Introduction to the Planetary Data System and PDS4

http://pds.nasa.gov/

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Planetary Data System

- Purpose: Collect, archive and make accessible the digital data and documentation produced from NASA's exploration of the solar system from the 1960s to the present.
- Infrastructure: The federated system includes associated sub-nodes as well as temporary data nodes often as part of mission archiving.
  - Diverse set of science disciplines
  - System driven by a well defined planetary science information model
  - Approximately 1 PB of data
  - Movement towards international interoperability

PDS Mission and Vision

Mission

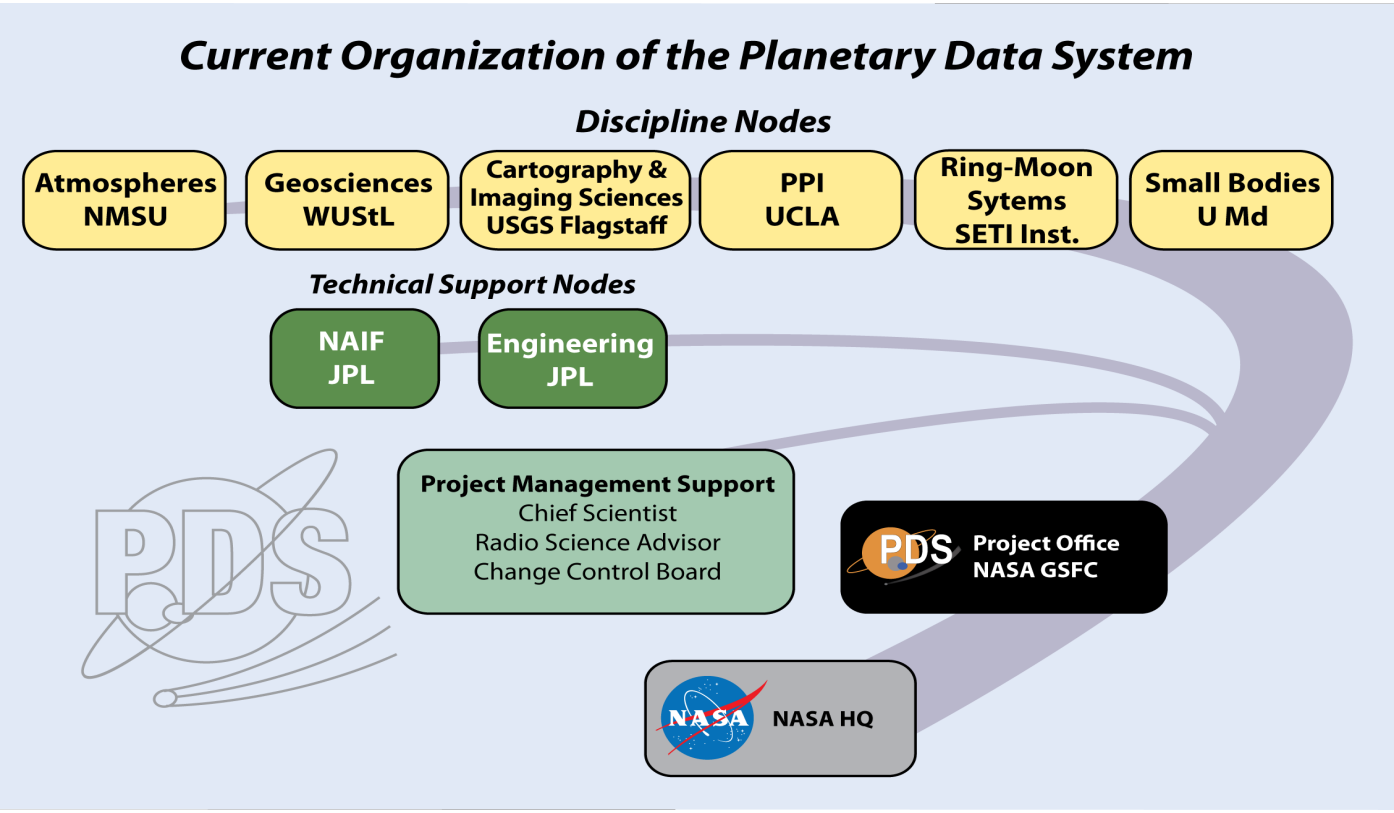
Facilitate achievement of NASA's planetary science goals by efficiently collecting, archiving, and making accessible digital data and documentation produced by or relevant to NASA's planetary missions, research programs, and data analysis programs.

