

THE NASA PLANETARY DATA SYSTEM: PAST, PRESENT, AND FUTURE

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6/8/15

Back in the Day....1978



Archiving was not part of our mindset



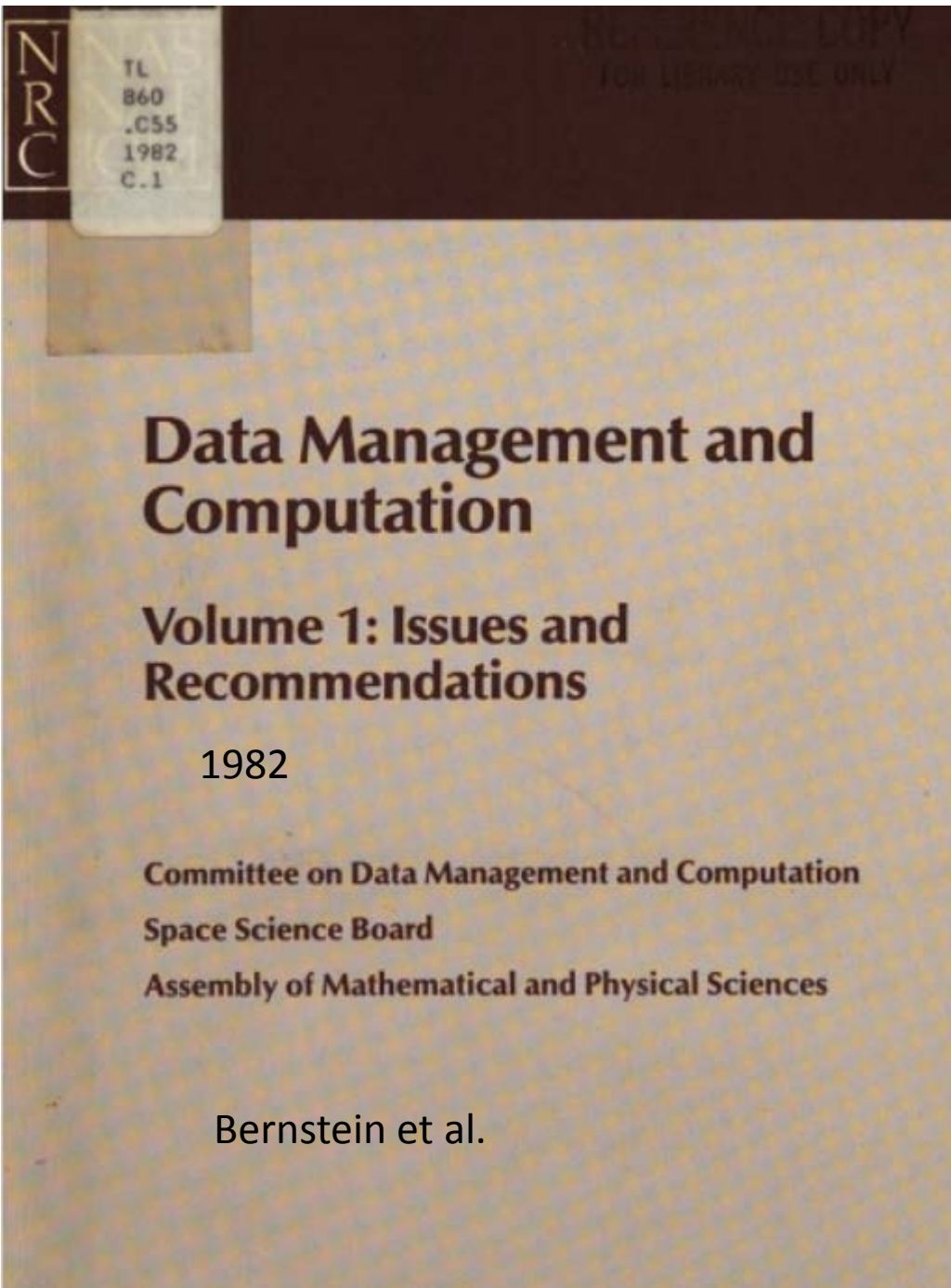
First use of interactive image processing with Apple

We Began to Recognize Limitations...Haphazard Archive Deliveries Without Proper Documentation



- Need more than large centralized archives
- Chartered Committee on Data Management and Computation (CODMAC) of the NAC/NRC Space Science Board (SSB) with three reports in 1980's before disbanding to look at how to do a better job

From "Raiders of the Lost Ark"



Guiding Principles for Archiving

- Management and not technology limitations are the major impediments to successful archives
- Highest quality archives are those housed with scientists who use the data and with oversight by those individuals
- Successful archives must have instrument and other data providers deliver well documented archives in standard form
- Formats and archive structure should be designed for use by scientists and strike balance between flexibility and economies of non-changing structures



**Issues and Recommendations
Associated with
Distributed Computation and
Data Management Systems
for the Space Sciences**

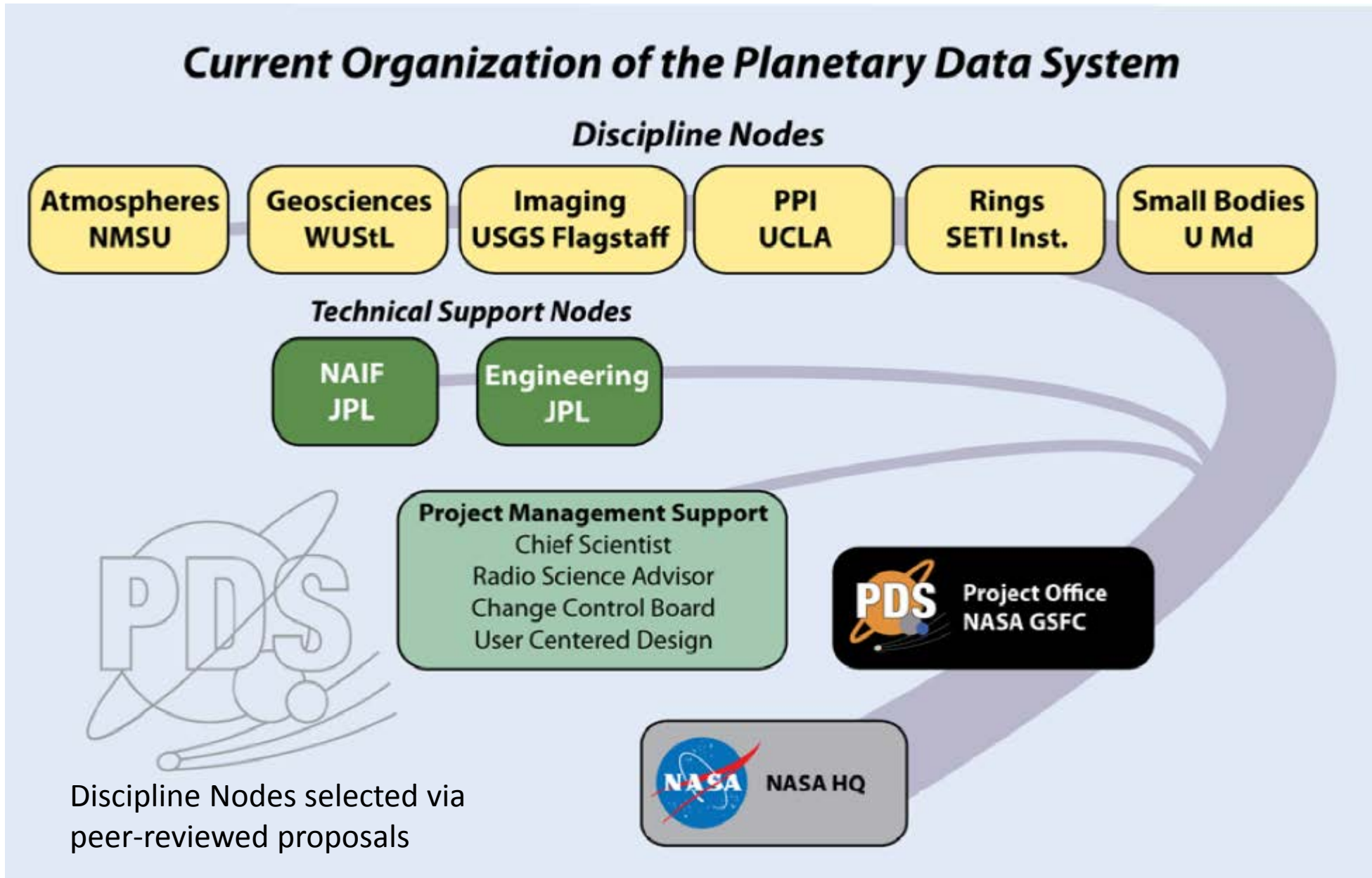
1986

Arvidson et al.

