Dawn Mission to Vesta and Ceres
Gravity Science Investigation
PDS4 Archive Software Interface Specification

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CHANGE LOG

DATE	CHANGES	REASON	REVISION
2022-07-02	All	Rewritten for PDS4 after migration from PDS3	1.0

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ACRONYMS AND ABBREVIATIONS

APC	Antenna Phase Center (file)
ASCII	American Standard Code for Information Interchange
CK	Camera (attitude) Kernel
CSV	Comma-Separated Variable
DOM	Distributed Object Manager
DSC	Dawn Science Center
DSMS	Deep Space Mission Systems
DSN	Deep Space Network
EK	Events Kernel
FK	Frames Kernel
GS	Gravity Science
GSI	Gravity Science Instrument
HGA	High Gain Antenna
ION	Ionosphere (in reference to Ionosphere calibration files)
JPL	Jet Propulsion Laboratory
kB	kilobyte
LGA	Low Gain Antenna
LID	Logical identifier
LIDVID	(versioned) logical identifier
MB	Megabyte
NAIF	Navigation Ancillary Information facility
NASA	National Aeronautics and Space Administration
ODF	Orbit Data File
OSCARX	server through which JPL/DSN radio tracking data are distributed
PDS	Planetary Data System
PDS3	PDS version 3
PDS4	PDS version 4
PPI	Planetary Plasma Interactions (PDS discipline node)
RDA	Raw Data Archive
RS	Radio Science
RSS	Radio Science Subsystem
SCLK	Spacecraft Clock Kernel
SBN	(PDS) Small Bodies Nodes
SCM	Spacecraft Mass History
SCT	Spacecraft Team
SFF	Small Forces File
SIS	Software Interface Specification
SPICE	Spacecraft, Planetary, Instrument, Camera, and Event toolkit/system
SPK	Spacecraft and Planetary (ephemerides) Kernel
TNF	Tracking and Navigation Service Data Files
TRO	Troposphere (in reference to Troposphere calibration files)
TSAC	Tracking System Analytic Calibration
VEGR	Vesta Gravity
VID	Version identifier
WEA	Weather (in reference to DSN Weather files)
XML	eXtensible Markup Language

1. INTRODUCTION

1.1. Purpose and Scope

This Software Interface Specification (SIS) describes the format and content of the Gravity Science (GS) Raw Data Archive (RDA) for the Dawn mission after 'migration' from Planetary Data System (PDS) Standards version 3 (PDS3) to version 4 (PDS4). The Dawn GS RDA is the complete archive of raw data from gravity science investigations conducted using the radio link between Dawn and NASA Deep Space Network (DSN) tracking stations while the spacecraft orbited Vesta and Ceres. The archive was generated by the Dawn Gravity Science Team and the Dawn Science Center (DSC); it was originally delivered to, and has been maintained and distributed by, the PDS. The 'migration' was carried out by the Planetary Plasma Interactions (PPI) node of PDS; it allows users to take advantage of new features available under PDS4.

Gravity Science (GS) is a subset of Radio Science (RS); because of this, the terms Gravity Science and Radio Science are used interchangeably in this document. Similarly, the terms Gravity Science Instrument (GSI) and Radio Science Subsystem (RSS) are also used interchangeably.

1.2. Data Overview

This archive contains raw, partially processed, and supporting gravity science data acquired while Dawn was in orbit around the asteroid Vesta and the dwarf planet Ceres. The radio observations were carried out using the telecommunications equipment aboard the Dawn spacecraft and at Earth-based stations of the NASA Deep Space Network. The data were collected to support generation of high-resolution gravity field models for the two target bodies — see, for example, Reference [2].

Of most interest are likely to be the Orbit Data Files (ODFs), which provided the raw radio range and Doppler input to the gravity investigations, and the ionospheric and tropospheric media calibration files (ION and TRO files, respectively).

