

**GRAIL**  
**ARCHIVE VOLUME**  
**SOFTWARE INTERFACE SPECIFICATION**

Version 2.0  
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## DOCUMENT CHANGE LOG

Change	Date	Affected Portions
Version 1.0 submitted for peer review.	2012-09-27	Various
Version 1.1 original release version.	2012-12-13	Various
Version 1.2 initial ADR/RDR team review.	2013-03-11	Various
Version 1.3 updated for extended mission.	2013-05-09	Section 4.2
Version 1.4 additional release 2 updates.	2013-06-10	Various
Version 1.5 added DSMAP.CAT to RDR catalog directory contents. Submitted for RDR peer review.	2013-06-18	Figure 2-4, Section 2.7
Version 1.6 RDR peer review revisions.	2013-08-23	Sections 2.2.1, 2.6, 3.1.3, Table 2-4
Version 1.7 added EXTRAS directory.	2013-09-13	Section 2.2.4, 2.10
Version 1.8 updated for Version 4 data	2014-04-01	Sections 2.2, 2.4, and 4.2
Version 1.9 updated for PDS release 5	2014-06-10	Figure 2-4, Section 2.10
Version 2.0 revised RDR extras and catalog directory contents.	2016-05-03	Figure 2-4, Tables 2-8, 2-11

## ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
BTC	Binary Time Code
CD-ROM	Compact Disk - Read-Only Memory
CD-WO	Write-Once Compact Disk
CDR	Calibrated Data Record
CODMAC	Committee on Data Management, Archiving, and Computation
CRC	Cyclical Redundancy Code
DRF	Data Record File
DSN	Deep Space Network
EDA	End of Data Acquisition
EDR	Experiment Data Record
EOP	Earth Orientation Parameters
ICD	Interface Control Document
ION	Ionospheric Media Calibration
ISO	International Standards Organization
GRAIL	Gravity Recovery and Interior Laboratory
HTML	HyperText Markup Language
JPL	Jet Propulsion Laboratory
LGRS	Lunar Gravity Ranging System
NAIF	Navigation and Ancillary Information Facility
ODF	Orbit Data File
ODL	Object Description Language
PDS	Planetary Data System
PDF	Portable Document Format
RDR	Reduced Data Record
RSDMAP	Radio Science Digital Map
RSR	Radio Science Receiver
RSS	Radio Science Systems
RTC	Real Time Clock
SDS	Science Data System
SFDU	Standard Formatted Data Unit
SHADR	Spherical Harmonic ASCII Data Record
SHBDR	Spherical Harmonic Binary Data Record
SIS	Software Interface Specification

SLP            Signaling Link Protocol

SPICE        **S-** Spacecraft ephemeris, given as a function of time.

**P-** Planet, satellite, comet, or asteroid ephemerides, or more generally, location of any target body, given as a function of time.

The P kernel also logically includes certain physical, dynamical and cartographic constants for target bodies, such as size and shape specifications, and orientation of the spin axis and prime meridian.

**I-** - Instrument description kernel, containing descriptive data peculiar to a particular scientific instrument, such as field-of-view size, shape and orientation parameters.

**C-** Pointing kernel, containing a transformation, traditionally called the C-matrix, which provides time-tagged pointing (orientation) angles for a spacecraft structure upon which science instruments are mounted. May also include angular rate data.

**E-** Events kernel, summarizing mission activities - both planned and unanticipated. Events data are contained in the SPICE EK file set, which consists of three components: Science Plans, Sequences, and Notes.

TBD            To Be Determined

TDB            Barycentric Dynamical Time

TDM            Tracking Data Message

TNF            Tracking and Navigation File

TRO            Tropospheric Media Calibration

TRSR          Turbo Rogue Space Receiver

TTS            Time Transfer System

UTC            Coordinated Universal Time

WEA            Weather

## GLOSSARY

**Archive** - An archive consists of one or more data sets. An archive is a logical construct independent of the medium on which it is stored.

**Archive Volume, Archive Volume Set** - A volume is a unit of media on which data products are stored; for example, one CD-ROM or DVD-ROM. An *archive volume* is a volume containing all or part of an archive--that is, data products plus documentation and ancillary files. When an archive spans multiple volumes, they are called an *archive volume set*. Usually the documentation and some ancillary files are repeated on each volume of the set, so that a single volume can be used alone.

**Catalog Information** - Descriptive information about a data set (e.g. mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL) which is suitable for loading into a PDS catalog.

**Data Product** - A labeled grouping of data resulting from a scientific observation. The product label identifies, describes, and defines the structure of the data. Examples of data products are a planetary image, a spectrum, or a time series, including the label in each case.

**Data Set** - An accumulation of data products that have some common theme.

**Standard Data Product** - A data product generated in a predefined way using well-understood procedures, processed in "pipeline" fashion. Data products that are generated in a nonstandard way are sometimes called *special data products*.

# 1. Introduction

## 1.1. Purpose and Scope

This Software Interface Specification (SIS) will be used by those who wish to understand the format and content of the GRAIL Archive. Typically, these individuals would be software engineers, data analysts, or planetary scientists.

The specifications in this document apply to all archive volumes that are generated by the GRAIL Project.

## 1.2. Document Overview

This archive contains data products from the Gravity Recovery and Interior Laboratory (GRAIL) Mission. The primary objective of the GRAIL mission is to obtain accurate global models for the mean components of the Moon's gravity field. This objective will be achieved by making measurements of inter-satellite range and its derivative for co-planar, low altitude, near-polar orbiting satellites, using the Lunar Gravity Ranging System (LGRS) instrumentation, which includes the Radio Science System (RSS). All raw data transmitted by the twin spacecraft are collected by the Deep Space Network (DSN) and processed to higher level products by the GRAIL Science Data System (SDS) at JPL and GRAIL Science Team members at their respective institutions.

This Software Interface Specification (SIS) describes the format, content, and generation of the GRAIL archive volumes. Section 2, Archive Volume Contents, describes the structure of the archive volumes and the contents of each file. Section 3, Archive Volume Format, describes the file formats used on the archive volumes. Section 4, Archive Volume Generation, describes the procedure for transferring data products to the Planetary Data System (PDS). Finally, Section 5, Support Staff and Cognizant Persons, lists the individuals responsible for generating the archive volumes.

## 1.3. Applicable Documents and Constraints

This Archive Volume SIS is intended to be consistent with the following documents:

1. *GRAIL Science Team and PDS Geosciences Node Interface Control Document (ICD)*.
2. *Data Product Software Interface Specification (DPSIS.PDF)* and other software interface specifications referenced therein.
3. *Planetary Data System Standards Reference*, February 27, 2009, Version 3.8. JPL D-7669, Part 2.

## 1.4. Relationships with Other Interfaces

This Archive Volume SIS could be affected by changes to the design of the GRAIL standard data products [2].



## 2. Archive Volume Contents

This section describes the contents of the GRAIL Archive volumes, including the file names, file contents, file types; and it identifies the organization responsible for providing each file.

### 2.1 Processing Levels

The GRAIL Science Data System (SDS) uses NASA processing levels, which are defined in Table 2-1. Data set IDs use the processing levels defined by the Committee on Data Management, Archiving, and Computation (CODMAC), also given in Table 2-1.

**Table 2-1. Processing Levels**

NASA	CODMAC	Description
Packet data	Raw - Level 1	Telemetry data with data embedded.
Level-0	Edited - Level 2	Corrected for telemetry errors and split or decommutated into a data set for a given instrument. Sometimes called Experimental Data Record. Data are also tagged with time and location of acquisition.
Level 1-A	Calibrated - Level 3	Edited data that are still in units produced by instrument, but that have been corrected so that values are expressed in or are proportional to some physical unit such as radiance. No resampling, so edited data can be reconstructed.
Level 1-B	Resampled - Level 4	Data that have been resampled in the time or space domains in such a way that the original edited data cannot be reconstructed. Could be calibrated in addition to being resampled.
Level 2	Derived - Level 5	Derived results, as maps, reports, graphics, etc.
	Ancillary - Level 6	Nonscience data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets; pointing information for scan platforms, etc.

## 2.2 Data Sets and Volumes

There are four data sets in this archive, entitled LGRS EDR, LGRS CDR, RSS EDR, and LGRS RDR. Each has been assigned to a distinct volume GRAIL\_xxxx, as shown in Table 2-2.

**Table 2-2. Data Sets and Volumes**

<b>Data Set (Volume ID) PDS-Assigned Data Set ID</b>	<b>Description</b>	<b>Data Volume (GB)</b>	<b>NASA Processing Level</b>
<b>LGRS EDR (GRAIL_0001)</b> GRAIL-L-LGRS-2-EDR-V1.0	Raw science data in time order with duplicates and transmission errors removed	26	0
<b>LGRS CDR (GRAIL_0101)</b> GRAIL-L-LGRS-3-CDR-V1.0	Calibrated and resampled data	45	1A & 1B
<b>RSS EDR (GRAIL_0201)</b> GRAIL-L-RSS-2-EDR-V1.0	Raw Radio Science data (includes DSN Doppler tracking data, troposphere and ionosphere media calibrations)	137	0
<b>LGRS RDR (GRAIL_1001)</b> GRAIL-L-LGRS-5-RDR-V1.0	Lunar gravitation field (includes gravity coefficient and covariance matrices, free air gravity map, geoid and uncertainty maps, and Bouguer gravity map). SPICE geometry and navigation kernels created by the GRAIL SDS	45	2

### 2.2.1 LGRS Experiment Data Record (EDR)

The LGRS EDR data set (Level 0, Figure 2-1) contains raw data in time order with duplicates and transmission errors removed. The root directory is divided into subdirectories by start date, wherein each subdirectory contains all data products for that date. These data are archived mainly for the sake of completeness, as they have already been processed to Level 1A in the LGRS CDR data set by the SDS team. However, the SOFTWARE directory contains examples of utilities or application programs to aid the user in viewing or extracting information from the NASA Level-0 data product files if desired.