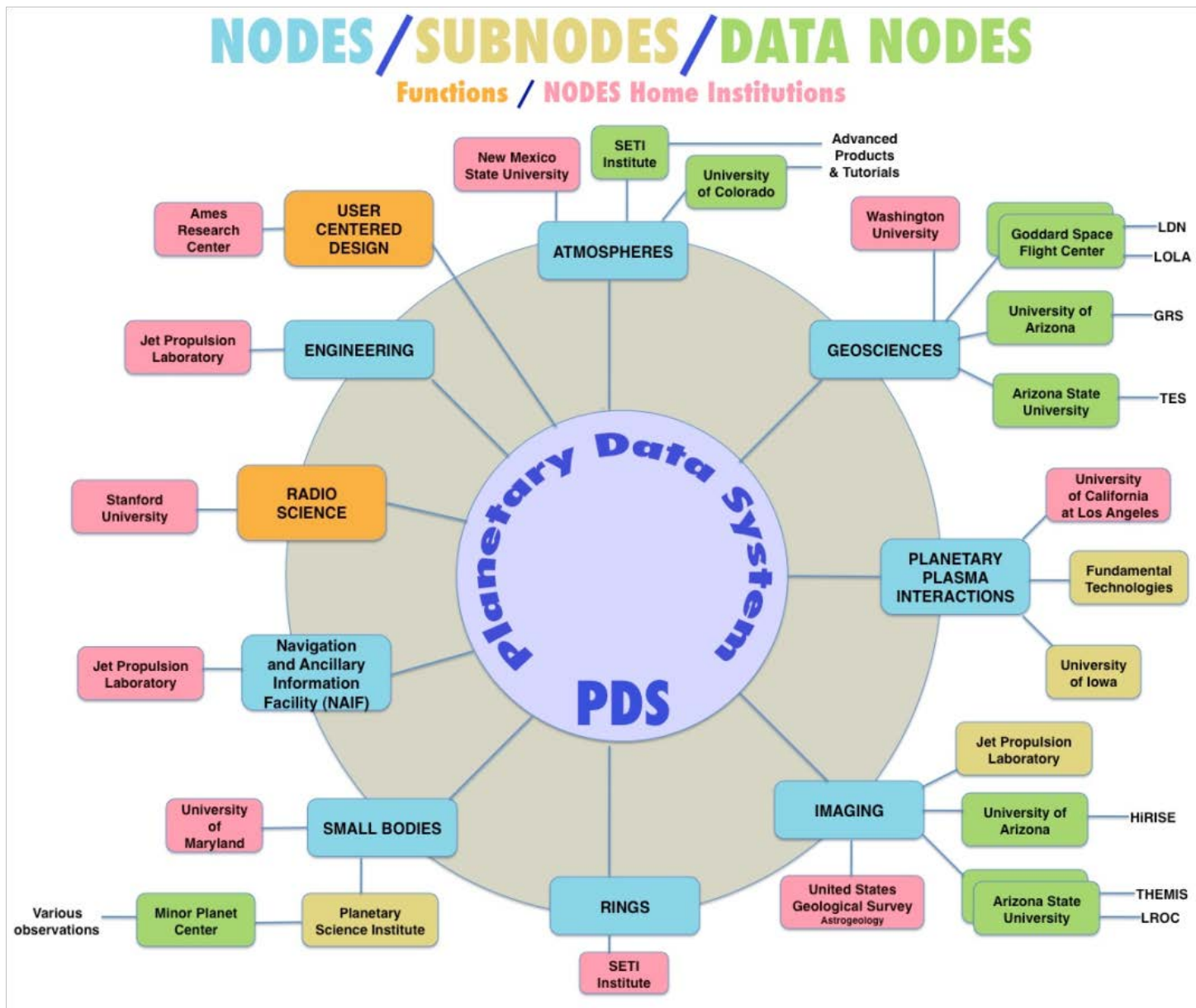
Guiding Principles for Distributed Archives

- Develop distributed archive centers focused on locations where scientists use the data and can provide archive oversight
- Continue to involve centralized archives for permanent storage
- Effective management and not technology limitations will be limiting factors in development of successful archives

PDS Approach...Distributed Data Archives

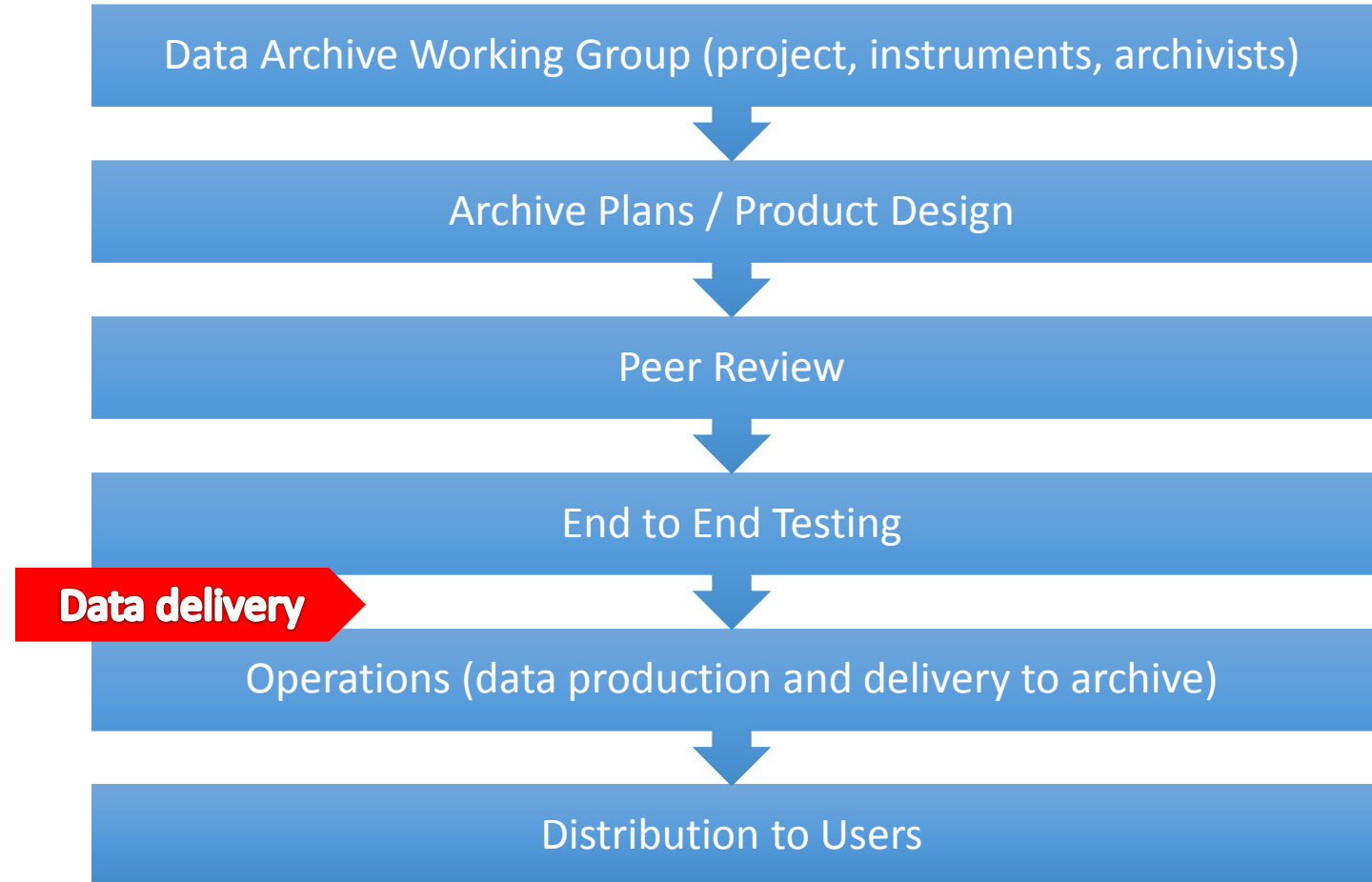


PDS Community Involvement



Structured Archive Development

Lessons learned from archiving experience have helped formulation of standard practices for interfacing with missions related to archive production.





