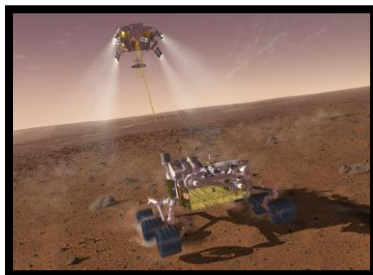




National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California



# The PDS4 Information Model (IM)

**Steve Hughes**

steve.hughes@jpl.nasa.gov

NASA Jet Propulsion Laboratory (JPL),  
California Institute of Technology

Third Planetary Data Workshop

Flagstaff, AZ June 12-14 2017

New planetary products, tools, data and services

Tuesday June 13, 8:55 am



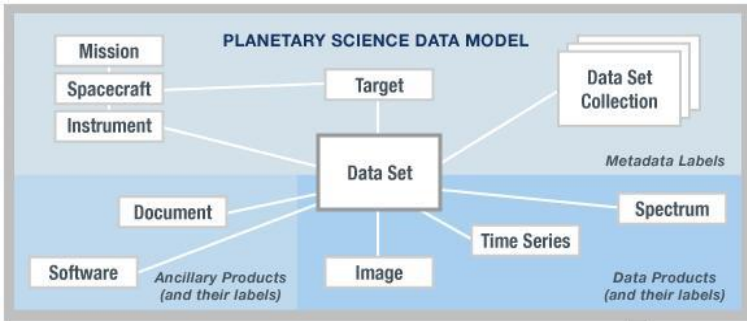
# Information Model Overview

- Developed using:
  - lessons learned from 20 years worth of archiving
  - best practices for information model development
- Foundational principles adopted from:
  - Open Archival Information System (OAIS) Reference Model - ISO 14721 - Foundational Principles
  - ISO/IEC 11179 - Volume 3 – Metadata Registry Specification - Hierarchy of data dictionaries and governance model.
  - W3C XML (Extensible Markup Language) - Rules for encoding documents electronically.
- Drives the PDS4 infrastructure by providing:
  - the representation of concepts and their relationships, constraints, rules, and operations
  - a sharable, stable, and organized structure of information requirements.
  - formal definitions that are suitable for configuring and generating code.

