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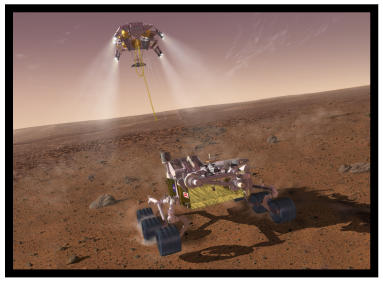

A Reference Model for Science Data Archives

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Earth Science Information Partners (ESIP)
Winter Meeting 2018
January 9-11th, 2018 – Bethesda, MD

2018 Geosemantics Symposium
Monday January 8, 2018

Overview

- The Consultative Committee for Space Data Systems (CCSDS) Data Archive Interoperability (DAI) working group has developed the core elements for the underlying processes for digital preservation.
  - *Reference Model for an Open Archival Information System (OAIS) – ISO 14721, CCSDS 650.0-M-2*
  - *Information Preparation to Enable Long Term Use (IPELTU)*

- The DAI working group is now addressing interoperable protocols and interface specifications.
  - *Enable the access, merging and interoperable re-use of the data*
  - *Support for the fundamental scientific technique of checking reproducibility of results.*

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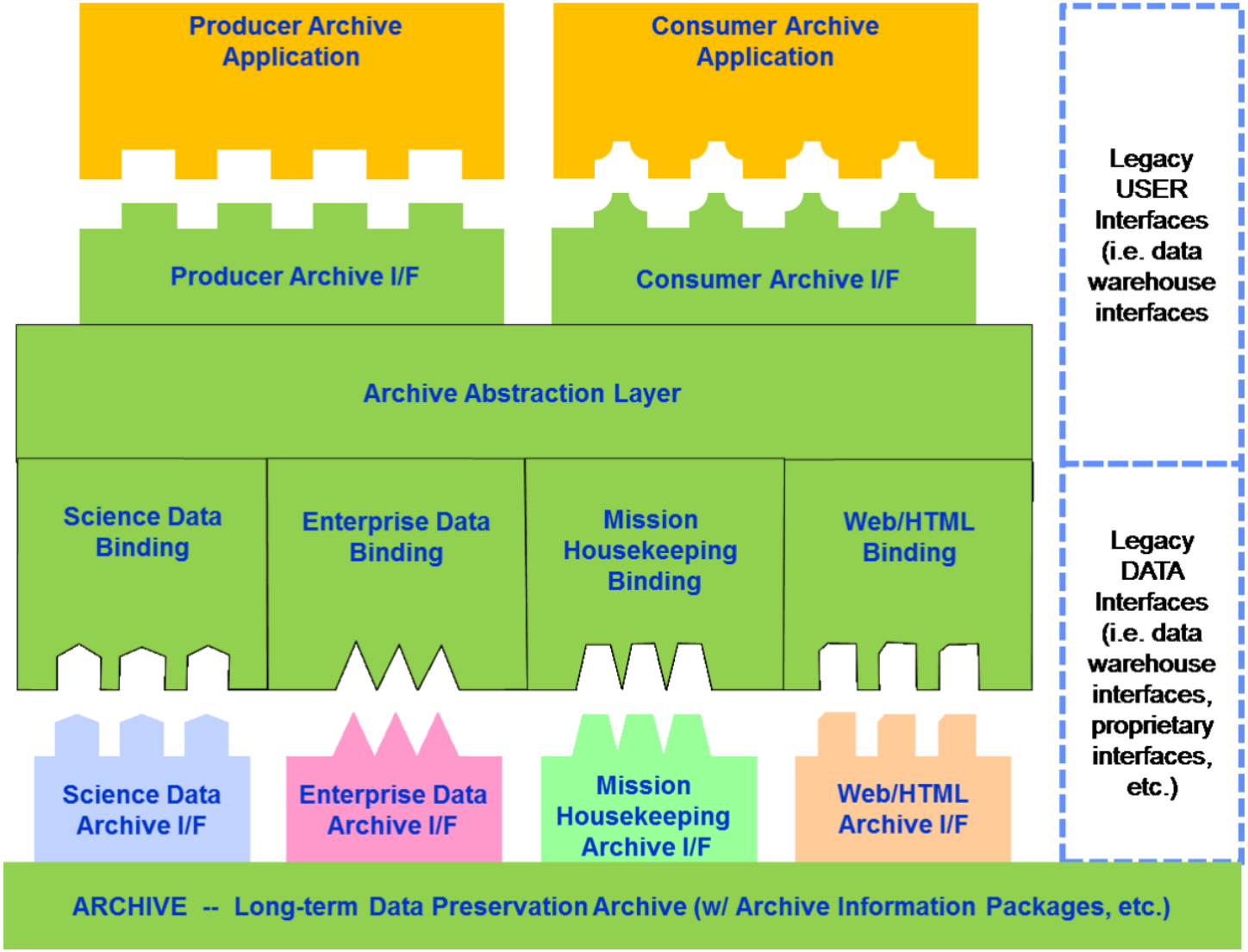
Abstract Protocol Architecture[2]



[2]Data Archive Ingest (DAI) WG Report to the CCSDS Management Council (CMC), Figure 2: Notional Data Archive Architecture, March 2017

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Data Archive Architecture Reference Model

- The Data Archive Architecture Reference Model (DAARM) is an implementable model for trusted digital repositories[1].
  - *Trusted Digital Repository - A repository whose mission is to provide usable, long-term access to digital resources for a designated community.*
  - *The model is an integration of concepts and standards from:*
    - Open Archival Information System (OAIS) Reference Model[1]
    - ISO/IEC 11179 Metadata Registry (MDR) standard
    - Three decades of digital repository development for science research.
  - *The intended scope of the reference model is for digital archives in general.*

[1] ISO 14721:2012 (CCSDSS 650.0-P-1.1) Open archival information system (OAIS) -- Reference model