Figure 2-1. GRAIL-L-LGRS-2-EDR-V1.0 (GRAIL\_0001)

```
root
|
|- AAREADME.TXT
|- ERRATA.TXT
|- VOLDESC.CAT
|
|- [CATALOG]
|   |- CATINFO.TXT
|   |- MISSION.CAT
|   |- INSTHOST_A.CAT
|   |- INSTHOST_B.CAT
|   |- LGRS_A_INST.CAT
|   |- LGRS_B_INST.CAT
|   |- REF.CAT
|   |- PERSON.CAT
|   `-- LGRS_EDR_DS.CAT
|
|- [DOCUMENT]
|   |- DOCINFO.TXT
|   |- ARCHSIS.HTM
|   |- ARCHSIS.PDF
|   |- ARCHSIS.LBL
|   |- DPSIS.HTM
|   |- DPSIS.PDF
|   |- DPSIS.LBL
|   |- [DPSIS_IMAGES]
|     |- IMAGE001.JPG
|     |- IMAGE002.JPG
|     |- IMAGE003.GIF
|     |- IMAGE004.JPG
|     |- IMAGE005.GIF
|     |- IMAGE006.JPG
|     |- IMAGE007.JPG
|     |- IMAGE008.JPG
|     |- IMAGE009.JPG
|     |- IMAGE010.JPG
|   |- 090_REVC_1.TXT
|   |- 090_REVC_1.PDF
|   |- 090_REVC_1.LBL
|   |- 0159_SCIENCE_L5.TXT
|   |- 0159_SCIENCE_L5.LBL
|   |- [0159_SCIENCE_L5_IMAGES]
|     |- 0159_SCIENCE2_1.JPG
|     |- 0159_SCIENCE2_2.JPG
|     |- 0159_SCIENCE2_3.JPG
|     |- 0159_SCIENCE2_4.JPG
|     |- 0159_SCIENCE2_5.JPG
|     |- 0159_SCIENCE2_6.JPG
|     |- 0159_SCIENCE2_7.JPG
|   |- 0161_TELECOMM_L5_8.TXT
|   |- 0161_TELECOMM_L5_8.PDF
```

```

| | |- 0161_TELECOMM_L5_8.LBL
| | |- 0171_TELECOMM_NJPL_L5.TXT
| | |- 0171_TELECOMM_NJPL_L5.PDF
| | |- 0171_TELECOMM_NJPL_L5.LBL
| | |- 0172_TELECOMM_CHDO_REVE_L5.TXT
| | |- 0172_TELECOMM_CHDO_REVE_L5.LBL
| | |- ATBD.PDF
| | |- ATBD.HTM
| | |- [ATBD_IMAGES]
| | |   |- IMAGE001.PNG - IMAGE052.PNG
| | |- ATBD.LBL
| | |- BLACKJACKDLP.TXT
| | |- BLACKJACKDLP.PDF
| | |- BLACKJACKDLP.LBL
| | |- DSN006_MEDIALCAL_REV2.HTM
| | |- DSN006_MEDIALCAL_REV2.LBL
| | |- FORTNIGHT_CALCULATION.HTM
| | |- FORTNIGHT_CALCULATION.PDF
| | |- FORTNIGHT_CALCULATION.LBL
| | |- GPA_TD_D_71987_REVE.TXT
| | |- GPA_TD_D_71987_REVE.PDF
| | |- GPA_TD_D_71987_REVE.LBL
| | |- GRAIL_TIMING.HTM
| | |- GRAIL_TIMING.PDF
| | |- GRAIL_TIMING.LBL
| | |- [GRAIL_TIMING_IMAGES]
| | |   |- GRAIL_TIMING_0.JPG
| | |   |- GRAIL_TIMING_1.JPG
| | |   |- GRAIL_TIMING_2.JPG
| | |   |- GRAIL_TIMING_3.JPG
| | |- LIB_10_GRAIL_COORD_TRANS_REV1.TXT
| | |- LIB_10_GRAIL_COORD_TRANS_REV1.PDF
| | |- LIB_10_GRAIL_COORD_TRANS_REV1.LBL
| | |- NAV023_ODF_2_18_REV3.HTM
| | |- NAV023_ODF_2_18_REV3_FIG2_1.JPG
| | |- NAV023_ODF_2_18_REV3.LBL
| | |- ONCE_UPON_A_FORTNIGHT.TXT
| | |- ONCE_UPON_A_FORTNIGHT.PDF
| | |- ONCE_UPON_A_FORTNIGHT.LBL
| | |- RSDMAP.HTM
| | |- RSDMAP.LBL
| | |- SHADR.HTM
| | |- SHADR.LBL
| | |- SHBDR.HTM
| | |- SHBDR.LBL
| | |- SPK_MM_SIS.HTM
| | |- SPK_MM_SIS.LBL
| | |- T2_24_L5.HTM
| | |- T2_24_L5.LBL
| | |- [T2_24_L5_IMAGES]
| | |   |- T2_24_IMG_0.JPG
| | |   |- T2_24_IMG_1.JPG
| | |   |- T2_24_IMG_2.JPG
| | |- TNFSIS.TXT
| | |- TNFSIS.LBL
| | |- TRACKINGDATAMESSAGESTANDARD.TXT
| | |- TRACKINGDATAMESSAGESTANDARD.PDF

```

```

| | | - TRACKINGDATAMESSAGESTANDARD.LBL
| | | - TRK_2_21_950831.TXT
| | | ` - TRK_2_21_950831.LBL
| |
| | - [INDEX]
| | | - INDXINFO.TXT
| | | - INDEX.LBL
| | | ` - INDEX.TAB
| |
| | - [SOFTWARE]
| | | - SOFTINFO.TXT
| | | - SOFTWARE.ZIP
| | | ` - SOFTWARE.LBL
| |
| | - [CALIB]
| | | - CALINFO.TXT
| | | - GRAILCOMPONENTS.TXT
| | | ` - GRAILCOMPONENTS.LBL
| |
| | - [LEVEL_0]
| | | - [YYYY_MM_DD]
| | | | - DTC00_YYYY_MM_DD_S_RL.EXT
| | | | - EHK00_YYYY_MM_DD_S_RL.EXT
| | | | - LTB00_YYYY_MM_DD_S_RL.EXT
| | | | - MAS00_YYYY_MM_DD_S_RL.EXT
| | | | - S7200_YYYY_MM_DD_S_RL.EXT
| | | | - S7300_YYYY_MM_DD_S_RL.EXT
| | | | - SAE00_YYYY_MM_DD_S_RL.EXT
| | | | - SCA00_YYYY_MM_DD_S_RL.EXT
| | | | - STC00_YYYY_MM_DD_S_RL.EXT
| | | | - TDE00_YYYY_MM_DD_NNNNN_S_RL.EXT
| | | | - THR00_YYYY_MM_DD_S_RL.EXT
| | | | ` - WRS00_YYYY_MM_DD_S_RL.EXT
| |
| | ` - [EXTRAS]
| | | - EXTRINFO.TXT
| | | ` - FORTNIGHT_CALCULATION.XLS
|=====

```

## 2.2.2 LGRS Calibrated Data Record (CDR)

The LGRS CDR data set (Figure 2-2) contains (calibrated and resampled) Level 1A and 1B science data from each Lunar Gravity Ranging System. It is divided into subdirectories by level and then by date, wherein each subdirectory contains all data products for that level and date.

```

|=====
|
|           Figure 2-2.   GRAIL-L-LGRS-3-CDR-V1.0 (GRAIL_0101)
|
|=====
|
| root
| |
| | - AAREADME.TXT
|

```

```

|- ERRATA.TXT
|- VOLDESC.CAT
|- [CATALOG]
|   |- CATINFO.TXT
|   |- MISSION.CAT
|   |- INSTHOST_A.CAT
|   |- INSTHOST_B.CAT
|   |- LGRS_A_INST.CAT
|   |- LGRS_B_INST.CAT
|   |- REF.CAT
|   |- PERSON.CAT
|   `-- LGRS_CDR_DS.CAT
|- [DOCUMENT]
|   |- DOCINFO.TXT
|   |- ARCHSIS.HTM
|   |- ARCHSIS.PDF
|   |- ARCHSIS.LBL
|   |- DPSIS.HTM
|   |- DPSIS.PDF
|   |- DPSIS.LBL
|   |- [DPSIS_IMAGES]
|       |- IMAGE001.JPG
|       |- IMAGE002.JPG
|       |- IMAGE003.GIF
|       |- IMAGE004.JPG
|       |- IMAGE005.GIF
|       |- IMAGE006.JPG
|       |- IMAGE007.JPG
|       |- IMAGE008.JPG
|       |- IMAGE009.JPG
|       |- IMAGE010.JPG
|- 090_REVC_1.TXT
|- 090_REVC_1.PDF
|- 090_REVC_1.LBL
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|- 0159_SCIENCE_L5.LBL
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|   |- 0159_SCIENCE2_2.JPG
|   |- 0159_SCIENCE2_3.JPG
|   |- 0159_SCIENCE2_4.JPG
|   |- 0159_SCIENCE2_5.JPG
|   |- 0159_SCIENCE2_6.JPG
|   |- 0159_SCIENCE2_7.JPG
|- 0161_TELECOMM_L5_8.TXT
|- 0161_TELECOMM_L5_8.PDF
|- 0161_TELECOMM_L5_8.LBL
|- 0171_TELECOMM_NJPL_L5.TXT
|- 0171_TELECOMM_NJPL_L5.PDF
|- 0171_TELECOMM_NJPL_L5.LBL
|- 0172_TELECOMM_CHDO_REVE_L5.TXT
|- 0172_TELECOMM_CHDO_REVE_L5.LBL
|- ATBD.PDF
|- ATBD.HTM
|- [ATBD_IMAGES]