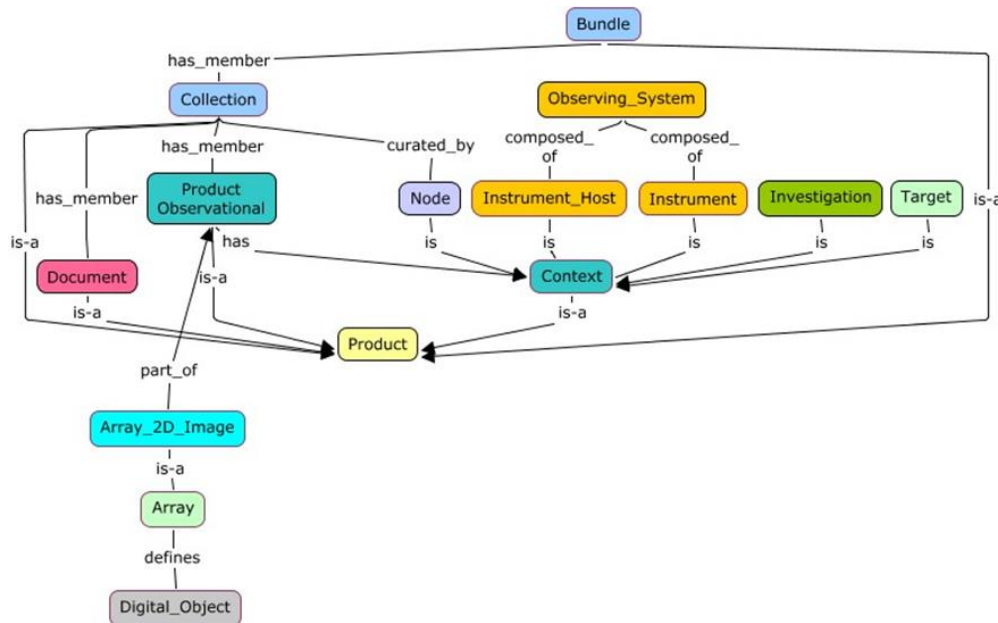


# Views

## Community's View



## Information Modeler's View



## Repository View

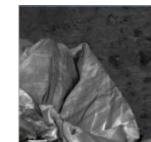
### Product

#### Tagged Data Object

(Information Object)

```
<local_identifier>MPFL_M_IMP_IMAGE</local_identifier>
<offset unit="byte">0</offset>
<axes>2</axes>
<axis_index_order>Last_Index_Fastest</axis_index_order>
<encoding_type>Binary</encoding_type>
<Element_Array>
  <data_type>SignedMSB4</data_type>
  <unit>pixel</unit>
</Element_Array>
<Axis_Array>
