Maestro User's Guide

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1 Introduction

Maestro is a publicly available version of the tool used by scientists to plan daily activities for the 2003 Mars Exploration Rover mission. With Maestro, you can view pictures taken by the rover. You can also select driving destinations and points of interest where you want to take your own pictures.

Maestro contains a simplified menu of commands that you can use to create your own driving and science activities, using all of the rover's instruments to enact your own day of mission operations. You are in the driver's seat…what will be next place we will explore on Mars?

(Note: The Athena science payload (Pancam, MI, Mini-TES, APXS, MB, RAT) is arguably the most sophisticated instrument suite that has yet operated on the surface of Mars. Although Maestro provides activities for the instruments in the Athena science payload, these activities are highly simplified compared to the actual way these instruments are commanded during mission operations.)

2 Getting Started

2.1 System requirements

Before installing Maestro, make sure that you are using a computer that meets or exceeds all of these minimum specifications:

- 500 Mhz processor
- 256 MB RAM
- 500 MB available disk space
- A 3D graphics accelerator card (highly recommended)

The recommended specs for the most pleasant experience running Maestro are:

- 1.5 Ghz processor
- 1 GB RAM
- 10 GB available disk space
- a high-end 3D graphics accelerator, such as NVidia FX series cards

2.2 Installing and starting Maestro

2.2.1 Maestro for Linux

After downloading the installer, unpack it and run the install script as follows:

```
gunzip WITS-2003.04-Public-Linux.tar.gz
tar xvf WITS-2003.04-Public-Linux.tar
cd R2003_04-Public-Linux
./install-Maestro
```

To start Maestro on Linux, run the startup script as follows:

```
JPL/Maestro/bin/Maestro
```

2.2.2 Maestro on Solaris

After downloading the installer, unpack it and run the install script as follows:

```
gunzip WITS-2003.04-Public-Solaris.tar.gz
tar xvf WITS-2003.04-Public-Solaris.tar
cd R2003_04-Public-Solaris
./install-Maestro
```

To start Maestro on Solaris, run the startup script as follows:

```
JPL/Maestro/bin/Maestro
```

2.2.3 Maestro on Mac OS X (10.3 Panther)

Maestro will run on Macintosh OS X version 10.3 (Panther) and higher. To install Maestro on Macintosh, run the Maestro installer to install Maestro in the Applications folder on your hard drive. If you are downloading the installer from our website, it will start automatically.

To start Maestro, click the Maestro icon in the /Applications/MacMaestro folder.

2.2.4 Maestro on Windows

Maestro will run on Windows 98, ME, 2000 and XP. For the best experience, run Maestro on Windows 2000 or XP.

To start Maestro, double-click the desktop shortcut icon, or launch from the Start Menu/Programs/JPL/Maestro menu.

2.3 Quick start

When you start Maestro, you see the mission chooser (see Figure 2.1). The first button on the mission chooser selects the ISIL (In-Situ Instrument Lab at the Jet Propulsion Laboratory, Pasadena, CA, USA) testbed facility, where engineers and scientists have tested MER rover operations for many months. Select this mission and the Conductor will appear to offer you a three-part tutorial. Click on the item labeled "Introduction to Maestro" and then click "Go" to get started using Maestro right away.

In the Introduction to Maestro, the Conductor will demonstrate Maestro's views and introduce you to the MER rover's instruments. To advance through the introduction, click the Next button at the top of the Conductor. To go back, click the Back button. To go back to the Mission Chooser, click the Home button. After the introduction, the Conductor will invite you to either continue with the next part of the tutorial (Viewing Pictures and 3D Views), or to start opening your own views and build your first rover activity. Once you complete as much of the tutorial as you like, you can close the Conductor window and use this guide to explore the features of Maestro.

Figure 2.1: The Maestro Mission Chooser.

2.4 Spirit and Opportunity

New sites for Spirit and Opportunity will be released periodically during the MER mission as add-on modules for Maestro. Return to the Maestro website frequently to stay up to date with new MER sites.

3 Viewing Rover Images

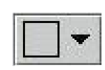
3.1 Browsing images

You can browse the available set of images captured by the rover in the Downlink selection tree located on the left side of the browser. The selection tree has folders that open up by clicking on the turnbuckle to the left of the folder. The folders that appear first in the tree are labeled “sites” (site-000, site-001, etc.) Under each site there is a folder for each instrument that captured pictures or other data at that site, such as “FRONT_HAZCAM” or “NAVCAM”. In each instrument folder there is one item per image from that instrument. There is also a “collections” folder for each site that contains items that represent collections of pictures taken with Navcam and/or Pancam.

To view an item from the Downlink selection tree you can:

- double-click on it to create a view
- drag and drop the item onto a view pane to the right of the tree
- right-click the item and select a type of view to open (or [Ctrl]-click if you have a single-button mouse)
- drag and drop the item onto a view grid tab (more on this in the following section)

3.2 Using the viewgrid and tabs



When the Downlink browser first appears it has a single view pane to the right of the Downlink selection tree. You can split the browser into multiple view panes to make it easier to view several images at a time, or several types of views at once. The main area of the browser is called the view grid, and you can rearrange its layout to show multiple view panes in the browser. To change the number of view panes or change how they are arranged, create a new view grid topology by selecting from the Browser->View Grid Topology menu or the toolbar.

In addition to adding more view pane by changing the topology, you can also open more views by adding additional tabs. The Downlink browser has a single tab when it first appears. To add more tabs, right-click (or [Ctrl]-click if you have a single-button mouse) on the tab to display the tab popup menu. Select “Insert New Tab” to create a second tab. You can open more views on the new tab and switch back to the first tab as needed. You can open as many tabs as you like, and you can even drag views from one tab to another by dragging a view’s title bar onto a tab.

The tab menu provides additional features as well, including Rename Tab (for you to describe the views contained on that tab for later reference), Remove Tab, Move Tab Left and Move Tab Right.

Figure 3.1: The Tab popup menu.

As you double-click or right-click to open views, each new view appears in one of the view panes on the current tab. If there was an empty view pane available, the new view will be placed there. If all of the view panes are occupied, the new view will replace the least recently selected view.

When you close a view, the view pane that it used to occupy becomes empty. If you would like closed views to also remove the view pane that they used to occupy, you can use the Lock View Grid Topology button on the browser toolbar. If you deselect this option, closing views will also remove their view panes, compacting the view grid topology (until there is only one viewpane remaining minimum).

3.3 Viewing single images and mosaics

Viewing images in image database is done by double-clicking on the image in the Downlink selection tree to open an Image view. An example of an Image view is shown in Figure 3.2. When you open the view, it will appear in an empty view pane if there is one, or in place of the least recently selected view. You may also open an Image view by dragging and dropping an image from the Downlink selection tree onto a view pane or onto a viewgrid tab (see Section 3.2).

Selecting which image to view

When you open an Image view, the default image is shown in the view. For groups of images such as left/right stereo image pairs or images from different color filters (such as from Pancam) you can select an image to view from the Image menu. Left/right images from a stereo pair are labeled “left” and “right”. Images from different color filters are labeled “left1”, “left2”, etc. according to the Pancam filter numbers. When Pancam red, green, and blue filters are used together, a color composite image is also made, such as “left2_5_6” for filters 2, 5, and 6. If a red, green, or blue filters isn’t available from the left Pancam, no color image will be available on the Image menu. For an instrument that is a single camera the image will be labeled “mono” (monoscopic).

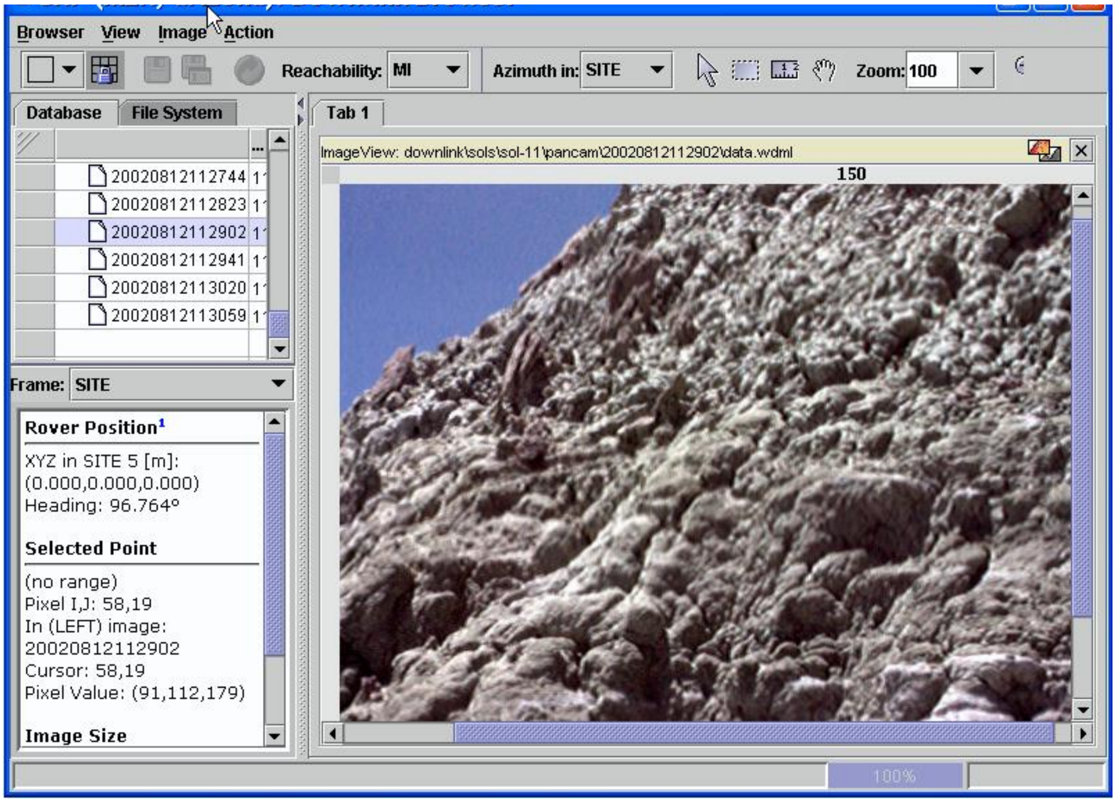
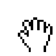


Figure 3.2: An Image view displaying a single color image.

3.3.1 Panning and Scrolling

If the image at full size is larger than the view pane, scroll bars will automatically appear. To view an unseen area of the image, click and drag the scroll bar in the direction of the unseen area.



The Pan cursor is also a convenient way to pan the image. To use it, click on the Pan button on the toolbar. The cursor will change to a hand cursor when the mouse is over the image. Click and drag with the hand to slide the image in any direction as if it were a piece of paper sliding on a table. (You can also select the Pan cursor from the Action menu.)

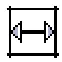
3.3.2 Resizing the image

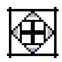
When you first look at an image in Image view, it is shown at full size. There are several ways to zoom in and out of the image to resize it to a useful size for your work.

Zoom field: enter a zoom percentage value (by clicking in the field and typing a number like 50) or choose one of the zoom values in the pull down menu, ranging from 12.5% to 800%. (toolbar only)


Zoom in (+): selects the next highest zoom


Zoom out (-): selects the next lowest zoom


Fit width: resize the image so that its width matches the width of the view pane


Fit in window: resize the image so that the entire image is visible in the view pane

3.3.3 Information from images

The Image view will give you a lot of useful information about the image you are viewing. This information is displayed in the Downlink Browser's info pane in the lower left corner in the lower left corner of the browser (see Figure 3.3):

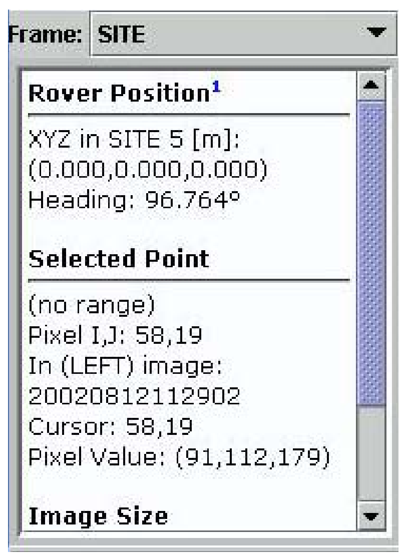


Figure 3.3: The Downlink browser's info pane in the lower left corner of the browser.

- Rover Position: The XYZ position of the rover in meters where the image was captured and the heading of the rover in degrees is displayed here. The position and heading are given in the coordinate frame of the site that was active when the image was captured.
- Selected point: position in meters, surface normal, range in meters, azimuth in degrees and elevation in degrees are given if the image is from a stereo image pair.

(For stereo image pairs, correlation analysis creates a range map that contains distance to each pixel in the image.) The position, surface normal, and azimuth are given in either site frame or rover frame. The frame used to report these values is selectable by choosing "SITE" or "ROVER" from the Frame pull down menu located above the info pane. The elevation of the pixel is given in the rover's mast coordinate frame. The surface normal is a normalized vector (magnitude 1) that results from a surface fit to the 3D surface, indicating the orientation of the surface at the point in question. The normal points outward from the underlying surface. The range (distance) to the point is in the rover coordinate frame. The pixel coordinates of the selected point (labeled "I,J") are listed along with the image ID of the image that was selected. The cursor position in the view is also displayed (always the same as the I,J pixel coordinates for a single image, but may be different for a mosaic image). Lastly, the pixel value(s) are listed for each of the one or more bands of the image.

- Ruler: if a ruler has been used in an image, the distance between the endpoints in meters, starting and ending position in meters, and starting and ending view coordinates are displayed. The starting and ending 3D positions are reported in either site frame or rover frame depending on which is selected in the Frame pull down menu located above the info pane. (See Section 3.3.4 for more information about the Ruler tool.)

- Image size: The width and height of the image in pixels and the number of bands (1 for greyscale, 3 for color, etc.) are displayed.

3.3.4 Selecting points

Query cursor

The Query cursor is the cursor that you have when you first load up an Image view. The cursor is pointer-shaped, and when you click once on a pixel in an image a Point of interest glyph is created. (Glyphs are what we call small icons, labels, or other graphics that annotate images.) The Point of interest glyph has a number of important features:

- When you select a Point of interest in one view, that same point is displayed in every other open view that also contains that point. This is useful for comparing one area imaged from two different points of view, or locating a particular image in a mosaic.

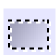
- The Point of interest is used to create Features and Targets for Activities (see Section 4.2.1).

Also, the appearance of the Point of interest tells you a lot about the location:


No range data, 3D position unknown. I,J pixel coordinates only listed in Downlink info pane, Point of interest only displayed in current image


Has 3D position information displayed in the Downlink info pane, Point of interest is displayed in all views containing that location


Has 3D position information like the previous blue cursor but also is reachable by the instrument arm from the current rover position (as determined by inverse kinematics only). Note: when the Point of interest tells you that it is reachable, it tries to test reachability for a particular arm instrument. The instrument that it checks for is selectable from the toolbar by using the Reachability pull down menu.



Region tool

The Region tool is useful for selecting a rectangular area of an image. To use the Region tool, select the Region icon on the toolbar or select it from the Action menu. Once Region is selected, click and drag a box in the image to indicate a region of interest for purposes of discussion.

Ruler tool

The Ruler tool is useful for measuring distances between two points. For instance, if there are two tall rocks in the direction that you are considering whether to drive, the ruler can measure how far apart they are to see whether the rover will fit easily between them. Or perhaps you are analyzing a rock in front of the rover and want to measure its size to see whether a particular instrument is suitable to place on it.

To use the Ruler tool, select the Ruler icon from the toolbar or select it from the Action menu. Once Ruler is selected, click and drag from one point in the image to another. If the starting point and ending point both have 3D information available, the Ruler glyph (a yellow line) will appear in the image. The Ruler glyph will also appear in every other open view that contains one or both of the selected points. The distance between the two points and their locations in 3D and pixel coordinates are displayed in the Downlink info pane.


Since 3D information can vary in accuracy in an image depending on the nature of the texture, etc., it is wise to try to measure distances several times, selecting slightly different endpoints for the ruler and comparing the distances that you see. If there are outliers (a value that is very different from others a set of reasonable values) then you can take the median distance of a set of measurements as a better estimate.

3.3.5 Azimuth/Elevation angle display

Many images have associated pointing information that are displayed in Image view in the Azimuth angle display and Elevation angle display. Figure shows an example of an image with both an Azimuth angle display and an Elevation angle display. The Azimuth angle display shows angles increasing in the direction you would turn your head right (clockwise) if you were standing at the rover's position. The Elevation angle display shows angles increasing in the direction you would tilt your head upward if you were standing at the rover's position, with 0 degrees looking straight ahead (no tilt). Both angles are displayed in degrees.

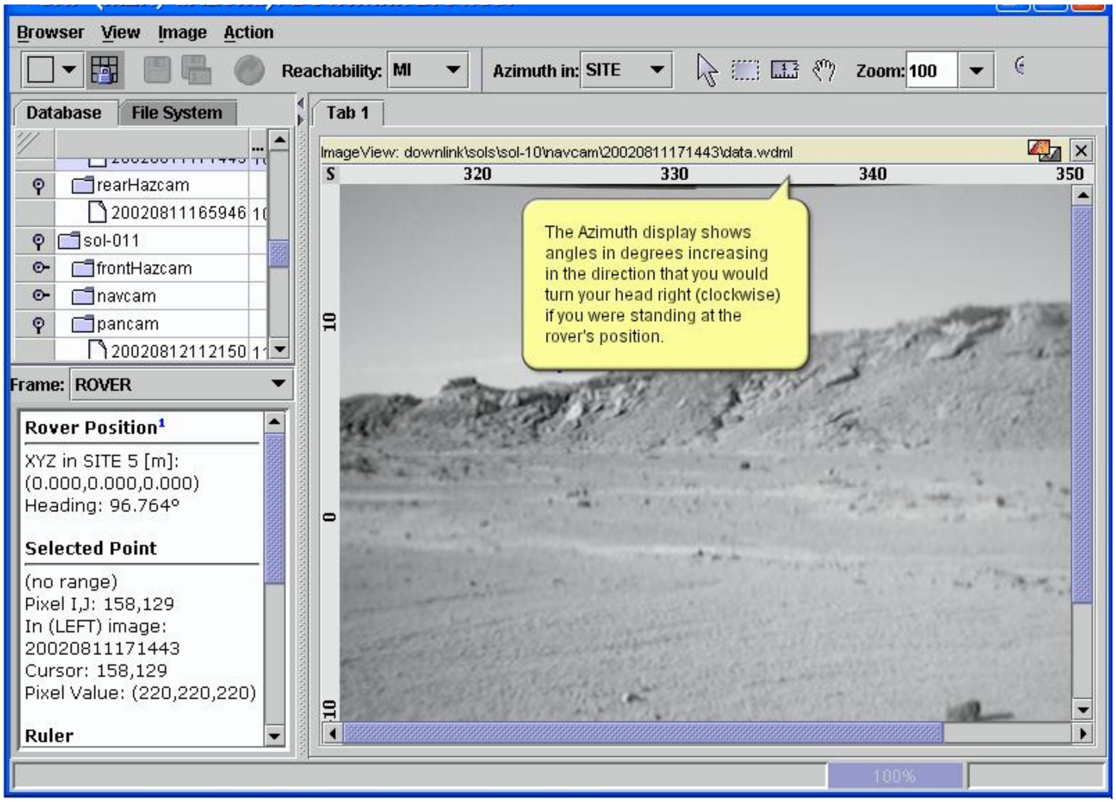
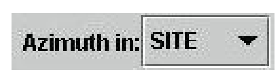


Figure 3.4: An Image view with an Azimuth angle display and an Elevation angle display.

The azimuth angle may be displayed in either site coordinate frame (0 points north) or rover coordinate frame (0 points along the rover's heading). By default the coordinate frame is site frame, but you can select the frame of the Azimuth angle display using the Azimuth pull down menu. To check what the frame is that is currently shown, also look to the extreme left of the Azimuth angle display for the letter "S" for site or "R" for rover.



3.3.6 Mosaic views

There are several mosaic views that you can use to view an entire scene at once where the rover has stopped to take images in every direction. The Cylindrical Mosaic view mosaics a set of images as if onto a large cylinder surrounding the rover, similar to Mercator maps of the world that you are used to seeing. The Azimuthal Mosaic view shows a bird's-eye view of the scene with the rover in the center and north pointing up in the image, similar to a map of the world looking down onto the North pole. The Panorama view puts together the images in a scene in a montage fashion, as if each image was pasted onto a wall like a collage. In the following sections we will discuss each Mosaic view in detail.

Opening a Mosaic View

To open a Mosaic view, you select a collection item from the Downlink selection tree. The collections folder is always contains folders for each site (each major destination that the rover visits). Within a site, the rover drives through a number of positions, which are all numbered starting at 0. The items in the collections->sites folder are named by instrument and the position number within the site. If the rover takes a Navcam panorama as soon as it reaches a new site (which it often does), The collection would be called "NAVCAMWedgeSet-position-0". The term "wedge" refers to a single image. Each image in the collection looks in a particular direction, and the collection can be thought of as a large pie with the rover in the middle. In that sense, a single image is one wedge of the entire pie, and "wedge set" is the whole set of wedges.

Figure 3.5: A Cylindrical Mosaic view of Navcam images.

