

# Lecture 22 – Data Models for Discovery

*Open Data Management & the Cloud*

(Data Science & Scientific Computing / UniTS – DMG)

# Metadata and Repositories



- Data Modelling and metadata modelling are first step in archiving, creating a repository of products
  - Custom ones for specific purposes
  - Common/shared ones to
    - Reach larger communities
    - Interoperate within or outside a research domain
- Models can be standardized exactly as can protocols or other technical specification
  - If not even more
    - Identifiers, vocabularies, formats, ...
- Better if standardization is open
  - Communities and organizations exist which have this goal
- (examples and details follow)

# Repository Metadata Standards



- Standards for metadata change by domain and granularity
- Keeping track of them is hard work
  - An example
    - <http://rd-alliance.github.io/metadata-directory/standards/>

# Metadata Standards



- Standards for metadata change by domain and granularity
- Keeping track of them is hard work
- An example

- <http://rd-alliance.github.io/metadata-directory/standards/>

## Physical Sciences & Mathematics

[AgMES \(Agricultural Metadata Element Set\)](#)

A semantic standard developed by the Food and Agriculture Organization (FAO) of the United Nations, AgMES enables description, resource discovery, interoperability and data exchange. Sponsored by the UN AIMS - Agricultural Information Management Standards, the current standard was issued in November 2010.

[AVM \(Astronomy Visualization Metadata\)](#)

The AVM scheme supports the cross-searching of collections of print-ready and screen-ready astronomical imagery rendered from telescopic observations (also known as 'pretty pictures'). Such images can combine data acquired at different wavelengths and from different observatories. While the primary intent is to cover data-derived astronomical images, there are broad

forecast data particularly in mind. However, it is equally applicable

11.

ular use for reporting crystal structure determinations to Acta Cryst

new version of the CIF standard is under consideration.

geographic grids used to calculate and project them, and the exper

ience Documentation (ES-DOC). The latest release dates from 20

designed to support data collected within a large-scale facility's sci

13.

includes elements focusing on instruments that capture data, tem

ered by the US Federal Government.

ndorsed ISO 19115 and began encouraging federal agencies to tr

map elements in data arrays to standard physical coordinates in th

etween and the integration of astronomical archives across the wa

use of astronomical data collections and services.

the identification, the extent, the quality, the spatial and temporal s

ince been split into parts: ISO 19115-1:2014 contains the fundam

structure of NeXus files is extremely flexible, allowing the storage o

field names.

specifically, this standard defines XML schemas for observations,

[instruments](#)

periments, nucleic acids, and complex assemblies, managed by the

of Crystallography (IUCr). PDBx has been extended by the wwPDB

in requirements.

As well as path, filename and data format conventions, it also spe

was released in February 2000.

which can be used to describe data along with its scientific context

composed of representatives of the International Helvophysics data

## General Research Data

[CERIF \(Common European Research Information Format\)](#)

The Common European Research Information Format is the standard that the EU recommends to its member states for recording information

[Data Package](#)

The Data Package specification is a generic wrapper format for exchanging data. Although it supports arbitrary metadata, the format defines

A separate but linked specification provides a way to describe the columns of a data table; descriptions of this form can be included directly

[DataCite Metadata Schema](#)

A set of mandatory metadata that must be registered with the DataCite Metadata Store when minting a DOI persistent identifier for a dataset

Sponsored by the DataCite consortium, version 3.0 was recently released in 2013.

[DCAT \(Data Catalog Vocabulary\)](#)

By using DCAT to describe datasets in data catalogs, publishers increase discoverability and enable applications easily to consume metadata

[Dublin Core](#)

A basic, domain-agnostic standard which can be easily understood and implemented, and as such is one of the best known and most widely

Sponsored by the Dublin Core Metadata Initiative, Dublin Core was published as ISO Standard 15836 in February 2009.

[OAI-ORE \(Open Archives Initiative Object Reuse and Exchange\)](#)

The goal of these standards is to expose the rich content in aggregations of Web resources to applications that support authoring, depositing, and

[Observations and Measurements](#)

This encoding is an essential dependency for the OGC Sensor Observation Service (SOS) Interface Standard. More specifically, this standard

[PREMIS](#)

The PREMIS (Preservation Metadata: Implementation Strategies) Data Dictionary defines a set of metadata that most repositories of digital

[PROV](#)

Provenance is information about entities, activities, and people involved in producing a piece of data or thing, which can be used to form

[RDF Data Cube Vocabulary](#)

The standard provides a means to publish multi-dimensional data, such as statistics, on the web in such a way that it can be linked to related

[Repository-Developed Metadata Schemas](#)

Some repositories have decided that current standards do not fit their metadata needs, and so have created their own requirements.

## Life Sciences

[ABCD \(Access to Biological Collection Data\)](#)

The Access to Biological Collections Data (ABCD) Schema free-text can be accommodated.

Sponsored by Biodiversity Information Standards TDWG

[Darwin Core](#)

A body of standards, including a glossary of terms (in other

Sponsored by Biodiversity Information Standards (TDWG)

[EML \(Ecological Metadata Language\)](#)

Ecological Metadata Language (EML) is a metadata schema

## Arts and Humanities

[Encoded Archival Description \(EAD\)](#)

A standard for encoding

[DDI \(Data Documentation Initiative\)](#)

A widely used, international

- DDI Codebook
- DDI Lifecycle

Both versions are available

[MIDAS-Heritage](#)

A British cultural heritage

Sponsored by the International

[OAI-ORE \(Open Archives Initiative Object Reuse and Exchange\)](#)

The goal of these standards is to

popular social networks of "Web 2.0".

[QuDEX \(Qualitative Data Exchange Format\)](#)

The QuDEX standard/schema is a

[SDMX \(Statistical Data and Metadata Exchange\)](#)

A set of common technical and

Sponsoring institutions include

[UKEOF](#)

A metadata standard for descri

## Engineering

[CIF \(Crystallographic Information File\)](#)

A well-established standard file

Sponsored by the International

[CSMD \(Core Scientific Metadata\)](#)

A standard for encoding

[ISA-TI \(International Standard Archival Thesauri Initiative\)](#)

A widely used, international

- DDI Codebook (or DDI version 2) is the simpler of the two, and intended
- DDI Lifecycle (or DDI version 3) is richer and may be used to document

Both versions are XML-based and defined using XML Schemas. They were

[MIDAS-Heritage](#)

A British cultural heritage standard

Sponsored by the Forum on Information Standards in Heritage, MIDAS Ver

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A metadata standard for describing environmental monitoring activities, programmes, networks and facilities published by the U

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A metadata standard for describing environmental monitoring activities, programmes, networks and facilities published by the UK Environmental Observation Framework (UKEOF).

