PDS\_VERSION\_ID = PDS3

RECORD\_TYPE = STREAM

OBJECT = TEXT

PUBLICATION\_DATE = 2014-07-16

NOTE = "The NH REX post-launch checkout

Raw VERSION 1.0

Data Archive

Be sure to read the Required Reading

note below before using the data in

this archive.

"

END\_OBJECT = TEXT

END

The NH REX LAUNCH Raw VERSION 1.0 Data Archive

========================================================================

Quick Start - New Horizons Radio Science Experiment (REX) data sets

===================================================================

This is an abbreviated guide to the data; many important details have been

omitted for the sake of brevity; refer to the documentation for full details.

REX data comprise two types of measurements:

1) In-phase and Quadrature-phase (IQ pair) measurements of ~7.2GHz input

uplink signals (tones, from the Earth-based Deep Space Network - DSN) for the

purpose of analyzing the temporal phase and frequency relationship between the

received signal and the on-board Ultra-Stable Oscillator (USO).

2) Radiometry of 4cm-wavelength (7.2GHz) emission e.g. from a body surface.

Continuous REX data-taking is broken up into a series of data files, each file

covering 1024ms is called an observation or REX Output Frame (ROF); this

derives from the on-board partitioning for storage and telemetering to Earth.

Although this description focuses on the data as partitioned into separate

files, a single continuous data-taking activity comprises many of these files.

Users will need to join several files' data to recreate the original sequence.

Each REX raw data file stores three primary data types from one ROF (1024ms):

1) IQ pair measurements of ~7.2GHz input signals, heterodyned (2.5MHz IF),

filtered (4.5MHz), sampled at 10MHz, downconverted to baseband, and stored as

1250 IQ pairs per file; 14-bit signed integers on-board, stored 16-bit.

2) Radiometry of the 10MHz samples, squared and summed over 102.4ms,

represented as 10 accumulating sums-of-squares per ROF, and reset to zero once

per ROF; 40-bit integers on-board per sum stored as 64-bit integers. The 10th

accumulated sum for each ROF is stored as the first Radiometry value in the

next ROF.

3) Time tags incrementing every 102.4ms, and not reset between ROFs; 24-bit

on-board counter (rollover at 1.4 fortnight) stored as 32-bit integers. Time

tags are an aid both to place each per-ROF file's data into their correct

temporal position within the original continuous data-taking sequence, and to

determine if any data (ROFs) are missing.

Additional data stored in each file include: the original 5088-byte ROF byte

stream, from before packet decommutation, with the individual bytes of the

primary data types (above) interleaved; several types of instrument and

spacecraft housekeeping (HK) data.

The REX calibrated data files contain the same measurements, but the values

are converted to 32-bit floating point and scientific units: IQ pairs are in

Volts; Radiometry is in dBm power derived from calculated incremental sums

over 102.4ms intervals; Time Tags are in seconds.

Each ROF is stored in two files: a FITS file, with suffix .fit, containing the

data; a PDS label file, with suffix .lbl, describing the FITS data layout. The

files are laid out in a hierarchichal structure of directories:

<== directory names | file name ==>

data/20110520\_016821/rex\_0168215489\_0x7b3\_sci\_1.lbl

<+-> <---+--> <--+-> <---+----> <-+-> <+> <+>

V V V V | | V

Top-level Year, MET prefix MET\* of | V File suffix; .fit=FITS;

subdirec- Month, 1st 6 MET obser- | Data .lbl=PDS label

ory in Day digits\* vation V Type; eng=Raw; sci=Calibrated

data set ApID: Application Process ID

\* see below for MET definition 0x7b0/0x7b1=Side A; 0x7b2/0x7b3=Side B

The following example has three files containing three contiguous ROFs:

rex\_0235942890\_0x7b3\_sci\_1.fit

rex\_0235942891\_0x7b3\_sci\_1.fit (MET = previous MET+1)

rex\_0235942893\_0x7b3\_sci\_1.fit (MET = previous MET+2)

The ten-digit MET (Mission Event Time) is the truncated integer time, in

spacecraft clock seconds since launch, of the time of the ROF. Note that since

the ROFs cover 1024ms (1.024s), the METs will jump two seconds, instead of

one, every 43 files in a contiguous sequence (44.032 = 1.024 x 43 > 44).