The closed-loop receiving system of the Deep Space Network used a phase-lock loop to track the downlink signal from the Dawn spacecraft, recording both amplitude and frequency measurements at rates of typically 10 times per second. Closed-loop data are efficient for characterizing slowly changing signals and are the input to operational navigation and orbit-determination processes.

The Vesta archive includes one type of primary data — the ODF. TNFs (Tracking and Navigation Files) are the output from the closed-loop receiver. ODFs are abstracted and compressed versions of TNFs specifically targeted to spacecraft navigators and scientists interested in gravity fields. Measurements of little or no interest to most navigators and scientists are omitted in the TNF to ODF conversion; measurements that *are* of interest are often averaged in time during the conversion to reduce noise and ODF data volume. The Ceres archive includes ODFs for 2015 and 2016; it includes TNFs (only) for 2018.

Typical users of these data might analyze range and Doppler measurements in ODFs to reconstruct the spacecraft trajectory. Relevant questions would include the measurement

uncertainties in range and Doppler at different DSN antennas. Those uncertainties could then set constraints on models of gravity fields developed later.

The migration from PDS3 to PDS4 primarily affected metadata. Except for minor simplifications in format (for example, padding lines in ASCII files with blanks so that all records have equal length), there were no changes to data files. However, new labels were written in XML to describe the data in more detail, and the data were organized into new hierarchies of bundles, collections, and products to facilitate tracking, inspection, and scientific analysis.

1.3. Content Overview

The Dawn GS RDA contains one type of observational radio science data (ODF)[1] and six types of supplementary data that may be used for calibration. The data types are described briefly below. The earliest and latest ODF data for the two targets are

1. **ODF:** Orbit Data Files — many files from both Vesta and Ceres contain the minimally processed output of the closed-loop receiver, including range and Doppler. The earliest and latest ODF date for the two targets are
   ```
   Vesta: from 2011-07-10T08:49:58 to 2012-09-05T19:17:08
   Ceres: from 2015-01-02T00:28:50 to 2016-09-06T10:15:09
   ```
2. **TNF**: Tracking and Navigation Files — many files contain a wide range of radio tracking data types. Earliest and latest TNF data are
   ```
   Ceres: from 2018-06-06T16:35:14 to 2018-11-01T08:25:01
   ```
3. **APC:** Antenna Phase Center file — one file for each target contains the times when the phase center changed due to selection of a low gain antenna (default was the high gain antenna)
4. **ION:** Ionosphere calibration files — approximately one file per month contains historical and predicted Earth ionosphere conditions
5. **SCM:** Spacecraft mass report file — one file for each target contains the spacecraft mass, center of mass, and propellant usage over time
6. **SFF:** Small forces files — two files from the Vesta phase and three files from the Ceres phase contain spacecraft thruster firing data
7. **TRO:** Troposphere calibration files — approximately one file per month contains historical and predicted Earth troposphere conditions
8. **WEA:** DSN weather files — a few files for each phase contain the half-hourly weather conditions at each DSN communication complex (located near Barstow, CA; Canberra, Australia; and Madrid, Spain)

1.4. References

[1] Deep Space Network Telecommunications Link Design Handbook, JPL-E-810-005, Jet Propulsion Laboratory, Pasadena, CA, 2013.

[2] Park R.S., A.S. Konopliv, B.G. Bills, N. Rambaux, J.C. Castillo-Rogez, C.A. Raymond, A.T. Vaughan, A.I. Ermakov, M.T. Zuber, R.R. Fu, M.J. Toplis, C.T. Russell, A. Nathues

[1] In the Ceres archive, TNFs are substituted for ODFs in 2018 (only).

and F. Preusker, A partially differentiated interior for (1) Ceres deduced from its gravity field and shape, **Nature 537**, 515-517, doi:10.1038/nature18955, 2016.