PDS Geosciences Node

Washington University in St. Louis

HOME DATA AND SERVICES TOOLS ABOUT US CONTACT US SITE MAP

Services

- Analyst's Notebooks
- Virtual Astronaut
- Orbital Data Explorers
- Spectral Library
- FTP Access
- Workshops

Geosciences Node Data

- Mars
- Venus
- Mercury
- Moon
- Earth
- Asteroids
- Gravity Models
- All Geosciences Data Holdings

Help

- Frequently Asked Questions
- Geosciences Node Forums
- Help for Data Users
- Help for Data Reviewers
- Help for Proposers
- About Checksums
- Email Us

Scheduled Maintenance

This site will be down on Tuesday, June 9, 6:00-7:00 am CDT, for an equipment upgrade.

This site will be down on the Thursday after the second Tuesday of the month between 7:00 and 9:30 pm Central Time for maintenance.

Welcome to the Geosciences Node

The Geosciences Node of NASA's **Planetary Data System** (PDS) archives and distributes digital data related to the study of the surfaces and interiors of terrestrial planetary bodies. We work directly with NASA missions to help them generate well-documented, permanent data archives. We provide data to NASA-sponsored researchers along with expert assistance in using the data. **All our archives are online and available to the public to download free of charge.**

Where's the Data?

Click on **DATA AND SERVICES** in the black navigation bar above to browse our data holdings.

Coming Soon

- Jun. 12, 2015 - **MER** Release 44
- Jun. 15, 2015 - **LRO** Release 22
- Jul. 1, 2015 - **Odyssey** Release 52
- Jul. 31, 2015 - **MSL** Release 9
- Sep. 1, 2015 - **MRO** Release 34
- Oct. 9, 2015 - **MESSENGER** Release 14

The Geosciences Node is part of the **Earth and Planetary Remote Sensing Laboratory** in the Department of Earth and Planetary Sciences at Washington University in St. Louis.

What's New

June 5, 2015. New **Mars Express Radio Science** and **HRSC data** are posted.

June 2, 2015. New **Odyssey radio science data** are posted.

May 29, 2015. **MRO Release 33** includes new CRISM, SHARAD, and Radio Science data are posted.

May 13, 2015. New **Odyssey radio science data** are posted.

Apr. 29, 2015. New **Mars Express MARSIS** data are posted.

Apr. 17, 2015. New **Mars Express Radio Science data** are posted.

Mar. 31, 2015. Odyssey Release 51 includes new **raw and derived HEND data**.

[What's Old](#)

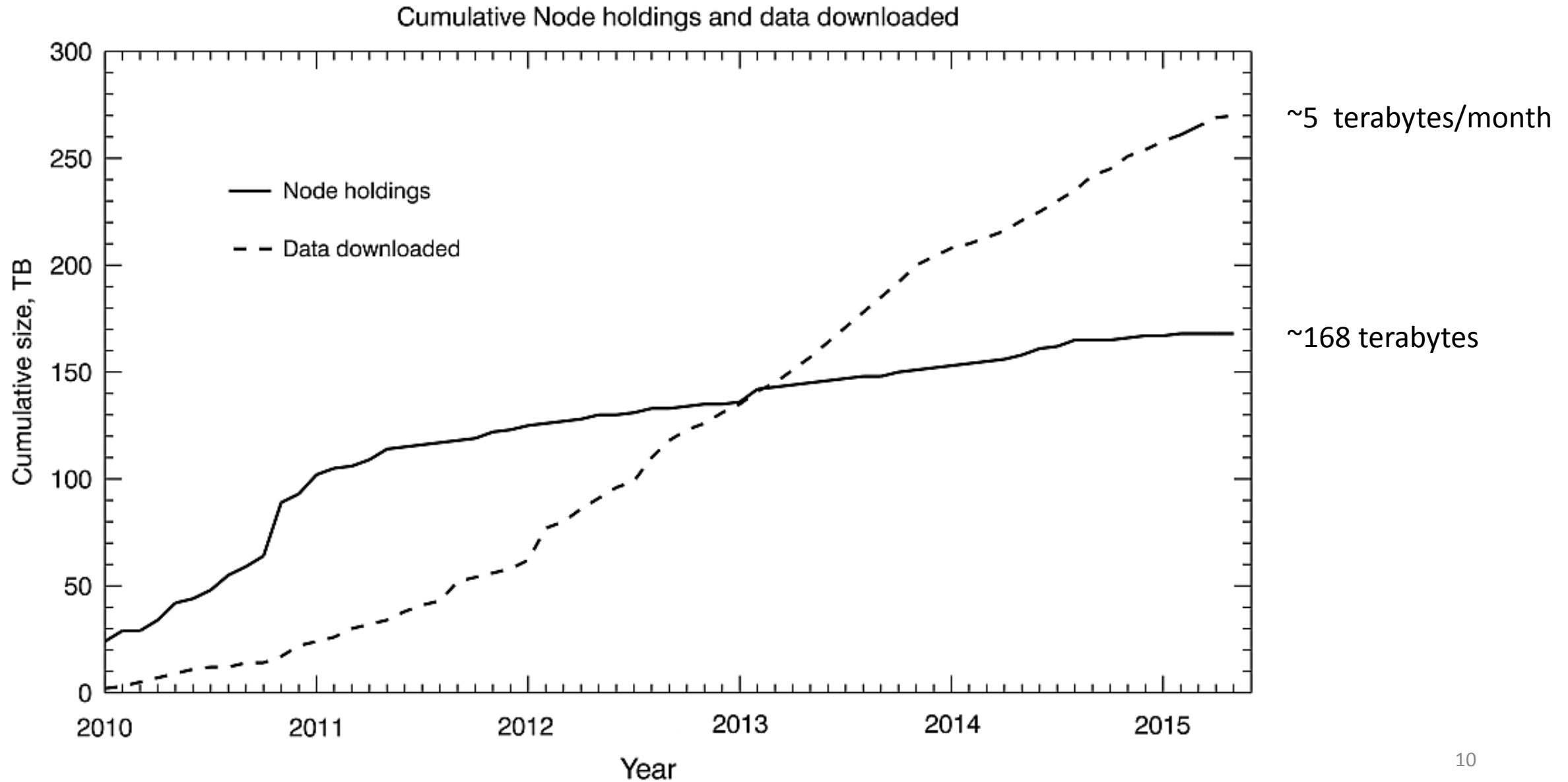
PDS Geosciences Node as an Example Discipline Node

- Focus on Mercury, Venus, Earth's Moon, Mars
- Directed by scientist who uses the archives
- Extensive cooperation with other Nodes
- Active in PDS-wide standards development
- Participants in international development of standards
- Close coordination with missions for archive planning, validation, and delivery