  <axis_name>Line</axis_name>
  <elements>248</elements>
  <sequence_number>1</sequence_number>
</Axis_Array>
<Axis_Array>
  <axis_name>Sample</axis_name>
  <elements>256</elements>
  <sequence_number>2</sequence_number>
</Axis_Array>
</Array_2D_Image>
```

Describes



Data Object

# Roles

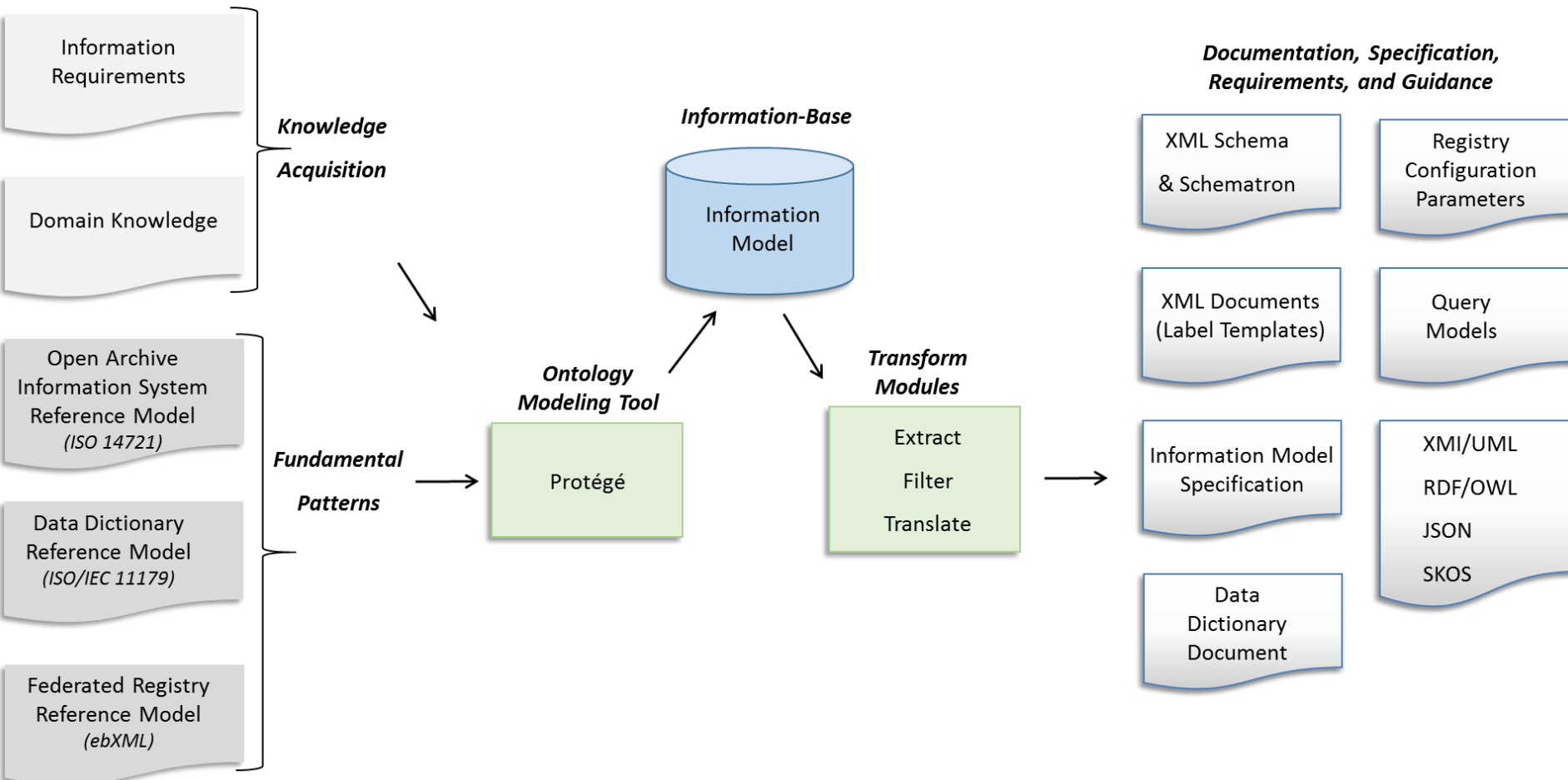
- Defines the:
  - *data structure (format)*
  - *science interpretation of the data*
  - *context within which the data was captured, processed, and archived*
  - *relationships between the data*

