

# Appendix: PDS4 Labels for SWIA CDF Data Files

Description of Archive Data File Structure and PDS4 Metadata

## 1 Introduction

This document describes the data file structure and PDS4 metadata required to describe archive products submitted by the data providers for SWIA. It is an addendum to the full Software Interface Specification (SIS) document.

## 2 CDF Formatted Data Files

Common Data Format (CDF) is a self-describing data format for the storage of scalar and multidimensional data in a platform- and discipline-independent way. It has both library and toolkit support for the most commonly used platforms and programming languages. For the PDS archive, CDF files are required meet CDF-A specification with the PDS extensions [CDF-A]. In addition, the MAVEN mission includes other attributes in the CDF file as defined in the MAVEN archive CDF document [MAVEN CDF].

## 3 CDF and PDS4 Metadata

The PDS4 product label is an XML file that accompanies the CDF file. The PDS4 labels are designed to enable data users to read the CDF files without the use of a CDF reader or any awareness that the data are stored in a CDF file. Since the data consist of multiple data parameters (arrays) which have very specific relationships, the label describes both the physical structure of the data file, as well as the logical relationships between data parameters. This section describes the approach used to document both the physical structure and logical relationships.

### 3.1 PDS Label Structure

The PDS label is subdivided into a series of separate sections or “areas”. Metadata describing the data parameters and their relationships are located in different areas of the label. Data parameters in the label are assigned a “local\_identifier” and this identifier is referenced in the descriptions of the logical structure. A complete PDS4 label contains many areas. In this section we concentrate only on the areas which describe the physical structure and the logical relationships.

#### 3.1.1 PDS Label Physical Structure Description

The physical structure of the data files are described in the “File\_Area\_Observational” portion of the label. Each data parameter is described using an “Array” object. The Array object contains location, data type, size, and descriptive information for each parameter. An

“Axis\_Array” object is provided for each axis of an array. Axis\_Array includes an “axis\_name” which is either set to the name of the CDF value associated with the axis or to the value “index” if the parameter is itself an independent variable. For each Array the “name” is the name assigned to the parameter (“variable” in CDF terms) in the CDF file. This is also assigned to “local\_identifier” since a variable name is unique within a CDF. Figure 1 contains sample Array objects.

```

<Array>
  <name>epoch</name>
  <local_identifier>epoch</local_identifier>
  <offset unit="byte">17477</offset>
  <axes>1</axes>
  <axis_index_order>Last Index Fastest</axis_index_order>
  <description>Time, start of sample, in TT2000 time base</description>
  <Element_Array>
    <data_type>IEEE754MSBDouble</data_type>
    <unit>ns</unit>
  </Element_Array>
  <Axis_Array>
    <axis_name>index</axis_name>
    <elements>5387</elements>
    <sequence_number>1</sequence_number>
  </Axis_Array>
</Array>
.
.
.
<Array>
  <name>diff_en_fluxes</name>
  <local_identifier>diff_en_fluxes</local_identifier>
  <offset unit="byte">66373737</offset>
  <axes>4</axes>
  <axis_index_order>Last Index Fastest</axis_index_order>
  <description>Calibrated Differential Energy Flux</description>
  <Element_Array>
    <data_type>IEEE754MSBSingle</data_type>
    <unit>ev/[eV cm^2 sr s]</unit>
  </Element_Array>
  <Axis_Array>
    <axis_name>epoch</axis_name>
    <elements>5387</elements>
    <sequence_number>1</sequence_number>
  </Axis_Array>
  <Axis_Array>
    <axis_name>phi_coarse</axis_name>
    <elements>16</elements>
    <sequence_number>2</sequence_number>
  </Axis_Array>
  <Axis_Array>
    <axis_name>dindex</axis_name>
    <elements>4</elements>
    <sequence_number>3</sequence_number>
  </Axis_Array>
  <Axis_Array>
    <axis_name>energy_coarse</axis_name>
    <elements>48</elements>
    <sequence_number>4</sequence_number>
  </Axis_Array>
</Array>

```

Figure 1. Sample PDS4 Array objects

### 3.1.2 Parameter Logical Relationships

The Discipline\_Area may contain objects which are specific to a discipline. The logical relationships of parameters is often specific to the types of observations, so is described in the Discipline\_Area. There are two logical relationship in the data products, one consisting of sets of values that are interchangeable and the other for particle observations.