# Metadata Standards



- Standards for
- Keeping track of
- An example
- <http://rd->

## General Research Data

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[Data Package](#)

The Data Package specification is a generic wrapper format for exchanging data. Although it supports arbitrary metadata, the format defines a set of mandatory metadata that must be registered with the DataCite Metadata Store when minting a DOI persistent identifier for a data package.

A separate but linked specification provides a way to describe the columns of a data table; descriptions of this form can be included directly in the data package.

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[Observations and Measurements](#)

This encoding is an essential dependency for the OGC Sensor Observation Service (SOS) Interface Standard. More specifically, this standard defines the metadata for observations and measurements.

[PREMIS](#)

The PREMIS (Preservation Metadata: Implementation Strategies) Data Dictionary defines a set of metadata that most repositories of digital objects use to describe the provenance of digital objects. The influence of the creation of local application profiles, an XML Schema is provided to allow the metadata to be serialized independently.

PREMIS was initially developed by the Preservation Metadata: Implementation Strategies Working Group, convened by OCLC and RLG.

[PROV](#)

Provenance is information about entities, activities, and people involved in producing a piece of data or thing, which can be used to form a chain of custody.

[RDF Data Cube Vocabulary](#)

The standard provides a means to publish multi-dimensional data, such as statistics, on the web in such a way that it can be linked to related metadata among organizations.

[Repository-Developed Metadata Schemas](#)

Some repositories have decided that current standards do not fit their metadata needs, and so have created their own requirements.

## Arts and Humanities

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[DDI \(Data Document\)](#)

A widely used, it

• DDI Code

• DDI Lifecycle

Both versions ar

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## Social and Behavioral Sciences

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• DDI Lifecycle

[MIBBI \(Metadata Interchange\)](#)

Both versions ar

[MIDAS-Heritage](#)

A British cultural

[NeXuS \(Neuroinformatics\)](#)

Sponsored by th

[OAI-ORE \(Open Archives Initiative\)](#)

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[SDMX \(Statistical Data Modeling\)](#)

A set of common

Sponsoring insti

Arts and Humanities

- Encoded Archival Description (EAD)
- DDI (Data Document)
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- OAI-ORE (Open Archives Initiative)

Engineering

- CIF (Crystallographic Information File)
- CSMD (Core Scientific Metadata)

Social and Behavioral Sciences

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- MIBBI
- MIDAS-Heritage
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- SDMX (Statistical Data Modeling)

# Metadata Standards



## ● Model extensions/integration

### Dublin Core

A basic, domain-agnostic standard which can be easily understood and implemented, and as such is c

Sponsored by the Dublin Core Metadata Initiative, Dublin Core was published as ISO Standard 15836

#### Summary Edit

##### Standard Website

<http://dublincore.org>

##### Specification

<http://dublincore.org/specifications/>

##### Related Vocabularies

[DCMI Vocabulary Management Community](#)

##### Mappings

[UK AGMAP \(Academic Geospatial Metadata Application Profile\)](#)

[DataCite Metadata Schema](#)

[PROV](#)

[DDI \(Data Documentation Initiative\)](#)

[MARC \(Machine-Readable Cataloging\)](#)

##### Subjects

[General Research Data](#)

##### Disciplines

[Multi-disciplinary](#)

### Extensions Add

#### [AGLS Metadata Profile](#) Edit

An application of [Dublin Core](#) designed to improve visibility and availability of online resources, orig

#### [AGRIS Application Profile](#) Edit

A metadata standard drawing on [Dublin Core](#) and [AgMES](#) created specifically to enhance the desc

#### [ANZLIC Metadata Profile](#) Edit

A profile of [ISO 19115](#), also mapping to the AGLS profile of [Dublin Core](#), designed to facilitate effici

#### [Dryad Metadata Application Profile](#) Edit

An application profile based on the [Dublin Core](#) Metadata Initiative Abstract Model, used to describ

#### [eBank UK Metadata Application Profile](#) Edit

A [Dublin Core](#) Metadata Application Profile created for the eBank UK project, which provides acces

#### [OpenAIRE Guidelines for publication repositories, data archives and CRIS systems](#) Edit

The OpenAIRE Guidelines are a suite of application profiles designed to allow research institutions the OAI-PMH metadata harvesting protocol:

- The OpenAIRE Guidelines for Literature Repositories are based on [Dublin Core](#);
- The OpenAIRE Guidelines for Data Archives are based on the [DataCite Metadata Schema](#);
- The OpenAIRE Guidelines for CRIS Managers is based on [CERIF](#).

While the focus of each profile is different, they allow for interlinking and the contextualization of res

#### [Resource Metadata for the Virtual Observatory](#) Edit

Defines metadata terms and concepts necessary for discovery and use of astronomical data collec

The extension is based on Dublin Core, but with astronomy-specific extensions. Resource Metadat and maintained by IVOA Resource Registry Working Group and NVO Metadata Working Group

- aka the Dublin Core Metadata Element Set
  - invitational workshop in Dublin, Ohio, 1995
  - "core" because its elements are broad and generic, usable for describing a wide range of resources
    - Not anymore only electronic
- 15 generic elements for describing resources
  - Creator, Contributor, Publisher, Title, Date, Language, Format, Subject, Description, Identifier, Relation, Source, Type, Coverage, Rights
- Later formally standardized and today used in countless implementations
  - one of the top metadata vocabularies on the web
  - “Later” because no semantic web (and, e.g., RDF) was available at the time
- Current version
  - Refers to a set of metadata vocabularies and technical specifications
    - Maintained by the Dublin Core Metadata Initiative (DCMI)
  - The full set of vocabularies includes sets of resource classes, vocabulary encoding schemes, and syntax encoding schemes
  - The terms in DCMI vocabularies are intended to be used in combination with terms from other, compatible vocabularies in the context of application profiles and on the basis of the DCMI Abstract Model [DCAM].
- Dublin Core Metadata Element Set, Version 1.1
  - <http://dublincore.org/documents/dces/>

- Semantic web evolution
  - DCMI includes formal domains and ranges in the definitions of its properties
  - not to affect the conformance of existing implementations of "simple Dublin Core"
    - domains and ranges have not been specified for the "initial" fifteen properties
      - namespace dc:
        - <http://purl.org/dc/elements/1.1/>
    - fifteen new properties with "names" identical to those of the Dublin Core Metadata Element Set Version 1.1 have been created
      - namespace dcterms:
        - <http://purl.org/dc/terms/>
    - These fifteen new properties have been defined as subproperties of the corresponding properties of DCES Version 1.1 and assigned domains and ranges



# Dublin Core – semantic evolution



## ● Property

<b>Term Name:</b> contributor	
<b>URI:</b>	<a href="http://purl.org/dc/elements/1.1/contributor">http://purl.org/dc/elements/1.1/contributor</a>
<b>Label:</b>	Contributor
<b>Definition:</b>	An entity responsible for making contributions to the resource.
<b>Comment:</b>	Examples of a Contributor include a person, an organization, or a service. Typically, the name of a Contributor should be used to indicate the entity.

