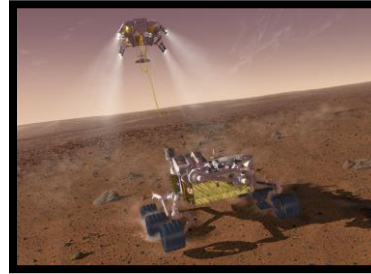




National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California



# **PDS4 Tool Development: Leveraging the PDS4 Information Model**

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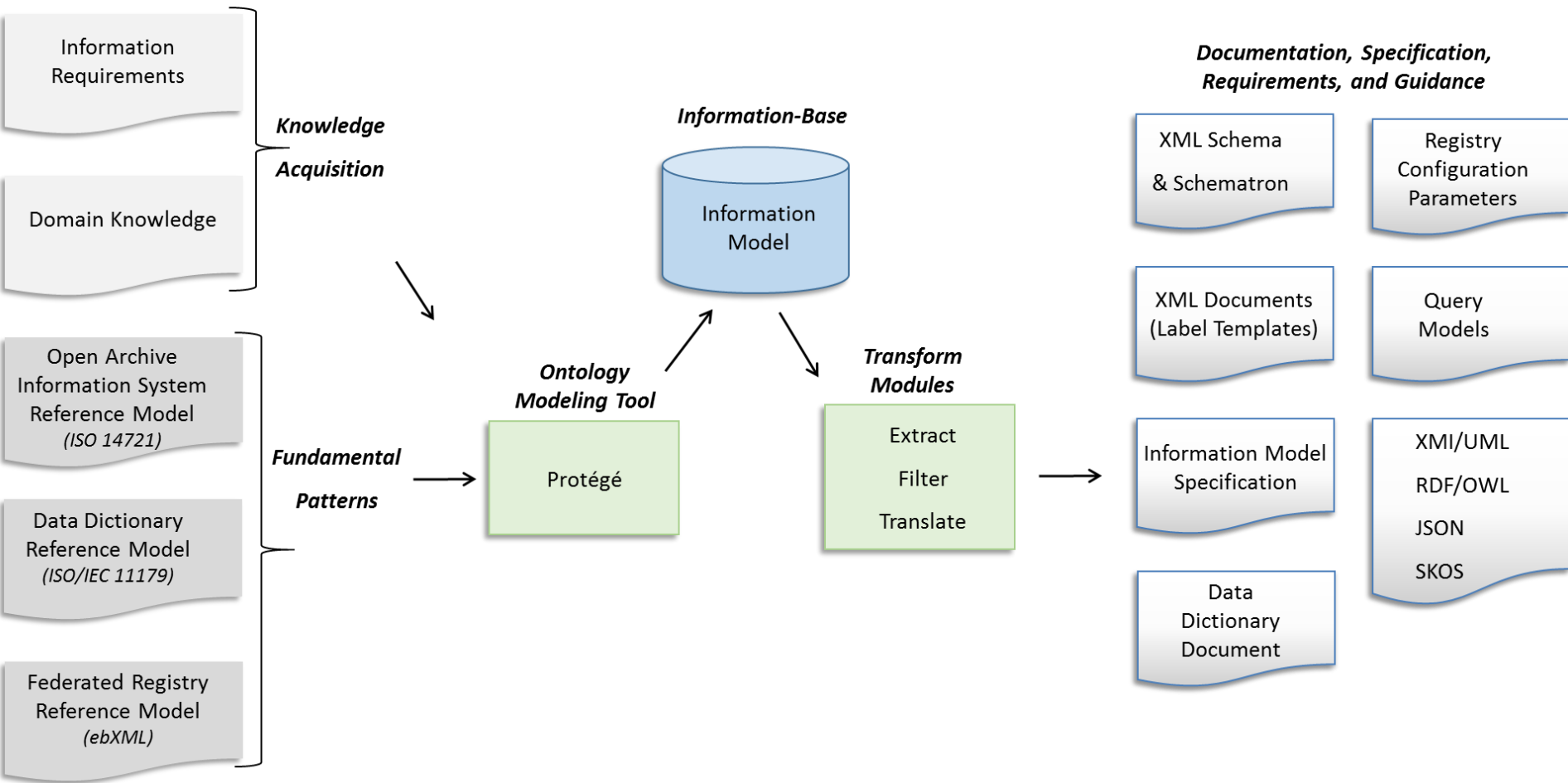
Flagstaff, AZ June 12-14 2017

