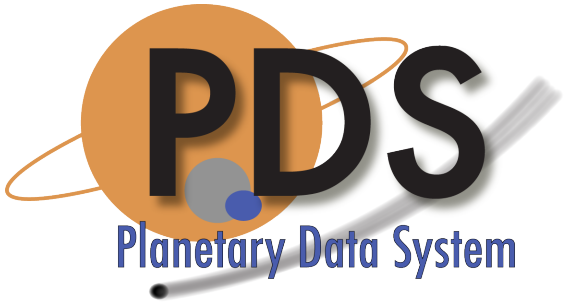
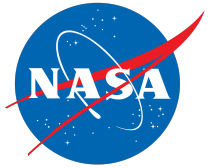


Engineering Node Performance Review

D. Crichton, S. Hardman, J.S. Hughes, E. Law
Jet Propulsion Laboratory, California Institute of Technology

January 2016



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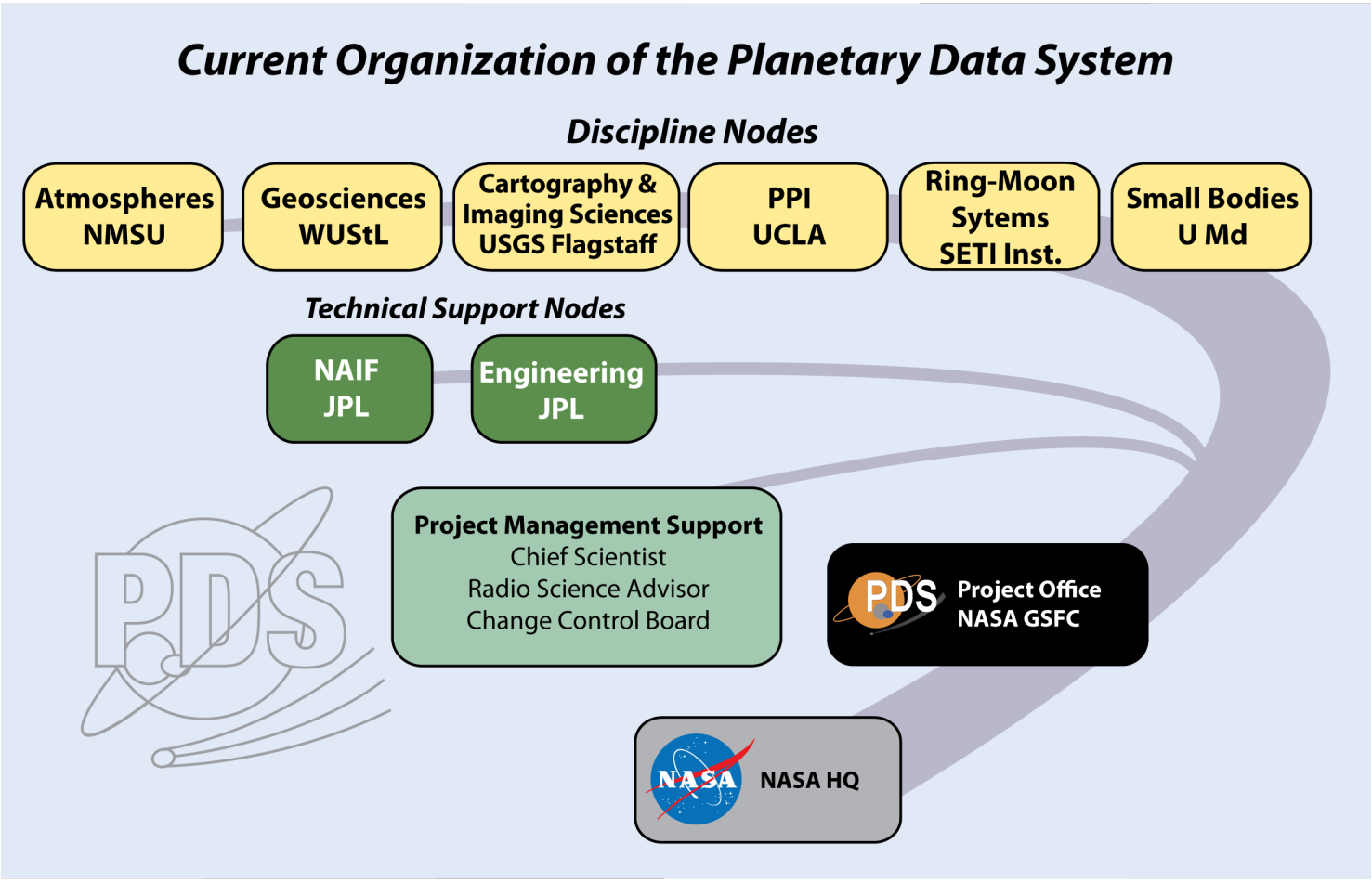
PDS Organization



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

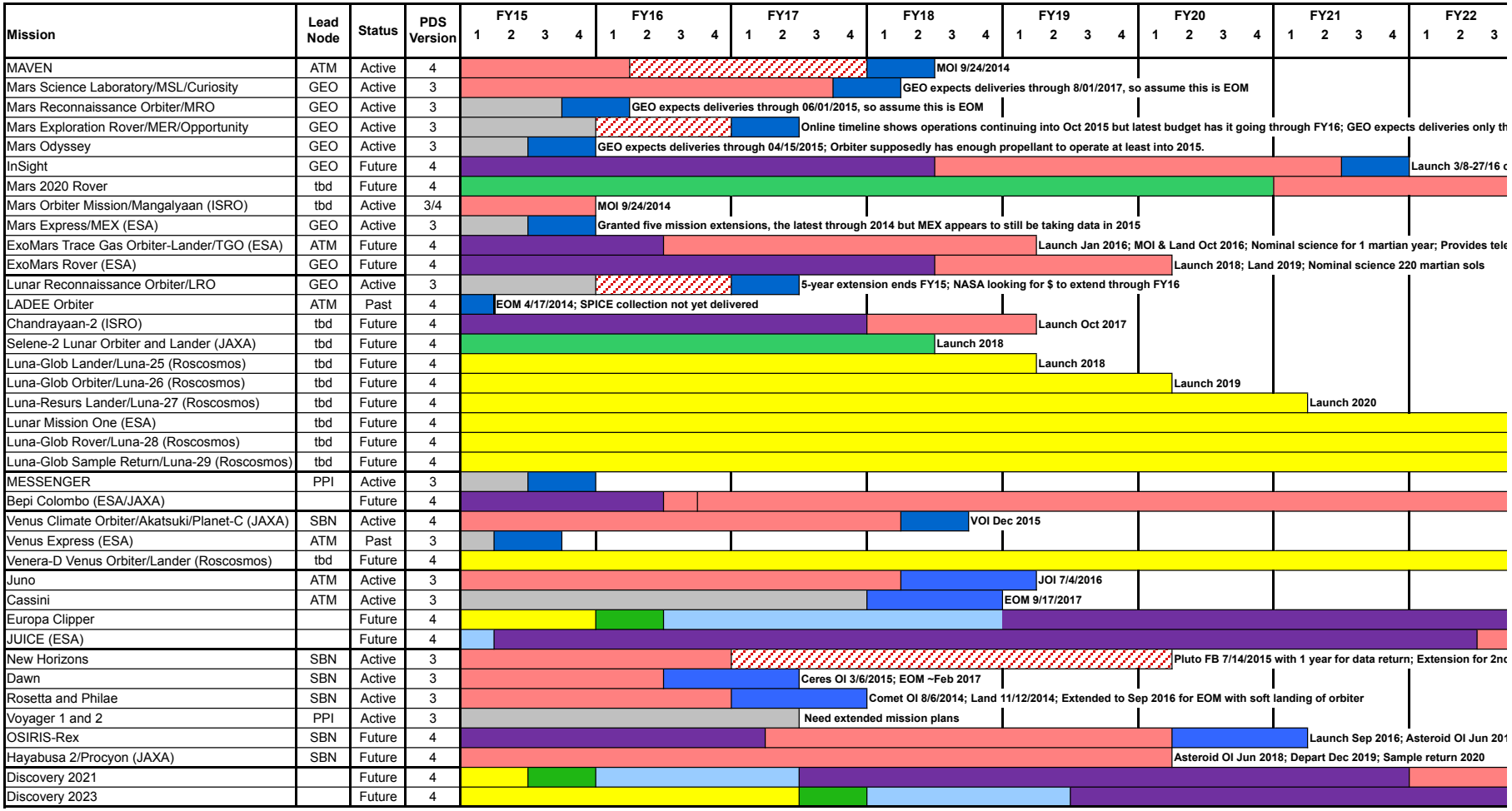
4. PDS will ensure the long-term preservation of the data and their usability

Mission Timeline

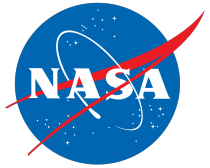
Project Summary Bar Charts -- Missions

Project Summary

Last Updated: 29 Dec 2015 (Rosetta extended; Akatsuki VOI successful; 2016 InSight launch canceled;)



Mission	Lead Node	Status	PDS Version
MAVEN	ATM	Active	4
Mars Science Laboratory/MSL/Curiosity	GEO	Active	3
Mars Reconnaissance Orbiter/MRO	GEO	Active	3
Mars Exploration Rover/MER/Opportunity	GEO	Active	3
Mars Odyssey	GEO	Active	3
InSight	GEO	Future	4
Mars 2020 Rover	tbd	Future	4
Mars Orbiter Mission/Mangalyaan (ISRO)	tbd	Active	3/4
Mars Express/MEX (ESA)	GEO	Active	3
ExoMars Trace Gas Orbiter-Lander/TGO (ESA)	ATM	Future	4
ExoMars Rover (ESA)	GEO	Future	4
Lunar Reconnaissance Orbiter/LRO	GEO	Active	3
LADEE Orbiter	ATM	Past	4
Chandrayaan-2 (ISRO)	tbd	Future	4
Selene-2 Lunar Orbiter and Lander (JAXA)	tbd	Future	4
Luna-Glob Lander/Luna-25 (Roscosmos)	tbd	Future	4
Luna-Glob Orbiter/Luna-26 (Roscosmos)	tbd	Future	4
Luna-Resurs Lander/Luna-27 (Roscosmos)	tbd	Future	4
Lunar Mission One (ESA)	tbd	Future	4
Luna-Glob Rover/Luna-28 (Roscosmos)	tbd	Future	4
Luna-Glob Sample Return/Luna-29 (Roscosmos)	tbd	Future	4
MESSENGER	PPI	Active	3
Bepi Colombo (ESA/JAXA)		Future	4
Venus Climate Orbiter/Akatsuki/Planet-C (JAXA)	SBN	Active	4
Venus Express (ESA)	ATM	Past	3
Venera-D Venus Orbiter/Lander (Roscosmos)	tbd	Future	4
Juno	ATM	Active	3
Cassini	ATM	Active	3
Europa Clipper		Future	4
JUICE (ESA)		Future	4
New Horizons	SBN	Active	3
Dawn	SBN	Active	3
Rosetta and Philae	SBN	Active	3
Voyager 1 and 2	PPI	Active	3
OSIRIS-Rex	SBN	Future	4
Hayabusa 2/Procyon (JAXA)	SBN	Future	4
Discovery 2021		Future	4
Discovery 2023		Future	4