Vision

- To gather and preserve the data obtained from exploration of the Solar System by the U.S.
- To facilitate new and exciting discoveries by providing access to and ensuring usability of those data to the worldwide community
- To inspire the public through availability and distribution of the body of knowledge reflected in the PDS data collection

PDS is a federation of distributed discipline and service nodes.

PDS Organization



Note: PDS is governed through a Management Council formed from the leadership across the nodes.

PDS Level 1 Requirements

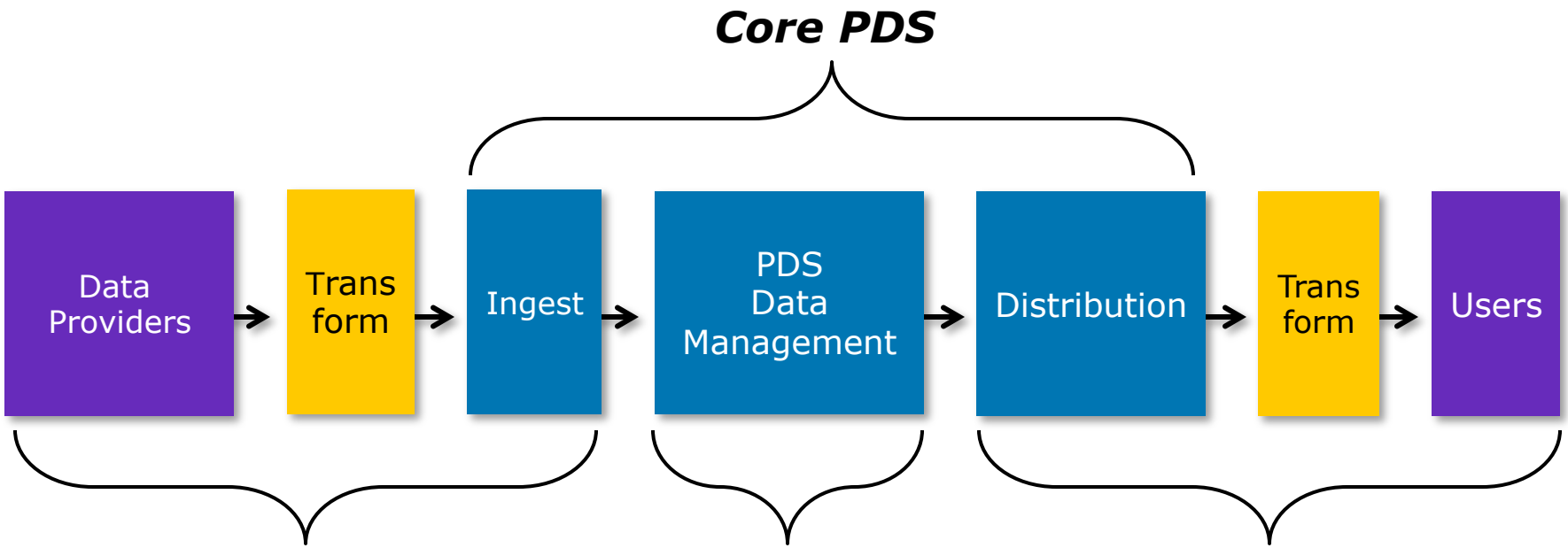
1. PDS will provide expertise to guide and assist missions, programs, and individuals to organize and document digital data supporting NASA's goals in planetary science and solar system exploration

2. PDS will collect suitable and well-documented data into archives that are peer reviewed and maintained by members of the scientific community

3. PDS will make these data accessible to users seeking to achieve NASA's goals for exploration and science

4. PDS will ensure the long-term preservation of the data and their usability

Major PDS Functions



Mission Support

Project Summary Bar Charts -- Missions

Project Summary Last Updated: 25 Oct 2016, Merged mission timelines, PDS4 Build schedule, node support, and possible future missions from the PDS Data Estimates 2017-2036 worksheet.