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# The PDS4 Information Model





# Usable Information

- Definitions for:
  - *data structure (format)*
  - *science interpretation of the data*
  - *context within which the data was captured, processed, and archived*
  - *relationships between the data*
- Expert knowledge from each of the science disciplines.
- Single authoritative source for the data standards.
- Drives the PDS4 infrastructure by providing:
  - *A sharable, stable, and organized structure of information requirements.*
  - *Formal definitions that are suitable for configuring and generating code.*
- Implementation agnostic



# Example

**urn:nasa:pds:sbn\_samples:fits:helloworld**

```
<Array_2D_Image>
  <local_identifier>Bob</local_identifier>
  <offset unit="byte">2880</offset>
  <axes>2</axes>
  <axis_index_order>Last Index Fastest</axis_index_order>
  <Element_Array>
    <data_type>UnsignedByte</data_type>
  </Element_Array>
  <Axis_Array>
    <axis_name>Line</axis_name>
    <elements>480</elements>
    <sequence_number>1</sequence_number>
  </Axis_Array>
  <Axis_Array>
    <axis_name>Sample</axis_name>
    <elements>640</elements>
    <sequence_number>2</sequence_number>
  </Axis_Array>
</Array_2D_Image>
```



# Information Model Specification

## 9.4 Array\_2D\_Image

*Root Class:* Tagged\_Digital\_Object

*Role:* Concrete

*Class Description:* The Array 2D Image class is an extension of the Array 2D class and defines a two dimen

*Steward:* pds

*Namespace Id:* pds

*Version Id:* 1.1.0.0

	Entity	Card	Value/Class	Ind
<b>Hierarchy</b>	<a href="#">Tagged_Digital_Object</a>			
	<a href="#">. Byte_Stream</a>			
	<a href="#">. . Array</a>			
	<a href="#">. . . Array_2D</a>			
	<a href="#">. . . . Array_2D_Image</a>			
<b>Subclass</b>	none			
<b>Attribute</b>	none			
<b>Inherited Attribute</b>	<a href="#">axis_index_order</a>	1	<a href="#">Last Index Fastest</a>	
	<a href="#">description</a>	0..1		
	<a href="#">offset</a>	1		
	<a href="#">axes</a>	1	<a href="#">2</a>	R
	<a href="#">local_identifier</a>	0..1		
	<a href="#">name</a>	0..1		
<b>Association</b>	<a href="#">has_Display_2d_Image</a>	0..1	<a href="#">Display_2D_Image</a>	
<b>Inherited Association</b>	<a href="#">associated_Special_Constants</a>	0..1	<a href="#">Special_Constants</a>	
	<a href="#">associated_Statistics</a>	0..1	<a href="#">Object_Statistics</a>	
	<a href="#">data_object</a>	1	<a href="#">Digital_Object</a>	
	<a href="#">has_Element_Array</a>	1	<a href="#">Element_Array</a>	