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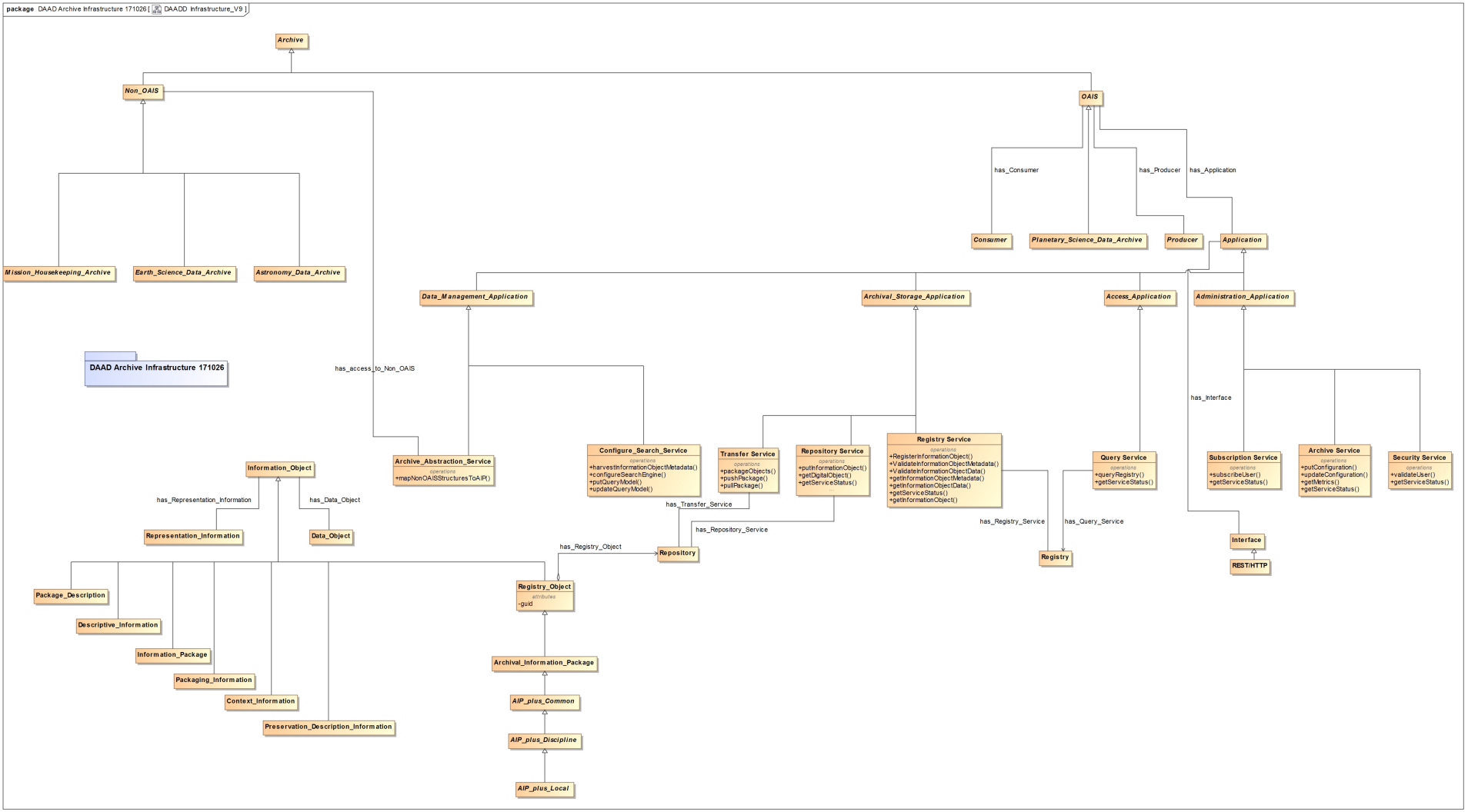
Draft UML Model



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Information Architecture[1]

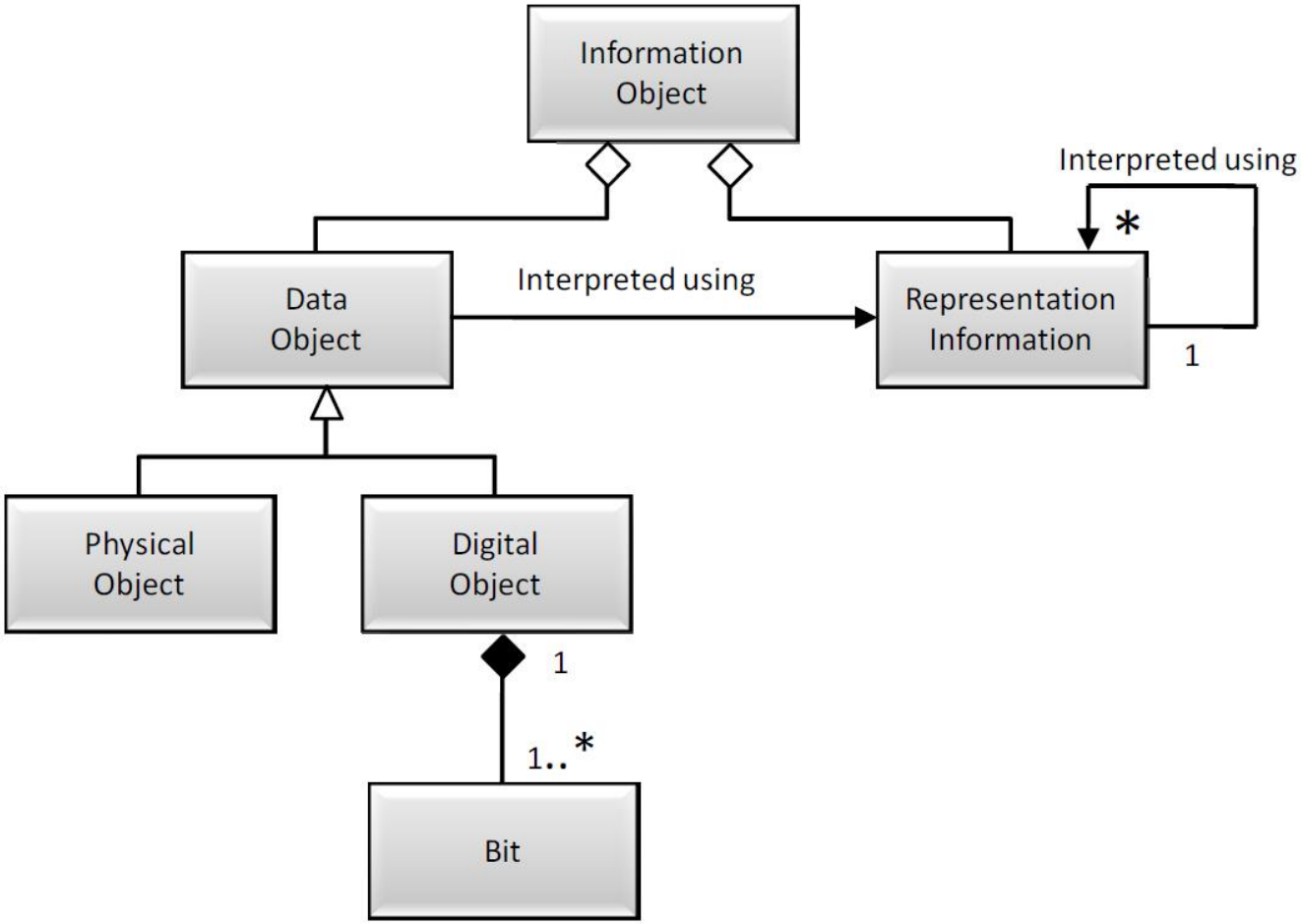

Figure 4-10: Information Object

[1] ISO 14721:2012 (CCSDSS 650.0-P-1.1) Open archival information system (OAIS) -- Reference model