PDS4 Release Version: 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10

a = Adoption of PDS4 release(s)
d = Distribution of PDS4 data

Mission	Lead Node	Other Nodes	Status	PDS Version	PDS4 Release Adopted	FY15–FY22
MAVEN	ATM	PPI,NAIF	Active	4	1.1-1.5	MOI Sep 2014; Extended through Sep 2018
Mars Science Laboratory/MSL/Curiosity	GEO		Active	3		Extended through Sep 2018
Mars Reconnaissance Orbiter/MRO	GEO		Active	3		Extended through Sep 2018
Mars Exploration Rover/MER/Opportunity	GEO		Active	3		Extended through Sep 2018
Mars Odyssey	GEO		Active	3		Extended through Sep 2018
InSight	GEO	IMG	Future	4	1.4-1.5 (?)	Launch May 2018; Land Nov 20
Mars 2020/Rover	IMG	ATM,GEO,NAIF	Future	4	1.8	
Mars Orbiter Mission/Mangalyaan (ISRO)	ISRO		Active	(?)	(?)	MOI 9/24/2014; Extended Apr 2015 through Sep 2015
Mars Express/MEX (ESA)	GEO		Active	3		NASA support extended through Sep 2018
ExoMars Trace Gas Orbiter & Lander (ESA)	PSA,ROS		Active	4	1.3-1.4 (?)	Launched Mar 2016; MOI Oct 2016; Schiaparelli landing failed Oct 2016; Nominal orbital s
ExoMars Rover (ESA)	PSA,ROS		Future	4	1.7	Launch May 2018; Land 2019; Nominal science for 220 martian
Lunar Reconnaissance Orbiter/LRO	GEO		Active	3		Extended through Sep 2018
LADEE Orbiter	ATM	SBN	Past	4	1.1	EOM 4/17/2014; SPICE collection not yet delivered
Chandrayaan-2 (ISRO)	ISRO		Future	4	1.6	Launch Sep 2017
Selene-2 Lunar Orbiter and Lander (JAXA)	DARTS		Future	4	(?)	Launch 2018
MESSENGER	PPI		Past	3		EOM Apr 2015
Bepi Colombo (ESA/JAXA)	PSA		Future	4	1.3-1.4 (?)	
Venus Climate Orbiter/Akatsuki/Planet-C (JAXA)	DARTS	SBN	Active	4(?)	(?)	VOI Dec 2015
Venus Express (ESA)	ATM		Past	3		EOM Nov 2014
Juno	ATM		Active	3		JOI Jul 2016; EOM Mar 2018
Cassini	ATM		Active	3		EOM Sep 2017
JUICE (ESA)	PSA		Future	4	1.7	
New Horizons	SBN		Active	3		Pluto FB Jul 2015 with 1 year for data return; Extended for flyby
Dawn	SBN		Active	3		Ceres OI Mar 2015; Ceres orbital studies extended from nominal EMO in Feb 2017 until out of fuel in Mar/Apr 2017.
Rosetta and Philae	PSA,SBN		Active	3		Comet OI Aug 2014; Landed Nov 2014; Extended to Sep 2016 for EOM with landing of orbiter on comet
Voyager 1 and 2	PPI		Active	3		Need extended mission plans
OSIRIS-REx	SBN		Active	4	1.1-1.4	Launched Sep 201
Hayabusa 2/Procyon (JAXA)	DARTS	SBN	Active	4	1.3 (?)	Asteroid OI Jul 2018; Depart Dec 2019; Sample ret