Usa a PDS (http://pdssbn.astro.umd.edu/tools/tools\_readPDS.shtml) or FITS

library (http://fits.gsfc.nasa.gov) to read these data. For the stubborn, a

brief summary of the REX FITS/PDS layout is given here:

FITS files comprise one or more contiguous Data Units (DUs); the first DU is

the Primary DU (PDU); subsequent DUs are Extension DUs (EDUs), numbered from 1

(the PDU is DU 0); each DU comprises a Header section and and an optional,

contiguous Data section; Header and Data sections always start on 2880-byte

boundaries, and will always be padded to a multiple of 2880 bytes. Multi-byte

binary values (e.g. 32-bit float; 16-bit integers, etc.) are MSByte-1st.

REX quantities are stored in binary form in FITS files.

PDS labels define DU sections in FITS files; PDS labels contain human- and

machine-readable 'KEYWORD = VALUE' statements. Pointer statements (starting

with a caret, ^) provide the ordinal, within the file, of the first

fixed-length 2880-byte record of each DU; here is an example:

<==FITS file sections===> <=Corresponding PDS Label KEYWORD = VALUE lines=>

[PDU Header ]

[PDU Data - Raw ROF ] ^IMAGE = ("REX\_0037927970\_0X7b\*.FIT", 10)

[EDU 1 Header ]

[EDU 1 Data; IQ Pairs ] ^EXTENSION\_IQVALS\_TABLE = ("REX\_003792\*.FIT", 12)

[EDU 2 Header ]

[EDU 2 Data; Rad. & TTag] ^EXTENSION\_RAD\_TIME\_TAGS\_TABLE = ("REX\*.FIT", 16)

The Raw ROF starts at byte 25921 (10\*2880-2779) of the file; IQ Pairs at byte

31681 (12\*2880-2779); Radiometery and Time Tags at byte 43201 (16\*2880-2779).

The PDS TABLE object describes the layout and format of the values in the FITS

Data section; refer to this //-annotated, truncated sample PDS TABLE object:

OBJECT = EXTENSION\_RAD\_TIME\_TAGS\_TABLE // Start of TABLE OBJECT

ROWS = 10 // There are 10 rows in the table

ROW\_BYTES = 12 // There are 12 bytes in each row

COLUMNS = 2 // There are 2 COLUMNs in each row

OBJECT = COLUMN // Start of 1st COLUMN OBJECT description

NAME = "Radiometer" // 1st COLUMN contains Radiometer values

DATA\_TYPE = "MSB\_INTEGER" // Radiometry is MSByte-first signed integers

BYTES = 8 // Radiometry is 8-byte (64-bit) integers

START\_BYTE = 1 // Radiometry values start at 1st byte in row

END\_OBJECT = COLUMN // End of 1st COLUMN OBJECT description

OBJECT = COLUMN // Start of 2nd COLUMN OBJECT description

NAME = "Time Tag" // 2nd COLUMN contains Time Tag values

DATA\_TYPE = "MSB\_INTEGER" // Time Tags are MSByte-first signed integers

BYTES = 4 // Time Tags are 4-byte (32-bit) integers

START\_BYTE = 9 // Time Tag values start at 9th byte in row

END\_OBJECT = COLUMN // End of 1st COLUMN OBJECT description

Combine the previous two sections: the 10 Radiometry values are 64-bit signed

MSByte-first integers, starting at file ordinal bytes 43201, 43213 (43201+12),

43225, 43237, 43249, 43261, 43273, 43285, 43297, 43309; the 10 Time Tag values

are 32-bit signed MSByte-first integers, starting at file ordinal bytes 43209

(43201+9-1), 43221 (43209+12), 43233, 43245, 43257, 43269, 43281, 43293,

43305, 43317.

Tracking and Navigation Files (TNFs; TRK-2-34 format), if present, are in the

data/tnf/ subdirectory, are summarized in ASCII tables in that same directory,

and are described in the document labeled with file TNFSIS.LBL.

Table of Contents

=================

Introduction

Required Reading

Processing Level

Volume Format

File Formats

Volume Contents

Data Filenames and Product IDs

Data directory naming convention

Suggested FITS & PDS software

PDS label overview

Generic PDS label details

Whom to Contact for Information

Introduction

============

This document provides an overview of this dataset of

the New Horizons (NH)

REX LAUNCH Raw VERSION 1.0

Data Archive, including a general listing of the dataset contents.