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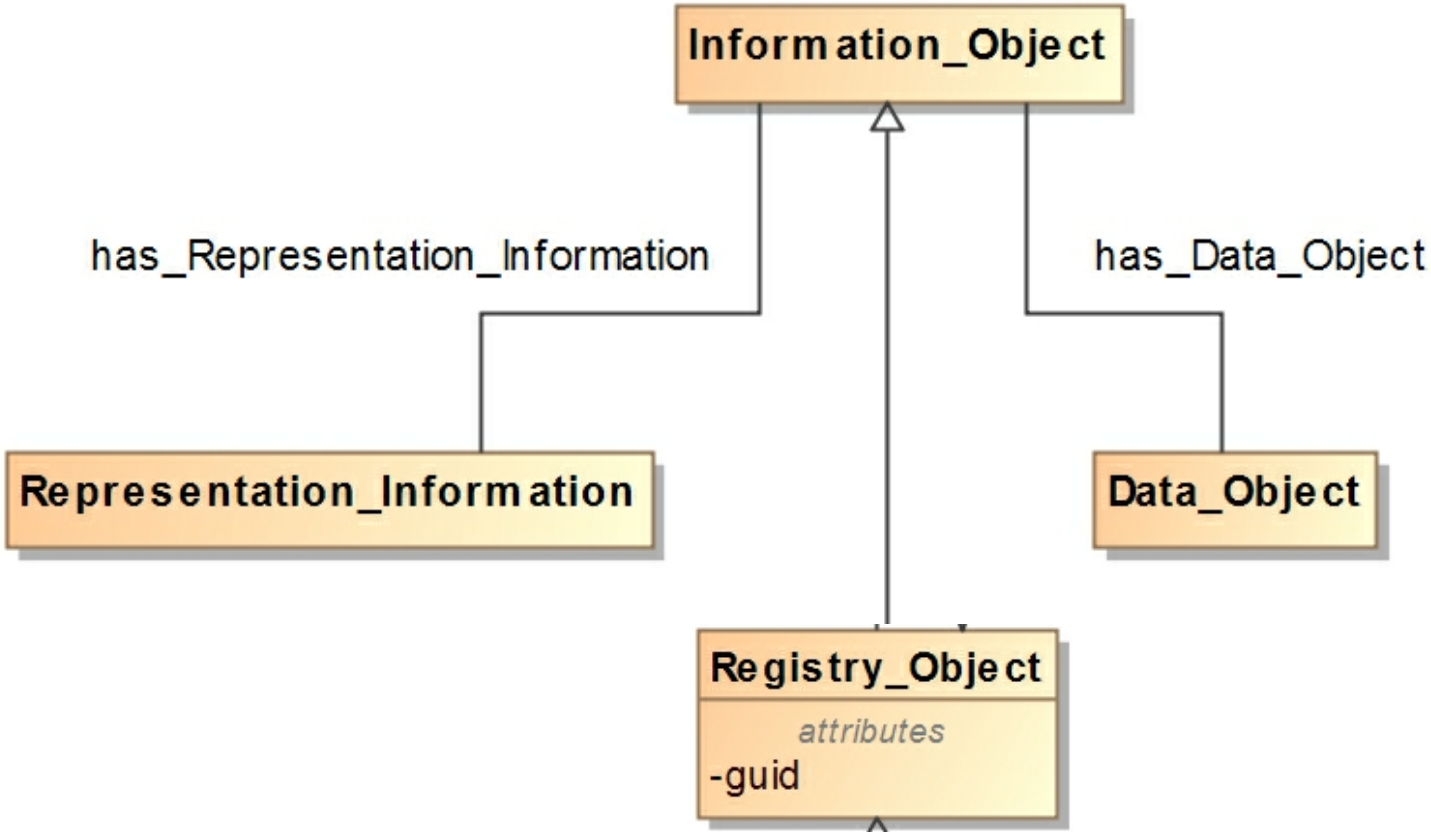
Registry Object



Information Categories[1]

1. Identification - Provides a unique and immutable identifier for each data object.

2. Representation/Format - Provides meaning for a data object and allows it to be interpreted.

3. Integrity - Ensures the data object has not been unintentionally altered.

4. Provenance - Provides the history of the data object and is essential for authenticity and reproducibility.

5. Context - Describes the environment in which the data object was created.

6. Reference - Allows the data object to be referenced.

7. Access Rights - Defines the access restrictions pertaining to the data object , including the legal framework, licensing terms, and access control

8. Quality* - Provides a scheme for assessing and assigning a quality measure to the data object .

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Functional Entities[1]