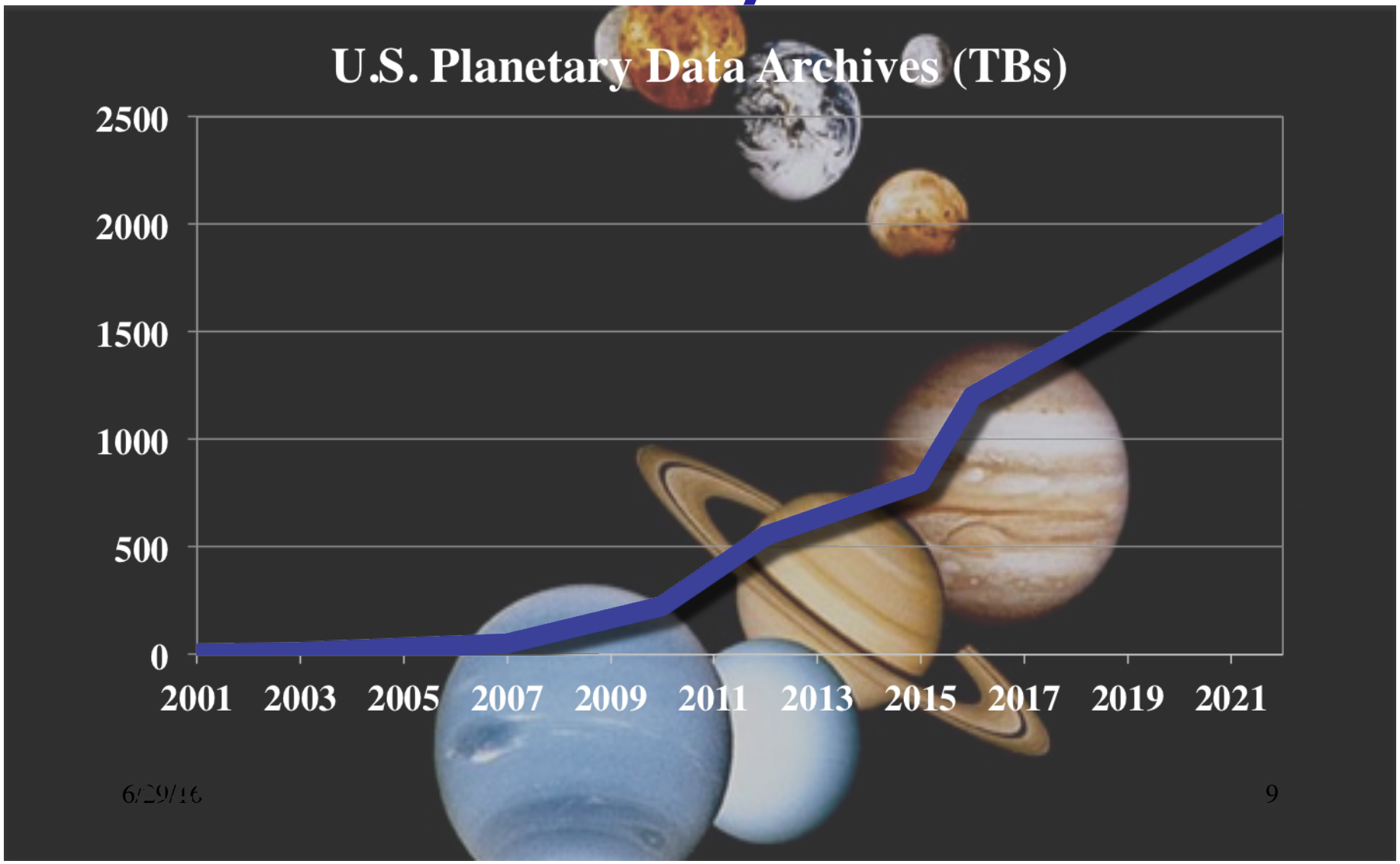
Key Drivers Impacting PDS *

- More Data
- More Complexity (instruments, data)
- More Producer Interfaces
- Greater User Expectations
- Archive vs. Usability
- Limited Funding
- Creating a system from the federation
- Internationalization
- Increasing IT security threats
- Failover capabilities across the PDS