```

```

| | |   |- IMAGE001.PNG - IMAGE052.PNG
| | |   |- ATBD.LBL
| | |   |- BLACKJACKDLP.TXT
| | |   |- BLACKJACKDLP.PDF
| | |   |- BLACKJACKDLP.LBL
| | |   |- DSN006_MEDIALCAL_REV2.HTM
| | |   |- DSN006_MEDIALCAL_REV2.LBL
| | |   |- FORTNIGHT_CALCULATION.HTM
| | |   |- FORTNIGHT_CALCULATION.PDF
| | |   |- FORTNIGHT_CALCULATION.LBL
| | |   |- GPA_TD_D_71987_REVE.TXT
| | |   |- GPA_TD_D_71987_REVE.PDF
| | |   |- GPA_TD_D_71987_REVE.LBL
| | |   |- GRAIL_TIMING.HTM
| | |   |- GRAIL_TIMING.PDF
| | |   |- GRAIL_TIMING.LBL
| | |   |- [GRAIL_TIMING_IMAGES]
| | |   |   |- GRAIL_TIMING_0.JPG
| | |   |   |- GRAIL_TIMING_1.JPG
| | |   |   |- GRAIL_TIMING_2.JPG
| | |   |   |- GRAIL_TIMING_3.JPG
| | |   |- LIB_10_GRAIL_COORD_TRANS_REV1.TXT
| | |   |- LIB_10_GRAIL_COORD_TRANS_REV1.PDF
| | |   |- LIB_10_GRAIL_COORD_TRANS_REV1.LBL
| | |   |- NAV023_ODF_2_18_REV3.HTM
| | |   |- NAV023_ODF_2_18_REV3_FIG2_1.JPG
| | |   |- NAV023_ODF_2_18_REV3.LBL
| | |   |- ONCE_UPON_A_FORTNIGHT.TXT
| | |   |- ONCE_UPON_A_FORTNIGHT.PDF
| | |   |- ONCE_UPON_A_FORTNIGHT.LBL
| | |   |- RSDMAP.HTM
| | |   |- RSDMAP.LBL
| | |   |- SHADR.HTM
| | |   |- SHADR.LBL
| | |   |- SHBDR.HTM
| | |   |- SHBDR.LBL
| | |   |- SPK_MM_SIS.HTM
| | |   |- SPK_MM_SIS.LBL
| | |   |- T2_24_L5.HTM
| | |   |- T2_24_L5.LBL
| | |   |- [T2_24_L5_IMAGES]
| | |   |   |- T2_24_IMG_0.JPG
| | |   |   |- T2_24_IMG_1.JPG
| | |   |   |- T2_24_IMG_2.JPG
| | |   |- TNFSIS.TXT
| | |   |- TNFSIS.LBL
| | |   |- TRACKINGDATAMESSAGESTANDARD.TXT
| | |   |- TRACKINGDATAMESSAGESTANDARD.PDF
| | |   |- TRACKINGDATAMESSAGESTANDARD.LBL
| | |   |- TRK_2_21_950831.TXT
| | |   `-- TRK_2_21_950831.LBL
| |
| | [- [INDEX]
| |   |- INDXINFO.TXT
| |   |- INDEX.LBL
| |   `-- INDEX.TAB

```

```

|- [CALIB]
|   |- CALINFO.TXT
|   |- GRAILCOMPONENTS.TXT
|   `-- GRAILCOMPONENTS.LBL
|
|- [LEVEL_1A]
|   |- [YYYY_MM_DD]
|       |- CLK1A_YYYY_MM_DD_S_RL.EXT
|       |- DEL1A_YYYY_MM_DD_S_RL.EXT
|       |- EHK1A_YYYY_MM_DD_S_RL.EXT
|       |- IHK1A_YYYY_MM_DD_S_RL.EXT
|       |- IHS1A_YYYY_MM_DD_S_RL.EXT
|       |- ILG1A_YYYY_MM_DD_S_RL.EXT
|       |- KBR1A_YYYY_MM_DD_S_RL.EXT
|       |- LTM1A_YYYY_MM_DD_S_RL.EXT
|       |- MAS1A_YYYY_MM_DD_S_RL.EXT
|       |- PCI1A_YYYY_MM_DD_S_RL.EXT
|       |- PLT1A_YYYY_MM_DD_S_RL.EXT
|       |- PPS1A_YYYY_MM_DD_S_RL.EXT
|       |- REL1A_YYYY_MM_DD_S_RL.EXT
|       |- SAE1A_YYYY_MM_DD_S_RL.EXT
|       |- SBR1A_YYYY_MM_DD_S_RL.EXT
|       |- SCA1A_YYYY_MM_DD_S_RL.EXT
|       |- SNV1A_YYYY_MM_DD_S_RL.EXT
|       |- TC11A_YYYY_MM_DD_S_RL.EXT
|       |- TC21A_YYYY_MM_DD_S_RL.EXT
|       |- TC31A_YYYY_MM_DD_S_RL.EXT
|       |- TC41A_YYYY_MM_DD_S_RL.EXT
|       |- TC51A_YYYY_MM_DD_S_RL.EXT
|       |- TC61A_YYYY_MM_DD_S_RL.EXT
|       |- THR1A_YYYY_MM_DD_S_RL.EXT
|       |- USO1A_YYYY_MM_DD_S_RL.EXT
|       |- VCM1A_YYYY_MM_DD_S_RL.EXT
|       `-- WRS1A_YYYY_MM_DD_S_RL.EXT
|
|- [LEVEL_1B]
|-   |- [YYYY_MM_DD]
|       |- CLK1B_YYYY_MM_DD_S_RL.EXT
|       |- EHK1B_YYYY_MM_DD_S_RL.EXT
|       |- GNI1B_YYYY_MM_DD_S_RL.EXT
|       |- GNV1B_YYYY_MM_DD_S_RL.EXT
|       |- KBR1C_YYYY_MM_DD_S_RL.EXT
|       |- MAS1B_YYYY_MM_DD_S_RL.EXT
|       |- SAE1B_YYYY_MM_DD_S_RL.EXT
|       |- SBR1B_YYYY_MM_DD_S_RL.EXT
|       |- SCA1B_YYYY_MM_DD_S_RL.EXT
|       |- THR1B_YYYY_MM_DD_S_RL.EXT
|       |- USO1B_YYYY_MM_DD_S_RL.EXT
|       |- VCM1B_YYYY_MM_DD_S_RL.EXT
|       |- VGS1B_YYYY_MM_DD_S_RL.EXT
|       |- VGX1B_YYYY_MM_DD_S_RL.EXT
|       |- VKB1B_YYYY_MM_DD_S_RL.EXT
|       `-- WRS1B_YYYY_MM_DD_S_RL.EXT
|
`-- [EXTRAS]
|   |- EXTRINFO.TXT
|   `-- FORTNIGHT_CALCULATION.XLS

