Orthorectification and DEM Extraction of CARTOSAT-1 Imagery

TUTORIAL

CARTOSAT-1 is the eleventh satellite to be built in the Indian Remote Sensing (IRS) series. This sun-synchronous satellite was launched on May 5, 2005 with the goal of providing stereo data for advanced and large scale mapping applications. It carries two panchromatic cameras that capture stereoscopic images over a 30km swath at 2.5m ground resolution. The cameras are mounted to allow for multiple images to be taken of one area, thereby enabling the creation of accurate three-dimensional maps.

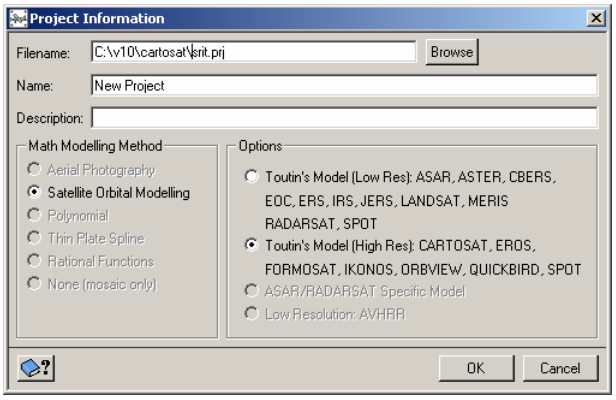
OrthoEngine offers two methods of processing CARTOSAT-1 imagery in Geomatica version 10.0.2. The rigorous model and the rational polynomial coefficients (RPC) can be applied to orthorectify the Standard No. 03 data (OrthoKit product) in GeoTIFF format. The procedure to apply these two models for orthorectification is outlined below. This tutorial also consists of steps involved for extracting a DEM from CARTOSAT-1 data.

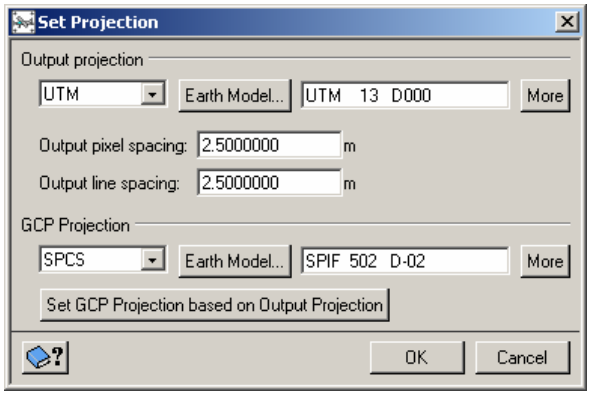
1.0 Rigorous Modeling

1.1 Project Setup

Start OrthoEngine and go to File | New to start a new project. In the Project Information panel, specify a file name for the project. Select 'Satellite Orbital Modeling' as the Math Modeling Method. Under Options, choose 'Toutin's Model (High Res)'. Click Accept.

In the Set Projection panel, specify the projection for the output and GCPs. Enter in the output pixel spacing as well. Click OK.

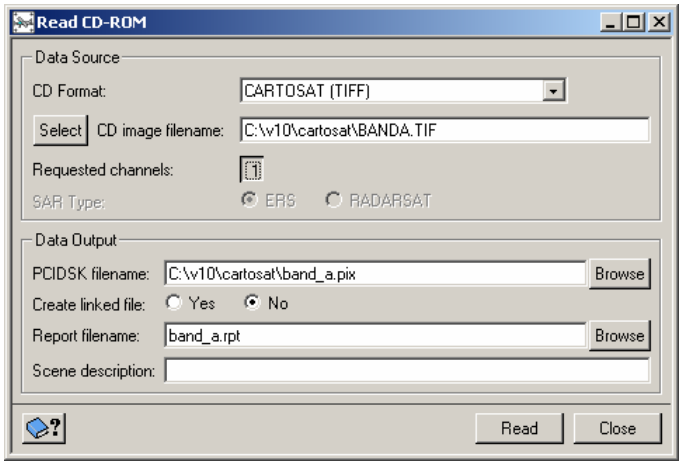




1.2 Data Input

In the Data Input processing step, the file is converted to a .pix file and the orbital information is imported.

First, click on the 'Read CD-ROM data' button on the OrthoEngine toolbar. In the Read CD-ROM panel, select CARTOSAT (TIFF) as the CD Format. Browse to the CD image filename. Click on channel 1 under Requested channels. Specify an output file name. Click Read.

