Data Providers Handbook

Archiving Guide to the PDS4 Data Standards

Data System Working Group

Jan, 2010

Version 0.101010101

CHANGE LOG

Revision	Date	Description	Author
0.1	Mar 30, 2009	Initial draft based on information collected by the Data System Working Group.	R.Joyner
0.2	Aug 6, 2009	Updated versions of all Classes	R. Joyner
0.3	Jan 3, 2010	Updated versions of all Classes	R. Joyner

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE

This PDS Data Providers Handbook (DPH) serves as a guide for the preparation of PDS4 compliant data intended for submission to the Planetary Data System (PDS). This document is to be used, in conjunction with the PDS Standards Reference and the Planetary Science Data Dictionary, for preparing a data set that meets the PDS4 archive criteria.

Note: This document is currently in draft form and contains sparse content in certain sections as well as transitional verbiage to aide in the flow of the document. These issues and others will be addressed in subsequent versions of the document.

1.2 AUDIENCE

This document is intended for scientists and engineers in the planetary science community who are in the process of submitting restored or new mission data to the PDS. While this document is applicable to all such submissions, for simplicity most of the discussions are couched in terms of mission/instrument submissions.

PDS has evolved new PDS4 requirements and standards for archival quality data to ensure that the data it provides to users in the science community are complete, accurate, and easily accessible. This manual is intended for all types of data suppliers and developers working with PDS.

1.3 DOCUMENT SCOPE

The information included here addresses the requirements of the PDS4 archive standards. Throughout this document are references to Version 4.0 of the Planetary Data System Standards Reference that addresses the data preparation requirements for preparing data sets that meet PDS4 archive standards.

1.4 DOCUMENT OVERVIEW

This version of the PDS Data Providers Handbook reflects a major revision in the data preparation and submission process. The PDS4 requirements, standards and procedures presented herein reflect the most recent updates to the PDS4 architecture [1].

This document collects the most important concepts with good examples of current practice and guides the new archivist through the forest of Planetary Data System standards, mission requirements, and general good sense to an archive that is both achievable and of high quality.

This document provides examples of a small subset of the allowed possibilities. The examples illustrated are thought to be the most common and adaptable.

1.5 APPLICABLE DOCUMENTS

1.5.1 CONTROLLING DOCUMENTS

1) Planetary Data System (PDS) PDS4 Information Model Specification, Version 0.09xxxxx.

1.5.2 REFERENCE DOCUMENTS

1) Planetary Data System (PDS) Standards Reference, February 27, 2009, Version 3.8, JPL D-7669, Part 2.

2) Planetary Data System Archive Preparation Guide (APG), August 29, 2006.

2.0 OVERVIEW

PDS is in a multi-year process to develop and deploy a major modernization of its entire archive and distribution system. The result is referred to as PDS version 4, or simply, PDS4.

This document provides information to assist data suppliers in the preparation of data for archiving under the PDS4 standards. In previous versions, the Standards Reference included substantial ancillary and tutorial information. Under PDS4 the Standards Reference remains the definitive source for PDS archiving, but that document is designed strictly as a reference. Tutorial information is provided in this document and other ancillary documents.

Among the goals of the redesign of the PDS archive system embodied in PDS4 are:

- improve efficiency and reduce costs in the data submission process,
- increase the robustness and integrity of data in the archive,
- simplify the location and retrieval of data from the archive,
- enhance value added services to end users.

The key principles underlying the development of PDS4 are:

- Data visualization and analysis software change relatively frequently. Formats optimized for such software generally are not optimal for archiving.

- Conversely, data structures optimized for archiving should be simple, rigidly controlled, and projected to be stable for extended periods. Such structures are in general less convenient for data visualization and analysis.

- Documents and software should be treated the same as any other data.

- The data system should be able to identify and retrieve individual objects and to identify all of the relevant associated with the object.

- The approach PDS has taken is to archive data in a few highly constrained, simple data structures which are projected to be stable for decades. Over the long term this will benefit PDS, and equally importantly data submitters, who will be able to access easy to use standards and to design stable pipelines.

- To provide broad support for end user communities, PDS will enhanced search capabilities and will develop software to convert between archive formats and current, widely used visualization and analysis formats.

3.0 PDS4 CONCEPTS

This section introduces key terms and concepts as they are used within the PDS. The internal meanings of several key phrases and/or concepts are presented to facilitate a clear and concise communication between the PDS and the archivist. Appendix B provides more technical definitions.

3.1 PDS4 BUILDING BLOCKS – THE PRIMARY PIECES

3.1.1 PDS4 BASE STORAGE STRUCTURES

PDS uses four base storage structures. The four structures are:

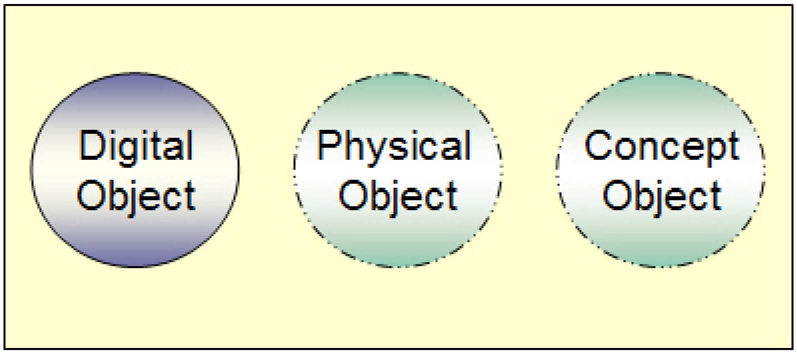
- Array_Base - Homogeneous N-dimensional array of scalars
- Table_Base - Heterogeneous repeating record of scalars
- Unencoded Stream Base
- Encoded Stream Base

These are described in more detail later in this document. These structures are simple, stable structures which are rigidly defined by PDS. The key point is that everything that goes into the archive must be stored using these structures.

3.1.2 PDS4 OBJECT

Object:

Can be either a Digital Object or a Physical Object or a Conceptual Object.



An example of a Digital Object is the sequence of bits that comprise a Table or an Image or a Document or a piece of Software. For an Image, the object is the image itself (exclusive of any associated items such as a header or histogram table each of which is also an object).

An example of a Physical Object is a spacecraft or moon rock. An example of a Conceptual Object is a Mission or Node. These latter two types of Objects are "intrinsic" in the sense that they exist and are in need of being described in such a manner that they can be referenced and associated with objects in the archive. Clearly, neither Physical or Conceptual Objects will actually be stored in the archive.

3.1.3 PDS4 OBJECT DESCRIPTION

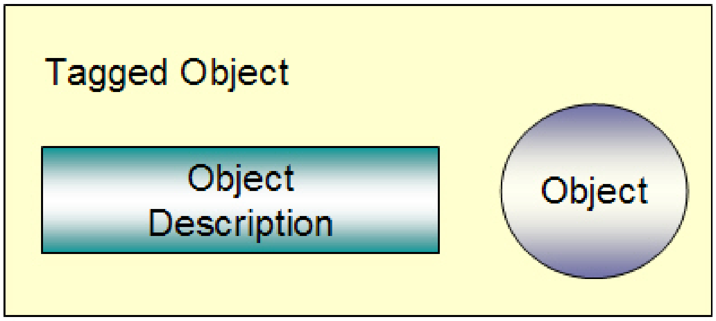
Object Description:

The Object Description is the collection of metadata (information about the data) that maps an Object into more meaningful concepts (e.g., Image, Table, Mission, Spacecraft). For an Image such metadata would include information such as the number of lines and samples, the filter used, time of observation, etc. The Object Description is expressed in XML as part of a PDS Label.

3.1.4 PDS4 TAGGED OBJECT

Tagged Object:

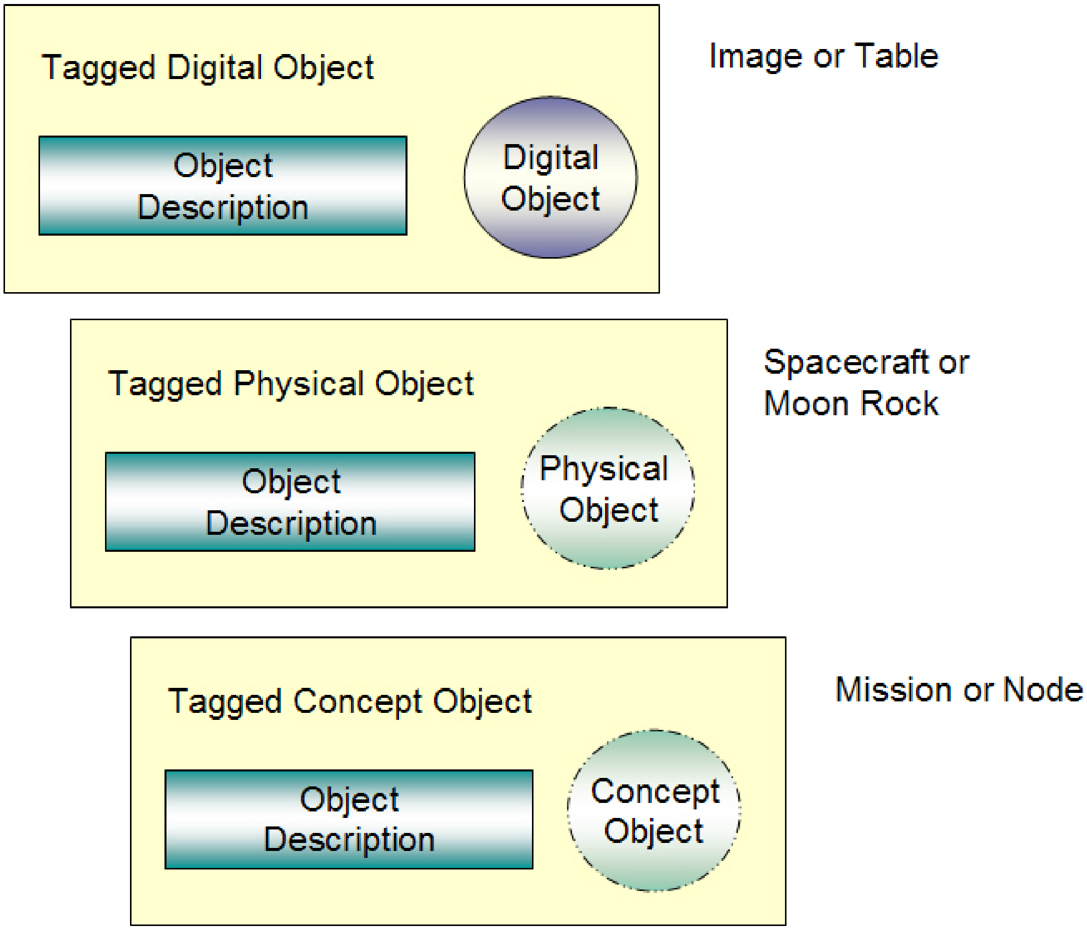
An Object Description and an associated Object form a Tagged Object.



3.1.5 PDS4 TYPES OF TAGGED OBJECTS

Types of Tagged Objects:

There are three types of Tagged Objects. The type of Tagged Object being described is dependent upon which type of Object is being described - Physical Object, or a Digital Object or a Conceptual Object.



3.1.6 PDS4 PRODUCT

Product:

A Product consists of Identification Information and one or more associated Tagged Object(s). Products are “identifiable”. An identifiable has a globally unique immutable identifier. The globally immutable identifier permits the “product” to be located and retrieved by a single query against any federated registry system, of which PDS4 is one.

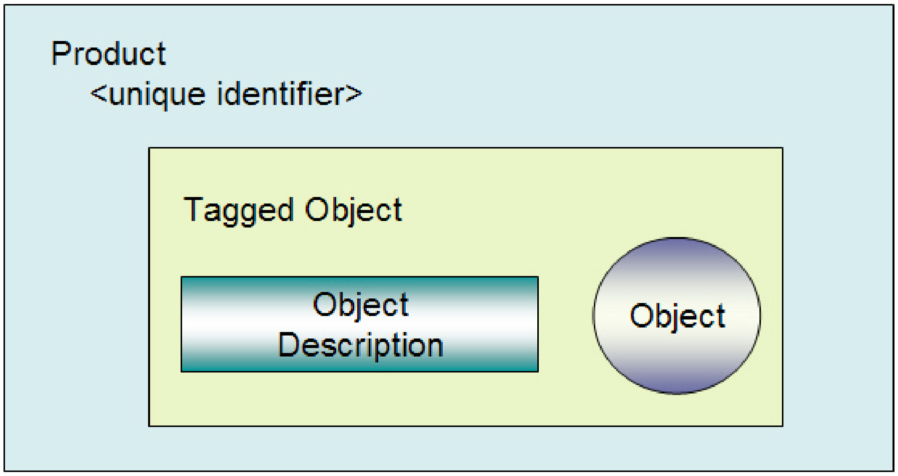
Products come in a couple of different types:

- Simple Product
- Compound Product

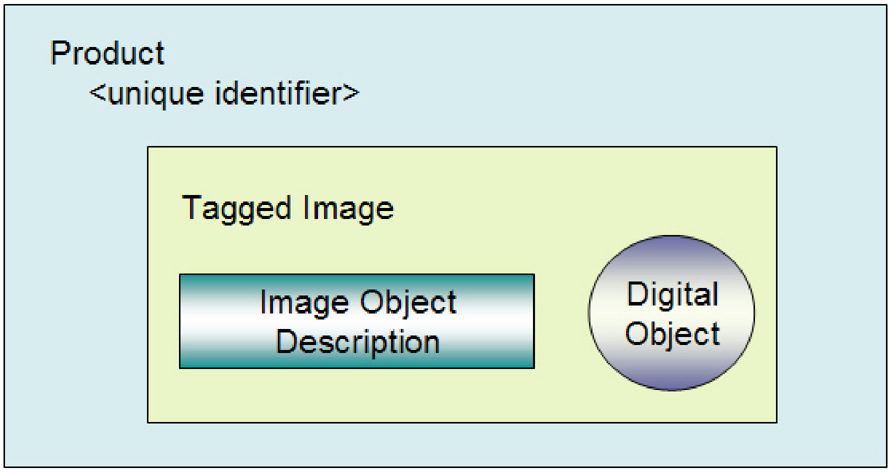
The following diagrams illustrate how products can be described. The following are only representative of possible types of product that can be described and are not encompassing of all possible types of products that can be described within a PDS archive:

- Simple Product
- Simple Image Product
- Compound Product
- Compound Image Product
- Compound Document Product
- Sets of Products

