



*International  
Virtual  
Observatory  
Alliance*

## **Catalogue Data Model**

**Version 0.25**

***IVOA DM WG Draft***

***2005 June***

**This version:**

ThisVersion-YYYYMMDD

**Latest version:**

<http://www.ivoa.net/Documents/latest/latest-version-name>

**Previous version(s):**

**Editors:**

**Pedro Osuna**

**Matteo Guainazzi**

**Author(s):**

Pedro Osuna

Matteo Guainazzi

Jesus Salgado

Brian Thomas

Aurelien Stebe

Jonathan McDowell

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## Abstract

This document describes the first IVOA attempt to homogenise Astronomical Catalogues through the use of a Data Model.

It also describes an elaborated **Source** Data Model, as **sources** are amongst the most common type of objects that astronomical catalogues are likely to collect.

Other future models for particular elements being catalogued shall be created in the future. The current Catalogue Data Model has been made flexible enough to accommodate references to those data models whenever they arise.

This Catalogue Data Model allows also to describe catalogues of arbitrary **QuantityList(s)**, where Quantity Lists are described in ref. 5.

Wherever possible, this Data Model points to other relevant Data Models within the IVOA specifications.

## Status of This Document

*This is an IVOA Working Draft for review by IVOA members and other interested parties. It is a draft document and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use IVOA Working Drafts as reference materials or to cite them as other than “work in progress”.*

## Acknowledgements

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## 1 Introduction

The IVOA proposed the creation of a subgroup of the Data Model group to deal with the definition and modeling of Astronomical Catalogues.

Discussions started on what a Catalogue is, and how it can be modelled. It was decided at the Interop meeting celebrated in Poona (India) in 2004 that we ought to model simple things first, and evolve to complex ones later.

Along these lines, a top level structure for a general catalogue was designed.

It was also agreed that one of the most relevant types of Catalogue is that of Sources, and therefore an effort was started to model astronomical sources. Please go to <http://www.ivoa.net/twiki/bin/view/IVOA/IVAODMCatalogsWP> for more details on the origination of this modeling effort.

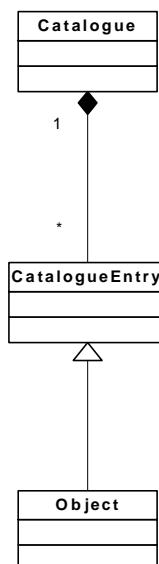
## 2 Catalogue Data Model

### 2.1 Summary

From the "Webster's Revised Unabridged Dictionary (1913)":

"A Catalogue is:[...] *A list or enumeration of names, or articles arranged methodically, often in alphabetical order; as, a catalogue of the students of a college, or of books, or of the stars. [...]*"

From the definition of Catalogue, it looks obvious that a possible Catalogue Data Model could be:



Which would read something like: "A Catalogue is a container that holds one or more entries. Each of these entries has some general attributes, plus others that differentiate them, and which comprise an Object."

The **Object** box could be left without further specification. However, this absence of specification leads to absence of knowledge of what it represents, and means that the user does not have any **a priori** information from the catalogue entries that would allow him/her to make judgements on how to extract the relevant information from those catalogues.

A specific case of an **Object** would be that of an astronomical **Source**. Leaving the Object box (in this case, Source) just as a collection of items would not be very helpful. A user (whether human or machine) would have to know a priori

which attributes define that Source object, so that he/she can compare with other catalogues. That constitutes the reason why Data Models are necessary to provide the a-priori knowledge need to deal with data.

The idea of the present document is, therefore, two-fold:

- The first part of the document will define the model for the general “container” (the Catalogue) i.e., will describe the Catalogue Data Model. This one will be an extremely simple model, as will only describe the top level structure of what a Catalogue is made of.
- The second part of the document will give a detailed description of the attributes that make up the one of the most relevant astronomical objects that can be catalogued: the so called astronomical Source. This second part of the document will, therefore, describe the Source Data Model.

At the end of this document, we expect to be able to describe in Conceptual Data Model terms “a Catalogue that contains a list of astronomical Sources”.

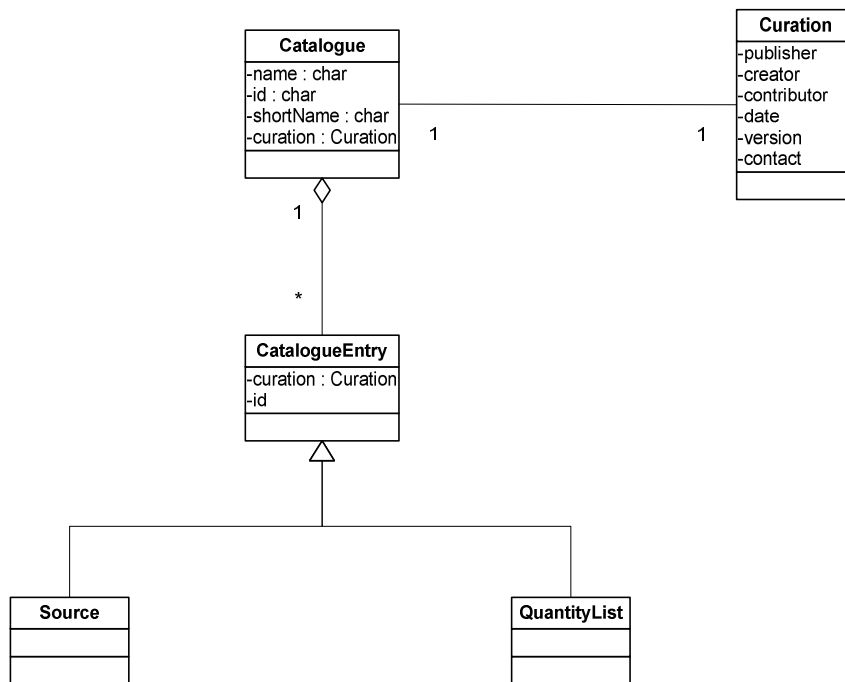
This will allow users (either human or machines) to have a priori knowledge enough as to perform the following hypothetical VOQL-like query: (written in non-standard pseudo-code):

```
Select * from Catalogue_A where Catalogue_A.id="1XMM" and  
Catalogue_A.Source.snr > 20 and Catalogue_A.Source.detectionProbability >  
0.9 and Catalogue_A.Source.Coordinates.AstroCoords.Position between  
circle(20,30,10) and Catalogue_A.Source.sed.counts > 1000 and  
Catalogue_A.Source.observation.integrationTime > 1000
```

The a priori knowledge of the structure of the contents of the catalogue will allow users to make comparisons between different catalogues without having to know the inner structure (and different column names, etc) of the different catalogues. The only structure one needs to know is the Catalogue Data Model structure and –in the aforementioned example- the Source Data Model structure.

## 2.2 Catalogue Data Model UML diagram

A simple UML diagram for the top level model of the Catalogue follows. The details of each of the specific objects can be found below in the XML schema definitions and diagrams.



## ***2.3 Catalogue Data Model Objects description***

We give here the description of the elements of the above diagram which are not pointers to already existing elements in other IVOA Data Models. Please check the references for the description of those.

