ROSETTA-RPC-IES
PLANETARY SCIENCE ARCHIVE
INTERFACE CONTROL DOCUMENT

APRIL 2011

SwRI® Project 10991

Document No. 10991-IES-EAICD-01

Contract JPL 1200670

Prepared by

SOUTHWEST RESEARCH INSTITUTE®

Space Science and Engineering Division
6220 Culebra Road, San Antonio, Texas 78228-0510
(210) 684-5111 • FAX (210) 647-4325

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Prepared by: Brad Trantham   14 April 2011
              Archivist

Approved by: _____   Date: _____
            James L. Burch, PhD, Principal Investigator

Approved by: _____   Date: _____
            Raymond Goldstein, PhD, Rosetta Project Manager

Approved by: _____   Date: _____
            L. D. McCullough, SwRI Project CM

Space Science and Engineering Division
Southwest Research Institute
P. O. Drawer 28510
6220 Culebra Road
San Antonio, Texas 78228-0510
(210) 684-5111

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REVISION NOTICE

Initial Issue: September 2005.

Revision 1:   Updated for version 2 archive products. August 2007

Revision 2:   Updated based on PSA feedback. March 2009

Revision 3:   Updated based on Steins review feedback. April 2011

1.   INTRODUCTION

1.1   Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is to provide users of the RPC-IES instrument data with detailed description of the product and a description of how it was generated, including data sources and destinations. It is the official interface between the instrument team and the archiving authority.

1.2   Archiving Authorities

The Planetary Data System Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS

- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

1.2.1   ESA's Planetary Science Archive (PSA)

ESA implements an online science archive, the PSA,

- to support and ease data ingestion

- to offer additional services to the scientific user community and science operations teams as e.g.

    o search queries that allow searches across instruments, missions and scientific disciplines

    o several data delivery options as

        ▪ direct download of data products, linked files and data sets

        ▪ ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3   Contents

This document describes the data flow of the IES instrument on the Rosetta mission from the spacecraft until the insertion into the PSA for ESA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained.

The design of the data set structure and the data product is given. An example data product is given in section 4.3 Data Product Design.

1.4   Intended Readership

This document's intended readership includes the staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the RPC-IES data.

1.5 Applicable Documents

Planetary Data System Data Archive Preparation Guide May 3, 2005 Version 0.050503, JPL D31224

Planetary Data System Standards Reference, August 1, 2003, Version 3.6, JPL, D-7669, Part 2

Rosetta Archive Generation, Validation and Transfer Plan, January 2006, RO-EST-PL-5011

Rosetta Plasma Consortium Users' Manual, V 1.0, December 2003, RO-RPC-UM

Ion and Electron Sensor (IES) Flight Software Requirements Document, November 14, 2000, Rev. 0 Change 0, SWRI, Document No. 8182-FSRD-01

1.6 Relationships to Other Interfaces

N/A

1.7 Acronyms and Abbreviations

CCSDS	Consultative Committee for Space Data Systems
DDS	Data Distribution System
EAICD	Experiment to Archive Interface Control Document
ESA	European Space Agency, Electrostatic Analyzer
ESOC	European Space Operations Centre
HGRTN	Heliocentric Radial-Tangential-Normal
IES	Ion and Electron Sensor
IESGS	IES Ground System
MCP	Microchannel Plate
PDS	Planetary Data System
PSA	Planetary Science Archive
RDDS	Rosetta Data Distribution System
RPC	Rosetta Plasma Consortium

1.8 Contact Names and Addresses

Brad Trantham
btrantham@swri.org
Southwest Research Institute
Space Science and Engineering Division
6220 Culebra Road, San Antonio, Texas 78238-5166
Telephone (210) 522-5241
Fax (210) 543-0052

Dr. Ray Goldstein
rgoldstein@swri.org
Southwest Research Institute
Space Science and Engineering Division
6220 Culebra Road, San Antonio, Texas 78238-5166
Telephone (210) 522-6223
Fax (210) 543-0052

Rob Thorpe
rthorpe@swri.org
Southwest Research Institute
Space Science and Engineering Division
6220 Culebra Road, San Antonio, Texas 78238-5166
Telephone (210) 522-2848
Fax (210) 543-0052

2.   OVERVIEW OF INSTRUMENT DESIGN, DATA HANDLING PROCESS AND PRODUCT GENERATION

2.1   Instrument Design

The IES for Rosetta is an electrostatic analyzer (ESA), featuring electrostatic angular deflection to obtain a field of view of 90º x 360º. The instrument objective is to obtain ion and electron distribution functions over the energy range extending from 1 eV/e up to 22 keV/e. The angular resolution for electrons is 5º x 22.5º (16 azimuthal and 16 polar-angle sectors). For ions the angular resolution is 5º x 45º (16 azimuthal and 8 polar-angle sectors) with additional segmentation to 5º x 5º in the 45º polar-angle sector most likely to contain the solar wind (giving a total of 16 polar-angle sectors for ions). The back-to-back top hat geometry of the IES electrostatic analyzer allows it to analyze both electrons and positive ions with a single entrance aperture. The IES top hat analyzers have toroidal geometry with a smaller radius of curvature in the deflection plane than in the orthogonal plane. This toroidal feature results in a flat deflection plate geometry at the poles of the analyzers and has the advantage that the focal point is located outside the analyzers rather than within them, as is the case with spherical top hat analyzers. Particles within a narrow 4% energy pass band will pass through the analyzers and be focused onto the electron and ion microchannel plates (MCPs), which produce charge pulses on 16 discrete anodes, which define the polar acceptance angles. In addition, the IES entrance aperture contains electrostatic deflection electrodes, which expand its azimuthal angle field of view to ±45º. With the typical top hat polar-angle field of view of 360º, the IES acquires a total solid angle of 2.8 pi steradians.