This dataset contains flight data obtained during the

post-launch checkout

mission phase of the New Horizons mission, taken by the

Radio Science Experiment

instrument of the New Horizons spacecraft.

The start and stop times of data products in this data set overlap the

\*\*\*NOMINAL\*\*\* start and stop times, i.e.

2006-01-19T00:00:00 and 2007-01-01T00:00:00 UTC,

respectively, of that mission phase (see also Note 1 below).

Refer to the data sequence list file

DOCUMENT/SEQ\_REX\_LAUNCH.\*

for descriptions of the sequences that generated these data

(see also Note 2 below).

See the Mission catalog file NH.CAT in the /CATALOG/ directory for a

description of the New Horizons mission, including a description of

mission phases (LAUNCH, JUPITER, PLUTOCRUISE, PLUTO\_CHARON, etc.).

Note 1: Because single data products may span from milliseconds to days

of data, their start time may precede, or their stop times may

follow, the mission \*\*\*NOMINAL\*\*\* phase start or stop times,

respectively. Refer to CATALOG/DATASET.CAT for the exact start

and stop times of data in this data set.

Note 2: Some planned sequences in that list were not executed, due to

operational considerations such as spacecraft safing events, so

some sequences will have no corresponding data

Required Reading

================

Almost all of the New Horizons instruments have complex modes of operation

and complex, multi-part data products; users who want to properly understand

these data should expect to spend a significant effort (at least a day per

instrument) reading about and researching the instrument, the data and the PDS

product formats. To support that, the data producer has provided the

following Required Reading list.

Required Reading Summary List (see Details below for suggested priority)

------------------------------------------------------------------------

In this file (sections and subsections below):

Details (next subsection of Required Reading)

Data Filenames and Product IDs

Data directory naming convention

Explanation of granularity

Suggested FITS & PDS software

PDS label overview

Under the /DOCUMENT/ subdirectory:

SOC\_INST\_ICD.\* Science Operations Center Interface Control Document

REX\_SSR.\* Space Science Review (SSR) Instrument paper

PAYLOAD\_SSR.\* Space Science Review (SSR) Payload paper

DOCINFO.TXT Summary of /DOCUMENT/ subdirectory

NH\_MISSION\_TRAJECTORY.\* NH Trajectory table for mission

NH\_TRAJECTORY.\* NH Trajectory table for Jupiter Encounter

SEQ\_REX\_LAUNCH.\* Sequence list for this data set

Under the /CATALOG/ subdirectory:

NH.CAT NH Mission Catalog objects

NHSC.CAT NH SpaceCraft catalog objects

REX.CAT NH Instrument catalog objects

REF.CAT References to other documents

CATINFO.TXT Summary of /CATALOG/ subdirectory

Under the /CALIB/ subdirectory:

CALINFO.TXT Summary of calibration files in /CALIB/ subdirectory

Details

-------

The information contained in all documents included with, and

referenced in, this archive, is an integral part of this archive.

Specifically, the information contained in the SOC Instrument

Interface Control Document (ICD), and in the documents submitted

for publication in Space Science Reviews in 2007, is crucial to

understanding the data in this archive. As such, the producers

of this archive have included the best possible version of these

documents with this archive.

\* SOC Instrument Interface Control Document (AKA the ICD)

The ICD specifies the interfaces between the New Horizons

Science Operations Center (SOC) and the instrument pipeline, which

process data from raw to calibrated units. The ICD's purpose is to

define the various aspects of the interfaces in sufficient detail

to establish a clear understanding between the SOC and the

instrument team to allow for a parallel pipeline development.

This file is located in the /DOCUMENT/ directory of this

data set and its filename is SOC\_INST\_ICD.PDF. Other versions

of this file in different formats may be listed in SOC\_INST\_ICD.LBL.

In addition to mission-wide information (approximately six pages), the

ICD contains an entire section devoted to the details of the

REX instrument (~16 pages). The most important aids provided

to the user of this archive by the ICD are

\* Descriptions of the data files that comprise the

data portion of this archive.

\* Descriptions of the calibration methodology of the

REX instrument data.