Cylindrical Mosaic View

The Cylindrical Mosaic view is the view that you see when you drag and drop a collection item from the Downlink selection tree to open a view. An example of this type of mosaic is shown in Figure 3.5. This creates a 360°mosaic, with 0 pointing north. Like in the Image view, you can switch the Azimuth angle display between displaying direction in site coordinate frame (north-aligned) to rover coordinate frame (0 degrees pointing in the rover's forward facing direction.) (see Section 3.3.5 for more on this.) The elevation display on the left side of the mosaic shows 0 pointing level with the ground, 90 degrees pointing straight up, and -90 degrees pointing straight down.

Viewing One Image from the Mosaic

When you are viewing a mosaic and you are interested in one particular image, you can directly open that image in its own Image view. To select an image to view, click on any pixel in the image to place the Point of interest cursor inside it and then select the Open Selected Wedge menu item in the Action menu. It is usually a good idea to configure your browser for multiple view panes before opening an individual Image view from the mosaic to prevent the Mosaic view from being replaced when the new view opens.

Setting the Mosaic Start Angle

If you are viewing a mosaic and a particular area of interest happens to fall near the left edge or right edge of the image, you can reset the starting azimuth angle of the mosaic to split it at a different location and reposition the area of interest nearer to the center of the image. To set the mosaic start azimuth angle, select the Set Start Angle menu item from the Action menu and a dialog will appear asking you to enter a new angle in degrees (between 0 and 360 degrees is recommended). When you click Ok, the mosaic will repaint, shifting the images with respect to the start angle you entered.

3.4 Working with images

In the Image and Mosaic views you can create color composite images, apply a set of contrast stretch and filter operations, overlay data from range maps and other instruments onto the images that you are viewing, and optionally export your image analysis work as image files. In this section we will discuss each of these features in detail.

3.4.1 Creating color composite images

There are two primary tools for creating color tools for creating color composite images in the Image view: Define Bands and Define Band Range. These tools let you specify a combination of image bands for each of the red, green and blue channels of the resulting image.

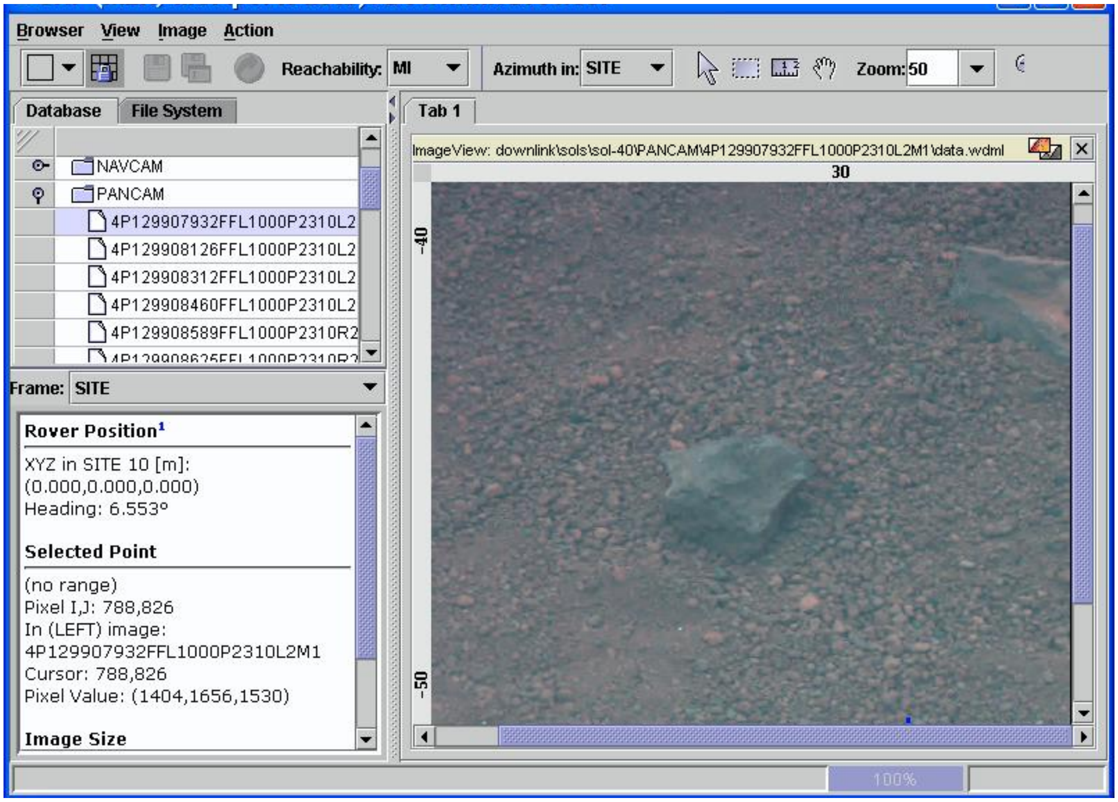


Figure 3.6: A Pancam color composite image in the Image view.

Define Bands

When an Image view is first opened, you can see the default color band(s) of the currently displayed image. With the Define Bands tool, you can create a color composite image from multiple bands (as in Figure 3.6). To use the Define Bands tool, select Define Bands from the Action menu. This will display the Define Bands dialog, as shown in Figure 3.7.

At the top of the dialog you see listed the list of available images in the view (left2, left5, left6). At the bottom there are the equation fields labeled Red, Green, and Blue. By default, these fields all contain the same equation (left[1]). Now we will show how you can enter you own equations to define an RGB composite image.

The format of the equations allows you specify arithmetic combinations of image bands. You can define an arithmetic combination using the following operators:

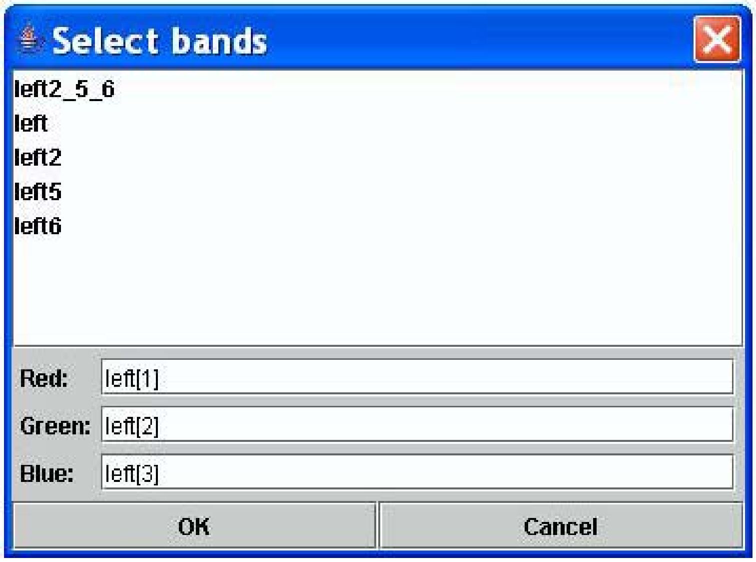


Figure 3.7: The Define Bands dialog (for creating a RGB composite image).

+	Add together two image bands, such as left1 + left2, or an image band and a constant, such as left1+42
-	Subtract two image bands, such as left5 - left2, or an image band and a constant, such as left1 - 0.5
*	Multiply two image bands, such as left1 * left2 or an image band and a constant, such as left2 * 1.25
/	Divide two image bands, such as left5 / left2 or an image band by a constant, such as left1 / 1.33
( )	Group a set of operations parenthetically to specify a particular evaluation order, such as 0.3*(left1+left2+left3)

The image band terms that you combine with the operators are formatted according to

$$imageName[bandNumber]$$

where *imageName* is one of the names of available images in the upper part of the Define Bands dialog, and *bandNumber* may range from 1 to the total number of bands in the image. (The number of bands in the image is given in the Downlink info pane.) Most of the time you may be interested in writing equations using only one particular image, but sometimes combinations of different images can be useful.

To see the result of your image composite equations, specify an equation for each of the red, green, and blue channels and click the Ok button. The image will recompute its appearance. To return to the image to its original appearance, select an image from the

Image menu to revert the display.

For Pancam images, you can also use the familiar Pancam filter naming convention in band equations, for example (L2+L5-L6)*0.5, which is equivalent to (left2+left5+left6)*0.5. L1 through L8 and R1 through R8 are valid, depending on what filters are available in a given dataset. The Define Bands dialog lists all the available filters in the area at the top of the dialog.

Define Band Range

The second tool for creating color composite images is the Define Band Range dialog. This tool lets you quickly define red, green, and blue color components with menus and spinner controls. It is particularly useful for averaging a set of adjacent bands and assigning the result to a color channel.

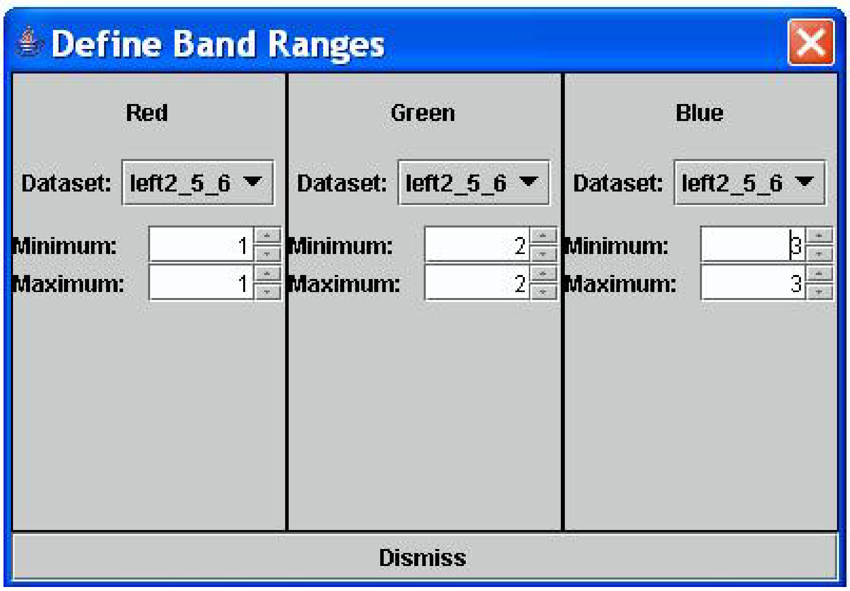
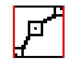


Figure 3.8: The Define Band Range dialog (for creating color composite images).

To use the Define Band Range dialog, select Define Band Range from the Action menu. The dialog is split into three panels from left to right, one for the red, green, and blue channel of the composite image (see Figure 3.8). At the top of each channel control panel you select the image to use. Next, for the selected image you set the minimum and maximum band index to use. If you set the minimum value to be the same as the maximum value, then only that band of the image will be assigned to that color. If you specify a range of bands (max > min), then that color will be computed by averaging the brightness of all the bands in the range.

As you select the band ranges for each color channel, the Image view display will automatically update to view the newly defined composite image as you work. When the image finally looks as you want it to, close the dialog or click the Dismiss button to continue working. To return to the image to its original appearance, select an image from the Image menu to revert the display.

3.4.2 Stretching



You can stretch an image in the ImageCube view to improve its contrast. To stretch the current image, select Stretch from the Action menu or toolbar. This displays the Contrast Adjuster dialog (see Figure 3.9).

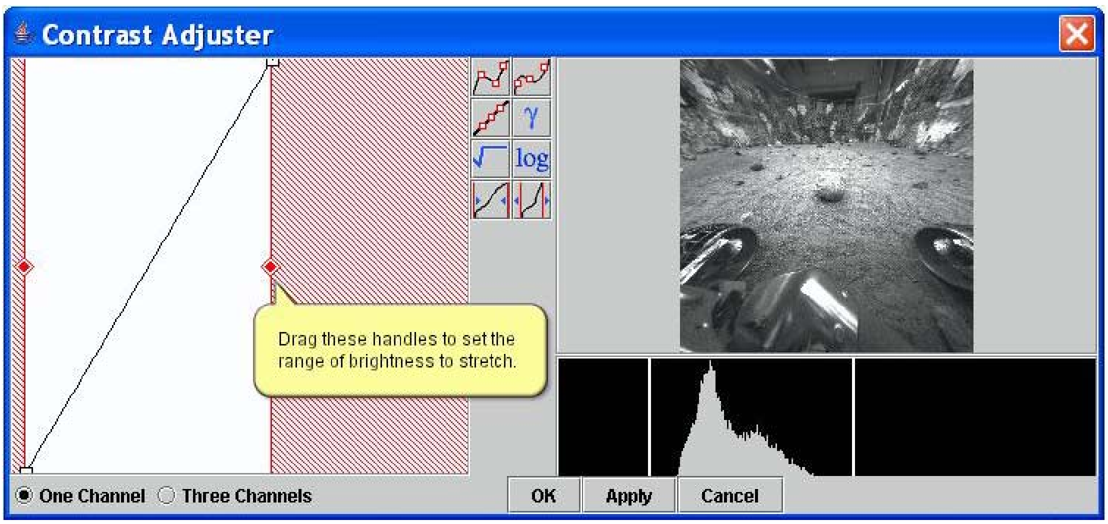


Figure 3.9: The Contrast Adjuster dialog.

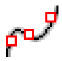
The Contrast Adjuster dialog shows you the image preview (upper-right), the histogram (lower-right), and the stretch tool panel (left). If the image appears too dark or too bright, you can brighten or darken the image by dragging the red, diamond-shaped handles in from the left and right as shown in Figure 3.9.

As you drag these handles, the vertical lines on the histogram that indicate the range of brightness that they represent track with them, and the overall brightness and contrast of the preview image will change. To temporarily apply the current stretch to the full-size image, click the Apply button. To cancel a stretch that isn't to your liking, click the Cancel button. To commit your stretch operation, click the Ok button.

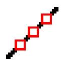
Within the brightness range of the stretch you can change the stretch curve from a line to any type of curve you like by adding control points and moving them around. To add a control point on the stretch curve, click on the curve with the mouse. You can drag a control point anywhere on the curve that you like to define the shape of the curve. You can add more points by clicking on other parts of the curve, and you can remove a control point by dragging it onto another point or off of the curve area. The first and last control points (located on the left and edges of the curve area, below and above the diamond-shaped handles) are special: they control the overall brightness of the curve, and when you drag them up or down, all of the other control points move with them.

In addition to defining your own curves by directly manipulating the stretch curve, the following tools let you specify particular kinds of stretches:

Linear interpolation: connect all stretch curve control points with straight lines



Smooth interpolation: connect all stretch curve control points a cubic spline curve

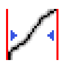


Linear mapping: place all control points in a straight line

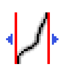
Gamma mapping: place all control points on a gamma curve. Takes an argument of exponent to the gamma function. Suggested range: 0.25 to 2.5

Square root mapping: place all control points on a square root curve (also equivalent to a gamma with exponent value of 2)

Log mapping: place all control points on a logarithmic curve



Increase contrast: places the minimum and maximum brightness value limits closer together, increasing overall contrast



Reduce contrast: spreads out the minimum and maximum brightness value, reducing overall contrast

By default the Contrast Adjuster dialog is configured to stretch the image with the same stretch in all 3 bands. To independently stretch the image in each the of red, green, and blue channels, select the Three Channels button at the bottom left of the dialog. The Contrast Adjuster will resize to display three channel control panels colored red, green, and blue according to their corresponding color channels. You can return to the single stretch curve mode by selecting the One Channel button in the lower left of the dialog.

3.4.3 Filtering

You can apply various filters to an imagecube to improve or enhance its appearance. The filters available in Maestro are:

Median filter: Takes the median value of a set of pixels in a window around each pixel. Good for removing "salt and pepper" (single bright or dark noise pixels) from an image. Recommended window size range: 3 to 15.

Low Pass filter: Takes the mean value of a set of pixels in a window around each pixel. Filters out areas of high contrast. Useful for removing noise from images. Recommended window size range, 3 to 15.

High Pass filter: Applies a sharpening convolution to the image. Good for sharpening blurry images.

Gaussian filter: Applies a Gaussian convolution to the image. Good for removing image noise. Recommended window size range, 3 to 15 pixels.

Edge filter (Sobel): Applies an edge detection convolution filter. Brightens areas of high gradient magnitude, darkens areas of similar brightness.

To apply a filter to an image, select it from the Action->Filters menu or from the toolbar. You can apply any number of filters in any order you need to enhance an image. The Undo tool lets you undo a filter if you aren't happy with how it changed the image. You can Undo a filter by selecting Undo from the Action menu or the toolbar.

Anaglyph stereo

For stereo image pairs it is often useful to view the image pair in 3D using red-blue stereo glasses (see Figure 3.10). The Anaglyph Stereo tool is a shortcut for creating a color composite images using the left and right image of a stereo pair. To use the Anaglyph Stereo tool, select Anaglyph Stereo from the Action menu. This will display a left-blue, right-red anaglyph image that you can view in 3D with red-blue anaglyph stereo glasses (red over the left eye and blue over the right).

3.4.4 Overlaying onto images

Maestro can overlay information such as 3D positions or data from other instruments onto images. In the following sections we explain how to use each of these features in more detail.

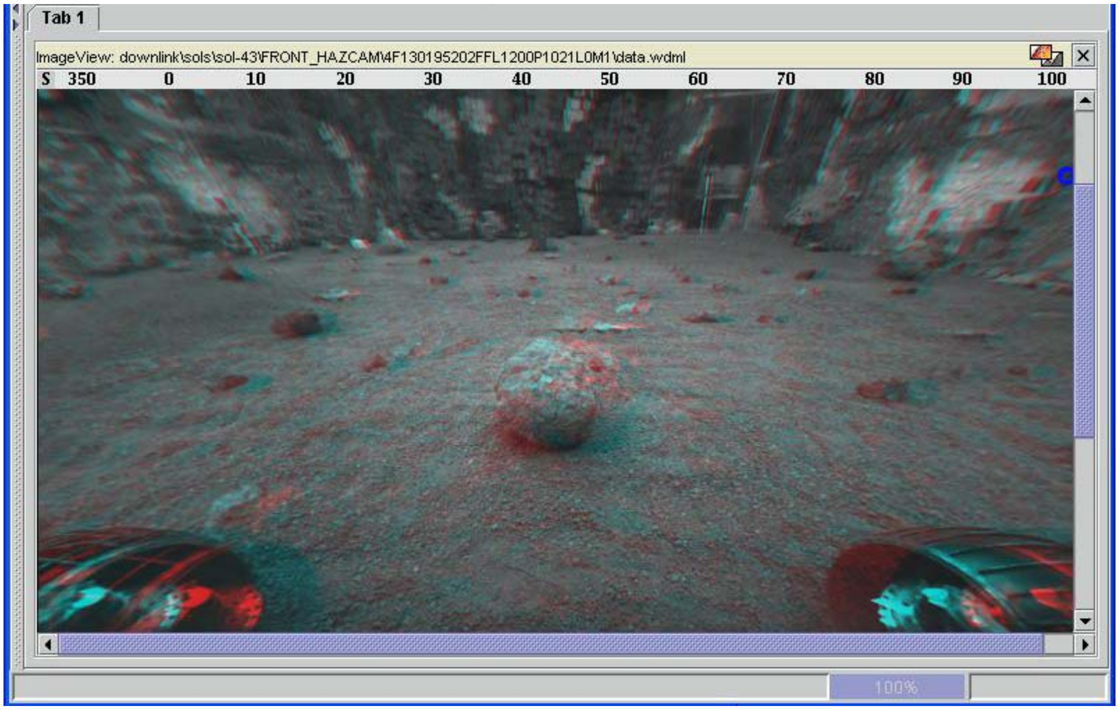


Figure 3.10: An anaglyph stereo image of a Front Hazcam image pair.

Range overlay

To visualize the distance to each point as a color overlay, select the Overlay Range menu item on the Action->Overlay menu. This action will overlay a color map onto the image. The overlay is colored varying from green to blue to red, where green pixels are close to the rover, blue are further away, and red is furthest (see Figure 3.11 for example). Wherever there is no color in the overlay there is no 3D position information available.

Elevation overlay

To visualize the distance to each point as a color overlay, select the Overlay Elevation menu item on the Action->Overlay menu. This action will overlay a color map onto the image. The overlay is colored varying from green to blue to red, where green pixels are lowest, blue are higher, and red is highest. Wherever there is no color in the overlay there is no 3D position information available.

Coregistration overlay

You can overlay images from different instruments using the coregistration feature. This is useful for determining placement of Mini-TES spectra relative to a Pancam, Navcam, or Hazcam image or mosaic (see Figure 3.12).