Operation of IES is controlled by its on-board software in conjunction with sets of (selectable) look up tables. A table in one set determines the sequence of voltages applied to the electrostatic analyzer, thereby selecting the energy/charge of electrons and ions entering the sensor. Likewise, a table in another set determines the sequence of voltages applied to the deflector plates, thereby defining the acceptance angle of the particles. In the typical operating mode, for each deflector voltage chosen the ESA is stepped over its range, the deflector voltage is stepped to its next value, and so on. A complete 2 voltage sequence thus determines a complete measurement cycle. Several versions of each table are stored in the instrument so different operating modes can be easily chosen. In addition, new tables can be uploaded if desired.

Over 128 seconds (Normal and Burst telemetry rates) or 1024 seconds (Minimal telemetry rate), the instrument obtains a full measurement of ion and electron flux within 16 azimuthal bins, 16 elevation bins and 128 energy bins, for a total of 65536 values (2x16x16x128) per measurement. To fit within the data volume allocated to IES, blocks of adjacent angle/energy bins are summed together. The details of this summation are mode-dependent, but this collapse and the 128 or 1024 second accumulation time are the only differences between IES operations in different modes.

2.2   Scientific Objectives

IES supports the RPC science goals by measurements of three-dimensional ion and electron velocity distributions and the derived quantities such as plasma density, flow velocity, and ion and electron pressure.

2.3   Data Handling Process

All RPC data packets are transmitted together during downlinks with Rosetta. RPC data is retrieved from the DDS at ESOC to a central RPC data server at Imperial College in London. Data for IES is copied from the RPC central data server by IESGS at Southwest Research Institute.

The pipeline processing software is the IES Ground System (IESGS). IESGS extracts IES CCSDS packets from the RPC collective data files stored on the RPC central data server at Imperial College. These packets are used to build ion and electron data products. The data products are grouped by date and written out to PDS compliant archive data files. One data file is created for each mode used in each day. IESGS also generates the labels for the archive data files. IES science products, archive and label files, and limited spectrograms are available to team scientists on the IESGS website.

Spectrograms can be generated from the IES archive data. These spectrograms can illustrate electron and ion counts per energy level, elevation angle, or azimuth bin. Spectrograms or spectrogram generating software may be introduced in a later release.

2.4   Data Products

2.4.1   Pre-Flight Data Products

None. Raw calibration data will be generated in the archive format for internal use, but there are no current plans to submit these data to the PSA.

2.4.2   Instrument Calibrations

IES calibration data will be added during a later release.

2.4.3   Other Files written during Calibration

None

2.4.4   In-Flight Data Products

To ensure that the IES goals can be achieved, data will be archived as:

- Edited raw data (CODMAC level 2) – the science data stream converted to human and PDS readable format.

- Calibrated data (CODMAC level 3) – the contents of the edited raw data with calibration information included. (To be included in a future release)

- Derived higher level data (CODMAC level 4) – quantities calculated from phase space density, such as plasma density, flow speed, ion and electron pressure, or electron pitch angle distributions. (To be included in a future release)

These data may be used for cross-instrument calibrations, and both stand-alone and cross-instrument scientific analysis.

2.4.5 Software

We do not intend to deliver any software.

2.4.5

2.4.6 Calibration Software

There is no calibration software that is applicable to IES at this time. Calibration data will be included in a later release.

2.4.5

2.4.7 Documentation

The document directory contains documentation that is considered to be either necessary or simply useful for users to understand the archive data set. These documents are not necessarily appropriate for inclusion in the PDS catalog. Documents may be included in multiple forms (ASCII, PDF, MS Word, HTML with image file pointers, etc.). PDS standards require that any documentation deemed required for use of the data be available in some ASCII format. HTML and PostScript are acceptable as ASCII formats in addition to plain text. Images and drawings will also be included as separate PNG files.

There will be a separate directory for each document that is to be archived. Each of the document directories will include the document in plain text (ASCII) and the document in another format (i.e. .DOC or .PDF). There will also be a single label file that describes all the different formats of the included documents. When reformatting to plain text affects the information content, this will be noted in the label file.

2.4.5

2.4.8 Derived and other Data Products

The IES higher level (derived) data products are still TBD, but may include plasma density, flow velocity, ion and electron pressure, ion and electron temperature, and ion and electron pitch angle distributions. Many of these calculations will require co-operation with other RPC instruments: Calculations of ion moments require some composition data (e.g. the mean mass to charge ratio) and electron pitch angle distributions require data on the direction of the magnetic field.

2.4.5

2.4.9 Ancillary Data Usage

Information on additional events may be desirable, if these events affect IES data (e.g. sweeping of the LAP voltages may affect the spacecraft electron sheath and therefore IES electron data.)

2.4.5

2.4.5

2.4.5

2.4.5

3.   ARCHIVE FORMAT AND CONTENT

3.1   Format and Conventions

3.1.1   Deliveries and Archive Volume Format

The IES team will submit the archive to PSA and PDS electronically. PSA and PDS will be responsible for creating the physical volumes used for deep archiving. ESA requests that archive deliveries be made six months after the end of a mission phase.

3.1.2   Data Set ID Formation

RO-E/M/A/C/CAL/X/SS/D-RPCIES-x-phase-Vn.m

where:

RO	= INSTRUMENT_HOST_ID
E/M/A/C/CAL/X/SS/D	= TARGET_ID (Earth/Mars/Asteroid/Comet/Calibration/Checkout/Solar System/Dust)
RPCIES	= INSTRUMENT_ID
x	= {2,3,5} CODMAC data processing level numbers.
phase	= Mission phase abbreviation (GRND, LEOP, CVP, CR1, EAR1, etc)
n.m	= Version number

Within each data set TARGET_NAME and TARGET_TYPE will then be used to identify the current target.