```



### 2.2.3 RSS Experiment Data Record (EDR)

The RSS EDR data set (Figure 2-3) contains raw radio science data, which include DSN Doppler tracking data, open-loop data, media calibrations, and others. The ODF and TNF directories contain, respectively, the Orbit Data Files (ODFs) and Tracking and Navigation Files (TNFs), both of which generally contain S-Band 2-way and X-band 1-way closed-loop data. The RSR directory contains open-loop raw data collected at the DSN with the Radio Science Receiver (RSR). The XFR directory contains ASCII sky frequency data computed from the RSR data. The TDM directory contains Tracking Data Message standard files containing the observable data derived from the sky frequency data, and the OLF (Open Loop File) directory contains the same information in ODF format. The ANCILLARY directory contains Weather Files (WEA), Earth Orientation Parameters (EOP), Ionospheric Media Calibration (ION), and Tropospheric Media Calibration (TRO) data in their similarly named subdirectories.

```
=====
|
|           Figure 2-3.  GRAIL-L-RSS-2-EDR-V1.0 (GRAIL_0201)
|
|=====
|
| root
| |
| |  |- AAREADME.TXT
| |  |- ERRATA.TXT
| |  |- VOLDESC.CAT
| |
| |  |- [CATALOG]
| | |  |- CATINFO.TXT
| | |  |- MISSION.CAT
| | |  |- INSTHOST_A.CAT
| | |  |- INSTHOST_B.CAT
| | |  |- LGRS_A_INST.CAT
| | |  |- LGRS_B_INST.CAT
| | |  |- REF.CAT
| | |  |- PERSON.CAT
| | |  `-- RSS_EDR_DS.CAT
| |
| |  |- [DOCUMENT]
| | |  |- DOCINFO.TXT
| | |  |- ARCHSIS.HTM
| | |  |- ARCHSIS.PDF
| | |  |- ARCHSIS.LBL
| | |  |- DPSIS.HTM
| | |  |- DPSIS.PDF
| | |  |- DPSIS.LBL
| | |  |- [DPSIS_IMAGES]
| | | |  |- IMAGE001.JPG
| | | |  |- IMAGE002.JPG
| | | |  |- IMAGE003.GIF
| | | |  |- IMAGE004.JPG
|
|=====
```

```

| | | | - IMAGE005.GIF
| | | | - IMAGE006.JPG
| | | | - IMAGE007.JPG
| | | | - IMAGE008.JPG
| | | | - IMAGE009.JPG
| | | | - IMAGE010.JPG
| | | - 090_REVC_1.TXT
| | | - 090_REVC_1.PDF
| | | - 090_REVC_1.LBL
| | | - 0159_SCIENCE_L5.TXT
| | | - 0159_SCIENCE_L5.LBL
| | | - [0159_SCIENCE_L5_IMAGES]
| | | | - 0159_SCIENCE2_1.JPG
| | | | - 0159_SCIENCE2_2.JPG
| | | | - 0159_SCIENCE2_3.JPG
| | | | - 0159_SCIENCE2_4.JPG
| | | | - 0159_SCIENCE2_5.JPG
| | | | - 0159_SCIENCE2_6.JPG
| | | | - 0159_SCIENCE2_7.JPG
| | | - 0161_TELECOMM_L5_8.TXT
| | | - 0161_TELECOMM_L5_8.PDF
| | | - 0161_TELECOMM_L5_8.LBL
| | | - 0171_TELECOMM_NJPL_L5.TXT
| | | - 0171_TELECOMM_NJPL_L5.PDF
| | | - 0171_TELECOMM_NJPL_L5.LBL
| | | - 0172_TELECOMM_CHDO_REVE_L5.TXT
| | | - 0172_TELECOMM_CHDO_REVE_L5.LBL
| | | - ATBD.PDF
| | | - ATBD.HTM
| | | - [ATBD_IMAGES]
| | | | - IMAGE001.PNG - IMAGE052.PNG
| | | - ATBD.LBL
| | | - BLACKJACKDLP.TXT
| | | - BLACKJACKDLP.PDF
| | | - BLACKJACKDLP.LBL
| | | - DSN006_MEDIALCAL_REV2.HTM
| | | - DSN006_MEDIALCAL_REV2.LBL
| | | - FORTNIGHT_CALCULATION.HTM
| | | - FORTNIGHT_CALCULATION.PDF
| | | - FORTNIGHT_CALCULATION.LBL
| | | - GPA_TD_D_71987_REVE.TXT
| | | - GPA_TD_D_71987_REVE.PDF
| | | - GPA_TD_D_71987_REVE.LBL
| | | - GRAIL_TIMING.HTM
| | | - GRAIL_TIMING.PDF
| | | - GRAIL_TIMING.LBL
| | | - [GRAIL_TIMING_IMAGES]
| | | | - GRAIL_TIMING_0.JPG
| | | | - GRAIL_TIMING_1.JPG
| | | | - GRAIL_TIMING_2.JPG
| | | | - GRAIL_TIMING_3.JPG
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.TXT
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.PDF
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.LBL
| | | - NAV023_ODF_2_18_REV3.HTM
| | | - NAV023_ODF_2_18_REV3_FIG2_1.JPG
| | | - NAV023_ODF_2_18_REV3.LBL

```

```

| | | - ONCE_UPON_A_FORTNIGHT.TXT
| | | - ONCE_UPON_A_FORTNIGHT.PDF
| | | - ONCE_UPON_A_FORTNIGHT.LBL
| | | - RSDMAP.HTM
| | | - RSDMAP.LBL
| | | - SHADR.HTM
| | | - SHADR.LBL
| | | - SHBDR.HTM
| | | - SHBDR.LBL
| | | - SPK_MM_SIS.HTM
| | | - SPK_MM_SIS.LBL
| | | - T2_24_L5.HTM
| | | - T2_24_L5.LBL
| | | - [T2_24_L5_IMAGES]
| | | | - T2_24_IMG_0.JPG
| | | | - T2_24_IMG_1.JPG
| | | | - T2_24_IMG_2.JPG
| | | - TNFSIS.TXT
| | | - TNFSIS.LBL
| | | - TRACKINGDATAMESSAGESTANDARD.TXT
| | | - TRACKINGDATAMESSAGESTANDARD.PDF
| | | - TRACKINGDATAMESSAGESTANDARD.LBL
| | | - TRK_2_21_950831.TXT
| | | ` - TRK_2_21_950831.LBL
| |
| | - [INDEX]
| | | - INDXINFO.TXT
| | | - INDEX.LBL
| | | ` - INDEX.TAB
| |
| | - [CALIB]
| | | - CALINFO.TXT
| | | - GRAILCOMPONENTS.TXT
| | | ` - GRAILCOMPONENTS.LBL
| |
| | - [ANCILLARY]
| | | - [EOP]
| | | - [ION]
| | | - [TRO]
| | | ` - [WEA]
| |
| | - [BOF]
| |
| | - [BTM]
| |
| | - [ODF]
| |
| | - [OLF]
| |
| | - [RSR]
| |
| | - [TNF]
| |
| | - [TDM]
| |
| | - [XFR]
| |

```

```

|   `-- [EXTRAS]
|   |   |-- EXTRINFO.TXT
|   |   `-- FORTNIGHT_CALCULATION.XLS
|=====

```

## 2.2.4 LGRS Reduced Data Record (RDR)

The LGRS RDR data set (Figure 2-4) contains Level-2 lunar gravitation field data. It is divided into directories for Spherical Harmonics ASCII Data Records (SHADR), Spherical Harmonics Binary Data Records (SHBDR), and Radio Science Digital Map Products (RSDMAP). It also contains SPICE orientation and navigation kernels, specifically Spacecraft and Planetary Ephemeris Kernels (SPK). The SPK products in this data set differ from those archived by NAIF; they are created by the GRAIL SDS and make use of the LGRS to provide a more refined solution than those initially produced by GRAIL Navigation.

```

|=====
|
|           Figure 2-4.   GRAIL-L-LGRS-5-RDR-V1.0 (GRAIL_1001)
|=====
|
|  root
|  |
|  |-- AAREADME.TXT
|  |-- ERRATA.TXT
|  |-- VOLDESC.CAT
|  |
|  |-- [CATALOG]
|  |   |-- CATINFO.TXT
|  |   |-- MISSION.CAT
|  |   |-- INSTHOST_A.CAT
|  |   |-- INSTHOST_B.CAT
|  |   |-- LGRS_A_INST.CAT
|  |   |-- LGRS_B_INST.CAT
|  |   |-- REF.CAT
|  |   |-- PERSON.CAT
|  |   |-- LGRS_RDR_DS.CAT
|  |   |-- DSMAP.CAT
|  |   `-- DSMAP_1200A.CAT
|  |
|  |-- [DOCUMENT]
|  |   |-- DOCINFO.TXT
|  |   |-- ARCHSIS.HTM
|  |   |-- ARCHSIS.PDF
|  |   |-- ARCHSIS.LBL
|  |   |-- DPSIS.HTM
|  |   |-- DPSIS.PDF
|  |   |-- DPSIS.LBL
|  |   |-- [DPSIS_IMAGES]
|  |       |-- IMAGE001.JPG
|  |       |-- IMAGE002.JPG
|  |       |-- IMAGE003.GIF
|  |       |-- IMAGE004.JPG
|  |       |-- IMAGE005.GIF
|  |       |-- IMAGE006.JPG
|