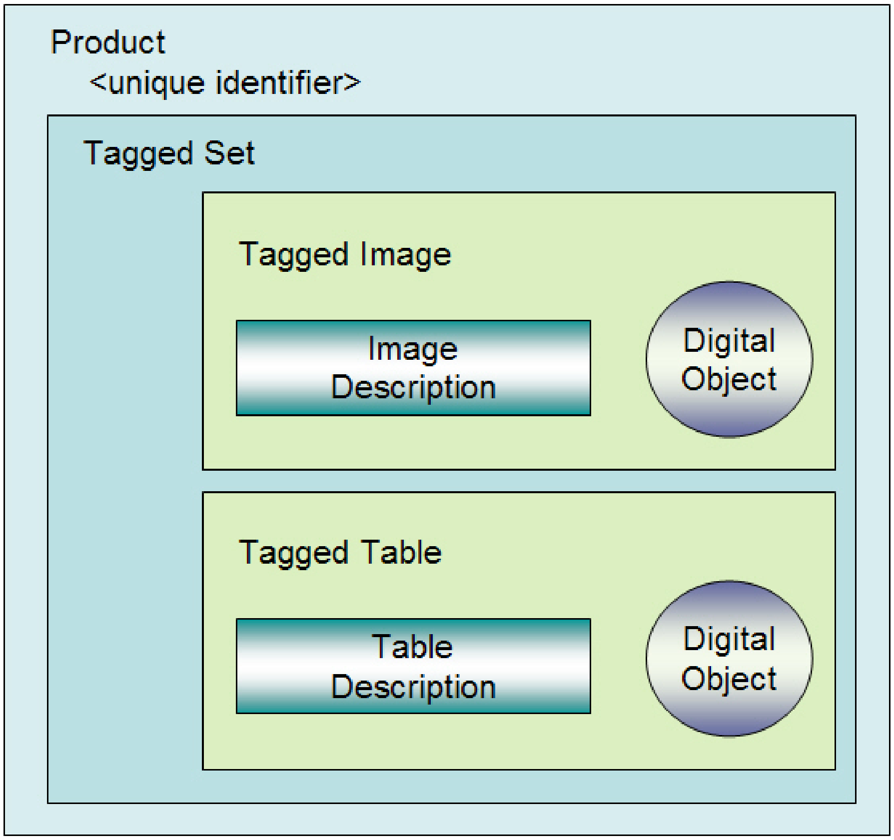
Simple Product



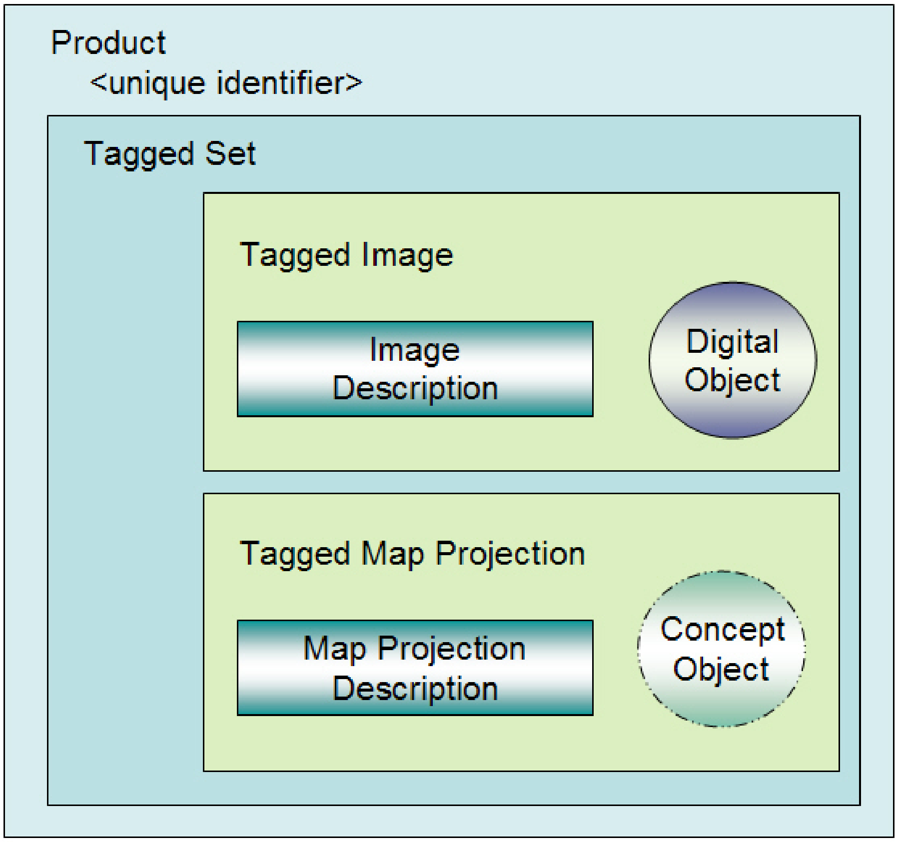
Simple Image Product

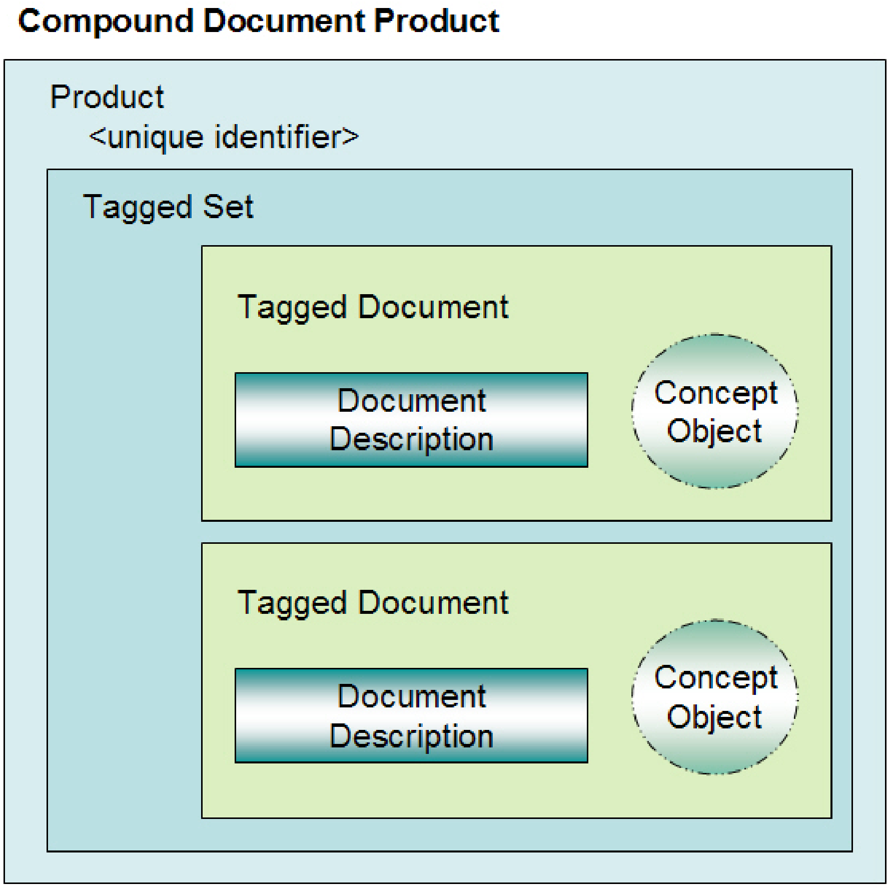


Compound Product



Compound Image Product

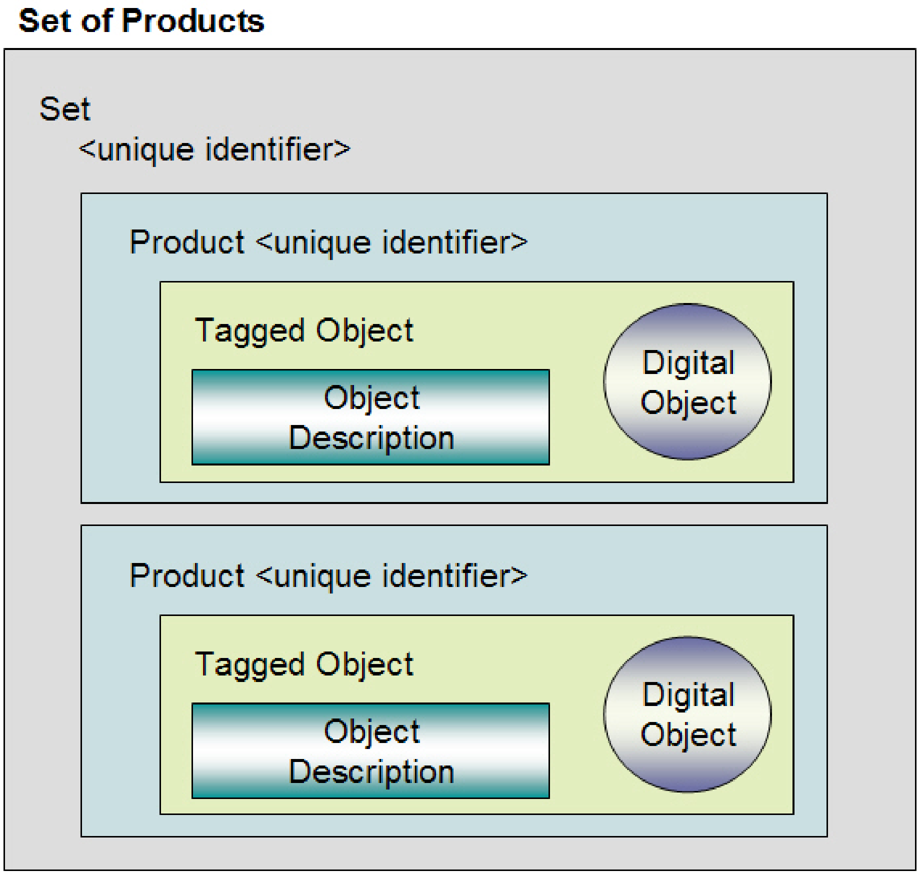




3.1.7 PDS4 SETS OF PRODUCTS

Sets of Products:

Products can be grouped into Sets of Products.



3.1.8 PDS4 LABEL

Label:

The PDS label contains all of the metadata associated with an object including structural parameters associated with the relevant base storage structure, and the full object description for each object in the data product.

3.1.9 PDS4 XML

XML:

PDS uses XML as the underlying language for the data system. It is beyond the scope of this document to provide a full tutorial for XML. PDS uses XML to generate a generic XML schema for each object class. Each schema is generated from the PDS governing documents to ensure their use will produce PDS4 compliant products. The use of schemas and XML to generate labels is outlined later in this document.

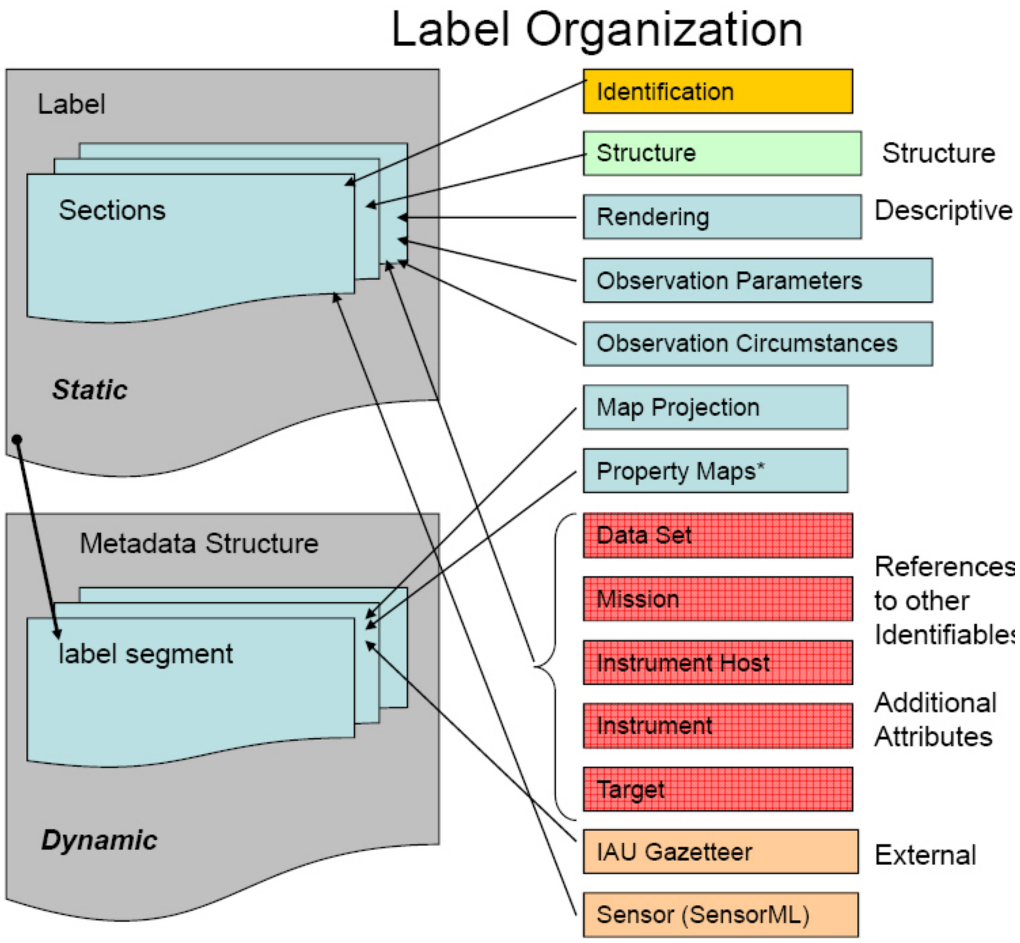
For a simple example of some of these concepts, consider a FITS image with a single ASCII table extension. The FITS image file will have four pieces, the primary header describing the image, the image, a secondary header describing the table, and the table.

Under PDS4, each of the four pieces is an object. The PDS data product will consist of the FITS image file and a PDS4 label with four object descriptions.

Each of the four objects conforms to one of the base storage structures. The headers are archived as Unencoded Byte Streams, the image as an Array_Base, and the ASCII table as a Table_Base.

3.2 THE LOGICAL ORGANIZATION

TBD



3.2.1 TYPES OF DATA

TBD – include the various types of dataType classes and where they are described in detail (similar to Appendix C in StdRef)

3.3 ASSOCIATING ONE PIECE WITH ANOTHER

TBD

3.4 PACKAGING FOR DELIVERY TO THE PDS

TBD

3.5 THE CONCEPT OF CARDINALITY

CARDINALITY:

> Cardinality of a set is a measure of the "number of elements" in the set. For example, the set A= {1,2,3} contains 3 elements, and therefore A has a cardinality of 3.

PDS3 adopted the use of "required" and "optional" to specify the relationship between sets of objects and elements. Object-A required Object-B but could optionally include Object-C. In turn, Object-A required Element-A and Element-B but could optionally include Element-D or Element-E).

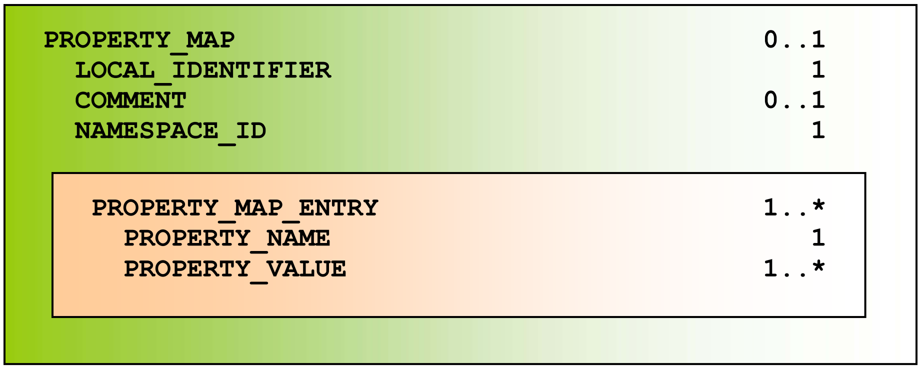
PDS4 has elected to adopt the concept of "cardinality" which allows PDS to specify the above releationships at a lower level of granularity. Cardinality allows the parent-child relationships to be defined more acutely.

Through out this document are diagrams that depict parent-child relationships using the cardinality nomenclature. Table 3-1 provides a description of the cardinality nomenclature used within the diagrams in this document.

Cardinality	***Desciption***
0..1	Within the context of the parent, the child may optionally exist as a single non-repeating instance
0..*	Within the context of the parent, the child may optionally exist as an ubounded repeating instance
1	Within the context of the parent, the child must exist once and only once
1..*	Within the context of the parent, the child must exist once, but may exist an unbounded number of times
2	Within the context of the parent, the child must exist twice and only twice
2..*	Within the context of the parent, the child must exist twice, but may exist an unbounded number of times

Figure 3-1. Cardinality Nomenclature

The following is an example diagram that illustrates the parent-child relationship using cardinality nomenclature.



```
PROPERTY_MAP                                      0..1
  LOCAL_IDENTIFIER                                   1
  COMMENT                                         0..1
  NAMESPACE_ID                                       1

   PROPERTY_MAP_ENTRY                             1..*
     PROPERTY_NAME                                   1
     PROPERTY_VALUE                               1..*
```

With respect to the above example:

1. The parent class, the PROPERTY_MAP class, is comprised of a single sub-class, the PROPERTY_MAP_ENTRY class.
2. The PROPERTY_MAP_ENTRY class must exist once but may exist many times within the context of the parent PROPERTY_MAP class.
3. The parent PROPERTY_MAP class is comprised of two required non-repeating data elements (e.g., LOCAL_IDENTIFIER and NAMESPACE_ID) and a single optional non-repeating data element (e.g., COMMENT).
4. The PROPERTY_MAP_ENTRY class is comprised of a single required non-repeating data element (e.g., PROPERTY_NAME) and a single required repeating data element (e.g., PROPERTY_VALUE).

4.0 PDS4 DATA REPRESENTATION

Data can be an elusive concept. Data may exist in some storage format on some disk somewhere, on paper somewhere else, in active memory on some server, or transmitted along some wire between two computers. All these can still represent the same data. That is, there is an important distinction to be made between the data and its representation. The data consist of numbers: abstract entities that usually represent measurements of something, somewhere. Data also consist of the relationships between those numbers, as when one number defines a time at which some quantity was measured.

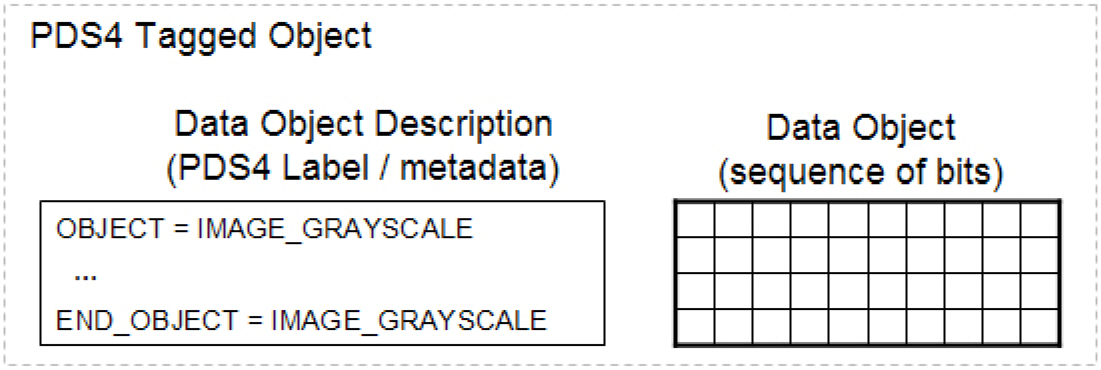
The abstract existence of data is in contrast to its concrete representation, which is how the data is viewed, manipulated, and stored. Data can be stored as BCD numbers in a file on a disk, or as twos-complement integers in the memory of some computer, or as numbers printed on a page. It can be stored in netCDF, HDF, JGOFS, a relational database and any number of other digital storage forms.

The PDS specifies a particular representation of data, to be used in archiving that data. This “archival” representation distinguishes it from the representations used in some computer’s memory (i.e., how the data is stored or represented on either the sending or receiving computer; or the transmission format used to communicate between the two servers).

For this document, we identify two special types of objects -- the "data object" and the "data object description." The data object contains "data," and (by itself) is not otherwise constrained. The data object description contains information about another object, such as a data object. By linking a data object with a data object description, we create a pair which includes both the data and enough information that we can start to read and interpret the bits --- a PDS Tagged Object.

A data object description can (and often does) exist without being physically accompanied by another object. The object it describes may not be physical (e.g., a space mission which, although it has physical components, is itself a concept) or it may not be practical to include the physical object (e.g., the planet Saturn).

Note that within the context of this document, of three types of data objects (digital, conceptual, and physical), we will only address “digital data objects”.



At its simplest, a PDS4 Tagged Object consists of a PDS4 Data Object Description (e.g., a PDS4 Label) and a "digital" Data Object (e.g., sequence of bits) that are described by the metadata resident in the PDS4 Label. The Data Object Description describes both the physical and logical structure of the referenced Data Object.

