Orthorectifying DigitalGlobe Imagery in PCI Geomatica v 10.3 using the Rigorous Model and Rational Polynomial Coefficients

Introduction

DigitalGlobe's QuickBird, WorldView-1 and WorldView-2 satellite images are built up of groups of scan lines acquired as the satellites moves forward in its orbit. As a result, different parts of the same image are acquired from different sensor positions. In order to rigorously describe the transformation from image coordinates to Earth surface coordinates, a mathematical sensor model that incorporates all of the physical elements of the imaging system can be exceedingly long and complex. **Rational Polynomial Coefficients (RPCs)** are simpler empirical mathematical models relating image space (line and column position) to latitude, longitude, and surface elevation. The name Rational Polynomial derives from the fact that the model is expressed as the ratio of two cubic polynomial expressions. Actually, a single image involves two such rational polynomials, one for computing line position and one for the column position. The coefficients of these two rational polynomials are computed by DigitalGlobe from the satellite's orbital position and orientation and the rigorous physical sensor model. Using the georeferenced satellite image, its rational polynomial coefficients, and a DEM to supply the elevation values, PCI OrthoEngine can compute the proper geographic position for each image cell, producing an orthorectified image. **Orthorectification** is the process of removing distortion in the image based on the factors previously mentioned. PCI OrthoEngine orthorectifies Basic L1B and OrthoReadyStandard2A level of WV data products.

The following is a brief tutorial describing the use of Geomatica OrthoEngine v10.3 for Orthorectifying WorldView -1 raw (Basic 1B) imagery with the Rigorous Model* and Rational Polynomial Coefficients (RPC). If the user is supplied with OrthoReadyStandard2A level of data with RPCs, then it is recommended to use RPC modeling instead of Rigorous Modeling.

Note: Processing steps for WorldView-2 are the same as WorldView-1 and QuickBird.

A **Rigorous Sensor Model of an image is used to reconstruct the physical imaging setting and transformations between the 3D object space and the image space. It includes physical parameters about the sensor, principal point location, pixel size and lens distortions and orientation parameters of the image such as position and attitude of the image.*

Orthorectification with the Rigorous Sensor Model

Initial Project Setup

1. Start **OrthoEngine** and click ***'New'*** on the File menu to start a new project. Give your project a '*Filename*', '*Name*' and '*Description*'. Select '*Optical Satellite Modeling*' as the Math Modeling Method.

2. Under Options, select ***'Toutin's Model'***. After accepting this panel you will be prompted to set up the projection information for the output files, the output pixel spacing, and the projection information of GCPs.