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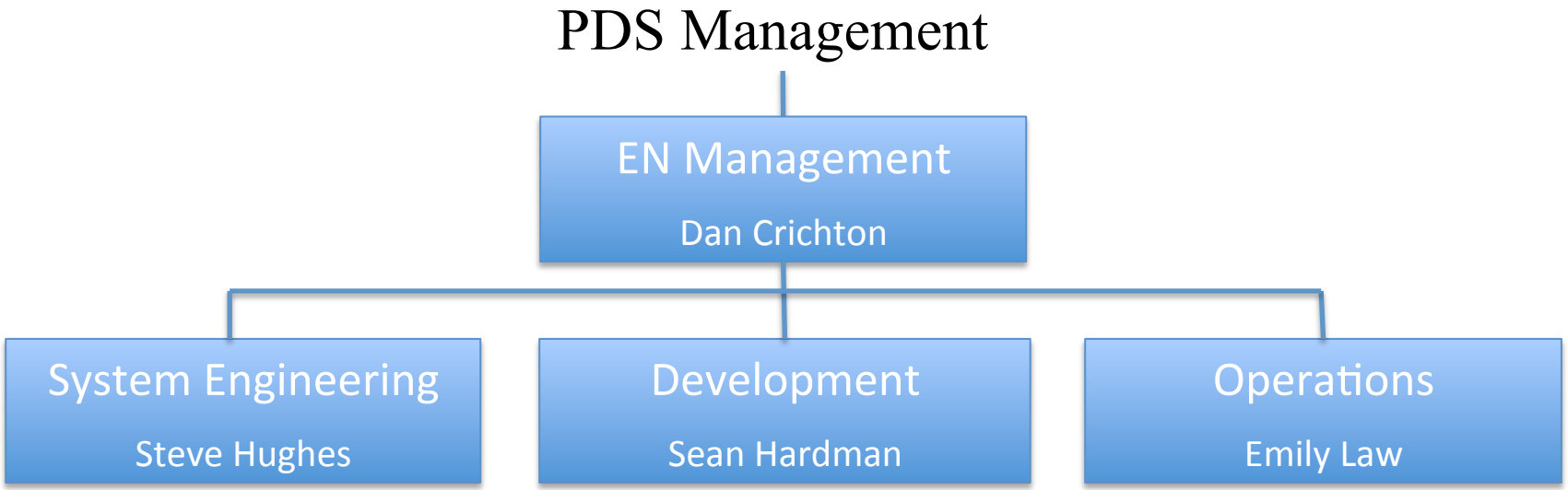
  - IPDA Participation
  - Future Plans/Roadmapping (added)
  - Resource Allocation and Budget Scenarios

EN Responsibilities

- PDS-wide System Engineering
  - Chair key working groups
  - Define overall system architecture
  - Lead data standards development and maintenance
  - Develop common operating procedures
  - Facilitate the CCB process
  - Integrate and test system releases
- Perform technology investigations
- Develop, implement, and operate the core PDS data and software services, and the PDS portal
- Support PDS/mission data engineering
- Support the IPDA in adopting PDS standards and integrating into an international federation

EN Organization



Architecture development & maintenance
Technology research & demonstrations
Standards development & maintenance
Information and system modeling
PDS system engineering
Change request assessment

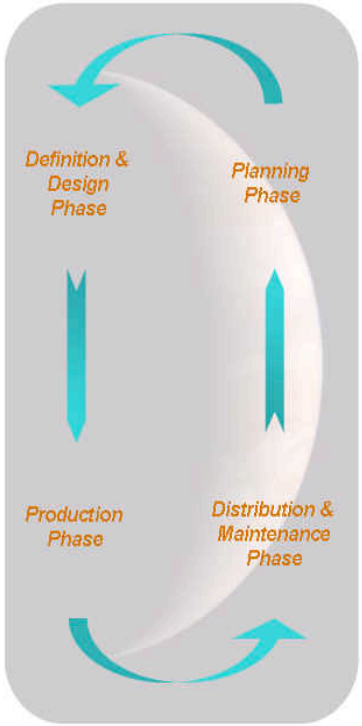
Software systems engineering
Database development & engineering
Tools development & sustaining
Web applications development
Configuration management
Operations deliveries

Operations engineering
Quality assurance (data & software)
Infrastructure development & maintenance
System operations
Data engineering
Data and system releases
Change control coordination
Website sustaining
Metrics collection & reporting
Operations coordination across PDS
PDS help desk
IT Security

EN Stakeholders

- PDS Management
- PDS Management Council
  - Set direction, policies, requirements
- Discipline Node Technical Staff
  - Implement PDS standards, services and tools for their systems
  - Serve as interface to the missions and their respective communities
- IPDA
  - Implement PDS standards, services and tools for their systems
  - Support international interoperability
- Data Providers
  - Missions and Data Analysis Program PIs who use PDS standards and tools and delivery data to the PDS
- Science Data User Community
  - Those who access pds.nasa.gov and use PDS data
- Data Science Technical Community

EN Support to Nodes and Missions



Planning Phase:
- Data archiving requirements written into mission Announcement of Opportunity
- Pre-proposal briefing on PDS data archiving requirements given to potential proposers
- Proposal data archiving section reviewed by PDS
- PDS orientation to flight project staff
- Data archiving working groups formed

Definition & Design Phase:
- Project Data Management and Archive Plans define data to be archived
- Data Product and Volume Organization Software Interface Specifications detail the data and volume structure
- Preliminary metadata labels loaded into PDS catalog

Production Phase:
- Raw and processed data products, labels (metadata) and documentation produced
- Preliminary and quick-look data made accessible via Project and PDS web pages
- Data archive products validated and peer-reviewed; liens corrected

Distribution & Maintenance Phase:
- Final data products made available on-line
- PDS add the data to the archive
- Physical copies sent to NSSDC
- PDS provides data, documentation and science expertise to users
- Data archive maintained via periodic media refreshes, addition of new / updated data products

Mission	Number of Data Release
Cassini	8
GRAIL	2
LADEE	1
LRO	10
MER	8
MRO	11
MSL	6
MAVEN	3
MESSENGER	4
Odyssey	10
Venus Express	1

2014-2015 PDS Data Releases

PDS-wide Engineering Challenges

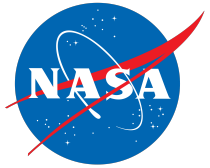
- Diversity of the planetary missions, community and PDS nodes
  - Within the PDS, as a federation, each node and local IT system is tailored for their community
- Requirements for preservation of data (> 50 years) and for usability are sometimes in conflict
- Limited budget which affect archiving/usability across data providers/ missions, PDS and the users
- International archiving and standards coordination
- Increasing volume of data
  - In 2002, the PDS archive was 10 TBs
  - In 2010, the PDS online archive is over 100 TBs
  - In 2016, the PDS online archive is approx 1 PB
- Rapid pace of change in information technologies

PDS4: The Next Generation PDS

- PDS4 is a PDS-wide project to upgrade from PDS version 3 to version 4 to address many of these challenges
- An explicit information architecture
  - All PDS data tied to a common model to improve validation and discovery
  - Use of XML, a well-supported international standard, for data product labeling, validation, and searching.
  - A hierarchy of data dictionaries built to the ISO 11179 standard, designed to increase flexibility, enable complex searches, and make it easier to share data internationally.
- An explicit software/technical architecture
  - Distributed services both within PDS and at international partners
  - Consistent protocols for access to the data and services
  - Deployment of an open source registry infrastructure to track and manage every product in PDS
  - A distributed search infrastructure
  - Configured by the Information Architecture

EN Highlights

- Common architecture and infrastructure in place for PDS4
  - Captured PDS4 information model in a modern modeling environment; implemented in XML
  - Designed, developed, and deployed PDS4 core software services (harvest, registry, search, transformation)
  - Developed and released PDS4 core tools and libraries (including validation)
- Transitioned PDS4 to Operations
  - Released PDS4 Version 1.0 to the community; Established Change Control Board; Issue tracking in place
  - Performed incremental system builds with increasing functionality and stability
  - Passed major system reviews including the Operational Readiness Review for LADEE & MAVEN
  - Transitioned EN data and systems to PDS4
- Successful adoption of PDS4 by missions
  - Deployed PDS4 software to the PDS nodes
  - Began LADEE and MAVEN data distribution under PDS4; Osiris-Rex and InSight preparation underway
- Received endorsement and adoption of PDS4 by the International Planetary Data Alliance
- Did not break PDS going from PDS3 to PDS4!



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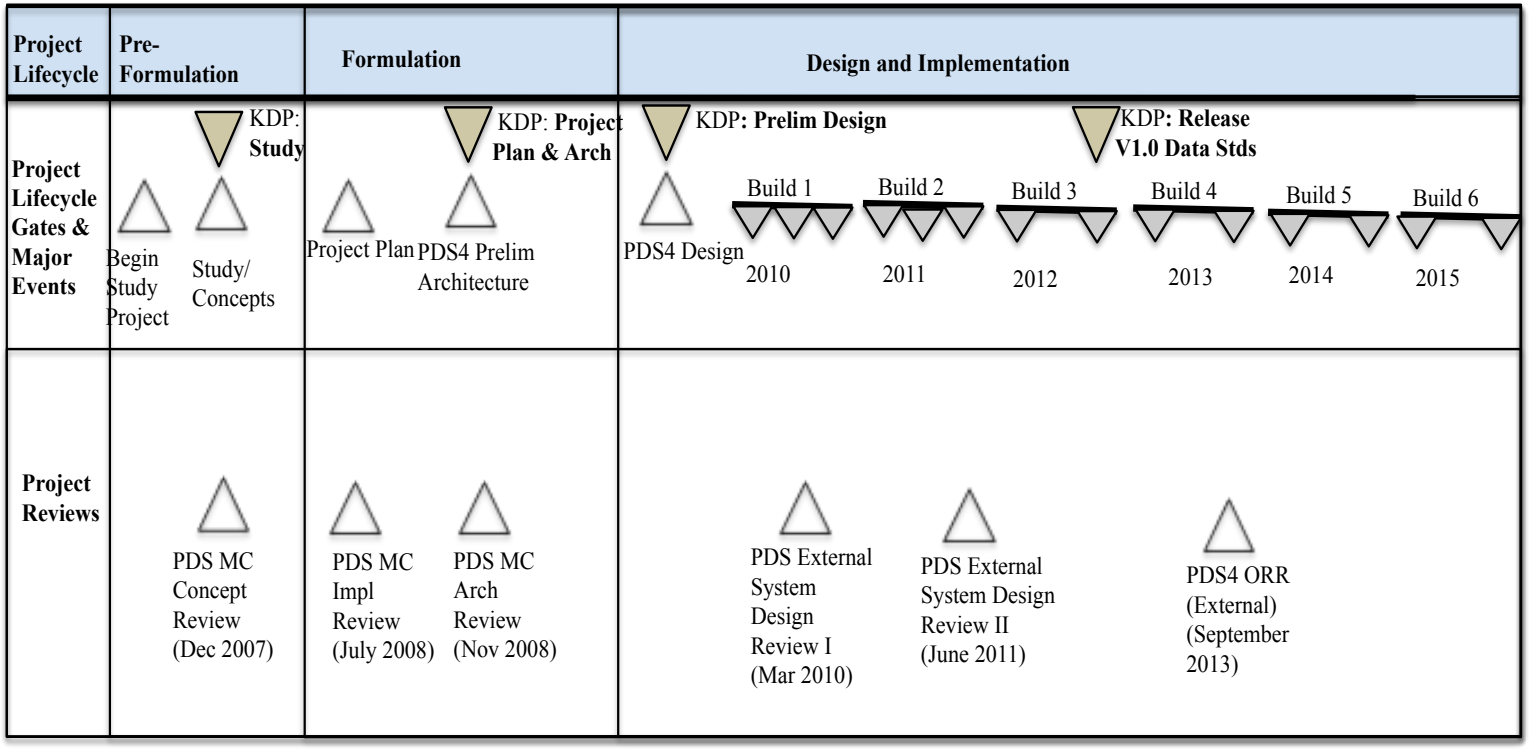
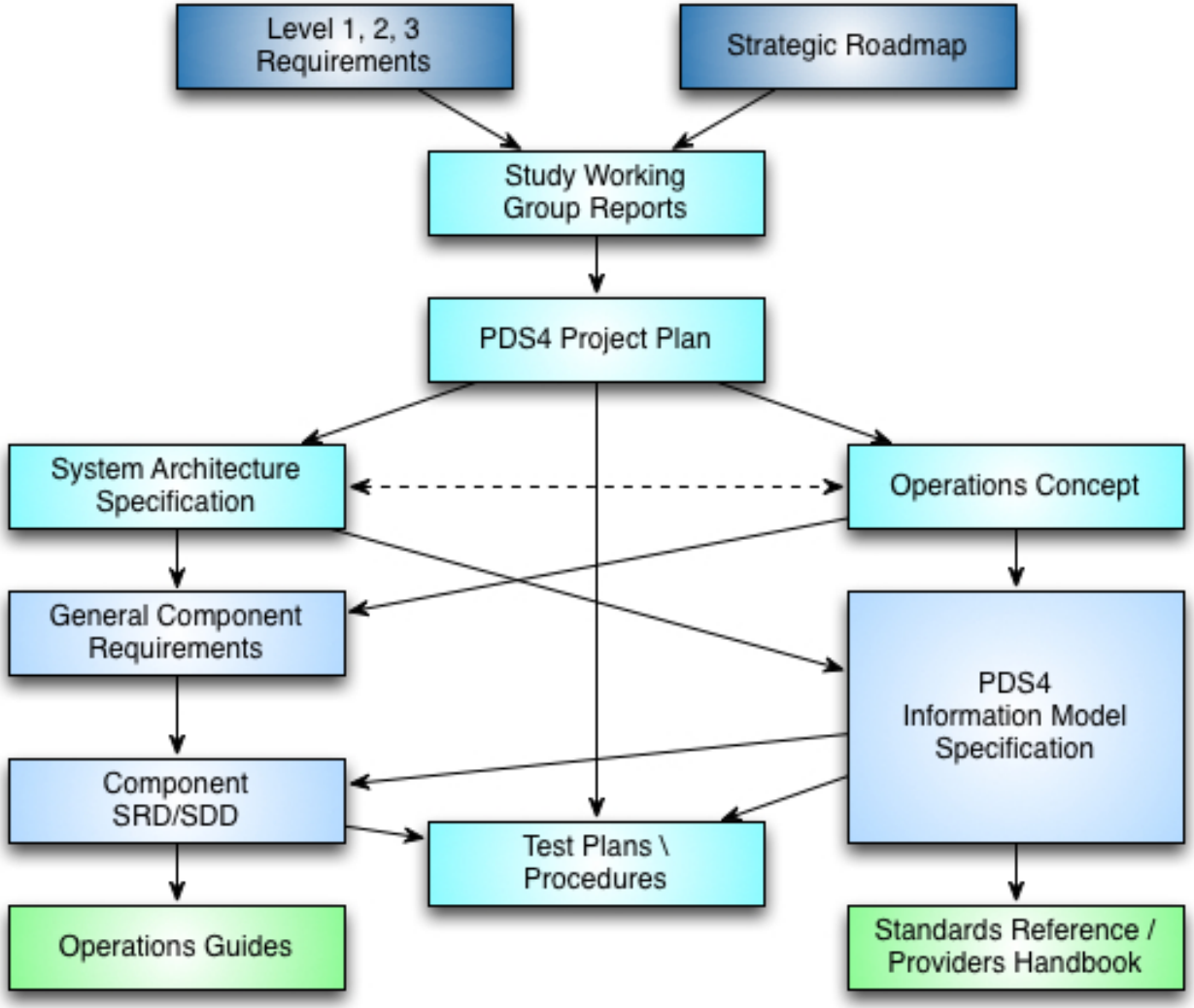
PDS4 Project Overview