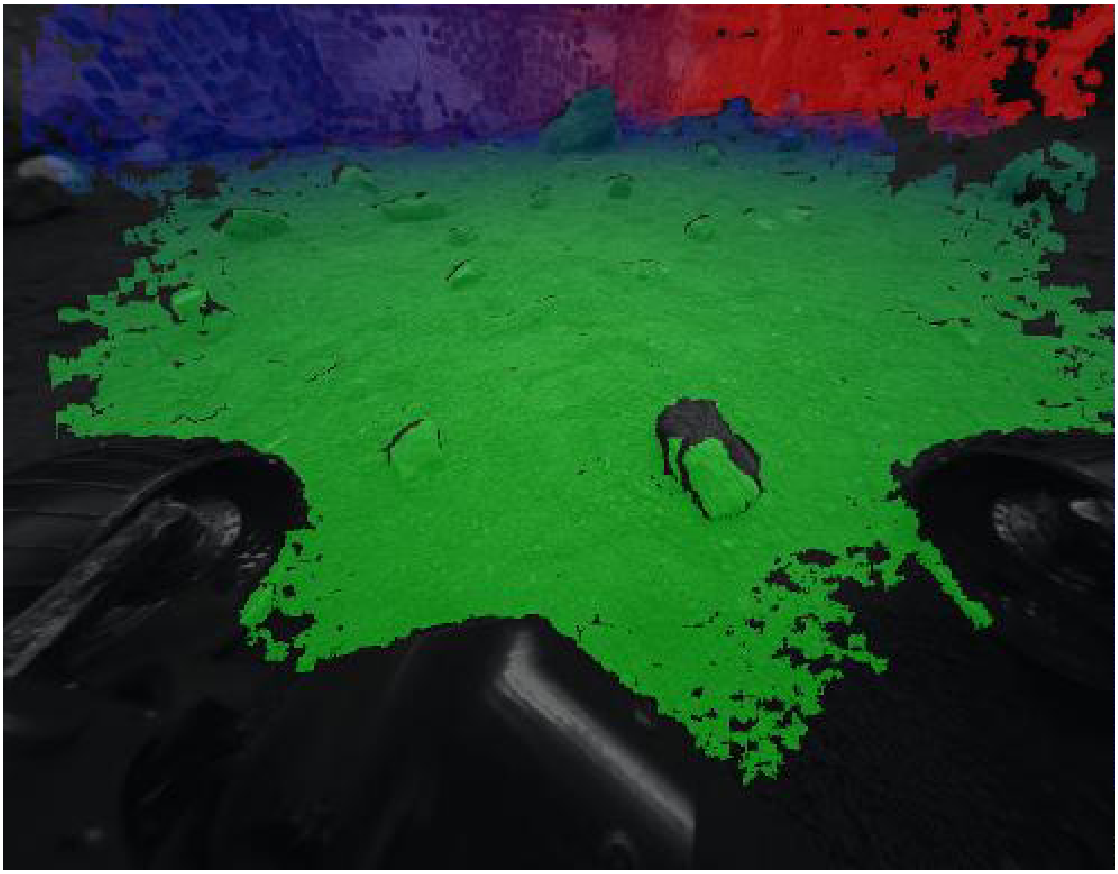


Figure 3.11: Front Hazcam image with range map overlay.

The Image view and ImageCube view each have a Coregistration overlay drag icon in the view pane title bar. If you click on this icon and drag it onto another Image view or Mosaic view, this will produce a coregistration overlay in the view you drop onto.

You can overlay any image that has the Coregistration Overlay drag icon in the view title bar. (To have the icon, the image must have a camera model that Maestro recognizes.) You can drag onto any image or mosaic that has a range map to provide 3D information. The coregistration overlay then takes every 3D position in the destination view and projects it into the camera model of the first view and copies the color in the image onto the coregistration overlay.

The Coregistration overlay procedure takes only a few seconds to run when overlaying camera images. When overlaying a Mini-TES imagecube onto a single image the overlay takes a little longer. When overlaying a Mini-TES imagecube onto a Mosaic view, the overlay can take 5 or more minutes to complete. For this reason, when you drag a Mini-TES imagecube onto a Mosaic view, a dialog (see Figure 3.13) pops up to ask you if you really want to perform this lengthy operation.

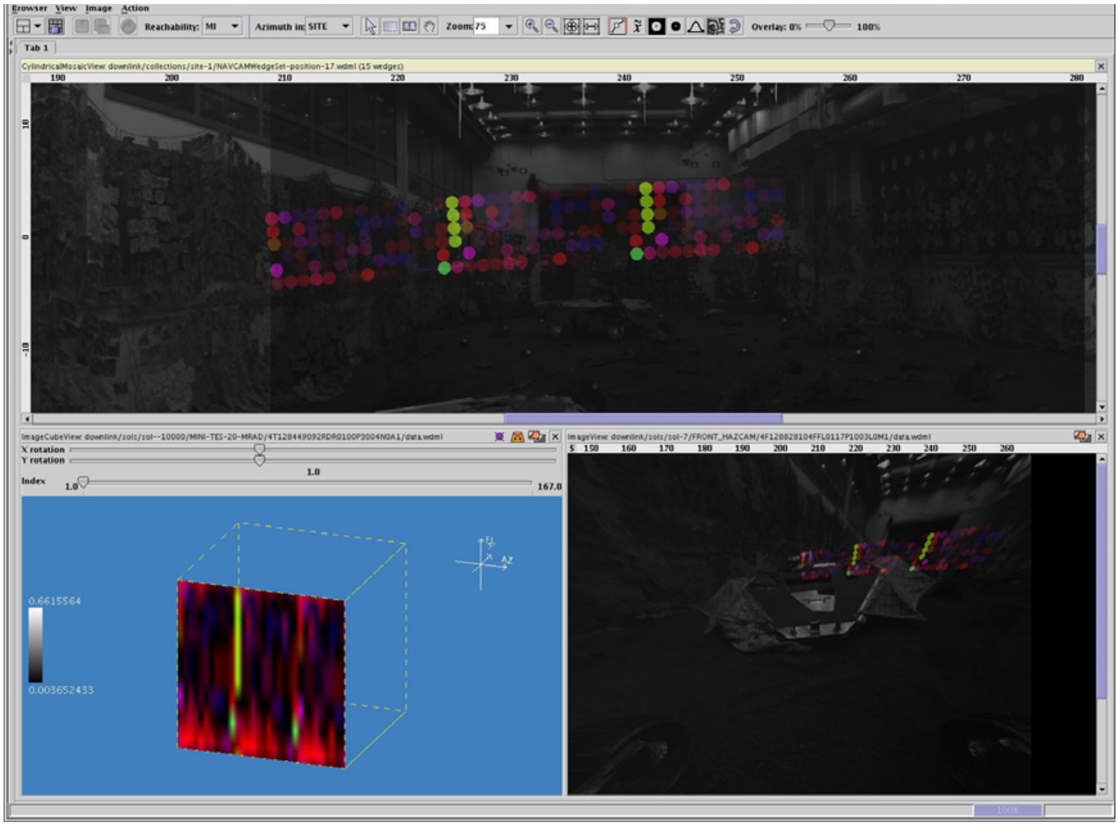


Figure 3.12: Coregistration overlay of a Mini-TES spectral cube onto a Navcam mosaic (top) and a Hazcam image (bottom right). The Mini-TES color composite image was made from a combination of three bands of the mineral map derived from the spectra.

Expert note: The determination of where overlaid images are coregistered is usually made using range map data for greater accuracy. However, sometimes range maps do not provide complete coverage of an area you want to overlay onto. You can direct the coregistration overlay to assume range at infinity in these cases by checking the "Coregistration range at infinity" check box menu item in the Browser menu, after which any coregistration overlays that you run will always assume range at infinity. Note that this will produce overlays that are not accurate for locations near to the rover.

Overlay transparency slider

When you are viewing an overlay of range, elevation, or coregistration, you see a blend of the overlay with the background image. It is often useful to vary the transparency of the overlay to see more or less of the overlay image than the background image. You can do

Figure 3.13: Dialog warning whether to proceed with lengthy coregistration overlay.

this by dragging the Overlay transparency slider located on the toolbar (see Figure 3.14). The slider is originally positioned at 50% overlay transparency to show the overlay and background equally. As you drag the slider to the right, the background dims and the overlay brightens. As you drag the slider to the left, the background image gets brighter and the overlay becomes more transparent.

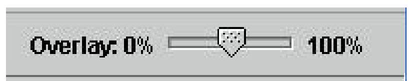


Figure 3.14: The Overlay transparency slider in the Image view and Mosaic view toolbar

3.4.5 Displaying the image header

You can display the header of a PDS image in an Image view or ImageCube view by selecting the Show Header menu item in the Action menu. The header is displayed in a separate window (see Figure 3.15).

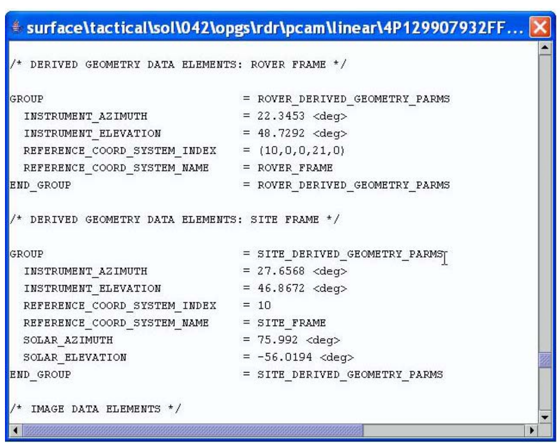


Figure 3.15: The PDS header of an image data file.

3.4.6 Exporting the image

The image that is displayed in the Image view can be exported as a JPEG or TIFF image file. To export, select one the following options on the Action->Save Image menu:

JPEG (100%)	Save in JPEG file format using 100% quality, resulting in low loss of data and a large file size
JPEG (75%)	Save in JPEG file format using 75% quality, resulting in lossy compression of data and a small file size
TIFF	Save TIFF in file format with no loss of data and a large file size

A Save file chooser will be displayed, in which you can select the folder and enter the filename of the image file to export.

3.5 Viewing images in 3D

For images with 3D information Maestro can create a ThreeD (3D) view. The ThreeD view is very good for analyzing the locations and shapes of the terrain around the rover. It is also great for viewing the rover at its current position and heading with respect to its local area (see Figure 3.16). As you create an Activity plan for the rover, the ThreeD view will position the rover and turn its mast and arm to the intended position specified in each Activity. We will cover planning in more detail in Section 4.3, so for now let's discuss how to navigate and analyze terrain with the ThreeD view.

To open a ThreeD view, right-click (or [Ctrl]-click if you have a single-button mouse) on an image or collection in the Downlink selection tree and select "Open in ThreeDView" or "Open in OverheadView". (The Overhead is a specific type of ThreeD view that displays terrain from a bird's eye view).

3.5.1 Navigation

There are a number of navigation tools in available in the ThreeD view:

Orbit navigation

Orbit navigation lets you rotate around the view center to see the terrain from different points of view. This style of navigation prevents you from moving the point of view below the ground plane; it will only view the terrain and rover from above. It will also keep the view center in the view as you zoom in and out of the scene.

To change orientation:

- drag the mouse while holding the left button down, or
- use up, down, left and right cursor keys

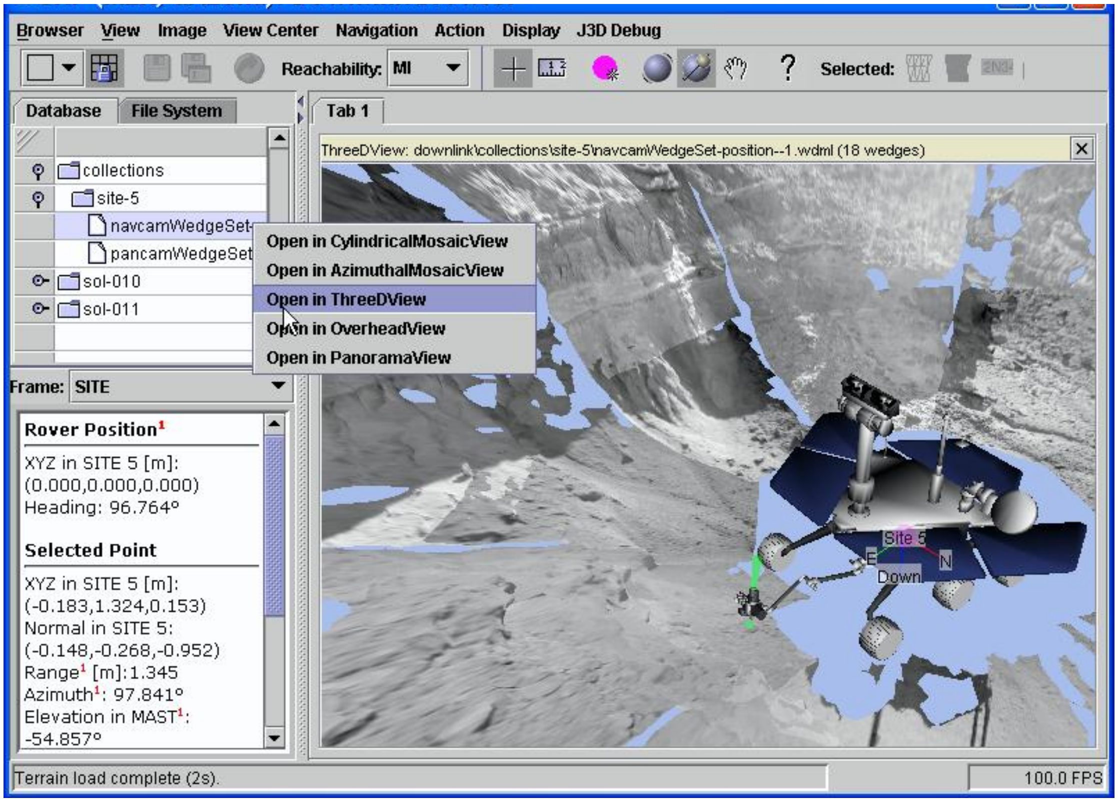


Figure 3.16: A ThreeD view displaying a full site of terrain data and the MER rover at its current position with the instrument arm extended to acquire a microscopic image.

To zoom in and out:

- drag the mouse up and down while holding the middle button down (if your mouse is single-button then drag while pressing [Alt]), or
- use the up and down cursor keys while pressing [Alt]
- Note: on a Sun workstation use the [Meta] key (with a diamond on it) in place of [Alt]

To pan from side to side or up and down:

- drag the mouse while holding the right button down (if your mouse is single-button then drag while pressing [Ctrl]), or
- use the left, right, up and down cursor keys while pressing [Ctrl]

To accelerate any motion, press the [Shift] key while moving.

Some operating systems and desktop environments may reserve some of these key/button combinations for other purposes...if you find that the controls don't work the way they are described here, try changing your system preferences.

Spin Navigation

Spin navigation is very similar to Orbit navigation but allows you unconstrained movement about the view center. You can move the point of view under the ground plane or view the terrain from any direction. The navigation key/mouse controls are the same as those used in Orbit navigation.

Slide Navigation

Slide navigation is similar to Orbit navigation except that rotation around the view center is not available. The key/mouse controls are the same as in Orbit navigation except that left-clicking and dragging pans (slides) the scene instead of rotating it.

Overhead Mode

Overhead mode navigation shows you the terrain from a bird's eye view. To activate Overhead mode in ThreeD view, select "Overhead mode" from the Action menu. This navigation mode is similar to Slide navigation; to pan the scene up, down left and right either click and drag the mouse while pressing the left button or use the up, down, left and right cursor keys. To zoom in and out, drag the mouse while pressing the second button (press [Alt] if using a single-button mouse), or use the up and down cursor keys while pressing [Alt].

If you open an Overhead view, this navigation is the only navigation that you can use; you cannot switch to another navigation mode in the view. To use a different navigation mode, close the view and re-open it in a ThreeD view.

Navigation disable

To freeze the ThreeD view at the current point of view temporarily, uncheck the "Navigation Enabled" checkbox menu item on the Navigation menu.

Navigation Help

To get information about navigation controls in the ThreeD view, select "Describe Navigation Controls" from the Navigation menu.

3.5.2 View center

In the last section we refer to the view center for Orbit and Spin navigation. When you open a ThreeD view, the view center is located at the site where the rover acquired the images that you see as terrain. When you rotate around in Orbit or Spin navigation, the view center is the center of the rotation. Also, when you zoom in and out of the scene, you move toward or away from the view center. The view center is shown as a translucent pink circle in the ThreeD view.

Sometimes you need to zoom in closely on a spot on the terrain that is far from the current view center. There are several tools to help you change the view center:

User defined view center

You can set the view center to any place you can see on the terrain by picking the point (click on it with the mouse) and setting a user-defined view center. After clicking with the mouse, select "User defined" from the View Center menu. This will display the User defined view center dialog (see Figure 3.17).

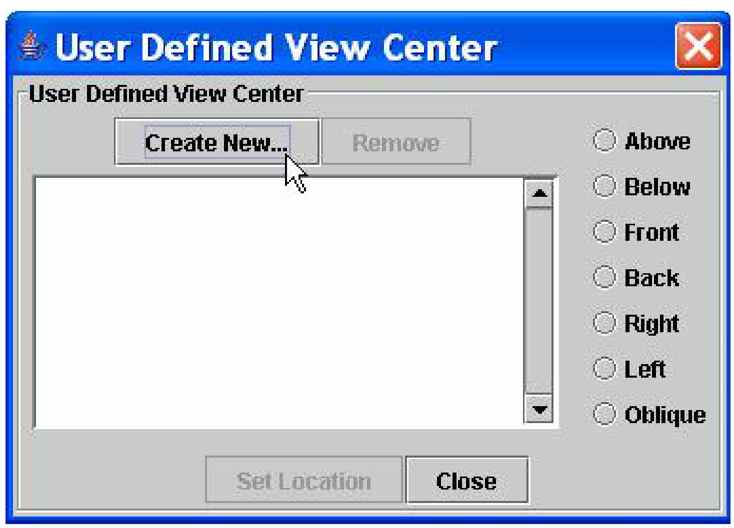


Figure 3.17: The User Defined View Center dialog.

Click the Create New... button to set the new view center (you may name it whatever you like or select Ok to use the default name). When you close the dialog, the view will use your new view center. You may return to this dialog and create as many view centers as you like, and switch between them as needed by highlighting the view center in the list and selecting "Set Location".

The list down the right side of the dialog is used to define the point of view you want to have for your view center. The options are:

- Above: Look down on the view center from above

- Below: Look up on the view center from below (only in Spin navigation mode)
- Front: Look at the view center from the north
- Back: look at the view center from the south
- Right: look at the view center from the east
- Left: look at the view center from the west
- Oblique: look down at the view center from a 45 degree angle. This is how the ThreeD view first appears when opened.

These options are also available in the other view center actions.

Terrain view center

To select a view center in the middle of a particular terrain wedge (segment), Select Terrain... from the View Center menu and select the ID of the terrain to set as the view center. (Terrain IDs are displayable via the Display->All Terrain->Labels->Show All menu item.)

Site-relative

You can select a Site as the view center by selecting a site from the View Center->Sites menu.

Global

To capture the entire scene in the ThreeD view you set the view center with the View Center->Global menu item. This will set the view center and zoom out so that the entire scene is visible in the view.

View center reset

To reset the view center to the initial settings, select the Reset to View Center Default menu item from the Navigation menu.

View center visibility

To show or hide the view center (it looks like a pink translucent circle), check or uncheck the Show View Center checkbox menu item on the Navigation menu.

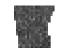
3.5.3 Terrain appearance

The level of detail (how detailed the shape of the terrain and the color appears) is managed automatically in ThreeD view depending on how far your navigation "eye" is from the scene. The ThreeD view also has a number of tools to adjust the appearance of the terrain:

Wireframe terrain

You can turn off the terrain texture (the images that are overlaid on the scene) and view the scene in wireframe as sort of a line drawing. To view the scene in wireframe, select Set All to Wireframe in the Display->All Terrain->Render Mode menu.

Textured terrain



To view the scene with images overlaid on the scene (as it appears when the view is opened), select Set All to Textured in the Display->All Terrain->Render Mode menu.

Terrain labels

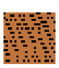
It is sometimes useful to see the ID labels of each terrain wedge in the view, for setting a view center or correlating a terrain with an image in a Mosaic view. To view the terrain ID labels for each terrain wedge, select Show All from the Display->All Terrain->Labels menu.

Terrain bounding boxes

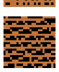
You can view rectangular box that surrounds each terrain wedge by selecting Show All from the Display->All Terrain->Bounding Boxes menu.

Terrain Level of detail

You can select the level of detail of the terrain geometry by selecting the following options from the Display->All Terrain->Geometric LOD menu:



Set All to Highest LOD: display the most geometry detail



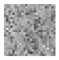
Set All to Lowest LOD: display the least geometry detail

Set All to Auto LOD: display the terrain using a level of detail appropriate for the current viewing distance. (This is the default.)

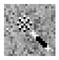
You can also select Set All to Terrain Quad LOD, which will make each terrain wedge appear as a four-sided polygon.

Texture Level of detail

You can select the detail of the textures (images overlaid on the terrain) by selecting the following options from the Display->All Terrain->Texture Resolution menu:

 Set All to Highest Texture Resolution: display the most image detail

 Set All to Lowest Texture Resolution: display the least image detail

 Set All to Auto Texture Resolution: display the terrain using images of resolution appropriate for the current viewing distance. (This is the default.)