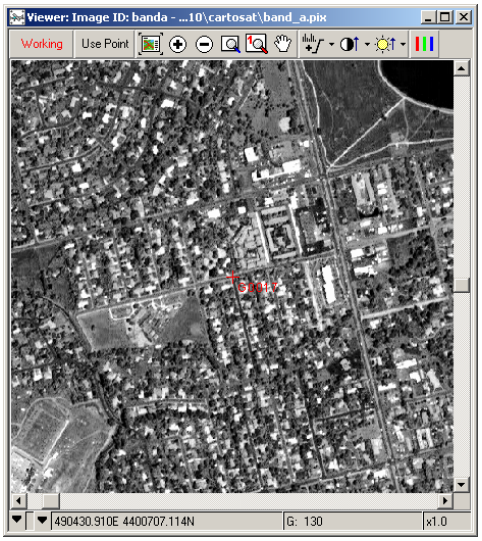


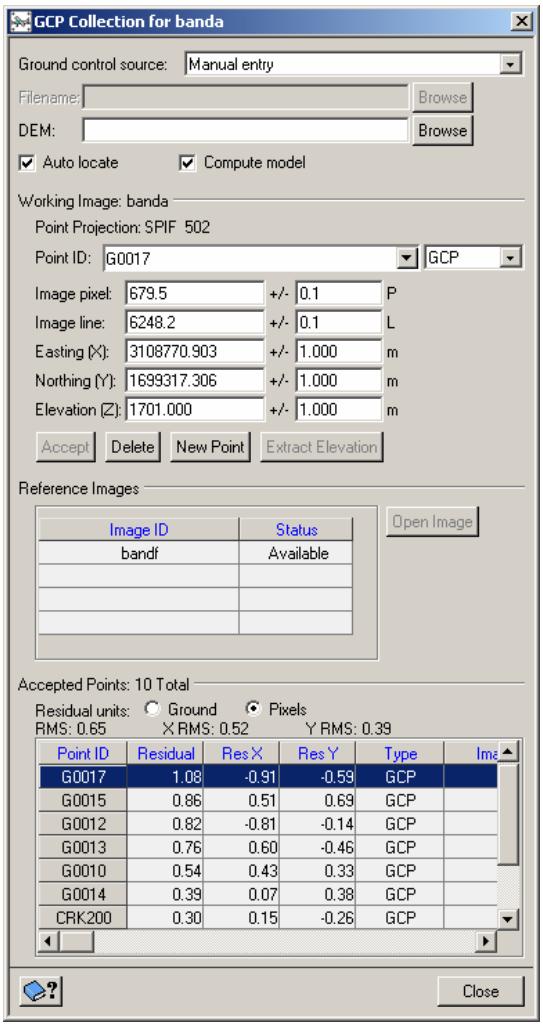
1.3 Collect GCPs and Tie Points

In the GCP/TP Collection processing step, GCPs can be manually collected from a variety of sources, namely geocoded images, vectors, chip databases, or a text file. Tie points can be collected to pull multiple scenes together.

On the OrthoEngine toolbar, click on the 'Open a new or existing image' button to open the imported .pix file. Next, click on the 'Collect GCPs Manually' button to open the GCP Collection panel.

For the CARTOSAT-1 rigorous model, a minimum of six GCPs per scene is required. More GCPs may be needed depending on the accuracy of the GCPs and accuracy requirement of the project.

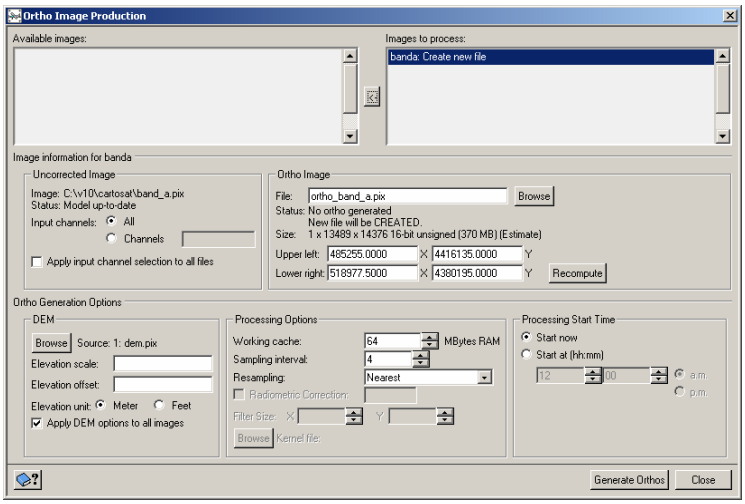




Once GCPs are collected, go to the Model Calculations processing step and compute the model. Afterwards, review the accuracy results in the residual report (under Reports in the GCP/TP Collection processing step).