An agile software development approach…

Document Tree



Development and Implementation Approach

- PDS nodes fully embedded in development process and builds
  - Management Council: Responsible for setting overall direction including policies and requirements.
  - Data Design Working Group: Responsible for overall development of the PDS4 information model and associated data standards.
  - CCB: Responsible for approving all changes to the PDS4 information model for builds.
  - Technical Group: Responsible for testing information model and software for their own systems as part of a build.

DDWG Attendees

Ed Bell
Richard Chen
Dan Crichton
Amy Culver
Patty Garcia
Ed Grayzeck
Ed Guinness
Mitch Gordon
Sean Hardman
Lyle Huber
Steve Hughes
Chris Isbell
Steve Joy
Ronald Joyner

Debra Kazden
Todd King
John Kodis
Joe Mafi
Mike Martin
Thomas Morgan
Lynn Neakrase
Jordan Padams
Paul Ramirez
Anne Raugh
Shannon Rees
Mark Rose
Matias Roybal
Elizabeth Rye
Boris Semenov

Dick Simpson
Susie Slavney
Dillon White

Peter Allan
David Heather
Michel Gangloff
Santa Martinez
Thomas Roatsch
Alain Sarkissian

* Anyone who sat through a DDWG 2-hour telecon or provided useful input.

Change Control Board (CCB) Members

- ATM - Lynn Neakrase (former Chair)
- CIS - Trent Hare
- GEO - Tom Stein, Chair
- IPDA - Santa Martinez
- PPI - Steve Joy
- RMS - Mark Showalter
- SBN - Ed Shaya
- EN - Emily Law, Coordinator

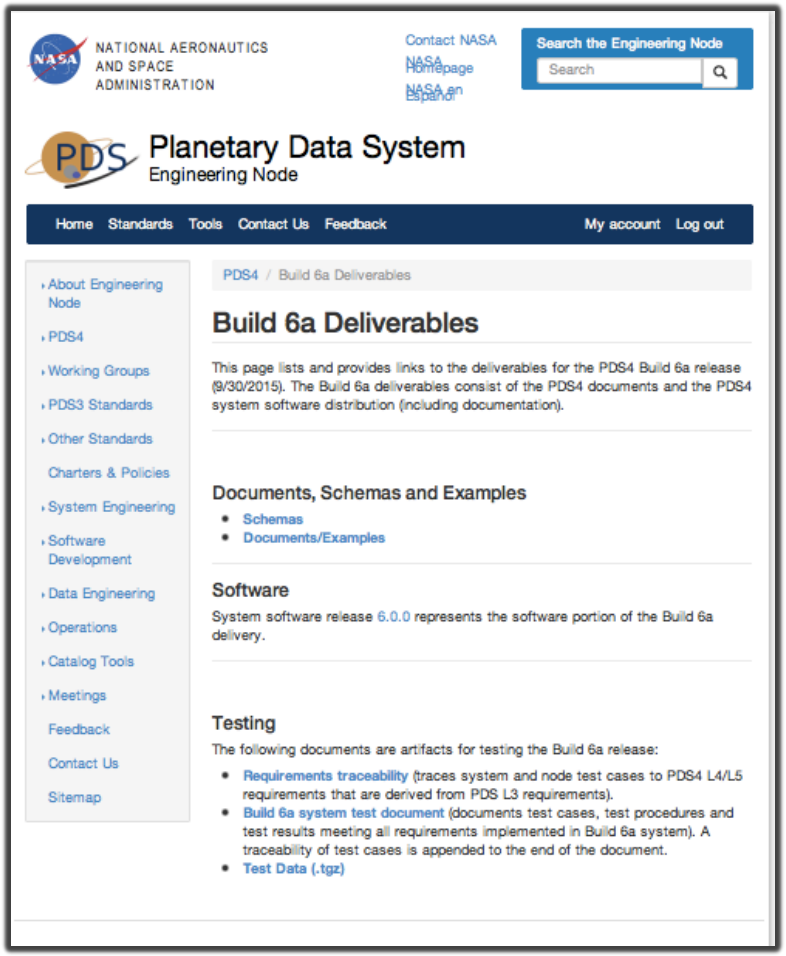
Reviews and Board Reports

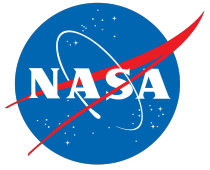
- Several reviews on PDS4 have been held both internally and externally. External reviews are as follows:
  - System Review I (2010)
  - System Review II (2011)
  - Operational Readiness Review (ORR) (2013)
    - Transition of PDS4 to Version 1.0 to support LADEE and MAVEN

"We would like to commend the PDS team on a truly excellent piece of system and software engineering, and recognize that you have figured out how to successfully navigate and manage a potentially very difficult distributed and diverse community." – PDS4 ORR Board

System Builds

- PDS4 uses system builds to bring together the software and the information model
  - Established very early in the project to organize releases
  - Provides a predictable structure to bring the teams together
  - Provides incremental functionality relative to budget constraints
  - Allows for feedback both inside and outside PDS
  - Allows for adoption by the DNs which have varying needs over time
- Each build provides a full lifecycle to capture, CM, integrate, test and deploy the release





Integration and Test Process

- Integration and Test (I&T) is used to integrate and test the various PDS4 components
  - Only approved SCRs are included in a build
  - Nodes are given a few weeks to test and review standards changes prior to starting a build
- Full suite of regression tests applied to each build
  - Test cases are documented
  - Test data is provided
- All results are documented

PDS4: Builds

Phase	Purpose	Date
Build 1 Concept Planning	• Early formalization of the data standards concepts • Early formalization of software concept • Development of build processes • Comments and feedback from community on concepts	Oct 2010 (a) Feb 2010 (b) May 201 (c) Aug 2011 (d)
Build 2 LADEE/MAVEN Prototyping	•Support LADEE, MAVEN Label Design Planning •PDS4 beta info model, standards reference, data dictionary, schemas baseline • Early prototype of software tools and services	Sept 2011 (a) Feb 2012 (b) June 2012 (c)
Build 3 Transition Planning at EN	•Transition testing of entire PDS3 catalog to PDS4 •Extensive testing of validation, harvest, registration •Stable release of data standards (V1.0 designated for ORR) •Deployment of software services and tools at EN	Sept 2012 (a) March 2013 (b)
Build 4 LADEE support	•Passed ORR (Sept 2013) •Release V1.1, V1.2; Support for LADEE •LADEE adoption of V1.1 at Atmos •EN full deployment and transition to PDS4	Sept 2013 (a) March 2014 (b)
Build 5 MAVEN support	•Release V1.3, V1.4; Support for MAVEN •MAVEN adoption of V1.3/V1.4 at Atmos, PPI, NAIF •O-Rex adoption of V1.3 •Data Distribution for LADEE and MAVEN	Sept 2014 (a) March 2015 (b)
Build 6 InSight and International Missions	•Release V1.5 (Sept 2015) •InSight adoption of V1.5 •Testing with International Community	Sept 2015 (a) March 2016 (b) (planned)

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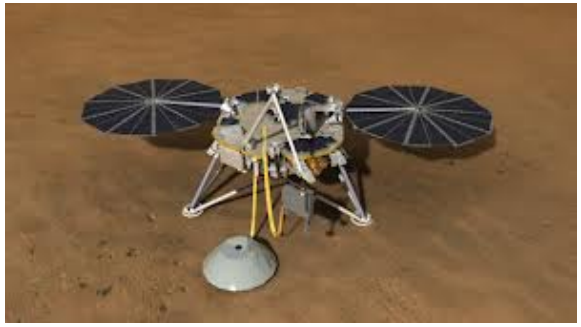
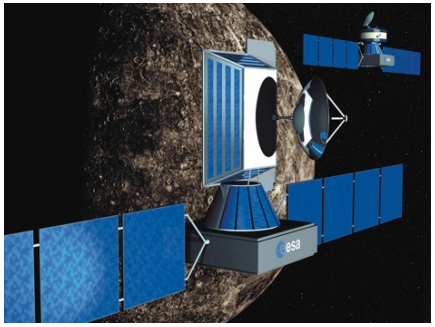
PDS4: Support for a New Era of International Missions

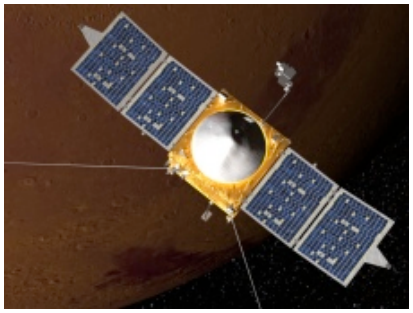
LADEE (NASA)



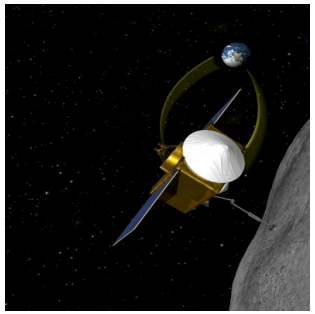
InSight (NASA)



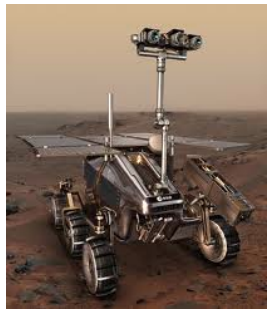
BepiColumbo (ESA/JAXA)



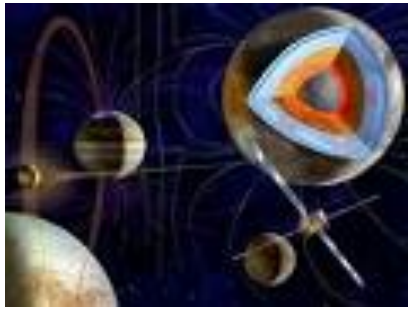
MAVEN (NASA)



Osiris-REx (NASA)



ExoMars (ESA/Russia)

