

# Magellan MIDR User's Guide

## for the PDS4 Dataset

11/20/2023

### 1.0 Introduction

This document is a quick start guide to the updated Magellan MIDR (Mosaicked Image Data Record) archive. This updated MIDR dataset was created by the Planetary Data System's (PDS) Geosciences Node as part of the Node's effort to migrate all its holdings to the PDS4 standard (<https://pds.nasa.gov/datastandards/documents/current-version.shtml>). The MIDR dataset consists of Synthetic Aperture Radar (SAR) images of the surface of Venus projected at four different resolutions. The resolutions of MIDRs are 75, 225, 675, and 2025 meters/pixel (Table 1). This new PDS4 MIDR archive contains the same data as the original PDS archive, but with the multiple small framelets of each product put together into a single mosaic. The updated archive also has contrast-enhanced and easier to display browse products stored as JPEG files, along with improved metadata in the MIDR PDS4 labels. This document will help users understand what is in the archive, how it was created, and how it is different from the original MIDR dataset. It also discusses several caveats and issues discovered during generation of the new, updated MIDR archive.

### 2.0 Magellan Mission

The Magellan radar mapping mission produced the first global, high-resolution image dataset of Venus. The spacecraft was launched on May 4, 1989. It arrived at Venus on August 10, 1990 and began systematic mapping of the Venus surface on September 15, 1990. One of main experiments for geologic mapping was Synthetic Aperture Radar (SAR) imaging. These SAR data were compiled into mosaics that make up the MIDR dataset originally archived with the PDS during the mission.

Magellan mission operations were divided into several mapping cycles, each being 243 Earth days in duration. This was the time it took Venus to rotate once under Magellan's orbit. The first three mapping cycles concentrated on collecting SAR imaging and altimetry and radiometry data. Ninety-eight percent of the surface was imaged during these three mapping cycles and many areas were viewed more than once with different imaging geometries and/or directions of illumination. The fourth and fifth cycles were devoted to mapping the planet's gravity field. The final cycle occurred after the spacecraft orbit was lowered to collect better gravity data near the poles. The mission completed on October 13, 1994 after the spacecraft was commanded to drop into the Venusian atmosphere (Saunders, *et al.*, 1990; Saunders, *et al.*, 1992).

### 3.0 SAR Image Data

The Magellan spacecraft orbit was elliptical (294 km by 8543 km) and nearly polar with an 85.5° inclination. The orbit period was 3.25 hours. Mapping started when Magellan was located above the North Pole and the High-Gain Antenna (HGA) was pointed toward the Venusian surface. Over four thousand usable SAR imaging orbits were obtained. The area covered by each orbit was typically 20 km wide and 17,000 km long. Because the area of new terrain observed by the sensor in equatorial latitudes was much greater than at the poles, it was possible to map high latitudes on alternating orbits with an acceptable margin of overlap. For example, in the first mapping cycle (Cycle 1), this technique was used to reduce redundancy and maximize areal coverage. Mapping started near the North Pole in each alternate orbit and continued to about 57°S latitude. In the intervening orbits, mapping started at about 70°N and extended to 74°S latitude.

The SAR data acquired on each orbit were formatted into an image product known as an F-BIDR (Full-resolution Basic Image Data Record). F-BIDRs are sampled to a pixel size of 75 m in both cross-track and along-track directions. However, the actual spatial resolution of the data in the cross-track direction varies with latitude. F-BIDRs were the input products for generating the F-MIDRs (Full-resolution MIDRs). A secondary image product, known as a C-BIDR, was also created from SAR data. C-BIDRs are similar to F-BIDRs, but they are down-sampled to a pixel size of 225 m. C-BIDRs were used to generate the C1-MIDRs. C2-MIDRs were made by down-sampling C1-MIDRS, and likewise, the C3-MIDRs were made by down-sampling the C2-MIDRs. Table 1 lists the pixel sizes for each of the four types of MIDRs.

The objective of mapping cycle 1 was to acquire radar data for 70% of the surface, but data for nearly 83.7% of the surface was obtained. The spacecraft was oriented to acquire left-looking data such that the HGA was pointed to the east of the spacecraft ground track. Mapping cycle 2 focused on filling gaps in coverage from cycle 1 and obtaining coverage of the South Pole region. These polar data were acquired with a right-looking orientation. Cycle 2 provided only about 54.5% surface coverage because of mapping time lost due to spacecraft issues. Cycle 2 also did a test for acquiring stereo data by observing areas mapped in cycle 1 with a different incidence angle. The last SAR mapping cycle, cycle 3, was focused on acquiring stereo image coverage. About 21.3% of the planet was covered with same-side stereo images.