4.1 PDS4 DATA STRUCTURES

PDS4 defined four new basic types of data structures for the purposes of describing data objects. All current PDS4 digital object classes fall into one of the four basic data structures.

1. Array_Base - Homogeneous N-dimensional array of scalars

Homogeneous N-dimensional array of scalars -- describes a collection of "items" of the same type. Every "item" takes up the same size block of memory, and all blocks are interpreted in exactly the same way (i.e., the number of "items" in an array is fixed by that specified by the size of its dimension). How each "item" in the array is to be interpreted is specified by a separate data-type class, of which one is associated with every array (i.e., the "items" in an array are represented by an identical storage format – MSB_INTEGER_4_BYTE, MSB_INTEGER_2_BYTE, etc).

An instance of the Array_Base class consists of a collection of contiguous one-dimensional segments of memory (owned by the array), combined with an indexing scheme that maps the "items". How many bytes in each "item" and how the bytes are interpreted is defined by the data-type class associated with the array (i.e., basic constraints on storage order, element types, and maximum number and length of axes are defined by the data-type class).

Example Classes:
- Image_Grayscale
- 3D Image

2. Table_Base - Heterogeneous repeating record of scalars

Heterogeneous repeating record of scalars -- describes a collection of "items" where the "items" characteristics may vary within a row of "items". Every column of "items" takes up the same size block of memory, and all blocks are interpreted in exactly the same way (i.e., the number of “items” in an array is fixed by that specified by the size of its dimension). How each "item" in the table is to be interpreted is specified by a separate data-type class, of which one is associated with every array (i.e., the “items” in an array are represented by various storage formats – ascii_integer, integer, ascii_real, real, etc).. The term record is used here to denote a data structure whose elements have heterogeneous data types.

An instance of the Table_Base class consists of a collection of contiguous one-dimensional segments of memory (owned by the table), combined with an indexing scheme that maps the "items". How many "items" in each row, how many bytes in each "item" and how the bytes are interpreted is defined by the data-type class associated with the table (i.e., basic constraints on storage order, element types, and number and length of rows are defined by the data-type class).

Example Classes:
- Binary table
- Character table

3. Unencoded Stream Base

Unencoded stream base -- describes a collection of "items" where the "items" are interpreted without any character encoding (e.g., ASCII character set).

An instance of the Unencoded_Stream_Base class consists of a contiguous stream of ASCII characters, combined with a field_delimiter scheme that maps the "items". How many "items" in each record, how the bytes are interpreted is defined by the data-type class associated with the unencoded_stream_base (i.e., basic constraints on number of fields in a record, element types, and the number of records are defined by the data-type class).

Example Classes:
- CSV_file
- Header

4. Encoded Stream Base

Encoded stream base -- describes a collection of "items" where the "items" are interpreted in accordance with a recognized International Standard (e.g., JPEG_2000).

Example Classes:
- SPICE_Kernel

4.2 PDS4 DATA PRODUCT DESCRIPTION

TBD

5.0 PDS4 PRODUCT LABEL SCHEMA

This section introduces the concept of a product label schema and how a schema is used in the process of designing, generating, and validating the products in your archive.

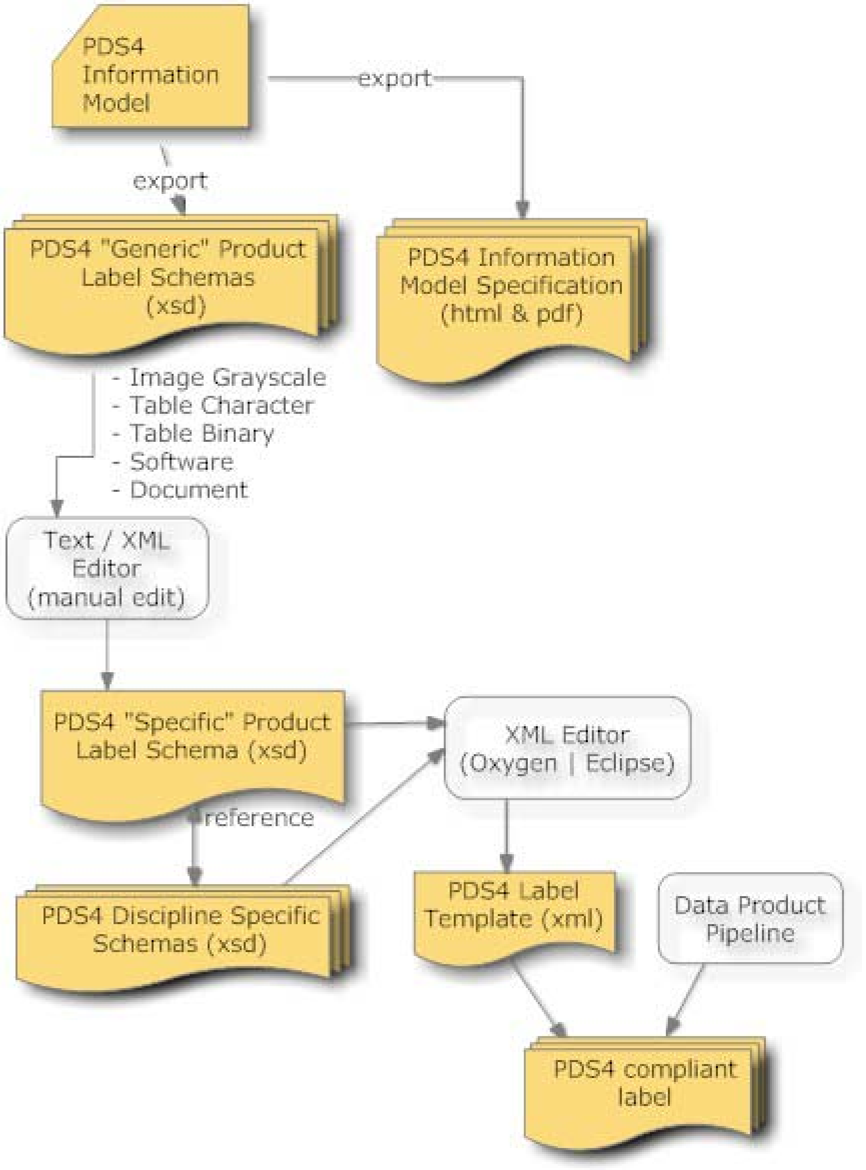


Figure 5-1. Diagram of the Lifecycle of a Product Label Schema

Once data products have been identified for archiving, the initial step of designing a data product should have been defined by science requirements. In most cases, the structure of the data was probably determined before your instrument was selected for the mission. The structure of the underlying data is typically obvious (e.g., table or image structure).

- TABLE - a uniform collection of ROWs and COLUMNs stored in either ASCII or binary format. ASCII forms are easily imported into a variety of spreadsheet and database applications.

- IMAGE - a two dimensional array of spatially organized measurements (LINES and SAMPLES). Many public domain image display programs can read PDS Image objects.

PDS has created sets of base product label schemas that address all of the envisioned PDS4 structures. Your first step is to select, from the set of PDS4 “Generic” Product Label Schemas, the schema that most closely represents your data product (e.g., Image Grayscale, Table Character, Table Binary, etc).

The next step is to review the “Generic” Product Label Schema and to tailor this schema to be more specific to the product that you want to archive with the PDS. The process by which the “Generic” schema is tailored to become the “Specific” schema is, at least at this point, a manual process. Expect several iterations and use the assistance of your PDS representative.

Note that both the “Generic” and “Specific” schemas are in fact an XML Schema; aka an XML Schema Document (XSD) – a document written in the XML schema language. Like all XML schema languages, XSD can be used to express a set of rules to which an XML document must conform in order to be considered “valid” according to that schema. XSD was also designed with the intent that determination of a document’s validity would produce a collection of information adhering to specific data types.

The “Specific” schema represents the overall structure and format of the archived data product. The “Specific” schema defines, in the strictest sense, the greatest latitude permissible in the validation of the product label to ensure PDS compliance.

The “Specific” schema is also the building block upon which a label template can be derived. Most XML Editors provide a capability to “export / create” an XML label from an XSD. This label template when used in conjunction with your data-product pipeline will generate the individual data-product labels. The PDS can offer suggestions for automating the process of generating labels; including, the use of PDS tools. Whether they use the term or not, instrument teams will need to develop a 'pipeline' for handling mission data. The pipeline begins with data collection (as from a telemetry stream) and ends with generation of standard products. Except for a few ancillary documents, the pipeline will provide most of the products you will need for your archive.

Even if you fully exploit the pipeline, there will be validation steps that will be unique to the archive. Validating the data product labels is where the data product schemas become invaluable. The use of XML in data product labels and in schemas provides an expedient method by which your pipeline can ensure your product labels are PDS compliant. The PDS can offer suggestions for automating the validation process; including, the use of PDS tools.

PDS has tools that can assist you in data validation. (Note: Consult your PDS rep to obtain the latest versions of validation tools and for assistance in effective use of them.) For example, there are tools that scan each directory to check that you have all of the expected pieces in place. Other tools provide convenient ways for you to check that individual products meet PDS archiving Standards while you are debugging the software that creates them. After the initial products have been validated, you will need to validate the pipeline software after each software upgrade and make occasional spot checks during production.

5.1 RESTRICTIONS IN TAILORING SCHEMAS

TBD

5.2 BUILDING AND USING LOCAL DATA DICTIONARIES

TBD

5.3 EXAMPLE RELATIONSHIP OF SCHEMAS TO LABELS

This section illustrates the lifecycle process of the “generic” and “specific” product label schemas and how they relate to the label template and the resulting product labels. The above is demonstrated by using an example PDS3 data product.

The example product is a simple ASCII table that is currently in the PDS3 archive.

- MGS-M-RSS-5-TPS-V1.0: A radio science data set that seems to consist of well-behaved ASCII tables with little or no additional keywords beyond those in a basic label. There are two tables in each label, but both tables are in the same file (one is a single line of header parameters).

The files that describe both the PDS3 and the PDS4 data products can be found at:

- PDS3 ODL Label: http://tbd
- PDS3 data product: http://tbd

- PDS4 XML Label: : http://tbd
- PDS4 XML Label template: : http://tbd
- PDS4 Generic Schema: : http://tbd
- PDS4 Specific Product Schema: : http://tbd
- PDS4 Specific Data_Set Schema: : http://tbd

Note that at this time, the above examples are out of date with the current information model and therefore do not provide an exact representation of the current schemas.

Step #1: Select, from the set of PDS4 "Generic" Product Label Schemas, the schema that most closely represents your data product (e.g., Image Grayscale, Table Character, Table Binary, etc)

Step #2: Download the "Generic" Product Label Schema from:

`http://pds/schema/pds4/common/`

Step #3: Make a copy of the "Generic" Product Label Schema and save the copy as the "Specific" Product Label Schema.

Step #4: Examine the as yet unmodified "Specific" Product Label Schema in your favorite XML editor (e.g., Oxygen or Eclipse). You may also examine the schema in a text editor (e.g., UltraEdit, BBEdit, etc). Ensure that the XML is fully formed (i.e., the XML editor will validate the XML and will have an indicator (which is usually a green or red box) that indicates if errors are present in the XML).

Note that if there are errors in the XML schema, contact your PDS representative for further instructions on how to resolve any discrepancies.

Step #5: Use the editor to tailor this schema to be more specific to the product that you want to archive with the PDS. The "Specific" schema represents the overall structure and format of the archived data product. The "Specific" schema defines, in the strictest sense, the greatest latitude permissible in the validation of the product label to ensure PDS compliance.

Examples of types of "edits / restrictions" that might be appropriate with respect to the specific schema; include:

1) Restrict the set of all possible target names to a single value (e.g., MARS).

2) Restrict the instances in the File_Area_Type to a single reference to the type of file being described (i.e., in our example we are describing a character table having fixed length records – so we would remove all instances except the reference to File_Character_Fixed).
3) As our example table product does not have any “Statistics”, remove all references to Object_Statistics_Type
4) As our example table product does not have any “Special Constants”, remove all references to Special_Constants_Type.

Expect several iterations and use the assistance of your PDS representative.

Step #6: Save the edited / tailored “Specific” Product Label Schema.

Step #7: Most XML Editors provide a capability to “export / create” an XML label from an XSD. You will want to use this feature to export / create a sample label (which is an XML file) from the “Specific” schema (which is an XSD file). Save the sample label.

Step #8: Examine the sample label in either your favorite XML editor or text editor. Ensure that the XML is fully formed (i.e., the XML editor will validate the XML and will have an indicator (which is usually a green or red box) that indicates if errors are present in the XML. As the sample label was generated by the XML editor, there shouldn’t be any errors. Contact your PDS rep to resolve any discrepancies.

Step #9: Now that you have a “valid” XSD and sample label, we can proceed with creating a data product pipeline that will pump out gazillions of PDS compliant labels.

Validating the data product labels is where the data product schemas become invaluable. The use of XML in data product labels and in schemas provides an expedient method by which your pipeline can ensure your product labels are PDS compliant. The PDS can offer suggestions for automating the validation process; including, the use of PDS tools.

6.0 PDS4 CONCEPT OF "IDENTIFIERS"

PDS4 has defined an "identifier" concept whereby "objects" can be referenced either internally or externally. Each identified "object" is termed an "identifiable". An identifiable has a globally unique immutable identifier. The globally immutable identifier permits the "object" to be located and retrieved by a single query against any federated registry system, of which PDS4 is one.

Examples of "Identifiers" include all types of Products and sets of Products.

- **PUID** – Unique, immutable identifier for an object; e.g. URN
- **Identifier** – PDS wide unique identifier for an object;
- **Logical Identifier** – Unique identifier for the set of all versions of an object; When provided a logical identifier, a service should return, by request, either all versions or the latest version of the object. This is probably the PDS identifier minus any version.
- **Title** (aka Label and Name) – The string (name) displayed to the user when this object is listed in a GUI or report. Not necessarily unique.
- **Alternative** – All known names for this object, past and current.

The following illustrates the "Identifiers" and the associated cardinality that comprise the IDENTIFICATION_AREA of a PDS4 label.

```
IDENTIFICATION_AREA                             1
  PUID                                          1
  IDENTIFICATION_AREA_DATA_SET_ID               1
  PRODUCT_ID                                    1
  VERSION_ID                                    1
  TITLE                                         1
  CREATION_TIME                                 1
  ALTERNATIVE                                0..1
  LOGICAL_IDENTIFIER                            1
```

The primary function of the IDENTIFICATION_AREA of the label is to explicitely specify the identity of the “object” so that the “object” can be located and retrieved globally by a single query against any federated registry system, of which PDS4 is one

The following is an example of an IDENTIFICATION_AREA for an IMAGE_GRAYSCALE object.

```
<Identification_Area>
    <puid>
       URN:NASA:PDS:MPFL-M-IMP-2-EDR-V1.0:PDS4_IMG_IMAGE_GRAYSCALE_ID:V1.0
    </puid>
    <Identification_Area_data_set_id>
       MPFL-M-IMP-2-EDR-V1.0
    </Identification_Area_data_set_id>
    <product_id>IMP_EDR-1246943630-REGULAR-0074051101</product_id>
    <version_id>1.0</version_id>
    <title>MARS PATHFINDER LANDER Experiment</title>
    <creation_time>1998-07-14T00:36:08.000</creation_time>
    <logical_identifier>
      URN:NASA:PDS:MPFL-M-IMP-2-EDR-V1.0:PDS4_IMG_IMAGE_GRAYSCALE_ID
    </logical_identifier>
</Identification_Area>
```

Once the above information has been registered with the PDS, in theory, the “object” can be located and retrieved globally by a single query against the PDS4 federated registry system.

Note that the above conventions for naming “Identifiers” is simply for the purpose of illustrating how to uniquely name “objects”. The actual naming convention will be fully documented at a later time.

7.0 PDS4 DATA PRODUCT CLASSES

7.1 Array_Base – Homogeneous N-Dimensional Array Of Scalars

7.1.1 IMAGE_GRAYSCALE

This section describes the IMAGE_GRAYSCALE extension of the PDS4 Array_Base, (i.e., Homogeneous N-dimensional array of Scalars) class where a contiguous stream of BINARY data, assembled as a two dimensional data structure, maps the "items" contained in a IMAGE_GRAYSCALE file.

This section identifies a mapping of the PDS3 IMAGE object to the PDS4 IMAGE_GRAYSCALE file construct and demonstrates how the byte stream (e.g., sequence of bits) can be described by both a PDS3 label and a PDS4 label.

7.1.1.1 IMAGE_GRAYSCALE Class Description and Schema

Figure 7.1.1-1 depicts a representation of the PDS4 IMAGE_GRAYSCALE class and the associated parent and child classes. The figure additionally lists the cardinality of each parent / child class.