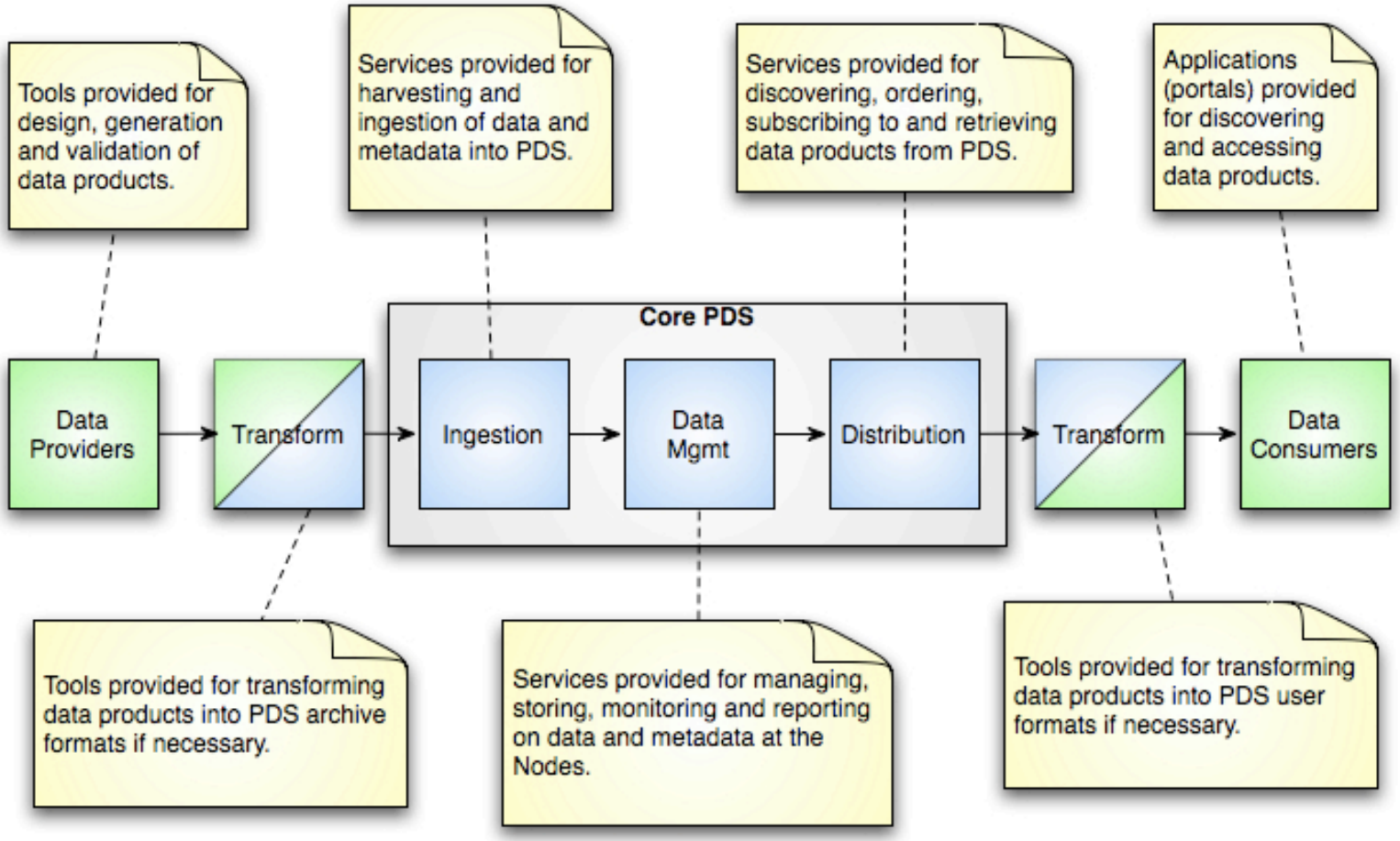


JUICE (ESA)

…also Hyabussa-2, Chandryaan-2, Mars 2020…

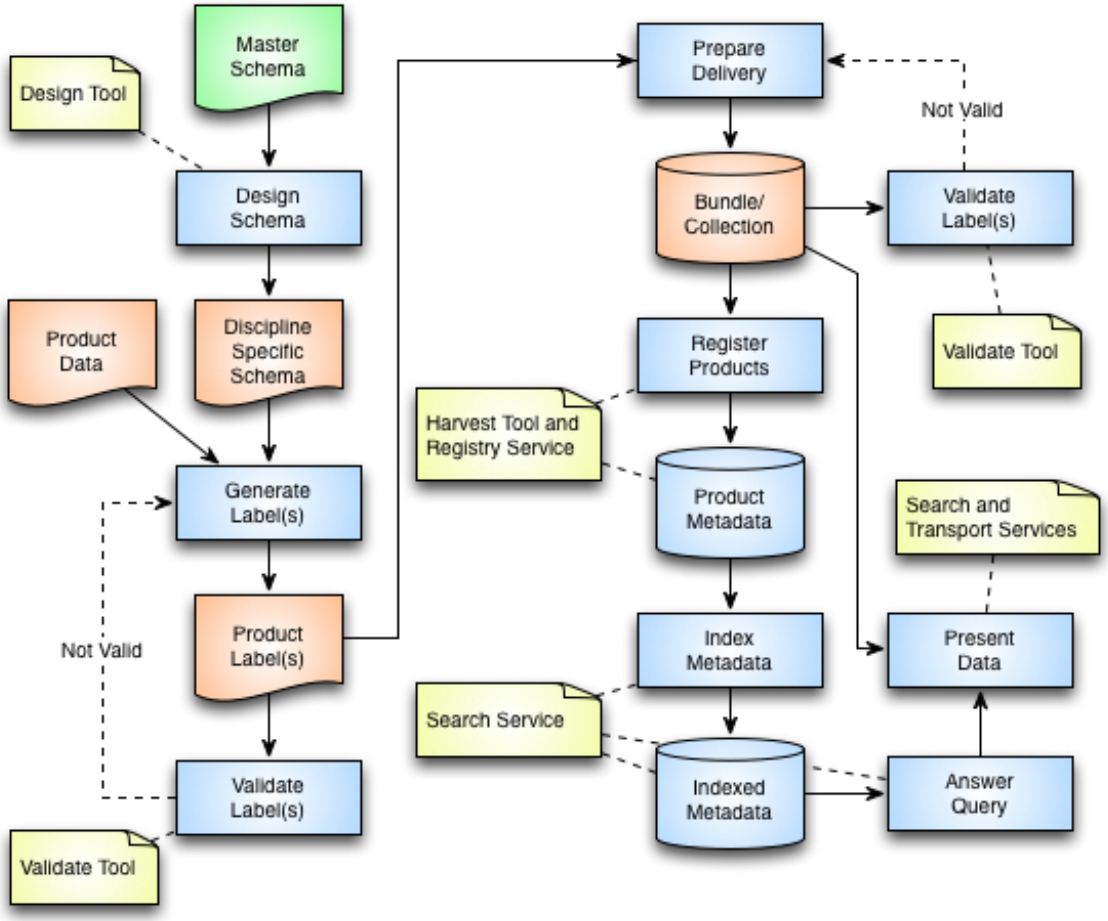
Endorsed by the **International Planetary Data Alliance** in July 2012 – https://planetarydata.org/documents/steering-committee/ipda-endorsements-recommendations-and-actions

PDS4 Operations Concept



PDS4 Software Components

Mapped to System Flow



Build Software and Standards Deliverables

Software System

- Registry Service
- Harvest Tool
- Validate Tool
- Security Service
- Report Service
- Search Service
- Transform Tool
- Catalog Tool
- PDS4 Libraries
- Upgraded portal search and page views to support PDS4

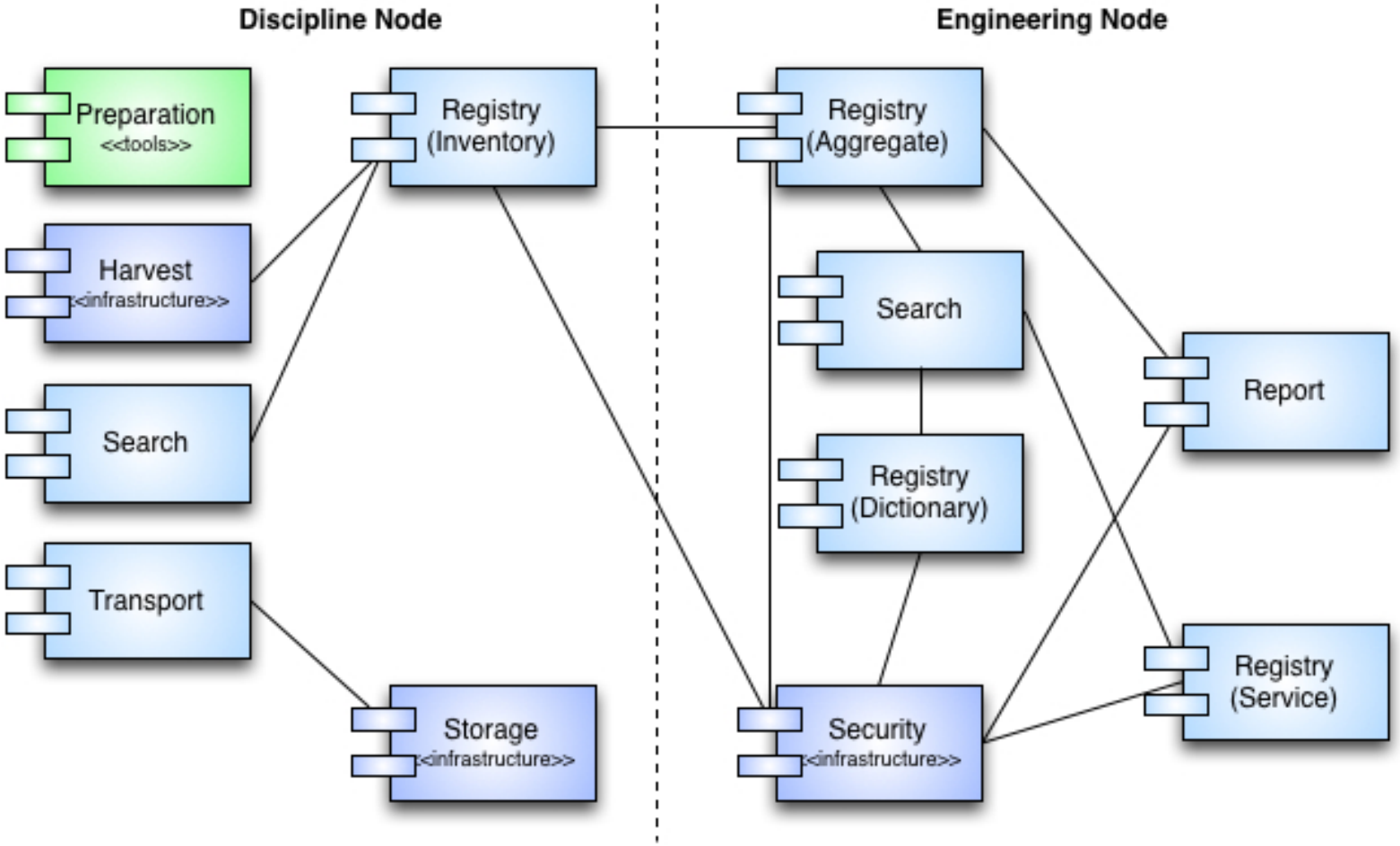
Data Standards*

- Information Model
- XML Schemas
- Data Dictionary
- Concepts Document
- Standards Reference
- Data Providers Handbook
- PDS4 Example Products

** Posted to http://pds.nasa.gov/pds4*

Component Provisioning

(Balanced between Centralized and Decentralized)



Document Status

- Concepts Document (v1.4, Sept 2015)
- Glossary (v1.4, Sept 2015)
- Data Provider's Handbook* (v1.3, Sept 2014)
- Standards Reference (v1.4, Sep 2015)
- Data Dictionary (v1.5 Sept 2015)
- Information Model Specification (v1.5, Sept 2015)
- Example Products (v1.4, Sept 2015)