### 4.0 Original MIDR Dataset

As noted, MIDRs are mosaics generated from either F-BIDRs or C-BIDRs. The MIDR dataset contains F-MIDRs (Full resolution), C-MIDRs (Compressed resolution MIDRs), and two P-MIDRs (Polar MIDRs). MIDR data products produced by the Magellan project used the best available source products (F-BIDR and C-BIDR) at the time MIDRs were made. As such, individual MIDR mosaics may contain data gaps in terms of the area covered or may contain

degraded data. Some MIDR products were regenerated later in the mission and, thus, may have some of the data gaps filled. In addition, the Magellan project did not have sufficient funds to create F-MIDRs covering the entire surface of Venus. The project focused on making F-MIDRs for key terrains of high science interest. As a result, three sets of C-MIDRs with reduced resolutions were generated to provide full coverage of the planet. C1-MIDRs were made from C-BIDRs and have a pixel size of 225 m, C2-MIDRs were reduced in pixel size by a factor of three relative to C1-MIDRs to yield a pixel size of 675 m. Finally C3-MIDRs were reduced by another factor of three relative to that of C2-MIDRs for a pixel size of 2025 m (Table 1). The P-MIDRs have a pixel size of approximately 225 m.

The format of the original MIDR dataset is described in a Magellan project document (Lewicki, 1991). F-MIDR and C-MIDR mosaics were generated without geometric resampling of F-BIDR or C-BIDR pixels. Each F-MIDR and C-MIDR mosaic contain 7168 lines and 8192 samples. The mosaics were divided into framelets that were 1024 x 1024 pixels in size for storage and distribution on CD-ROMs (McMullen, S., 1992). The creation of framelets and their small size were designed to match the available computer and image display capabilities at the time of the Magellan Mission in the early 1990s. The full mosaic was divided into 56 framelets in an array of eight columns and seven rows. The two P-MIDRs were also divided into smaller files with 100 framelets in each mosaic. The P-MIDR framelets are also 1024 x 1024 pixels in size. When the P-MIDR framelets are reassembled there are 10 columns and 10 rows of framelets in each mosaic.

Table 1. Summary of MIDR Product Characteristics

Product Type	Pixel Size, m	Area Coverage <sup>1</sup> , km	Area Coverage <sup>2</sup> , deg
F-MIDR	75	540 x 610	5 x 5
C1-MIDR	225	1600 x 1800	15 x 15
C2-MIDR	675	4800 x 5500	45 x 45
C3-MIDR	2025	9500 x 13000	90 x 120
P-MIDR	225		~15 x 360

<sup>1</sup>Values in km are approximate. <sup>2</sup>Approximate area coverage for latitude x longitude.

All MIDR products are map projected. F-MIDRs and C-MIDRs are projected in sinusoidal map projections, whereas the P-MIDRs are in polar stereographic projections. Section 7.0 describes the map projections in more detail.

The MIDRs were originally put onto a series of 126 CD-ROMs by the Magellan project (McMullen, 1992). There were several hundred copies of each CD-ROM made and they were widely distributed to the interested research community. Each CD-ROM contains ten mosaics, along with ancillary data. An additional volume (volume\_id MG\_0127) was produced as a write-once CD (CD-WO) with the two polar MIDRs and five C3-MIDRs. This last CD had only limited distribution. The PDS Geosciences Node has since copied all the CD-ROMs and the CD-WO to the node's online repository (original dataset located at: pds-

geosciences.wustl.edu/missions/magellan/fmidr). The Geosciences Node's online repository was used as the source to generate the new products in this updated PDS4 archive.

## 5.0 PDS4 Archive Organization

The updated MIDR dataset was created using the PDS4 standard. This section describes the organization of the dataset according to PDS4 standards. The highest level of organization for a PDS4 dataset is called a **bundle**. A bundle is a set of one or more related collections that can be of different types. A **collection** is a set of one or more related **basic products**, which are typically all of the same type (e.g., raw, calibrated, or derived data, documents; etc.). Basic products in PDS4 contain one or more digital objects (table, images, etc). Bundles and collections are logical structures, not necessarily tied to any physical directory structure, although the physical organization of a PDS4 dataset usually follows the bundle and collection structure.

