PDS GEOSCIENCES NODE DATA AND SERVICES. S. Slavney, E. A. Guinness, T. C. Stein, J. Wang, L. E. Arvidson, and R. E. Arvidson, Earth and Planetary Sciences, Washington University, 1 Brookings Drive, Campus Box 1169, Saint Louis, Missouri, 63130, Susan.Slavney@wustl.edu.

Introduction: The Geosciences Node of NASA's Planetary Data System (PDS) archives and distributes digital data for the study of surfaces and interiors of the terrestrial planetary bodies. The Node works directly with NASA missions and the planetary science community to assist them in generating high quality and well-documented data archives.

The Geosciences Node (https://pds-geosciences.wustl.edu/) is one of six PDS Discipline Nodes, focusing on science data related to the study of terrestrial planets and the Moon. The Node maintains its archives online and provides them to all interested planetary scientists. The archives are also available to educators and the public to download free of charge. Node personnel provide expert assistance to researchers on use of data in the Node archives and are glad to answer questions from interested non-scientists as well. The Node has an Advisory Group of eight members who are active users of the Node's archives and services or providers of new data to our archives. The Advisory Group regularly reviews the Node's plans and provides advice on future Node activities.

Node Data Holdings: The Geosciences Node archives currently contain about 220 terabytes of digital data and are expanding at a rate of about one terabyte per month. The Node holdings include data from past NASA planetary missions, current missions, and data contributed by individual researchers. Data in the Node archives from past missions include the Lunar Crater Observation and Sensing Satellite (LCROSS), Chandrayaan-1, Clementine, Gravity Recovery and Interior Laboratory (GRAIL), Lunar Prospector, and Apollo for the Moon; MESSENGER for Mercury; Magellan for Venus; and Viking Orbiter and Lander, Mars Global Surveyor, Mars Pathfinder, and Phoenix Lander for Mars. The Node archives also contain data from earth-based and laboratory observations provided by several investigators.

Mission Interface: A major effort of the Geosciences Node is to work with planetary missions as they are designing and producing their data archives to help guarantee that the archives will be of high quality, well-documented and useful to the planetary science community at present and well into the future. Node personnel assist the mission archive producers during their archive design to ensure that the resulting archive will meet PDS standards for metadata content and archive structure. The Node also leads a peer review of planned mission archives to ensure that they are scientifically useful to the community. Once the mission is actively collecting data, the Node assists in validating that data deliveries conform to the intended design. Most active missions release new data once every three months.

Table 1 lists the planetary missions and instrument teams that deliver data to the Geosciences Node. The set of missions includes Lunar Reconnaissance Orbiter (LRO), Mars Reconnaissance Orbiter (MRO), Mars Exploration Rover (MER), Mars Odyssey, and the Mars Science Laboratory (MSL). In addition, the InSight Lander will begin delivering data in April 2019. The Geosciences Node also serves as a mirror site for data from the European Space Agency's (ESA) Mars Express mission through a Memorandum of Understanding between ESA and NASA.

The Geosciences Node is currently working with several instrument teams from the Mars 2020 Rover and Europa Clipper missions to design and plan their archives (Table 1).

Individual Data Providers: NASA has begun to emphasize that data generated by data analysis programs must be archived in the PDS or similar archive. The Geosciences Node is currently working with 35 funded investigators to archive their data with our node. We help these investigators with advice on PDS standards, archive design, peer review, and validation of the submitted datasets.

Data Migration: PDS has developed PDS4, an updated set of archive standards that replace the older PDS3 standards. Missions confirmed for flight after November 1, 2011 are required by NASA to use the PDS4 standards. For example, InSight, Mars 2020, and Europa Clipper will use PDS4 standards for their archives. PDS4 is a redesign of the PDS standards from the ground up, with a governance structure based on an information model that ensures consistency of data and metadata format across all missions and data providers. PDS4 data product labels are written in XML (eXtensible Markup Language), which will aid metadata conformance and allow the use of widely available XML tools for accessing the metadata. As a result PDS has been directed by NASA to begin migrating existing legacy data to the new PDS4 standard. The Geosciences Node recently migrated its MESSENGER data archives to PDS4, adding PDS4 metadata while preserving the contents and structure of the existing PDS3 archives (see: https://pds-geosciences.wustl.edu/missions/messenger/index.htm).