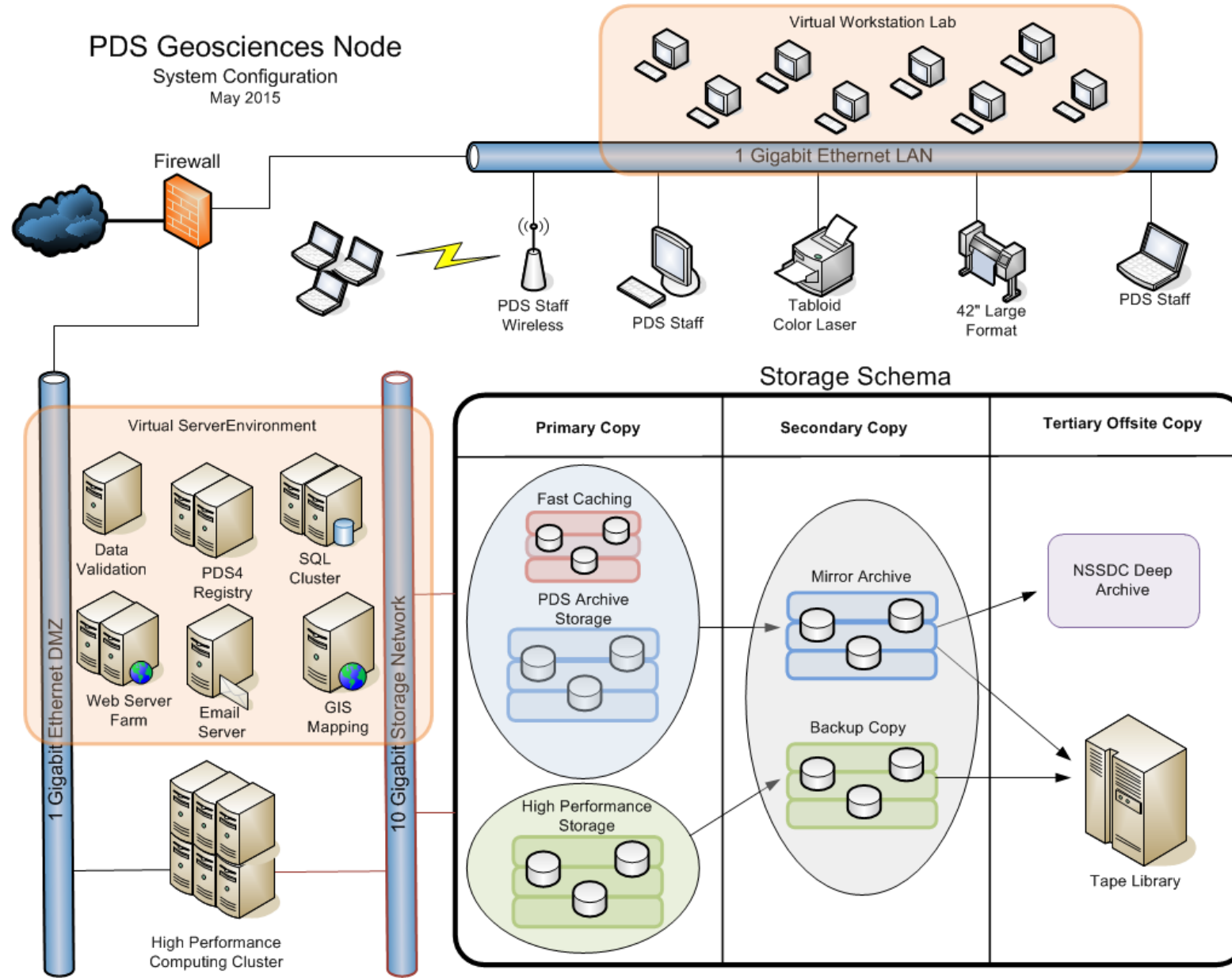
PDS Nodes: PDS Atmospheres Geosciences Imaging NAIF PPI Rings Small Bodies



Growth of Geosciences Node Archives and Downloads



Geosciences Node Infrastructure



PDS Geosciences Node

Washington University in St. Louis

HOME DATA AND SERVICES TOOLS ABOUT US CONTACT US SITE MAP

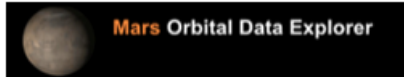
Welcome to the Orbital Data Explorer

The PDS Geosciences Node Orbital Data Explorer (ODE) website is a cross-mission and instrument query, search, display, and download tool for locating and retrieving PDS orbital science data archives of Mars, Mercury, Venus, and Earth's moon.

Orbital Data Explorer Targets:

Mars Orbital Data Explorer

The Mars Orbital Data Explorer (ODE) provides search, display, and download tools for selected PDS science data archives of the Mars Reconnaissance Orbiter (MRO), the Mars Global Surveyor, and the European Space Agency's Mars Express missions.

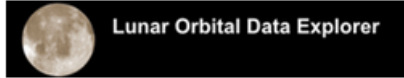


Supported Missions and Instruments:

Mars Reconnaissance Orbiter (MRO): CRISM, CTX, Gravity/Radio Science, HiRISE, MCS, SHARAD
ESA's Mars Express: HRSC, MARSIS, OMEGA, PFS
Mars Global Surveyor: MOC, MOLA

Lunar Orbital Data Explorer

The Lunar Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the Lunar Reconnaissance Orbiter (LRO), the Clementine, the Lunar Prospector, and the Indian Space Research Organisation's Chandrayaan-1 missions.

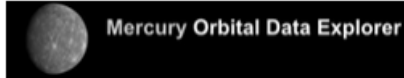


Supported Missions and Instruments:

Lunar Reconnaissance Orbiter (LRO): DLRE, LAMP, LEND, LOLA, LROC, MRFLRO
ISRO's Chandrayaan-1: M3
Clementine: HIRES, LIDAR, LWIR, NIR, RSS, UVVIS
Lunar Prospector: ER, GRS, MAG, NS, RSS

Mercury Orbital Data Explorer

The Mercury Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the MESSENGER (Mercury Surface, Space Environment, Geochemistry, and Ranging) mission.

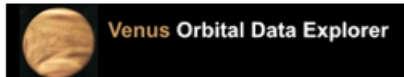


Supported Missions and Instruments:

MESSENGER: GRS, MASCS, MDIS-NAC, MDIS-WAC, MLA, NS, RSS, and XRS

Venus Orbital Data Explorer

The Venus Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the Magellan mission and the MESSENGER mission's Venus data.



Supported Missions and Instruments:

Magellan: RDRS, RSS
MESSENGER (Venus Data): GRS, MASCS, MDIS-NAC, MDIS-WAC, MLA, NS, RSS, and XRS

PDS Nodes: PDS Atmospheres Geosciences Imaging NAIF PPI Rings Small Bodies

Orbital Data Explorers

- Forms and map-based searches
- Feature-based searches, e.g., by crater name
- Cross PDS Node searches
- Granular level searches
- Custom archives for delivery
- Representational State Interface (REST) included to allow users to design their own interfaces to archives

Search for MESSENGER MASCS (UV to IR Spectrometer) and MLA Data (laser altimeter) From the Geosciences Node and MDIS-NAC Image Data From the Imaging Node for Cahokia Vallis

The screenshot displays the Mercury Orbital Data Explorer (ODE) interface. The top navigation bar includes links for Home, Data Product Search, Map Search, Tools, Data Set Browser, Download, and Help & Resources. The main map area shows a cylindrical projection of Mercury with a red rectangular selection box around Cahokia Vallis. The left sidebar contains 'Map Display Controls' and a 'SELECTION RESULTS SUMMARY' table.

Product Type	Search Results Count
MESSENGER MASCS VIRCDR	64
MESSENGER MDIS-NAC CDRNAC	12
MESSENGER MLA RDR	70
Total Products Found	146