## ● Term

<b>Term Name:</b> contributor	
<b>URI:</b>	<a href="http://purl.org/dc/terms/contributor">http://purl.org/dc/terms/contributor</a>
<b>Label:</b>	Contributor
<b>Definition:</b>	An entity responsible for making contributions to the resource.
<b>Comment:</b>	Examples of a Contributor include a person, an organization, or a service.
<b>Type of Term:</b>	<a href="#">Property</a>
<b>Refines:</b>	<a href="http://purl.org/dc/elements/1.1/contributor">http://purl.org/dc/elements/1.1/contributor</a>
<b>Has Range:</b>	<a href="http://purl.org/dc/terms/Agent">http://purl.org/dc/terms/Agent</a>
<b>Version:</b>	<a href="http://dublincore.org/usage/terms/history/#contributorT-001">http://dublincore.org/usage/terms/history/#contributorT-001</a>

# Dublin Core – OAI-PMH usage



- OAI-PMH
  - Open Archives Initiative Protocol for Metadata Harvesting
  - application-independent interoperability framework based on metadata harvesting
  - two classes of participants
    - Data Providers support OAI-PMH as a means of exposing metadata
    - Service Providers harvest metadata via the OAI-PMH
      - for building value-added services
      - Harvest: issue OAI-PMH requests
- OAI-PMH supports the dissemination of records in multiple metadata formats from a repository
  - metadataPrefix arguments are used in ListRecords, ListIdentifiers, and GetRecord requests to retrieve records, or the headers of records that include metadata in the format specified by the metadataPrefix
  - For purposes of interoperability, repositories must disseminate Dublin Core, without any qualification
    - metadataPrefix “oai\_dc” reserved
    - XML namespace URI → [http://www.openarchives.org/OAI/2.0/oai\\_dc/](http://www.openarchives.org/OAI/2.0/oai_dc/)
    - URL → [http://www.openarchives.org/OAI/2.0/oai\\_dc.xsd](http://www.openarchives.org/OAI/2.0/oai_dc.xsd).

# Dublin Core – OAI-PMH usage



- OAI-PMH

- Open Archives Initiative

- application

- two classes

- Data

- Services

- 

- 

- OAI-PMH :  
from a repository

- metadata requests  
in different formats

- For purposes  
of any quality

- metadata

- XML

- URL

A XML schema for validating Unqualified Dublin Core metadata associated with the reserved oai\_dc metadataPrefix

```
<schema targetNamespace="http://www.openarchives.org/OAI/2.0/oai_dc/"
  xmlns:oai_dc="http://www.openarchives.org/OAI/2.0/oai_dc/"
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified" attributeFormDefault="unqualified">

  <annotation>
    <documentation>
      XML Schema 2002-03-18 by Pete Johnston.
      Adjusted for usage in the OAI-PMH.
      Schema imports the Dublin Core elements from the DCMI schema for unqualified Dublin Core.
      2002-12-19 updated to use simpledc20021212.xsd (instead of simpledc20020312.xsd)
    </documentation>
  </annotation>

  <import namespace="http://purl.org/dc/elements/1.1/"
    schemaLocation="http://dublincore.org/schemas/xmls/simpledc20021212.xsd"/>

  <element name="dc" type="oai_dc:oai_dcType"/>

  <complexType name="oai_dcType">
    <choice minOccurs="0" maxOccurs="unbounded">
      <element ref="dc:title"/>
      <element ref="dc:creator"/>
      <element ref="dc:subject"/>
      <element ref="dc:description"/>
      <element ref="dc:publisher"/>
      <element ref="dc:contributor"/>
      <element ref="dc:date"/>
      <element ref="dc:type"/>
      <element ref="dc:format"/>
      <element ref="dc:identifier"/>
      <element ref="dc:source"/>
      <element ref="dc:language"/>
      <element ref="dc:relation"/>
      <element ref="dc:coverage"/>
      <element ref="dc:rights"/>
    </choice>
  </complexType>

</schema>
```

This Schema is available at [http://www.openarchives.org/OAI/2.0/oai\\_dc.xsd](http://www.openarchives.org/OAI/2.0/oai_dc.xsd)

a harvesting

ata formats

d GetRecord  
etadata in the

Core, without

- DCAT is an RDF vocabulary designed to facilitate interoperability between data catalogs published on the Web
- Using DCAT to describe datasets in data catalogs, publishers increase discoverability and enable applications easily to consume metadata from multiple catalogs
- DCAT does not make any assumptions about the format of the datasets described in a catalog
  - Other, complementary vocabularies may be used together with DCAT to provide more detailed format-specific information
- <https://www.w3.org/TR/vocab-dcat/>
  - <https://www.w3.org/TR/vocab-dcat-2/>

- DCAT defines three main classes:
  - `dcat:Catalog` represents the catalog
  - `dcat:Dataset` represents a dataset in a catalog.
  - `dcat:Distribution` represents an accessible form of a dataset
- A dataset does not have to be available as a downloadable file.
  - A dataset that is available via an API can be defined as an instance of `dcat:Dataset`
  - the API can be defined as an instance of `dcat:Distribution`
- Class `dcat:CatalogRecord` describes a dataset entry in the catalog
  - `dcat:Dataset` represents the dataset itself
  - `dcat:CatalogRecord` represents the record that describes a dataset in the catalog
    - is optional
    - is used to capture provenance information