\* Overview descriptions of the REX instrument theory

and operations.

\* References to more detailed documentation.

\* REX Space Science Reviews documents (AKA SSR paper(s))

Scientific papers describing the New Horizons mission,

spacecraft, mission design, payload and instruments were submitted

to the publication Space Science Reviews in 2007 after the Jupiter

encounter; refer to the references catalog for full citations.

These files are located in the /DOCUMENT/ directory of this

data set.

The filename of the instrument SSR paper is REX\_SSR.PDF;

other versions of this file are listed in REX\_SSR.LBL.

The filename of the payload SSR paper is PAYLOAD\_SSR.PDF;

other versions of this file are listed in PAYLOAD\_SSR.LBL.

The REX instrument and payload overview SSR papers, I.E.

Tyler, G.L., et al., 2008 [TYLERETAL2007]

and

Weaver, H.A., et al., 2008 [WEAVERETAL2007],

provide details of the REX theory, design, ground testing

and calibration, operational considerations, and post-launch

checkout results.

Because of time and copyright restrictions, the SSR papers could not

be included in this archive in their peer-reviewed and published form.

However, Space Science Reviews did agree to allowing the submitted

versions of these papers to be included in this archive. This has

been done with the initial version of this archive as a convenience

to the user of this archive. However, it should be noted that

(1) NASA archive procedures do not guarantee that archive

documentation will remain with archive data as archives are

migrated to newer media. Therefore, it may in the future be

up to the user of this archive to use the references provided

to obtain the documents.

(2) There will be changes made to the submitted papers before they

are published. Where any differences exist between the

submitted versions of these documents in this archive and the

final published versions, the final published versions should

be considered authoritative, and it is up to the user of this

archive to assess if any such differences will affect their use

of this archive.

Other important documents are available in the following files:

NH Trajectory table through Jupiter Encounter:

/DOCUMENT/NH\_TRAJECTORY.\*

- Includes Jupiter-centric ephemeris in Jupiter frame

NH Heliocentric Trajectory table for mission

/DOCUMENT/NH\_MISSION\_TRAJECTORY.\*

REX Field Of View definitions:

/DOCUMENT/NH\_FOV.\*

/DOCUMENT/NH\_REX\_V###\_TI.TXT

Further pointers to important documents for this data set

are available in the following files:

/CATALOG/CATINFO.TXT

/CATALOG/REF.CAT

/CALIB/CALINFO.TXT

/DOCUMENT/DOCINFO.TXT

All reasonable efforts have been made to include the documents in

multiple formats in the document portion of this archive. Where

that was not possible due to copyright restrictions, references

to the documents have been included in this archive, and it is

up to the user of this archive to obtain a copy of such documents.

The original format of the ICD was MSWORD, and the original format

of the SSR papers was PDF, as noted above. All other formats may

show some loss in quality, especially in images, so the user is

encouraged to get the best possible version of these documents.

Processing Level

================

This data set contains Raw data, one of the two

levels of processed data provided by the NH project to PDS.

A brief discussion of processing levels follows:

Processing Description

Level => CODMAC Level

========== ===============

Raw Instrument telemetry formatted for scientific use

=> CODMAC Level 2

Calibrated Raw data converted to scientific units

=> CODMAC Level 3

Raw data are in instrument units, typically binary integers referred to

as COUNTs or DATA NUMBER (DN). The raw data are stored in data files

with ancillary information such as observation time timestamps and

observational geometry.

Calibrated data are in scientific or engineering units, such as

radiance (W/(m\*\*2 um sr)) or impact particle mass (GRAMs). The

conversion to calibrated data from raw data was performed according

to an instrument performance model, which was developed from

scientific analysis of ground- and inflight-calibrations, and which

is documented in files in this data set under the /DOCUMENT/ and

/CALIB/ subdirectories. Refer to to /DOCUMENT/DOCINFO.TXT and

/CALIB/CALINFO.TXT for pointers to more information.

Volume Format

=============

This volume has been formatted according to the PDS Standards

Reference 3.x version current as of this data set's publication date.

File Formats

============

All text documents and other meta information files such as

descriptions, PDS object definitions and detached PDS labels are

stream format files, with a carriage return (ASCII 13) and a line

feed character (ASCII 10) at the end of the record. This allows

the files to be read by most current operating systems.