3. Enter the appropriate projection information for your project.

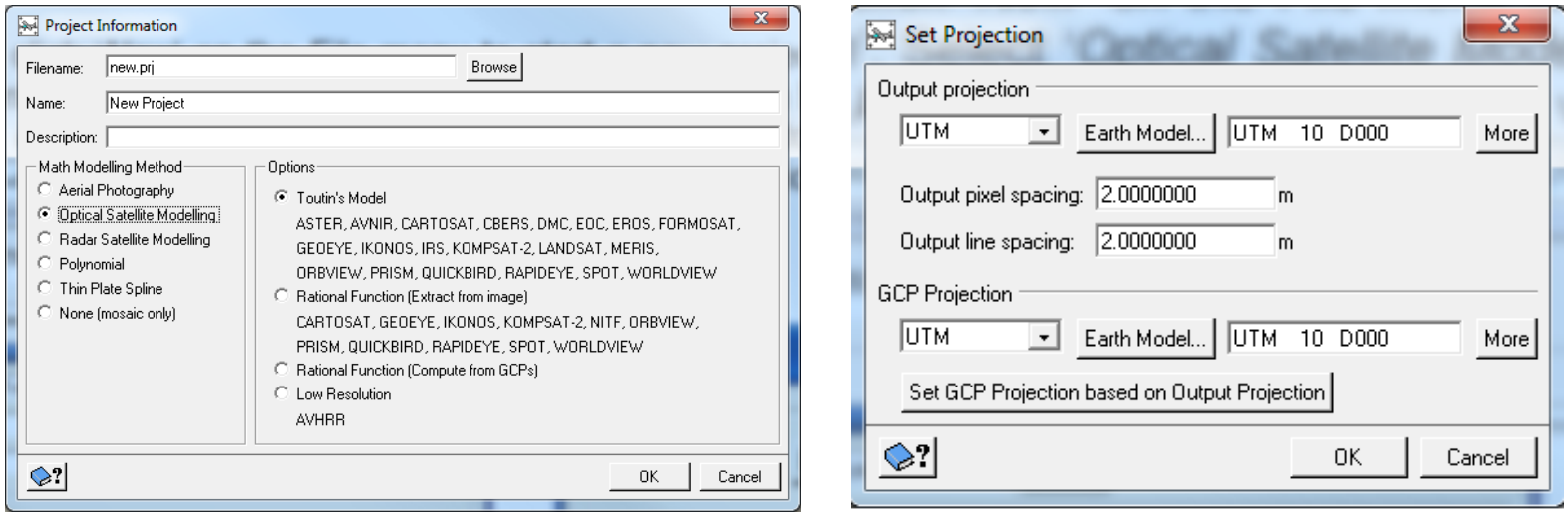


Fig.1. Project Setup

Data Input

For Rigorous Modeling with Geomatica OrthoEngine, the user should have either a WorldView-1, WorldView-2 or QuickBird "Basic (L1B) Imagery" product. WorldView-1, WorldView-2 and QuickBird data is delivered in *Geotiff 1.0, NITF 2.0, and NITF 2.1* formats, which are fully supported by Geomatica OrthoEngine v10.3. The data is also delivered with a number of support files (*ATT, EPH, GEO, IMD, RPB, STE, TIL and XML*) for Basic (L1B) and *(IMD, RPB, STE, TIL and XML*) for Ortho Ready Standard. Please note that these support files should be located in the same directory as the image data while reading the data. Depending

upon your media of delivery, you may have to copy or extract your data to the hard disk. After successful extraction of data to your hard disk, proceed to the **'*Data Input*'** processing step.

1. Select **'*Data Input*'** option from **'*Processing Step*'** drop down and click on the **'*Read CD-ROM data*'** button

(Please note that we are treating this data as if it is on a CD-ROM, even though it is actually located on the hard disk)

2. Choose **'*WORLDVIEW*'** as the **'*CD Format*'** and select your TIFF or NITF image file.

(For QuickBird imagery, choose **'QuickBird'** as the ***'CD Format'*** and select your TIFF or NITF image file.)

3. Press the appropriate channel buttons (for WorldView-1, 1 channel is selected, for WorldView-2, 8 channels can be selected, for QuickBird, 4 channels can be selected).

4. Specify an appropriate output **'*PCIDISK filename*'**, a **'*Scene description*'**, and a **'*Report filename*'**. This step will convert the file to '*.pix*' format, and add the information needed for modeling.