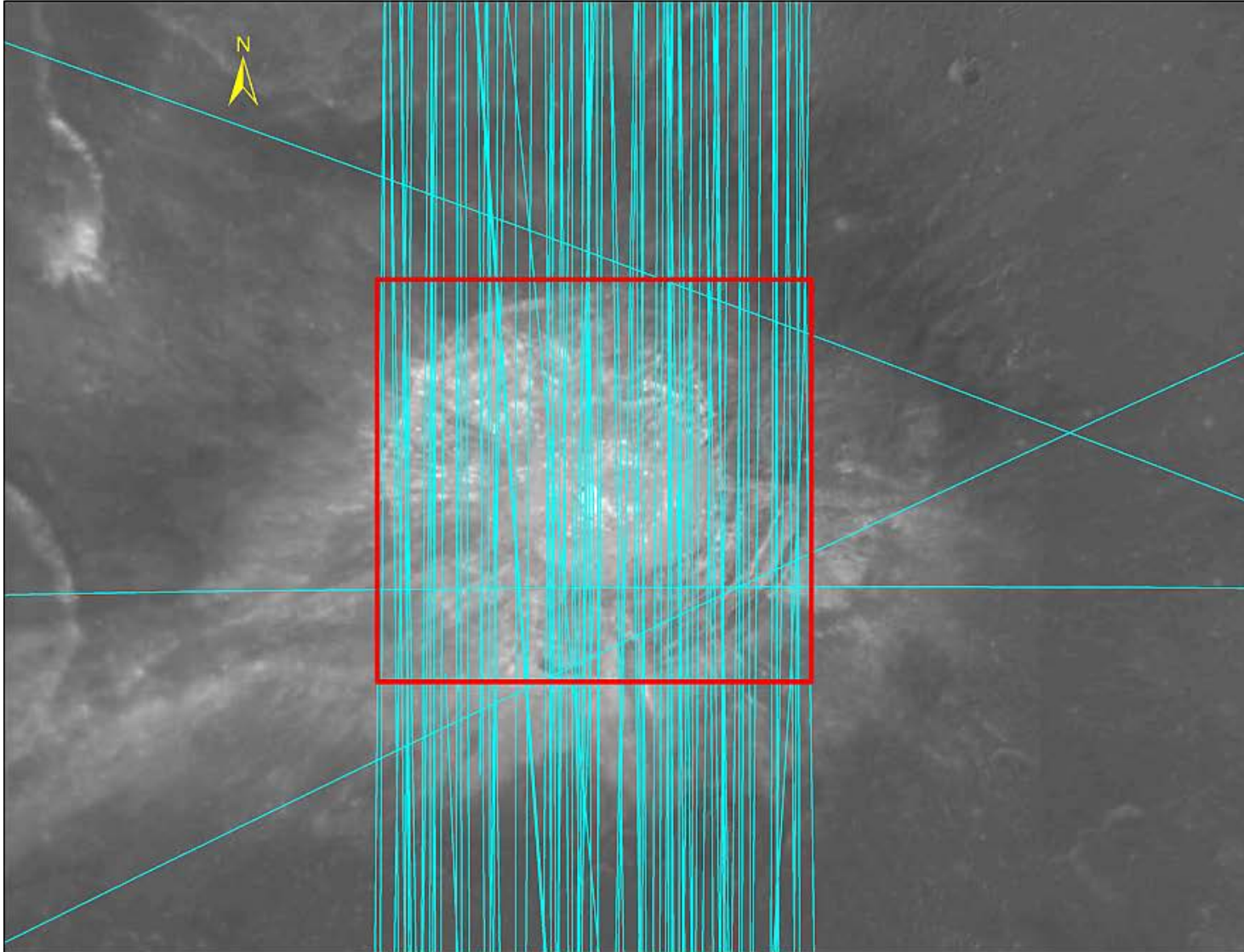
Below the summary is a 'SELECTION RESULTS LIST' with a table of product details:

Instrument	Product ID
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12177_070123_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12177_150122_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12201_072728_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12201_152707_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12201_232651_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_12353_073634_DAT
MESSENGER MASCS VIRCDR	VIRSNC_OB2_13011_080409_DAT

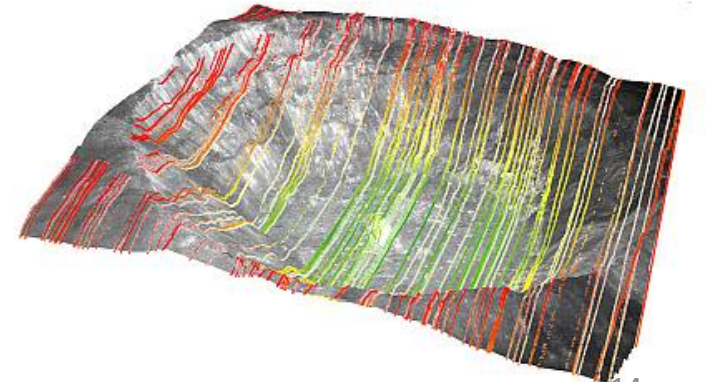
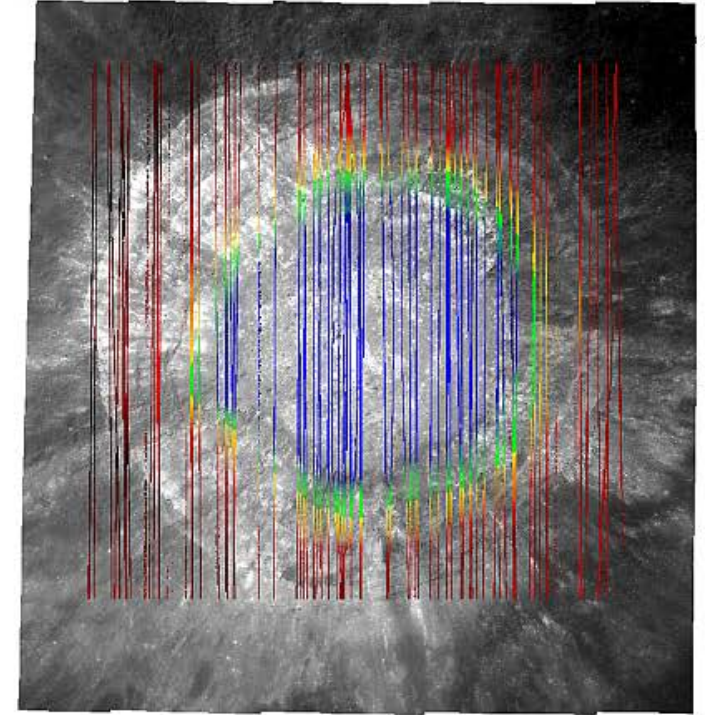
The map interface also includes a scale bar indicating 19 km and coordinates 124.28, 67.35.

Lunar ODE to Find and Generate Binned Data LRO LOLA (laser altimeter) Data Covering Aristarchus

LOLA Orbits Over Crater



Custom-Binned Data





Analyst's Notebook

Use the Analyst's Notebook to explore planetary data from NASA Mars and lunar landed missions. The Notebook integrates sequence information, engineering and science data, and documentation into standard web-accessible pages.



Curiosity

Analyst's Notebook for MSL

Mars rover data through sol 804.



Opportunity and Spirit

Analyst's Notebook for MER

Mars rover data through sol 3780.



Phoenix

Analyst's Notebook for Phoenix

Mars lander data for the entire mission.



LCROSS

Analyst's Notebook for LCROSS

Data from the entire mission.



Apollo

Analyst's Notebook for Apollo

Data from Apollo 11, 12, 14, 15, 16, and 17 missions.

This application works best on laptops and desktops.
Netbook and mobile users may experience poor performance.