(Thus they will not stay the same within one data set, but data set id will.)

3.1.3   Data Directory Naming Convention

We intend to use a year/month/day directory hierarchy. The directory structure is covered in more detail in section 3.4.3.

```
        DATA_SET_ROOT
             |
    +----+---+-------+---. . .
    |    |           |
 DATA DOCUMENT   CATALOG. . .
    |
 EDITED
    |
   YYYY
   |  |
   MM MM
   |  |
```

```
    DD DD
```

3.1.4 Filenaming Convention

For uncalibrated and calibrated data there will be two IES data files generated per day. There will be one file for electron data and one file for ion data. The file names will follow the following naming convention:

```
POSITION: 0123456789012345678.012
FILENAME: RPCIESYYMMDD_nnn_VV.EXT

where:

YY  = Year
MM  = Month
DD  = Day
nnn = ELC (electron) or ION (ion)
VV  = Archive product version
EXT =  LBL or TAB
```

3.2   Standards Used in Data Product Generation

3.2.1 PDS Standards
IES complies to PDS version 3, and we use version 3.6 of the PDS standard reference.

3.2.2 Time Standards
Time(UTC) in LBL files: yyyy-mm-ddThh:mm:ss.sss
Time(UTC) in TAB files: yyyy-mm-ddThh:mm:ss.sss
Spacecraft Clock (OBT) in LBL files: "1/nnnnnnnnnn"
Spacecraft Clock (OBT) in TAB files: nnnnnnnnnn
OBT is defined as seconds since 1/1/2003T00:00:00 UTC.

3.2.3 Reference Systems
In order to determine IES pointing, attitude data for the Rosetta spacecraft is obtained through SPICE kernels and converted from the J2000 coordinate system to the HGRTN coordinate system. HGRTN is the heliocentric RTN system such that the sun-spacecraft vector defines the positive x-axis and the positive y-axis is the cross-product of the heliographic polar axis and the HGRTN positive x-axis. J2000 is the inertial frame defined by the intersection of the Earth mean equator and the ecliptic plane at the J2000 epoch of January 1, 2000 at noon.

The pointing for each bin of IES is thereafter determined by multiplying the converted spacecraft attitude matrix in HGRTN by the vector representation of each particle measurement bin. The resulting vectors represent the flow of particles through the respective particle measurement bins in HGRTN coordinates.

3.3 Data Validation

Data will be scanned for internal consistency when decommutating to edited raw format. Derived data will be compared to independent measurements by other instruments when possible. Before archiving a data set from some mission phase, this set will have been used internally by RPC scientists. It is planned to base all scientific analysis on the data products formatted. To actually have the data used by scientists before delivery to archive is considered the best way of revealing problems, and this is the approach taken by IES.

After submission a PDS peer review will assess the data set and documentation for compliance and scientific usability. The peer review is typically done once for the initial submission and all subsequent submissions are merely checked for conformance to the standards put forth in this document. There will also be peer reviews from the Rosetta archive team as the data is made ready for ingestion into the PSA.

3.4 Content

3.4.1 Volume Set

The IES archive will be submitted electronically, so there will initially be one volume for the entire dataset. PDS will create physical volumes for deep archiving. PSA requires no physical volumes, as the PSA is a completely online system.

3.4.2 Data Set

Our naming convention for the data set will follow the same principles as the DATA_SET_ID thus.

```
DATA_SET_NAME="ROSETTA-ORBITER  E/M/A/C/CAL/X/SS/D  RPCIES  d  PHASE
Vm.n"

where:

ROSETTA-ORBITER          = INSTRUMENT_HOST_NAME

E/M/A/C/CAL/X/SS/D       = TARGET_NAME  (EARTH  MARS  ASTEROID  COMET
                           CALIBRATION CHECKOUT SOLAR SYSTEM DUST)


RPCIES                   = INSTRUMENT_ID

d                        = CODMAC data processing level numbers 2,3
  or 5.

PHASE                    = Mission  phase  abbreviation  (GRND, LEOP,
  CVP, CR1, EAR1, etc)

Vm.n                     = Version number
```
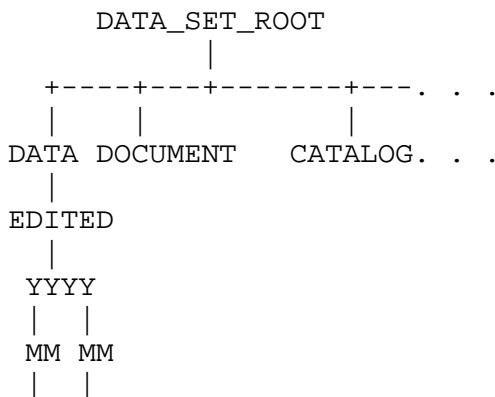
One data set will be used for each processing level. Multiple targets will be used for each data set and within each data set TARGET_ID will be used to identify the current target (Thus they will not stay the same within one data set, but data set id will). The data set name fits in the full length thus 60 characters.

