



IPCE Integrated Photogrammetric Control Environment

USER'S MANUAL

**U.S. Geological Survey
Astrogeology Science Center
Flagstaff, AZ, USA**

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REVISION SHEET

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Rev. 0	4/24/2018	Initial version	kle
Rev 1	10/17/2018	Draft for Isis3 Release 3.6.0	kle



<p>USER'S MANUAL</p> <p>AUTHORIZATION MEMORANDUM</p>

I have carefully assessed the User's Manual for the Integrated Photogrammetric Control Environment. This document has been completed in accordance with the requirements of the USGS Astrogeology System Development Methodology.

MANAGEMENT CERTIFICATION - Please check the appropriate statement.

_____ The document is accepted.

_____ The document is accepted pending the changes noted.

_____ The document is not accepted.

We fully accept the changes as needed improvements and authorize initiation of work to proceed. Based on our authority and judgment, the continued operation of this system is authorized.

NAME
Project Leader

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Program Area/Sponsor Representative

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Program Area/Sponsor Director

DATE

USER'S MANUAL

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INTRODUCTION

1.1 Overview

1 The objective of the *Integrated Photogrammetric Control Environment* (IPCE) is to incorporate all aspects of the photogrammetric control process within a single interactive and user friendly environment. By simplifying data management, providing statistical and 2D/3D graphical data analysis tools, and automating processes and analysis, we improve the efficiency and cost-effectiveness of the process. This in turn is likely to improve the quality of products such as Digital Image Mosaics and Digital Terrain Models, and geologic maps using them as basemaps.

1.2 Points of Contact

1.2.1 Information

To be completed. Provide a list of the points of organizational contact (POCs) that may be needed by the document user for informational and troubleshooting purposes. Include type of contact, contact name, department, telephone number, and e-mail address (if applicable). Points of contact may include, but are not limited to, help desk POC, development/maintenance POC, and operations POC.

1.2.2 Help Desk

To report issues and ask questions, visit the Astrogeology Support and Issue Tracking System at the link below.

<https://isis.astrogeology.usgs.gov/fixit>

1.3 Organization of the Manual

To be completed

2.0 – User Interface - What’s in the menus, Project Tree and its corresponding nodes.

3.0 – Cnet Editor View - Overview of editing control nets using tables and filter options.

4.0 – Cube DN View - How to display image DN data as well as the available tools for analyzing the data.

5.0 – Footprint View - How to display polygon(s) of image borders in order to show image locations relative to one another.

6.0 – Control Point Editor - Overview of the tools available in control point editor.

7.0 – Control Net Health Monitor - What to expect from the control net health monitor as well as how to use it to keep nets healthy.

8.0 – Image Measurements – This section will expand on using the control point editor to add and remove points to control networks.

9.0 – Bundle Adjustment - This will be a guide on how to use ipce for bundle adjusting and controlling images.

10.0 – Known Issues - This program is still under construction and known issues will be listed here.

1.4 Acronyms and Abbreviations

Provide a list of the acronyms and abbreviations used in this document and the meaning of each.

- USGS – United States Geological Survey
- ASC – Astrogeology Science Center
- ISIS – Integrated Software for Imagers and Spectrometers
- IPCE – Integrated Photogrammetric Control Environment

1.5 Installation and System Information

1.5.1 Installing ISIS3

Detailed instructions for downloading and installing ISIS3 are provided at the link below.

<https://isis3.astrogeology.usgs.gov/documents/InstallGuide/index.html>

1.5.2 System Requirements

System requirements are provided in the installation link in Section 2.0.1 above and repeated below for quick reference.

Operating System Requirements

ISIS DOES NOT RUN ON MS WINDOWS.

Supported UNIX variants include...

- Ubuntu
- RHEL
- Debian
- Fedora
- Mac OSX

Minimum Hardware Requirements

- 64-bit (x86) processors
- 2 GB memory
- 10-180 GB disk space for ISIS installation
- 10 GB (to many TB) for processing images
- Quality graphics card

1.6 Data Requirements

In the future IPCE will be able to ingest images into ISIS3 cube format. As of now please take these steps with images to get images into cube format so IPCE can further process them.

1.6.1 ISIS3 Cubes

In the future IPCE will be able to ingest images into ISIS3 cube format. Currently however, images must already be in the ISIS3 cube format to import into IPCE. Further, they must be in Level1 space (i.e. not projected) and must contain SPICE information (via *spiceinit*). If *footprintinit* has not been run on the cubes, a footprint will be created upon import (which can be time consuming).

1.6.2 Control Networks

Currently control networks can be edited but not created within IPCE. Use ISIS3 applications such as *autoseed*, *seedgrid*, *findfeatures*, and *pointreg* to create a control network to import into IPCE.

USER INTERFACE

The IPCE user interface (UI) (Figure 1) consists of three major components, 1) the project tree on the left; 2) the work space to the right of the tree; and 3) the warnings and history windows at the bottom of the interface. The project tree contains all project data including imported data and generated results (e.g. from

2

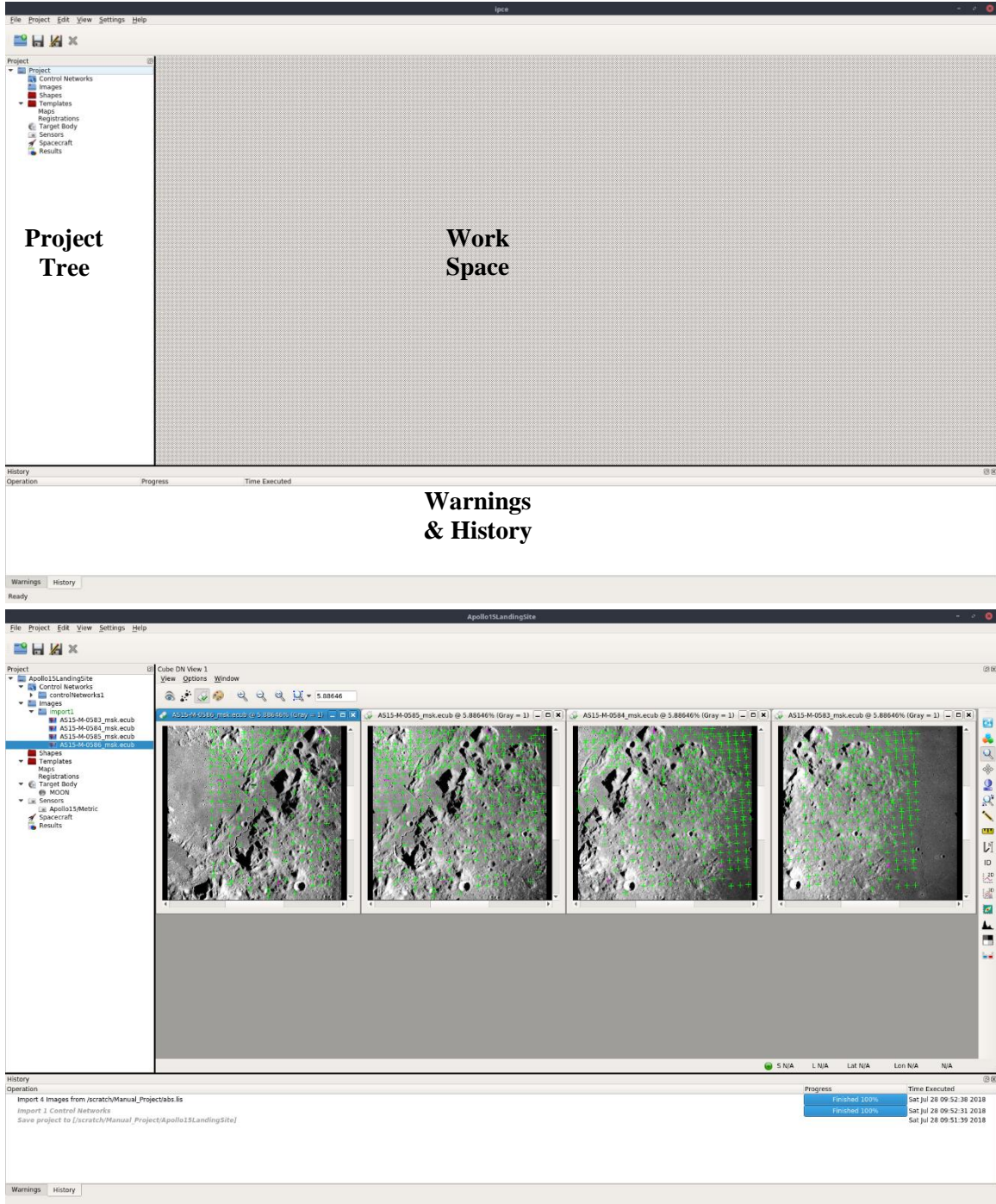


Figure 1: IPCE user interface. Top: interface display on startup with project tree view on the left and working space on the right. Bottom: example project with image cube view displayed in the working space.

the bundle adjustment). The project tree is described in Section 3.3 below. In the working space all imported data can be displayed and manipulated (e.g. Figure 1, bottom).

2.1 Main Menu

2.1.1 File Menu

From the File menu (Figure 2) one can open, save, and close projects; import data; and exit IPCE.

2.1.1.1 *Open Project*

An existing project can be opened from the file menu shown below and clicking open project or a file can be opened from the main menu by clicking on the blue file with the green plus sign in the top right corner. Open Project opens a “Select Project Directory” dialog ipce projects are stored as directories. A directory will be selected and then click ok. If there is an existing file in the current directory using command line >> ipce (Project Name)

This will open IPCE and load the project to its last saved point.

2.1.1.2 *Save Project*

This saves the state of the current project including any changes made to control networks. The first time a project is saved, the user is prompted with a dialog to choose a project location.

2.1.1.3 *Save Project As*

The user is prompted with a dialog to choose a new project location.

2.1.1.4 *Import*

Import options are as below (Figure 2, center). The user is prompted with a dialog to choose the item to import.