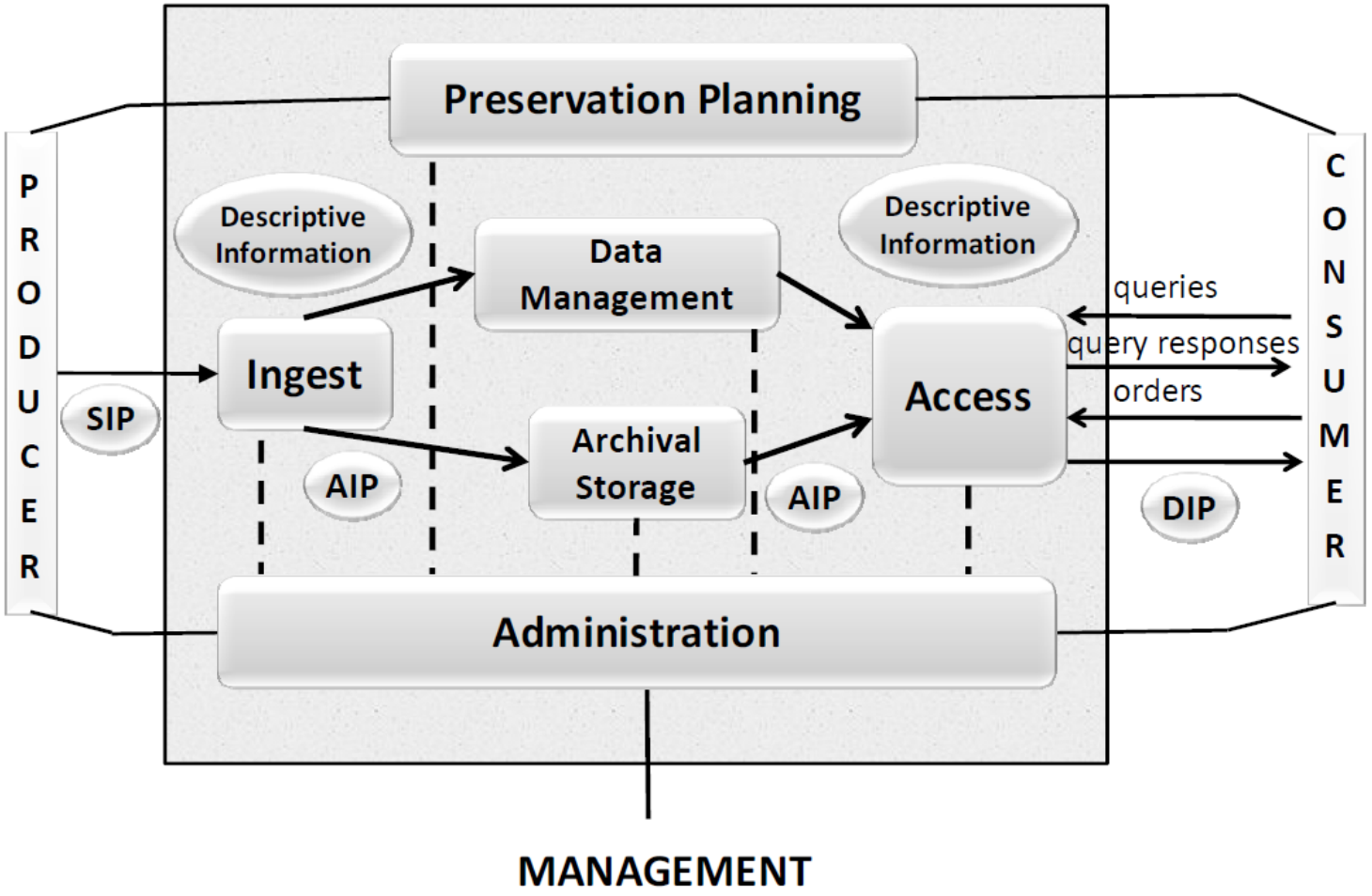

Figure 4-1: OAIS Functional Entities

[1] ISO 14721:2012 (CCSDSS 650.0-P-1.1) Open archival information system (OAIS) -- Reference model

Functional Entities[1]

- Ingest - Accept information objects from producers, prepares them for storage, and ensures that they become established.
- Archival – Store and retrieve Information Objects.
- Data Management – Maintaining administrative information, for example consumer access statistics.
- Access - Make the archival information holdings and related services visible to Consumers.
- Administration - Control the operation of the other functional entities.
- Preservation Planning - Monitoring the environment to ensure that the information stored remains usable by the Designated Community.

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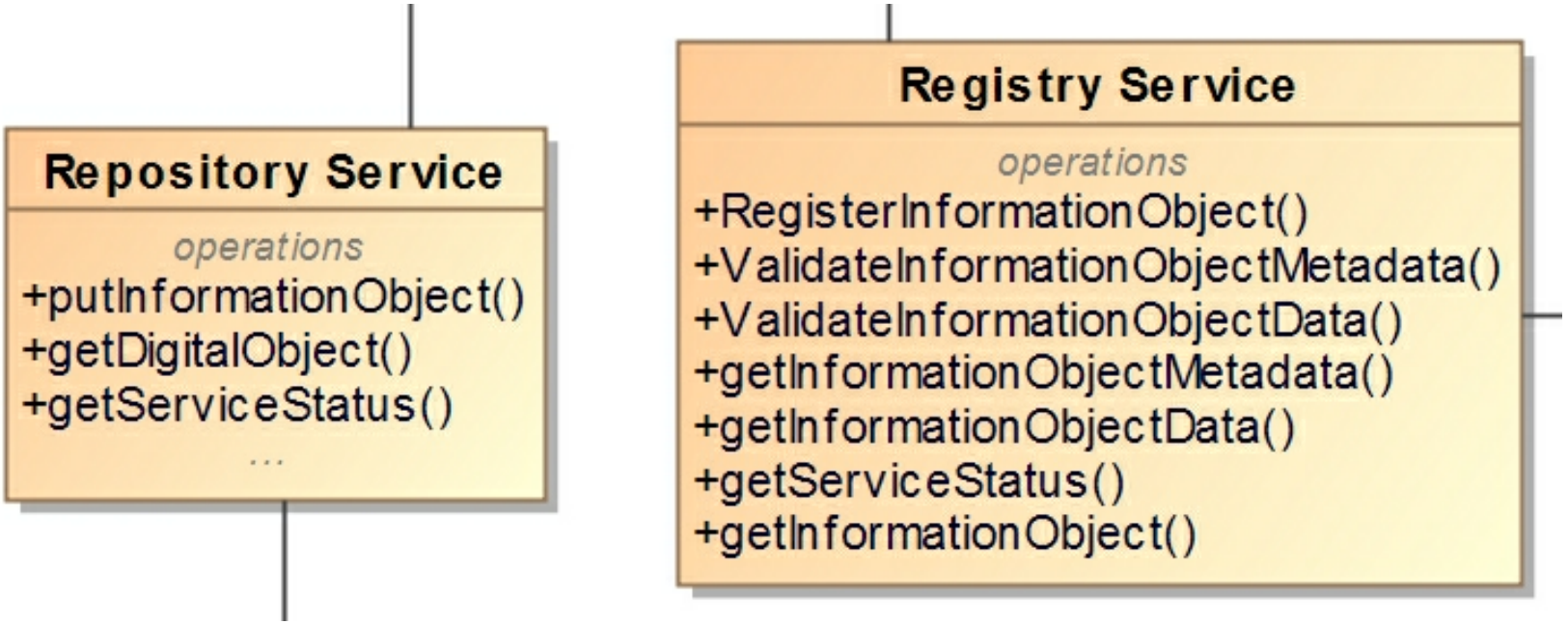
Archival
Store and Retrieve Information Objects



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Information Model Definitions

- "An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse." [1]
- It provides a sharable, stable, and organized structure of information requirements or knowledge for the domain context.
- Information Modeling is an essential discipline within Data Science

[1] 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.