acquired from domain experts from each of the science disciplines

- Provides a multilevel governance framework
  - *Common dictionary provides core definitions*
  - *Discipline and mission level extensions*
  - *Governance authority resides with dictionary Stewards*
- Provide a single authoritative source for the data standards
- Remains independent of its implementation.



# Context





# IM Software

- Information Model Tool (IMTool)
  - *Builds the IM master database from a protégé object model, protégé data dictionary database, and configuration files.*
  - *Extracts the database content and converts it to system files in various formats for system configuration.*
- Local Data Dictionary Tool (LDDTool) -- IMTool -l
  - *Accepts one or more Local Data Dictionary (LDD) definition files (Ingest\_LDD).*
  - *Validates the syntax, semantics, and modeling approach*
  - *Ingests the LDD(s) into the master database*
  - *Checks consistency against the Common dictionary*
  - *Writes system files*



# Version 1.8.0.0 - Build 7b

- Delivered to I&T on March 31, 2017.
- Documents and artifacts available on PDS4 web site
  - *Information Model Specification (HTML)*
  - *Release Notes*
  - *Data Dictionary (HTML and PDF)*
  - *XML Schema and Schematron*
  - *System files in various formats*
    - JSON, XMI/UML, RDF/OWL
  - *Updated Namespace Registry*



# Changes

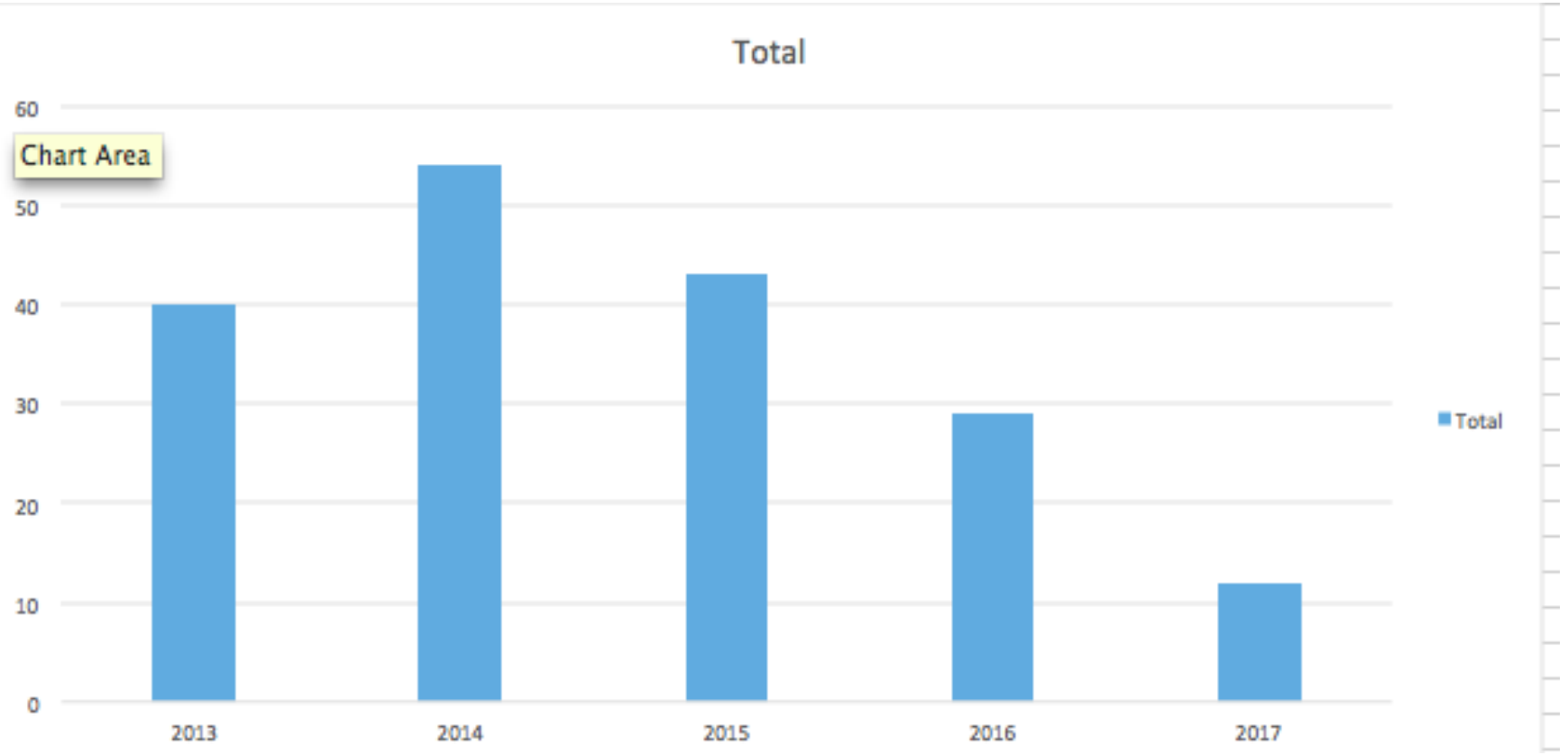
- Common Dictionary
  - *Made the ASCII numeric data types boundaries more precise*
- Other changes
  - *Product\_SIP\_Deep\_Archive*
  - *Property Maps*
  - *JSON file*
  - *Documents*





