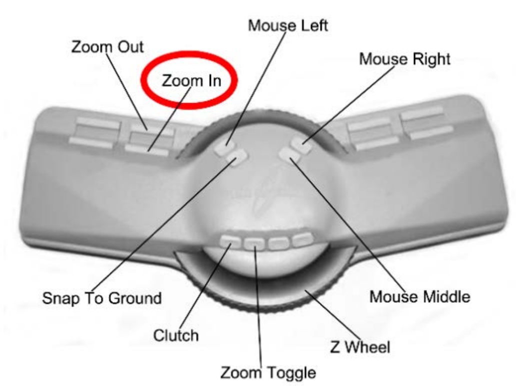


7) Clear parallax by moving the Right image only and place the extraction cursor on the ground. You may use the Z wheel to fine-tune the height adjustment of the extraction cursor after Y-parallax is removed.

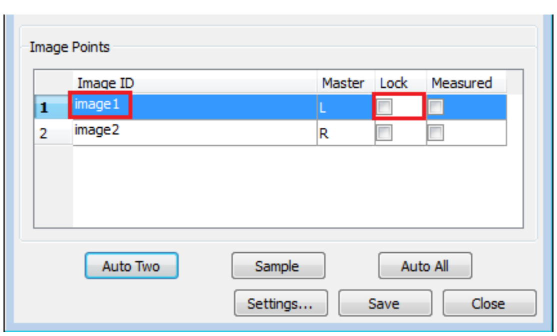


Note: You need to practice the placement of the cursor on the ground several times, until you have clear sense of when it is above or below the ground. See Appendix: A-3 Placing Dot on the Ground.

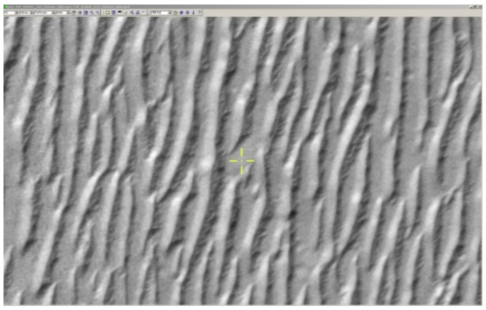
8) Use the TopoMouse “Zoom In” button (repeatedly) to set view to 1:1 ratio.



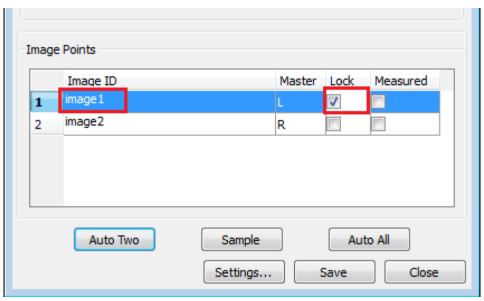
9) In the IPM window, Unlock the Left image by unchecking its Lock box.



10) Refine the extraction cursor position to a highly discernible location that is representative of surrounding terrain and free of high relief or slope. **Do not measure edges of shadows**, because shadows "move" between image scenes, and the extraction cursor will not be truly on the ground.



11) In the IPM window, lock the Left image by checking its Lock box.

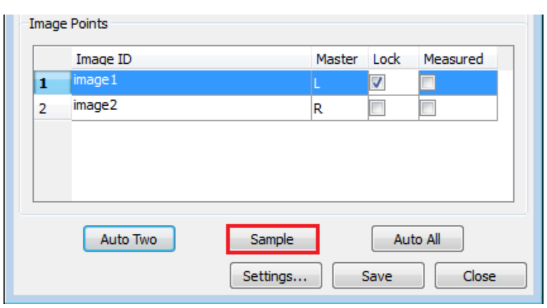


12) Refine the parallax removal (at ground level) by moving the Right image only. In other words, put the dot on the ground.

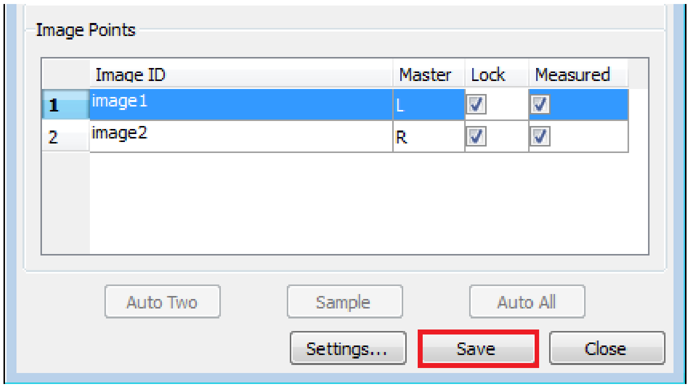
Note: Experienced analysts with good stereo acuity to recognize when auto-correlation has correlated to a false positive result, may want to use the "Auto-Two" feature in this step. For details, see Appendix: A6.1 Auto Two Feature in IPM.

13) Press "Sample" on the IPM window to collect the point measurement.

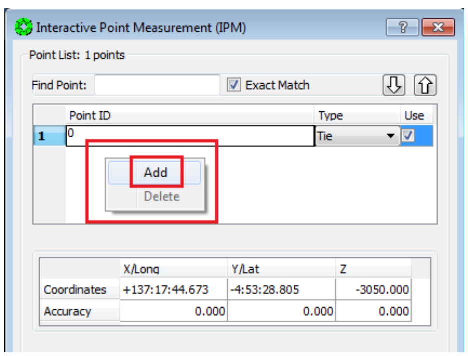
Note: **Sample stores the measurement in computer memory only**. *After Sample is pressed, both images will be locked and measured.*



14) Press “Save” on the IPM window to write the measurement to disk.

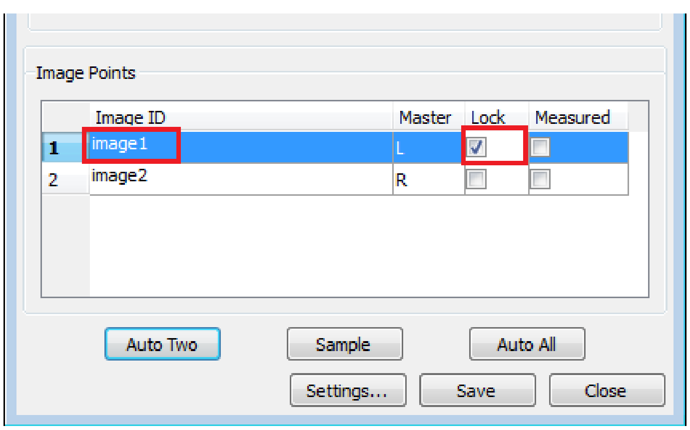


15) Start measurement of second (buddy) point in the same region:
   a. In the IPM window, Right Click in the Point ID field.
   b. Select “Add” in the pop-up window.



16) Move the extraction cursor to a new location in the current field of view.

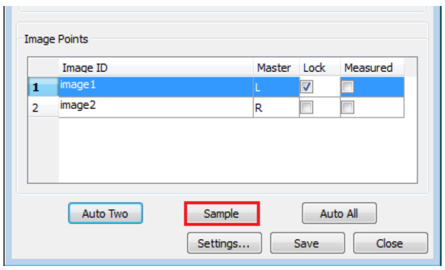
17) In the IPM window, lock the Left image by checking its Lock box.



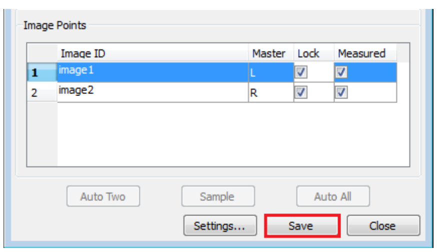
18) Refine the parallax removal (at ground level) by moving the Right image only. In other words, put the dot on the ground.

    Note: Experienced analysts with good stereo acuity to recognize when auto-correlation has correlated to a false positive result, may want to use the "Auto-Two" feature in this step. For details, see Appendix: A6.1 Auto Two Feature in IPM.

19) Press "Sample" on the IPM window to measure the (buddy) point.

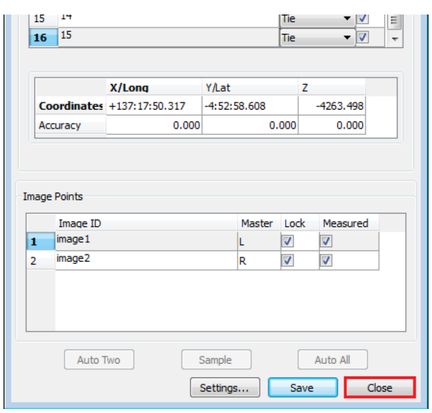


20) Press "Save" on the IPM window to write the measurement to disk.



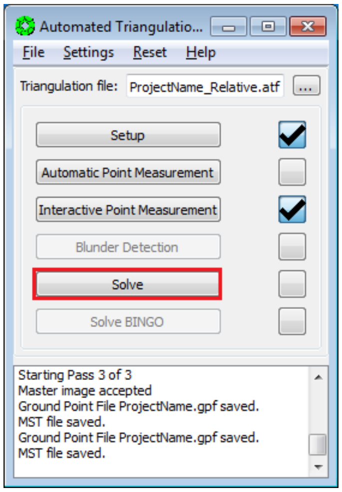
21) **Go To: Step 1 of this section (17.4 Manual Tie Point Measurement), and repeat this procedure for each of the regions defined in 17.2 Tie Point Distribution.**

22) After completing the measurement process for all 8 regions (16 points), press "Close" on the IPM window.

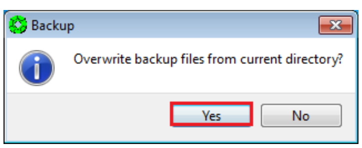


17.5 Bundle Adjustment

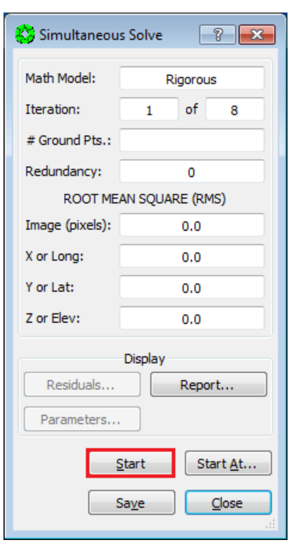
1) Return to the Automated Triangulation /Full Block menu in the MST, and activate the adjustment procedure by pressing “Solve”.



2) The “Simultaneous Solve” window will open, along with a “Backup” pop-up window. Press “Yes” on the pop-up to overwrite back up files.



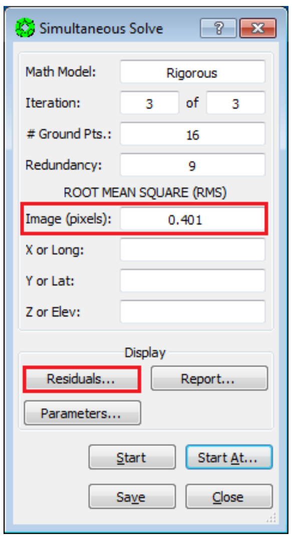
3) In the “Simultaneous Solve” window, press “Start” to perform the bundle adjustment.



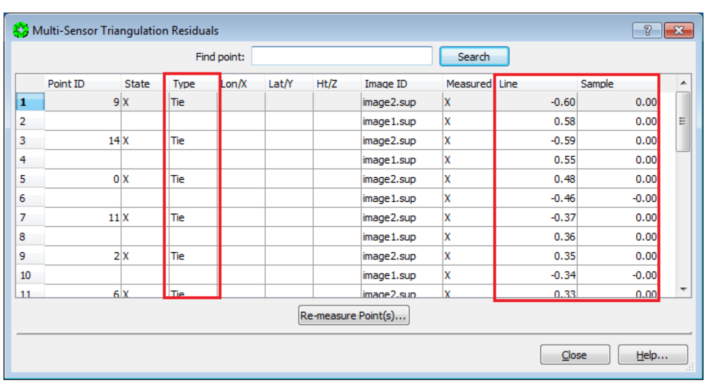
4) Once the adjustment is completed, the “Simultaneous Solve” window will be updated with a report of: Number of ground points generated, solution redundancy, and most importantly the RMS residual error (in Image pixels).

An acceptable solution has (1) an Image (pixels) RMS of ~0.6 or less, and (2) no individual point measurement has an error greater than 2 pixels.

Press “Results” in the “Simultaneous Solve” window to review the error of individual point measurements.



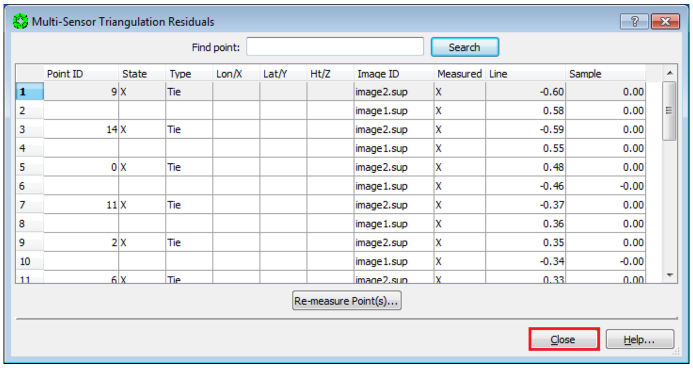
5) Points in the Residuals window are grouped by Type, and automatically sorted from highest to lowest residual. The Line and Sample fields list the point measurement errors in pixels. In a Relative Orientation, all points are Tie, so inspecting the top of the list will suffice.



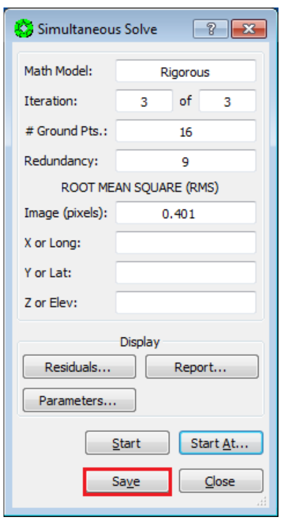
	Point ID	State	Type	Lon/X	Lat/Y	Ht/Z	Image ID	Measured	Line	Sample
1	9	X	Tie				image2.sup	X	-0.60	0.00
2							image1.sup	X	0.58	0.00
3	14	X	Tie				image2.sup	X	-0.59	0.00
4							image1.sup	X	0.55	0.00
5	0	X	Tie				image2.sup	X	0.48	0.00
6							image1.sup	X	-0.46	-0.00
7	11	X	Tie				image2.sup	X	-0.37	0.00
8							image1.sup	X	0.36	0.00
9	2	X	Tie				image2.sup	X	0.35	0.00
10							image1.sup	X	-0.34	-0.00
11	6	X	Tie				image2.sup	X	0.33	0.00

6) If points have pixel errors greater than 2.0 pixels, SKIP TO: 17.6 Point Re-Measurement Process. Otherwise, continue to the next step.

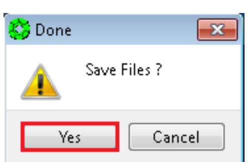
7) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, then press “Close” on the Multi-Sensor Triangulation Residuals window.



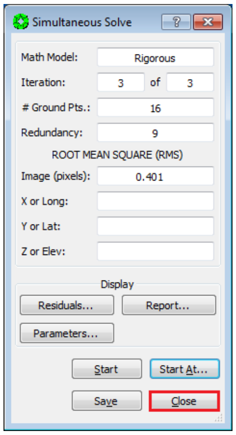
8) Press “Save” on the simultaneous solve window.



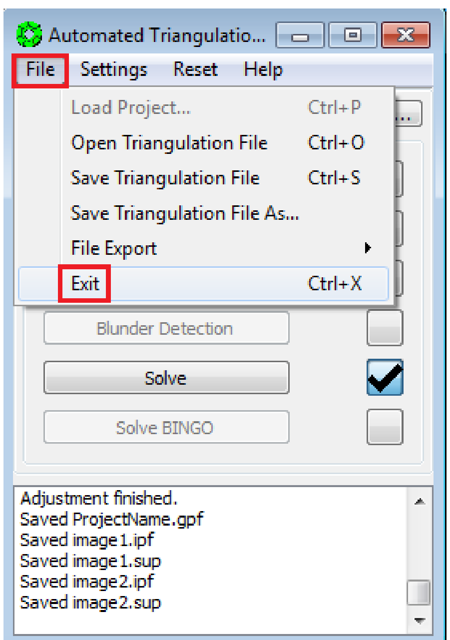
9) Press “Yes” on the Done pop-up window.



10) Press “Close” on the Simultaneous Solve window.



11) Select “File” > “Exit” on the Automatic Triangulation window.



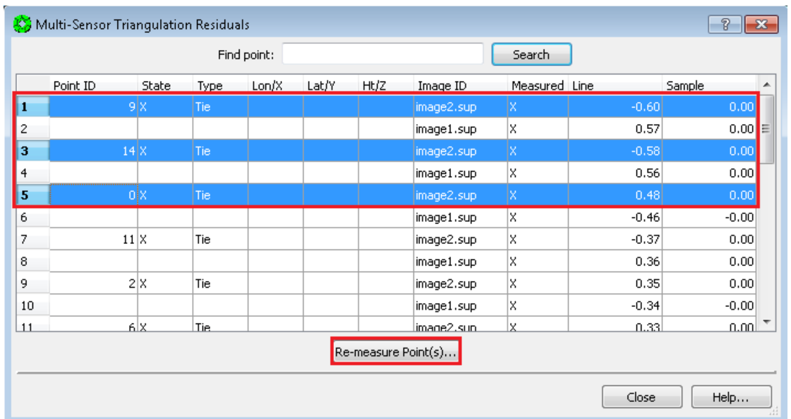
Relative Orientation is now complete!

12) SKIP: 17.6 Point Re-Measurement Process, GO TO: 17.7 Re-Load Images.

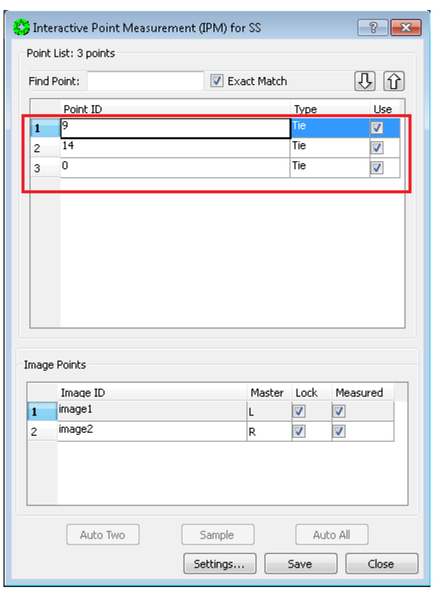
17.6 Point Re-Measurement Process

Continuing from 17.5 Bundle Adjustment…

1) On the “Multi-Sensor Triangulation Residuals” window, Left-Click on the Point ID(s) of the points to re-measure. (Hold the Control Key down to select multiple points.) Then press “Re-measure Point(s)…”. The re-measure point window will now open with the points selected.

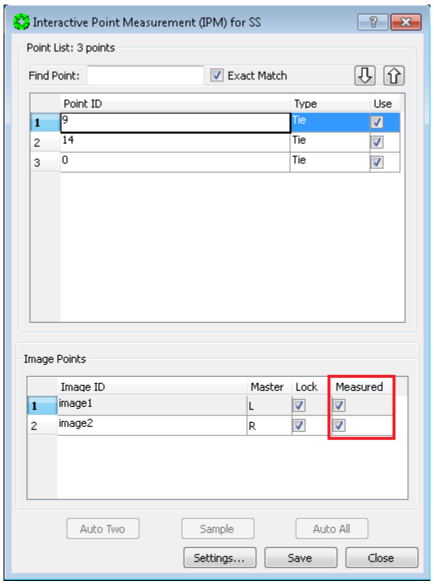


2) Left-Click on the point to re-measure. The View 1 (stereo display) will display the current point measurement.

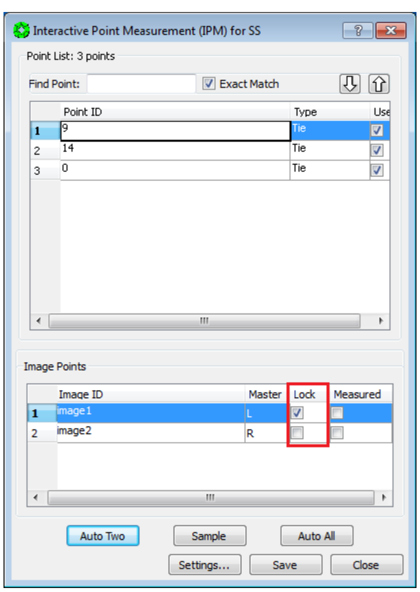


3) You have an option of relocating the point or clearing parallax:
   a. To relocate the point, Un-check the boxes in the “Measured” field for both images.
   b. To remove residual parallax, Un-check the Measured box for the Right image only.

NOTE: Un-checking a Measured box will also un-Lock the image so it is free to move using the TopoMouse.

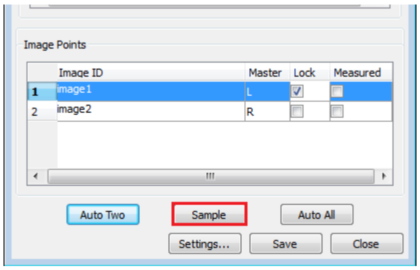


4) If you are re-locating the point, place the extraction cursor on the feature in the Left image that you would like to measure. Then Lock the Left image by checking the box in the Lock field for the Left image.

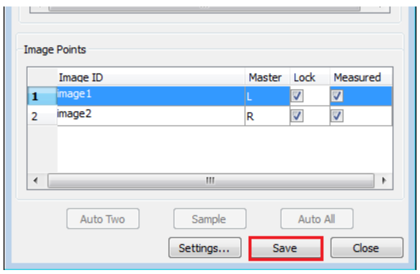


5) For either option (re-locating the point, or removing residual parallax), clear the parallax by moving the Right image only (i.e., put the dot on the ground).

6) Press “Sample” to collect the point measurement.

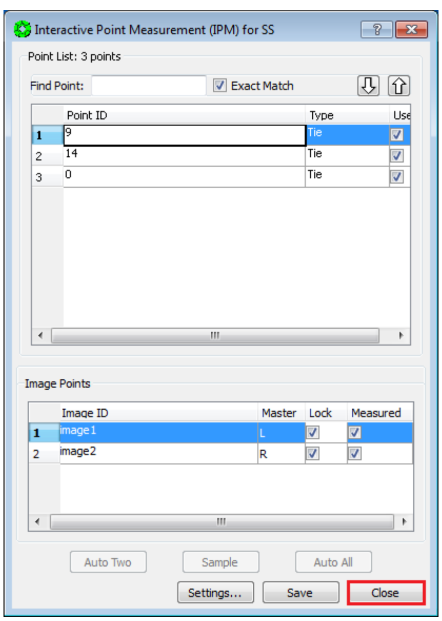


7) Press “Save” to write the measurement to disk.

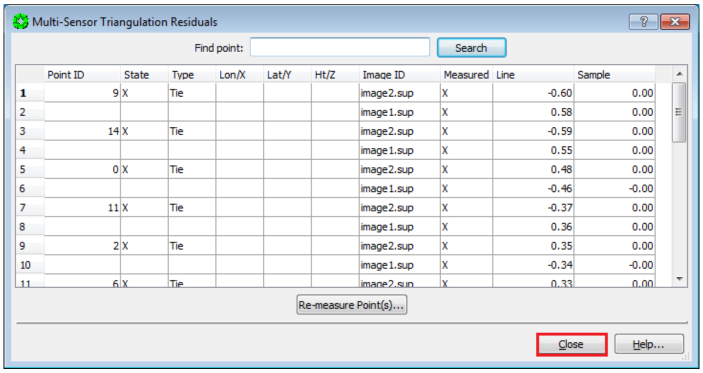


8) Repeat re-measurement process for remaining points in the list. (Go back to step 2.)

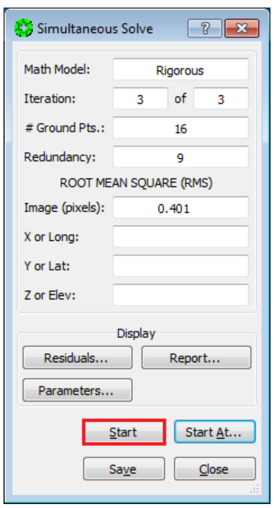
9) Press “Close” after all points in the list are re-measured.



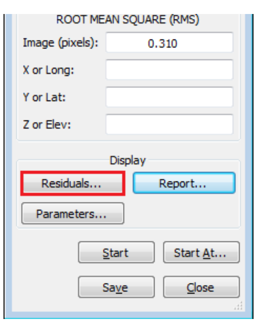
10) Press “Close” on the Multi-Sensor Triangulation Residuals window.



11) Press “Start” on the Simultaneous Solve window.

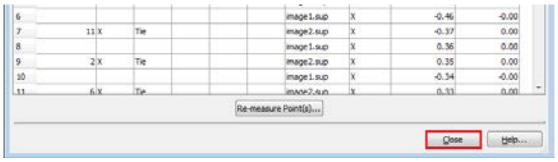


12) Press “Residuals” on the Simultaneous Solve window and make sure no individual point has an error greater than 2 pixels.

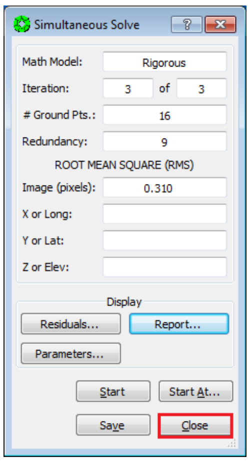


13) If there are points with larger than 2 pixel errors, Go To: Step 1 of this section (17.6 Point Re-Measurement Process) and further refine the measurements.

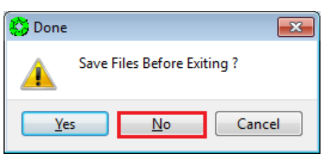
14) If the overall RMS < ~0.6 pixels, and all points have less than a 2 pixel error, we will exit Multi-Sensor Triangulation, and re-enter it in order to refresh the values stored in computer memory. First press “Close” on the Multi-Sensor Triangulation Residuals window.



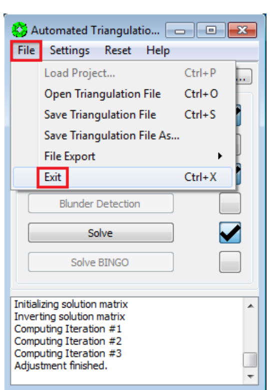
15) Press “Close” on the Simultaneous Solve window. (Do Not Press “Save”.)



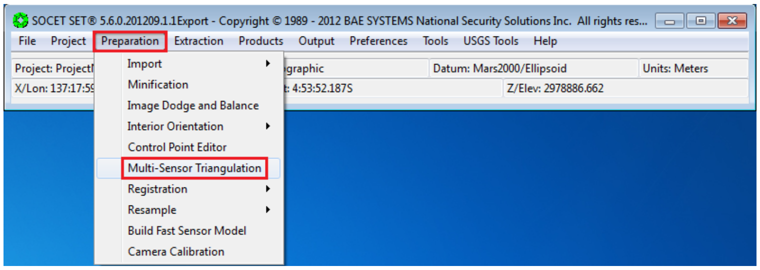
16) Press “No” to Saving Files in the Done pop-up window.



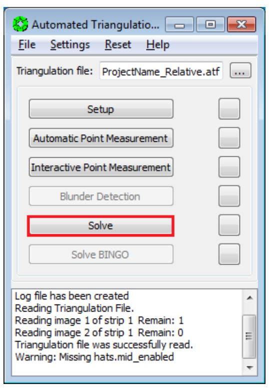
17) Select “File” > “Exit” on the Automatic Triangulation window.



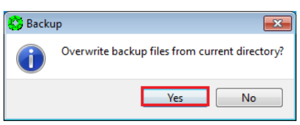
18) From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



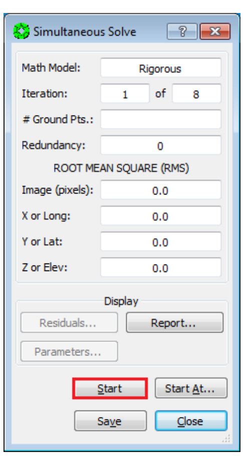
19) Press “Solve” on the Automatic Triangulation window. (The triangulation file, ProjectName_Relative, should load automatically.)



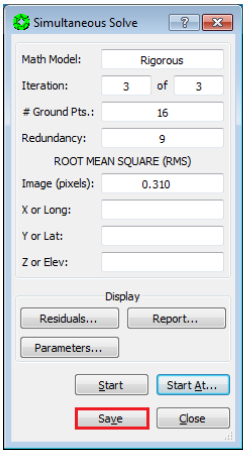
20) Press “Yes” on the pop-up to overwrite back up files.



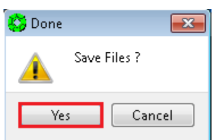
21) Press “Start” on the Simultaneous Solve window.



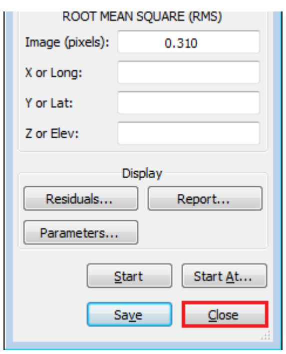
22) If the Image (pixels) RMS is < ~0.6 pixels, Press “Save” on the Simultaneous Solve window.



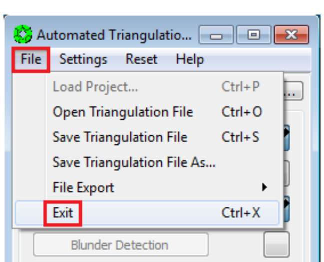
23) Press “Yes” on the Done pop-up window.



24) Press “Close” on the Simultaneous Solve window.



25) Select “File” > “Exit” on the Automatic Triangulation window.

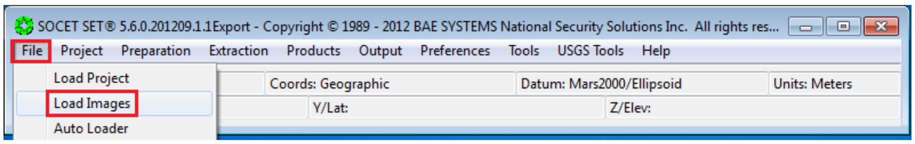


Relative Orientation is now complete!

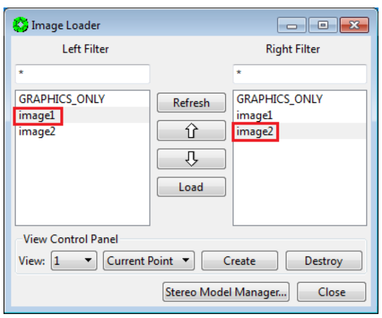
17.7 Re-Load Images

After the Relative Orientation is complete, it is necessary to re-Load the images in order to view them with the results of the adjustment. You should now have a parallax-free stereo model.

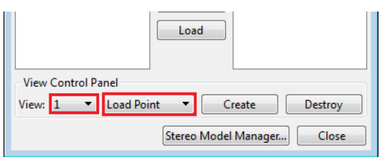
1) From the SOCET SET menu bar, select “File” > “Load Images”.



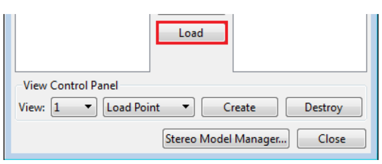
2) In the Image Loader window, select the Left and Right Image to display by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)



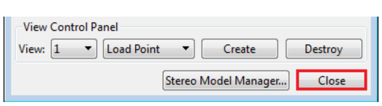
3) Under “View Control Panel” settings: Ensure that View = 1 and that “Load Point” is selected.



4) Press “Load”.



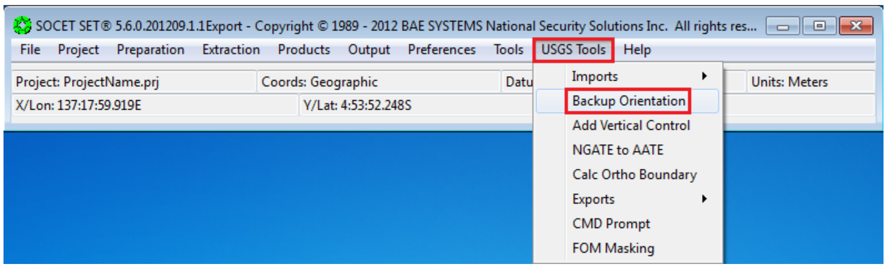
5) Press “Close”



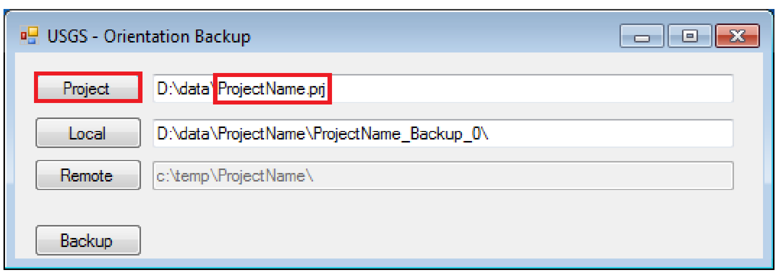
17.8 Backup Relative Orientation Results

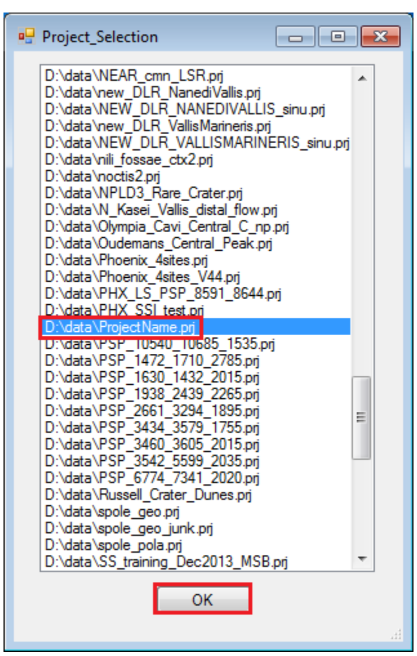
At this point, it is prudent for the operator to backup the project data in order to have a re-entry point that does not require the re-measure of tie points.

1) From the SOCET SET menu bar, select “USGS Tools” > “Backup Orientation”.

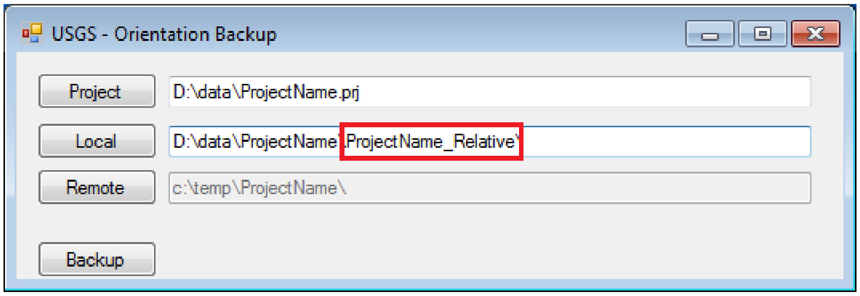


2) **Make sure the current project name is listed in the Project field. If not, press “Project” to select the current project, then press “OK”.** (Otherwise the backup will be made in, and for, the wrong project!)

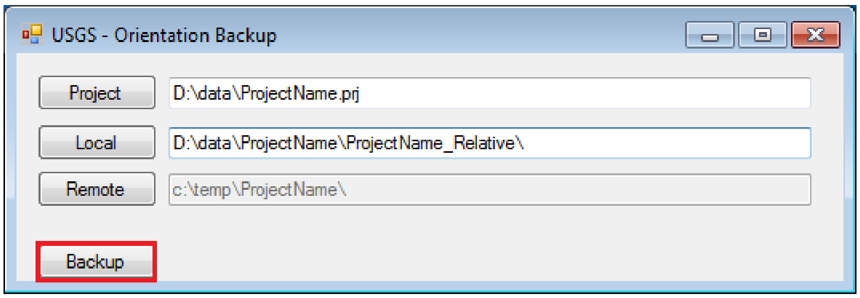




3) Replace **Backup_0** with **_Relative** in the Local folder name field. The backup folder will be named <ProjectName>_Relative.



4) Press “Backup”.



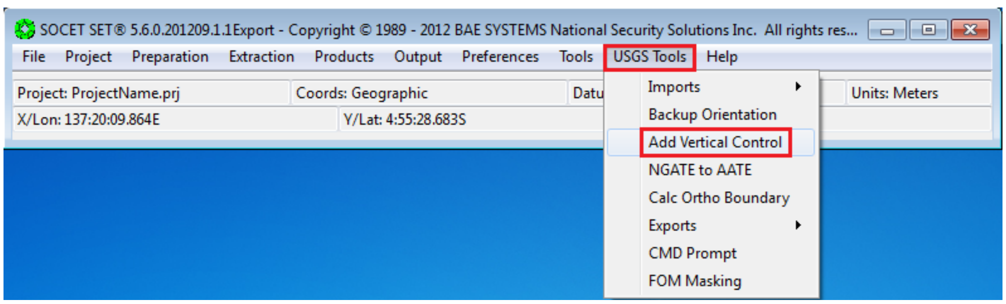
18Image Control Stage 2: Vertical Adjustment to MOLA

18.1 Update Tie Points to Vertical (Z) Control

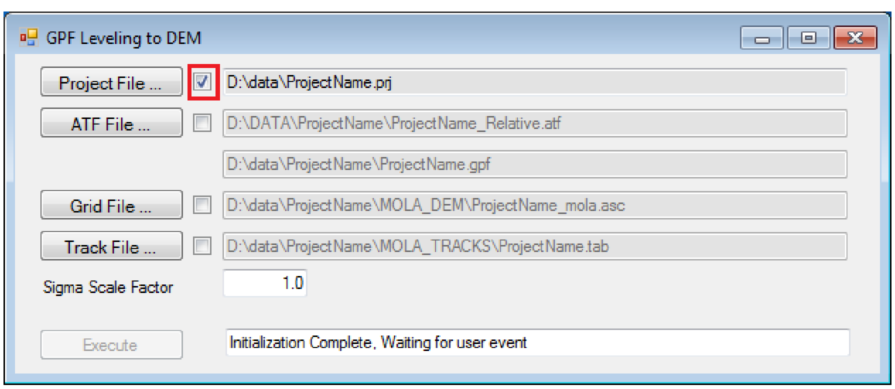
Utility “Add Vertical Control” adds elevation information based on MOLA heights to the tie points measured in the Relative Orientation. The tie points are then flagged as Z-Control points in the ground point file (GPF).

The “Add Vertical Control” utility will auto-fill the input files based on the <ProjectName> listed. If the grayed out entries are correct, simply check the boxes next to each field to confirm them. Otherwise, press the buttons associated with each field to select the correct files. The following steps detail the procedure.

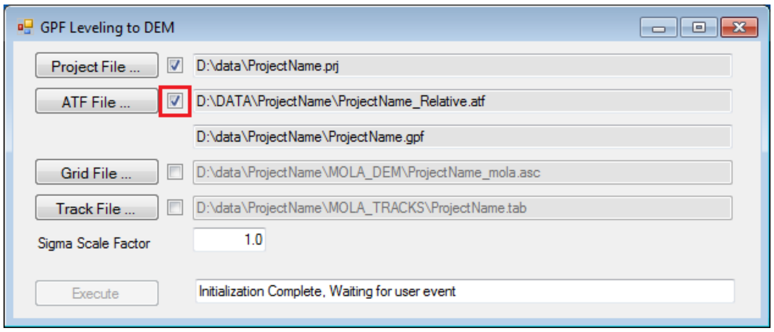
1) From the SOCET SET menu bar, select “USGS Tools” > “Add Vertical Control”.



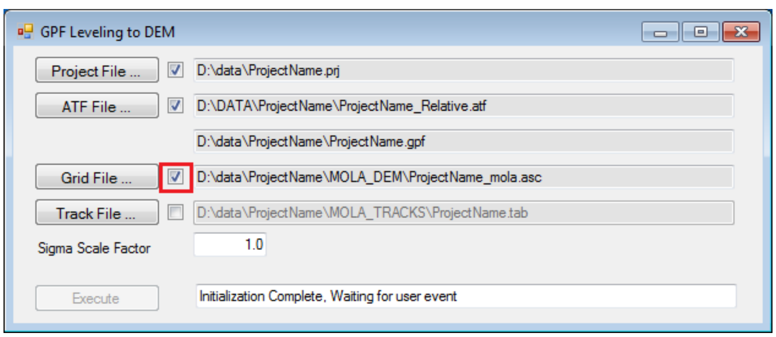
2) If the project file listed in the “Project File” field is correct, check the box next to the Project File field to confirm it. Otherwise, press the “Project File…” button to bring up the list of projects and select the project from the list.



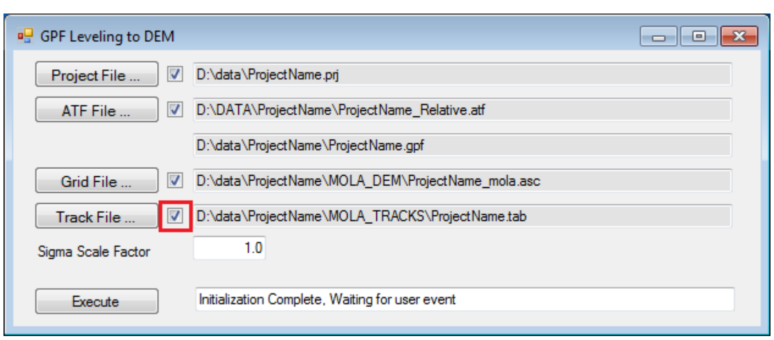
3) The input ATF File should be <ProjectName>_Relative.atf. Either confirm the “ATF File” listed is correct by checking its check box, or press the “ATF File…” button to select <ProjectName>_Relative.atf. (The Ground Point File (GPF) is also listed. It should be <ProjectName>.gpf.)



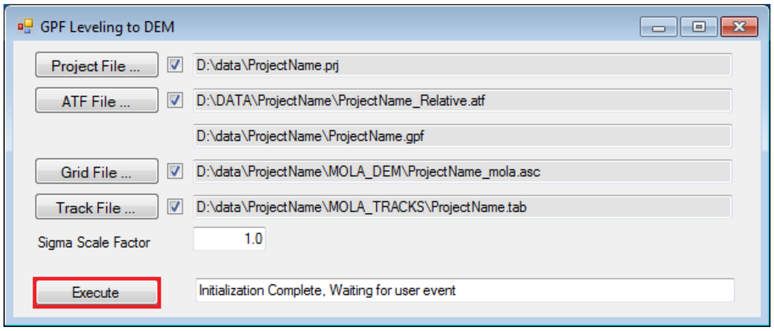
4) The input Grid File should be <ProjectName>_mola.asc located in the MOLA_DEM folder. Either confirm the “Grid File” listed is correct by checking its check box, or press the “Grid File…” button to select D:\DATA\<ProjectName>\MOLA_DEM\<ProjectName>_mola.asc.



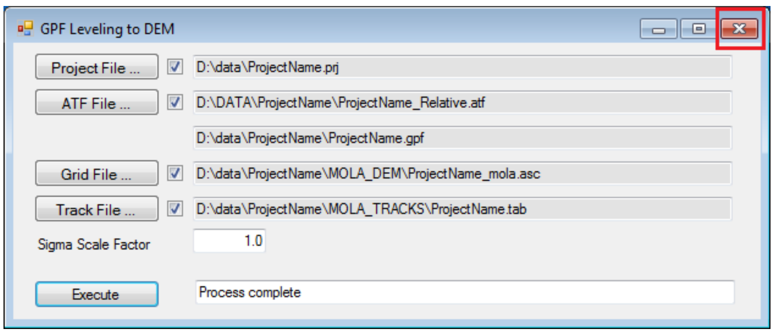
5) The input Track File should be <ProjectName>.tab located in the MOLA_TRACKS folder. Either confirm the “Track File” listed is correct by checking its check box, or press the “Track File…” button to select D:\DATA\<ProjectName>\MOLA_TRACKS\<ProjectName>.tab. (Note: If a Track File does not exist, keep the Track File field blank and check the confirmation box.)



6) Press "Execute". (If the Execute button is not activated please check the confirmation checkboxes.)



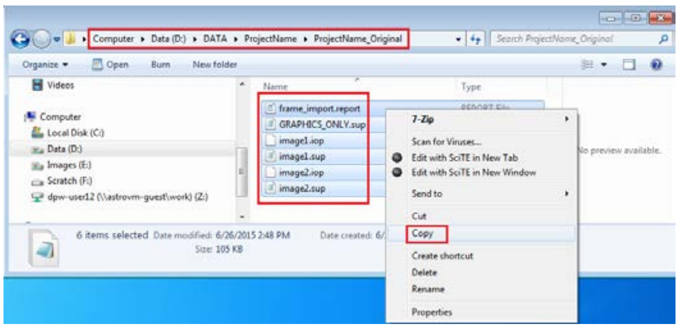
7) Close the window via the upper-right close button.



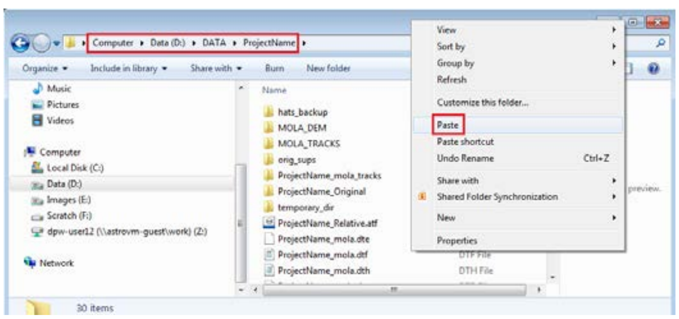
18.2 Restore Original (A-priori) Support Files

1) Open Windows Explorer. Navigate to D:\DATA\<ProjectName>\<ProjectName>_Original, select all the files in the folder, and Copy them.