### **2.3.1 Catalogue.name**

The Catalogue name

### **2.3.2 Catalogue.id**

An identifier for the Catalogue (rules to govern this identifier still TBD)

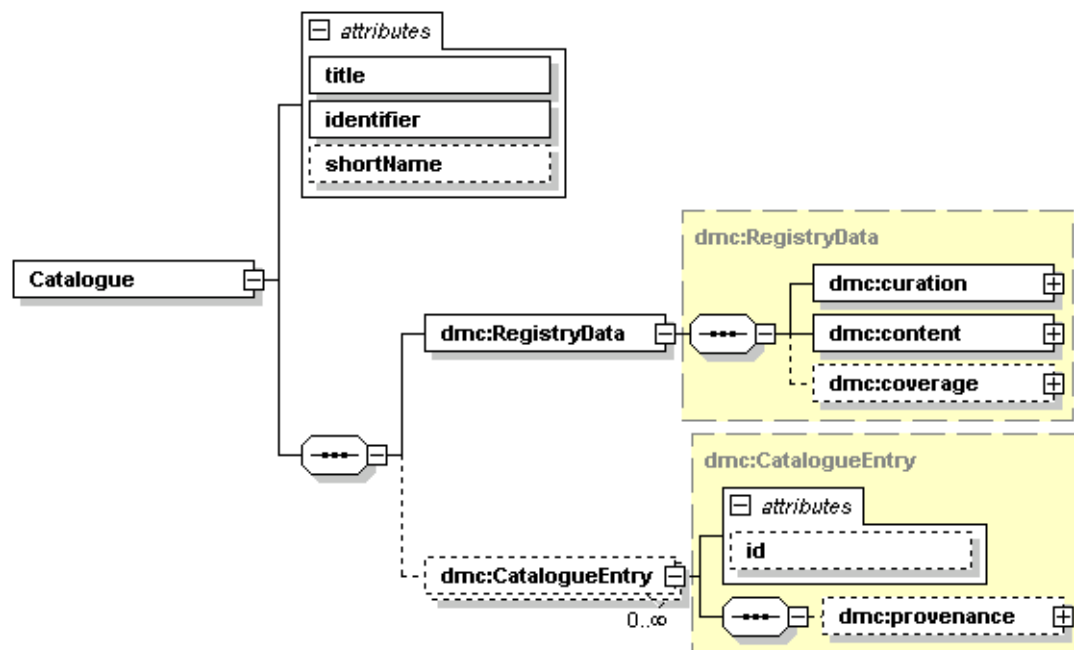
### **2.3.3 Catalogue.shortName**

A short name for the catalogue

### **2.3.4 Catalogue.curation**

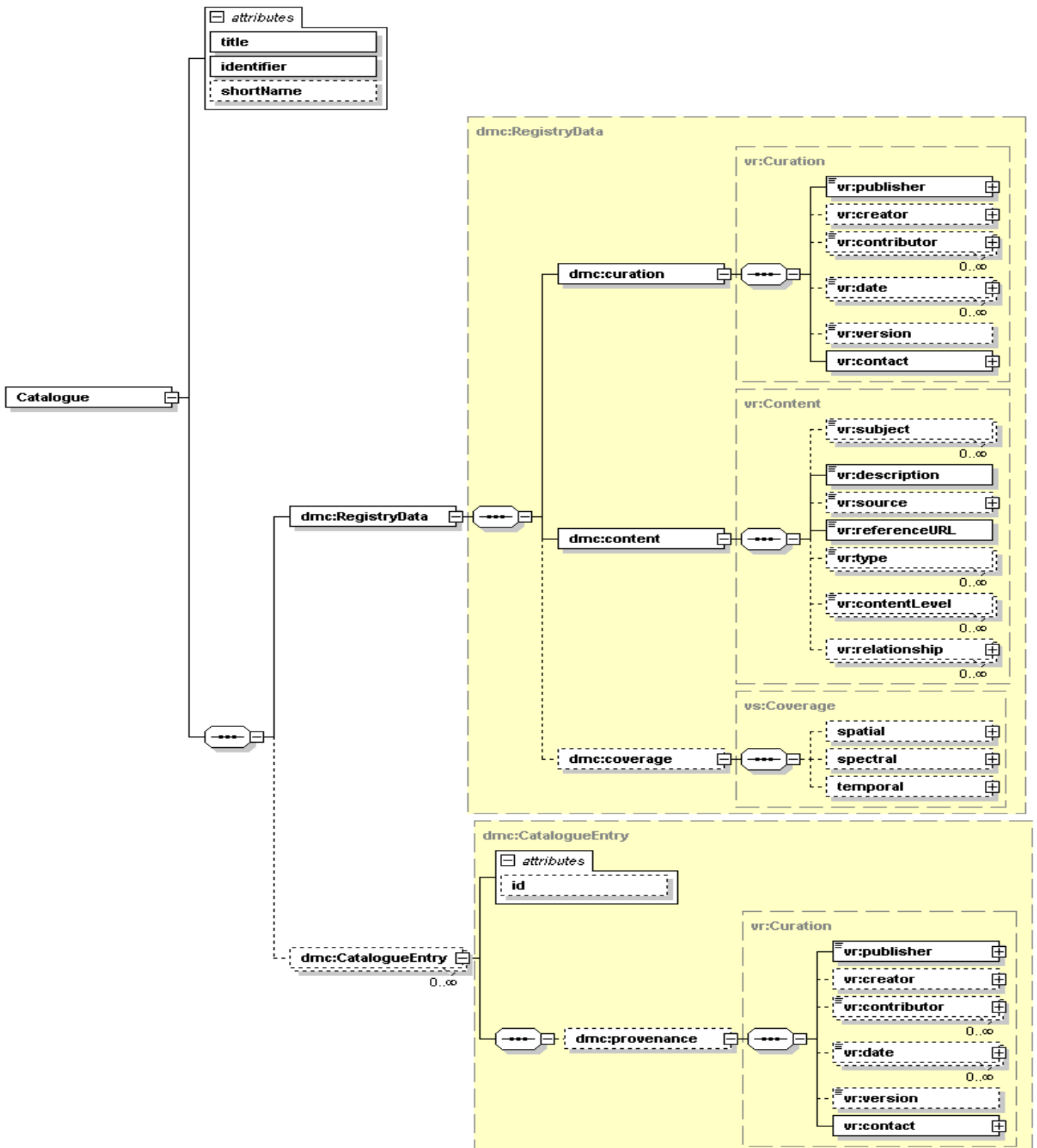
See the Resource Registry specification for the Curation metadata definitions.

## 2.4 Catalogue Data Model XML Schema Serialization



Generated with XMLSpy Schema Editor [www.altova.com](http://www.altova.com)





## 3 Source Data Model

### 3.1 Introduction

Although the Catalogue Data Model is quite general and flexible, and allows for any type of objects to be “catalogued”, one of the most interesting types of catalogues for the Virtual Observatory are the **Catalogues of Astronomical Objects**.

The most basic of all those objects is an **Astronomical Source**. We present in what follows a proposed Data Model for those Sources, in what we call the **Source Data Model**.

In order to clarify what we mean by a Source (as many different interpretations could arise) we give the following definitions:

*“A Source is a statistically significant radiation excess above the background fluctuations in a given sky position”.*

From the definition, and the different astronomical objects we can find in the sky, we could say that a source can correspond to one or more of the following main three types:

- An individual physical celestial object (e.g., a star, a quasar, a galaxy, ...)
- An intrinsically extended celestial structure (e.g., diffuse X-Ray emitting gas in a galaxy cluster, Supernova Remnant, HII region, Planetary Nebula...)
- An unresolved collection of individual celestial objects (galaxy, multiple star system, cluster of galaxies, ...)

It looks obvious from the above definitions that the same object in the sky might appear with different classifications depending on the wavelength under study, the resolution of the instrument and many other factors.

The current Source Data Model will describe the general properties of a Source as defined above, while the specific correspondence with any of the three types above will be relegated to the “**type**” attribute of a Source, which will eventually be pointing to external –and concrete- data models.

