PDS4 Radar Local Data Dictionary Users' Guide

Small Bodies Node

May 6, 2025

1 Introduction

The Radar discipline dictionary was originally created by the PDS Small Bodies Node in support of groundbased radar data (from Arecibo, Goldstone, and similar installations). It is structured such that it can be expanded to include spacecraft radar data.

1.1 Purpose of this Users' Guide

The users' guide is intended to provide help in using the Radar discipline dictionary to include metadata specific to radar data in PDS4 Product_Observational labels.

1.2 Audience

This user's guide is for anyone submitting or using PDS radar data . Familiarity with basic PDS4 concepts is helpful.

1.3 Applicable Documents

PDS4 Standards Reference: https://pds.jpl.nasa.gov/datastandards/documents/sr/
PDS4 Information Model: https://pds.nasa.gov/datastandards/documents/im/

2 Overview of the Radar Discipline Data Dictionary

Radar is intended to provide classes and attributes for metadata specific to ground based radar data. The Small Bodies Node holds the stewardship of Radar, with Jesse Stone (jstone@psi.edu) and Beatrice Mueller (mueller@psi.edu) as the current points of contact.

Section 3 of this Guide covers how to include the classes and attributes of the dictionary in a PDS label file. Section 4 goes into more detail on the structure of the classes and attributes and how they are intended to be used. See section 5 for detailed specifications of each class and attribute.

3 How to Include the Radar Dictionary in a PDS4 Label

3.1 Data Dictionary Files

PDS4 dictionaries appear in several forms, typically having the same filename with different extensions. It can either be an ingest file, or a schema file coupled with a schematron file. The ingest file, with xml extension, is used for authoring the dictionary and often for ingesting it into tools, while the schema (.xsd) and schematron (.sch) files, which are compiled from the ingest file, are used to actually validate a product label. For released dictionaries, all these can be obtained from the PDS4 released schema page at https://pds.jpl.nasa.gov/datastandards/schema/released/.

3.2 Including the schema file in a label

In order to use the schema file, the Product_Observational element of your product label will need to have references to the dictionary added to it, as follows (for IM 1.22.0.0):

```
<Product_Observational   xmlns="http://pds.nasa.gov/pds4/pds/v1"
xmlns:radar="http://pds.nasa.gov/pds4/radar/v1"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1M00.xsd
http://pds.nasa.gov/pds4/radar/v1
https://pds.nasa.gov/pds4/radar/v1/PDS4_RADAR_1M00_1000.xsd">
```

This example assumes that the radar dictionary is the only dictionary in your label. If you have multiple dictionaries, you will need to make other modifications.

3.3 Including the schematron in a label

In order to use the schematron file, the xml prolog of your product label will need to have references to the dictionary added to it, as follows:

```
<?xml-model
href="https://pds.nasa.gov/pds4/radar/v1/PDS4_RADAR_1M00_1000.sch"
schematypens="http://purl.oclc.org/dsdl/schematron"?>
```

3.4 Including the data dictionary elements

The data dictionary defines XML elements that can be used in a `Discipline_Area`. A minimal example of the discipline area follows. A more detailed example for each class is given in the later sections of this Guide.

```
<Discipline_Area>
  <radar:Radar>
     <radar:Groundbased_Radar>
        <radar:observation_purpose>Doppler</radar:observation_purpose>
     </radar:Groundbased_Radar>
   </radar:Radar>
 </Discipline_Area>
```

4 Organization of Classes and Attributes

The overall organization of classes and attributes for all of Radar is shown in Figure 1. The dictionary contains four classes underneath Groundbased_Radar: Transmission_Properties, Quality, Target_Properties, and Sampling_Properties.
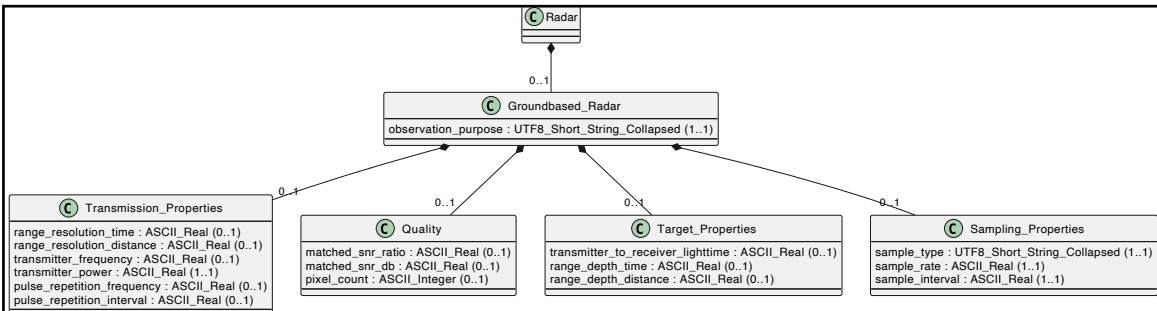