* Derived from PDS Study on Drivers for PDS4

"*Support the ongoing effort to evolve the Planetary Data System from an archiving facility to an effective online resource for the NASA and international communities.*" -- Planetary Science Decadal Survey, NRC, 2013-2022

Growth of Planetary Data Archived from U.S. Solar System Research



Scale of the PDS

Type of Data	Distinct Products
Data Sets	2151
Instrument Hosts	199
Instruments	625
Targets	4231
Missions/ Investigations	71
Volumes	5847

- Total volume is currently ~1PB
- Represents 40M data products with 33K descriptions from over 580 unique instruments
- The current MAVEN mission has a compliment of 8 diverse instruments with 300K data products at the current time
- Some missions have few instruments but many data products, e.g., LADEE

Timeline of PDS Technical Implementations and Upgrades

- PDS 1 – 1990
  - High-Level Catalog for finding data sets by mission, instrument, spacecraft and target.
  - Archive volumes stored and distributed on tape.
  - The Object Description Language (ODL) is invented for product labeling and capturing catalog information.
- PDS 2 - 1994
  - CD-ROM become the archive and distribution volume of choice.
  - High-Level Catalog simplified by using more text instead of keywords to capture descriptive information.
- PDS 3 - 2000
  - PDS sets up and maintains a web presence.
  - Movement to online distribution of products (PDS-D).
  - On-line mass storage and data bricks replace CD/DVD as archive and distribution media.
- PDS4 - 2012
  - Movement to a distributed, service architecture
  - Integrated federation
  - New data standards, data formats and structures
  - International Collaboration

PDS4: The Next Generation

- An international standard and set of data services for planetary science archives
- An explicit information architecture
  - All products are tied to a common model for validation and discovery
  - Use of XML, a well-supported international standard, for labeling, validation, and searching
  - A hierarchy of dictionaries designed to increase flexibility, enable complex searches, and make it easier to share data internationally
- Distributed services both within PDS and at international partners
  - Distributed services both within PDS and at international partners
  - Consistent protocols for access to the data and services
  - A distributed search infrastructure
  - Configured by the Information Architecture

Characteristics of the PDS4 Standards

- Multiple disciplines (Atmospheres, Geosciences, Plasma, Small Bodies, etc) supported
- Multi-level governance enabled (independent extensions)
- Multiple data models integrated into a planetary science standard
  - A core model that describe the missions, instruments, targets, observations, etc
  - Models that describe disciplines
  - Models for registries, data dictionaries, etc
- Active Data Design Working Group to accommodate updates
- Maintained by a Change Control Board with representatives both across the Planetary Data System and Internationally

PDS4 Software Tools and Services

- PDS4 is enabled by a set of core software services for registration, search, and distribution
- Core PDS-wide tools are provided for design, validation, and transformation of PDS4 data products
  - Use of XML provides significant leveraging for using common libraries
- Regular (6 month) software builds and releases integrate software and information model, and released for use by data providers, nodes, and international partners
- Each node builds search and support services tailored for their community
- Increasing shift to distribute software via open source channels

International Planetary Data Alliance

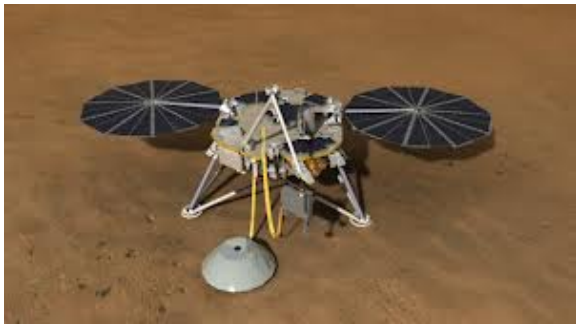
- Founded in 2006
  - Resulted from meeting between the ESA Planetary Science Archive and the PDS at ESAC
- Includes all major space agencies involved in planetary science data archiving
- Mission is to build compatible, international planetary data archives for the purpose of interoperability
- Major investment and buy-in in PDS4
  - Leveraging both the PDS4 Information Model and core software tools and services