3.4.3   Directories

3.4.3.1 Root Directory

Table 1: Root Directory Contents	
File Name	**File Contents**
AAREADME.TXT	This file completely describes the Volume organization and contents
VOLDESC.CAT	A description of the contents of this Volume in a PDS format readable by both humans and computers
CATALOG/	Catalog directory
DOCUMENT/	Document directory
INDEX/	Index directory
DATA/	Data directory
BROWSE/	Browse directory
EXTRAS/	Supplemental information directory

3.4.3.2 Catalog Directory

Table 2: Catalog Directory Contents	
File Name	**File Contents**
CATINFO.TXT	A description of the contents of this directory
DATASET.CAT	PDS Data Set catalog description of all the IES data files
INSTHOST.CAT	PDS instrument host (spacecraft) catalog description of the Rosetta orbiter spacecraft
RPCIES_INST.CAT	PDS instrument catalog description of the IES instrument
MISSION.CAT	PDS mission catalog description of the Rosetta mission
RPCIES_PERS.CAT	PDS personnel catalog description of IES Team members and other persons involved with generation of IES Data Products
RPCIES_REF.CAT	IES-related references mentioned in other *.CAT files
RPCIES_SOFTWARE.CAT	Software catalog file
TARGET.CAT	Information on mission targets

3.4.3.3 Index Directory

This directory contains the index files generated by the ESA S/W PVV.

3.4.3.4 Browse Directory and Browse Files

Spectrograms or other browse products may be introduced at a later date.

3.4.3.5 Geometry Directory

The geometry directory will contain any necessary instrument or frame kernels.

3.4.3.6 Document Directory

Table 3: Document Directory Contents	
File Name	**File Contents**
DOCINFO.TXT	A description of the contents of this directory and all subdirectories.
IES_EAICD/	Directory containing the IES EAICD document
IES_EAICD/IES_EAICD.DOC	The IES Experiment-Archive Interface Control Document as a MS Word doc
IES_EAICD/IES_EAICD.TXT	The IES Experiment-Archive Interface Control Document in plain text
IES_EAICD/IES_EAICD.LBL	A PDF detached label that describes IES_EAICD.HTM, IES_EAICD.ASC, and IES_EAICD.PDF

3.4.3.7 Data Directory

The data directory will contain .TAB files that have the archive data in fixed width, comma separated columns corresponding to PDS table objects. Accompanying each .TAB file will be a label file (.LBL) containing metadata about the archive.

3.4.3.8 Extras Directory

Table 4: Extras Directory Contents	
File Name	**File Contents**
EXTRINFO.TXT	A description of the contents of this directory and all subdirectories.
ENERGY_STEPS.TAB	Step to energy mapping
ENERGY_STEPS.LBL	Label for ENERGY_STEPS.TAB
ELEVATION_STEPS.TAB	Step to elevation mapping
ELEVATION_STEPS.LBL	Label for ELEVATION_STEPS.TAB

4.   DETAILED INTERFACE SPECIFICATIONS

4.1   Structure and Organization Overview

See section 3.1.3 for general overview.

Now as defined in section 3.1.3 we have the following structure for the DATA directory.

```
              DATA_SET_ROOT
                    |
       +----+---+-------+---. . .
       |    |           |
    DATA
       |
    EDITED
       |
     YYYY
     |  |
    MM  MM
     |  |
    DD  DD
```
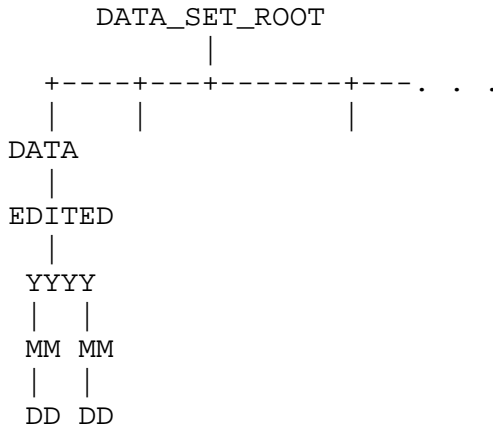
4.2   Data Sets, Definition and Content

IES data is archived in PDS table objects. Each line represents a set of electron or ion counts for the azimuth bin groups at a given time, energy, and elevation. The following columns will be first in each archive file:

Spacecraft Event Time (UTC)	UTC time at the beginning of sample integration. UTC time is converted from the spacecraft clock time using the SPICE toolkit.
Mode	Instrument mode, which defines the structure of the energy-elevation-azimuth collapse for the counts.
Energy Start Step	Each electron or ion count occurs within a specified energy range. This is the number of the step that defines the start of the range of energy values.
Energy Stop Step	Each electron or ion count occurs within a specified energy range. This is the number of the step that defines the end of the range of energy values.
Angle Start Step	Each electron or ion count occurs within a specified elevation angle range. This is the number of the step that defines the start of the range of angle values.
Angle Stop Step	Each electron or ion count occurs within a specified elevation angle range. This is the number of the step that defines the end of the range of angle values.

Following these columns is a series of azimuth columns. The value represents the number of electrons or ions observed in the azimuth bin (commonly referred to as "counts") at the given time, energy, and

elevation. These values are transmitted in groups of azimuth bins, which we expand by dividing the value by the number of azimuth bins in the group.

