# Interoperable Data Access
# Planetary Science Resource Data Model
# (PSR-DM)

## Version 2.0
### *EPN/JRA4-IDIS/Task 2*

**This version:**

http://voparis-europlanet.obspm.fr/docs/PlanetaryScienceResource-DM-V2.0.pdf

**Latest version:**

http://voparis-europlanet.obspm.fr/docs/PlanetaryScienceResource-DM-latest.pdf

**Previous version(s):**

http://typhon.obspm.fr/idis/data-model.html

**Editors:**

Baptiste Cecconi, Jérôme Berthier

**Authors:**

J. Berthier, B. Cecconi, M. Gangloff, N. Bourrel, P. Le Sidaner, S. Érard, C. Jacquey, E. Pallier, N. André, N. Lormant, F. Topf

## Abstract

This document defines the specifications of the Planetary Science Resource Data Model, designed by EuroPlaNet IDIS (Integrated and Distributed Information Service) to allow the interoperability of planetary data exchange and discovery. It exposes the main concepts of the data model, and it provides guidelines to use it to describe planetary resources, and to define data types into data acces protocols, such as the Planetary Science Table Access Protocol (PSTAP) and the Planetary Data Access Protocol (PDAP and extensions). It aims at providing a useful data model to be used by data providers that wish to publish and share planetary science data into the planetology Virtual Observatory.

# Status of this document

*This document has been produced by the IDIS Data Model Science Working Group for review by EuroPlaNet members and other interested parties. It is a draft document and may be updated, replaced, or obsolete by other documents at any time. It is inappropriate to use this working draft as reference materials or to cite them as other than "work in progress".*

This document defines the core components of the Planetary Science Resource data model, and the metadata to be used to describe planetology resources. It contains also a guide for to user the datamodel within the Planetary Science Table Access Protocol (PSTAP) and Planetary Data Access Protocol (PDAP) frameworks.

# Acknowledgements

This work has been funded by EC (Grant agreement n°228319). This document has been edited by the IDIS Data Model Science Working Group (EPN/JRA4-IDIS/Task 2).

## Conformance-related definitions

The words "MUST", "SHALL", "SHOULD", "MAY", "RECOMMENDED", and "OPTIONAL" (in upper or lower case) used in this document are to be interpreted as described in IETF standard, RFC 2119 [1]. XML document validation is a software process that checks that an XML document is not only well-formed XML but also conforms to the syntax rules defined by the applicable schema. Typically, when the schema is defined by one or more XML Schema documents [2], validation refers to checking for conformance to the syntax described in those Schema documents. This document describes additional syntax constraints that cannot be enforced solely by the rules of XML Schema; thus, in this document, use of the term validation includes the extra checks that go beyond common Schema parsers which ensure conformance with this document.

## Syntax Notation using XML Schema

The eXtensible Markup Language, or XML, is a document syntax for marking textual information with named tags and is defined by the World Wide Web Consortium (W3C) Recommendation, XML 1.0 [3]. The set of XML tag names and the syntax rules for their use is referred to as the document schema. One way to formally define a schema for XML documents is using the W3C standard known as XML Schema [2].

This document defines the Planetary Science Resource schema using XML Schema. All parts of the schema can be downloaded from http://voparis-europlanet.obspm.fr/xml/PSR/.

References to specific elements and types defined in the Planetary Science Resource schema include the use of prefixed namespaces, as in `psr:Resource`. References to specific elements and types defined in the VOResource, VODataService, VOMetadata and IVOA STC include the prefixed namespaces, respectively, `vr`, `vs`, `vm`, and `stc`.

Use of the `psr` prefixes in compliant instance documents is strongly recommended, particularly in the applications that involve Planetary Science Registries. Elsewhere, the use is not required.

# Table of Contents

# List of Acronyms

| | |
|---|---|
| **DAL** | Data Access Layer |
| **DM** | Data Model |
| **PSR-DM** | Planetary Science Resource Data Model |
| **PS-TAP** | Planetary Science Table Access Protocol |
| **IDIS-DM-SWG** | IDIS Data Model Science Working Group |
| **IDIS-DOC** | IDIS Data Organization Convention |
| **IPDA** | International Planetary Data Alliance |
| **IVOA** | International Virtual Observatory Alliance |
| **PDAP** | Planetary Data Access Protocol |
| **PDS** | NASA Planetary Data Science Archive |
| **ObsCore-DM** | Observation Core components Data Model |
| **TAP** | Table Access Protocol |
| **STC** | Space-Time Coordinates |
| **UCD** | Unified Content Descriptor |
| **VO** | Virtual Observatory |

# 1. Introduction

The Planetary Science Resource Data Model (PSR-DM) defines types and elements to be used to define the meta-data of planetary science resources. PSR-DM is designed to allow planetary science data providers to describe their resources into VO registries [14]. For that, PSR-DM is build as an extension of IVOA resource data model to maximize the interoperability between planetary and astronomical sciences.

The Planetary Science Resource Data Model aims to enable the discovery of planetary data sets into the frameworks of data access protocols. The main description criteria are: the target, the data type, and the time and space coverage. Other criteria, such as the calibration level or the measurement type, can be used to filter the answers of planetary data services.

This work rests on collective discussion within EuroPlaNet IDIS Data Model Science Working Group (IDIS-DM-SWG [6]), and is an evolution of version 1.18a of what was called IDIS-DM, published on February 2011 by IDIS.

# 2. Main Concepts

The Planetary Science Resource Data Model is designed to maximize the interoperability between users and resources by providing a reference specification on how to represent a planetary science resource. It is intended that the Planetary Science Resource Data Model is central for describing services that support the planetary science data access layer protocols such as PSTAP and PDAP.

The Planetary Science Resource Data Model is build as an extension of the IVOA VODataService data model, which extends itself the VOResource data model. It makes use of several other IVOA data models, as STC, Utypes, UCDs, and VOUnits. The Planetary Science Resource data model can also make reference to specific data models such as SPASE or IVOA Characterization DM, Spectrum DM and Simple Spectral Line Data Model. As a consequence, the use of PSR-DM is subject to the rules and recommendations for XML [3], XML Schema[2], VODataService [5], VOResource [4], and all used data models.

The Planetary Science Resource Data Model provides a means of encoding planetary science meta-data in XML. It uses XML Schema [2] to define most of the XML syntax rules. The purpose of the data model is to define common XML Schema types that are needed for describing data collections and services that access planetary data.

The Planetary Science Resource Data Model complies to the IDIS Data Organization Convention (IDIS-DOC), published by the IDIS-DM-SWG [6]. This document defines a dataset as a series of homogeneous entities called granules. The granule is defined as the smallest portion of a dataset that is available and that can be accessed through a data service. It defines the data granularity. A granule can be a file, a set of files, a line of a table or even the full dataset. Refer to the IDIS-DOC document for more details.

The Planetary Science Resource Data Model follows the IVOA VOUnits specifications [13] to define the units of metadata. It makes use of the IVOA Space-Time Coordinate (STC) standard schema [12] to register standard coordinate systems, positions, or regions, and of the IVOA Characterisation standard schema [11] to characterize parameters.

# 3. Data Model Building Blocks

Accurate data description is required in order to achieve interoperability in a VO context. A lot of work as been already done in the astronomical context with IVOA. We will use part of these developments and adapt it to the planetary science context.

The main difference with astronomical data lies in the coordinate axes. In astronomy, the main coordinate system used to identify an observation is its location on the celestial sphere. In planetary sciences, the relevant spatial coordinate system depends on the object, and is not only sky projected. Most of the time, the three spatial dimensions and one time dimension are required. This strong difference is a consequence of the ability to resolve the observed planetary systems, as well as the capability to explore them in situ. Temporal and spectral coordinates are also of great importance, as for astronomy. Another difference is the type of measurements that are conducted. Thanks to the planetary exploration probes, it is possible to carry on in situ observations, thus enabling observations of local physical parameters (magnetic field, density, pressure, composition...), contrarily to astronomical observations restricted to photons.

The Planetary Science Resource Data Model is built to describe a resource as dataset and granule. A dataset is a series of data with homogeneous content. This means that all the data records of the dataset must have the same structure. A granule is a group of records in a dataset. The distinction between a dataset and a granule is a question of data granularity, i.e. the size of the data chunks that are made available. It is up to the data provider to choose the granularity of his data. Hence, we can identify two extreme cases: (i) the data provider is distributing the full dataset as a whole; (ii) the data provider is distributing each individual record of his dataset independently. In the first case, the granule (i.e. the minimal portion of data distributed) is the full dataset, while in the second case, each record is a granule. Usually, a granule is a file (or a series of files, like the ‘label’ and ‘data’ files in PDS) containing a series of data grouped over an identified time span.

The Planetary Science Resource Data Model provides an XML encoding standard for describing planetary resource metadata. It is referred to as PSR-DM. It is designed as an extension of the IVOA VODataService data model, and allows to declare a dataset (or granule) as a data collection or a data service. PSR-DM uses the same architecture than the VODataService data model (Title, shortName, Identifier, Curation, Content, Capability, Coverage and TableSet), and extends two types of resources:

- **`psr:DataCollection`**: inheriting directly from `vs:DataCollection`, it declares the existence of a set of data as a collection, what it represents, and how to get it
- **`psr:DataService`**: inheriting directly from `vs:DataService`, it declares the existence of a set of data which can be retrieved through a service.

PSR-DM declares also new types and elements. It extends the `vs:ParamHTTP` element to introduce a `psr:templateQuery` element which allow to describe how to query the service within the interface of the `vs:capability` element. It defines a new metadata element, referred as `psr:Resource` to describe the resource in terms of dataset and/or granule, including the targets concerned by the resource, the instrument used to acquire the data, and the parameter axes which characterize the data.

# 4. Schema Namespaces and Location

The namespace associated with the Planetary Science Resource Data Model is:

http://voparis-europlanet.obspm.fr/xml/PSR/v1.0

The namespace URI can be interpreted as a URL. Resolving it will return the XML Schema document that defines the Planetary Science Resource schema.

Authors of Planetary Science Resource instance documents may choose to provide a location for the appropriate XML Schema document and its extensions, using the `xsi:schemaLocation` attribute. While the choice of the location value is the choice of the author, this specification recommends using the appropriate namespace URI as its location URL.

# 5. The Planetary Science Resource Data Model

The PSR-DM extension defines two types of resources (Fig. 1), which may be used to describe planetary science data into the Planetology Virtual Observatory framework. It inherits directly from VODataService, and extends two types:

- **psr:DataCollection**: Inheriting from `vs:DataCollection`, this resource declares the existence of a collection of data, what it represents, and how to get it.
- **psr:DataService**: Inheriting from `vs:DataService`, this type is for services that access planeteray science data. It adds the ability to describe how to access data using a service.

The metadata includes all the generic metadata necessary to identify and describe the data. Hence, it contains several metadata elements that are directly inherited from the VOResource and VODataService. As defined in the core VOResource metadata, the first metadata are grouped as follows:

- **identity metadata:** the `<title>`, `<shortName>`, and `<identifier>` elements
- **curation metadata**: the `<curation>` element
- **general content metadata**: the `<content>` element
- **capability metadata**: the `<capability>` element
- **coverage metadata**: the `<coverage>` element

The next metadata are two new metadata elements which extend the `vs:DataCollection` and `vs:DataService` types:

- **psr:resource metadata**: the `<dataset>`, and `<granule>` elements
- **psr:tableset metadata**: the `<tableset>`, `<tableschema>`, `<table>`, and `<table-param>` elements

The types and elements inherited from VOResource and VODataService are described in [5]. The new types and elements defined in PSR-DM are described in the following paragraphs and appendix. A complete documentation of the XML data model can be found available in [8].