PDS4 Releases

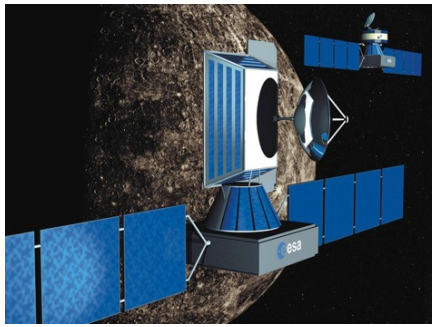
- PDS4, V1.7, October 2016
- PDS4, V1.6, April 2016
- PDS4, V1.5, October 2015
- PDS4, V1.4, April 2015
- PDS4, V1.3, October 2014
- PDS4, V1.2, April 2014
- PDS4, V1.1, October 2013
- PDS4, V1.0, May 2013

PDS4 Mission Support

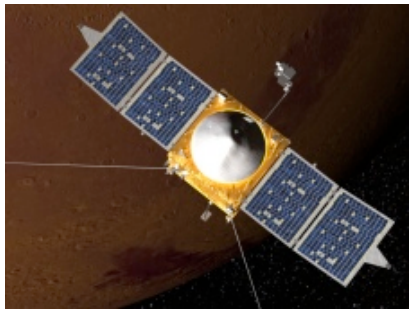
LADEE (NASA)



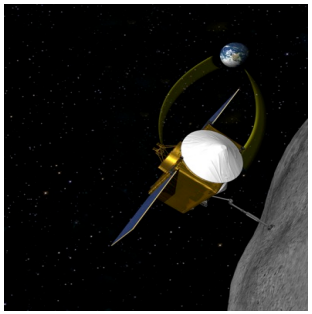
InSight (NASA)



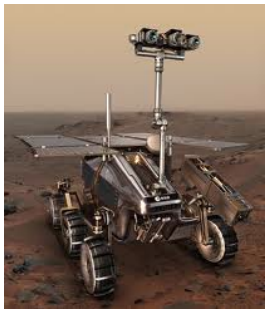
BepiColombo (ESA/JAXA)



MAVEN (NASA)



Osiris-REx (NASA)



ExoMars (ESA/Russia)

JUICE (ESA)

Mars 2020 (NASA)