4.3 Data Product Design

4.3.1 Data Product Uncalibrated Design

Example of edited raw data detached label file (e.g. RPCIES050329T_ELC_V2.LBL):

```
PDS_VERSION_ID              = PDS3

DATA_SET_ID                 = "RO-E-RPCIES-2-EAR1-V2.0"

DATA_SET_NAME               = "
    ROSETTA-ORBITER EARTH RPCIES 2 EAR1 V2.0"

STANDARD_DATA_PRODUCT_ID    = "ELECTRON"

PRODUCT_ID                  = "RPCIES050329_ELC_V2"

PRODUCT_TYPE                = "EDR"

PROCESSING_LEVEL_ID         = "2"

PRODUCT_CREATION_TIME       = 2007-08-10T18:20:29.345

PRODUCT_VERSION_ID          = "2.0"

LABEL_REVISION_NOTE         = "RELEASE VERSION 2.0"


RECORD_TYPE                 = FIXED_LENGTH

RECORD_BYTES                = 388

FILE_RECORDS                = 22848

MD5_CHECKSUM                = "ae03492f5152586086e3e795483f268b"


START_TIME                  = 2005-03-29T09:54:42.000

STOP_TIME                   = 2005-03-29T14:06:26.000

SPACECRAFT_CLOCK_START_COUNT = "1/70710882"

SPACECRAFT_CLOCK_STOP_COUNT  = "1/70725986"


MISSION_NAME                = "INTERNATIONAL ROSETTA MISSION"

MISSION_ID                  = "ROSETTA"

MISSION_PHASE_NAME          = "EARTH SWING-BY 1"

TARGET_NAME                 = "EARTH"

TARGET_TYPE                 = "PLANET"
```

```
INSTRUMENT_HOST_NAME        = "ROSETTA-ORBITER"

INSTRUMENT_HOST_ID          = "RO"

INSTRUMENT_ID               = "RPCIES"

INSTRUMENT_NAME             = "
    ROSETTA PLASMA CONSORTIUM - ION AND ELECTRON SENSOR"

INSTRUMENT_TYPE             = "PLASMA INSTRUMENT"


COORDINATE_SYSTEM_ID        = "N/A"

COORDINATE_SYSTEM_NAME      = "N/A"


PRODUCER_ID                 = "RPC_IES_TEAM"

PRODUCER_FULL_NAME          = "BRAD TRANTHAM"

PRODUCER_INSTITUTION_NAME    = "SOUTHWEST  RESEARCH  INSTITUTE,  SAN
ANTONIO"

DATA_QUALITY_ID             = "N/A"

DATA_QUALITY_DESC           = "This archive contains raw uncalibrated
data"


SC_SUN_POSITION_VECTOR      = "
    (1.0074628317975645, 0.1795336471864208, 0.09048890386861619)"

NOTE                        = "Unit for SC_SUN_POSITION_VECTOR is AU"

SC_TARGET_POSITION_VECTOR   = "
    (0.020545226762147286, 0.04041582957112126, 0.030181810865584725)"

NOTE                        = "Unit for SC_TARGET_POSITION_VECTOR is
AU"

SC_TARGET_VELOCITY_VECTOR   = "
    (0.020545226762147286, 0.04041582957112126, 0.030181810865584725)"

NOTE                        = "Unit for SC_TARGET_VELOCITY_VECTOR is
km/s^2"

SPACECRAFT_ALTITUDE         = 8140864.60363458

NOTE                        = "Unit for SPACECRAFT_ALTITUDE is km"

SUB_SPACECRAFT_LATITUDE     = -33.48785968370159

SUB_SPACECRAFT_LONGITUDE    = -92.46586575835545
```

```
DESCRIPTION                = "

    This file contains IES raw electron sensor counts acquired during

    the Earth Swing-by 1 between 2005-03-29T09:54:42.000 and

    2005-03-29T14:06:26.000."


^HEADER                    = ("RPCIES050329_ELC_V2.TAB", 1)
^TABLE                     = ("RPCIES050329_ELC_V2.TAB", 2)
OBJECT                     = HEADER
  HEADER_TYPE              = "SPREADSHEET"
  INTERCHANGE_FORMAT       = ASCII
  BYTES                    = 388
  DESCRIPTION               = "Row of comma delimited, quoted column
names"
END_OBJECT                 = HEADER


OBJECT                     = TABLE
  INTERCHANGE_FORMAT       = ASCII
  ROWS                     = 22848
  COLUMNS                  = 23
  ROW_BYTES                = 388


  OBJECT                   = COLUMN
    NAME                   = "SPACECRAFT EVENT TIME (UTC)"
    COLUMN_NUMBER          = 1
    DATA_TYPE              = TIME
    START_BYTE             = 1
    BYTES                  = 23
    DESCRIPTION            = "

    This  field  contains  the  UTC  time  at  the  spacecraft  at  the
beginning

    of the sample integration. This field has been generated from
```

```
    the  spacecraft  clock  counter  using  the  SPICE  toolkit  and
appropriate

    leap seconds and spacecraft clock kernels. Time is provided in
the

    standard PDS month/day format (i.e. 2005-03-05T00:00:00.215).

    All  records  from  a  single  integration  are  assigned  the  same
time.

    A complete integration requires the instrument to sweep through
16

    azimuth  directions  for  each  of  the  128  energy  steps.  Each
azimuth

    step takes 1/16th of a second to complete, therefore a complete

    energy  step  requires  1.0  second  and  a  complete  integration
requires

    128.0 seconds."
  END_OBJECT                    = COLUMN


  OBJECT                        = COLUMN
    NAME                        = "MODE"
    COLUMN_NUMBER               = 2
    START_BYTE                  = 25
    BYTES                       = 11
    DATA_TYPE                   = CHARACTER
    DESCRIPTION                 = "

    Instrument mode, which determines the values used for the energy

    and elevation steps."
  END_OBJECT                    = COLUMN


  OBJECT                        = COLUMN
    NAME                        = "ENERGY_START_STEP"
    COLUMN_NUMBER               = 3
    START_BYTE                  = 37
    BYTES                       = 16
    DATA_TYPE                   = ASCII_INTEGER
```

```
      FORMAT                 = "I3"

      DESCRIPTION            = "
        The number of the energy step that starts this range"
    END_OBJECT               = COLUMN


    OBJECT                   = COLUMN

      NAME                   = "ENERGY_STOP_STEP"

      COLUMN_NUMBER          = 4

      START_BYTE             = 54

      BYTES                  = 16

      DATA_TYPE              = ASCII_INTEGER

      FORMAT                 = "I3"

      DESCRIPTION            = "
        The number of the energy step that ends this range"
    END_OBJECT               = COLUMN


    OBJECT                   = COLUMN

      NAME                   = "ANGLE_START_STEP"

      COLUMN_NUMBER          = 5

      START_BYTE             = 71

      BYTES                  = 16

      DATA_TYPE              = ASCII_INTEGER