Picking a Point of interest

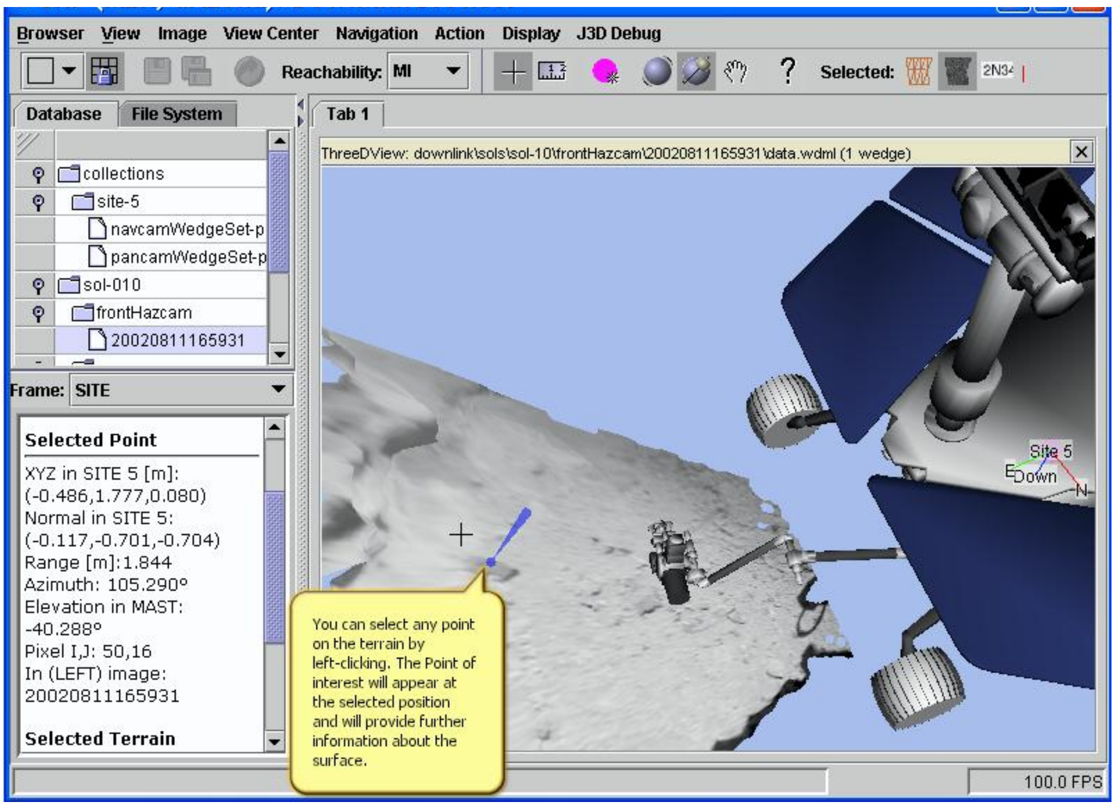


Figure 3.18: ThreeD view with a Point of interest selected.

You can click on any point on the terrain in the ThreeD view to get more information about that point (see Figure 3.18). The Point of interest looks like an exclamation point with the point placed at the selected position. The cone of the Point of interest points in the direction normal to the underlying surface. (A perfectly level surface would have a Point of interest pointing straight up, where a sloped surface would show a similarly sloped Point of interest.)

Downlink info pane

The ThreeD view provides information about the rover's position where the images in the scene were taken and about the selected point. (See Section 3.3.3 for more details on the selected position.) It also gives you details about the currently selected terrain wedge:

- Current Level of detail
- Level of detail mode (high, low, auto, or quad)
- Number of vertices and triangles in the current geometry
- Number of textures used on the current geometry
- Render mode (wireframe or textured)
- Texture version
- Texture resolution (width and height in pixels)

Disabling picking

Sometimes if you have selected a Point of interest it is useful to switch off picking as you navigate around to view it from different angles. To temporarily switch picking on or off, check or uncheck the Picking Enabled checkbox menu item in the Navigation menu.

Ruler

The Ruler tool lets you select two points on the terrain and measure the distance between them. To use the Ruler tool, select the Ruler menu item on the Action menu or the toolbar. To measure between two points, click and drag while pressing the left button from one point on the terrain to another. As you drag the mouse, the ruler will appear as a yellow line that follows your mouse as you move to the second point. When you release the mouse, the ruler will remain in place. The Downlink info pane will tell you the positions of the two ruler endpoints and the distance between them.

In Ruler mode you cannot navigate around in the scene. To restore navigation, select the Pick and Navigate menu item on the Action menu or the toolbar.

Open selected wedge

If you are viewing a scene that has a collection of terrain wedges, you can open a new ThreeD view with just the currently selected wedge in it. To open the selected wedge in its own ThreeD view, make sure you have clicked on the wedge you want to view and select the Open Selected Wedge menu item in the Action menu.

If your browser only has one view pane, opening a new ThreeD view from the current ThreeD view will replace the current view. To avoid this, configure your browser for multiple view panes (see Section 3.2).

Site axis display

The ThreeD view displays a site reference frame in the scene for reference. The site frame is positioned at the site where the rover was when the images were captured. The site axis display points north, east, and down with respect to the site. You can show or hide the site axis display by checking or unchecking the site axis checkbox menu item on the Display menu.

3.6 Viewing spectra

The ImageCube view is specially designed for viewing spectra like those from the MER Mini-Thermal Emission Spectrometer (Mini-TES). These spectra can have hundreds of bands of information. To quickly scan through the spectral bands for information of interest, you can drag the Index slider from left to right to show different images in the imagecube.

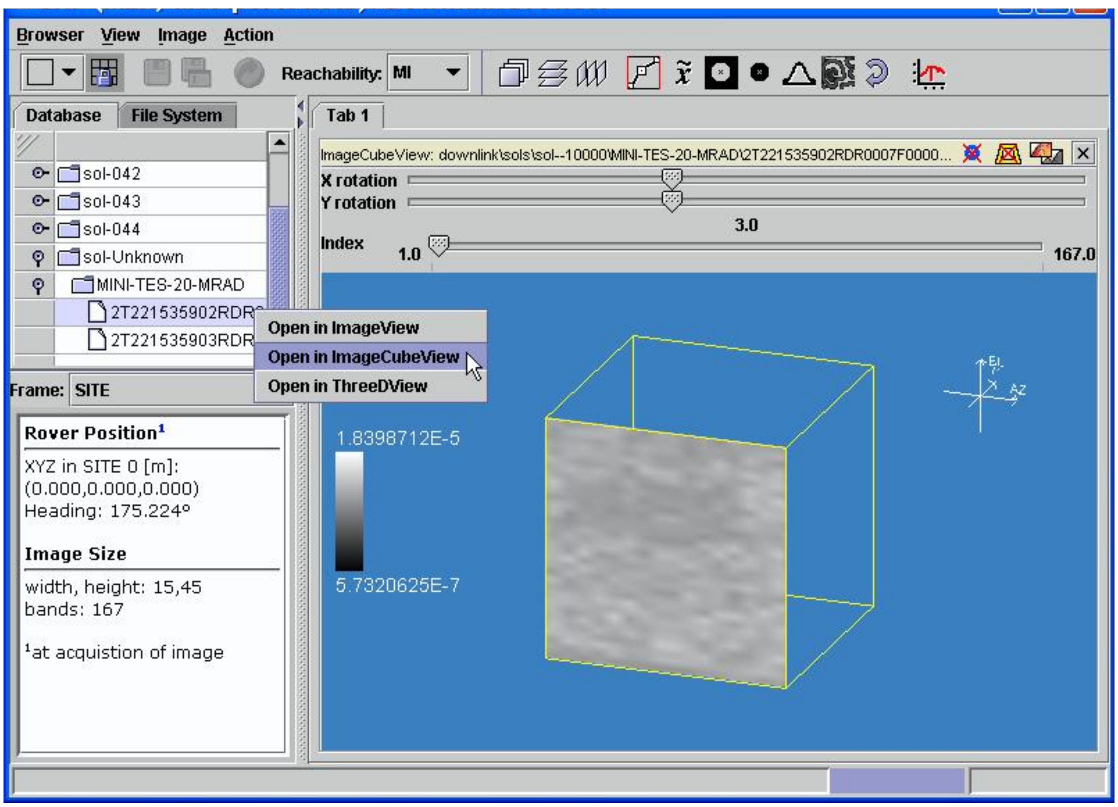


Figure 3.19: An ImageCube view displaying a Mini-TES spectral cube.

As you move the index slider through the bands of the image, the image plane slides through the imagecube with it. The current band of the image is displayed above the slider at all times. There is a legend to the left of the imagecube to display the mapping of pixel values to brightness. The brightness range is always set from the minimum and maximum pixel value in the imagecube.

You can rotate the imagecube horizontally and vertically with the X rotation and Y rotation sliders located above the imagecube. As you rotate, the coordinate axis to the right of the imagecube helps keep you oriented. On the coordinate axes, AZ points along azimuth (west to east), EL points along elevation (low to high), and WL points along increasing wavelength.

You can also change the orientation of the plane in the imagecube with the following options:

Azimuth-Elevation: The image plane shows a single wavelength over a range of azimuth and elevation.

Wavelength-Azimuth: The image plane shows all wavelengths over a single elevation.

Wavelength-Elevation: The image plane shows all wavelengths over a single azimuth.

These options are located on the Action menu and the toolbar.

3.6.1 Spectra in Image view

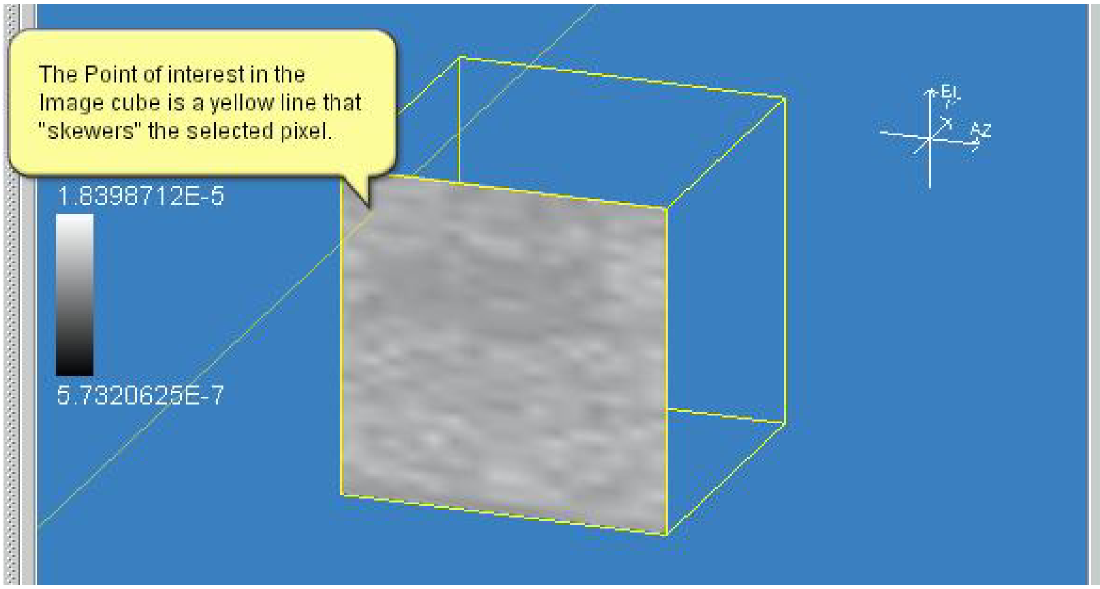
You can also view an Mini-TES imagecube in the Image view (right-click on the imagecube in the Downlink selection tree and select "Open in ImageView".) You can apply all of the image filtering, stretching, and coregistration overlay features in the Image view to an imagecube. However, the Image view doesn't provide the wavelength slider or the Spectrum plot feature (discussed in the following section).

3.7 Working with spectra

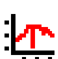
When viewing an imagecube in the ImageCube view, you can display detailed information about any pixel of interest by selecting it. Clicking on a pixel in the ImageCube view (azimuth-elevation view only) selects the pixel and displays a Point of interest. The Point of interest appears as a yellow line that "skewers" the imagecube at the selected pixel.

When a Point of interest is selected, information about that pixel is displayed in the Downlink info pane:

- Position of the rover (in meters) in site coordinate frame and heading (in degrees) where the rover was located when the spectra were captured
- Image coordinates (labeled I,J) in the imagecube for the selected pixel
- Image ID of the imagecube being displayed



- Ick (instrument heartbeat) value when the pixel was captured
- Angle of the mast azimuth gimbal, in degrees (This angle is approximately 180 degrees offset from the Mini-TES pointing azimuth.)
- Angle of the Mini-TES elevation mirror, in degrees (0 is level, increasing toward zenith)
- Width and height of the spectral imagecube
- Number of bands of the spectral imagecube



3.7.1 Plotting a spectrum

You can plot a spectrum at any selected pixel in the imagecube. First, select the pixel to plot (azimuth-elevation view only). To create a plot, select the Plot Spectrum menu item in the Action menu or the toolbar.

A new window will appear that displays the spectrum plot. The title bar label displays the ID of the imagecube. The title of the graph indicates the spectral cube type (radiance, emissivity, brightness/temperature, or mineral map), the pixel line and sample, the Ick value, mast azimuth gimbal angle and elevation mirror angle. The horizontal axis is labeled in decreasing wavenumber and the vertical axis shows the pixel value.

3.7.2 Creating color composite images

The ImageCube lets you combine spectral cube bands to produce color composite images. There are two tools to help you do this: the Define Bands tool and the Define Band Range tool.

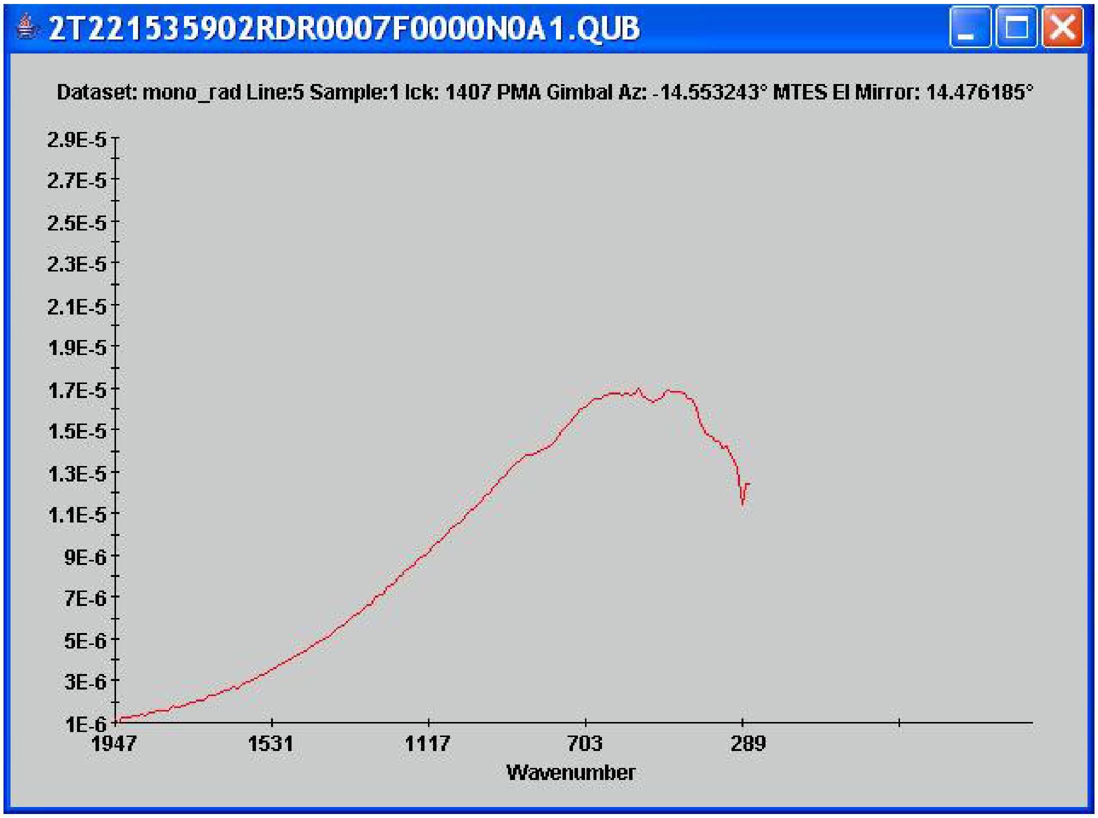


Figure 3.20: A Mini-TES spectrum plot.

Define Bands

When an ImageCube view is first opened, you can see one band of the spectral cube at a time. With the Define Bands tool, you can create a color composite image from multiple bands (as in Figure 3.21). To use the Define Bands tool, select Define Bands from the Action menu. This will display the Define Bands dialog, as shown in Figure 3.22.

At the top of the dialog you see listed the list of available images in the view (mono_rad, mono_emiss, mono_temp). At the bottom there are the equation fields labeled Red, Green, and Blue. By default, these fields all contain the same equation (mono_rad[1]). Now we will show how can enter you own equations to define an RGB composite image.

The format of the equations allows you specify arithmetic combinations of image bands. You can define an arithmetic combination using the following operators:

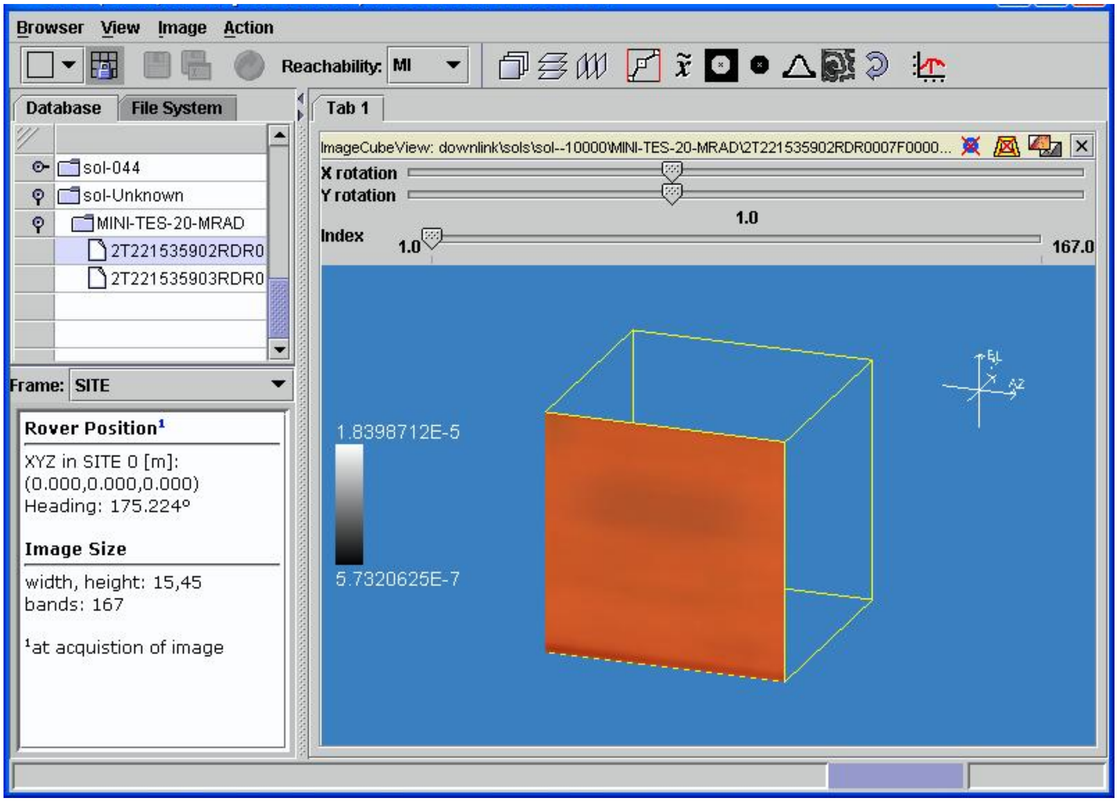


Figure 3.21: A composite RGB image in the ImageCube view.

+	Add together two image bands, such as mono[1] + mono[2], or an image band and a constant, such as mono[1]+42
-	Subtract two image bands, such as mono[1] - mono[2], or an image band and a constant, such as mono[1] - 0.5
*	Multiply two image bands, such as mono[1] * mono[2] or an image band and a constant, such as mono[1] * 1.25
/	Divide two image bands, such as mono[1] / mono[2] or an image band by a constant
()	Group a set of operations parenthetically to specify a specific evaluation order, such as 0.3*(mono[1]+mono[2]+mono[3])

The image band terms that you combine with the operators are formatted according to

$$imageName[bandNumber]$$

where *imageName* is one of the names of available images in the upper part of the Define Bands dialog, and *bandNumber* may range from 1 to the total number of bands in the image. (The number of bands in the image is given in the Downlink info pane.)

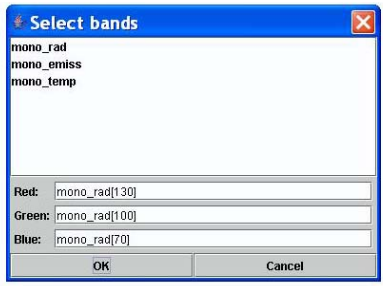


Figure 3.22: The Define Bands dialog (for creating a RGB composite image).

Most of the time you may be interested in writing equations using only one particular image, but sometimes combinations of different images can be useful.

To see the result of your image composite equations, specify an equation for each of the red, green, and blue channels and click the Ok button. The image will recompute its appearance. In the ImageCube view, specifying an RGB composite image will move the image plane back to the front of the cube. If you drag the slider after you create a composite image, the composite image will be replaced with the image of the band you drag the slider to.

To return to the image to its original appearance, select an image from the Image menu or move the Index slider to revert the display.

Define Band Range

The second tool for creating color composite images is the Define Band Range dialog. This tool lets you quickly define red, green, and blue color components with menus and spinner controls. It is particularly useful for averaging a set of adjacent spectral bands and assigning the result to a color channel.