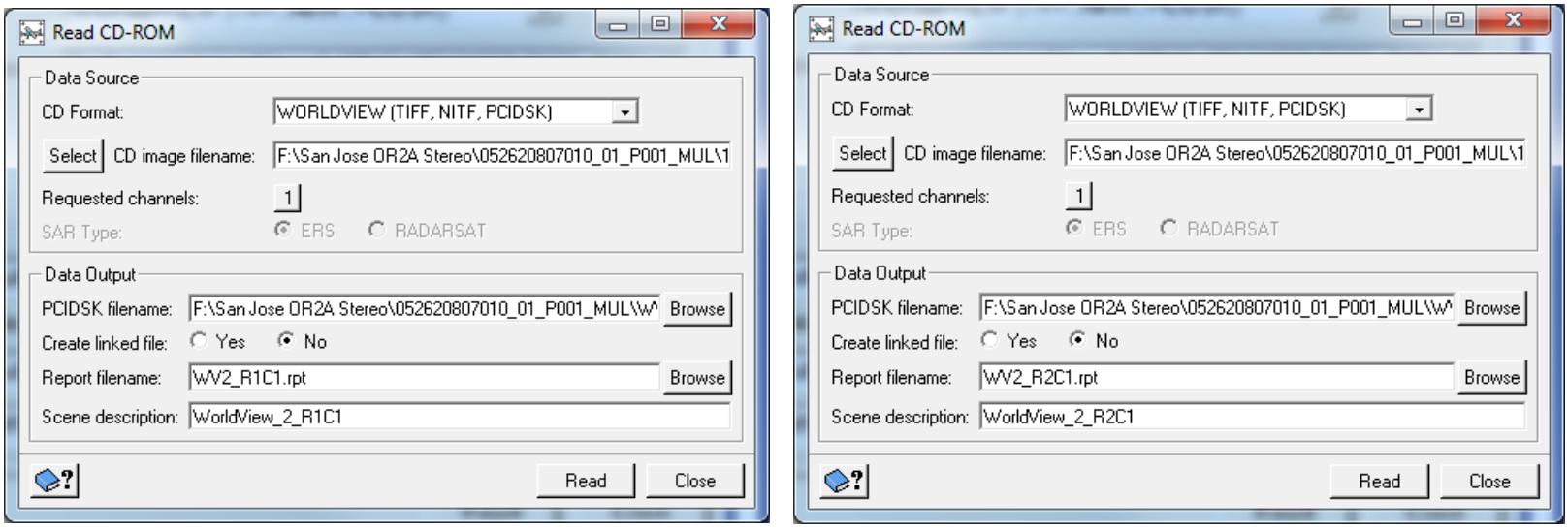


Fig.2. Data Input Stage

Stitch Images (optional)

If the imagery product is tiled it will contain image filenames containing the Row and Column of the image tile, e.g. R1C1, R2C1, etc. The files must be stitched using ***'Utilities > Stitch Image Tiles'*** option in OrthoEngine. Stitching operation merges different tiles, obtained from the same orbit on the same day, into one complete scene. It rebuilds the orbital data for the whole strip to maintain the ephemeris information and/or RPC positioning.

1. To stitch tiles go to '***Stitch Image Tiles with RPC***' under '***Utilities***' menu. For the Ortho Ready Standard product you have the option to select Assemble 'QuickBird/WorldView Ortho Ready Tiles…' *Note: This will work for both WorldView-1 and WorldView-2.*