- Import Control Networks
- Import Images
- Import Shape Models
- Import Templates

2.1.1.5 *Export*

Control networks and images can be exported from the IPCE project (Figure

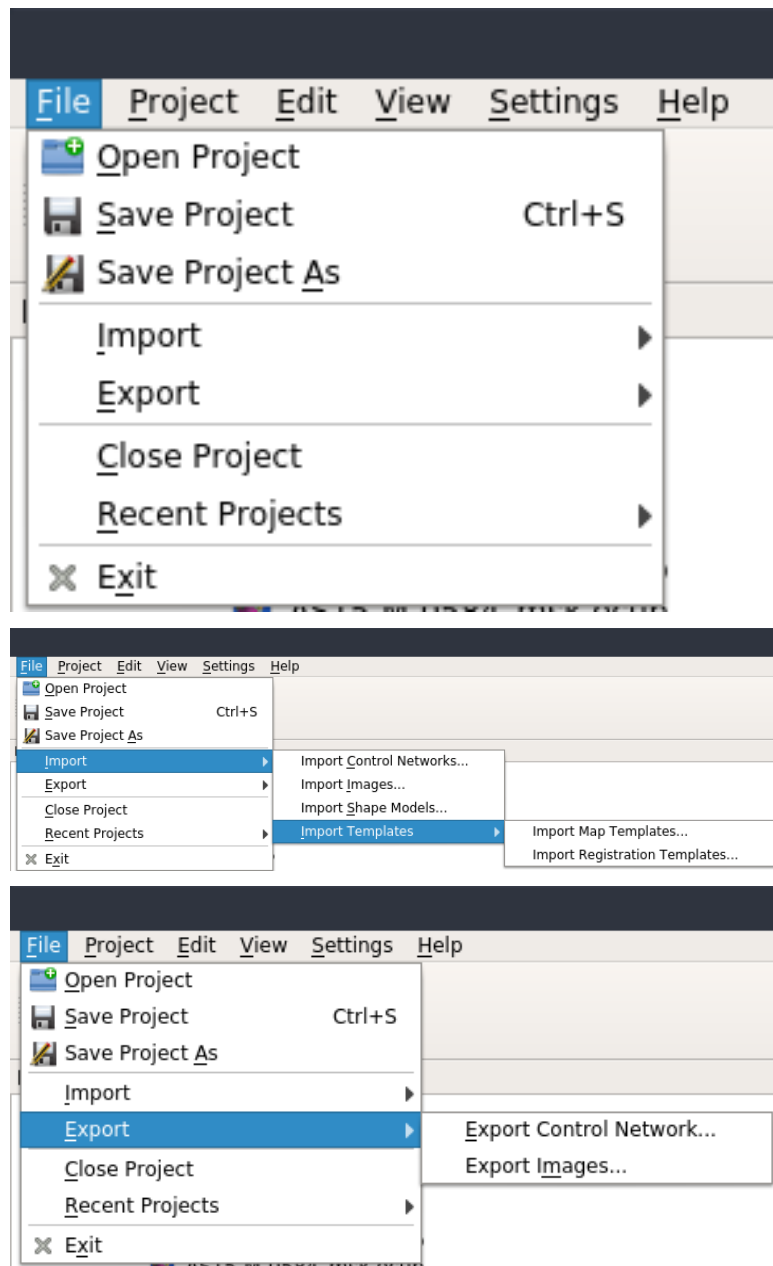


Figure 2: File menu (top). Import options (center) and export options (bottom).

2, center). Note that if there are no images or control networks in the current project these options will be unavailable. The user is prompted with a dialog to choose the export location.

2.1.1.6 *C*lose Project

This closes the current project. IPCE remains open.

2.1.1.7 *R*ecent Projects

Up to five recently opened projects will appear in chronological order under the *Recent Projects* submenu. These can be re-opened directly by selecting them from the submenu.

2.1.1.8 *E*xit

Exit closes the program. The user is prompted to save the current project if there are unsaved modifications.


2.1.2 Project Menu


The Project menu (Figure 3, top) contains options to rename the current project and to perform a bundle adjustment (Section 4) Note that a project can also be renamed by right clicking the project name on the project tree.

2.1.3 Edit Menu

This menu contains Undo and Redo commands (Figure 3).

2.1.4 View Menu

From the View menu (Figure 3) the user can Tab or Tile existing views. The default view mode is to open new views as separate tabs in the main workspace. Each view can be activated by clicking the corresponding tab (Figure 4, top). If Tile Views is selected the display will look like (Figure 4, bottom). All views in IPCE can be undocked by clicking and dragging the view from the upper portion where the view title is located. The views can then again be redocked by clicking the box with two squares  in the upper right corner. Views can be tabbed tiled and undocked all the same time.

When ipce is in full screen and the views are tabbed clicking the detach view button  will detach the view while keeping it in the same size and location making it appear as nothing has happened. This problem only exists while in full screen.

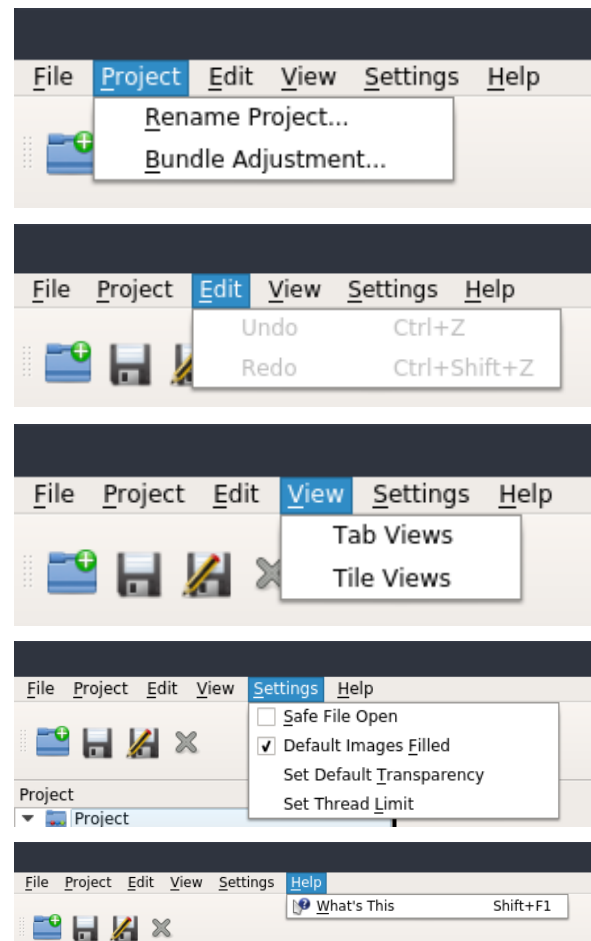


Figure 3: From top to bottom: Project, Edit, View, Settings, and Help menus.

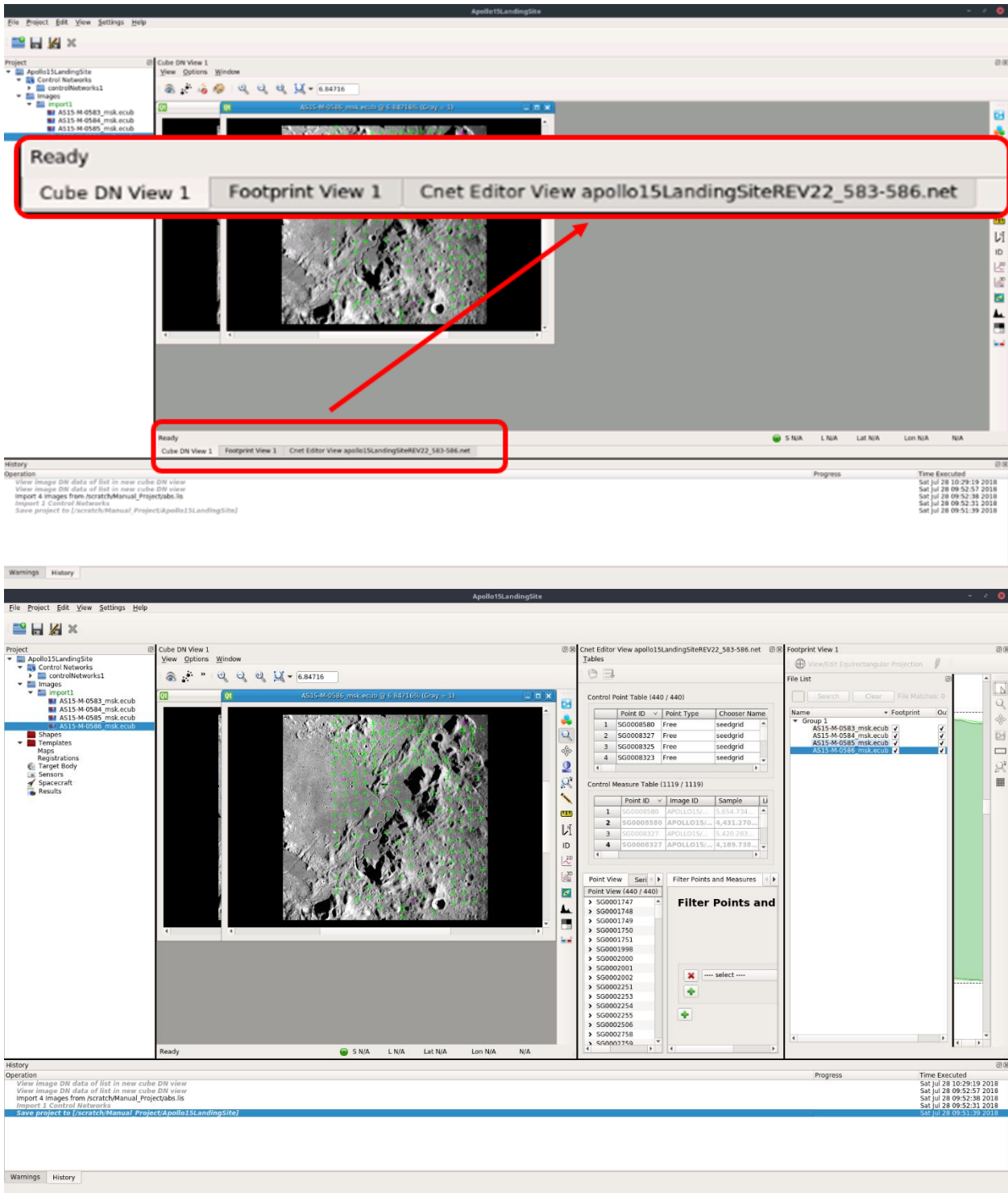






Figure 4: Top - shows the default view configuration in which each view opened is in its own tab. Bottom - shows the results of clicking Tile Views each is now visible in the workspace.

2.1.5 Settings Menu

To be completed. What’s going on with this stuff, how to document?

2.1.6 Help Menu

Currently there is only one option in the Help menu. Selecting the

What's This Shift+F1 option (Figure 5, top) will change the cursor to either  or . When hovering over an item that has associated Help content the cursor changes to . When this item is then clicked, a popup dialog with the help content appears (e.g. Figure 5, bottom). If there is no help content available, the cursor changes to .

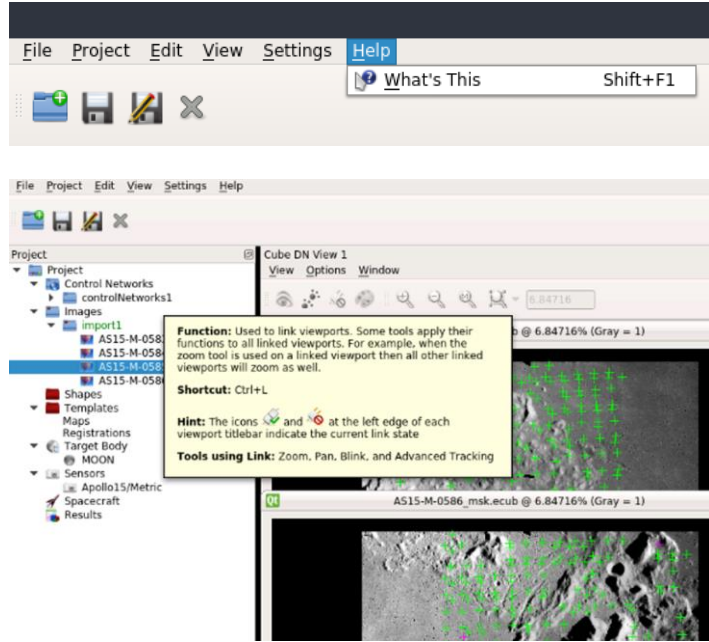


Figure 5: What's This option on Help Menu (top). Example of popup help content (bottom).

2.2 Project Tree View

The project tree contains all imported data as well as results from bundle adjustments.

Within the project tree, under the top level Project node, are eight distinct nodes including Control Networks, Images, Shapes, Target Body, Sensors, Spacecraft, Templates and Results. Each node is described in detail below. What's This Shift+F1

2.2.1 Project Node

The top level project node contains all eight nodes. When opening a new project this node will be named Project (Figure 6, left) until the project is saved. At that point this node is renamed to the project name (Figure 6, right).