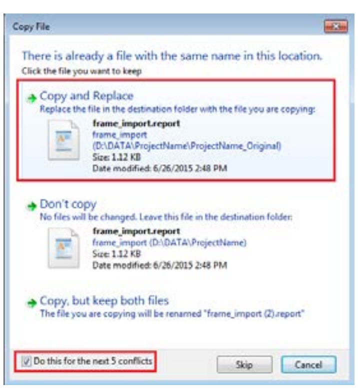
   Note: There are more than image support files in this folder, but there is no harm copying the extraneous files, and it is quickest to just select all the files.



2) Move up one folder so you are now in D:\DATA\<ProjectName>, and paste the files.



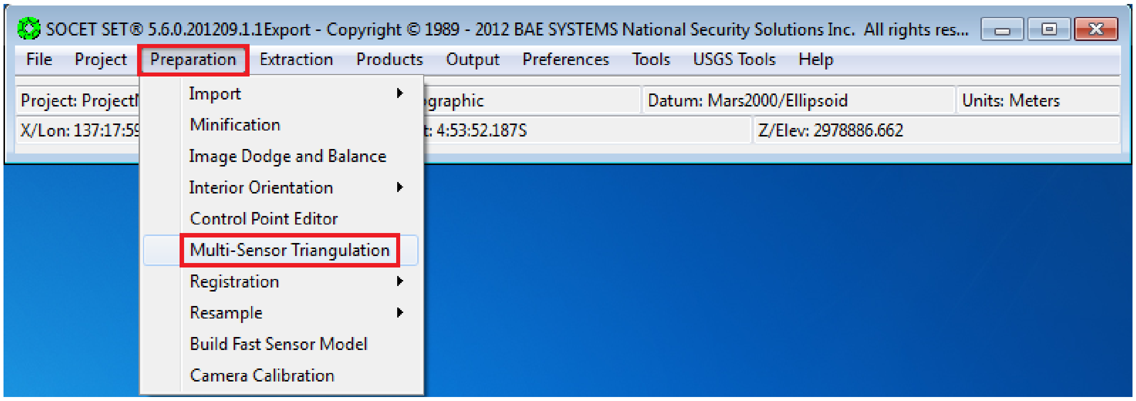
3) In the pop-up window, check the box in the lower left corner to "do this for the next 3 conflicts", then select "Copy and Replace".



4) Close the Windows Explorer window.

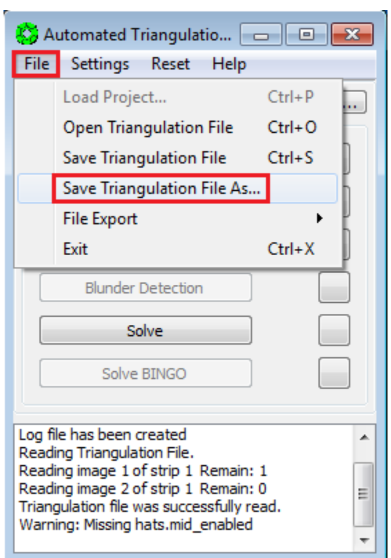
18.3 Bundle Adjustment

1) From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.

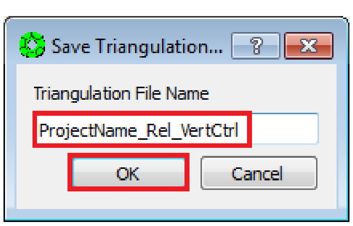


2) Select “File” > “Save Triangulation File As…” in the Automated Triangulation window.

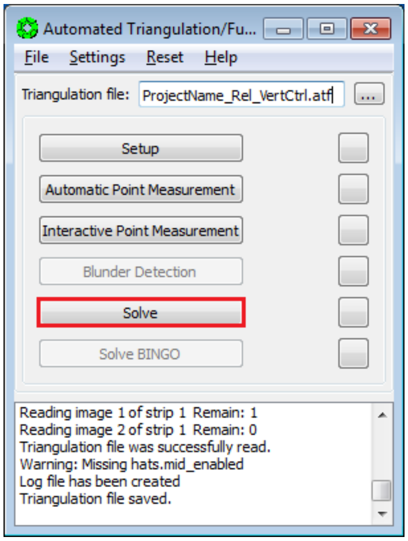
Note that <ProjectName>_Relative.atf was automatically loaded. For the Vertical Adjustment to MOLA, no changes will be made to the Setup, however, we will provide a more meaningful name to the ATF file.



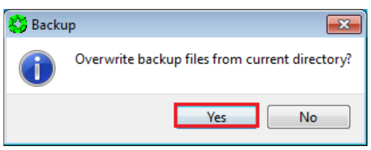
3) In the pop-up window, enter <ProjectName>_Rel_VertCtrl, and press “OK”.



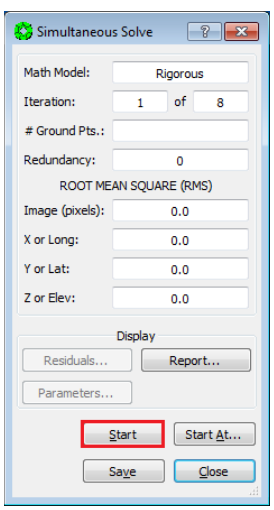
4) Press “Solve” in the Automated Triangulation window.



5) The “Simultaneous Solve” window will open, along with a “Backup” pop-up window. Press “Yes” on the pop-up to overwrite back up files.



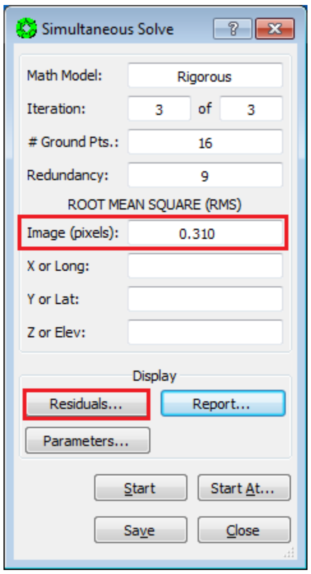
6) In the “Simultaneous Solve” window, press “Start” to perform the bundle adjustment.



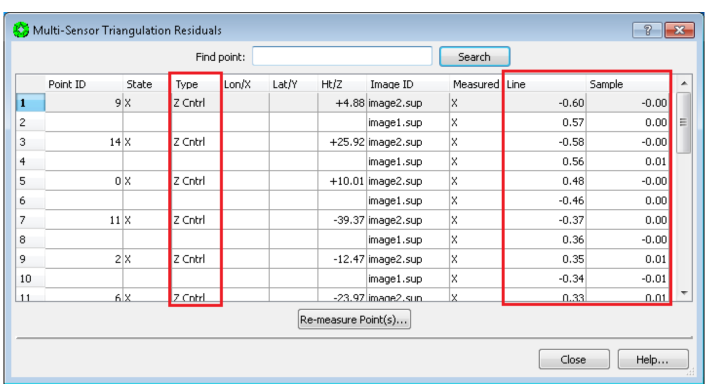
7) Once the adjustment is completed, evaluate the errors in the adjustment.

An acceptable solution has (1) an Image (pixels) RMS of ~0.6 or less, and (2) no individual point measurement has an error greater than 2 pixels.

Press "Results" button in the Simultaneous Solve window to review error of individual point measurements.

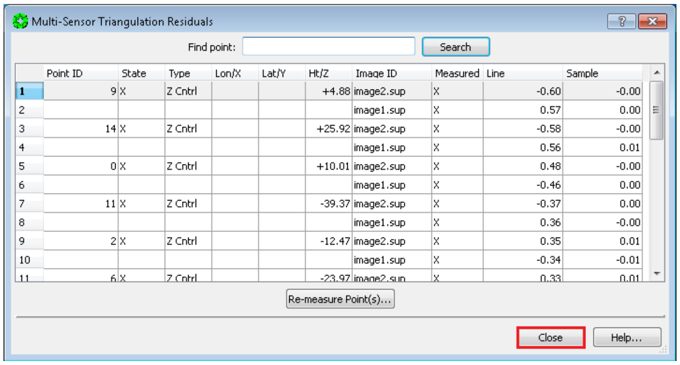


8) In the Vertical Adjustment procedure, all points are now Z-Control, so inspecting the top of the list will suffice.

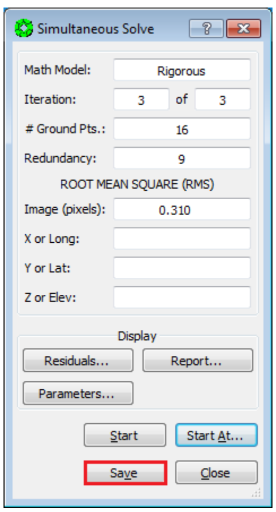


9) If points have pixel errors greater than 2.0 pixels, SKIP TO: 18.4 Point Weights Refinement. Otherwise, continue to the next step.

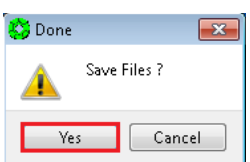
10) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, then Press “Close” on the Multi-Sensor Triangulation Residuals window.



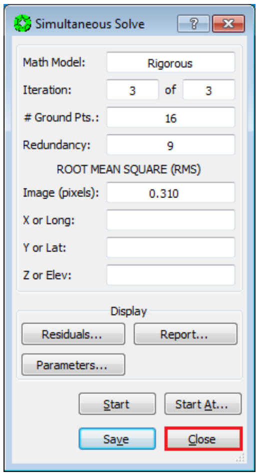
11) Press “Save” on the simultaneous solve window.



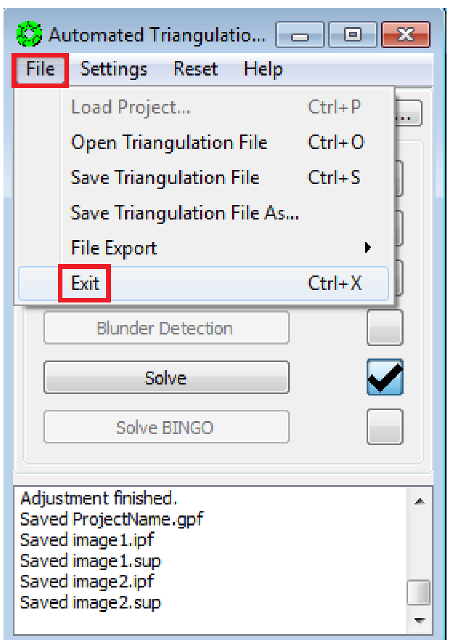
12) Press “Yes” on the Done pop-up window.



13) Press “Close” on the Simultaneous Solve window.



14) Select “File” > “Exit” on the Automatic Triangulation window.



Vertical Adjustment is now complete!

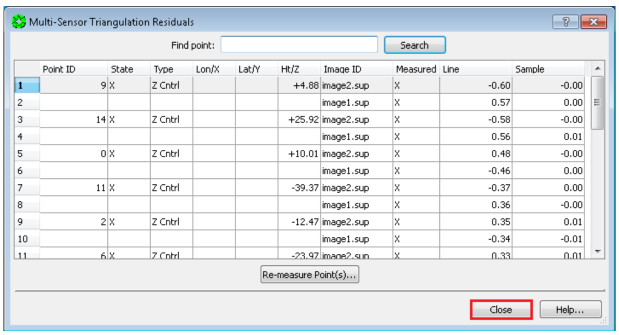
15) SKIP: 18.4 Point Weight Refinement *and* 18.5 Point Re-Measurement Process, GO TO: 18.6 Re-Load Images.

18.4 Point Weights Refinement

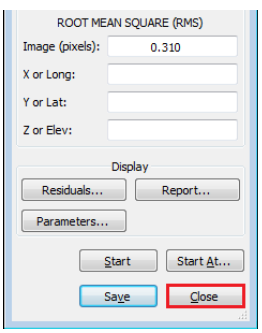
Continuing from 18.3 Bundle Adjustment…

The previous Relative Orientation adjustment should have met the criteria of the Image RMS less than ~0.6 pixels, and individual point errors less than 2.0 pixels. The only change since the Relative Orientation is that we added elevation estimates to the measured points. If the Image RMS < ~0.6 pixels; Point Errors < 2.0 pixels criteria is not met now, the cause is most likely that the weights (i.e., Accuracy Values) assigned to the elevation estimates by "Add Vertical Control" are too stringent. We will first evaluate and adjust Accuracy values. If the criteria of an acceptable solution is still not met after another bundle adjustment (Solve), then we will re-measure points.

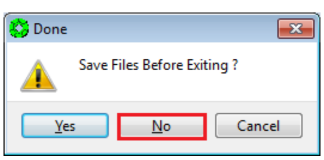
1) From the "Multi-Sensor Triangulation Residuals" window, record (on a piece of paper) the Point ID's of the points with > 2.0 pixel line and/or sample errors. Then close the Residuals window.



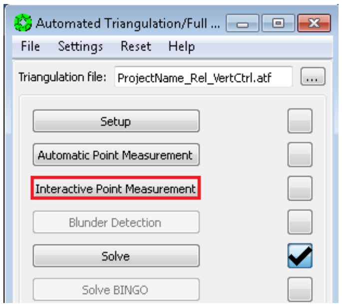
2) Press "Close" on the Simultaneous Solve window. (Do not press "Save".)



3) Press "No" to Saving Files in the Done pop-up window.

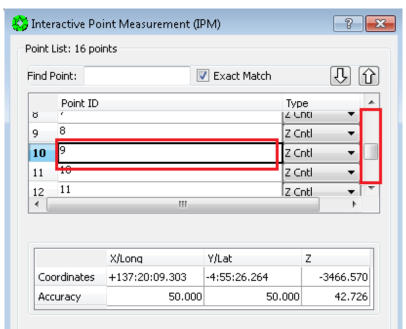


4) Press “Interactive Point Measurement” on the Automated Triangulation window.

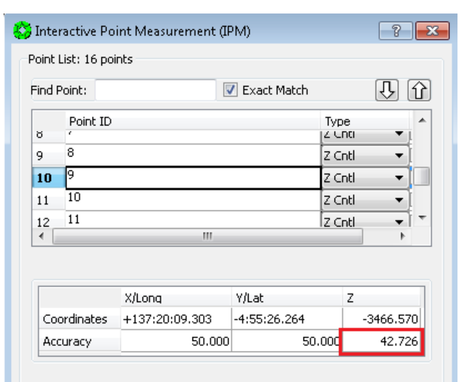


5) For each point recorded on your list:

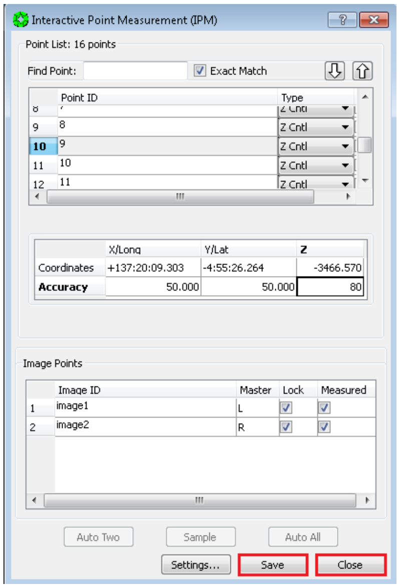
   a. Use the Scroll Bar to the right of the point list, and scroll to the point. Click on the point’s Point ID to select it.



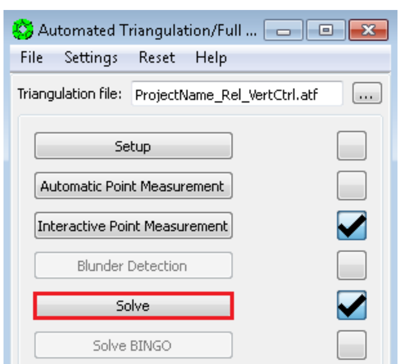
   b. IPM will move the stereo display to the selected point. Look at the measurement in stereo. If the point is on a slope, the Accuracy assigned to the Z coordinate may be too tight. We suggest you **increase the Accuracy by approximately a factor of 2: double click in the Accuracy field for Z, delete the old value and type in the new value, then press the enter key.**



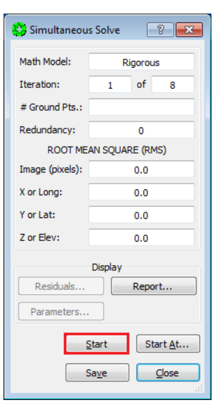
6) When you are done updating Accuracy values, press “Save” then “Close” on the IPM window.



7) Press “Solve” on the Automated Triangulation window.



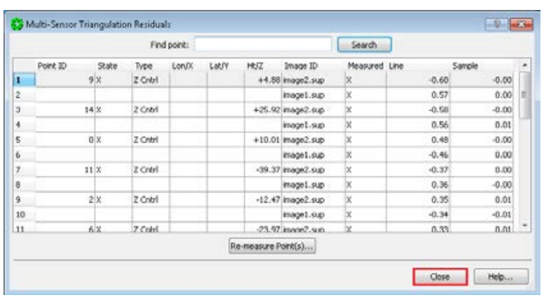
8) Press “Start” on the Simultaneous Solve window.



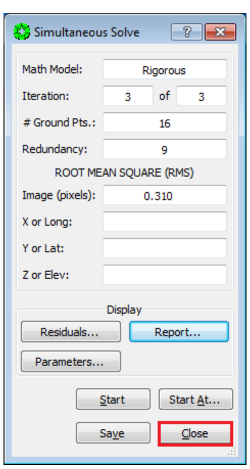
9) Press “Residuals” on the Simultaneous Solve window and make sure no individual point has an error greater than 2 pixels.

10) If the solution continues to have points with larger than 2 pixel errors, the problem may be a bad measurement(s), so GO TO 18.5 Point Re-Measurement Process. Otherwise, continue to the next step.

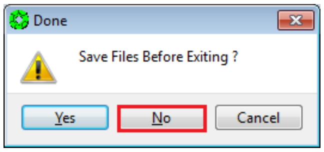
11) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, we will exit Multi-Sensor Triangulation, and re-enter it in order to refresh the values stored in computer memory. First press “Close” on the Multi-Sensor Triangulation Residuals window.



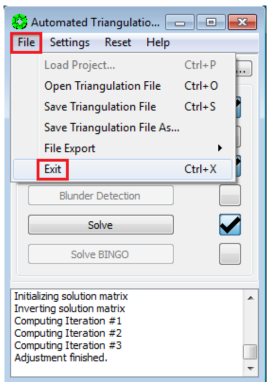
12) Press “Close” on the Simultaneous Solve window (Do Not Press “Save”.)



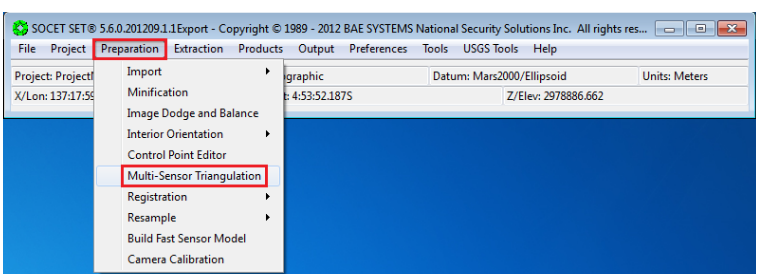
13) Press “No” to Saving Files in the Done pop-up window.



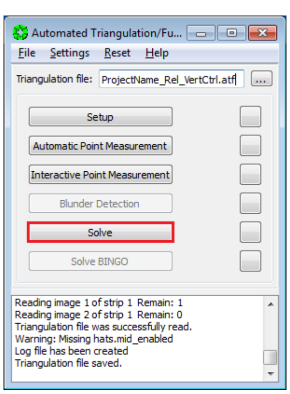
14) Select “File” > “Exit” on the Automatic Triangulation window.



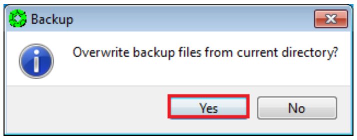
15) Re-enter MST: From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



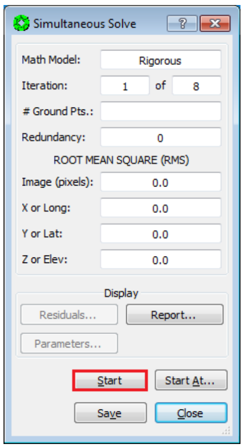
16) Press “Solve” on the Automatic Triangulation window. (The triangulation file, <ProjectName>_Rel_VertCtrl should load automatically.)



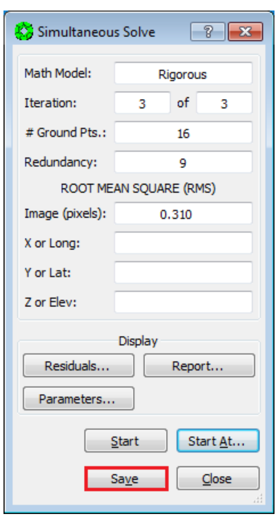
17) Press “Yes” on the pop-up to overwrite back up files.



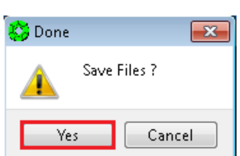
18) Press “Start” on the Simultaneous Solve window.



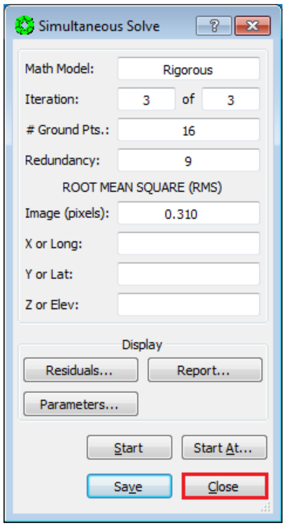
19) If the Image (pixels) RMS is < ~0.6 pixels, Press “Save” on the Simultaneous Solve window.



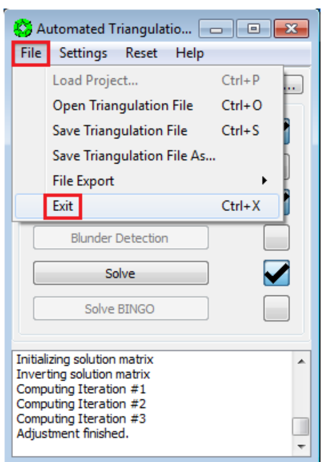
20) Press “Yes” on the Done pop-up window.



21) Press “Close” on the Simultaneous Solve window.



22) Select “File” > “Exit” on the Automatic Triangulation window.



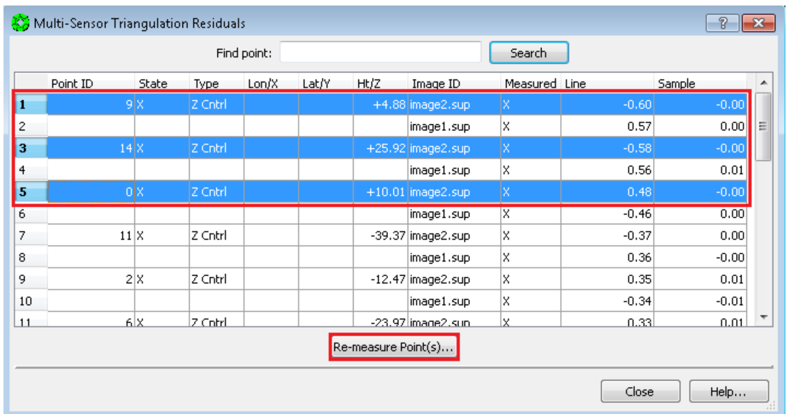
Vertical Adjustment is now complete!

23) SKIP: 18.5 Point Re-Measurement Process, GO TO: 18.6 Re-Load Images.

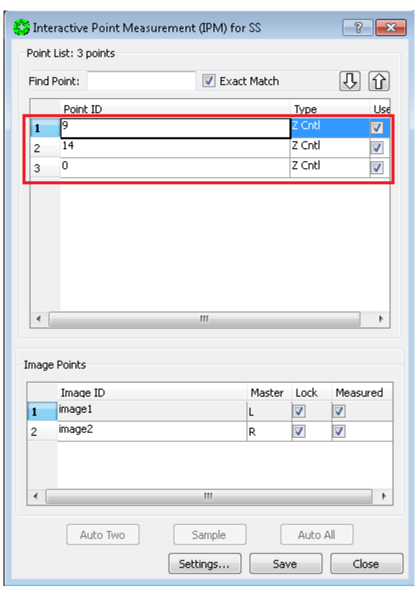
18.5 Point Re-Measurement Process

Continuing from 18.4 Point Weights Refinement…

1) On the "Multi-Sensor Triangulation Residuals" window, Left-Click on the Point ID(s) of the points to re-measure. (Hold the Control Key down to select multiple points.) Then press "Re-measure Point(s)…". The re-measure point window will now open with the points selected.

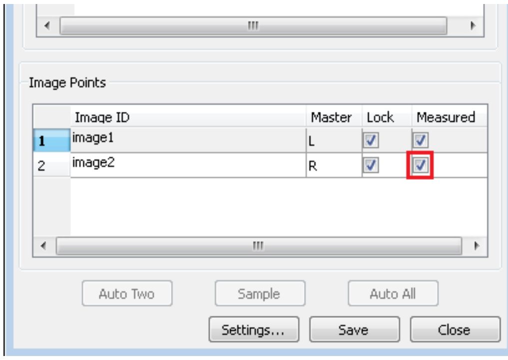


2) Left-Click on the point to re-measure. The View 1 (stereo display) window will display the current point measurement.



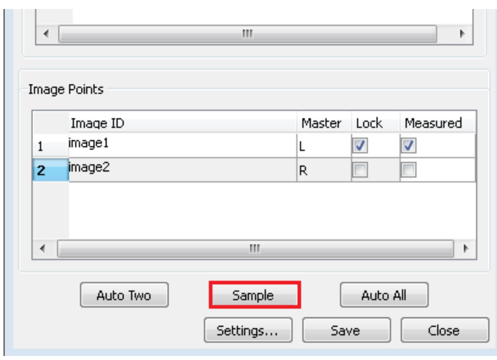
3) Un-check the Measured box for the Right image only, to remove parallax.

NOTE: Relocating the point is not advised because there is now an elevation estimate associated with the point.

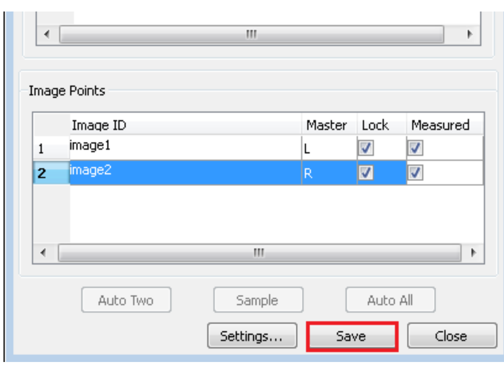


4) Clear the parallax by moving the Right image only (i.e., put the dot on the ground).

5) Press “Sample” to collect the point measurement.

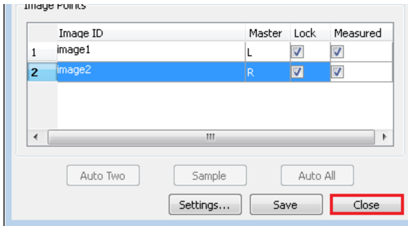


6) Press “Save” write the measurement to disk.

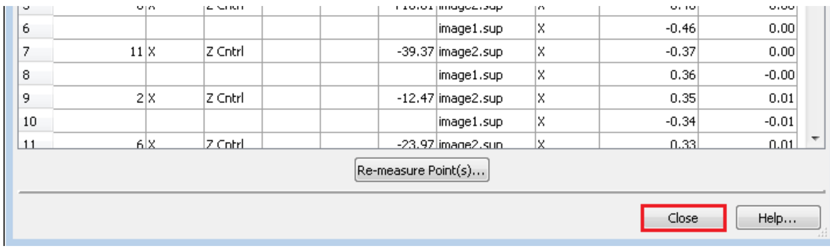


7) Repeat re-measurement process for remaining points in the list. (Go back to step 2.)

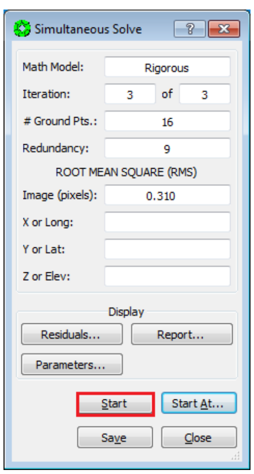
8) After points in the list are re-measured press “Close”.



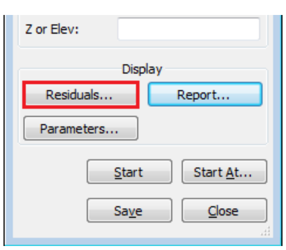
9) Press “Close” on the Multi-Sensor Triangulation Residuals window.



10) Press “Start” on the Simultaneous Solve window.

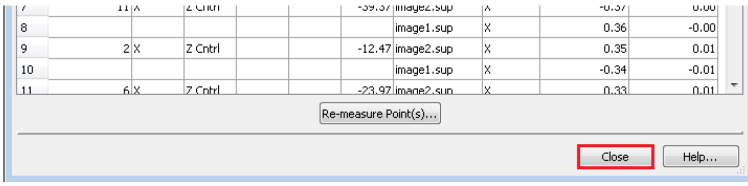


11) Press “Residuals” on the Simultaneous Solve window and make sure no individual point has an error greater than 2 pixels.

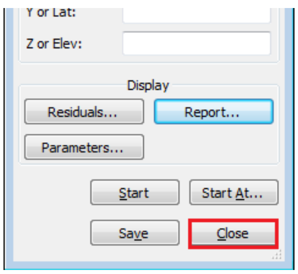


12) If there are points with larger than 2 pixel errors, repeat the Point Re-Measurement Process starting from step 1.

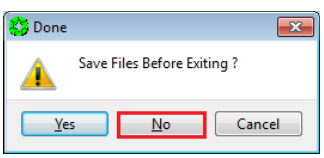
13) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, we will exit Multi-Sensor Triangulation, and re-enter it in order to refresh the values stored in computer memory. First press "Close" on the Multi-Sensor Triangulation Residuals window.



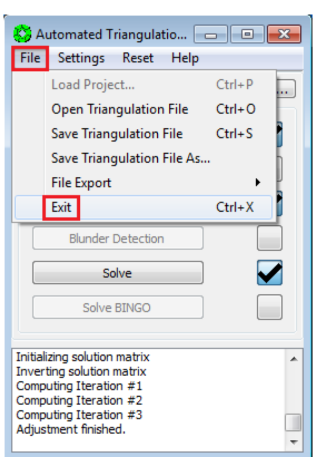
14) Press "Close" on the Simultaneous Solve window (Do Not Press "Save".)



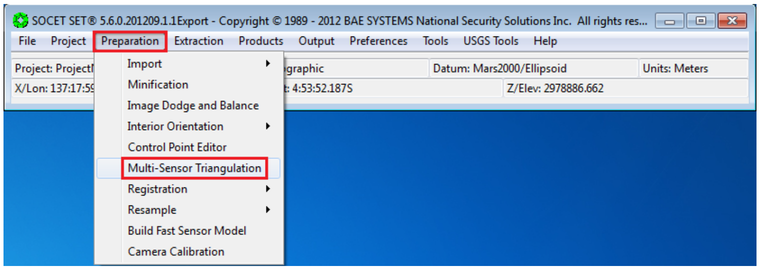
15) Press "No" to Saving Files in the Done pop-up window.



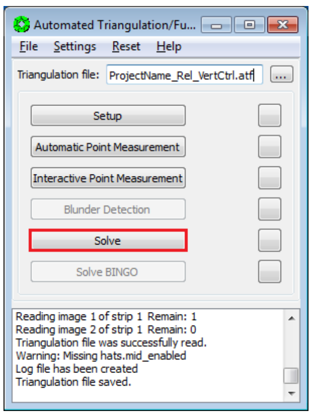
16) Select "File" > "Exit" on the Automatic Triangulation window.



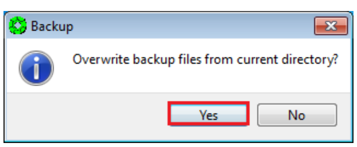
17) Re-enter MST: From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



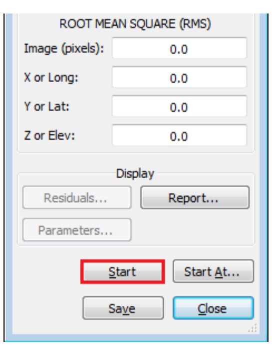
18) Press “Solve” on the Automatic Triangulation window. (The triangulation file, <ProjectName>_Rel_VertCtrl should load automatically.)



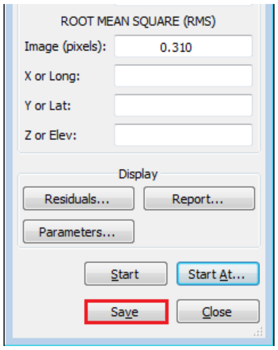
19) Press “Yes” on the pop-up to overwrite back up files.



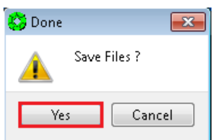
20) Press “Start” on the Simultaneous Solve window.



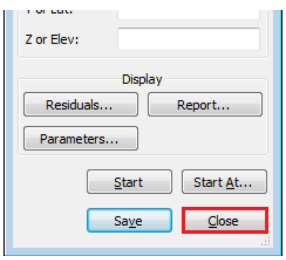
21) If the Image (pixels) RMS is < ~0.6 pixels, Press “Save” on the Simultaneous Solve window.



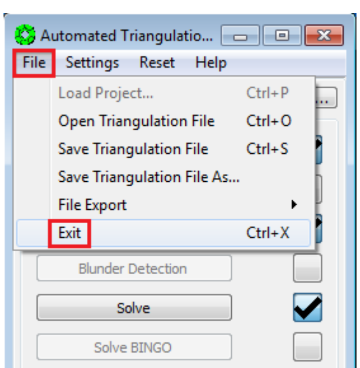
22) Press “Yes” on the Done pop-up window.



23) Press “Close” on the Simultaneous Solve window.



24) Select “File” > “Exit” on the Automatic Triangulation window.

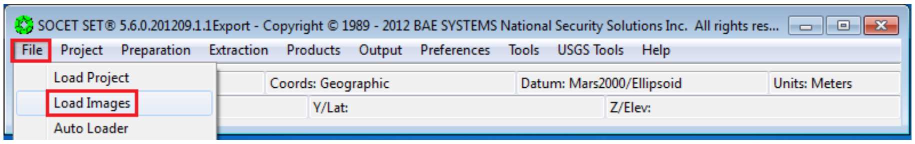


Vertical Adjustment to MOLA is now complete!

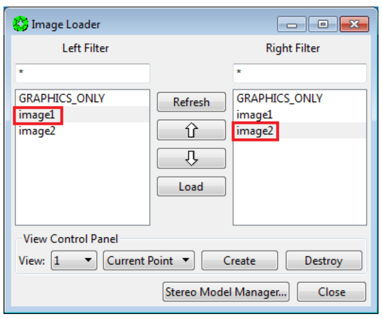
18.6 Re-Load Images

After the Vertical Adjustment to MOLA is complete, it is necessary to re-Load the images in order to view them with the results of the adjustment.

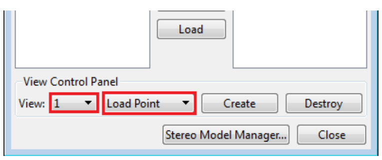
1) From the SOCET SET menu bar, select “File” > “Load Images”.



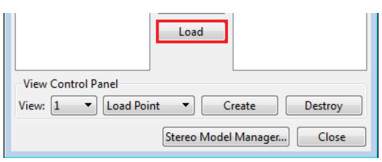
2) In the Image Loader window, select the Left and Right Image to display by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)



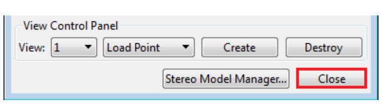
3) Under “View Control Panel” settings: Ensure that View = 1 and that “Load Point” is selected.



4) Press “Load”.



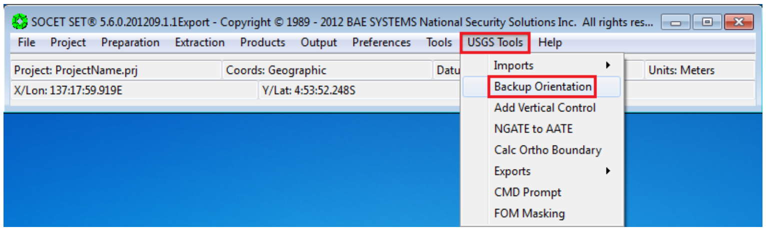
5) Press “Close”



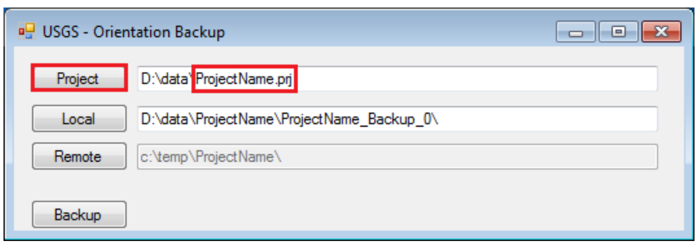
18.7 Backup Vertical Adjustment Results

At this point, it is prudent to backup the project data in order to have a re-entry point for the up-coming Absolute Orientation of the stereo images to MOLA.

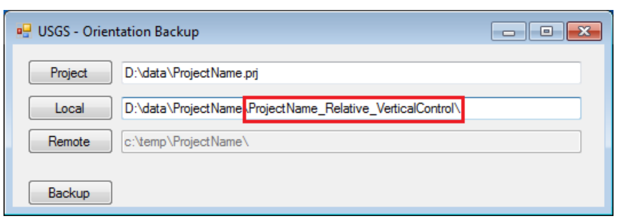
1) From the SOCET SET menu bar, select “USGS Tools” > “Backup Orientation”.



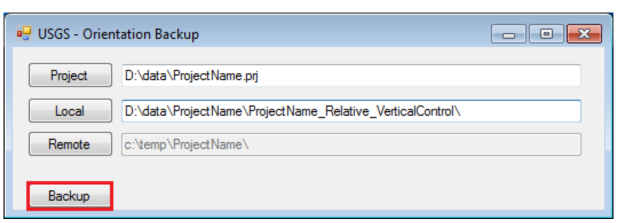
2) **Make sure the current project name is listed in the Project field. If not, press “Project” to select the current project, then press “OK”.** (Otherwise the backup will be made in, and for, the wrong project!)



3) Replace **Backup_0** with **Relative_VerticalControl** in the “Local” folder name field. The backup folder will be named <ProjectName>_Relative_VerticalControl.



4) Press “Backup”.



19Image Control Stage 3: Absolute Orientation

19.1 Overview

The objective of this stage is to better align the stereo model to the surface topography represented by the MOLA tracks. This step is highly subjective in nature and the analyst should look for "trends" in the stereo model not fitting the altimetry tracks. The goal will be to look for shifts in the XY plane and to identify the movement required to make the entirety of the stereo coverage align the tracks properly through the use of horizontal control gathered from the MOLA Tracks.

Subjectively picking horizontal control is not an exact process, so we will use a *single* horizontal control point to translate the stereo pair in alignment with the MOLA Tracks. Using more than one horizontal control point can distort (buckle, twist, stretch) the stereo model if multiple points are inaccurate.

If there are not adequate MOLA Track data for horizontal control (either the MOLA tracks are too sparse, or the terrain is too flat to tie a feature to an XY location) we will stop the controlling process and use the "dead-reckoning" results of the Vertical Alignment. (Note that in the Vertical Alignment, horizontal positioning is controlled by holding the nadir-most image, and accurate to the level of the nadir-most image's position and pointing accuracy.)

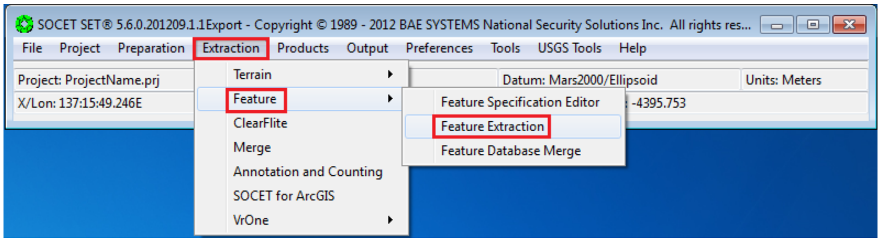
NOTE:

1) In this procedure, we will use the Feature Extraction, Coordinate Measurement and Multi-Sensor Triangulation tools. Many windows will be open, so try to arrange them on the console monitor to allow easy access between tools.

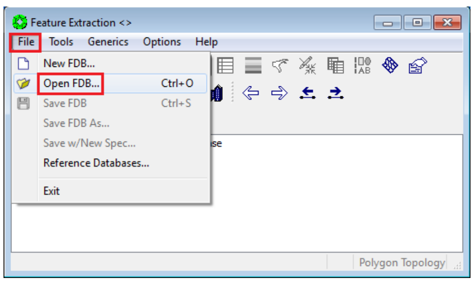
2) You may also encounter erroneous MOLA Tracks that appear out of alignment with surrounding tracks. The erroneous tracks should be ignored.

19.2 Evaluate MOLA Tracks for Horizontal (XYZ) Control

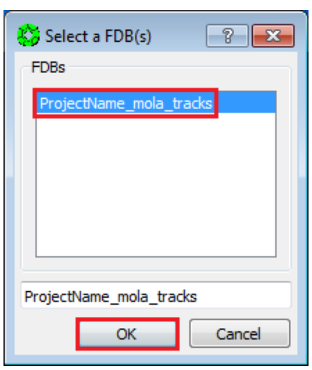
1) From the SOCET SET menu bar, select “Extraction” > “Feature” > “Feature Extraction”.



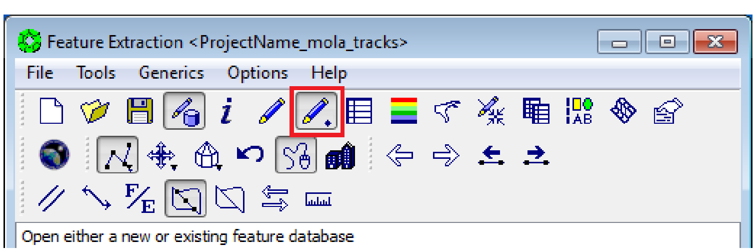
2) From the Feature Extraction window select “File” > “Open FDB…”.



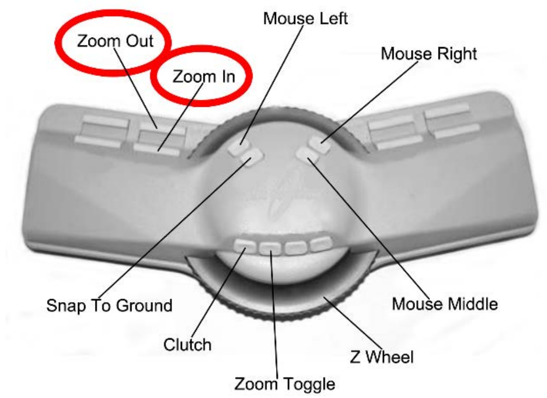
3) Select <ProjectName>_mola_tracks, and press “OK”.



4) Make sure Auto-Draw is on. Press the “Auto-Draw” icon until it appears in a depressed state.

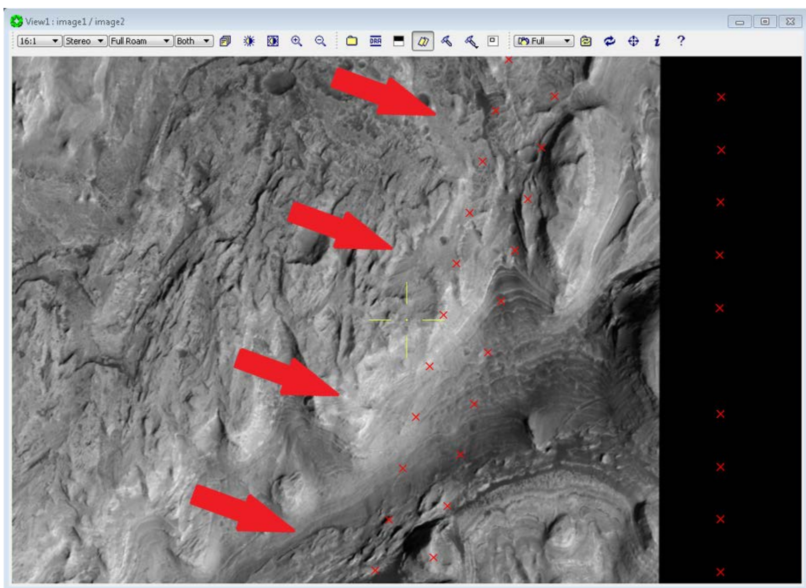


5) Using the Zoom In or Zoom out buttons on the TopoMouse, set the Zoom Level to 16:1 in order to have an overview of the relief of the tracks and the relief in the stereo model.



6) Roam the stereo model to discern if horizontal movement of the stereo images would better align the stereo model to the altimetry (e.g., MOLA) tracks.

   Note: The images loaded must be from the Vertical Alignment solution so that the tracks are closer to the stereo surface vertically.



7) If no trend in terrain shift can be identified, then the Image Control process is complete. Close the Feature Extraction window, and SKIP to 20 Epipolar (Pair-Wise) Rectify Controlled Images.