```

```

| | | | - IMAGE007.JPG
| | | | - IMAGE008.JPG
| | | | - IMAGE009.JPG
| | | | - IMAGE010.JPG
| | | - 090_REVC_1.TXT
| | | - 090_REVC_1.PDF
| | | - 090_REVC_1.LBL
| | | - 0159_SCIENCE_L5.TXT
| | | - 0159_SCIENCE_L5.LBL
| | | - [0159_SCIENCE_L5_IMAGES]
| | | | - 0159_SCIENCE2_1.JPG
| | | | - 0159_SCIENCE2_2.JPG
| | | | - 0159_SCIENCE2_3.JPG
| | | | - 0159_SCIENCE2_4.JPG
| | | | - 0159_SCIENCE2_5.JPG
| | | | - 0159_SCIENCE2_6.JPG
| | | | - 0159_SCIENCE2_7.JPG
| | | - 0161_TELECOMM_L5_8.TXT
| | | - 0161_TELECOMM_L5_8.PDF
| | | - 0161_TELECOMM_L5_8.LBL
| | | - 0171_TELECOMM_NJPL_L5.TXT
| | | - 0171_TELECOMM_NJPL_L5.PDF
| | | - 0171_TELECOMM_NJPL_L5.LBL
| | | - 0172_TELECOMM_CHDO_REVE_L5.TXT
| | | - 0172_TELECOMM_CHDO_REVE_L5.LBL
| | | - ATBD.PDF
| | | - ATBD.HTM
| | | - [ATBD_IMAGES]
| | | | - IMAGE001.PNG - IMAGE052.PNG
| | | - ATBD.LBL
| | | - BLACKJACKDLP.TXT
| | | - BLACKJACKDLP.PDF
| | | - BLACKJACKDLP.LBL
| | | - DSN006_MEDIALCAL_REV2.HTM
| | | - DSN006_MEDIALCAL_REV2.LBL
| | | - FORTNIGHT_CALCULATION.HTM
| | | - FORTNIGHT_CALCULATION.PDF
| | | - FORTNIGHT_CALCULATION.LBL
| | | - GPA_TD_D_71987_REVE.TXT
| | | - GPA_TD_D_71987_REVE.PDF
| | | - GPA_TD_D_71987_REVE.LBL
| | | - GRAIL_TIMING.HTM
| | | - GRAIL_TIMING.PDF
| | | - GRAIL_TIMING.LBL
| | | - [GRAIL_TIMING_IMAGES]
| | | | - GRAIL_TIMING_0.JPG
| | | | - GRAIL_TIMING_1.JPG
| | | | - GRAIL_TIMING_2.JPG
| | | | - GRAIL_TIMING_3.JPG
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.TXT
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.PDF
| | | - LIB_10_GRAIL_COORD_TRANS_REV1.LBL
| | | - NAV023_ODF_2_18_REV3.HTM
| | | - NAV023_ODF_2_18_REV3_FIG2_1.JPG
| | | - NAV023_ODF_2_18_REV3.LBL
| | | - ONCE_UPON_A_FORTNIGHT.TXT
| | | - ONCE_UPON_A_FORTNIGHT.PDF

```

```

| | | - ONCE_UPON_A_FORTNIGHT.LBL
| | | - RSDMAP.HTM
| | | - RSDMAP.LBL
| | | - SHADR.HTM
| | | - SHADR.LBL
| | | - SHBDR.HTM
| | | - SHBDR.LBL
| | | - SPK_MM_SIS.HTM
| | | - SPK_MM_SIS.LBL
| | | - T2_24_L5.HTM
| | | - T2_24_L5.LBL
| | | - [T2_24_L5_IMAGES]
| | | | - T2_24_IMG_0.JPG
| | | | - T2_24_IMG_1.JPG
| | | | - T2_24_IMG_2.JPG
| | | - TNFSIS.TXT
| | | - TNFSIS.LBL
| | | - TRACKINGDATAMESSAGESTANDARD.TXT
| | | - TRACKINGDATAMESSAGESTANDARD.PDF
| | | - TRACKINGDATAMESSAGESTANDARD.LBL
| | | - TRK_2_21_950831.TXT
| | | ` - TRK_2_21_950831.LBL
| |
| | - [INDEX]
| | | - INDXINFO.TXT
| | | - INDEX.LBL
| | | ` - INDEX.TAB
| |
| | - [CALIB]
| | | - CALINFO.TXT
| | | - GRAILCOMPONENTS.TXT
| | | ` - GRAILCOMPONENTS.LBL
| |
| | - [SHADR]
| |
| | - [SHBDR]
| |
| | - [RSDMAP]
| |
| | - [SPK]
| |
| | ` - [EXTRAS]
| | | - EXTRINFO.TXT
| | | - [COVARIANCE]
| | | | - *_COEFFICIENTS.ASC
| | | | - *_COEFFICIENTS.TXT
| | | | - *_COVARIANCE.ASC
| | | | - *_COVARIANCE.TXT
| | | - [CLONES]
| | | | - [GGGRX_0900C_CLONES_0001_0100]
| | | | - [GGGRX_0900C_CLONES_0101_0200]
| | | | - [GGGRX_0900C_CLONES_0201_0300]
| | | | - [GGGRX_0900C_CLONES_0301_0400]
| | | | - [GGGRX_0900C_CLONES_0401_0500]
| | | | - CLONE_DESCRIPTION.PDF
| | | | - CLONE_DESCRIPTION.LBL
| | | - [GEOTIFF]

```

```
| | | | - GGGRX_1200A_*.TIF |
| | | - FORTNIGHT_CALCULATION.XLS |
|=====|
```

## 2.3. ROOT Directory Contents

Files in the root directory (Table 2-3) of each data set include an overview of the archive, a description of the volume for the PDS Catalog, and a list of errata or comments about that particular data set.

**Table 2-3. ROOT Directory Contents**

<b>File Name</b>	<b>File Contents</b>	<b>File Provided By</b>
AAREADME.TXT	Volume content and format information	Geosciences Node
ERRATA.TXT	A cumulative listing of comments and updates concerning the archive volume	GRAIL Science Team
VOLDESC.CAT	A description of the contents of this volume in a PDS format readable by both humans and computers	Geosciences Node



## 2.4. DATA Directory Contents and Naming

Table 2-4 lists the product types provided in this archive, ordered by data set and showing the product ID as defined in [2], wherein XXX refers to a three-character mnemonic and LL specifies the data product level.

**Table 2-4. DATA Directory Contents by Data Set**

<b>Data Set</b>	<b>Product Type (XXXLL)</b>	<b>Spacecraft A/B = individual products of Grail-A and Grail-B X = combined product of GRAIL A and B</b>	<b>Product</b>
LGRS EDR	DTC00	A/B	Time Correlation (DRF)
	EHK00	A/B	Spacecraft Engineering Housekeeping Data
	LTB00	X	LGRS Time Bias
	MAS00	A/B	Satellite Mass Data
	S7200	A/B	Engineering SFDU (ID #72)
	S7300	A/B	Engineering SFDU (ID #73)
	SAE00	A/B	Solar Array Eclipse Data
	SCA00	A/B	Star Tracker Data
	STC00	A/B	Time Correlation SFDU
	TDE00	A/B	Time Transfer System (TTS) Direct to Earth
	THR00	A/B	Thruster Activation Data
	WRS00	A/B	Wheel Rotational Speed Data
LGRS CDR	CLK1A	A/B	Smoothed On-Board Clock Solution
	DEL1A	X	inter-satellite clock offset (LGRS) eps_time = non-shifted offset eps_drift = shifted offset
	EHK1A	A/B	Level 1A spacecraft Engineering Housekeeping data
	IHK1A	A/B	LGRS Housekeeping Data
	IHS1A	A/B	Level 1A LGRS Health Status data (LGRS Time)
	ILG1A	A/B	LGRS log messages (LGRS

		Time)
KBR1A	A/B	Ka-Band Ranging Data
LTM1A	A/B	Position vector and light time between one S/C and DSN station
MAS1A	A/B	Satellite Mass Data
PCI1A	A/B	Level 1A Spacecraft Phase Center to Center of Gravity correction and derivatives (TDB Time)
PLT1A	X	Position vector and light time between two spacecraft
PPS1A	A/B	Level 1A LGRS PPS Time (LGRS Time)
REL1A	A/B	Relativistic time correction (TDB to onboard satellite proper time)
SAE1A	A/B	Solar Array Eclipse Data (UTC time)
SBR1A	A/B	Level 1A SBR data (LGRS Time)
SCA1A	A/B	Star Tracker Data
SNV1A	A/B	Level 1A S-Band navigation solution (LGRS Time)
TC11A	A/B	Time correlation LGRS+Bias to BTC from Level-0 SFDUs eps_drift = RTC from Level-0 SFDUs (LGRS Time)
TC21A	A/B	Time correlation LGRS+Bias to BTC 1PPS (LGRS Time)
TC31A	A/B	Time correlation BTC to RTC (BTC Time)
TC41A	A/B	Time correlation LGRS+Bias to RTC 1PPS (LGRS Time)
TC51A	A/B	Time correlation RTC to UTC (RTC Time)
TC61A	A/B	Time correlation UTC to TDB (UTC time)
THR1A	A/B	Thruster Activation Data
USO1A	A/B	Oscillator frequency data (derived from RSR data) (LGRS Time)

	VCM1A	A/B	Vector offset file for Center of Mass solution from calibration maneuvers or tracking model in SRF (spacecraft frame) (LGRS Time)
	WRS1A	A/B	Level 1A Wheel rotational speed data (UTC Time)
	CLK1B	A/B	Precise Clock Solution
	EHK1B	A/B	Level 1B spacecraft Engineering Housekeeping data
	GNI1B	A/B	Level 1B GRAIL satellite orbit solution in Moon centered Inertial frame
	GNV1B	A/B	GRAIL Orbit Solution in lunar body fixed frame
	KBR1C	X	Dual-One-Way Ranging Data
	MAS1B	A/B	Spacecraft Mass Data
	SAE1B	A/B	Solar Array Eclipse Data (UTC time)
	SBR1B	X	S-Band Ranging data
	SCA1B	A/B	Star Tracker Solution
	THR1B	A/B	Thruster Activation Data
	USO1B	A/B	USO Frequency Estimate
	VCM1B	A/B	Center of Mass Offset Estimate
	VGS1B	A/B	S-Band antenna switch time (TDB time)
	VGX1B	A/B	X-Band antenna switch time (TDB time)
	VKB1B	A/B	K-Band Antenna Offset
	WRS1B	A/B	Level 1B Wheel rotational speed data (TDB Time)
RSS EDR	BOF	A/B	Biased Open Loop File
	BTM	A/B	Biased Tracking Data Message Standard
	EOP	X	Earth Orientation Parameters
	ION	X	Ionospheric Media Calibration
	ODF	A/B	Tracking Data, Orbit Data

			File
	OLF	A/B	Open Loop File
	RSR	A/B	Radio Science Receiver 0159
	TDM	A/B	Tracking Data Message Standard
	TNF	A/B	Tracking and Navigation File
	TRO	X	Tropospheric Media Calibration
	WEA	X	Weather Files
	XFR	A/B	X-Band sky frequency
LGRS RDR	SHADR	X	Spherical Harmonics ASCII Data Record
	SHBDR	X	Spherical Harmonics Binary Data Record
	RSDMAP	X	Radio Science Digital Map Product
	SPK	A/B	Spacecraft and Planet Ephemeris Kernel

## 2.5. INDEX Directory Contents

Files in the INDEX directory (Table 2-5) are provided to help the user locate products in the data set.