Volume Contents

===============

Files on this volume are organized into a set of subdirectories

below the top-level directory. The following table shows the general

structure and content of these directories, but does not exhaustively

list every file in each directory. See the \*INFO.TXT files in each

top-level sub-directory for specific information about the files

under that directory.

In this table, directory names are surrounded by forward slashes (/),

and the top-level of the volume is indicated by a single forward slash.

/ Top level of volume.

|

+-- AAREADME.TXT The AAREADME file; a backup is in /DOCUMENT/

+-- VOLDESC.CAT Description of the logical contents of this volume.

|

+--/DOCUMENT/ Directory containing dataset-related documents.

| +-- AAREADME\_BU.TXT A backup of the top-level /AAREADME.TXT file

| +-- DOCINFO.TXT Description of files in the DOCUMENT directory.

| +-- \*.\* Documentation files

| +--/SAMPLES/ Sub-directory containing data samples

| +-- SAMPINFO.TXT Description of files in the SAMPLES dir.

| +-- \*.\* Data sample files and documentation

|

|--/CATALOG/ Directory containing PDS catalog objects.

| +-- CATINFO.TXT Description of files in the CATALOG directory.

| +-- \*.\* Catalog files

|

+--/DATA/ Top-level data directory

| +--/YYYYMMDD\_SCRMET/ Sub-directories of /DATA/ containing data files

| +-- \*.\* Data files

|

+--/CALIB/ Top-level directory containing calibration files

| +-- CALINFO.TXT Description of files in the CALIB directory

| +-- \*.\* Calibration files

|

+--/INDEX/ Directory containing index files.

|

+-- INDXINFO.TXT Description of files in the INDEX directory

+-- \*.\* Index files and labels

Data Filenames and Product IDs

==============================

The filenames of data files and the Product IDs of observations adhere

to a common convention e.g.

ALI\_0123456789\_0X0AB\_ENG\_1.FIT

^^^ ^^^^^^^^^^ ^^^^^ ^^^ ^\\_\_/

| | | | | ^^

| | | | | |

| | | | | +--File type (includes dot)

| | | | | - .FIT for FITS file

| | | | | - .LBL for PDS label

| | | | | - not part of Product ID

| | | | |

| | | | +-- Version number from the SOC

| | | | (Science Operations Center)

| | | |

| | | +--ENG for Raw data \*

| | | SCI for Calibrated data \*

| | |

| | +--Application ID (ApID) of the telemetry data

| | packet from which the data come

| |

| +--Spacecraft Receipt Mission Elapsed Time (SCRMET)

|

+--Instrument/observation designator

Note that, depending on the observation, the SCRMET in the data

filename and in the Product ID may be similar to the Mission Elapsed Time

(MET) of the actual observation acquisition, but should not be used as an

analog for the acquisition time. The SCRMET is the time that the data

are transferred from the instrument to spacecraft memory and is therefore

not a reliable indicator of the actual observation time. The PDS label

and the index tables are better sources to use for the actual timing of

any observation. The specific keywords and index table column names for

which to look are

\* START\_TIME

\* STOP\_TIME

\* SPACECRAFT\_CLOCK\_START\_COUNT

\* SPACECRAFT\_CLOCK\_STOP\_COUNT

Data directory naming convention

================================

All of the data files in this dataset are under, but not in, the top-level

/DATA/ directory. Sub-directories, based on the SCRMET (see above) of the

top-level /DATA/ directory have been provided to increase the granularity of

data storage locations which in turn keeps there from being too many data

files in any one directory. The granularity implemented is one sub-directory

per 10,000 counts of the SCRMET (see Data Filenames and Product IDs section

above).

The subdirectory names on this volume reflect that granularity. These

names are of the form

YYYYMMDD\_SCRMET/

where SCRMET is a grouping of the first six digits of the ten-digit SCRMET

count, and YYYY, MM, and DD are the year, month and day of the first

possible SCRMET corresponding to that six-digit SCRMET prefix. Any data file

will be located in a directory whose six-digit SCRMET prefix matches that

of the data file.