To use the Define Band Range dialog, select Define Band Range from the Action menu. The dialog is split into three panels from left to right, one for the red, green, and blue channel of the composite image (see Figure 3.23). At the top of each channel control panel you select the image to use. Next, for the selected image you set the minimum and maximum band index to use. If you set the minimum value to be the same as the maximum value, then only that band of the image will be assigned to that color. If you specify a range of bands (max > min), then that color will be computed by averaging the brightness of all the bands in the range.

As you select the band ranges for each color channel, the ImageCube view display will automatically update to view the newly defined composite image as you work. When the image finally looks as you want it to, close the dialog or click the Dismiss button to continue working. To return to the image to its original appearance, select an image from the Image menu or move the Index slider to revert the display.

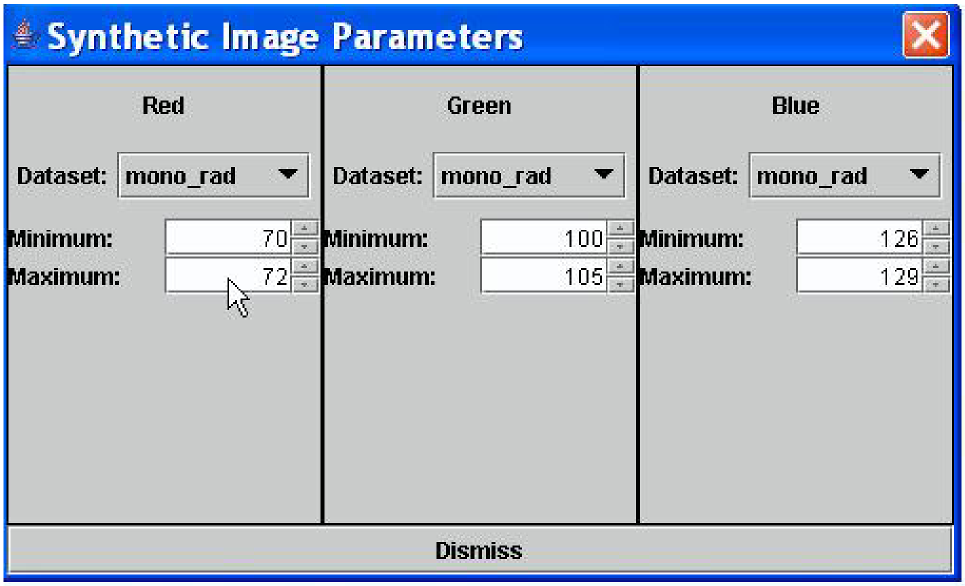
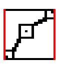


Figure 3.23: The Define Band Range dialog (for creating color composite images).



3.7.3 Stretching

You can stretch an image in the ImageCube view to improve its contrast. To stretch the current image, select Stretch from the Action menu or toolbar. For more information on image stretching and how to use the Contrast Stretch dialog, see Section 3.4.2.

3.7.4 Filtering

You can apply various filters to an imagecube to improve or enhance its appearance. The filters available in Maestro are median, high-pass, low-pass, Gaussian, and Sobel edge detection. To apply a filter to an image, select it from the Action->Filters menu or from the toolbar. You can apply any number of filters in any order you need to enhance an image. The Undo button lets you undo a filter if you aren't happy with how it changed the image. For more information on filtering, see Section 3.4.3.

3.7.5 Exporting the image

The image that displayed in the ImageCube view can be exported as a JPEG image file. To export, select the Save Image menu item from the Action menu. A Save file chooser will be displayed, in which you can select the folder and enter the filename of the image file to export.

3.7.6 Image appearance

You can change the appearance of the image in the ImageCube view by selecting the interpolation options. The following interpolation options appear in the Action->Appearance menu:

- No interpolation: Each pixel is rendered in the view using only its own brightness. This results in a very coarse "pixellated" image.

- Bilinear interpolation: Each pixel is rendered in the view using a linear combination of its color and those of its neighbors, resulting in a smoother image.

Figure 3.24 shows an example of a spectral cube rendered with different appearance settings.

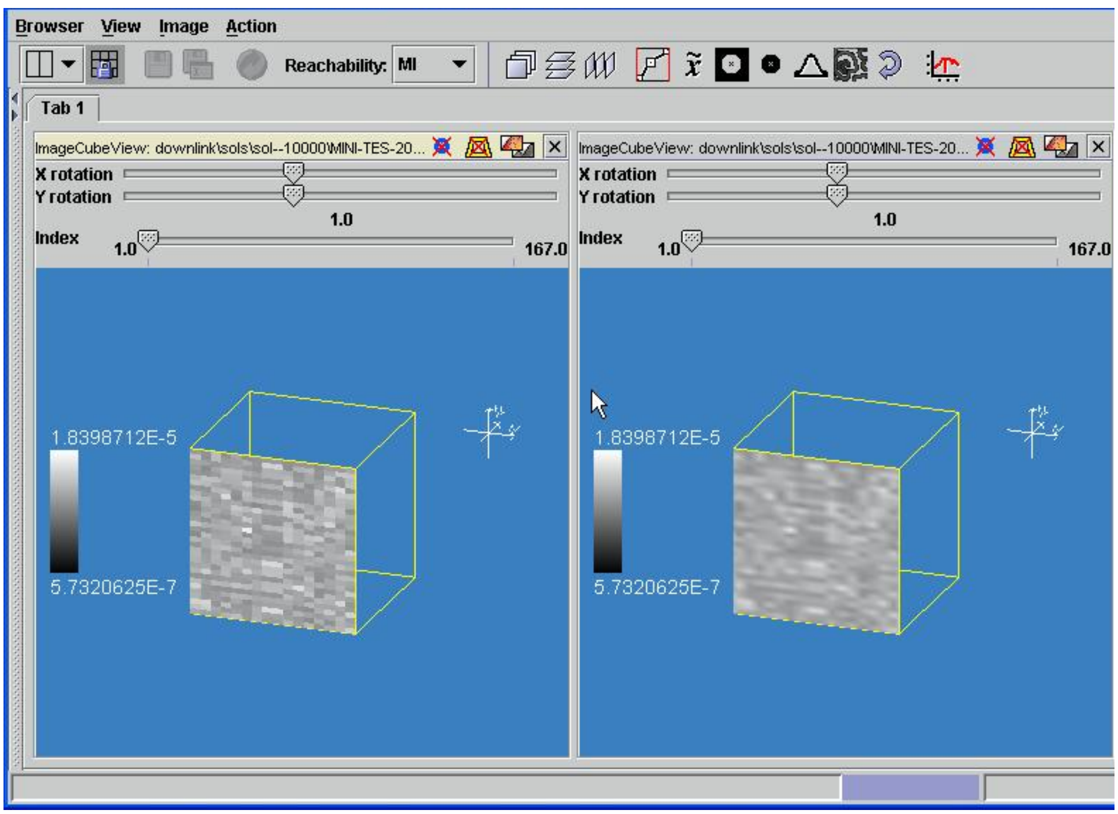


Figure 3.24: A spectral cube rendered with no interpolation (left) and bilinear interpolation (right).

3.7.7 Displaying the image header

You can display the header of a PDS image in an Image view or ImageCube view by selecting the Show Header menu item in the Action menu. The header is displayed in a separate window (see Figure 3.25).

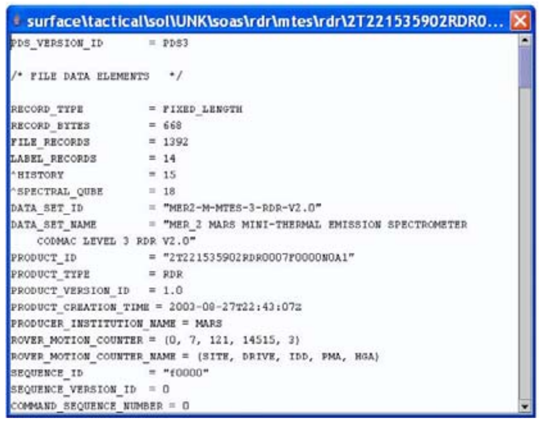


Figure 3.25: The PDS header of an imagecube data file.

4 Activity Planning

4.1 Creating a New Plan for the Rover

When you start Maestro, the Uplink browser will be hidden and empty. Before you can create targets or perform any other activity planning function, you must make the Uplink browser visible and then either load a saved plan or create a new plan. In this section we describe the steps necessary for creating a new plan.

Begin by selecting the Uplink browser item from the Browser menu on the Downlink browser. locating the Uplink browser and clicking on the New Plan Button on the toolbar. This can also be done by selecting the New Plan item in the Browser menu.

When you click the New Plan button, the Create New Plan dialog is displayed as shown in Figure 4.1. This dialog asks you to select a Session to associate the new plan with. If you click on the box in the center of the dialog, a list of the available sessions will be displayed. You can think of the Session as a set of instructions that "set the stage" for the activities you are building for the rover. The Session you should select for your plan depends primarily on what Martian day (sol) it would make sense to execute the activities you are developing.

The only session available for use with the ISIL database (bundled with Maestro) is called "training". There is a Session for each site on Mars that is released for Maestro with names like "site-000", "site-001", etc. Let's say that you have been looking at the results of the rover's activities at site-001 and you would like to build some activities for the rover to execute next. It this situation you would select the "site-001" Session in the Create New Plan dialog.

It is *critical* that you select the proper Session for the plan you are creating because the Session establishes the initial conditions for the plan you are about to build.

After you select a Session and click OK, a new plan view will be added to the Uplink browser View Grid. This plan will be empty except for a single, blank Observation, and will have the name "Unsaved" in its view's title bar until you save the plan to a file. The view title bar will also contain the plan's Session, as shown in Figure 4.2. Note that once you have created a plan, you cannot change its Session. To reuse an activity from another session you must first copy it to a plan in the correct Session. Copying activities between plans is covered in section **??**.

Now that you have created a new plan, you can begin adding features and targets.

Figure 4.1: The Create New Plan dialog.

This is covered in the next section.

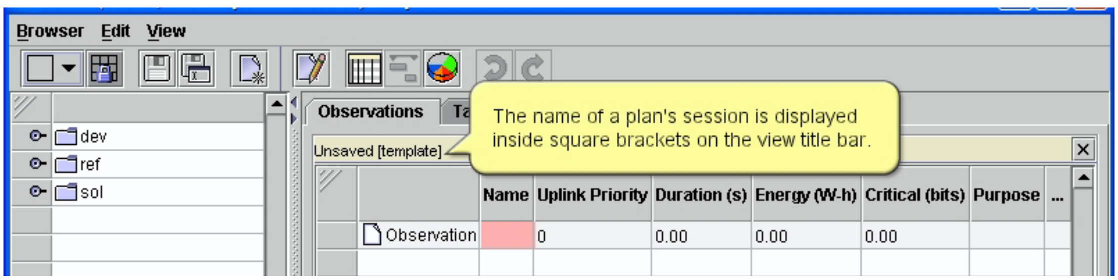


Figure 4.2: After creating a new plan.

4.2 Labeling Objects in the Rover's Environment

When data arrives from the rover, it is useful to assign names to the points of interest in the vicinity of the rover. These names facilitate planning discussions and are used within Maestro to specify positions and directions within Activities that require this information. A Maestro user names a position in the rover's environment by creating a Feature or a Target. Features and Targets are related concepts with important differences, described in Section 4.2.1. Features and Targets are created in different ways depending on whether there is range information available for the point of interest, that is, information stating how far the point of interest is from the rover. The impact of the availability of range information on Feature and Target creation is discussed in Section 4.2.3.

4.2.1 Features versus Targets

A *Feature* refers in a general manner to a whole object in the environment, such as a rock, a cliff, or a patch of soil. For instance, if you decide that a particular rock looks like a big melon and want to name it "Cantaloupe", you would create a new Feature with that name at the location of that rock, as shown in Figure 4.3. When discussing what the rover should do at a high level, scientists usually refer to Feature names. For instance, someone might say that the rover should drive toward Cantaloupe on the next sol. Features are not intended to refer to a particular location on an object and cannot be used to specify a position for an Activity in Maestro. Targets, described below, are used for this purpose. Features are displayed in Maestro downlink views as a pink circle.

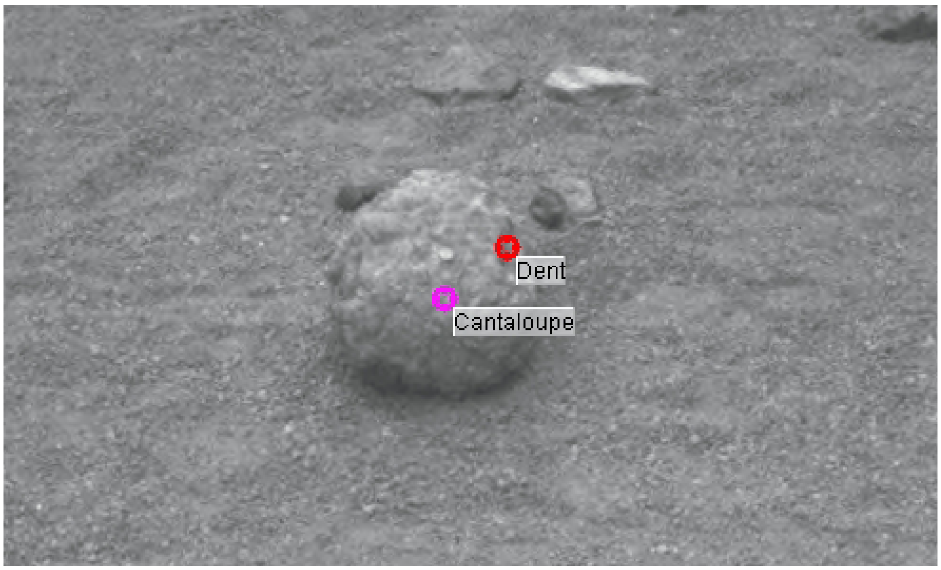


Figure 4.3: An example of a Feature and a Target.

A *Target* refers to a precise location or direction in the vicinity of the rover. Where a Feature names a whole object, a Target names a specific spot on that Feature that is significant for some reason. For instance, let's say that the rock named Cantaloupe appears to have an irregular spot on the side that would be a good thing to take a picture of. You would create a Target at that location and give it a name that describes its appearance, such as "Dent". A Target must be associated with a Feature when it is created, which means that Maestro will not allow you to create a Target until there is at least one Feature in the Session. Targets can be used to specify the location for an Activity, and are generally aren't built until it a Maestro user decides that they would like the rover to execute an Activity on a position within a Feature. Targets are displayed in Maestro downlink views as a red circle.

4.2.2 Creating Features and Targets

Before you can create a Feature or Target, you must first have a plan loaded in the Uplink browser, either by following the steps in Section 4.1 to build a new plan or the steps in Section 4.3.5 to load a saved plan. Features and Targets, when created, are added to the Session associated with the plan that is currently selected in the Uplink browser (for more information on Sessions see Section 4.1). You also need to follow the steps in Section 3.1 to load a data product in the Downlink browser. Once you have a plan loaded in the Uplink browser and a data product loaded in the Downlink browser, you are ready to create a Feature or a Target. Note that if no Features have been built in the selected plan's Session, you must create at least one Feature before you will be able to create a Target.

Creating a Feature

Begin by adjusting the data product that you are viewing in the Downlink browser until the object you would like to name is visible. Click somewhere on the object to move the Point of Interest glyph to the object. As discussed in Section 3.3.4, the Point of Interest glyph is represented as a cross ( ) if there is no range data available and as a circle ( ) if there is range available. In this Section we will assume that you have found a position with range data as shown in Figure 4.4. In the next Section we will describe how the Feature and Target creation process changes when no range data is available.

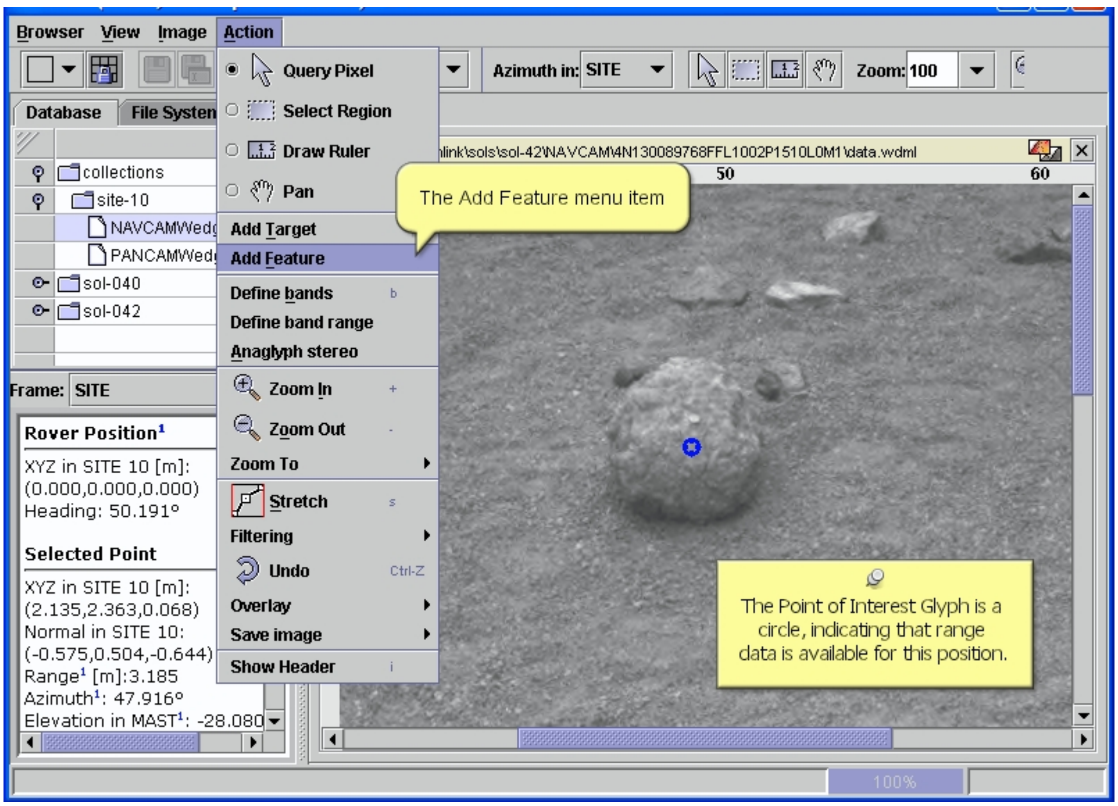


Figure 4.4: Adding a Feature

Once you have clicked on a suitable position, select the Add Feature menu item within the Action menu on the Downlink browser menu bar as shown in Figure 4.4. This will cause the Add Feature dialog to be displayed as shown in Figure 4.5. Two values must be entered in this dialog, described in the table below:

Field	Description
Feature name	A short, unique name for the object you are assigning a name to.
custodian name	The name of the person or group that is responsible for this Feature.

The custodian field informs other users who to contact with questions about this feature. You should enter your name in this field, or the name of the group you are working with. Once you have entered a custodian name once, Maestro remembers the value you provided so that you don't have to type it the next time you add a Feature or Target. When you click the OK button, Maestro will create the Feature and display it at the correct location in the view.

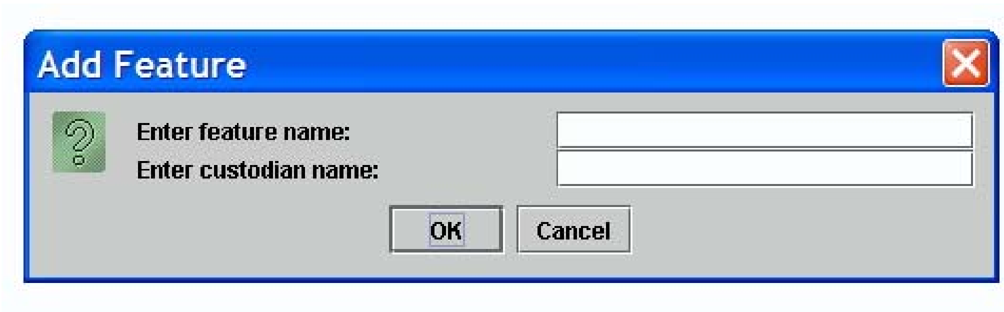


Figure 4.5: The Add Feature dialog

Creating a Target

The procedure for creating a Target is almost identical to the procedure for creating a Feature. Once you have clicked on a suitable location, select the Add Target menu item from the Downlink browser Action menu. It is located directly above the Add Feature menu item, as shown in Figure 4.4. When you select this menu item, the Add Target dialog will be displayed as shown in Figure 4.6. The Add Target dialog has three fields that must be filled out, described in the table below:

Field	Description
Target name	A short, unique name for the position you are assigning a name to.
Feature	The Feature that the target should be associated with. This is a pull-down menu containing all of the currently available Features.
custodian name	The name of the person or group that is responsible for this Target.