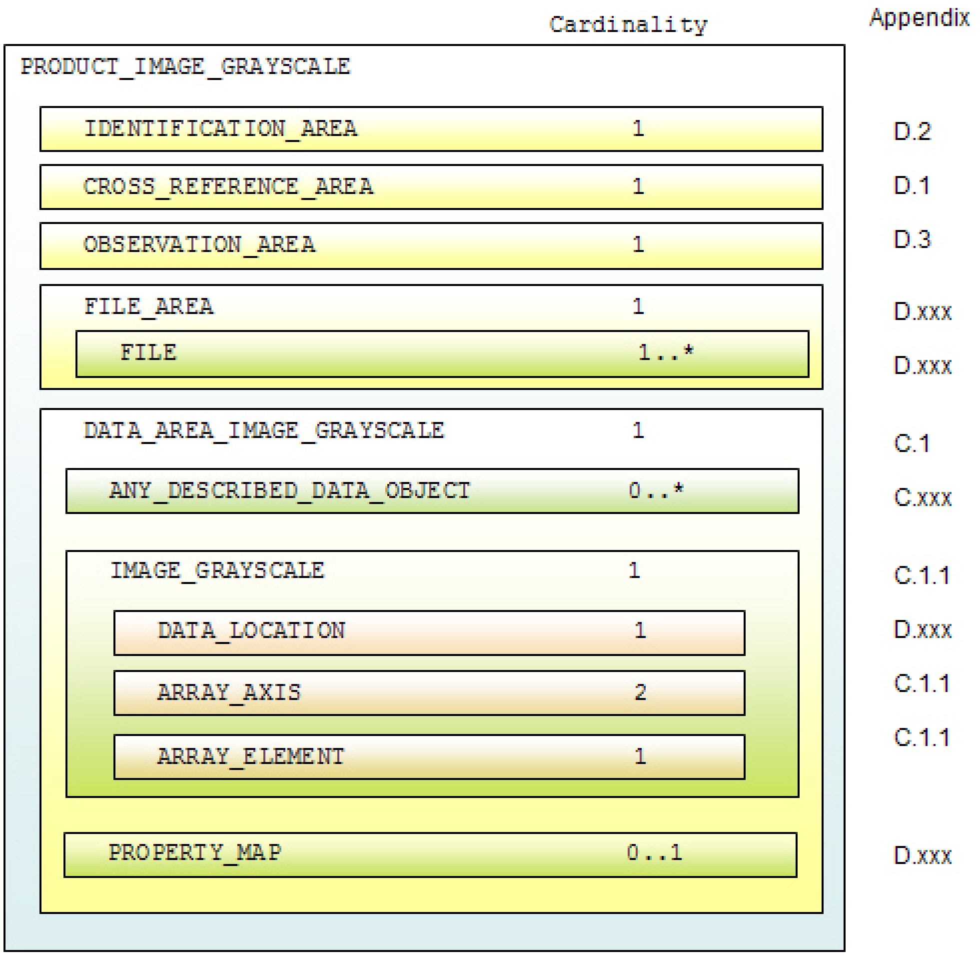


Figure 7.1.1-1. Diagram of the IMAGE_GRAYSCALE Schema

From Figure 7.1.1-1, the overall structure of the IMAGE_GRAYSCALE data product description can be easily discerned and understood. A detailed set of diagrams of the composite classes that comprise the IMAGE_GRAYSCALE data product description can be found in Appendix C and Appendix D.

7.1.1.2 IMAGE_GRAYSCALE Data Product Byte Stream

Figure 7.1.1-2 depicts a representation an IMAGE_GRAYSCALE byte-stream. The first two rows of the diagram are for the purposes of illustrating the byte positions relative to the IMAGE fields and would not normally be contained in a data object description file. The remaining twenty+ rows illustrate a typical IMAGE_GRAYSCALE data object description, where the data object fields are homogeneous in fixed-width ASCII across the rows in the file.

With respect to the data object:

1. There are 248 rows (lines) of data (of which 240+ rows have been omitted from the diagram for ease of reading)
2. There are 256 fields (samples) in each row / record in this example file (of which 240+ have been omitted from the diagram for ease of reading)
3. Each element is identical in type and represented by an identical storage format across all rows in this example file.
4. Each field is comprised of BINARY data formatted as 2-byte msb unsigned integers.
5. There are 512 bytes in each row / record in this example data object file.

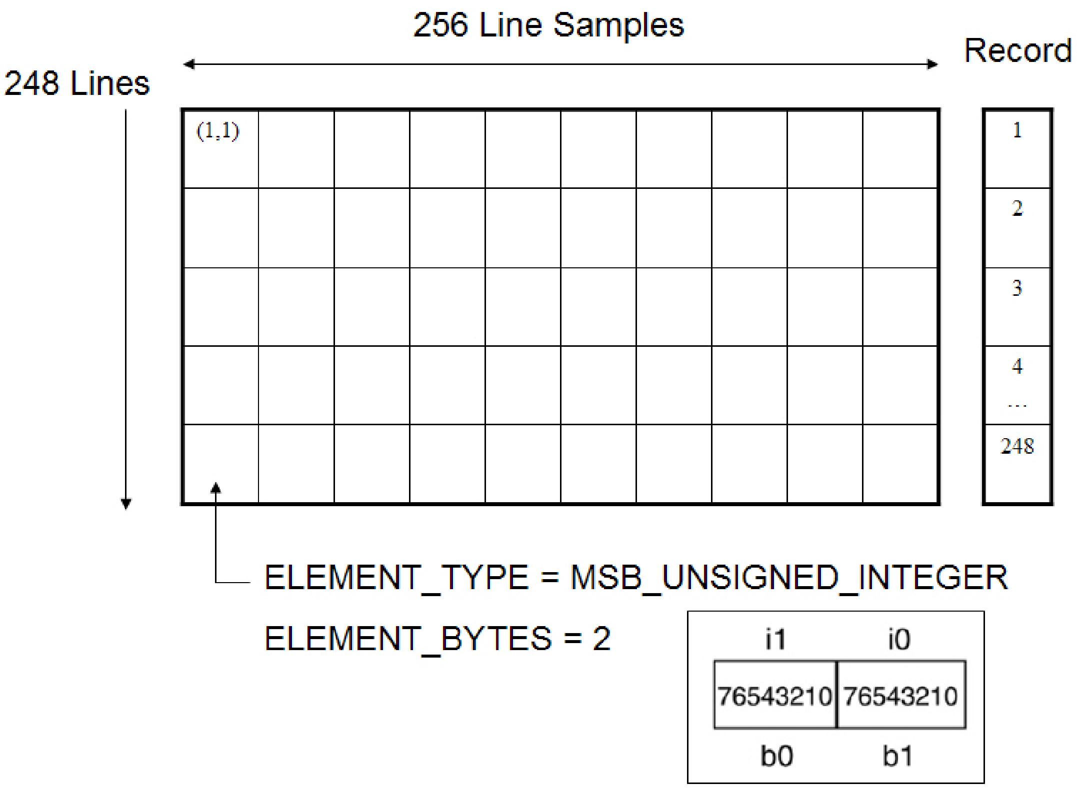


Figure 7.1.1-2. Diagram of the IMAGE_GRAYSCALE Byte Stream

Figure 7.1.1-3. Image as represented by IMAGE_GRAYSCALE Byte Stream

Figure 7.1.1-2 and Figure 7.1.1-3 depict the above IMAGE_GRAYSCALE byte-stream as it would be represented as a 2-dimensional array. This representation is helpful in understanding how the data object fields are represented in the data object description (e.g., PDS4 product label). Specifically that the IMAGE_GRAYSCALE is comprised of two axes each of which have specific attributes that both identify and define the structure of the data object:

```
AXIS_NAME              = ("LINE", "SAMPLE")
NUMBER_OF_AXES         = 2
AXES_ORDER             = FAST2SLOW
AXIS_LENGTH            = (248, 256)
AXIS_SCALE_TYPE        = ("N/A", "N/A")
AXIS_UNIT              = ("N/A", "N/A")
```

With respect to the above example, the axis identified first varies the fastest (i.e., “first subscript fastest” is the default).

Each of the two axes is further comprised of a set of homogeneous fields each identical in type, format, and structure:

```
ELEMENT_BYTES          = 2
ELEMENT_OFFSET         = "N/A"
ELEMENT_SCALING_FACTOR = "N/A”
ELEMENT_TYPE           = MSB_UNSIGNED_INTEGER
ELEMENT_UNIT           = "DATA NUMBER
```

7.1.1.3 IMAGE_GRAYSCALE Label Scheme

This section depicts how the IMAGE_GRAYSCALE byte-scheme, as illustrated above, can be described by both a PDS3 label and a PDS4 label.

The PDS4 IMAGE_GRAYSCALE class is the successor to the PDS3 IMAGE object.

The files that describe both the PDS3 and the PDS4 data products described within this section can be found at:

- PDS3 ODL Label: http://tbd
- PDS3 data product: http://tbd

- PDS4 XML Label: : http://tbd
- PDS4 XML Label template: : http://tbd
- PDS4 Generic Schema: : http://tbd
- PDS4 Specific Product Schema: : http://tbd
- PDS4 Specific “other” Schema(s): : http://tbd

7.1.1.3.1 PDS3 IMAGE_GRAYSCALE Label Scheme

The data product depicted in Figure 7.1.1-2 could be described in PDS3 by use of the IMAGE object:

```
PDS_VERSION_ID                  = PDS3

/* FILE CHARACTERISTICS */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 512
FILE_RECORDS                    = 270

/* POINTERS TO DATA OBJECTS */

^IMAGE                          = "I943630R.RAW"

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                     = "MPFL-M-IMP-2-EDR-V1.0"
DATA_SET_NAME                   = "MPF LANDER MARS IMAGER FOR MARS
                                   PATHFINDER 2 EDR V1.0"
PRODUCER_ID                     = "MIPL OF JPL"
PRODUCER_FULL_NAME              = "ALLAN J. RUNKLE"
PRODUCER_INSTITUTION_NAME       = "MULTIMISSION IMAGE PROCESSING
                                   LABORATORY, JET PROPULSION LAB"
PRODUCT_ID                      = "IMP_EDR-1246943630-REGULAR-0074051101"
IMAGE_ID                        = 74051101
COMMAND_SEQUENCE_NUMBER         = 74
IMAGE_OBSERVATION_TYPE          = REGULAR
FRAME_ID                        = BOTH
MISSION_NAME                    = "MARS PATHFINDER"
INSTRUMENT_HOST_NAME            = "MARS PATHFINDER LANDER"
```

```
INSTRUMENT_NAME                 = "IMAGER FOR MARS PATHFINDER"
INSTRUMENT_ID                   = "IMP"
TARGET_NAME                     = "MARS"
OBSERVATION_NAME                = "FILTER_5_IN_4_TIERS_FOURTH_Q_PAN.3CMD"
IMAGE_TIME                      = 1997-07-07T05:13:42.763Z
PLANET_DAY_NUMBER               = 3
MPF_LOCAL_TIME                  = 13:39:12
SPACECRAFT_CLOCK_START_COUNT    = 1246943630
EARTH_RECEIVED_START_TIME       = 1997-07-07T23:48:33.442Z
EARTH_RECEIVED_STOP_TIME        = 1997-07-07T23:48:51.766Z
PRODUCT_CREATION_TIME           = 1998-07-14T00:36:08.000Z

/* DESCRIPTIVE DATA ELEMENTS */

EXPECTED_PACKETS                = 17
RECEIVED_PACKETS                = 17
APPLICATION_PACKET_ID           = 34
APPLICATION_PACKET_NAME         = "SCI_IMG_3"
EXPOSURE_DURATION               = 46.0000
EXPOSURE_TYPE                   = AUTO
EXPOSURE_COUNT                  = 3
AUTO_EXPOSURE_DATA_CUT          = 3000
AUTO_EXPOSURE_PIXEL_FRACTION    = 1.0000
ERROR_PIXELS                    = 0
FILTER_NAME                     = "L670_R670"
FILTER_NUMBER                   = 5
INSTRUMENT_TEMPERATURE          = (-12.2836, -12.0856)
INSTRUMENT_TEMPERATURE_COUNT    = (162, 161)
INSTRUMENT_DEPLOYMENT_STATE     = "DEPLOYED"
DETECTOR_PIXEL_HEIGHT           = 23.0000
DETECTOR_PIXEL_WIDTH            = 23.0000
SOURCE_PRODUCT_ID               = "SEQ_S0074E_IMPEK"
SOFTWARE_NAME                   = "MPFTELEMPROC_IMP"
SOFTWARE_VERSION_ID             = "V1.24.46"
PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                   VIA JPL/MIPL MPFTELEMPROC"

/* GEOMETRY DATA ELEMENTS */

INSTRUMENT_AZIMUTH              = 265.3520
AZIMUTH_FOV                     = 14.0032
AZIMUTH_MOTOR_CLICKS            = 551
INSTRUMENT_AZIMUTH_METHOD       = "TELEMETRY"
INSTRUMENT_ELEVATION            = -43.0955
ELEVATION_FOV                   = 13.5656
ELEVATION_MOTOR_CLICKS          = 96
INSTRUMENT_ELEVATION_METHOD     = "TELEMETRY"
SURFACE_BASED_INST_AZIMUTH      = 61.6981
SURFACE_BASED_INST_ELEVATION    = -45.7609
SURFACE_BASED_INST_METHOD       = "L_FRAME-QUATERNION"
POSITIVE_ELEVATION_DIRECTION    = UP
SOLAR_AZIMUTH                   = 262.8440
SOLAR_ELEVATION                 = 65.8379
LANDER_SURFACE_QUATERNION       = (0.2102, -0.0146, -0.0293, 0.9771)

/* IMP FLIGHT SOFTWARE COMMAND DATA ELEMENTS */

COMMAND_NAME                    = "IMP_IMAGE_AZ_EL"
COMMAND_DESC                    = "This is the image taken by the IMP
                                   Using absolute azimuth and elevation as
                                   the coordinate system"
TLM_CMD_DISCREPANCY_FLAG        = FALSE
DOWNLOAD_TYPE                   = IM
```

```
      DARK_CURRENT_DOWNLOAD_FLAG     = "NULL"
      DARK_CURRENT_CORRECTION_FLAG   = FALSE
      FLAT_FIELD_CORRECTION_FLAG     = FALSE
      BAD_PIXEL_REPLACEMENT_FLAG     = TRUE
      SHUTTER_EFFECT_CORRECTION_FLAG = FALSE
      SQRT_COMPRESSION_FLAG          = FALSE

      /* COMPRESSION DATA ELEMENTS */

      INST_CMPRS_BLK_SIZE            = (8, 8)
      INST_CMPRS_BLOCKS              = 992
      INST_CMPRS_MODE                = 8
      INST_CMPRS_PARAM               = 250
      INST_CMPRS_QUALITY             = 250
      INST_CMPRS_QUANTZ_TBL_ID       = "INTERNAL_0"
      INST_CMPRS_QUANTZ_TYPE         = TABULAR
      INST_CMPRS_SYNC_BLKS           = 1024
      INST_CMPRS_NAME                = "JPEG DISCRETE COSINE TRANSFORM (DCT);
                                        ARITHMETIC/RATIO/LCT"
      INST_CMPRS_RATE                = 2.0187
      INST_CMPRS_RATIO               = 5.9446
      PIXEL_AVERAGING_HEIGHT         = 1
      PIXEL_AVERAGING_WIDTH          = 1
      RICE_START_OPTION              = -1
      RICE_OPTION_VALUE              = -1
      SQRT_MINIMUM_PIXEL             = 0
      SQRT_MAXIMUM_PIXEL             = 0

      /* IMAGE OBJECT DATA ELEMENTS */

      OBJECT                         = IMAGE
        INTERCHANGE_FORMAT           = BINARY
        LINES                        = 248
        LINE_SAMPLES                 = 256
        BANDS                        = 1
        SAMPLE_TYPE                  = MSB_UNSIGNED_INTEGER
        SAMPLE_BITS                  = 16
        SAMPLE_BIT_MASK              = 2#0000111111111111#
        MAXIMUM                      = 4095
        MEAN                         = 1385.3000
        MEDIAN                       = 894
        MINIMUM                      = 145
        STANDARD_DEVIATION           = 538.0290
        FIRST_LINE                   = 3
        FIRST_LINE_SAMPLE            = 1
        CHECKSUM                     = 8427608
      END_OBJECT                     = IMAGE
      END
```