### 3.2 Summary of the model

Three elements of this model are described in this document:

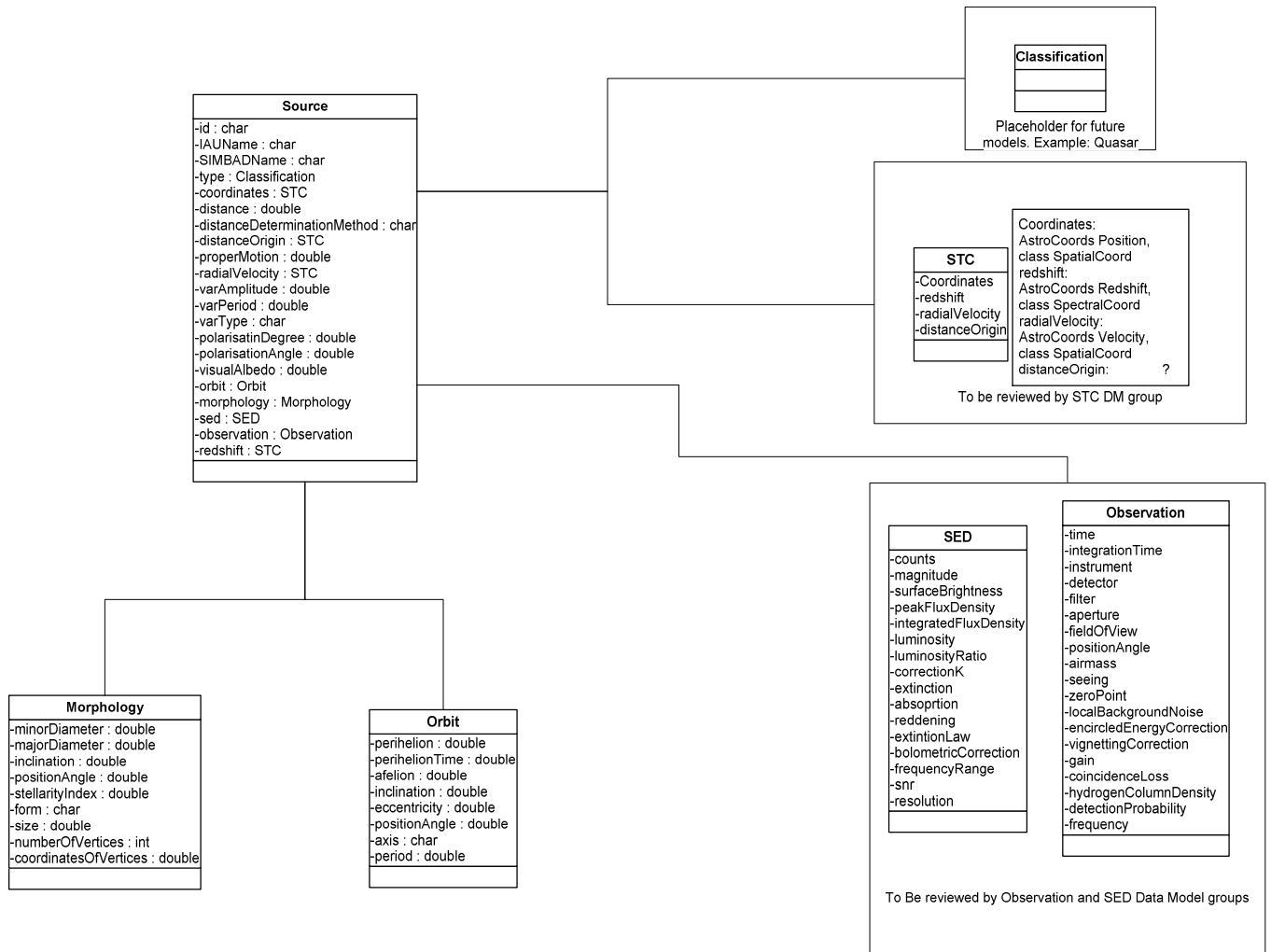
- `Source`, which describes general (mainly physical) properties associated to the source measurements in a given observation, which are not covered by other models, such as names, variability, polarization
- `Morphology`, i.e. the observational properties describing the appearance of extended or complex sources on the sky, whenever relevant
- `Orbit`, i.e. the observational properties describing the source orbit, whenever relevant

Other elements represent links to other models:

- `STC`, i.e. the source Space-Time coordinates
- `SED`, i.e. the counts/magnitude/flux density for a given wavelength, and their derived quantities (luminosities, reddening, bolometric corrections etc.)
- `Observation`, i.e. quantities describing the observational configuration

The element `Classification` is intended to describe definitions and properties pertinent to a specific class of objects (AGN, cluster of galaxies, stars etc.). As such, it can be linked from the main Source Data Model from the attribute `Source.type`, or directly accessed in the framework of the Catalogue Data Model as an independent model (see Sect.2)

### 3.3 Source Data Model UML diagram



### 3.4 Source Data Model objects description

#### 3.4.1 Source

##### 3.4.1.1 Source.id

Name of the source

#### **3.4.1.2 Source.IAUName**

IAU name of the source

#### **3.4.1.3 Source.SIMBADName**

SIMBAD name of the identified counterpart

#### **3.4.1.4 Source.type**

Source classification. It may reflect a standard object classification as in, e.g., <http://simbad.u-strasbg.fr/guide/chF.htm>

#### **3.4.1.5 Source.coordinates**

The sky coordinates of the source

#### **3.4.1.6 Source.distance**

Distance of the source from "distanceOrigin". The cosmological redshift is a possible instantiation of this attribute

#### **3.4.1.7 Source.distanceDeterminationMethod**

Method employed to determine "distance". "Spectra", "Photometric", "Parallax" are possible values of this attribute

#### **3.4.1.8 Source.distanceOrigin**

Origin from which "distance" is being measured

#### **3.4.1.9 Source.properMotion**

The source proper motion on the sky vault

#### **3.4.1.10 Source.radialVelocity**

The radial component of the source velocity

#### **3.4.1.11 Source.varAmplitude**

The amplitude of "varType". It can be expressed either in physical absolute, r.m.s., or in fractional units

#### **3.4.1.12 Source.varPeriod**

The type of source variability: "Periodic", "Quasi-periodic", "Burst of Type I", "Aperiodic" are possible values of this attribute

#### **3.4.1.13 Source.polarisationDegree**

Degree of source polarization

#### **3.4.1.14 Source.polarisationAngle**

Positional angle of the source polarization

#### **3.4.1.15 Source.visualAlbedo**

Source visual albedo

### **3.4.2 Morphology**

#### **3.4.2.1 Morphology.minorDiameter**

Size of the minor diameter of the source

#### **3.4.2.2 Morphology.majorDiameter**

Size of the major diameter of the source

#### **3.4.2.3 Morphology.inclination**

Angle between the line-of-sight to the source and the normal of the main source symmetry plane

#### **3.4.2.4 Morphology.positionAngle**

Apparent position angle of the source on the sky vault

#### **3.4.2.5 Morphology.stellarityIndex**

Parameter ranging from 0 (galaxy) to 1 (star), related to the probability that a given object is extended or point-like

#### **3.4.2.6 Morphology.form**

String describing the geometrical shape and/or symmetry of the source. "Boxy", "Patchy", "Ring", are possible values for this attribute

#### **3.4.2.7 Morphology.numberOfVertices**

The number of vertices, which allow describing the shape of a complex extended structure (such as molecular clouds, supernovae remnants of radio galaxies)

#### **3.4.2.8 Morphology.coordinatesOfVertices**

Coordinates of the vertices describing the shape of complex extended astronomical objects. It is a vector with `numberOfVertices` pairs

### **3.4.3 Orbit**

#### **3.4.3.1 Orbit.perihelion**

Minimum distance from a reference point along the orbit

#### **3.4.3.2 Orbit.perihelionTime**

Time of the source passing through the orbit perihelion

#### **3.4.3.3 Orbit.aphelion**

Maximum distance from a reference point along the orbit

#### **3.4.3.4 Orbit.inclination**

Angle between the line-of-sight to the source and the normal to the plane containing the orbit

#### **3.4.3.5 Orbit.eccentricity**

Fraction of the distance along the semi-major axis at which the focus lies ( $e=c/a$ , where  $c$  is the distance from the center of the conic section to the focus and  $a$  is the semi-major axis)