      FORMAT                 = "I4"

      DESCRIPTION            = "
        The number of the elevation step that starts this range"
    END_OBJECT               = COLUMN


    OBJECT                   = COLUMN

      NAME                   = "ANGLE_STOP_STEP"

      COLUMN_NUMBER          = 6

      START_BYTE             = 88

      BYTES                  = 16
```

```
    DATA_TYPE                = ASCII_INTEGER

    FORMAT                   = "I4"

    DESCRIPTION              = "

      The number of the elevation step that ends this range"
  END_OBJECT                 = COLUMN


  OBJECT                     = COLUMN

    NAME                     = "AZIMUTH 0 COUNTS"

    COLUMN_NUMBER            = 7

    START_BYTE               = 105

    BYTES                    = 16

    DATA_TYPE                = ASCII_REAL

    FORMAT                   = "F9.4"

    DESCRIPTION              = "

      This field contains electron counts observed in

      azimuth bin 0 divided by the size of the azimuth

      bin grouping. A fill value of -1 is used when data is

      not available for this bin."
  END_OBJECT                 = COLUMN
  OBJECT                     = COLUMN

    NAME                     = "AZIMUTH 1 COUNTS"

    COLUMN_NUMBER            = 8

    START_BYTE               = 122

    BYTES                    = 16

    DATA_TYPE                = ASCII_REAL

    FORMAT                   = "F9.4"

    DESCRIPTION              = "

      This field contains electron counts observed in

      azimuth bin 1 divided by the size of the azimuth

      bin grouping. A fill value of -1 is used when data is

      not available for this bin."
  END_OBJECT                 = COLUMN
```

```
    OBJECT                      = COLUMN

      NAME                      = "AZIMUTH 2 COUNTS"

      COLUMN_NUMBER             = 9

      START_BYTE                = 139

      BYTES                     = 16

      DATA_TYPE                 = ASCII_REAL

      FORMAT                    = "F9.4"

      DESCRIPTION               = "

        This field contains electron counts observed in

        azimuth bin 2 divided by the size of the azimuth

        bin grouping. A fill value of -1 is used when data is

        not available for this bin."

    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN

      NAME                      = "AZIMUTH 3 COUNTS"

      COLUMN_NUMBER             = 10

      START_BYTE                = 156

      BYTES                     = 16

      DATA_TYPE                 = ASCII_REAL

      FORMAT                    = "F9.4"

      DESCRIPTION               = "

        This field contains electron counts observed in

        azimuth bin 3 divided by the size of the azimuth

        bin grouping. A fill value of -1 is used when data is

        not available for this bin."

    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN

      NAME                      = "AZIMUTH 4 COUNTS"

      COLUMN_NUMBER             = 11

      START_BYTE                = 173

      BYTES                     = 16

      DATA_TYPE                 = ASCII_REAL
```

```
          FORMAT                  = "F9.4"

          DESCRIPTION             = "

            This field contains electron counts observed in

            azimuth bin 4 divided by the size of the azimuth

            bin grouping. A fill value of -1 is used when data is

            not available for this bin."

      END_OBJECT                  = COLUMN

      OBJECT                      = COLUMN

          NAME                    = "AZIMUTH 5 COUNTS"

          COLUMN_NUMBER           = 12

          START_BYTE              = 190

          BYTES                   = 16

          DATA_TYPE               = ASCII_REAL

          FORMAT                  = "F9.4"

          DESCRIPTION             = "

            This field contains electron counts observed in

            azimuth bin 5 divided by the size of the azimuth

            bin grouping. A fill value of -1 is used when data is

            not available for this bin."

      END_OBJECT                  = COLUMN

      OBJECT                      = COLUMN

          NAME                    = "AZIMUTH 6 COUNTS"

          COLUMN_NUMBER           = 13

          START_BYTE              = 207

          BYTES                   = 16

          DATA_TYPE               = ASCII_REAL

          FORMAT                  = "F9.4"

          DESCRIPTION             = "

            This field contains electron counts observed in

            azimuth bin 6 divided by the size of the azimuth

            bin grouping. A fill value of -1 is used when data is

            not available for this bin."
```

```
END_OBJECT                 = COLUMN
OBJECT                     = COLUMN
  NAME                     = "AZIMUTH 7 COUNTS"
  COLUMN_NUMBER            = 14
  START_BYTE              = 224
  BYTES                    = 16
  DATA_TYPE                = ASCII_REAL
  FORMAT                   = "F9.4"
  DESCRIPTION              = "
    This field contains electron counts observed in
    azimuth bin 7 divided by the size of the azimuth
    bin grouping. A fill value of -1 is used when data is
    not available for this bin."
END_OBJECT                 = COLUMN
OBJECT                     = COLUMN
  NAME                     = "AZIMUTH 8 COUNTS"
  COLUMN_NUMBER            = 15
  START_BYTE              = 241
  BYTES                    = 16
  DATA_TYPE                = ASCII_REAL
  FORMAT                   = "F9.4"
  DESCRIPTION              = "
    This field contains electron counts observed in
    azimuth bin 8 divided by the size of the azimuth
    bin grouping. A fill value of -1 is used when data is
    not available for this bin."
END_OBJECT                 = COLUMN
OBJECT                     = COLUMN
  NAME                     = "AZIMUTH 9 COUNTS"
  COLUMN_NUMBER            = 16
  START_BYTE              = 258