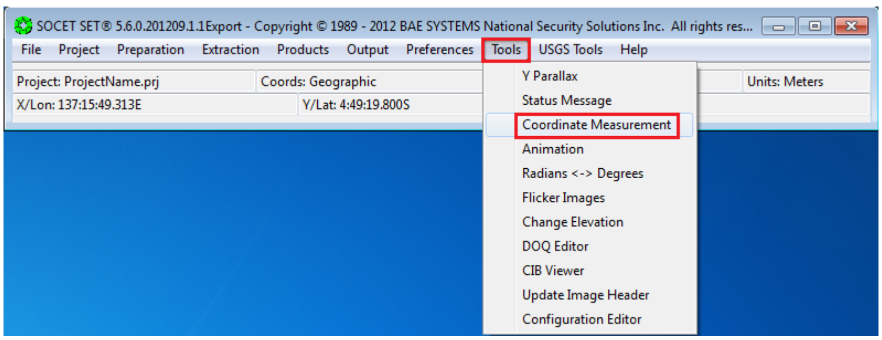
19.3 Determine Horizontal Control Point

Continue on in Feature Extraction to identify a horizontal control point as follows:

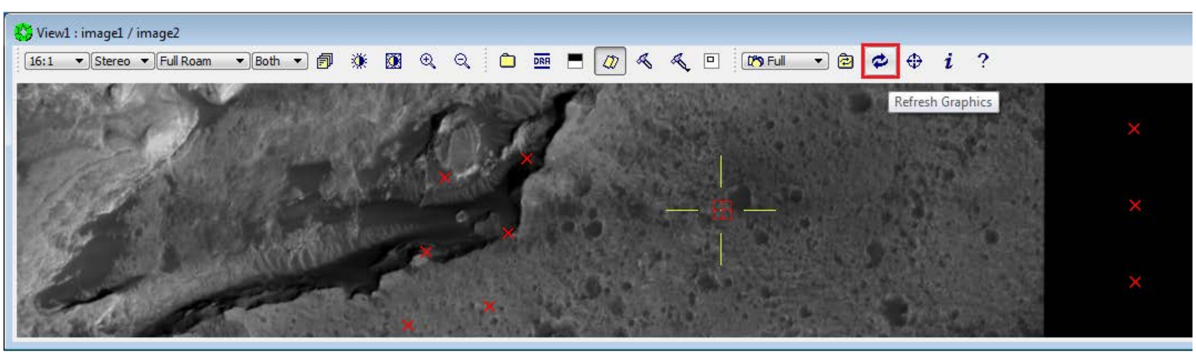
1) Roam the stereo model and visually correlate a distinguishable trend in one of the MOLA tracks (e.g., the tracks going over a ridge), with a distinguishable feature in the stereo model (e.g., a ridge). Zoom-In and Zoom-Out during the search for these features.

2) In the identified trend, choose a single MOLA track point to "tie" to a distinguishable correlated feature in the stereo model.

3) From the SOCET SET menu bar, select "Tools" > "Coordinate Measurement". (We will use Coordinate Measurement to store the coordinates of the MOLA Track point to be used for XYZ control.)

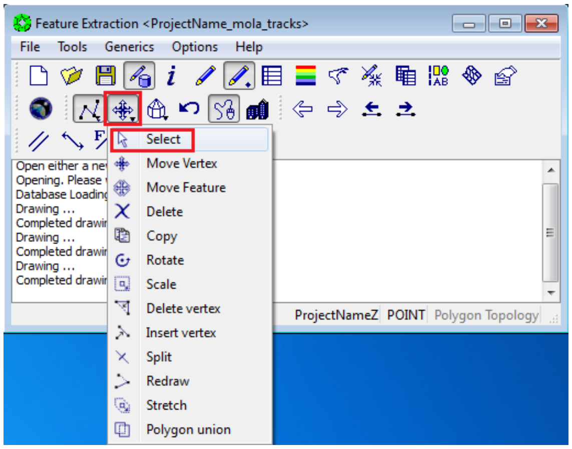


4) On the View1 (stereo display window), press the "Refresh Graphics" icon to remove the anchor point drawn by Coordinate Measurement. Wait for the MOLA Tracks to re-draw.

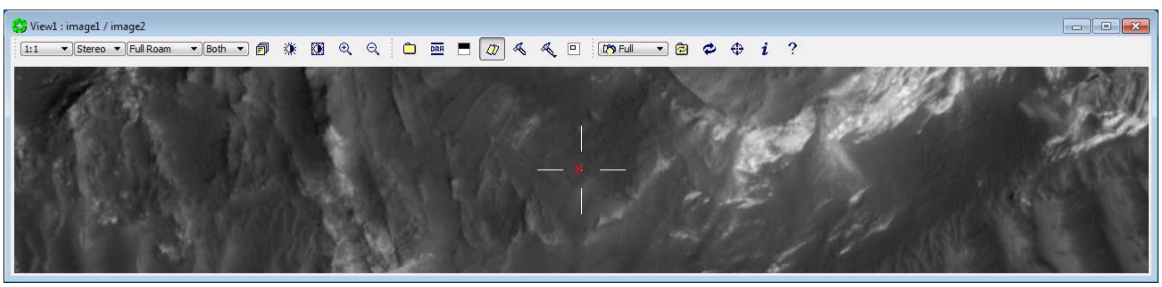


5) In the Feature Extraction window, hold the Edit icon down to display a menu of available “Edit Tools”. Select the “Select” tool.

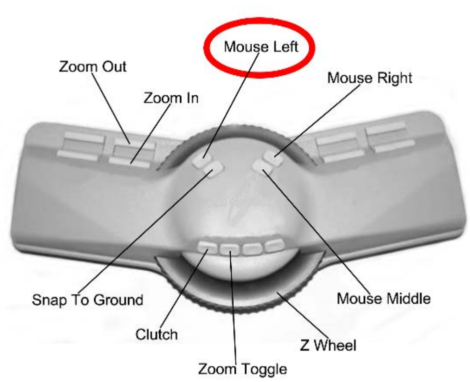
Note: The Edit icon will now appear as a white arrow and should be seen in a depressed state. The extraction cursor on the stereo display has also changed in color to white.



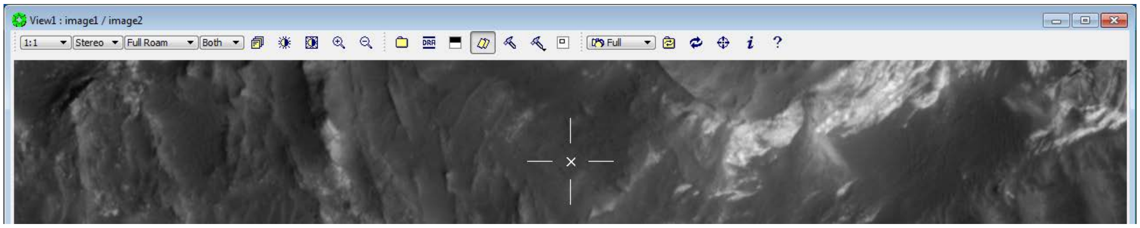
6) Move the extraction cursor close to the MOLA Track point of interest (i.e., the one that is correlated with a feature in the stereo model.) Zoom to 1:1 and refine the placement of the extraction cursor if needed.



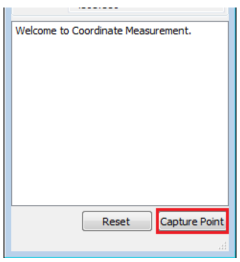
7) Press the Left Mouse button on the TopoMouse to select the track point.



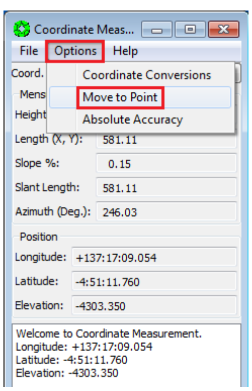
The extraction cursor will jump to the MOLA Track point, and the selected track point will be displayed as white.



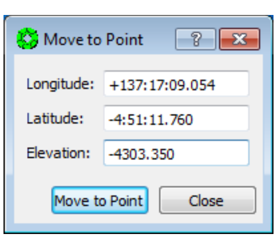
8) **DO NOT MOVE THE TOPOMOUSE**. (If you think you moved it, re-select the track point before proceeding.) On the Coordinate Measurement window, select Capture Point. This will record the longitude, latitude and elevation of the selected MOLA track point in the report section of the Coordinate Measurement window.



9) On the Coordinate Measurement Tool window, select “Options” > “Move To Point”.

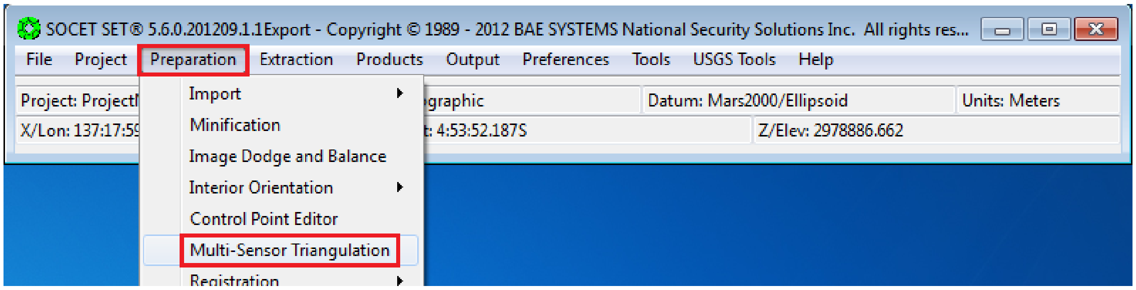


The “Move To Point” window will appear, populated with the coordinates of the MOLA Track point.

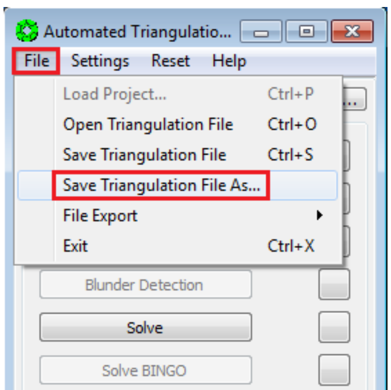


19.4 Absolute Orientation Setup

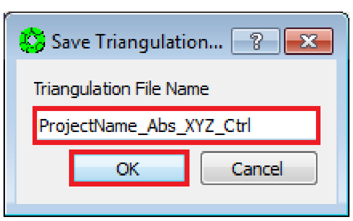
1) From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



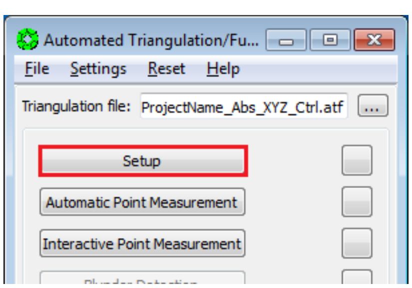
2) Select “File” > “Save Triangulation File As…” in the Automated Triangulation window.



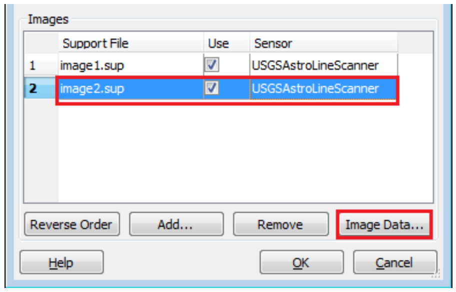
3) In the pop-up window, enter <ProjectName>_Abs_XYZ_Ctrl, and press “OK”.



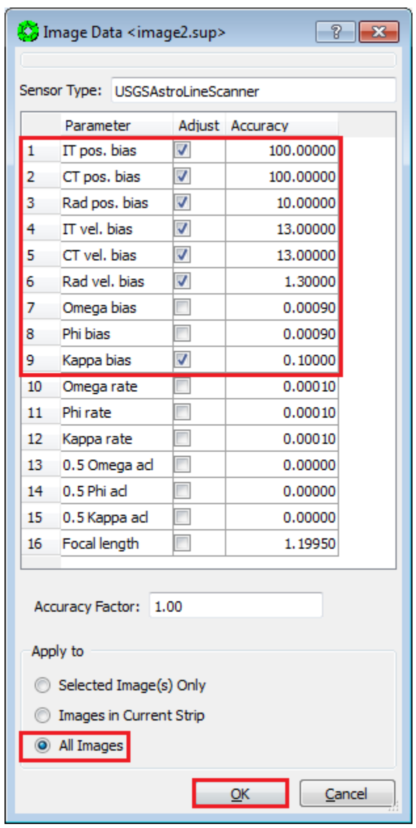
4) Press “Setup” on the Automated Triangulation window. We will be setting up image parameters for an Absolute Orientation (where both images will be allowed to adjust.)



5) In the Setup window, select the oblique image of the stereo pair, and press “Image Data…”.



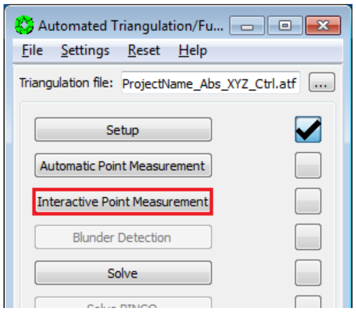
6) Insure the Adjustable Image Parameters are as shown, Press the radio button for “All Images”, and then press “OK”. (These adjustable parameters will be copied to the nadir-most image.)



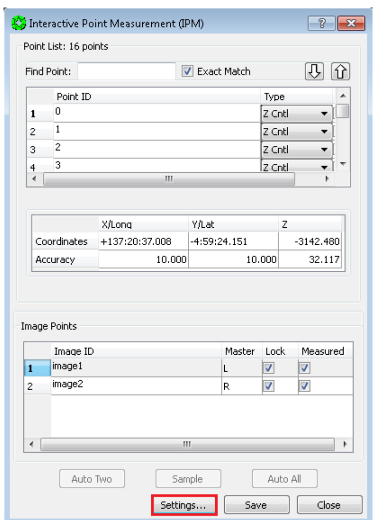
Parameter	Accuracy
IT pos. bias	100 m
CT pos. bias	100 m
Radial pos. bias	10 m
IT vel. bias	13 m/s
CT vel. bias	13 m/s
Radial vel. bias	1.3 m/s
Kappa bias	0.1 degree

19.5 Measure Horizontal Control Point

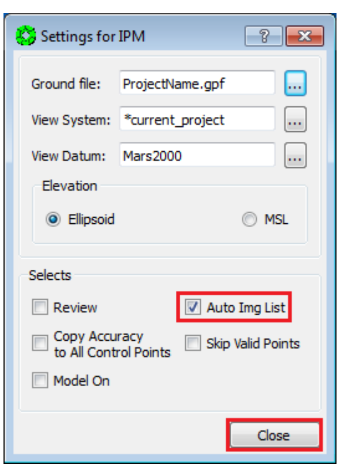
1) Press “Interactive Point Measurement” on the Automated Triangulation window.



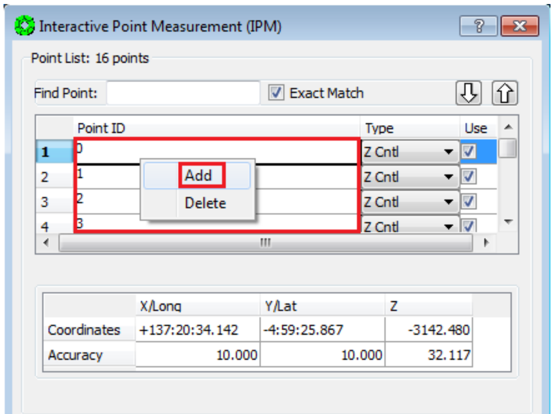
2) Press “Settings” in the Interactive Point Measurement (IPM) window.



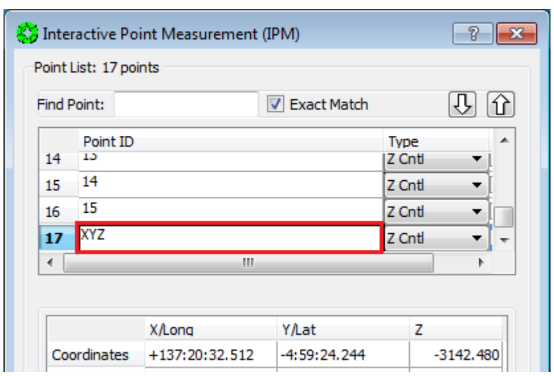
3) In the Settings for IPM window, make sure the “Auto Img List” box is checked, then press “Close”.



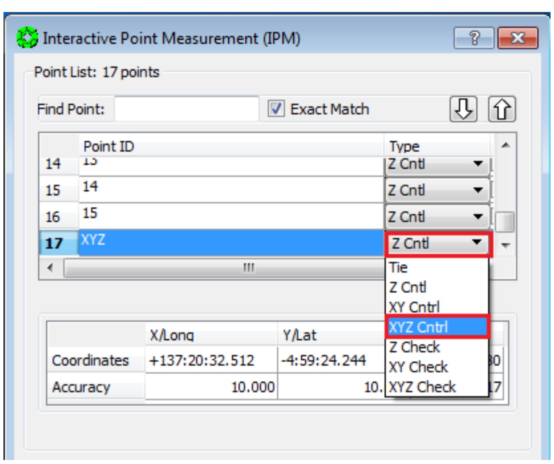
4) Right Click in the Point ID field, and Select "Add" in the pop-up window.



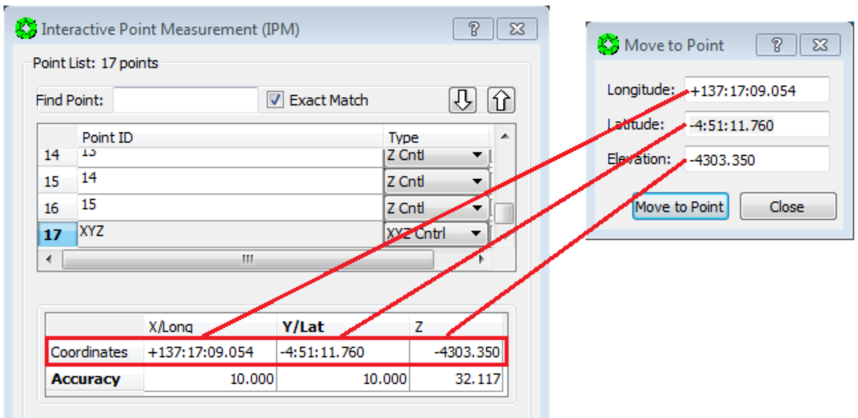
5) IPM will automatically scroll to the bottom of the list to where the new point is added. Double left-click on the Point ID of the new point to enable editing the default id. Replace the current id (e.g., 16) with XYZ and press the enter key.



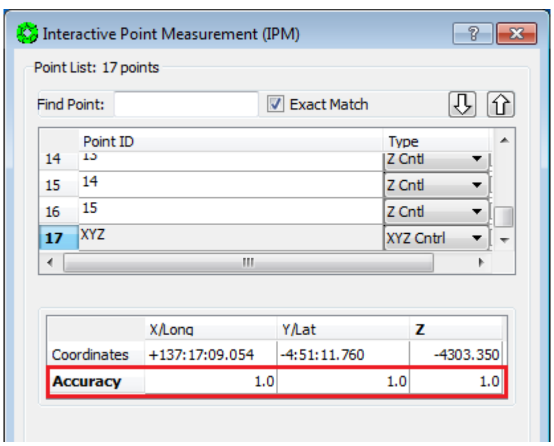
6) For this new point, click on its Type field (i.e., the box that says Z Ctrl) to bring up the Point Type Options. Select "XYZ Ctrl" from the list of options.



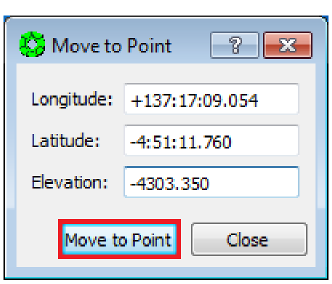
7) From the Move To Point window, Copy the Longitude, Latitude and Elevation coordinates, and Paste them into the Coordinates fields for the XYZ point. Make sure not to leave behind any negative signs. (Alternatively, you can copy the captured coordinates listed in the Coordinate Measurement window.)



8) Set the Accuracy values for the Longitude, Latitude and Z coordinates to 1 meter each. (We are going to hold to this coordinate tightly.)

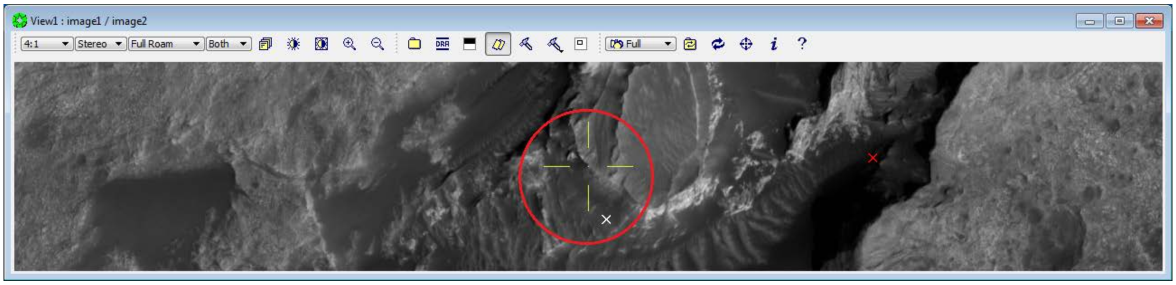


9) On the Move To Point window, press “Move To Point”. This will move the extraction cursor to the location of the selected MOLA Track point. (The selected track point will still be colored white.)

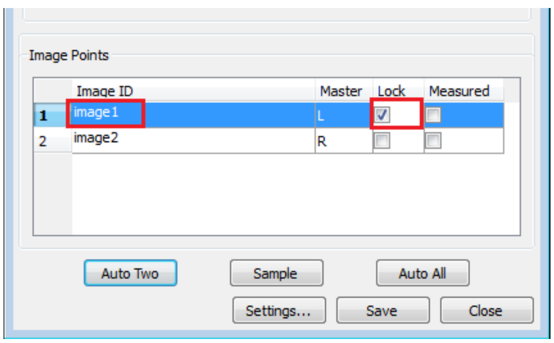


10) Place the extraction cursor on the feature in the stereo model you want to correlate with the selected track point. (Make sure the extraction cursor is on the ground.)

    In the following figure, the area circled in red shows an example of a selected track point (the white x), and the location of a feature to correlate with the track point (the center of the yellow extraction cursor).

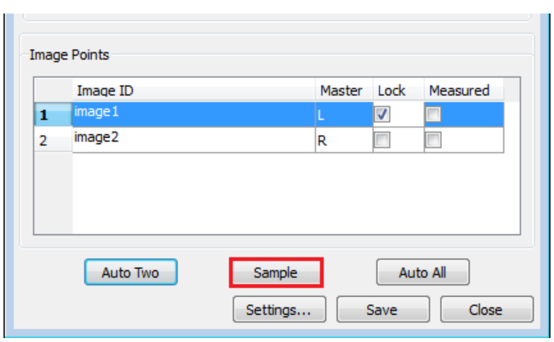


11) In the IPM window, lock the Left image by checking the Lock box.

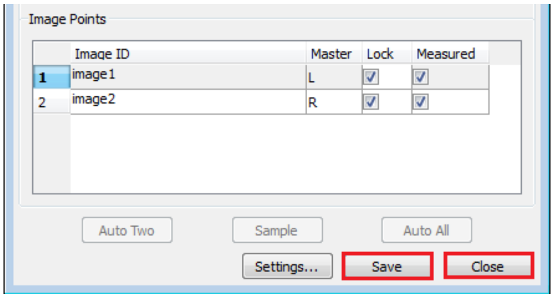


12) Refine the parallax removal (at ground level) by moving the Right image only. In other words, put the dot on the ground.

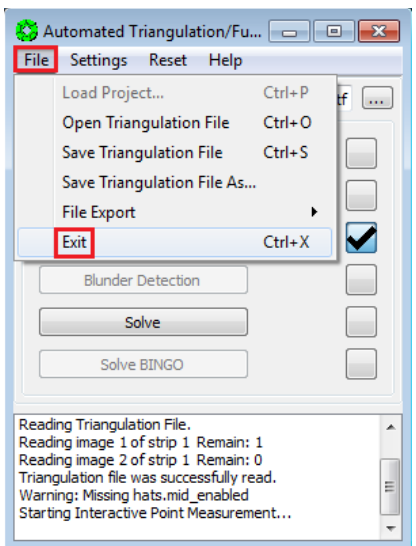
13) Press “Sample” on the IPM window to collect the point measurement.



14) Press “Save” on the IPM window to write the measurement to disk. Then press “Close”.



15) Select “File” > “Exit” on the Automated Triangulation window.

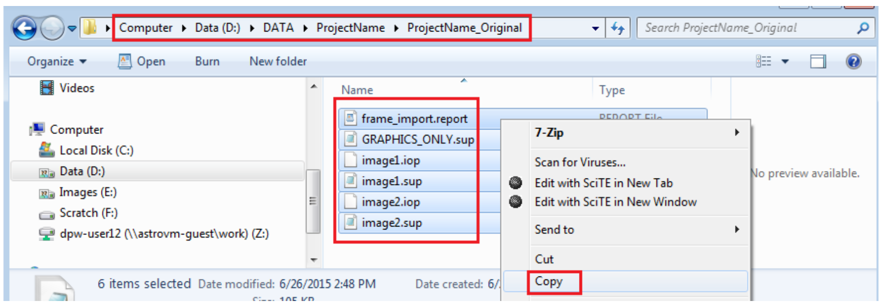


19.6 Iterative Steps to Fine-Tune XYZ Control Point

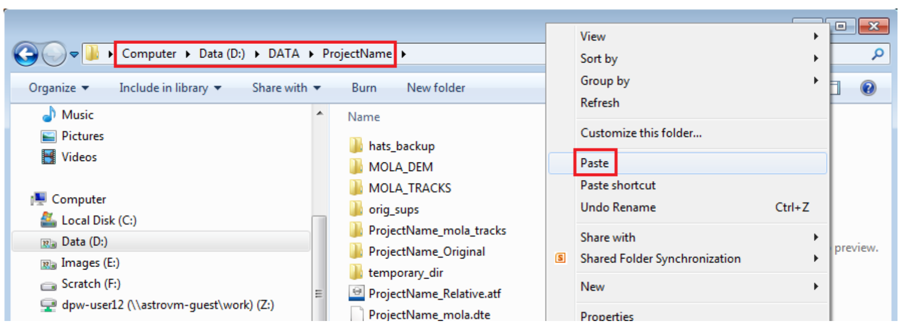
The following steps, preceded with **, are iterative. The process stops when you have established an XYZ Control point that aligns the stereo model to the MOLA tracks at a level that meets your needs.

19.6.1 **Restore Original (A-Priori) Support Files

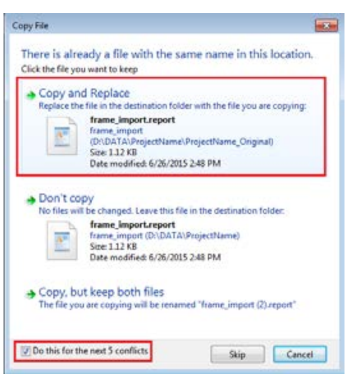
1) Open Windows Explorer. Navigate to D:\DATA\<ProjectName>\<ProjectName_Original, select all the files in the folder, and Copy them.



2) Move up one folder so you are now in D:\DATA\<ProjectName>, and paste the files.



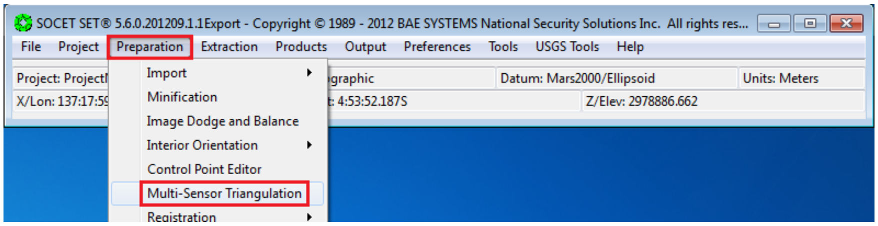
3) In the pop-up window, check the box in the lower left corner to "do this for the next 3 conflicts", then select "Copy and Replace".



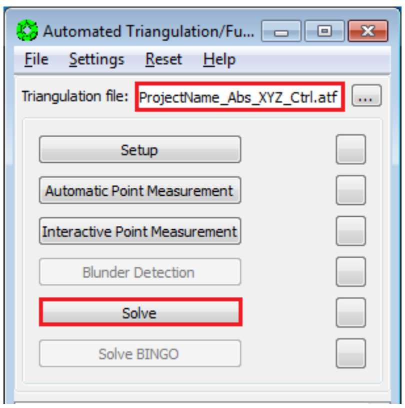
4) Close the Windows Explorer window.

19.6.2 **Bundle Adjust

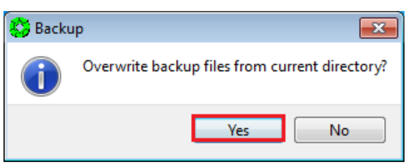
1) From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”



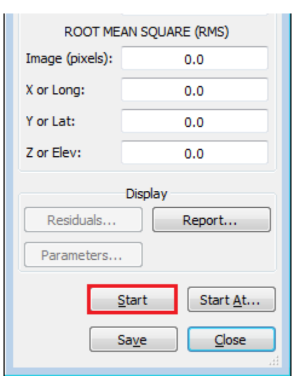
2) In the Automated Triangulation window, press “Solve”. (Note that <ProjectName>_Abs_XYZ_Ctrl was automatically loaded.)



3) Press “Yes” on the pop-up to overwrite back up files.



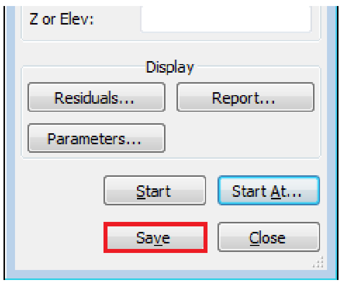
4) Press “Start” in the “Simultaneous Solve” window.



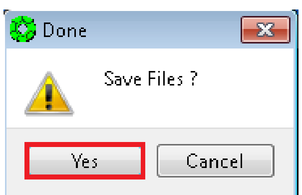
5) If the Image Pixels RMS has not "blown up" (e.g., it is under 1 pixel), press "Save" on the simultaneous solve window.

Note: Because finding the image location of the XYZ (track) point is iterative, getting a "perfect" solution at each iteration is not efficient. Later on we will evaluate the individual point errors.

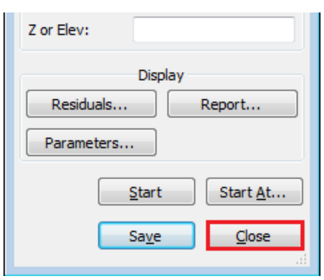
If the Image RMS is more than 1 pixel, the likely problem is that the XYZ Control point is mis-measured or has an error in its Coordinates. To check it, press "Close" on the "Simultaneous Solve" window; select "No" for saving files, then go back into IPM to check the XYZ point.



6) Press "Yes" on the Done pop-up window.



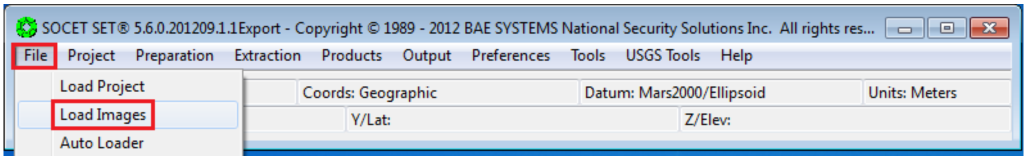
7) Press "Close" on the Simultaneous Solve window.



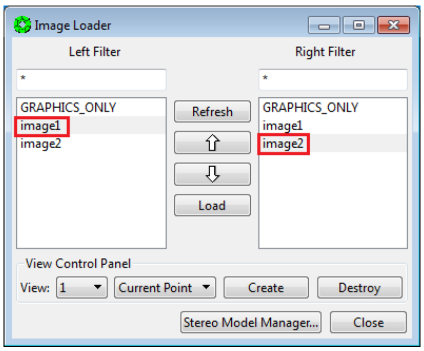
19.6.3 **Re-Load Images

It is necessary to Re-Load the images in order to view the stereo images with the results of the horizontal adjustment.

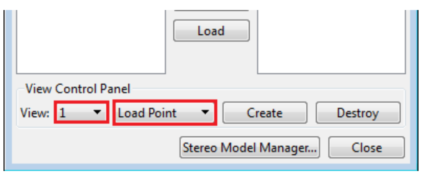
1) From the SOCET SET menu bar, select "File" > "Load Images".



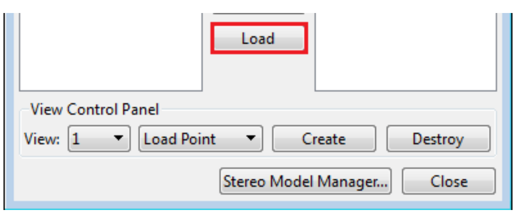
2) In the Image Loader window, select the Left and Right Image to display by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)



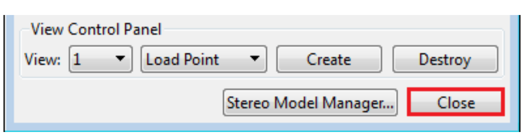
3) Under "View Control Panel" settings: Ensure that View = 1 and that "Load Point" is selected.



4) Press "Load".



5) Press "Close".



19.6.4 **Evaluate Horizontal Shift of Stereo Model

1) Roam the stereo model to evaluate the new alignment of the stereo model to the MOLA Tracks. Now that the stereo model is closer to truth, it should be easier to decide how to further move the stereo model to better align it with the MOLA Tracks. You will have three options:

   a. If you want to **tweak the placement** (image measurement) of the currently selected track point:

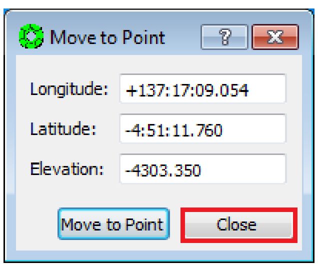
      i. **GO TO 19.6.5 Re-Position Current Horizontal Control Point.**

   b. If you want to **select a different track point** for horizontal control:

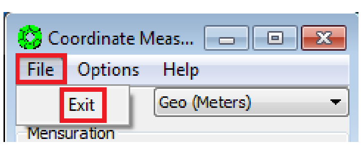
      i. **GO TO 19.6.6 Select Different Horizontal Control Point**

   c. If the **alignment is satisfactory**:

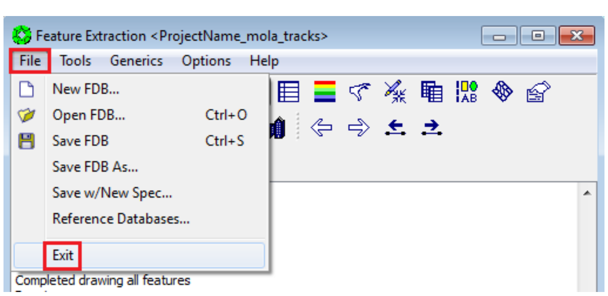
      i. Press “Close” on the “Move to Point” window.



      ii. Select “File” > “Exit” on the Coordinate Measurement window.



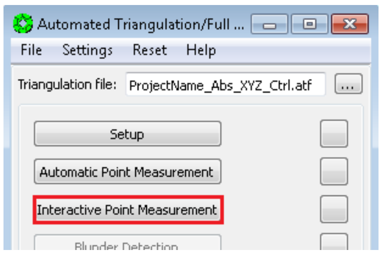
      iii. Select “File” > “Exit” on the Feature Extraction window.



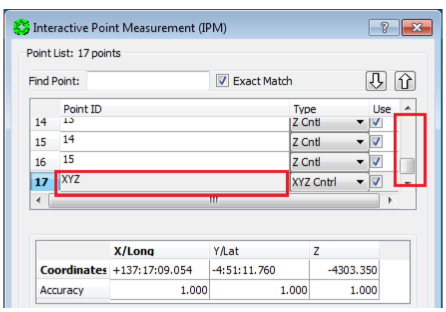
iv. GO TO 19.7 Update Vertical (Z) Control.

19.6.5 **Re-Position Current Horizontal Control Point

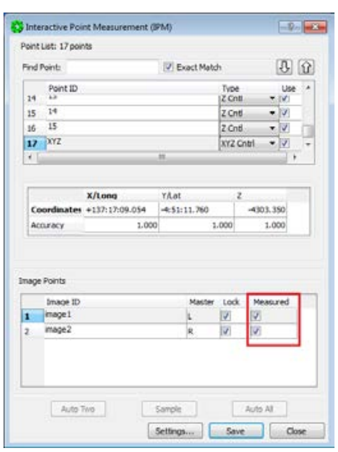
1) Press “Interactive Point Measurement” on the Automated Triangulation window.



2) Use the Scroll Bar to the right of the point list, and scroll to the bottom of the list. Click on the Point ID of the XYZ Control point to select it. (IPM will move the stereo display to the measured point.)

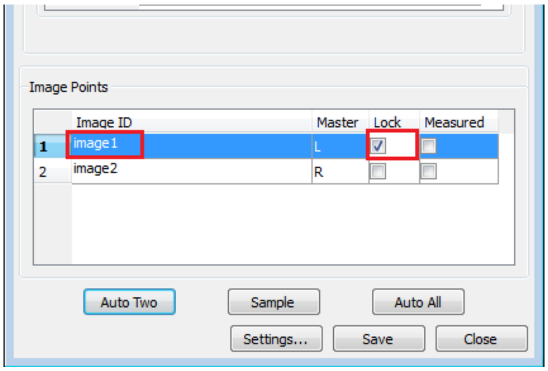


3) Un-check the boxes in the “Measured” field for both images. (This will also unlock both images so that point can be measure at another location.)



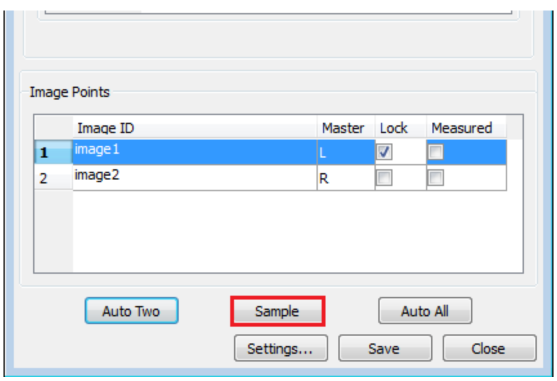
4) Place the extraction cursor on the new location/feature in the stereo model you want to correlate with the selected track point. (Make sure the extraction cursor is also on the ground.)

5) In the IPM window, lock the Left image by checking its Lock box.

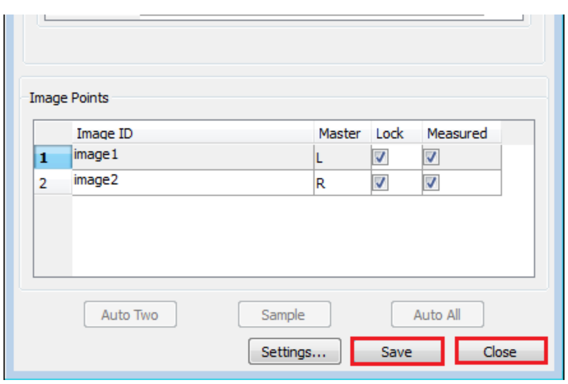


6) Refine the parallax removal (at ground level) by moving Right image only. In other words, put the dot on the ground.

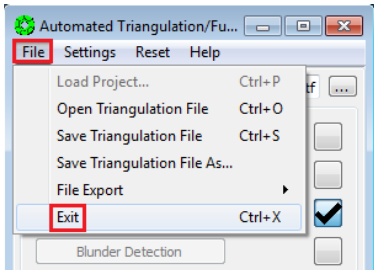
7) Press "Sample" on the IPM window to collect the point measurement.



8) Press "Save" on the IPM window to write the measurement to disk. Then press "Close".



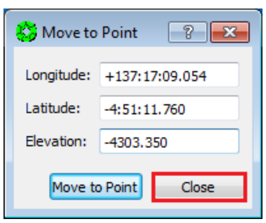
9) Select “File” > “Exit” on the Automated Triangulation window.



10) GO TO 19.6.1 **Restore Original (A-Priori) Support Files, and reiterate.

19.6.6 **Select Different Horizontal Control Point

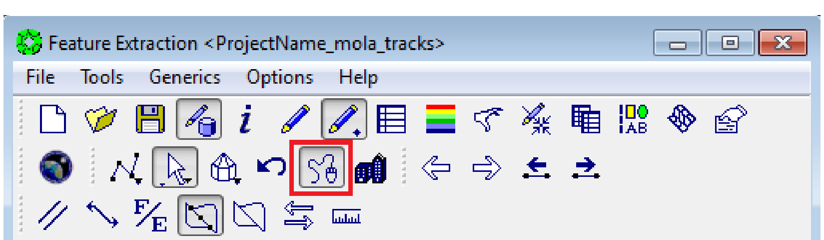
1) Close the Move To Point window (but keep the Coordinate Measurement tool running.)



2) Roam the stereo model and visually correlate a distinguishable trend in one of the MOLA tracks (e.g., the tracks going over mound), with a distinguishable feature in the stereo model (e.g., a mound). Zoom-In and Zoom-Out during the search for these features.

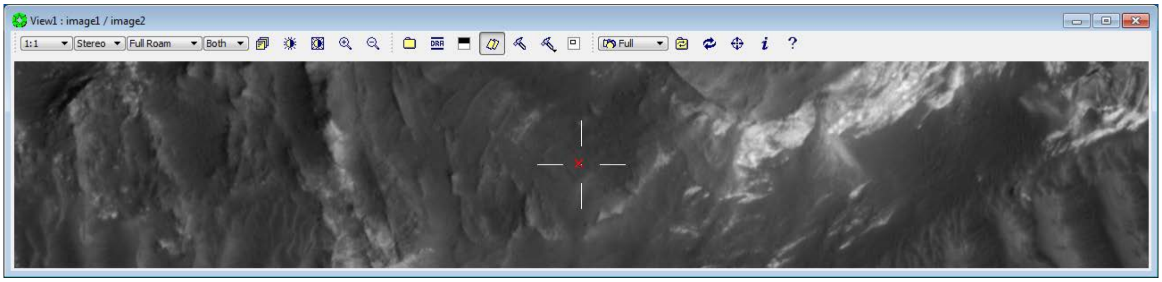
3) In the identified trend, choose a single MOLA track point to “tie” to a distinguishable correlated feature in the stereo model.

4) Press the “On-Line” icon on the Feature Extraction window. This will give control of the extraction cursor back to the Feature Extraction Tool.

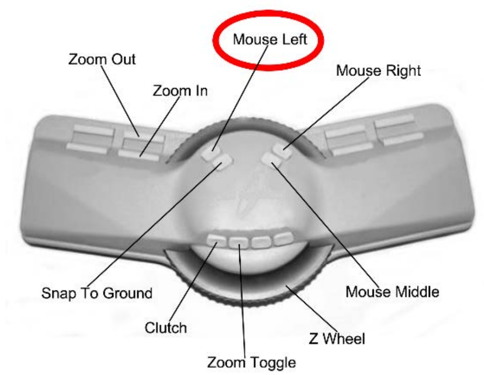


Note: Interactive Point Measurement (IPM) takes automatic control of the extraction cursor and IPM cannot be running when we use the Feature Extraction tool. If IPM is running, you must exit it before returning to the Feature Extraction tool. There is no conflict if the main Automated Triangulation window remains open.

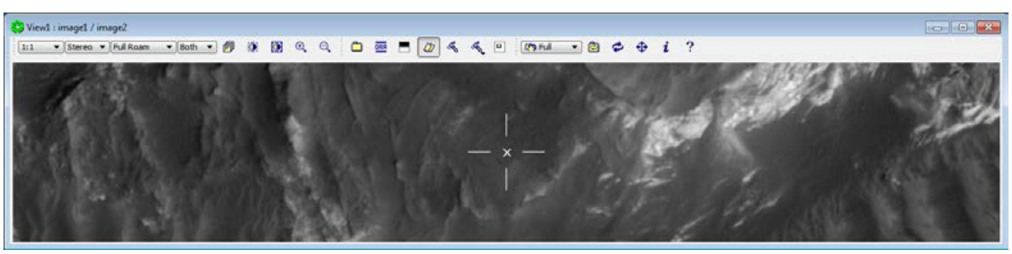
5) Move the extraction cursor close to the MOLA Track point of interest (i.e., one that is correlated with a feature in the stereo model.) Zoom to 1:1 and refine the placement of the extraction cursor if needed.



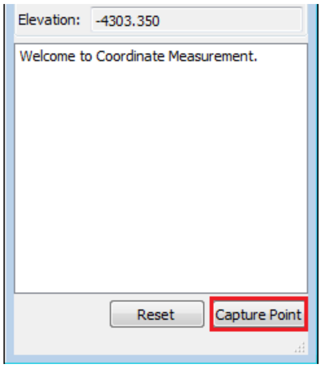
6) Press the Left Mouse button on the TopoMouse to select the track point.



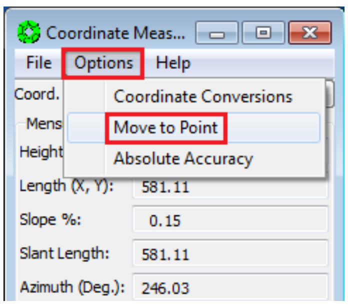
The extraction cursor will jump to the MOLA Track point, and the selected track point will be displayed as white.



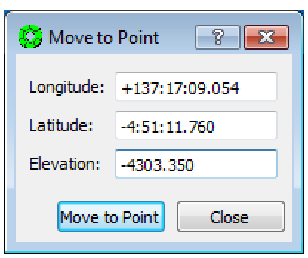
7) **DO NOT MOVE THE TOPOMOUSE**. (If you think you moved it, re-select the track point before proceeding.) On the Coordinate Measurement window, select Capture Point. This will record the longitude, latitude and elevation of the selected MOLA track point in the report section of the Coordinate Measurement window.



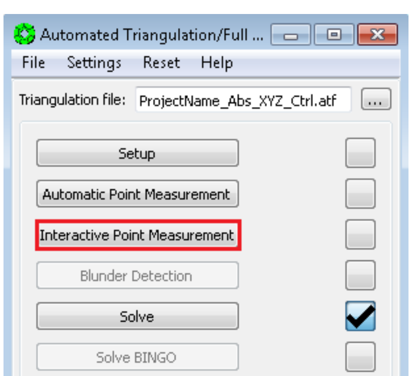
8) On the Coordinate Measurement Tool window, select “Options” > “Move To Point”.



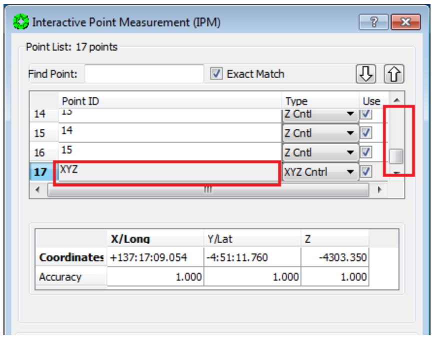
The Move To Point window will appear, populated with the coordinates of the MOLA Track point.