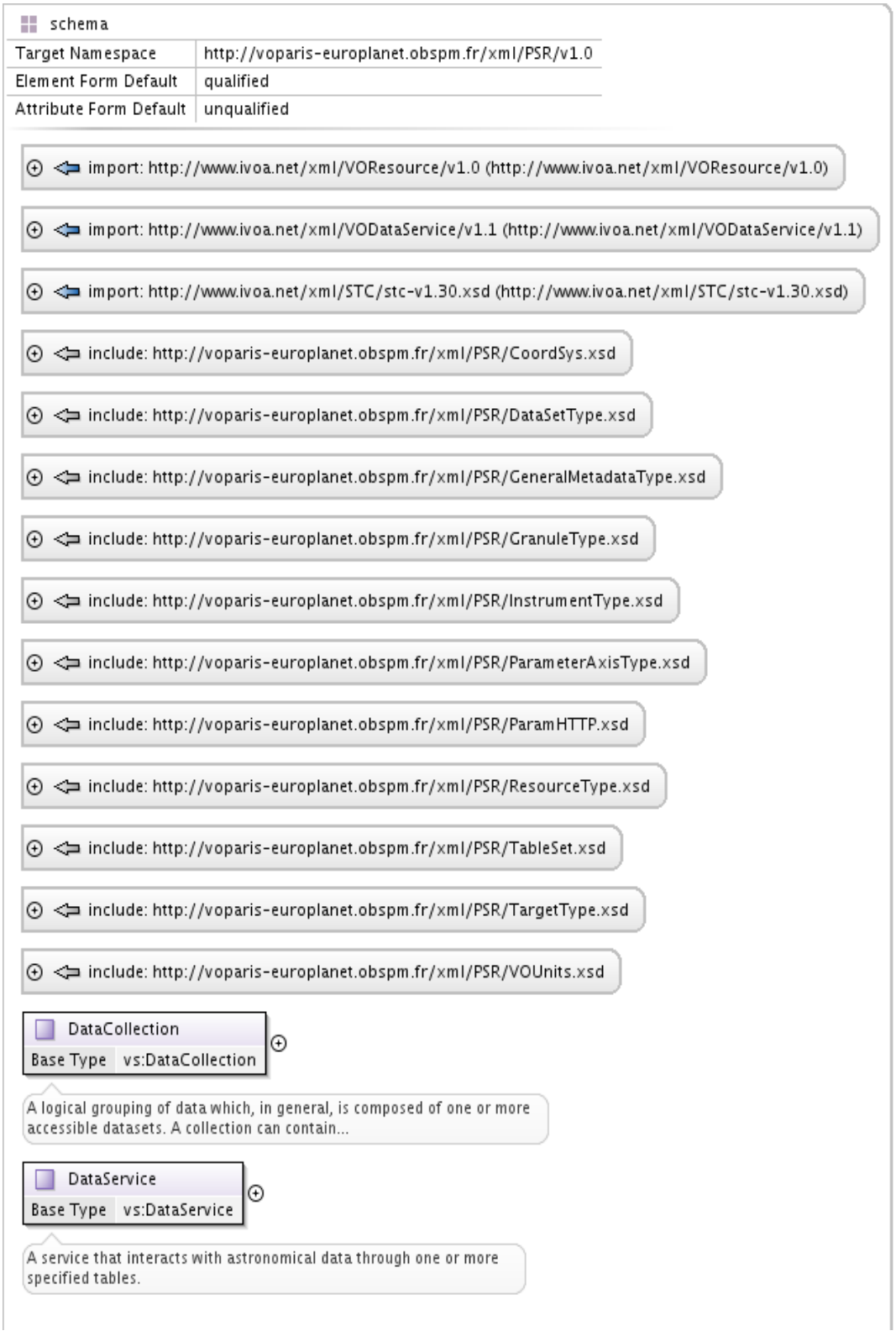


*Fig. 1: Design of the Planetary Science Resource Data Model*

## 5.1. DataCollection metadata elements

As defined by the VODataService DM, a data collection, which is describable with the `psr:DataCollection` resource type, is a logical group of data comprising one or more accessible datasets. The access to the data may be limited to a human-readable web page (given by `content/referenceURL`); however, if the contents of the collection are available statically via a URL (e.g. an FTP URL to a directory containing all the files), that URL can be provided. A collection can contain any combination of images, spectra, catalogs, time-series, or other data. The `psr:DataCollection` type adds one additional metadata element (`psr:resource`) beyond the core of the VODataService metadata. The figure 2 presents the design of the `psr:DataCollection` type, and the following table details the additional metadata.

| **psr:DataCollection Extension Metadata Elements** | | |
|---|---|---|
| **Element** | **Definition** | |
| resource | *Value Type:* | Composite; `psr:ResourceType` |
| | *Semantic Meaning:* | The definition of the resource as a dataset or a granule |
| | *Occurences:* | Single occurrence required |

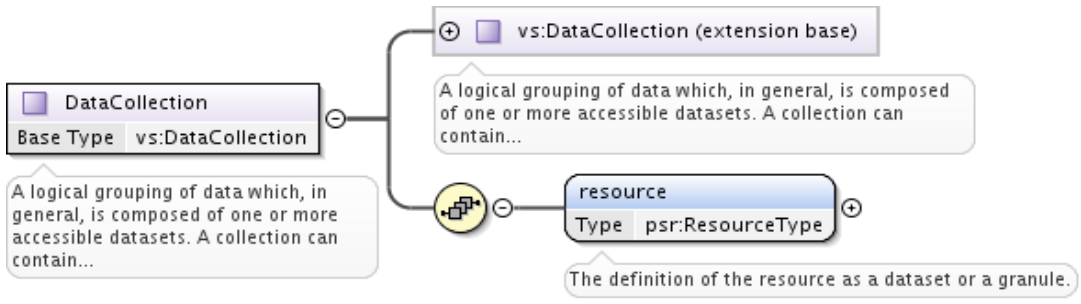


*Fig. 2: Design of the psr:DataCollection metadata element*

The metadata directly inherited from `vs:DataCollection` are described in [5]. The `psr:resource` metadata is described in §

## 5.2. DataService metadata elements

The `psr:DataService` resource type is for describing a resource which provides access to planetology data through a service. It inherits directly from `vs:DataService`, and uses the same architecture as `psr:DataCollection`, to which it adds a `<tableset>` element to describe planetary datasets. The figure 3 presents the design of the `psr:DataService` type, and the following table details the additional metadata.

| psr:DataService Extension Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| resource | *Value Type:* | Composite; `psr:ResourceType` |
| | *Semantic Meaning:* | The definition of the resource as a dataset or a granule |
| | *Occurences:* | Single occurrence required |
| tableset | *Value Type:* | Composite, `psr:TableSet` |
| | *Semantic Meaning:* | A description of the tables that are accessible through the service |
| | *Occurences:* | Single occurrence required |

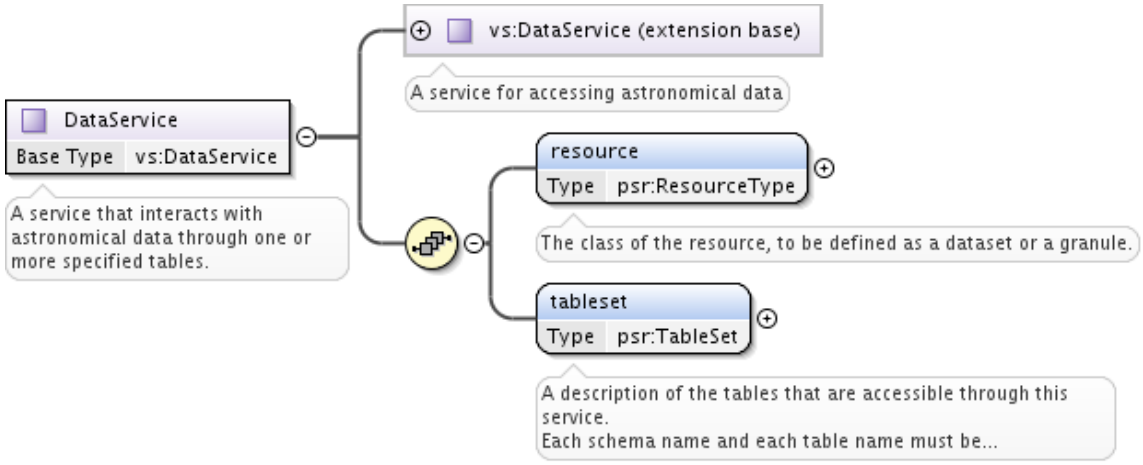


*Fig. 3: Design of the psr:DataService metadata element*

The metadata directly inherited from `vs:DataCollection` are described in [5]. The `psr:resource` and `psr:tableset` metadata are described in § and §

## 5.3. ResourceType metadata elements

The `psr:ResourceType` type provides a means to describe a resource as a dataset or a granule [6]. Both are sharing the same syntax and semantics, except that a dataset may contain one or more granules. Choosing to declare a set of data as a dataset or a granule is subject to discussion, at least from the user point of view. From the resource point of view, it is intended that a granule is composed of a single table or file, and that a dataset is a set of granules.

The design of the `psr:ResourceType` type is depicted in Fig. 4, and the following table declares its elements.

| **psr:ResourceType Metadata Elements** | | |
|---|---|---|
| **Element** | **Definition** | |
| dataset | *Value Type:* | Composite; `psr:DataSetType` |
| | *Semantic Meaning:* | The definition of a dataset |
| | *Occurences:* | Choice with granule; single occurrence allowed |
| granule | *Value Type:* | Composite; `psr:GranuleType` |
| | *Semantic Meaning:* | The definition of a granule |
| | *Occurences:* | Choice with dataset; single occurrence allowed |

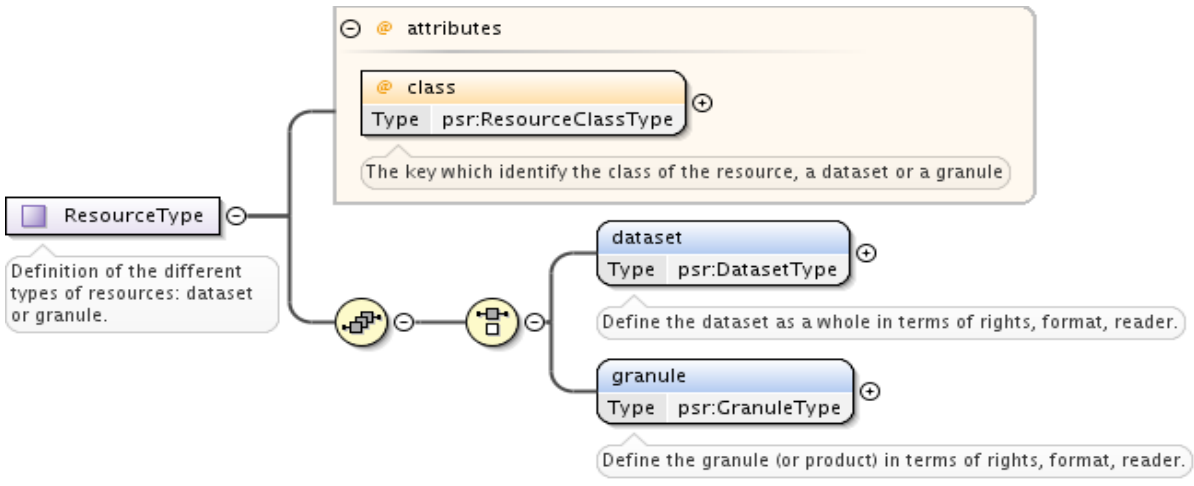


*Fig. 4: Design of the psr:ResourceType type*

The `psr:ResourceType` type provides a key attribute for indicating the class of the resource in the schema.

| psr:ResourceType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| class | *Value Type:* | String; `psr:ResourceClassType` |
| | *Semantic Meaning:* | The class of the resource |
| | *Occurences:* | Required |
| | *Recommended Values:* | *dataset* or *granule* |

## 5.4. TableSet metadata elements

The `psr:TableSet` type is a complex type inherited from `vs:TableSet`. It shares the same syntaxe and semantics, and differs only by the definition of the table parameters (`psr:TableParam`). The full description of the `vs:TableSet` type can be found in [5]. The `psr:TableParam` type is an extension of `vs:TableParam` to add a new metadata element to characterize the axis of parameters.

The design of `psr:TableParam` type is depicted in Fig. 5. It inherits directly from `vs:TableParam`, and adds one new element:

| psr:TableParam Extension Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| parameterAxis | *Value Type:* | Composite; `psr:ParameterAxisType` |
| | *Semantic Meaning:* | Characterization of axis parameters |
| | *Occurences:* | Optional |

The `psr:TableParam` type provides an attribute for tagging parameters with a unique identifier.

| **psr:TableParam Extension Attribute** | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | Token providing a unique identifier to the parameter. It could be a numeric value or a short string |
| | *Occurences:* | Optional |

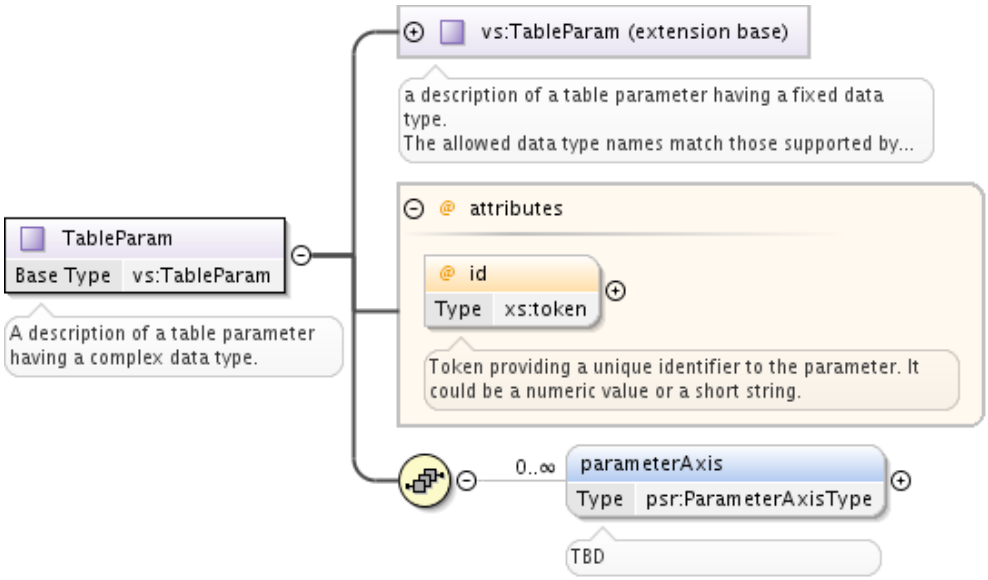


*Fig. 5: Design of the psr:TableParam type*

## 5.5. GranuleType metadata elements

The `psr:GranuleType` type declares a group of records in terms of general information, targets (to which the data correspond) and instrument (used to acquire the data). Parameter axis of the granule can also be defined. The design of this complex type is depicted in Fig. 6, and the following table declares its elements.

