Near Earth Asteroid Rendezvous (NEAR) Radio Science Derived Data Archive (PDS4)

Software Interface Specification (SIS)

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Document Change Log

PDS4 Rev	Revision Date	Author	Sections	Remarks
1.0	2024-06-19	Kahan	All	Summary of PDS4 NEAR Derived RS archive as migrated from PDS3.

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Acronyms and Abbreviations

APL	JHU Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
CSV	Comma Separated Value file
DAT	extension on names of binary data files
DDA	Derived Data Archive
DSN	Deep Space Network
JPL	Jet Propulsion Laboratory
LID	Logical Identifier
NEAR	Near Earth Asteroid Rendezvous
NASA	National Aeronautics and Space Administration
PDF	Adobe Portable Document Format
PDS	Planetary Data System
PDS3	PDS Standards version 3
PDS4	PDS Standards version 4
RS	Radio Science
RSSN	Radio Science Sub-Node
RST	Radio Science Team
SBN	Small Bodies Node
SHADR	Spherical Harmonic ASCII Data Record
SHBDR	Spherical Harmonic Binary Data Record
SIS	Software Interface Specification
TAB	Extension on names of ASCII table files
TXT	Text, extension on names of text files

Contents

1 Introduction

This Software Interface Specification (SIS) describes the format and content of the Near Earth Asteroid Rendezvous (NEAR) Radio Science (RS) Derived Data Archive (DDA). The NEAR RS DDA is the complete archive of derived data from investigations conducted using the radio link between the NEAR spacecraft and stations of the NASA Deep Space Network (DSN).

The data were originally delivered according to version 3 of the PDS Standards (PDS3). The PDS3 archive has been 'migrated' so that it is now compliant with version 4 of the Standards (PDS4). The migration was carried out so that users could take advantage of new capabilities and tools that are available under PDS4. The NEAR RS PDS4 DDA contains the contents chiefly from the PDS3 derived data set listed in Table 1

Table 1. Original PDS3 Datasets

PDS3 dataset	Description
NEAR-A-RSS-5-EROS/GRAVITY-V1.0	Eros Gravity Field

This SIS and the PDS4 archive that it describes have been peer reviewed by the NASA Planetary Data System (PDS) Small Bodies Node (SBN) and have been ingested into the PDS4 system. The document provides information to enable users to understand the files and their organization in the PDS4 archive. Those users are expected to be scientists and investigators who will process and analyze the data, including both those who have been associated with the NEAR Project and others.

The Johns Hopkins University Applied Physics Laboratory (APL) managed the NEAR mission and was responsible for delivering the RS data to the SBN, where the data were originally posted for public use. Migration of the RS derived data was implemented by the Radio Science Sub-Node (RSSN) of the Ring Moon Systems node and delivered to the SBN.

2 Data Overview

The NEAR RS DDA includes data and documentation generated by various elements of the NEAR Project, the NEAR Radio Science Team (RST), and others. The SHADR collection contains a set of spherical harmonic coefficients of the gravity field of the asteroid Eros derived from data acquired from the Radio Science Subsystem. Similarly, the SHBDR collection contains a binary set of spherical harmonic coefficients of the gravity field of the Eros. The Gravity Map Collection (IMG) contains a set of gravity maps of the asteroid Eros derived from data acquired from the Radio Science Subsystem. The landmark file contains Eros pole, spin, and landmark data derived during the gravity field solution by the NEAR Radio Science Team. It contains a table giving X, Y, and Z coordinates of the centers of craters on the asteroid Eros projected onto a plane tangent to each crater's rim. Data types are summarized in **Error! Reference source not found.**.

Table 2. Derived Data in the NEAR RS DDA

Type	Description	Data Source	# Files	Est Total Volume
IMG	NEAR Gravity Map Collection	RST	4	2 MB
LANDMARK	NEAR gravity pole, spin, and landmark data	RST	1	252 KB
SHADR	Spherical Harmonic ASCII Data Record	RST	1	20 KB
SHBDR	Spherical Harmonic Binary Data Record	RST	1	260 KB

Data are stored in files of various sizes and formats. The formats vary among product types; users should consult the appropriate data product SIS for details at the bit and byte level (see Table 4). For the most part, this document provides an overview at the product and higher levels.

3. Archive Organization

3.1 Products, Collections, and Bundles

Derived data measurements were captured as digital data objects. A common example of a digital data object is a table, which may be either ASCII or binary. A SHBDR may be viewed as a binary table; SHADRs are organized into ASCII tables. Accompanying each digital data object is a description object — ASCII text in an XML document that contains information about the digital data object's structure and content, such as the number of columns and rows in the table, maximum and minimum values, etc.