7.1.1.3.2 PDS4 IMAGE_GRAYSCALE Label Scheme

The same data product can also be described in PDS4 by use of the IMAGE_GRAYSCALE class:

```
<?xml version="1.0" encoding="UTF-8"?>
<Product_Image_Grayscale xmlns:ns1="http://pds.nasa.gov/schema/pds4/dt"
 xmlns="http://pds.nasa.gov/schema/pds4/common"
```

```
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://pds.nasa.gov/schema/pds4/common
file:/D:/IMG_grayscale/Product_Image_Grayscale_2009-06-09p.xsd">
   <Identification_Area>
       <puid>
          URN:NASA:PDS:MPFL-M-IMP-2-EDR-V1.0:PDS4_IMG_IMAGE_GRAYSCALE_ID:V1.0
       </puid>
       <Identification_Area_data_set_id>
          MPFL-M-IMP-2-EDR-V1.0
       </Identification_Area_data_set_id>
       <product_id>IMP_EDR-1246943630-REGULAR-0074051101</product_id>
       <version_id>1.0</version_id>
       <title>MARS PATHFINDER LANDER Experiment</title>
       <creation_time>1998-07-14T00:36:08.000</creation_time>
       <logical_identifier>
          URN:NASA:PDS:MPFL-M-IMP-2-EDR-V1.0:PDS4_IMG_IMAGE_GRAYSCALE_ID
       </logical_identifier>
   </Identification_Area>
   <Cross_Reference_Area>
       <instrument_host_puid>URN:NASA:PDS:MPFL-V1.0</instrument_host_puid>
       <instrument_puid>URN:NASA:PDS:IMP-V1.0</instrument_puid>
       <mission_puid>URN:NASA:PDS:MARS PATHFINDER-V1.0</mission_puid>
       <node_puid>URN:NASA:PDS:IMAGING-V1.0</node_puid>
       <target_puid>URN:NASA:PDS:MARS-V1.0</target_puid>
   </Cross_Reference_Area>
   <Observation_Area>
       <spacecraft_clock_start_count>1246943630</spacecraft_clock_start_count>
       <spacecraft_clock_stop_count>n/a</spacecraft_clock_stop_count>
       <start_time>n/a</start_time>
       <stop_time>n/a</stop_time>
   </Observation_Area>
   <File_Area>
       <File>
           <local_identifier>
              URN:NASA:PDS:PDS4_MPFL_M_IMP_IMAGE_FILE_ID
           </local_identifier>
           <creation_time>2009-05-04</creation_time>
           <checksum>123</checksum>
           <directory_path_name>\data\N2075WE02R.FIT</directory_path_name>
           <file_name>N2075WE02R.FIT</file_name>
           <file_size>12345</file_size>
           <max_record_bytes>512</max_record_bytes>
           <number_of_records>270</number_of_records>
       </File>
   </File_Area>
   <Data_Area_Image_Grayscale>
       <Any_Described_Data_Object>
           <Object_Statistics>
               <local_identifier>
                  URN:NASA:PDS:MPFL_M_IMP_STATISTICS
               </local_identifier>
               <checksum>8427608</checksum>
               <maximum>4095</maximum>
               <mean>894</mean>
               <minimum>145</minimum>
               <standard_deviation>538.0290</standard_deviation>
           </Object_Statistics>
       </Any_Described_Data_Object>
       <Image_Grayscale>
           <local_identifier>
               URN:NASA:PDS:MPFL-M-IMP_IMG_GRAYSCALE
           </local_identifier>
           <Image_Grayscale_axes_order>
```

```
       FIRST_INDEX_FASTEST
    </Image_Grayscale_axes_order>
    <Image_Grayscale_byte_order>MSBF</Image_Grayscale_byte_order>
    <Array_Base_file_type>BINARY</Array_Base_file_type>
    <Array_Base_first_element>TOPLEFT</Array_Base_first_element>
    <Array_Base_min_index>0</Array_Base_min_index>
    <Array_2D_number_of_axes>2</Array_2D_number_of_axes>
    <Data_Location>
        <file_local_identifier>
           PDS4_MPFL_M_IMP_IMAGE_FILE_ID
        </file_local_identifier>
        <offset>1</offset>
    </Data_Location>
    <Array_Axis>
        <axis_index>0</axis_index>
        <axis_length>248</axis_length>
        <axis_name>LINE</axis_name>
        <axis_scale_type>n/a</axis_scale_type>
        <Array_Axis_axis_unit>n/a</Array_Axis_axis_unit>
    </Array_Axis>
    <Array_Axis>
        <axis_index>1</axis_index>
        <axis_length>256</axis_length>
        <axis_name>SAMPLE</axis_name>
        <axis_scale_type>n/a</axis_scale_type>
        <Array_Axis_axis_unit>n/a</Array_Axis_axis_unit>
    </Array_Axis>
    <Array_Element>
        <element_bytes>2</element_bytes>
        <element_scaling_factor>n/a</element_scaling_factor>
        <element_type>MSB_UNSIGNED_INTEGER</element_type>
        <element_unit>DATA NUMBER</element_unit>
        <element_value_offset>n/a</element_value_offset>
    </Array_Element>
</Image_Grayscale>

<!-- IDENTIFICATION DATA ELEMENTS -->
<Property_Map>
    <local_identifier>
        URN:NASA:PDS:MPFL_M_IMP_PROPMAP-1
    </local_identifier>
    <comment>IDENTIFICATION DATA ELEMENTS</comment>
    <namespace_id>MPFL_M_IMP_IMAGE</namespace_id>
    <Property_Map_Entry>
        <property_name>PRODUCER_ID</property_name>
        <property_value>MIPL OF JPL</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>PRODUCER_FULL_NAME</property_name>
        <property_value>ALLAN J. RUNKLE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>PRODUCER_INSTITUTION_NAME</property_name>
        <property_value>
          MULTIMISSION IMAGE PROCESSING LABORATORY, JPL
        </property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>PRODUCT_ID</property_name>
        <property_value>
          IMP_EDR-1246943630-REGULAR-0074051101
        </property_value>
    </Property_Map_Entry>
```

```
    <Property_Map_Entry>
        <property_name>IMAGE_ID</property_name>
        <property_value>74051101</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>COMMAND_SEQUENCE_NUMBER</property_name>
        <property_value>74</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>IMAGE_OBSERVATION_TYPE</property_name>
        <property_value>REGULAR</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>FRAME_ID</property_name>
        <property_value>BOTH</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>OBSERVATION_NAME</property_name>
        <property_value>
          FILTER_5_IN_4_TIERS_FOURTH_QUAD_MONSTER_PAN.3CMD
        </property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>IMAGE_TIME</property_name>
        <property_value>1997-07-07T05:13:42.763Z</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>PLANET_DAY_NUMBER</property_name>
        <property_value>3</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>MPF_LOCAL_TIME</property_name>
        <property_value>13:39:12</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>EARTH_RECEIVED_START_TIME</property_name>
        <property_value>1997-07-07T23:48:33.442Z</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>EARTH_RECEIVED_STOP_TIME</property_name>
        <property_value>1997-07-07T23:48:51.766Z</property_value>
    </Property_Map_Entry>
</Property_Map>

<!-- DESCRIPTIVE DATA ELEMENTS -->
<Property_Map>
    <local_identifier>
       URN:NASA:PDS:MPFL_M_IMP_PROPMAP-2
    </local_identifier>
    <comment>DESCRIPTIVE DATA ELEMENTS</comment>
    <namespace_id>MPFL_M_IMP_IMAGE</namespace_id>
    <Property_Map_Entry>
        <property_name>EXPECTED_PACKETS</property_name>
        <property_value>17</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>RECEIVED_PACKETS</property_name>
        <property_value>17</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>APPLICATION_PACKET_ID</property_name>
        <property_value>34</property_value>
    </Property_Map_Entry>
```

```
<Property_Map_Entry>
    <property_name>APPLICATION_PACKET_NAME</property_name>
    <property_value>SCI_IMG_3</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>EXPOSURE_DURATION</property_name>
    <property_value>46.0000</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>EXPOSURE_TYPE</property_name>
    <property_value>AUTO</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>EXPOSURE_COUNT</property_name>
    <property_value>3</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>AUTO_EXPOSURE_DATA_CUT</property_name>
    <property_value>3000</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>AUTO_EXPOSURE_PIXEL_FRACTION</property_name>
    <property_value>1.0000</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>ERROR_PIXELS</property_name>
    <property_value>0</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>FILTER_NAME</property_name>
    <property_value>L670_R670</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>FILTER_NUMBER</property_name>
    <property_value>5</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>INSTRUMENT_TEMPERATURE</property_name>
    <property_value>-12.2836</property_value>
    <property_value>-12.0856</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>INSTRUMENT_TEMPERATURE_COUNT</property_name>
    <property_value>162</property_value>
    <property_value>161</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>INSTRUMENT_DEPLOYMENT_STATE</property_name>
    <property_value>DEPLOYED</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>DETECTOR_PIXEL_HEIGHT</property_name>
    <property_value>23.0000</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>DETECTOR_PIXEL_WIDTH</property_name>
    <property_value>23.0000</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
    <property_name>SOURCE_PRODUCT_ID</property_name>
    <property_value>SEQ_S0074E_IMPEK</property_value>
</Property_Map_Entry>
<Property_Map_Entry>
```

```
        <property_name>SOFTWARE_NAME</property_name>
        <property_value>MPFTELEMPROC_IMP</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SOFTWARE_VERSION_ID</property_name>
        <property_value>V1.24.46</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>PROCESSING_HISTORY_TEXT</property_name>
        <property_value>
          CODMAC LEVEL 1 TO LEVEL 2 CONVERSION VIA
          JPL/MIPL MPFTELEMPROC
        </property_value>
    </Property_Map_Entry>
</Property_Map>

<!-- GEOMETRY and COMPRESSION DATA ELEMENTS -->
<Property_Map>
    <local_identifier>
       URN:NASA:PDS:MPFL_M_IMP_PROPMAP-3
    </local_identifier>
    <comment>GEOMETRY and COMPRESSION DATA ELEMENTS</comment>
    <namespace_id>MPFL_M_IMP_IMAGE</namespace_id>
    <Property_Map_Entry>
        <property_name>INSTRUMENT_AZIMUTH</property_name>
        <property_value>265.3520</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>AZIMUTH_FOV</property_name>
        <property_value>14.0032</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>AZIMUTH_MOTOR_CLICKS</property_name>
        <property_value>551</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INSTRUMENT_AZIMUTH_METHOD</property_name>
        <property_value>TELEMETRY</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INSTRUMENT_ELEVATION</property_name>
        <property_value>-43.0955</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>ELEVATION_FOV</property_name>
        <property_value>13.5656</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>ELEVATION_MOTOR_CLICKS</property_name>
        <property_value>96</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INSTRUMENT_ELEVATION_METHOD</property_name>
        <property_value>TELEMETRY</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SURFACE_BASED_INST_AZIMUTH</property_name>
        <property_value>61.6981</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SURFACE_BASED_INST_ELEVATION</property_name>
        <property_value>-45.7609</property_value>
    </Property_Map_Entry>
```

```
    <Property_Map_Entry>
        <property_name>SURFACE_BASED_INST_METHOD</property_name>
        <property_value>L_FRAME-QUATERNION</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>POSITIVE_ELEVATION_DIRECTION</property_name>
        <property_value>UP</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SOLAR_AZIMUTH</property_name>
        <property_value>262.8440</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SOLAR_ELEVATION</property_name>
        <property_value>65.8379</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>LANDER_SURFACE_QUATERNION</property_name>
        <property_value>0.2102</property_value>
        <property_value>-0.0146</property_value>
        <property_value>-0.0293</property_value>
        <property_value>0.9771</property_value>
    </Property_Map_Entry>
</Property_Map>

<!-- IMP FLIGHT SOFTWARE COMMAND DATA ELEMENTS -->
<Property_Map>
    <local_identifier>
        URN:NASA:PDS:MPFL_M_IMP_PROPMAP-1
    </local_identifier>
    <comment>IMP FLIGHT SOFTWARE COMMAND DATA ELEMENTS</comment>
    <namespace_id>MPFL_M_IMP_IMAGE</namespace_id>
    <Property_Map_Entry>
        <property_name>COMMAND_NAME</property_name>
        <property_value>IMP_IMAGE_AZ_EL</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>COMMAND_DESC</property_name>
        <property_value>This is the image taken by the IMP
                         Using absolute azimuth and elevation as
                         the coordinate system</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>TLM_CMD_DISCREPANCY_FLAG</property_name>
        <property_value>FALSE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>DOWNLOAD_TYPE</property_name>
        <property_value>IM</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>DARK_CURRENT_DOWNLOAD_FLAG</property_name>
        <property_value>NULL</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>DARK_CURRENT_CORRECTION_FLAG</property_name>
        <property_value>FALSE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>FLAT_FIELD_CORRECTION_FLAG</property_name>
        <property_value>FALSE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
```

```
        <property_name>BAD_PIXEL_REPLACEMENT_FLAG</property_name>
        <property_value>TRUE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SHUTTER_EFFECT_CORRECTION_FLAG</property_name>
        <property_value>FALSE</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>SQRT_COMPRESSION_FLAG</property_name>
        <property_value>FALSE</property_value>
    </Property_Map_Entry>
</Property_Map>

<!-- COMPRESSION DATA ELEMENTS -->
<Property_Map>
    <local_identifier>
       URN:NASA:PDS:MPFL_M_IMP_PROPMAP-1
    </local_identifier>
    <comment>COMPRESSION DATA ELEMENTS</comment>
    <namespace_id>MPFL_M_IMP_IMAGE</namespace_id>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_BLK_SIZE</property_name>
        <property_value>8</property_value>
        <property_value>8</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_BLOCKS</property_name>
        <property_value>992</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_MODE</property_name>
        <property_value>8</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_PARAM</property_name>
        <property_value>250</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_QUALITY</property_name>
        <property_value>250</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_QUANTZ_TBL_ID</property_name>
        <property_value>INTERNAL_0</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_QUANTZ_TYPE</property_name>
        <property_value>TABULAR</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_SYNC_BLKS</property_name>
        <property_value>1024</property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_NAME</property_name>
        <property_value>JPEG DISCRETE COSINE TRANSFORM (DCT);
                        ARITHMETIC/RATIO/LCT
        </property_value>
    </Property_Map_Entry>
    <Property_Map_Entry>
        <property_name>INST_CMPRS_RATE</property_name>
        <property_value>2.0187</property_value>
    </Property_Map_Entry>
```

```
            <Property_Map_Entry>
                <property_name>INST_CMPRS_RATIO</property_name>
                <property_value>5.9446</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>PIXEL_AVERAGING_HEIGHT</property_name>
                <property_value>1</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>PIXEL_AVERAGING_WIDTH</property_name>
                <property_value>1</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>RICE_START_OPTION</property_name>
                <property_value> -1</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>RICE_OPTION_VALUE</property_name>
                <property_value>-1</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>SQRT_MINIMUM_PIXEL</property_name>
                <property_value>0</property_value>
            </Property_Map_Entry>
            <Property_Map_Entry>
                <property_name>SQRT_MAXIMUM_PIXEL</property_name>
                <property_value>0</property_value>
            </Property_Map_Entry>
        </Property_Map>

    </Data_Area_Image_Grayscale>
</Product_Image_Grayscale>
```

7.1.1.4 PDS4 IMAGE_GRAYSCALE and PDS3 IMAGE Parallellisms

This section provides a high level discussion of the parallelisms between the PDS3 IMAGE Data Object Description (DoD) and the PDS4 IMAGE_GRAYSCALE class.

The PDS3 IMAGE (DoD) by definition was very flexible in that the DoD could define both simple Images and very complex types of Images depending on the representation of the data product byte stream. An example of a simple image is where the data product byte stream is represented as a 2-dimensional, single-banded, non-interleaved, no prefix or suffix byte construct. A more complex example of an image is where the data product byte stream is represented by any of the following:

a. Line or Sample interleaved data
b. Row prefix and/or suffix bytes
c. Multi-banded data
d. Line and Sample display counter direction

The PDS4 IMAGE_GRAYSCALE class has been specifically designed to be more restrictive in the permissible representations of the data object byte stream.

And as such, these restrictions ensure a more rigorous set of archival quality image constructs. The PDS4 IMAGE_GRAYSCALE class supports the following variations:

1. Axis order – the default, FAST2SLOW, indicates that each axis on the left varies faster than the axis to the right (i.e., the leftmost axis varies the fastest; with the axis to the most right varying the slowest).
2. Byte order – the default, MSBF, indicates that the bytes are represented as most-significant-byte-first.
3. First element – the default, TOPLEFT, indicates that the first element of the byte stream is the top leftmost element.
4. Minimum index – the default, 0, indicates that the bytes are numbered sequentially starting from 0.

TBD

7.2 Table_Base – Heterogeneous Repeating Record of Scalars

7.2.1 TABLE_CHARACTER

This section describes the TABLE_CHARACTER extension of the PDS4 Table_Base (i.e., Heterogeneous repeating record of Scalars) class where a contiguous stream of ASCII characters, assembled as fixed-width fields, maps the "items" contained in a TABLE_CHARACTER file.

This section identifies a mapping of the PDS3 TABLE object to the PDS4 TABLE_CHARACTER file construct and demonstrates how the byte stream (e.g., sequence of bits) can be described by both a PDS3 label and a PDS4 label.

7.2.1.1 TABLE_BASE Class Description and Schema

Figure 7.2-1 depicts a representation of the PDS4 TABLE_BASE class and the associated parent and child classes. The figure additionally lists the required or optional status, and the cardinality of repeating structures.

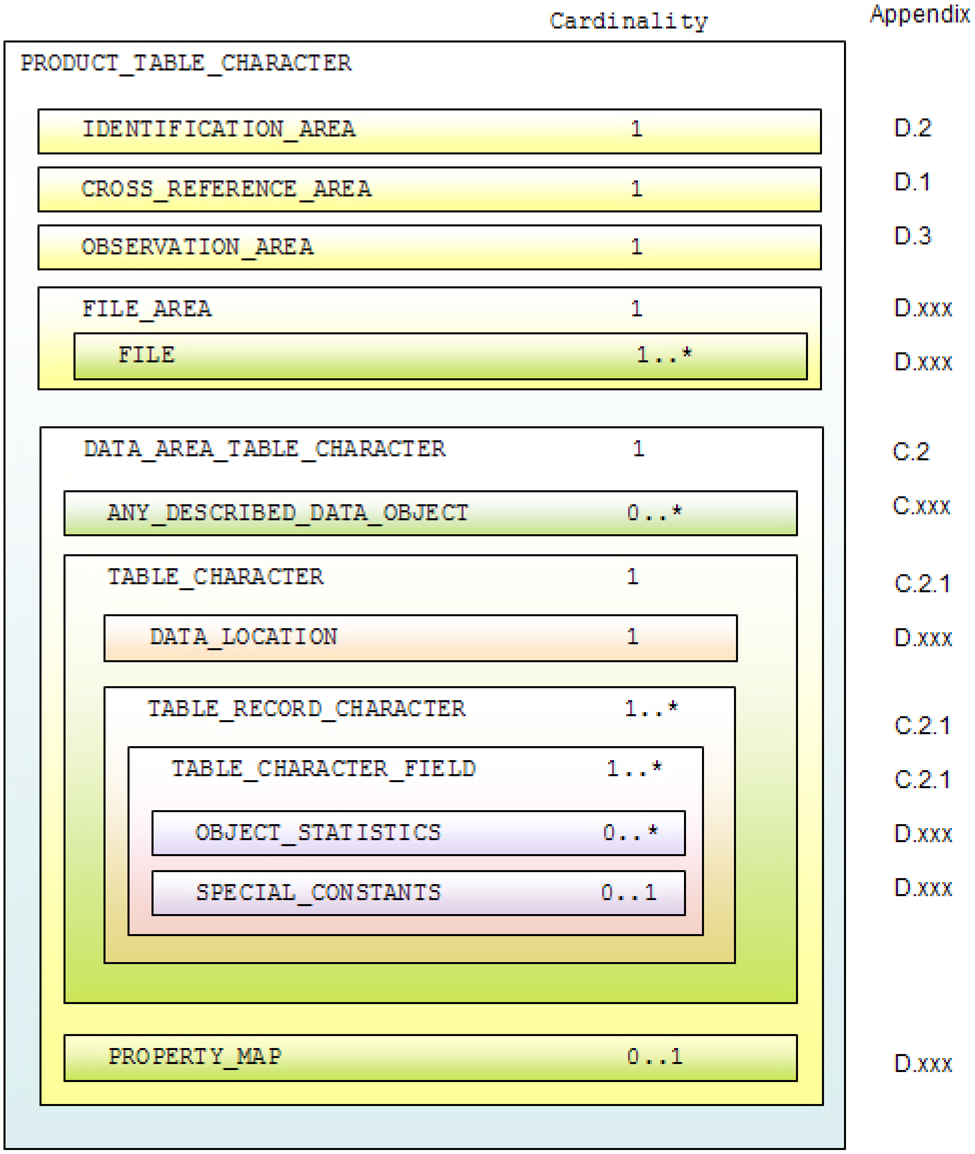


Figure 7.2.1-1. Diagram of the TABLE_CHARACTER Schema

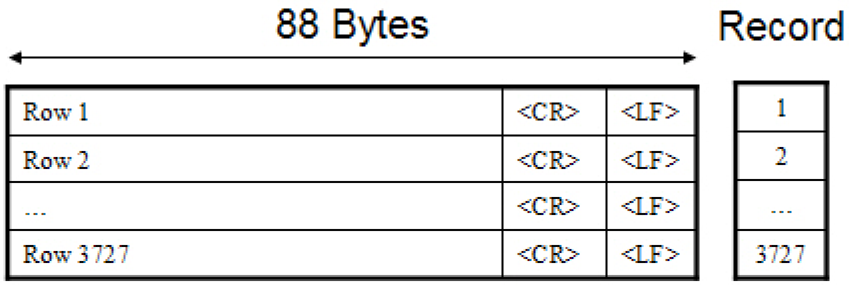
From Figure 7.2.1-1, the overall structure of the TABLE_CHARACTER data product description can be easily discerned and understood. A detailed set of diagrams of the composite classes that comprise the TABLE_CHARACTER data product description can be found in Appendix C and Appendix D.