| psr:GranuleType Elements | | |
|---|---|---|
| **Attribute** | **Definition** | |
| generalMetadata | *Value Type:* | Composite; `psr:GeneralMetadataType` |
| | *Semantic Meaning:* | General information about the dataset |
| | *Occurences:* | Optional; single occurrence allowed |
| instrument | *Value Type:* | Composite; `psr:InstrumentType` |
| | *Semantic Meaning:* | Definition of the instrument used to acquire the data |
| | *Occurences* | Optional; multiple occurrences allowed |
| targets | *Value Type:* | Composite; `psr:TargetsType` |
| | *Semantic Meaning:* | Defines the targets to which the dataset or the product applies to. Multiple combinations can be defined, mixing class and name elements. |
| | *Occurences* | Optional; single occurrence allowed |
| parameterAxis | *Value Type:* | Composite; `psr:ParameterAxisType` |
| | *Semantic Meaning:* | TBD |
| | *Occurences* | Optional; multiple occurrences allowed |

The `psr:GranuleType` type provides two attributes for tagging the granule with a unique identifier (`id`), and making reference to the relevant table (`table-id`).

| psr:GranuleType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | Token providing a unique identifier to the dataset. It could be a numeric value or a short string |

| psr:GranuleType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| | *Occurences:* | Optional |
| table-id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | Token pointing to a unique identifier of a table in a tableset element. It could be a numeric value or a short string. |
| | *Occurences:* | Optional |

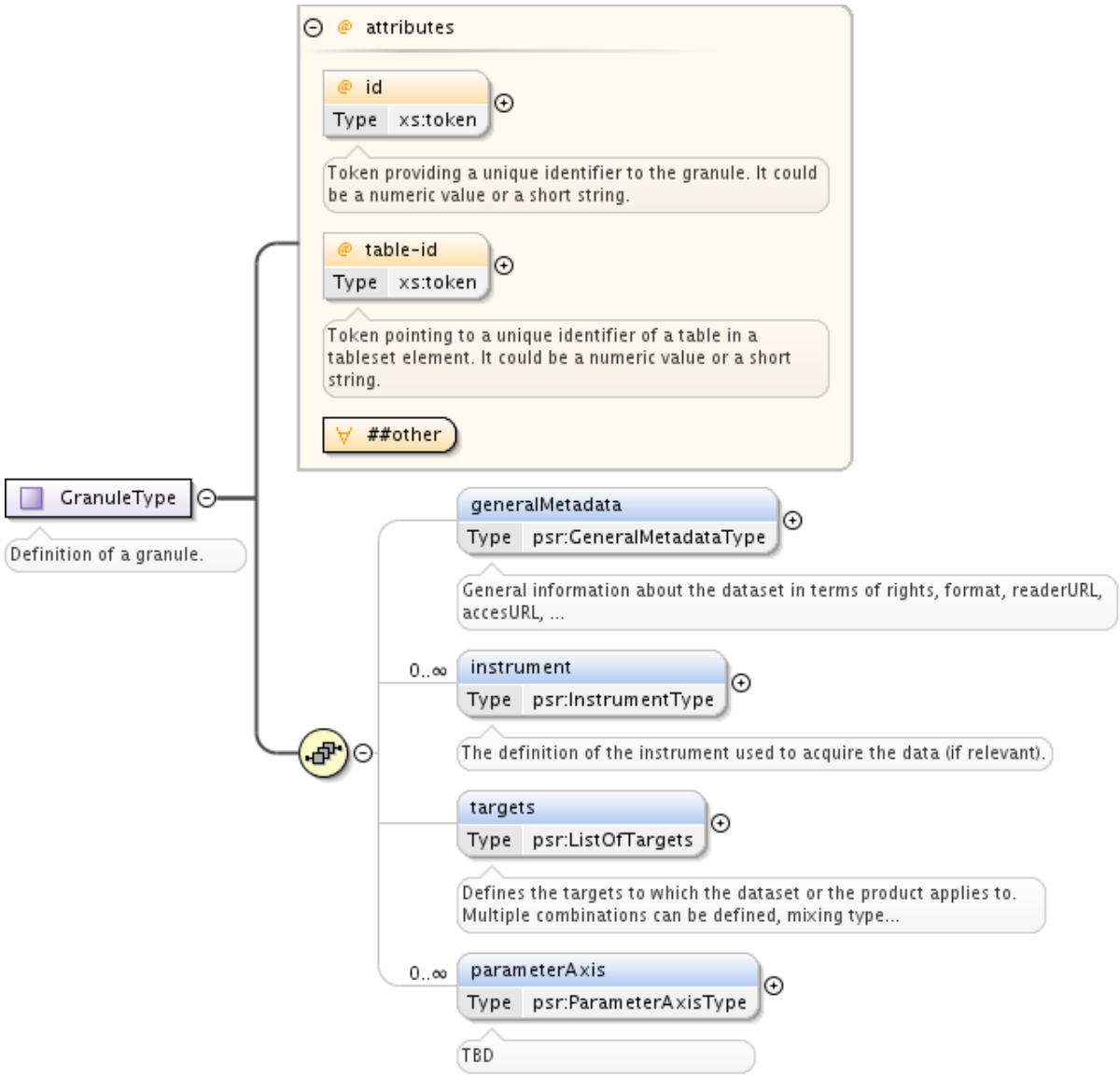


*Fig. 6: Design of the psr:GranuleType type*

## 5.6. DataSetType metadata elements

The `psr:DataSetType` type shares the same syntax and semantic than the `psr:GranuleType` type, and extends it with a granule element. The following part of schema shows an example of dataset (and granule) declaration within a data service to access abundance profiles of Titan's atmosphere acquired by the instrument CIRS onboard Cassini spacecraft.

**psr:DataSet Example: Abundance Vertical Profile at Titan with Cassini/CIRS**

```
<psr:resource class="dataset">
    <psr:dataset id="Cassini/CIRS/AbundanceProfileTitan">
        <psr:generalMetadata>
            <psr:rights>public</psr:rights>
            <psr:format>native</psr:format>
            <psr:readerURL>
    http://cdpp2.cnes.fr/cdpp/data/documents/PLAS-LO-STR_SWAVES-00551-LES/00551.tar
            </psr:readerURL>
        </psr:generalMetadata>
        <psr:targets>
            <psr:target id="606">
                <psr:class>satellite</psr:class>
                <psr:name>Titan</psr:name>
                <psr:alternateName>606</psr:alternateName>
                <psr:description>Saturn satellite</psr:description>
            </psr:target>
            <psr:target id="titan_atm">
                <psr:class>region</psr:class>
                <psr:name>Atmosphere</psr:name>
                <psr:description>Titan's atmosphere</psr:description>
            </psr:target>
        </psr:targets>
        <psr:instrument>
            <psr:facility>Cassini</psr:facility>
            <psr:instrumentName>CIRS</psr:instrumentName>
            <psr:instrumentClass>Imaging Spectrometer</psr:instrumentClass>
            <psr:referenceURL>http://cirs.gsfc.nasa.gov/</psr:referenceURL>
        </psr:instrument>
        <psr:granule id="AbundanceProfile" table-id="AbundanceProfileTitan">
            <psr:generalMetadata>
                <psr:rights>public</psr:rights>
                <psr:format compressed="false">votable</psr:format>
            </psr:generalMetadata>
            <psr:parameterAxis>
                <psr:dataSourceClass>measurement</psr:dataSourceClass>
                <psr:dataProduct>profile</psr:dataProduct>
                <psr:processingLevel>
                  calibrated (fully calibrated data)
                </psr:processingLevel>
            </psr:parameterAxis>
        </psr:granule>
    </psr:dataset>
</psr:resource>
```

One may remark the use of attributes `id` and `table-id` in the granule element, which are used to link, respectively, the granule (`resource/dataset/granule#id`) and the query (`capability/interface/templateQuery#granule-id`) which provide it, and the granule

(`resource/dataset/granule#table-id`) and the table (`tableset/schema/table#id`) which describes the data. In that way, multiple granules can be retrieved by different query interfaces, and can be mapped to different definitions (tables).

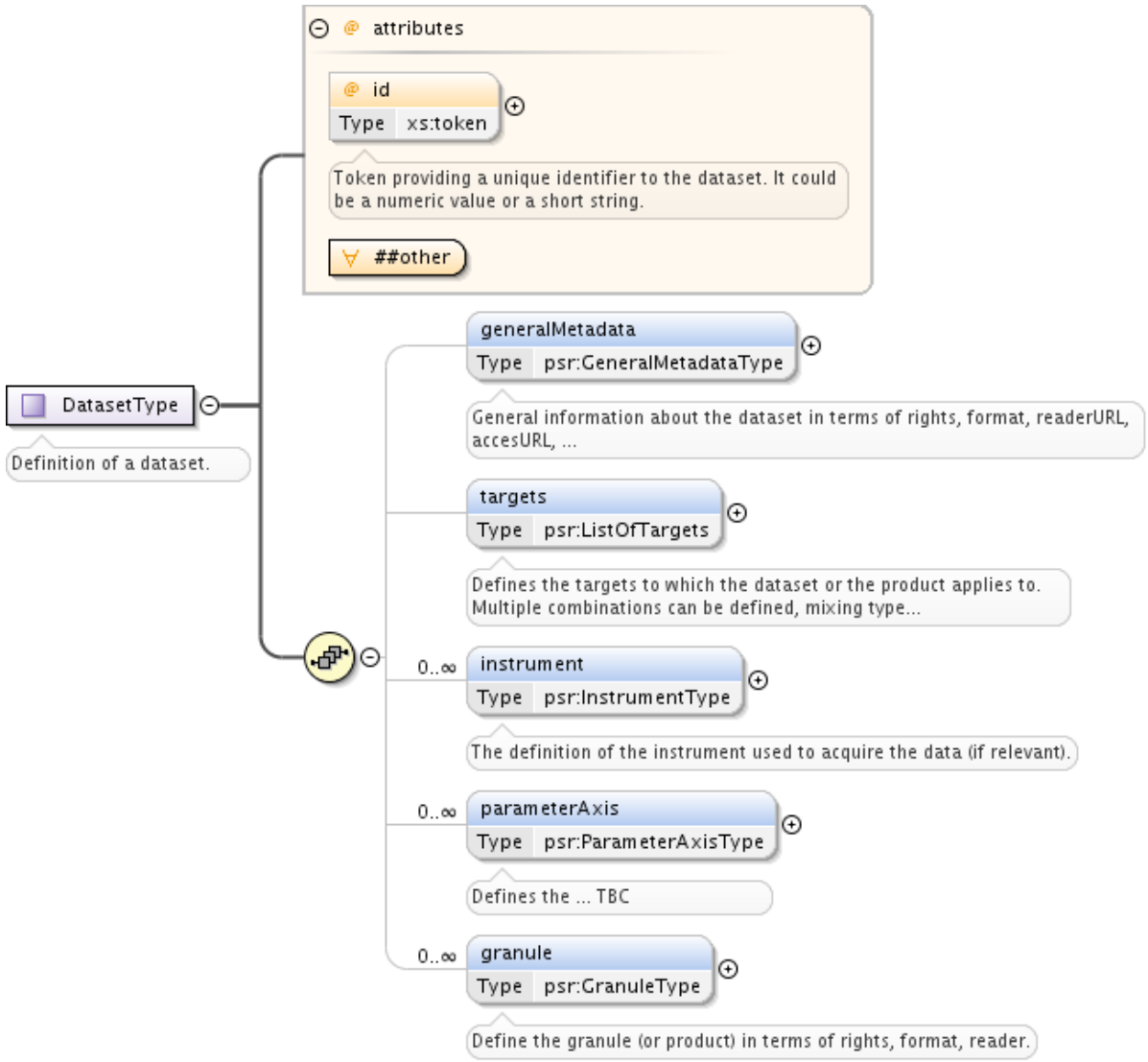


*Fig. 7: Design of the psr:DataSetType type*

The design of `psr:DataSetType` type is depicted in Fig. 7, and the following table declares its extension element (see § for other elements).

| psr:DataSetType Extension Elements | | |
|---|---|---|
| **Attribute** | **Definition** | |
| granule | *Value Type:* | Composite; `psr:GranuleType` |
| | *Semantic Meaning:* | Definition of the granule (or product) |
| | *Occurences* | Optional; multiple occurrences allowed |

The `psr:DataSetType` type provides an attribute for tagging datasets with a unique identifier.

| psr:DataSetType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | Token providing a unique identifier to the dataset. It could be a numeric value or a short string |
| | *Occurences:* | Optional |