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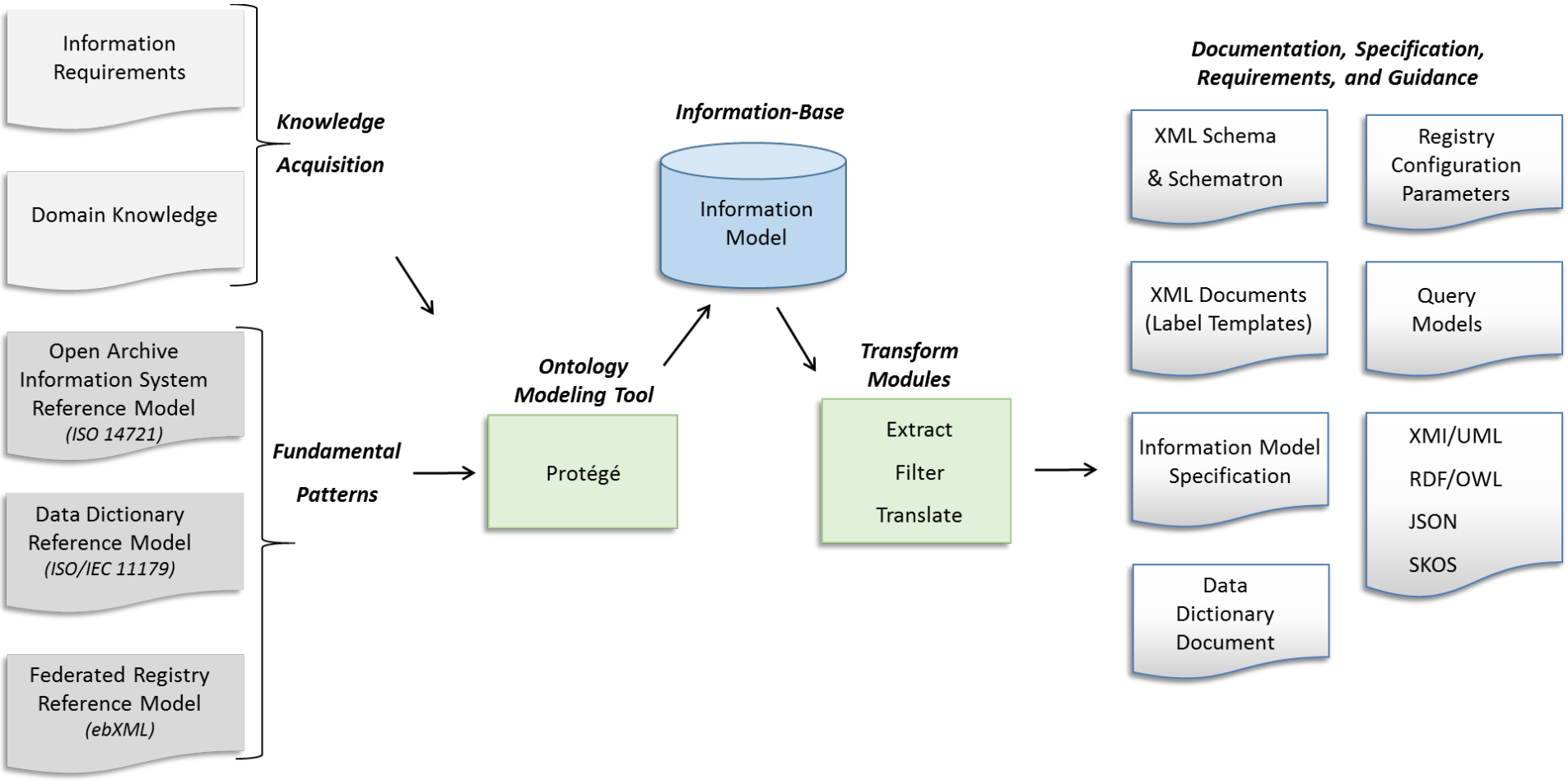
Information Model (IM)



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Information Model Roles

- Requirements: The IM is the primary source for information requirements.
- Governance: A multi-level governance scheme reduces the impact of change as the science community grows and evolves.
- Semantics: The IM provides named relationships to support semantic technologies
- Usability: The IM provides the metadata needed to interpret and use the data.
- Interoperability: The IM is designed by discipline experts to provide interoperability, at multiple levels.
- Configuration: Extracts from the IM are used to configure tools and services

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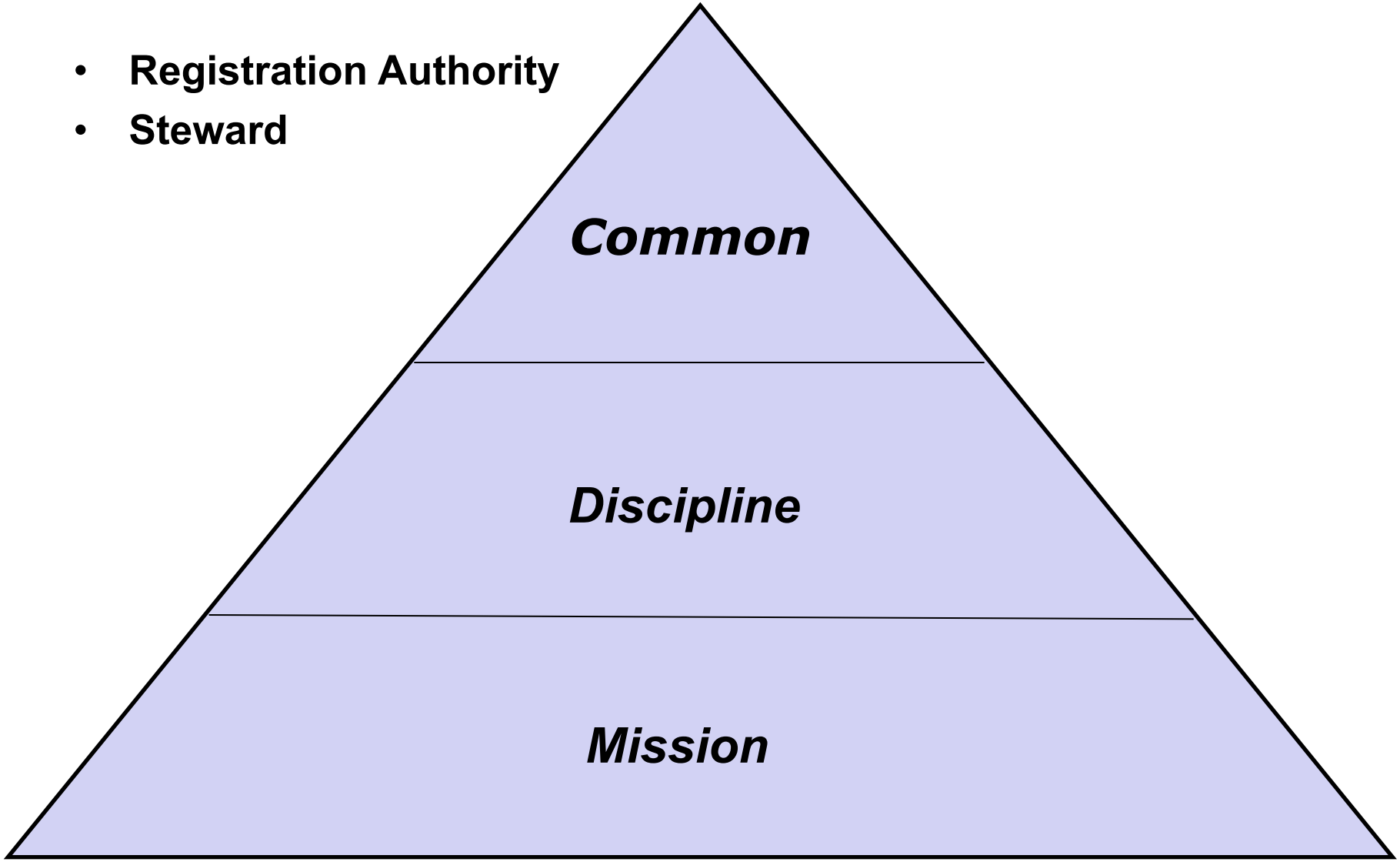
Multi-level Governance