If while you are filling out the fields of the Add Target dialog you discover that a suitable Feature for the Target does not exist, you must cancel the Add Target dialog

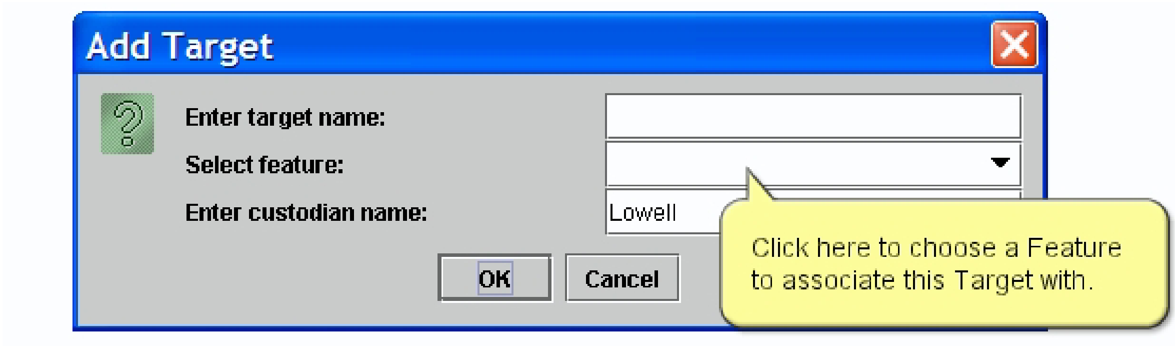


Figure 4.6: The Add Target dialog

and add the required Feature before continuing. Maestro does not allow you to associate a Target with a different Feature after it has been created. When you click OK, Maestro will create the Target as specified and display it at the correct location in the view.

Features and Targets are immediately saved within the current Session when they are created. There is no need to manually save Features or Targets.

4.2.3 Creating estimated Features and Targets

In the last Section, we assumed that the location you had selected as a Point of Interest had range information, meaning that Maestro knows the distance from the rover to the selected point. Unfortunately, range data is not available for every point in every image for a variety of reasons. Despite the lack of range data, it may still be desirable to build a Feature or Target at these positions anyway. To address this need, Maestro allows the user to create estimated Features and Targets.

When a user selects the Add Target or Add Feature menu items from the Downlink browser Action menu while the Point of Interest Glyph is at a position without any range data, a special dialog is displayed. Figure 4.7 shows the Add Estimated Target dialog. The Add Estimated Feature dialog is identical except that it does not ask the user to select an associated Feature. In addition to warning the user that they are about to create an estimated Target, the dialog provides some special information to the user and requests some additional information as well. The new fields in the dialog are described in the table below:

Field	Description
azimuth	Read-only field that informs the user of the current azimuth of the Point of Interest Glyph.
elevation	Read-only field that informs the user of the current elevation of the Point of Interest Glyph.
estimated range	The approximate distance to the Point of Interest Glyph in meters, or infinity if the point is above the horizon.

The first two fields (azimuth and elevation) are provided for informational purposes only and cannot be edited. The estimated range field is a critical field that requires the user to provide an estimated distance to the Point of Interest Glyph using their own knowledge of the environment and tools in Maestro. Usually, an appropriate value for this field can be determined by clicking on points near the desired Target position that *do* have range before selecting the Add Target menu item. While it is good to enter an accurate value, even a very approximate value is sufficient in many situations. If the Point of Interest Glyph is above the horizon, then select the "Infinity" option rather that attempting to enter an estimated range. When the OK button is clicked, Maestro will create the estimated Target and display it at the correct position in the view. Estimated Features and Targets are represented by pink and red crosses, respectively.

Estimated Targets cannot be used as arguments to an activities that use the rover instrument arm, and should only be used when there is not a suitable position near the Point of Interest that has range data.

4.2.4 Viewing information about Features and Targets

As you and other Maestro users you are collaborating by adding Features and Targets to a Session, they will be displayed at the correct position in all Maestro downlink views. In addition, you can view a list of all created Features and Targets and access details about them using the Targets tab of the Uplink browser. To access the Targets tab, make sure you have a plan loaded and then click on the tab labeled "Targets" near the top of the Uplink browser as shown in Figure 4.8. This will display a hierarchical list of all the Features and Targets in the Session for the loaded plan. Features are displayed as folders which contain their associated Targets. The Targets Tab displays the name, custodian, and notes for each Target and Feature and also provides a Visible checkbox that allows the user to hide and show individual Features and Targets. To hide a Feature or Target, click once on its row to highlight it, then click on the Visible checkbox on that row to uncheck it. This will cause the highlighted Feature or Target to be hidden in all Maestro Downlink views. To show the Feature or Target again, repeat the process to re-check the Visible checkbox.

Additional information on each Feature and Target shown in the Targets tab is displayed in the Details dialog when a Feature or Target is selected. Figure 4.9 shows the contents of the Details dialog when the Target called "Eye" from Figure 4.8 is selected. The Details dialog is a companion window to the Uplink browser that is visible by de-

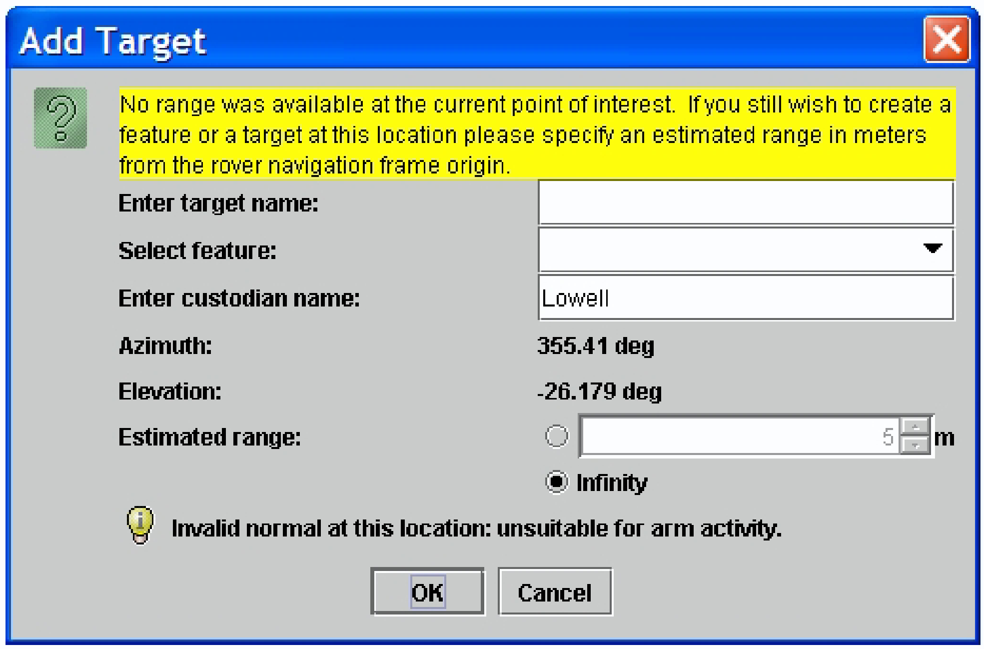


Figure 4.7: The Add Estimated Target dialog.

fault. If it is not visible, you can cause it to be displayed again by clicking on the Details icon in the Uplink browser toolbar.

When a Target is selected, the Details dialog will display all of the information in the Targets tab plus several additional read-only values. Among these are the x,y,z position of the Target in meters, the x,y, and z components of the surface normal at the location of the Target, and the date when the Target was created. The custodian and notes fields can be modified in the Details dialog. When modifying a field in the Details dialog, note that your change will be applied if you press Enter or click somewhere else in the application.

Since other users may decide to use the Features and Targets that you create in their work, they cannot be deleted and most of their attributes cannot be edited after creation. Therefore, it is important that the values you specify in the creation dialogs are correct!

4.3 Editing Rover Plans

Maestro is used on each sol of the mission to specify the high-level plan that the rover will execute on Mars. The plans that Maestro builds are a collection of *Observations* and *Activities*. An Observation contains a group of related Activities that accomplish a particular goal on Mars. Observations also document the scientific intent of the Activities.

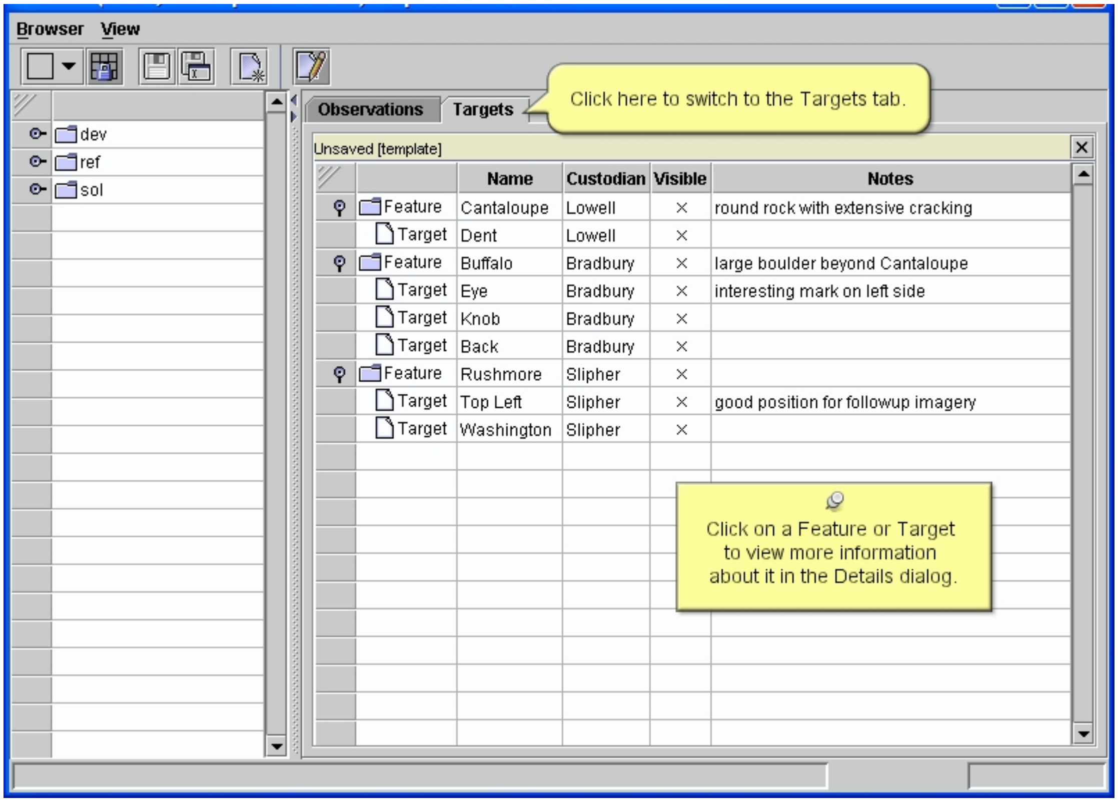


Figure 4.8: The Targets tab of the Uplink browser

Activities are specific orders for the rover that are eventually refined into the commands that are executed on-board the rover on Mars. Different Activity types are used to tell the rover to do different things. Activities describe *what* and *how* the rover should do things on Mars while Observations explain *why*. This chapter describes how to build a plan for the rover from a combination of Observations and Activities, visualize the expected results of the plan, and confirm that the plan can be executed within the resources available on the rover.

4.3.1 Adding, removing, and arranging Observations and Activities

Adding Observations and Activities

After you have created a new plan by following the steps in Section 4.1, you are ready to begin adding Observations and Activities to the plan. Begin by selecting the Observations tab in the Uplink browser. New Observations and Activities are added to the plan using the Uplink palette (as shown in Figure 4.10), which is located in the bottom-left corner of the Uplink browser when the Observations tab is selected. To add a new Observation to the plan, click and drag the folder labeled "New Observation" out of the Uplink palette

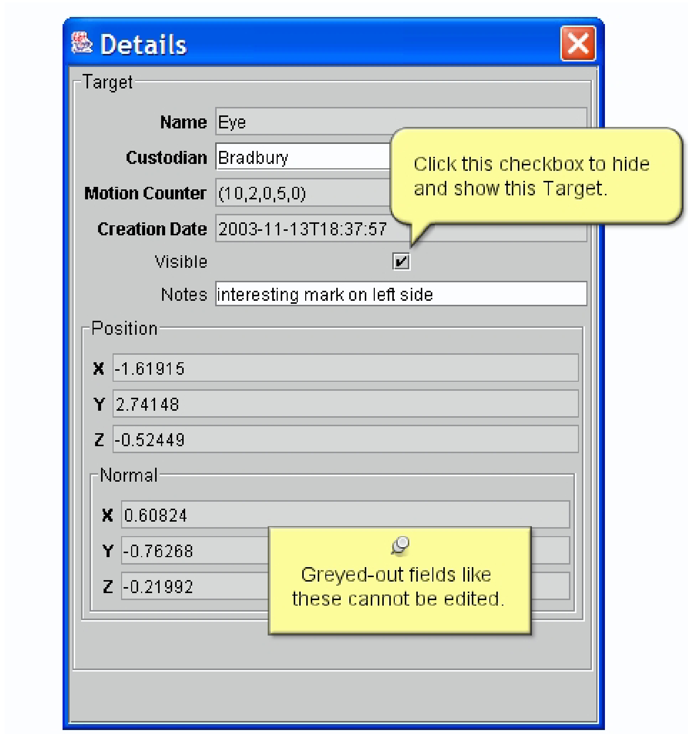


Figure 4.9: The Details dialog showing information about a Target.

into the currently open plan in the Uplink browser view grid.

Your mouse cursor will change to indicate that a drag operation is in progress. As you drag the mouse over the plan, a black insertion line will be displayed, indicating where the Observation would be added if you were to release the mouse button with the mouse pointer in its current position (see Figure 4.11). Move your mouse pointer so that the insertion line is at the position where you wish to add the new Observation and then release the mouse button. If you drop a new Observation on top of an existing Observation, the new Observation will be added after the Observation it was dropped on.

You can also add Observations to the plan by double-clicking the New Observation button in the Uplink palette. This will cause a new Observation to be added after the currently selected Observation, or at the end of the plan if no Observations are selected.

The bottom part of the Uplink palette contains a list of Activity types that you can add to a plan. Each of these Activity types represent something that the rover can do on Mars. Above the list of Activity types is a pull-down menu labeled “Instrument”. Clicking on this pull-down menu will list the different categories of activities that are available. Selecting a category from this list will cause the list of Activities beneath it to change to show only the Activities within that category. The exact categories and activities that are available will vary depending on what version of the Activity dictionary is currently

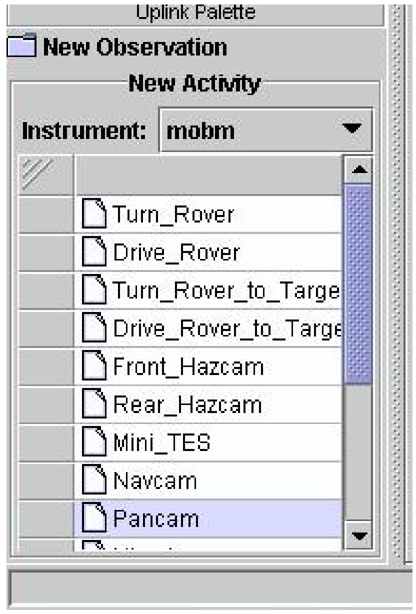


Figure 4.10: The Uplink Palette.

loaded in Maestro.

Activities can be added to the plan in both of the ways that Observations can be added to a plan, as described above. First, you can add Activities at a particular location in the plan by clicking on an Activity type and dragging the mouse over the plan so that the black insertion line is displayed at the location where you wish to add the new Activity. Releasing the mouse button causes the new Activity to be added to the plan. Note that Activities can only be added inside Observations, so the new Activity will automatically be placed inside the first open Observation above the position at which it is dropped. To insert an activity inside a closed Observation you must first open the Observation by clicking on the turnbuckle to the left of the Observation in the plan view. You can also double-click on the Activity type to insert a new Activity of that type after the currently selected item in the plan, or inside the final Observation if nothing in the plan is selected.

Duplicating Observations and Activities

Sometimes, you will want to create a copy of an Activity or Observation rather than working from a new one. To create a copy of an Observation or Activity, highlight it in the plan view and select the Duplicate menu item from the Uplink browser's Edit menu. A copy of the currently selected item will be added to the plan directly beneath the selected item. If you use the Duplicate menu item when an Observation is selected, all of the Activities inside it will be duplicated as well. You can also perform the Duplicate action by pressing the Insert key on your keyboard.

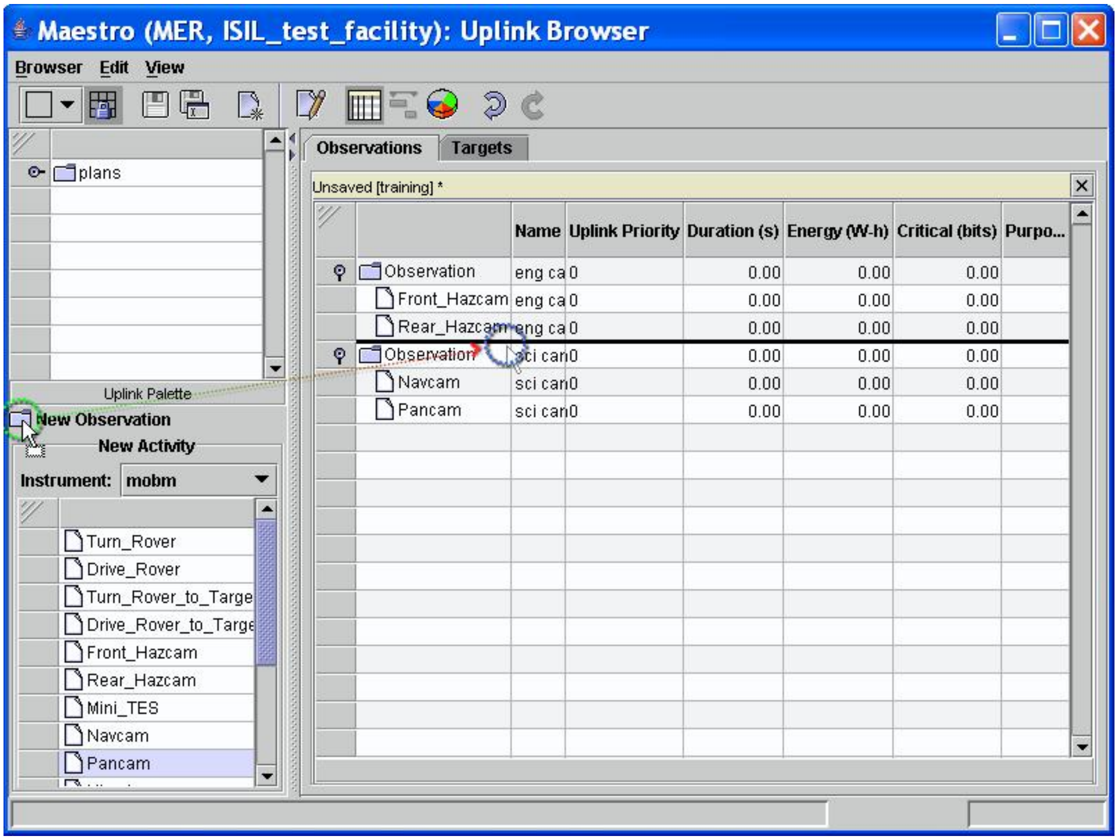


Figure 4.11: Adding an Observation to a plan.

Removing Observations and Activities

To delete an Observation or Activity, first click on it in the plan view. Then, select the Delete menu item from the Uplink browser's Edit menu. Note that if you delete an Observation, all of the Activities inside that Observation will be deleted as well. You can also delete an item from the plan by pressing the Delete key on your keyboard.

Arranging Observations and Activities

Observations and Activities can be rearranged within the plan using drag-and-drop. Simply click on the Observation or Activity you would like to move and drag it so that the black insertion line is displayed at the location where you would like to drop the item. When you release the mouse, the Observation or Activity you dragged will be moved.

Undo and Redo

It's easy to make mistakes while adding, removing, and arranging Observations and Activities. Fortunately, Maestro allows you to undo every modification you have made to a


plan since you last opened or created it. To undo a modification, click the Undo button on the toolbar or select the Undo menu item from the Uplink browser's Edit menu. When you undo one or more modifications to the plan, the Redo button will become available. Clicking the Redo button causes the modifications that you have reversed with the Undo button to be applied again.

Moving an Observation or Activity via drag-and-drop counts as two modifications to the plan: one to remove the item from the old location and another to add it at the new location. To undo a drag-and-drop modification you must press the Undo button twice. Similarly, to redo a drag-and-drop you must press the Redo button twice.