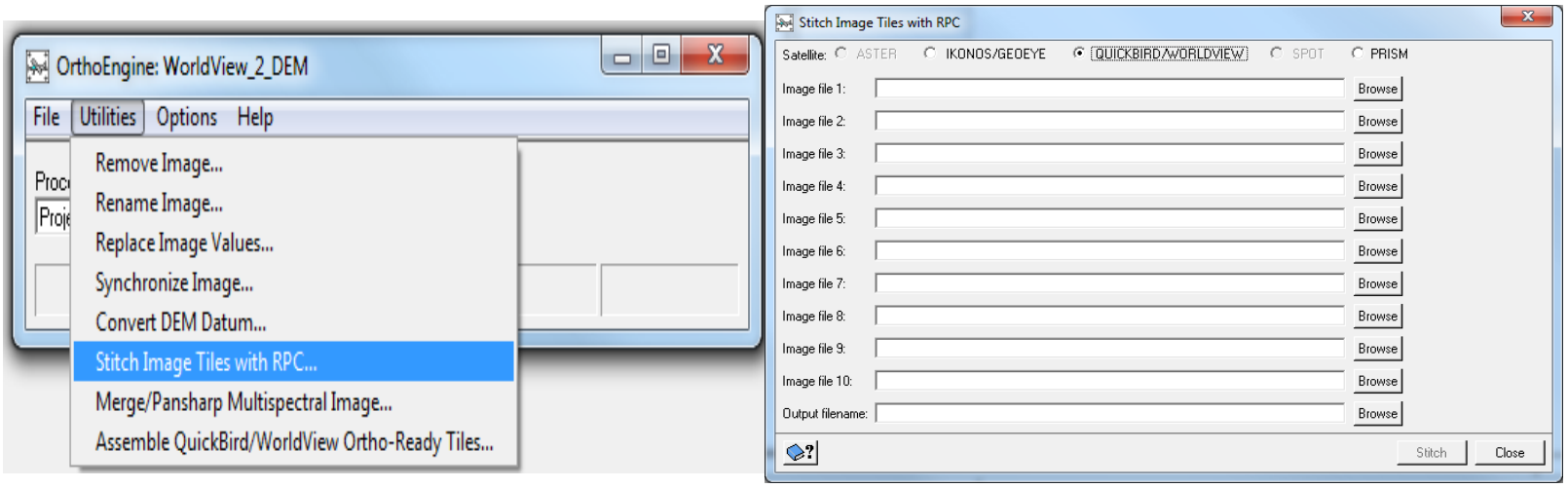


Fig.3. Stitch Tiled Imagery

2. After the successful completion, the software will prompt to add the stitched image to the project. Select ***OK*** to continue with the project

Collect GCPs and Tie Points

1. Select the ***'GCP/TP Collection'*** processing step. GCP collection can be done using various options. '*Manual Entry*', '*Geocoded Images/Vectors*', '*Chip Database*' or a '*Text File*'. For this exercise we use a *Geocoded Image* to collect GCP's from.

2. Navigate to an orthorectified image for the GCP source under **Filename**

3. Next, navigate to the location of the DEM you will use for your elevation source. The ortho image used to collect GCPs from will load in a viewer with the DEM source underlying it.

4. In the viewer, pan around the image and find good photo identifiable points for your GCP's, e.g. sidewalk intersections, corner of a curb, and edge of concrete.

5. Once you have located a control point to use in the GCP Collection window in the **Point ID** window name the GCP, e.g. GCP 01.

6. In the **Viewer** click the **Use Point** button

7. The coordinates and pixel coordinates will populate in the GCP Collection window.

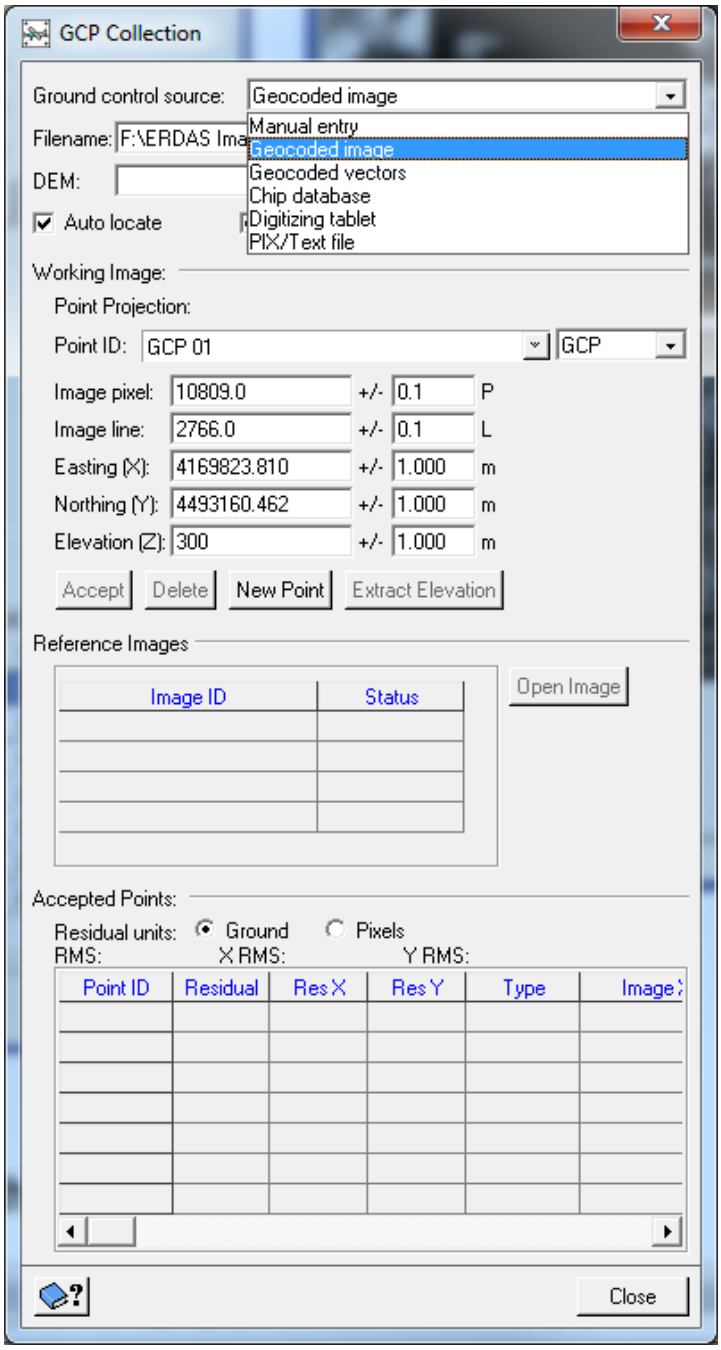
8. If satisfied with the point click the **Accept** button.