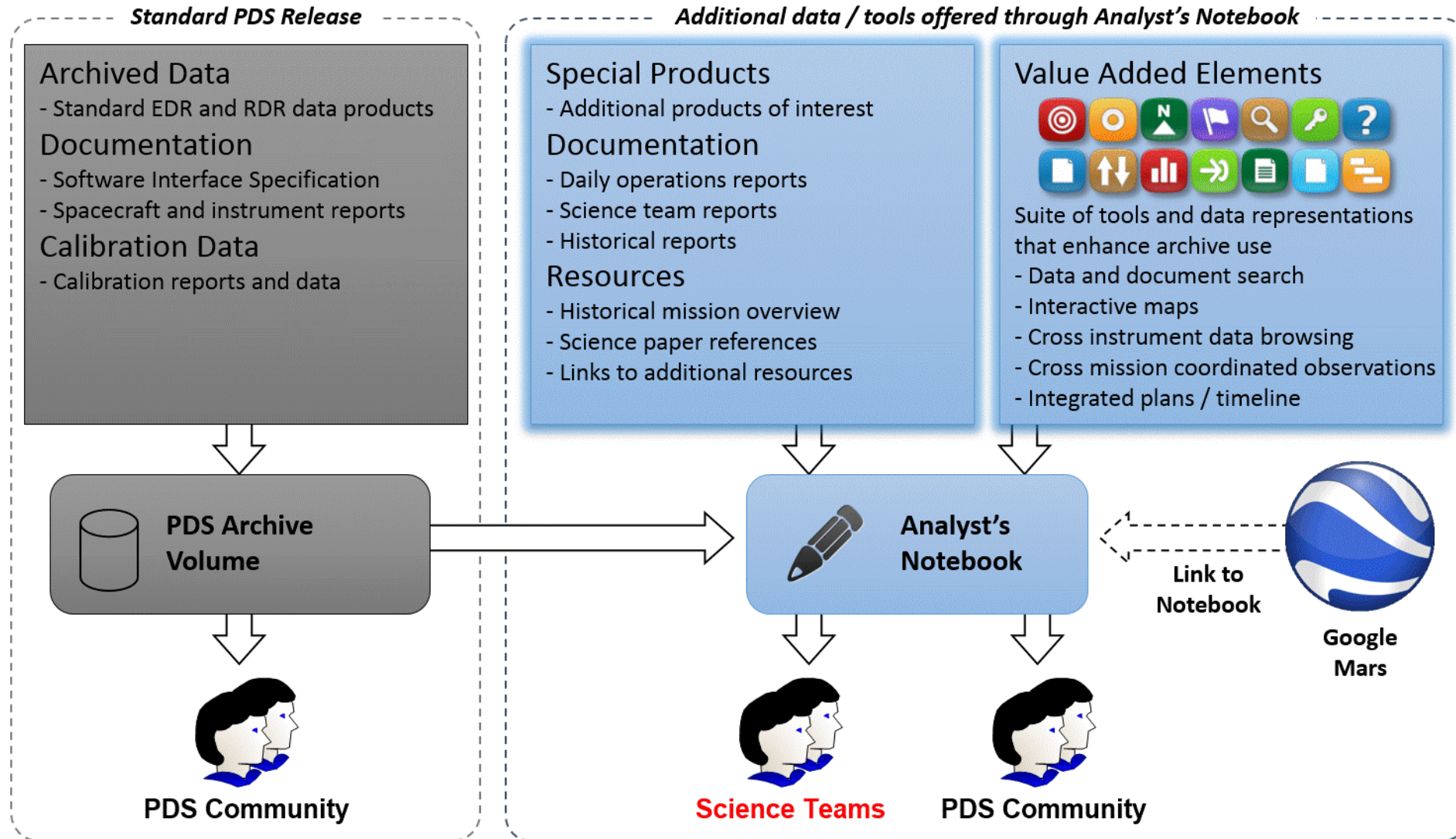


The Analyst's Notebook is produced by NASA's PDS Geosciences Node at Washington University in St. Louis. [Contact us with comments and questions](#), or visit our [community forum](#).

Analysts' Notebooks

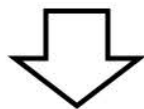
- Developed to ensure proper documentation of daily activities, linking plans, sequences, data products, and contexts for observations
- A digital play-back of the mission

Analyst's Notebook Systems View



MSL Curiosity Analyst's Notebook Example Search for Observations Associated With "Mammoth" Target

Document search for "APXS" and "mammoth" returns 5 results.



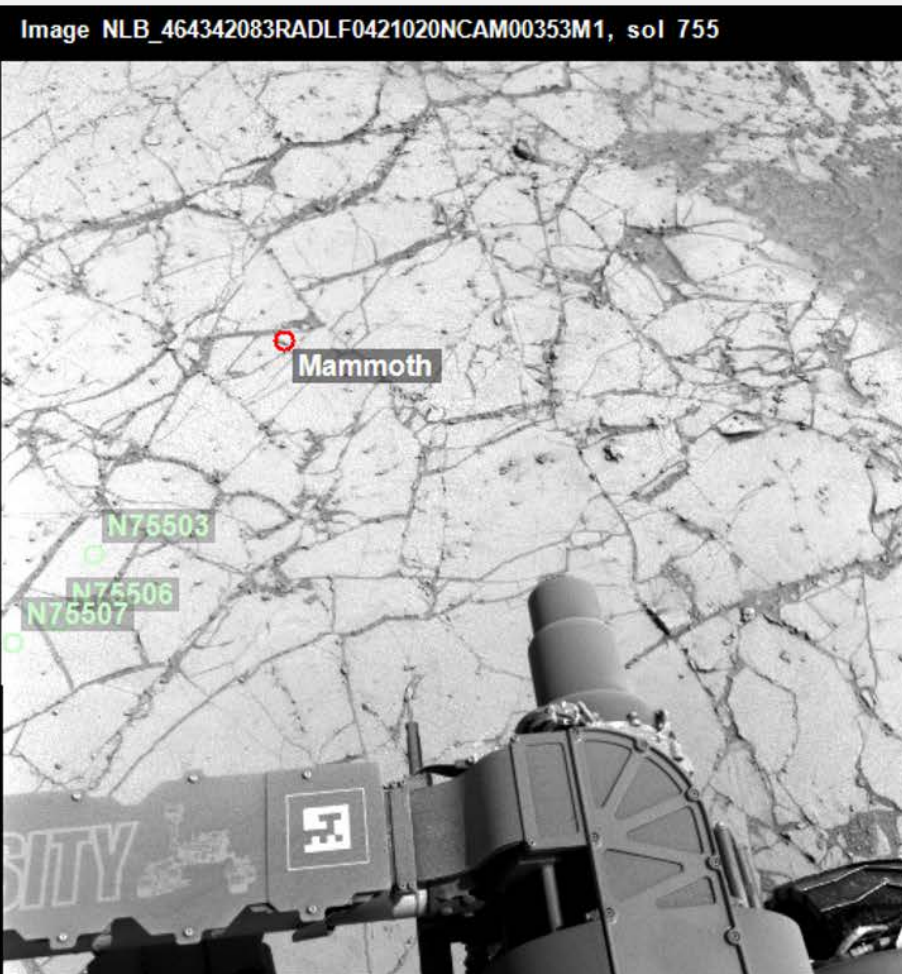
First document "Sol 758 SOWG Documentarian report" references data sequence IDs for several instruments.

<u>Instrument</u>	<u>Sequence</u>
APXS	apxs00028
	apxs10030
ChemCam	ccam01758
MastCam	mcam03255
MAHLI	mhli00125
	mhli00190
	mhli00337
	mhli00412

Data found by sequence search or sol 758 summary view.



Target search for "mammoth" returns finder frame.



MSL Curiosity Analyst's Notebook Search Results for "Mammoth" Target

The screenshot displays the MSL Curiosity Analyst's Notebook interface. At the top, the navigation bar includes links for Home, Mission, Sol, Search, Map, Resources, and User. The main content area is divided into several panels:

- Mammoth Target Panel:** Located at the top left, it identifies the target as "Mammoth" defined on sol 755 at site 42, position 1020.
- Map View:** The central panel shows a grayscale map of the Martian surface with a red circle marking the "Mammoth" target. Other targets are labeled with IDs like N76503, N75506, and N76507.
- ChemCam Image Panel:** A circular inset shows a "ChemCam Partially rad-corrected image" of the target, with metadata including Sol 758 - Site 42 / 1020 / 72 and product ID CR0_464778608PRC_F0421020CCAM01758L1.
- MAHLI Image Panel:** A vertical panel on the right shows a "MAHLI Losslessly Compressed 8 Bit Image" of the target, with metadata including Sol 758 - Site 42 / 1020 / 98 and product ID 643 C00_DRCL.
- APXS Spectrum Panel:** A panel at the bottom right displays an "APXS RDR spectrum" for Sol 612 - Site 31 / 1330 / 26, with product ID APB_451820687RSP 06120311330.

The bottom status bar shows various window titles and IDs, including "Popups", "79775", "MH 0758MH00041700102046", "MC 0758MR00325500004037", "CC CR0_464778608PRC_F04", and "AP APB_451820687RSP0612".

PDS4 Information Model - Modern, Streamlined Approach

The information model defines objects, attributes, and relationships in the archive at a conceptual level. There are four fundamental objects. Science data are described as Array or Table objects.

Fundamental Object	Examples	Examples of Attributes	Examples of Relationships	Notes
Array	2-dimensional image	Number of lines, number of pixels per line, bits per pixel, data type, display direction	An image has pixels (array elements); a pixel has data type, byte order, units.	Arrays are defined with 2 to 16 dimensions.
Table	Spectrum	Number of rows, number of columns	A table has columns; a column has size, data type, start location, definition.	Binary and ASCII text tables are defined. Text tables may have fixed-width or variable-width columns (i.e. CSV).
Parsable byte stream	ASCII text file	Parsing standard (e.g. ASCII, XML, SPICE)	A science observation is associated with a SPICE kernel.	Parsable byte streams are text files that can be read using standard rules.
Encoded byte stream	PDF document, JPEG image	Encoding standard (e.g. PDF, JPEG, PNG), size, description	A science observation is associated with a calibration document in a PDF file.	Encoded byte streams require software to read them. Only standard encodings are allowed.