## 5.7. GeneralMetadataType metadata elements

The design of `psr:GeneralMetadataType` type is depicted in Fig. 8, and the following table declares its elements.

| psr:GeneralMetadataType Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| rights | *Value Type:* | String; `vr:Rights` |
| | *Semantic Meaning:* | Information about rights held in and over the resource. |
| | *Occurences:* | Optional; multiple occurrences allowed |
| format | *Value Type:* | String; `psr:Format` |
| | *Semantic Meaning:* | Format of the data within the dataset or granule. |

| psr:GeneralMetadataType Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| | *Occurences:* | Optional; single occurrence allowed |
| readerURL | *Value Type:* | String; `xs:anyURI` |
| | *Semantic Meaning:* | URL where to download a reader compliant with the data-set. |
| | *Occurences* | Optional; single occurence allowed |
| accessURL | *Value Type:* | String; `xs:anyURI` |
| | *Semantic Meaning:* | URL where to acces the dataset. |
| | *Occurences* | Optional; single occurence allowed |

The `psr:GeneralMetadataType` type provides an attribute for tagging datasets with a unique identifier.

| psr:GeneralMetadataType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| created | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | The UTC date and time this resource metadata description was created. |
| | *Occurences:* | Optional |
| updated | *Value Type:* | Datetime; `xs:DateTime` |
| | *Semantic Meaning:* | The UTC date this resource metadata description was last updated. |
| | *Occurences:* | Optional |
| status | *Value Type:* | Datetime; `xs:DateTime` |
| | *Semantic Meaning:* | A tag indicating whether this resource is believed to be still actively maintained. |

| psr:GeneralMetadataType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| | *Occurences:* | Optional |

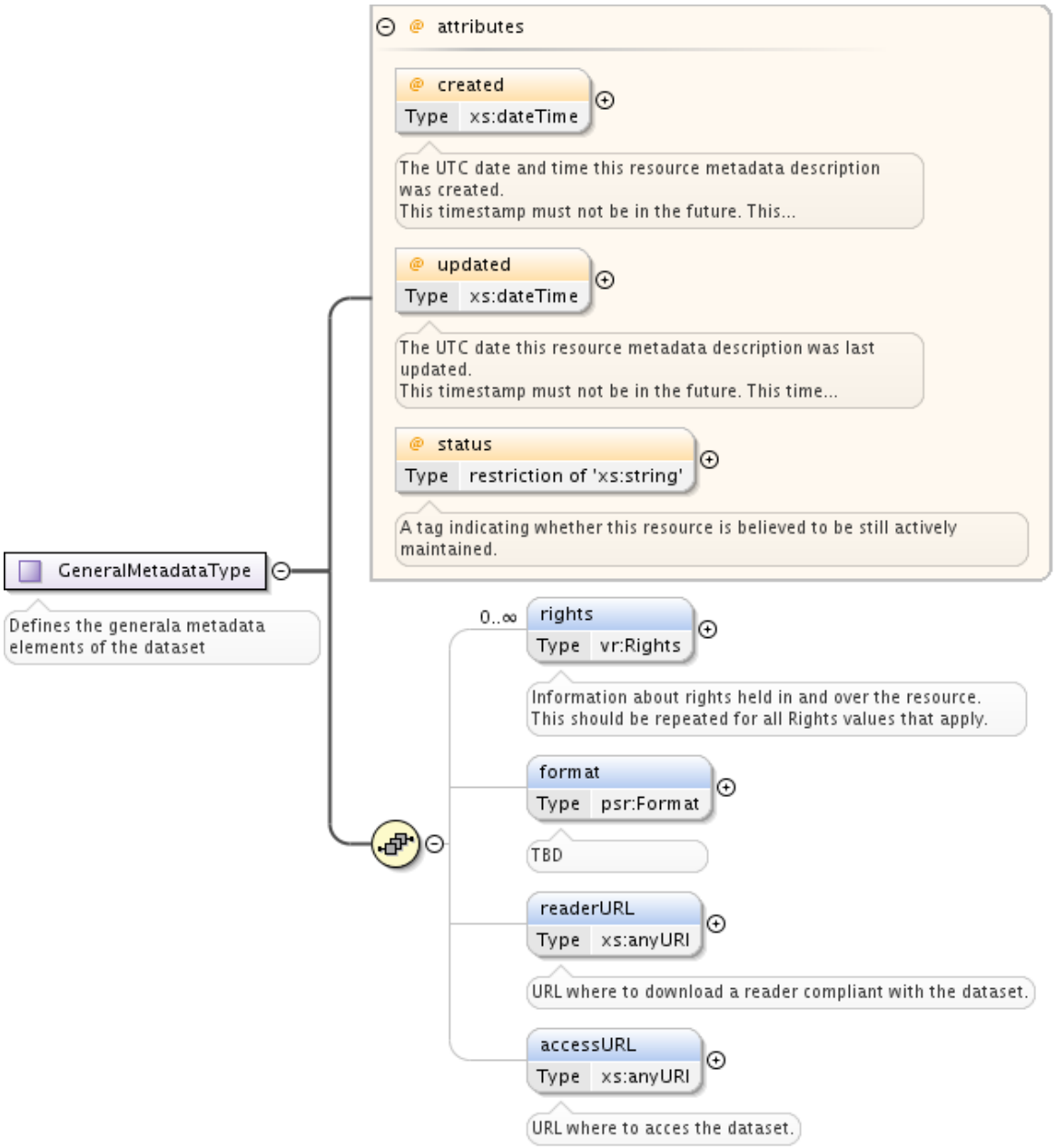


*Fig. 8: Design of the psr:GeneralMetadataType type*

## 5.8. InstrumentType metadata elements

The design of `psr:InstrumentType` type is depicted in Fig. 9, and the following table declares its elements.

| psr:InstrumentType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| facility | *Value Type:* | String; `vr:ResourceName` |
| | *Semantic Meaning:* | Name of the facility where the physical parameter was acquired. |
| | *Occurences:* | Optional; single occurrence allowed |
| instrumentName | *Value Type:* | String; `vr:ResourceName` |
| | *Semantic Meaning:* | Name of the instrument |
| | *Occurences:* | Optional; single occurrence allowed |
| alternateInstrumentName | *Value Type:* | String; `xs:string` |
| | *Semantic Meaning:* | An alternate name of the instrument |
| | *Occurences* | Optional; multiple occurences allowed |
| instrumentClass | *Value Type:* | String; `psr:InstrumentClassList` |
| | *Semantic Meaning:* | Class of the instrument |
| | *Occurences* | Optional; multiple occurences allowed |
| referenceURL | *Value Type:* | String; `vr:AccessURL` |
| | *Semantic Meaning:* | The URL that can be used to get information about the instrument. |
| | *Occurences* | Optional |

The `psr:InstrumentClassList` type defines the list of recommended instrument designations:

> *Antenna, Chaneltron, Coronograph, DoubleSphere, DustDetector, Electron Drift Instrument, Electrostatic Drift Instrument, Electrostatic Analyser, Energetic Particle Instrument, Faraday Cup, Flux Feedback, Fourier Transform Spectrograph, Geiger-Mueller Tube, Imager, Ima-*

*ging Spectrometer, Interferometer, Ion Chamber, Ion Drift, Langmuir Probe, Long wire, Magnetometer, Mass Spectroter, Micro Channel Plate, Multispectral imager, Neutral Atom imager, Neutral Particle Detector, ParticleCorrelator, Particle Detector, Photometer, Photopolarimeter, Platform, Proportional Counter, Quadispherical Analyser, Radar, Radiometer, Resonance Sounder, Retarding Potential Analyser, Rieter, Scintillation Detector, Search Coil, Sounder, Spacecraft Potential Control, Spectral Power Receiver, Spectrometer, Time of Flight, Unspecified, Waveform receiver*

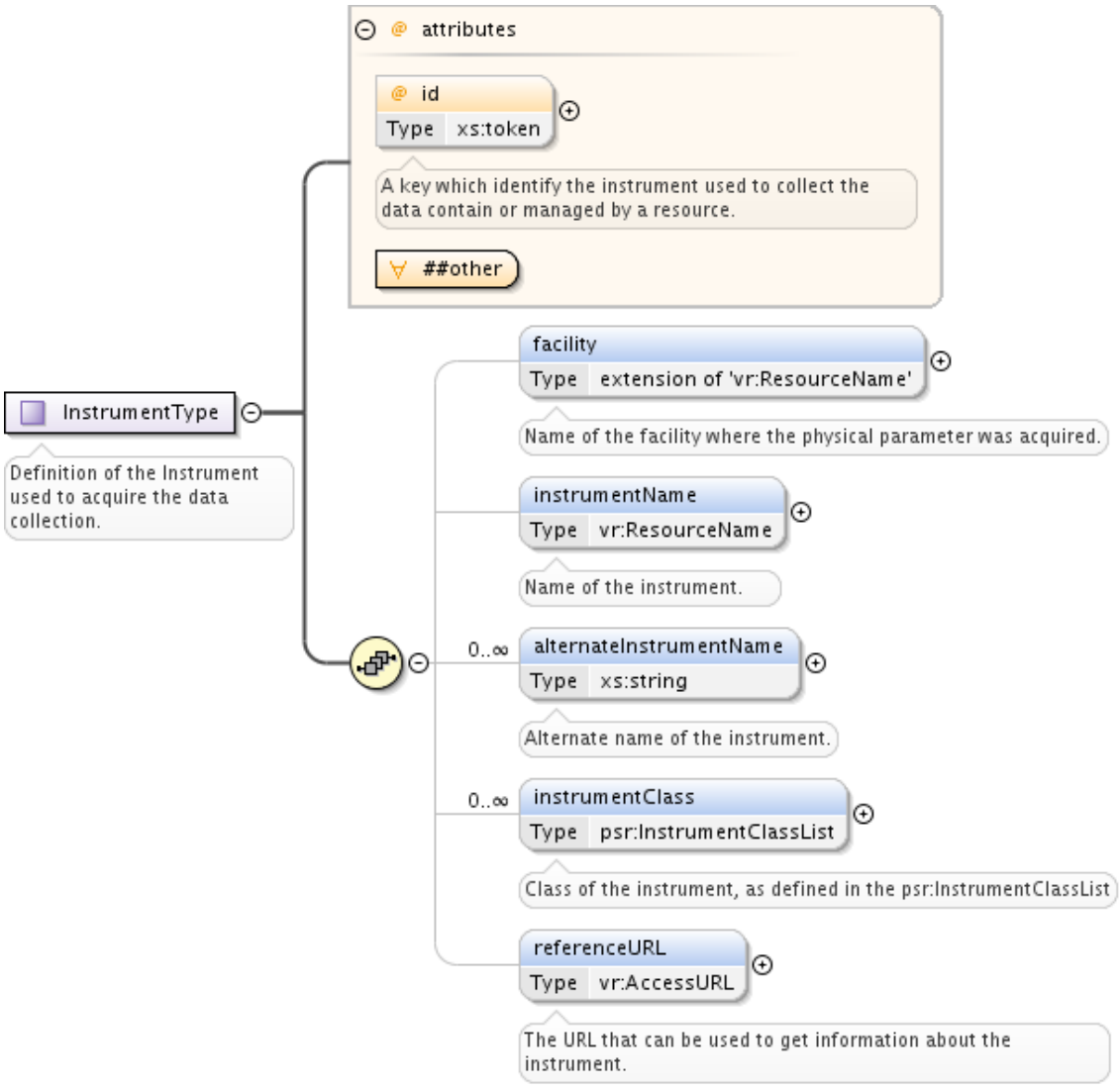


*Fig. 9: Design of the psr:InstrumentType type*

The `psr:InstrumentType` type provides a key attribute for indicating the instrument used to collect the data contain or managed by a resource.

| psr:InstrumentType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | A key which identify the instrument used to collect the data contain or managed by a resource |
| | *Occurences:* | Optional |

## 5.9. TargetType metadata elements

The `psr:TargetType` type defines a target by its name or designation. The target may be any solar system body, exoplanet, planetary region or feature, and, in some cases, astronomical objects. Best practice is to use the official name of the target as defined by IAU [9]. To avoid ambiguity in target name, a target class is associated [7]. The use of the IAU nomenclature is recommended. The `psr:TargetClass` type defines the list of allowed classes (case insensitive):

> *asteroid, comet, dust, dwarfplanet, exoplanet, feature, galaxy, ipm, meteorite, nebula, planet, region, ring, sample, satellite, sky, spacecraft, spacejunk, star*

To help data provider to handle multiple denominations of Solar system object, a name resolver is provided by IMCCE and VOParis Data Center through a standard Web service [10].