All items in a PDS4 archive are considered products. A PDS4 product consists of a PDS4 label and the item that the label describes, typically one or more files. For example, an image product comprises both the image and the label that describes that image. The exception is a bundle product, which is a single xml file that lists the collections in the bundle. Bundle products can also reference an optional readme file. PDS4 labels use XML (eXtensible Markup Language) to express the metadata about a product. The PDS4 label is stored in a file separate from the object it describes. Each PDS4 product is uniquely identified by a string in its label called a Logical Identifier (or LID). A LID consists of up to six tokens separated by a colon. The first three are fixed for datasets archived by the PDS. These first three are: "urn:nasa:pds". The fourth token is the bundle identifier. In this case the bundle identifier is: "magellan\_midr". The fifth token is a collection identifier, whereas the sixth token is a product identifier. This formation rule generates a unique LID across all of PDS because the bundle identifier has to be unique across the PDS, the collection identifier has to be unique within the bundle, and finally the product identifier has to be unique within its collection. An example of a MIDR product LID is:

urn:nasa:pds:magellan\_midr:data:fmidr\_15s054\_201

The product identifier token is usually based on the product file name without the extension. The file name formation rule for MIDR products is described in the next section.

If there are multiple versions of a PDS4 product, these can be distinguished by version identifier (VID), which has the form M.n, with M indicating the major version (starts with 1) and n noting minor version revisions (starts at 0 for each major version). The VID is listed as an attribute in the PDS4 label. The LID and the VID can be combined to refer to a specific product version by concatenating the LID and VID with two colons. This is known in PDS4 as a LIDVID. For example, the LIDVID of version 1 of the product above would be:

urn:nasa:pds:magellan\_midr:data:fmidr\_15s054\_201::1.0

The MIDR PDS4 bundle has four collections – data (MIDR mosaics), browse, document, and miscellaneous. Each collection is described in more detail below.

## 5.1 Data Collection

The PDS4 MIDR products are stored in the data collection. The collection identifier is "data", and all mosaics are stored in a physical directory named "data" under the bundle root directory. The directory "data" contains the collection product, which is a PDS4 label and a CSV file with an inventory of all products in the collection. The inventory file has two fields. The first field indicates whether the product is a primary or secondary member of the collection. All MIDRs are primary members. The second field lists the LIDVID for a product. For example:

```
P,urn:nasa:pds:magellan_midr:data:c1midr_00n163_1::1.0
```

There are three subdirectories under the "data" directory. These are: "fmidr" for F-MIDRs, "cmidr" for all types of C-MIDRs, and "pmidr" for the two P-MIDRs.

Each mosaic product consists of three files. There is the mosaic image file (\*.img), an ENVI header file (\*.hdr) for use in reading the mosaic into the commercial ENVI software package, and a PDS4 label (\*.xml) that describes both. The file names have the form of:

```
zmidr_nnhmmm_vvv.ext
```

where z is the MIDR type (f, c1, c2, c3, or p); nn is the approximate center latitude; h indicates which hemisphere the mosaic is centered in (n or s); mmm is the approximate center east longitude; and vvv is a pseudo version number of one or three digits. This version number was assigned in the original product delivered by the Magellan project. A single digit version number indicates the mapping cycle in which the data were acquired, whereas for a three digit version number, the left-most digit is the mapping cycle and the right-most digit is a version for the product. This version number is important because there can be mosaics with the same center, but acquired in different mapping cycles. There are also a few cases where a mosaic from a given mapping cycle was redone leading to a second version. An example file name for an image product is:

```
fmidr_30s041_201.img
```

As noted, the mosaic file name without an extension is used as the product identifier in its LID.

The naming convention for the two polar MIDRs is different. The polar mosaics are named *pmidr\_north.img* and *pmidr\_south.img*, for the north and south products, respectively.