# DCAT (W3C)



- DCA

- C

- C

- C

- A da

- A

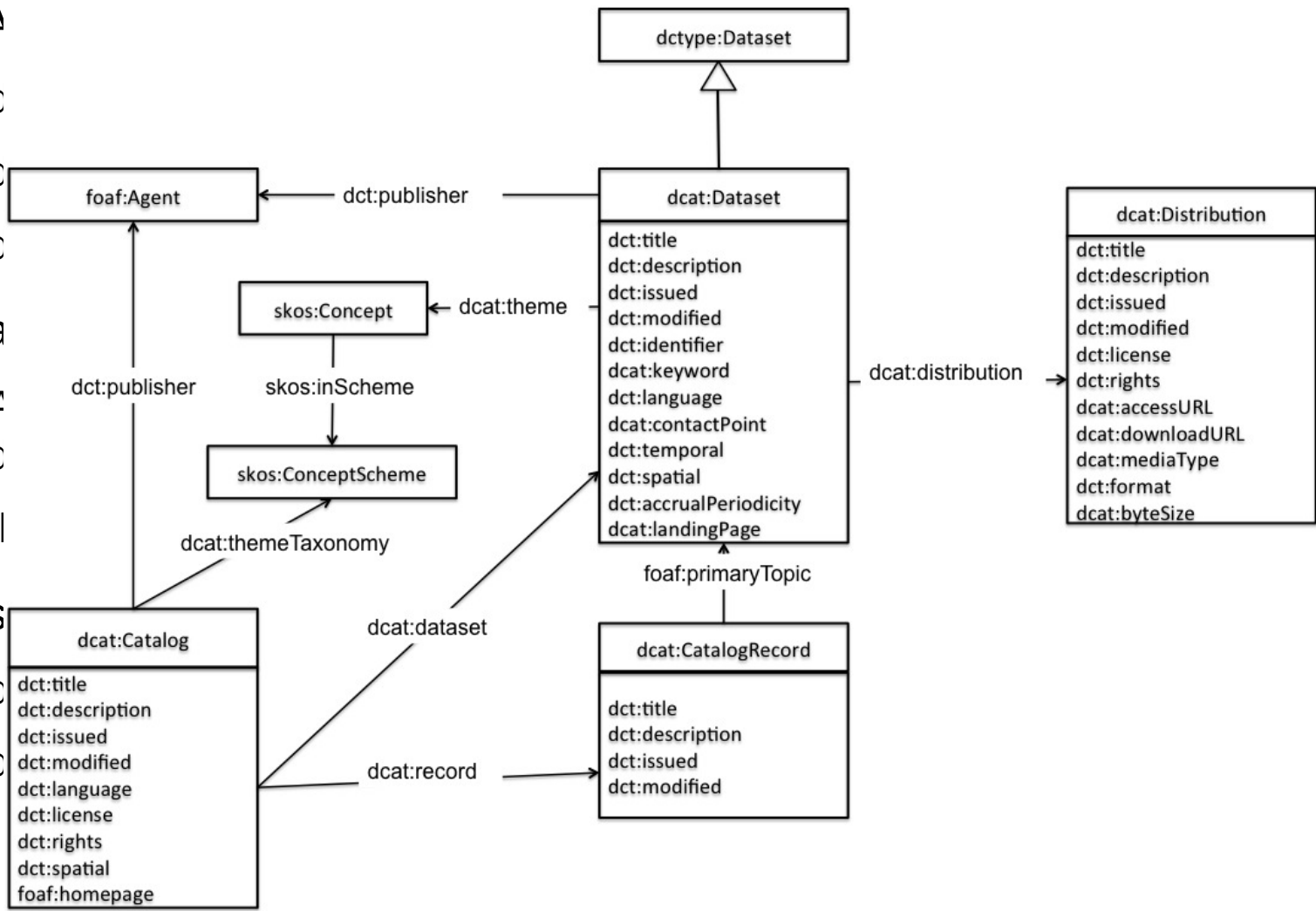
- C

- t|

- Clas

- C

- C



catalog

Prefix dct: namespace to Dublin Core elements 1.1

- The DataCite Metadata Schema
  - list of core metadata properties chosen for an accurate and consistent identification of a resource for citation and retrieval purposes
  - The resource that is being identified can be of any kind, but it is typically a dataset
  - term 'dataset': its broadest sense
- Collaborate with the Dublin Core Metadata Initiative (DCMI) to maintain a Dublin Core Application Profile for the schema
- Presents 3 different levels of obligation for the metadata properties
  - Mandatory (M) properties must be provided
  - Recommended (R ) properties are optional, but strongly recommended for interoperability
  - Optional (O) properties are optional and provide richer description
- <http://schema.datacite.org/meta/kernel-4.3/>
  - v.4.1: explicit changes to improve software citation
  - v.4.2: alternate identifiers and machine readable licences
  - v.4.3: "funder" identifiers...

# DataCite Metadata – Properties



Table 1: DataCite Mandatory Properties

<i>ID</i>	<i>Property</i>	<i>Obligation</i>
1	Identifier (with mandatory type sub-property)	M
2	Creator (with optional given name, family name, name identifier and affiliation sub-properties)	M
3	Title (with optional type sub-properties)	M
4	Publisher	M
5	PublicationYear	M
10	ResourceType (with mandatory general type description sub-property)	M

Table 2: DataCite Recommended and Optional Properties

<i>ID</i>	<i>Property</i>	<i>Obligation</i>
6	Subject (with scheme sub-property)	R
7	Contributor (with optional given name, family name, name identifier and affiliation sub-properties)	R
8	Date (with type sub-property)	R
9	Language	O
11	AlternateIdentifier (with type sub-property)	O
12	RelatedIdentifier (with type and relation type sub-properties)	R
13	Size	O
14	Format	O
15	Version	O
16	Rights	O
17	Description (with type sub-property)	R
18	GeoLocation (with point, box and polygon sub-properties)	R
19	FundingReference (with name, identifier, and award related sub-properties)	O

- Among Recommended

- Description (17) is considered the most important
- Especially in connected usage with the Recommended sub-property
  - descriptionType = "Abstract"



# DataCite Metadata – Mandatory



ID	DataCite-Property	Occ	Definition	Allowed values, examples, other constraints
1	Identifier	1	The Identifier is a unique string that identifies a resource. For software, determine whether the identifier is for a specific version of a piece of software, (per the Force11 Software Citation Principles <sup>13</sup> ), or for all versions.	DOI (Digital Object Identifier) registered by a DataCite member. Format should be "10.1234/foo"
1.1	identifierType	1	The type of Identifier.	<i>Controlled List Value:</i> DOI
2	Creator	1-n	The main researchers involved in producing the data, or the authors of the publication, in priority order. To supply multiple creators, repeat this property.	May be a corporate/institutional or personal name. Note: DataCite infrastructure supports up to 8000-10000 names. For name lists above that size, consider attribution via linking to the related metadata.
2.1	creatorName	1	The full name of the creator.	Examples: Charpy, Antoine; Foo Data Center  Note: The personal name, format should be: family, given. Non-roman names may be transliterated according to the ALA-LC schemas <sup>14</sup> .
2.1.1	nameType	0-1	The type of name	<i>Controlled List Values:</i> Organizational Personal

ID	DataCite-Property	Occ	Definition	Allowed values, examples, other constraints
2.2	givenName	0-1	The personal or first name of the creator.	Examples based on the 2.1 names: Antoine; Mae
2.3	familyName	0-1	The surname or last name of the creator.	Examples based on the 2.1 names: Charpy; Jemison
2.4	nameIdentifier	0-n	Uniquely identifies an individual or legal entity, according to various schemas.	The format is dependent upon schema.
2.4.1	nameIdentifierScheme	1	The name of the name identifier schema.	If nameIdentifier is used, nameIdentifierScheme is mandatory.  Examples: ORCID <sup>15</sup> , ISNI <sup>16</sup>
2.4.2	schemaURI	0-1	The URI of the name identifier schema.	Examples: <a href="http://www.isni.org">http://www.isni.org</a> <a href="http://orcid.org">http://orcid.org</a>
2.5	affiliation	0-n	The organizational or institutional affiliation of the creator.	Free text.
3	Title	1-n	A name or title by which a resource is known. May be the title of a dataset or the name of a piece of software.	Free text.
3.1	titleType	0-1	The type of Title.	<i>Controlled List Values:</i> AlternativeTitle Subtitle TranslatedTitle  Other