  BYTES                    = 16
```

```
   DATA_TYPE                 = ASCII_REAL

   FORMAT                    = "F9.4"

   DESCRIPTION               = "

     This field contains electron counts observed in

     azimuth bin 9 divided by the size of the azimuth

     bin grouping. A fill value of -1 is used when data is

     not available for this bin."

 END_OBJECT                  = COLUMN

 OBJECT                      = COLUMN

   NAME                      = "AZIMUTH 10 COUNTS"

   COLUMN_NUMBER             = 17

   START_BYTE                = 275

   BYTES                     = 16

   DATA_TYPE                 = ASCII_REAL

   FORMAT                    = "F9.4"

   DESCRIPTION               = "

     This field contains electron counts observed in

     azimuth bin 10 divided by the size of the azimuth

     bin grouping. A fill value of -1 is used when data is

     not available for this bin."

 END_OBJECT                  = COLUMN

 OBJECT                      = COLUMN

   NAME                      = "AZIMUTH 11 COUNTS"

   COLUMN_NUMBER             = 18

   START_BYTE                = 292

   BYTES                     = 16

   DATA_TYPE                 = ASCII_REAL

   FORMAT                    = "F9.4"

   DESCRIPTION               = "

     This field contains electron counts observed in

     azimuth bin 11 divided by the size of the azimuth

     bin grouping. A fill value of -1 is used when data is
```

```
          not available for this bin."
  END_OBJECT              = COLUMN
  OBJECT                  = COLUMN
    NAME                  = "AZIMUTH 12 COUNTS"
    COLUMN_NUMBER         = 19
    START_BYTE            = 309
    BYTES                 = 16
    DATA_TYPE             = ASCII_REAL
    FORMAT                = "F9.4"
    DESCRIPTION           = "
      This field contains electron counts observed in
      azimuth bin 12 divided by the size of the azimuth
      bin grouping. A fill value of -1 is used when data is
      not available for this bin."
  END_OBJECT              = COLUMN
  OBJECT                  = COLUMN
    NAME                  = "AZIMUTH 13 COUNTS"
    COLUMN_NUMBER         = 20
    START_BYTE            = 326
    BYTES                 = 16
    DATA_TYPE             = ASCII_REAL
    FORMAT                = "F9.4"
    DESCRIPTION           = "
      This field contains electron counts observed in
      azimuth bin 13 divided by the size of the azimuth
      bin grouping. A fill value of -1 is used when data is
      not available for this bin."
  END_OBJECT              = COLUMN
  OBJECT                  = COLUMN
    NAME                  = "AZIMUTH 14 COUNTS"
    COLUMN_NUMBER         = 21
    START_BYTE            = 343
```

```
    BYTES                     = 16

    DATA_TYPE                 = ASCII_REAL

    FORMAT                    = "F9.4"

    DESCRIPTION               = "

      This field contains electron counts observed in

      azimuth bin 14 divided by the size of the azimuth

      bin grouping. A fill value of -1 is used when data is

      not available for this bin."

  END_OBJECT                  = COLUMN

  OBJECT                      = COLUMN

    NAME                      = "AZIMUTH 15 COUNTS"

    COLUMN_NUMBER             = 22

    START_BYTE                = 360

    BYTES                     = 16

    DATA_TYPE                 = ASCII_REAL

    FORMAT                    = "F9.4"

    DESCRIPTION               = "

      This field contains electron counts observed in

      azimuth bin 15 divided by the size of the azimuth

      bin grouping. A fill value of -1 is used when data is

      not available for this bin."

  END_OBJECT                  = COLUMN

  OBJECT                      = COLUMN

    NAME                      = "QUALITY FLAGS"

    COLUMN_NUMBER             = 23

    START_BYTE                = 377

    DATA_TYPE                 = CHARACTER

    BYTES                     = 9

    DESCRIPTION               = "

     These flags describe the quality of the data.

     The quality is coded in a 8 byte string. Each character can have

     the following values:
```

```
    VALUE:      MEANING:

    x          property described by flag is still unknown

    0          no disturbance, good quality

    1..9       specific disturbance/problems, see below


    Description of the specific flags:


    FLAG-STRING FLAG DESCRIPTION

    87654321

    ::::::::------ 1 OVERALL QUALITY:

    :::::::            x = overall quality not assessed

    :::::::            0 = quality good without any processing

    :::::::            1 = quality good after data processing

    :::::::             2 = quality improved by data processing, still
not good

    :::::::            3 = data disturbed by unknown source

    :::::::            4 = TBD

    :::::::            5 = TBD

    :::::::            6 = TBD

    :::::::            7 = TBD

    :::::::            8 = TBD

    :::::::            9 = quality bad

    :::::::

    :::::::------- 2 HIGH BACKGROUND PRESSURE

    ::::::            x = impact not assessed

    ::::::            0 = no disturbance

    ::::::            1 = disturbance eliminated during data analysis

    ::::::            2 = data disturbed

    ::::::

    ::::::-------- 3 HIGH DUST FLUX

    :::::             x = disturbance not assessed

    :::::             0 = no disturbance
```

```
:::::                     1 = disturbance eliminated during data analysis

:::::                     2 = data disturbed

:::::

:::::--------- 4 TBD

::::                      x = no assessment

::::

::::--------- 5 TBD

:::                       x = no assessement

:::

:::---------- 6 TBD

::                        x = no assessment

::

::----------- 7 TBD

:                         x = no assessment

:

:------------ 8 TBD

                          x = no assessment"
    END_OBJECT                    = COLUMN
END_OBJECT                        = TABLE


END
```