1.4 Generating Orthos

For the final step, proceed to the Ortho Generation processing step. Click on the 'Schedule Ortho Generation' button to open the Ortho Image Production panel. Under Available Images, select the image and click on the arrow (->) to specify it as an image to process. Under Ortho Generation Options, enter a DEM. Click on 'Generate Ortho'.

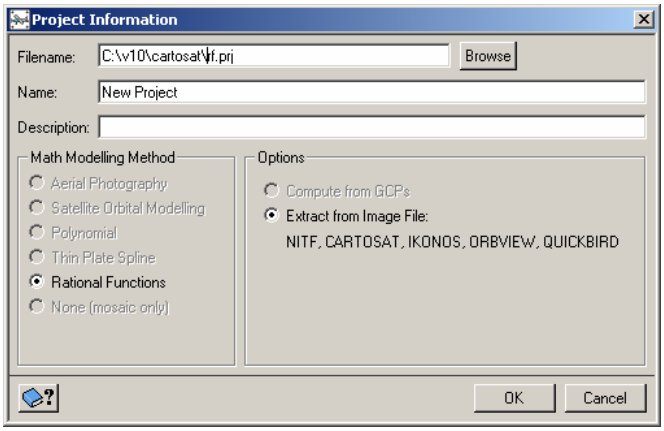


2.0 Rational Polynomial Coefficients (RPC)

As CARTOSAT-1 data (Standard No. 3) is delivered with RPCs, orthorectification can be performed without using GCPs in a Rational Functions model project. However, the addition of 1 to 4 GCPs to the project can greatly improve the accuracy of the final orthorectified output. The setup for a RPC model is similar to that for a rigorous model, except for the project setup and data input steps.

2.1 Project Setup

Start a new project and in the Project Information panel, specify a Rational Functions math modeling method. Under Options, select 'Extract from Image File'. Click OK. Proceed to the Set Projection panel and enter in the projection and pixel spacing information.



2.2 Data Input

In the Data Input processing step, click on the 'Open an existing image' button on the OrthoEngine toolbar and then the 'New Image' button. Browse to the tiff file. With image data loaded to the project, OrthoEngine will look for the files that store the coefficients and then add them to the project. The coefficients can be viewed in the Project Report (Processing Step: Reports) with Geometric Model option selected.

2.3 GCP Collection

GCPs can be collected to improve accuracy of the model and ultimately the orthorectified image. Please refer to the details of this step above. If no GCPs are to be included in the project, the model will be based on the supplied RPCs.

2.4 Ortho Generation

After a model is computed (Processing Step: Model Calculations), go to the Ortho Generation processing step. In the Ortho Image Production panel, specify the file to be processed and the DEM to be used. Enter an output file name and click on 'Generate Orthos'.

3.0 DEM Extraction

A Digital Elevation Model (DEM) can be extracted from stereo CARTOSAT-1 imagery. The procedure involves the computation of a model, creation of an epipolar pair and then the extraction of a DEM.

3.1 Compute Model

For this workflow, a new OrthoEngine project can be created or an existing project can be used. The project would consist of the stereo images required for DEM extraction.

To start a new project, please refer to the steps above for specifying project and projection information. The project can be of a Satellite Math Model or Rational Functions model. Add the image files, as outlined above, in accordance to the project type. The project would then consist of two files (.pix format if Satellite Math Model; .tiff format if Rational Functions model).

If an existing project is used, be sure that the two images are in the project. One way to check this is to go to the GCP/TP Collection processing step, and click on the 'Open a new or existing image' button. The images in the project will be listed in the Open Image panel. If need be, return to the Data Input processing step and import/add the other image file to the project.