2.2.2 Control Networks Node

The Control Networks Node contains all imported control networks. Multiple networks can be imported at the same time. All control networks imported at the same time appear under a single sub-node below the

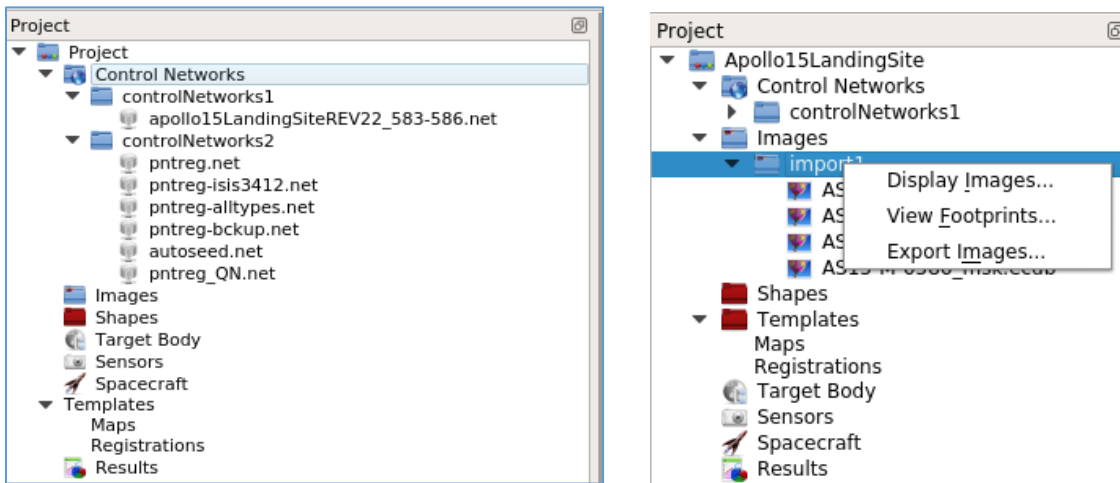


Figure 6: Control Network import with multiple control nets in the same node (left). Menu displayed when right-clicking an image import node (right).

Control Networks node (Figure 6, left). The sub-nodes for each import are named e.g. controlNetworks1, controlNetworks2, etc.

2.2.3 Images Node

Under the Images node, consecutive imports are labeled Import1, Import2, etc. After import these can be renamed by double clicking the import name and typing in the desired name and pressing enter. To see the list of images that make up an import, expand the import node by clicking the arrow next to it. Right-clicking on an import node or a selection of images displays a popup context menu (Figure 7). This menu contains options to 1) *Set Active Image List* (Section 2.2.31); 2) *Display Images* in the Cube DN View (Section 2.4), 3) *View Footprints* (Section 2.5); and 4) *Export Images* (Section 2.1.1.5).

2.2.3.1 The Active Image List

If there is only one image list in the project it will default to the active image list and the text on the import name will turn green. If there are multiple imports in a project, then after right clicking an import the option to set that import to the active image list will appear. It can be seen in Figure 7 that import2 is set as the active image list and the text is green. Now that there are two imports in the project the option to set the non-active image list to the active image list is now available.

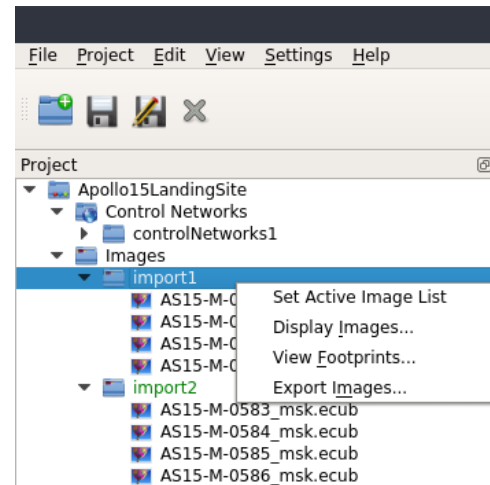


Figure 7: This shows import2 as the active image list and now import1 has the option to be set as the active image list. If there is only one import in the project by default it is the active image list and Set Active Image List will not be an option.

2.2.4 Shapes Node

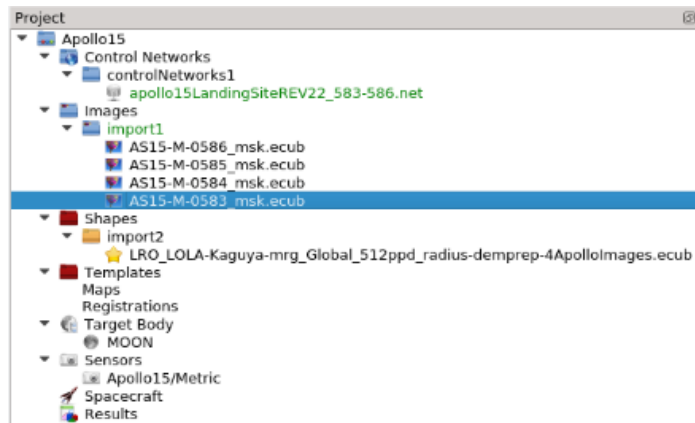


Figure 8: Project tree after a shape model is imported.

The shape node will contain images that can be referenced by control points that have a point type that is controlled or fixed. When a new control point is created or edited there is an option to change the point type and when that is changed to either controlled or fixed a new option will appear labeled ground source. The options to select from in ground source will be any imported shape files in a drop-down menu. Currently the shape files are 2.5D DEMs (digital Elevation Models) located in /usgs/cpkgs/isis3/data/base/dems/. In the future this will include true 3D objects (e.g. TINs, NAIF plate models, etc.).

Ground Source- Will be an image cube can be used as seen in (Figure 9)

Radius source – This will be a digital elevation model (DEM) and with latitude and longitude from the ground source file an accurate radius can be obtained from the Z coordinate on the DEM.

2.2.5 Target Body Node, Sensors Node, Spacecraft Node

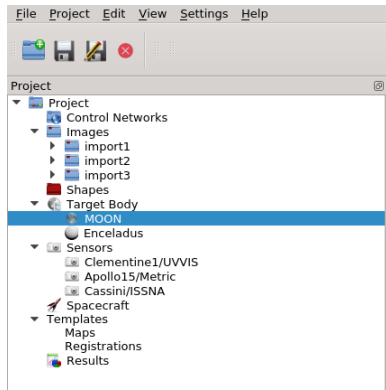


Figure 10 Sensors/Spacecraft populated in the project tree from cube label

This is auto populated based on the data contained inside the cube

labels (Figure 10). For every different target body sensor and spacecraft there will be one generated in the corresponding nodes. This image shows different nodes based off of data contained within the three image imports. If an individual node is right clicked on there is a get info option which will pull up a page of useful info on the given item.

- In the current version Sensors displays (spacecraft/Sensor) ex Apollo/Metric and spacecraft is left empty.

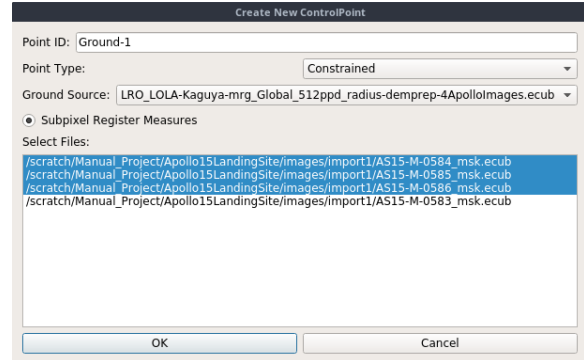


Figure 9 Image showing the use of a shape model when creating a new point in the control point editor

2.2.6 Templates Node

To be completed.

After templates are imported they can be right clicked on and then select edit template to edit. In (Figure 13) the editing area can be seen after edits are complete click Save Changes to keep edits there is also a Save Changes As option. The editor can be closed or undocked with the small x or square button in the top right corner.

2.2.6.1 Map Templates

Map templates can be found at /usgs/cpkgs/isis3/data/base/templates/maps. Map templates are used for projecting flat images to their appropriate body shape and defining their location as well as resolution of the images. Templates are used in isis3 programs such as cam2map and map2map if no template is provided a list of where default values will come from can be seen below Figure 11.

In IPCE, the maps node is present to have multiple map templates imported in order to change quickly between different options to obtain the desired results. (currently templates can be imported and saved but not used unless reloaded into the footprint view map tool)

Parameters	Default Value
MinimumLatitude, MaximumLatitude, MinimumLongitude, MaximumLongitude	Automatically computed using information from the camera model
PixelResolution	Automatically computed using information from the camera model
EquatorialRadius, PolarRadius, LatitudeSystem, LongitudeRange, LongitudeDomain	Automatically computed using the TargetName from the cube labels.
CenterLatitude, CenterLongitude, and other projection specific parameters	Automatically computed using the middle of the ground range

Figure 11: Default parameters for map templates

```

equirectangular.map
#*****
#*****
# This is a map template file for the equirectangular
# projection.
#
# Most of the parameters are commented (#) which means
# a program will try
# to determine a good value. For example, a program will
# look at cube
# labels to determine the target name and then read
# system radii values.
#|
# If you want to use something other than a system default
# uncomment the
# appropriate line and give the parameter your value. For
# example,
# PixelResolution = 10 <meters/pixel>
#
# The equirectangular projection has two required
# parameters CenterLatitude
# and CenterLongitude. If not uncommented in this file
# programs usually
# compute them to be the average of the latitude/
# longitude range.
#
#*****
#*****

Group = Mapping
ProjectionName = Equirectangular
# CenterLatitude = 0.0 <degrees>
# CenterLongitude = 0.0 <degrees>

# TargetName = Mars
# EquatorialRadius = 3396190.0 <meters>
# PolarRadius = 3376200.0 <meters>

# LatitudeType = Planetocentric
# LongitudeDirection = PositiveEast
# LongitudeDomain = 360 <degrees>

# MinimumLatitude = 47.431079407022 <degrees>
# MaximumLatitude = 49.323205331047 <degrees>
# MinimumLongitude = 276.4825037824 <degrees>
# MaximumLongitude = 279.27207041615 <degrees>

# PixelResolution = 115.77089360021 <meters/pixel>
# Scale = 512.0 <pixels/degree>
End_Group

```

Figure 12: Equirectangular map template example

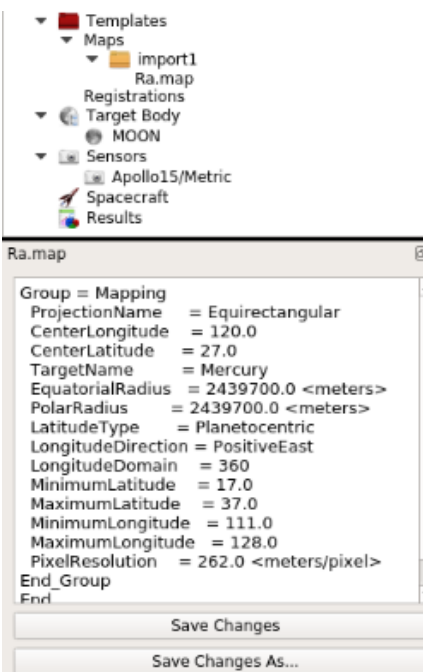


Figure 13: Template editor

2.2.6.2 Registration Templates

Registration templates can be found at `/usgs/cpkgs/isis3/data/base/templates/autoreg`. Automatic registration is the attempt to match a pattern in an image cube. Pattern matching has many different purposes.