Since each count represents about one second, there may be as many as nine

six-digit SCRMET prefixes with the same YYYYMMDD values. Also, since days

will not start or end exactly on 10,000 count SCRMET boundaries, directories

with the naming convention may span day boundaries. That is, the YYYYMMDD

value corresponding to the start of a 10,000 count SCRMET range may not be

the same as the YYYYMMDD that corresponds to the end of that range.

Explanation of granularity

--------------------------

The granularity of sub-directories under /DATA/ on this volume has been

copied from that used on the Science Operations Center (SOC) where the

data files were originally generated. On the SOC, the same granularity

was implemented across all eight New Horizons instruments' directory

structures. Because the mission instruments generate data files at

varying rates, from one or more data files per second to one or more days

per data file, a compromise granularity of 10,000 SCRMET counts was chosen,

and propagated to this volume.

Suggested FITS & PDS software

=============================

For working with PDS-labeled data, software packages are available

at Planetary Data System (PDS) nodes (as of 2007). Several other options

for reading either FITS or PDS-labeled data are listed here. If not

included in the text below, references to the packages may be either found

at one or more PDS nodes or found via a search engine. Data users

planning to write custom software should refer to the PDS label

description in the subtopics that follow for a general introduction and

to the PDS Standards document available at PDS nodes.

The following URLs were current as of 2007 when the early New

Horizons data sets were delivered; given the availability of search engines

for the World Wide Web, no attempt has been or will be made to update this

information throughout the mission.

Readers and viewers (Package name, format handled by it, and URL):

READPDS PDS http://pdssbn.astro.umd.edu/nodehtml/software.shtml

NASAVIEW PDS http://pds.nasa.gov/tools/software\_download.cfm

FV FITS http://heasarc.gsfc.nasa.gov/docs/software/ftools/fv/

DS9 FITS http://hea-www.harvard.edu/RD/ds9/

Development toolkits for IDL (http://www.ittvis.com/idl/):

OAL PDS http://pds-rings.seti.org/toolkits/

ASTRO FITS http://idlastro.gsfc.nasa.gov/

Development toolkits for C & FORTRAN:

OAL PDS http://pds-rings.seti.org/toolkits/

CFITSIO FITS http://heasarc.gsfc.nasa.gov/docs/software/fitsio/

Development toolkit for Python and Perl:

PyFITS FITS http://www.stsci.edu/resources/software\_hardware/pyfits/

CFITSIO.pm FITS http://hea-www.harvard.edu/~rpete/cfitsio/

General FITS info and many more references may be found at

The FITS Suport Office: http://fits.gsfc.nasa.gov/

N.B. The following description of PDS labels is only meant to be

sufficient to write a program to read the FITS data files in this

data set using the information contained in the corresponding

detached PDS labels in this data set, and is therefore neither a

complete nor PDS-sanctioned exposition of the PDS label format or

PDS standards. For full details of the PDS standards, refer to

the source from which this data set was obtained.

PDS label overview

==================

Under the DATA/ subdirectory of this data set, each PDS label file is a

multi-record flat ASCII file describing the Data Units in a corresponding FITS

data file that represent a single observation or group of observations.

A FITS file is made up of one or more contiguous 2880-byte records. Each

Data Unit (DU) in a FITS data file comprises one or more records. The data in

each DU starts at the first byte of the DU and is arranged as described in the

PDS label. If the data in a DU do not end at a 2880-byte boundary, then that

DU is padded out to the boundary.

Each record in a PDS label is 80 bytes long comprising 78 printable 7-bit

ASCII characters and/or spaces and ending with a carriage return and a line

feed. Most records are of the form

KEYWORD = VALUE

where KEYWORD is the name of a quantity, and VALUE represents the value of

that quantity. Spaces before, after, and between the keyword, the equals

sign, and the value(s) are not significant.

String values may span multiple records, and are usually delimited by (i.e.

enclosed in) double quotes. Strings contain no double quotes. Some string

values, such as UTC times, are not enclosed in quotes.

Most integer & floating point numeric values are displayed without quotes.

Multiple values for a single keyword are indicated by enclosing the values

in parentheses or curly braces and separating the values with commas.

Comments are initiated by a contiguous forward-slash & asterisk pair (i.e.

/\*) on the left and continue to the end of a single record where they are

usually terminated by a matching asterisk & forward-slash pair (\*/). Whether

or not the terminating pair is present, the comment ends at the end of the

record, and another initiating pair must be present on the next record if that

record is intended to continue the comment.