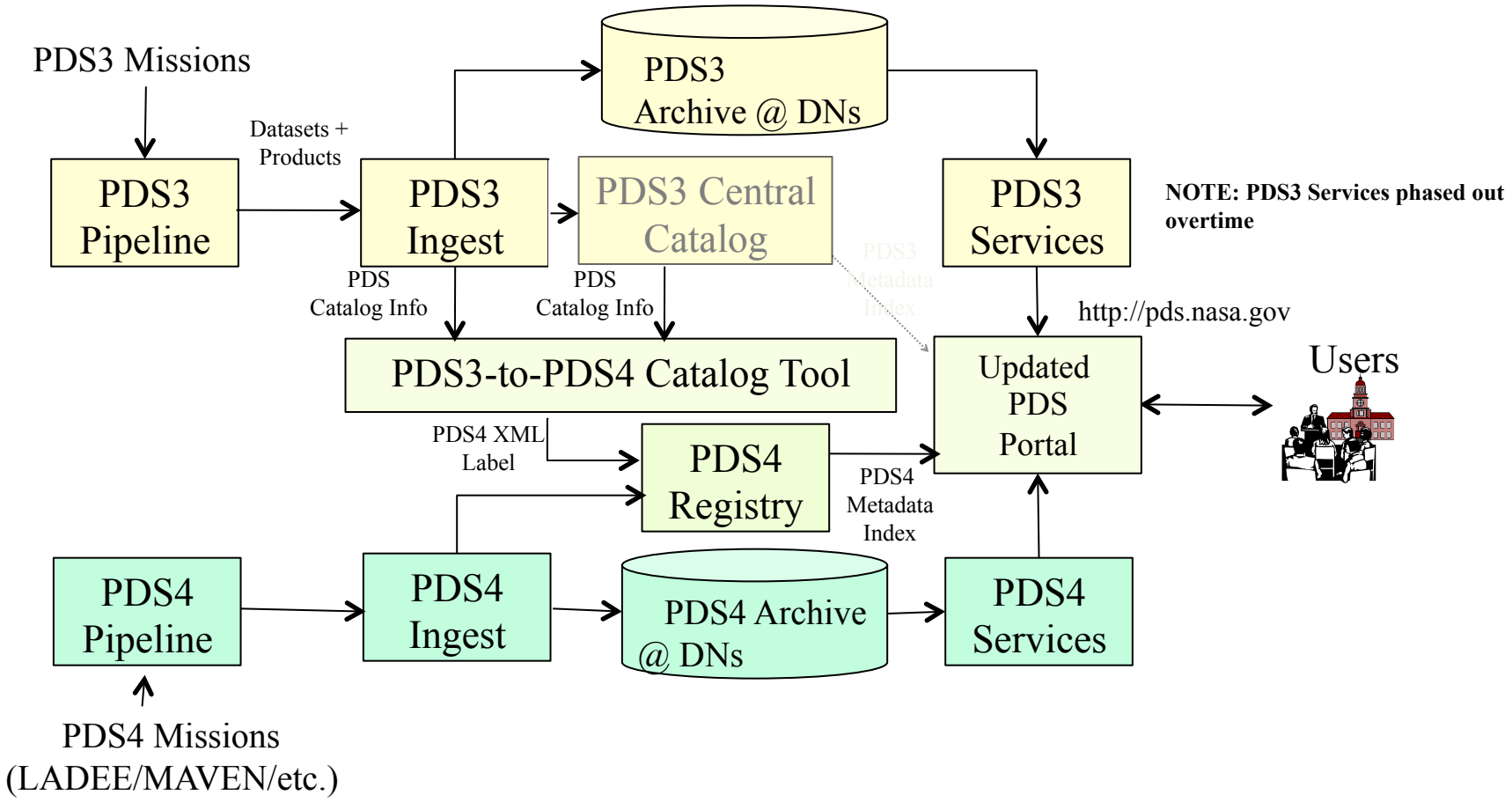
** We expect the DPH will become more than one document in the future to address different stakeholder needs (e.g., large-scale missions vs DAPs).*

Transition from PDS3 to PDS4

- PDS designed PDS4 to be able to access both PDS3 and PDS4 archives through a single system given that
  - PDS is required to continue to support PDS3 data deliveries from active missions (e.g., Cassini, MSL, etc)
  - Discipline Node adoption to PDS4 will occur independently
  - Desire to support a single, operational system

- The architecture of PDS4 allowed the Engineering Node to do this by enabling "registration" of PDS3 and PDS4 data
  - PDS3 catalog information explicitly included in the model as a PDS4 product type
  - All PDS3 "catalog" information has been migrated

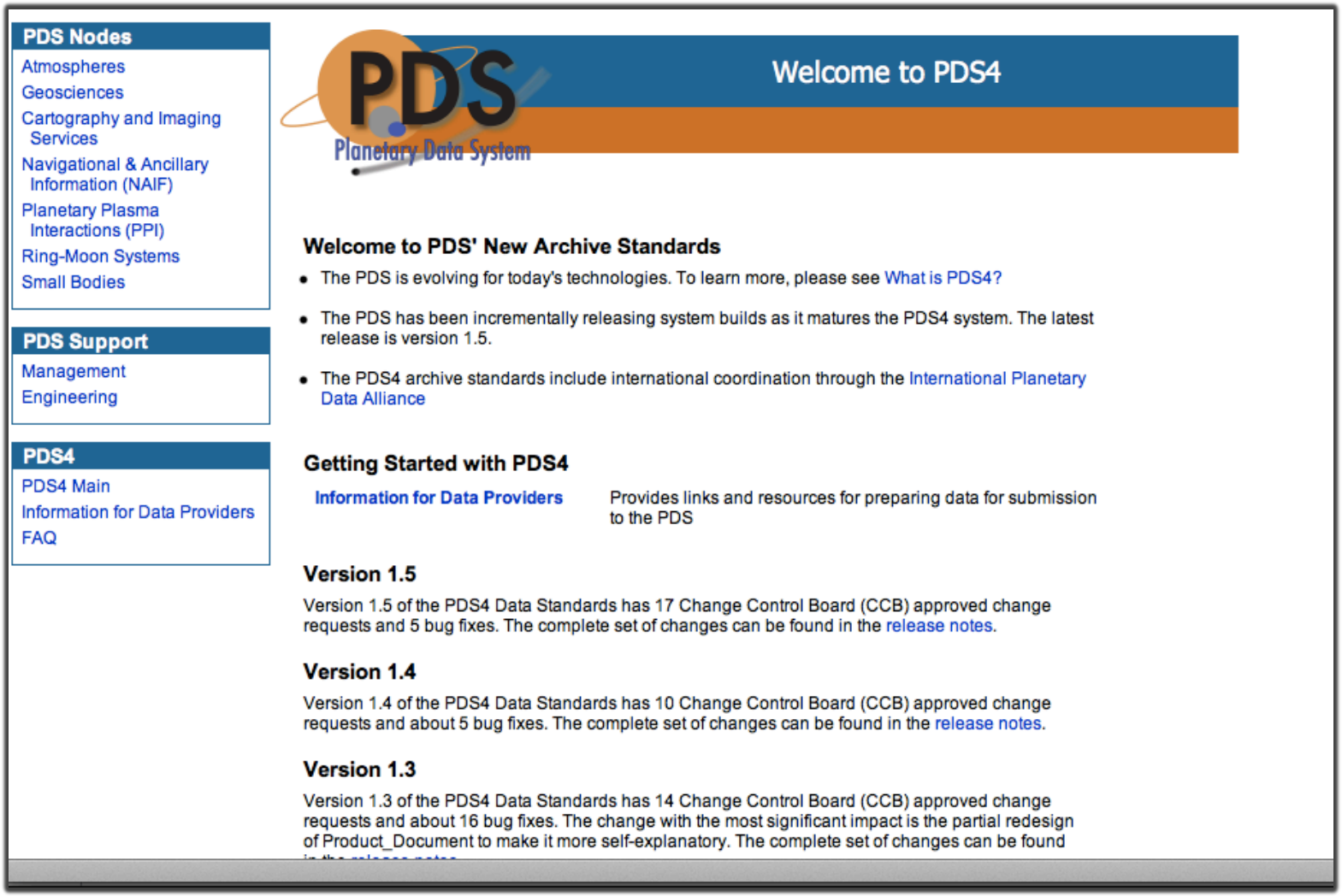
EN Transition to PDS4

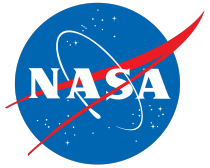


PDS4 Software at Nodes

- Atmospheres – Build 5b
- Geosciences – Build 5b
- Imaging (JPL) – Build 5a
- Imaging (USGS) – Build 5b
- NAIF – Build 4b
- PPI – Build 4b
- Rings – Build 5a
- Small Bodies – Build 4b
- Small Bodies (PSI) – Build 5b

Public Releases





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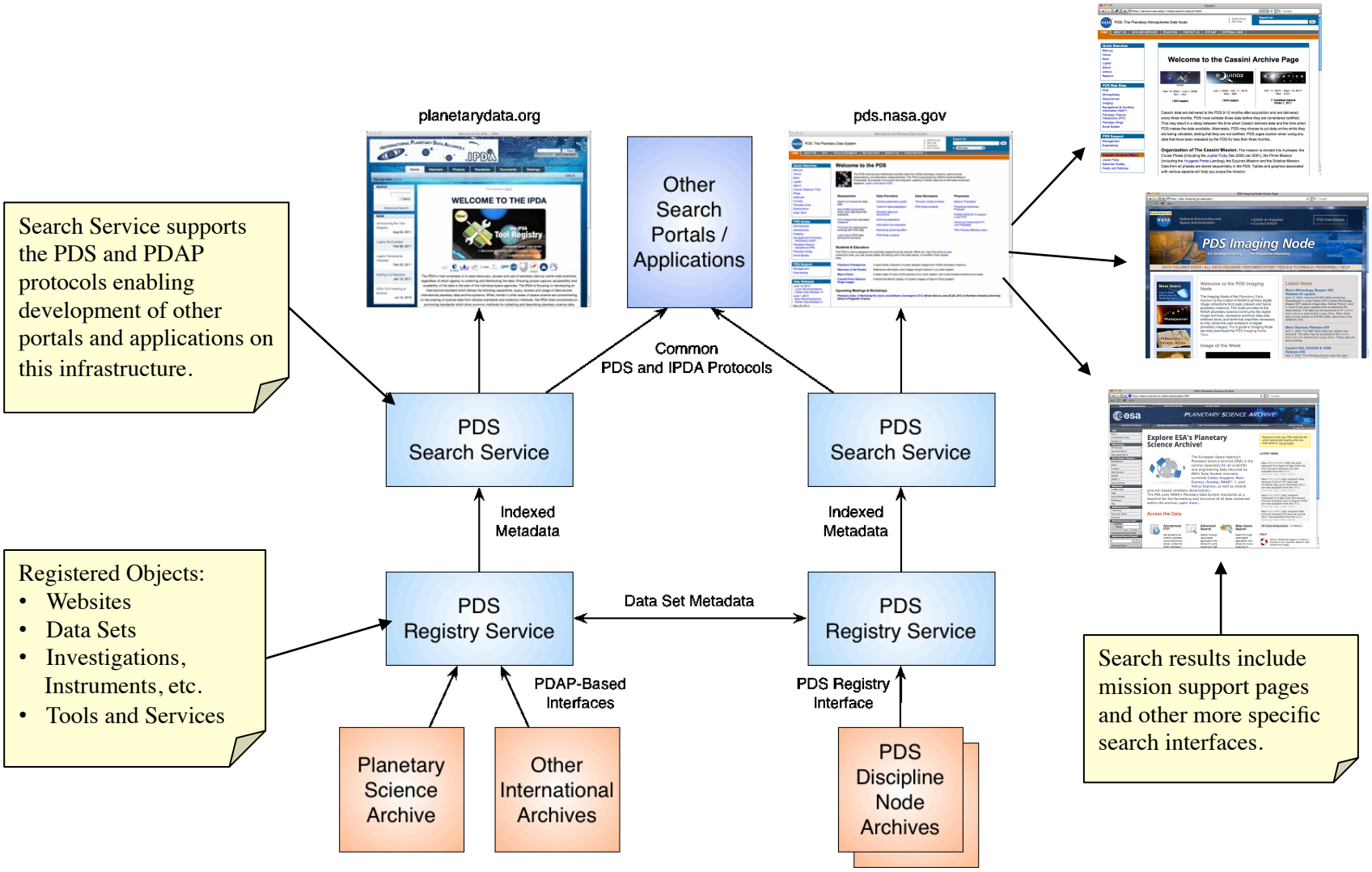
Archive Capabilities

- Design and Label Preparation
  - XML and design tools in place
- Validation
  - Validate Tool in place for PDS4 labels
- Ingest capabilities for PDS4
  - Part of the registration process
- Several missions have now been through or are going through this process
  - LADEE, MAVEN, Insight, O-Rex, and international missions