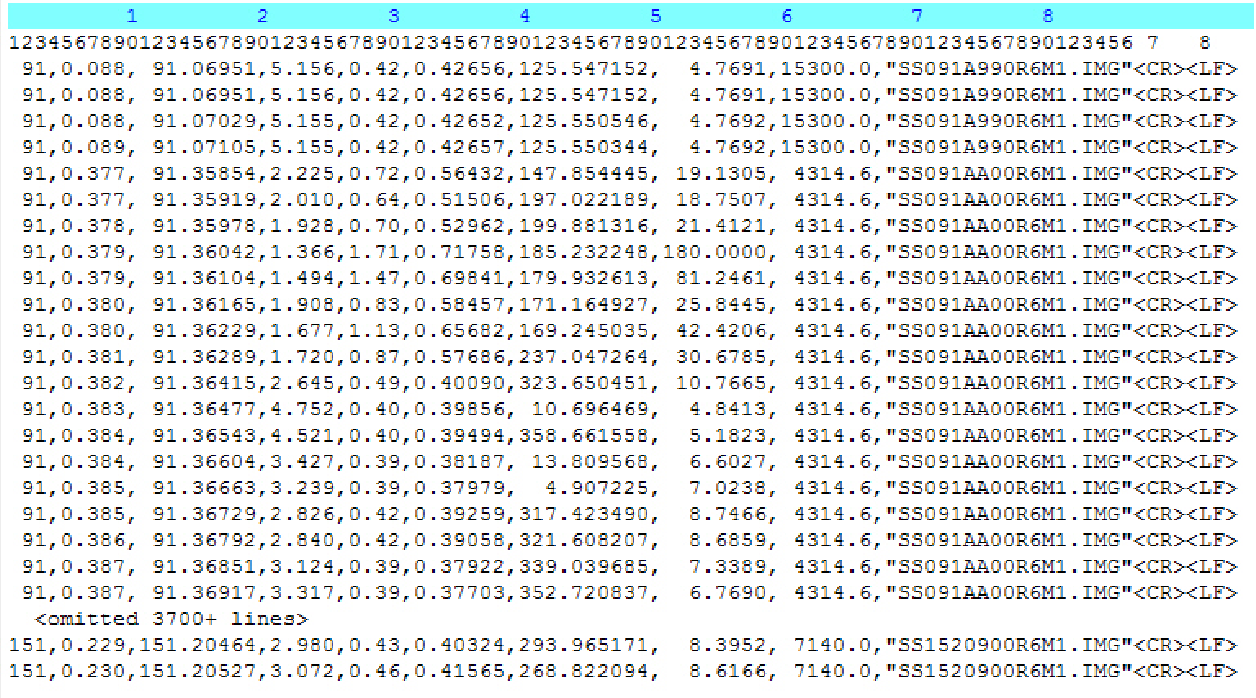
7.2.1.2 TABLE_CHARACTER Data Product Byte Stream

Figure 7.2.1-2 depicts a representation a TABLE_CHARACTER byte-stream. The first two rows of the diagram are for the purposes of illustrating the byte positions relative to the TABLE fields and would not normally be contained in a data product file. The remaining twenty+ rows illustrate a typical TABLE_CHARACTER data product where the fields are fixed-width ASCII across the rows in the file.

With respect to the data product:

1. There are 3727 rows of data (of which 3700+ rows have been omitted from the diagram for ease of reading)
2. There are 10 fields in each row / record in this example file.
3. Each field is fixed-width across all rows in this example file.
4. Each field is comprised of ASCII characters.
5. There are 88 bytes in each row / record in this example file.

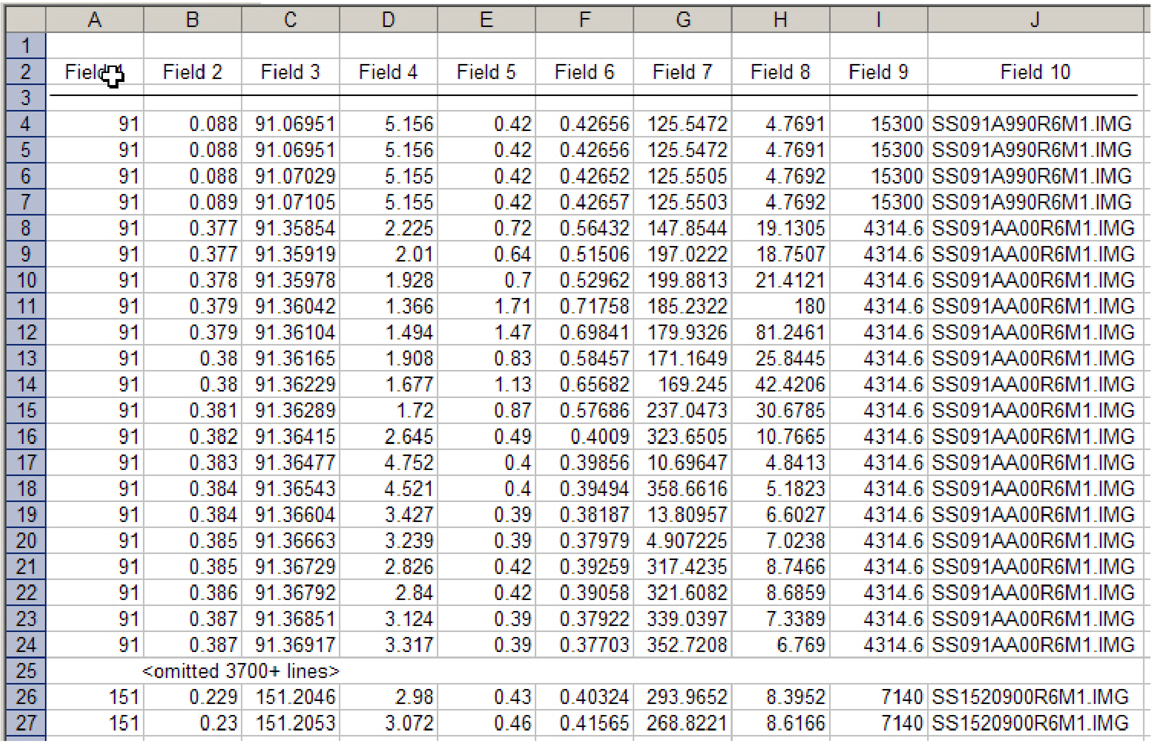




```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456 7   8
 91,0.088, 91.06951,5.156,0.42,0.42656,125.547152,  4.7691,15300.0,"SS091A990R6M1.IMG"<CR><LF>
 91,0.088, 91.06951,5.156,0.42,0.42656,125.547152,  4.7691,15300.0,"SS091A990R6M1.IMG"<CR><LF>
 91,0.088, 91.07029,5.155,0.42,0.42652,125.550546,  4.7692,15300.0,"SS091A990R6M1.IMG"<CR><LF>
 91,0.089, 91.07105,5.155,0.42,0.42657,125.550344,  4.7692,15300.0,"SS091A990R6M1.IMG"<CR><LF>
 91,0.377, 91.35854,2.225,0.72,0.56432,147.854445, 19.1305, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.377, 91.35919,2.010,0.64,0.51506,197.022189, 18.7507, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.378, 91.35978,1.928,0.70,0.52962,199.881316, 21.4121, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.379, 91.36042,1.366,1.71,0.71758,185.232248,180.0000, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.379, 91.36104,1.494,1.47,0.69841,179.932613, 81.2461, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.380, 91.36165,1.908,0.83,0.58457,171.164927, 25.8445, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.380, 91.36229,1.677,1.13,0.65682,169.245035, 42.4206, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.381, 91.36289,1.720,0.87,0.57686,237.047264, 30.6785, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.382, 91.36415,2.645,0.49,0.40090,323.650451, 10.7665, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.383, 91.36477,4.752,0.40,0.39856, 10.696469,  4.8413, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.384, 91.36543,4.521,0.40,0.39494,358.661558,  5.1823, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.384, 91.36604,3.427,0.39,0.38187, 13.809568,  6.6027, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.385, 91.36663,3.239,0.39,0.37979,  4.907225,  7.0238, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.385, 91.36729,2.826,0.42,0.39259,317.423490,  8.7466, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.386, 91.36792,2.840,0.42,0.39058,321.608207,  8.6859, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.387, 91.36851,3.124,0.39,0.37922,339.039685,  7.3389, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
 91,0.387, 91.36917,3.317,0.39,0.37703,352.720837,  6.7690, 4314.6,"SS091AA00R6M1.IMG"<CR><LF>
  <omitted 3700+ lines>
151,0.229,151.20464,2.980,0.43,0.40324,293.965171,  8.3952, 7140.0,"SS1520900R6M1.IMG"<CR><LF>
151,0.230,151.20527,3.072,0.46,0.41565,268.822094,  8.6166, 7140.0,"SS1520900R6M1.IMG"<CR><LF>
```

Figure 7.2.1-2. Diagram of the TABLE_CHARACTER Byte Stream

Figure 7.2.1-3 depicts the above TABLE_CHARACTER byte-stream as it would be represented as an Excel spreadsheet. This representation is helpful in understanding how the fields are represented in the data product label. Specifically that the TABLE_CHARACTER schema is compatible with most database management and spreadsheet applications. Note that the first three rows are for purposes of illustrating how the data relates to the TABLE_CHARACTER fields defined in the data product label. These first three rows would not normally be present in a data product file. The remaining twenty+ rows illustrate a typical TABLE_CHARACTER data product where the number of fields Is fixed across the rows in the file, each field has a fixed-width, each field is comprised of ASCII characters, and where each row is delimited by a row delimiter (e.g., <CR><LF>).



	A	B	C	D	E	F	G	H	I	J
1										
2	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8	Field 9	Field 10
3										
4	91	0.088	91.06951	5.156	0.42	0.42656	125.5472	4.7691	15300	SS091A990R6M1.IMG
5	91	0.088	91.06951	5.156	0.42	0.42656	125.5472	4.7691	15300	SS091A990R6M1.IMG
6	91	0.088	91.07029	5.155	0.42	0.42652	125.5505	4.7692	15300	SS091A990R6M1.IMG
7	91	0.089	91.07105	5.155	0.42	0.42657	125.5503	4.7692	15300	SS091A990R6M1.IMG
8	91	0.377	91.35854	2.225	0.72	0.56432	147.8544	19.1305	4314.6	SS091AA00R6M1.IMG
9	91	0.377	91.35919	2.01	0.64	0.51506	197.0222	18.7507	4314.6	SS091AA00R6M1.IMG
10	91	0.378	91.35978	1.928	0.7	0.52962	199.8813	21.4121	4314.6	SS091AA00R6M1.IMG
11	91	0.379	91.36042	1.366	1.71	0.71758	185.2322	180	4314.6	SS091AA00R6M1.IMG
12	91	0.379	91.36104	1.494	1.47	0.69841	179.9326	81.2461	4314.6	SS091AA00R6M1.IMG
13	91	0.38	91.36165	1.908	0.83	0.58457	171.1649	25.8445	4314.6	SS091AA00R6M1.IMG
14	91	0.38	91.36229	1.677	1.13	0.65682	169.245	42.4206	4314.6	SS091AA00R6M1.IMG
15	91	0.381	91.36289	1.72	0.87	0.57686	237.0473	30.6785	4314.6	SS091AA00R6M1.IMG
16	91	0.382	91.36415	2.645	0.49	0.4009	323.6505	10.7665	4314.6	SS091AA00R6M1.IMG
17	91	0.383	91.36477	4.752	0.4	0.39856	10.69647	4.8413	4314.6	SS091AA00R6M1.IMG
18	91	0.384	91.36543	4.521	0.4	0.39494	358.6616	5.1823	4314.6	SS091AA00R6M1.IMG
19	91	0.384	91.36604	3.427	0.39	0.38187	13.80957	6.6027	4314.6	SS091AA00R6M1.IMG
20	91	0.385	91.36663	3.239	0.39	0.37979	4.907225	7.0238	4314.6	SS091AA00R6M1.IMG
21	91	0.385	91.36729	2.826	0.42	0.39259	317.4235	8.7466	4314.6	SS091AA00R6M1.IMG
22	91	0.386	91.36792	2.84	0.42	0.39058	321.6082	8.6859	4314.6	SS091AA00R6M1.IMG
23	91	0.387	91.36851	3.124	0.39	0.37922	339.0397	7.3389	4314.6	SS091AA00R6M1.IMG
24	91	0.387	91.36917	3.317	0.39	0.37703	352.7208	6.769	4314.6	SS091AA00R6M1.IMG
25		<omitted 3700+ lines>								
26	151	0.229	151.2046	2.98	0.43	0.40324	293.9652	8.3952	7140	SS1520900R6M1.IMG
27	151	0.23	151.2053	3.072	0.46	0.41565	268.8221	8.6166	7140	SS1520900R6M1.IMG

Figure 7.2.1-3. Excel Spreadsheet Representation of the TABLE_CHARACTER Byte Stream

7.2.1.3 TABLE_CHARACTER Label Scheme

This section depicts how the TABLE_CHARACTER byte-scheme, as illustrated above, can be described by both a PDS3 label and a PDS4 label.

The PDS4 TABLE_CHARACTER class is the successor to the PDS3 TABLE object.