One or more digital data objects in a file accompanied by their concatenated description objects in a second file is a 'product'. The first file type is often called the 'data' and the second is called the 'label'. An aggregation of related products is a 'collection', and an aggregation of related collections is a 'bundle'.

3.2 Products, Collections, and Bundles in the NEAR RS DDA

The NEAR RS DDA is one bundle comprising five collections. In the NEAR RS DDA there are four collections of derived data products and a document collection.

RS documents, such as this file, belong to a NEAR RS document collection in the NEAR DDA bundle. Context products, which provide information on the mission, spacecraft, RS instrument, etc., are hosted and maintained by the PDS Engineering Node.

3.3 Logical and Version Identifiers

Each bundle, collection, and product in PDS4 is uniquely identified by a 'logical identifier' (LID) and a version identifier (VID); the combination is known as a versioned logical identifier (LIDVID). Bundle LIDs are constructed using four fields — *e.g.*, *urn:nasa:pds:near_rs_derived* for the NEAR RS DDA. Collection LIDs have a fifth field appended — *e.g.*, *urn:nasa:pds:near_rs_derived:data_shadr* for the collection of NEAR SHADRs. Product LIDs have a sixth field— *e.g.*, *urn:nasa:pds:near_rs_derived:data_shadr: jge15a01_sha*. Note that a single colon ":" separates fields in a LID. The VID has two fields — major and minor version numbers separated by a single period — *e.g.*, 2.*0*. The VID is appended to the LID by a double colon "::". VIDs may be applied to bundle, collection, and product LIDs. The product LIDVID*,urn:nasa:pds:near_rss_derived:data_shadr: jge15a01_sha::1.0* identifies the first version (0^{th}, or original, sub-version) of the SHADR product *jge15a01_sha.* Note that the LIDVID is a unique *logical* identifier; it does not necessarily imply a physical storage location, such as in a computer directory or folder (although they are often closely related).

3.4 Archive Physical Structure

The physical structure of the archive follows the logical organization of the bundles and collections. There are data and document directories under the root.

3.5 LID and File Name Construction

3.5.1 Bundle and Collection LIDs

The NEAR RS DDA is a single bundle; the bundle's LID is *urn:nasa:pds:near_rs_derived*. The collections under the bundle have the LIDs shown in Table 3.

Table 3 Collection LIDs for NEAR Derived Radio Science Data

Collection	Type	Collection LID
data_img	Data	*urn:nasa:pds:near_rs_derived:data_img*
data_landmark	Data	*urn:nasa:pds:near_rs_derived:data_landmark*
data_shadr	Data	*urn:nasa:pds:near_rs_derived:data_shadr*
data_shbdr	Data	*urn:nasa:pds:near_rs_derived:data_shbdr*
document	Document	*urn:nasa:pds:near_rss_derived:document*

3.5.2 Product LIDs and File Names

Product identifiers (the sixth field in the product LID) are constructed using rules that vary slightly among product types. The extension ".dat" is appended to the product identifier, which is also the base file name, to form the name of a binary data file. When the data file is an ASCII table with fixed width fields, the extension is ".tab"; when the data file is an ASCII table with variable width fields, the extension is ".csv"; when the data file is ASCII text, the extension is ".txt"; and when the data file is a PDF/A-formatted document, the extension is ".pdf". In each case labels use the base name of the data file and the extension ".xml". Details and examples are shown below.

IMG LIDs are derived from file names; the IMG file names have the form

pmtsssdd_img.dat

where '*p*' is the data provider with 'j' indicating JPL; '*m*' is the map type with 'b' indicating Bouguer or 'g' indicating radial gravity; '*t*' is the target with 'e' indicating Eros; 'sss' is the designation of the gravity solution; and '*ddd*' is the maximum degree of the field used to create the map. An example of this type of file name is

jbe15a05_img.dat

where 'b' in the file name indicates it is Bouguer gravity, 'e' is for Eros, '15a' indicates the NEAR15A solution, and '05' indicates the maximum degree of the field used to create the map. The corresponding IMG LID is derived from the file name by dropping the extension "*.dat*"; the LID then has the form

urn:nasa:pds:near_rss_derived:data_img: pmtsssdd_img

Landmark files are ASCII tables archived as text files. Landmark file names have the form

landmark.tab

The corresponding EOP LID is derived from the file name by dropping the extension "*.tab*"; the LID then has the form

urn:nasa:pds:near_rss_derived:data_landmark:landmark

SHADR files are ASCII tables archived as text files. SHADR file names have the form

pmtsssdd_sha.tab

where '*p*' is the data provider with 'j' indicating JPL; '*m*' is the map type with 'b' indicating Bouguer or 'g' indicating radial gravity; '*t*' is the target with 'e' indicating Eros; 'sss' is the designation of the gravity solution; and '*ddd*' is the maximum degree of the field used to create the map. An example of this type of file name is