# XML Schema and Schematron Files

```
<xs:complexType name="Array_2D_Image">  
  <xs:annotation>  
    <xs:documentation>The Array 2D Image class is an extension of the  
      Array 2D class and defines a two dimensional  
      image.</xs:documentation>  
  </xs:annotation>  
  <xs:complexContent>  
    <xs:extension base="pds:Array_2D">
```

```
<xs:complexType name="Array">  
  <xs:annotation>  
    <xs:documentation>The Array class defines a homogeneous N-dimensional array of scalars. ...  
  </xs:annotation>  
  <xs:complexContent>  
    <xs:extension base="pds:Byte_Stream">  
      <xs:sequence>  
        <xs:element name="offset" type="pds:offset" minOccurs="1" maxOccurs="1"> </xs:element>  
        <xs:element name="axes" type="pds:axes" minOccurs="1" maxOccurs="1"> </xs:element>  
        <xs:element name="axis_index_order" type="pds:axis_index_order" minOccurs="1" ...  
        <xs:element name="description" type="pds:description" minOccurs="0" maxOccurs="1"> ...  
        <xs:element name="Element_Array" type="pds:Element_Array" minOccurs="1" ...  
        <xs:element name="Axis_Array" type="pds:Axis_Array" minOccurs="1" ...
```

```
<sch:pattern>  
  <sch:rule context="pds:Array/pds:axis_index_order">  
    <sch:assert test=". = ('Last Index Fastest')">  
      The attribute pds:axis_index_order must be equal to the value 'Last Index Fastest'.</sch:assert>
```



# Data Dictionary Document (pdf and html formats)

## Array\_2D\_Image

<i>Name:</i> Array_2D_Image			<i>Version Id:</i> 1.1.0.0
<i>Description:</i> The Array 2D Image class is an extension of the Array 2D class and defines a two dimensional image.			
<i>Namespace Id:</i> pds	<i>Steward:</i> pds	<i>Role:</i> concrete	<i>Status:</i> Active
<i>Class Hierarchy:</i> Tagged_Digital_Object :: Byte_Stream :: Array :: Array_2D :: Array_2D_Image			
<i>Attribute(s)</i>	<i>Name</i>	<i>Cardinality</i>	<i>Value</i>
	name	0..1	None
	local_identifier	0..1	None
	offset	1..1	None
	axes	1..1	2
	axis_index_order	1..1	Last Index Fastest
	description	0..1	None
<i>Association(s)</i>	<i>Name</i>	<i>Cardinality</i>	<i>Class</i>
	has_Element_Array	1..1	Element_Array
	has_Axis_Array	2..2	Axis_Array
	associated_Special_Constants	0..1	Special_Constants
	associated_Statistics	0..1	Object_Statistics
	data_object	1..1	Digital_Object



# Query Model

- The search service is configurable from the IM
  - Provide the list of attributes to harvest from the product labels.
  - Provide the list of attributes and their roles {search field, facet}

```
<Property_Map>
  <identifier>0001_NASA_PDS_1.pds.Property_Map.pds.QueryModel.MissionScienceDataCollection.pds....
  <description>This Property Map indicates that the attribute Collection.pds.collection_type ...

  <Property_Map_Entry>
    <property_name>field</property_name>
    <property_value>collectionType</property_value>
  </Property_Map_Entry>

  <Property_Map_Entry>
    <property_name>facet</property_name>
    <property_value>Collection Type</property_value>
  </Property_Map_Entry>

  <Property_Map_Entry>
    <property_name>constraint</property_name>
    <property_value>Data</property_value>
```





# Registry Configuration Parameters

reg\_object\_type:

Product\_Observational

metadata: {

slot1: start\_date\_time

slot2: stop\_date\_time

slot3: version\_id

slot4: title

slot5: product\_class

slot6: logical\_identifier

slot7: alternate\_title

slot8: alternate\_id

slot9: version\_id

}



# JSON File Tool Configuration

```
"class": {
  "identifier": "0001_NASA_PDS_1.pds.Array_2D_Image" ,
  "title": "Array_2D_Image" ,
  "registrationAuthorityId": "0001_NASA_PDS_1" ,
  "nameSpaceId": "pds" ,
  "steward": "pds" ,
  "versionId": "1.1.0.0" ,
  "description": "The Array 2D Image class is an extension of the Array 2D class ..."
  , "associationList": [
    {"association": {
      "identifier": "0001_NASA_PDS_1.pds.Array_2D_Image.Array_2D.generalization" ,
      "title": "Array_2D" ,
      "assocType": "parent_of" ,
      "isAttribute": "false" ,
      "isChoice": "false" ,
      "isAny": "false" ,
      "groupName": "null" ,
      "minimumCardinality": "1" ,
      "maximumCardinality": "1" ,
      "classOrder": "0000" ,
      "attributeId": [
        "0001_NASA_PDS_1.pds.Array_2D"
```