PDS4 Archive Components

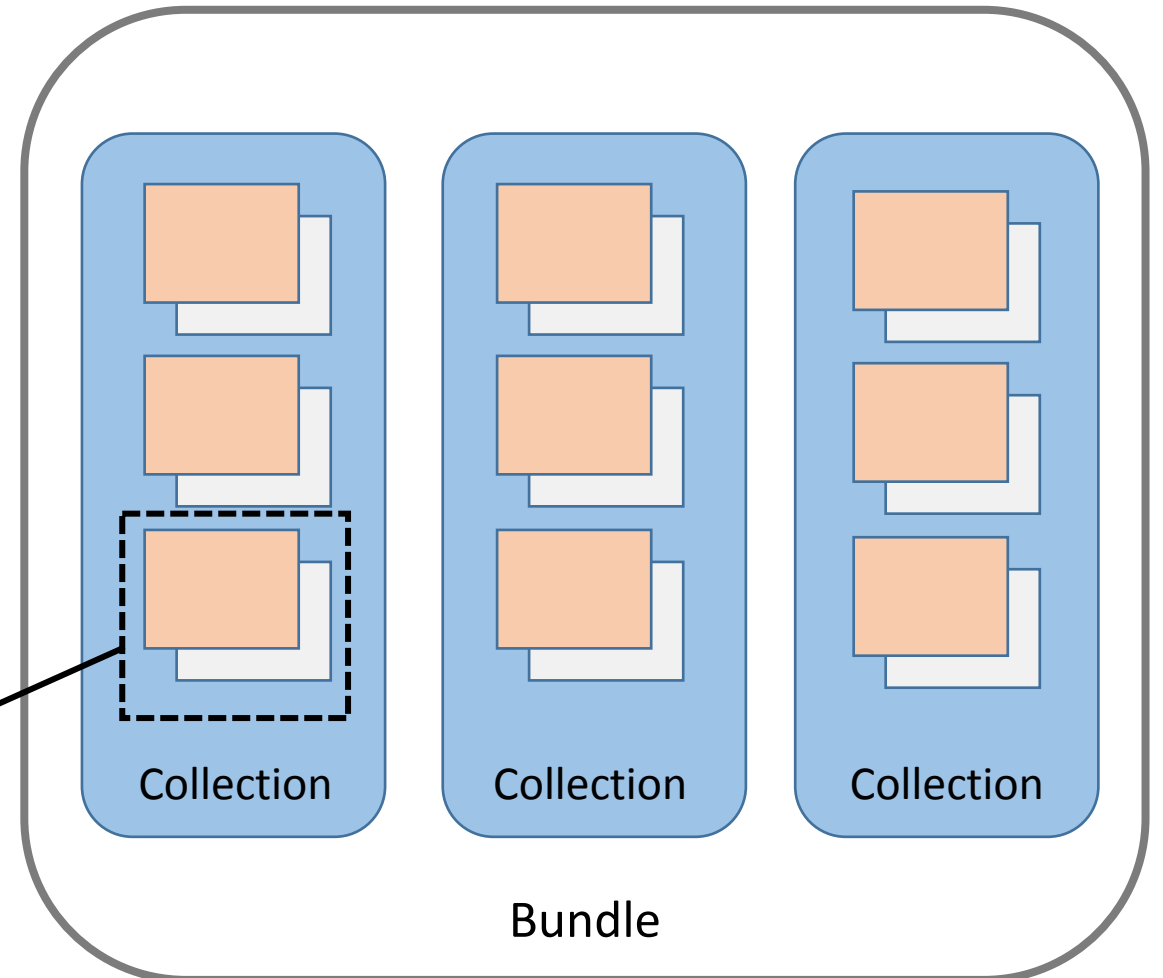
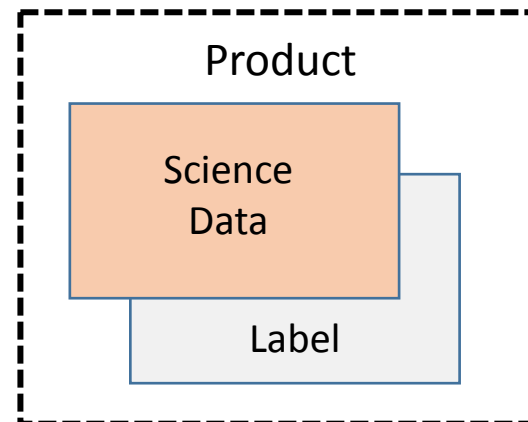
Everything in a PDS4 archive is a **product**, including data, documents, calibration files, browse images, etc.

A **data product** is a science observation, such as an image or a spectrum, and its label.

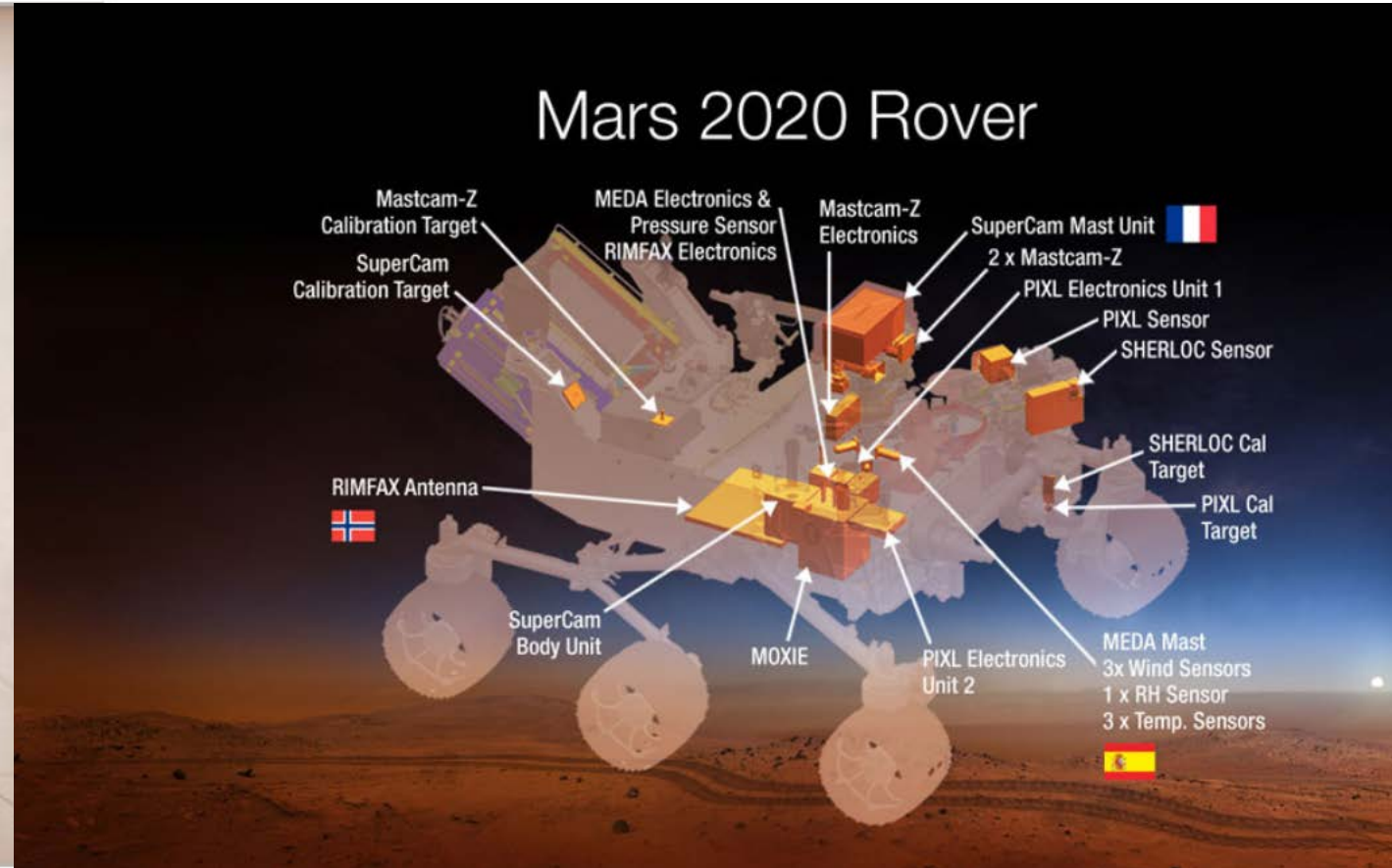
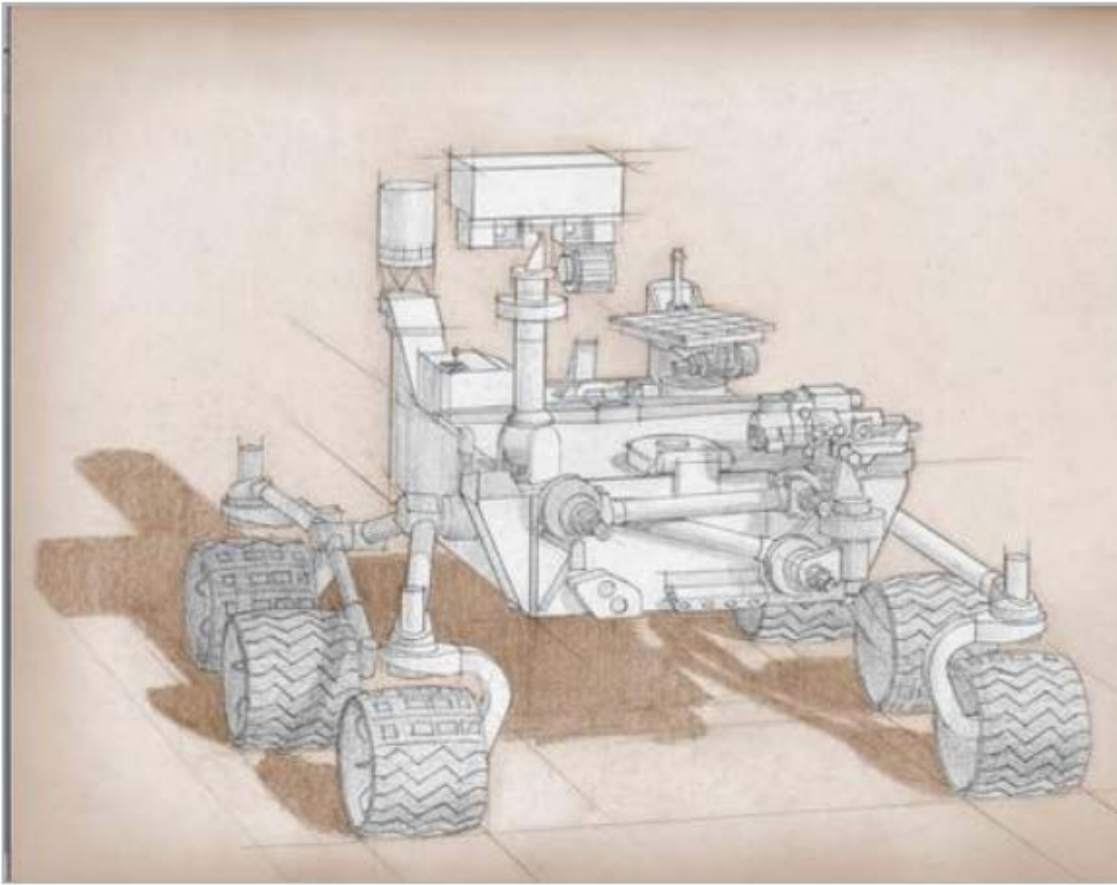
A **collection** is a group of data products, such as the set of all Mars InSight Lander HP³ calibrated temperature data.