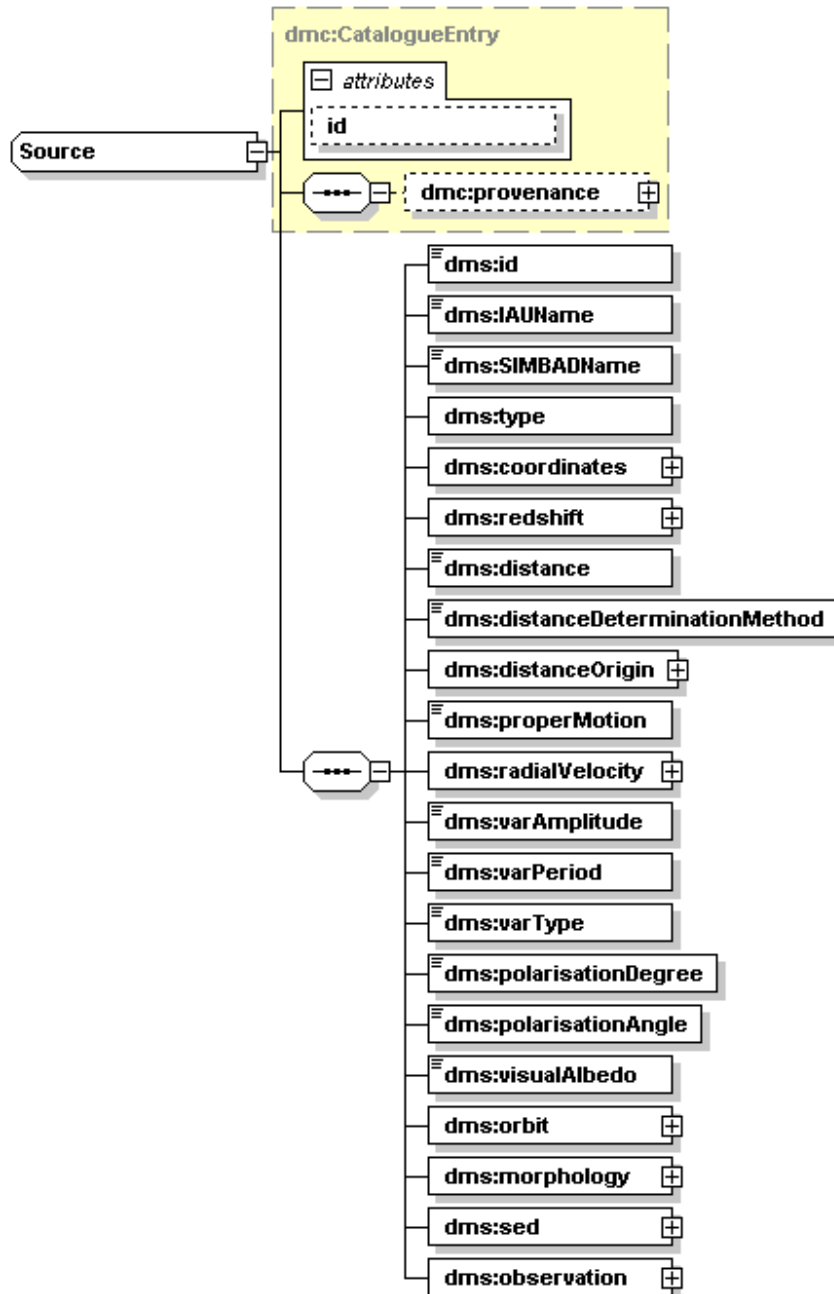
#### **3.4.3.6 Orbit.positionAngle**

Apparent position angle of the orbit on the sky vault

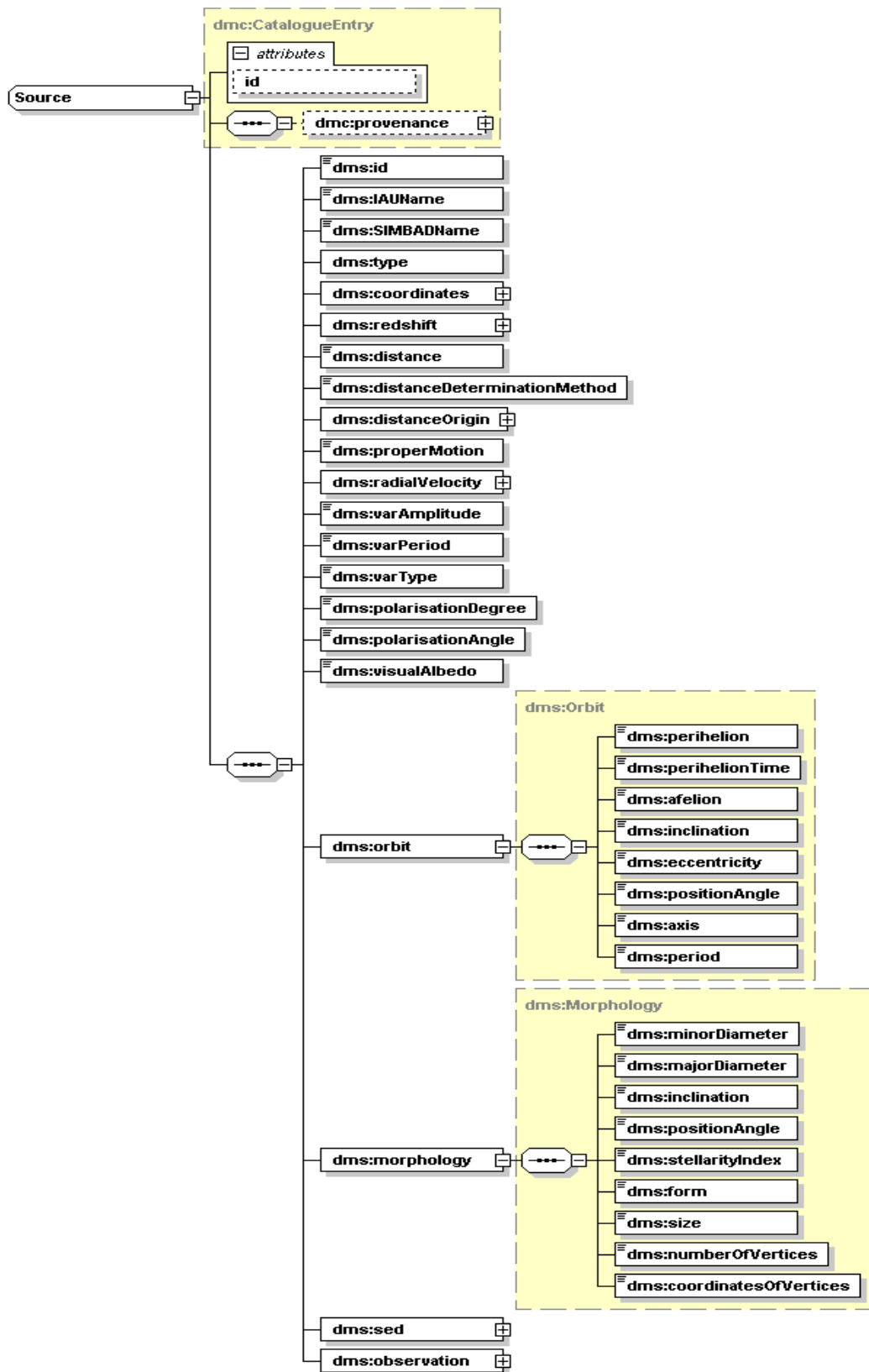
#### **3.4.3.7 Orbit.period**

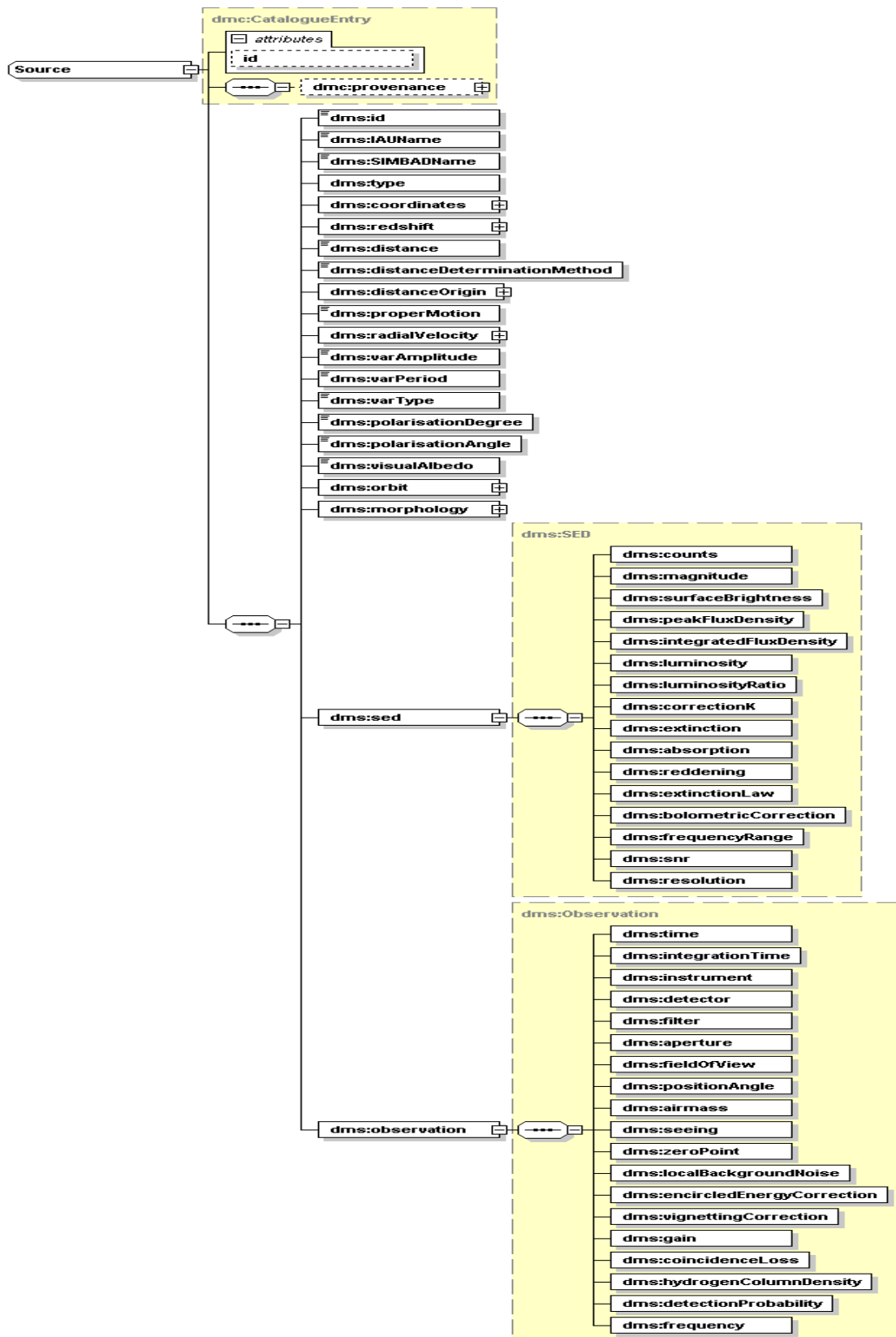
Orbital period

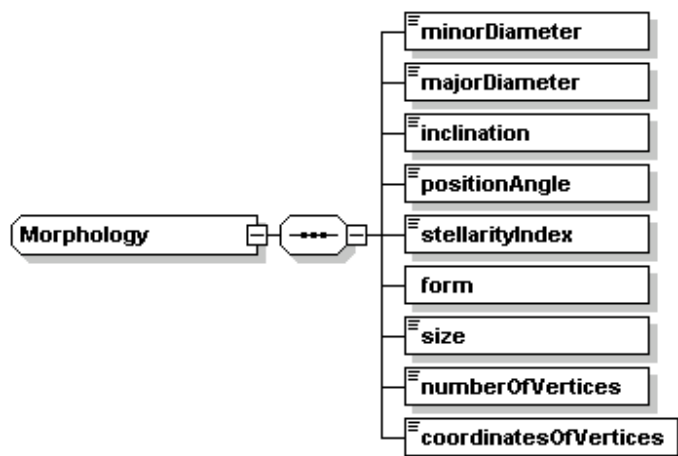