Examples:

1. Register an entire image to a second image. The registration of an image is performed by moving (rubber-sheet) the pixels to output pixel locations that result in pattern matching directly to a second 'fixed' or 'truth' image. (*coreg*).
2. Relative cartographic registration between a number of overlapping images. Pattern matching is used to build a control point network across a number of overlapping images for solving and adjusting the camera pointing that are then applied to map project the images. (*pointreg*, *jigsaw*).
3. Find and record the pixel location(s) of a camera reference mark (e.g., Vidicon reseau mark) across an image (*findrx*).

Templates are used in ipce in the control point editor tool for subpixel registration more information will be found in IMAGE MEASUREMENT.

2.2.7 Results Node

Bundle adjustment (BA) solution information appears under the Results node of the project tree (Figure 14). Each individual BA run appears on the tree under a child node labeled by default with the run time. Note that this label can be edited by double-clicking the label and typing directly in the resulting edit box. Information displayed for each BA run includes...

- *Settings*: BA settings are saved (currently can't be displayed).
- *Output Control Network*: Right clicking on the adjusted output control network displays a popup context menu with options to 1) set as active control network; 2) view/edit the network in the Cnet Editor View (Section 2.3); and 3) export.
- *Statistics*: A bundle summary and statistics for image measures, images, and control points are available under this node. Each can be displayed by right-clicking and choosing *View...* from the resulting popup menu. The summary is displayed as text and the statistics in tables.
- *Images*: This node contains detached image cube labels with SPICE as updated from the BA. Right-clicking on an individual image or the images immediate parent node displays a popup menu with options to 1) *Display Images...*; 2) *View Footprints...*; or 3) *Export Images...* Displaying updated images or footprints utilizes the original DN data with the updated SPICE.
- *Note footprint view will not be available until the project is saved as or saved closed and reopened.*

2.3 Cnet Editor View

To be completed. Cnet Editor View) is used to view control networks and to edit the active control net. The main views in Cnet Editor are:

2.3.1 Control Point Table

A table that contains a list of all control points in the control net. This table will update when a filter is applied. The list can be sorted by clicking (^, down) in the tip of the desired column. The editable tabs in this table are:

By double clicking in any of the editable cells the option to type in a value or to select an option from a drop down menu will be given. Once a cell has been changed the cell can be right clicked on and there is an option to copy to all cells.

2.3.2 Control Measure Table

A table that contains a list of all the control measures in the control net. This table also updates when a filter is applied. The list can be sorted by clicking (^, down) in the tip of the desired column. The editable tabs in this table are:

By double clicking in any of the editable cells the option to type in a value or to select an option from a drop down menu will be given. Once a cell has been changed the cell can be right clicked on and there is an option to copy to all cells.

2.3.3 Point, Serial, and Connection Views

These three views occupy the same working space and it is necessary to click on the tab of the desired view. **Point View**- this will display a list of all the control points with a drop down menu on each that contains a list of the images that make up that control point. This list will update when a filter is applied. No editing can be done from this view.

Serial View- This view contains a list of cubes and each cube has a drop down menu which contains a list of all the control points that exist in that cube.

Connection View- This view contains a list of cubes and each cube has a drop down menu which contains a list of other cubes that are connected to it. **(I am not sure if this information is correct)**

2.3.4 Filtering Views

Filter Points and measures, Filter Images and Points, Filter Connections

These three views share the same work space and it is necessary to click on the desired tab. Each tab will filter different corresponding views.

Filter Points and Measures- This filter will be applied to the Control Point Table, Control Measure Table and Point View.

Filter Images and Points- This filter will be applied only to the Serial View

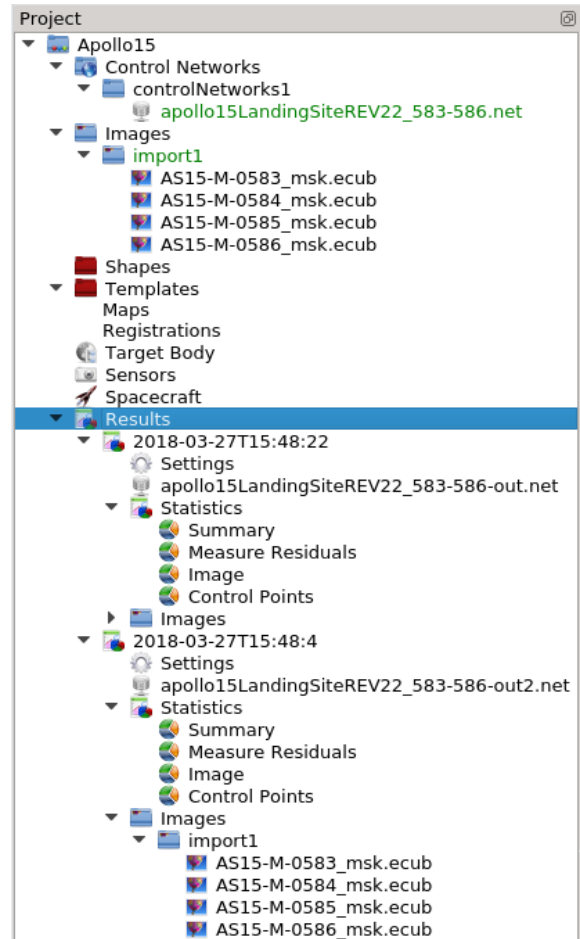


Figure 14: Bundle adjustment solution statistics under the Results node. Two separate BA results are shown, under the sub-nodes 2018-03-27T15:48:22 and 2018-03-27T15:48:4.

Filter Connections- There is no functionality in this filter yet but it would be applied to the Connection View.

Filter Options

To add a filter to any of the three tabs click on the box that contains the green +. Once this is clicked done another box containing a red x will appear with a drop down menu next to it. Once a filter is selected more options will appear based on the type of filter selected the main types of filtering options are.

- Inclusive exclusive
- <=, >=, Will have a text entry box to input a value for comparison
- Points, Measures, Min Count for Points This option will let you choose to filter between Control Points and Control Measures if the control point option is on then the Min Count for Control Points will be available if not this option is not available.

Multiple filters can be applied by clicking on another green + there will then be an option to link these filters with AND, OR logic statements. It can be seen in Figure 15 that it is possible to have multiple lines of filters each will be contained in a box and logic statements only apply to the filters in its box but if multiple boxes are open then another logic statement to link them will be at the top of all the boxes. There will be a line of text above the filter options that will use words to say what the logical statements are doing. Check this line of text to ensure it will give the desired results.

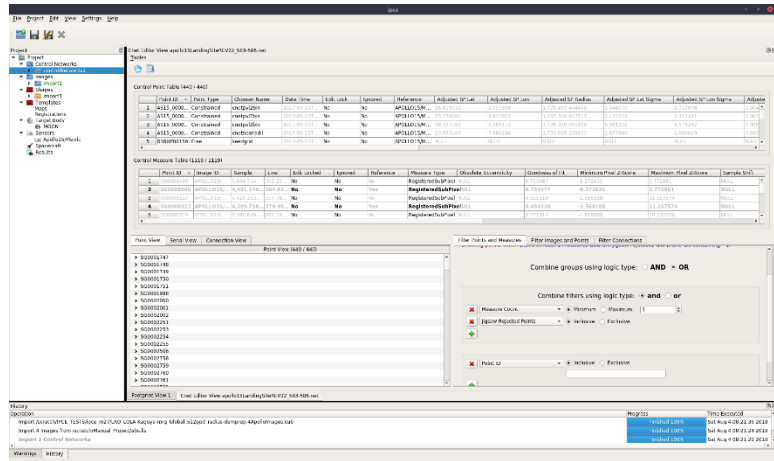


Figure 15: This shows how filters are chained together with logical statements.

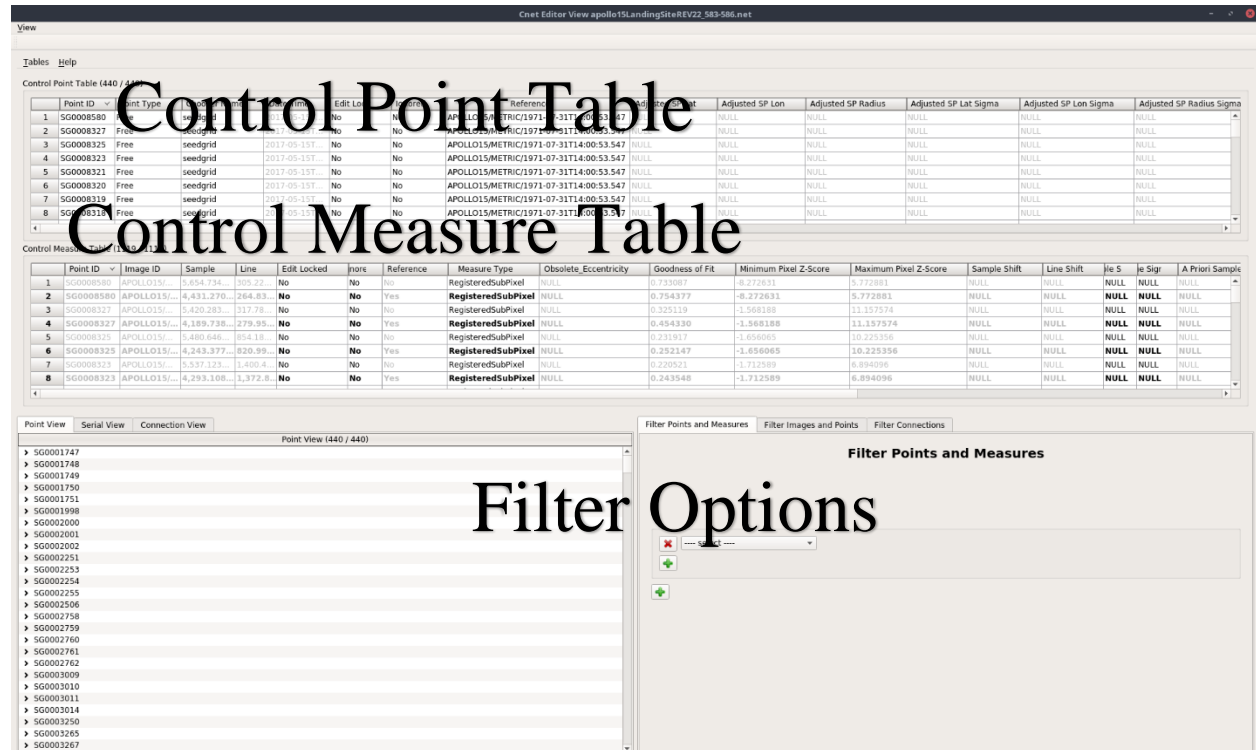
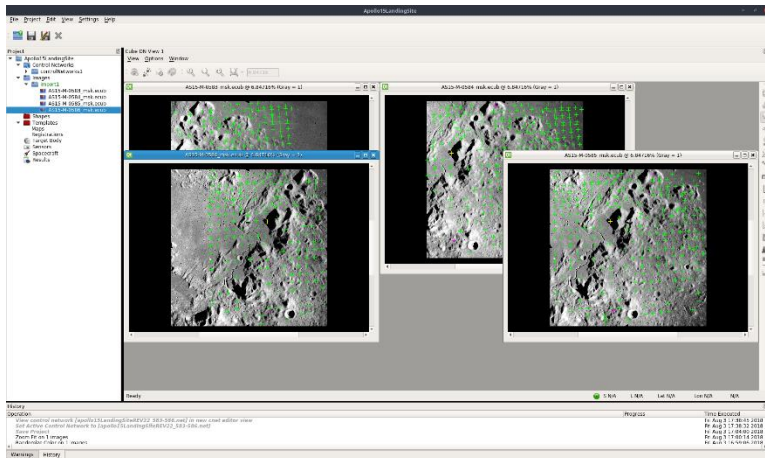


Figure 16: Tables in cneteditor view.