2. RAW DATA ARCHIVE OVERVIEW

2.1. Archive Overview

The Dawn RS RDA is organized into two bundles — one for the Vesta mission phase and one for the Ceres phase (see Figure 1). The Vesta bundle has nine member collections — one for ODF observational data, one each for the six types of calibration data (APC, ION, SCM, SFF, TRO, and WEA), one for 'context' products, and one for documents needed to understand the archive. The Ceres bundle also includes a TNF collection. The members of collections are data products, each including its own label written in XML. The members of each collection are listed in a collection Inventory, which is accompanied by an XML label. The bundle has a label which lists the member collections, but there is no separate inventory file.

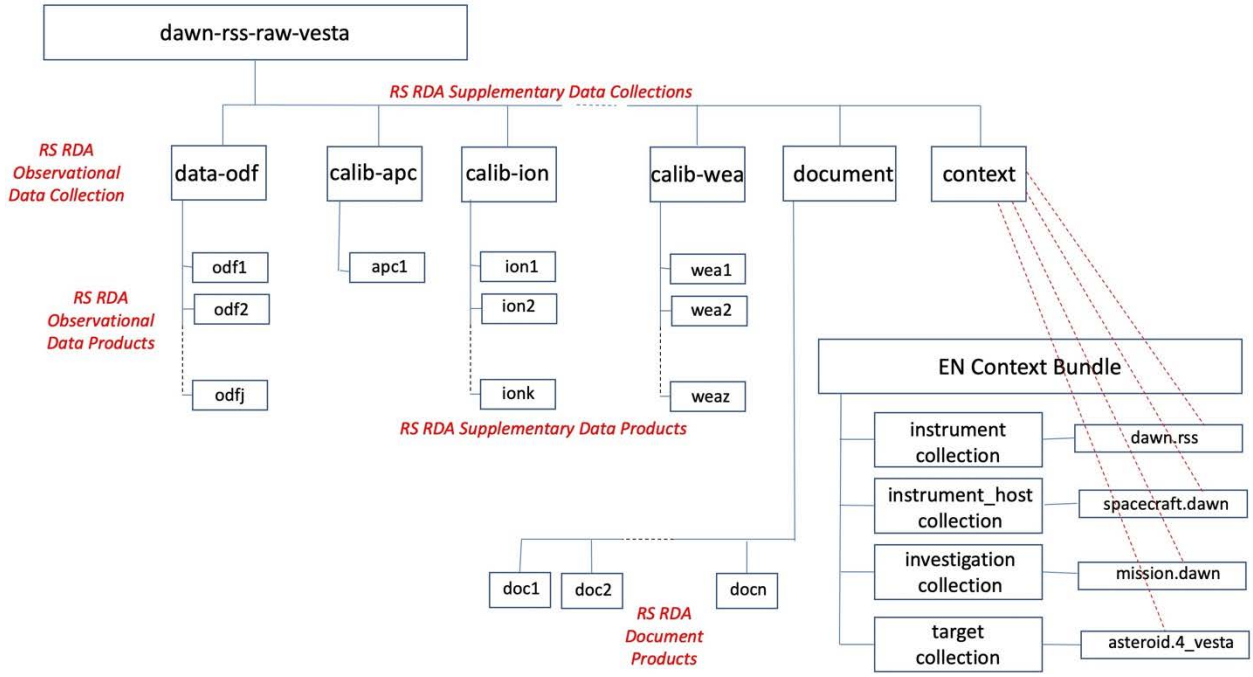

Figure 1. Diagram showing the bundle, collection, and product hierarchy for the Vesta portion of the Dawn Radio Science Raw Data Archive. The Ceres diagram is identical except for the substitutions "*dawn-rss-raw-ceres*" in the upper left and "*dwarf_planet.1_ceres*" in the lower right. The Ceres bundle includes ODFs for 2015 and 2016; but TNFs were substituted in 2018.