**Table 2-5. INDEX Directory Contents**

File Name	File Contents	File Provided By
INDXINFO.TXT	A description of the contents of this directory	Geosciences Node
INDEX.TAB	A table listing all data products in this data set	GRAIL SDS
INDEX.LBL	A PDS detached label that describes INDEX.TAB	GRAIL SDS

The index table contains one row for each product in a data set. Table 2-6 lists the columns of the index table.

**Table 2-6. INDEX Table Contents**

Column Name	Description	Source
VOLUME_ID	PDS archive volume on which a data product is stored	Specified at time of index table creation
PATH_NAME	Directory path to data product, relative to volume root	Determined by location of PDS label file
FILE_NAME	Name of <i>label</i> file for data product	PDS label file name
PRODUCT_ID	Unique identifier for data product	PDS label
PRODUCT_TYPE	Product type, e.g. ODF, TNF, as in the identifier column in Table 2-4.	PDS label
PRODUCT VERSION ID	Version number of data product	PDS label
PRODUCT_CREATION_TIME	Date and time of data product creation	PDS label
START_TIME	UTC date and time of start of data	PDS label
STOP_TIME	UTC date and time of end of data	PDS label

## 2.6. DOCUMENT Directory Contents

The DOCUMENT Directory (Table 2-7) contains documentation to help the user understand and use the archive data. Each data set contains the document collection for the entire archive; not all documents are necessary for understanding every data set.

**Table 2-7. DOCUMENT Directory Contents**

<b>File Name</b>	<b>File Contents</b>	<b>File Provided By</b>
DOCINFO.TXT	A description of the contents of this directory	Geosciences Node
ARCHSIS.HTM	The Archive Volume SIS (this document) as hypertext.	GRAIL SDS
ARCHSIS.PDF	The Archive Volume SIS (this document) as a PDF file	GRAIL SDS
ARCHSIS.LBL	A PDS detached label that describes both ARCHSIS.HTM and ARCHSIS.PDF.	Geosciences Node
DPSIS.HTM	The Data Product SIS as hypertext. Associated images are in the DPSIS_IMAGES directory.	GRAIL SDS
DPSIS.PDF	The Data Product SIS as a PDF file	GRAIL SDS
DPSIS.LBL	A PDS detached label that describes both DPSIS.HTM and DPSIS.PDF	Geosciences Node
090_REVC_1.TXT	0172 Telecomm 090 Rev C as an ASCII text document.	GRAIL SDS
090_REVC_1.PDF	0172 Telecomm 090 Rev C as a PDF document.	GRAIL SDS
090_REVC_1.LBL	A PDS detached label that describes 090_REVC_1.TXT/PDF.	Geosciences Node
0159_SCIENCE_L5.TXT	0159 Science Radio Science Receiver Standard Formatted Data Unit. Associated images are in the 0159_SCIENCE_L5_IMAGES directory.	GRAIL SDS
0159_SCIENCE_L5.LBL	A PDS detached label that describes 0159_SCIENCE_L5.TXT.	Geosciences Node

0161_TELECOMM_L5_8.TXT	0161-Telecomm Telemetry Standard Formatted Data Unit (SFDU) Interface as an ASCII text document.	GRAIL SDS
0161_TELECOMM_L5_8.PDF	0161-Telecomm Telemetry Standard Formatted Data Unit (SFDU) Interface as a PDF document.	GRAIL SDS
0161_TELECOMM_L5_8.LBL	A PDS detached label that describes 0161 TELECOMM L5 8.TXT/PDF.	Geosciences Node
0171_TELECOMM_NJPL_L5.TXT	0171-Telecomm-NJPL JPL created SFDU structures as an ASCII text document.	GRAIL SDS
0171_TELECOMM_NJPL_L5.PDF	0171-Telecomm-NJPL JPL created SFDU structures as a PDF document.	GRAIL SDS
0171_TELECOMM_NJPL_L5.LBL	A PDS detached label that describes 0171_TELECOMM_NJPL_L5.TXT/PDF.	Geosciences Node
0172_TELECOMM_CHDO_REVE_L5.TXT	0172-Telecomm-CHDO DSN Created CHDO Structures as an ASCII text document.	GRAIL SDS
0172_TELECOMM_CHDO_REVE_L5.LBL	A PDS detached label that describes 0172_TELECOMM_CHDO_REVE_L5.TXT.	Geosciences Node
ATBD.PDF	GRAIL "primer" that describes the data processing flow from EDR to CDR as implemented by the GRAIL Team as a PDF file.	GRAIL SDS
ATBD.HTM	GRAIL "primer" that describes the data processing flow from EDR to CDR as currently implemented by the GRAIL Team as hypertext. Associated images are located in the ATBD_IMAGES folder. Please see the PDF for equations that do not display properly in this version of the document.	GRAIL SDS
ATBD.LBL	A PDS detached label that describes ATBD.PDF/HTM.	Geosciences Node

BLACKJACKDLP.TXT	BlackJack Data Link Protocol Interface and Implementation Description as an ASCII text document.	GRAIL SDS
BLACKJACKDLP.PDF	BlackJack Data Link Protocol Interface and Implementation Description as a PDF document.	GRAIL SDS
BLACKJACKDLP.LBL	A PDS detached label that describes BLACKJACKDLP.TXT/PDF.	Geosciences Node
DSN006_MEDIALCAL_REV2.HTM	TRK-2-23 Media Calibration Interface.	GRAIL SDS
DSN006_MEDIALCAL_REV2.LBL	A PDS detached label that describes DSN006_MEDIALCAL_REV2.HTM.	Geosciences Node
FORTNIGHT_CALCULATION.HTM	Supporting document for ONCE_UPON_A_FORTNIGHT.PDF, JPL D-61501, containing the numerical content described therein, as hypertext. Please see the EXTRAS directory for the original Excel file, FORTNIGHT_CALCULATION.XLS.	GRAIL SDS
FORTNIGHT_CALCULATION.PDF	Supporting document for ONCE_UPON_A_FORTNIGHT.PDF, JPL D-61501, containing the numerical content described therein, as a PDF file. Please see the EXTRAS directory for the original Excel file, FORTNIGHT_CALCULATION.XLS.	GRAIL SDS
FORTNIGHT_CALCULATION.LBL	A PDS detached label that describes FORTNIGHT_CALCULATION.HTM/PDF.	Geosciences Node
GPA_TD_D_71987_REVE.TXT	GRAIL Telemetry Dictionary as an ASCII text document.	GRAIL SDS
GPA_TD_D_71987_REVE.PDF	GRAIL Telemetry Dictionary as a PDF document.	GRAIL SDS
GPA_TD_D_71987_REVE.LBL	A PDS detached label that describes GPA_TD_D_71987_REVE.TXT/PDF.	Geosciences Node



GRAIL_TIMING.HTM	Timing of Science Data for the GRAIL Mission as hypertext. Associated images are in the GRAIL_TIMING_IMAGES folder. Please see the PDF for equations that do not display properly in this version of the document.	GRAIL SDS
GRAIL_TIMING.PDF	Timing of Science Data for the GRAIL Mission as a PDF document.	GRAIL SDS
GRAIL_TIMING.LBL	A PDS detached label that describes GRAIL_TIMING.HTM/PDF.	Geosciences Node
LIB_10_GRAIL_COORD_TRANS_REV1.TXT	ACS Hardware Coordinate Frame Definitions and Transformations as an ASCII text document.	GRAIL SDS
LIB_10_GRAIL_COORD_TRANS_REV1.PDF	ACS Hardware Coordinate Frame Definitions and Transformations as a PDF file.	GRAIL SDS
LIB_10_GRAIL_COORD_TRANS_REV1.LBL	PDS detached label that describes the ACS documents.	Geosciences Node
NAV023_ODF_2_18_REV3.HTM	TRK-2-18 Orbit Data File Interface.	GRAIL SDS
NAV023_ODF_2_18_REV3_FIG2_1.JPG	Figure 2-1 of NAV023_ODF_2_18_REV3.HTM.	GRAIL SDS
NAV023_ODF_2_18_REV3.LBL	A PDS detached label that describes NAV023_ODF_2_18_REV3.HTM and NAV023_ODF_2_18_REV3_FIG2_1.JPG.	Geosciences Node
ONCE_UPON_A_FORTNIGHT.TXT	GRAIL Time Transfer Assembly Algorithm document as an ASCII text file.	GRAIL SDS
ONCE_UPON_A_FORTNIGHT.PDF	GRAIL Time Transfer Assembly Algorithm document as a PDF file.	GRAIL SDS
ONCE_UPON_A_FORTNIGHT.LBL	A PDS detached label that describes ONCE_UPON_A_FORTNIGHT.TXT/PDF.	Geosciences Node