- Registration Authority
- Steward



[1] ISO 14721:2003 - Open Archival Information System (OAIS) Reference Model

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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	http://pds.nasa.gov/pds4/pds/v1	urn:nasa:pds:	Common	PDS EN Node*****	CCB
0001_NASA_PDS_1	atm	atm	http://pds.nasa.gov/pds4/atm/v1	urn:nasa:pds:	Discipline	PDS ATM Node	
0001_JAXA_DARTS_1	darts	darts	http://pds.nasa.gov/pds4/darts/v1	urn:jaxa:darts:	Discipline	DARTS (JAXA)	
0001_NASA_PDS_1	en	dph	http://pds.nasa.gov/pds4/dph/v1	urn:nasa:pds:	Discipline	PDS EN Node	
0001_NASA_PDS_1	geo	geo	http://pds.nasa.gov/pds4/geo/v1	urn:nasa:pds:	Discipline	PDS GEO Node	
0001_NASA_PDS_1	geo	geom	http://pds.nasa.gov/pds4/geom/v1	urn:nasa:pds:	Discipline	PDS GEO Node	
0001_NASA_PDS_1	img	cart	http://pds.nasa.gov/pds4/cart/v1	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	img	disp	http://pds.nasa.gov/pds4/disp/v1	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	img	img	http://pds.nasa.gov/pds4/img/v1	urn:nasa:pds:	Discipline	PDS IMG Node	
0001_NASA_PDS_1	naif	naif	http://pds.nasa.gov/pds4/naif/v1	urn:nasa:pds:	Discipline	PDS NAIF Node	
0001_NASA_PDS_1	ops	pds	http://pds.nasa.gov/pds4/pds/v1	urn:nasa:pds:	Discipline	PDS EN Node	
0001_NASA_PDS_1	ppi	alt	http://pds.nasa.gov/pds4/alt/v1	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	particle	http://pds.nasa.gov/pds4/particle/v1	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	ppi	http://pds.nasa.gov/pds4/ppi/v1	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_NASA_PDS_1	ppi	wave	http://pds.nasa.gov/pds4/wave/v1	urn:nasa:pds:	Discipline	PDS PPI Node	
0001_ESA_PSA_1	psa	psa	http://psa.esa.int/psa/v1	urn:psa:esa:	Discipline	ESA PSA	
0001_NASA_PDS_1	rings	rings	http://pds.nasa.gov/pds4/rings/v1	urn:nasa:pds:	Discipline	PDS Rings Node	
0001_NASA_PDS_1	rs	rs	http://pds.nasa.gov/pds4/rs/v1	urn:nasa:pds:	Discipline	PDS RS Node	
0001_ROS_RSSA_1	rssa	rssa	http://pds.nasa.gov/pds4/rssa/v1	urn:ros:rssa:	Discipline	RSSA (IKI)	
0001_NASA_PDS_1	sbn	sbn	http://pds.nasa.gov/pds4/sbn/v1	urn:nasa:pds:	Discipline	PDS SBN	
0001_NASA_PDS_1	sbn	sp	http://pds.nasa.gov/pds4/sp/v1	urn:nasa:pds:	Discipline	PDS SBN	
0001_NASA_PDS_1	atm	ladee	http://pds.nasa.gov/pds4/mission/ladee/v1	urn:nasa:pds:	Mission	PDS ATM Node	
0001_NASA_PDS_1	atm	ladee	http://pds.nasa.gov/pds4/ladee/v1	urn:nasa:pds:	Mission	PDS ATM Node	
0001_NASA_PDS_1	geo	insight	http://pds.nasa.gov/pds4/mission/insight/v1	urn:nasa:pds:	Mission	PDS GEO Node	
0001_NASA_PDS_1	img	mgs	http://pds.nasa.gov/pds4/mission/mgs/v1	urn:nasa:pds:	Mission	PDS IMG Node	
0001_NASA_PDS_1	img	mpf	http://pds.nasa.gov/pds4/mission/mpf/v1	urn:nasa:pds:	Mission	PDS IMG Node	
0001_NASA_PDS_1	sbn	orex	http://pds.nasa.gov/pds4/mission/orex/v1	urn:nasa:pds:	Mission	PDS SBN	
0001_NASA_PDS_1	ppi	mvn	http://pds.nasa.gov/pds4/mission/mvn/v1	urn:nasa:pds:	Mission	PDS PPI Node	
0001_NASA_PDS_1	ppi	mvn	http://pds.nasa.gov/pds4/mvn/v1	urn:nasa:pds:	Mission	PDS PPI Node	
0001_NASA_PDS_1	sbn	bopps	http://pds.nasa.gov/pds4/mission/bopps/v1	urn:nasa:pds:	Mission	PDS SBN	