The design of `psr:TargetType` type is depicted in Fig. 10. The following table declares its elements.

| psr:TargetType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| class | *Value Type:* | String; `psr:TargetClass` |
| | *Semantic Meaning:* | The definition of the target class |
| | *Occurences:* | Optional; single occurrence allowed |
| name | *Value Type:* | String; `xs:string` |
| | *Semantic Meaning:* | Official or usual name of the target as defined by IAU |
| | *Occurences:* | Optional; single occurrence allowed |

| psr:TargetType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| alternateName | *Value Type:* | String; `xs:string` |
| | *Semantic Meaning:* | Alternate name of the target |
| | *Occurences* | Optional; multiple occurrences allowed |
| description | *Value Type:* | String; `xs:string` |
| | *Semantic Meaning:* | Free description of the target |
| | *Occurences* | Optional; single occurrence allowed |

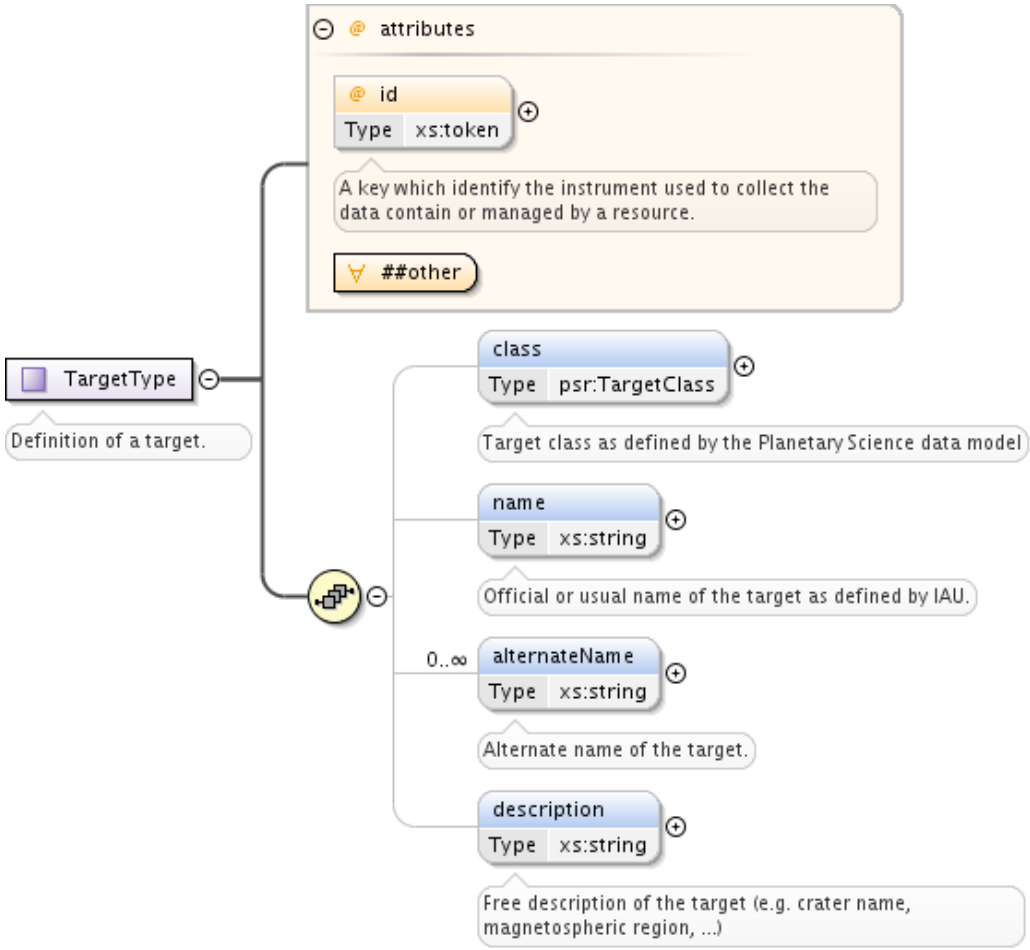


*Fig. 10: Design of the psr:TargetType type*

The psr:TargetType type provides an attribute for tagging the targets with a unique identifier.

| psr:TargetType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; xs:token |
| | *Semantic Meaning:* | Token providing a unique identifier to the target. It could be a numeric value or a short string |
| | *Occurences:* | Optional |

## 5.10. ListOfTargets metadata elements

The psr:ListOfTargets type declares the targets which are concerned by the dataset and granules. It may be a generic class of target defined by multiple occurences of the psr:class element, or a list of given targets provided by multiple occurrences of the psr:class element. The psr:maxrec element can be used to provide the number of targets which are concerned by the resource. Value zero means unbounded.

The design of psr:ListOfTargets type is depicted in Fig. 11. The following table declares its elements.

| psr:ListOfTargets Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| class | *Value Type:* | string; psr:TargetClass |
| | *Semantic Meaning:* | The definition of the target class |
| | *Occurences:* | Optional; multiple occurrences allowed |
| | *Recommended values:* | Asteroid, Comet, Dust, Meteorite, Satellite, Planet, Small Body, Region, Feature, Star, Galaxy, Nebula |
| target | *Value Type:* | Composite; psr:TargetType |
| | *Semantic Meaning:* | Official or usual name of the target as defined by IAU |
| | *Occurences:* | Optional; multiple occurrences allowed |

| psr:ListOfTargets Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| maxrec | *Value Type:* | `xs:int` |
| | *Semantic Meaning:* | The Maximum number of targets of the resource. 0 stands for no limit |
| | *Occurences* | Optional; single occurrence allowed |

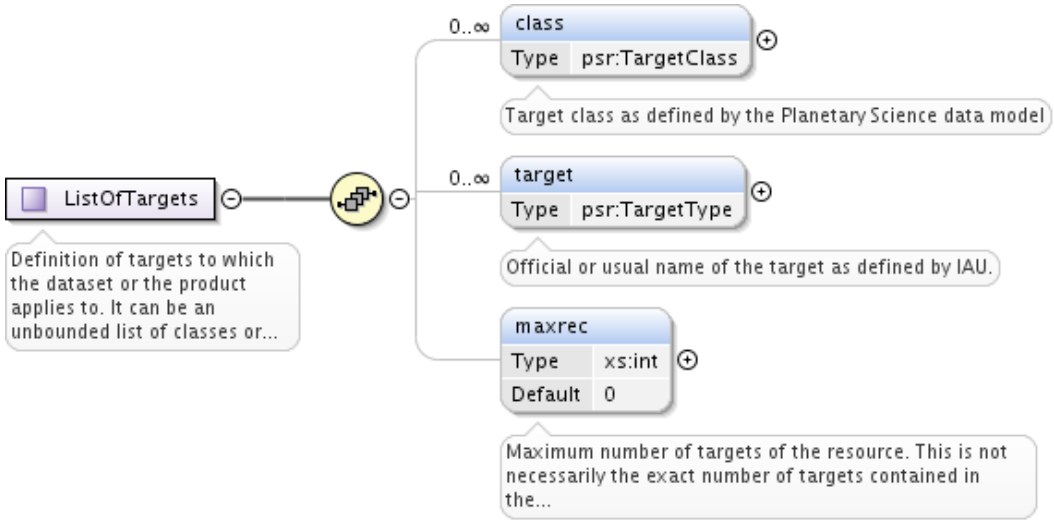


*Fig. 11: Design of the psr:ListOfTargets type*

## 5.11. ParameterAxisType metadata elements

TBD

The design of `psr:ParameterAxisType` type is depicted in Fig. 12. The following table declares its elements.

| psr:ParameterAxisType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| axisName | *Value Type:* | String; `xs:string` |

The `psr:ParameterAxis`Type type provides an attribute for tagging the targets with a unique identifier.

| **psr:TargetType Attribute** | | |
|---|---|---|
| **Attribute** | **Definition** | |
| id | *Value Type:* | String; `xs:token` |
| | *Semantic Meaning:* | Token providing a unique identifier to the parameter axis. It could be a numeric value or a short string |
| | *Occurences:* | Optional |

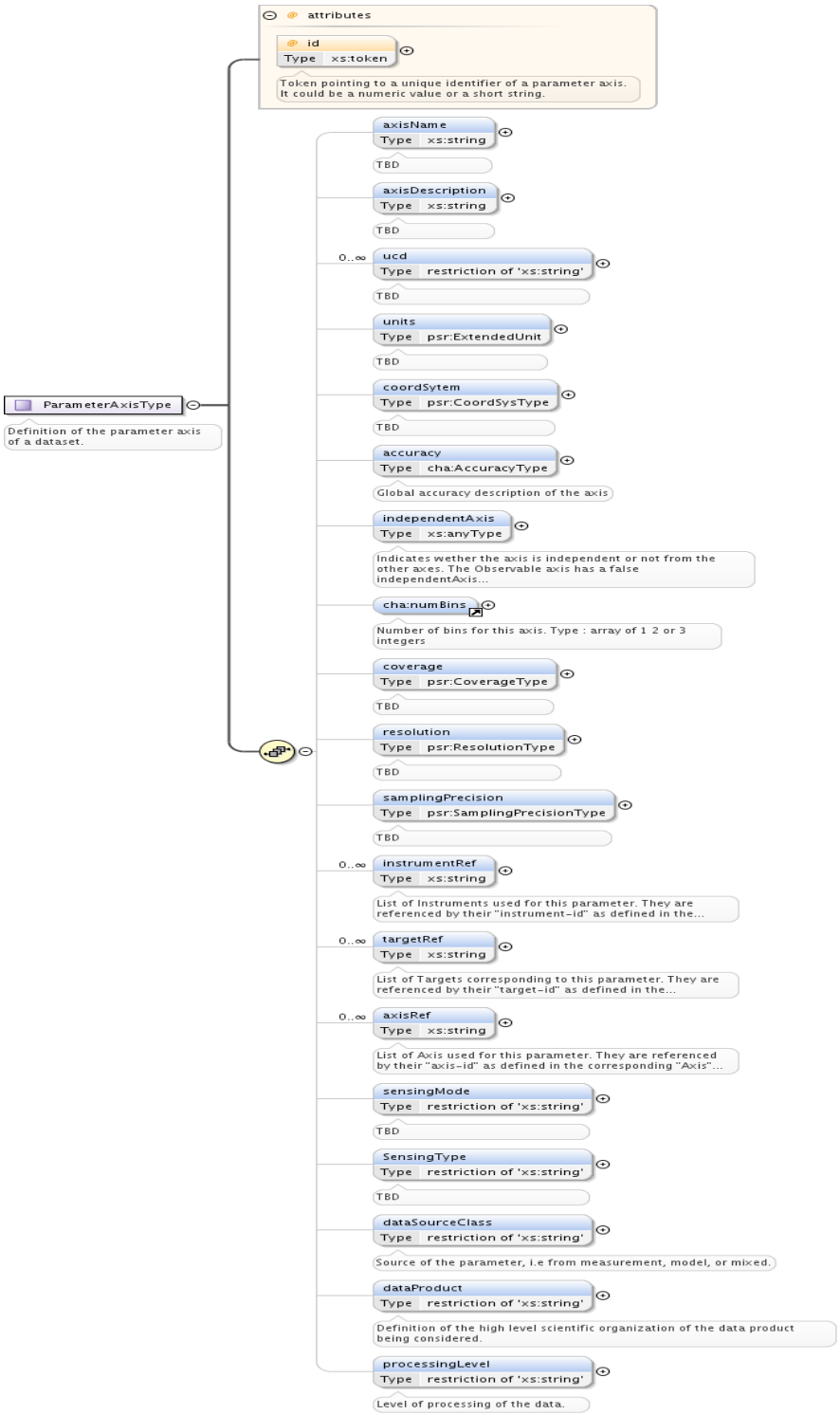


*Fig. 12: Design of the psr:ParameterAxisType type*

**DataProduct:**

The data product type describes the high level scientific organization of the data product being considered. The list of product values is:

- **Image:** associated scalar fields with two spatial axes, e.g. image with multiple color planes, from multichannel cameras for example. Maps of planetary surfaces are considered Images
- **Spectrum:** data product for which the spectral coverage is the primary attribute, e.g. a set of spectra
- **DynamicSpectrum:** consecutive spectral measurements through time, organized as a time series. voir baptiste 1D temp, 1D Spectral
- **SpectralCube:** set of spectral measurements with 1D or 2D spatial coverage, e. g. imaging spectroscopy. The choice between Image and Spectral_cube is related to the characteristics of the instrument
- **Profile:** scalar or vectorized measurements along one spatial dimension, e.g. atmospheric profiles, atmospheric paths, sub-surface profiles, etc.
- **Volume:** any measurement with three spatial dimensions
- **Movie:** set of chronological 2D spatial measurements
- **Cube:** multidimensional data with three or more axes, e.g. all that is not described by other 3D data types such as spectral cubes
- **TimeSeries:** measurements organized primarily as a function of time (with exception of dynamical spectra). A light curve is a typical example of a time series dataset.
- **Catalogue:** it can be a list of events, a catalog of object parameters, a list of feature, …, e.g. list of asteroid properties
- **SpatialVector:** list of summit coordinates defining a vector, e.g. vector information from GIS, spatial footprints, …

## 5.12. CoordSysType metadata elements

TBD

The design of `psr:CoordSysType` type is depicted in Fig. X. The following table declares its elements.

| **psr:CoordSysType Metadata Elements** | | |
|---|---|---|
| **Element** | **Definition** | |
| TBD | *Value Type:* | |

| psr:CoordSysType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| | *Semantic Meaning:* | |
| | *Occurences:* | |