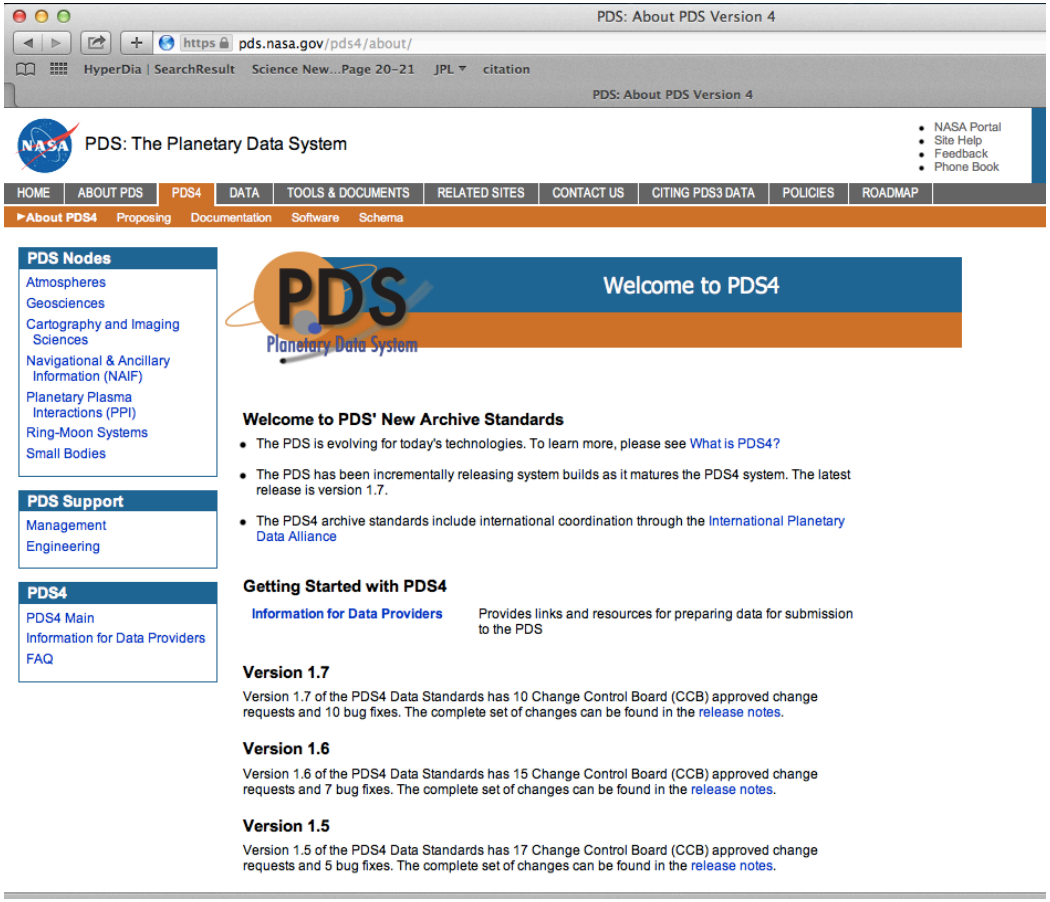
…also Hayabussa-2, Chandrayaan-2

Endorsed by the **International Planetary Data Alliance** in July 2012 – https://planetarydata.org/documents/steering-committee/ipda-endorsements-recommendations-and-actions

Accessing PDS4 Information

- http://pds.nasa.gov/pds4

- Documents
- Schemas
- Tools



Continued Support for PDS3

- Per agreement with NASA leadership, all new missions are required to archive in PDS4.
- Missions delivering PDS3 can continue with that version of PDS per agreement with the PDS Management Council.
  - PDS as a system can archive and distribute both PDS3 and PDS4 versions.
- Each PDS node will determine which data to migrate on a schedule that fits their community needs and their resources.

PDS Change Control Board (CCB)

The **PDS4 Standards Change Control Board (CCB)** is a subcommittee of the PDS Management Council (MC). It manages the evolution of PDS4 Standards by evaluating proposed changes, determining which should be approved, and monitoring their implementation if approved.

The CCB assesses impact of, prioritizes, and approves (or rejects) requests for changes to PDS4 Standards.

For approved changes, it plans and integrates changes into future releases of the PDS4 Standards. It determines which changes require MC review and approval.

PDS CCB Process

- SCRs are submitted electronically through the JIRA tracking system
- Once all editing is complete, EN adds a formal technical assessment indicating any issues and/or dependencies for the Information Model (e.g., backwards compatibility issues etc.)
- CCB Chair and Coordinator discuss and schedule SCRs that are "ready for vote". This includes designating what type of meeting is needed for which SCRs — namely is the SCR a **bug fix** (consent item over email), **Minor issue** (email E-Vote), or **complicated issue** (telecon).
- CCB meets for appropriate meeting – VOTES on scheduled SCRs (Pass, Reject, Send back to Design Group).
- Chair submits report to Coordinator (and interested parties) for posting to official CCB Website

PDS in the Future

- PDS is currently working on a decadal roadmap
  - Build on the PDS4 data standards
  - Foster international collaborations between the groups on open architectures, services, and tools
  - Support upcoming mission and user needs
- Increasing collaborations for PDS Standards and Interoperability between NASA and ESA

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