A **bundle** is a group of collections, such as all InSight HP³ temperature data collections (raw, calibrated and derived).

XML labels and schema
(Extensible Mark-up
Language)



New kid on the block – NASA's 2020 Mars Rover Mission



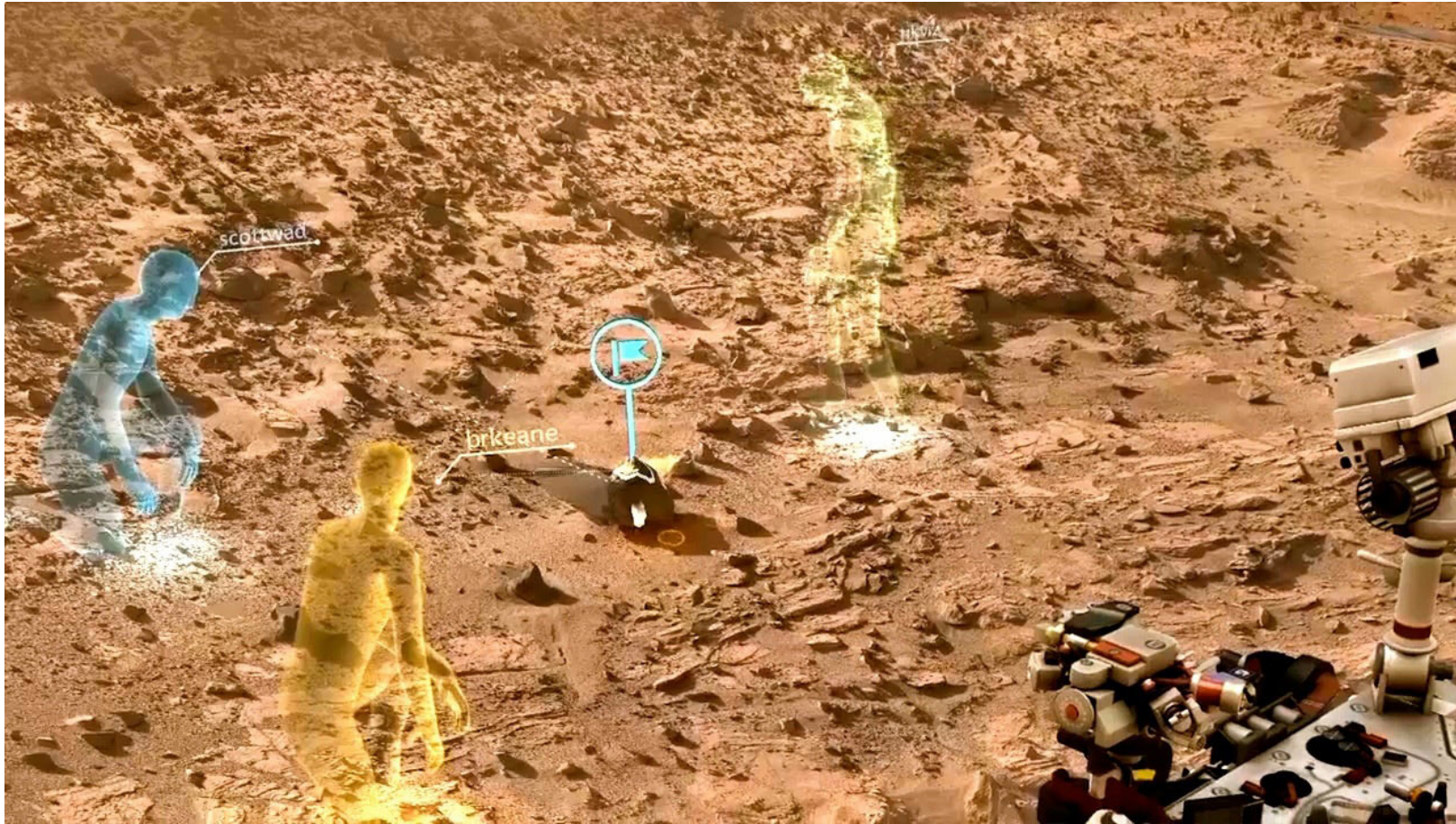
Blue-Print-Style Rover Sketch, Artist's Concept

This artist's sketch is based on the Curiosity rover in NASA's Mars Science Laboratory mission, with proposed modifications based on the science definition team's recommendations. NASA/JPL-Caltech

Mars 2020 New Challenge...Cache Documentation and Linking to Curated Returned Samples

- Use rover-based time as key variable to link tables of context observations, drilling site, core sample, cluster-drop location to actual samples returned to Earth
- Track samples through the Curatorial Facility
- Requires major effort on end to end tracking from planned observations, to sequence implementations and results, to data products, in addition to providing linkages among all observations and locations

What is Around the Corner.....



- Immersive 3D visualization in your office or laboratory environment
- Faster internet speeds
- What else?

Microsoft's HoloLens Prototype for Planning Curiosity observations

International Planetary Data Alliance



IPDA member agencies

Italian Space Agency

National Centre for Space Studies (CNES – France)

China National Space Agency

German Aerospace Center

European Space Agency

Space Research Institute (Russia)

Indian Space Research Organisation

Japanese Aerospace Exploration Agency

National Air and Space Administration

United Kingdom Space Agency

Stick to your guiding principle

Best archives are those sited at locations where scientists use the data and where scientific oversight is a key management element