### 3.5 Source Data Model XML Schema serialization



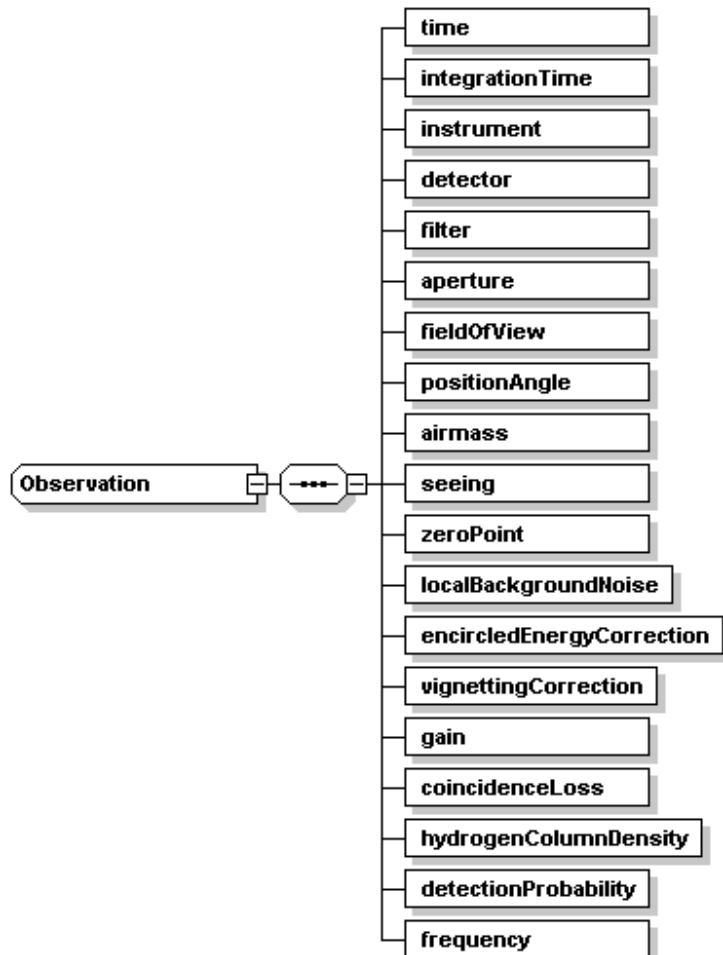




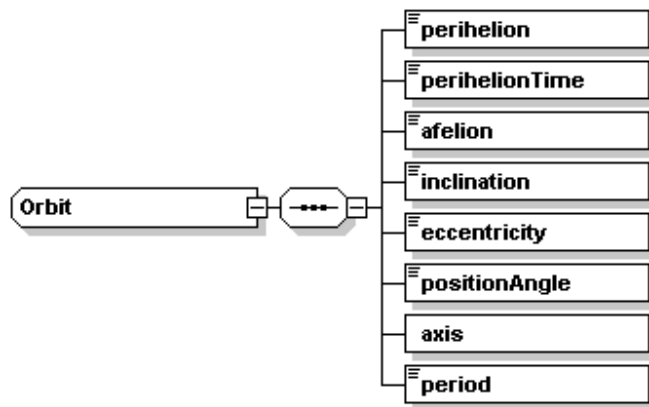




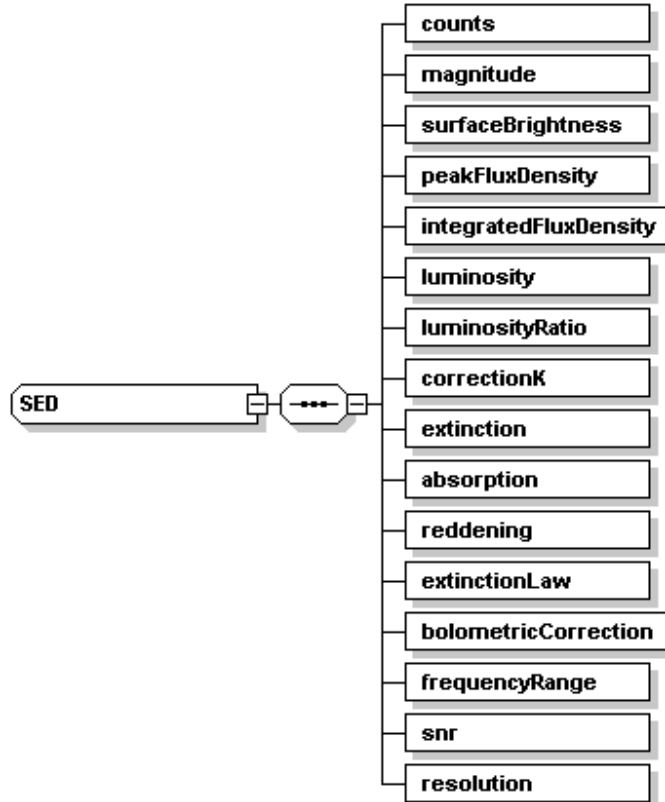
Generated with XMLSpy Schema Editor [www.altova.com](http://www.altova.com)