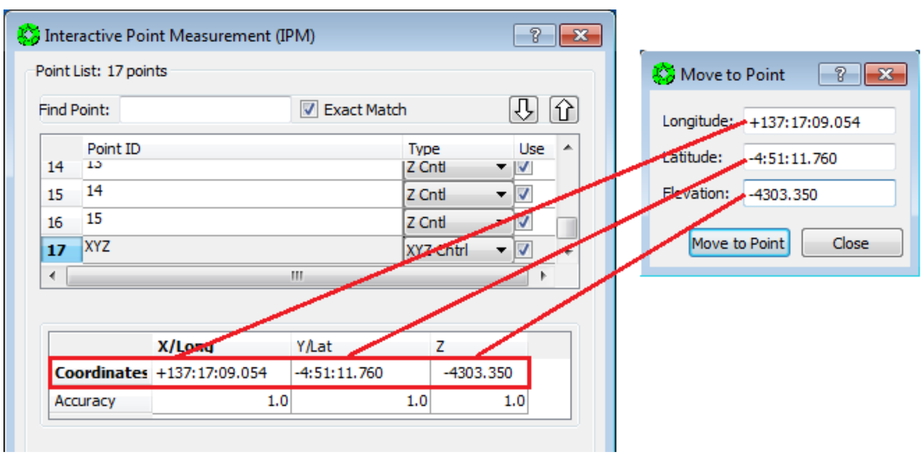
9) Press “Interactive Point Measurement” on the Automated Triangulation window.



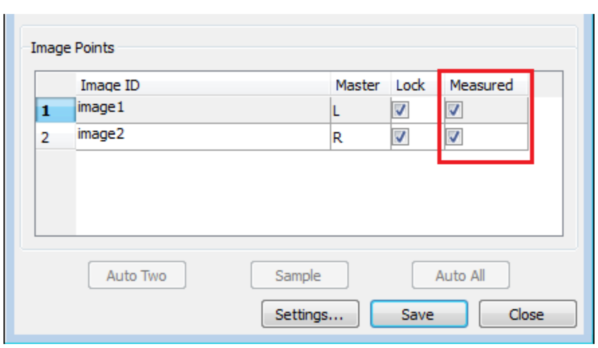
10) Use the Scroll Bar to the right of the point list, and scroll to the bottom of the list. Click on the Point ID of the XYZ Control point to select it. (IPM will move the stereo display to the measured point.)



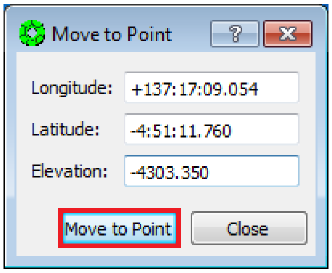
11) From the Move To Point window, copy the Longitude, Latitude and Elevation coordinates, and Paste them into the Coordinates fields for the XYZ point. Make sure not to leave behind any negative signs. (Alternatively, you can copy the captured coordinates listed in the Coordinate Measurement window.)



12) Un-check the boxes in the “Measured” field for both images. (This will also unlock both images so that point can be measure at another location.)

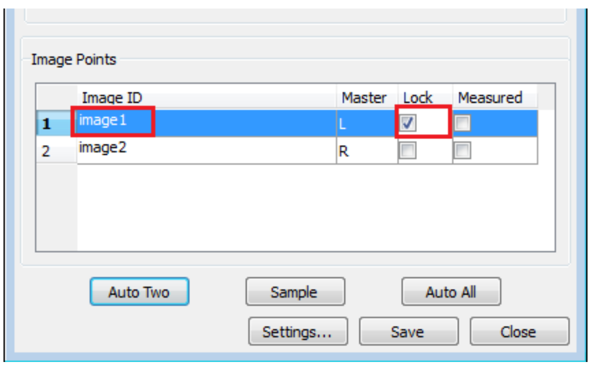


13) On the Move To Point window, press “Move To Point”. This will move the extraction cursor to the location of the selected MOLA Track point. (The selected track point will still be colored white.)



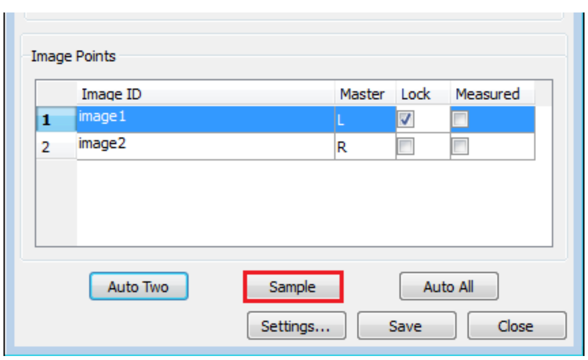
14) Place the extraction cursor on the feature in the stereo model you want to correlate with the selected track point. (Make sure the extraction cursor is also on the ground.)

15) In the IPM window, lock the Left image by checking its Lock box.

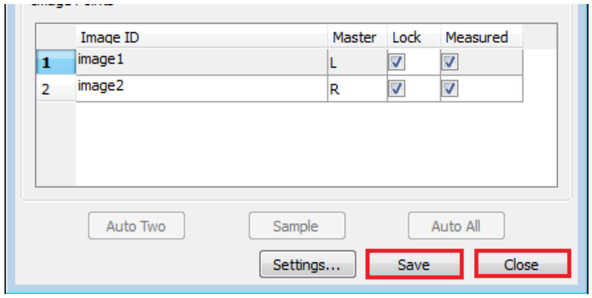


16) Refine the parallax removal (at ground level) by moving Right image only. In other words, put the dot on the ground.

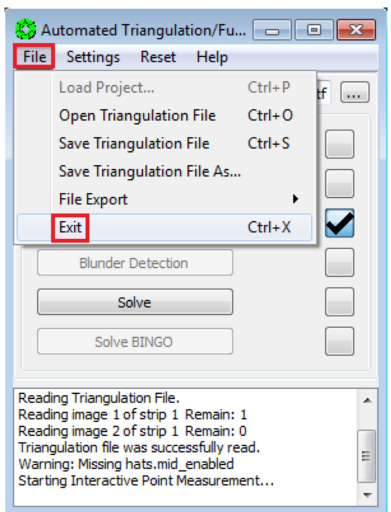
17) Press “Sample” on the IPM window to collect the point measurement.



18) Press “Save” on the IPM window to write the measurement to disk. Then press “Close”.



19) Select “File” > “Exit” on the Automated Triangulation window.

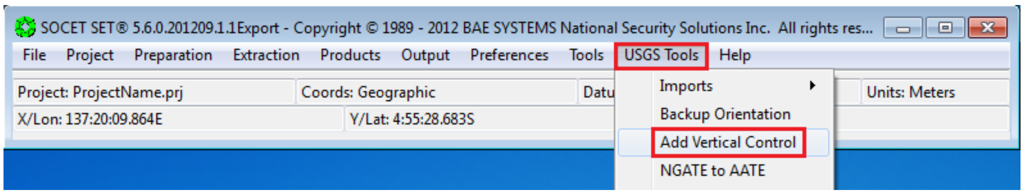


20) GO TO 19.6.1 **Restore Original (A-Priori) Support Files, and reiterate.

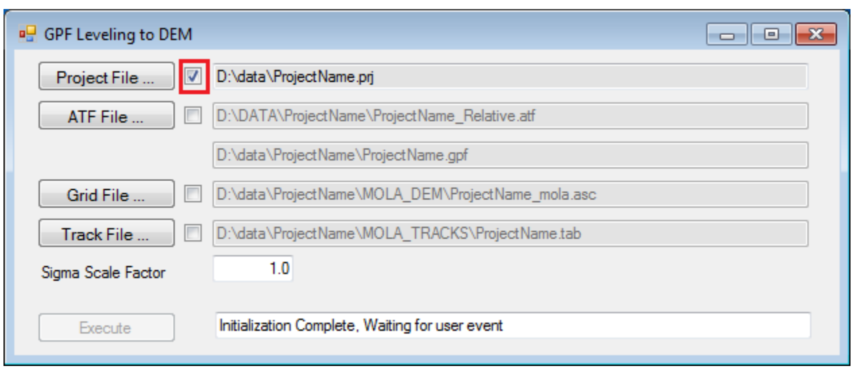
19.7 Update Vertical (Z) Control

Because we have shifted the stereo model horizontally, we must correct the elevation estimates of the Z Control points.

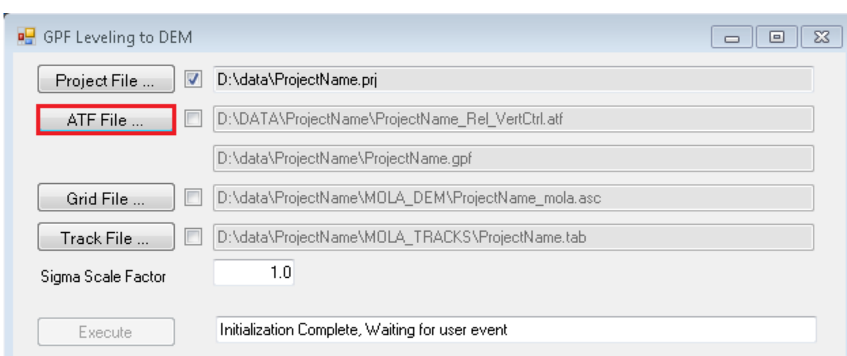
1) From the SOCET SET menu bar, select “USGS Tools” > “Add Vertical Control”.



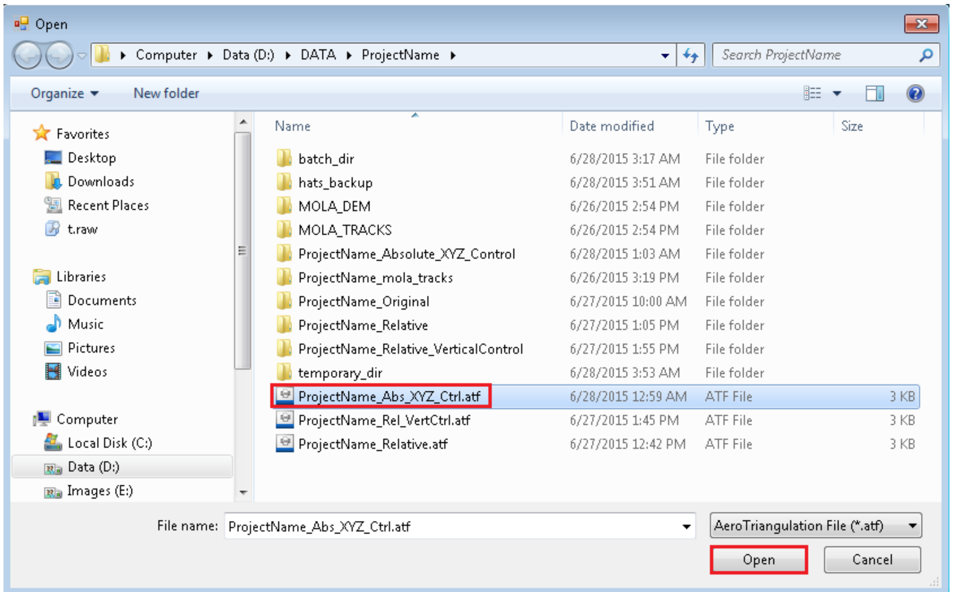
2) If the project file listed in the Project File field is correct, check the box next to the Project File field to confirm it. Otherwise, press the “Project File…” button to bring up the list of project files, and select <ProjectName>.prj from the list.



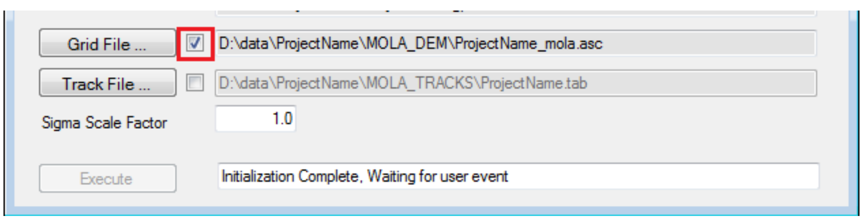
3) Press “ATF File…”. (We must select the current ATF file.)



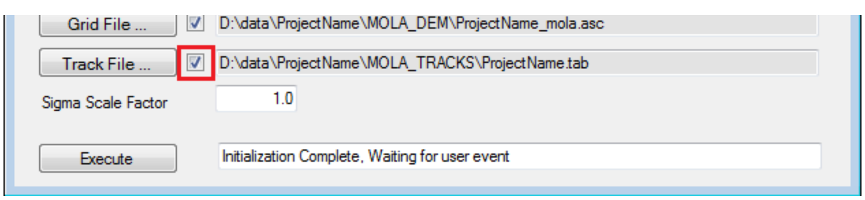
4) In the Open window, select <ProjectName>_Abs_XYZ_Ctrl, and then press “Open”.



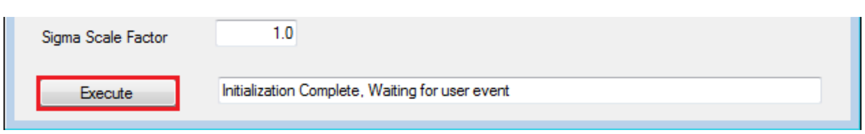
5) The input Grid File should be <ProjectName>_mola.asc located in the MOLA_DEM folder. Either confirm the “Grid File” listed is correct by checking its check box, or press the “Grid File…” button to select D:\DATA\<ProjectName>\MOLA_DEM\<ProjectName>_mola.asc.



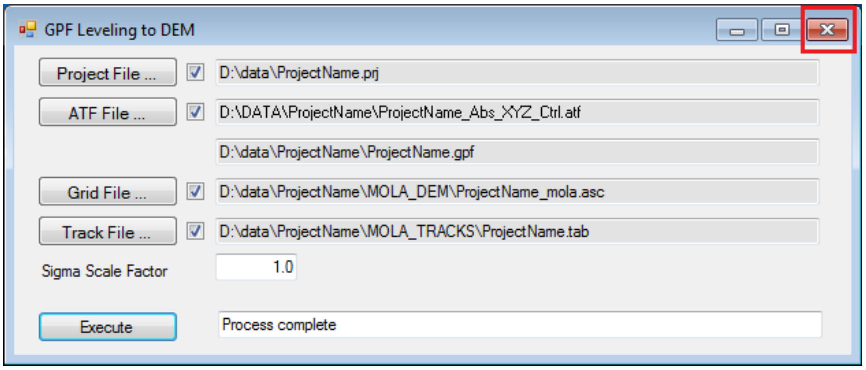
6) The input Track File should be <ProjectName>.tab located in the MOLA_TRACKS folder. Either confirm the “Track File” listed is correct by checking its check box, or press the “Track File…” button to select D:\DATA\<ProjectName>\MOLA_TRACKS\<ProjectName>.tab.



7) Press “Execute”. (If the Execute button is not activated please check the confirmation checkboxes.)

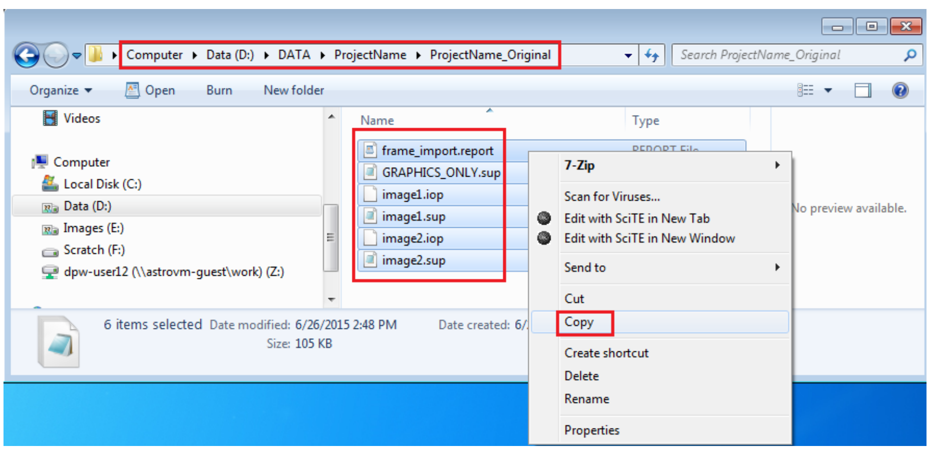


8) Close the GUI via the close icon.

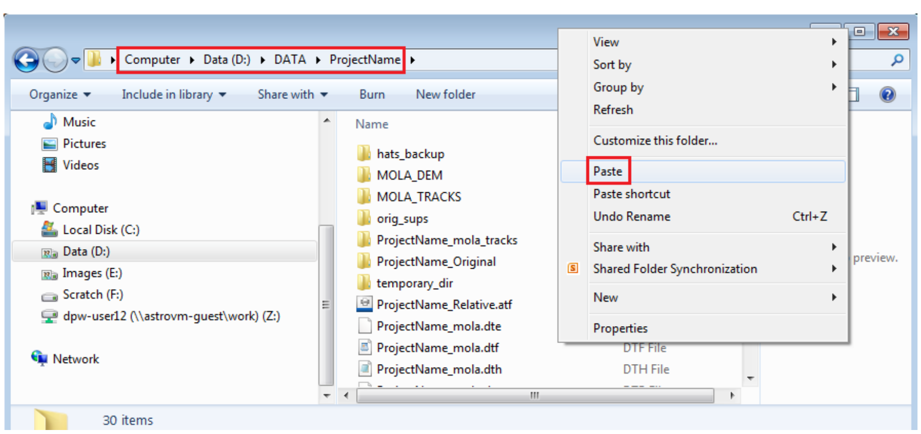


19.8 Restore Original (A-priori) Support Files

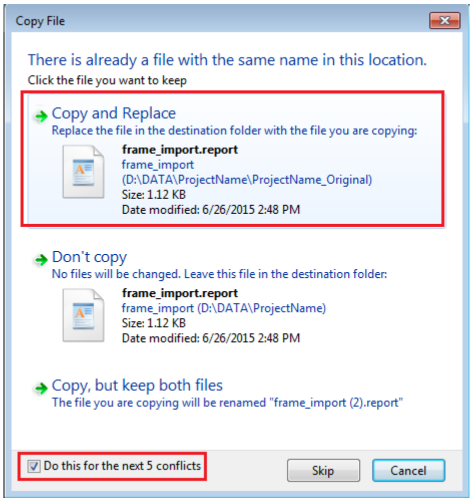
1) Open Windows Explorer. Navigate to D:\DATA\<ProjectName>\<ProjectName_Original, select all the files in the folder, and Copy them.



2) Move up one folder so you are now in D:\DATA\<ProjectName>, and paste the files.



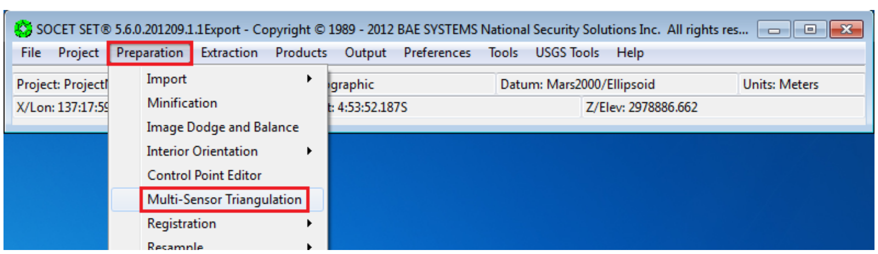
3) In the pop-up window, check the box in the lower left corner to "do this for the next 3 conflicts", then select "Copy and Replace".



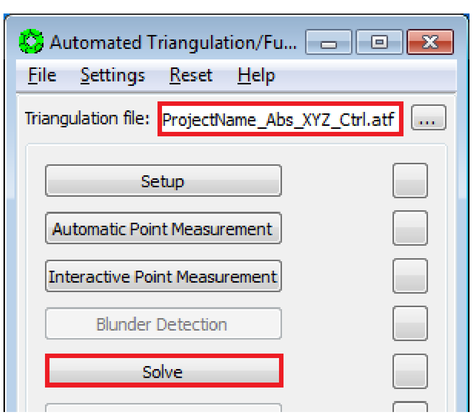
4) Close the Windows Explorer window.

19.9 Final Bundle Adjustment

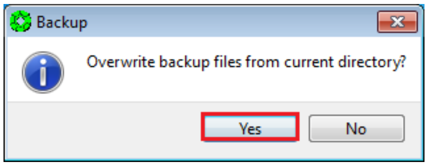
1) From the SOCET SET menu bar, select "Preparation" > "Multi-Sensor Triangulation".



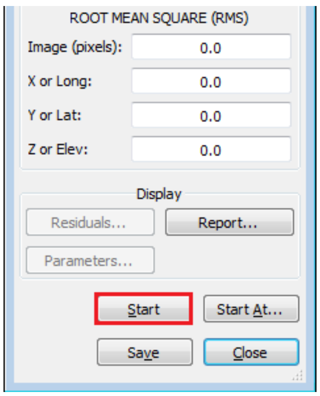
2) In the Automated Triangulation window, press "Solve".



3) Press “Yes” on the pop-up to overwrite back up files.



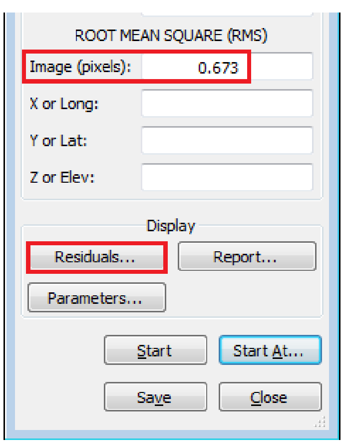
4) Press “Start” in the “Simultaneous Solve” window.



5) Once the adjustment is completed, evaluate the errors in the adjustment.

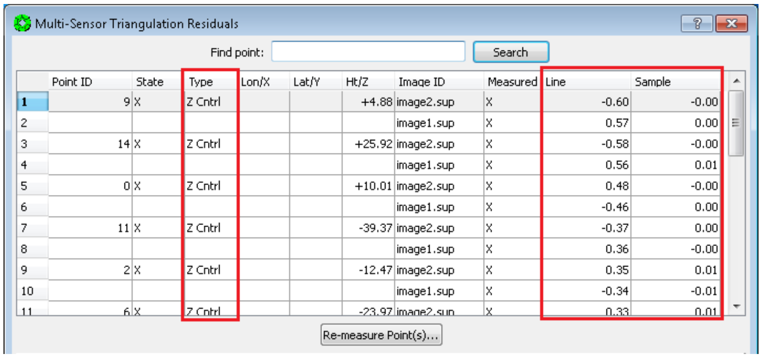
An acceptable solution has (1) an Image (pixels) RMS of ~0.6 or less, and (2) no individual point measurement has an error greater than 2 pixels.

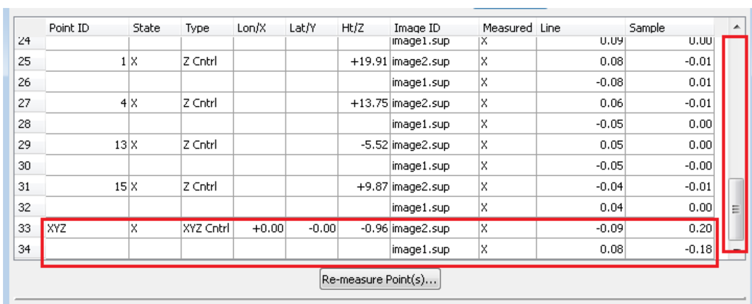
Press “Results” button in the Simultaneous Solve window to review error of individual point measurements



6) Points in the Residuals window are grouped by Type, and automatically sorted from highest to lowest residual within each Type category. The Line and Sample fields list the point measurement

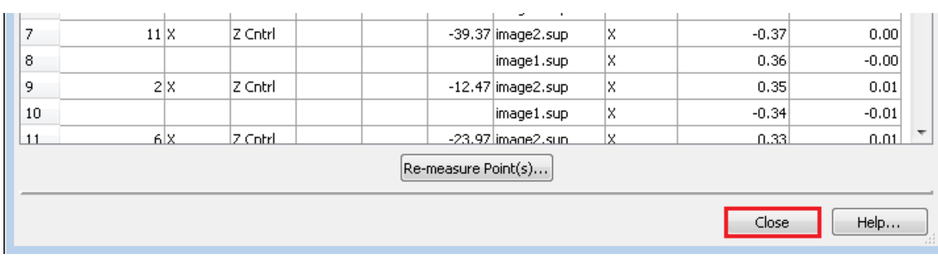
errors in pixels. In the Absolute Orientation procedure, there is a mix of Z-Control and XYZ-Control points, so scroll through the list to each section looking for unacceptable point measurement errors.



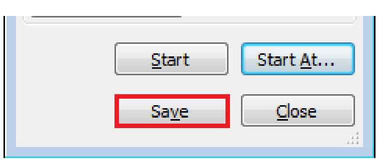


7) If points have pixel errors greater than 2.0 pixels, GO TO: 19.10 Point Weights Refinement. Otherwise, continue to next step.

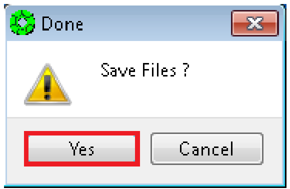
8) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, then Press “Close” on the Multi-Sensor Triangulation Residuals window.



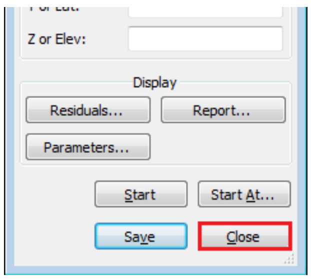
9) Press “Save” on the Simultaneous Solve window.



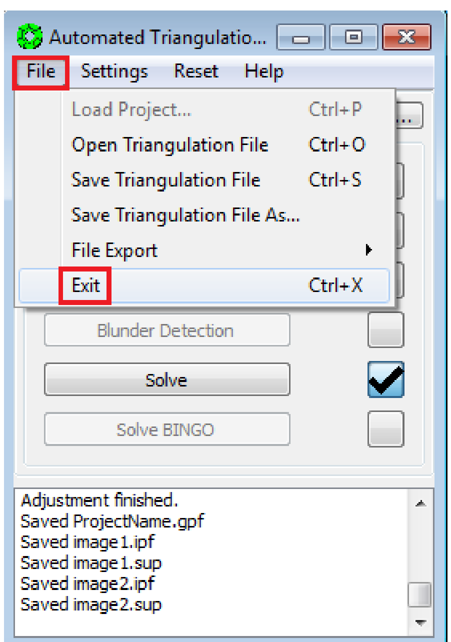
10) Press “Yes” on the Done pop-up window.



11) Press “Close” on the Simultaneous Solve window.



12) Select “File” > “Exit” on the Automatic Triangulation window.



Absolute Orientation is now complete!

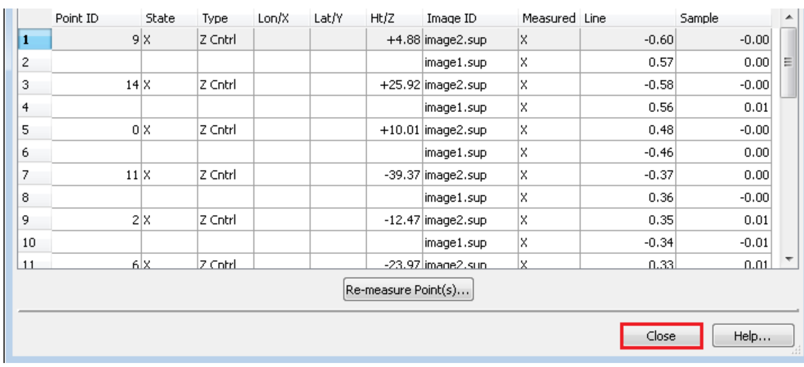
13) SKIP: 19.10 Point Weights Refinement *and* 19.11 Point Re-Measurement Process, GO TO: 19.12 Re-Load Images.

19.10 Point Weights Refinement

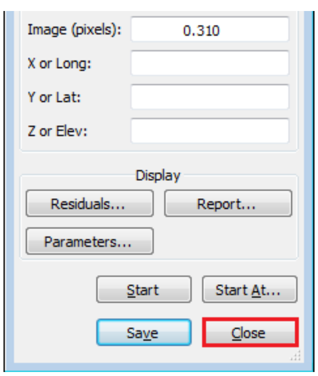
Continuing from 19.9 Final Bundle Adjustment…

We have now updated the elevation estimates to the Z-Control points. If the Image RMS < ~0.6 pixels; and Point Errors < 2.0 pixels criteria has not been met, the cause may be that the weights (i.e., Accuracy Values) assigned to the elevation estimates by “Add Vertical Control” are too stringent. We will first evaluate and adjust Accuracy values. If the criteria of an acceptable solution is still not met after another bundle adjustment (Solve), then we will re-measure points.

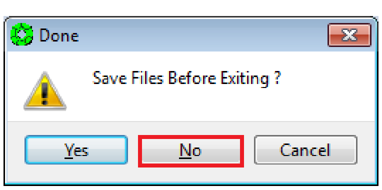
1) From the “Multi-Sensor Triangulation Residuals” window, record (on a piece of paper) the Point ID’s of the points with > 2.0 line/sample errors. Then close the Residuals window.



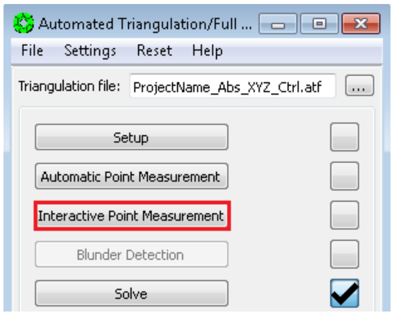
2) Press “Close” on the Simultaneous Solve window. (Do not press “Save”.)



3) Press “No” to Saving Files in the Done pop-up window.

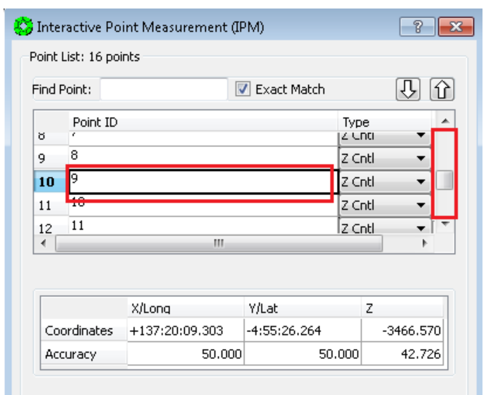


4) Press “Interactive Point Measurement” on the Automated Triangulation window.

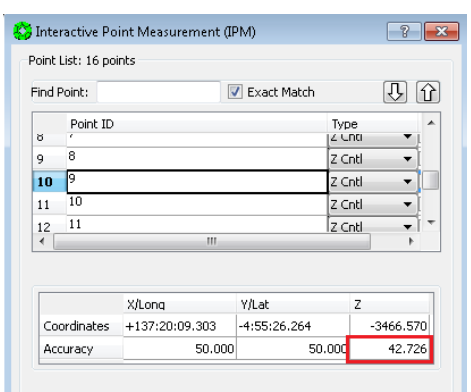


5) For each point recorded on your list:

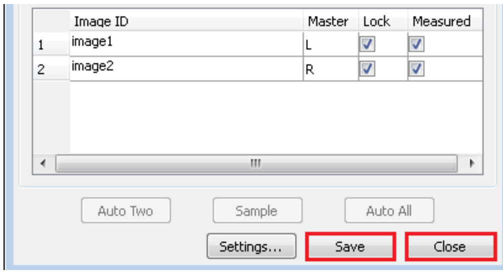
a. Use the Scroll Bar to the right of the point list, and scroll to the point. Click on the point’s Point ID to select it.



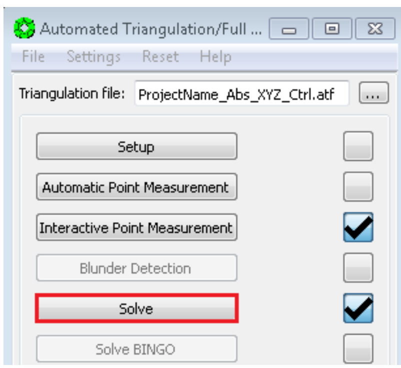
b. IPM will move the stereo display to the point. Look at the measurement in stereo. If the point is on a slope, the Weight/Accuracy assigned to the Z coordinate may be too tight. We suggest you **increase the accuracy by approximately a factor of 2: double click in the Accuracy field for Z, delete the old value and type in the new value, then press the enter key.**



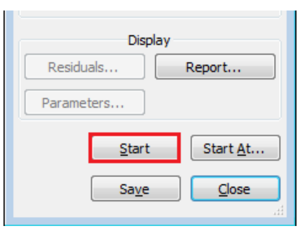
6) When you are done updating Accuracy values, press “Save” then “Close” on the IPM window.



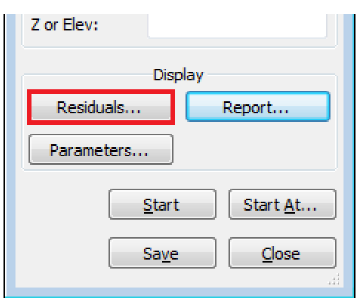
7) Press “Solve” on the Automated Triangulation window.



8) Press “Start” on the Simultaneous Solve window.

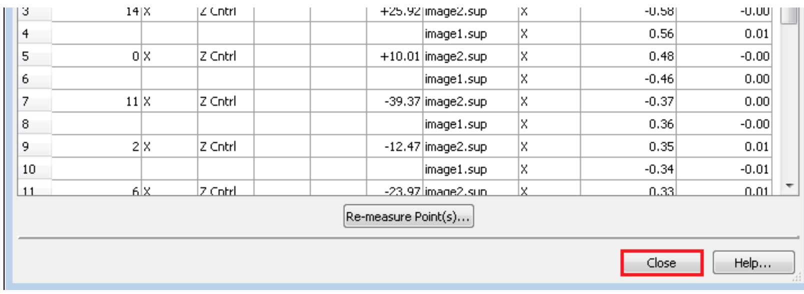


9) Press “Residuals” on the Simultaneous Solve window and make sure no individual point has an error greater than 2 pixels.

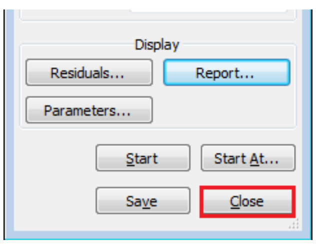


10) If the solution continues to have points with larger than 2 pixel errors, the problem may be a bad measurement(s), so GO TO 19.11 Point Re-Measurement Process. Otherwise, continue to next step.

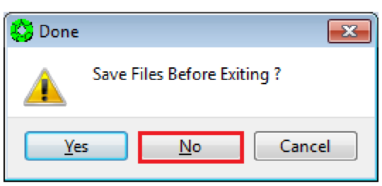
11) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, we will exit Multi-Sensor Triangulation, and re-enter it in order to refresh the values stored in computer memory. First press “Close” on the Multi-Sensor Triangulation Residuals window.



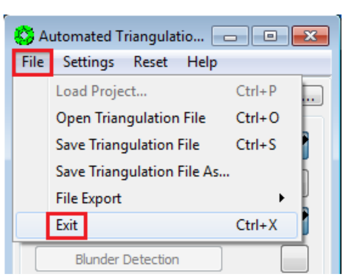
12) Press “Close” on the Simultaneous Solve window. (Do Not Press “Save”.)



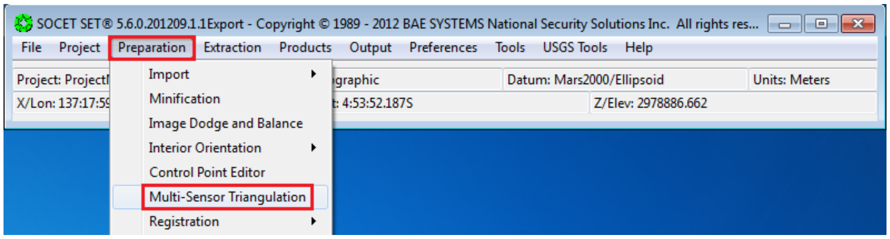
13) Press “No” to Saving Files in the Done pop-up window.



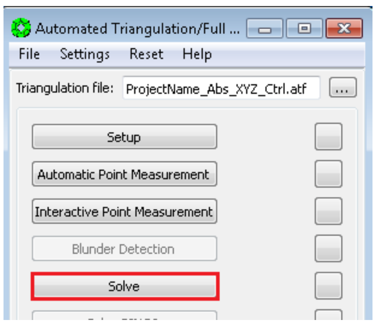
14) Select “File” > “Exit” on the Automatic Triangulation window.



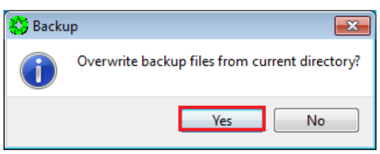
15) Re-enter MST: From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



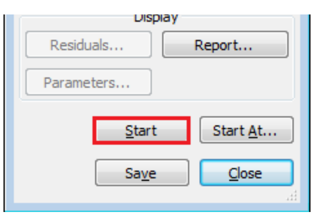
16) Press “Solve” on the Automatic Triangulation window.



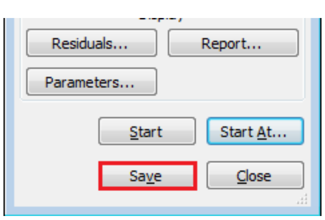
17) Press “Yes” on the pop-up to overwrite back up files.



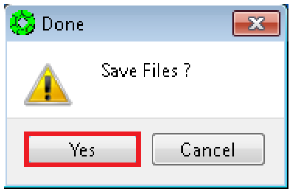
18) Press “Start” on the Simultaneous Solve window.



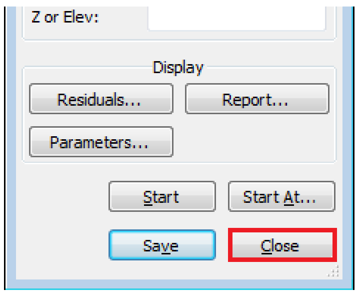
19) If the Image (pixels) RMS is < ~0.6 pixels, Press “Save” on the Simultaneous Solve window.



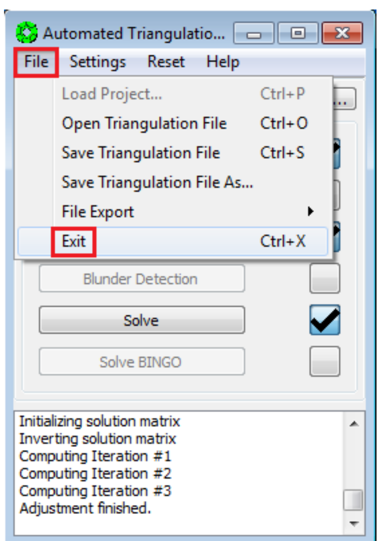
20) Press "Yes" on the Done pop-up window.



21) Press "Close" on the Simultaneous Solve window.



22) Select "File" > "Exit" on the Automatic Triangulation window.



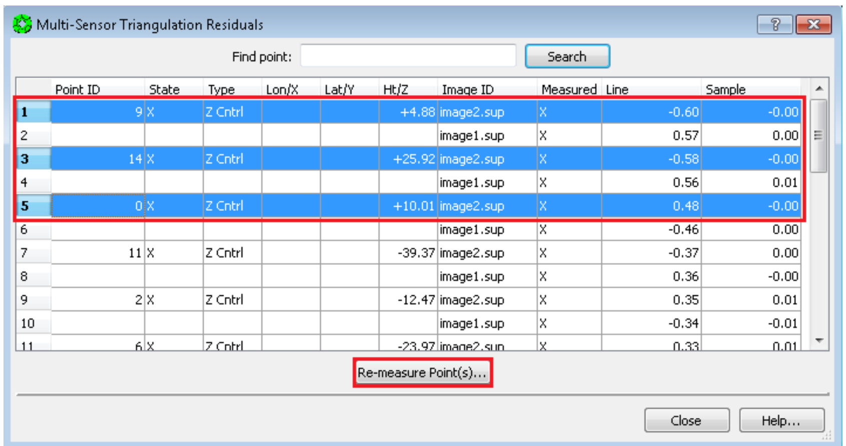
Absolute Orientation is now complete!

23) SKIP: 19.11 Point Re-Measurement Process, GO TO: 19.12 Re-Load Images.

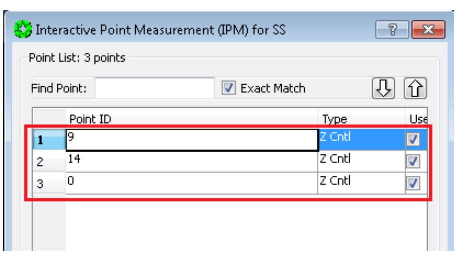
19.11 Point Re-Measurement Process

Continuing from 19.10 Point Weights Refinement…

1) On the "Multi-Sensor Triangulation Residuals" window, Left-Click on the Point ID(s) of the points to re-measure. (Hold the Control Key down to select multiple points.) Then press "Re-measure Point(s)…". The re-measure point window will now open with the points selected.

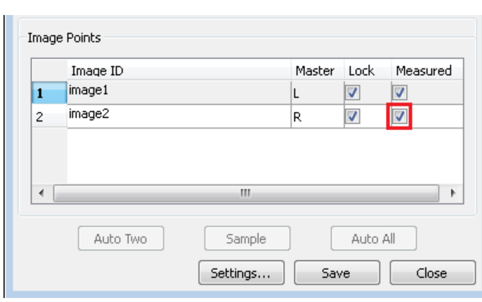


2) Left-Click on the point to re-measure. The View 1 (stereo display) window will display the current point measurement.



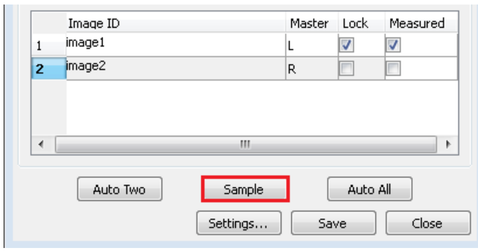
3) Un-check the Measured box for the Right image only, to remove parallax.

NOTE: Relocating the point is not advised because an elevation estimate is associated with the point.

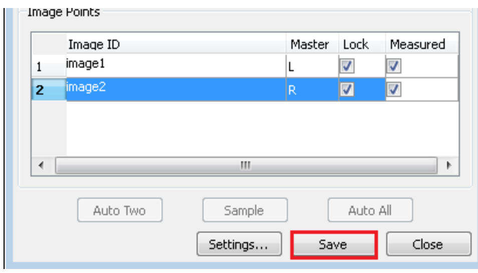


4) Clear the parallax by moving the Right image only (i.e., put the dot on the ground).

5) Press “Sample” to collect the point measurement.

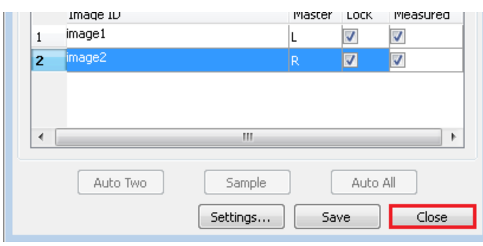


6) Press “Save” to write the measurement to disk.

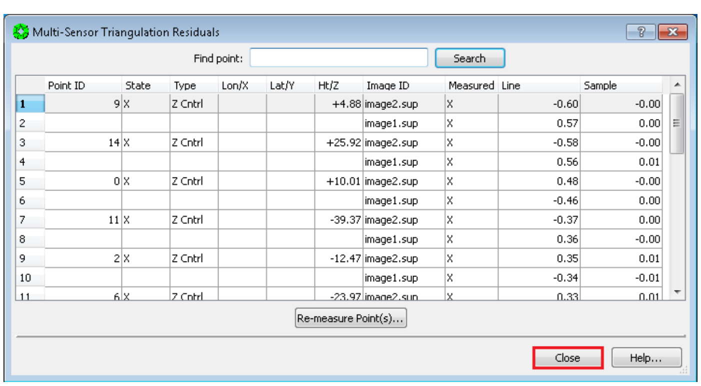


7) Repeat re-measurement process for remaining points in the list. (Go back to step 2.)

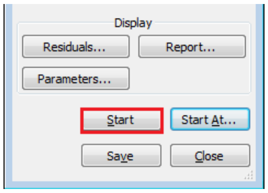
8) Press “Close” after all points in the list are re-measured.



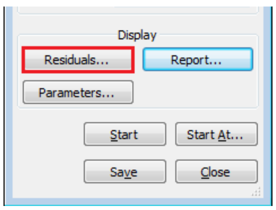
9) Press “Close” on the Multi-Sensor Triangulation Residuals window.



10) Press “Start” on the Simultaneous Solve window.

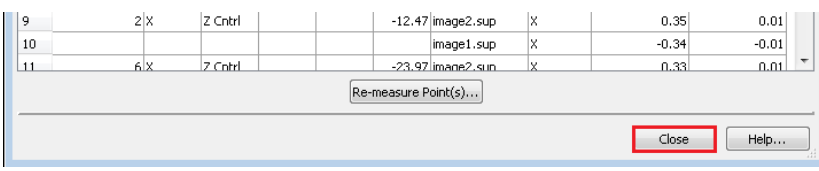


11) Press “Residuals” on the Simultaneous Solve window and make sure no individual point has an error greater than 2 pixels.

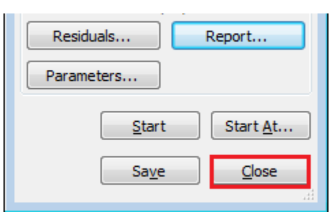


12) If there are points with larger than 2 pixel errors, repeat the 19.11 Point Re-Measurement Process from step 1.

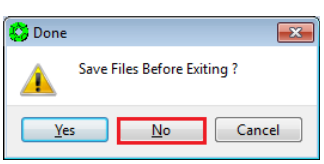
13) If the image RMS is < ~0.6 pixels, and the maximum point measurement error is < 2.0 pixels, we will exit Multi-Sensor Triangulation, and re-enter it in order to refresh the values stored in computer memory. First press “Close” on the Multi-Sensor Triangulation Residuals window.