## 5.2 Browse Collection

The browse collection contains a subsampled and contrast-enhanced version of each MIDR mosaic stored as a JPEG image. The collection identifier is "browse". All of the browse products are located in a directory named "browse" under the bundle root directory. The organization of the browse collection is the same as for the data collection in terms of subdirectories. Details on how the browse products were created are given in Section 6.2. The browse products are intended for quick-look reviewing of the mosaics. Each browse product consists of two files: the JPEG image (\*.jpg) and its PDS4 label (\*.xml). The PDS4 label for the browse product has a

pointer to the LID of the primary mosaic product. The pointer can be found in the Reference\_List of the PDS4 label and looks like this:

```
<Reference_List>
  <Internal_Reference>
    <lid_reference>urn:nasa:pds:magellan_midr:data:fmidr_30s041_201</lid_reference>
    <reference_type>browse_to_data</reference_type>
  </Internal_Reference>
</Reference_List>
```

File names for browse products have the same formation rule as file names for mosaic products with the addition of "\_brw" before the file extension. For example:

*fmidr\_30s041\_201\_brw.jpg*

The product identifier for a browse image in the product LID is the browse file name without the extension.

### 5.3 Document Collection

The document collection contains several types of documentation about the Magellan MIDR PDS4 archive. The collection identifier is "document". The document collection includes a series of ASCII text files that were derived from the PDS catalog files found on the original CD-ROMs. These files describe the Magellan mission, the spacecraft, the radar instrument, and the original MIDR dataset. This documentation was largely written in the 1990s by Magellan project personnel and science team members. The collection also includes two Magellan-project-produced SIS (Software Interface Specification) documents. One describes the MIDR products as stored on magnetic tape and the other describes the MIDR CD-ROMs. Both of these documents were only available as paper copies. A paper copy of each was scanned into PDF files for inclusion in this archive. This user's guide is also located in the document collection as a PDF file. Another document is an ASCII text file, *midr\_release\_notes.txt*, that lists any issues and notes found when generating the new PDS4 archive. Each document product is accompanied by a PDS4 XML label.

### 5.4 Miscellaneous Collection

A miscellaneous collection in PDS4 contains supplementary information useful in the interpretation and use of the data in the bundle, but that does not fit in the other collections. The MIDR bundle miscellaneous collection has a catalog of MIDR PDS4 products containing metadata about the MIDR mosaics. The file name of the catalog product is *midr\_catalog.csv*. This is a CSV file that contains metadata about each MIDR product, such as the mapping cycle in which the data acquired, whether the SAR data are left or right looking or acquired for same-side stereo, the latitude and longitude bounding box for the mosaic, and the volume\_id of the CD-ROM that contains the original framelets. It is intended to help users quickly look through the dataset to find mosaics of interest. The collection also contains a product that lists the parameters used to contrast enhance browse products. The *browse\_parameters.csv* file contains

three fields: browse file name, low\_DN, and high\_DN. The low\_DN is the Digital Number (DN) value of the MIDR product that is mapped to 0 DN in the browse product. Likewise, the high\_DN is the DN value of the MIDR product that is mapped to 255 DN in the browse product.

## 6.0 Detailed Data Product Descriptions

The subsections describe how the new products were generated, their structure, and their PDS4 labels.

### 6.1 MIDR Mosaics

As noted, the original MIDR products were divided into a series of framelets, each 1024 lines by 1024 samples in size. For the non-polar MIDRs there are 56 framelets in a mosaic arranged in 7 rows and 8 columns (Lewicki, 1991; McMullen, 1992). The framelets are arranged and numbered in a row-major order. The first framelet is located in the upper-left corner of the mosaic, the second is to the right of that, and so forth. The framelet number 56 is in the lower-right corner. Each mosaic was reassembled by simply reading the 56 framelets into a blank array without any geometric adjustments. Reconstructed MIDRs are 7168 lines by 8192 samples for non-polar mosaics. Pixel values are stored as unsigned bytes. The center longitude of the projection is the same in all framelet labels. The value in the first (upper-left corner) framelet was used for the PDS4 label. The remaining map projection parameters, such as the latitude and longitude limits of the mosaic, were computed because each framelet label only contained such information that framelet and not the mosaic as a whole. Note that during testing of the mosaic generation process, several errors were found for map projection parameters in the original PDS labels. See Section 8 for details.

The two polar MIDRs were divided into 100 framelets, arranged into a 10 x 10 array. The framelets have 1024 lines and 1024 samples. Thus, each reconstructed polar mosaic has 10,240 lines by 10,240 samples. The pixel size for the polar MIDRs is approximately 225 meters/pixel, the same as for C1-MIDRs. The north polar mosaic was constructed using left-looking data, whereas the south polar mosaic consists of right-looking data. The polar mosaics were reassembled in the same manner as the non-polar mosaics. The pixel values are also stored as unsigned bytes. In addition, some of the map projection parameters had to be computed because none of the framelets contained geometric information about the polar mosaic as a whole.