Generated with XMLSpy Schema Editor [www.altova.com](http://www.altova.com)



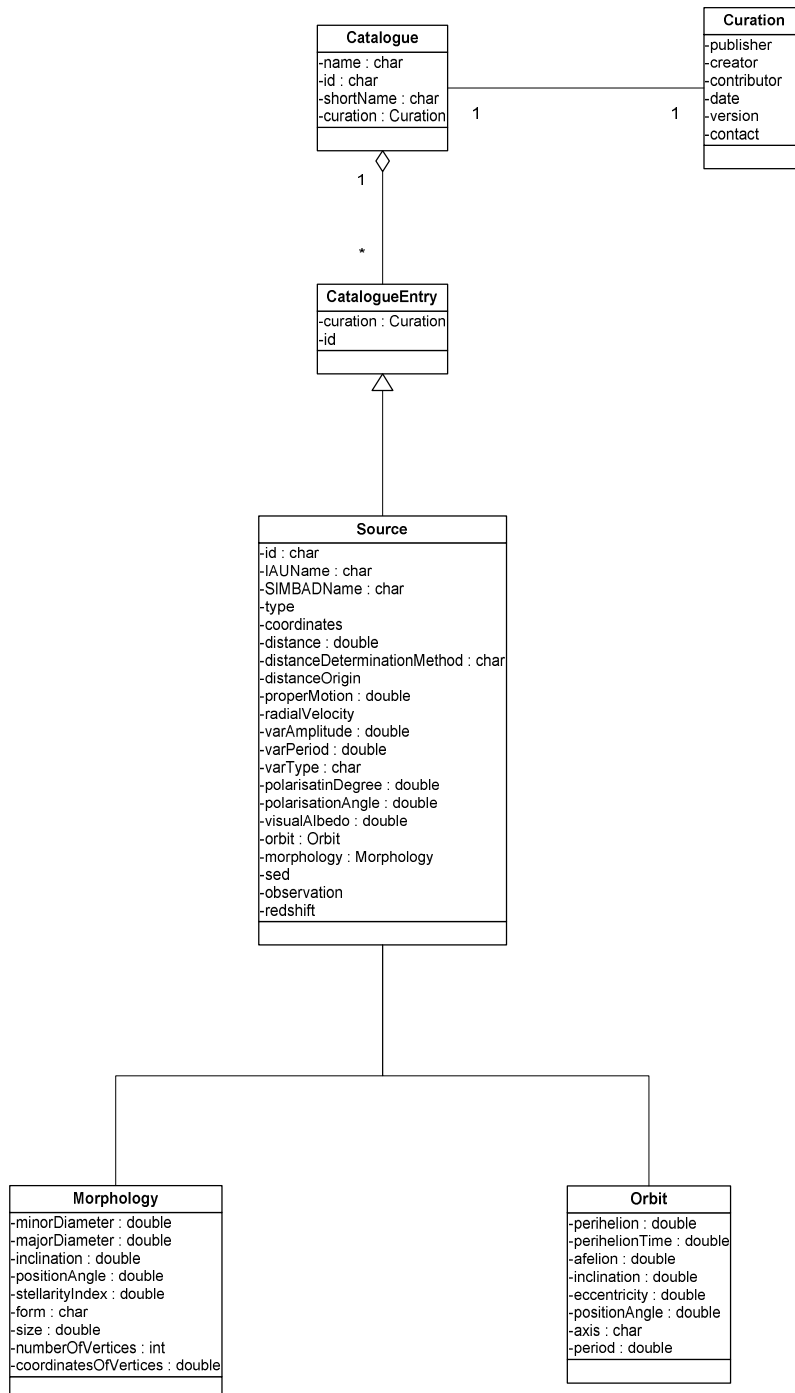
Generated with XMLSpy Schema Editor [www.altova.com](http://www.altova.com)



Generated with XMLSpy Schema Editor [www.altova.com](http://www.altova.com)