# JSON File Tool Configuration

```
, {"association": {  
  "identifier": "0001_NASA_PDS_1.pds.Array.pds.axis_index_order.axis_index_order" ,  
  "title": "axis_index_order" ,  
  "assocType": "attribute_of" ,  
  "isAttribute": "true" ,  
  "isChoice": "false" ,  
  "isAny": "false" ,  
  "groupName": "null" ,  
  "minimumCardinality": "1" ,  
  "maximumCardinality": "1" ,  
  "classOrder": "1030" ,  
  "attributeId": [  
    "0001_NASA_PDS_1.pds.Array.pds.axis_index_order"  
  ]  
}
```



# JSON File Tool Configuration

```
"attribute": {
  "identifier": "0001_NASA_PDS_1.pds.Array.pds.axis_index_order" ,
  "title": "axis_index_order" ,
  "registrationAuthorityId": "0001_NASA_PDS_1" ,
  "nameSpaceId": "pds" ,
  "steward": "pds" ,
  "versionId": "1.5" ,
  "description": "The axis_index_order attribute provides the axis index that varies fastest ..." ,
  "isNillable": "false" ,
  "isEnumerated": "true" ,
  "dataType": "ASCII_Short_String_Collapsed" ,
  "dataTypeId": "0001_NASA_PDS_1.pds.ASCII_Short_String_Collapsed" ,
  "minimumCharacters": "1" ,
  "maximumCharacters": "255" ,
  "minimumValue": "Unbounded" ,
  "maximumValue": "Unbounded" ,
  "pattern": "null" ,
  "unitOfMeasure": "null" ,
  "unitOfMeasureId": "null" ,
  "unitId": "null" ,
  "defaultUnitId": "null"
, "PermissibleValueList": [
  {"PermissibleValue": {
    "value": "Last Index Fastest" ,
    "valueMeaning": "The values of a multi-dimensional array are stored in an order such that the last index
changes fastest and the first index slowest."}}
```