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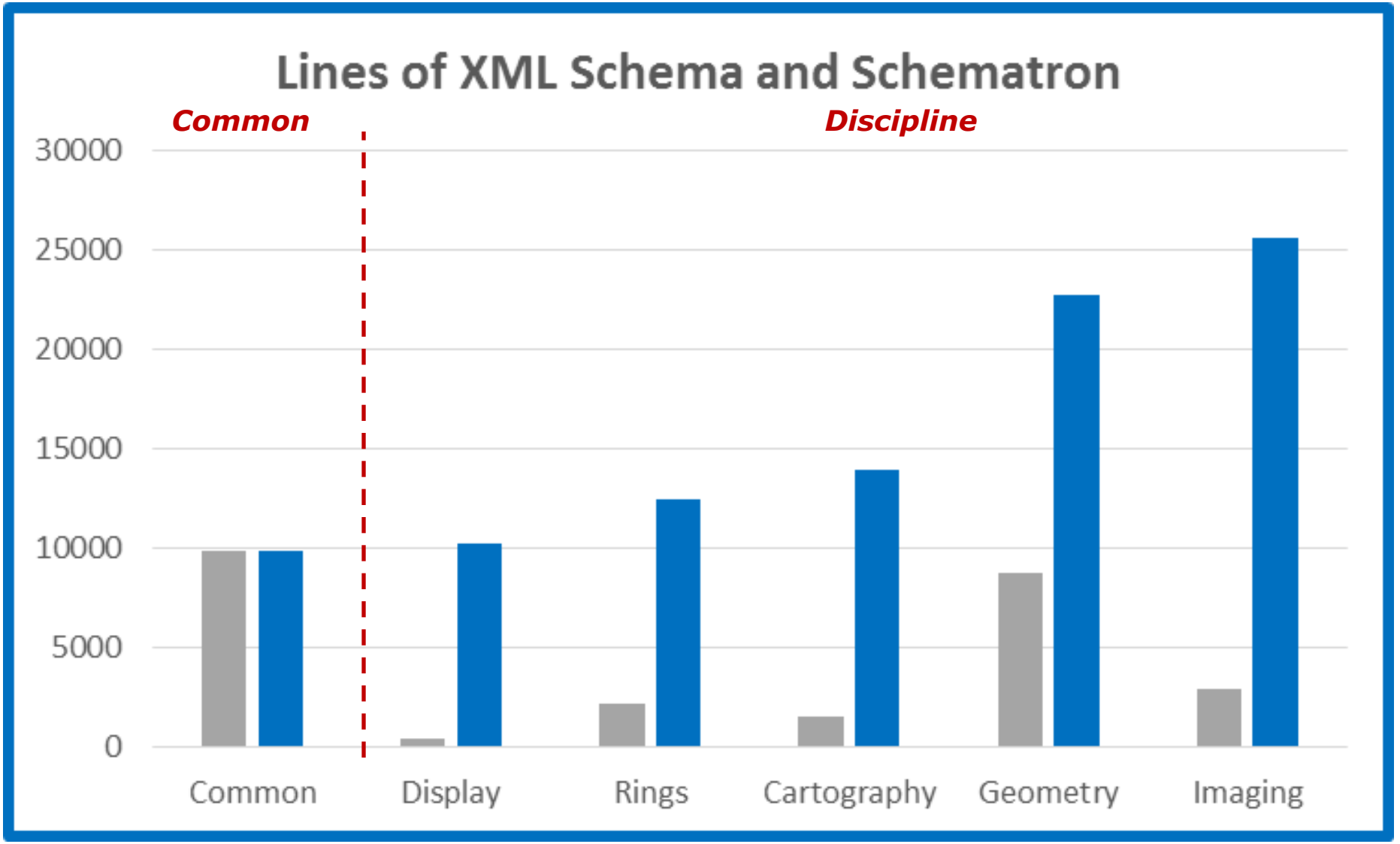
Information Requirements Generated from the Dictionaries



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Usability

- A desk assessment of PDS4 against ISO 16363[1], the instrument for assessing a repository against the OAIS Reference Model[2], found that 92% of the metrics of the ISO 16363 standard were satisfied
    - Governance and Organizational Viability
    - Digital Object Management
    - Infrastructure and Security Risk Management.
- *Maintain the value of the data over time*

[1] ISO 16363:2012 (CCSDS 652.0-R-1) Audit and certification of trustworthy digital repositories
[2] ISO 14721:2012 (CCSDSS 650.0-P-1.1) Open archival information system (OAIS) -- Reference model

Next Steps

- **CCSDS Data Archive Interoperability (DAI) Working Group**
  - *Write and review CCSDS Blue Book*
    - CCSDS Fall 2018 Technical Meetings (Spring and Fall)
    - Develop two working prototypes
    - Reference Model Review
      - *JPL's Center for Data Science and Technology – D. Crichton*
      - *NASA Planetary Data System (PDS) System Development – S. Hardman*
      - *CCSDS Systems Architecture (SAWG) Chair – P. Shames*
      - *JPL's Multimission Ground System and Services (MGSS) Project – C. Radulescu*
      - *Life Storage of Mission Data (LSMD) task – M. McAuley*
      - *FernUniversität in Hagen - M. Hemmje*
      - *Engineering Data Management (EDM) task – L. Jewell*
      - *Information Retrieval and Data Science Group – C. Mattmann*

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  - Mike Kearney
  - Terry Longstreth
  - Don Sawyer

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- NASA Planetary Data System (PDS) – Sean Hardman, Ronald Joyner
- JPL Principal Data Scientist, USC Adjunct Associate Professor – Chris Mattmann
- JPL's Multimission Ground System and Services (*MGSS*) Project – Costin Radulescu
- CCSDS Systems Architecture (SAWG) Chair – Peter Shames
- Life Storage of Mission Data (LSMD) task – Mike McAuley
- Engineering Data Management (EDM) task – Laura Jewell

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References

- *Reference Model for an Open Archival Information System (OAIS), ISO 14721:2012.*
- *Data Archive Ingest (DAI) WG Report to the CCSDS Management Council (CMC), Figure 2: Notional Data Archive Architecture, March 2017*
- *DAI Architecture Analysis, SEA System Architecture WG, Slide 16, Alternative Standardized Archive System Architecture Deployment Option (3), May 2017*
- *Planetary Data System PDS4 Information Model Specification, Version 1.8.0.0, March 2017.*
- *Planetary Data System - PDS4 System Architecture Specification September 1, 2013, Version 1.3.*
- *CCSDS Reference Architecture for Space Information Management (RASIM) CCSDS 311.0-M-1*
- *The Semantic Planetary Data System, PV2005, Edinburgh, November 2005.*
- *PDS-D – The Planetary Data System Distribution Subsystem. Lunar and Planetary Science XXXIV (2003)*
- *The Planetary Data System - Distributed Inventory System, IEEE Forum on Research and Technology Advances in Digital Libraries, 1999. Proceedings.*

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Thank You

Questions and Answers

PDS homepage: https://pds.nasa.gov/

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Status Continued

- **Utilize the Cornerstone Framework (NPO-49832) for model capture and management.**
  - *Cornerstone is the framework used to capture and manage the PDS4 Information Model.*
  - *Provides a framework for model-driven information system development*
  - *Maintains Information Model independence.*