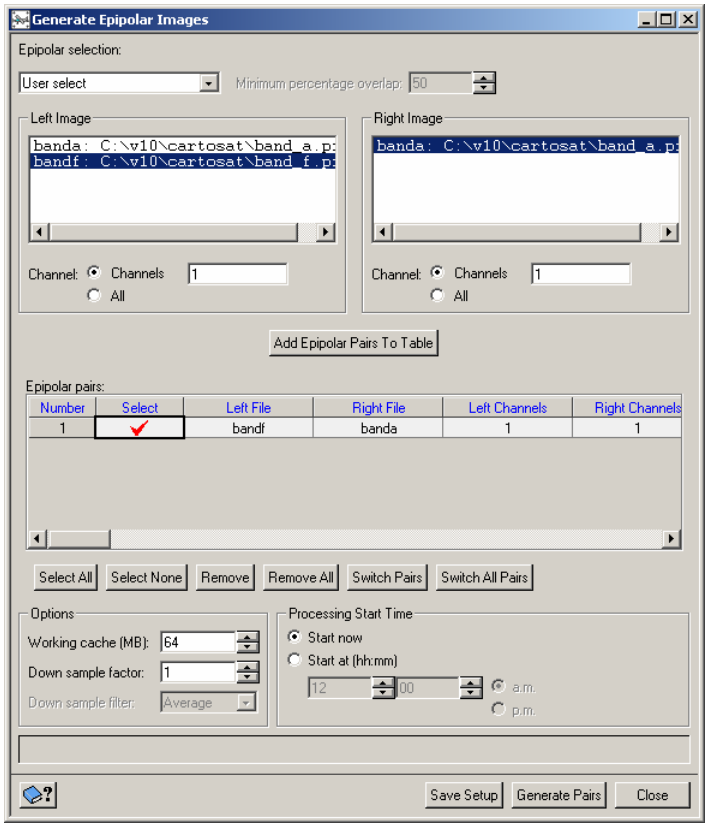
Then, if applicable or desired, collect GCPs on the images.

Go to the Model Calculations processing step to compute the model.

3.2 Create Epipolar Images

Epipolar images are stereo pairs that have been reprojected so that the two images have a common orientation. DEMs can be extracted from the overlap between epipolar pairs.

- First, go to the DEM from Stereo processing step and select 'Create Epipolar Image'. In the Generate Epipolar Images panel, select the left and right images.
- With both images highlighted, click on the 'Add Epipolar Pairs to Table' button. Information to generate the epipolar pairs would then be shown.
- Check off the epipolar pair under the Select column and then click on 'Generate Pairs'.

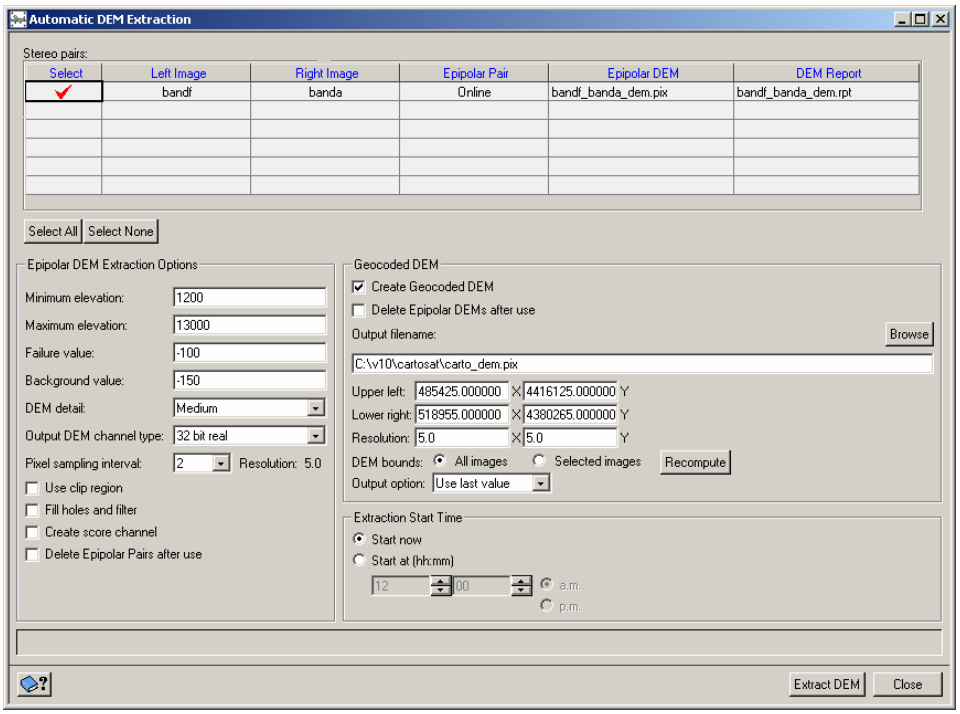


3.3 Extract DEM

Under the DEM from Stereo processing step, click on the 'Extract DEM Automatically' button.

- In the Select column, check off the epipolar pair from which the DEM will be extracted
- Under the Epipolar DEM Extraction Options:
  - Enter the minimum and maximum elevation values. This elevation range is used to estimate the search area for the correlation. This would increase the speed of the correlation and reduce errors. If the resulting DEM contains failed areas on peaks or valleys, then try increasing the range.
  - For Failure value, enter the value used to represent the failed pixels in the output DEM. The default is set to be -100.
  - Enter a Background value to represent "No Data" pixels that lie outside the DEM. These pixels are distinguished so that they would not be mistaken for elevation values. The default value is -150.
  - For DEM Detail, specify the level of detail desired for the output DEM. Low detail indicates that the process stops during the coarse correlation phase of aggregated pixels. High detail would mean that the process continues until correlation is performed on images at full resolution.
  - In the Output DEM channel type, enter 32 bit real.
  - Select the desired Pixel Sampling Interval, or sampling frequency. This parameter controls the size of the pixel in the output DEM relative to the input images. The higher the number specified, the larger the DEM pixel will be and the faster the DEM is processed.
- Under the Geocoded DEM section, select Create Geocoded DEM to geocode and merge the epipolar DEMs. However if the DEM is to be edited prior to geocoding, leave this option unselected.