The files that describe both the PDS3 and the PDS4 data products described within this section can be found at:

- PDS3 ODL Label: http://tbd
- PDS3 data product: http://tbd

- PDS4 XML Label: : http://tbd
- PDS4 XML Label template: : http://tbd
- PDS4 Generic Schema: : http://tbd
- PDS4 Specific Product Schema: : http://tbd
- PDS4 Specific “other” Schema(s): : http://tbd

7.2.1.3.1 PDS3 TABLE_CHARACTER Label Scheme

The data product depicted in Figure 7.2.1-2 could be described in PDS3 by use of the TABLE and COLUMN objects:

```
PDS_VERSION_ID                 = PDS3

RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 88
FILE_RECORDS                   = 3727
^TABLE                         = "CHAR_TABLE_COLLAPSED.TAB"

DATA_SET_ID                    = "PHX-M-TT-5-WIND-VEL-DIR-V1.0"
MISSION_NAME                   = "PHOENIX"
INSTRUMENT_HOST_NAME           = "PHOENIX"
INSTRUMENT_NAME                = "TELLTALE"
PRODUCT_ID                     = "TELLTALE_91_151"
TARGET_NAME                    = "MARS"
SPACECRAFT_CLOCK_START_COUNT = "904250279.448"
SPACECRAFT_CLOCK_STOP_COUNT  = "909588864.598"
START_TIME                     = 2008-08-26T20:36:36.856
STOP_TIME                      = 2008-10-27T15:32:50.952
PRODUCT_CREATION_TIME          = 2009-04-15

OBJECT                         = TABLE
  INTERCHANGE_FORMAT           = ASCII
  ROW_BYTES                    = 88
  ROWS                         = 3727
  COLUMNS                      = 10

  OBJECT                       = COLUMN
    NAME                       = "SOL"
```

```
  DATA_TYPE                = ASCII_INTEGER
  START_BYTE               = 1
  BYTES                    = 3
  FORMAT                   = "I3"
  UNIT                     = "N/A"
  DESCRIPTION              = "PHOENIX Sol number"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "LTST"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 5
  BYTES                    = 5
  FORMAT                   = "F5.3"
  UNIT                     = "N/A"
  DESCRIPTION              = "Local True Solar Time"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "LMST"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 11
  BYTES                    = 9
  FORMAT                   = "F9.5"
  UNIT                     = "N/A"
  DESCRIPTION              = "Local Mean Solar Time"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "V"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 21
  BYTES                    = 5
  FORMAT                   = "F5.3"
  UNIT                     = "METERS/SECOND"
  DESCRIPTION              = "Wind speed in meters per second"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "DV+"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 27
  BYTES                    = 4
  FORMAT                   = "F4.2"
  UNIT                     = "METERS/SECOND"
  DESCRIPTION              = "Error in wind speed (positive)"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "DV-"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 32
  BYTES                    = 7
  FORMAT                   = "F7.5"
  UNIT                     = "METERS/SECOND"
  DESCRIPTION              = "Error in wind speed (negative)"
END_OBJECT                 = COLUMN

OBJECT                     = COLUMN
  NAME                     = "DIR"
  DATA_TYPE                = ASCII_REAL
  START_BYTE               = 40
  BYTES                    = 10
```

```
      FORMAT                   = "F10.6"
      UNIT                     = "DEGREES"
      DESCRIPTION              = "Wind direction in degrees given in
                                  meteorological convention (0 = from N,
                                  90 = from E, 180 = from S, 270 = from
                                  W)"
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
      NAME                     = "DDIR"
      DATA_TYPE                = ASCII_REAL
      START_BYTE               = 51
      BYTES                    = 8
      FORMAT                   = "F8.4"
      UNIT                     = "DEGREES"
      DESCRIPTION              = "Error in direction (given in degrees).
                                  If dv+ is larger than v, then this is
                                  set to 180"
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
      NAME                     = "EXPOSURE TIME"
      DATA_TYPE                = ASCII_REAL
      START_BYTE               = 60
      BYTES                    = 7
      FORMAT                   = "F7.1"
      UNIT                     = "MILLISECONDS"
      DESCRIPTION              = "Exposure time by SSI in milliseconds"
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
      NAME                     = "FILE NAME"
      DATA_TYPE                = CHARACTER
      START_BYTE               = 69
      BYTES                    = 17
      FORMAT                   = "A17"
      UNIT                     = "N/A"
      DESCRIPTION              = "Image filename used for the analysis"
    END_OBJECT                 = COLUMN

  END_OBJECT                   = TABLE
  END
```

7.2.1.3.2 PDS4 TABLE_CHARACTER Label Scheme

The same data product can also be described in PDS4 by use of the TABLE_CHARACTER and the TABLE_FIELD_CHARACTER classes.

```
<?xml version="1.0" encoding="UTF-8"?>
<Product_Table_Character xmlns="http://pds.nasa.gov/schema/pds4/common"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation="http://pds.nasa.gov/schema/pds4/common
file:/D:/WINWORD/OnlineSystemDevelopment/PDS4_DataModel/DDWG_product_examples_2
0100201/MGS-M-RSS-5-TPS-V1.0/Product_Table_Character_2009-06-09p.xsd">
    <Identification_Area>
        <puid>
          URN:NASA:PDS:PHX-M-TT-5-WIND-VEL-dIR:PDS4_ATM_PRODUCT_TABLE_CHAR_ID:1.0
        </puid>
        <Identification_Area_data_set_id>
           PHX-M-TT-5-WIND-VEL-DIR-V1.0
```

```
    </Identification_Area_data_set_id>
    <product_id>TELLTALE_91_151</product_id>
    <version_id>1.0</version_id>
    <title>PHOENIX Mars Wind Experiment</title>
    <creation_time>2009-01-01T23:34:30</creation_time>
    <logical_identifier>
       URN:NASA:PDS:PHX-M-TT-5-WIND-VEL-DIR:PDS4_ATM_PRODUCT_TABLE_CHAR_ID
    </logical_identifier>
</Identification_Area>
<Cross_Reference_Area>
    <instrument_host_puid>URN:NASA:PDS:PHX-V1.0</instrument_host_puid>
    <instrument_puid>URN:NASA:PDS:TT-V1.0</instrument_puid>
    <mission_puid>URN:NASA:PDS:PHOENIX-V1.0</mission_puid>
    <node_puid>URN:NASA:PDS:ATMOS-V1.0</node_puid>
    <target_puid>URN:NASA:PDS:MARS-V1.0</target_puid>
</Cross_Reference_Area>
<Observation_Area>
    <spacecraft_clock_start_count>
        904250279.448
    </spacecraft_clock_start_count>
    <spacecraft_clock_stop_count>
        909588864.598
    </spacecraft_clock_stop_count>
    <start_time>2008-08-26T20:36:36.856</start_time>
    <stop_time>2008-10-27T15:32:50.952</stop_time>
</Observation_Area>
<File_Area>
    <File>
        <local_identifier>
           URN:NASA:PDS:PDS4_PHX_M_TT_TABLE_FILE_ID
        </local_identifier>
        <comment>
           this file identifies the character table product bits
        </comment>
        <creation_time>1998-10-15</creation_time>
        <checksum>123</checksum>
        <directory_path_name>
           \data\MGS-M-RSS-5-TPS-V1.0\SimpleTableCharacter_20100201.tab
        </directory_path_name>
        <file_name>SimpleTableCharacter_20100201.tab</file_name>
        <file_size>111</file_size>
        <max_record_bytes>3727</max_record_bytes>
        <number_of_records>77</number_of_records>
    </File>
</File_Area>
<Data_Area_Table_Character>
    <Table_Character>
        <local_identifier>
            URN:NASA:PDS:PHX_M_TT_TABLE
        </local_identifier>
        <Table_Base_Character_file_type>
            CHARACTER
        </Table_Base_Character_file_type>
        <number_of_fields>10</number_of_fields>
        <number_of_records>3727</number_of_records>
        <record_bytes>88</record_bytes>
        <Data_Location>
            <file_local_identifier>
               URN:NASA:PDS:PDS4_PHX_M_TT_TABLE_FILE_ID
            </file_local_identifier>
            <offset>1</offset>
        </Data_Location>
        <Table_Record_Character>
```

```
<Table_Character_Field>
  <field_name>SOL</field_name>
  <field_number>1</field_number>
  <field_data_type>ASCII_INTEGER</field_data_type>
  <field_location>1</field_location>
  <field_length>3</field_length>
  <field_format>I3</field_format>
  <field_min_physical>91</field_min_physical>
  <field_max_physical>151</field_max_physical>
  <field_unit>N/A</field_unit>
  <field_description>PHOENIX Sol number</field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>LTST</field_name>
  <field_number>2</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>5</field_location>
  <field_length>5</field_length>
  <field_format>F5.3</field_format>
  <field_min_physical>0.088078704</field_min_physical>
  <field_max_physical>0.230243056</field_max_physical>
  <field_unit>N/A</field_unit>
  <field_description>Local True Solar Time</field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>LMST</field_name>
  <field_number>3</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>11</field_location>
  <field_length>9</field_length>
  <field_format>F9.5</field_format>
  <field_min_physical>91.0695122</field_min_physical>
  <field_max_physical>151.2052778</field_max_physical>
  <field_unit>N/A</field_unit>
  <field_description>Local Mean Solar Time</field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>V</field_name>
  <field_number>4</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>21</field_location>
  <field_length>5</field_length>
  <field_format>F5.3</field_format>
  <field_min_physical>3.072451472</field_min_physical>
  <field_max_physical>5.15605715</field_max_physical>
  <field_unit>METERS/SECOND</field_unit>
  <field_description>Wind speed in meters per second
  </field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>DV+</field_name>
  <field_number>5</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>27</field_location>
  <field_length>4</field_length>
  <field_format>F4.2</field_format>
  <field_min_physical>0.428682136</field_min_physical>
  <field_max_physical>0.46032408</field_max_physical>
  <field_unit>METERS/SECOND</field_unit>
  <field_description>Error in wind speed (positive)
  </field_description>
</Table_Character_Field>
<Table_Character_Field>
```

```
  <field_name>DV-</field_name>
  <field_number>6</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>32</field_location>
  <field_length>7</field_length>
  <field_format>F7.5</field_format>
  <field_min_physical>0.415653998</field_min_physical>
  <field_max_physical>0.42656498</field_max_physical>
  <field_unit>METERS/SECOND</field_unit>
  <field_description>Error in wind speed (negative)
  </field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>DIR</field_name>
  <field_number>7</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>40</field_location>
  <field_length>10</field_length>
  <field_format>F10.6</field_format>
  <field_min_physical>125.5471521</field_min_physical>
  <field_max_physical>268.8220941</field_max_physical>
  <field_unit>DEGREES</field_unit>
  <field_description>Wind direction in degrees given in
                     meteorological convention (0 = from N,
                     90 = from E, 180 = from S, 270 = from W)
  </field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>DDIR</field_name>
  <field_number>8</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>51</field_location>
  <field_length>8</field_length>
  <field_format>F8.4</field_format>
  <field_min_physical>4.769160219</field_min_physical>
  <field_max_physical>8.616672754</field_max_physical>
  <field_unit>DEGREES</field_unit>
  <field_description>Error in direction (given in degrees).
                     If dv+ is larger than v, then this is
                     set to 180</field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>EXPOSURE TIME</field_name>
  <field_number>9</field_number>
  <field_data_type>ASCII_REAL</field_data_type>
  <field_location>60</field_location>
  <field_length>7</field_length>
  <field_format>F7.1</field_format>
  <field_min_physical>7140</field_min_physical>
  <field_max_physical>15300</field_max_physical>
  <field_unit>MILLISECONDS</field_unit>
  <field_description>Exposure time by SSI in
                      milliseconds</field_description>
</Table_Character_Field>
<Table_Character_Field>
  <field_name>FILE NAME</field_name>
  <field_number>10</field_number>
  <field_data_type>CHARACTER</field_data_type>
  <field_location>69</field_location>
  <field_length>17</field_length>
  <field_format>A17</field_format>
  <field_unit>N/A</field_unit>
  <field_description>Image filename used
```

```
                                       for the analysis</field_description>
                </Table_Character_Field>
            </Table_Record_Character>
        </Table_Character>
    </Data_Area_Table_Character>
</Product_Table_Character>
```

7.2.1.4 PDS4 TABLE_CHARACTER and PDS3 TABLE Parallelisms

This section provides a high level discussion of the parallelisms between the PDS3 TABLE Data Object Description (DoD) and the PDS4 TABLE_CHARACTER class.

The PDS3 TABLE (DoD) by definition was very flexible in that the DoD could define both simple Tables and very complex types of Tables depending on the representation of the data product byte stream. An example of a simple table is where the data product byte stream is represented as a 2-dimensional construct where neither dimension has either prefix or suffix bytes. A more complex example of a table is where the data product byte stream is represented by any of the following:

a. Row prefix and/or suffix bytes
b. The data is represented as row major storage
c. The data does not contain any contiguous unused or spare bytes

The PDS4 TABLE_CHARACTER class has been specifically designed to be more restrictive in the permissible representations of the data object byte stream. And as such, these restrictions ensure a more rigorous set of archival quality table constructs

APPENDIX A ACRONYMS

The following acronyms are pertain to this document:

ADM	Architecture Development Method
API	Application Programming Interface
COTS	Commercial Off-The-Shelf
EN	Engineering Node (PDS)
ESDIS	Earth Science Data and Information System
FTP	File Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IPDA	International Planetary Data Alliance
IT	Information Technology
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
PDS	Planetary Data System
RM-ODP	Reference Model of Open Distributed Processing
RSS	Really Simple Syndication
SDSC	San Diego Supercomputing Center
SOA	Service-Oriented Architecture
TB	Terabyte
TOGAF	The Open Group Architecture Framework
XML	eXtensible Markup Language

APPENDIX B DEFINITION OF TERMS

The following are definitions of essential terms used throughout this document:

Association:
An "association" is a type of defined relationship between classes.

Attribute:
An "attribute" is a property or characteristic that allows both identification and distinction.

Cardinality:
"Cardinality" is the number of values allowed to an attribute or association in a single class. Cardinality in general is stated as a range with a minimum and maximum. For example, an attribute that may be multi-valued will have a cardinality of "1..*". A cardinality where the minimum and maximum are the same is often shown as the single value. For example, an attribute required to have exactly one value will have a cardinality of "1". When a value is required the minimum cardinality is at least 1. At least one value is always required in PDS4.

Class:
A "class" is the set of attributes which identifies a family. A class is generic -- a template from which individual members of each family may be constructed.

Class Hierarchy:
A "class hierarchy" is a classification of object types, denoting objects as the instantiations of classes.

Data Elements:
A "data element" is a discrete unit of data or metadata. It is an elementary piece of information in a data dictionary.

Entity:
An "entity" is something that has a distinct, separate existence.

Metadata:
Metadata is data about data.

Model:
A "model" is a representation or description designed to show an entity and its composition.

Object:
An "object" is a specific instance of a class.

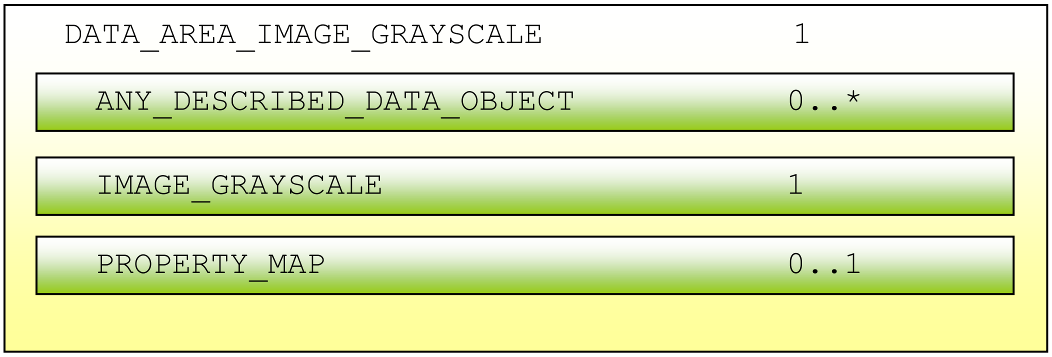
APPENDIX C DIGITAL OBJECT DESCRIPTIONS

This section provides a detailed diagrams of the Classes that collectively comprise the Digital Object Descriptions that are referenced within this document:

(1) IMAGE_GRAYSCALE_SET
(2) TABLE_CHARACTER_SET
(3) TABLE_BINARY_SET
(4) SOFTWARE_SET
(5) DOCUMENT_SET

C.1 DATA_AREA_IMAGE_GRAYSCALE

Class Description: TBD



DATA_AREA_IMAGE_GRAYSCALE	1
ANY_DESCRIBED_DATA_OBJECT	0..*
IMAGE_GRAYSCALE	1
PROPERTY_MAP	0..1

C.1.1 IMAGE_GRAYSCALE

IMAGE_GRAYSCALE	1
LOCAL_IDENTIFIER	1
COMMENT	0..1
IMAGE_GRAYSCALE_AXES_ORDER	1
IMAGE_GRAYSCALE_BYTE_ORDER	1
ARRAY_BASE_FILE_TYPE	1
ARRAY_BASE_FIRST_ELEMENT	1
ARRAY_BASE_MIN_INDEX	1
ARRAY_2D_NUMBER_OF_AXES	1

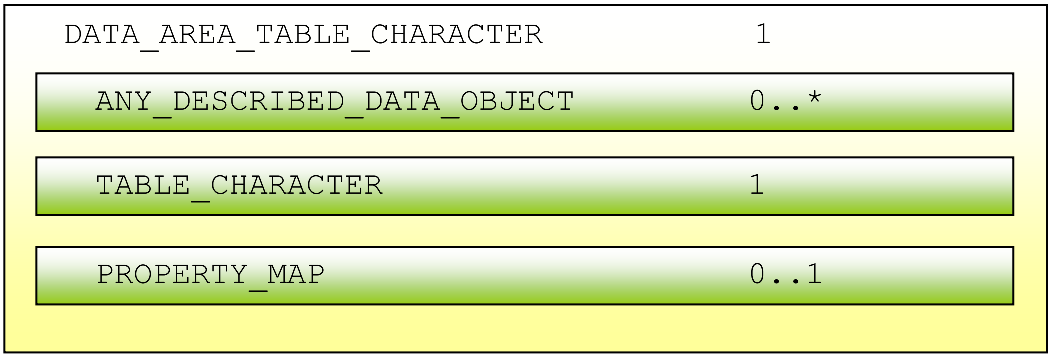
DATA_LOCATION	1
FILE_LOCAL_IDENTIFIER	1
OFFSET	1

ARRAY_AXIS	2
AXIS_INDEX	1
AXIS_LENGTH	1
AXIS_NAME	1
AXIS_SCALE_TYPE	1
AXIS_UNIT	1

ARRAY_ELEMENT	1
ELEMENT_BYTES	0..1
ELEMENT_SCALING_FACTOR	0..1
ELEMENT_TYPE	1
ELEMENT_UNIT	0..1
ELEMENT_VALUE_OFFSET	0..1