9. The GCP will then be added to the **Accepted Points** list at the bottom of the GCP Collection window

10. To add another point click **New Point** and pan to an area in the image to collect a second GCP from and repeat steps 4-9. *Note: Try to evenly disburse the GCP points across the image.*

11. For the WorldView-1 *Rigorous Model*, a minimum of six accurate GCPs per image (or more, depending on the accuracy of the GCPs and accuracy requirements of the project) are recommended.

12. After collecting the GCPs, select the **'Model Calculation'** Processing Step and click on **Compute Model**. Check '**Residual Report**' panel (under the Reports processing step) to review the initial results.



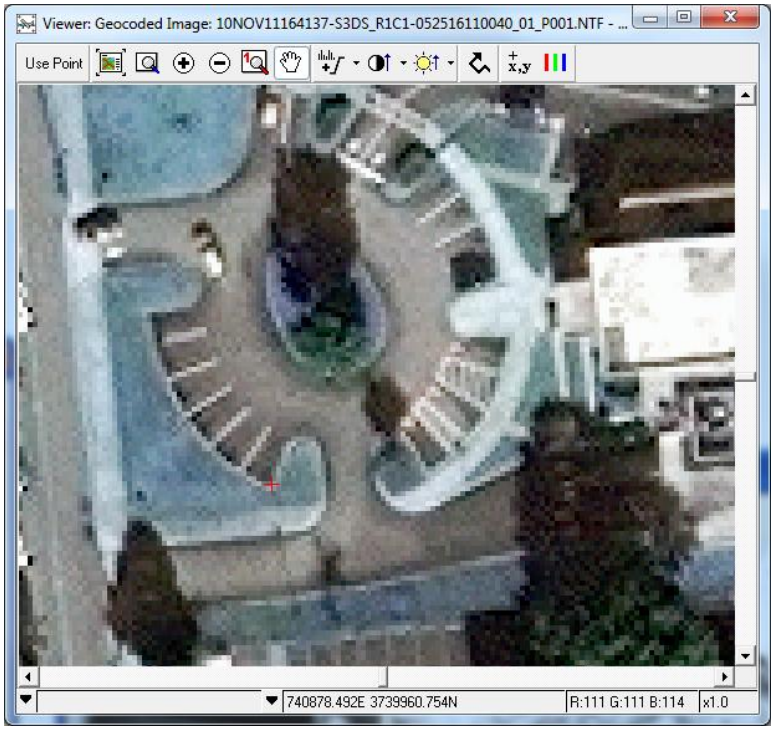


Fig.4. GCP Collection

Generating Orthos

The final step is to set up your **'*Ortho Image Production*'**.