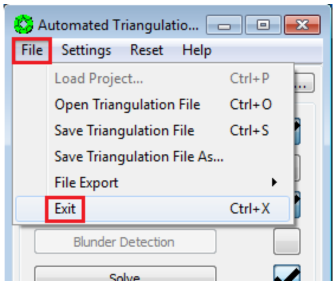
14) Press “Close” on the Simultaneous Solve window. (Do not press “Save”.)



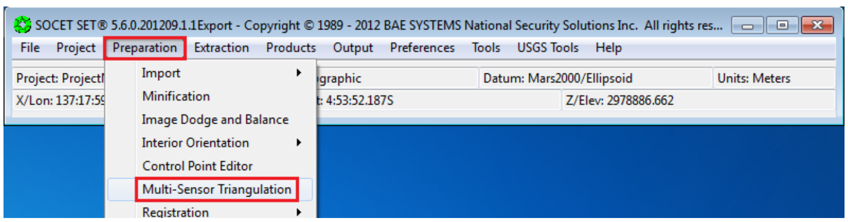
15) Press “No” to Saving Files in the Done pop-up window.



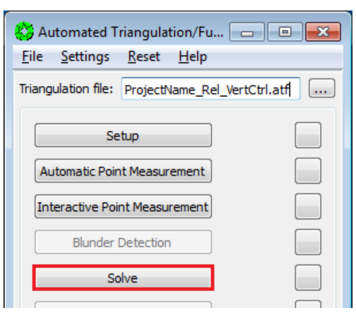
16) Select “File” > “Exit” on the Automatic Triangulation window.



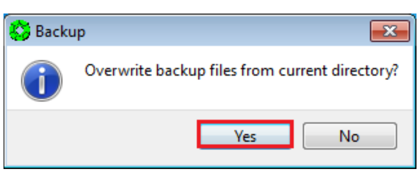
17) Re-enter MST: From the SOCET SET menu bar, select “Preparation” > “Multi-Sensor Triangulation”.



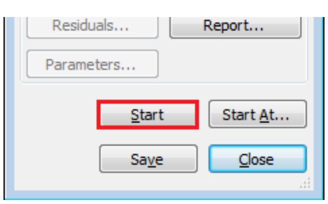
18) Press “Solve” on the Automatic Triangulation window.



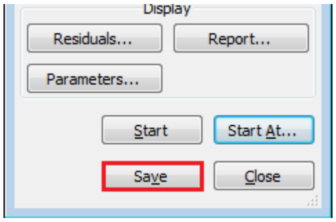
19) Press “Yes” on the pop-up to overwrite back up files.



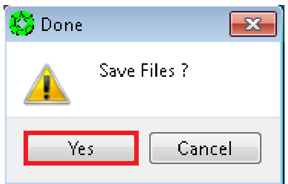
20) Press “Start” on the Simultaneous Solve window.



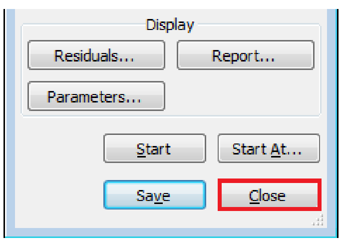
21) If the Image (pixels) RMS is < ~0.6 pixels, Press “Save” on the Simultaneous Solve window.



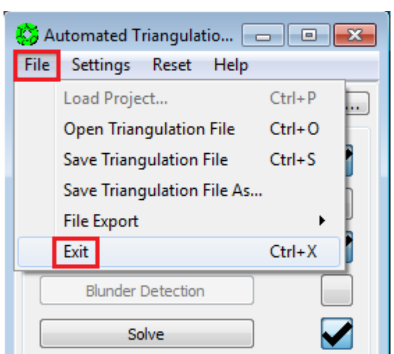
22) Press “Yes” on the Done pop-up window.



23) Press “Close” on the Simultaneous Solve window.



24) Select “File” > “Exit” on the Automatic Triangulation window.

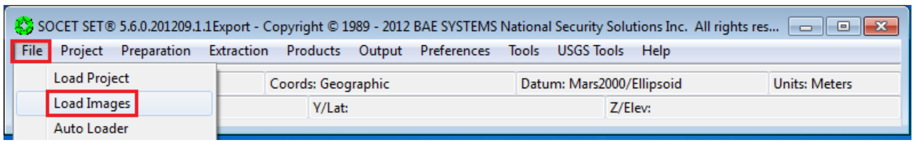


Absolute Orientation is now complete!

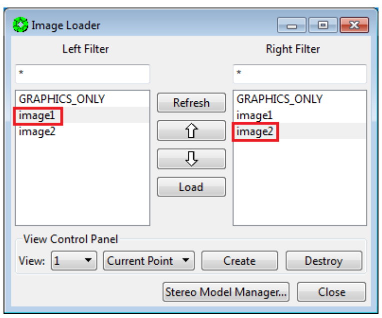
19.12 Re-Load Images

After the Absolute Orientation is complete, it is necessary to re-Load the images in order to view them with the results of the adjustment.

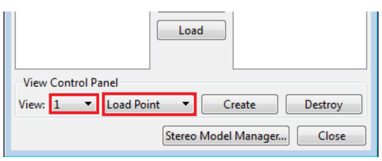
1) From the SOCET SET menu bar, select "File" > "Load Images".



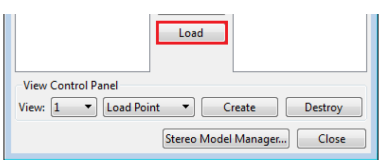
2) In the Image Loader window, select the Left and Right Image to display by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)



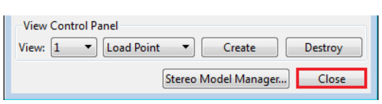
3) Under "View Control Panel" settings: Ensure that View = 1 and that "Load Point" is selected.



4) Press "Load".

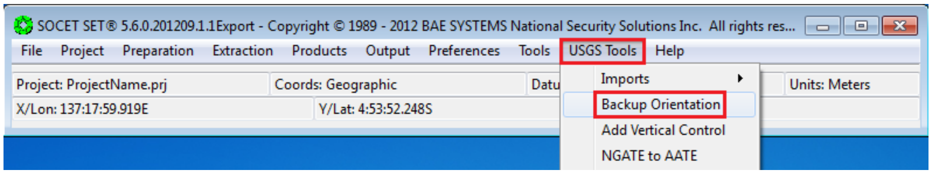


5) Press "Close".

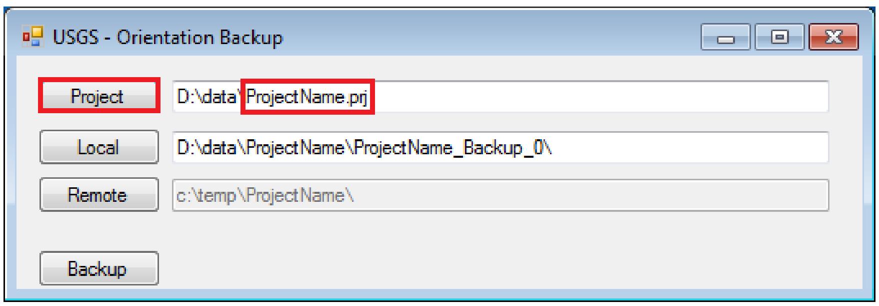


19.13 Backup Absolute Orientation Results

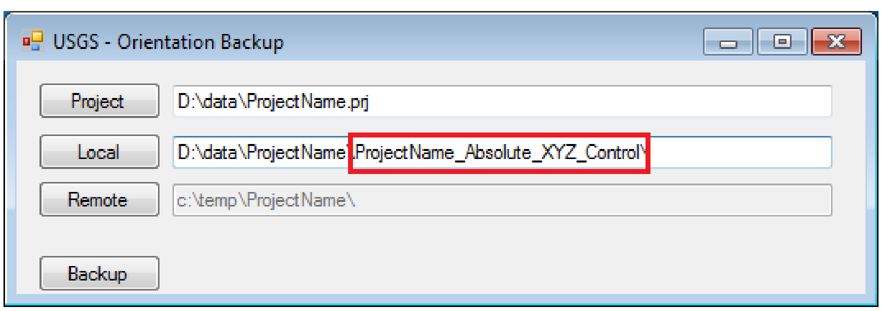
1) From the SOCET SET menu bar, select “USGS Tools” > “Backup Orientation”.



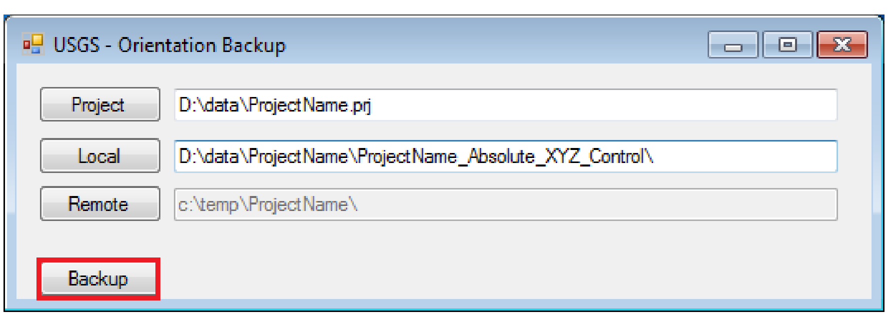
2) **Make sure the current project name is listed in the Project field. If not, press “Project” to select the current project, then press “OK”.** (Otherwise the backup will be made in, and for, the wrong project!)



3) Replace **Backup_0** with **Absolute_XYZ_Control** in the Local folder name field. The backup folder will be named <ProjectName>_Absolute_XYZ_Control.



4) Press “Backup”.



20Epipolar (Pair-Wise) Rectify Controlled Images

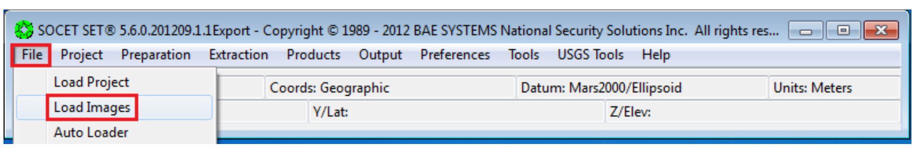
Epipolar rectification is used to enhance or enable stereo visualization of a stereo image pair. This rectification process: rotates the images so the epipolar (e.g., X-parallax) direction is horizontal, and scales the images to a common resolution.

Generally, SOCET SET can handle epipolar rectification on-the-fly (also referred to as Pairwise Rectification in the SOCET SET user's manual). Although on-the-fly rectification works for viewing pushbroom/linescanner stereo images, it is unreliable when automatically generating a DTM. Therefore, we need to generate epipolar (pair-wise) rectified images of the stereo pair and supply them to NGATE (Next Generation Automatic Terrain Extraction) and AATE (Adaptive Automatic Terrain Extraction).

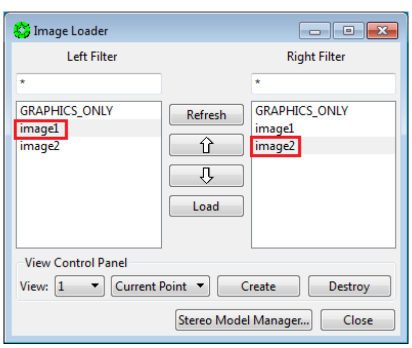
20.1 Load Controlled Images

Load the images to insure the stereo display is using the final controlled solution of the images.

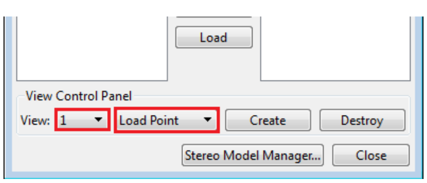
1) From the SOCET SET menu bar, select "File" > "Load Images"



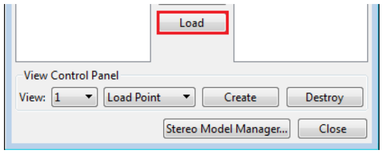
2) In the Image Loader window, select the Left and Right Image to display by clicking on the image id in the Left and Right panels. (Selected images will be highlighted.)



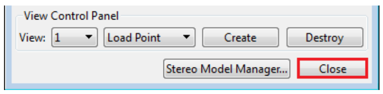
3) Under "View Control Panel" settings: Ensure that View = 1 and that "Load Point" is selected.



4) Press “Load”.

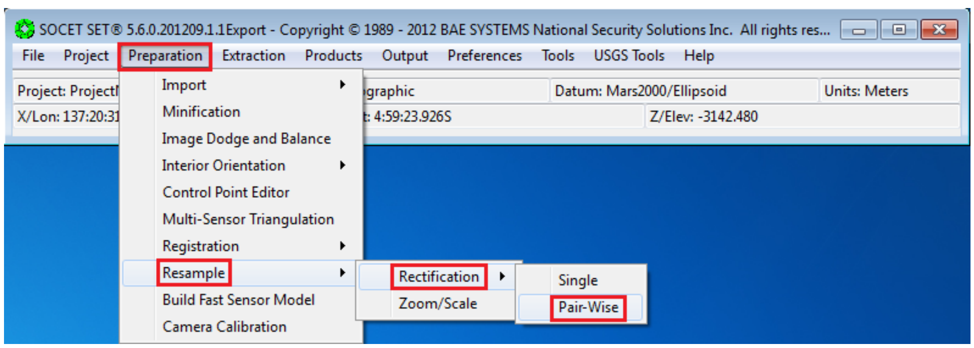


5) Press “Close”.



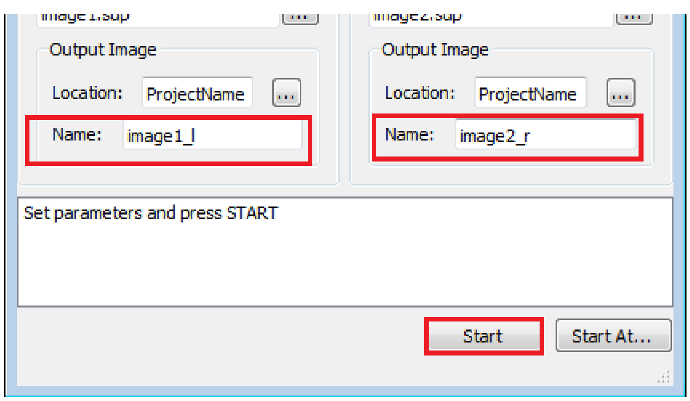
20.2 Generate Epipolar Rectified Images

1) From the SOCET SET menu bar, select “Preparation” > “Resample” > “Rectification” > “Pair-Wise”.

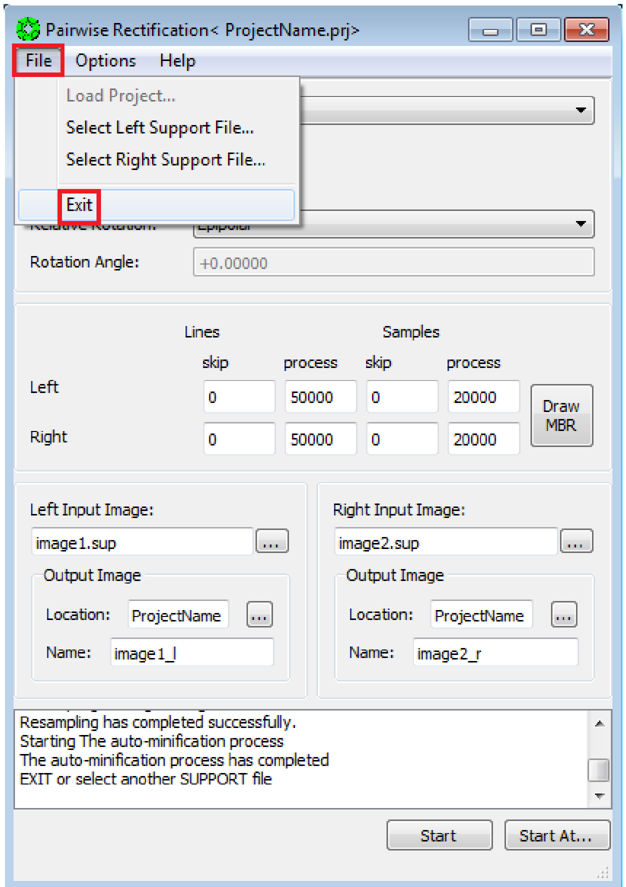


2) In the Pairwise Rectification window, verify the Output Image section is correct. Then press “Start”.

SOCET SET will automatically populate this GUI based on the stereo pair loaded. Just make sure the Output Image Location is correct. The output image names are based are the left and Right images loaded, and will have “_l” and “_r” appended.



3) Upon completion, Select “File” > “Exit” in the Pairwise Rectification window

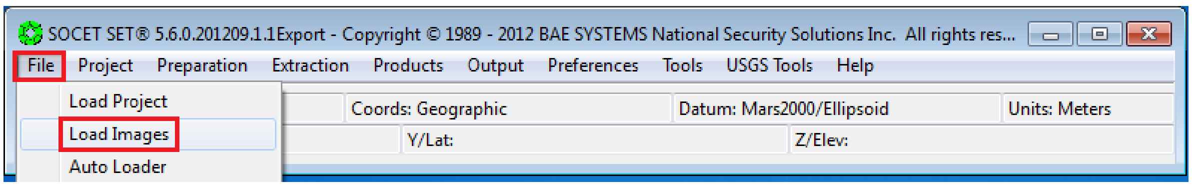


21Generate DTM

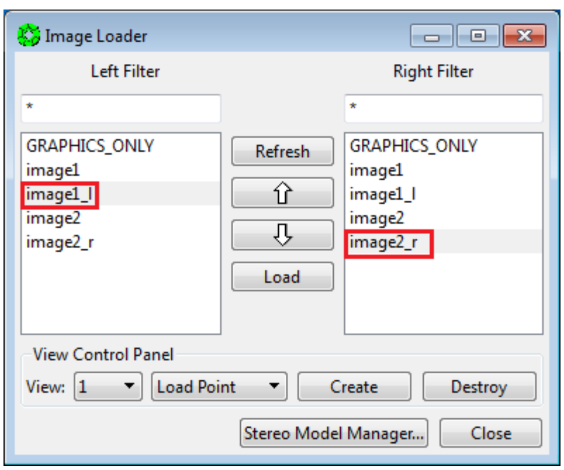
For HiRISE, both NGATE and AATE are used to generate a one meter post DTM. In stereo pairs with substantial relief, and when the stereo images are controlled to the MOLA (either from the Vertical Adjustment or the Absolute Orientation), we use the MOLA DTM as a seed file. This closer approximation to ground-truth greatly increases success of the matcher. In stereo pairs of flat terrain, seeding with MOLA is not necessary.

21.1 Load Epipolar Rectified Images

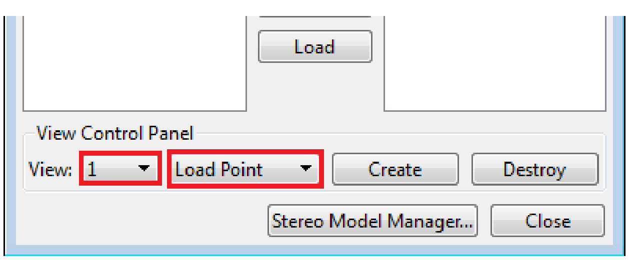
1) From the SOCET SET menu bar, select “File” > ‘Load Images”.



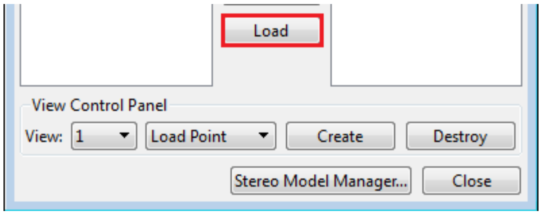
2) In the Image Loader window, select <image1>_l for the Left image, and <image1>_r for the Right Image.



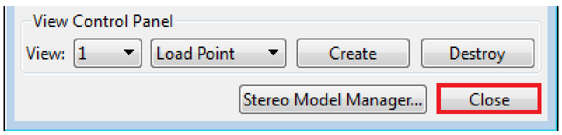
3) Under “View Control Panel” settings: Ensure that View = 1 and that “Load Point” is selected.



4) Press “Load”.

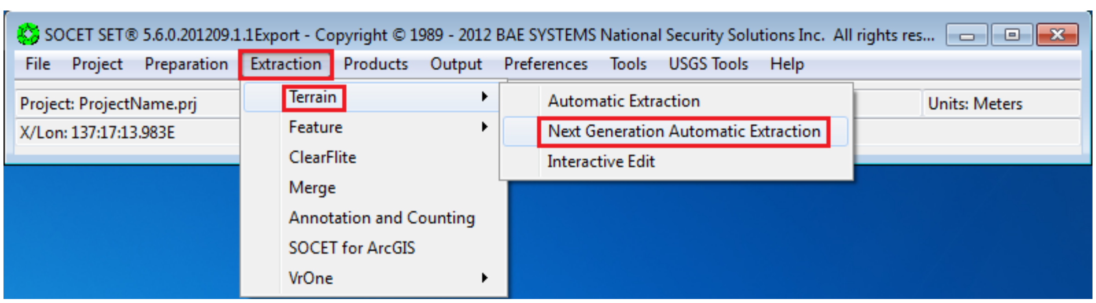


5) Press “Close”.



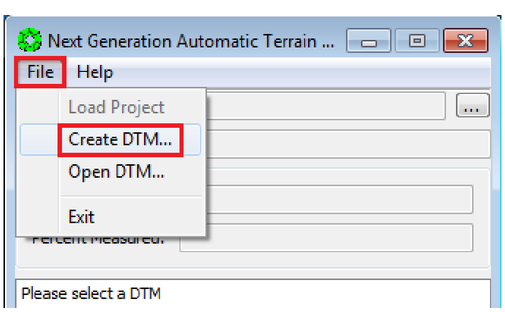
21.2 Next Generation Automatic Extraction (NGATE)

From the SOCET SET menu bar, select “Extraction” > “Terrain” > “Next Generation Automatic Extraction”.

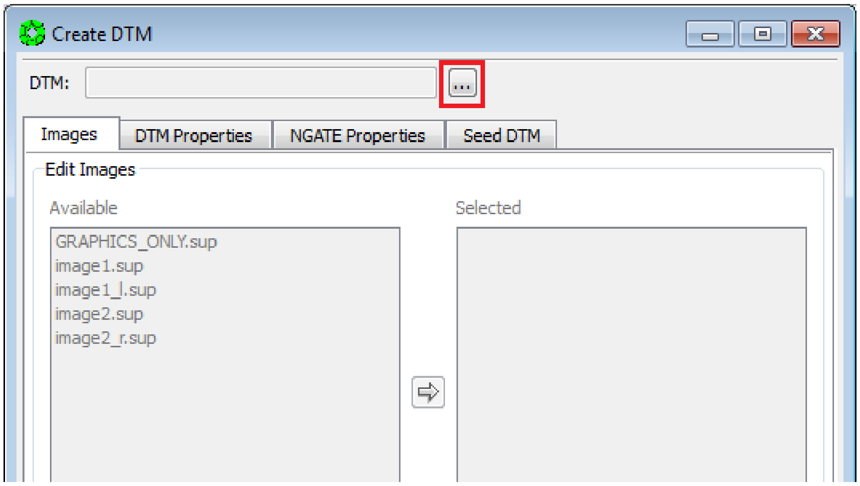


21.2.1 Create a New DTM

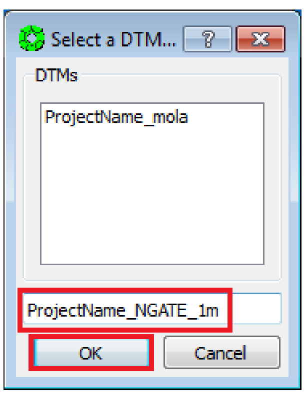
1) In the NGATE window, select “File” > “Create DTM”. (This will bring up the Create DTM window.)



2) In the Create DTM window, press the box next to the DTM field.

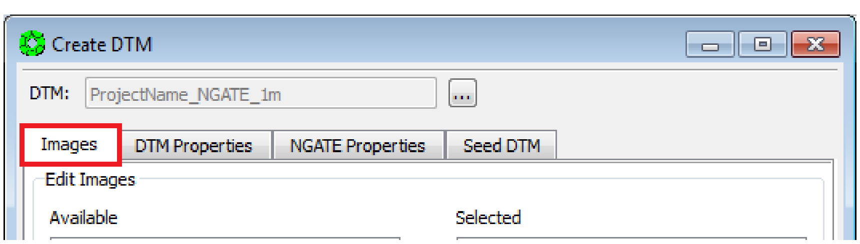


3) In the Select a DTM window, hand enter the name of the DTM to be created as <ProjectName>_NGATE_1m. Then press "OK".

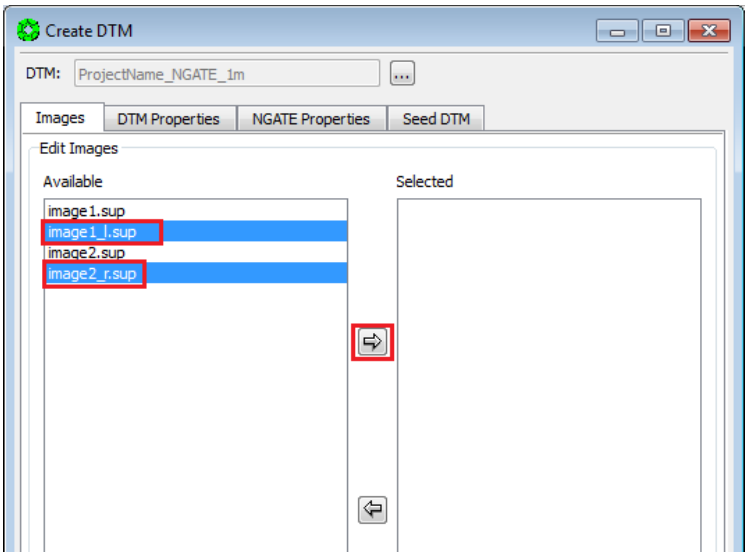


21.2.2 Images Tab

1) In the Create DTM window: Stay in the Images Tab.

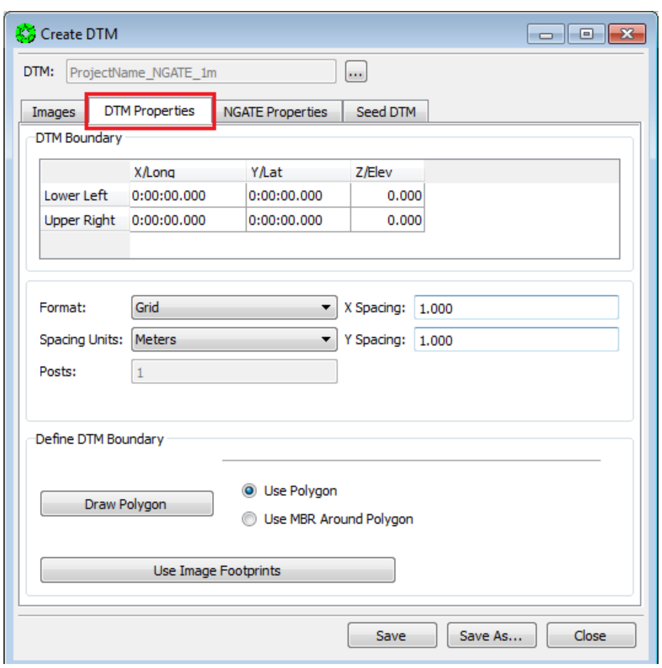


2) Under Edit Images, select the epipolar rectified images in the “Available” list and move them to “Selected” list via the arrow button. (The epipolar rectified images have _l and _r appended to the image name.)

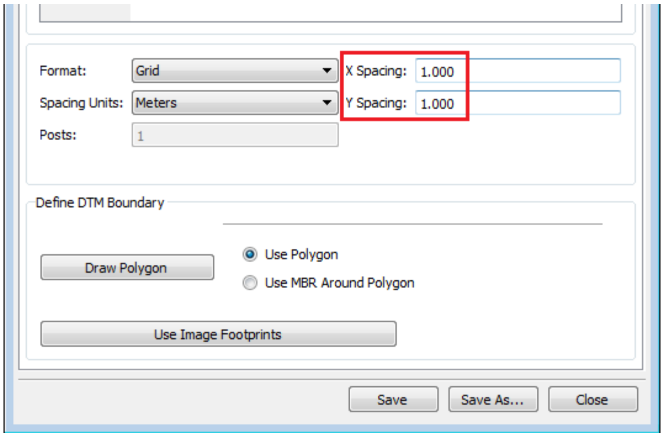


21.2.3 DTM Properties Tab

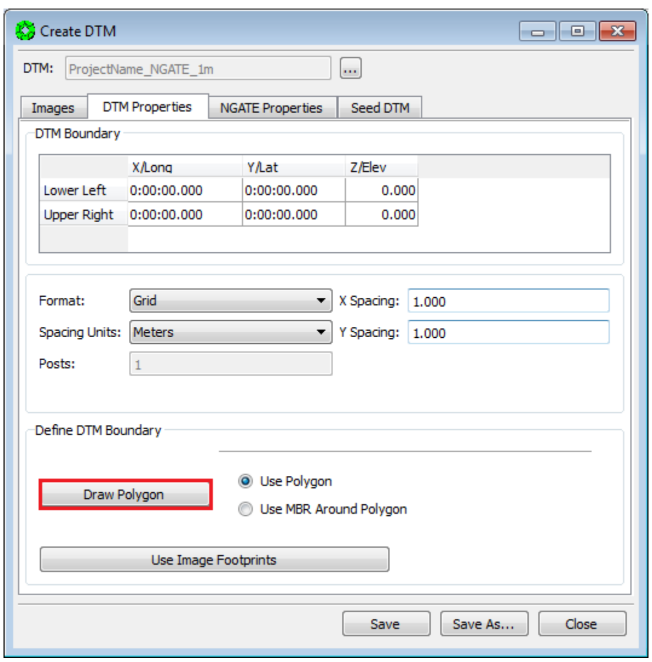
1) In the Create DTM window: Press the “DTM Properties” tab.



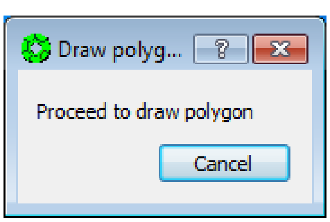
2) Set the X Spacing and Y Spacing to 1.0: Double click in the spacing fields, enter 1.0, and press the enter key.



3) Press "Draw Polygon" to define the DTM Boundary.



4) A Draw polygon window will pop-up on the stereo monitor. Move the window over to the console monitor.



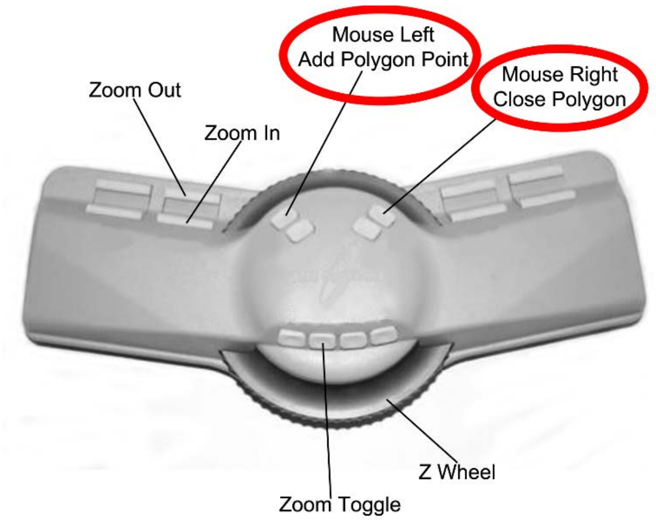
5) Draw the polygon as follows:

   a. Use the TopoMouse to define the polygon:

      The Left Mouse button measures/samples points.

      The Right mouse button closes the polygon.

      Note: the first point of the polygon will display ONLY after a second point is measured.



   b. Make sure each DTM Boundary point is on the ground.

   c. For stereo pairs of flat terrain, 4 corner points plus 2 points halfway down in the flight direction will suffice.

   d. For stereo pairs of steep terrain, measure a DTM Boundary point at 'major' min/max elevations (i.e., at the rim of a large crater, at the crater bottom, etc.)

   e. Establish the boundary within the stereo coverage by ~50 pixels. To estimate this distance:

      i. Bring up the Cursor Editor (under Preferences), and change the Cursor size to 17.

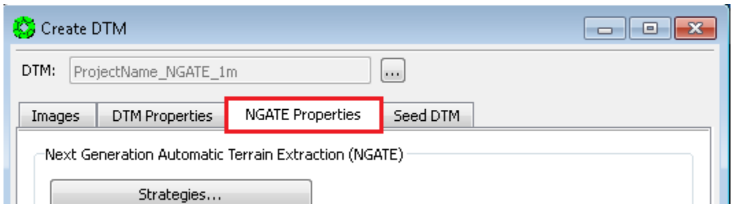
      ii. Move to where you want to place a boundary point.

      iii. Set the image Zoom to 4:1.

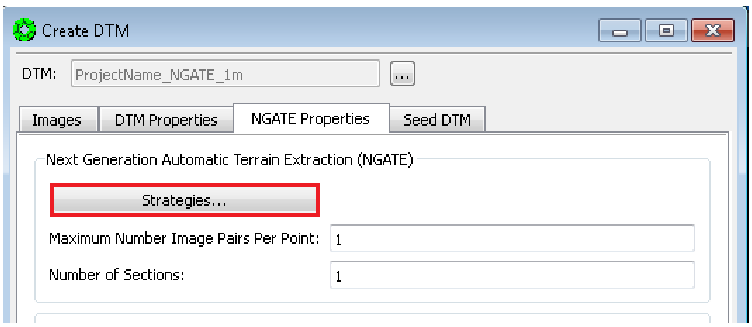
      iv. Aligned the cursor with the edge of the stereo coverage, then sample/measure the point.

21.2.4 NGATE Properties Tab

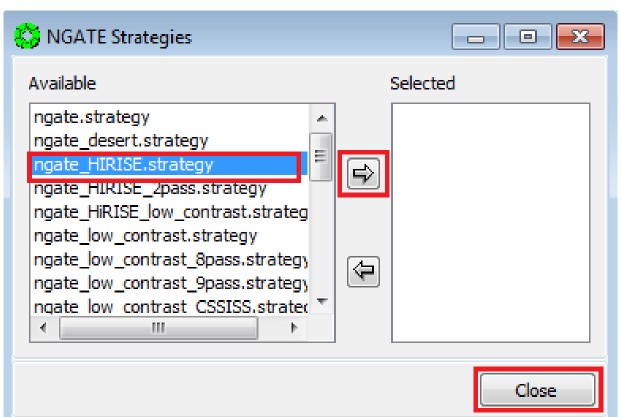
1) Press the "NGATE Properties" tab.



2) Press "Strategies…" to bring up the list of available NGATE strategies.

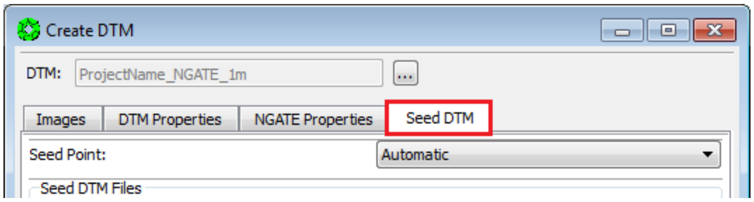


3) In the NGATE Strategies window, select ngate_HIRISE.strategy in the "Available" list and move it to "Selected" list via the arrow button. Then press "Close".

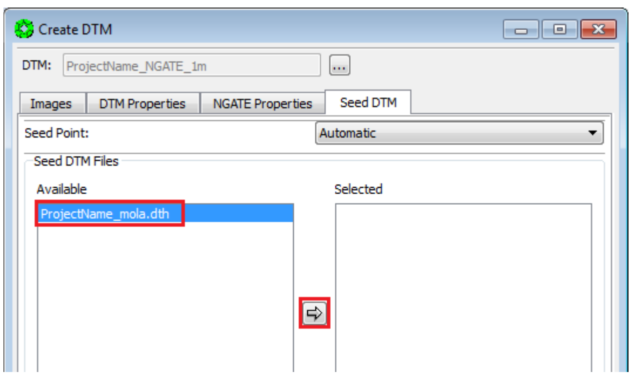


21.2.5 Seed DTM Tab

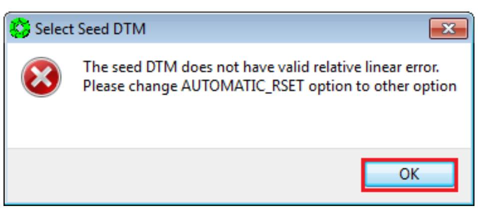
1) Press the “Seed DTM” tab.



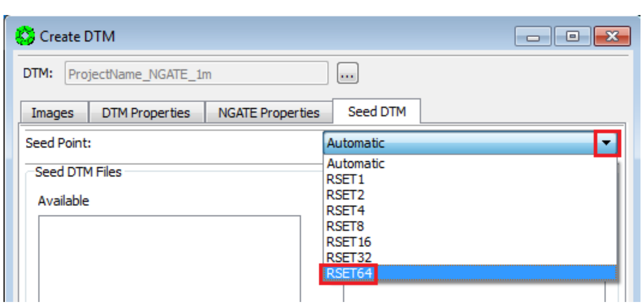
2) Select <ProjectName>_mola.dth in the “Available” list and move it to “Selected” list via the arrow button.



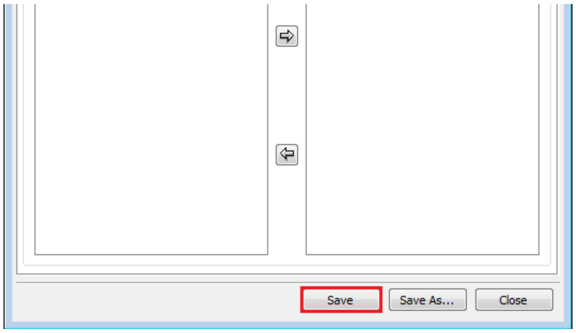
3) An error message will pop-up to change the AUTOMATIC_RSET value. Press “OK”.



4) Left-Click on the down arrow next to the Automatic option to display a drop-down box of options and select “RSET64".



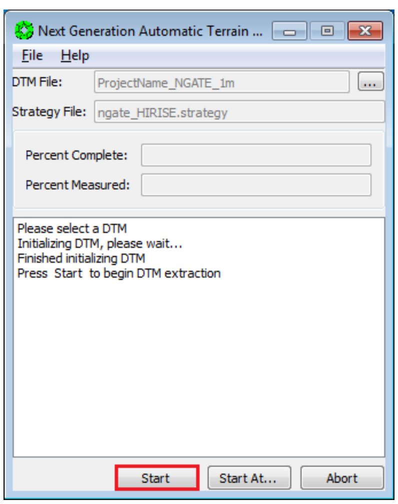
5) Finally, press “Save” to write an initialized DTM to disk. The Create DTM window will automatically close.



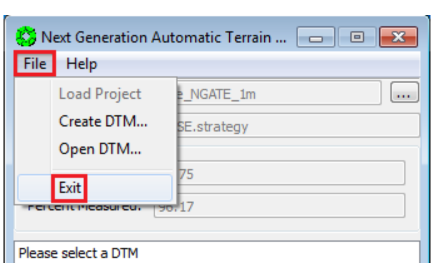
21.2.6 Run NGATE

NOTE: NGATE will take hours to run when extracting a DTM of the entire HiRISE stereo model. **For Guest Facility Users, or others, doing production work, see Appendix: A 5.2 NGATE and AATE Batch Processing** for how to run NGATE in batch.

1) Press “Start” on the NGATE window.



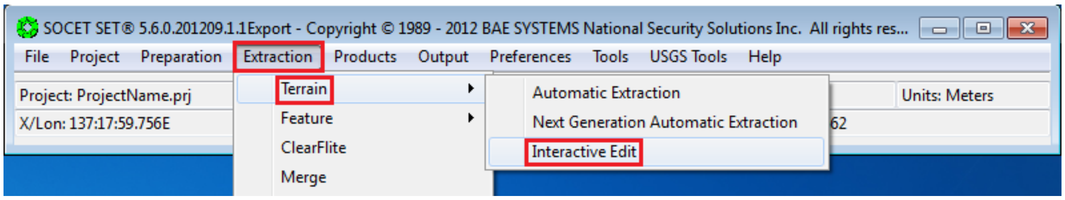
2) Upon completion of NGATE, select “File” > “Exit”.



21.3 Convert NGATE DTM to AATE format

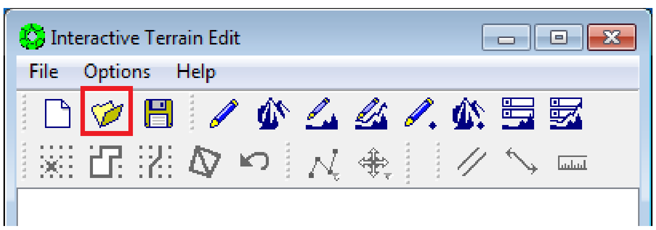
21.3.1 Copy/Save NGATE DTM using Interactive Terrain Edit (ITE)

1) From the SOCET SET menu bar, select “Extraction” > “Terrain” > “Interactive Edit”.

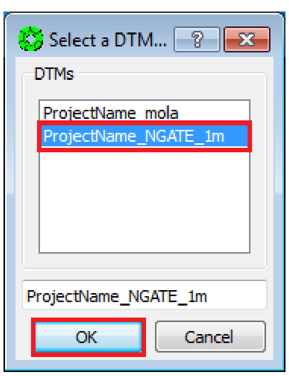


2) Open the newly created NGATE DTM:

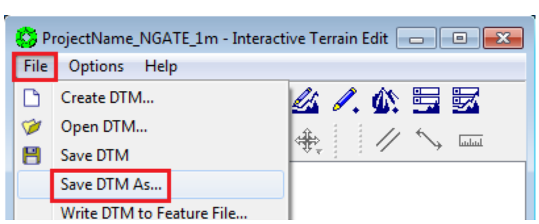
a. Press the “Open DTM” icon in the ITE window to bring up the selection window.



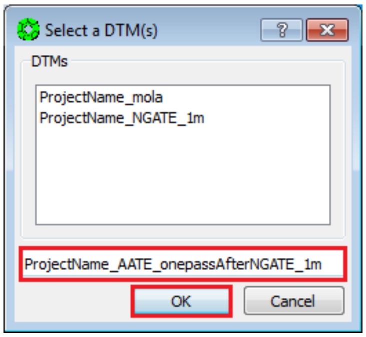
b. Select <ProjectName_NGATE_1m from the DTM list. Then press “OK”.



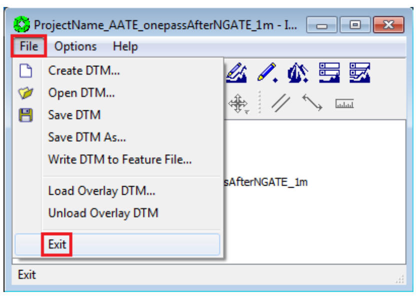
3) On the ITE window, Select “File” > “Save DTM As…”.



4) In the selection window, hand enter the name of the output DTM as <ProjectName>_AATE_onepassAfterNGATE_1m. Then press "OK".



5) On the ITE window, select "File" > "Exit".

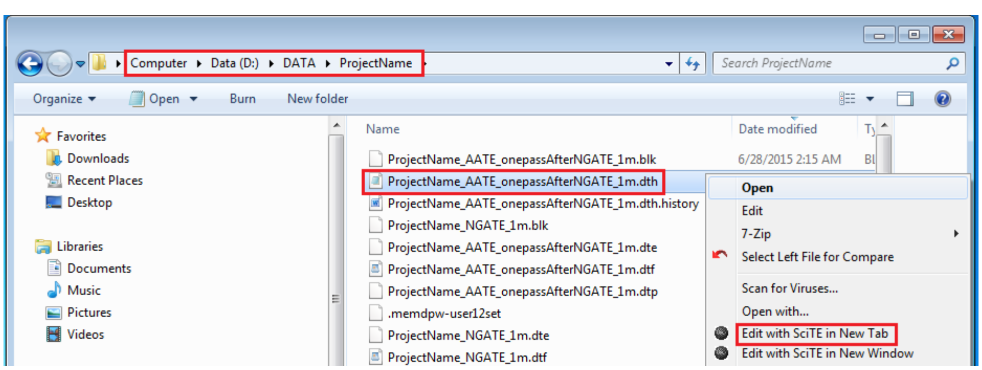


21.3.2 Update AATE Header File

Edit <ProjectName>_AATE_onepassAfterNGATE_1m.dth to convert it to AATE format. (This is the DTM header file, located in the project's data folder/directory.)

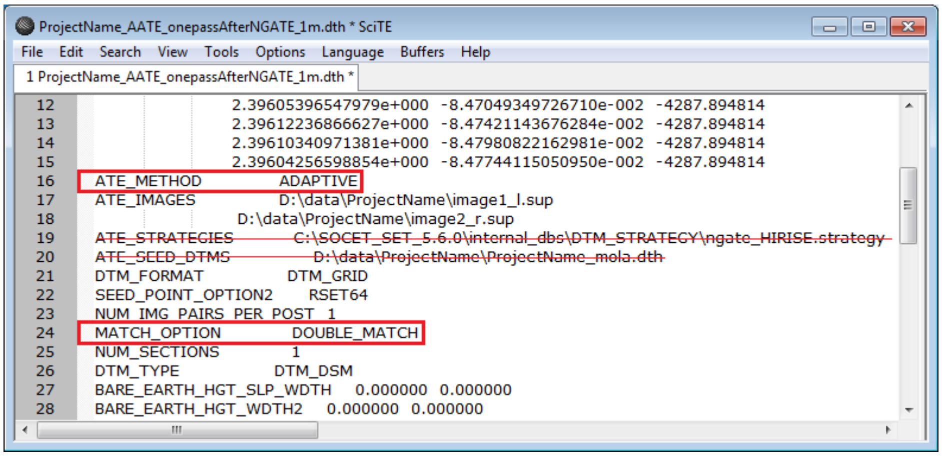
1) Bring up Windows/File Explorer.