The Node plans to migrate most of its legacy PDS3 archives to PDS4 over roughly the next five years starting with its lunar and Venus datasets.

Web Services: The Geosciences Node's primary interface to the planetary science community is its web site at https://pds-geosciences.wustl.edu. All Node data holdings are online and available for download through the web site. The archives are organized by planet, mission, instrument, and dataset on the site. Given the large number of datasets and data products housed at the Node, we offer several search services to assist users in locating data that are of interest to them. The Orbital Data Explorer (ODE, https://ode.rsl.wustl.edu/) provides search and download capability for orbiter-based datasets from missions to Mercury, Venus, Mars and the Moon [1,2]. Users can search for data housed at the Geosciences Node and selected datasets archived at other PDS discipline nodes and data nodes. ODE offers form-based and map-based search filtered by mission, instrument, processing level, observation type, location, time, observation angle, and PDS product identifier. ODE provides a detailed view of its cataloged PDS metadata and provides a shopping cart system for downloading with Aspera, HTTP and FTP options. ODE supports a specialized granular query tool for subsetting science data at specified regions. An additional tool is provided to locate MRO and Phoenix coordinated observations. ODE also generates product type coverage KML (Keyhole Markup Language) files and shapefiles for use with GIS tools. Additionally, a Representational State Transfer (REST) interface (https://oderest.rsl.wustl.edu/) allows external users to access the ODE metadata and data products without using ODE web interfaces.

A complementary tool for searching and downloading landed mission data is the Analyst's Notebook [3,4]. The Analyst's Notebook also includes higher-order data products and documentation not included in the PDS archives, such as color context mosaics and APXS concentration data for MSL, and regular documentarian and mission manager reports for MER and MSL. Additional value-added components include integration of the Mars Target Enclyclopedia literature references linked to targets, interactive APXS concentration plots, feature measurement and 3-D profile tools, and image format transformations. Notebooks are available for the MER, MSL, Phoenix, and LCROSS missions. A version is also planned for the InSight mission. The Analyst's Notebooks are available at https://an.rsl.wustl.edu.

Users who need additional help or have questions about datasets at the Geosciences Node are encouraged to send email to geosci@wunder.wustl.edu or post a request on the Node forum at https://geoweb.rsl.wustl.edu/community/.

Technology Development: An advanced computational and storage infrastructure is required to support archiving operations at the Geosciences Node. In addition to the archives, hundreds of additional terabytes are required to house archive preparation space, databases, and virtual computing instances. The Node has fully integrated a virtual server platform that enables administrators to provision and deploy new servers and services within minutes.

The Node's infrastructure is comprised of a primary site that houses production systems and a secondary site that serves as a warm backup location. Data are synchronized to the secondary site daily to ensure continued operation of Node services in the event of a disaster.

High-speed networking and data transfer tools have been incorporated into the Node's systems to accommodate the process of ingesting and disseminating large amounts of data. Data providers are now able to upload data to the Node in a fraction of the amount of time compared to previous methods. Data transfer tools have also been added to sections of our public-facing web interfaces so users can download data over the high-speed network.

Table 1. Geosciences Node Archives of Instrument Data from Active and Future Missions

Active Missions	**Instruments**
Mars Odyssey	GRS, HEND, NS, Radio Science
MER	APXS, Mössbauer, RAT, Mini-TES, Pancam, MI, Navcam, Rover Motion Counter, Atmospheric Opacity, Radio Science
MRO	CRISM, SHARAD, Radio Science
LRO	Diviner, LEND, LOLA, Mini-RF, Radio Science
MSL	APXS, ChemCam, CheMin, DAN, SAM
InSight	HP^3/RAD, RISE, SEIS, IDA
Future Missions	**Instruments**
Mars 2020	PIXL, RIMFAX, SHERLOC, SuperCam, Returned Sample Science
Europa Clipper	MISE, REASON

References: [1] Scholes D. et al. (2018) *LPS XLIX*, Abstract #1235. [2] Wang J. et al. (2019) *LPS L*, this volume. [3] Stein T. C. et al. (2018) *LPS XLIX*, Abstract #1248. [4] Stein T. C. et al. (2017) *LPS XLVIII*, Abstract #1236.