1. Proceed to the '***Ortho Generation*'** processing step and select the file(s) to be orthorectified.

2. Choose the **DEM** file to be used in the processing and other processing parameters.

3. Click on '*Generate Orthos*' to create the final Orthorectified image

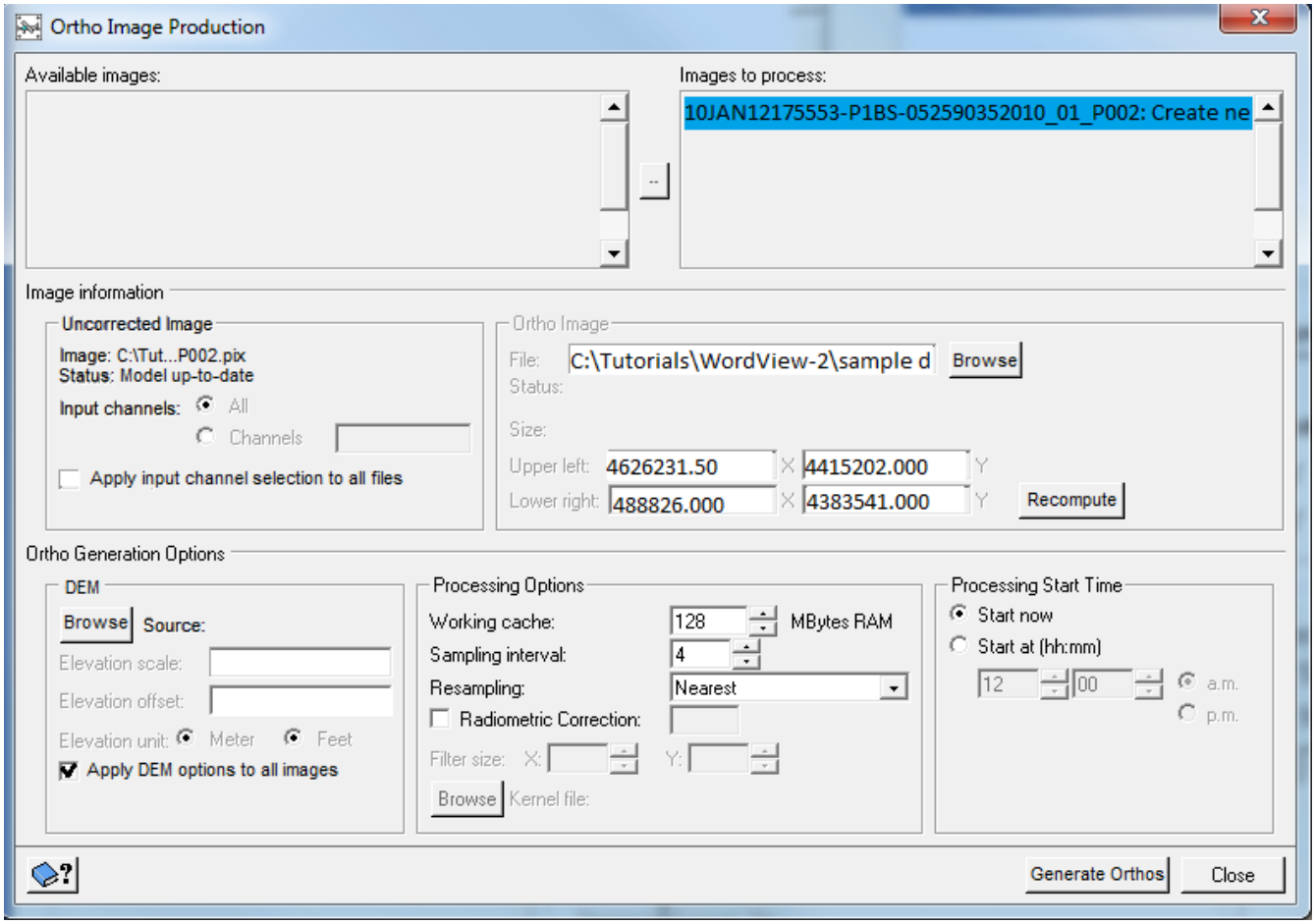


Fig.5. Ortho Image Production

Rational Polynomial Coefficients (RPC)

WorldView-1, WorldView-2 and QuickBird Basic L1B (Basic) data and Ortho Ready Standard Data is also delivered with RPCs, which can be used in the absence of adequate GCPs. Further addition of 1-4 GCPs into your project, in addition to the delivered RPCs, can significantly improve the accuracy of your final ortho photo.