Blank lines may be inserted between other lines to enhance readability.

1) PDS pointers

Pointers are special cases of keyword/value pairs in the PDS label, and

define where each DU starts in the FITS file; pointers look like this:

^HEADER = "XYZ.FIT" /\* Primary Header DU (HDU) \*/

^IMAGE = ("XYZ.FIT",11) /\* Primary DU \*/

^ERROR\_HEADER = ("XYZ.FIT",22) /\* Extension #1 HDU \*/

^ERROR\_IMAGE = ("XYZ.FIT",31) /\* Extension #1 DU \*/

^HOUSEKEEPING\_HEADER = ("XYZ.FIT",43) /\* Extension #2 HDU \*/

^HOUSEKEEPING\_TABLE = ("XYZ.FIT",44) /\* Extension #2 DU \*/

^THRUSTERS\_HEADER = ("XYZ.FIT",45) /\* Extension #3 HDU \*/

^THRUSTERS\_TABLE = ("XYZ.FIT",51) /\* Extension #3 DU \*/

Pointer keywords HEADER and IMAGE refer to the Primary Header Data Unit

(HDU) and Primary Data Unit, respectively. Pointer keywords that end in

\_HEADER refer to Extension HDUs. Pointer keywords that end in \_IMAGE or

\_TABLE or \_ARRAY refer to Extension DUs.

The text after the equals sign in each pointer is usually enclosed by

parentheses and comprises the filename of the file where the DU resides and

the DU's location in that file. The filename and the location are delimited

by a comma. The filename is a string enclosed in double quotes, and the DU

location is a decimal integer value indicating the cardinal location in the

file of the first 2880-byte record of the DU.

For example, the ^IMAGE DU above, with a location value of 11, starts at

an offset of 28800 bytes (= [11-1]\*2880) from the first byte of the

file.

If only the filename is given, with neither the parentheses nor the comma

nor the location, then the DU starts at the beginning of the file i.e. the

location is implicitly set to one.

2) OBJECT stanzas

Each pointer in a PDS label will have a corresponding OBJECT stanza.

OBJECT stanzas comprise the lines between corresponding 'OBJECT=<object\_name>'

& 'END\_OBJECT=<object\_name>' keyword lines.

OBJECT stanzas referring to TABLEs will contain one or more

'OBJECT=COLUMN'/'END\_OBJECT=COLUMN' stanzas.

See the comments (/\* ... \*/) to the right of the keywords in the example

below to understand the OBJECTs and keywords that describe binary tables.

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* N.B. This example does not describe every keyword \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* that will be present in each table, but only \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* those necessary to read and understand the \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* arrangement of the data in the DU to which \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* OBJECTs refer. Refer to the PDS standards \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* for more details. \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* Example starts after the next line \*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

^S\_TABLE = ("XYZ.FIT",51) /\* EDU #3; Data table \*/

OBJECT = S\_TABLE /\* Start of object describing data of pointer ^S\_TABLE \*/

INTERCHANGE\_FORMAT = BINARY

ROWS = 463 /\* Table comprises 463 rows \*/

COLUMNS = 97 /\* Table comprises 97 columns \*/

ROW\_BYTES = 1080 /\* Each row comprises 1080 bytes \*/

DESCRIPTION = "..."

OBJECT = COLUMN /\* OBJECT describing column 1 \*/

NAME = STATUSES /\* Column name \*/

COLUMN\_NUMBER = 1 /\* Column location within row \*/

DATA TYPE = MSB\_INTEGER /\* Column data element type \*/

ITEMS = 3 /\* Number of data elements in column \*/

ITEM\_BYTES = 2 /\* Size of each data element in column \*/

START\_BYTE = 1 /\* Byte location in row of 1st byte of column \*/

BYTES = 6 /\* Column width (bytes); <= ITEMS\*ITEM\_BYTES \*/

DESCRIPTION = "..."