The bundle has a logical identifier (LID) which is unique across all of PDS. The <*bundle_ID*> for Vesta is "*dawn-rss-raw-vesta*" and the <*bundle_ID*> for Ceres is "*dawn-rss-raw-ceres*". The LIDs for the Dawn Vesta and Ceres bundles are then, respectively:

urn:nasa:pds:dawn-rss-raw-vesta
urn:nasa:pds:dawn-rss-raw-ceres

Each collection has a LID, which is the bundle LID with a fifth field (the collection identifier) appended; the Dawn RS RDA Collection LIDs are:

urn:nasa:pds:<bundle_ID>:data-odf
urn:nasa:pds:<bundle_ID>:data-tnf (Ceres in 2018 only)
urn:nasa:pds:<bundle_ID>:calib-apc
urn:nasa:pds:<bundle_ID>:calib-ion
urn:nasa:pds:<bundle_ID>:calib-scm
urn:nasa:pds:<bundle_ID>:calib-sff
urn:nasa:pds:<bundle_ID>:calib-tro
urn:nasa:pds:<bundle_ID>:calib-wea
urn:nasa:pds:<bundle_ID>:context
urn:nasa:pds:<bundle_ID>:document

For example, the Collection LID for raw weather data collected during the Ceres phase is:

urn:nasa:pds:dawn-rss-raw-ceres:calib-wea

Each product has a LID, which is the collection LID with a sixth field (the product identifier) appended; the Dawn RS RDA product LIDs are described below. The general form is

urn:nasa:pds:<bundle_ID>:<collection_ID>:<product_ID>

Section 2.4.1 contains more detail and examples of product LIDs, data file names, and label file names.

Bundles, collections, and products may have different versions — for example, when different calibrations are applied. PDS4 allows data providers to distinguish different versions of the same bundle, collection, or product using a version identifier (VID). The VID is appended to the LID by a double colon, as illustrated below, where M denotes a 'major' revision and 'n' denotes a 'minor' revision:

urn:nasa:pds:<bundle_ID>::M.n
urn:nasa:pds:<bundle_ID>:<collection_ID>::M.n
urn:nasa:pds:<bundle_ID>:<collection_ID>:<product_ID>::M.n

A versioned bundle, collection, or product, is absolutely unique across PDS; there can never be two bundles, collections, or products with the same LIDVID. By convention, when a bundle, collection, or product is identified only by its LID, the most recent version is assumed.

2.2. Archive Physical Structure

The physical structure of the archive closely follows that of the logical organization of the bundles and collections. Each collection is located in a separate subdirectory, with the data in a ‘data’ directory, and the calibration files in a ‘calib’ directory. Individual data files may be further divided into year directories for ease of use.

2.3. Instrument Overview

The Dawn Gravity Science Instrument (GSI) included the transponder aboard the Dawn spacecraft and transmitting and receiving equipment at the Deep Space Network to collect ranging and Doppler measurements which would be used to determine the spacecraft trajectory and the gravitational fields of Vesta and Ceres.

The exact frequency transmitted from the spacecraft was controlled by the signal received from a ground station ('two-way' or 'coherent' mode) or by an oscillator onboard the spacecraft ('one-way' or 'non-coherent' mode). In some circumstances an uplink signal was transmitted from one ground station while a different ground station participated in reception – the 'three-way' mode. In the absence of an 'uplink' signal, the spacecraft switched automatically to one-way mode.

For more details on the Gravity Science Instrument, see

urn:nasa:pds:<bundle_ID>:document:instrument-rs

in the Dawn RS RDA Document Collection, or references in the Dawn RS RDA instrument Context product

urn:nasa:pds:<bundle_ID>:context:dawn.rss

2.4. Data Product Overview

ODFs are binary files with detached PDS labels describing the file's content and format at the bit level. The calibration product types (APC, ION, SCM, SFF, TRO, and WEA) are ASCII files; like ODFs, they have detached descriptive labels. Where appropriate a source product is given in the label; it is constructed from the PDS3 DATA_SET_ID and PDS3 FILE_NAME. The table below lists the data product types and summary descriptions.