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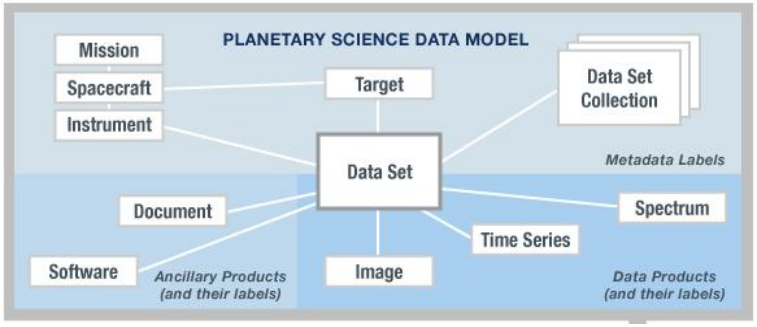
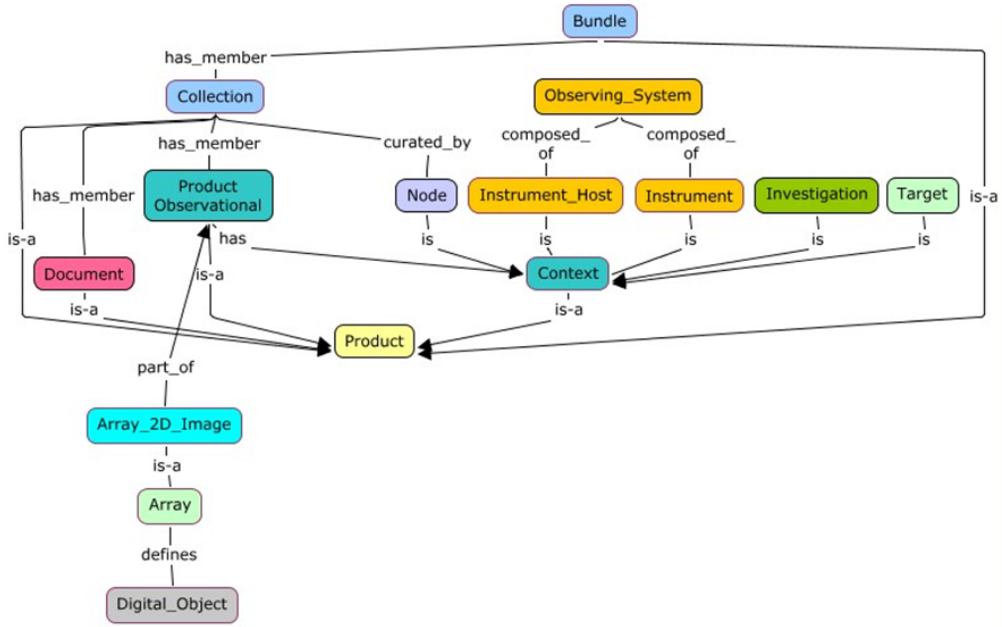
View Points

Community's View



Information Modeler's View



Repository View

Product

Tagged Data Object

(Information Object)

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   <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>
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   </Axis_Array>
</Array_2D_Image>
```

↓ **Describes**

Data Object

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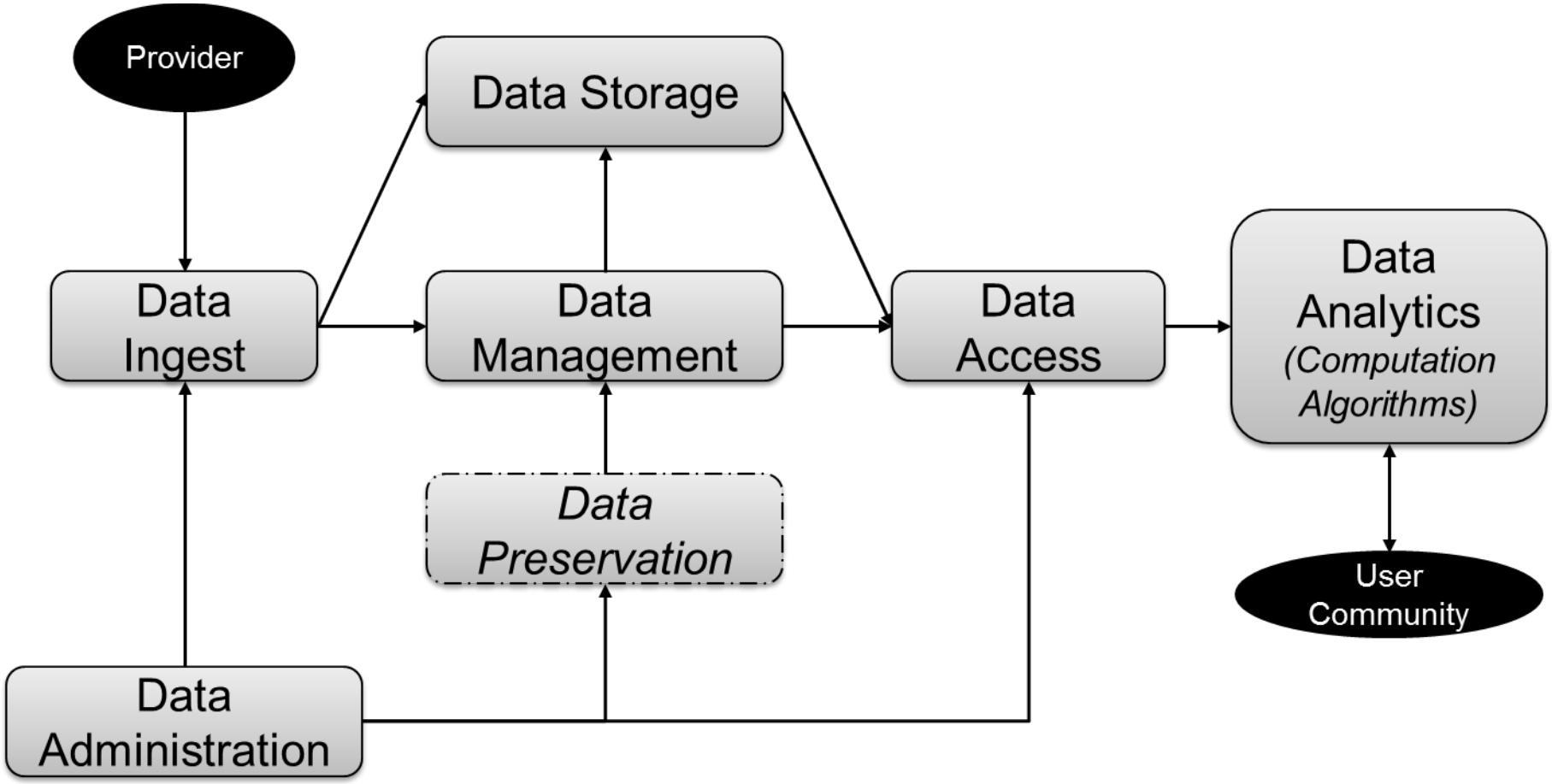
Conceptual Architecture[1]



[1] ISO 14721:2012 (CCSDSS 650.0-P-1.1) Open archival information system (OAIS) -- Reference model

Semantics

- All registry objects are first class products.
  - *All products have a Persistent Identifier (PID)*
  - *Named relationships are used to relate objects (semantic)*
    - data, documents, people, software, and contextual objects
  - *Supports Linked Open Data.*