Figure 1: Organization of classes and attributes in the Radar dictionary

4.1 The Groundbased_Radar Class

Indicates that the observations were carried out with a groundbased radar facility. It has a required attribute of observation_purpose.

Here is an example of how this class might be included in a label:

```
<radar:Radar>
  <radar:Groundbased_Radar>
     <radar:observation_purpose>Doppler</radar:observation_purpose>
  <radar:Groundbased_Radar>
</radar:Radar>
```

3

4.1.1 The Transmission_Properties Class

Specifies the transmission properties of the radar used for the observations.

It includes several optional attributes.

Here is an example of how this class may be included in a label:

```
<radar:Radar>
  <radar:Groundbased_Radar>
    …
    <radar:Transmission_Properties>
     <radar:transmitter_power unit="W">298000<radar:transmitter_power>
    </radar:Transmission_Properties>
   </radar:Groundbased_Radar>
</radar:Radar>
```

4.1.2 The Quality Class

Specifies the quality of the radar observations

For example:

```
<radar:Radar>
  <radar:Groundbased_Radar>
   …
    <radar:Quality>
     <radar:pixel_count>5<radar:pixel_count>
    </radar:Quality>
  </radar:Groundbased_Radar>
</radar:Radar>
```

4.1.3 The Target_Properties Class

Gives pertinent radar properties with respect to the target

For example:

```
<radar:Radar>
  <radar:Groundbased_Radar>
    …
    <radar:Target_Properties>
     <radar:transmitter_to_receiver_lighttime unit="s">1.65830002e+02</
radar:transmitter_to_receiver_lighttime>
    </radar:Target_Properties>
  </radar:Groundbased_Radar>
</radar:Radar>
```

4.1.4 The Sampling_Properties Class

Gives the radar sampling type and rate.

For example:

```
<radar:Radar>
  <radar:Groundbased_Radar>
   …
    <radar:Sampling_Properties>
     <radar:sample_rate>5</radar:sample_rate>
    </radar:Sampling_Properties>
   </radar:Groundbased_Radar>
</radar:Radar>
```

5 Definitions

Groundbased_Radar — class

This class specifies the parameters for radar observations acquired from groundbased facilities.

Member of: Radar

Cardinality: Single, Required

Members:

- Quality
- Sampling_Properties
- Target_Properties
- Transmission_Properties
- observation_purpose

Radar — class

This class specifies the parameters for radar data.

Member of: Discipline_Area

Cardinality: Single, Required

Members:

- Groundbased_Radar

Quality — class

Specifies the quality of the radar observations

Member of: Groundbased_Radar

Cardinality: Single, Optional

Members:

- matched_snr_db
- matched_snr_ratio
- pixel_count

Sampling_Properties — class

Specifies the sampling propertied of the radar observations

Member of: Groundbased_Radar

Cardinality: Single, Optional

Members:

- sample_type
- sample_rate

Target_Properties — class

Specifies the radar properties to the target

Member of: Groundbased_Radar

Cardinality: Single, Optional

Members:

- range_depth_distance
- range_depth_time
- transmitter_to_receiver_lighttime

Transmission_Properties — class

Specifies the transmission properties of the radar system

Member of: Groundbased_Radar

Cardinality: Single, Optional

Members:

- pulse_repetition_frequency
- pulse_repetition_interval
- range_resolution_distance
- range_resolution_time
- transmitter_power

matched_snr_db — attribute

Specifies the total matched-filter signal-to-noise ratio in one run, expressed in db.

Member of: Quality

Cardinality: Single, Optional

Data Type: Real

matched_snr_ratio — attribute

Specifies total matched-filter signal-to-noise ratio in one run, expressed as a ratio.

Member of: Quality

Cardinality: Single, Optional

Data Type: Real

observation_purpose — attribute

Specifies the type of radar experiment performed.