2) Navigate to D:\DATA\<ProjectName>. Right-Click on <ProjectName>_AATE_onepassAfterNGATE_1m.dth and select a text editor. At USGS, use SciTE editor.

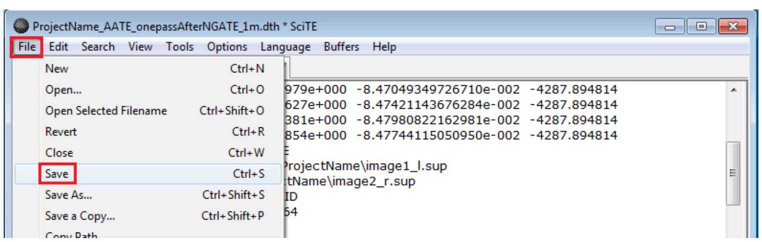


3) Make the following Edits:

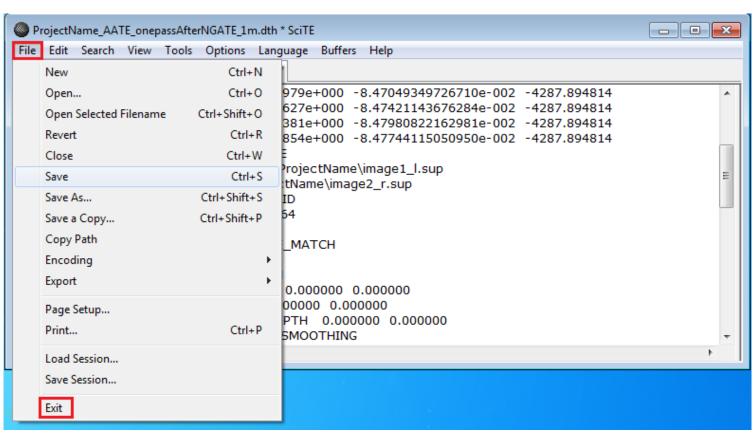
   a. Set ATE_METHOD to ADAPTIVE.
   b. Delete ATE_STRATEGIES line.
   c. Delete ATE_SEED_DTMs line.
   d. Set MATCH_OPTION to DOUBLE_MATCH.



4) Select “File” > “Save”.



5) Select “File” > “Exit”.



6) Close the Windows/File Explorer window.

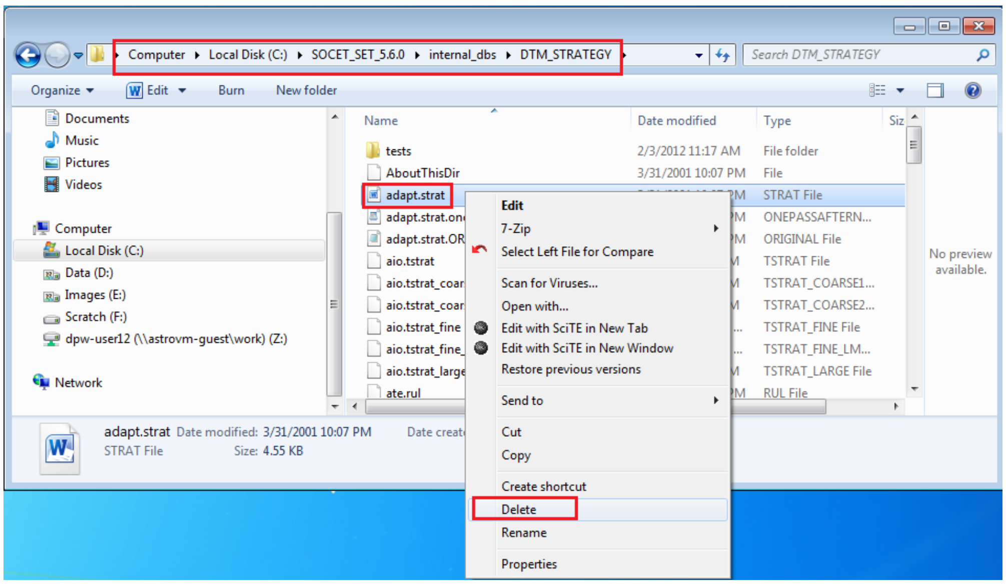
21.4 Replace strategy file for AATE

Replace adapt.strat with adapt.strat.onepassAfterNGATE.strat in the <install_path>\internal_dbs\DTM_STRATEGY folder:

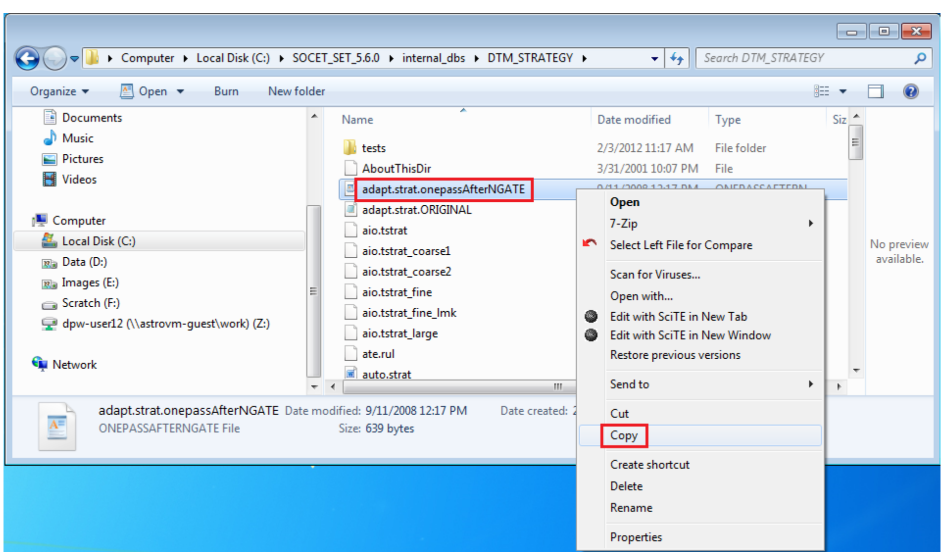
1) Bring up a Windows Explorer window.

2) Navigate to C:\SocetSet_5.6.0\internal_dbs\DTM_STRATEGY.

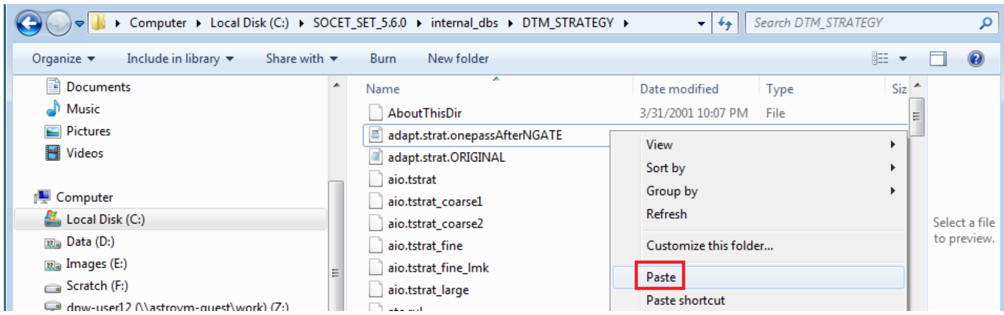
3) Right-Click on adapt.strat and select “Delete”.



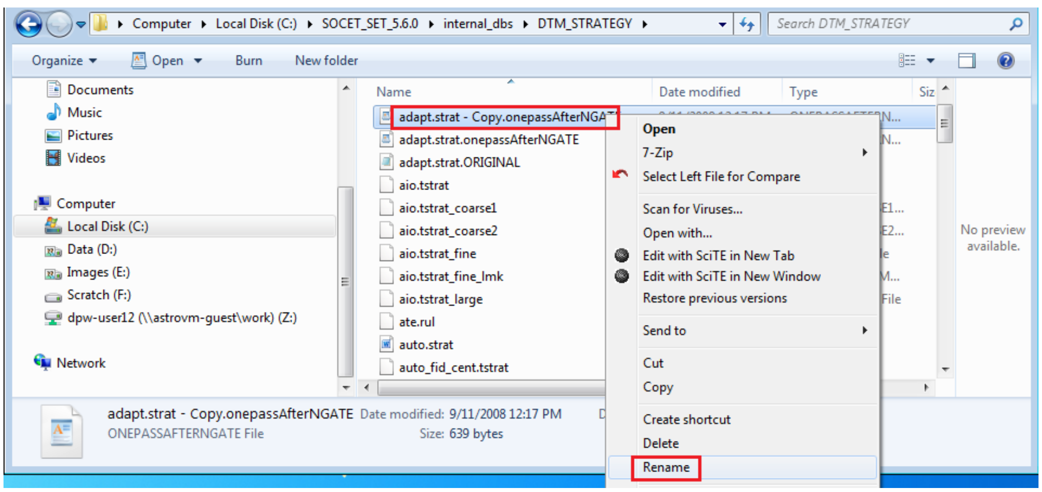
4) Right-Click on adapt.strat.onepassAfterNGATE.strat and select “Copy”.



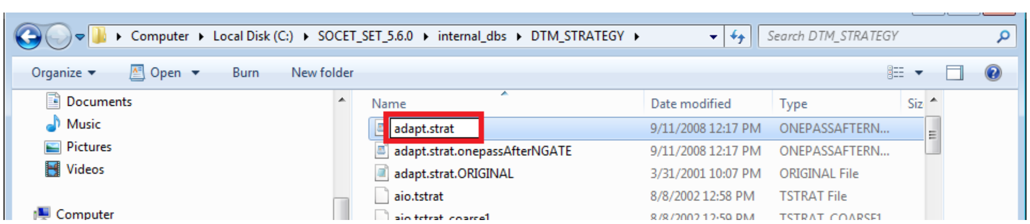
5) Right-Click within the folder and select “Paste”.



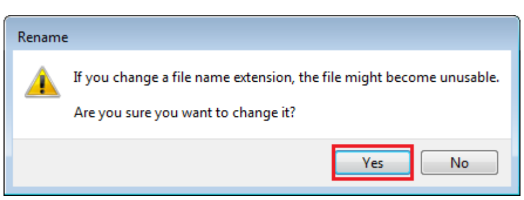
6) Right-Click on adapt.strat – Copy.onepassAfterNGATE and select “Rename”.



7) Rename the file adapt.strat.



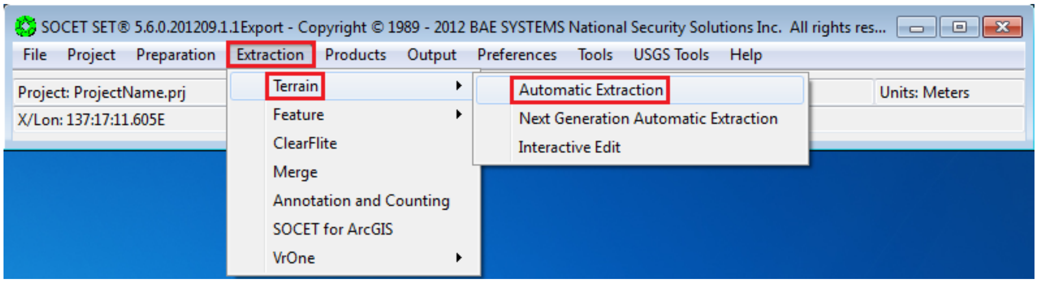
8) Confirm change in extension (press “Yes”).



9) Close Windows/File Explorer window.

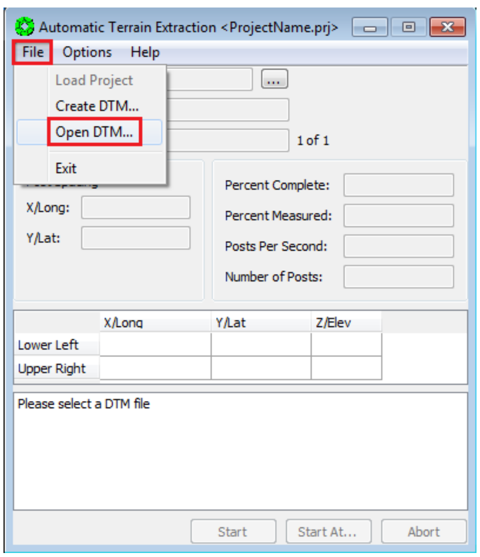
21.5 Adaptive Automatic Terrain Extraction (AATE)

From the SOCET SET menu bar, select “Extraction” > “Terrain” > “Automatic Extraction”.

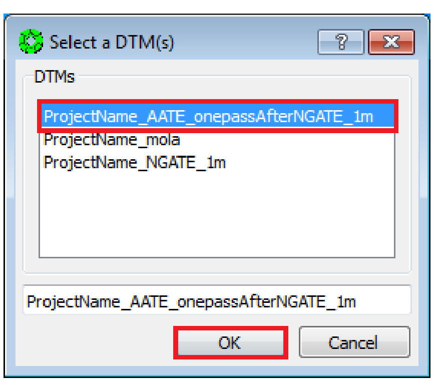


21.5.1 Load NGATE DTM for AATE process

1) From the AATE window, select “File” > “Open DTM…”.



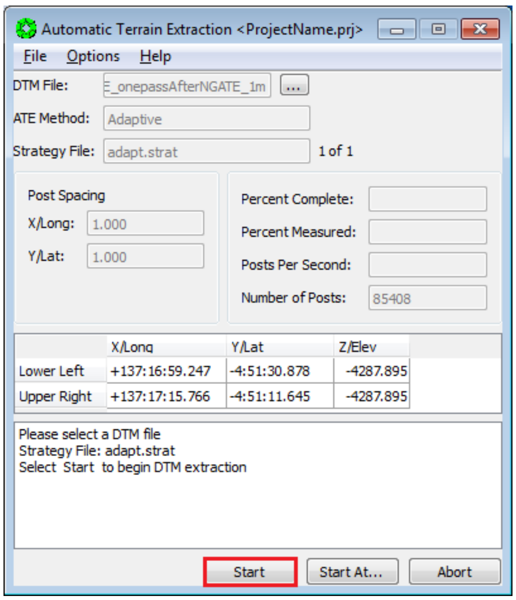
2) Select <ProjectName>_AATE_onepassAfterNGATE_1m in the selection window. Then press “OK”.



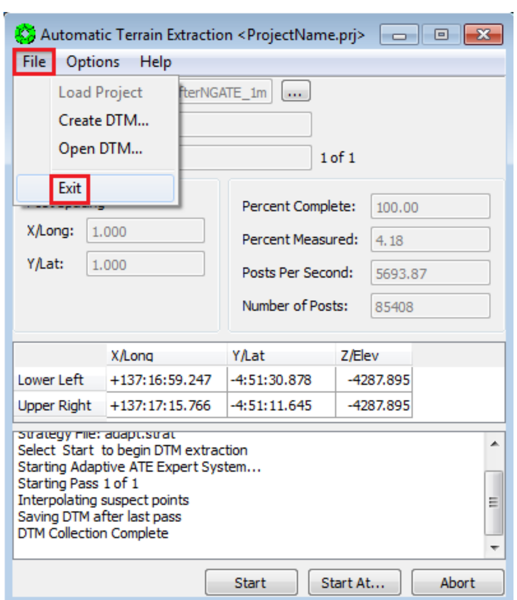
21.5.2 Run AATE

NOTE: AATE can take approximately one to two hours to run when using the “onepassAfterNGATE” strategy. **For Guest Facility Users, or others, doing production work, see Appendix: A 5.2 NGATE and AATE Batch Processing** for how to run AATE in batch**.**

1) Press “Start” on the AATE window.



2) Upon completion of AATE, select “File” > “Exit”.



22Edit DTM

Use Interactive Terrain Edit (ITE) to display and edit DTMs. ITE provides post (point), geomorphic (line), and area editing tools. The Post Editor allows post-by-post review and edit. It is used for detailed editing of small areas. The Area Editor changes all posts within an area delineated by a polygon. It is used for smoothing, plane fill, interpolation, etc. The Geomorphic editor forces a DTM to conform to breaklines such as ridges and drains, that you draw.

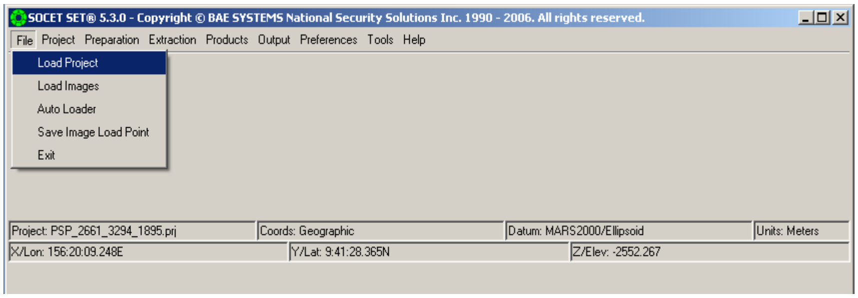
The scope of this section is not to show how to use all the tools, but to suggest a few that we find most useful. What follows is our training guide for ITE. It is self-contained and steps you through loading a project, loading images, stereo display options needed for editing, setting graphical display and cursor preferences, ITE options and tips, and a FAQ section.

22.1 Loading a Project

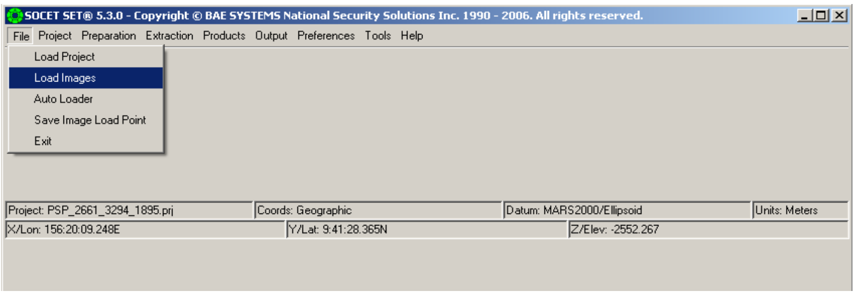
Start SOCET SET.

Open a current project: SOCET SET > “File” > “Load Project”

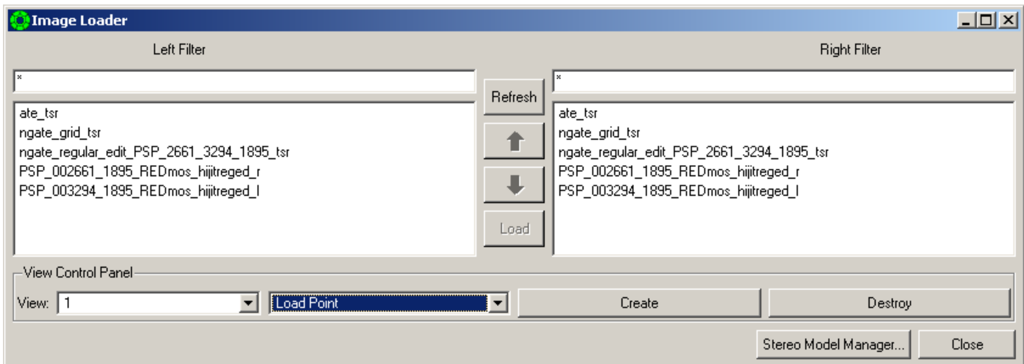
Select the project from the window



Open the Image Loader Window: SOCET SET > “File” > “Load Images”

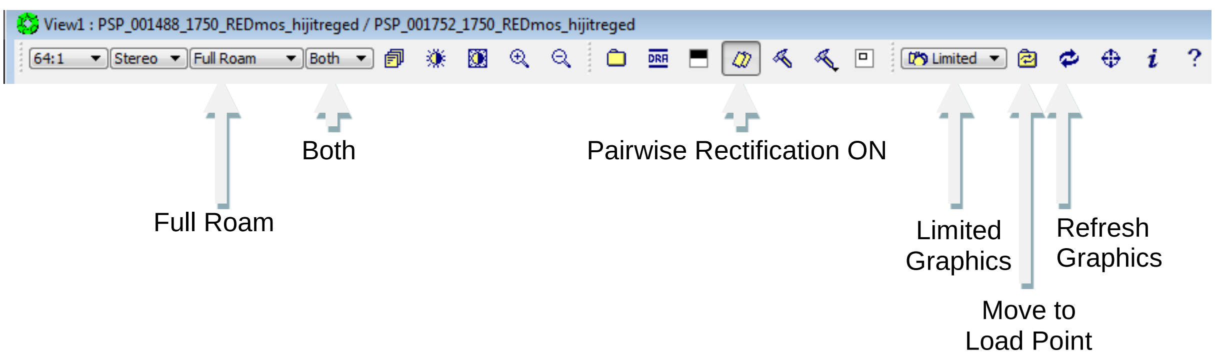


The following window will appear. Select the Left and Right Images to display. Make sure that "Load Point" is selected at the bottom of the window, under "View Control Panel" settings. Use this interface to load the epipolar rectified Left and Right images into View 1.



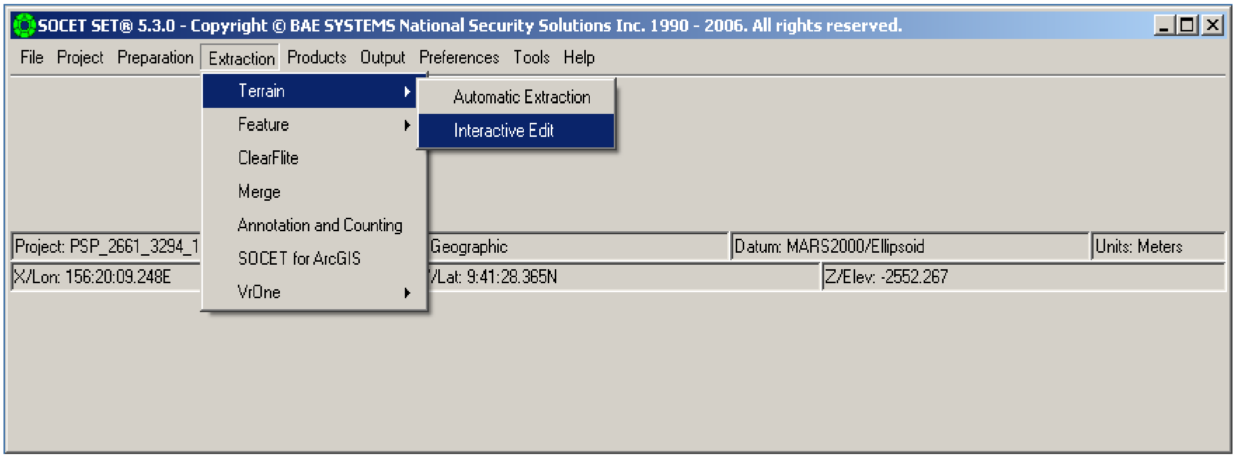
22.2 Set the stereo display, planar monitor settings

Below is an example of the settings typically used for View 1 during an editing session. (These are on the View 1 window.) The standard settings for the planar monitor, stereo display are highlighted with an arrow.



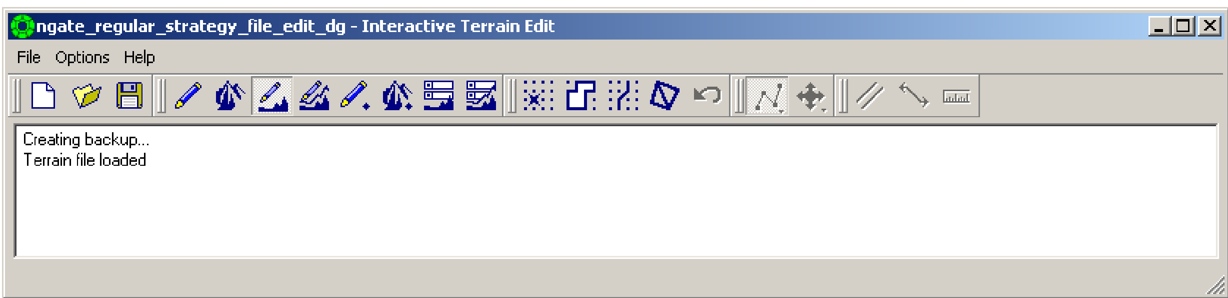
22.3 Start Interactive Terrain Edit (ITE)

Open Interactive Terrain Edit (ITE): SOCET SET > Extraction > Terrain > Interactive Edit



The following window will open.

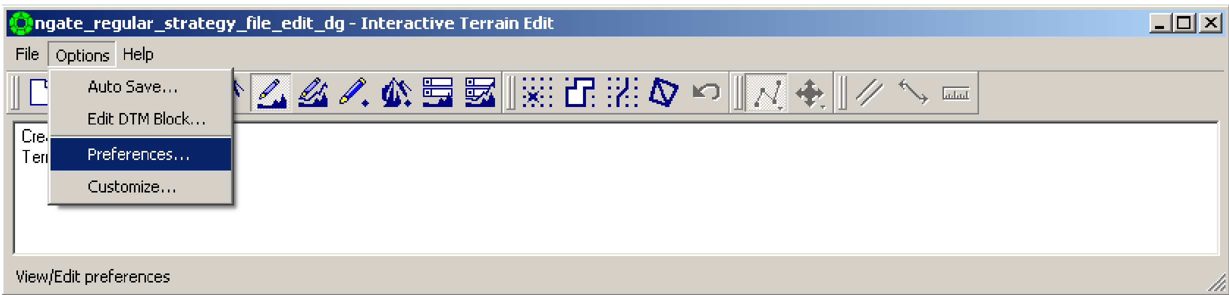
Open or load the DTM with "File" > "Open", or press the "open file" icon



22.4 Setting graphical display options

Open the Graphic Display Preference window for ITE: Select ITE > “Options” > “Preferences” (see Method 1). A faster, alternate method to open the Graphic Display Preference window is by clicking on the icon button toolbar along the top of the ITE Window.

Method 1:

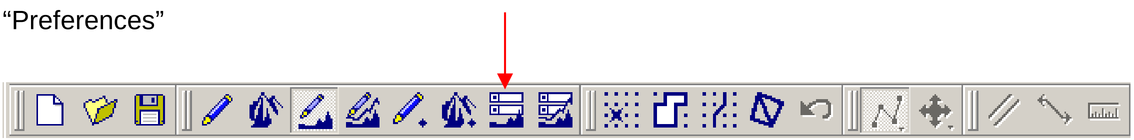


Press the “Setup DTM Graphics” Icon button (see Method 2)

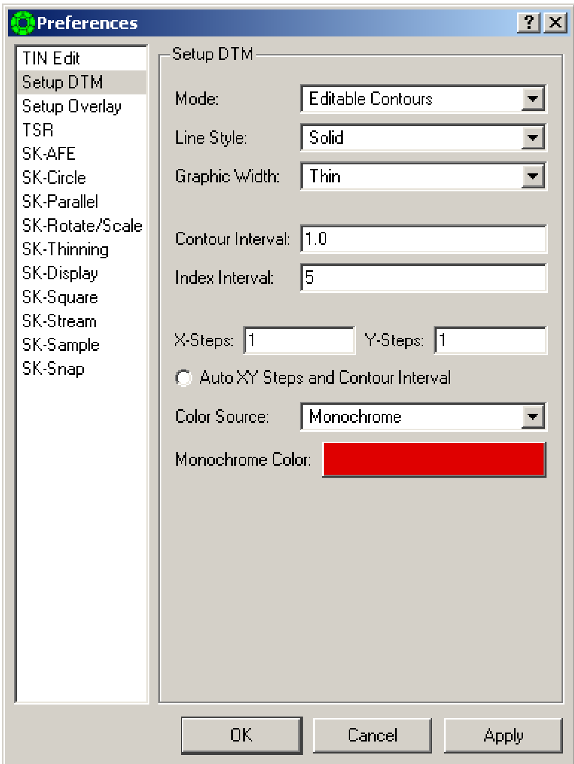
Method 2:

Shown below is the ITE Window toolbar.

Select the Icon shown below from the toolbar. This has the same effect as clicking on ITE > “Options” > “Preferences”



Shown below is the ITE Graphic Preferences window: The settings shown in this example are typical settings used for HiRISE DTM editing.

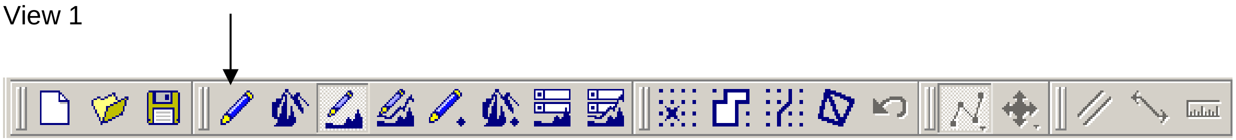


Tip –

Remember to click on “Apply” after setting your preferences here. Any changes will not take effect until you click on “Apply” and redraw the graphics (see pencil tool indicated on the toolbar below)

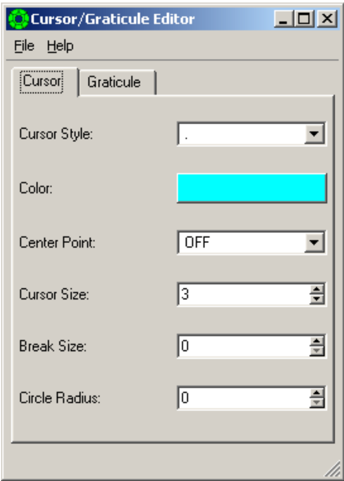
After setting your DTM graphic preferences, press the icon indicated below to draw the graphics in

View 1

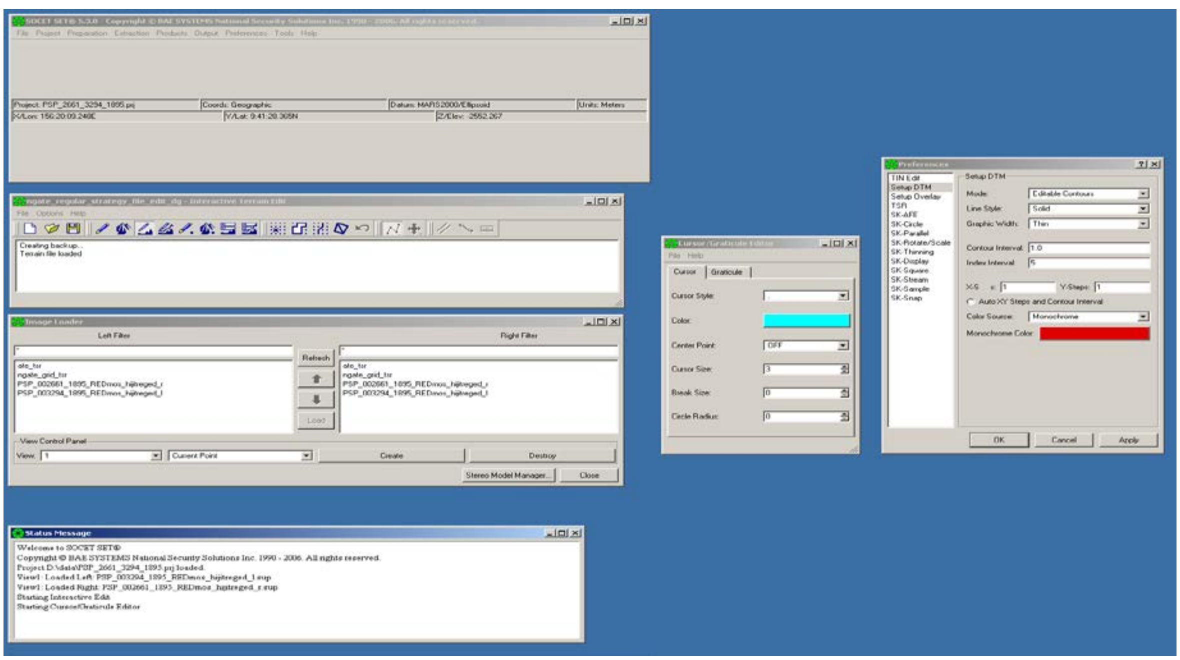


22.5 Setting cursor preferences

To assist in setting editing preferences, open the Cursor preference window. Select SOCET > "Preferences" > "Cursor/Graticule Editor". Use this to save or load a cursor editor style. While editing a DTM using ITE, the cursor style keeps resetting to the default cursor style which may not be an individual user's preferred cursor style. After setting the cursor editor style options, use File > Save Cursor to save your own style, and use File > Load to open a previously save cursor editor style.



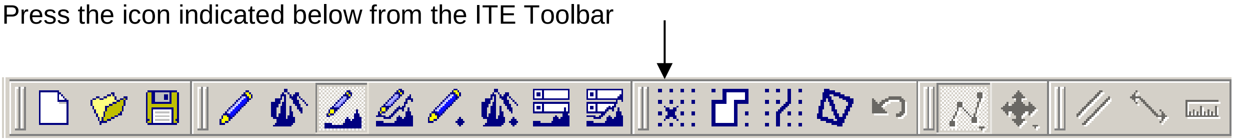
Below is an example of a desktop, with SOCET SET/Interactive Terrain Edit initiated, and other options and preferences discussed above available.



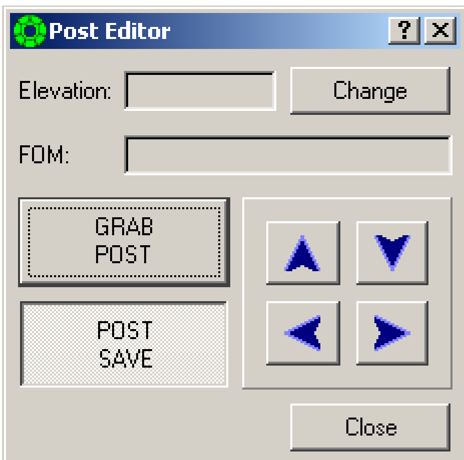
22.6 SOCET SET Interactive Terrain Editing

Post Editing – Use this editing function when you want to adjust the elevation of the individual posts. Beware – this is a time-consuming editing choice, but it allows for high accuracy in setting individual post elevation.

Press the icon indicated below from the ITE Toolbar



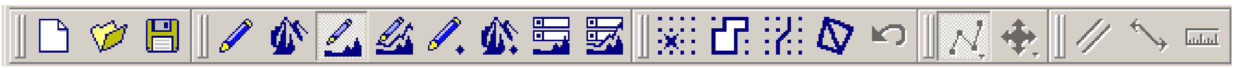
The following window will open



For this editor, change the graphic display Mode (under the Preferences window) to Dots, Icons, or Editable Contours & Dots – in other words, a graphical display in which you can identify the individual posts. Click on "Grab Post" to snap to the post you want to adjust. Use the cursor arrows to move from post to post. To release the post, click again on "GRAB POST" and the cursor will release the post. Be sure to intermittently toggle the graphical display between Off/Limited at View 1 to verify that you are "on the ground". You can also use the "snap to ground" button on the cursor to quickly move the post to ground. Visually verify that the post was moved to ground. Don't just rely on the software.

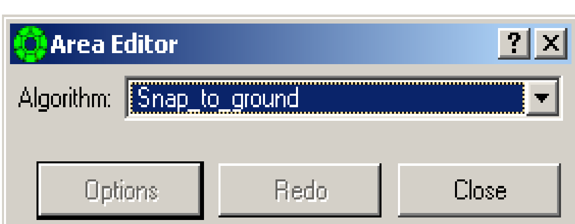
Area Editing – Use this editing feature to adjust the elevation for a group of posts. There are many available functions within this edit feature. Below are 3 of the most commonly used .

Press the icon indicated below from the ITE Toolbar: Using the TopoMouse, draw a polygon around the area to be edited.



This area editor is great for spikes (where one or more posts are obviously off of the ground and the surrounding posts are generally on the ground). Just draw a polygon around the spike and the software will interpolate the elevation of the posts inside the polygon from those directly outside of the polygon. However, this editor rarely works against the outer edge of the DTM.

Use this area editor whenever a general smoothing of an area of post elevations is desired. It works well when the posts are generally close to the ground, but there is artificial noise. Use the "Redo" button for as many repetitions as desired. This is a good follow up to an "Interpolate_1st_order" area edit. However, if your post are "off the ground" to begin with, this area editor isn't the best choice.



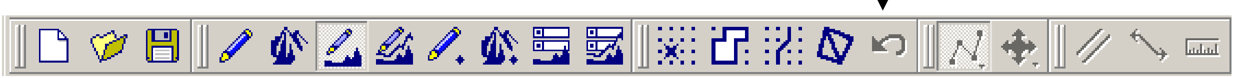
This is a great area editor when it works. It systematically moves through each post within the delineated polygon and snaps it to ground. Beware! Save your edits prior to using this editor, because you cannot undo your edits – sometimes spikes are introduced! Only use this for small area edits. ITE will crash if you draw a polygon that is too large.

Geomorphic Editing – Use this editing feature to adjust the elevation for a group of posts along ridgelines, within depressions, and along slopes. It also works within crater walls and along the crater rim. With this editor, you are essentially drawing a line along the face of a feature with the goal of changing the elevation of posts within a defined (interpolation) distance on either side of the line.

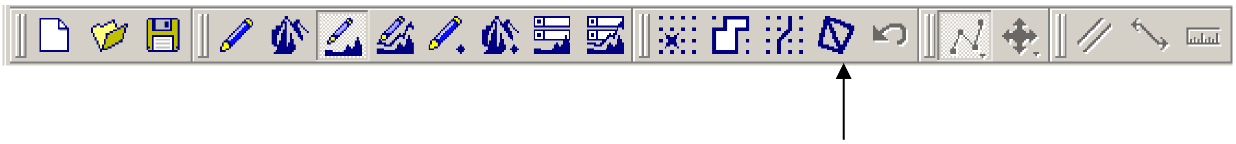
Press the icon indicated below from the ITE Toolbar:

The most commonly used Algorithm with this editor is "Uniform Slope". Set the "Interpolation Distance" by first estimating the distance based on the resolution of the DTM to be edited (For HiRISE DTMs use 1 – 5 M, MER MI DTMs require a much smaller distance). Then, using trial-and-error, find the best distance for the type of feature that you are editing. Generally, along the sides of slopes, a greater Interpolation Distance works well, while along a crest or ridge line, a narrower, or smaller distance is used. Be sure to toggle between Limited/Off for the graphics display to make sure that the posts (as displayed by contours) are on the ground.

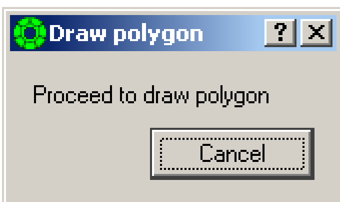
UNDO The button indicated below allows one "undo" following the execution of any edit except the "Snap_to_ground" area edit. Use this if any edit function produces unexpected and undesired results! But remember that you can only "back-up" once.



Editing Using a Triangulated Irregular Network (TIN) A special editing function is accessed by clicking on the indicated icon. This edit feature allows the user to use TIN tools to edit a delineated area within a DTM/GRID. Remember that the DTMs normally produced for editing are in a GRID format, meaning that the posts are in a regularly spaced grid pattern. A TIN is an irregularly spaced framework of posts. Unique editing tools are available once a defined area is temporarily converted into a TIN. Use this edit feature for terrain that is complicated and requires high DTM accuracy.



The first step is to click the highlighted icon. The following window will open. Draw a polygon around an area to be edited, as requested.



TIN editing mouse button functions to remember:
Toggle cursor and delineate a polygon (left mouse button).
Accept polygon (right mouse button) to start the area tool.
Pick/Move Post = Left mouse button
Delete Post = Middle mouse button
New Post = Right mouse button

Once the delineated area has been converted into a TIN, the other edit functions describe above are available for use. Post editing is especially useful here. One option is to set the DTM graphic preferences to a mesh to see the posts and TIN structure easily. TIN based editing functions are flexible and powerful.

22.7 FAQ's

1. What should I do when it appears that the edit function I have selected isn't doing anything?

First make sure that you closed the edit polygon (area edits) or completed your line drawn (geomorphic editor). Then make sure that the edit settings are reasonable for the DTM you are currently working on. Is the Interpolation Distance defined in the geomorphic editing window entered correctly? If everything appears to be set up correctly, close the editor and re-open it. Sometimes ITE gets "stuck" and needs to be restarted.

2. I can't get ITE to open. The Menu button for ITE is grayed out and nothing happens when I click it.

Make sure that you have opened "Load Images". From the "Load Images" window, correctly select both images, and press "Load". ITE can't be initialized without images loaded in View 1.

23Generate Orthorectified Images

For HiRISE, it is useful to generate an orthoimage of each image in the stereo pair at both (a) 1 m resolution, exactly matching the DTM, and (b) 0.25 m resolution to preserve the maximum information in the images.

We use the controlled images (not the epipolar rectified images with _r and _l extensions), *without enhancements*, as input for orthorectification.

23.1 Move or Delete Enhancement Files

1) Make sure there are no image enhancement files associated with the input image in the project data directory before proceeding. Enhancement files are stored in the Project's data folder (i.e., D:\DATA\<ProjectName>) and have an extension of .enh.

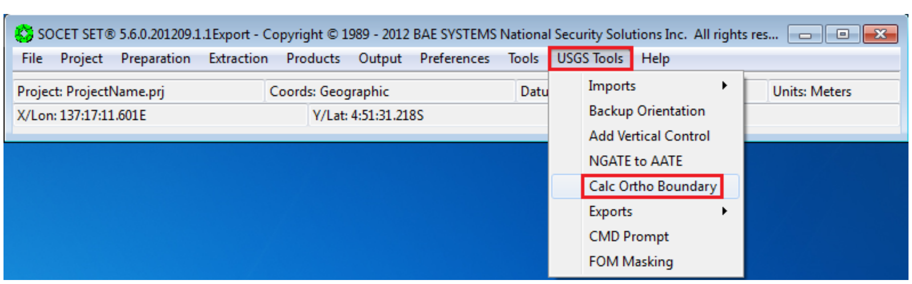
    a. If there are enhancement files, delete them or move them somewhere else temporarily.

    b. We do this because image brightness/contrast adjustments in the enhancement files will be applied to the orthorectified image upon creation. We are keeping track of the stretch to 8-bit when processing HiRISE images for SOCET SET import so that we can get back to radiometric values if needed. Appling an arbitrary stretch through enhancement files will defeat this purpose.

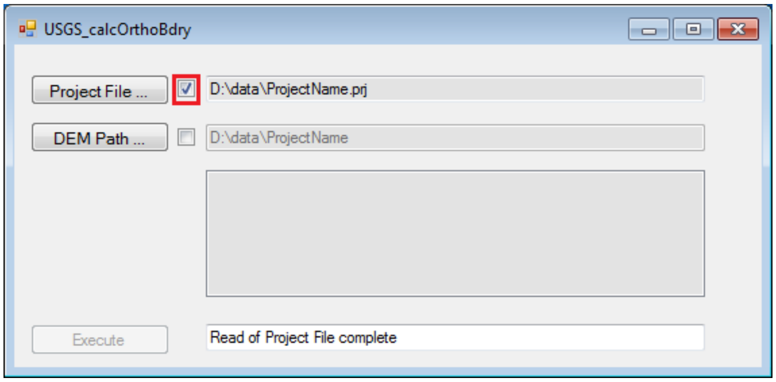
23.2 Run Calc Ortho Boundary

So that a 1:1 correspondence between the DTM and the 1 m orthoimages is maintained in software packages such as ISIS and Photoshop, we run "calc Ortho Boundary" to calculate Lower Left and Upper Right georeferencing corner coordinates to be used as input for orthophoto generation.

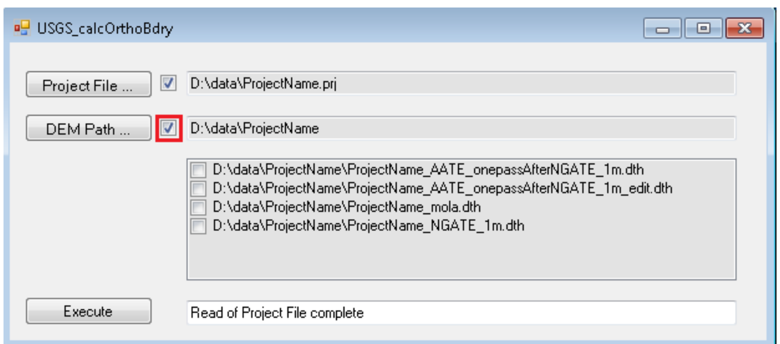
1) From the SOCET SET menu bar, select "USGS Tools" > "Calc Ortho Boundary".



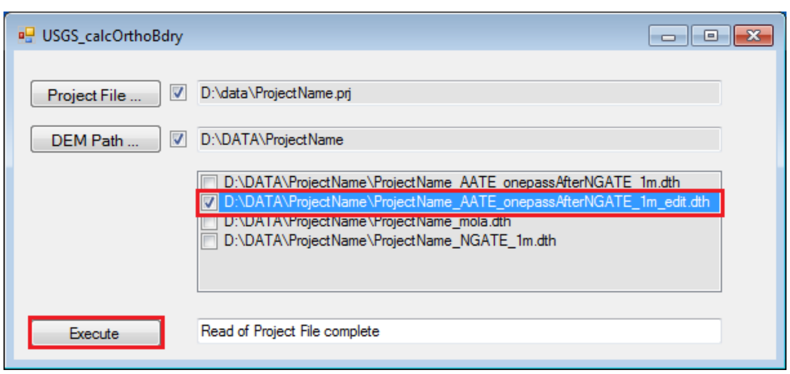
2) If the project file listed in the Project File field is correct, check the box next to the Project File field to confirm it. Otherwise, press the "Project File…" button to bring up the list of projects and select the project from the list.



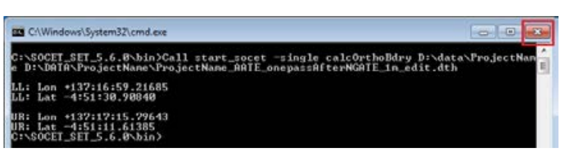
3) The path listed in the DEM Path field should be the path to the current project's data folder. If the path is correct, check the box next to the DEM Path field to confirm it. Otherwise, press "DEM Path…", and navigate to the project's data folder to select it.