# XMI/UML

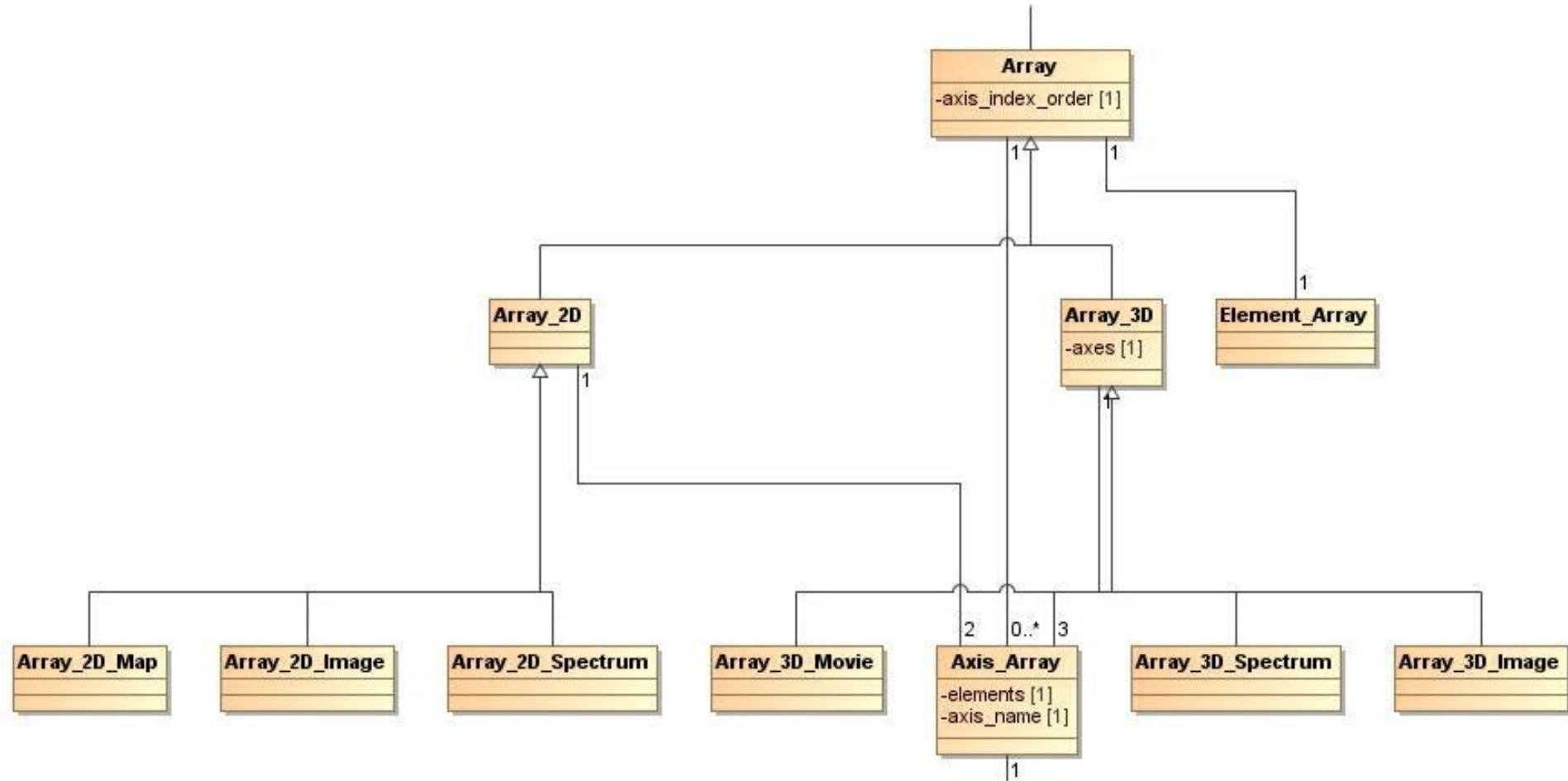
```
<ownedMember xmi:type="uml:Class" xmi:id="Array" name="Array" visibility="public">
  <generalization xmi:type="uml:Generalization" xmi:id="Array_Generalization" general="Byte_Stream"/>
  <ownedAttribute xmi:type="uml:Property" xmi:id="axes" name="axes" visibility="private">
    <upperValue xmi:type="uml:LiteralInteger" xmi:id="axes_1000501" visibility="public" value="1"/>
    <lowerValue xmi:type="uml:LiteralInteger" xmi:id="axes_1000502" visibility="public" value="1"/>
  </ownedAttribute>
  <ownedAttribute xmi:type="uml:Property" xmi:id="description" name="description" visibility="private">
    <upperValue xmi:type="uml:LiteralInteger" xmi:id="description_1000503" visibility="public" value="1"/>
    <lowerValue xmi:type="uml:LiteralInteger" xmi:id="description_1000504" visibility="public" value="0"/>
  </ownedAttribute>
  <ownedAttribute xmi:type="uml:Property" xmi:id="offset" name="offset" visibility="private">
    <upperValue xmi:type="uml:LiteralInteger" xmi:id="offset_1000505" visibility="public" value="1"/>
    <lowerValue xmi:type="uml:LiteralInteger" xmi:id="offset_1000506" visibility="public" value="1"/>