jge15a01_sha.tab

where 'g' in the file name indicates radial gravity, 'e' is for Eros, '15a' indicates the NEAR15A solution, and '01' indicates the maximum degree of the field used to create the map. The corresponding SHADR LID is derived from the file name by dropping the extension ".tab"; the LID then has the form

urn:nasa:pds:near_rss_derived:data_shadr:pmtsssdd_sha

SHBDR files are binary tables archived as binary data files. SHBDR file names have the form

pmtsssdd_sha.dat

where '*p*' is the data provider with 'j' indicating JPL; '*m*' is the map type with 'b' indicating Bouguer or 'g' indicating radial gravity; '*t*' is the target with 'e' indicating Eros; 'sss' is the designation of the gravity solution; and '*ddd*' is the maximum degree of the field used to create the map. An example of this type of file name is

jge15a01_shb.dat

where 'g' in the file name indicates radial gravity, 'e' is for Eros, '15a' indicates the NEAR15A solution, and '01' indicates the maximum degree of the field used to create the map. The corresponding SHBDR LID is derived from the file name by dropping the extension ".dat"; the LID then has the form

urn:nasa:pds:near_rss_derived:data_shbdr:pmtsssdd_shb

NEAR RS DDA labels reference several context products bundled by SBN at https://arcnav.psi.edu/urn:nasa:pds:near.mission:context

Documents relevant to the NEAR RS DDA are members of a collection in the NEAR raw data bundle. Their LID is:

urn:nasa:pds:near_rss_derived:document

Table 4 lists SIS documents for products that are included in the NEAR RS DDA (including this one). The rightmost column gives the document product identifier, which is appended to the collection LID (above) to create the full product LID. Documents are provided in either 7_Bit ASCII Text or PDF/A format. See Appendix A in this document for notes on specific product types which may have been modified during the migration to PDS4.

Table 4. Documents Directory Contents

Type	File Name	SIS Title	SIS Product ID
Archive Software Interface Specification	near_rs_derived_sis.pdf near_rs_derived_sis.docx	Near Earth Asteroid Rendezvous (NEAR) Radio Science Derived Data Archive (PDS4) Software Interface Specification (SIS)	near_rs_derived_sis
Radio Science Instrument	near_rss_inst.txt	NEAR Radio Science Subsystem Instrument Description	near_rs_inst
Data Set	near_rss_derived_ds.txt	NEAR Radio Science Derived Dataset Description	near_rs_derived_ds
Gravity Field Determination	space01v5.asc space01v5.pdf	A GLOBAL SOLUTION FOR THE GRAVITY FIELD, ROTATION, LANDMARKS, AND EPHEMERIS OF EROS	space01v5

3.6 Product Formats

3.6.1 Label Files

All PDS4 label files are XML documents. Original PDS3 labels (*.lbl) are also provided in all collections other than documents.

3.6.2 Data Files

The product LID uniquely identifies a product within the PDS4 domain, but it does not reveal the storage format; that information can be found in the label content. In the NEAR RS DDA, format may also be inferred from the file name extension.

All tabular files (".tab" extension) are filled with ASCII characters. Some are formatted for direct reading into data base management systems. They consist of data fields which are defined by position alone; each record has the same fields in exactly the same locations as its predecessor within a single table. Character fields may optionally be enclosed in double quotation marks ("); if so, they are padded with spaces to keep quotation marks in the same position in successive records. Values are left justified in character fields and right justified in numeric fields. The records in tabular files have fixed length, and the last two bytes of each record contain the ASCII Carriage-Return and Line-Feed characters. A single tabular file may contain more than one table, in which case the specifications for the tables may differ.

All Comma separated value (CSV) files (".csv" extension) are filled with ASCII characters. Some are formatted for direct reading into database management systems. They consist of data fields which are separated by commas. Character fields may also be enclosed by pairs of double quotation marks (") ; a comma within a pair of double quotes is taken to be part of the field value rather than a field delimiter. The records in CSV files generally have variable length. The last two bytes of each record contain the ASCII Carriage-Return and Line-Feed characters. A single CSV file may contain more than one delimited table, in which case the specifications for the tables may differ.

All text files (".*txt*" extension) are filled with 7-bit ASCII characters, but there is no specific structure. The last two bytes of each record contain the ASCII Carriage-Return and Line-Feed characters. A single text file may contain more than one text digital object, in which case the specifications for the text objects may differ.

Portable document format (PDF) files (".*pdf*" extension) exist in the document collection. PDF files are encoded byte streams in a format developed by Adobe Systems. The Adobe proprietary format was released as an open standard in 2008 (ISO 32000-1:2008). The PDF/A-1a (preferred) and PDF/A-1b versions are especially suitable for archiving since they embed all fonts and disallow encryption (ISO 19005-1); no other PDF versions are allowed in PDS4.