## 5.13. CoordsType metadata elements

TBD

The design of `psr:CoordsType` type is depicted in Fig. X. The following table declares its elements.

| psr:CoordsType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| TBD | *Value Type:* | |
| | *Semantic Meaning:* | |
| | *Occurences:* | |

## 5.14. ResolutionType metadata elements

TBD

The design of `psr:ResolutionType` type is depicted in Fig. X. The following table declares its elements.

| psr:ResolutionType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| TBD | *Value Type:* | |
| | *Semantic Meaning:* | |

| psr:ResolutionType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| | *Occurences:* | |

## 5.15. CoverageType metadata elements

TBD

The design of `psr:CoverageType` type is depicted in Fig. X. The following table declares its elements.

| psr:CoverageType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| TBD | *Value Type:* | |
| | *Semantic Meaning:* | |
| | *Occurences:* | |

## 5.16. SamplingPrecisionType metadata elements

TBD

The design of `psr:SamplingPrecisionTypeType` type is depicted in Fig. X. The following table declares its elements.

| psr:SamplingPrecisionTypeType Metadata Elements | | |
|---|---|---|
| **Element** | **Definition** | |
| TBD | *Value Type:* | |
| | *Semantic Meaning:* | |
| | *Occurences:* | |

## 5.17. TemplateQueryType metadata elements

The design of `psr:TemplateQueryType` type is depicted in Fig. 13. The following table declares its elements. This type extends the `vs:paramHTTP` type to provide a means to describe how to query a data service.

| **psr:TemplateQueryType Metadata Elements** | | |
|---|---|---|
| **Element** | **Definition** | |
| accessURL | *Value Type:* | `vr:accessURL` |
| | *Semantic Meaning:* | The URL (or base URL) that a client uses to access the service. How this URL is to be interpreted and used depends on the specific Interface subclass |
| | *Occurences:* | Required |
| templateParam | *Value Type:* | `vs:inputParam` |
| | *Semantic Meaning:* | A description of the value of an input parameter (provided as ${parameter_name}) which must be substituted to provide a name=value argument to the service. |
| | *Occurences:* | Optional; multiple occurrences allowed |

The `psr: TemplateQueryType` type provides attributes for tagging the targets with a unique identifier.

| **psr:TargetType Attribute** | | |
|---|---|---|
| **Attribute** | **Definition** | |
| use | *Value Type:* | `vs:ParamUse` |
| | *Semantic Meaning:* | An indication of whether this parameter is required to be provided for the application or service to work properly. |
| | *Occurences:* | Optional |
| std | *Value Type:* | `xs:boolean` |

| psr:TargetType Attribute | | |
|---|---|---|
| **Attribute** | **Definition** | |
| | *Semantic Meaning:* | If true, the meaning and behavior of this parameter is reserved and defined by a standard interface. If false, it represents an implementation-specific parameter that effectively extends the behavior of the service or application. |
| | *Occurences:* | Optional |
| granule-id | *Value Type:* | `vs:ParamUse` |
| | *Semantic Meaning:* | Token pointing to a unique identifier of a granule. It could be a numeric value or a short string. |
| | *Occurences:* | Optional |

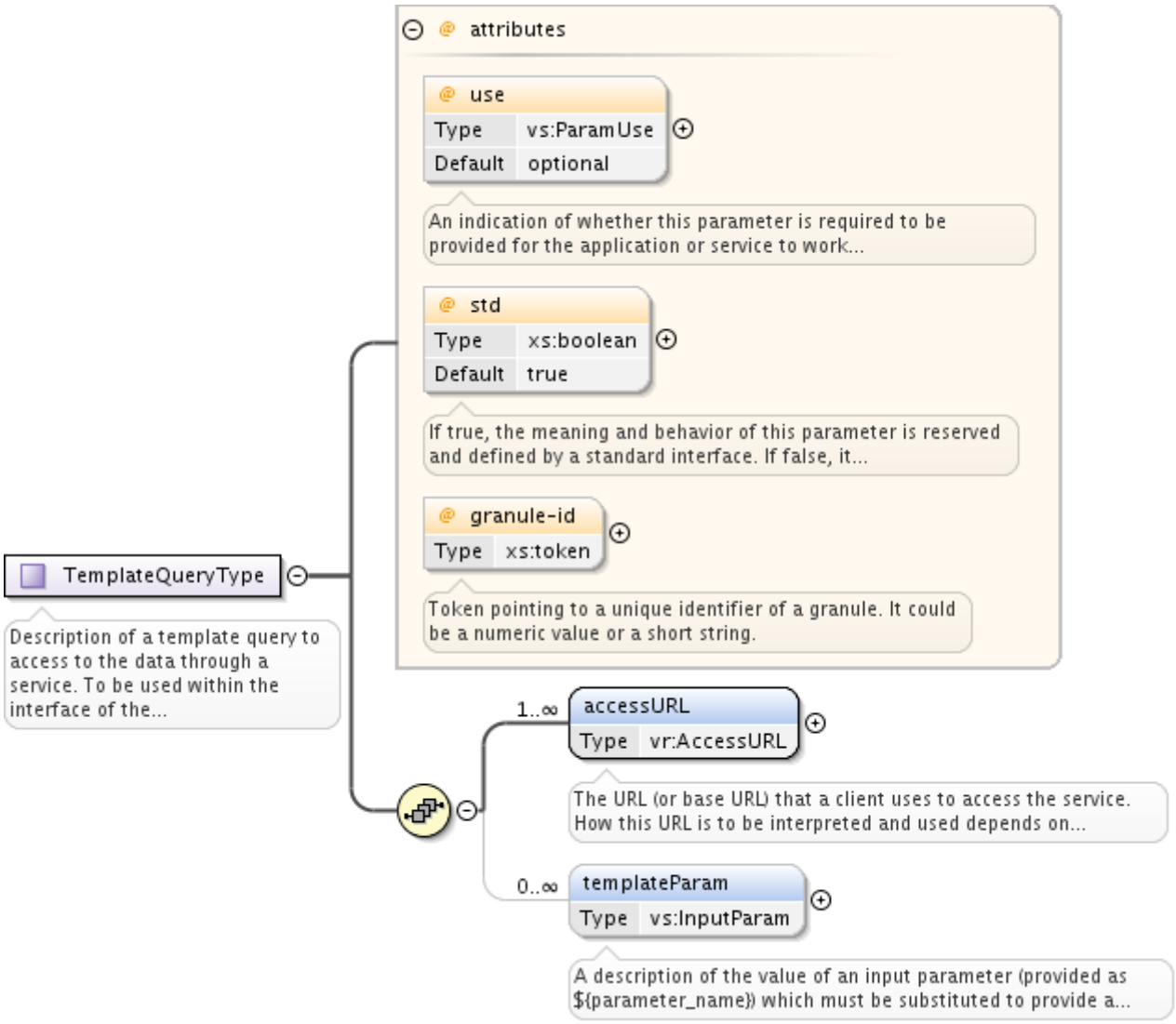


*Fig. 13: Design of the psr:TemplateQueryType type*

### 5.18. xxx

# 6. Use of PSR-DM into PS-TAP

Some elements of PSR-DM must be developed / transformed into types in order to be used by TAP-Core (e.g. DataProductType). The list of elements to transform remains TBD.

TBD

# 7. Use of PSR-DM into PDAP

TBD

# References

[1]

Bradner, S. 1997. Key words for use in RFCs to Indicate Requirement Levels, IETF RFC 2119, http://www.ietf.org/rfc/rfc2119.txt

[2]

Fallside, David C., Walmsley, Priscilla (editors) 2004, XML Schema Part 0: Primer Second Edition, W3C Recommendation 28 October 2004, http://www.w3.org/TR/xmlschema-0/

[3]

Bray, Tim, Paoli, Jean, Sperberg-McQueen, C. M., Maler, Eve, Yergeau, Francois (editors) 2004, Extensible Markup Language (XML) 1.0 (Third Edition), W3C Recommendation 04 February 2004, http://www.w3.org/TR/REC-xml

[4]

Plante, R., Benson, K., Graham, M., Greene, G., Harrison, P., Lemson, G., Linde, T., Rixon, G., Stébé, A. 2008, VOResource: an XML Encoding Schema for Resource Metadata, v1.03, IVOA Recommendation, http://www.ivoa.net/Documents/REC/ReR/VOResource-20080222.html

[5]

Plante, R., Stébé, A., Benson, K., Dowler, P., Graham, M., Greene, G., Harrison, P., Lemson, G., Linde, T., Rixon, G., and the IVOA Registry Working Group, 2010. VODataService: a VOResource Schema Extension for Describing Collections and Services, version 1.1, IVOA Recommendation, www.ivoa.net/Documents/VODataService/20101202/REC-VODataService-1.1-20101202.html

[6]

Cecconi, B., Berthier, J., Gangloff, M., Bourrel, N., Le Sidaner, P., Erard, S., Jacquey, C., Pallier, E., André, N., Lormant, N., Topf, F. 2012, Data Organization Conventions, v1.0, EuroPlaNet-IDIS Recommendation, http://typhon.obspm.fr/idis/docs/IDIS-DataOrganization-latest.pdf

[7]

Cecconi, B., Jacquey, C., Gangloff, M., Pallier, E., Bourrel, N., André, N., Erard, S., Vinatier, S., Lormant, N., Topf, F. 2011, Interoperable Data Access Data Model – Initial Prototype for Plasmas, v1.18, EuroPlaNet-IDIS Working Draft, http://typhon.obspm.fr/idis/docs/XXX-latest.pdf

[8]

IDIS Data Model Science Working Group, 2012, Planetary Science Resource Data Model Documentation, http://voparis-europlanet.obspm.fr/xml/PSR/doc/pdf/PSResource.pdf

[9]

The committee on Small Body Nomenclature handles Minor Planet names and designations, comet names and designations, and cross listed objects. In addition, the IAU Working Group for Planetary System Nomenclature (WGPSN) defines feature names on planetary surfaces

[10]

Name resolver returning body official names and astronomical coordinates at a specific time

[11]

IVOA Data Model Working Group, 2008, Data Model for Astronomical DataSet Characterization, v1.13, IVOA Recommandation, http://www.ivoa.net/Documents/latest/CharacterisationDM.html

[12]

Rots, H.-A., 2007, Space-Time Coordinate Metadata for the Virtual Observatory, v1.33, IVOA Recommendation, http://www.ivoa.net/Documents/latest/STC.html

[13]

Derriere, S., Bonnarel, F., Gray, N., Louys, M., Mc Dowell, J., Ochsenbein, F., Osuna, P., Rino, B., Salgado, J., 2011. Units in the VO version 1.0, IVOA Working Dratf, http://www.ivoa.net/Documents/VOUnits/20111216/index.html

[14]

Benson K., Plante R., Auden E., Graham M., Greene G., Hill M., Linde T., Morris D., O'Mullane W., Rixon G., Stébé A., Andrews K., 2009. IVOA Registry Interfaces Version 1.0, IVOA Recommendation, http://ivoa.net/Documents/RegistryInterface/20091104/REC-RegistryInterface-1.0.pdf

# Appendix A

# Example of description of a simple resource

The two following XML documents show how to use the Planetary Science Resource Data Model to describe a resource, by using i) the `psr:DataCollection`, and ii) the `psr:DataService` metadata elements. In both cases, the resource is the same one, but what differs is the method to access the data. The first provides access to the data as a simple compressed ascii file (original dataset), while the second provides access to the data through a TAP service. The dataset used in this example is the Asteroid Orbital Elements Database.

The dataset parameters are described by using i) the `vs:tableset` element (simple case, the data are grouped in a single file which can be easily mapped by the tableset), and ii) the `psr:tableset` element (complex case, the data are retrieved through a service and need to be mapped by one or more tables or granules).