  </ownedAttribute>
  <ownedAttribute xmi:type="uml:Property" xmi:id="axis_index_order" name="axis_index_order" visibility="private">
    <upperValue xmi:type="uml:LiteralInteger" xmi:id="axis_index_order_1000507" visibility="public" value="1"/>
    <lowerValue xmi:type="uml:LiteralInteger" xmi:id="axis_index_order_1000508" visibility="public" value="1"/>
  </ownedAttribute>
</ownedMember>

<ownedMember xmi:type="uml:Class" xmi:id="Array_2D" name="Array_2D" visibility="public">
  <generalization xmi:type="uml:Generalization" xmi:id="Array_2D_Generalization" general="Array"/>
  <ownedAttribute xmi:type="uml:Property" xmi:id="axes" name="axes" visibility="private">
    <upperValue xmi:type="uml:LiteralInteger" xmi:id="axes_1000515" visibility="public" value="1"/>
    <lowerValue xmi:type="uml:LiteralInteger" xmi:id="axes_1000516" visibility="public" value="1"/>
  </ownedAttribute>
</ownedMember>

<ownedMember xmi:type="uml:Class" xmi:id="Array_2D_Image" name="Array_2D_Image" visibility="public">
  <generalization xmi:type="uml:Generalization" xmi:id="Array_2D_Image_Generalization" general="Array_2D"/>
</ownedMember>
```