Search and Access in PDS4

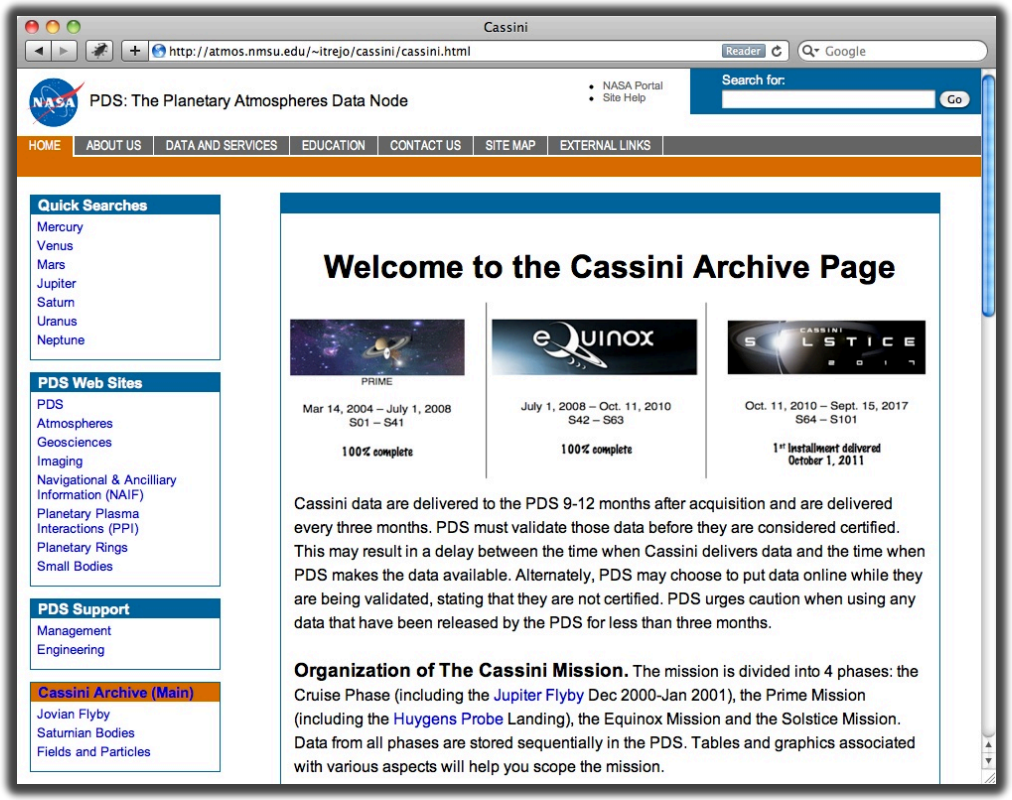
- PDS4 provides significant improvement for search and access
  - Registration of a variety of PDS data products (data collections, tools, websites, etc) at the PDS home page for *access across PDS and internationally*
  - Classification of data into facets for navigation
  - A scalable search engine to quickly return results
  - Specialized searches of individual data products (e.g., observational data) provided by Discipline Nodes
- Archive Support Pages
- Transformation services

PDS Search Architecture



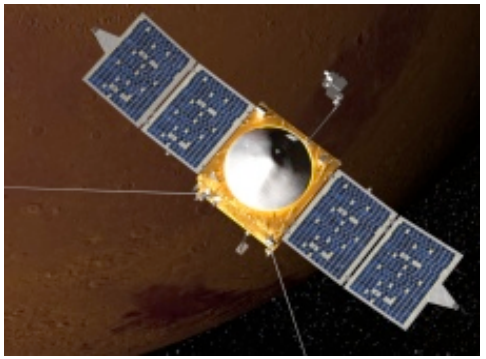
Archive Support Pages

- Cassini Archive Support page has been received well and used for PDS4
  - Used to support Cassini Senior Review
- Those pages show up at the top of a search now with the new search service



LADEE and MAVEN Archive, Search and Access

LADEE

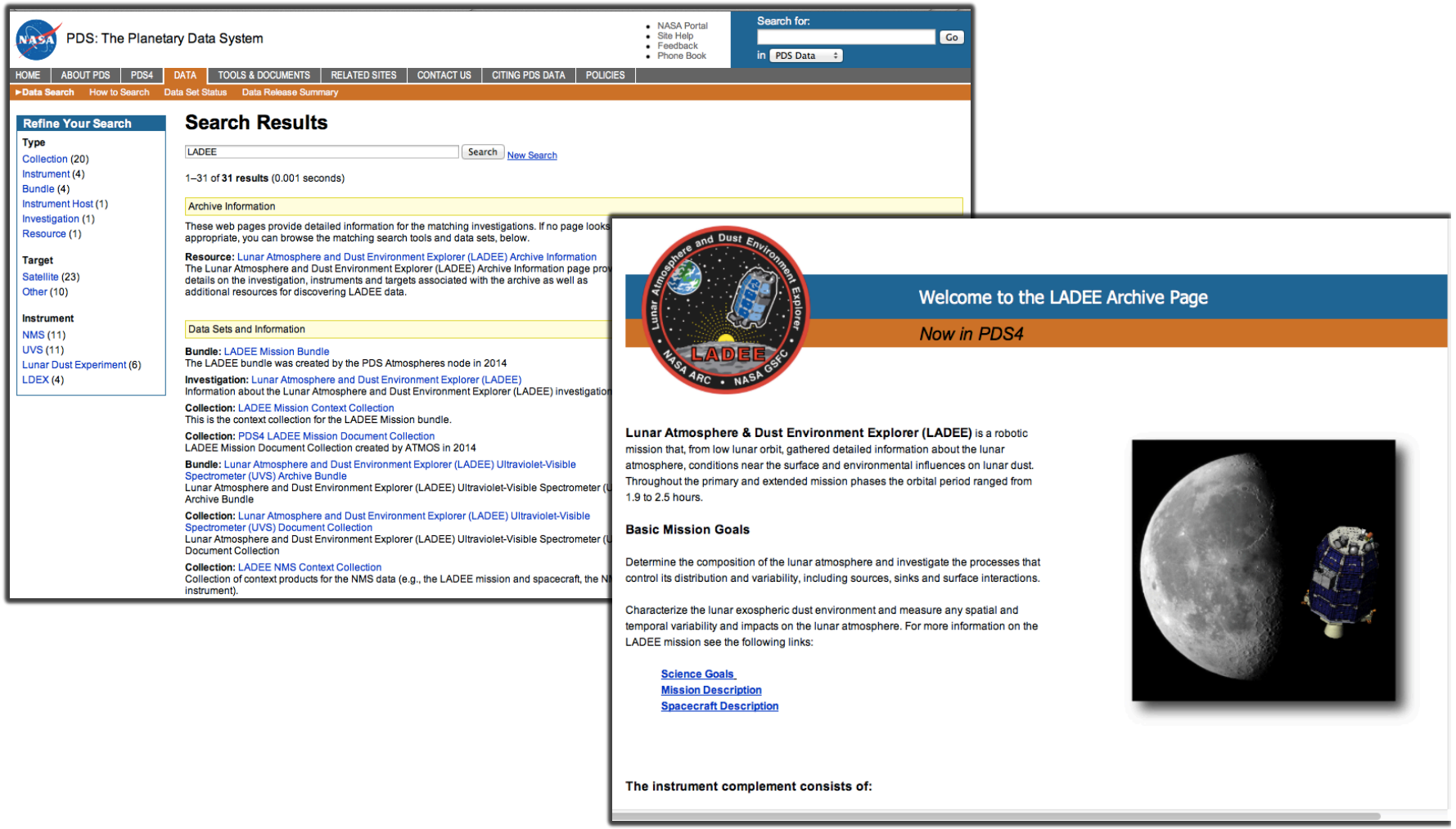


MAVEN

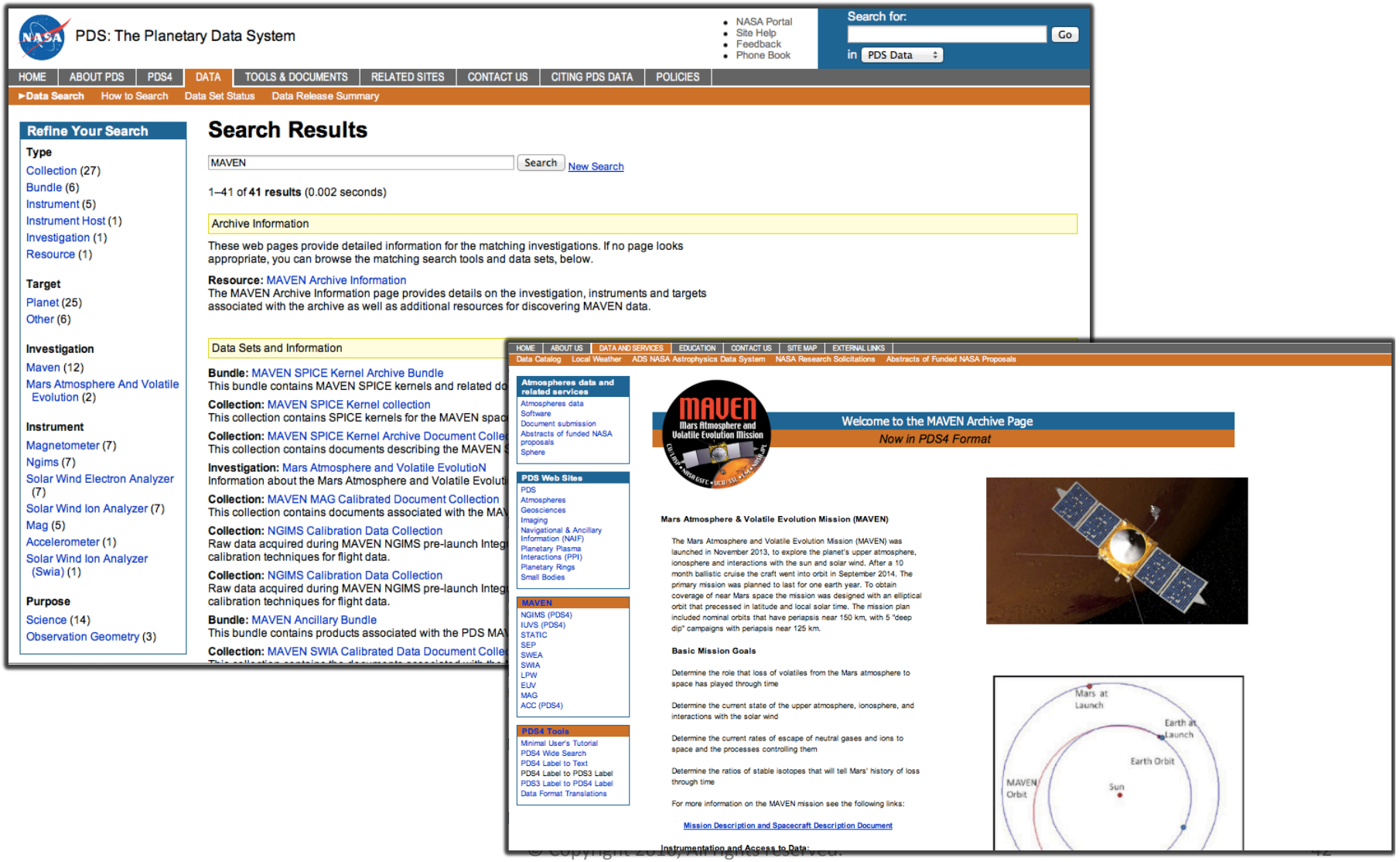
Full archive and data distribution occurring under PDS4 for these missions.