Initial Project Setup

1. Start a new project and select the math modeling method as **'*Optical Satellite Modeling*'**.

2. Under **'*Options*'** select **'*Rational Functions' (Extract from Image)*'** option.

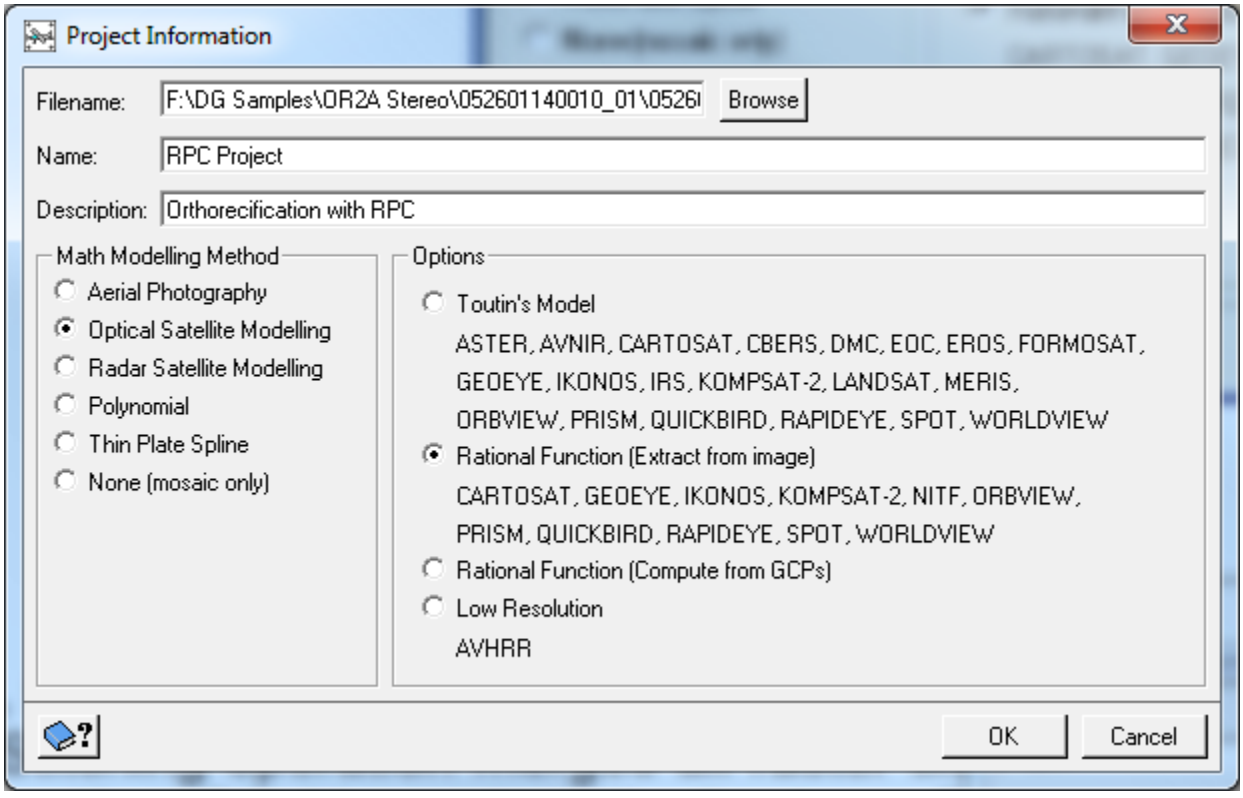


Fig.6. Project Setup RPC Orthorectification

Stitch Images (optional)