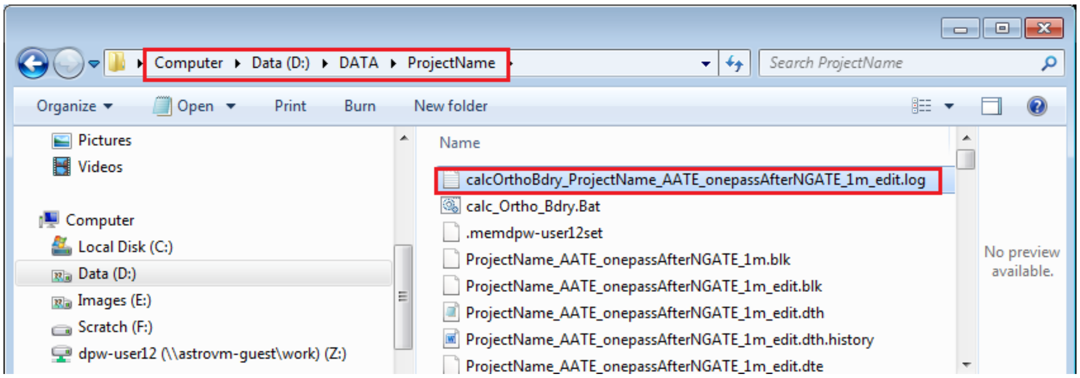
4) Upon confirming the DEM Path, the available DTMs in the project will be listed. Select the final edited version of the DTM by clicking on its check box twice. Then press "Execute".



5) Close the Command Prompt Window that came up.



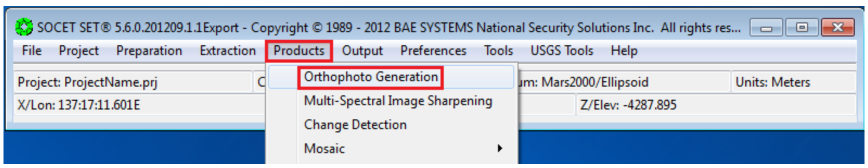
6) The results of Calc Ortho Boundary is written to a log file in the project's data folder. The log name is of the form calcOrthoBdry_<the_input_DTM_name>.log.



23.3 Orthophoto Generation

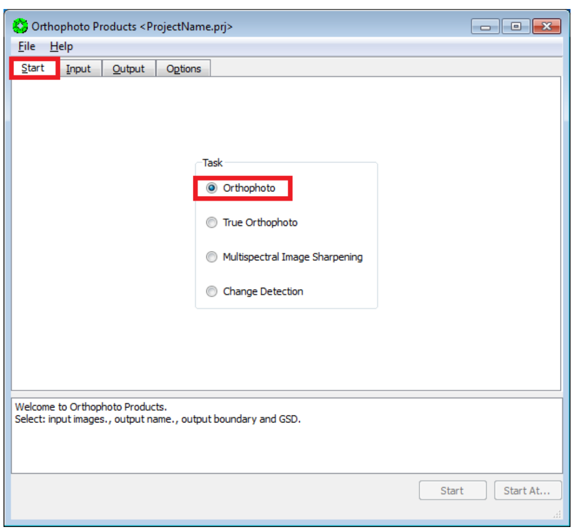
Note: Generation of 1 m orthoimages takes 1 to 2 hours. Generation of 0.25 m orthoimages can take up to 12 hours each. (These time estimates are based on the current processors configuration at the Planetary Photogrammetry Facility.) **For Guest Facility Users or Astrogeology staff, doing production work, see Appendix: A-5.3 Orthophoto GenerationBatch Processing for how to run Orthophoto in batch.**

From the SOCET SET menu bar, select “Products” > “Orthophoto Generation”.



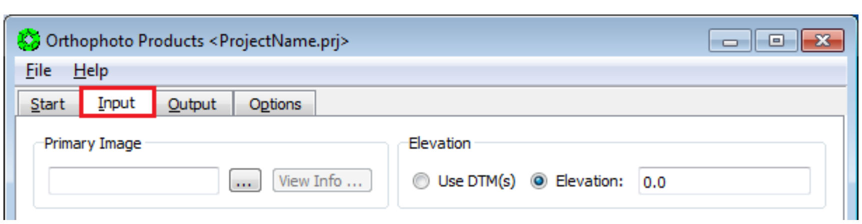
23.3.1 Start Tab

1) In the Start Tab, make sure Task is set to Orthphoto.

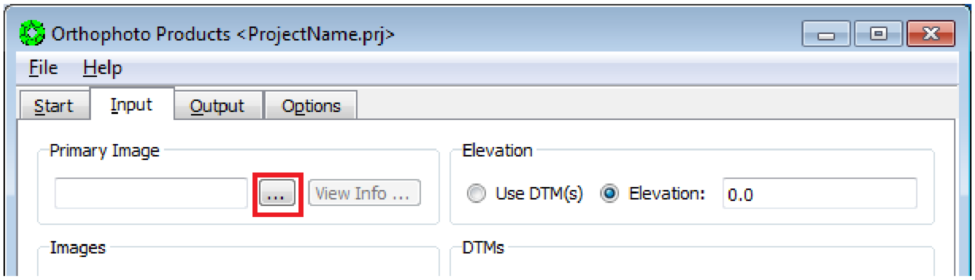


23.3.2 Input Tab

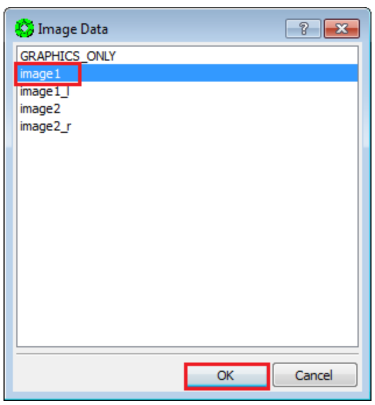
1) Press the “Input” tab.



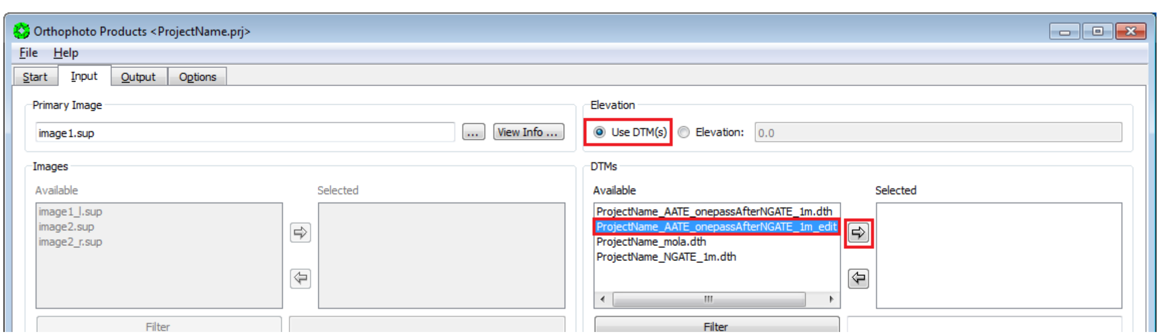
2) Press the button next to the "Primary Image" field.



3) In the pop-up window, select the image to orthorectify. Then press "OK". Do not select the epipolar rectified images.

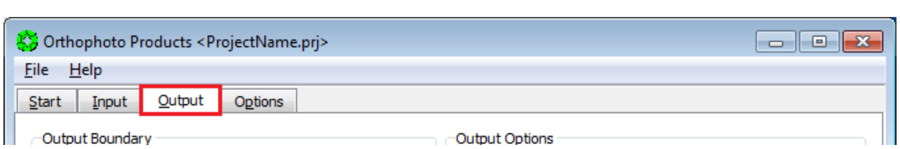


4) Press the radio button for "Use DTM". Then, from the list of "Available" DTMs, move the final (edited) DTM to the "Selected" list via the arrow button.

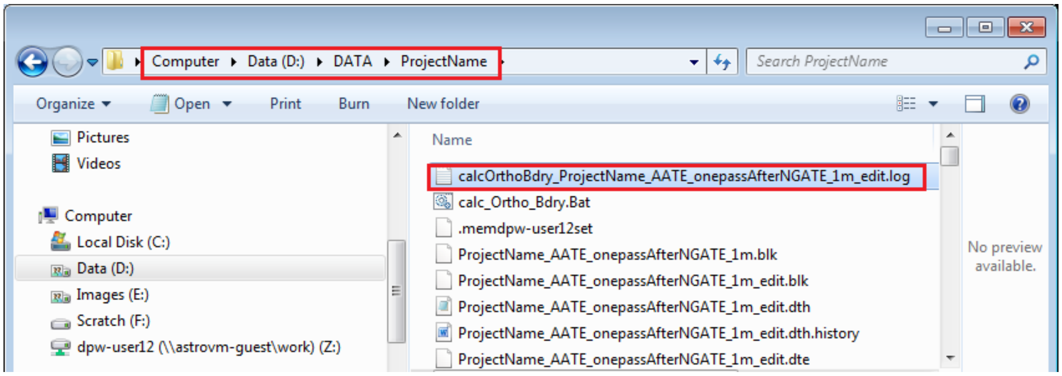


23.3.3 Output Tab

1) Press the "Output" tab.



2) Bring up a Windows/File Explorer window. Navigate to D:\DATA\<ProjectName> and open calcOrthoBdry_<DTMname>.log with a text editor.

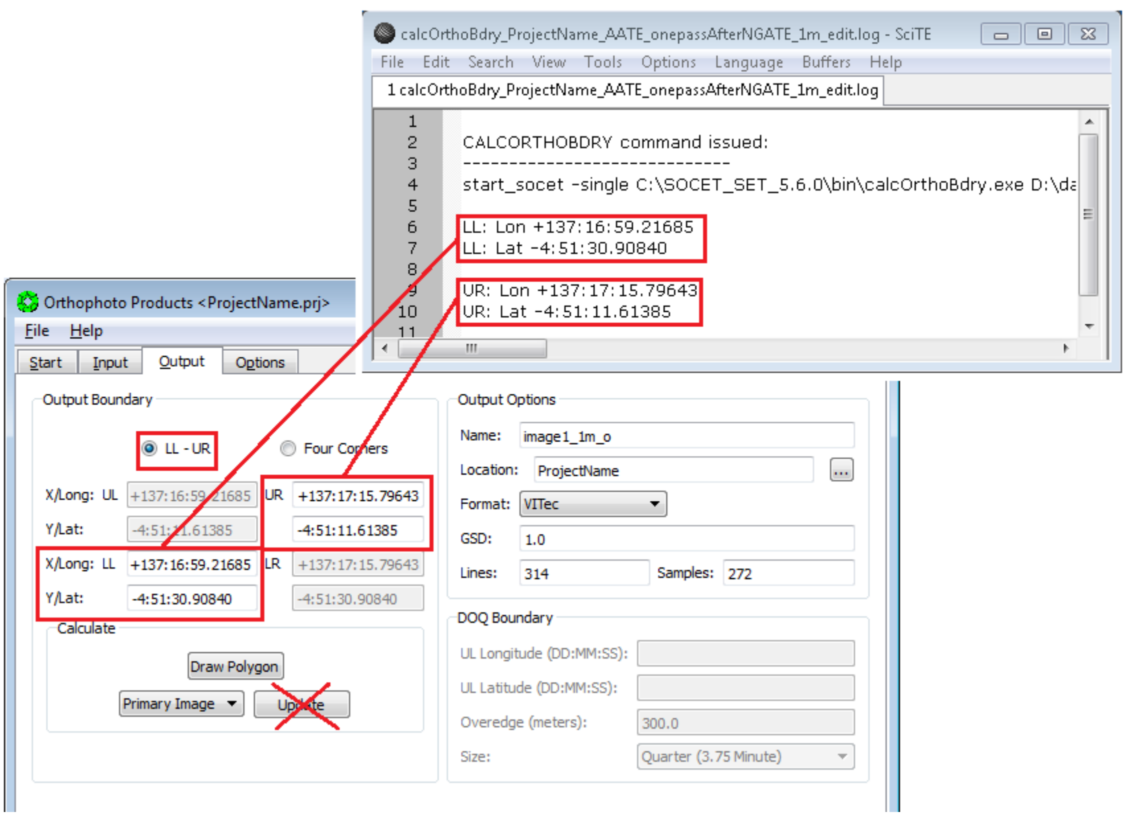


3) In the Output Boundary Section of the Orthophoto window:

a. Turn on radio button LL-UR in the Output Boundary section.

b. Then copy-and-paste the LL and UR coordinates from calcOrthoBdry_<DTMname>.log into the LL and UR boxes. Do not press “Update” after entering LL and UR coordinates.

Note: You only need to copy-and-paste the LL and UR coordinates once…the values will hold for multiple orthophoto setups.



4) In the Output Options Section:

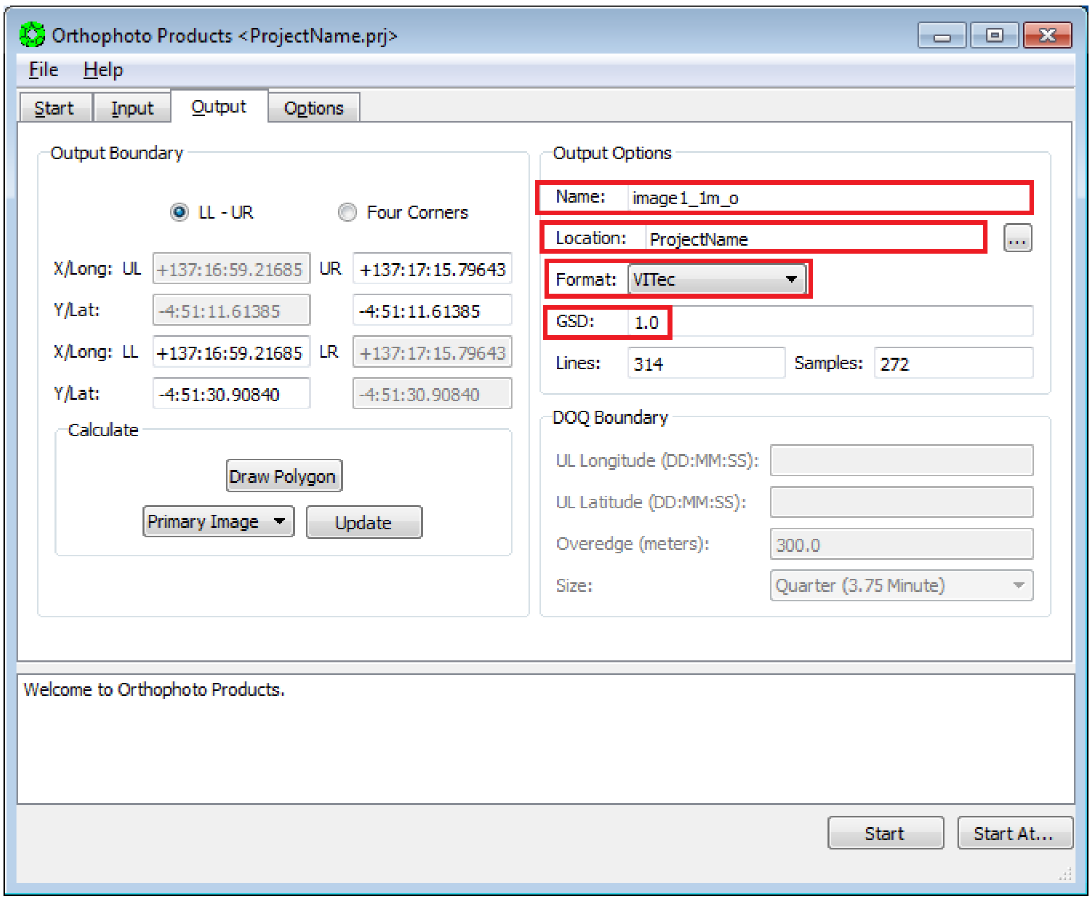
   a. Change the default “Name” of the orthoimage from <image>_o to <image>_1m_o or <image>_25cm_o, as appropriate.

   b. Make sure the “Location” is set to the project’s image location,

   c. Use the drop down arrow to set “Format” to Vitec.

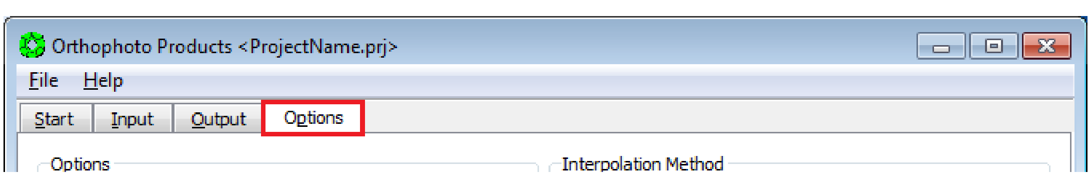
      Note: We’ve had problems with TIFF-Tiled format when orthorectifying large images.

   d. Type in the “GSD” (ground sample distance) of the desired resolution (e.g., 1 m or 0.25 m). Then press the enter key.



23.3.4 Options Tab

1) Press the “Options” tab.



2) In the Options Section:

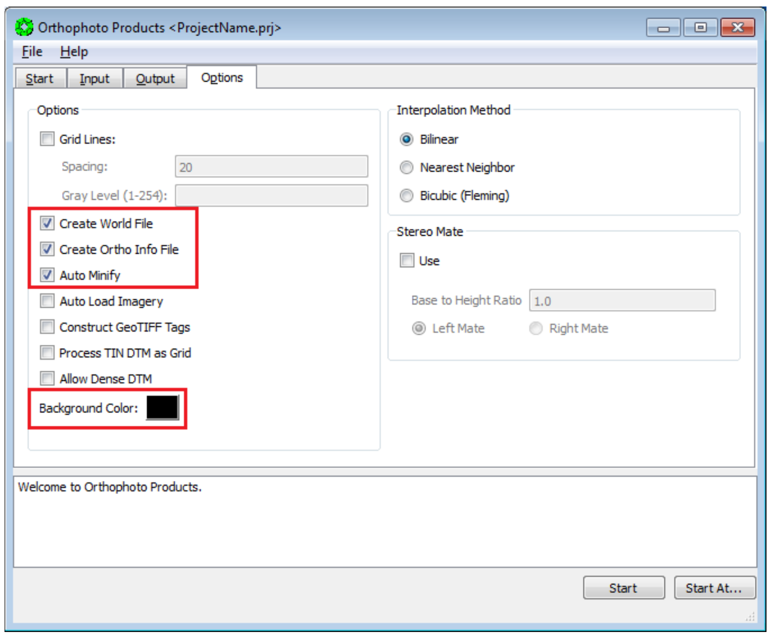
a. Check the boxes for:

i. Create World File.

ii. Create Ortho Info File.

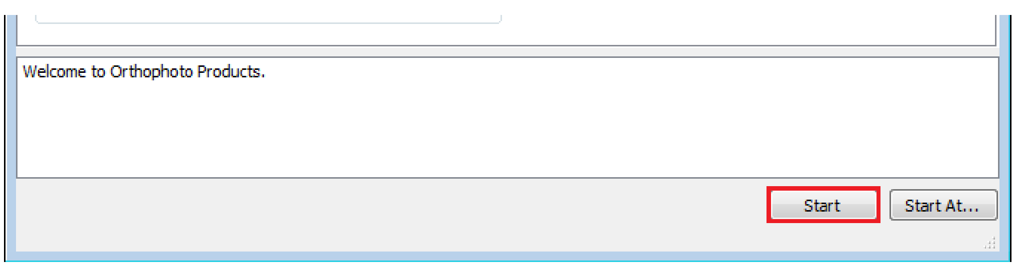
iii. Auto Minify.

b. Set the Background Color to Black: Click on box displaying background color to cycle through color options.



23.3.5 Run Orthophoto

1) Press “Start” at the bottom of the Orthophoto window.



2) Go To 23.3.2 Orthophoto Generation, and repeat the steps for next orthoimage.

3) Close the Orthophoto Products window when all orthoimages are generated.

24Export DTMs and Orthoimages

24.1 Brief Overview

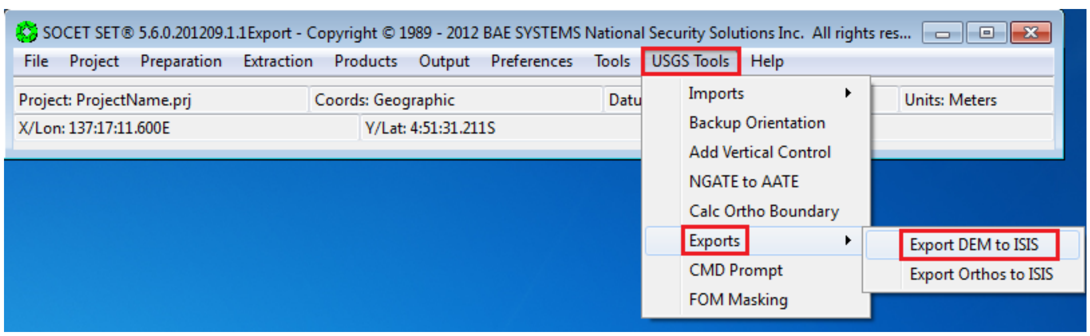
Exporting DTMs and Orthoimages is a two step process:

1) First we run utilities/programs on the SOCET SET workstations to convert SOCET SET file formats to raw binary files and build corresponding ISIS3 scripts. All raw binary files and ISIS3 scripts are placed in folder D:\DATA\<ProjectName>\Output_Products.

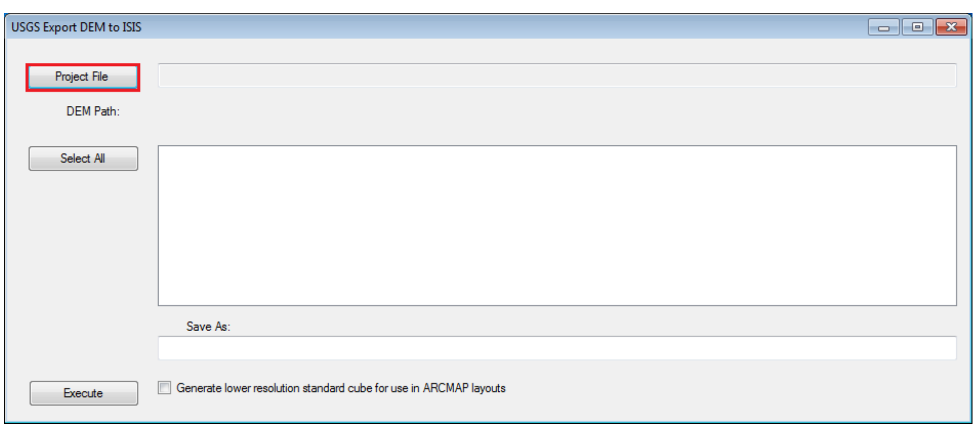
2) Then we copy the entire D:\DATA\<ProjectName>\Output_Products folder to an ISIS3 processing machine, where the scripts are executed to generate the ISIS3 cubes.

24.2 Export DTMs

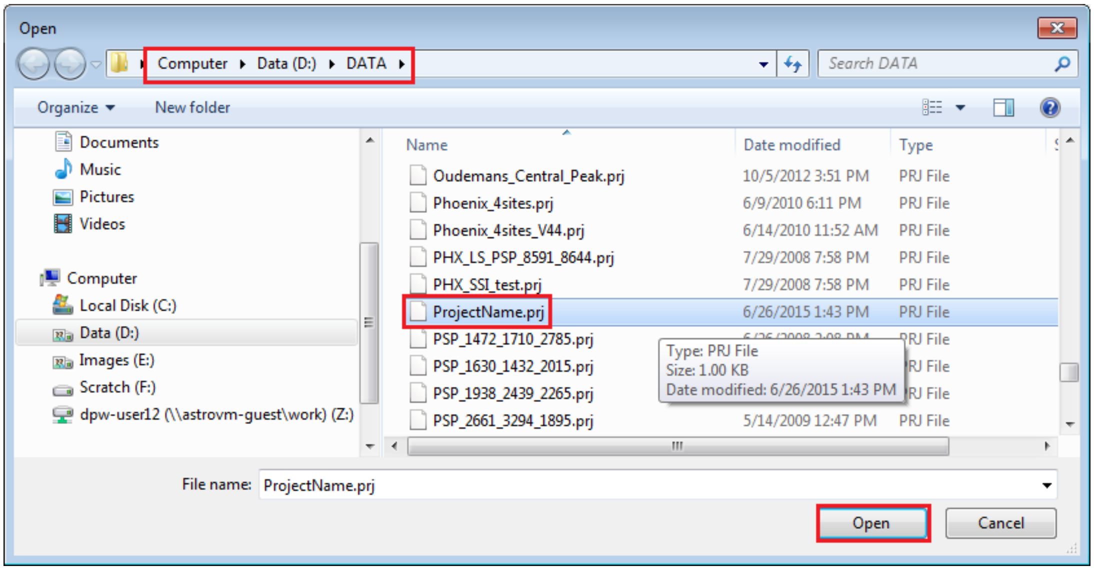
1) From the SOCET Set menu bar, select “USGS Tools” > “Exports” > “Export DEM to ISIS”.



2) Press “Project File”.



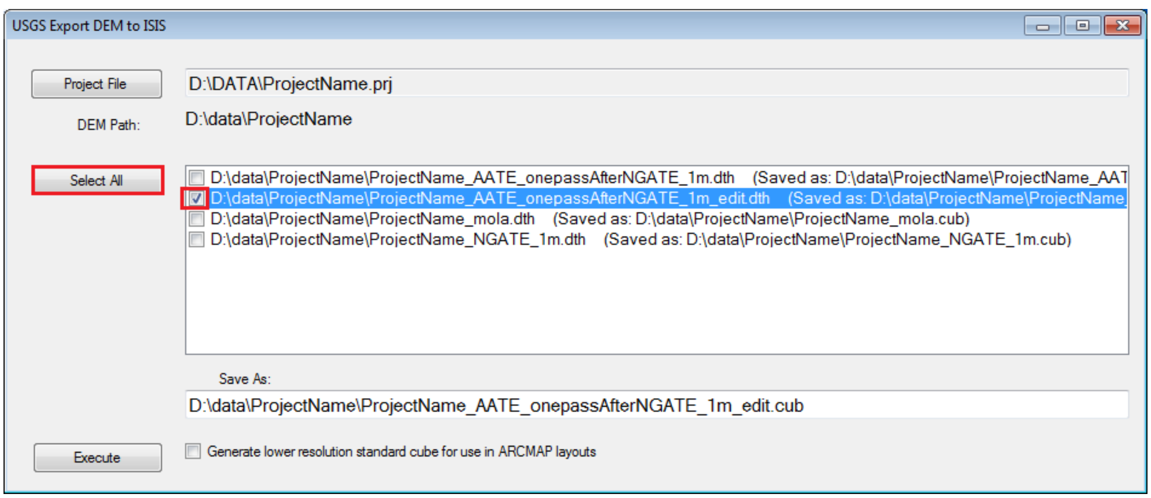
3) In the Open window, navigate to the main SOCET SET DATA folder (D:\DATA), select file <ProjectName>.prj, and then press “Open”.



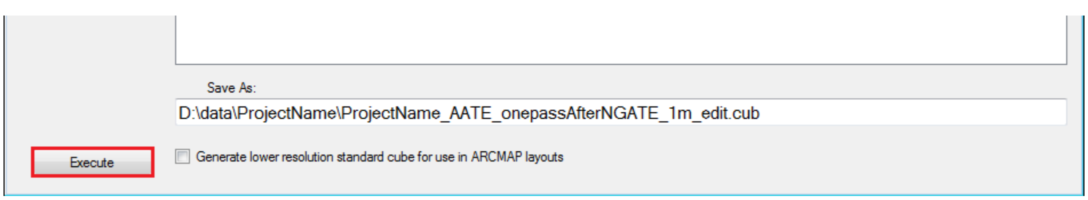
4) Select DTM(s) to export. Either:

a. Press “Select All” if you wish to export all DTMs, or

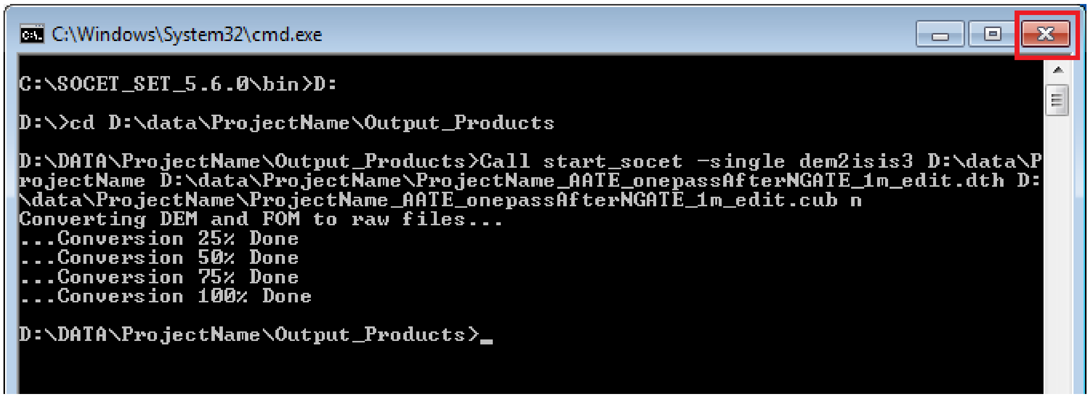
b. Double click on the check box for each DTM you wish to export.



5) Press “Execute”.

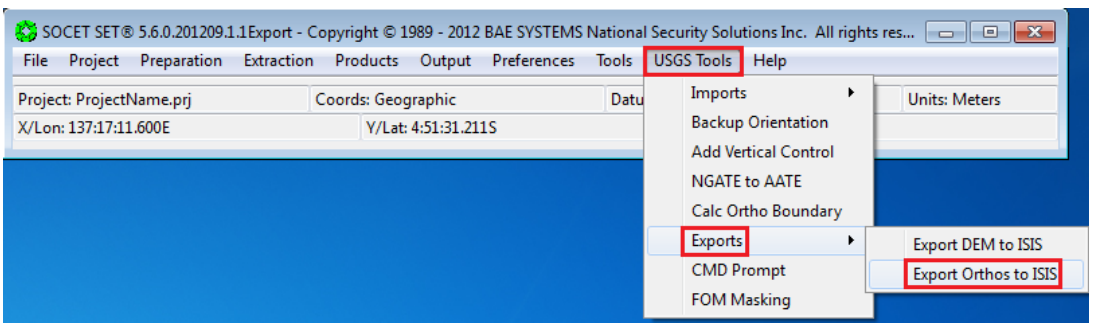


6) A Command Prompt window will pop-up. Upon completion of the program, close the Command Prompt window.

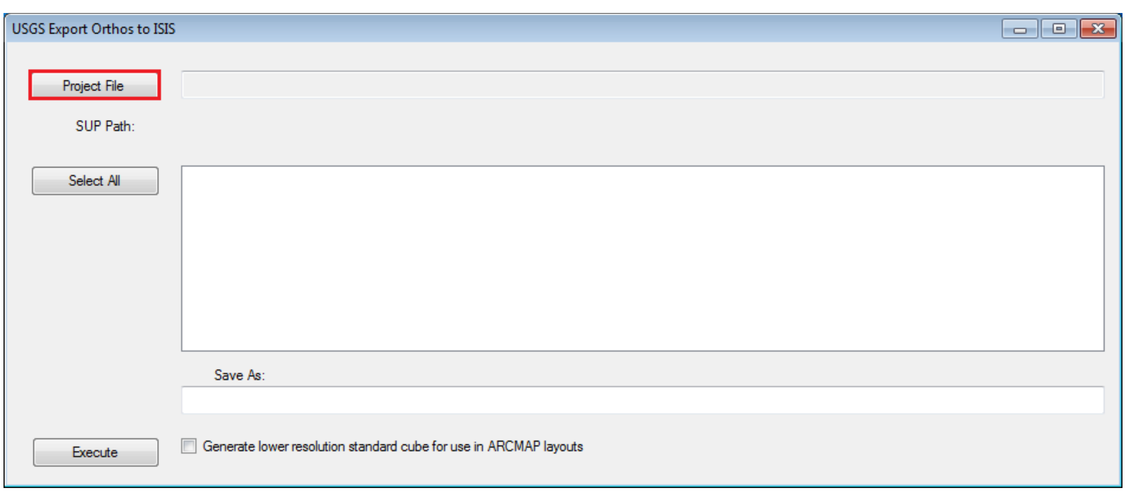


24.3 Export Orthoimage(s)

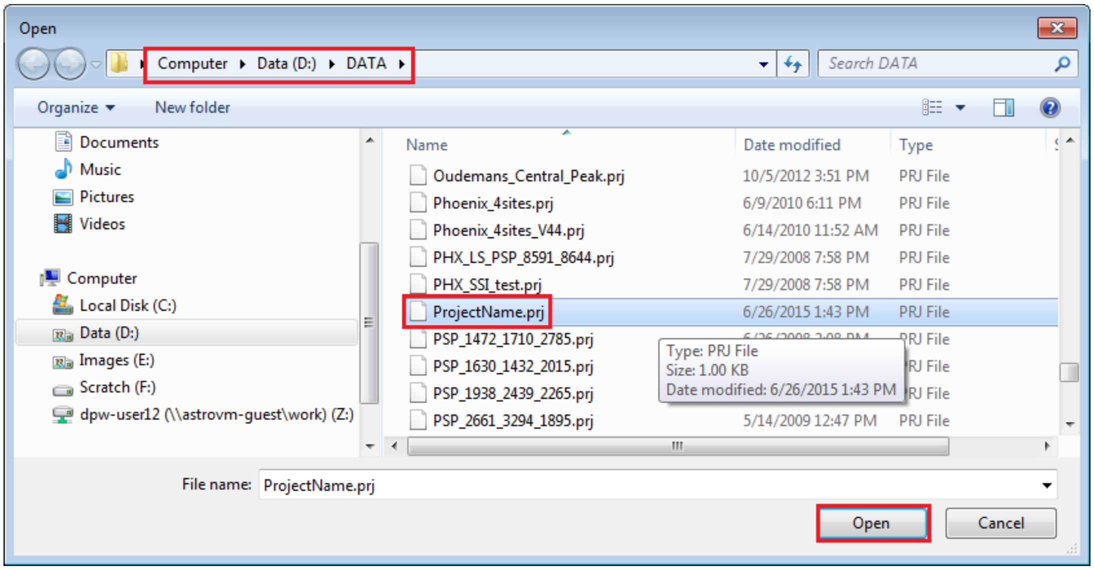
1) From the SOCET Set menu bar, select “USGS Tools” > “Exports” > “Export Orthos to ISIS”.



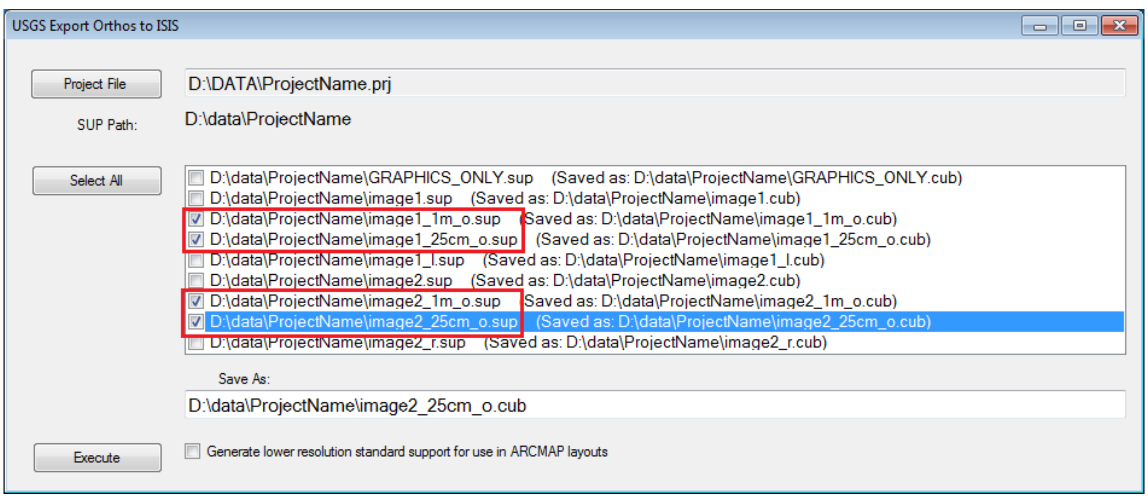
2) Press “Project File”.



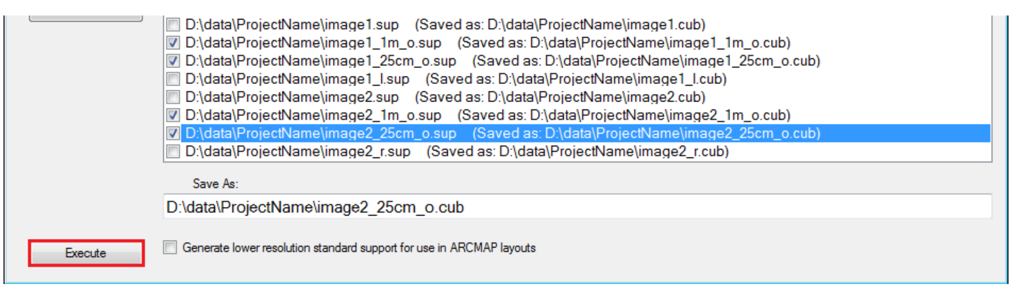
3) In the Open window, navigate to the main SOCET SET DATA folder (D:\DATA), select file <ProjectName>.prj, and then press “Open”.



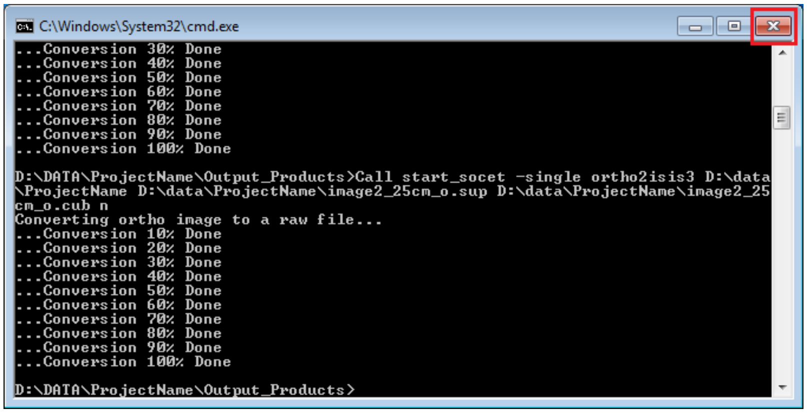
4) Select Orthoimages to export (these will have the _o suffix): double click on the check box for each Orthoimage you wish to export.



5) Press “Execute”.



6) A Command Prompt window will pop-up. Upon completion of the program, close the Command Prompt window.



24.4 Transfer Files to ISIS Processing Machine

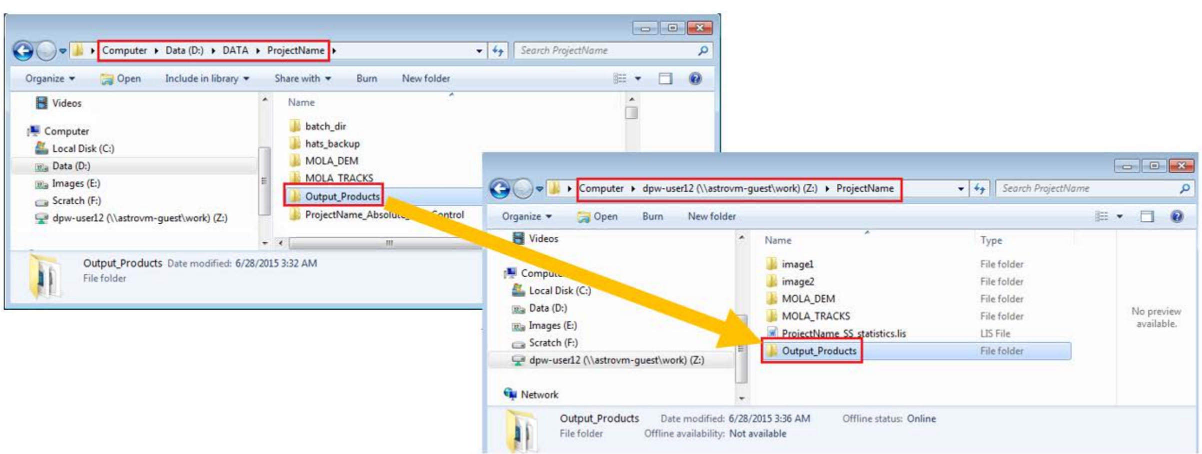
Using Windows/File Explorer, copy the <data_path>\<ProjectName>\Output_Products folder to a shared network drive. Place Output_Products in the <ProjectName> working directory/folder on the ISIS machine.

24.4.1 File Transfer for USGS Astrogeology Guest Facility Users

1) Bring up Windows Explorer and navigate to D:\DATA\<ProjectName>.

2) Bring up a second Window Explorer window, and navigate to Z:\<ProjectName>.

3) Copy the entire Output_Products folder from D:\DATA\<ProjectName> to Z:\<ProjectName>.



24.5 Generate ISIS3 Cubes

1) Log onto the ISIS Processing (UNIX) Machine. For Guest Facility Users, log onto astrovm-guest (see 1 Guest Facility Log On Procedure for details.)

2) In the Unix window, change directory into the <ProjectName>/Output_Products directory.

   <u>Unix Command for Guest Facility Users is:</u>
   cd <ProjectName>/Output_Products

   <u>Unix Command for Astro Employees is:</u>
   cd <path_to_ProjectName>/Output_Products

3) Run dos2unix on the scripts to update linefeed/carriage-return differences between Windows and UNIX. Use the wildcard (*) to update all scripts with one command, as follows:

   dos2unix *.sh

4) Run setisis to initiate ISIS, as follows:

   setisis isis3

5) Use the source command to execute each script. Wildcarding does not work with source, so use awk to generate a script to source all the dem- and ortho-to-isis scripts “automatically. The commands are:

   ls *.sh | awk ‘{print “source”,$1}’ > generate_cubes.script
   source generate_cubes.script

25 Conversion of ISIS3 Cubes to ARC Compatible Formats

25.1 Coordinate System Compatibility Requirements for ArcMap

1) **For Mars**: when working in a Geographic project, the native SOCET SET files are in the ographic latitude, +E longitude system. To use the most widely used coordinate system for Mars (East longitude and planetocentric latitude), use the standard ISIS3 cubes exported from SOCET SET (not the cubes with the “SS_” prefix)

2) ArcMap expects positive East longitude coordinates, but some planetary bodies have positive West longitude definitions as per the IAU. The SOCET SET to ISIS export software maintains the IAU standards on longitude direction. To insure ArcMap 10+ will ingest both positive East or positive West defined cubes correctly, the CENTER_LONGITUDE on the ISIS cubes are set to 0.0.

   Geographic projects in SOCET SET produce Equi-Rectangular map projected DTMs and Orthoimages. For the Equi-Rectangular map projection, changing the CENTER_LONGITUDE value will not require a resampling of the DTMs and Orthoimages. It only translates the x-coordinates of the Equi-Rectangular map projection coordinates.

25.2 ISIS3 Cubes Compatible with ArcMap 10+

The good news is that ArcMap version 10+ will directly load ISIS3 map-projected cubes, so conversion of file formats is no longer required!

25.3 Conversion to GeoTiff

SOCET Set has an export tool to output DTMs and images as GeoTiff images, however, it does not cover planetary images correctly (the GeoTiff header out of SOCET SET is incomplete.)

To generate GeoTiff images and DTMs, start with the ISIS3 cube as input, and run hi_isis2geotiff.pl as follows:

1) To convert an ortho image, enter the following on the command line::

   hi_isis2geotiff.pl -ortho <ortho.cub>

2) To convert a DTM, enter the following on the command line:

   hi_isis2geotiff.pl -dem <DTM.cub>

25.4 Conversion to JP2

To convert ISIS3 Orthoimage (8 bit cube) to 8-bit JPEG 2000 file: only one extension is allowed in the input cube name (this is a GDAL PCI Aux format issue), so if two extensions exist e.g., PSP_00XXXX_XXXX_1m_o.isis3.cub, then

1) First rename the cube as follows:

   mv <image_id>_1m_o.isis3.cub <image_id>_1m_o_isis3.cub

2) Then run isis3gdal_jp2.pl as follows:

   isis3gdal_jp2.pl <input>.cub <output>.jp2

APPENDIX

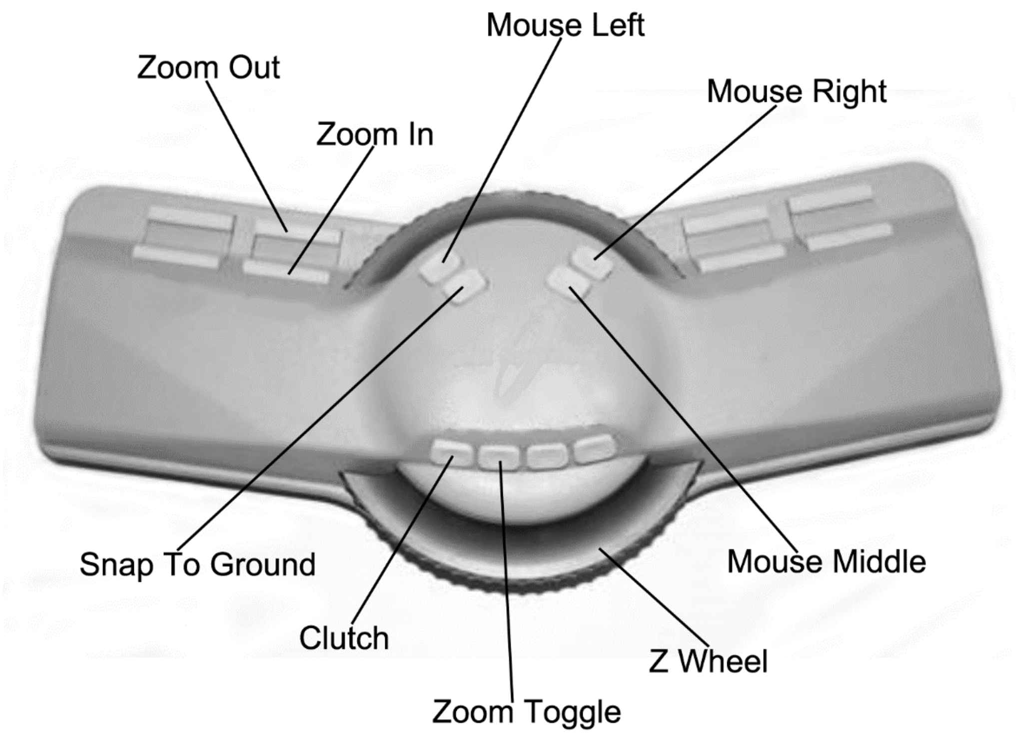
A-1 HiRISE Stereo Processing Workflow

The following table outlines the end-to-end processing steps we use for HiRISE stereo images. For details, refer to the section indicated.