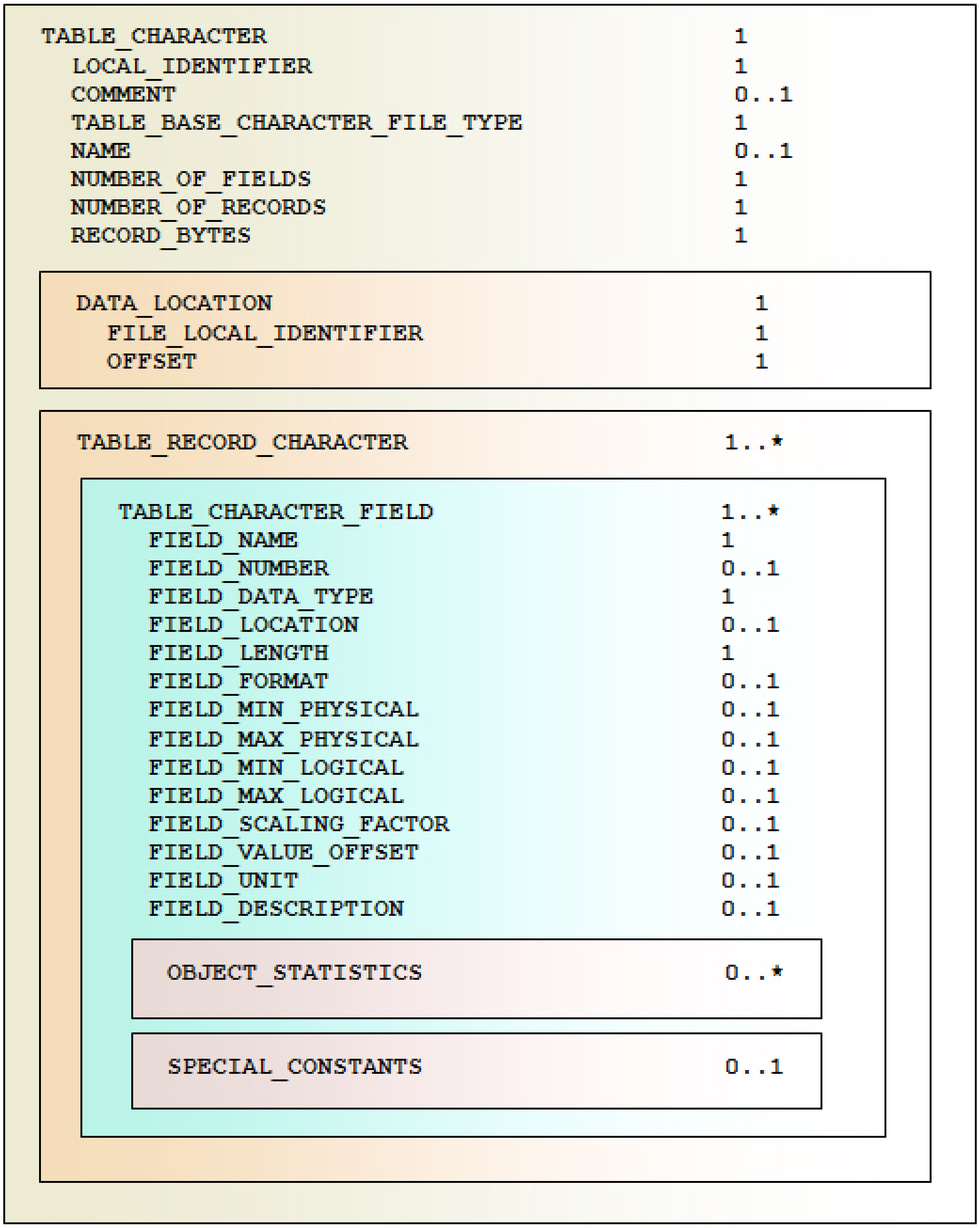
C.2 DATA_AREA_TABLE_CHARACTER

Class Description: TBD



C.2.1 TABLE_CHARACTER

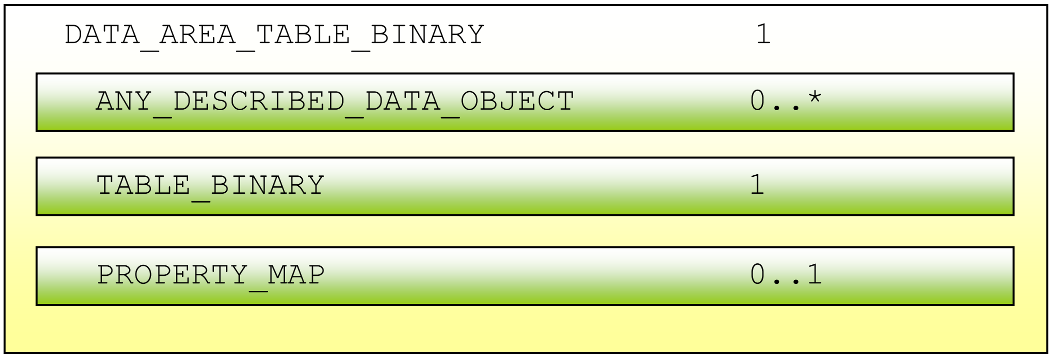
Class Description: TBD



TABLE_CHARACTER	1
LOCAL_IDENTIFIER	1
COMMENT	0..1
TABLE_BASE_CHARACTER_FILE_TYPE	1
NAME	0..1
NUMBER_OF_FIELDS	1
NUMBER_OF_RECORDS	1
RECORD_BYTES	1
DATA_LOCATION	1
FILE_LOCAL_IDENTIFIER	1
OFFSET	1
TABLE_RECORD_CHARACTER	1..*
TABLE_CHARACTER_FIELD	1..*
FIELD_NAME	1
FIELD_NUMBER	0..1
FIELD_DATA_TYPE	1
FIELD_LOCATION	0..1
FIELD_LENGTH	1
FIELD_FORMAT	0..1
FIELD_MIN_PHYSICAL	0..1
FIELD_MAX_PHYSICAL	0..1
FIELD_MIN_LOGICAL	0..1
FIELD_MAX_LOGICAL	0..1
FIELD_SCALING_FACTOR	0..1
FIELD_VALUE_OFFSET	0..1
FIELD_UNIT	0..1
FIELD_DESCRIPTION	0..1
OBJECT_STATISTICS	0..*
SPECIAL_CONSTANTS	0..1

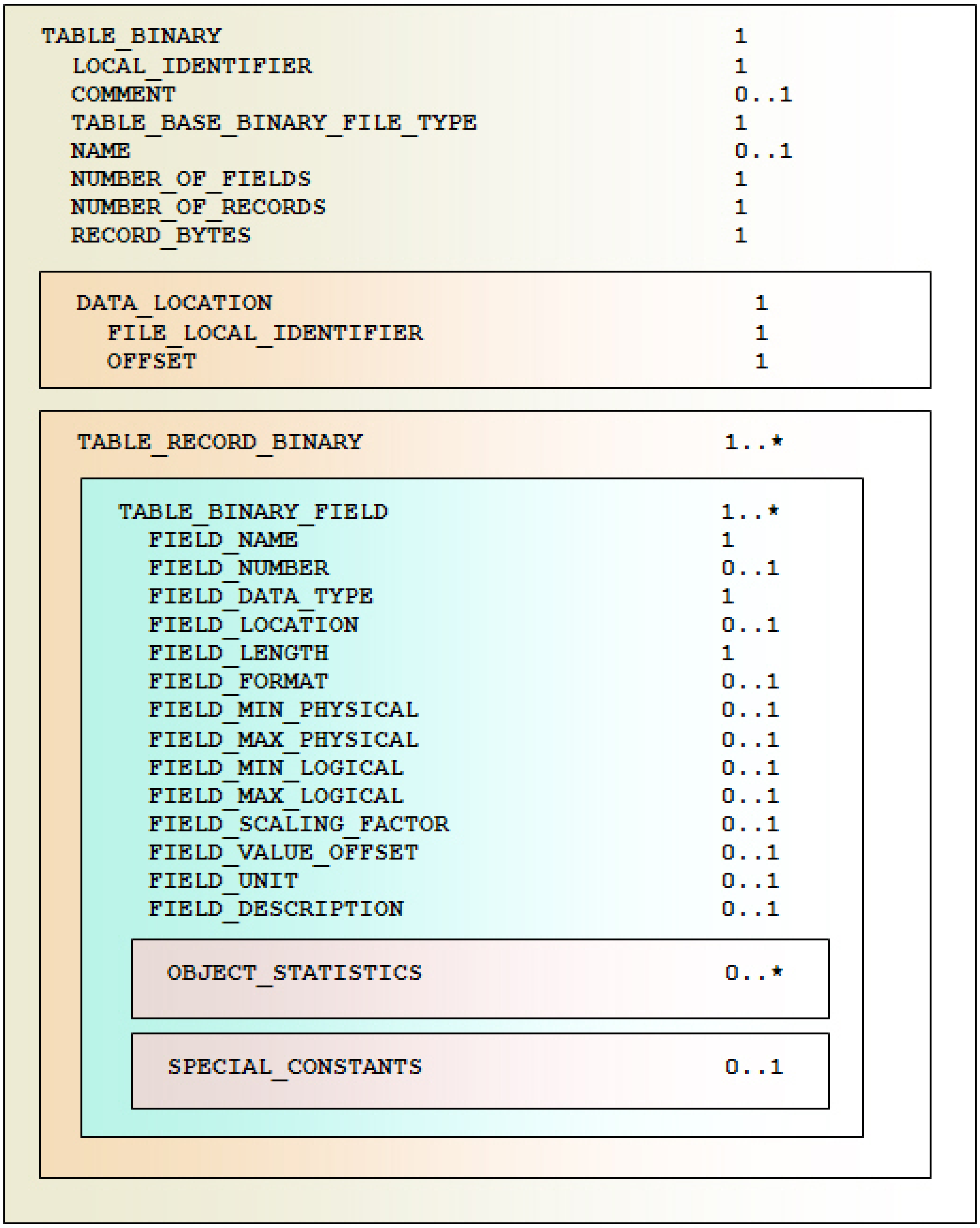
C.3 DATA_AREA_TABLE_BINARY

Class Description: TBD



C.3.1 TABLE_BINARY

Class Description: TBD



TABLE_BINARY	1
LOCAL_IDENTIFIER	1
COMMENT	0..1
TABLE_BASE_BINARY_FILE_TYPE	1
NAME	0..1
NUMBER_OF_FIELDS	1
NUMBER_OF_RECORDS	1
RECORD_BYTES	1
DATA_LOCATION	1
FILE_LOCAL_IDENTIFIER	1
OFFSET	1
TABLE_RECORD_BINARY	1..*
TABLE_BINARY_FIELD	1..*
FIELD_NAME	1
FIELD_NUMBER	0..1
FIELD_DATA_TYPE	1
FIELD_LOCATION	0..1
FIELD_LENGTH	1
FIELD_FORMAT	0..1
FIELD_MIN_PHYSICAL	0..1
FIELD_MAX_PHYSICAL	0..1
FIELD_MIN_LOGICAL	0..1
FIELD_MAX_LOGICAL	0..1
FIELD_SCALING_FACTOR	0..1
FIELD_VALUE_OFFSET	0..1
FIELD_UNIT	0..1
FIELD_DESCRIPTION	0..1
OBJECT_STATISTICS	0..*
SPECIAL_CONSTANTS	0..1

C.4 TABLE_CHARACTER_GROUPED_SET

Class Description: TBD

C.4.1 TABLE_CHARACTER_GROUPED

Class Description: TBD

C.4.2 TABLE_RECORD_CHARACTER_GROUPED

Class Description: TBD

C.4.3 TABLE_CHARACTER_GROUPED_SEQUENCE

Class Description: TBD

C.5 STREAM_DELIMITED_SET

Class Description: TBD

C.5.1 STREAM_DELIMITED

Class Description: TBD

C.5.2 STREAM_DELIMITED_RECORD

Class Description: TBD

C.6 SOFTWARE_FORMAT_SET

Class Description: TBD

C.6.1 SOFTWARE_SET_DESC

Class Description: TBD

C.7 DOCUMENT_FORMAT_SET

Class Description: TBD

C.7.1 DOCUMENT_SET_DESC

Class Description: TBD

C.x HEADER_SET

Class Description: TBD

C.x.1 HEADER

Class Description: TBD

APPENDIX D NON-DIGITAL OBJECT DESCRIPTIONS

This section provides a detailed diagrams of the Classes that collectively comprise the Non-Digital Object Descriptions that are referenced within this document:

(1) DESCRIPTION_AREA
(2) IDENTIFICATION_AREA
(3) CROSS_REFERENCE_AREA
(4) OBSERVATION_SECTION
(5) SPACECRAFT_OBSERVATION_SECTION
(6) OBJECT_STATISTICS
(7) SPECIAL_CONSTANTS
(8) PROPERTY_MAP
(9) FILE_AREA
(10) DATA_LOCATION

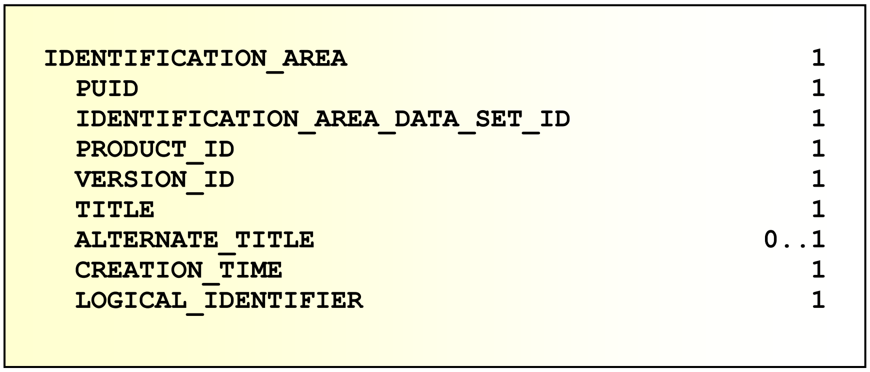
D.1 DESCRIPTION_AREA

Class Description: TBD

```
DESCRIPTION_AREA                                         0..1
  DESCRIPTION                                               1
```

D.2 IDENTIFICATION_AREA

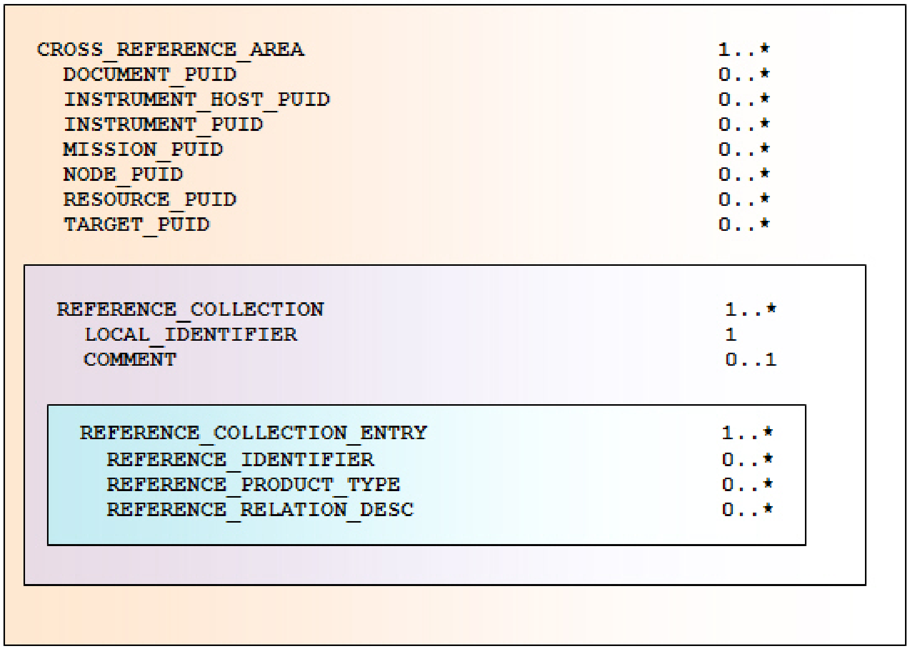
Class Description: TBD



IDENTIFICATION_AREA	1
PUID	1
IDENTIFICATION_AREA_DATA_SET_ID	1
PRODUCT_ID	1
VERSION_ID	1
TITLE	1
ALTERNATE_TITLE	0..1
CREATION_TIME	1
LOGICAL_IDENTIFIER	1

D.3 CROSS_REFERENCE_AREA

Class Description: TBD



CROSS_REFERENCE_AREA	1..*
DOCUMENT_PUID	0..*
INSTRUMENT_HOST_PUID	0..*
INSTRUMENT_PUID	0..*
MISSION_PUID	0..*
NODE_PUID	0..*
RESOURCE_PUID	0..*
TARGET_PUID	0..*

REFERENCE_COLLECTION	1..*
LOCAL_IDENTIFIER	1
COMMENT	0..1

REFERENCE_COLLECTION_ENTRY	1..*
REFERENCE_IDENTIFIER	0..*
REFERENCE_PRODUCT_TYPE	0..*
REFERENCE_RELATION_DESC	0..*

D.4 OBSERVATION_AREA

Class Description: TBD

```
OBSERVATION_AREA                                  1
  COMMENT                                         0..1
  START_TIME                                      1
  STOP_TIME                                       1
```

D.5 SPACECRAFT_OBSERVATION_AREA

Class Description: TBD

```
SPACECRAFT_CIRCUMSTANCES_OF_OBSERVATION_AREA      1
  COMMENT                                         0..1
  SPACECRAFT_CLOCK_START_COUNT                    0..1
  SPACECRAFT_CLOCK_STOP_COUNT                     0..1
  START_TIME                                      1
  STOP_TIME                                       1
```

D.6 OBJECT_STATISTICS

Class Description: TBD

```
OBJECT_STATISTICS                              0..*
  LOCAL_IDENTIFIER                             1
  COMMENT                                      0..1
  CHECKSUM                                     0..1
  MAXIMUM                                      0..1
  MEAN                                         0..1
  MEDIAN                                       0..1
  MINIMUM                                      0..1
  STANDARD_DEVIATION                           0..1
```

D.7 SPECIAL_CONSTANTS

Class Description: TBD

```
SPECIAL_CONSTANTS                           0..1
  ERROR_CONSTANT                            0..1
  INVALID_CONSTANT                          0..1
  MISSING_CONSTANT                          0..1
  NOT_APPLICABLE_CONSTANT                   0..1
  SATURATED_CONSTANT                        0..1
  UNKNOWN_CONSTANT                          0..1
```

D.8 PROPERTY_MAP

Class Description: TBD

PROPERTY_MAP	0..1
LOCAL_IDENTIFIER	1
COMMENT	0..1
NAMESPACE_ID	1

PROPERTY_MAP_ENTRY	1..*
PROPERTY_NAME	1
PROPERTY_VALUE	1..*

D.9 FILE_AREA

Class Description: TBD

FILE_AREA	1

FILE	1

D.10 DATA_LOCATION

Class Description: TBD

DATA_LOCATION	1
FILE_LOCAL_IDENTIFIER	1
OFFSET	1