File	Abbrev.	File Type	Average File Size (kB)	Generation Frequency	Source of Files
Orbit Data	ODF	Binary	100	Per request	DSN/OSCARX
Tracking and Navigation	TNF	Binary	20000	Per request	DSN/OSCARX
Antenna Phase Center	APC	ASCII	4	Once per target	Dawn Gravity Team
Ionosphere Calibration	ION	ASCII	24	Monthly	TSAC/OSCARX
Spacecraft Mass Report	SCM	ASCII	8	Once per target	Dawn DOM
Small Forces	SFF	ASCII	25000	Twice per target	Dawn DOM
Troposphere Calibration	TRO	ASCII	150	Monthly	TSAC/OSCARX
DSN Weather	WEA	ASCII	1100	Weekly[2]	TSAC/OSCARX

[2] Although DSN weather files were updated approximately weekly, each was an accumulation of data for the current year. Only the annual file for each DSN complex has been retained in the PDS4 archive for 2011, 2012, and 2015; the 2016 file covers days 001-353, which extends well beyond the last ODF data, collected on day 250.

2.4.1. Detailed Descriptions

Unless otherwise noted, the abbreviation '*yyyy*' indicates the year, and '*ddd*' indicates the day of year in the remainder of this section. In a string, such as '*yyyy_ddd_yyyy_ddd*', the first date ('*yyyy_ddd*') indicates the starting date and the second date indicates the end date of the file coverage. If only one string is provided, it is the start date of the file.

Orbit Data File (ODF)

An ODF is the abstracted, minimally processed output from one or more closed-loop DSN receivers. It contains the most important information (range, Doppler, and transmitter frequency ramps) needed by spacecraft navigators and investigators interested in determining gravity fields.

ODF data records include an 'observable', which is identified by a numerical 'data type'. The most common observables in Dawn ODF records and their numerical data types are:

11	One-way Doppler (Hertz)
12	Two-way Doppler (Hertz)
13	Three-way Doppler (Hertz)
37	Sequential range (range units)

All ODFs are members of the ODF Collection.

ODF file names have the form *yyyy_ddd_hhmmxuuwvn.dat* where 'yyyy' is the four-digit year, 'ddd' is the three-digit day-of-year, 'hh' is the two-digit hour, and 'mm' is the two-digit minute at the beginning of the file. 'x' indicates an X-band uplink ('n' denotes no uplink), 'uu' indicates the uplink station (set to 'nn' for no uplink or 'mm' for two or more uplinking stations during the time interval covered), 'w' indicates the downlink mode ('1', '2', '3', or 'm' for 1-way, 2-way, 3-way, or 'multiple', respectively), and 'vn' indicates the version number of the file. The associated ODF label has the same file name except for the extension *.xml*. The typical ODF contains about 100 kB. Format and content of the files are described by *sis-odf* in the Document Collection.

An ODF LID is the file name (less the 'vn.dat' trailing characters) appended to the ODF Collection LID (see Section 2.1). For example:

File name: *2015_282_1009xmmmv1.dat*
LID: *urn:nasa:pds:dawn-rss-raw-vesta:data-odf:2015_282_1009xmmm*

Tracking and Navigation File (TNF)

A TNF is the minimally processed output from one or more closed-loop DSN receivers. It contains data characterizing the uplink transmissions and downlink receptions needed by spacecraft navigators and investigators interested in reconstructing a spacecraft trajectory or determining a gravity field.

There are 18 TNF record formats, identified by a numerical 'data type'. The most common data types in Dawn TNFs are:

00	Uplink carrier phase

01 Downlink carrier phase
02 Uplink sequential ranging phase
03 Downlink sequential ranging phase
07 Sequential Ranging
09 Ranging
11 DRVID
16 Carrier observable
17 Phase

All TNFs are members of the TNF Collection.