4.3.2 Editing Activities

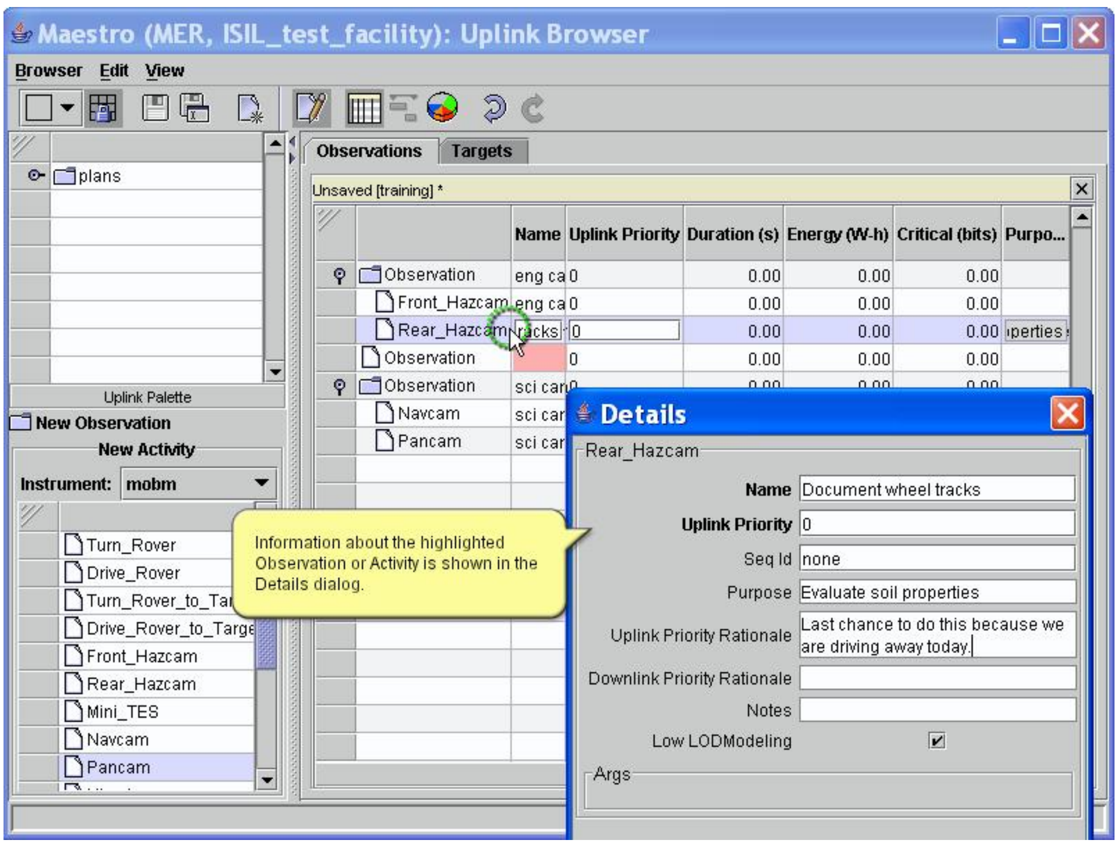


Figure 4.12: Selecting an Activity to display its details.

Each Activity in a plan carries with in multiple pieces of information that describe exactly what you want the rover to do and how it should do it. When a new Activity is added to a plan, this information is set to default values that probably don't reflect your intentions. You must edit Activities in Maestro to provide the correct information.

To select an Activity for editing, click on it in the plan View so that it becomes highlighted as shown in Figure 4.12. This will display detailed information about the selected Activity in the Details dialog. The Details dialog is a companion window to the Uplink browser that is visible by default. If it is not visible, you can cause it to be displayed again by clicking on the Details icon in the Uplink browser toolbar.

When an Activity is selected, the top portion of the Details dialog will show a set of generic fields that are present for every Activity, as shown in Figure 4.12. These fields are described in the following table:

Field	Description
Name	A concise description of what this Activity will accomplish. Don't include the instrument name or Activity type name here as this is redundant information.
Uplink Priority	A number between 0 and 3 indicating the importance of this Activity relative to other Activities inside this Observation. Note that a 0 indicates that this Activity is so essential to the Observation that removing it would render the entire Observation useless.
Seq Id	Used by Payload Uplink Leads to indicate what spacecraft sequence will be used to accomplish the work dictated by this Activity.
Purpose	A brief explanation of why this Activity was added to the plan.
Uplink Priority Rationale	Justification for the value specified in the Uplink Priority field above.
Downlink Priority Rationale	Justification for the downlink priorities specified in the Activity arguments (discussed in more detail below).
Notes	Any additional information about this Activity that should be recorded but wasn't covered by the other fields.
Low LOD Modeling	A checkbox that toggles Maestro between high and low level-of-detail modeling for this Activity (discussed in Section 4.3.3).

Though they appear initially as a single line, most of these fields will grow as you type multiple lines of text into them. Modifications made to these fields will be applied whenever you press the Enter key or click the mouse outside the field. Note that some field names are shown in bold text. This indicates that the field is required, and a value must be provided in order for the Activity to be considered valid.

You can move to the next field in the Details dialog by pressing the Tab key, and move to the previous field by pressing Shift-Tab. Any changes made will be applied when you change to a different field.

Argument fields

Following the generic fields described above is the arguments section of the Details dialog, abbreviated as "Args". Arguments are the real meat of the Activity — they allow you to tell the rover exactly what you want it to do. The Args section of the Details dialog has a section for each argument in the activity. Argument fields vary widely in appearance depending on their type and purpose, but they all have the same basic structure. A typical argument field is shown in Figure 4.13.

Figure 4.13: A typical argument field.

Each argument field is made up of three parts. In the top left corner, the name of the argument is shown in bold text. Beside this is the beginning of the argument's description, taken from the Activity dictionary. If the description of the argument is too long to fit in the space provided, an ellipsis (. . .) will be displayed at its end. If you click and hold the mouse button on the description, a yellow pop-up will be displayed showing the full description of the argument until you release the mouse button. Below the name and description of the argument are one or more components that allow you to edit the value of the argument. Most of these components fall into one of three categories, show in Figure 4.14. The first argument in this figure is a simple field that accepts text input. The second is a field that can be edited in the same way as the first or by clicking the spin arrows on the right side of the field. The third argument accepts only a limited set of values and can only be edited by clicking on the arrow on the right side of the field. This will display a list of allowed values to select from.

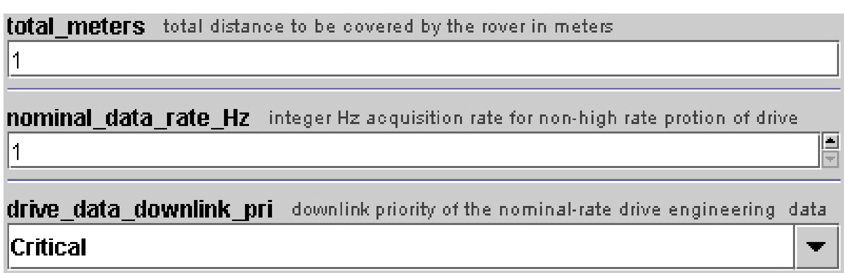


Figure 4.14: The three basic argument field types

Argument fields enforce restrictions specified in the Activity dictionary on their values. For instance, if an argument is of a numeric type, it will not allow to enter text into it. For numeric types, the Argument field will check that the value entered is within the limits specified by the Activity dictionary. If a value is entered that is outside these limits, the Argument field will turn red to indicate this to the user. Figure 4.15 shows the field from Figure 4.13 with an invalid value entered into it.

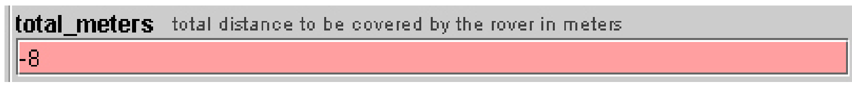


Figure 4.15: An argument field indicating that an invalid value has been entered.

4.3.3 Visualizing Activities with Footprints

It can be very challenging to set all of the arguments in a MER Activity correctly. Fortunately, Maestro provides two capabilities that will assist you in this task by providing a graphical simulation of the what the rover will do if the activity you have created is executed. This section describes the first of these capabilities, called *Footprints*. For imaging and Mini-TES activities, Maestro draws footprints in its downlink views that indicated the area that will be imaged by the selected Activity. To use this capability, first open a Navcam collection in the Cylindrical Mosaic view by following the steps in Section 3.3. Next, add an Activity that produces Footprints to the plan (a Pancam activity, for instance). Select the Activity and set the values of its arguments in the Details dialog as desired. As you change some of these arguments, the Footprint(s) being displayed will immediately change to illustrate the expected outcome of the Activity given the arguments' current values.

Figure 4.16 shows a Footprint for a Pancam activity. Whenever you create or modify an Activity for the Navcam, Hazcam, Pancam, or Mini-TES, Maestro analyzes the values you provide for the Activity's arguments and determines where the instrument will be pointing when the rover executes the selected activity. Given that, it determines whether the instrument will be pointed toward a region where the rover has already acquired imagery. If it is, then Maestro will draw a yellow outline around the area that will be included in the Activity's measurement in all currently loaded Downlink views. If this sounds confusing, think about what happens when you shine a flashlight at a wall in a dark room. It makes a shape on the wall that will change size and shape depending on how far the wall is away from you and at what angle you are holding the flashlight. If you were to ask a friend to trace the outline of the shape on the wall with a marker, you would be left with a Footprint for the flashlight. Maestro does something very similar when it creates an Footprint — it shows you what the instrument will see if the selected activity is executed. Maestro displays Footprints in all views except for the 3D view and the ImageCube view.

The size, shape and position, and number of Footprints produced by an Activity

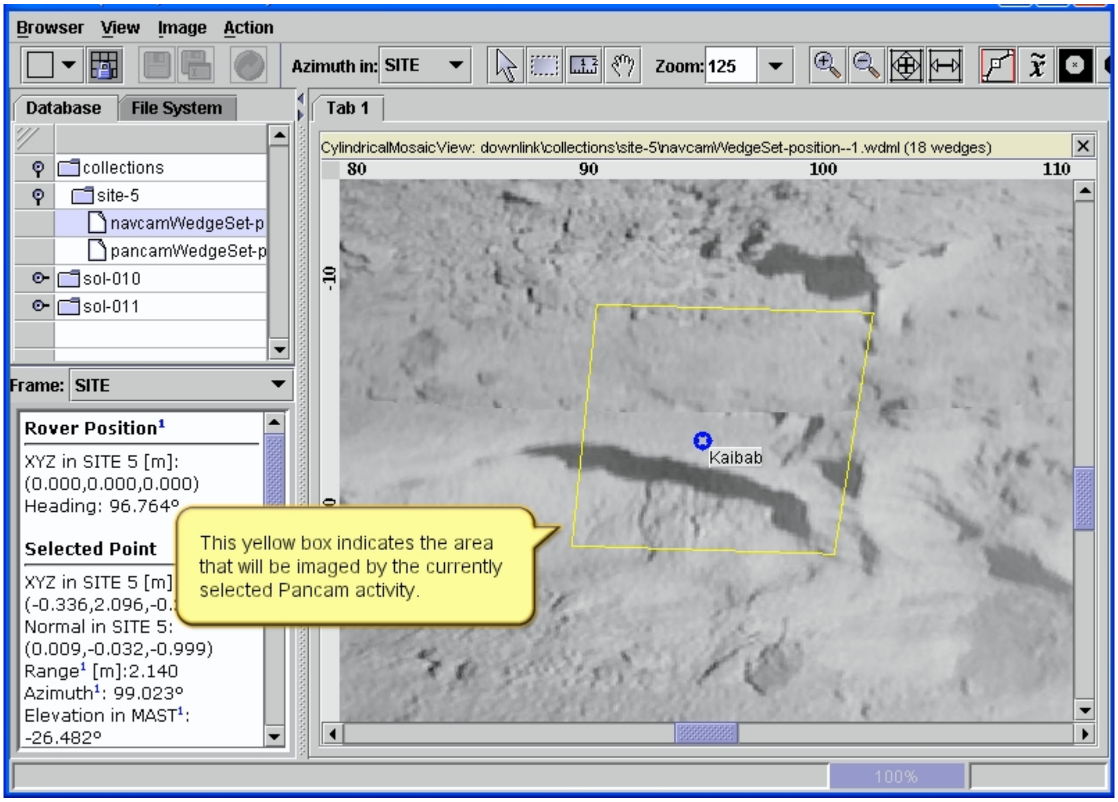


Figure 4.16: A Footprint for a Pancam activity.

depend on what type of activity is being used and the values that its arguments are set to. Some Activities cause the rover to point an instrument at a single location and thus generate a single Footprint, as shown in Figure 4.16. Other Activities will cause the rover to point an instrument at multiple locations and thus generate multiple Footprints, as shown in Figure 4.17. The Footprints in Figure 4.17 were created by a Mini-TES activity and thus are round to reflect the shape of that instrument's field of view.

To create a Footprint, just add a Navcam, Pancam, Hazcam or Mini-TES activity to the current plan by following the steps in Section 4.3.1. Then set the arguments for that activity so that the instrument is pointed at the desired location. Most of the time, you will be using the Mast-Target argument field described in Section 4.3.2 to do this. Some activities will have other arguments that will affect the size and location of their Footprint(s) — try experimenting with the arguments in these Activities to see how they affect the Footprint(s) being drawn.

If you select an Observation, the Footprints for all of the Activities within that Observation will be displayed.

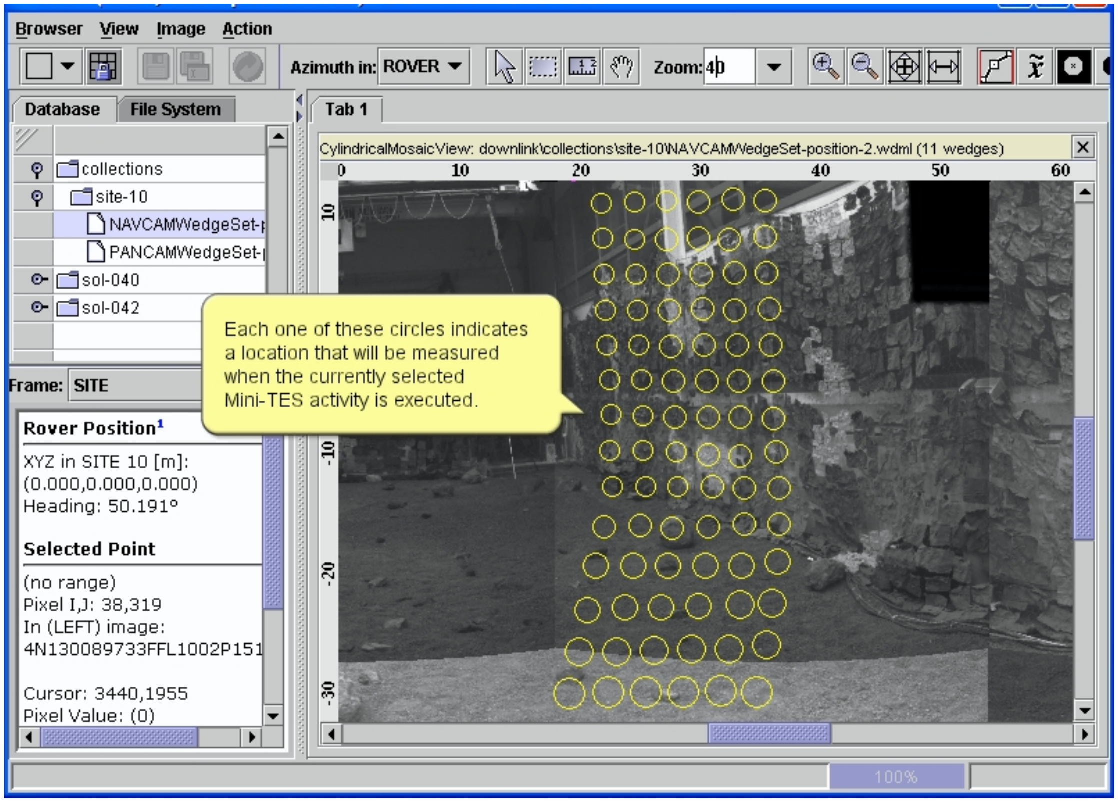


Figure 4.17: Footprints for a Mini-TES activity.

Approximate footprints

In order to draw an accurate Footprint for an Activity, Maestro must have access to information about the terrain in the direction that the instrument is pointing. Sometimes, this information is unavailable. Stereo data may not have been acquired for that region, or the instrument may be pointing above the horizon. In these situations, Maestro is only able to draw an approximate Footprint. Approximate Footprints assume that the instrument is pointing in a direction where it cannot see the terrain, and therefore are drawn as if they were a very long distance away. These Footprints are only intended to provide a rough idea of what the instrument will see and should not be used when precision is required. Approximate Footprints are drawn as pink dashed lines or pink circles in order to distinguish them from the more accurate Footprints described above, which are drawn in yellow. An approximate Pancam Footprint is shown in Figure 4.18.

High and low level of detail (LOD) footprints

Generating an accurate Footprint can require significant computation. When an Activity produces many Footprints, this computation time really adds up! Often, you will find

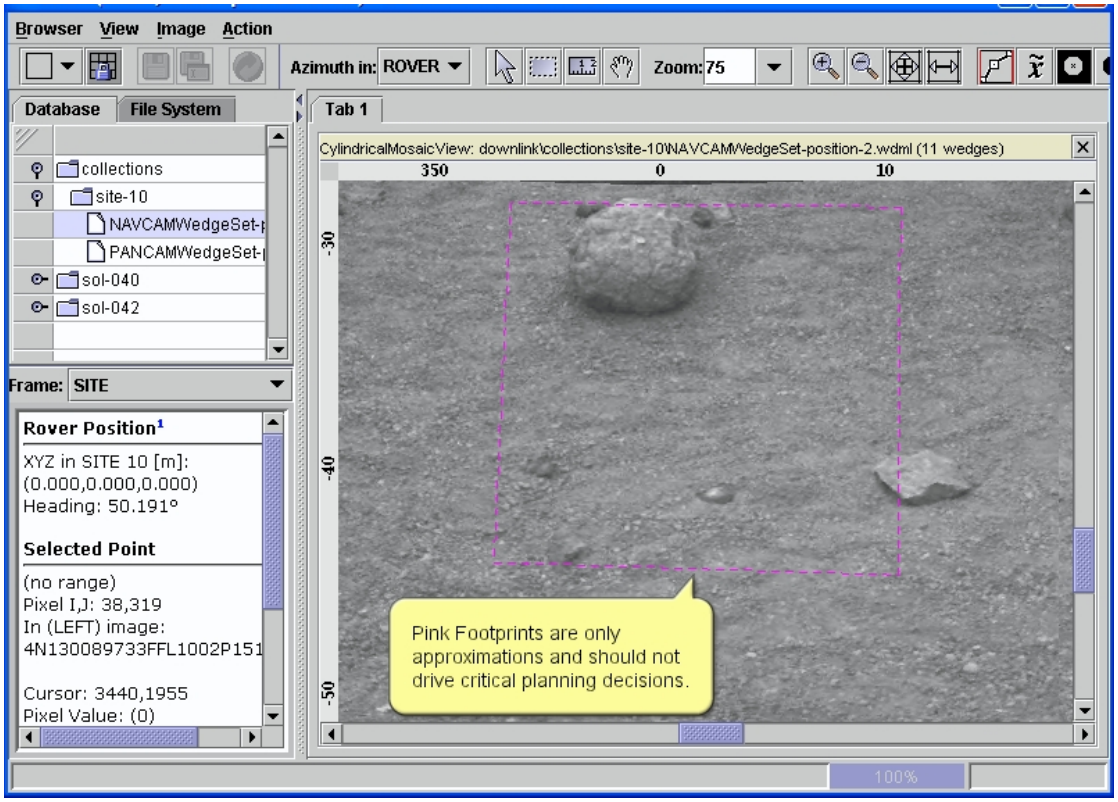


Figure 4.18: An approximate Pancam Footprint.

that you are most interested in the outer boundary of the region covered by the produced Footprints and not the precise location of each Footprint within that region. This outer boundary is called a *Low Level of Detail (LOD) footprint* in Maestro. Maestro draws Low LOD footprints by default.

Figure 4.19 shows a Low LOD footprint for a Pancam mosaic activity. The yellow box shown indicates the outer boundary of the area that will be imaged by the Activity. Several assumptions are made that affect the appearance of a Low LOD footprint, and thus it should not be considered to be a precise representation of the area that will be imaged by the activity. Figure 4.20 shows a set of High LOD footprints for the same Pancam Mosaic activity. Here, a separate Footprint is drawn for each image in the mosaic. High LOD footprints provide a more precise representation of the area that will be imaged by a Mosaic activity, and allow you to evaluate the spacing and overlap between individual images.