2.4 Cube DN View



Cube DN View will display any imported images as well as control networks if there are any present. The Cube DN View has a toolbox associated with it that will be located on the right side of the IPCE program. Under the view menu there are options to link images, tile the image view, moving images and zooming on images.





Figure 17: Cube DN View after selecting Display Images from the Project Tree.

Display Images (brings up qview)-Tools- (short cuts)






Descriptions of each tool can be seen by using the (What's This Tool) under Help or on the toolbar.

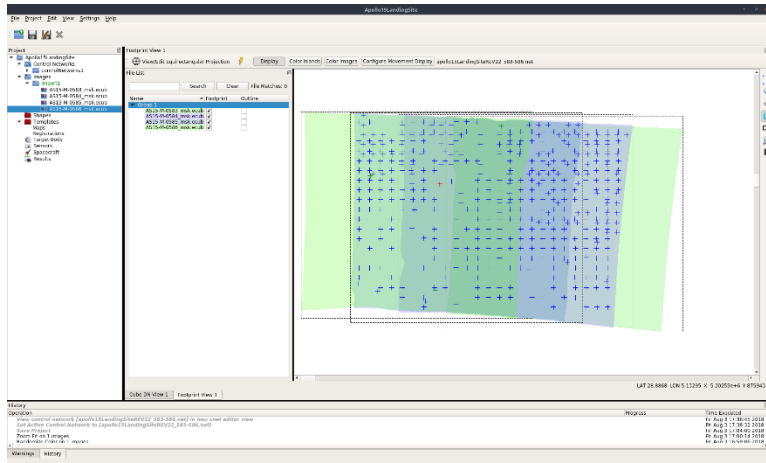
Right

-  Control point editor (T)
-  Band Selection (B)
-  Zoom (Z)
-  Pan (P)
-  Stretch (S)
-  Find (F)
-  Image Edit (E)
-  Measure (M)
-  Sun Shadow (U)
-  Nomenclature (N)
-  Spatial Plot Tool
-  Spectral Plot Tool

-  Scatter Plot
-  Histogram (H)
-  Statistics
-  Stereo

Upper left

-  Blink
-  Tracking
-  Link Viewports
-  Special Pixel Tool
-  What's This











2.5 Footprint View

To be completed. Footprint view allows the user to visualize cubes in relation to each other by displaying the cube outline. By doing this the overlap of cubes can be seen as well as how the control network is dispersed among overlapping regions Figure 18.

Figure 18: Footprint View with the active control network display which is done by clicking the cneteditor tool on the toolbar on the right side.

Tools in the footprint view


-  Select (s) - allows to click on images or files and select
-  Zoom (z) - zoom in, zoom out, fit to screen
-  Pan (p) - allows images to be clicked and dragged
-  Control net (c) - Enables the editing of control points
-  Show Area (a) - draws a box on footprints, input lat/long and box size
-  Find (f) - input a lat/long and go to that point or click on images to get lat/long of that point
-  Grid (g) - will display a grid on the footprint view
-  Quick Load Map (lightning bolt) – Load in map files for projections and lat/long setup

Right Click on Image in Footprint will give the following options.

-
- Delete images from project...
- Export Images...
-
- Close Cube
-
- Change Transparency
- Change Color
- Randomize color
- Show Label
- Show Unfilled
- Show Cube Data
- Hide Outline
-
- Bring to Front
- Bring Forward
- Send to Back
- Send Backward
-
- Zoom Fit
-
- Display Images...
- View Footprints...

2.6 Control Point Editor View

2.6.1 Loading a Control Point

The Control Point Editor View is used to visually manipulate control measures. Similar to the ISIS3 *qnet* application, this is accessible from the Footprint or Cube Display views when the control point editor tool is selected . It is also accessible from the Cnet Editor View by right-clicking on a control point and selecting “Edit Control Point” from the resulting context menu.

Control Measures are drawn on displayed cubes or footprints with the following colors:

- **green** “+” control point
- **magenta** “+” ground point
- **yellow** “+” ignore point
- **red** “+” current edit point

When the control point editor tool is selected, the mouse buttons have the following functions on the cube display view and the footprint view:

- Left Button: Modify the closes control point
- Middle Button: Delete the closest control point
- Right Button: Create new control point

Note: when creating a new control point using the right mouse button, the new point will not be added to the control net until the “Save Point” button is selected. The control point will not appear on the Cube DN or Footprint views until it is saved to the control net.

2.6.2 Editing a Control Point

This window displays information about the control point and two control measures. Initially the measures displayed will be the “Reference” cube on the left and the next cube in the control point on the right. The measures displayed are chosen from the combo-boxes under the labels “Left Measure” and “Right Measure.” The previous or next right measure is selected with the **PageUp** and **PageDown** shortcut keys, respectively.

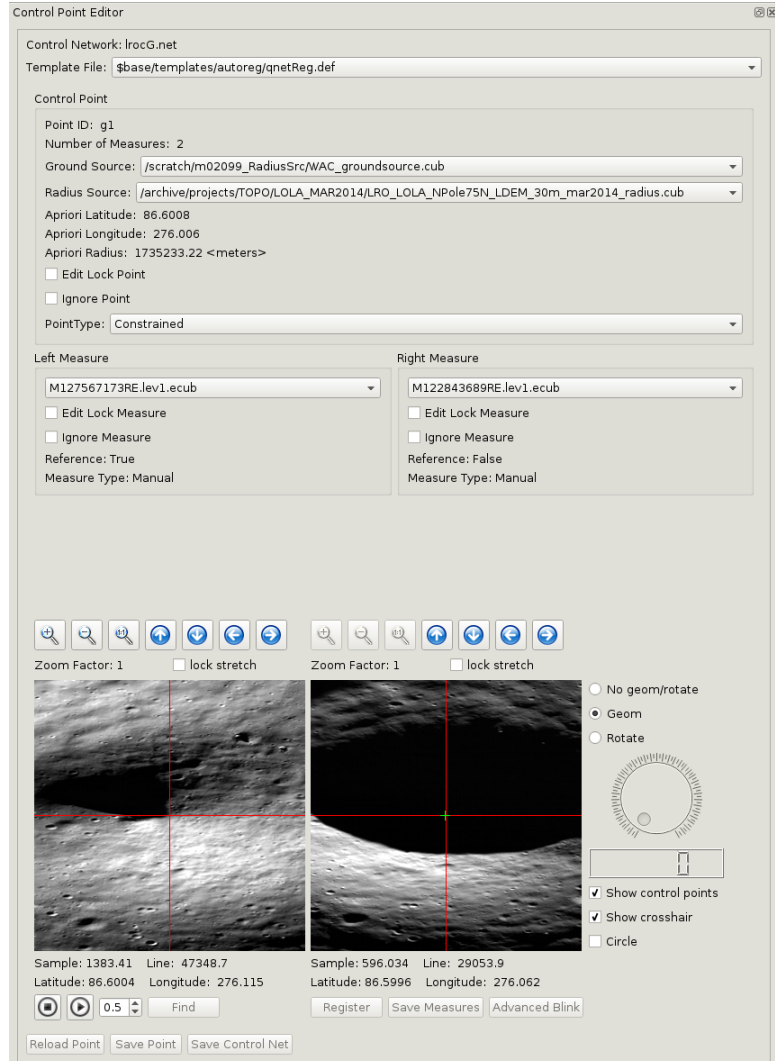


Figure 19: Control Point Editor view

2.6.2.1 Control Point Information

- Point ID
- Number of Measures
- Ground Source: For fixed or constrained control points, allows choice of any imported ground source to be used to calculate the Apriori Latitude and Apriori Longitude.
- Radius Source: For fixed or constrained control points, allows choice of imported dems to be used to calculate the Apriori Radius.
- Apriori Latitude
- Apriori Longitude
- Apriori Radius
- Edit Lock Point: Allows the control point to be locked which disallows any changes to
- Ignore Point: Any ignored control point is not included in a bundle adjustment.
- Point Type: Change the point type to Free, Constrained or Fixed.

2.6.2.2 Changing Measure Locations

The measure location can be adjusted by:

- Move the cursor location under the crosshair by clicking the left mouse button
- Move 1 pixel at a time by using arrow keys on the keyboard
- Move 1 pixel at a time by using arrow buttons above the view

2.6.2.3 Other Point Editor Functions

Along the right side of the measure display:

- **Geom:** Geometrically match the right view to the left view
- **Rotate:** Rotate the right view using either the dial or entering degrees
- **Show control points:** Draw crosshairs at all control point locations visible within the view
- **Show crosshair:** Show a red crosshair across the entire view
- **Circle:** Draw circle which may help center measure on a crater

Below the left measure view:

- **Blink controls:** Blink the left and right view in the left view window using the "Blink Start" button (with play icon) and "Blink Stop" button (with stop icon). Both arrow keys above the right view and the keyboard arrow keys may be used to move the right view while blinking.
- **Find:** Center the right view so that the same latitude / longitude is under the crosshair as the left view. **Shortcut: F**

Below the right measure view:

- **Register:** Sub-pixel register the right view to the left view. **Shortcut: R**
- **Undo Registration:** Undo the sub-pixel registration. **Shortcut: U**
- **Save Measures:** Save the control measure under the right view to the edit control point. **Shortcut: M**
- **Advanced Blink: Note: This is a prototype.** This allows a more advanced blinking functionality. All control measures in this point will be listed. Currently this list contains the full file name including path so scrollbars allow the entire file name to be viewed. Select any number of files in this list that you want to blink. This list can also be re-ordered through drag and drop to sort the blink order. The blinking will happen in the right measure view.

Along the bottom:

- **Reload Point:** Discard any edits that have not been saved and re-load the current edit control point.

- **Save Point:** Save the edit control point to the control network. **Note:** Whichever measure is on the left will be set to the Reference measure. **Shortcut: P**
- **Save Control Net:** Save the current active control net. **Shortcut: S**

2.7 Control Net Health Monitor

The Health Monitor is a real-time representation of the state of a control network and statistics with respect to that health. The idea is that as changes are made to the control network real time feedback will be available through the health monitor.

2.7.1 Overview Tab

This tab holds the status, a description of that status, and a history table of modifications made to the network.

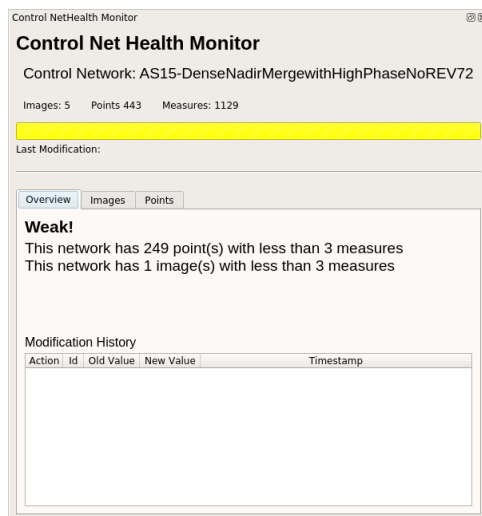


Figure 20: Over view tab

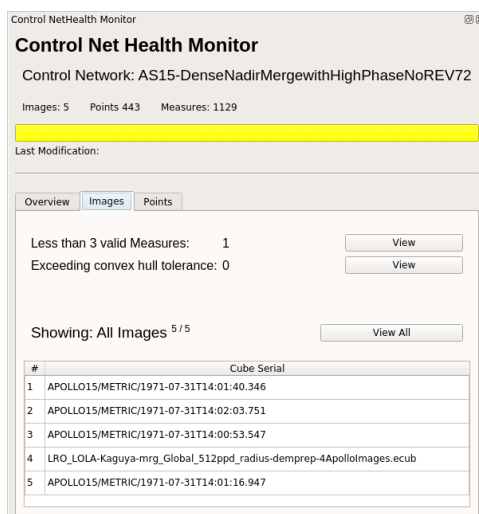


Figure 21: Image tab showing all images associated with the control network.