- Properties 4,5 have occurrence 1 (being mandatory) without mandatory sub-properties

- Property 10 has mandatory resourceTypeGeneral sub-property, with values in a controlled list:

- Audiovisual, Collection, DataPaper, Dataset, Event, Image, InteractiveResource, Model, PhysicalObject, Service, Software, Sound, Text, Workflow, Other



- ...some details
- Most Recommended/Optional properties and sub-properties
  - Have values within controlled list vocabularies
    - 7 Contributor [0-n]: Free text
      - 7.1 contributorType [1]: controlled list
        - ContactPerson, DataCollector, DataCurator, DataManager, Distributor, Editor, HostingInstitution, Producer, ProjectLeader, ProjectManager, ProjectMember, RegistrationAgency, RegistrationAuthority, RelatedPerson, Researcher, ResearchGroup, RightsHolder, Sponsor, Supervisor, WorkPackageLeader, Other
  - Specify free text values through (optional) schema & value URI identifiers
    - 6 Subject [0-n]: Free text
      - 6.1 subjectScheme [0-1] The name of the subject scheme: Free text
      - 6.2 schemeURI [0-1] The URI of the subject identifier scheme
      - 6.3 valueURI [0-1] The URI of the subject term
  - Point to external standard formats, models, schemas, ...
    - 9 Language [0-1]: allowed values from IETF BCP 47, ISO 639-1 language codes
      - Examples: en, de, fr

- Metadata expressed through XSD documents (and associated Recommendation documents)
  - “Resource Metadata” describes the basic concepts
  - VOResource brings it to XSD and provides a technical entry point
    - Multiple extensions follow: standards, simple access protocols, collections and services, ...
  - Connected interfaces and identifiers specifications

ReR	VOA Identifiers	2.0		2.0 2.0 2.0 2.0 1.12 1.11 1.10 1.10 1.10 1.00
	VOA Registry Interfaces	1.1		1.1 1.1 1.1 1.1 1.1 1.1 1.0 1.0 1.00 1.02 1.01 1.00
	RM - Resource Metadata for the Virtual Observatory	1.12		1.12 1.12 1.10 1.10 1.01 1.01 1.00 1.00
	StandardsRegExt: a VOResource Schema Extension for Describing IVOA Standards	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0
	SimpleDALRegExt - Describing Simple Data Access Services	1.1		1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0
	VOResource - an XML Encoding Schema for Resource Metadata	1.1		1.1 1.1 1.1 1.1 1.1 1.03 1.02 1.02 1.01 1.00
	VODataService - A VOResource Schema Extension for Describing Collections and Services	1.1	1.2	1.2 1.1 1.1 1.1 1.1 1.1 1.10
	RegTAP - Registry Relational Schema	1.0	1.1	1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0

- <http://ivoa.net/documents/> (ReR section in the table)
  - But TAPRegExt in the DAL part...
  - (future) maybe protocol dedicated extensions will end up in the protocol document itself

# Resource Metadata for the VO



- Starts out from FITS usage scenario
- General concepts are or map directly Dublin Core
  - The harvesting interface to the Registry is OAI-PMH
- Hierarchical system for metadata management
  - Lower levels provide more extensive and complex metadata
    - description of query syntax, access protocols, and usage policies
- Basic concepts
  - Resource is a general term
    - Described in terms of who curates or maintains it
    - Can be given a name and a unique identifier
  - Organisation is specific type of resource that brings people together to pursue participation in VO applications
    - Can be hierarchical and range greatly in size and scope
      - University, observatory, or government agency, ..., scientific project, space mission, or individual researcher
      - A provider is an organisation that makes data and/or services available to users over the network
  - Service is any VO resource that can be invoked by the user to perform some action on their behalf
    - Query service supports a query/response protocol
    - Non-query services: copy or delete files on remote files systems, mail information, kill existing jobs, authorize actions, ...
    - Registry is a query service for which the response is a structured description of resources
- Resource metadata include
  - Identity metadata (name, identifier, ... )
  - Curation metadata (who supports the resource, its availability, ... )
  - Content metadata (types of data, sky coverage, spectral coverage, ... )

# Resource Metadata - Structure



- Identity
  - Title, Shortname, Identifier (IVOID)
- Curation
  - Publisher (with PublisherID), Creator, Contributor
  - Date, Version
  - Contact
- General Content
  - Subject (controlled IAU vocabulary), Description, Source (Bibliographic reference), ReferenceURL, Type (controlled vocabulary), ContentLevel (target user), Relationship
- Collection & Service
  - Facility, Instrument
  - Coverage: spatial, spectral, bounds, resolution
  - UCD, format, rights
  - Quality flags, validation, uncertainties
- Interface & Capabilities
  - Interface: BaseURL and other URLs
  - Capability: identified by a StandardID (IVOID)

- Specifies through XSD hierarchical structure of Resource Metadata
  - What's a timestamp?
    - vr:UTCTimestamp

```
<xs:simpleType name="UTCTimestamp" >  
  <xs:restriction base="xs:dateTime" >  
    <xs:pattern  
      value="\d{4}-\d\d-\d\dT\d\d:\d\d:\d\d(\.\d+)?Z?" />  
    </xs:restriction>  
  </xs:simpleType>
```

- Relation among Interface and Capability elements

```
<capability xsi:type="ex:ExampleCapType"  
  standardID="ivo://example.com/std/exampleAccess"  
  xmlns:ex="http://ivoa.net/std/example-1.xsd">  
  ...  
</capability>  
  
<capability>  
  <interface xsi:type="vr:WebBrowser">  
    <accessURL use="full"  
      >http://example.org/browser-service</accessURL>  
    </interface>  
  </capability>
```

- Provide guidelines to extend the VOResource schema

# Standards Extensions



- Extend VOResource to add 3 resource types

- vstd:Standard
- vstd:ServiceStandard
- vstd:StandardKeyEnumeration

## vstd:Standard Type Schema Definition

```
<xs:complexType name="Standard" >
  <xs:complexContent >
    <xs:extension base="vr:Resource" >
      <xs:sequence >
        <xs:element name="endorsedVersion" type="vstd:EndorsedVersion"
          maxOccurs="unbounded" />
        <xs:element name="schema" type="vstd:Schema" minOccurs="0"
          maxOccurs="unbounded" >
        <xs:element name="deprecated" type="xs:token" minOccurs="0" />
        <xs:element name="key" type="vstd:StandardKey" minOccurs="0"
          maxOccurs="unbounded" />
      </sequence>
    </extension>
  </complexContent>
</complexType>
```