*The Alternate\_Values object is used to indicate parameters which may be used interchangeably with each other. For example, this object may be used to associate multiple time arrays which may be included in the data file. An Alternate\_Values object will contain a series of Data\_Values objects which references a parameter with a Local\_Internal\_Reference. Each of the Data\_Values parameters within a single Alternate\_Values group must have the same dimensions. Figure 2*

contains a sample Alternate\_Values object. The schema for the Alternate\_Values object is defined in the "alt" schema [ALT].

```
<Alternate_Values xmlns="http://pds.nasa.gov/pds4/alt/v0">
  <name>time values</name>
  <Data_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>epoch</local_identifier_reference>
<local_reference_type>data_values_to_data_values</local_reference_type>
    </Local_Internal_Reference>
  </Data_Values>
  <Data_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>time_met</local_identifier_reference>
<local_reference_type>data_values_to_data_values</local_reference_type>
    </Local_Internal_Reference>
  </Data_Values>
  <Data_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>time_unix</local_identifier_reference>
<local_reference_type>data_values_to_data_values</local_reference_type>
    </Local_Internal_Reference>
  </Data_Values>
</Alternate_Values>
```

*Figure 2. Sample Alternate\_Values object.*

*The Particle\_Observation class is used to describe the relationship between (typically) multi-dimensional data and values that are associated with an axis or face of the mutli-dimensional data. In Particle\_Observation the Primary\_Values object identifies the primary data parameter. Each Axis\_Values object in Particle\_Observation associates data with one of the axes for the primary parameter. A Face\_Values object is used to indicate the relationship between multi-dimensional arrays and a face perpendicular to an axis of the primary parameter. In Face\_Values is a Face\_Plane object which indicates which of the primary parameter's axes each of the "face" parameters' axes align with. Each "primary", "axis", and "face" parameter is referenced using the local\_identifier attribute of a Local\_Internal\_Reference. Figure 3*

Figure 3 contains a sample Particle\_Observation object. The schema for the Particle\_Observation object is defined in the "particle" schema [PARTICLE].

```

<Particle_Observation xmlns="http://pds.nasa.gov/pds4/particle/v0">
  <name>counts</name>
  <description>Raw Instrument counts</description>
  <Primary_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>counts</local_identifier_reference>
    </Local_Internal_Reference>
  </Primary_Values>
  <local_reference_type>particle_observation_to_observation_values</local_reference_type>
  <Axis_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>epoch</local_identifier_reference>
    </Local_Internal_Reference>
  </Axis_Values>
  <Axis_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>phi_coarse</local_identifier_reference>
    </Local_Internal_Reference>
  </Axis_Values>
  <Axis_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>dindex</local_identifier_reference>
    </Local_Internal_Reference>
  </Axis_Values>
  <Axis_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>energy_coarse</local_identifier_reference>
    </Local_Internal_Reference>
  </Axis_Values>
  <Face_Values>
    <Local_Internal_Reference>
      <local_identifier_reference>theta_coarse</local_identifier_reference>
    </Local_Internal_Reference>
  </Face_Values>
  <Face_Plane>
    <face_axis>3</face_axis>
    <face_axis>4</face_axis>
  </Face_Plane>
</Particle_Observation>

```

Figure 3. Sample Particle\_Observation object.

### 3.1.3 Constant Values

In some cases constants have been included as data parameters in the data files. These parameters are labeled in the File\_Area\_Observational as degenerate arrays (i.e. an array with a single axis, which contains a single element). The Mission\_Area provides the values of constant parameters included in the data file. This information is provided in a “Parameter” object. Figure 4 contains sample Parameter objects.

```
<Parameter>
  <name>geom_factor</name>
  <description>Full Analyzer Geometric Factor</description>
  <value>0.0056</value>
</Parameter>
<Parameter>
  <name>de_over_e_coarse</name>
  <description>Coarse DeltaE/E</description>
  <value>0.15</value>
</Parameter>
```

*Figure 4. Sample Parameter objects.*



## 4 References

*CDF Internal Format Description, Version 3.4.* (2012, February 28). Retrieved from NASA/Goddard Space Flight Center/Space Physics Data Facility/CDAWeb: <http://cdaweb.gsfc.nasa.gov/pub/software/cdf/doc/cdf34/cdf34ifd.pdf>. PDS product LID = urn:nasa:pds:gsfc.spdf.cdf:document:cdf34ifd.

Halekas, J.S., MAVEN SWIA PDS Archive SIS, Rev. 1.2, 30 Jan 2013, PDS product LID = urn:nasa:pds:maven.swia.calibrated:document:sis

MAVEN CDF, Archive of MAVEN CDF in PDS4, Ver. 4, 15 Apr 2015, PDS product LID = usn:nasa:pds:maven:document:maven-cdf-pds4

CDF-A Specification, Version 1.0, <http://ppi.pds.nasa.gov/doc/CDF-A-Specification-v1.0.pdf>

ALT, Alternative Values Schema, Version 0.0.1, PDS product LID = urn:nasa:pds:system\_bundle:xml\_schema:alt-xml\_schema

PARTICLE, Particle Observation Schema, Version 0.0.1. PDS product LID = urn:nasa:pds:system\_bundle:xml\_schema:particle-xml\_schema