# SCR metrics over time

## Common Dictionary





# Dictionary Governance

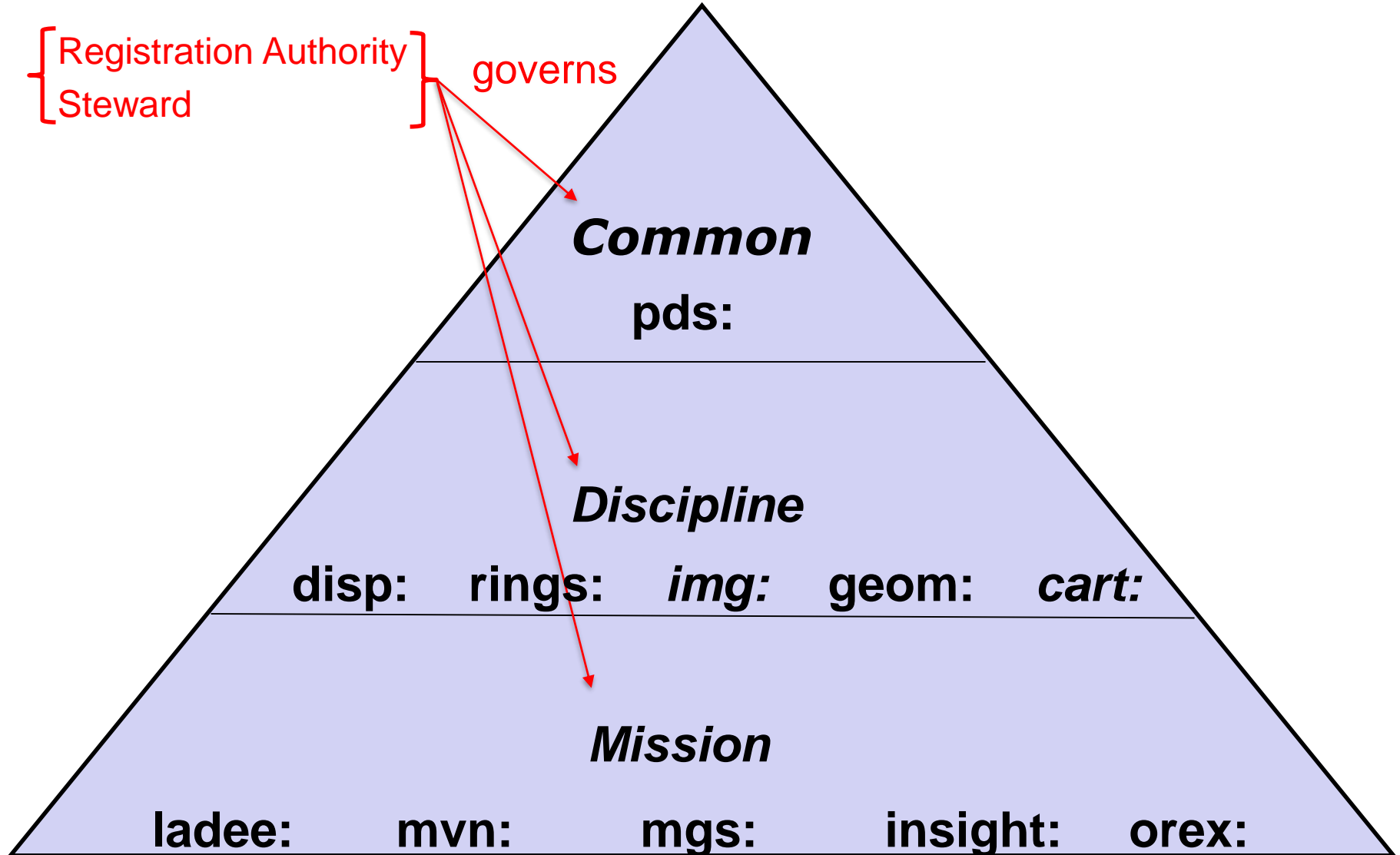
- Registration Authority is an entity that has the authority and responsibility to govern one or more dictionaries.
- Steward is a entity consisting of a group of domain experts that is given authority and responsibility by a Registration Authority to govern (i.e., create and manage) one or more dictionaries within a domain area.
  - *One member of the group is identified as a primary steward.*
  - *The steward in general can create one or more namespaces within a domain.*
- Namespace is a “container” for a logical grouping under a single identifier of classes and attributes.