An Activity can be switched between Low and High LOD mode by checking and unchecking the Low LOD Modeling checkbox in the Details Dialog when that Activity is selected. Activities are created in Low LOD mode by default. To activate High LOD modeling and footprints for an Activity, select that Activity in the plan and uncheck

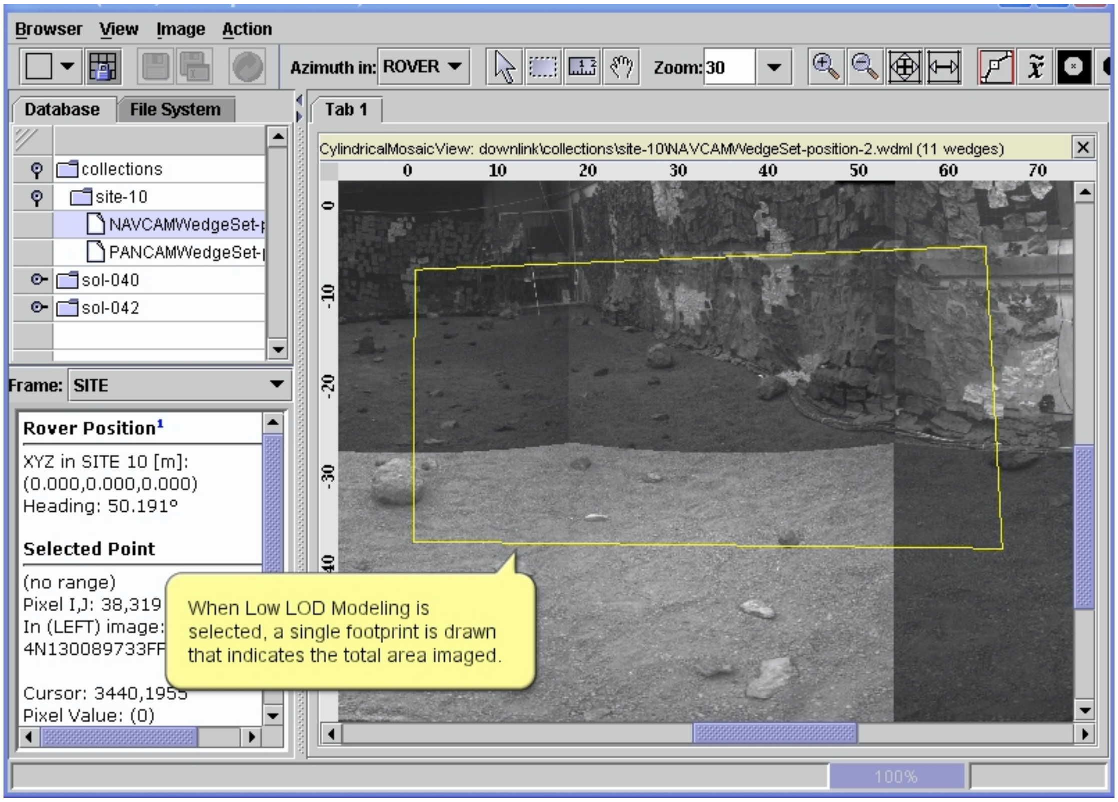


Figure 4.19: A Low LOD Pancam footprint (the default), drawn when the Low LOD Modeling checkbox is checked.

the Low LOD Modeling checkbox as shown in Figure 4.21. Since High LOD modeling requires significant system resources, the Activity will only remain in High LOD mode until another activity is selected. At that time, the Activity is returned to Low LOD mode.

Large Mini-TES activities can produce hundreds of footprints. High LOD Footprints for these Activities may take up to a minute to draw, so don't un-check the Low LOD Modeling checkbox on these Activities unless you are prepared to wait a while!

4.3.4 Visualizing Activities in the 3D view

When an Activity would cause the rover arm, mast, or the rover itself to move, Maestro simulates these effects by modifying the state of the 3D rover model in all open 3D views whenever the Activity is selected. To use this activity, first open a 3D or Overhead view by following the steps in Section 3.5. Next, make sure you have a plan open (see Section 4.1) and add an Activity to the plan that would cause the rover to move — a rover

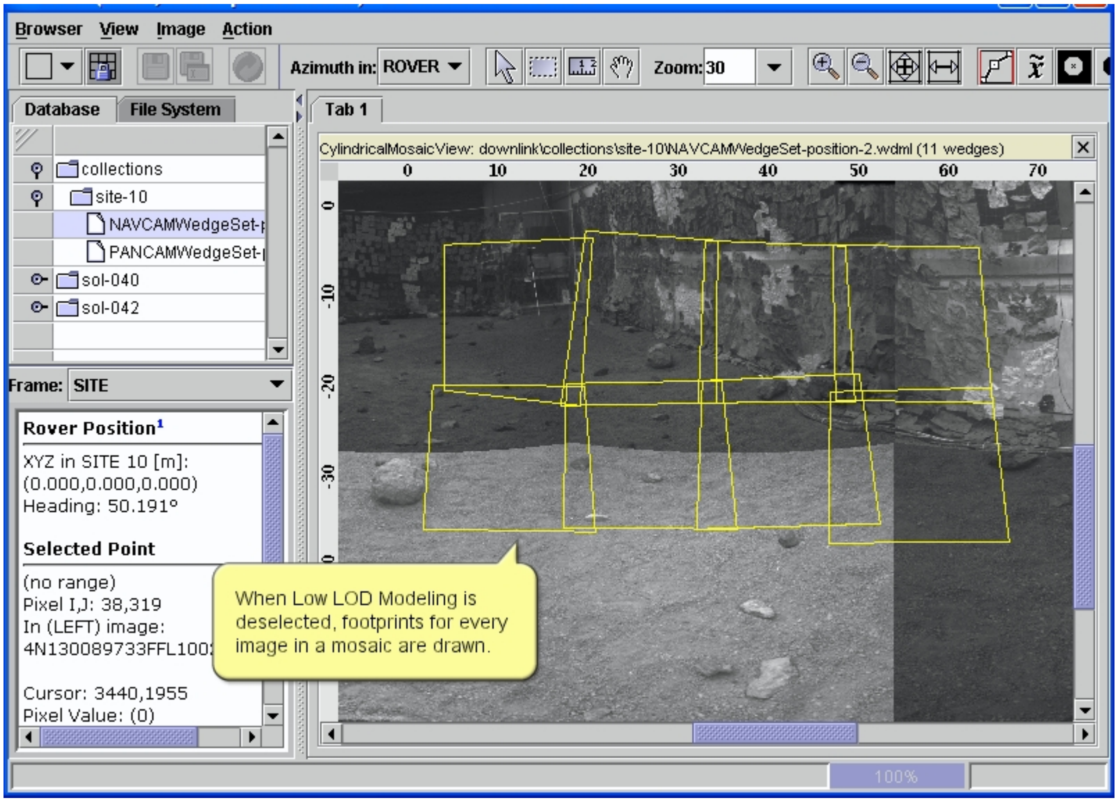


Figure 4.20: A set of High LOD Pancam Footprints, drawn when the Low LOD Modeling checkbox is unchecked.

drive activity, for instance. Select the Activity and set the values of the arguments in the Details Dialog as desired. As you change the arguments that control the movement of the rover (distance or destination in the case of a rover drive activity), the 3D model of the rover will immediately move in the 3D view. You can quickly step through the expected states of the rover by clicking through the activities in the plan while watching the 3D view.

Figure 4.22 shows three ways that the rover's state is simulated in the 3D view. The first image shows the appearance of the 3D rover when a Microscopic Imager Activity is selected. The rover's arm is shown in the position that it is expected to be in at the conclusion of the selected activity. This capability allows you to confirm that a potential arm target does not place the rover arm at a particularly awkward angle. Rover driving activities will cause the 3D model of the rover to move to a new position in all open 3D views, as shown in the middle image of Figure 4.22. Also, it is occasionally useful to confirm that an Activity is causing the rover's Pancam/Mast Assembly to point in the correct direction. By navigating in the 3D view such that the rover's mast becomes clearly visible (see Section 3.5 for information on 3D view navigation), you can see which

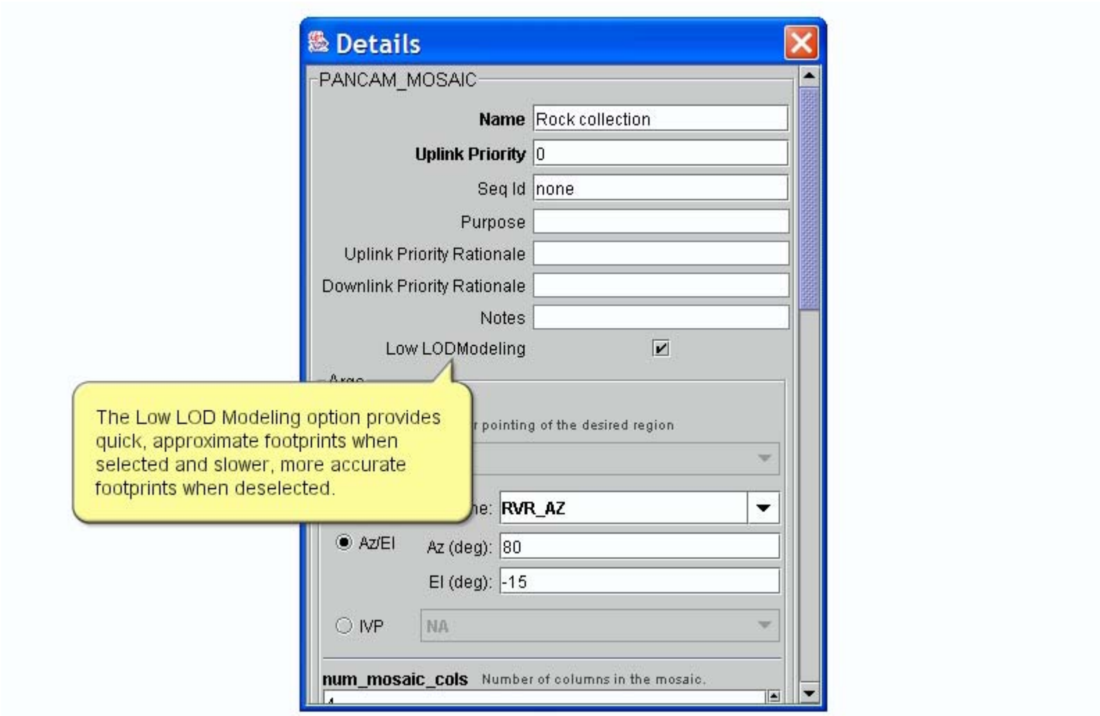


Figure 4.21: The Low LOD Modeling option in the Details dialog.

direction the mast will be facing at the conclusion of the selected Activity. The right image of Figure 4.22 shows the configuration of the mast at the conclusion of a Pancam activity of the area in front of the rover.

When you select an Observation, the 3D rover will be shown in the state it is expected to be in at the conclusion of all the Activities in that Observation.

4.3.5 Saving and loading plans

As you build plans within Maestro using the steps described in Section 4.3, you should periodically save your work. To do this, click on the save button in the Uplink browser toolbar or click on the Save menu item within the Browser menu in the Uplink browser. If this is the first time you have attempted to save this plan, the dialog show in Figure 4.23 will be displayed. You must use this dialog to navigate to the directory where you wish to save the plan. It is not necessary to add the ".rml" extension to the end of the plan name — this will be added automatically when you click the Save button in the dialog. Later, clicking the save button will not display the Save dialog but will instead just save the plan to the same file as before.

When you save a plan, the name of the file that it was saved to will be displayed in

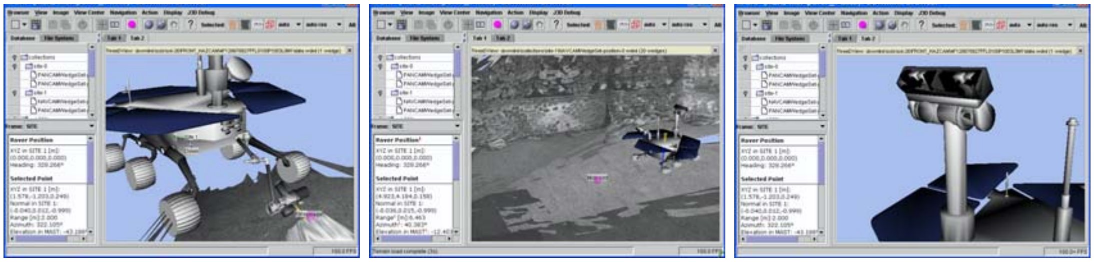


Figure 4.22: The 3D view showing the expected state of the rover after a Microscopic Imager Activity (left), a rover drive Activity (center), and a Pancam activity (right).

the title bar of the plan's view. When a plan has modifications that have not been saved, an asterisk (*) is displayed at the end of the filename in the view title bar. Whenever the plan is saved, this asterisk diMaestropears until a new modification is made.

Sometimes you will need to save a plan to a new file. To do this, click on the Save As button in the Uplink browser toolbar or click on the Save As menu item within the Browser menu. This will display the Save Plan dialog shown in Figure 4.23 and allow you to choose a new filename for your plan.

Once a plan is saved, it can be loaded from the Uplink selection tree on the left side of the Uplink browser. As shown in Figure 4.24, you can navigate to the location on the filesystem where the plan is saved and drag the plan in question into the view grid on the right side of the browser. You can also load the plan in the least recently used pane of the view grid by double clicking on it.

The selection tree is automatically updated each time you open or close one of its folders. If you save a new file to a folder and don't see it, just open and close the folder to refresh its contents.

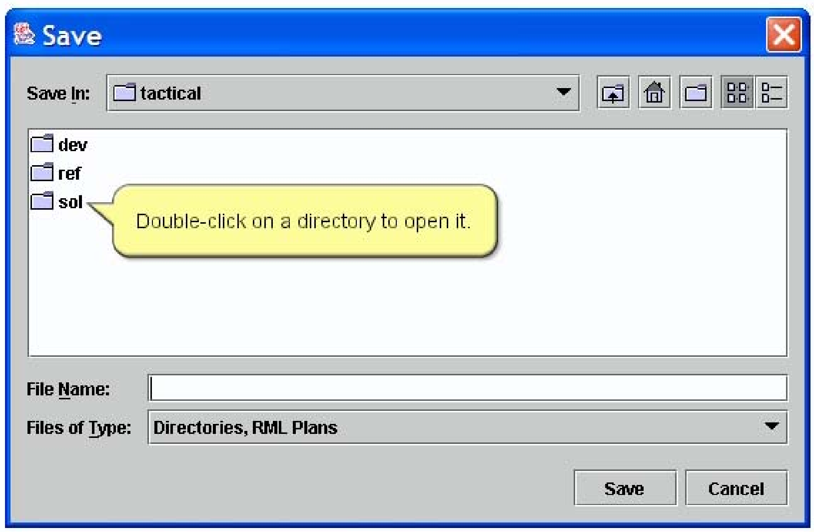


Figure 4.23: The Save Plan dialog.

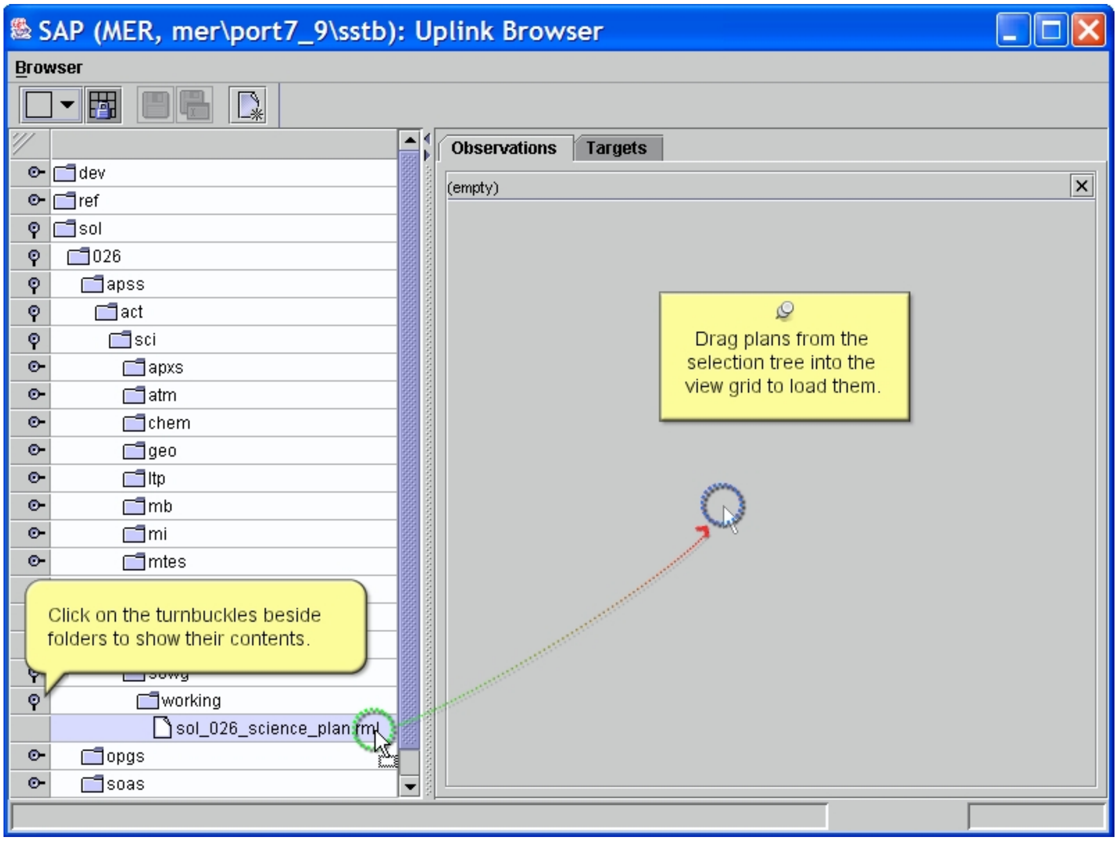


Figure 4.24: Loading a plan from the Uplink browser selection tree.

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Glossary

- Activity: A low-level planning construct that describes a specific action or set of actions that the user wishes the rover to execute. Activities contain arguments, which are set to specify exactly how the rover should accomplish the action. Activities are contained within Observations.

- APXS: The Alpha Particle Xray Spectrometer, one of the IDD instruments for detailed compositional analysis of rocks and soils.

- azimuth: Direction of facing, as in a compass heading. For sites, zero degrees points north and the azimuth angle increases through 360 degrees in the clockwise direction.

- browser: One of the two main SAP windows, the Uplink Browser and the Downlink Browser.

- color composite image: a color image that is generated by combining several images together to form the red, green, and blue channels.

- Details dialog: A companion window of the Uplink browser that allows the user to view and edit the details about the selected Observation, Activity, Feature, or Target.

- elevation: Direction of tilt, as in when you nod your head. Zero degrees is looking straight ahead, and the elevation angle increases through 90 degrees looking straight up and decreases through -90 degrees looking straight down.

- Feature: A label for an object or region on Mars. A Feature refers to an object, such as a rock, cliff, or patch of soil as a whole. Features contain Targets, which refer to a specific location within the Feature.

- Footprint: A box or circle drawn in a SAP downlink view that indicates the area that is expected to be imaged by the currently selected Activity. Described in detail is section 4.3.3.

- Hazcam (Front and Rear): Stereo camera pairs located at the front and rear of the rover that are used for assessing reachable arm instrument targets and also for automatic obstacle avoidance during rover drive activities.

- header (of an image, also PDS header): archived mission data products have an attached header that describes the image, the state of the spacecraft at the time of acquisition, and other related information.

- IDD: The Instrument Deployment Device. The instrument arm, located on the front of the rover and carries the MI, APXS, Moessbauer, RAT instruments for detailed in situ (close range) analysis of rocks and soils.

- LOD: Level of Detail. This term is typically used in the context of high or low LOD modeling and footprints, described in section 4.3.3.

- Mini-TES: The Mini Thermal Emission Spectrometer. Located in the body of the rover and looking up through the PMA like a periscope, Mini-TES can see the surroundings in the infrared spectrum. Using this infrared spectral data, mineral composition of rocks, soil, and other geological formations can be determined from a distance to identify scientifically interesting destinations to drive to and examine up close.

- MI: The Microscopic Imager camera. Located on the instrument arm (IDD), the MI can take extremely close up images of soil or rock surfaces by extending the arm and placing the camera up close (~2 cm).

- Moessbauer: The Moessbauer (or Mössbauer) spectrometer, one of the IDD instruments for detailed compositional analysis of rocks and soils. This instrument excels at detecting iron-bearing minerals.

- monoscopic camera: a single camera or instrument (as opposed a stereo camera pair).

- Navcam: The Navigation Camera. A stereo camera pair that is lower resolution than Pancam but is useful for quickly characterizing the topograhy of a site with 3D images to support the planning of rover drives (traverses) and approaches to nearby rock and soil targets of interest.

- Observation: A high level planning construct that contains a group of Activities. Observations contain detailed intent information that describe why the activities they contain are being proposed.

- Pancam: The Panoramic camera. Located on the mast (PMA), Pancam is a high-resolution narrow field of view stereo camera pair capable of capturing color and 3D images using 16 color filters (8 filters per eye). Pancam also tracks the position of the Sun as an aid to navigation.

- pixel coordinates: the location of a pixel in an image, denoted (i, j).$(0, 0)$ is the upper-left pixel, i increases to the right and j increases down.

- PMA: The Pancam Mast Assembly. The mast that pans and tilts the camera bar to aim the Pancam, Navcam, and Mini-TES at remote targets.

- position: A minor driving destination of the rover. Positions are automatically defined as the rover drives from one site (major destination) to the next. Position 0 is always co-located with the site.
- RAT: The Rock Abrasion Tool. One of the IDD instruments, used for grinding down into the unweathered interior of rocks to compare the inner composition and structure with the outer weathered surface.
- resource modeling: The task of estimating the impact of a set of Activities on the resources available to the rover on Mars. Examples of resources include energy, time, and downlink capacity.
- site: A major driving destination of the rover. Site 0 is on the lander and new sites are declared from mission control as the rover completes each major drive activity. Sites are almost always characterized by a partial or full panorama of images to establish the vehicle's local context in the surrounding terrain.
- sol: a Martian day (24 hours and 39.5 minutes of Earth time).
- stereo camera pair: Two cameras positioned adjacent to each other (as human eyes are arranged) to acquire 3D imagery of a scene
- Target: A label for a specific location on Mars. Targets are contained by Features, and are used as arguments to Activities.
- xyz coordinates: a three-dimensional location in space. For sites, xyz indicates position in a coordinate frame where x increases to the north, y to the east, and z straight down (nadir).

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