Every MIDR image file is supported by two separate ancillary files. One of these is an ENVI header file (\*.hdr). ENVI is a commercial image processing package that is widely used by researchers. The ENVI header file is an ASCII file that contains a number of parameters, such as image size in lines and samples and data type, which allows the software to read and display the mosaics. It also contains map projection information so that ENVI can convert pixel locations into latitude and longitude position on the planet.

The other ancillary file is the PDS4 label written as an XML document. It has the same base name as the image file, but with a file extension of \*.xml. The PDS4 label is broken up into a

number of sections. The first is the identification area, which contains the product LID, a title for the product, and the version of PDS4 standards that were used to construct the label. The next section contains pertinent metadata that can be used to support search tools, image display, and data analysis. For example, the `Mission_Area` contains metadata listing the product type (F-MIDR, etc.) and version, the mapping cycle in which the data were acquired, the look direction, and a pointer back to the original CD-ROM that the mosaic came from. There is a separate label section that provides the details about the mosaic map projection using the PDS4 cartography dictionary. The PDS4 label does not contain the time range when the data were acquired nor pointers to the F-BIDRs or C-BIDRs used in making the mosaic. This is because the information was not available in the original PDS labels on the CD-ROMs. The PDS4 label does list the mapping cycle in which the MIDR data were acquired. The last section of the PDS4 label describes the physical structure of the image file. This includes the number lines and samples in the mosaic and the data type. It also contains a pointer to the ENVI header file.

The reconstructed MIDR mosaics are binary image arrays with each pixel stored as an unsigned byte with a range of 0 to 255. Valid values in a MIDR mosaic range from 1 to 251 with DN values of 0 indicating no data and values above 251 intended for special use. The original MIDR dataset documentation (Lewicki, 1991; McMullen, 1992) does not define the meaning of these special values and it appears that the special values were not used. Valid DN values in the image can be converted to a relative radar cross section ( $\sigma_r$ ) using the following equation:

$$\sigma_r = \frac{DN - 101}{5}$$

or

$$\sigma_r = -20 + \frac{DN - 1}{5}$$

The relative radar cross section is the radar cross section divided by the Muhleman Law (Muhleman, 1964). The relative radar cross section is in decibels (dB). Using the equation above shows that the range in dB is from -20 to +30 because the range of DNs in the images goes from 1 to 251. See Campbell (1995) for details on computing radar cross section.

Several validation steps were done to ensure the quality control of the reconstructed mosaics. Each MIDR on the original CD-ROMs has a binary file named *hist.tab*, which contains a histogram of the complete mosaic. The file lists the number of pixels in the mosaic that occur for each DN value from 0 to 255. These data were used as a quality control check by comparing the histogram of the reconstructed mosaic with the values in the *hist.tab* file. Any inconsistencies were investigated by visually inspecting the mosaic to make sure the mosaic looked correct and that there were no obvious problems due to the mosaic generation process. If the mosaic looked correct, then the discrepancy in the histograms was noted in the release notes

(*midr\_release\_notes.txt*) file in the document collection. Spot checks were also done by displaying a subset of the reconstructed mosaics in ENVI and the PDS4 data viewing tool ([https://sbnwiki.astro.umd.edu/wiki/PDS4\\_Viewer](https://sbnwiki.astro.umd.edu/wiki/PDS4_Viewer)). Latitude and longitude location information was also spot-checked when the mosaic was displayed in ENVI.

## 6.2 Browse Products

A browse version of each mosaic was generated to provide a quick-look product that can be used to scan through the collection of mosaics. The browse products for F-MIDRs and C-MIDRs were created by first subsampling the mosaic by a factor of 2 in each dimension by averaging pixel values in each 2x2 array from the mosaic. The resulting browse product contains 3584 lines and 4096 samples. A linear contract stretch was then applied to the subsampled browse image. Stretch parameters were computed by first ignoring zero valued pixels and then setting the stretch limits using values of 0.3% and 99.7% of the cumulative histogram. The stretch limits were based on what gave reasonable-looking images based on a set of test mosaics. P-MIDR browse products were made by subsampling the original mosaic by a factor of 4 in each dimension because these products are nearly twice as big as the other MIDR types. The browse images are stored with JPEG compression to further reduce the browse file size and for easy display.