# UML Class Diagram





# RDF/OWL-DL

```
<owl:Class rdf:about="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Array">
  <rdfs:subClassOf rdf:resource="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Byte_Stream"/>
  <dc:title>Array</dc:title>
  <dc:description>The Array class defines a homogeneous N-dimensional array of scalars. ...</dc:description>
  <rdfs:label>0001_NASA_PDS_1.pds.Array</rdfs:label>
  <rdfs:comment>The definition of class 0001_NASA_PDS_1.pds.Array.</rdfs:comment>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="http://pds.nasa.gov/ontologies/1800/pds/has_attribute"/>
      <owl:someValuesFrom rdf:resource="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Array.pds.axes"/>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="http://pds.nasa.gov/ontologies/1800/pds/has_attribute"/>
      <owl:someValuesFrom rdf:resource="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Array.pds.description"/>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="http://pds.nasa.gov/ontologies/1800/pds/has_attribute"/>
      <owl:someValuesFrom rdf:resource="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Array.pds.offset"/>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="http://pds.nasa.gov/ontologies/1800/pds/has_attribute"/>
      <owl:someValuesFrom rdf:resource="http://pds.nasa.gov/pds4/pds#0001_NASA_PDS_1.pds.Array.pds.axis_index_order"/>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
```



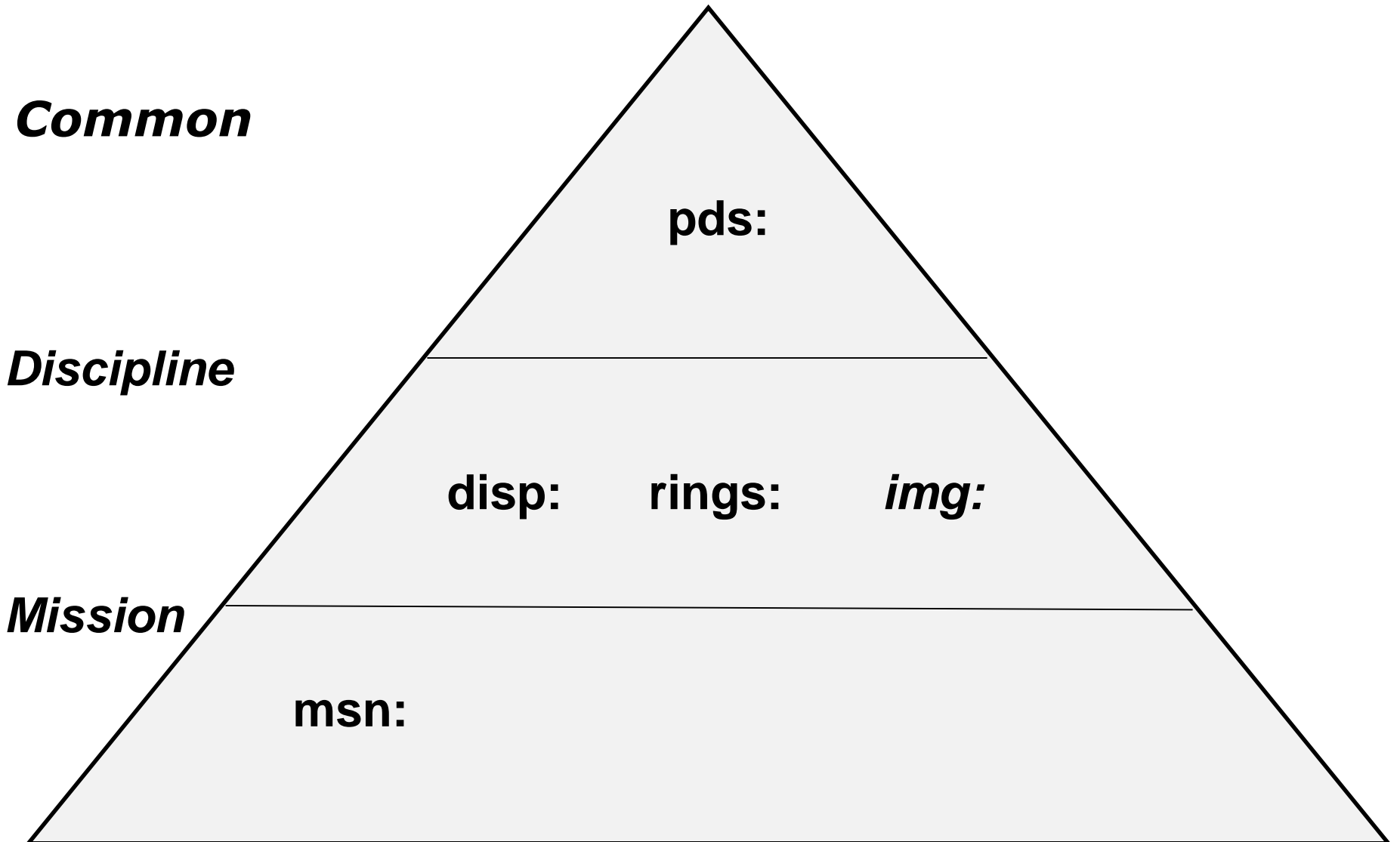
# Summary

- Leveraging the IM
  - *Registry*
    - Configuration files (JSON)
  - *Harvester/Search Application*
    - Query model for “Mission Science Data Collection” (Property Map)
  - *Tools*
    - PLAID (LDT)
      - *PLAID functionality for a particular product type is dependent on a JSON file containing a set of consistent dictionaries.*
      - *IMTool and LDDTool generate JSON files containing dictionary stacks*
  - *Others*





# JSON File for V1.7.0.0





National Aeronautics and  
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Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