The health of the control network is displayed at the top of the view there are three health modes currently.

Healthy! – This indicates that there are no islands i.e. (no images that are not connected by control points) and all control points have 3 measures or more.

Weak! – Will be displayed when there are no islands present but there are control points present containing less than three control measures.

Broken! – Whenever islands are present broken will be displayed.

Modification History – every change made to the control network will show up in this history. The tabs in the history are: Action, Id, Old Value, New Value, and Timestamp.

2.7.2 Images Tab

This tab displays information about images (Figure 21). It contains a table of cube serial numbers in the network.

The number of images with less than 3 valid measures is displayed.

Note: convex hull tolerance has not yet been implemented.

Double-clicking a cube serial number displays the associated image in the Cube DN View.

2.7.3 Points Tab

The points tab displays point specific information and includes a table that contains point information.

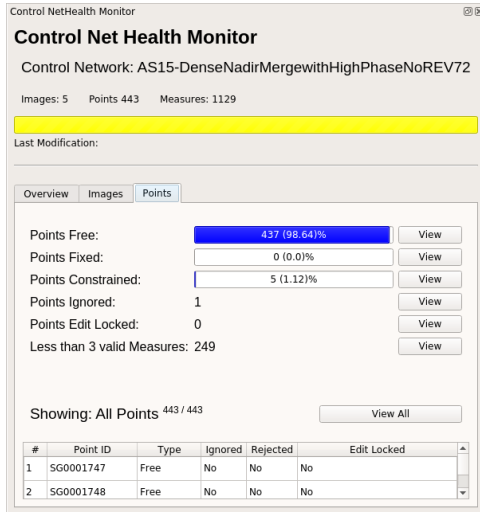


Figure 22: Points tab showing the overall breakdown of control points.

The point distribution is shown in this view breaking them down by percent Figure 22. Next to each point type is what percent of the control network is composed of that point type. On the far right of the view is a view button that will display that particular point type in the table below. In the point table at the bottom points can be double clicked and it will pull up the control point editor.

IGNORED POINTS DO NOT CONTRIBUTE TO THEIR POINT TYPE STAT.

Points Table: Should display the filtered points (based on which view button is clicked) and if a point is double clicked, it should open that point in Control Point Editor.

IMAGE MEASUREMENT

To be completed.

3.1 Manual Measurement

Describe the steps to make a manual measurement on a set of images

3

3.1.1 Viewing and Adding Control Points

In order to make manual measurements in images, an existing control network is needed as well as an image list.

Ipce | import Control Networks | import Images



Once the required data is imported it helps but is not mandatory to organize the views in the workspace so the Cube DN View and the Footprint View are both visible. Within each view the control point editor tool must be activated to begin measuring images. To do this click on the blue box with three white dots. The setup should now look similar to Figure 23. Notice the red crosshair represents a control point and it can be seen in all the images it exists in as well as the footprint view. Once a control point is clicked in either Footprint or Cube DN view the Control Point Editor will be brought up and the point can be edited.

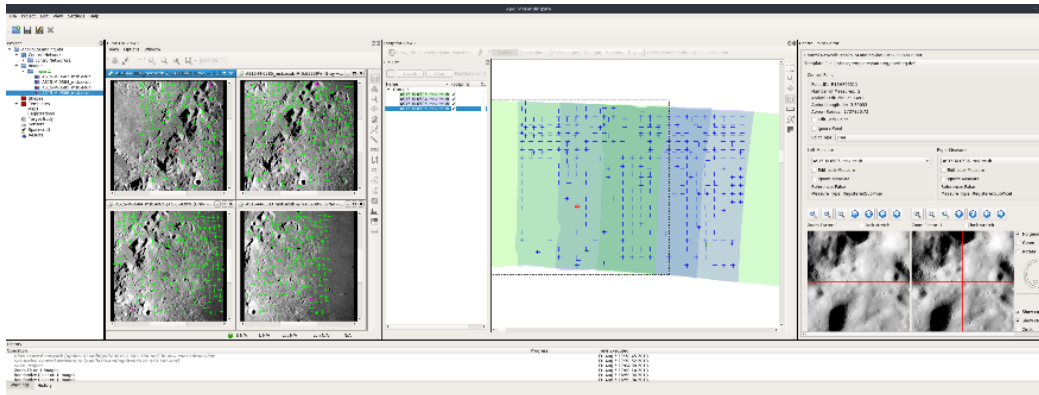


Figure 23: Setup for adding and editing control point.

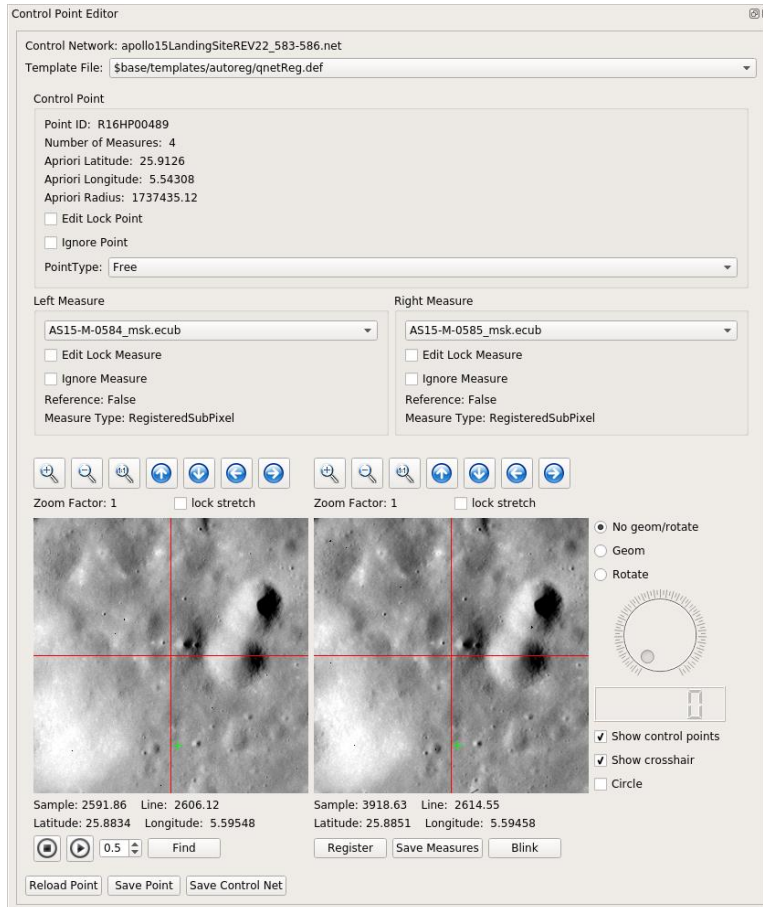


Figure 25: Control Point Editor

be imported. Once images are chosen the control point editor will pop up and the point can be edited with more detail. Once the point is saved in the control point editor it will then show in the Footprint and Cube DN Views.

3.2 Editing Control Points

Changing the exact location of a control measure can be done in the control point editor. By ensuring the control measures exist at the same geographical location in each image will make the control point more accurate.

Within the Control Point Editor two measures can be viewed side by side this aids in making sure each measure does indeed lie at the same geographical location. The points are moved by either clicking a new location on the image or using the arrow keys seen in Figure 25. This process is further strengthened by selecting a control point at a distinct feature such as a crater in this example but it can also be anything that is easily distinguishable in all images. In Figure 26 it shows the red crosshair with a circle around it and the green + indicate control points. These are tools to aid in getting measures located accurately. In the left image the red crosshair is at the location of the control point. In the right image the crosshair has been moved the right of the green control point. Notice save measures is in red this is because the red crosshair represents the location of the measure in that image and since it has been moved the option to save that new location is now available.

Reference Measure

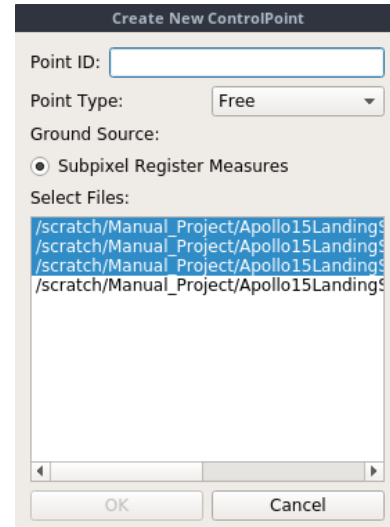


Figure 24 Dialog box for adding control point

Creating a new control point

Right clicking anywhere on the image or footprint view will create a point at that location and a dialog box will appear to select which images to include in the point Figure 24. Under point type there are three options free, constrained, fixed in order to select constrained or fixed a shape file must

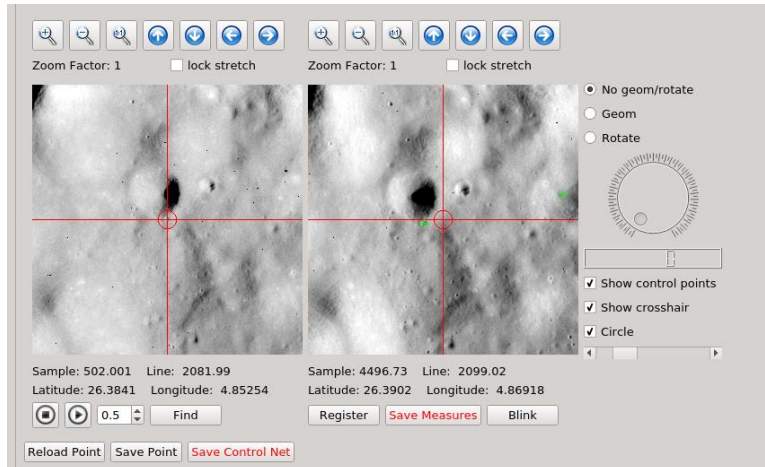


Figure 26 Red crosshair and circle options

The left image in the control point editor will be saved as the reference measure when save measures is clicked. This will be the reference for all the other images in the control point. If the reference measure is moved and then save measures is clicked a warning will occur to make sure the action is necessary since all other measures may need to be adjusted in result of the move. In order to change which image is the reference image the image must be viewed on the left side and then save measures clicked. Under left measure Reference: True will now be seen for that image.

Control Point

Point ID: The name or serial number of the control point

Number of Measures: Number of measures in the control point

Apriori Latitude: The unadjusted latitude

Apriori Longitude: The unadjusted longitude

Apriori Radius:

Edit Locke Point: If this box it ticked ...

Ignore Point: If this box is ticked ...