## An example of a Standard resource that summarizes this specification

```
<?xml version="1.0" encoding="UTF-8"?>
<ri:Resource xsi:type="vstd:Standard" status="active"
  created="2012-02-17T11:15:00" updated="2012-02-17T11:15:00"
  xmlns:ri="http://www.ivoa.net/xml/RegistryInterface/v1.0"
  xmlns:vstd="http://www.ivoa.net/xml/StandardsRegExt/v1.0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <title> StandardsRegExt: a VOResource Schema Extension for Describing IVOA Standards </title>
  <shortName> StandardsRegExt </shortName>
  <identifier> ivo://ivoa.net/std/StandardsRegExt </identifier>
  <curation>
    .....
  </curation>
  <content>
    .....
  </content>
  <endorsedVersion status="pr"> 1.0 </endorsedVersion>
  <schema namespace="http://www.ivoa.net/xml/StandardsRegExt/v1.0">
    <location>http://www.ivoa.net/xml/StandardsRegExt/v1.0</location>
    <description>
      the VOResource extension XML Schema for registering standards
    </description>
    <example>http://rofr.ivoa.net/examples/StandardsRegExt.xml</example>
    <example>http://rofr.ivoa.net/examples/SIA.xml</example>
    <example>http://rofr.ivoa.net/examples/VOSpace.xml</example>
  </schema>
</ri:Resource>
```

# Observational Core Metadata



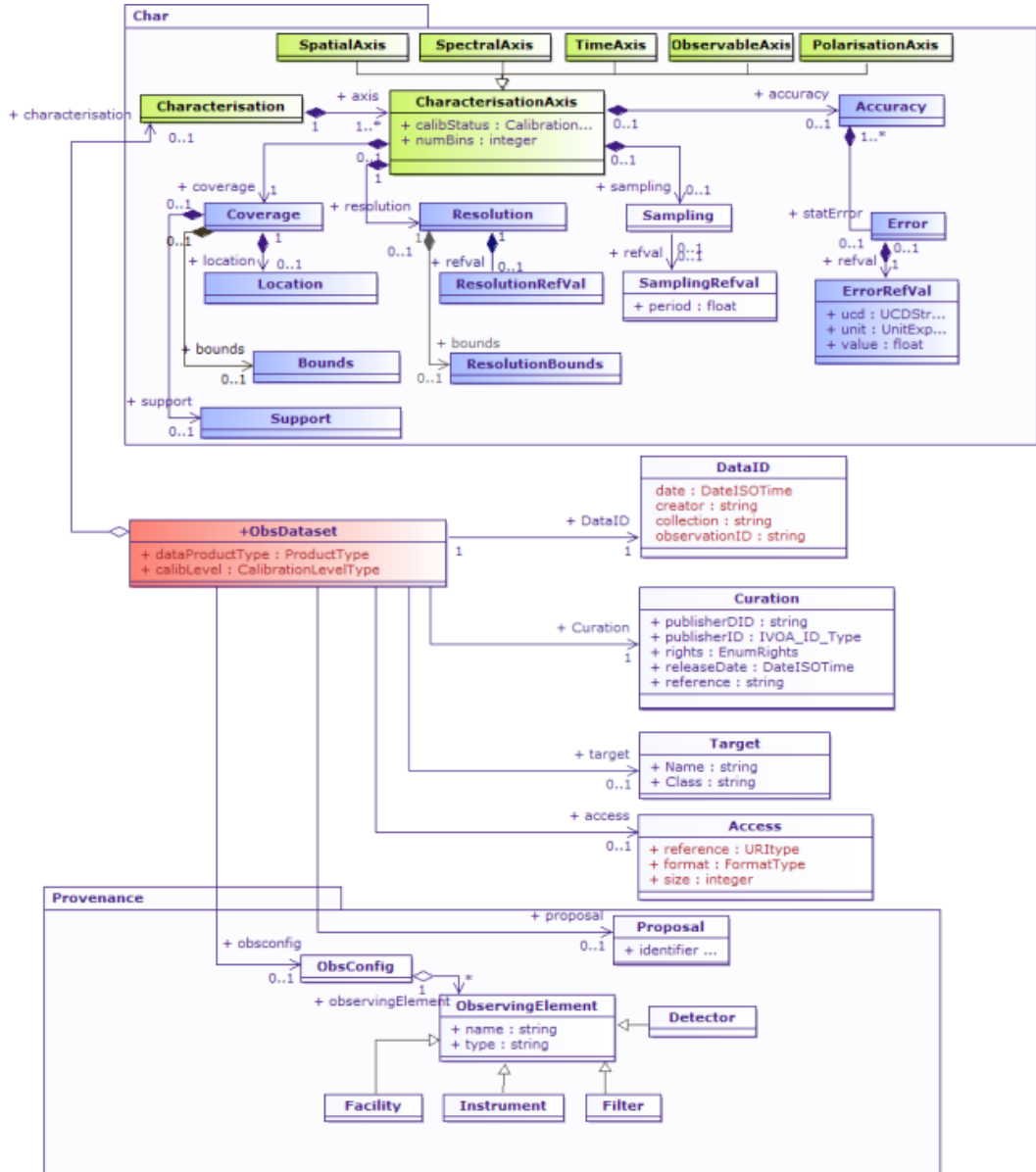
- Core components of the Observation data model necessary to perform data discovery when querying data centers for astronomical observations of interest
- Focus is on data discovery
  - A number of use-cases have been defined
  - Aimed at finding observational data products
  - Broadcasting the same query to multiple archives
    - global data discoverability and accessibility
- Need to give data providers a set of metadata attributes that they can easily map to their database system in order to support queries
- <http://www.ivoa.net/documents/ObsCore/20170509/REC-ObsCore-v1.1-20170509.pdf>



# Observational Core Metadata



- Core compc discovery w/
- Focus is on
  - A number
  - Aimed at
  - Broadcas
    - global
- Need to giv map to their
- <http://www.ivoa.i>