END\_OBJECT = COLUMN

OBJECT = COLUMN /\* OBJECT describing column 2 \*/

NAME = TEMPERATURE /\* Column name \*/

COLUMN\_NUMBER = 2 /\* Column location within row \*/

DATA TYPE = IEEE\_REAL /\* Column data type \*/

ITEMS = 1 /\* Number of data elements in column \*/

ITEM\_BYTES = 4 /\* Size of each data element in column \*/

START\_BYTE = 7 /\* Byte location in row of 1st byte of column \*/

BYTES = 4 /\* Column width (bytes); <= ITEMS \* ITEM\_BYTES \*/

DESCRIPTION = "..."

END\_OBJECT = COLUMN

...

END\_OBJECT = S\_TABLE /\* End of object S\_TABLE \*/

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\* Example ends before the previous line \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

In the example above:

- the table S\_TABLE starts at byte 144001 ((51-1)\*2880 + 1)

of the file, and comprises 97 rows each of width 1080 bytes.

- the first column, named STATUSES, in each row starts at the

1st byte of that row and comprises three MSB-first 16-bit

integers using 6 bytes total on each row.

- the second column, named TEMPERATURE, in each row starts at

the seventh byte of that row and comprises one IEEE 32-bit

floating point value using four bytes total on each row.

- Subsequent rows are offset 1080 bytes from the previous row.

Generic PDS label details

=========================

The PDS label has meta-data which describe the circumstances surrounding the

data in the FITS file. These meta-data are in keyword and value pairs (e.g.

the pointers above) and each of these keywords is described in the PDS Data

Dictionary plus the New Horizons mission- specific local data dictionary

supplemental items, both of which are available in this archive.

All FITS Header Data Units (HDUs) and Data Units are described in the PDS

labels. In some cases, no Data Unit will be described in the PDS label

because there is nothing to describe i.e. it is not present in the FITS file.

PDS LABELS: Column Descriptions in binary tables

-------------------------------------------------

FITS extensions may contain data that are a subset of

instrument and/or spacecraft housekeeping telemetry packets

formatted as binary tables. Where possible, each column

included in such extensions has a DESCRIPTION field something

like this:

DESCRIPTION = "

Full Mnemonic:

SWAP\_RT.SEC64\_ST

General Description:

A bit indicating the beginning of a 64-second cycle

Conversion: STATES

- [lo:hi]=state description:

[0:0]=CONT

[1:1]=START

Subsystem: SWAP

Packet ApID: 0X584

Byte Offset within ApID packet: 10

Bit Offset within Byte of ApID packet: 0

Bit Length within ApID packet: 1

Type of value: UNSIGNED

Units: N/A

"

The sub-fields used in these DESCRIPTION fields are as follows:

Full Mnemonic: The complete mnemonic used in the definition

of the packet. The COLUMN name will typically

be a subset of this mnemonic.

General Description: A description of the column

Extended Description: More information

- this field is not always present

Conversion: This item describes the conversion of the value

found in the column to a meaningful quantity.

It takes one of two forms: STATES and polynomial.

If the conversion form is STATES, then the bits of

the column are combined into an integer and compared

against the ranges list. In the example above, if the

value of the bit is zero, then the SWAP\_RT.SEC64T

column represents a continuing state. If the value of

the bit is 1, then the SWAP\_RT\_SEC64T column indicates

that a new 64-second cycle has just begun.

If the conversion form is polynomial, then the bits of

the column are combined into an integer and used as

the independent value of the polynomial with the

coefficients given. For example, if the integer

value of a column is 100, and its conversion looks

like this:

Conversion: polynomial coefficients:

Order 0: 0.925

Order 1: 0.979

Then the derived value of this instrument is

0.925 + (0.979 \* 100) = 98.825

Subsystem: Which subsystem generated the packet

Packet ApID: The Application ID of the packet

Byte & Bit Offsets & Bit Length: the location of the column's

value in the packet, including

the 10-byte CCDS header.

Type of value: For integer values, whether the value

is signed or unsigned

Units: Nominal units of the derived column values

Whom to Contact for Information

===============================

New Horizons REX Principal Investigator:

Len Tyler

350 Serra Mall, David Packard #372

Stanford University

Stanford, CA 94305-9515

USA

See also PDS\_USER\_ID

LTYLER

in CATALOG/PERSONNEL.CAT for additional contact information.

New Horizons Science Operation Center (SOC):

Joe Peterson

Southwest Research Institute (SWRI)

Department of Space Studies

1050 Walnut Street, Suite 400

Boulder, CO 80302

USA