► Download the examples

**Example i) a description of a resource as a psr:DataCollection**

```
<?xml version="1.0" encoding="UTF-8"?>
<ri:Resource status="active" updated="2012-03-11T14:30:00.00" created="2011-02-19T02:00:00.00"
 xmlns:xs="http://www.w3.org/2001/XMLSchema"
 xmlns:ri="http://www.ivoa.net/xml/RegistryInterface/v1.0"
 xmlns:stc="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"
 xmlns:vg="http://www.ivoa.net/xml/VORegistry/v1.0"
 xmlns:vr="http://www.ivoa.net/xml/VOResource/v1.0"
 xmlns:vs="http://www.ivoa.net/xml/VODataService/v1.1"
 xmlns:psr="http://voparis-europlanet.obspm.fr/xml/PSR/v1.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 xsi:schemaLocation="http://www.ivoa.net/xml/RegistryInterface/v1.0 http://www.ivoa.net/xml/Re-
gistryInterface/RegistryInterface-v1.0.xsd http://www.ivoa.net/xml/VOResource/v1.0
http://www.ivoa.net/xml/VOResource/VOResource-v1.0.xsd http://www.ivoa.net/xml/VODataService/v1.0
http://www.ivoa.net/xml/VODataService/VODataService-v1.0.xsd http://www.ivoa.net/xml/VOTable/v1.2
http://www.ivoa.net/xml/VOTable/v1.2 http://voparis-europlanet.obspm.fr/xml/PSR/v1.0 http://voparis-
europlanet.obspm.fr/xml/PSR/v1.0"
 xsi:type="psr:DataCollection">

 <title>The Asteroid Orbital Elements Database</title>
 <shortName>Astorb</shortName>
 <identifier>ivo://vopdc.obspm/imcce/ssodnet/astorb</identifier>

 <!-- Curation -->
 <curation>
 <publisher ivo-id="ivo://idis.autorithy/lowell">Lowell Observatory</publisher>
 <creator>
 <name>T. Bowell</name>
 <logo><!-- URL DU LOGO DU CREATEUR --></logo>
 </creator>
 <date>2012-03-11</date>
 <version>2012</version>
 <contact>
 <name><!-- NOM DU CONTACT --></name>
 <address><!-- ADRESSE DU CONTACT --></address>
 <email><!-- COURRIEL DU CONTACT --></email>
```

## Example i) a description of a resource as a psr:DataCollection

```
 <telephone><!-- TELEPHONE DU CONTACT --></telephone>
 </contact>
 </curation>

 <!-- Content -->
    <content>
        <!-- subject = IAU thesaurus key words (http://www.mso.anu.edu.au/library/thesaurus/) -->
        <subject>Asteroids</subject>
        <subject>Osculatory elements</subject>
        <!-- LISTE DE MOTS CLES CARACTERISANT L'ORGANISATION -->
        <description><!-- DESCRIPTION DE L'ORGANISATION --></description>
        <source><!-- SOURCE BIBITEM --></source>
        <referenceURL>ftp://ftp.lowell.edu/pub/elgb/astorb.html</referenceURL>
        <type>Other</type>
        <contentLevel>General</contentLevel>
        <contentLevel>University</contentLevel>
        <contentLevel>Research</contentLevel>
        <contentLevel>Amateur</contentLevel>
    </content>

    <!-- Coverage -->
    <coverage>
        <stc:STCResourceProfile>
            <stc:AstroCoordSystem id="TT-ICRS-BARY" xlink:href="ivo://STClib/CoordSys#TT-ICRS-BARY"
xlink:type="simple"/>
            <stc:AstroCoordArea coord_system_id="TT-ICRS-BARY">
                <stc:TimeInterval>
                    <stc:StartTime>
                        <stc:Timescale>TT</stc:Timescale>
                        <stc:JDTime>0.0</stc:JDTime>
                    </stc:StartTime>
                    <stc:StopTime>
                        <stc:Timescale>TT</stc:Timescale>
                        <stc:JDTime>3000000.0</stc:JDTime>
                    </stc:StopTime>
                </stc:TimeInterval>
                <stc:AllSky fill_factor="1.0E0"/>
            </stc:AstroCoordArea>
        </stc:STCResourceProfile>
        <waveband>Optical</waveband>
    </coverage>

    <!-- Product -->
    <tableset>
        <schema>
            <name>ASTORB</name>
            <description>Astorb is an ASCII file of high-precision osculating orbital elements,
                ephemeris uncertainties, and some additional data for all the numbered asteroids
                and the vast majority of unnumbered asteroids (multi-apparition and single-
                -apparition) for which it is possible to make reasonably determinate computations.
            </description>
            <table type="output">
                <name>astorb</name>
                <title>Asteroid Orbital Elements Database</title>
                <description>High-precision osculating orbital elements of asteroids</description>
                <column>
                    <name>number</name>
                    <description>Asteroid number</description>
                    <unit>-</unit>
                    <ucd>meta.id;meta.number</ucd>
                    <dataType xsi:type="psr:SimpleDataType">int</dataType>
                    <flag>nullable</flag>
                </column>
                <column>
                    <name>name</name>
                    <description>Asteroid name or designation</description>
                    <unit>-</unit>
```

## Example i) a description of a resource as a psr:DataCollection

```
                    <ucd>meta.id;meta.main</ucd>
                    <dataType xsi:type="psr:SimpleDataType">string</dataType>
                    <flag></flag>
                </column>

<!-- ... more columns … -->
            </table>
        </schema>
    </tableset>

    <!-- Access to the data -->
    <accessURL use="full">
        ftp://ftp.lowell.edu/pub/elgb/astorb.dat.gz
    </accessURL>

    <!-- Definition of the resource class -->
    <psr:resource class="dataset">
        <psr:dataset id="AstorbDataset">
            <psr:granule id="astorb">
                <psr:rights>public</psr:rights>
                <psr:format compressed="true">ascii</psr:format>
            </psr:granule>
        </psr:dataset>
    </psr:resource>

    <!-- Targets covered by the resource -->
    <psr:targets>
        <psr:class>asteroid</psr:class>
        <psr:maxrec>0</psr:maxrec>
    </psr:targets>

</ri:Resource>
```

## Example ii) a description of a resource as a psr:DataService

```
<?xml version="1.0" encoding="UTF-8"?>
<ri:Resource status="active" updated="2012-03-11T14:30:00.00" created="2011-02-19T02:00:00.00"
 xmlns:xs="http://www.w3.org/2001/XMLSchema"
 xmlns:ri="http://www.ivoa.net/xml/RegistryInterface/v1.0"
 xmlns:stc="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"
 xmlns:vg="http://www.ivoa.net/xml/VORegistry/v1.0"
 xmlns:vr="http://www.ivoa.net/xml/VOResource/v1.0"
 xmlns:vs="http://www.ivoa.net/xml/VODataService/v1.1"
 xmlns:psr="http://voparis-europlanet.obspm.fr/xml/PSR/v1.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 xsi:schemaLocation="http://www.ivoa.net/xml/RegistryInterface/v1.0 http://www.ivoa.net/xml/Re-
gistryInterface/RegistryInterface-v1.0.xsd http://www.ivoa.net/xml/VOResource/v1.0
http://www.ivoa.net/xml/VOResource/VOResource-v1.0.xsd http://www.ivoa.net/xml/VODataService/v1.1
http://www.ivoa.net/xml/VODataService/VODataService-v1.1.xsd http://www.ivoa.net/xml/VOTable/v1.2
http://www.ivoa.net/xml/VOTable/v1.2 http://voparis-europlanet.obspm.fr/xml/PSR/v1.0 http://voparis-
europlanet.obspm.fr/xml/PSR/v1.0"
 xsi:type="psr:DataService">

 <title>The Asteroid Orbital Elements Database</title>
 <shortName>Astorb</shortName>
 <identifier>ivo://vopdc.obspm/imcce/ssodnet/astorb</identifier>

 <!-- Curation -->
 <curation>
```

## Example ii) a description of a resource as a psr:DataService

```
<publisher ivo-id="ivo://idis.autorithy/lowell">Lowell Observatory</publisher>
<creator>
<name>T. Bowell</name>
<logo><!-- URL DU LOGO DU CREATEUR --></logo>
       </creator>
       <date>2011-02-19</date>
       <version>2011</version>
       <contact>
           <name><!-- NOM DU CONTACT --></name>
           <address><!-- ADRESSE DU CONTACT --></address>
           <email><!-- COURRIEL DU CONTACT --></email>
           <telephone><!-- TELEPHONE DU CONTACT --></telephone>
       </contact>
   </curation>

   <!-- Content -->
   <content>
       <!-- subject = IAU thesaurus key words (http://www.mso.anu.edu.au/library/thesaurus/) -->
       <subject>Asteroids</subject>
       <subject>Osculatory elements</subject>
       <!-- LISTE DE MOTS CLES CARACTERISANT L'ORGANISATION -->
       <description><!-- DESCRIPTION DE L'ORGANISATION --></description>
       <source><!-- SOURCE BIBITEM --></source>
       <referenceURL>ftp://ftp.lowell.edu/pub/elgb/astorb.html</referenceURL>
       <type>Other</type>
       <contentLevel>General</contentLevel>
       <contentLevel>University</contentLevel>
       <contentLevel>Research</contentLevel>
       <contentLevel>Amateur</contentLevel>
   </content>

   <!-- How to access to the data through a service -->
   <capability standardID="ivo://ivoa.net/std/TAP">
       <interface role="std" xsi:type="psr:ParamHTTP">
           <accessURL use="base">
               http://vodev.imcce.fr/webservices/ssodnet/tap/sync/?
           </accessURL>
           <queryType>GET</queryType>
           <resultType>text/xml+votable</resultType>
           <param std="true" use="required" >
               <name>REQUEST</name>
               <description>Standard REQUEST parameter of TAP</description>
               <dataType>string</dataType>
           </param>
           <param std="true" use="required">
               <name>LANG</name>
               <description>Standard LANG parameter of TAP</description>
               <dataType>string</dataType>
           </param>
           <param std="true" use="required">
               <name>FORMAT</name>
               <description>Standard FORMAT parameter of TAP</description>
               <dataType>string</dataType>
           </param>
           <param std="true" use="required">
               <name>QUERY</name>
               <description>Standard QUERY parameter of TAP</description>
               <dataType>string</dataType>
           </param>
           <testQuery>
               http://vodev.imcce.fr/webservices/ssodnet/tap/sync/?
REQUEST=doQuery&#38;LANG=ADQL&#38;FORMAT=votable&#38;QUERY=SELECT * FROM orbit_aster WHERE orbit_as-
ter.name=&#39;Ceres&#39;
           </testQuery>

           <psr:templateQuery granule-id="astorb">
               <psr:accessURL>
```

## Example ii) a description of a resource as a psr:DataService

```
                    http://vodev.imcce.fr/webservices/ssodnet/tap/sync/?
REQUEST=doQuery&#38;LANG=ADQL&#38;FORMAT=votable&#38;QUERY=SELECT * FROM orbit_aster WHERE orbit_as-
ter.name=&#39;${TARGET_NAME}&#39;
                </psr:accessURL>
                <psr:templateParam use="required">
                    <name>TARGET_NAME</name>
                    <description>Target name</description>
                    <dataType>string</dataType>
                </psr:templateParam>
            </psr:templateQuery>

        </interface>
    </capability>

    <!-- Coverage -->
    <coverage>
        <stc:STCResourceProfile>
            <stc:AstroCoordSystem id="TT-ICRS-BARY" xlink:href="ivo://STClib/CoordSys#TT-ICRS-BARY"
xlink:type="simple"/>
            <stc:AstroCoordArea coord_system_id="TT-ICRS-BARY">
                <stc:TimeInterval>
                    <stc:StartTime>
                        <stc:Timescale>TT</stc:Timescale>
                        <stc:JDTime>0.0</stc:JDTime>
                    </stc:StartTime>
                    <stc:StopTime>
                        <stc:Timescale>TT</stc:Timescale>
                        <stc:JDTime>3000000.0</stc:JDTime>
                    </stc:StopTime>
                </stc:TimeInterval>
                <stc:AllSky fill_factor="1.0E0"/>
            </stc:AstroCoordArea>
        </stc:STCResourceProfile>
        <waveband>Optical</waveband>
    </coverage>

    <!-- Resource -->
    <psr:resource class="dataset">
        <psr:dataset id="AstorbDataset">
            <psr:granule id="astorb" table-id="astorb">
                <psr:rights>public</psr:rights>
                <psr:format compressed="false">ascii</psr:format>
            </psr:granule>
        </psr:dataset>
    </psr:resource>

    <!-- TARGETS covered by the resource -->
    <psr:targets>
        <psr:class>asteroid</psr:class>
        <psr:maxrec>0</psr:maxrec>
    </psr:targets>

    <!-- Product -->
    <psr:tableset>
        <psr:schema>
            <psr:name>ASTORB</psr:name>
            <psr:description>
                Astorb is an ASCII file of high-precision osculating orbital elements,
                ephemeris uncertainties, and some additional data for all the numbered asteroids
                and the vast majority of unnumbered asteroids (multi-apparition and single-
                -apparition) for which it is possible to make reasonably determinate computations.
            </psr:description>
            <psr:table id="astorb" type="output">
                <psr:name>astorb</psr:name>
                <psr:title>Asteroid Orbital Elements Database</psr:title>
                <psr:description>
                   High-precision osculating orbital elements of asteroids
```

**Example ii) a description of a resource as a psr:DataService**

```
                </psr:description>
                <psr:column id="number">
                    <name>Number</name>
                    <description>Asteroid number</description>
                    <unit>-</unit>
                    <ucd>meta.id;meta.number</ucd>
                    <dataType xsi:type="psr:SimpleDataType">int</dataType>
                    <flag>nullable</flag>
                </psr:column>
                <psr:column id="name">
                    <name>Name</name>
                    <description>Asteroid name or designation</description>
                    <unit>-</unit>
                    <ucd>meta.id;meta.main</ucd>
                    <dataType xsi:type="psr:SimpleDataType">string</dataType>
                    <flag></flag>
                </psr:column>
<!-- ... more columns ... -->
            </psr:table>
        </psr:schema>
    </psr:tableset>

</ri:Resource>
```

# Appendix B

# Example of a complex resource

The next XML document shows how to use the Planetary Science Resource and Observation Data Models to describe a resource. The example shows the description of the *Abundance Vertical Profile at Titan with Cassini/CIRS* as a TAP-based `psr:dataservice`. The Observation DM is used to define accurately some parameters of the granules. This resource is a dataset of files which contains the granules (i.e. the parameters of interest), which have to be downloaded in a second query (based on HTTP protocol).