perform data  
ons of interest

they can easily

# ObsCore – Flat View



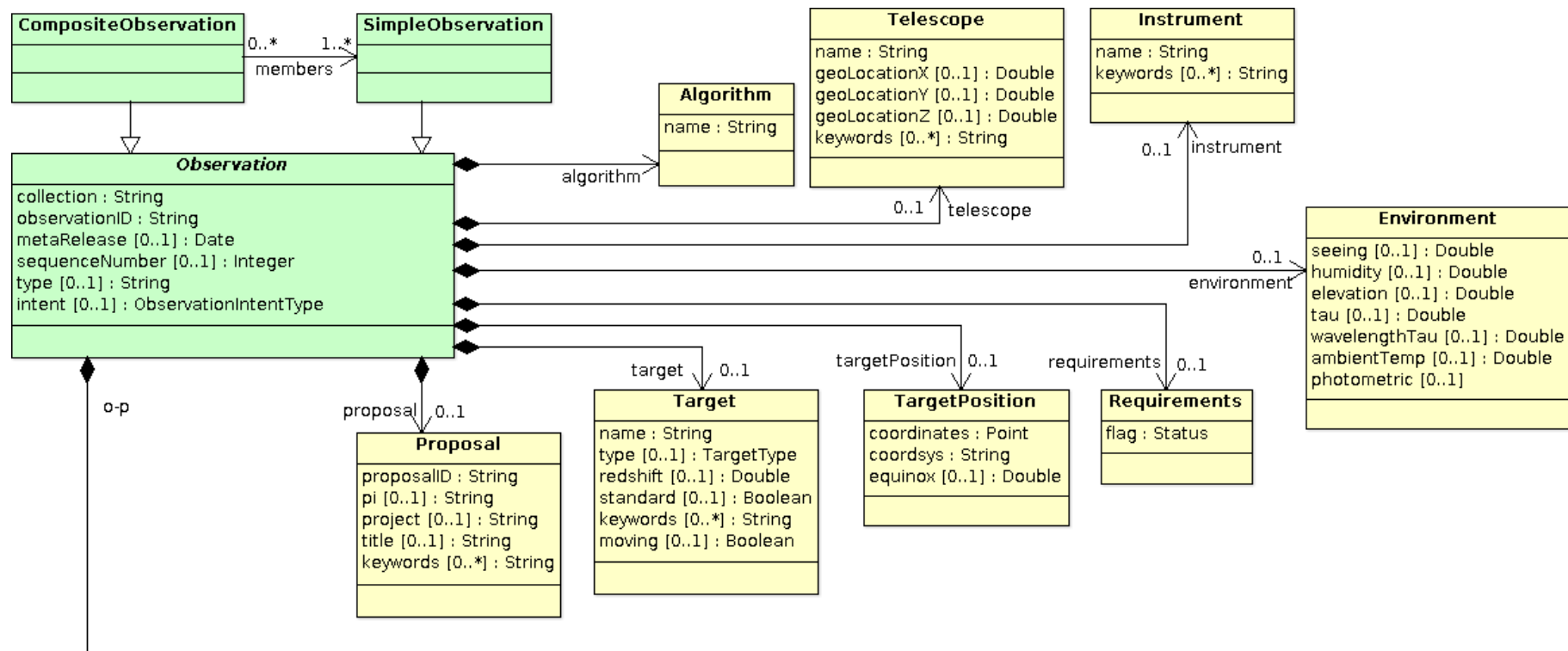
- Flat table approach
- Mandatory Structure but NULL-able values
  - Exceptions
    - calib\_level, obs\_collection, obs\_id, obs\_publisher\_did
- Mandatory
  - Units
  - Data domain
  - Coordinate frames
- Comprehensive usage of
  - Vocabularies
  - Identifiers
- Limited number of mandatory elements
  - Optional standardized ones
  - Custom additions allowed

Column Name	Unit	Type	Description
dataprodect_type	unitless	String	Logical data product type (image etc.)
calib_level	unitless	enum integer	Calibration level {0, 1, 2, 3, 4}
obs_collection	unitless	String	Name of the data collection
obs_id	unitless	String	Observation ID
obs_publisher_did	unitless	String	Dataset identifier given by the publisher
access_url	unitless	String	URL used to access (download) dataset
access_format	unitless	String	File content format (see in App. BB.5.2)
access_estsize	kbyte	integer	Estimated size of dataset in kilo bytes
target_name	unitless	String	Astronomical object observed, if any
s_ra	deg	double	Central right ascension, ICRS
s_dec	deg	double	Central declination, ICRS
s_fov	deg	double	Diameter (bounds) of the covered region
s_region	unitless	String	Sky region covered by the data product (expressed in ICRS frame)
s_xel1	unitless	integer	Number of elements along the first spatial axis
s_xel2	unitless	integer	Number of elements along the second spatial axis
s_resolution	arcsec	double	Spatial resolution of data as FWHM
t_min	d	double	Start time in MJD
t_max	d	double	Stop time in MJD
t_exptime	s	double	Total exposure time
t_resolution	s	double	Temporal resolution FWHM
t_xel	unitless	integer	Number of elements along the time axis
em_min	m	double	Start in spectral coordinates
em_max	m	double	Stop in spectral coordinates
em_res_power	unitless	double	Spectral resolving power
em_xel	unitless	integer	Number of elements along the spectral axis
o_ucd	unitless	String	UCD of observable (e.g. phot.flux.density, phot.count, etc.)
pol_states	unitless	String	List of polarization states or NULL if not applicable
pol_xel	unitless	integer	Number of polarization samples
facility_name	unitless	String	Name of the facility used for this observation
instrument_name	unitless	String	Name of the instrument used for this observation