Point Type:

- Free....
- Constrained....
- Fixed

Left/Right Measures

Edit Lock Measure

Ignore Measure

Reference: (True/False)

Measure Type: (RegisteredSubPixel, Manual)

List of everything within Control Point Editor (From ISIS3 Astrogeology page with modifications for ipce)

Other Point Editor Functions

Along the right border of the window:

- **Geom:** Geometrically match the right view to the left view
- **Rotate:** Rotate the right view using either the dial or entering degrees
- **Show control points:** Draw crosshairs at all control point locations visible within the view
- **Show crosshair:** Show a red crosshair across the entire view
- **Circle:** Draw circle which may help center measure on a crater

Below the left view:

- **Blink controls:** Blink the left and right view in the left view window using the "Blink Start" button (with play icon) and "Blink Stop" button (with stop icon). Both arrow keys above the right view and the keyboard arrow keys may be used to move the right view while blinking.

- **Find:** Center the right view so that the same latitude / longitude is under the crosshair as the left view. Shortcut: F

Below the right view:

- **Register:** Sub-pixel register the right view to the left view (Shortcut: R). This is where the Registrations templates comes in. At the top of Figure 25 there is a drop down to select Template file. This will default to \$base/templates/autoreg/qnetReg.def but it can be changed to any of the imported Registration Templates.
- **Undo Registration:** Undo the sub-pixel registration. Shortcut: U
- **Save Measures:** Save the control measure under the left and right view to the edit control point. The image on the left will be set as (Reference: True) Shortcut: M
- **Blink:** This will give the option to blink all images not just left and right.

Along the bottom:

- **Save Point:** Save the edit control point to the control network. Shortcut: P
- **Reload Point:** This will reload to the last Save Point
- **Save Control Net:** This saves the control network. This will have

3.3 Automated Image Measurement

To be completed.

BUNDLE ADJUSTMENT

4 **To be completed.** The process of photogrammetric control consists of two basic steps: image measurement followed by the least-squares bundle adjustment (Brown, 1958). The bundle adjustment improves image position and pointing parameters (together known as *exterior orientation* or EO) and generates the triangulated ground coordinates of tie and control points. Further, the bundle adjustment provides solution statistics and estimated parameter uncertainties. These statistics are another important justification of the control process, for without them it is impossible to compare products with any known level of confidence. The ISIS3 standalone bundle adjustment program is called *jigsaw* (Edmundson, et al., 2012). The bundle adjustment can be performed within IPCE as well.

Jigsaw is currently capable of adjusting image data from frame and line scan cameras and the Chandrayaan-1/LRO Mini-RF radar sensor. Although Magellan SAR and Cassini RADAR images can be processed in ISIS3, they are produced in map-projected form and are handled as maps rather than images. Currently, only Mini-RF radar images can be bundle adjusted (Kirk and Howington-Kraus, 2008).

Using jigsaw, one may solve for sensor pointing alone, sensor position alone, or pointing and position simultaneously. Three dimensional coordinates (latitude, longitude, and radius) of all ground points are also determined in the adjustment. Through rigorous weighting, parameters may be held fixed, allowed to adjust freely, or constrained with *a priori* precision or accuracy information.

4.1 Jigsaw Setup



● **NOTE:** currently, all images in an IPCE project will be utilized in the bundle adjustment. So, for now, only images associated with the control network in the bundle should be in the project.

To perform the bundle adjustment in IPCE requires a control network and associated images. Choosing *Bundle Adjustment...* from the *Project* menu displays the Jigsaw Setup dialog as a docked widget below the Project Tree Figure 27. Bundle settings are distributed among three (currently functional) tabs, *General*, *Observation Solve Settings*, and *Target Body*.

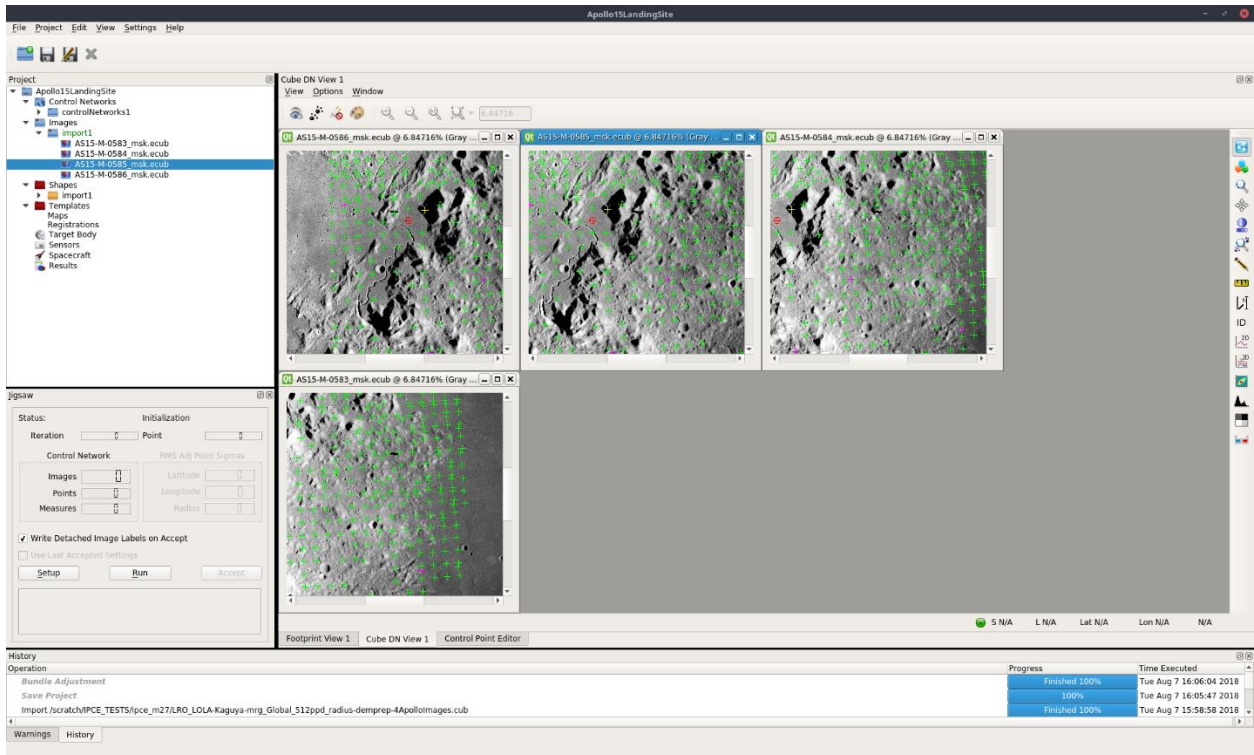


Figure 27Jigsaw docked widget

4.1.1 General

Data	
Input	Input network
Output	Adjusted network (can be renamed)
Outlier Rejection Options	Automatic rejection of outlier image measures
Sigma Multiplier	Will default to 3 when selected
	Image measures are flagged as rejected if their residuals are greater than the multiplier times the current standard deviation (sigma) If Residuals > (multiplier * sigma) Then Rejected
Maximum Likelihood Estimation	
Model Options	HUBER - description
	HUBER Modified – description
	WELSCH – description
	CHEN – description
C Quantile	Must be between Zero and One
Convergence Criteria	
Sigma0 Threshold	Standard deviation of unit weight 4.1.2
Maximum Iterations	Number of iterations program will stop at if not converged
Global Apriori Point Sigmas (meters)	
Latitude	
Longitude	
Radius	
Other	
Observation Mode	
Error Propagation	