If your imagery product is tiled, stitch the image tiles that contain R1C1 and R2C1 by '*Stitch Image Tiles with RPC*' under Utilities menu. Stitching operation merges all raster tiles and recalculate stitched image RPCs from individual RPCs of image tiles. Stitching automatically stores final RPCs as a binary segment in output PIX file. Click '*Yes*' to add the stitched scene with RPC segment into project file. *See Page 4 for stitching instructions under 'Stitch Images'*

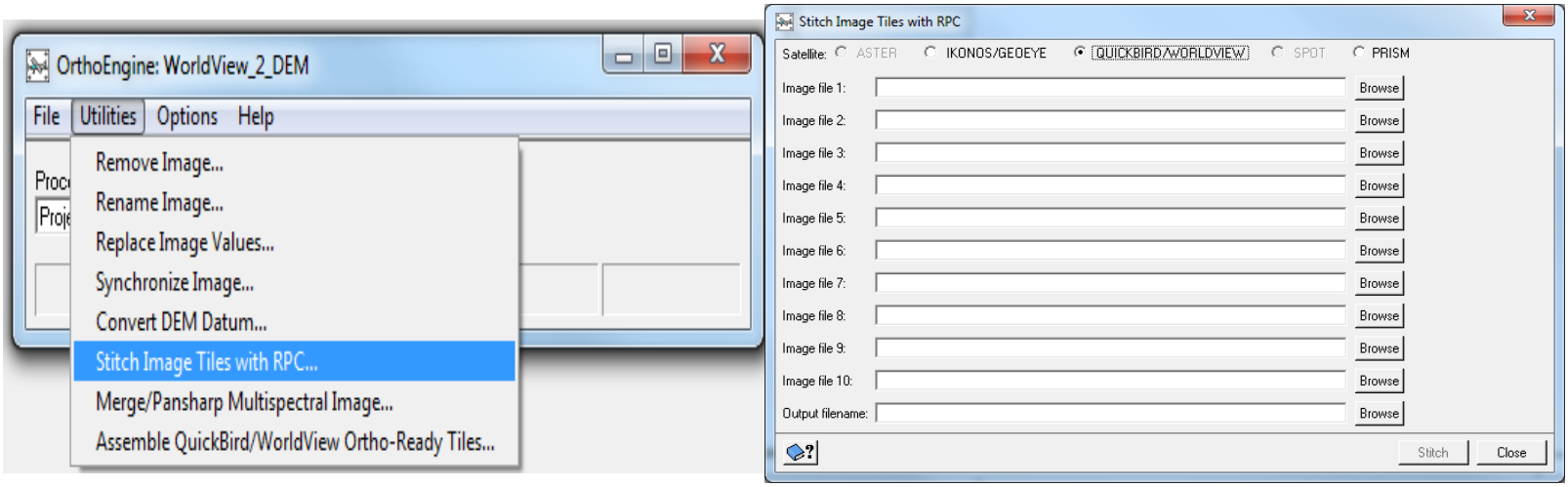


Fig.7. Stitch Image Tiles with RPCs

GCP Collection (optional)

At this stage an Orthorectified image can be directly generated in the absence of any GCPs. The model will be computed based on the supplied RPCs. If GCPs are available, they can be added into the project using the same process as defined in pages 4 and 5 of this document. The model will be automatically computed, and GCPs can be reviewed through **Residual Report**.

Note: It is recommended to use ZERO order RPC adjustment (i.e. minimum of 1 GCP) for WV-1 and WV-2 imagery. A FIRST order RPC adjustment (I.e. minimum of 3 GCPs, well distributed in entire image) is recommended for QuickBird imagery. For more information on image accuracy and Zero and First Order please visit http://www.pcigeomatics.com/pdfs/WorldView-1.pdf

Ortho Generation

The final step is to '***Schedule Ortho Generation***'.

1. Proceed to the **'*Ortho Generation*'** processing step and select the file(s) to be processed.

2. Select an appropriate DEM file and set other processing options before generating the final orthorectified image. *See Page 4 of this document for 'Ortho Generation' steps*

For more technical information on DigitalGlobe Imagery Products please visit
http://www.digitalglobe.com/resources

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