STEP	ISIS3 Workstation	SOCET® SET (SS) Workstation	Section
1	Download Balanced Cubes		3.1-3.3
2	Evaluate for jitter and image quality		3.4-3.5
3	Generate noproj'ed images and USGSAstroLineScanner keywords via **hi4socet.pl**		3.6-3.7
4	Extract MOLA DEM and MOLA Track data for project area via **hidata4socet.pl**		3.8
5		Create SS project	5-6
6		Transfer raw image files, USGSAstroLineScanner keyword files, MOLA DEM and MOLA Track data to SS Machine	7
7		Import images via **import_pushbroom**	8-9
8		Import MOLA DEM	11
9		Import MOLA Tracks	12
10		Control Images (Multi-Sensor Triangulation):	13-19
11		Generate epipolar rectified images	20
12		Generate DEM	21
13		Edit DEM	22
14		Generate Orthoimages with input from calcOrthoBdry	23
15		Export DEM to raw data file and ISIS3 script via **dem2isis3**	24.2
16		Export Orthoimages to raw image file and ISIS3 script via **ortho2isis3**	24.3
17	Transfer raw DEM, raw Orthoimages and ISIS3 processing scripts to ISIS machine		24.4
18	Generate ISIS3 cubes of DEM via ISIS3 script *_dem2isis3.sh		24.5
19	Generate ISIS3 cubes of Orthoimages via ISIS3 script *_ortho2isis3.sh		24.5

A-2 TopoMouse Functionality

Here we show the most commonly used TopoMouse buttons and their assigned functionality.



A-3 Placing the "Dot on the Ground"

A commonly used phrase in photogrammetry is "place/put the dot on the ground". By that, we mean that the extraction cursor (extraction cursor) on the stereo display lays flush on the ground surface in the stereo model. Technically, this means that the extraction cursor is on the same feature in both the left- and right-eye images. However, the quality and perspective of images are rarely such that an operator can place the extraction cursor on the *exact* location in both "eyes", and there is a small elevation range where the dot appears on the ground. To minimize this elevation range, we have devised a stereo training exercise for our operators that involves placing the dot on ground (below).

Why do the training? Although a novice operator may have stereo acuity, practice placing the dot on the ground will improve overall accuracy in our stereo processing procedures. For a reference on stereo acuity, see http://en.wikipedia.org/wiki/Stereoscopic_acuity. Per this article, stereo perception improves rapidly with training, and that trained observers can distinguish parallax angles as small as 0.1

arcminute. The article also says that 97% of a group of undergraduates tested could distinguish at 2.3 arcminute level prior to training. So, training could improve one's ability by as much as 20x.

Our stereo training exercise requires more time than what is available during our workshop. However, columnGuest Facility Users, or those setting up a SOCET SET workstation at their facility are encouraged to do the following exercise for a few hours (over the course of a couple days) to improve stereo acuity. Our overall goal is that an operator can consistently make repeat elevation measures that fall within the expected precision of any given stereo pair. Once this happens, the training is considered successful.

NOTE: The nominal expected precision of a HiRISE stereo pair is 1 meter. The nominal expected precision of a MRO CTX stereo pair is 6 meters.

A-3.1 Stereo Training Exercise

1) Use a high quality stereo model (Y-parallax removed, images are of high quality). At a zoom level of 1:1, measure and record heights within the stereo coverage (method of recording below). Initially select features that are well defined with crisp edges, and optimal brightness/contrast. At this stage, avoid slopes or shadowed areas. Take three height measurements for a single location/feature. Using an Excel spreadsheet, populate a single row and 3 fields with the measured height for each measured feature/location as follows:

   - Field A will hold the initial measured ground height. Trainee is free to adjust the measurement cursor as they see fit, until the dot is on the ground. Copy/paste the height into the spreadsheet cell using SOCET's Coordinate Measurement tool.

   - Without moving the TopoMouse in X or Y, measure the height at the same position a second time. This time use the Z-wheel to move the extraction cursor well above the feature/ground and, using one continuous direction (e.g., down), drop the cursor to the ground. Don't "fine-tune" the cursor to place it on the ground (i.e., don't move the cursor up-and-down). If ground is "overshot", repeat the entire motion by moving the cursor back to a starting position well above the ground and then drop the cursor back to the ground. Stop when the cursor is on the ground. Record this height in field B of the same row on the spreadsheet.

   - Measure the height at the same position a third time, using the same single motion technique, but this time, move the measurement cursor so as to start from well below the ground. Record this height in field C of the same row on the spreadsheet.

2) Refrain from checking the last height measurement taken at this location. Definitely do not force measurements to match. We need independent measurements to certify stereo acuity.

Continue this process until the standard deviation of the 3 measurements regularly meets the expected precision of the stereo pair.

3) Once the height measurements regularly achieve the expected precision of the stereo pair, move to more difficult terrain such as smooth, bland areas where the features are not as crisp. Measure the heights of enough features until the precision of the height measurements regularly meets the expected precision of the imagery

4) After the expected precision is achieved with measuring heights in these bland areas, move to steep slopes for additional measurements. Measure the heights of enough features until the precision of the height measurements regularly meets the expected precision of the imagery.

A-4 Troubleshooting Issues using SOCET SET

A-4.1 Loss of Stereo Viewing on View1

Two common reasons for loss of stereo viewing and the remedies follow:

1) Cursor from the system (three-button) mouse is on the View 1 window.

   Solution: Move the cursor back onto the console monitor. Stereo viewing will be immediately restored.

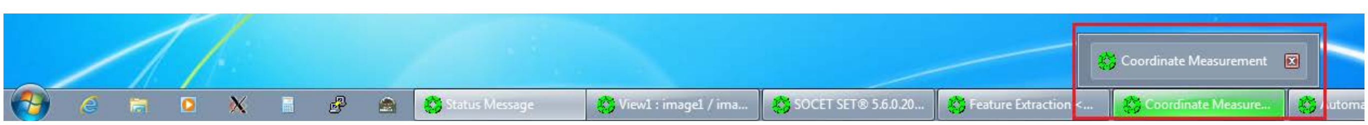
2) One of the Planar monitors time-out and goes blank.

   Solution: Turn the power button off and then on again to reset the monitor. Stereo viewing will be immediately restored.

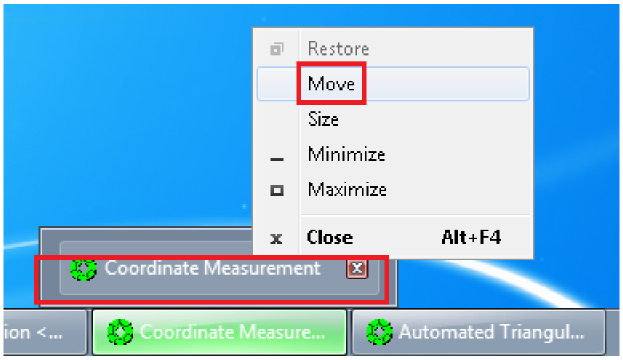
A-4.2 SOCET SET Windows Not On Monitors

Often SOCET SET windows come up outside of the monitor screens. To locate the window and drag it back onto the monitor, do the following

1) On the task bar, hover over the icon of the SOCET SET tool you cannot find on the monitors. Wait a little, and a thumbnail for the tool will pop-up.



2) Right click on the thumbnail, and select “Move”.



3) Press one of the arrow keys on the keyboard to grab the window.

4) Drag the window onto the monitor with the system (three-button) mouse.

5) When you have the window where you want it, press the left mouse button to release the window.

A-4.3 SOCET SET Memory Files

SOCET SET uses three “memory” files to track the files last loaded by all the tools. This is also how SOCET SET automatically loads the last project you worked on. For various reasons, you may find that allowing SOCET SET to automatically load files is causing problems.

To “reset” SOCET SET and clear its memory of what was last run, delete the following files:

D:\DATA\<ProjectName>\.cur<user_name>set

D:\DATA\<ProjectName>\.mem<user_name>set

C:\Users\<user_name>\.proj<user_name>set

Note that D:\DATA is the SOCET SET <data-path> at USGS Astrogeology. For users not at USGS Astrogeology, replace D:\DATA with your local <data_path> definition.

A-4.4 USGS Tools Crashes

USGS Tools is a set of Graphic User Interface (GUI) programs to in-house SOCET SET software. These GUI programs look for their own set of “memory” files that they create on a SOCET SET workstation.

New installations of SOCET SET will not come with the USGS Tools memory files, and the very first time a USGS Tools program is run (such as an image import), the GUI program will crash because it cannot find its “memory” file.

Solution: Exit SOCET SET, and then re-enter it. The missing file will have been created just prior to the crash of the USGS Tools program, and you should not have this problem again.

A-5 Batch Processing

A-5.1 Windows Account Requirements

To be able to do SOCET SET batch processing, the Windows account that the user is logged into must have administrative privileges (see the SOCET SET Systems Administration Manual for details.) At the USGS Astrogeology Science Center, we have a special service account available on the SOCET SET workstations with the privileges needed for SOCET SET batch processing.

For Guest Facility Users: We cannot, and will not share the user name and password to this account, but we can log onto the account and with our supervision, help you to set up batch processing if desired.

A-5.2 NGATE and AATE Batch Processing

1) Exit SOCET SET on the "normal" user account.

2) Log onto the Service Account.

    a. Note that because NGATE and AATE create an initialized DTM that can be loaded to execute the DTM extraction at a later time, you have a choice for the point in which you can log onto the service account. Either:

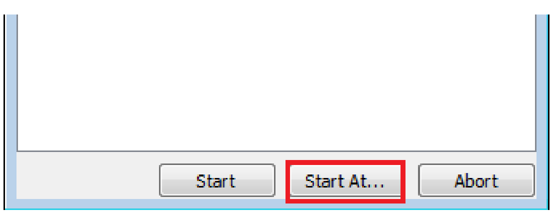
        i. After initializing the DTMs, i.e., after doing all the setup steps except pressing "Start", or

        ii. Prior to setting up the DTMs, log onto the service account to do the entire NGATE or AATE setup and batch processing there.

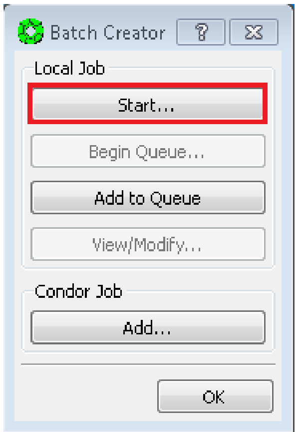
3) On the service account, bring up SOCET SET, and then NGATE or AATE

4) If you running NGATE or AATE on DTMs that were created under the normal user account, select "File" > "Load", and load the DTMs. Otherwise, follow the procedures to initialize the DTMs. Do not press "Start".

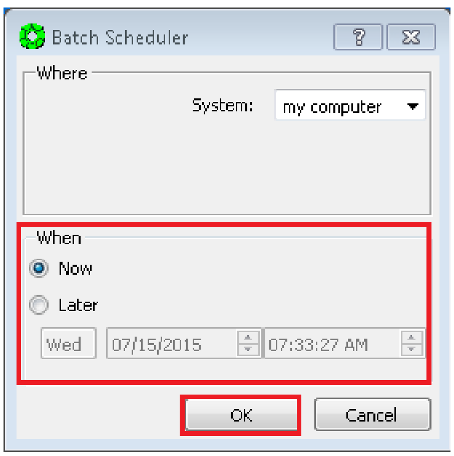
5) Instead of pressing "Start", press "Start At" to bring up the Batch Creator window.



6) In the Batch Creator window, press “Start”.



1) In the Batch Scheduler window, enter when you would like the job to begin and press “OK”.



7) Log of service account.

A-5.3 Orthophoto Generation Batch Processing

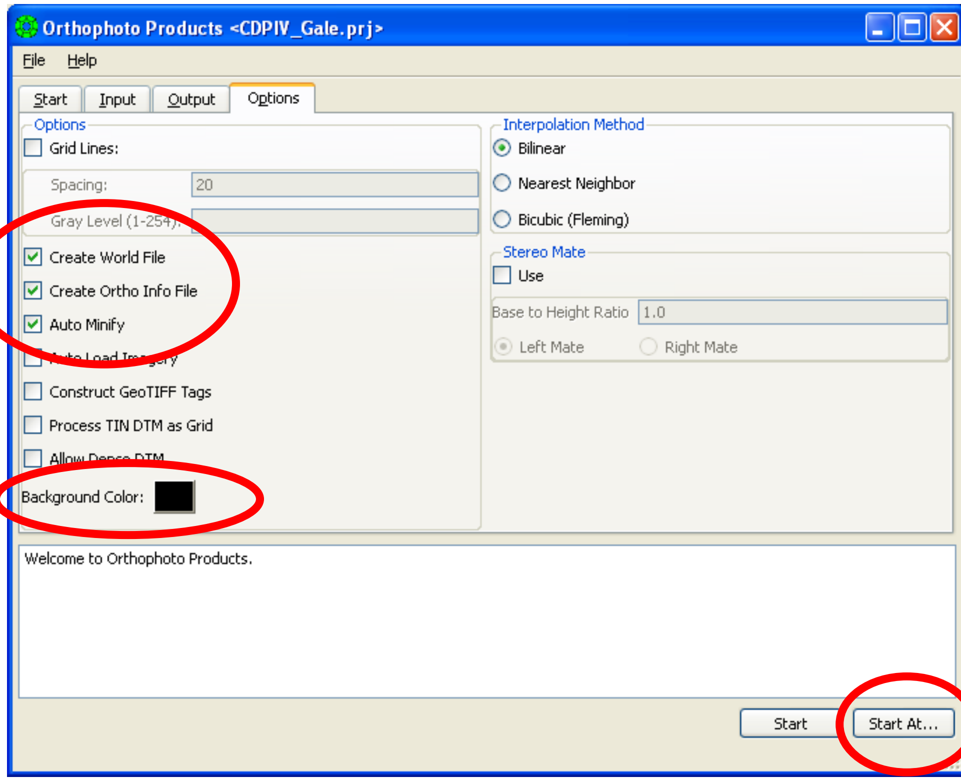
2) After running USGS Tools > Calc Ortho Boundary, exit SOCET SET on the “normal” user account.

3) Log onto the service account.

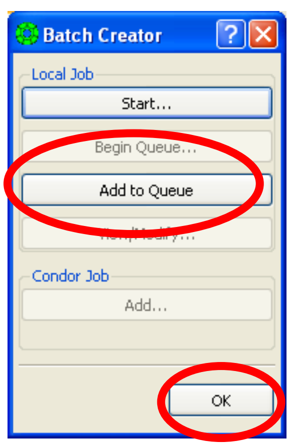
4) Bring up SOCET SET.

5) Follow the Orthophoto Generation procedure, but do not press “Start”.

6) Instead of pressing Start, press “Start At” to bring up the Batch Creator window.



7) In the Batch Creator window, press “Add to Queue” and the press “OK”.



8) Repeat the Orthophoto set-up for the same image, but with the other GSD, i.e.,

   a. Go back into the Output Tab and

      i. Update the GSD (e.g., to 0.25 m).

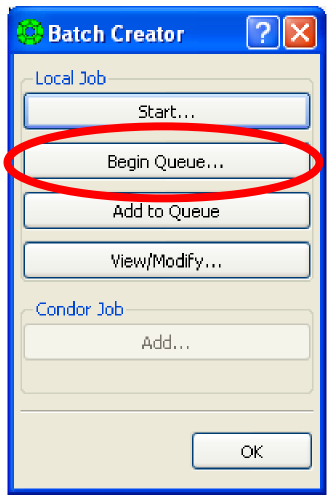
      ii. Update the output file name.

      iii. Press “Start At” and add the job to the batch queue.

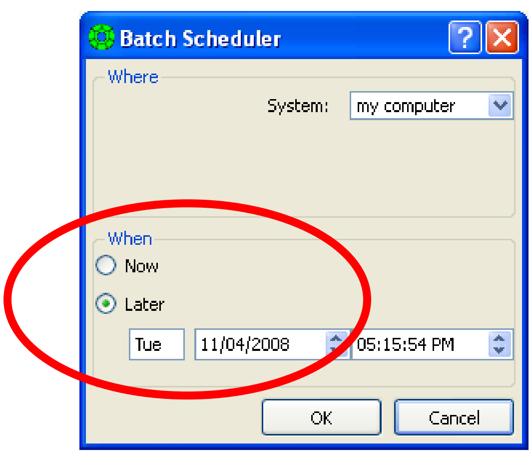
9) Set up the Orthophoto Generation of the other image (at 1 m and 25 cm), adding the jobs to the batch queue each time.

10) After the last job is added to the batch queue: Press "Begin Queue".

Note: Do not View/Modify the queue with the Batch Creator GUI. This will result in only the last batch job viewed being executed. If you want to double-check yourself, use a text editor to review the settings files in the project's batch_dir directory.



11) In the Batch Scheduler window, enter when you would like the job to begin and press "OK"

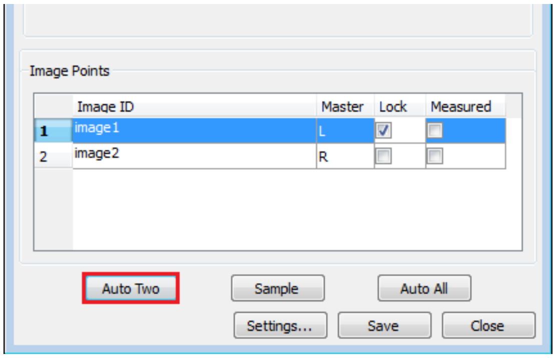


12) Log of service account

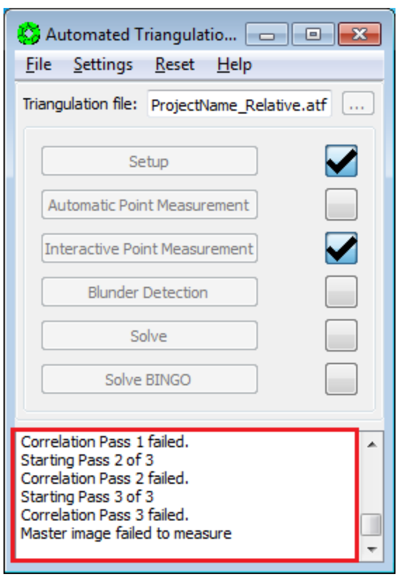
A-6 Alternative Procedures for Expert Users

A-6.1 Auto Two Feature in IPM

1) When measuring points in IPM, after locking the Left image, press “Auto Two” to auto correlate the images.



2) **If the correlation fails**, your will get an “error” message in the Automated Triangulation window, and the Right image will not be locked and measured. When this happens, either try to measure another feature, or manually measure the point.



3) **If the correlation did not fail, make sure the outcome is not a false positive**. The only way to verify the correlation is to view the results in stereo. If the dot is not on the ground, either un-measure (and hence un-lock) the Right image and manually measure the point. Or, un-measure both images to relocate the point and try again.

4) **If the correlation is a success** (i.e., not a false positive), **press “Sample” and then “Save”**.

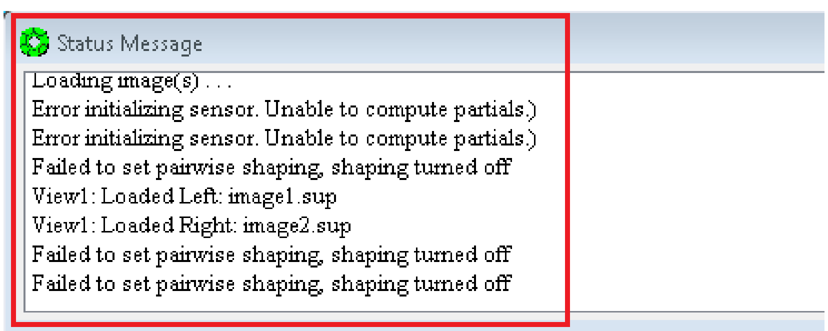
A-6.2 Restore A-Priori Support Files as Needed During Absolute Orientation

When iterating in the search for an adequate XYZ Control point, it is not necessary to restore the original (a-priori) support files before *each* Solve and then Save in MST. We can repeatedly save solutions until we are satisfied with the horizontal alignment of the stereo model to the MOLA Tracks. ***However, the bundle adjustment will eventually diverge (see details below.)*** When this happens, we must exit MST, restore the a-priori support files from <ProjectName>_Original, then go back into MST and re-rerun the bundle adjustment (i.e., Solve). Even if the MST solutions did not diverge, the final bundle adjustment must also be re-done starting with the a-priori (original) support files to avoid “creep” introduced by the previous bundle adjustment results.

When and MST solution diverges, one of two things will occur:

1) In the Solve window, you will get very large RMS errors, or NaN (Not a Number) values, or

2) When you load the images, you will get errors in the Status Message window that the Sensor model could not be initialized, and the image failed to load. Note, however, that the images will not disappear in the View1 (stereo) window, and SOCET SET will continue to use the information it has in memory (from the previous time the images were loaded) for the View1 display.



A-7 USGS Tools Documentation

A-7.1 Command Prompt

USGS Tools > Command Prompt brings up a Windows Command Prompt window with the SOCET SET environment variables established. **You must use this Command Prompt window in order to run our in-house SOCET SET programs using the command line option, or to run batch files generated by SOCET SET.**

A-7.2 Import Pushbroom

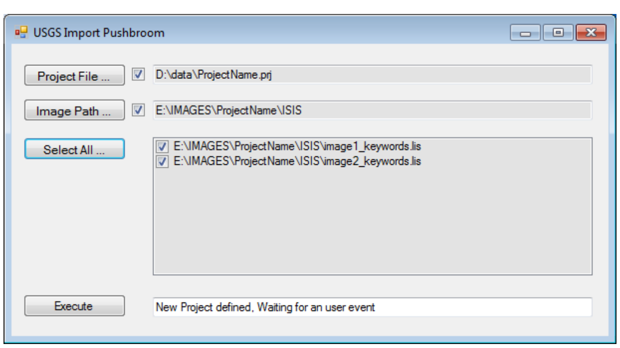
USGS Tools > Imports > Import Pushbroom is a Graphical User Interface program to in-house SOCET SET program *import_pushbroom*.

import_pushbroom imports pushbroom/linescanner images in two stages. First it will import the raw image as a framing camera with unknown position and orientation. Importing as a framing camera converts the raw image into a format SOCET SET utilizes, creates a pyramid of reduced resolution images needed by SOCET SET, and populates the Base-Sensor portion of a SOCET SET support file. (SOCET SET support files are detached image labels comprised of Base-Sensor keywords, followed by keywords specific to a sensor type, such as the USGSAstroLineScanner.)

Once the images have been imported, *import_pushbroom* next merges what we need from the support file created by the frame import, with the USGSAstroLineScanner keywords found in the *_keywords.lis file to create a USGSAstroLineScanner support file. Any framing camera support files are no longer needed and are deleted.

A-7.2.1 Run import_pushbroom via USGS Tool Menu

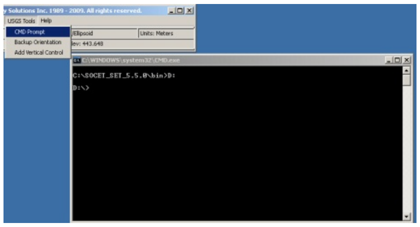
Import_pushbroom can be initiated from a GUI interface by selecting "USGS Tools" > "Imports" > "Import Pushbroom". As with the other scripting utilities, it follows the same user interface guidelines as previously outlined for the other USGS Tools. This interface is described in detail in chapter 8: Import Pushbroom/Linescanner Images.



A-7.2.2 Run import_pushbroom via Windows Command Prompt

1) Open a Command Prompt Window via USGS Tools

   a. USGS Tools > CMD Prompt



2) Run *import_pushbroom* as follows:

   start_socet -single import_pushbroom <project> <full_path>\<image.raw> <full_path>\<keywords>.lis

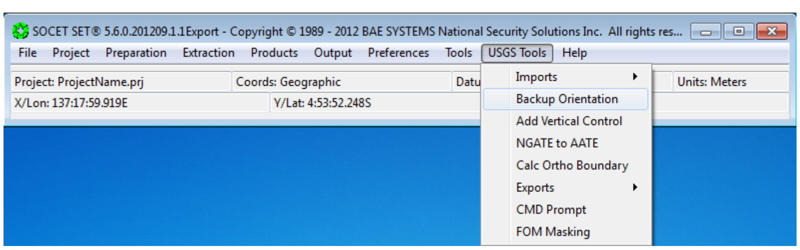
   Where: <project> = SOCET SET project name to import images under.

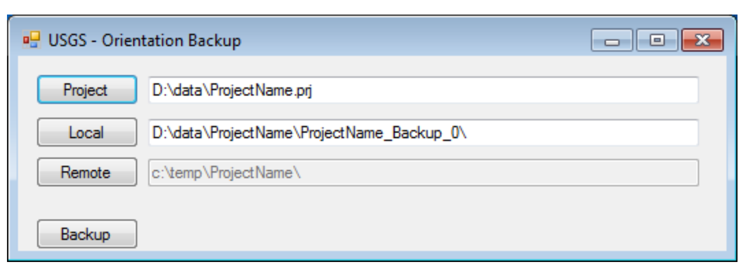
   <full_path>/<image.raw> = *raw* 8-bit linescanner/pushbroom image.

   <full_path>/<_keywords>.lis = output file of hi4socet.pl associated with input image.

A-7.3 Backup Orientation Documentation

The backup utility found under the USGS Tools Menu selection for "Backup Orientation", will copy all orientation and support files to a predetermined folder name that will based on the current project name and a backup "version" number (e.g., 0..1..2….n). If the operator chooses to follow default convention, then the process is completed by simply pushing the "Backup" button. The operator may override the default convention by entering desired folder names in the Local field.





Note: There is an additional option for those users that would prefer to maintain and archive of the project on a remote storage device. This option is intended to serve as a final backup (e.g., when the project is complete and the archive has value beyond the scope of this setup process.

In the SOCET SET executable directory there is a file named “USGS_Orientation_Backup.txt” that will allow the user to establish a default ROOT path for such archive(s). This file can be edited with a simple text editor and will contain a single entry that specifies the path that can be interpreted on the users system in order to find the storage location (e.g., a mapped drive, network path or URL.)

Note: The “Remote” path or “Local” path for storage may be changed as user requires by simply pushing the button associated with the storage option and navigating to the desired storage location. The difference in the options is that the Remote Path option will overwrite the data of pre-existing path storage while the Local path option will automatically generate new folders denoted by revision level.

A-7.4 Add Vertical Control

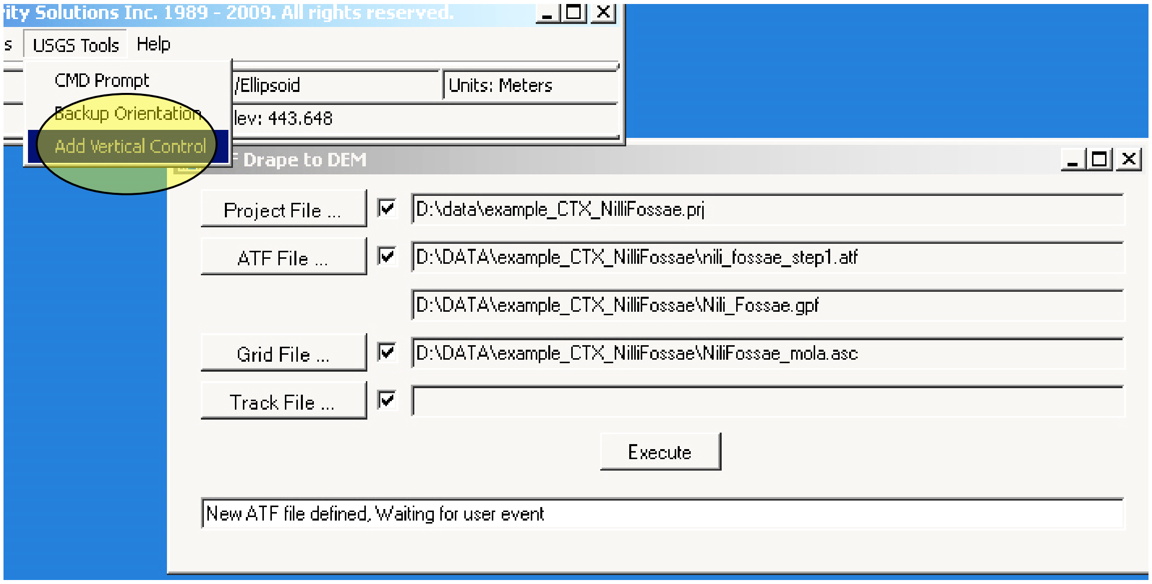
Even though the images are provided with a-priori orientation on import, the very small “systematic” errors associated with this information will have adverse effects to properly controlling the model and “leveling” the model. Use of heuristic terrain information will aid in the process of controlling the model.

“Add Vertical control” will drape previously measured tie points onto a DTM Grid (The DTM data format currently supported is the “ESRI ASCII GRID Format”) and flag those points as Z control in the ground point file.

If the track laser altimetry data exist, it will be used as well, but is not required for this process to work. The data format expected is the PEDR tabular format for laser altimetry and will only be used if the track data is sufficiently close to the tie point location.

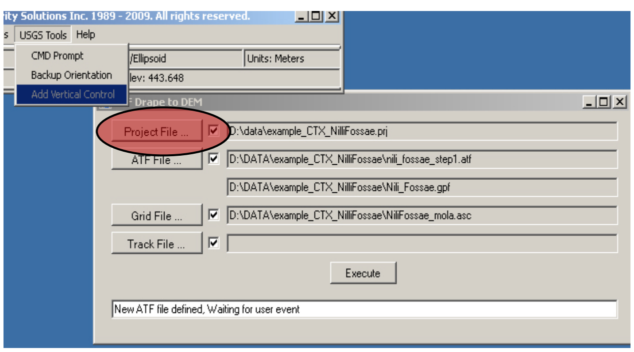
Even though the images are provided with a-priori orientation on import, the very small “systematic” errors associated with this information will have adverse effects to properly controlling the model and “leveling” the model by use of heuristic terrain information will aid in the process of controlling the model. Within the “USGS Tools” menu there will be a selection for accessing a utility “Add Vertical control”, which will drape the previously measured tie points onto a DTM Grid (The DTM data format currently supported is the “ESRI ASCII GRID Format”) and flag those points as Z control.

Note: If the track laser altimetry data exist, it will be used as well, but is not required for this process to work. The data format expected is the PEDR tabular format for laser altimetry and will only be used if the track data is sufficiently close to the tie point location.



1) Use the Project button to bring up the list of projects and select the project from the list of projects.

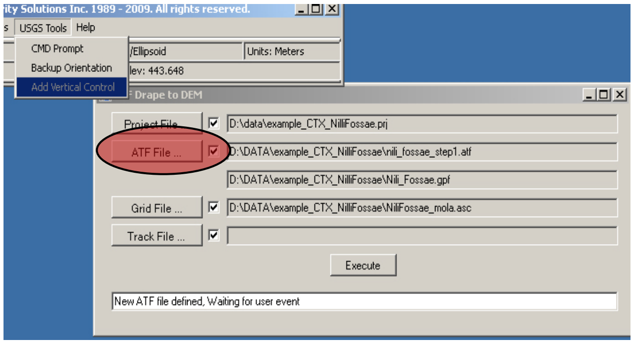
Note: The User confirmation of the selection is required for the project selection (and all other settings) by clicking the check box beside the button before the utility will acknowledge this as a valid entry.



2) Either confirm the ATF file located by use of the check box, or select the Current ATF file by use of the “ATF File” button.

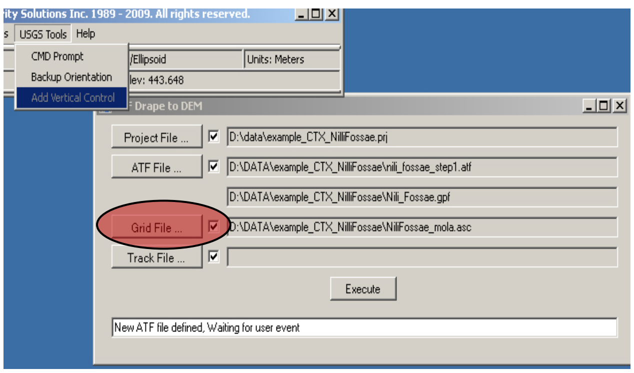
Also confirm that the GPF file associated to the ATF is correct. If this is not true, then you have probably selected the wrong ATF file.

Note: The utility will attempt to determine the current ATF file for the selected project but this determination is based on the current user profile and can be erroneous when different user logins are used for the same workstation. Please confirm the selection of the ATF file carefully before proceeding.



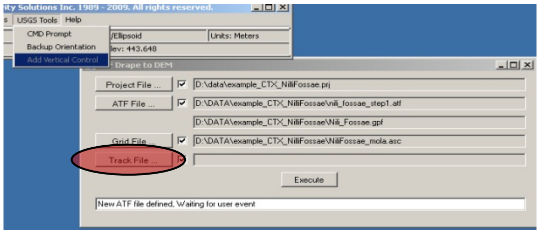
3) Either confirm the DTM “Grid File” located by utility using the check box, or select the desired Grid File by use of the “Grid File” button.

Note: The utility will attempt to determine the current DTM file for the selected project by a recursive search from the current project directory and offer the first “*.ASC” found as the most likely candidate. This technique can be erroneous when different “.ASC” files exist in the workstations currently selected project path. Confirm the selection of the Grid file carefully before proceeding.



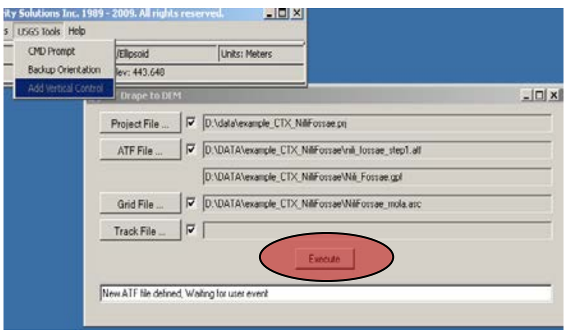
4) Either confirm the “Track File” located by utility (or the non-existence of a Track File) using the check box, or select the desired Grid File by use of the “Track File” button.

Note: The utility will attempt to determine the current Track file for the selected project by a recursive search from the current project directory and offer the first “*.PRM” found as the most likely cadidate, this technique can be erroneous when different “.PRM” files exist in the workstations currently selected project path. Confirm the selection of the Track file carefully before proceeding.



5) Once all the data required has been confirmed by the User, the Execute button will become active. If the Execute button is not activated please check the confirmation checkboxes.

   Execute the process by selecting the execute button and various stages of the process will be reported in the small window area directly below the Execute button. If the process completes normally the window will exit.



6) The process will generate a new GPF file that has modified elevation, sigma, and point type information. It is prudent to confirm the existence of this "new" GPF and that all the tie points have been re-classified as Z-control in the file before proceeding to the measurement adjustment phase. The process will maintain "versions" of the GPF file by naming the current input file as the same base name appended by a version number.

   Note: If this is the first pass of the GPF leveling process there will be the raw gpf file with a name similar to "GPF_File_0.GPF, and the new file existing in the original filename named GPF_File.GPF. Each subsequent run of the GPF leveling process will create a file with a new version appendage …. E.g. GPF_File_1.GPF, GPF_File_2.GPF, GPF_File_3.GPF … GPF_File_(n).GPF.

A-7.5 Calc Ortho Boundary

USGS Tools > Calc Ortho Boundary is a Graphical User Interface program to in-house SOCET SET program *calcOrthoBdry*.

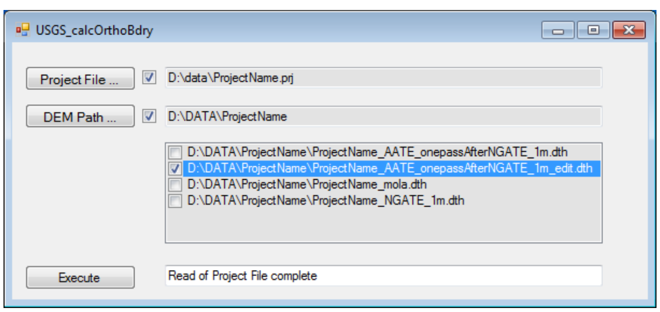
calcOrthoBdry calculates Upper Left and Lower Right coordinates to be used in Orthophoto Generation. Coordinates, and appends the coordinates to logfile: <data_path>/<ProjectName>/calcOrthoBdry_<DTM_name>.log, and outputs the values to the screen.

When setting up for orthoimage generation, the user has the option to use the lower left (LL) and upper right (UR) corners of the selected DTM to define the boundaries of the orthoimage. Unfortunately, this will result in an orthoimage that is 1 pixel smaller than the DTM in both line and sample because the LL and UR DTM corners are defined at center of pixel, but are used as edge-of-pixel coordinates during Orthophoto Generation. This results in an orthoimage that does not have a 1:1 correspondence with the DTM, and may cause problems when working with DTMs and orthoimages in software that does no georeferencing (such as Photoshop).

To alleviate this potential problem, we run *calcOrthoBdry* to calculate LL and UR corner coordinates to be used as input for orthophoto generation so that 1:1 correspondence with the DTM is maintained.

A-7.5.1 Run calcOrthoBdry via USGS Tool Menu

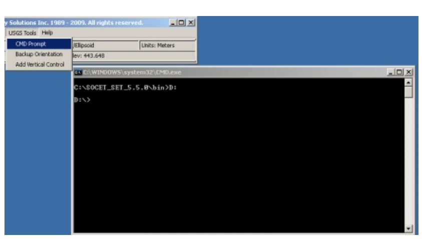
calcOrthoBdry can be initiated from a GUI interface by selecting “USGS Tools” > “Calc Ortho Boundary”. As with the other scripting utilities, it follows the same user interface guidelines as previously outlined for the other USGS Tools. This interface is described in detail in section 23.2 Run Calc Ortho Boundary.



A-7.5.2 Run calcOrthoBdry via Windows Command Prompt

3) Open a Command Prompt Window via USGS Tools

   a. USGS Tools > CMD Prompt



4) run *calcOrthoBdry* as follows:

start_socet -single calcOrthoBdry <project> <DTM>

where: <project> = SOCET SET project name

<DTM> = SOCET SET DTM to be used for Orthophoto Generation

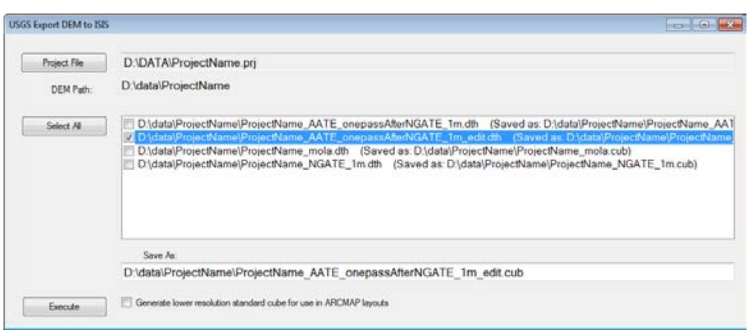
A-7.6 DEM to ISIS

USGS Tools > DEM to ISIS is a Graphical User Interface program to in-house SOCET SET program *dem2isis3*.

To export DTMs from SOCET SET to ISIS3, the DTM and Figure of Merit (FOM) file are converted to a raw-format files (*.raw) along with an ISIS3 script (*.sh) to convert the raw files to ISIS3 cubes with all geo-referencing information. SOCET SET and ISIS use different approaches for scaling radii when working in geographic coordinates (i.e., equi-rectangular map projection), so the script produces two versions of an ISIS cubes for each SOCET SET product. The first version has a prefix of “SS_” and contains the native SOCET SET pixels in equi-rectangular map projection. The second version (called ‘standard’ below) has the name of the DTM specified by the user, and has had some resampling done to scale the pixels as ISIS expects, and to place the products in the most widely used coordinate system for Mars (East longitude and planetocentric latitude). Standard cubes are in either equi-rectangular (with clat=0, clon=0) or polar-stereographic map projection based on latitude (equi-rectangular for products within ±65° latitude, polar-stereographic for products between ±65° latitude and the poles.) Finally, the user also has the option to output a ‘layout’ version of the cube – mainly used by USGS to generate page layouts of the DTMs and Orthoimages in ARCMAP. By default, the layout cubes will not be generated.

A-7.6.1 Run dem2isis3 via USGS Tool Menu

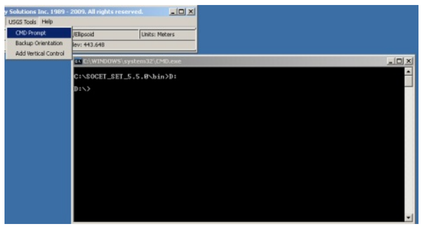
dem2isis3 can be initiated from a GUI interface by selecting “USGS Tools” > “Export DEM to ISIS”. As with the other scripting utilities, it follows the same user interface guidelines as previously outlined for the other USGS Tools. This interface is described in detail in section 24.2 Export DTMs.



A-7.6.2 Run dem2isis3 via Windows Command Prompt

1) Open a Command Prompt Window via USGS Tools

   a. USGS Tools > CMD Prompt



2) Change directory to the project data directory.

3) Create an Output_Products folder if it does not already exist.

4) Change directory into Output_Products.

5) Run dem2isis3 as follows:

start_socet -single dem2isis3 <project> <socet_dem> <isis>.cub [layout_flag]

where: <project> = SOCET SET project name to export DTM from.

<socet_dem> = SOCET SET DTM to export.

<isis>.cub = desired name of standard isis cube.

layout_flag = optional flag to generate lower resolution standard cube for use in ARCMAP layouts. Enter y or n, default=n.

Output files generated are as follows:

1) <isis>.raw - a 32-bit raw-format file of the DTM data file.

2) <FOM_isis>.raw - a 8-bit raw-format file of the Figure Of Merit (FOM) data file.

3) <isis>_dem2isis3.sh - an ISIS3 command-line script.

Output file names are automatically generated, based on the name of the standard isis cube (<isis>.cub).

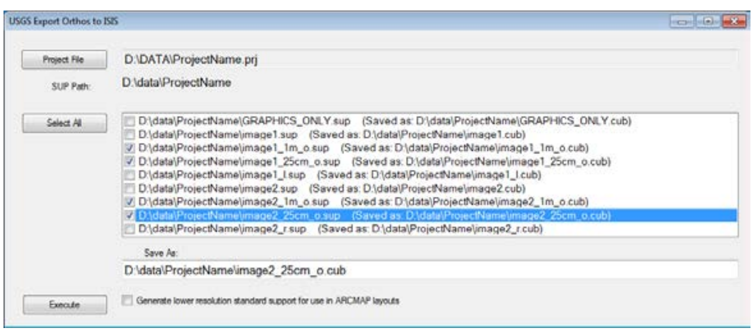
A-7.7 Export Orthos to ISIS

USGS Tools > Orthos to ISIS is a Graphical User Interface program to in-house SOCET SET program *ortho2isis3*.

To export Orthoimages from SOCET SET to ISIS3, the Orthoimage is converted to a raw-format file (*.raw) along with an ISIS3 script (*.sh) to convert the raw file to an ISIS3 cube with all geo-referencing information. SOCET SET and ISIS use different approaches for scaling radii when working in geographic coordinates, so the script produces two versions of an ISIS cube for each SOCET SET product. The first version has a prefix of "SS_" and contains the native SOCET SET pixels in equi-rectangular map projection. The second version (called 'standard' below) has the name of the Orthoimage specified by the user, and has had some resampling done to scale the pixels as ISIS expects, and to place the products in the most widely used coordinate system for Mars (East longitude and planetocentric latitude). Standard cubes are in either equi-rectangular (with clat=0, clon=0) or polar-stereographic map projection based on latitude (equi-rectangular for products within ±65° latitude, polar-stereographic for products between ±65° latitude and the poles.) Finally, the user also has the option to output a 'layout' version of the cube – mainly used by USGS to generate page layouts of the DTMs and Orthoimages in ARCMAP. By default, the layout cubes will not be generated.

A-7.7.1 Run ortho2isis3 via USGS Tool Menu

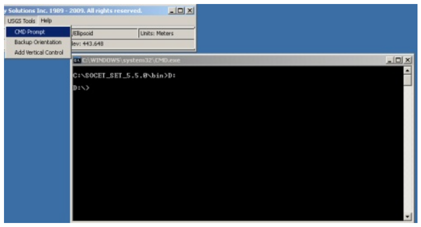
Ortho2isis3 can be initiated from a GUI interface by selecting "USGS Tools" > "Export Orthos to ISIS." As with the other scripting utilities, it follows the same user interface guidelines as previously outlined for the other USGS Tools. This interface is described in detail in section 24.3 Export Orthoimage(s).



A-7.7.2 Run ortho2isis3 via Windows Command Prompt

1) Bring up a Windows command prompt via USGS Tools.

    a. USGS Tools > CMD Prompt



2) Change directory to the project data directory.

3) Create an Output_Products folder if it does not already exist.

4) Change directory into Output_Products.

5) Run ortho2isis3 as follows:

start_socet -single ortho2isis3 <project> <ortho> <isis>.cub [layout_flag].

where: <project> = SOCET SET project name to export Orthoimage from.

<ortho> = SOCET SET support file of orthoimage to export.

<isis>.cub = desired name of standard isis cube.

layout_flag = optional flag to generate lower resolution standard cube for use in ARCMAP layouts. Enter y or n, default=n.

output files generated are

1) <isis>.raw – an 8-bit raw-format file of the orthoimage.

2) <isis>_ortho2isis3.sh - an ISIS3 command-line script.

Output file names are automatically generated, based on the name of the standard isis cube (<isis>.cub).