► Download the examples

**Example: a description of an advanced resource as a psr:DataService**

```
<?xml version="1.0" encoding="UTF-8"?>
<ri:Resource status="active" updated="2012-03-11T14:30:00.00" created="2011-02-19T02:00:00.00"
    xmlns:ri="http://www.ivoa.net/xml/RegistryInterface/v1.0"
    xmlns:stc="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"
    xmlns:vg="http://www.ivoa.net/xml/VORegistry/v1.0"
    xmlns:vr="http://www.ivoa.net/xml/VOResource/v1.0"
    xmlns:vs="http://www.ivoa.net/xml/VODataService/v1.1"
    xmlns:psr="http://voparis-europlanet.obspm.fr/xml/PSR/v1.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    xsi:schemaLocation="http://www.ivoa.net/xml/RegistryInterface/v1.0 http://www.ivoa.net/xml/Re-
gistryInterface/RegistryInterface-v1.0.xsd http://www.ivoa.net/xml/VOResource/v1.0
http://www.ivoa.net/xml/VOResource/VOResource-v1.0.xsd http://www.ivoa.net/xml/VODataService/v1.0
http://www.ivoa.net/xml/VODataService/VODataService-v1.0.xsd http://www.ivoa.net/xml/VOTable/v1.2
http://www.ivoa.net/xml/VOTable/v1.2 http://voparis-europlanet.obspm.fr/xml/PSR/v1.0 http://voparis-
europlanet.obspm.fr/xml/PSR/v1.0"
    xsi:type="psr:DataService">

    <validationLevel validatedBy="ivo://vopdc.obspm">4</validationLevel>

    <title>Abundance Vertical Profile at Titan with Cassini/CIRS</title>
    <shortName>AltProfileTitan</shortName>
    <identifier>ivo://vopdc.obspm/lesia/Cassini-CIRS-AltitudeProfileTitan</identifier>

    <!-- Curation -->
    <curation>
        <publisher ivo-id="ivo://vopdc.obspm/lesia">Observatoire de Paris / LESIA</publisher>
        <creator>
            <name>S. Vinatier</name>
            <logo>http://vo.obspm.fr/logo/lesia.png</logo>
        </creator>
        <date>2011-01-13</date>
        <version>1</version>
        <contact>
            <name>S. Vinatier</name>
            <address>Observatoire de Paris, 5 place Jules Jansen, 92195 Meudon, France</address>
            <email>Sandrine.Vinatier@obspm.fr</email>
            <telephone>+33145077730</telephone>
        </contact>
    </curation>

    <!-- Content -->
    <content>
```

## Example: a description of an advanced resource as a psr:DataService

```
        <!-- subject = IAU thesaurus key words (http://www.mso.anu.edu.au/library/thesaurus/) -->
        <subject>Planet satellites</subject>
        <subject>Atmospheres</subject>
        <subject>Space research</subject>
        <description>This database displays the temperature vertical profiles in Titan's atmosphere
            at nine different latitudes between 100 and 500 km. These profiles were retrieved from
            the infrared spectra acquired… by the Composite Infrared Spectrometer (CIRS) aboard the
            Cassini spacecraft. The retrieval method and the description of the used dataset is
            detailed by Vinatier et al., 2009, Analysis of Cassini/CIRS limb spectra of Titan
            acquired during the nominal mission. I: Hydrocarbons, nitriles and CO2 vertical mixing
            ratio profiles, Icarus, in press. doi:10.1016/j.icarus.2009.08.013. </description>
        <source>2007Icar..188..120V</source>
        <referenceURL>http://lesia.obspm.fr/CIRS-sur-Cassini.html?decoupe_recherche=titan</refer-
enceURL>
        <type>Archive</type>
        <contentLevel>General</contentLevel>
        <contentLevel>University</contentLevel>
        <contentLevel>Research</contentLevel>
        <contentLevel>Amateur</contentLevel>
        <relationship>
            <relationshipType>related-to</relationshipType>
            <relatedResource ivo-id="ivo://vopdc.obspm">VO-Paris Data Centre</relatedResource>
        </relationship>
    </content>

    <!-- How to access to the data through a service -->
    <capability standardID="ivo://ivoa.net/std/TAP">
        <interface role="std" xsi:type="psr:ParamHTTP">
            <accessURL use="base">
                http://voparis-srv.obspm.fr/srv/tap-titan_temperature/sync?
            </accessURL>
            <queryType>GET</queryType>
            <resultType>text/xml+votable</resultType>
            <param std="true" use="required" >
                <name>REQUEST</name>
                <description>Standard REQUEST parameter of TAP</description>
                <dataType>string</dataType>
            </param>
            <param std="true" use="required">
                <name>LANG</name>
                <description>Standard LANG parameter of TAP</description>
                <dataType>string</dataType>
            </param>
            <param std="true" use="required">
                <name>FORMAT</name>
                <description>Standard FORMAT parameter of TAP</description>
                <dataType>string</dataType>
            </param>
            <param std="true" use="required">
                <name>QUERY</name>
                <description>Standard QUERY parameter of TAP</description>
                <dataType>string</dataType>
            </param>
            <testQuery>
                http://voparis-srv.obspm.fr/srv/tap-titan_temperature/sync?
REQUEST=doQuery&amp;LANG=ADQL&amp;QUERY=SELECT * FROM proft WHERE name LIKE &#39;titan&#39;
            </testQuery>

            <psr:templateQuery granule-id="AbundanceProfile">
                <psr:accessURL>
                    http://voparis-srv.obspm.fr/srv/tap-titan_temperature/sync?
REQUEST=doQuery&amp;LANG=ADQL&amp;QUERY=SELECT * FROM proft WHERE name LIKE &#39;titan&#39;
                </psr:accessURL>
            </psr:templateQuery>

        </interface>
    </capability>
```

**Example: a description of an advanced resource as a psr:DataService**

```
<!-- Coverage -->
<coverage>
    <stc:STCResourceProfile>

        <stc:AstroCoordSystem id="TITAN-PLANETO">
            <stc:SpaceFrame>
                <stc:BODY>
                    <stc:Name>Titan</stc:Name>
                </stc:BODY>
                <stc:TOPOCENTER>
                    <stc:PlanetaryEphem>JPL-DE405</stc:PlanetaryEphem>
                </stc:TOPOCENTER>
                <stc:CARTESIAN coord_naxes="3" handedness="right"/>
            </stc:SpaceFrame>
        </stc:AstroCoordSystem>

        <stc:AstroCoordSystem id="UTC-ICRS-TOPO-TITAN">
            <stc:TimeFrame>
                <stc:Name>UTCTime</stc:Name>
                <stc:TimeScale>UTC</stc:TimeScale>
                <stc:GEOCENTER/>
            </stc:TimeFrame>
            <stc:SpaceFrame>
                <stc:Name>TitanRefFrame</stc:Name>
                <stc:BODY ref_frame_id="TITAN-PLANETO"/>
                <stc:TOPOCENTER/>
                <stc:SPHERICAL coord_naxes="2" handedness="right"/>
            </stc:SpaceFrame>
        </stc:AstroCoordSystem>

        <stc:AstroCoords coord_system_id="UTC-ICRS-TOPO-TITAN">
            <stc:Position2D unit="deg">
                <stc:Name>Longitude,Latitude</stc:Name>
                <stc:Name1>Long</stc:Name1>
                <stc:Name2>Lat</stc:Name2>
            </stc:Position2D>
        </stc:AstroCoords>

        <stc:AstroCoordArea coord_system_id="UTC-ICRS-TOPO-TITAN">
            <stc:TimeInterval>
                <stc:StartTime>
                    <stc:Timescale>UTC</stc:Timescale>
                    <stc:ISOTime>2004-10-26T00:00:00</stc:ISOTime>
                </stc:StartTime>
            </stc:TimeInterval>
            <stc:Position2VecInterval>
                <stc:LoLimit2Vec>
                    <stc:C1>0</stc:C1>
                    <stc:C2>-56</stc:C2>
                </stc:LoLimit2Vec>
                <stc:HiLimit2Vec>
                    <stc:C1>360</stc:C1>
                    <stc:C2>80</stc:C2>
                </stc:HiLimit2Vec>
            </stc:Position2VecInterval>
        </stc:AstroCoordArea>

    </stc:STCResourceProfile>
    <waveband>Infrared</waveband>
</coverage>

<!-- Resource Class -->
<psr:resource class="dataset">
    <psr:dataset id="Cassini/CIRS/AbundanceProfileTitan">
        <psr:generalMetadata>
            <psr:rights>public</psr:rights>
```

## Example: a description of an advanced resource as a psr:DataService

```
                <psr:format>native</psr:format>
                <psr:readerURL>http://cdpp2.cnes.fr/cdpp/data/documents/PLAS-LO-STR_SWAVES-00551-
LES/00551.tar</psr:readerURL>
            </psr:generalMetadata>
            <psr:instrument>
                <psr:facility>Cassini</psr:facility>
                <psr:instrumentName>CIRS</psr:instrumentName>
                <psr:instrumentClass>Imaging Spectrometer</psr:instrumentClass>
                <psr:referenceURL>http://cirs.gsfc.nasa.gov/</psr:referenceURL>
            </psr:instrument>
            <psr:targets>
                <psr:target id="606">
                    <psr:class>satellite</psr:class>
                    <psr:name>Titan</psr:name>
                    <psr:alternateName>606</psr:alternateName>
                    <psr:description>Saturn satellite</psr:description>
                </psr:target>
                <psr:target id="titan_atm">
                    <psr:class>region</psr:class>
                    <psr:name>Atmosphere</psr:name>
                    <psr:description>Titan's atmosphere</psr:description>
                </psr:target>
            </psr:targets>
            <psr:granule id="AbundanceProfile" table-id="AbundanceProfileTitan">
                <psr:generalMetadata>
                    <psr:rights>public</psr:rights>
                    <psr:format compressed="false">votable</psr:format>
                </psr:generalMetadata>
                <psr:parameterAxis>
                    <psr:dataSourceClass>measurement</psr:dataSourceClass>
                    <psr:dataProduct>profile</psr:dataProduct>
                    <psr:processingLevel>calibrated (fully calibrated data)</psr:processingLevel>
                </psr:parameterAxis>
            </psr:granule>
        </psr:dataset>
    </psr:resource>

    <!-- Product -->
    <psr:tableset>
        <psr:schema>
            <psr:name>Cassini/CIRS/AbundanceProfileTitan</psr:name>
            <psr:description>
                This table provides the list of available abundance vertical profiles in
                the Titan middle atmosphere. Each profile can be downloaded by following the URL
                provided in column 'filename'.
            </psr:description>
            <psr:table id="AbundanceProfileTitan" type="output">
                <psr:name>ListOfProfile</psr:name>
                <psr:description>
                    Abundance vertical profiles in the Titan middle atmosphere at nine different
latitudes
                    between 100 and 500 km. These profiles were retrieved from the infrared spectra,
and was
                    acquired by the Composite Infrared Spectrometer (CIRS) aboard the Cassini space-
craft.
                </psr:description>
                <psr:column id="id">
                    <name>ID</name>
                    <description>Granule identifier</description>
                    <unit>-</unit>
                    <ucd>meta.id;meta.number</ucd>
                    <dataType xsi:type="psr:SimpleDataType">int</dataType>
                    <flag>nullable</flag>
                </psr:column>
                <psr:column id="latitude">
                    <name>Latitude</name>
                    <description>Latitude of the profile in Titan's reference frame</description>
```

**Example: a description of an advanced resource as a psr:DataService**

```
                    <unit>deg</unit>
                    <ucd>pos.latitude</ucd>
                    <utype>stc:AstroCoords.Position2D.Value2.C2</utype>
                    <dataType xsi:type="psr:SimpleDataType">double</dataType>
                    <flag>nullable</flag>
                </psr:column>
                <psr:column id="longitude">
                    <name>Longitude</name>
                    <description>Longitude of the profile in Titan's reference frame</description>
                    <unit>deg</unit>
                    <ucd>pos.longitude</ucd>
                    <utype>stc:AstroCoords.Position2D.Value2.C1</utype>
                    <dataType xsi:type="psr:SimpleDataType">double</dataType>
                    <flag>nullable</flag>
                </psr:column>
                <psr:column id="date">
                    <name>Date</name>
                    <description>Date of acquisition of the profile</description>
                    <unit>-</unit>
                    <ucd>pos.epoch</ucd>
                    <dataType xsi:type="psr:SimpleDataType">string</dataType>
                    <flag>nullable</flag>
                </psr:column>
                <psr:column id="filename">
                    <name>Filename</name>
                    <description>URL to download the profile</description>
                    <unit>-</unit>
                    <ucd>meta.ref.url</ucd>
                    <dataType xsi:type="psr:SimpleDataType">string</dataType>
                    <flag>nullable</flag>
                </psr:column>
            </psr:table>
        </psr:schema>
    </psr:tableset>

</ri:Resource>
```