Member of: Groundbased_Radar

Cardinality: Single, Required

Data Type: String

Rules:

- must be one of the following values: 'Doppler', 'Range', 'Range-Doppler', 'Total Power'

pixel_count — attribute

Specifies the number of pixels in an image with measurable signal.

Member of: Quality

Cardinality: Single, Optional

Data Type: Integer

pulse_repetition_frequency — attribute

For repeating waveforms including pulse patterns, it specifies the frequency at which the waveform or pulse pattern repeats.

Member of: Transmission_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: 'THz', 'GHz', 'MHz', 'kHz', 'Hz', 'mHz'

pulse_repetition_interval — attribute

For repeating waveforms including pulse patterns, it specifies the interval from the beginning of one waveform or pulse pattern to the beginning of the next.

Member of: Transmission_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: 'yr', 'julian day', 'day', 'hr', 'min', 's', 'ms', 'microseconds', 'ns'

range_depth_distance — attribute

This is an indicator of the usefulness of the observation for analysis

Member of: Target_Properties

Cardinality: Single, Optional

Data Type: Integer

Rules:

- If range_depth_distance is specified specified, range_resolution_distance must also be specified

- the unit for range_depth_distance must match the unit for range_resolution_distance

- the unit must be one of the following values: 'AU', 'km', 'm', 'cm', 'mm', micrometer', 'nm', 'Angstrom'

range_depth_time — attribute

This is an indicator of the usefulness of the observation for analysis

Member of: Target_Properties

Cardinality: Single, Optional

Data Type: Integer

Rules:

- If range_depth_time is specified specified, range_resolution_time must also be specified
- the unit for range_depth_time must match the unit for range_resolution_time
- the unit must be one of the following values: 'yr', 'julian day', 'day', 'hr', 'min', 's', 'ms', 'microseconds', 'ns'

range_resolution_distance — attribute

The minimum separation distance that can be resolved between two closely spaced targets by a radar in units of distance

Member of: Transmission_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: 'AU', 'km', 'm', 'cm', 'mm', micrometer', 'nm', 'Angstrom'

range_resolution_time — attribute

The minimum separation distance that can be resolved between two closely spaced targets by a radar in units of time

Member of: Transmission_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: ''yr', 'julian day', 'day', 'hr', 'min', 's', 'ms', 'microseconds', 'ns'

sample_rate — attribute

Specifies the interval between the beginning of one time sample and the beginning of the next time sample for a data acquisition system

Member of: Sampling_Properties

Cardinality: Single, Required

Data Type: Real

Rules:

- the unit must be one of the following values: 'THz', 'GHz', 'MHz', 'kHz', 'Hz', 'mHz'

sample_type — attribute

Specifies whether the time samples are real values or complex value pairs obtained simultaneously for a data acquisition system. It does not imply a numeric format. Sample Type is whether the (usually voltage) samples are single real values or a complex number pair (a + ib), which depends on the hardware used. In either case, the numbers themselves can be any numeric type. In raw form, they are usually few-bit integers or pairs of few-bit integers. But they may get converted to floating point in processing if filtering is done in software.

Member of: Sampling_Properties

Cardinality: Single, Required

Data Type: String

Rules:

- must be one of the following values: 'Complex', 'Real'.

transmitter_to_receiver_lighttime — attribute

Specifies the distance from the transmitter, to the target, and back to the receiver at the time of observation, expressed as light time.

Member of: Target_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: ''yr', 'julian day', 'day', 'hr', 'min', 's', 'ms', 'microseconds', 'ns'

transmitter_frequency — attribute

Specifies the transmitter power

Member of: Transmission_Properties

Cardinality: Single, Optional

Data Type: Real

Rules:

- the unit must be one of the following values: 'THz', 'GHz', 'MHz', 'kHz', 'Hz', 'mHz'

transmitter_power — attribute

Specifies the transmitter power

Member of: Transmission_Properties

Cardinality: Single, Required

Data Type: Real

Rules:

- the unit must be one of the following values: 'YW', 'ZW', 'EW', 'PW', 'TW', 'GW', 'MW', 'kW', 'hW', 'daW', 'W', 'aW', dW', 'cW', 'mW', 'microW', 'nW', 'pW', 'fW', 'aW', 'zW', 'yW', 'dBm'