

**RESTORATION OF MAGELLAN VENUS DATA USING PDS4 ARCHIVING STANDARDS.** E. A. Guinness, D. V. Politte, R. E. Arvidson, and P. K. Byrne, Dept. of Earth and Planetary Sciences, McDonnell Center for the Space Sciences, Washington University in St. Louis, 1 Brookings Drive, Campus Box 1169, St. Louis, Missouri, 63130; guinness@wustl.edu.

**Introduction:** The Planetary Data System (PDS) Geosciences Node at Washington University maintains an archive of Venus data from the Magellan Mission. Data returned by Magellan is currently one of the prime sources of data for Venus surface geology and geophysical studies [e.g., 1, 2]. The Magellan data archive at the Geosciences Node consists of twelve datasets that together comprise a data volume of about 750 Gbytes with over 700,000 files (Table 1). The PDS Geosciences Node is restoring its collection of Magellan Venus datasets in FY22 and FY23 using the current PDS archiving standard, known as PDS4 [3]. The restoration of Magellan datasets will make these data more accessible and useful to science investigators and will support science from recently selected Discovery missions to Venus, VERITAS and DAVINCI, as well as the ESA EnVision Mission.

**Magellan Mission:** The Magellan 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. The main experiments for geologic mapping were Synthetic Aperture Radar (SAR) imaging, altimetry and radiometry measurements using the spacecraft's main antenna, along with radio science experiments [4, 5]. The mission phases were divided into 243 Earth-day mapping cycles. The first three mapping cycles concentrated on collecting radar imaging and altimetry data. 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.

**Magellan Datasets at the Geosciences Node:** Table 1 summarizes the twelve Magellan datasets in the PDS Geosciences Node archive. F-BIDR (Full-resolution Basic Image Data Record) and C-BIDR (Compressed Basic Image Data Record) SAR data are along-orbit-track images that span nearly pole to pole with F-BIDRs being full resolution (75 m/pixel) and C-BIDRs being at a reduced resolution. F-MIDR (Full-resolution Mosaic Image Data Record) and Cx-MIDR (Compressed Mosaic Image Data Record) products are mosaics derived from the F-BIDRs and C-BIDRs, respectively. Cx-MIDRs have three different levels of resolution reduction. The ALT-EDR dataset contains

raw altimetry data organized by orbit track. Raw microwave radiometry data are stored with the F-BIDRs. The ARCDR data contain reduced altimetry and radiometry data stored in along-orbit-track format. The GxDR dataset contains a set of four global maps derived from altimetry and radiometry data, namely topography, slope, and microwave reflectivity and emissivity. SCVDR and GVDR datasets contain surface property parameters (e.g., RMS slopes and Fresnel reflectivity) derived from other Magellan datasets. Finally, several datasets were produced from radio sciences observations, including the raw radio science tracking data, gravity datasets (LOSAPDR and spherical harmonic models), and Bi-Static Radar (BSR) observations.

**Original Magellan Data Archives:** The Magellan Mission was one of the first planetary missions to archive its data to the PDS during its operational lifetime. PDS standards were in the early stages of development at that time, however. The standards used by Magellan pre-date even the PDS3 standard for some the datasets. Much of the documentation on data processing and storage formats only existed in paper form. In addition, early datasets were created on VAX computers using VAX storage formats for binary data, which are no longer in common use. Many of the raw datasets were written onto 9-track magnetic tape for delivery to PDS. Image mosaics and altimetry and radiometry data were transferred to CD-ROMs with hundreds of copies made and widely distributed to the interested research community. The remaining datasets were written to a limited number of write-once CDs (CD-WO). The Geosciences Node also transferred the several thousand F-BIDR 9-track tapes to hundreds of CD-WOs. The Geosciences Node currently has all of its Magellan archives online (see: [pds-geosciences.wustl.edu/missions/magellan](https://pds-geosciences.wustl.edu/missions/magellan)).