Each browse JPEG image file is accompanied by a separate PDS4 label as a separate XML file. The label has the same base name as the browse image, but with an extension of \*.xml. The browse label is similar to the label for the mosaic product. It contains the standard identifying information in all PDS4 labels and information on the physical structure of the browse file, in this case noting that it is a JPEG file. The label also has a pointer to the full-resolution mosaic product.

## 7.0 Map Projections

There are two map projections used in the Magellan MIDR dataset. A sinusoidal projection is used for the non-polar mosaics and a polar stereographic projection is used for the two polar mosaics. The subsections below describe the details of each projection type. Both projections use a spherical model for Venus with a radius of 6051.0 km. East longitudes are positive. The PDS4 map projection parameters assume that whole number values of line and sample correspond to the center of a pixel. For example, the center of the upper-left corner pixel has coordinate values of 1.0 for both line and sample, whereas, the upper left corner of this pixel has coordinate values of 0.5 for both line and sample.

### 7.1 Sinusoidal Projection

Non-polar MIDR mosaics are projected as sinusoidal projections, which is an equal-area projection. In a sinusoidal projection, lines of latitude are equally-spaced, straight lines. The central longitude is also a straight line, but all other lines of longitude are convexly curved, with the spacing between lines of longitude decreasing away from the equator. The spacing between

longitude lines scales with the cosine of latitude, so they converge as the latitude increases away from the equator. The center latitude of all Magellan MIDR mosaics is  $0^\circ$  even if the mosaic does not cover the equator. The center longitude of each mosaic is picked to be at the center of the mosaic and varies from mosaic to mosaic.

The map projection section of the PDS4 label has a set of attributes that define the bounding box of a sinusoidal MIDR mosaic. Latitude values of the bounding box were computed based on the first and last lines of a mosaic. For mosaics that cover at least part of the northern hemisphere, the longitude limits were determined from the upper left and upper right corner pixels of the mosaic. For mosaics completely in the southern hemisphere, the lower left and lower right corner pixels were used to compute the longitude limits. Note that these corner points may be blank areas for some C2-MIDR and C3-MIDR mosaics because lines of longitude are curved inward in a Sinusoidal projection. Also, if a computed longitude value was less than  $0^\circ$  or greater than  $360^\circ$ , the value was adjusted to be in the range of  $0^\circ$  to  $360^\circ$  by either adding  $360^\circ$  or subtracting  $360^\circ$  as needed.

## 7.2 Polar Stereographic Projection

The two polar MIDRs use polar stereographic map projections centered on either the North or South Pole. Lines of longitude extend radially out from the center and lines of latitude are concentric circles around the center. The center longitude is  $90^\circ$  east and extends straight down from the center. Longitude  $180^\circ$  extends to the right.

The bounding box attributes in the PDS4 label indicates that the mosaic covers  $360^\circ$  of longitude. Latitudes extends to about  $\pm 74.67^\circ$  based on the corners of the polar mosaics.

## 8.0 Caveats

There are a few cases where the metadata in the original PDS labels on CD-ROMs are not correct. In addition, the information in these labels is limited. As a result, the metadata in the PDS4 labels has been corrected and augmented where needed.

A difference was discovered for the value of Venus' radius listed in the MIDR SIS (Lewicki, 1991) and in the original PDS labels on the CD-ROMs. The labels have a radius value of 6051.92 km whereas the MIDR tape SIS (Lewicki, 1991) states that a value of 6051.0 km was used to project the data. In addition, there is a difference in the value of map scale, which is derived from the planet radius. The map scale for F-MIDRs is 1407.4 pixels/degree in the original PDS labels and 1408.13045 pixel/degree in the SIS. Note the map scale decreases by a factor of 3 for each C-MIDR size reduction. It was determined that the values for radius and map scale given in the SIS were the correct values used to project the data. Using the SIS values gives accurate results for computing the latitude and longitude of the bounding area of a mosaic and

for individual pixel locations within a mosaic. Therefore the SIS values are the values provided in the PDS4 labels.

The original PDS labels on CD-ROM lists the mission phase for all MIDRs as "Primary Mission", which is not one of the defined project mission phases. Mission phase values used in the PDS4 labels are standard mission phase (e.g., mapping cycle 1) values. Mission phase information in the PDS4 labels was derived from an ancillary table found on the original CD-ROMs. The PDS4 labels also contains a new attribute "radar\_look\_direction" to indicate whether left-looking or right-looking data are contained in the mosaic. This attribute was also used in the PDS4 labels to indicate that the mosaic was acquired for same-side stereo.

## 9.0 References

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