APPENDIX A – IES ACQUISITION TABLES

This table defines the configurations of the acquisition tables used by IES.

Table Slot	Use	ID	Cycle Duration	Rate	Bins			#	Steps	eV	Collapse	Bins	Total Bins
6	Slow Photo-electrons	A21	**1024**	**Normal**	6144	ION	Energies	64	0 to 127	Full Range + FB	Adjacent 2	3072	6144
							Elevations	6	0 to 15		0-1,2-4,5-7,8-10,11-13,14-15		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	64	0-62, 123	4-811, highest	Full Res	3072	
							Elevations	8	0 to 15		Adjacent 2		

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Slot	Use	ID	Cycle Duration	Rate	Bins			#	Steps	eV	Collapse	Bins	Total Bins
							Azimuths	6	0 to 15*		0-1,2-4,5-7,8-10,12-13,14-15		
5	Solar Wind at the Comet	A22	**1024**	**Normal**	6144	ION	Energies	32	5 to 100	25 to 5400	Adjacent 3	4096	6144
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	16	0 to 15		Full res		
						ELC	Energies	32	0 to 63	4 to 811	Adjacent 2	2048	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		
8	High Res Angular	A31	**1024**	**Burst**	32256	ION	Energies	64	0 to 127	Full Range + FB	Adjacent 2	16384	31744
							Elevations	16	0 to 15		Full Res		
							Azimuths	16	0 to 15		Full Res		
						ELC	Energies	64	0 to 127	Full Range + FB	Adjacent 2	15360	
							Elevations	16	0 to 15		Full Res		
							Azimuths	15	0 to 15*		Full Res*		
9	High Res Energy	A32	**1024**	**Burst**	32256	ION	Energies	124	0 to 123	Full Range	Full Res	15872	32256
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	16	0 to 15		Full Res		
						ELC	Energies	128	0 to 127	Full Range + FB	Full Res	16384	
							Elevations	16	0 to 15		Full Res		
							Azimuths	8	0 to 15*		Adjacent 2*		

Table Slot	Use	ID	Cycle Duration	Rate	Bins			#	Steps	eV	Collapse	Bins	Total Bins
3	Solar Wind at the Comet	921	**512**	**Normal**	3072	ION	Energies	24	5 to 100	25 to 5400	Adjacent 4	1536	3072
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	24	0 to 71	4 to 1225	Adjacent 3	1536	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		
4	Pickup, High Res	931	**512**	**Burst**	16128	ION	Energies	32	0 to 127	Full Range + FB	Adjacent 4	8192	16112

Table Slot	Use	ID	Cycle Duration	Rate	Bins			#	Steps	eV	Collapse	Bins	Total Bins
	Angular						Elevations	16	0 to 15		Full Res		
							Azimuths	16	0 to 15		Full Res		
						ELC	Energies	33	0 to 95, 123	4 to 4202 + highest	Adjacent 3	7920	
							Elevations	16	0 to 15		Full Res		
							Azimuths	15	0 to 15*		Full Res*		
12	Full Coverage, Low Res	821	256	Normal	1536	ION	Energies	32	0 to 127	Full Range + FB	Adjacent 4	1024	1536
							Elevations	4	0 to 15		Adjacent 4		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	32	0 to 127	Full Range + FB	Adjacent 4	512	
							Elevations	4	0 to 15		Adjacent 4		
							Azimuths	4	0 to 15*		Adjacent 4*		
1	Slow Photo-electrons	831	256	Burst	8064	ION	Energies	63	0 to 125	Full Range	Adjacent 2	4032	8064
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	63	0 to 62	4 to 772	Full Res	4032	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		

Table Slot	Use	ID	Cycle Duration	Rate	Bins			#	Steps	eV	Collapse	Bins	Total Bins
0	Solar Wind at the Comet	832	256	Burst	8064	ION	Energies	33	0 to 98	4 to 4901	Adjacent 3	4224	8064
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	16	0 to 15		Full res		
						ELC	Energies	32	0 to 63	4 to 811	Adjacent 2	3840	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	15	0 to 15*		Full res*		
2	Pickup	833	256	Burst	8064	ION	Energies	63	0 to 125	Full Range	Adjacent 2	4032	8064
							Elevations	8	0 to 15		Adjacent 2		

#	Name			Mode		Species	Parameter	N	Range	Energy Range	Binning	Subtotal	Total
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	63	0 to 125	Full Range	Adjacent 2	4032	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		
10	Solar Wind at the Comet	721	**128**	**Normal**	768	ION	Energies	16	36 to 99	202 to 5156	Adjacent 4	384	768
							Elevations	3	0 to 15		0-4, 5-10, 11-15		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	16	0 to 63	4 to 811	Adjacent 4	384	
							Elevations	3	0 to 15		0-4, 5-10, 11-15		
							Azimuths	8	0 to 15*		Adjacent 2*		
11	Full Range, Low Res	731	**128**	**Burst**	4032	ION	Energies	32	0 to 127	Full Range + FB	Adjacent 4	2048	4032
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15		0,1,2,3-11,12,13,14,15		
						ELC	Energies	31	0 to 123	Full Range	Adjacent 4	1984	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		
7	Solar Wind at the Comet	732	**128**	**Burst**	4032	ION	Energies	16	36 to 99	202 to 5156	Adjacent 4	2048	4032
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	16	0 to 15		Full Res		
						ELC	Energies	31	0 to 92	4 to 3603	Adjacent 3	1984	
							Elevations	8	0 to 15		Adjacent 2		
							Azimuths	8	0 to 15*		Adjacent 2*		