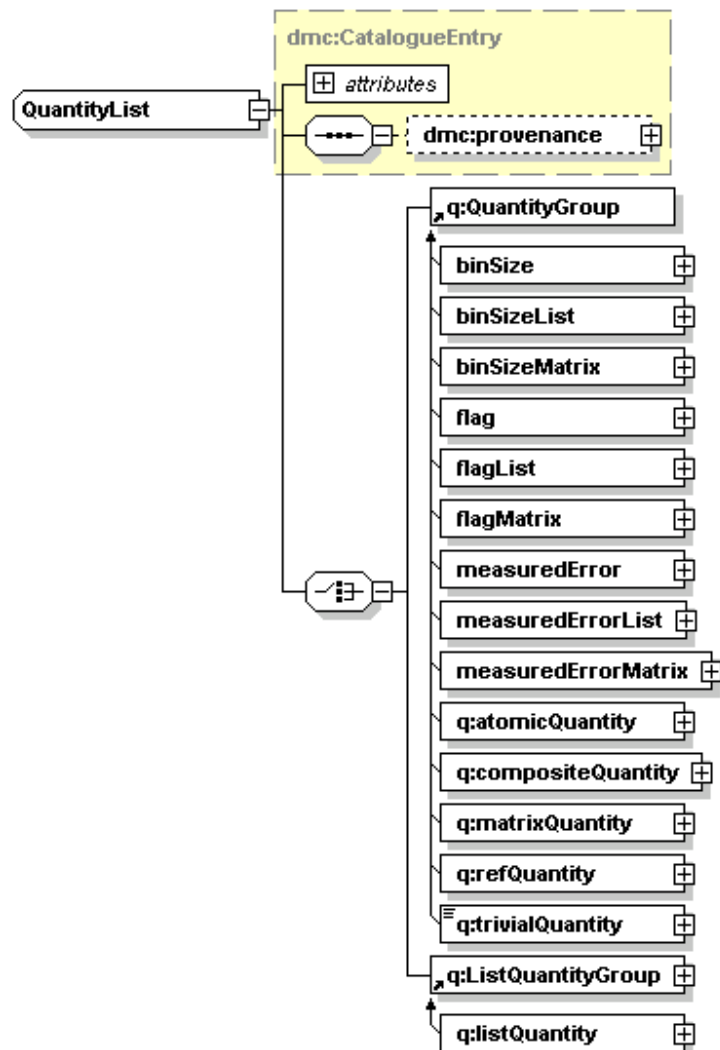
## 4 Catalogue of Sources

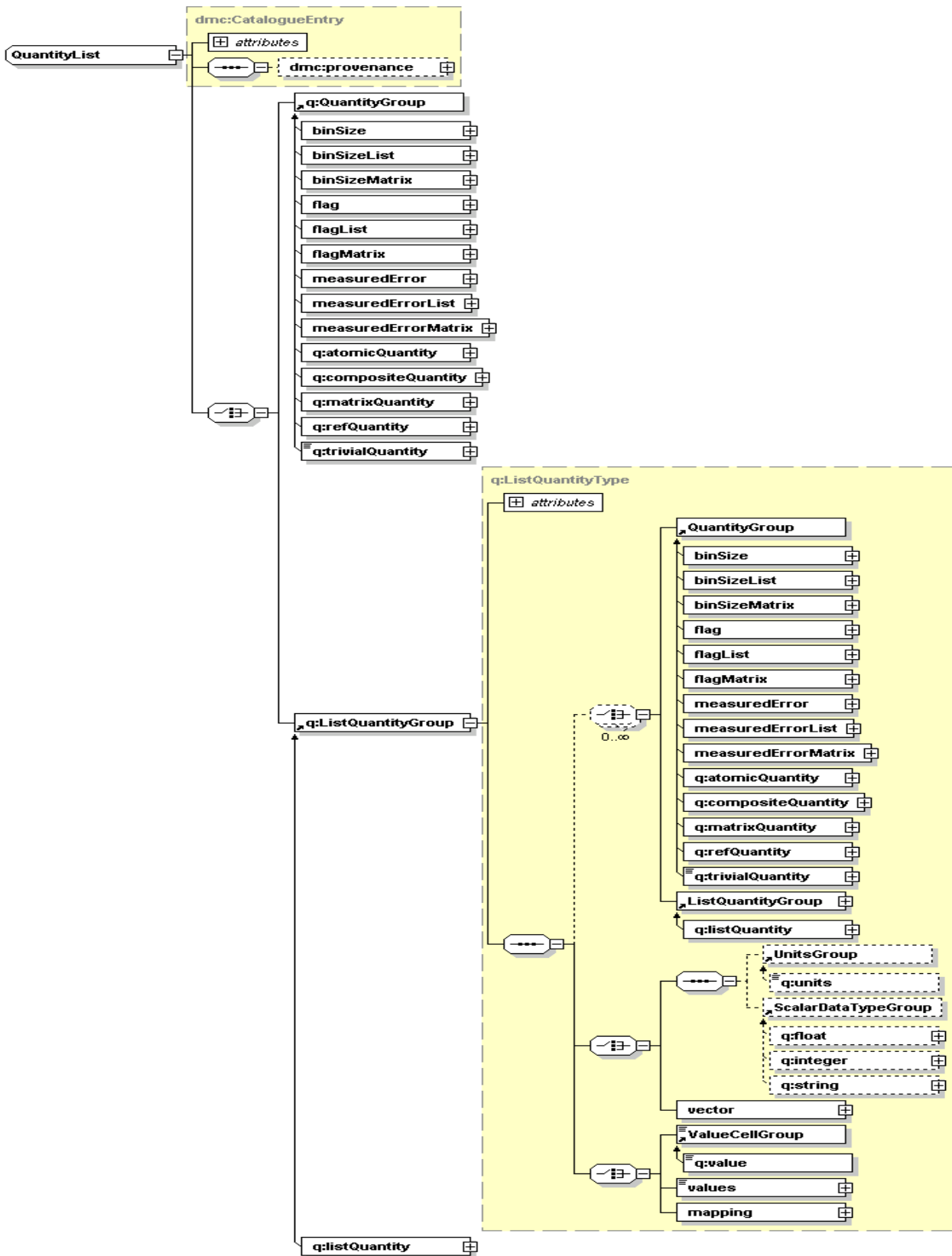
A UML diagram for a Catalogue of Sources combining previous ones follows.

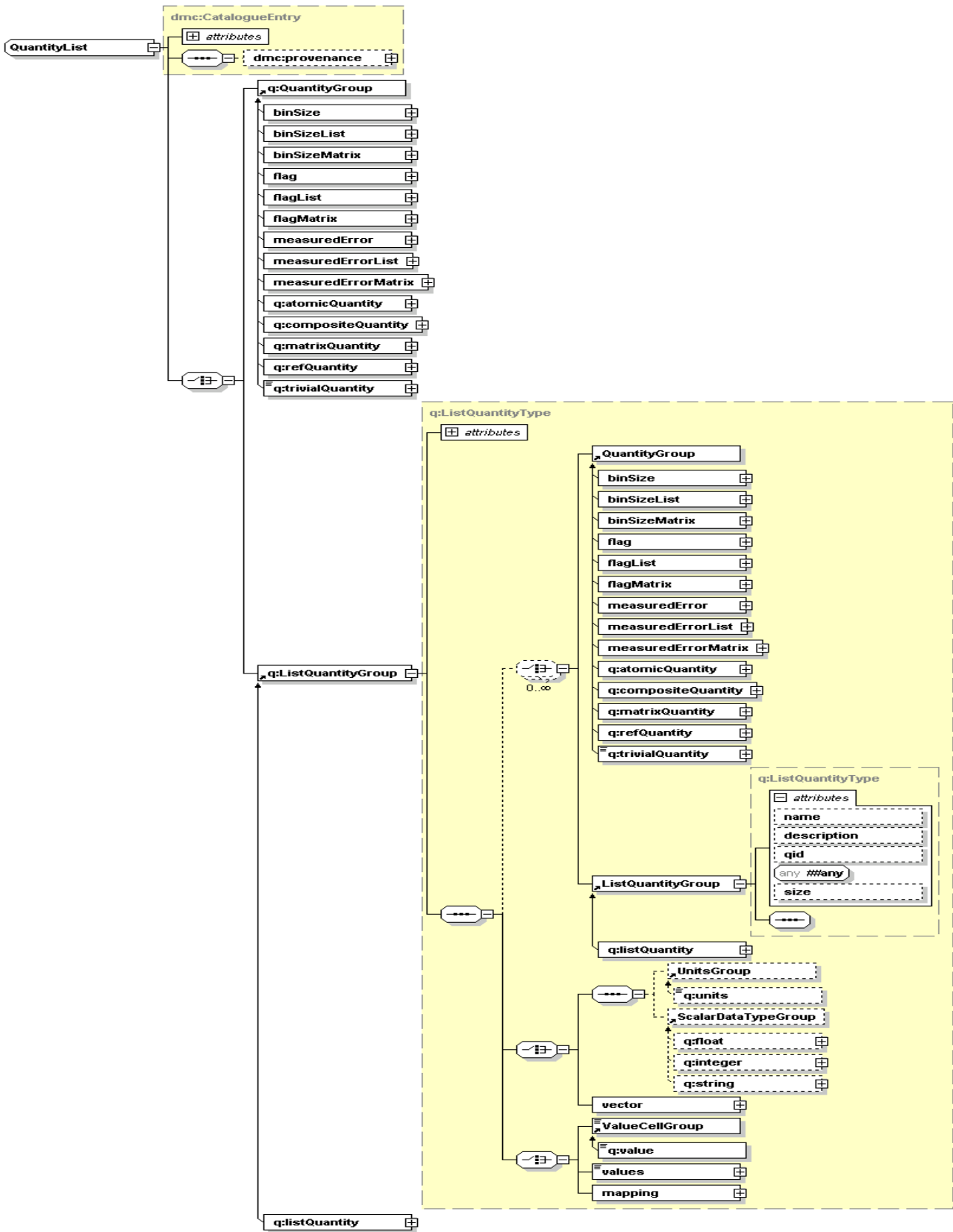


## 5 Catalogue of QuantityList

As already explained in section 2 above, a Catalogue can contain a QuantityList. We give here a brief description of this case. For further details please check ref. [4].