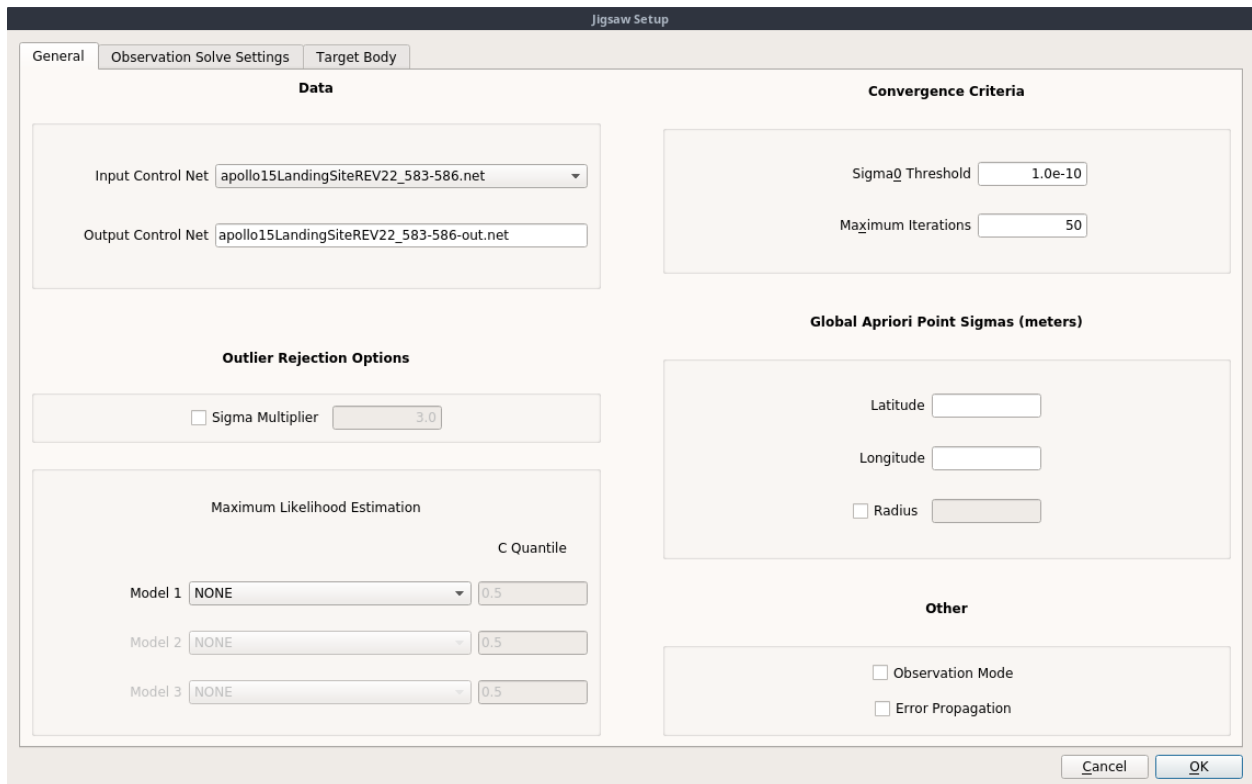


Figure 28

4.1.3 Observation Solve Settings

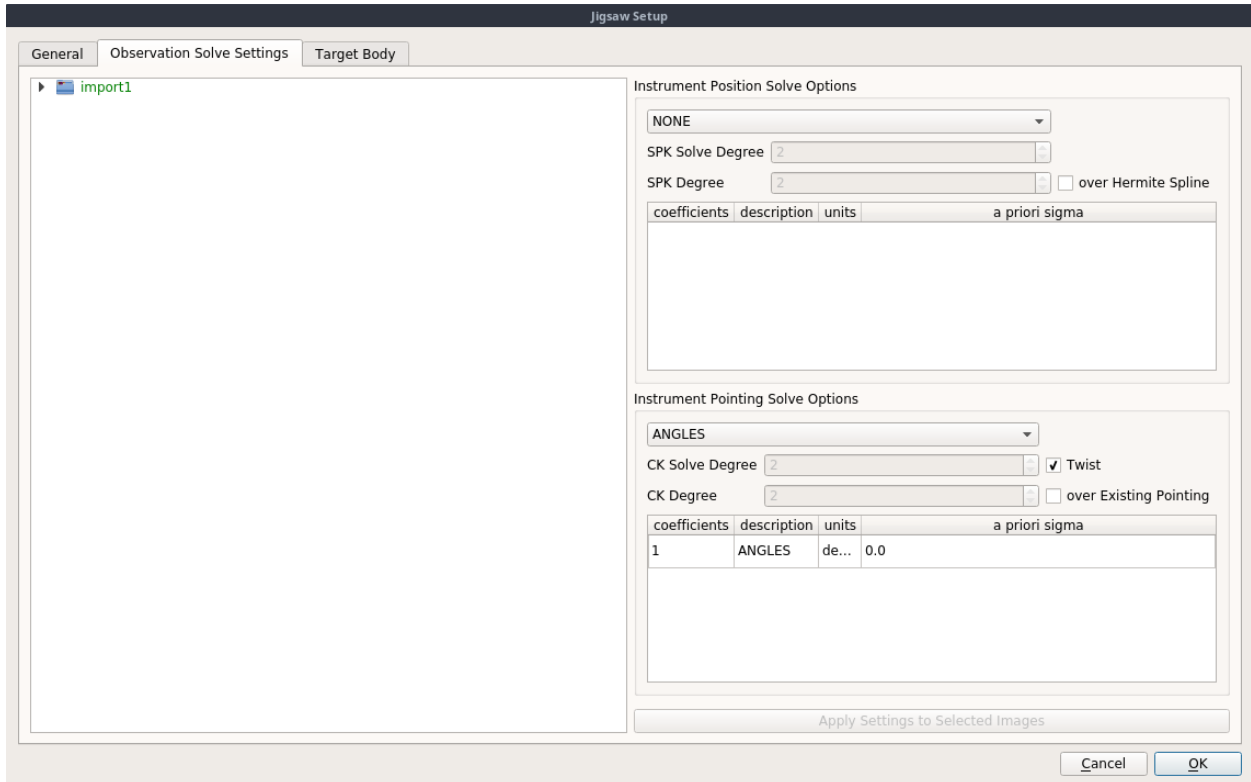


Figure 29

Instrument Position Solve Options	
SPK Solve Degree	
SPK Degree	
Solve Over Hermite Spline	
Instrument Pointing Solve Options	
CK Solve Degree	
CK Degree	
Twist	
Fit Polynomial Over Existing Pointing	

4.1.4 Target Body

Jigsaw Setup

General | Observation Solve Settings | Target Body

Target:

TextLabel
Target Parameters

	value	sigma
<input type="checkbox"/> Pole Right Ascension	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Pole Right Ascension Velocity	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Pole Declination	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Pole Declination Velocity	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Prime Meridian Offset (W0)	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Spin Rate (WDot)	<input type="text"/>	<input type="text"/>

Radii

none

triaxial radii

mean radius

a

b

c

Cancel OK

Figure 30

Target	Need Info
Target Parameters	
Pole Right Ascension	
Pole Right Ascension Velocity	
Pole Declination	
Pole Declination Velocity	
Prime Meridian Offset (wo)	
Spin Rate (WDot)	
Radii	
None	
Triaxial Radii	
Mean Radius	

4.2 Running Jigsaw

Once the Jigsaw is open the only option will be setup Figure 31 Top. Jigsaw run dialoge Bottom. Abort option while jigsaw is running . Setup must be completed after the option to run will be available then once the bundle is complete the results can be accepted Figure 32 to and will add the data to the project tree under results. While the bundle adjustment is running the run button will change to an abort button this will stop the bundle at the current iteration and the results will not be available to accept. Selecting the write detached image labels will add and image list in the results with updated image labels.

4.3 Output

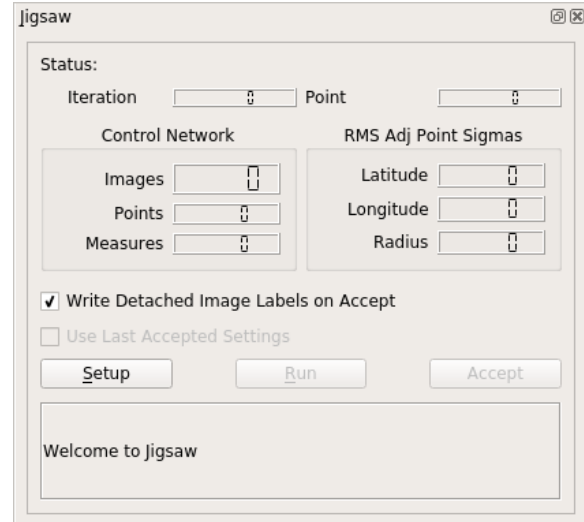


Figure 31 Top. Jigsaw run dialoge Bottom. Abort option while jigsaw is running

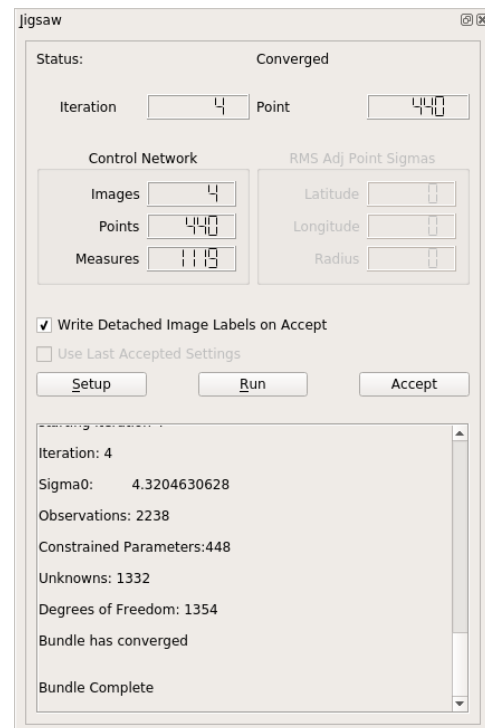




Figure 32 Jigsaw widget after a bundle has ran

EXAMPLE USE CASE DATA FLOWS

5.1 Import Data; Bundle Adjust; Save, Close, and Reopen Project

- 5
 1. Start ipce by typing “ipce” on the command line
 2. Create project by ...
 - a. selecting "Save Project As" from File menu or
 - b. "Save Project As" button on the toolbar.
 3. Import images. You can either multi-select Isis cube files or a list file containing a list of cubes. Important Note: Currently you will want to import all images you will be working on or running through the Bundle Adjustment in a single import. More flexibility will be available in a future version of ipce.
 - a. Select “Import Images...” from the File menu or
 - b. From the context menu on Project Tree. Right-click on “Images” node, selecting “Import Images...”.
 - c. Ipce creates *ecub* files (i.e. detached labels) which contain the cube labels and SPICE blobs and a pointer to the DN data or original cube file. You can choose to also import the DN data which will copy the original cube into the project folder. If you choose not to import the DN data, the ecub will have a pointer to the original cube.
 4. Import control net.
 - a. Select “Import Control Networks...” from the File menu or
 - b. From the context menu on the Project Tree. Right-click on the “Control Networks” node, choosing “Import Control Networks...”.
 5. If you have more than one control network imported, you will need to first set one of the imported control networks to the active control by right-clicking on the control network, selecting “Set Active Control Network”.
 6. Run jigsaw (Bundle Adjustment)
 - a. Select “Bundle Adjustment...” from Project menu.
 - b. Select appropriate settings for your data (Section 4.1).
 - c. Select “Run” on Jigsaw dialog.
 - d. Select “Accept”, then “Close” on Jigsaw dialog.
 - i. There will be a new node on the Project tree under the Results node (Section 2.2.7) labeled with the date/time of the bundle run.
 7. Right-click on output control network selecting “Set Active Control Network”, then right-click again, selecting “View Network...”.
 - a. You can then sort on Residual Magnitude under the Control Measure Table. If this control network is set as the active control network, editing from this view is enabled and can be done by right-clicking on any field in the tables and selecting “Edit selected control point”
 - b. This will start the Control Point Edit View, which is similar in functionality to the *qnet* application.
 8. Correct any bad measures in the Control Point Edit View, saving the control network when finished.
 9. Re-run bundle adjust on the correct control network, making sure to select the previously bundle adjusted and manually adjusted control network in the Bundle Adjust setup dialog.
 - a. Select “Bundle Adjustment” from the Project menu.
 - b. Select correct control network on the “Input” option.
 - c. Optionally, rename Output control network.
 - d. Select “Ok” on setup dialog
 - e. Select “Run” on Jigsaw dialog.

- f. Select “Accept”, then “Close” on Jigsaw dialog.
 - g. There will be a new node on the Project tree under the Results node (Section 2.2.7) labeled with the date/time of the bundle run.
10. Other ways to see the active control network displayed and edit control points.
- a. Right-click on “import#” node of images on project tree (e.g. import1) and select “Display Images”. This brings up a view similar to the *qview* application with all of the *qview* tools. If a control net is imported the measures will automatically display when images are viewed.
 - i. Click the “Control Point Editor” tool icon  to edit measures overlaid on the images. Mouse buttons operate the same as in the *qnet* application.
 - 1. Left click - edit closest control point
 - 2. Middle click - delete closest control point
 - 3. Right click - create new control point at cursor location
 - b. Right-click on “import#” node of images on project tree (e.g. import1) and select “View Footprints”. This brings up a view similar to the *qmos* application with all of the *qmos* tools.
 - i. Selecting the “Control Net” tool icon  to display points overlaid on the footprint view and to enable control point editing. Mouse buttons operated the same as in the *qnet* application.
 - 1. Left click - edit closest control point
 - 2. Middle click - delete closest control point
 - 3. Right click - create new control point at cursor location
11. Save the project from the File menu or the “Save Project” button on the toolbar
12. The saved project can be reopened by...
- a. Select “Open” from the File menu, browse to the desired project folder in the Select Project Directory dialog, select the project folder, click the Choose button.
 - b. Or Select “Recent Projects” from the File menu and choose the corresponding project name from the popup menu.
 - c. Or by typing from the command line `> ipce projectName`

KNOWN ISSUES

6.1 General Issues

- 6
- Cubes must be Level1 (i.e. not projected) in order to import into IPCE. They must contain SPICE information (via *spiceinit*). If *footprintinit* has not been run on the cubes, a footprint will be created upon import (which can be time consuming).
 - All images in an IPCE project are currently utilized in the bundle adjustment. So for now, only images associated with the active control network should be in the project.
 - Images and control networks cannot be deleted from a project once imported.
 - Target body and sensors are not visible on the project tree after invoking **File->Save Project As** from the main menu to save the project.
 - The **Spacecraft** node of the project tree is empty for now. Sensor info appears in **Sensors** node.
 - When a project is closed, but IPCE remains open, the project name on the tree does not reset to the default name "Project."
 - Closing cubes within the Footprint view cube list can cause crash.
 - Loading large image lists can take time (e.g. ~ 6 minutes for 1486 cubes). **NOTE:** It is highly recommended that you create and save a project before importing data.
 - Images in bundle results will not contain footprint information until the project is saved and closed. Re-opening the project will generate the footprint information.
 - It is recommended that bundle output control networks be named uniquely. Otherwise there may be some unpredictable behavior.

6.2 Operating System and Window Manager Related Issues

6.2.1 Linux

6.2.1.1 KDE Window Manager

- Under KDE, using "Focus Follows Mouse" under Window Management settings, detaching a view from the ipce main window causes the detached view to be hidden when ipce is not the active window. This can be fixed with the following KDE setting:
 - Window Management->Window Behavior->Advanced tab->Uncheck "Hide utility windows for inactive applications"

REFERENCES

7