# IM Governance

[Registration Authority]  
[Steward]

governs





# Model Components

## Common, Discipline and Mission Dictionaries

Registration Authority	Steward Id	Namespace Id*	XML Schema Namespace	Logical Identifier Prefix	Governance Level	Steward	Oversight
0001_NASA_PDS_1	pds	pds	<a href="http://pds.nasa.gov/pds4/pds/v1">http://pds.nasa.gov/pds4/pds/v1</a>	urn:nasa:pds:	Common	PDS EN Node*****	CCB
0001_NASA_PDS_1	atm	atm	<a href="http://pds.nasa.gov/pds4/atm/v1">http://pds.nasa.gov/pds4/atm/v1</a>	urn:nasa:pds:	Discipline	PDS ATM Node	
0001_JAXA_DARTS_1	darts	darts	<a href="http://pds.nasa.gov/pds4/darts/v1">http://pds.nasa.gov/pds4/darts/v1</a>	urn:jaxa:darts:	Discipline	DARTS (JAXA)	
0001_NASA_PDS_1	en	dph	<a href="http://pds.nasa.gov/pds4/dph/v1">http://pds.nasa.gov/pds4/dph/v1</a>	urn:nasa:pds:	Discipline	PDS EN Node	
0001_NASA_PDS_1	geo	geo	<a href="http://pds.nasa.gov/pds4/geo/v1">http://pds.nasa.gov/pds4/geo/v1</a>	urn:nasa:pds:	Discipline	PDS GEO Node	
0001_NASA_PDS_1	geo	geom	<a href="http://pds.nasa.gov/pds4/geom/v1">http://pds.nasa.gov/pds4/geom/v1</a>	urn:nasa:pds:	Discipline	PDS GEO Node	
0001_NASA_PDS_1	img	cart	<a href="http://pds.nasa.gov/pds4/cart/v1">http://pds.nasa.gov/pds4/cart/v1</a>	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	img	disp	<a href="http://pds.nasa.gov/pds4/disp/v1">http://pds.nasa.gov/pds4/disp/v1</a>	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	img	img	<a href="http://pds.nasa.gov/pds4/img/v1">http://pds.nasa.gov/pds4/img/v1</a>	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	naif	naif	<a href="http://pds.nasa.gov/pds4/naif/v1">http://pds.nasa.gov/pds4/naif/v1</a>	urn:nasa:pds:	Discipline	PDS NAIF Node	
0001_NASA_PDS_1	ops	pds	<a href="http://pds.nasa.gov/pds4/pds/v1">http://pds.nasa.gov/pds4/pds/v1</a>	urn:nasa:pds:	Discipline	PDS EN Node	
0001_NASA_PDS_1	ppi	alt	<a href="http://pds.nasa.gov/pds4/alt/v1">http://pds.nasa.gov/pds4/alt/v1</a>	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	particle	<a href="http://pds.nasa.gov/pds4/particle/v1">http://pds.nasa.gov/pds4/particle/v1</a>	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	ppi	<a href="http://pds.nasa.gov/pds4/ppi/v1">http://pds.nasa.gov/pds4/ppi/v1</a>	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	wave	<a href="http://pds.nasa.gov/pds4/wave/v1">http://pds.nasa.gov/pds4/wave/v1</a>	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_ESA_PSA_1	psa	psa	<a href="http://psa.esa.int/psa/v1">http://psa.esa.int/psa/v1</a>	urn:psa:esa:	Discipline	ESA PSA	
0001_NASA_PDS_1	rings	rings	<a href="http://pds.nasa.gov/pds4/rings/v1">http://pds.nasa.gov/pds4/rings/v1</a>	urn:nasa:pds:	Discipline	PDS Rings Node	
0001_NASA_PDS_1	rs	rs	<a href="http://pds.nasa.gov/pds4/rs/v1">http://pds.nasa.gov/pds4/rs/v1</a>	urn:nasa:pds:	Discipline	PDS RS Node	
0001_ROS_RSSA_1	rssa	rssa	<a href="http://pds.nasa.gov/pds4/rssa/v1">http://pds.nasa.gov/pds4/rssa/v1</a>	urn:ros:rssa:	Discipline	RSSA (IKI)	
0001_NASA_PDS_1	sbn	sbn	<a href="http://pds.nasa.gov/pds4/sbn/v1">http://pds.nasa.gov/pds4/sbn/v1</a>	urn:nasa:pds:	Discipline	PDS SBN	
0001_NASA_PDS_1	sbn	sp	<a href="http://pds.nasa.gov/pds4/sp/v1">http://pds.nasa.gov/pds4/sp/v1</a>	urn:nasa:pds:	Discipline	PDS SBN	
0001_NASA_PDS_1	atm	ladee	<a href="http://pds.nasa.gov/pds4/mission/ladee/v1">http://pds.nasa.gov/pds4/mission/ladee/v1</a>	urn:nasa:pds:	Mission	PDS ATM Node	
0001_NASA_PDS_1	atm	ladee	<a href="http://pds.nasa.gov/pds4/ladee/v1">http://pds.nasa.gov/pds4/ladee/v1</a>	urn:nasa:pds:	Mission	PDS ATM Node	
0001_NASA_PDS_1	geo	insight	<a href="http://pds.nasa.gov/pds4/mission/insight/v1">http://pds.nasa.gov/pds4/mission/insight/v1</a>	urn:nasa:pds:	Mission	PDS GEO Node	
0001_NASA_PDS_1	img	mgs	<a href="http://pds.nasa.gov/pds4/mission/mgs/v1">http://pds.nasa.gov/pds4/mission/mgs/v1</a>	urn:nasa:pds:	Mission	PDS IMG Node	
0001_NASA_PDS_1	img	mpf	<a href="http://pds.nasa.gov/pds4/mission/mpf/v1">http://pds.nasa.gov/pds4/mission/mpf/v1</a>	urn:nasa:pds:	Mission	PDS IMG Node	
0001_NASA_PDS_1	sbn	orex	<a href="http://pds.nasa.gov/pds4/mission/orex/v1">http://pds.nasa.gov/pds4/mission/orex/v1</a>	urn:nasa:pds:	Mission	PDS SBN	
0001_NASA_PDS_1	ppi	mvn	<a href="http://pds.nasa.gov/pds4/mission/mvn/v1">http://pds.nasa.gov/pds4/mission/mvn/v1</a>	urn:nasa:pds:	Mission	PDS PPI Node	
0001_NASA_PDS_1	ppi	mvn	<a href="http://pds.nasa.gov/pds4/mvn/v1">http://pds.nasa.gov/pds4/mvn/v1</a>	urn:nasa:pds:	Mission	PDS PPI Node	
0001_NASA_PDS_1	sbn	bopps	<a href="http://pds.nasa.gov/pds4/mission/bopps/v1">http://pds.nasa.gov/pds4/mission/bopps/v1</a>	urn:nasa:pds:	Mission	PDS SBN	