## 6 XML Schemas

### 6.1 Catalogue

```
<?xml version="1.0" encoding="UTF-8" ?>
- <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:dmc="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5"
xmlns:vr="http://www.ivoa.net/xml/VOResource/v0.10" xmlns:vs="http://www.ivoa.net/xml/VODataService/v0.5"
targetNamespace="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5" elementFormDefault="qualified"
attributeFormDefault="unqualified" version="0.5">
  <xs:import namespace="http://www.ivoa.net/xml/VOResource/v0.10" schemaLocation="VOResource-
v0.10.xsd" />
  <xs:import namespace="http://www.ivoa.net/xml/VODataService/v0.5" schemaLocation="VODataService-
v0.5.xsd" />
- <xs:element name="Catalogue">
- <xs:complexType>
- <xs:sequence>
  <xs:element name="RegistryData" type="dmc:RegistryData" />
  <xs:element name="CatalogueEntry" type="dmc:CatalogueEntry" minOccurs="0"
maxOccurs="unbounded" />
</xs:sequence>
  <xs:attribute name="title" type="xs:string" use="required" />
  <xs:attribute name="identifier" type="vr:IdentifierURI" use="required" />
  <xs:attribute name="shortName" type="vr:ShortName" />
</xs:complexType>
</xs:element>
- <xs:complexType name="RegistryData">
- <xs:sequence>
  <xs:element name="curation" type="vr:Curation" />
  <xs:element name="content" type="vr:Content" />
  <xs:element name="coverage" type="vs:Coverage" minOccurs="0" />
</xs:sequence>
</xs:complexType>
- <xs:complexType name="CatalogueEntry" abstract="true">
- <xs:sequence>
  <xs:element name="provenance" type="vr:Curation" minOccurs="0" />
</xs:sequence>
  <xs:attribute name="id" type="xs:int" use="required" />
</xs:complexType>
</xs:schema>
```

### 6.2 Source

```
<?xml version="1.0" encoding="UTF-8" ?>
- <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:dms="http://www.ivoa.net/xml/DM/DMSource/v0.5"
xmlns:dmc="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5"
xmlns:crd="http://www.ivoa.net/xml/STC/STCcoords/v1.20"
targetNamespace="http://www.ivoa.net/xml/DM/DMSource/v0.5"
elementFormDefault="qualified" attributeFormDefault="unqualified" version="0.5">
<xs:import namespace="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5"
schemaLocation="DMCatalogue-v0.5.xsd" />
<xs:import namespace="http://www.ivoa.net/xml/STC/STCcoords/v1.20" schemaLocation="coords-
v1.20.xsd" />
- <xs:complexType name="Source">
- <xs:complexContent>
- <xs:extension base="dmc:CatalogueEntry">
```

```

- <xs:sequence>
  <xs:element name="id" type="xs:string" />
  <xs:element name="IAUName" type="xs:string" />
  <xs:element name="SIMBADName" type="xs:string" />
  <xs:element name="type" />
  <xs:element name="coordinates" type="crd:vector2CoordinateType" />
  <xs:element name="redshift" type="crd:scalarCoordinateType" />
  <xs:element name="distance" type="xs:double" />
  <xs:element name="distanceDeterminationMethod" type="xs:string" />
  <xs:element name="distanceOrigin" type="crd:scalarCoordinateType" />
  <xs:element name="properMotion" type="xs:double" />
  <xs:element name="radialVelocity" type="crd:vector2CoordinateType" />
  <xs:element name="varAmplitude" type="xs:double" />
  <xs:element name="varPeriod" type="xs:double" />
  <xs:element name="varType" type="xs:string" />
  <xs:element name="polarisationDegree" type="xs:double" />
  <xs:element name="polarisationAngle" type="xs:double" />
  <xs:element name="visualAlbedo" type="xs:double" />
  <xs:element name="orbit" type="dms:Orbit" />
  <xs:element name="morphology" type="dms:Morphology" />
  <xs:element name="sed" type="dms:SED" />
  <xs:element name="observation" type="dms:Observation" />
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
- <xs:complexType name="Orbit">
- <xs:sequence>
  <xs:element name="perihelion" type="xs:double" />
  <xs:element name="perihelionTime" type="xs:double" />
  <xs:element name="afelion" type="xs:double" />
  <xs:element name="inclination" type="xs:double" />
  <xs:element name="eccentricity" type="xs:double" />
  <xs:element name="positionAngle" type="xs:double" />
  <xs:element name="axis" type="xs:string" />
  <xs:element name="period" type="xs:double" />
</xs:sequence>
</xs:complexType>
- <xs:complexType name="Morphology">
- <xs:sequence>
  <xs:element name="minorDiameter" type="xs:double" />
  <xs:element name="majorDiameter" type="xs:double" />
  <xs:element name="inclination" type="xs:double" />
  <xs:element name="positionAngle" type="xs:double" />
  <xs:element name="stellarityIndex" type="xs:double" />
  <xs:element name="form" type="xs:string" />
  <xs:element name="size" type="xs:double" />
  <xs:element name="numberOfVertices" type="xs:int" />
  <xs:element name="coordinatesOfVertices" type="xs:double" />
</xs:sequence>
</xs:complexType>
- <xs:complexType name="SED">
- <xs:sequence>
  <xs:element name="counts" />
  <xs:element name="magnitude" />
  <xs:element name="surfaceBrightness" />
  <xs:element name="peakFluxDensity" />
  <xs:element name="integratedFluxDensity" />
  <xs:element name="luminosity" />
  <xs:element name="luminosityRatio" />
  <xs:element name="correctionK" />
  <xs:element name="extinction" />

```

```

<xs:element name="absorption" />
<xs:element name="reddening" />
<xs:element name="extinctionLaw" />
<xs:element name="bolometricCorrection" />
<xs:element name="frequencyRange" />
<xs:element name="snr" />
<xs:element name="resolution" />
  </xs:sequence>
</xs:complexType>
- <xs:complexType name="Observation">
- <xs:sequence>
  <xs:element name="time" />
  <xs:element name="integrationTime" />
  <xs:element name="instrument" />
  <xs:element name="detector" />
  <xs:element name="filter" />
  <xs:element name="aperture" />
  <xs:element name="fieldOfView" />
  <xs:element name="positionAngle" />
  <xs:element name="airmass" />
  <xs:element name="seeing" />
  <xs:element name="zeroPoint" />
  <xs:element name="localBackgroundNoise" />
  <xs:element name="encircledEnergyCorrection" />
  <xs:element name="vignettingCorrection" />
  <xs:element name="gain" />
  <xs:element name="coincidenceLoss" />
  <xs:element name="hydrogenColumnDensity" />
  <xs:element name="detectionProbability" />
  <xs:element name="frequency" />
</xs:sequence>
</xs:complexType>
</xs:schema>

```

### 6.3 QuantityList

(This one only describes an artificial link to the Quantity data model. See ref. [4] for more specific information)

```

<?xml version="1.0" encoding="UTF-8" ?>
- <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:dmq="http://www.ivoa.net/xml/DM/DMQuantity/v0.5"
  xmlns:dmc="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5" xmlns:q="http://www.data-model.net/Quantity"
  targetNamespace="http://www.ivoa.net/xml/DM/DMQuantity/v0.5" elementFormDefault="qualified"
  attributeFormDefault="unqualified" version="0.5">
  <xs:import namespace="http://www.ivoa.net/xml/DM/DMCatalogue/v0.5" schemaLocation="DMCatalogue-
v0.5.xsd" />
  <xs:import namespace="http://www.data-model.net/Quantity" schemaLocation="Quantity/QML_03.xsd" />
- <xs:complexType name="QuantityList">
- <xs:complexContent>
- <xs:extension base="dmc:CatalogueEntry">
- <xs:choice>
  <xs:element ref="q:QuantityGroup" />
  <xs:element ref="q:ListQuantityGroup" />
</xs:choice>
</xs:extension>
</xs:complexContent>
</xs:complexType>
</xs:schema>

```

## 7 References

*(To be updated)*

[1] Catalogue Data Model mailing list

[http://www.ivoa.net/internal/IVOA/IVAODMCatalogsWP/Catalogue\\_DM\\_mails.txt](http://www.ivoa.net/internal/IVOA/IVAODMCatalogsWP/Catalogue_DM_mails.txt)

[2] Catalogue Working group twiki pages

<http://www.ivoa.net/twiki/bin/view/IVOA/IVAODMCatalogsWP>

[3] Poona presentation

[http://www.ivoa.net/internal/IVOA/IVAODMCatalogsWP/Poona\\_2004\\_Catalogue\\_DM.pdf](http://www.ivoa.net/internal/IVOA/IVAODMCatalogsWP/Poona_2004_Catalogue_DM.pdf)

[4] B. Thomas, E. Shaya: *Brian to give reference*

[5] Reference to STC Specification

[6] Reference to Observation DM

[7] Reference to SED DM