TNF file names have the form *yyyy_ddd_hhmmxuuwvn.dat* where 'yyyy' is the four-digit year, 'ddd' is the three-digit day-of-year, 'hh' is the two-digit hour, and 'mm' is the two-digit minute at the beginning of the file. 'x' indicates an X-band uplink, 'uu' indicates the uplink station (set to 'nn' for no uplink or 'mm' for two or more uplinking stations during the time interval covered), 'w' indicates the downlink mode ('1', '2', '3', or 'm' for 1-way, 2-way, 3-way, or 'multiple', respectively), and 'vn' indicates the version number of the file. The associated TNF label has the same file name except for the extension *.xml*. The typical TNF contains about 20 MB. Format and content of the files are described by *sis-tnf* in the Document Collection.

A TNF LID is the file name (less the 'vn.dat' trailing characters) appended to the TNF Collection LID (see Section 2.1). For example:

File name: *2015_282_1009xmmmv1.dat*
LID: *urn:nasa:pds:dawn-rss-raw-vesta:data-tnf:2015_282_1009xmmm*

Note: TNF records delivered by the DSN were in absolute time order, with record types interleaved. Retaining that structure would have made the PDS4 label much larger than the data file itself. Ordinarily, the PDS4 migration would have included a sorting step in which records were grouped by data type; then the blocks with common data type would have been concatenated into a new file — containing all original records, but in a different order. The TNFs in the Ceres archive had already been sorted according to data type when they were delivered to PDS3; so the sort carried out as part of the migration changed nothing.

Antenna Phase Center files

The Dawn spacecraft utilized four antennas during operations — one high gain antenna and three low gain antennas, mounted with phase centers as shown in the table below.

Body ID	X-component (meters)	Y-component (meters)	Z-component (meters)
PLUS_X_HGA	1.22	0.00	1.58
PLUS_X_LGA	0.99	0.45	0.33
PLUS_Z_LGA	0.26	-0.43	2.29
MINUS_Z_LGA	0.45	0.45	-0.01

Antenna Phase Center (APC) files are ASCII tables produced by the JPL Dawn Gravity Science Team. Files contain the start times and stop times when any of the low gain antennas were being

used. During times not specified in these files, the high gain antenna was being used. The original sources of these data were the Dawn Sequence of Events (SOE) files. APC data file names, label file names, and LIDs have the forms, respectively:

yyyy_ddd_yyyy_ddd.tab
yyyy_ddd_yyyy_ddd.xml
urn:nasa:pds:<bundle_ID>:calib-apc:yyyy_ddd_yyyy_ddd

Ionosphere Calibration files

Ionosphere calibration (ION) files are ASCII files produced by the Tracking System Analytic Calibration (TSAC) Group at JPL. They provide historical and predicted Earth ionospheric conditions. Typical file size is 24 KB. Format and content of the files are described by *sis-media* in the Document Collection. ION data file names, label file names, and LIDs have the forms, respectively:

yyyy_ddd_yyyy_ddd.txt
yyyy_ddd_yyyy_ddd.xml
urn:nasa:pds:<bundle_ID>:calib-ion:yyyy_ddd_yyyy_ddd

Spacecraft Mass History files

Spacecraft Mass History (SCM) files are ASCII files that were produced by the Dawn Spacecraft Team. They contain estimates of spacecraft mass, center of mass, and propellant usage in a comma-separated variable (CSV) format. The file is cumulative; the Vesta file size is 6 kB, and the Ceres file is 16 kB. SCM data file names, label file names, and LIDs have the forms, respectively:

yyyy_ddd.csv
yyyy_ddd.xml
urn:nasa:pds:<bundle_ID>:calib-scm:yyyy_ddd

Small Forces Files

Small Forces Files (SFF) were created from the Dawn spacecraft engineering telemetry stream. These are ASCII files in CSV format. File sizes range from 0.5 MB to 61 MB. File content and structure are defined by *sis-sff* in the Document Collection. SFF data file names, label file names, and LIDs have the forms, respectively:

yyyy_ddd_yyyy_ddd.csv
yyyy_ddd_yyyy_ddd.xml
urn:nasa:pds:<bundle_ID>:calib-sff:yyyy_ddd_yyyy_ddd