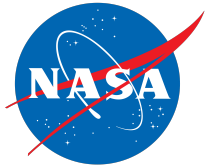
PDS4 Mission	Bundles	Collections	Products
LADEE	4	20	2,086,895
MAVEN	6	27	9,531

PDS4 Data Search: LADEE



PDS4 Data Search: MAVEN





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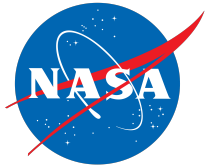
  - Role of UCD
  - IPDA Participation
  - Future Plans (added)
  - Resource Allocation and Budget Scenarios

NSSDCA Deep Archive

- Serves as the long-term archive for PDS
  - Managed and operated at GSFC
- Working Group formed in DDWG to support the interface
- PDS4 standards extended to provide specific support for data deliveries to NSSDCA based on OAIS reference model
- NSSDCA currently upgrading their infrastructure to support PDS4 deliveries
- Testing is underway using the LADEE NMS bundle from ATMOS
- Operational support will be included in Build 6b (March)
- Preparing for LADEE deliveries to NSSDCA (Spring 2016)



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User Centered Design Support to Engineering Node

- Ames has provided support for user-centered design consulting and tool development
  - Developed PDS3 Volume Validator, Data Slicer tools and PDS4 LACE (Label Design) tool
  - Consulting on look-and-feel of PDS web interfaces
  - Working with EN to create an integrated PDS3/PDS4 validation tool
- Ames will be delivering the software and procedures to EN in February
  - Capture software of all tools in EN CM
  - Transition operations of Volume Validator to EN
  - Consider the future of LACE

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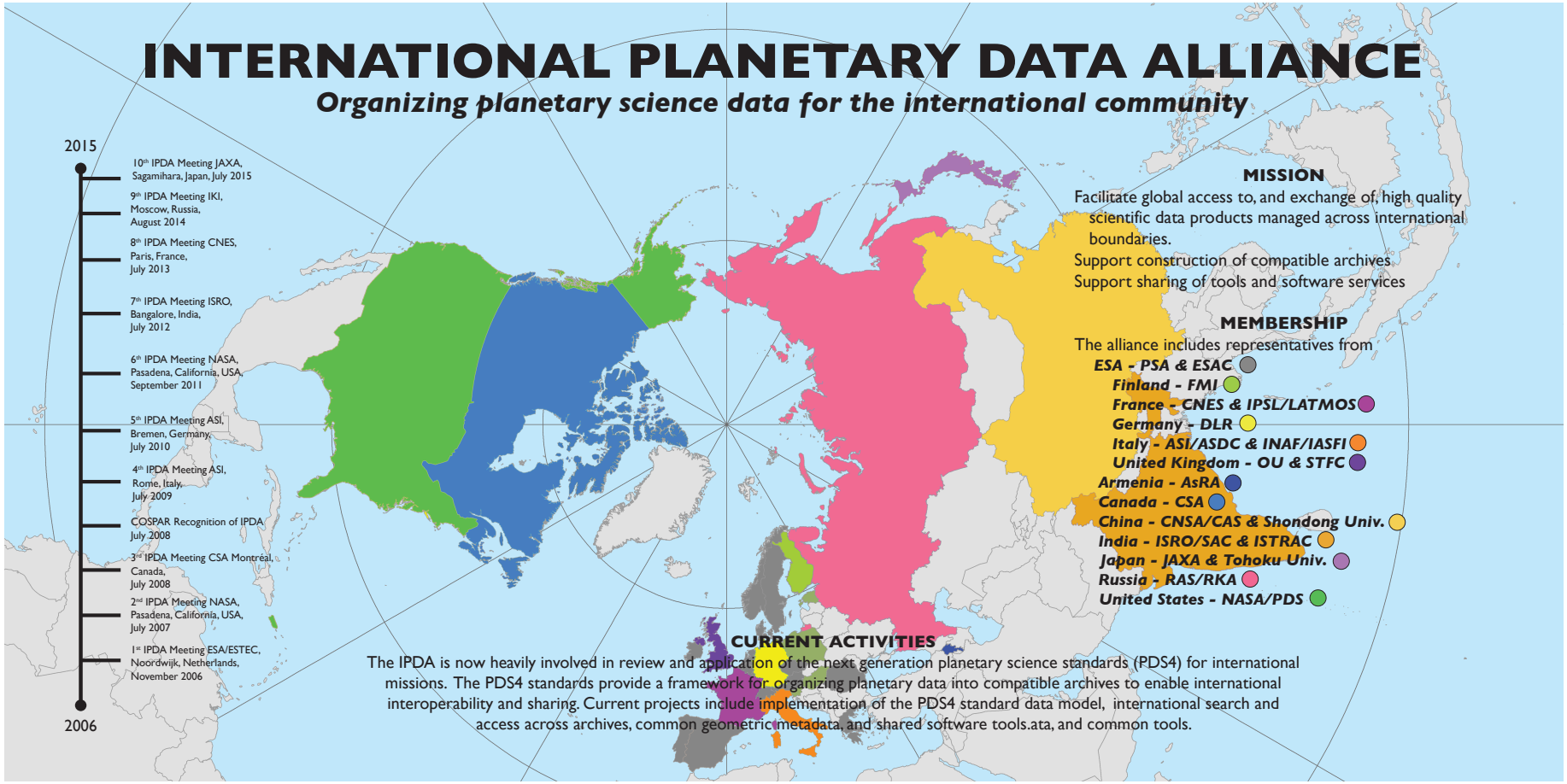
International Planetary Data Alliance

- Founded in 2006
  - Resulted from meeting between Planetary Science Archive and PDS at ESAC
- Mission is to build compatible, international planetary data archives for the purpose of interoperability
- IPDA has chair that rotates every two years
  - Crichton served as chair from 2011-2013
- Major investment in PDS4

World-wide Engagement



وكالة الإمارات للفضاء
UAE SPACE AGENCY

United Arab Emirates

Ref: IPDA/OA/DG/069
Date: 29 December 2015

To the attention of the IPDA Chair
Gopala Krishna
Email: bgk@sac.isro.gov.in

Copy to:
Tom Stein - stein@wunder.wustl.edu
Daniel Crichton - Daniel.J.Crichton@jpl.nasa.gov
Reta Beebe - rbeebe@nmsu.edu

Subject: Application for Membership in the IPDA

Dear Dr. Gopala Krishna

I write to you on behalf of the United Arab Emirates Space Agency (UAE SA) and its chairman Dr. Khalifa AlRomaithi asking you kindly to formally convey to the International Planetary Data Association (IPDA) that UAE Space Agency's desire to join as a participating member in the IPDA. The UAE SA hereby states that it fully shares and accepts the IPDA charter detailing its principles and objectives.

This timely request reflects the UAE SA interest and commitment towards Space and Planetary Exploration and ensuring that the resulting science data is made freely available to all the international science community in compliance with the UN principles for the peaceful usage and exploration of Space for the benefit of all mankind. Moreover, the UAE SA has now been accepted as a participating member of the International Space Exploration Coordination Group (ISECG) which paves the way for the UAE to play a proactive role in Space and Planetary exploration.

The UAE SA has been tasked by its country's leadership to set in motion a mission to explore the planet Mars (EMM). The objective is to send an orbiting probe (The Hope Probe) to the red planet that will allow the collection of new and unique data sets that will enable planetary scientists to better understand the behavior of the Martian atmosphere. The goal is to reach Mars orbit in 2021, to coincide with the 50th Anniversary of the establishment of the United Arab Emirates. Below is a summary of the "Hope" probe science mission objectives:

The EMM Science Objectives:
The EMM science objectives stem from the collective consensus of the global Mars science community, exemplified by MEPAG, on what are the key questions that have not yet been addressed fully by other mission, past present and planned.

وكالة الإمارات للفضاء
UAE SPACE AGENCY

United Arab Emirates

The EMM objectives focus on:

1. Searching of connections between today's weather and the ancient climate of the Red Planet.
2. Study why Mars is losing its atmosphere to space by tracking the behavior and escape of hydrogen and oxygen, which are the building blocks of water.
3. Investigate how the lower and upper levels of the Martian atmosphere are connected.
4. Create the first global picture of how the Martian atmosphere changes throughout the day and between the seasons.

The Hope Probe Science Instruments:
1. An Imager – Visble/NearUV - a high-resolution multi-spectral imaging digital camera.
2. An Infra-Red Spectrometer – which will examine temperature patterns, ice, water vapour and dust in the atmosphere.
3. An Ultraviolet Spectrometer – which will study the upper atmosphere and traces of oxygen and hydrogen further out into space.

EMM Science data:
Over its planned 2 year mission life time the spacecraft will be orbiting Mars in a an elliptical orbit (55hour, 20k – 40k Km orbit) collecting and sending back to Earth new Mars data. This information will be received and processed in the Science Data Center (SDC) in the UAE. These never-seen-before data will be catalogued and analysed in the UAE by the Emirates Mars Mission science team, and then shared freely with the international Mars science community as a service to human knowledge. We hope that this can be done in a way compliant to the IPDA recommended standards and procedures. The EMM team is familiar with the MAVIN experience with the PDS4 implementation project and looks forward to applying this to the EMM data. The UAE SA is keen to support the IPDA initiative for using a standardised basic data model and XML that would enable users from the international science community to perform top down searches and access data residing at our local SDC.

The UAE Space Agency shall designate its director of Space Mission Management, Mr. Khaled Al-Hashmi to be representative for the UAE at the IPDA. You may contact him directly via his email K.AlHashmi@space.gov.ae should you require any further information.

Yours Sincerely,

Dr. Eng. Mohamed N. Al Ahbabi
Director General
United Arab Emirates Space Agency
P. O. Box 7133, Abu Dhabi, UAE
Email: dg@space.gov.ae

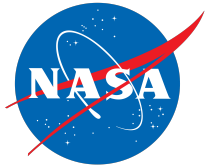
2015-2016 Projects

- Data Access Protocols (Isa, Baptiste, Sean)
- Website Project (Dan)
- Registry and Search (Sean, Dan)
- PDS4 Implementation (Santa, Steve)
- MOU Project (Yukio, Reta)
- IVOA/IPDA Coordination (Baptiste)
- Citing IPDA (Alain)

IPDA Outreach at Conferences

- AGU 2011-2015
- COSPAR 2012, 2014, 2016
- EPSC 2013-2014
- EPSC/DPS 2011
- IVOA 2014
- LPSC 2011-2014
- Planetary Data Workshop 2012, 2015
- Planetary GIS Workshop 2015
- PV 2011, 2015
- VAO 2012

More than 30 papers and presentations at planetary and data science conferences from 2010-2015.



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  - Resource Allocation and Budget Scenarios

Overall Goals (2016-2021)

1. Automate ingestion of data
2. Capture well-formed, high quality PDS4 data collections
3. Expand from Stewardship to User Services
4. Establish Virtualization
5. Upgrade legacy software tools to 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

PDS4 Technical/Software Roadmap

Function	2010-2015	2016-2021
Ingestion	Manual process for submission; tools based on PDS4 standards for design/validation	Automated ingestion/submission of data; include increased support for capturing mission information.
Data Management	Independent data management systems across PDS; initial PDS4 software installed and registration beginning.	Integrated data registries with PDS3 and PDS4 data across the PDS to allow for end-to-end tracking and search; interoperability with international partners.
Storage Management	Data stored online in independent storage repositories; backup/ failover unique at each node.	Virtualization/commodity storage services to increase integration and reduce cost; PDS-wide disaster recovery and failover in place.
Preservation Planning	Data maintained in a few simple formats	Transformation services to transform from archive formats to contemporary formats.
Distribution/ Access	Data distributed in archival format	Enhanced portal for access to data/services/tools; Data distributed in user formats; user services and tools to better facilitate and meet user analysis needs.

2010 to 2015: Focus on shifting missions and nodes to support PDS4
2016-2021: Future plans on integrating data, nodes, services, etc, together to improve user experience

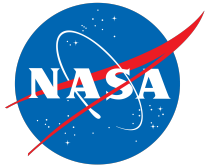
PDS4 Information Architecture/ Model Roadmap

Function	2010-2015	2016-2021
Data Model	Entire PDS model captured as an explicit model (ontology) defining all aspects including data, missions, instruments, etc.	Expanded discipline node and mission models to provide increased capture of mission/science information and provide more tailored user support (search, tools, analysis, etc.). Improve integration between software and model.
Data Dictionary	Captured using a rigorous, well-defined structure based on the ISO/IEC 11179 standard; elements organized into namespaces to allow for international coordination	Online data dictionary registries for mission and user use.
Grammar	Extensible Markup Language (XML) used to capture PDS metadata; Standard XML tools used	In addition to XML-based support, support for multiple standards for expressing the PDS model (RDF, JSON, etc.) to increase use of information model in tools.

2010 to 2015: PDS4 IM stable and released with data dictionary and grammar.
2016-2021: Future plans in the information architecture/model focus on discipline node extensions to improve users support.

FY17/FY18 Plan

- Continue development, maintenance and operations of core PDS4 services and tools
- Develop and deploy the *PDS4 Tracking Service*
- Begin design and development of a new *PDS portal*
- Begin design and development of a new *PDS4 inspection tool*
- Support system I&T for Builds 7a, 7b, 8a, and 8b
- Support ingestion and release of PDS3 and PDS4 data deliveries for Cassini, LRO, MER, MSL, MRO, MAVEN, Mars Odyssey, InSight, Osiris Rex, and various small bodies.
- Support for data deliveries from the PDS Discipline Nodes to NSSDCA.
- Chair DDWG teleconferences.
- Support International Coordination for IPDA.
- Support PDS roadmapping efforts.



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In-guide Scenario Impacts

- ***Even with in-guide funding, the EN is losing 1.6 FTE going from 9.9 to 8.3 which will affect development and node support***

- Activities not supported by in-guide scenario
  - No funding identified to support UCD transition or maintenance of the software.
  - Support for PDS4 integration at the nodes and internationally.
  - Virtualization/cloud computing models.
  - Limited support for new portal redesign.