# Dictionary Governance

- Dictionary

- *Name:* Common
- *Registration Authority:* 0001\_NASA\_PDS\_1
- *Steward\_id:* pds
- *Steward<sup>1</sup>:* PDS EN Node
- *Namespace\_id:* pds
- *Namespace:* <http://pds.nasa.gov/pds4/pds/v1>

- Dictionary

- *Name:* Geometry
- *Registration Authority:* 0001\_NASA\_PDS\_1
- *Steward\_id:* geo
- *Steward<sup>1</sup>:* PDS GEO Node
- *Namespace\_id:* *geom*
- *Namespace:* <http://pds.nasa.gov/pds4/geom/v1>

<sup>1</sup> The primary governance entity within the stewardship group



# IM V1.9.0.0 Release Schedule

Last DDWG meeting for SCR review is August 3, 2017.

1. *Aug 17, 2017 – All SCRs to be implemented have been identified*
2. *Aug 17 - 30, 2017 – Finish implementation*
  - *Release IM to development directory*
  - *Internal testing*
  - *Fix bugs*
3. *Aug 31 – 13, 2017 – EN, DN, and IPDA testing*
  - *Release IM to development directory*
  - *Perform regression testing at EN*
4. *Sep 14 - 28, 2017 – Prepare IM for release to System I&T*
5. *Sep 29, 2017 – Release IM to release directory*
  - *“Start of Build” and System I&T*
  - *IM is frozen*
6. *System I&T - System Testing*
7. *System Release Build*



# Summary

- The PDS4 Information Model and Standards are being used successfully
  - *Have been adopted by the International Planetary Data Alliance (IPDA).*
- Still work to be done
  - *Discipline Dictionaries*
  - *Leverage the IM in system development*
    - Configuration of search engines and other services
    - Development of model-driven software
- Desk Assessment of PDS4 against ISO 16363 found that 92% of the metrics of the ISO 16363 standard were satisfied
  - 80% of the metrics for Governance and Organizational Viability
  - 95% of the metrics for Digital Object Management
  - 96% of the metrics for Infrastructure and Security Risk Management.



**National Aeronautics and  
Space Administration**

**Jet Propulsion Laboratory**  
California Institute of Technology  
Pasadena, California

# **Thank You**

## **Questions and Answers**

**PDS homepage: <https://pds.nasa.gov/>**

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





**National Aeronautics and  
Space Administration**

**Jet Propulsion Laboratory**  
California Institute of Technology  
Pasadena, California

# Backup



# Definitions

- “An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse.”<sup>1</sup>
- It provides a sharable, stable, and organized structure of information requirements or knowledge for the domain context.

<sup>1</sup> Lee, Y. T. 1999. Information Modeling: From Design To Implementation. In Proceedings of the Second World Manufacturing Congress, ed. S. Nahavandi and M. Saadat, 315-321. Canada/Switzerland: International Computer Science Conventions.



# Summary of Changes to Standards Reference (SR)

SCR	
CCB-171	Revised definitions of ASCII_Integer, ASCII_NonNegative_Integer, and ASCII_Real.

ALL CHANGES were captured in Change Log and reviewed by Document Review Team



# Summary of Changes to Data Provider's Handbook (DPH)

SCR	
CCB-98	Choose most specific class available to describe an object.
CCB-146, CCB-160	Added “ros” and “jaxa” as valid agencies for context product LIDs.
n/a	Incorporated comments from Ed Guinness, Matt Tiscareno, Santa Martinez, Lev Nagdimunov, Dick Simpson, Ron Joyner, and Richard Chen.
n/a	<p>Completely reorganized sections in main text and appendices. Rewrote existing text and added sections. Moved detailed instructions to appendices. The goal has been to make the flow of information more logical in the order of presentation and in the level of detail for the non-expert reader.</p> <p>The Appendix on Creating and Using Local Data Dictionaries has not been rewritten. It needs special attention. Consider making it a separate document.</p>



# Dictionary Consistency

Release	Discipline	Stack <i>(Italics - Not Ingested)</i>	Description
<b>1800</b>			
	<b>Common</b>	PDS4_PDS_1800	The Common dictionary.
	<b>Discipline</b>		
		PDS4_PDS_1800	
	Display	PDS4_DISP_1800	The Display dictionary.
	Imaging	PDS4_IMG_1300	The Cartography and Imaging Sciences dictionary.
	Rings	PDS4_RINGS_1100	The Ring-Moon Systems dictionary.
		PDS4_PDS_1800	
	Cartography	PDS4_CART_1701	The Cartography dictionary.
		PDS4_PDS_1800	
	Geometry	<i>PDS4_GEOM_1700_1401</i>	The Geometry Dictionary.