RSDMAP.HTM	Software Interface Specification - Radio Science Digital Map (RSDMAP) Products.	GRAIL SDS
RSDMAP.LBL	A PDS detached label that describes RSDMAP.HTM.	Geosciences Node
SHADR.HTM	Software Interface Specification - Spherical Harmonics ASCII Data Record.	GRAIL SDS
SHADR.LBL	A PDS detached label that describes SHADR.HTM.	Geosciences Node
SHBDR.HTM	Software Interface Specification - Spherical Harmonics Binary Data Record.	GRAIL SDS
SHBDR.LBL	A PDS detached label that describes SHBDR.HTM.	Geosciences Node
SPK_MM_SIS.HTM	SPICE Spacecraft and Planet Ephemeris Kernel (SPK)	GRAIL SDS
SPK_MM_SIS.LBL	A PDS detached label that describes SPK MM SIS.HTM.	Geosciences Node
T2_24_L5.HTM	TRK-2-24 DSN Tracking system Interfaces Weather Data Interface. Associated images are in the T2 24 L5 IMAGES directory.	GRAIL SDS
T2_24_L5.LBL	A PDS detached label that describes TRK 2 24.HTM.	Geosciences Node
TNFSIS.TXT	TRK-2-34 DSN Tracking System Data Archival Format	GRAIL SDS
TNFSIS.LBL	A PDS detached label that describes TNFSIS.TXT.	Geosciences Node
TRACKINGDATAMESSAGESTANDARD.TXT	Tracking Data Message Recommended Standard as an ASCII text file.	GRAIL SDS
TRACKINGDATAMESSAGESTANDARD.PDF	Tracking Data Message Recommended Standard as a PDF file.	GRAIL SDS
TRACKINGDATAMESSAGESTANDARD.LBL	A PDS detached label that describes TRACKINGDATAMESSAGE.*	Geosciences Node
TRK_2_21_950831.TXT	TRK-2-21 DSN Tracking System Earth Orientation Parameter Data Interface	GRAIL SDS

TRK_2_21_950831.LBL	A PDS detached label that describes TRK 2 21 950831.TXT.	Geosciences Node
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## 2.7. CATALOG Directory Contents

The files in the CATALOG directory (Table 2-8) provide a top-level understanding of the mission, spacecraft, instruments, and data sets. The files in this directory are coordinated with the PDS data engineer, who is responsible for loading them into the PDS catalog.

**Table 2-8. CATALOG Directory Contents**

File Name	File Contents	File Provided By
CATINFO.TXT	A description of the contents of this directory	Geosciences Node
LGRS_EDR_DS.CAT	LGRS EDR Data set information for the PDS catalog (LGRS EDR volume only)	GRAIL SDS
LGRS_CDR_DS.CAT	LGRS CDR Data set information for the PDS catalog (LGRS CDR volume only)	GRAIL SDS
RSS_EDR_DS.CAT	RSS EDR Data set information for the PDS catalog (RSS EDR volume only)	GRAIL SDS
LGRS_RDR_DS.CAT	LGRS RDR Data set information for the PDS catalog (LGRS RDR volume only)	GRAIL SDS
DSMAP.CAT	A description of the mapping scheme for GRAIL RSDMAP data products in simple cylindrical projection (LGRS RDR volume only)	GRAIL SDS
DSMAP_1200A.CAT	A description of the mapping scheme for GRAIL GRGM1200A RSDMAP data products in simple cylindrical projection (LGRS RDR volume only)	GRAIL SDS
INSTHOST_A.CAT	LGRS-A instrument host (i.e., spacecraft) information for the PDS catalog	GRAIL SDS
INSTHOST_B.CAT	LGRS-B instrument host (i.e., spacecraft) information for the PDS catalog	GRAIL SDS
LGRS_A_INST.CAT	LGRS-A instrument information for the PDS catalog	GRAIL SDS
LGRS_B_INST.CAT	LGRS-B instrument information for the PDS catalog	GRAIL SDS
MISSION.CAT	Mission information for the PDS catalog	GRAIL SDS
PERSON.CAT	Personnel information for the PDS catalog (Team and PDS personnel responsible for generating the archive)	GRAIL SDS
REF.CAT	References mentioned in other *.CAT files	GRAIL SDS

## 2.8. SOFTWARE Directory Contents

The SOFTWARE directory contains utilities or application programs to aid the user in viewing or extracting data from the Level 0 data product files. The codes (C++ and accompanying header (.h) files) are provided as illustrations of how to extract the Blackjack packets from Blackjack binary data. For a description of Blackjack, see section 4.2.1 in [2].

Table 2-9 lists the files in the SOFTWARE Directory on the GRAIL\_0001 volume (GRAIL-L-LGRS-2-EDR-V1.0).

**Table 2-9. SOFTWARE Directory Contents**

File Name	File Contents	File Provided By
SOFTINFO.TXT	A description of the contents of this directory	GRAIL SDS
SOFTWARE.ZIP	Compressed ZIP file containing the software files listed below.	GRAIL SDS
SOFTWARE.LBL	PDS label for SOFTWARE.ZIP.	Geosciences Node
TRSRCRC.H	Interface for the TRSRCRC class. This class provides standard X-MODEM-style CRC generation and checking	GRAIL SDS
TRSRFLAGBYTE.H	Interface for the TRSRFlagByte class. This class defines the TRSR packet header flag byte type.	GRAIL SDS
TRSRHEADER.H	Interface for the TRSRHeader class.	GRAIL SDS
TRSRRCVBUFFER.H	Interface for a receive buffer class	GRAIL SDS
TRSRRCVPACKET.H	Interface for the TRSR receive packet class	GRAIL SDS
TRSRSENDPACKET.H	Interface for the TRSR send packet class	GRAIL SDS
TESTAPP.CPP	A receiver-based SLP to test the TRSR output protocol	GRAIL SDS
TRSRCRC.CPP	Implementation for the TRSRCRC class. This class provides standard X-MODEM-style CRC generation and checking	GRAIL SDS
TRSRFLAGBYTE.CPP	Implementation for the TRSRFlagByte class. This class defines the TRSR packet header flag byte type.	GRAIL SDS
TRSRHEADER.CPP	Implementation for the TRSRHeader class. This class defines the TRSR packet header.	GRAIL SDS
TRSRRCVBUFFER.CPP	Implementation of a receive buffer class	GRAIL SDS
TRSRRCVPACKET.CPP	Implementation of the TRSR receive packet base class	GRAIL SDS

TRSRSENDPACKET.CPP	Implementation of the TRSR send packet base class	GRAIL SDS
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## 2.9. CALIB Directory Contents

The CALIB directory contains one file describing spacecraft properties such as dimensions and reflectivity.

**Table 2-10. CALIB Directory Contents**

File Name	File Contents	File Provided By
CALINFO.TXT	A description of the contents of this directory	GRAIL SDS
GRAILCOMPONENTS.TXT	Abstract of a paper describing the spacecraft bus component model with dimensions and orientations, as well as the specular/diffuse reflectivity properties of the spacecraft components. Points to online published paper.	GRAIL SDS
GRAILCOMPONENTS.LBL	PDS label that describes GRAILCOMPONENTS.TXT.	Geosciences Node

## 2.10. EXTRAS Directory Contents

The EXTRAS directory contains ancillary material that may be useful but is not required for the understanding of the archive.

**Table 2-11. EXTRAS Directory Contents**

File Name	File Contents	File Provided By
EXTRINFO.TXT	A description of the contents of this directory	GRAIL SDS
COVARIANCE/*	This directory contains reference text files to allow the user to confirm proper reading of the (binary) SHBDR files.	GRAIL SDS

CLONES/*	This directory contains 500 "clones" of the GRGM900C field, each uniquely identified by an index number (0001-0500). The clones are organized into folders of 100 files each. CLONE_DESCRIPTION.PDF describes the method used to generate the files. (LGRS RDR volume only)	GRAIL SDS
GEOTIFF/*	This directory contains non-PDS-standard products provided to users to facilitate the use and analysis of GRAIL gravity maps. The GeoTIFF files contain the same data as the corresponding files in the RSDMAP folder of the main GRAIL archive. Popular mapping software such as ESRI ArcMap and QGIS are able to import the GeoTIFF files directly.	GRAIL SDS
FORTNIGHT_CALCULATION.XLS	This is a supporting document for ONCE_UPON_A_FORTNIGHT.PDF, JPL D-61501, containing the numerical content described therein, as a Microsoft Excel file. This is the original version of the file FORTNIGHT_CALCULATION.PDF, located in the DOCUMENT directory.	GRAIL SDS

## 3. Archive Volume Format

This section describes the general format of GRAIL Archive Volumes. Data that comprise the Archive are formatted in accordance with Planetary Data System specifications [3].

### 3.1. File Formats

This section describes file formats for the kinds of files contained on Archive Volumes.

#### 3.1.1. Text Files

Files with the .TXT or .ASC suffix exist in the root, INDEX, SOFTWARE, CATALOG, CALIB, DOCUMENT, and data directories. They are (typically) ASCII files, which may have pre-pended PDS labels. Lines in a .TXT file end with a carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be read under various operating systems.