# Thank You

## *Questions and Answers*

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

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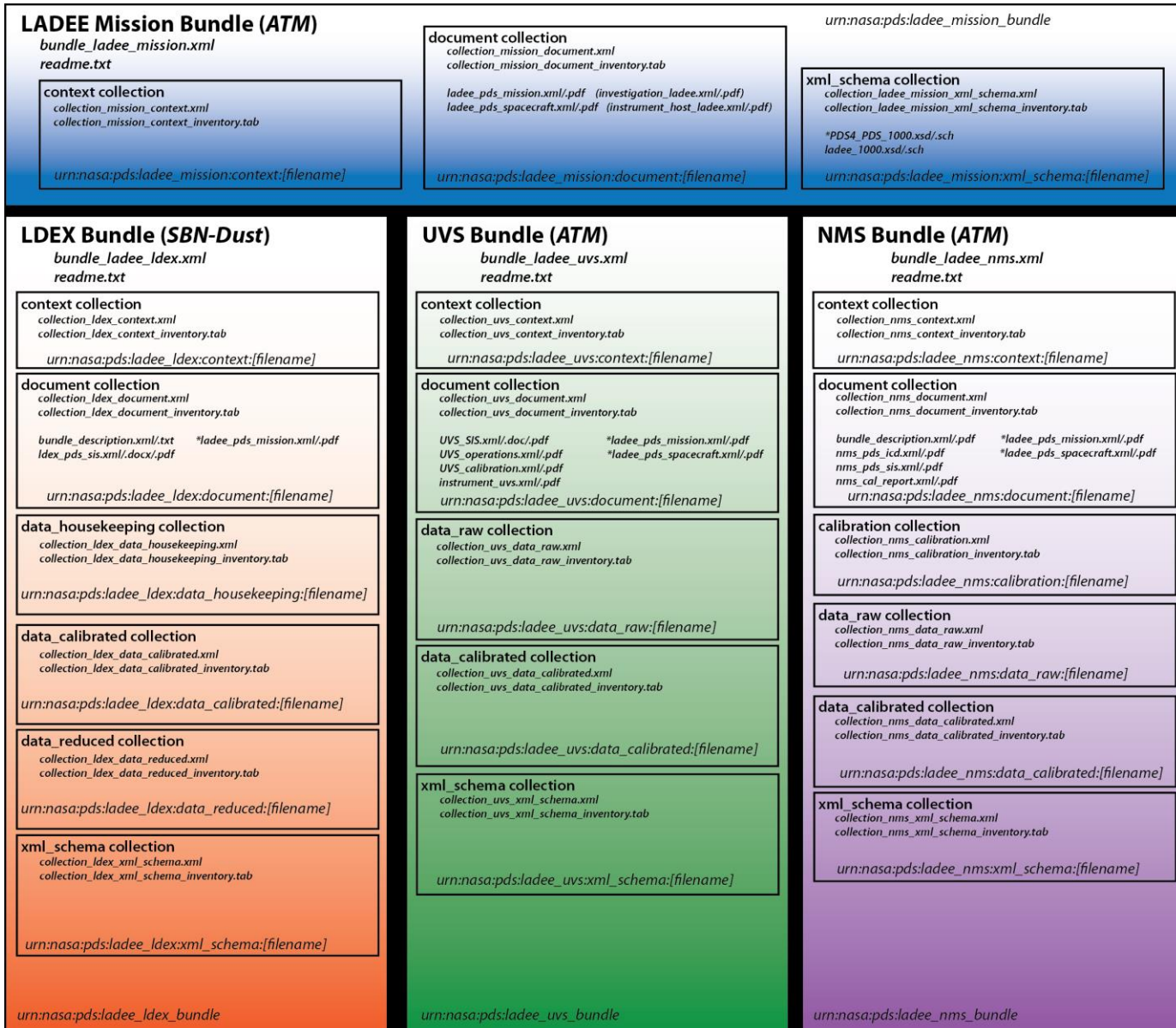
**National Aeronautics and  
Space Administration**

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

# Backup



# PDS 4: Example Data





# XML Product Templates and Labels

<Product\_Observational

<Identification\_Area>

<logical\_identifier>urn:nasa:pds:example.dph.sampleproducts:exampleproducts:array2d\_image ...

<version\_id>1.0</version\_id>

<title>MARS PATHFINDER LANDER Experiment</title>

<Array\_2D\_Image>

<local\_identifier>MPFL-M-IMP\_IMG\_GRAYSCALE</local\_identifier>

<offset unit="byte">0</offset>

<axes>2</axes>

<axis\_index\_order>Last Index Fastest</axis\_index\_order>

<Element\_Array>

<data\_type>UnsignedMSB2</data\_type>

<unit>data number</unit>

<scaling\_factor>1</scaling\_factor>

<value\_offset>0</value\_offset>

</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>



# 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	



# Dictionary Stacks

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