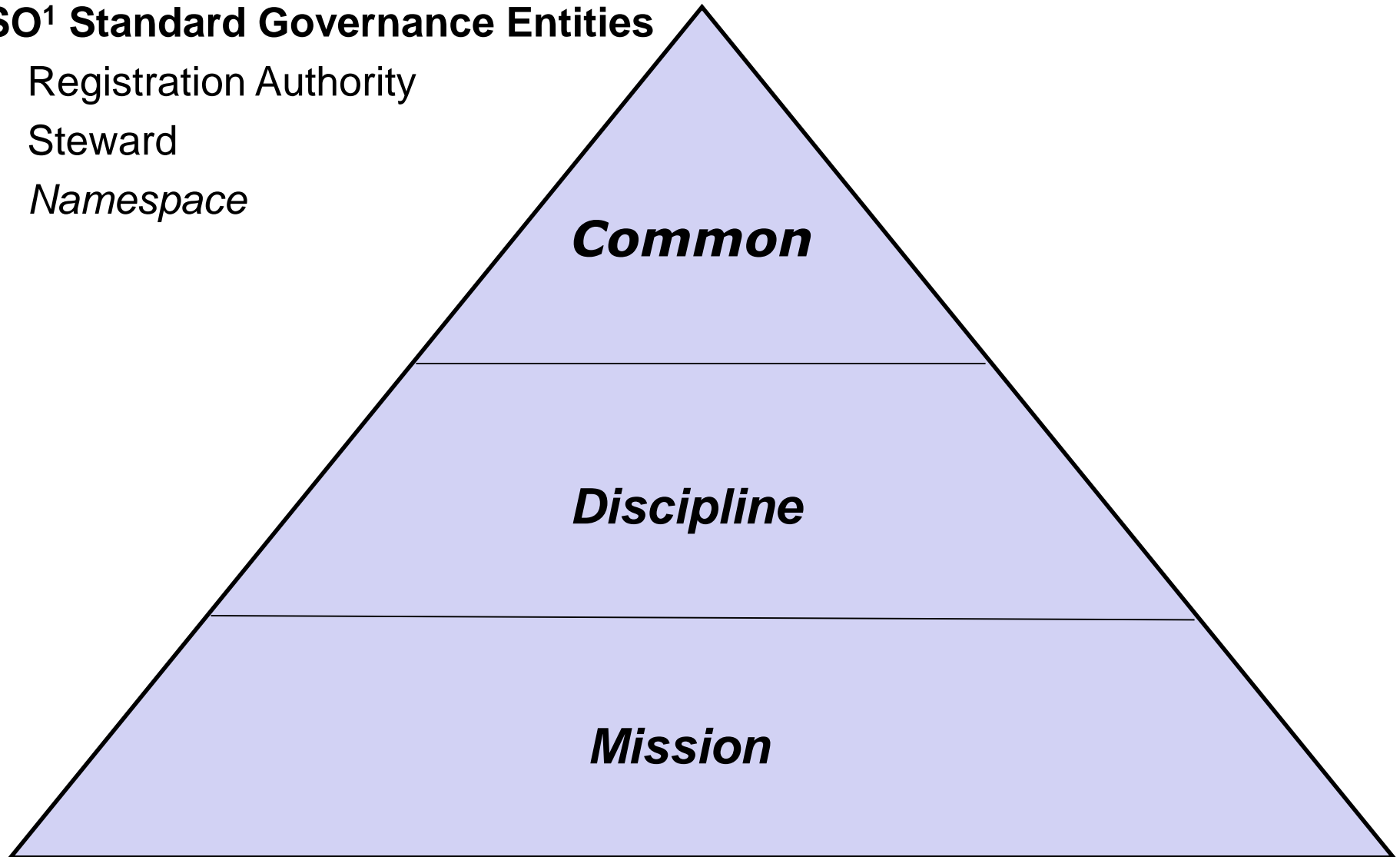
<sup>1</sup> A dictionary stack consists of a known set of consistent dictionaries available for PDS4 product



# Dictionary Governance

## ISO<sup>1</sup> Standard Governance Entities

- Registration Authority
- Steward
- *Namespace*



<sup>1</sup> ISO 14721:2003 - Open Archival Information System (OAIS) Reference Model