#### 3.1.2. Tabular File Format

Tabular files (.TAB suffix) exist in the INDEX and data directories. Tabular files are ASCII files with fixed-length records. All fields are separated by commas, and character fields are enclosed in double quotation marks ("). (Character fields are padded with spaces to keep quotation marks in the same position in successive records.) Character fields are left justified, and numeric fields are right justified. The "start byte" and "bytes" values listed in the labels do not include the commas between fields or the quotation marks surrounding character fields. The records are of fixed length, and the last two bytes of each record contain the ASCII carriage return and line feed characters. This allows a table to be treated as a fixed length record file on computers that support this file type and as a text file with embedded line delimiters on those that don't.

All tabular files are described by PDS labels. The PDS label file has the same name as the data file it describes, with the extension .LBL; for example, the file INDEX.TAB is accompanied by the detached label file INDEX.LBL in the same directory.

#### 3.1.3. PDS Label Format

All data files in the archive have PDS labels, either embedded at the beginning of the file or detached in a separate file. For examples of PDS labels for each type of data product, see the Data Product SIS [2].

A PDS label, whether embedded in or detached from its associated file, consists of lines of ASCII text in the form of keyword = value statements that provide descriptive information about the data file. The label is intended to be readable both by humans and by software. Details of the syntax and semantics of PDS labels can be found in the PDS Standards Reference [3], and definitions of the keywords used in the label can be found by using the PDS Data Dictionary Lookup web service at

[http://pds.jpl.nasa.gov/tools/ddlookup/data\\_dictionary\\_lookup.cfm](http://pds.jpl.nasa.gov/tools/ddlookup/data_dictionary_lookup.cfm).

Lines of text in detached labels end with a carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be read under various operating systems.



### 3.1.4. Catalog File Format

Catalog files (suffix .CAT) exist in the root and CATALOG directories. Like PDS labels, they are text files formatted as keyword = value statements. They contain descriptions of the data set, instrument, spacecraft, and mission, as well as personnel contact information and references to published literature. They are called Catalog Files because they are loaded into the PDS online catalog to make the information available to users searching for data. Catalog files do not have separate label files for themselves.

### 3.1.5. Science Data File Formats

A detailed description of the format, contents, and file naming convention of each data product is provided in the Data Product SIS [2].

### 3.1.6 Documents

Documents in the DOCUMENT directory may be in ASCII format, hypertext, and/or PDF. Since PDFs may contain formatting and figures that cannot be rendered as ASCII text, such files are also provided in hypertext. The hypertext file contains ASCII text plus hypertext markup language (HTML) commands that enable it to be viewed in a Web browser such as Firefox, Safari, or Microsoft Internet Explorer. The hypertext file may be accompanied by ancillary files such as images and style sheets that are incorporated into the document by the Web browser. The PDF (Portable Document Format) is now an ISO standard (ISO 32000) that is frequently used for distributing documents. Free software is available for viewing PDF files.

## 4. Archive Volume Generation

### 4.1. Data Transfer and Validation Methods

The GRAIL Archive will be transferred to the PDS via Internet or by mailed physical media, as agreed upon by the GRAIL Team and the PDS Geosciences Node. The Geosciences Node will validate the archive for PDS compliance and for compliance with the GRAIL SIS documents using standard PDS validation tools and specific tools developed by the Geosciences Node.

### 4.2. Data Product Sizes and Delivery Rates

Table 4-1 summarizes sizes and production rates for the GRAIL standard products. LGRS EDR, LGRS CDR, and LGRS RDR data cover the GRAIL primary and extended missions. RSS EDR data cover the entire mission.

**Table 4-1. Product Sizes and Delivery Rates**

Product	Product Size	Production Rate	Number of Products	Total Data Volume
DTC00	31 MB	2 per day	394	12 GB
EHK00	2 MB	2 per day	394	616 MB
LTB00	4 KB	1 per day	197	788 KB
MAS00	31 KB	2 per day	394	12 MB
S7200	166 KB	2 per day	394	64 MB
S7300	7 MB	2 per day	394	2.6 GB
SAE00	1 MB	2 per day	394	419 MB
SCA00	29 MB	2 per day	394	11 GB
STC00	14 KB	2 per day	394	5.2 MB
TDE00	88 KB	~1 per 2 days	99	8.5 MB
THR00	8 KB	2 per day	394	3 MB
WRS00	239 KB	2 per day	394	92 MB
CLK1A	8 KB	2 per day	394	3.0 MB
DEL1A	645 KB	1 per day	197	124 MB
EHK1A	1 MB	2 per day	394	430 MB
IHK1A	759 KB	2 per day	394	292 MB
IHS1A	52 KB	2 per day	394	20 MB
ILG1A	39 KB	2 per day	394	15 MB
KBR1A	65 MB	2 per day	394	25 GB
LTM1A	10 MB	2 per day	394	3.8 GB
MAS1A	4 KB	2 per day	394	1.6 MB
PCI1A	3 MB	2 per day	394	1008 MB

PLT1A	16 MB	1 per day	197	3.0 GB
PPS1A	195 KB	2 per day	394	75 MB
REL1A	1 MB	2 per day	394	508 MB
SAE1A	876 KB	2 per day	394	337 MB
SBR1A	7 MB	2 per day	394	2.6 GB
SCA1A	2 MB	2 per day	394	718 MB
SNV1A	12 KB	2 per day	394	4.7 MB
TC11A	613 KB	2 per day	394	236 MB
TC21A	476 KB	2 per day	394	183 MB
TC31A	1 MB	2 per day	394	402 MB
TC41A	483 KB	2 per day	394	186 MB
TC51A	8 KB	2 per day	394	3.0 MB
TC61A	1 MB	1 per day	197	244 MB
THR1A	6 KB	2 per day	394	2.5 MB
USO1A	4 KB	2 per day	394	1.6 MB
VCM1A	4 KB	2 per day	394	1.6 MB
WRS1A	146 KB	2 per day	394	56 MB
CLK1B	569 KB	2 per day	394	219 MB
EHK1B	1 MB	2 per day	394	430 MB
GNI1B	2 MB	2 per day	394	913 MB
GNV1B	205 KB	2 per day	394	79 MB
KBR1C	9 MB	1 per day	197	1.8 GB
MAS1B	4 KB	2 per day	394	1.6 MB
SAE1B	875 KB	2 per day	394	337 MB
SBR1B	9 MB	1 per day	197	1.7 GB
SCA1B	2 MB	2 per day	394	671 MB
THR1B	6 KB	2 per day	394	2.5 MB
USO1B	112 KB	2 per day	394	43 MB
VCM1B	4 KB	2 per day	394	1.6 MB
VGS1B	4 KB	2 per day	394	1.6 MB
VGX1B	4 KB	2 per day	394	1.6 MB
VKB1B	4 KB	2 per day	394	1.6 MB
WRS1B	146 KB	2 per day	394	56 MB
BOF	520 KB	6 per day	1178	598 MB
BTM	828 KB	6 per day	1178	953 MB
EOP	32 KB	1 per year	2	64 KB

ION	21 KB	2 per month	32	684 KB
ODF	4 MB	1-2 per day	677	2.4 GB
OLF	624 KB	6 per day	2096	1.2 GB
RSR	120 MB	6 per day	2096	247 GB
TDM	1.3 MB	6 per day	2096	2.7 GB
TNF	101 MB	1-2 per day	677	67 GB
TRO	160 KB	1 per month	16	2.5 MB
WEA	1 MB	1 per year per DSN complex	6	6.4 MB
XFR	955 KB	6 per day	2096	1.9 GB
SHADR	23 MB	1 delivery	1	23 MB
SHBDR	variable	1 delivery	4	832 GB
RSDMAP	1 MB	1 delivery	1	1 MB
SPK	15 MB	2 per day	362	334 MB

The approximate total archive size is estimated to be 1.2 TB. Further revisions of the gravity field (LGRS RDR) may add several hundred more GB.

Lien-resolved volumes containing the complete LGRS EDR, LGRS CDR, RSS EDR, and LGRS RDR data sets will be delivered to PDS according to the schedule in [1].

### 4.3. Backup and Duplicates

The GRAIL Team will retain backup copies of all data delivered to the Geosciences Node until the data have been released to the public.

The Geosciences Node will maintain three copies of the GRAIL archive that is kept online for public use, according to standard PDS policy for backup copies. When the GRAIL archive is complete at the end of the mission, the Geosciences Node will deliver a copy of the archive to the National Space Science Data Center (NSSDC) for long-term storage, but the Geosciences Node will maintain its own copies of the archive indefinitely.

### 4.4. Labeling and Identification

There will be four archive volumes resulting from GRAIL deliveries to the PDS. As per Table 2-2, the Volume IDs will be GRAIL\_0001, GRAIL\_0101, GRAIL\_0201, and GRAIL\_1001, which will contain, respectively, the data sets GRAIL-L-LGRS-2-EDR-V1.0, GRAIL-L-LGRS-3-CDR-V1.0, GRAIL-L-RSS-2-EDR-V1.0, and GRAIL\_L-LGRS-5-RDR-V1.0.

Individual products will be identified by the PDS keyword PRODUCT\_ID in the product label. For GRAIL, the file name of the product will be unique across the archive and therefore will be used as the value for PRODUCT\_ID. File naming schemes are given in the Data Product SIS [2]. Each product's PDS label will also include the keywords VERSION\_ID and PRODUCT\_CREATION\_TIME, which will be updated in the case of revisions to products.

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