Troposphere Calibration files

Troposphere calibration (TRO) files are ASCII files produced monthly by the Tracking System Analytic Calibration (TSAC) Group at JPL. They provide historical and predicted Earth tropospheric conditions. Typical file size is 150 kB. Format and content of the files are described by *sis-media* in the Document Collection. TRO data file names, label file names, and LIDs have the forms, respectively:

yyyy_dd_yyyy_ddd.txt

yyyy_dd_yyyy_ddd.xml
urn:nasa:pds:<bundle_ID>:calib-tro:yyyy_ddd_yyyy_ddd

DSN Weather files

DSN Weather (WEA) files were produced by the Tracking System Analytic Calibration (TSAC) Group at JPL. Files give weather calibration information for DSN complexes. These are ASCII files with constant length records. WEA files were typically released weekly and contained all weather data for the complex since January 1st of a given year. Only files covering the entire years of 2011-2013 and 2015-2018 are included in the Vesta and Ceres bundles, respectively. Typical file sizes are 1.1 MB. Format and content of the files are described by *sis-wea* in the Document Collection. WEA data file names, label file names, and LIDs have the forms, respectively:

yyyy_ddd_yyyy_ddd_ss.tab
yyyy_ddd_yyyy_ddd_ss.xml
urn:nasa:pds:<bundle_ID>:calib-tro:yyyy_ddd_yyyy_ddd_ss

where *ss* identifies the DSN complex where the weather data were acquired (10, 40, or 60).

Documents

Document LIDs, file names, sources, and formats are summarized in the table below. The Dawn RS RDA document is a primary members of the Document Collection in each of the two Dawn RS RDA bundles (Figure 1). Four mission-independent SIS documents are also included as secondary members of the document collection. The APC and SCM documents are described by their PDS4 labels; there is no descriptive document for either. Label files have the same base name as their respective document files, then use the extension **.xml* — for example, the ODF SIS label file name is *odf_sis.xml*.

Document	Source	LID	File Name	Format	Notes
Dawn RS RDA SIS	PDS	**:sis-rs-rda*	*dawn_rs_rda_sis.pdf*	PDF/A	
ODF SIS	DSN	**:sis-odf*	*odf_sis.pdf*	PDF/A	TRK-2-18
TNF SIS	DSN	**:sis-tnf*	*tnf_sis.pdf*	PDF/A	TRK-2-34
Media SIS	DSN	**:sis-media*	*media_sis.pdf*	PDF/A	TRK-2-23
SFF SIS	SCT	**:sis-sff*	*sff_sis.pdf*	PDF/A	
WEA SIS	DSMS	**:sis-wea*	*wea_sis.pdf*	PDF/A	TRK-2-24
Instrument Descr.	PDS	**instrument_rs*	*instrument_rs.txt*	Text	
References	GS Team	**:ref*	*ref.txt*	Text	
ODF Conversion	PDS	**:odf2ascii*	*odf2ascii.{docx,pdf}*	Word, PDF/A	

* The first five fields of the LID are *urn:nasa:pds:<bundle_id>:document*

2.5. Data Processing

Data processing was performed by various groups and organizations at the Jet Propulsion Lab and the Deep Space Network. For details on each individual type, refer to the appropriate document in the Document Collection.

2.6. Software

No software is included in this archive. The SPICE Toolkit provides useful tools and algorithms for data processing and is located at the NAIF PDS node (see below).

3. RELEVANT DATA ARCHIVED AT OTHER SITES

3.1. NAIF Node

The Navigation and Ancillary Information Facility (NAIF) is the navigation node of the PDS. NAIF provides archival files of spacecraft trajectory and attitude, mission event records, clock conversions, and planetary ephemerides for most NASA missions. Additionally, NAIF provides the SPICE Toolkit, which contains useful algorithms for using and manipulating NAIF data.