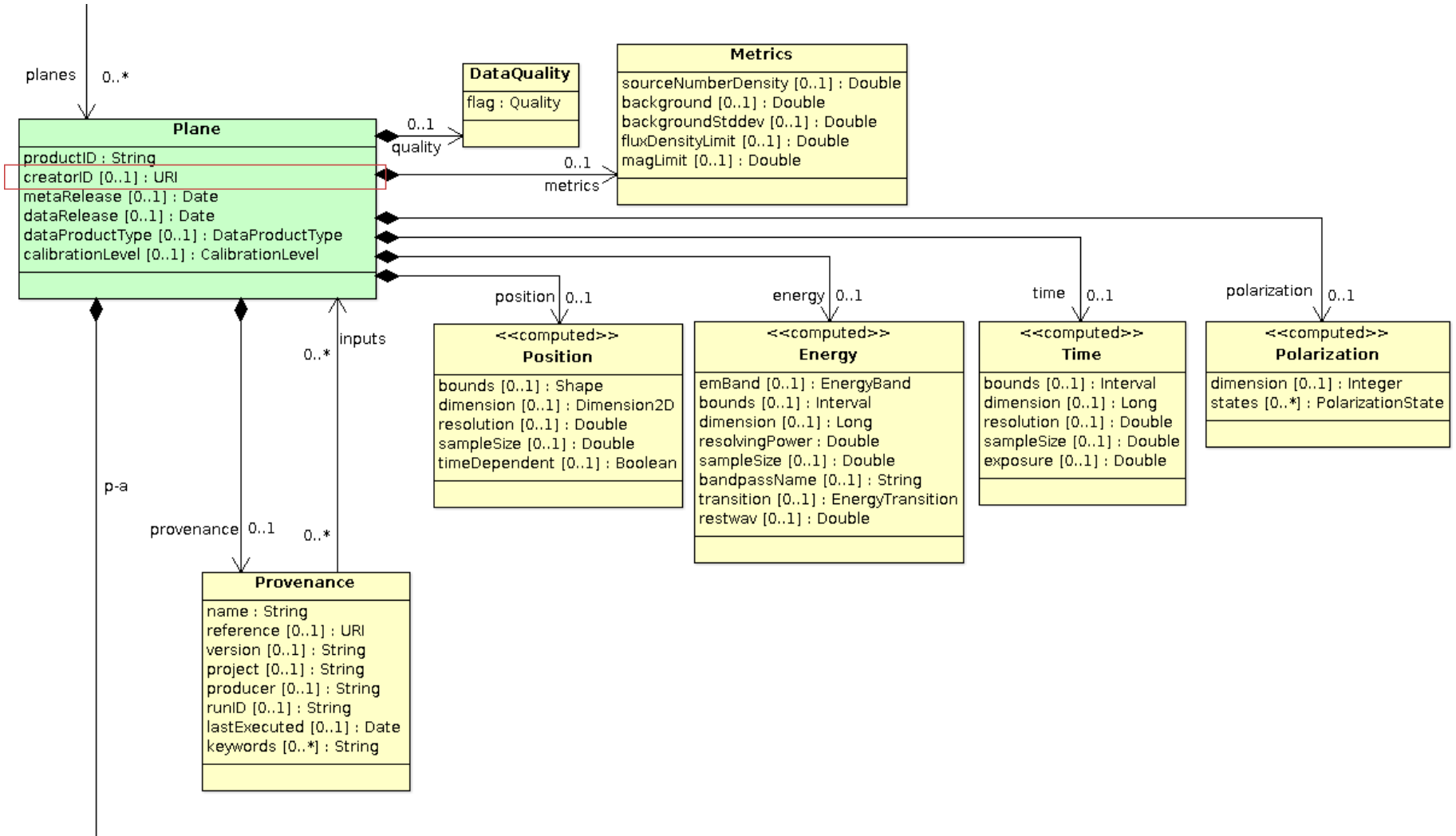
- Common Archive Observation Model, enables
  - Storage of observational metadata from the complete set of telescopic data
  - Searching through that metadata using a single interface
- The generalized capability of CAOM comes at the expense of some model complexity and the requirement of adopting a language that is unfamiliar to users
- To decrease the learning curve for users
  - expose CAOM via a simplified search web page interface
  - expose via a Table Access Protocol (TAP) web service
    - for users requiring access to more details of the observations and greater flexibility in query construction
- Model structure
  - Observation: overall container for all associated datasets (top level of the model)
  - Plane: to store each dataset associated to an Observation
  - Artifact: the actual data files containing the observational data (e.g. FITS)
  - Part: each describable part within an Artifact that has a complex data structure
    - Description and discovery of the Part(s) rely on the Artifact's internal metadata content
  - Chunk: further fine-grain level if also Part is a complex data structure (rare)
    - Usually not clearly separated in term of Artifact metadata
- <http://www.opencadc.org/caom2/>

```
Observation
-> Plane
    -> Artifact
        -> Part
            -> Chunk
        -> Part
            -> Chunk
        -> Part
            ...
-> Plane
    -> Artifact
        ...
-> Plane
    ...
```

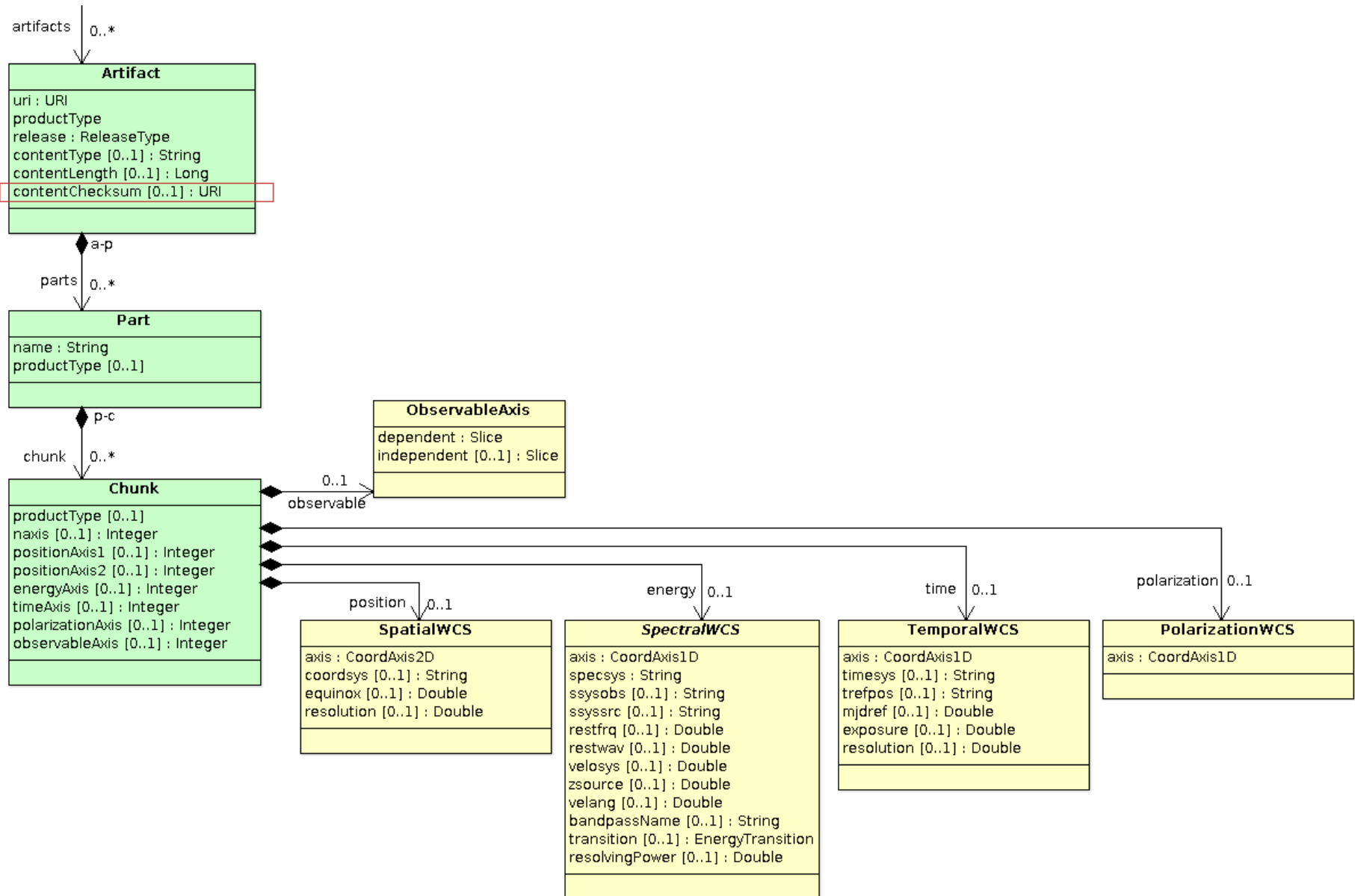
# CAOM – Observation



# CAOM – Plane



# CAOM – Artifact, Part, Chunk



# CAOM – Access to Instances