**Data Improvements from PDS4 Restoration:** The restoration of Magellan data archives is in some sense a project of "data archaeology" given the current use of obsolete formats and limited digital documentation. The restoration effort will include the use of simpler data storage formats, more uniform and robust metadata, and XML for metadata in labels, enabling a variety of standard software tools to access the metadata. As such, many of the Magellan data products will have to be reformatted to meet these goals and PDS4 data storage standards. For example,

the F-BIDR and C-BIDR image products must be reformatted because they contain line prefix bytes that are not compatible with PDS4. In addition, any binary data that was originally stored using VAX binary format will be converted to IEEE formats. For the F- and Cx-MIDR image products, the original 56 1k x 1k pixel frames of each mosaic will be merged into a single 8k x 7k pixel mosaic. Browse products will be generated, where appropriate, and stored in a commonly used format such as JPEG or PNG. Any dataset where the data have been reformatted, such as MIDRs, will undergo a full PDS peer review by a group of scientists interested in these datasets, consistent with PDS policy to have such a peer review when data bytes have been changed or re-ordered in a dataset.

**Dataset Restoration Priorities and Project Status:** Table 1 lists the priorities for restoration of Magellan datasets based on expected use by the science community and on input from our Node Advisory Group. We have assembled the relevant mission documentation for data formats. Paper documents have been scanned into digital format. We have designed PDS4 bundles and collections structures for each dataset, along with bundle and collection logical identifiers (LIDs, the unique identifiers used in PDS4). We have also started software development for data conversion for the MIDR and F-BIDR datasets. For the MIDRs, we have designed PDS4 labels and produced software to mosaic the 56 frames into a single map image (Figure 1), generate a JPEG browse product, and write the PDS4 label. The code is currently being tested to ensure that the metadata for the created mosaic is correct, particularly the map projection information. We are also developing software to convert the radar image data for each F-BIDR into a PDS4-compatible array format. As a dataset is restored, the new dataset will be ingested into the Geosciences Node Orbital Data Explorer (ODE) service for Venus ([ode.rsl.wustl.edu/venus](http://ode.rsl.wustl.edu/venus)), so that users can search, browse, and download the data.

**References:** [1] Byrne, P. K. et al. (2021) *Geology*, 49, 81-85. [2] Byrne, P. K. et al. (2020) *PNAS*, 118 (26) e2025919118. [3] Planetary Data System Standards Reference, Version 1.17.0.0, Oct. 14, 2021. [4] Saunders et al. (1992) *JGR*, 97, 13,067-13,090. [5] Johnson, W. T. K. (1991) *Proc. IEEE*, 79, 777-790.

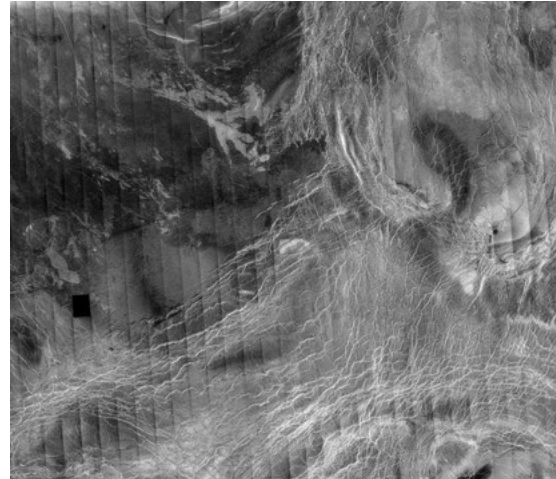


Figure 1: Example of a reconstructed F-MIDR mosaic centered at 10° north latitude and 42° east longitude.

Table 1: Geosciences Node Magellan Datasets <a href="http://pds-geosciences.wustl.edu/missions/magellan">pds-geosciences.wustl.edu/missions/magellan</a>			
Data Type	Restoration Priority	Volume, GBytes	Files
F-BIDR	1	480.698	229,632
C-BIDR	2	77.252	134,231
F-; Cx-MIDR	1	75.453	153,449
ALT-EDR	4	43.319	90,880
ARCDR	1	8.342	39,794
GxDR	1	0.507	802
SCVDR	3	29.664	51,786
GVDR	3	0.567	412
BSR	4	7.018	1,871
LOSAPDR	2	1.057	2,699
Spherical Harmonics	1	0.884	54
Radio Tracking	5	9.293	765
Totals		747.288	703,574
Restoration priorities: 1=highest; 5=lowest.			