Over-guide Scenario Additions

- Support deployment of PDS4 services at the nodes and internationally, particularly to integrate registries and services for improved discovery and access
  - This is critical for improving integration and long-term usability of PDS nodes and data.
- Investigate virtualization models (e.g., cloud computing services) for storing primary or secondary data
  - This is critical for scaling PDS to support new mission data and users needs.
- Support UCD function including maintenance of existing tools and overhauling the PDS web look-and-feel
  - This is critical for improving navigation and usability of PDS4 for the community

Even with this scenario, the EN will still be <u>below FY16 levels</u>

Reduction Scenario Impacts

- EN budget reduced by 2.1 FTEs eliminating:
  - PDS4 Tracking Service
    - Usability of PDS-wide search and reporting (up through OMB) are directly affected because nodes are not integrated into a tracking system
  - Redesign of PDS portal based on PDS4
    - Current portal was an upgrade from PDS3, not a redesign. Long-term need better leveraging PDS4 capabilities at EN and across nodes for usability.
  - PDS4 inspection tool (e.g.. similar to NASAView)
    - NASAView is the most widely used tool from PDS. There is no equivalent in PDS4 today.

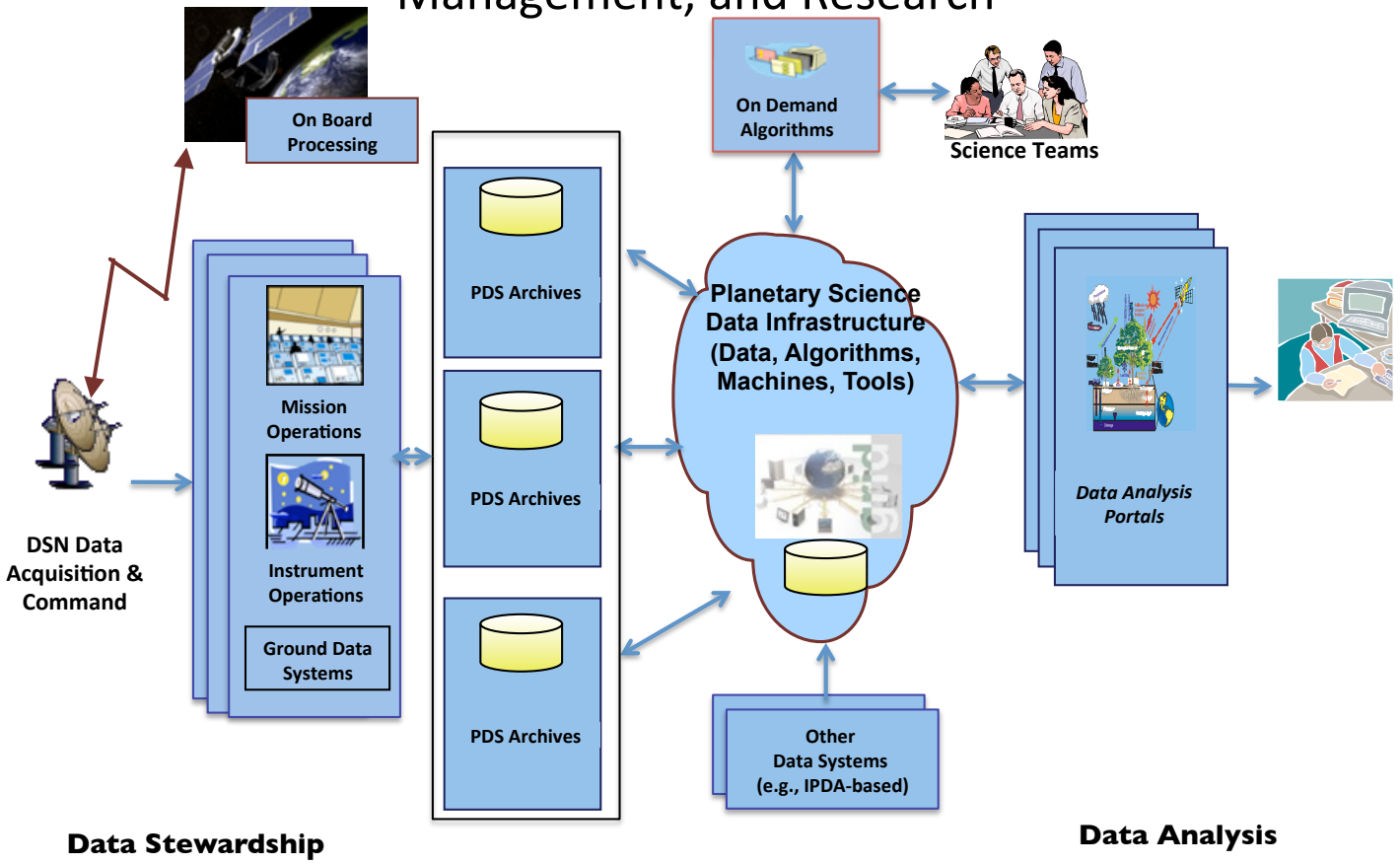
This scenario focuses the Engineering Node on sustaining current development and operations.

Review Criteria

- ✓ Evaluate the release of PDS4 and associated documentation
- ✓ Determine the adequacies to both archive and search the data in PDS4
- ✓ Evaluate tools, especially for web page access, with focus on end-users
- ✓ Evaluate the status for data delivery to the NSSDCA (deep archive) in PDS4
- ✓ Evaluate the participation in the International Planetary Data Alliance
- ✓ Itemize resource allocation (EN and NAIF separately)and show all funding
- ✓ Outline the role of the User Centered Design function with EN and NAIF
- ✓ Determine the Engineering Node's development and implementation process

PDS Engineering: Future Vision

"An International Platform for Planetary Data Archiving, Management, and Research"



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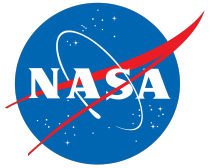
Questions?

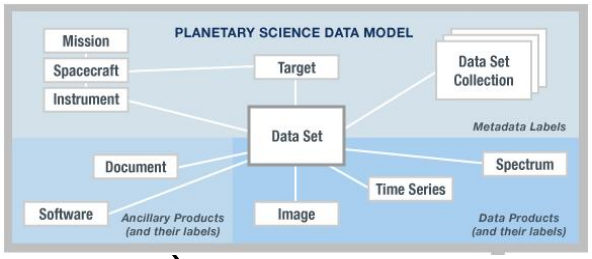
This research was carried out by the Jet Propulsion Laboratory,
managed by the California Institute of Technology
under a contract with the National Aeronautics and Space Administration.



Backup

PDS4 Information Model and Standards

Information Model



Used to Create

Label Schema

Validates

Expressed As

Extracted/Specialized

Data Element

has

Class

Planetary Science Data Dictionary

Product

Tagged Data Object (Information Object)

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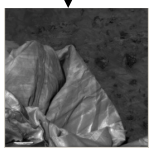
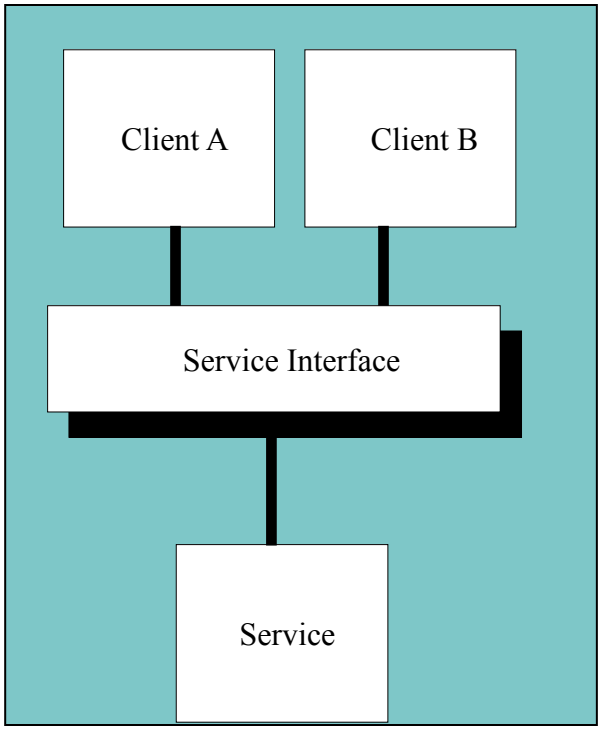


Data Object

System Design Approach

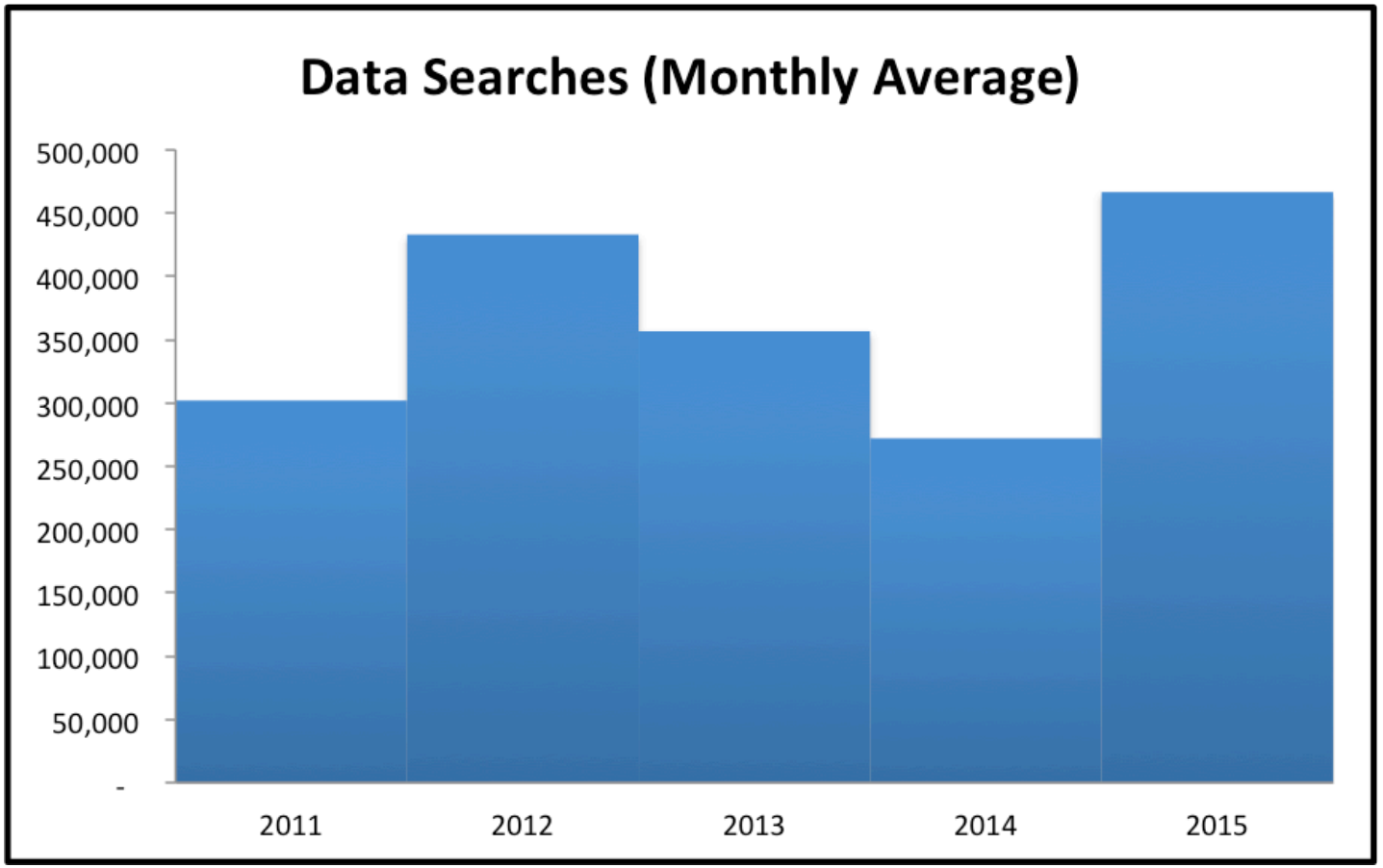
- Based on a distributed information services architecture (aka SOA-style)
  - Allow for common and node specific network-based services.
  - Allow for integrating with other systems through IPDA standards.
- System includes services, tools and applications
- Use of online registries across the PDS to track and share information about PDS holdings
- Implement distributed services that bring PDS forward into the online era of running a national data system
  - With good data standards, they become critical to ultimately improving the usability of PDS
  - Support on-demand transformation to/from PDS



2015 Meeting at JAXA

- Held at JAXA, July 22-24, 2016
  - 3 Day Meeting
- Representation from ESA, JAXA, ISRO, CNES, NASA
- Significant discussions around use of PDS4 for upcoming international missions

PDS Portal Searches



Software Downloads