The following data types are relevant to gravity science:

- **CK:** Spacecraft and solar array attitude orientation files
- **EK:** Spacecraft events kernel
- **FK:** Reference frame specifications
- **SCLK:** Conversion between spacecraft time and ephemeris time
- **SPK:** Spacecraft and Planetary ephemeris data

The NAIF PDS archive for Dawn is located at:

https://naif.jpl.nasa.gov/pub/naif/pds/data/dawn-m_a-spice-6-v1.0/

3.2. Optical Navigation Data – Small Bodies Node

The PDS Small Bodies Node (SBN) hosts data from Dawn Framing Cameras 1 and 2 (FC1 and FC2, respectively). The Framing Camera archives include optical navigation data, which may be useful in the analysis of the DSN radiometric tracking data contained in this archive.

The PDS Small Bodies Node with Dawn data is located at:

https://sbn.psi.edu/pds

The Framing Camera imaging data can be found at:

https://sbn.psi.edu/pds/resource/dawn/

4. PERSONNEL

The following people were involved in the collection, analysis, and archiving of the Dawn raw radio science data:

- Ryan S. Park, Chair of the Dawn Gravity Science Working Group, NASA Jet Propulsion Laboratory

- Alexander S. Konopliv, Dawn Gravity Science Co-Investigator, NASA Jet Propulsion Lababoratory
- Sami W. Asmar, Dawn Gravity Science Co-Investigator, NASA Jet Propulsion Laboratory
- Andrew T. Vaughan, Dawn Gravity Science Analyst, NASA Jet Propulsion Laboratory
- Dustin R. Buccino, Dawn Radio Science Analyst, NASA Jet Propulsion Laboratory

Richard Simpson and Ashok Verma carried out the archive migration from PDS3 to PDS4; their contact information can be found on the cover page of this document.

5. APPENDIX

5.1.

5.1. Deep Space Network Antenna Locations

The Deep Space Network has multiple antennas at three sites:

Goldstone, California, United States
Canberra, Australia
Madrid, Spain.

Station locations are documented in Applicable Document [1] and in *instrument_rs* in the Document Collection.

5.2 Migration Notes

Migration of the PDS3 data sets to PDS4 bundles was carried out by the PDS PPI Discipline Node over the years 2020-2022. The long time span resulted from delays in bringing a new 'review' web site on line at PPI, which was not used in the end. Except as noted below, the data objects were not modified in the migration, and the curating node (SBN/PSI) determined that an internal (PDS only) migration review would be sufficient.

The data sets migrated are listed in the table below:

PDS3 DATA_SET_ID	VERSION_ID	PDS4 LID	Version
DAWN-A-RSS-1-VEGR-V1.0	1	urn:nasa:pds:dawn-rss-raw-vesta	1.0
DAWN-A-RSS-1-CEGR-V2.0	2	urn:nasa:pds:dawn-rss-raw-ceres	1.0

During migration, the following anomalies were noted and corrections or improvements made:

a. A new SIS (specific to the PDS4 archive) was written; the PDS3 SIS was not migrated.

b. One Ceres PDS3 SFF had <LF> delimiters; these were corrected to <CR><LF> in the PDS4 file.

c. There were file size errors in some Ceres SFFs (PDS3 labels); those have been corrected in the PDS4 labels.

d. The 2012 WEA DSS 60 file has data from 12/30 and 12/31 repeated at the end of the PDS3 file; the duplicate tables/headers have been removed in the PDS4 file.

e. WEA data records were padded to fixed length to simplify labeling; there may be other records that were padded, but no list was kept. The PDS4 labels should correctly reflect the structure of the associated PDS4 data objects.

f. The TNF SIS included in both the PDS3 and PDS4 archives is dated 2008; there is a version of the SIS dated 2017 in the RS Documentation Bundle, which likely would be a better match to the Dawn TNFs from 2018.

g. TNF (TRK-2-34) records in the PDS3 Ceres data set had been sorted according to data type when they were originally delivered; so there was no need to sort them again when migrating to PDS4. There are no TNFs in the Vesta data set.