  If this option is selected, enter the file name for output DEM.
- Click on 'Extract DEM'.



3.4 Edit DEM

The generated DEM may contain pixels and/or areas of failed or incorrect values. It is possible to edit the DEM to smooth out the irregularities and create a more pleasing output.

The tool to edit DEMs can be accessed in OrthoEngine | DEM from Stereo | Manually Edit Generated DEM. Once this button is clicked on, Focus will open and the DEM Editing panel will be shown.

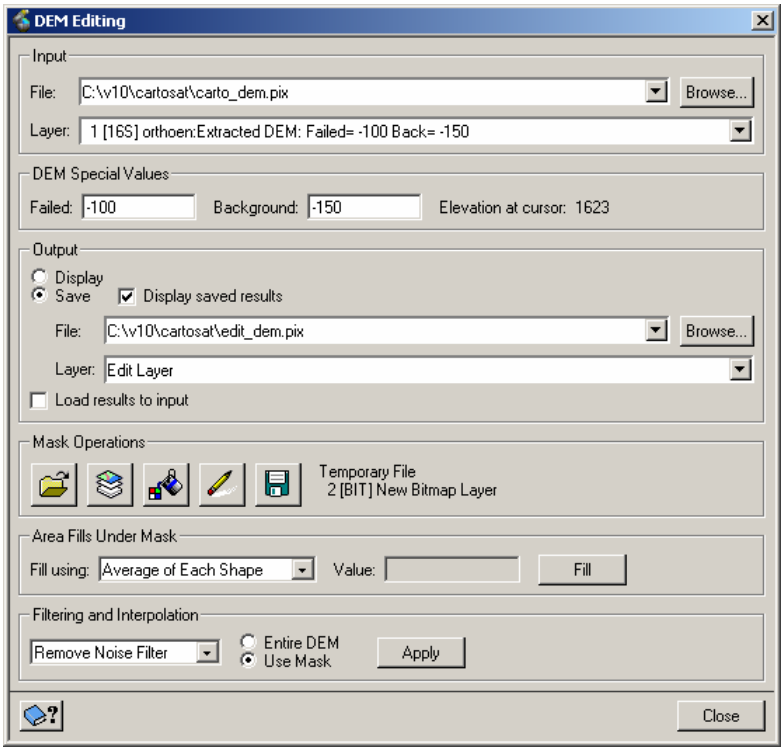
In the DEM Editing panel:

- For Input, browse to the DEM that was created from DEM Extraction step and select the layer that contains the DEM.
- Under DEM Special Values, enter the failed and background values of the DEM.
- As output, select Save and specify an output file name. Enter in a layer name as well. Enable 'Load results to input' if edits are to be done repeatedly to achieve a cumulative effect on the data. Click on 'Display saved results'.
- Masks can be used to identify areas that are to be edited. Area fills, filtering and interpolation will be performed to the area under the mask.

  In the Mask Operations section of the panel, click on the 'New Mask Layer' button. Then click on the 'Mask Failed Pixels' button to generate a bitmap mask over pixels that have the DN value of failed areas.

  Pixel values under the mask can be replaced with a specified value or average based on other shapes. To replace values, select the method under 'Fill using' and then click Fill.

  Filters can be used to eliminate failed or incorrect values. Filters can be applied repeatedly or in different combinations for a cumulative effect. It is also possible to filter areas under masks. To apply a filter, specify the desired method under 'Filtering and Interpolation'. Select the area to be filtered (entire DEM or area under mask). Click on 'Apply'.



3.5 Examine Results

Examine the DEM in Focus and continue editing if necessary.

Bad results in the DEM can often be caused by the data, the stereo coverage, the accuracy of the model generated from control points, etc. If there are numerous failed areas that cannot be easily corrected using the DEM Editing Tools, then try returning to OrthoEngine and generating epipolar images again or extracting DEM using different parameters (e.g. increase the down scale factor). The PCI Geomatica help files on Applying Tool Strategies for Common Situations in Digital Elevation Models contain more information about improving DEM output.