File formats for binary files (".*dat*" extension) are described at the bit level in accompanying SIS documents. In the NEAR RS DDA, all binary files contain binary tables meaning that data fields are defined by position alone; each record has the same fields in exactly the same locations as its predecessor within a single table. Individual fields may contain numerical values in integer, floating point, character or other formats. A single binary file may contain more than one digital data object, in which case the specifications for the digital objects may differ. No two digital data objects may be interleaved in a single file, and no digital object may extend beyond a single file.

4 Documentation

4.1 Controlling Documents

The following govern the structure and content of the NEAR RS DDA:

Planetary Data System Standards Reference, JPL D-7669, Part 2, version 1.18.0, Pasadena, CA: Jet Propulsion Laboratory, March 31, 2022.

Planetary Data System Information Model, version 1.16.0.0, including schemas
https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1G00.xsd
https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1G00.sch

Planetary Data System Information Model, version 1.17.0.0, including schemas
https://pds.nasa.gov/pds4/mission/near/v1/PDS4_NEAR_1H00_1000.xsd
https://pds.nasa.gov/pds4/mission/near/v1/PDS4_NEAR_1H00_1000.sch

Planetary Data System Information Model, version 1.21.0.0, including schemas
http://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.xsd
http://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch

See also the documents listed in Table 4 of this document.

4.2 Reference Documents

The following provide important background and contextual information for understanding PDS4 archives, individual product types, and NEAR RS instrumentation:

Data Design Working Group, *PDS4 Concepts*, version 1.14.0, Planetary Data System, May 19, 2019 (available at https://pds.nasa.gov/datastandards/documents/concepts/Concepts_1.14.0.pdf).

Asmar, S. W., and N. A. Renzetti, The Deep Space Network as an Instrument for Radio Science Research, Jet Propulsion Laboratory Publication, 80-93, Rev. 1, 15 April 1993.

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DSN Geometry and Spacecraft Visibility, Document 810-5, Rev. D, Vol. 1, DSN/Flight Project Interface Design, Jet Propulsion Laboratory, Pasadena, CA, 1987.

Moyer, T., Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation, JPL Publication 00-7, Jet Propulsion Laboratory, Pasadena, 2000.

4.3 Publications and Presentations

The following are selected publications and presentations listed in the PDS3 catalog file ref.cat:

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Antreasian, P.G., C.L. Helfrich, J.K. Miller, W.M. Owen, B.G.Williams, D.K. Yeomans, J.D. Giorgini, D.J. Scheeres, D.W. Dunham, R.W. Farquhar, J.V. McAdams, A.G. Santo, G.A. Heyler, 'Preliminary Planning for NEAR's Low-Altitude Operations at 433 Eros,' AAS 99-465, AAS/AIAA/Astrodynamics Specialist Conference, Girdwood, AK, USA, 1999.

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Asmar, S.W., R.G. Herrera, and T. Priest, Radio Science Handbook, JPL D-7938 Volume 6, Jet Propulsion Laboratory, Pasadena, CA, USA, 1995.

Cheng, A.F., A. Santo, K. Heeres, J. Landshof, R. Farquhar, et al., 'Near-Earth Asteroid Rendezvous: Mission Overview,' Journal of Geophysical Research, 102, 23695-23708, 1997.

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Deep Space Network / Flight Project Interface Design Book, Document 810-5, Jet Propulsion Laboratory, Pasadena, CA, USA.

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DSN Geometry and Spacecraft Visibility, Document 810-5, Rev. D, Vol. 1, DSN/Flight Project Interface Design, Jet Propulsion Laboratory, Pasadena, CA, USA, 1987.

Mars Global Surveyor Project, Telecommunications System Operations Reference Handbook, Version 2.1 (MGS 542-257), JPL Document D-14027, Jet Propulsion Laboratory, Pasadena, CA, USA, 1996.

Kaula, W.M. 'Theory of Satellite Geodesy,' Blaisdell, Waltham, MA, USA, 1966.

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5. List of Tables

Appendix A – Notes from the PDS3 to PDS4 Migration

The NEAR RSS derived dataset SIS (`near_rss_derived_ds.txt`) was adapted from `dataset.cat` in the Eros Gravity PDS3 archive.

The instrument description document (`near_rss_inst.txt`) was adapted from `rsinst.cat` in the PDS3 archives.

The NEAR Mission Bundle Document Collection (https://sbnarchive.psi.edu/pds4/near/near_mission/document/) contains the mission description adapted from mission.cat in the PDS3 archive.

The NEAR Mission Bundle Document Collection (https://sbnarchive.psi.edu/pds4/near/near_mission/document/) contains the instrument host (spacecraft) information adapted from insthost.cat in the PDS3 archive.