ROSETTA-RPC-IES
PLANETARY SCIENCE ARCHIVE
INTERFACE CONTROL DOCUMENT

APRIL 2013

SwRI® Project 14568

Document No. 10991-IES-EAICD-01

JPL Contract 1345493

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Prepared by: Brad Trantham 10 April 2013
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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 on Steins review feedback. April 2011

Revision 4: Updated on Lutetia review feedback, April 2013

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

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.
    - search queries that allow searches across instruments, missions and scientific disciplines
    - 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, Issue 2.12, September 7, 2007, 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

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

2.1 Instrument Design

The Rosetta Ion and Electron Sensor (RPC-IES) instrument is comprised of a double toroidal top-hat electrostatic analyzer (ESA), one analyzer for electrons, the other for ions, arranged back-to-back. The common entrance aperture has a 360° field of view in the symmetry (denoted here by azimuth) plane. Electrostatic angular deflection optics give a scanned field of view of +/- 45° normal to the azimuth plane (denoted here by the elevation angle).

The instrument objective is to obtain ion and electron distribution functions over the energy range from 4.32 eV/e to 17.67 keV/e, with a basic time resolution of 128 s. This geometry allows IES to analyze both electrons and positive ions with a single entrance aperture simultaneously. 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. The IES field of view (FOV) thus encompasses a total solid angle of 2.8 Pi steradians. Ions and electrons approaching the IES first encounter a toroidal-shaped grounded grid encircling the instrument. Once inside the grid the electric field produced by bipolar electrodes deflects ions and electrons with a range of energies and incident directions into a field-free entrance aperture containing serrated walls to minimize scattering of ultraviolet light and stray charged particles into the instrument. The particles then enter the top hat region and the electric field produced by the flat electrostatic analyzer segments of the ion and electron analyzers. Particles with an energy accepted by the ESA and within a narrow 4% energy pass band will pass through the analyzers and be focused onto either the electron or ion microchannel plates (MCPs), which produce charge pulses on 16 discrete anodes for each, which define the azimuth acceptance angles. For electrons the anodes are of equal width so the azimuth resolution is 22.5°. A diagram showing the layout of the anode arrangement is shown in `DOCUMENT\ANODES\ANODES.PDF`. (It was discovered after launch that electron channel 11 was noisy so it was decided not to download the data from that channel. Hence only fill data appear for that channel.) For ions the 16 anodes are divided unequally in size, with 9 of them each 5° wide oriented in the instrument in a direction expected to view the solar wind most of the time (anodes 3 to 11). The remaining 7 anodes are each 45° wide. For both electrons and ions nominal resolution in the elevation direction is 5°. This resolution would provide 18 measurement bins over the 90° full elevation FOV. However, in order to simplify the instrument electronics, the FOV has been divided into 16 (=2^4) bins. This results in a small gap in coverage between bins.

The selected energy will correspond to a particular 5 degree elevation entrance angle, depending on the ratio of voltages on the angle deflectors and the ESAs. Note that the use of the terms "azimuth" and "elevation" angle for IES differs from the conventional terminology of "polar" and "azimuth" and is essentially the reverse useage. This arises from the location and attitude of the FOV relative to the Rosetta spacecraft.

Operation of IES is controlled by its on-board software in conjunction with sets of look up tables (LUTs). One table determines the sequence of voltages applied to the electrostatic analyzer, thereby selecting the energy/charge of electrons and ions entering the sensor. Likewise, another table 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 ESA voltage the deflector voltage is stepped over its range, the ESA voltage is stepped to its next value, and so on. A complete 2-voltage sequence thus determines a basic measurement cycle of 128 s. Other selectable tables stored in IES determine how the collected data are combined in order to fit into the available telemetry rate. These tables determine the science mode.

Each IES Standard Mode commanded from the ground is indicated by a Mode ID with three significant characters (examples – 731, A22) and determines the duration of each cycle, overall data rate, and azimuth and elevation collapsing.

During IES operation, data are collected and accumulated during a cycle, then compressed and telemetered over an amount of time that is equal to the cycle duration after completion of the cycle, i.e. in the next cycle. This works seamlessly during periods when the mode remains unchanged, transitions between modes with identical cycle durations, and transitions from a mode with a shorter cycle to a mode with a longer cycle as shown in the figures below.

Mode Command	832	832	821	821	821	
Acquire Cycle#	1	2	3	4	5	
Telemeter Cycle#		1	2	3	4	5
Resulting Mode	832	832	821	821	821	

0 128 256 384 512 640 768 896 1024 1152 1280 1408 1536

0	128	256	384	512	640	768	896	1024	1152	1280	1408	1536
Mode Command	722	722	722	722	821		821		821			
Acquire Cycle#	1	2	3	4	5		6		7			
Telemeter Cycle#		1	2	3	4	-	5		6		7	
Resulting Mode	722	722	722	722	821		821		821			

However this method presents a problem when the transition is from a mode with a longer cycle to mode with a shorter cycle as the first cycle of the new mode completes before the telemetering of the last cycle of the prior mode. To avoid discarding data and a corresponding data gap, the shorter cycle of the new mode is acquired and repeatedly summed until the telemetering of the longer cycle is complete.
This arrangement allows for return of continuous data without any gaps by in-flight creation of a virtual transition mode with a resulting cycle that has the duration of the prior mode and collapse configuration of the new mode. That Virtual Mode is represented by an ID with four significant characters. The most significant character corresponds to the number of cycles summed together (starting from zero) and the 3 least significant characters represent the new commanded Standard Mode. Following this single cycle with the Virtual Mode, the standard processing of cycles continues with the new mode.

0	128	256	384	512	640	768	896	1024	1152	1280	1408	1536	1664
Mode Command	921				731	731	731	731	731	731	731	731	
Acquire Cycle#	1				2	3	4	5	6	7	8	9	
Telemeter Cycle#					1				2-5	6	7	8	9
Resulting Mode	921				3731				731	731	731	731	

In the example shown above for a transition between a 512s cycle mode (921) to a 128s cycle mode (731), the virtual transition cycle has the duration of the 921 mode (512s) i.e. includes 4 cycles and the collapse configuration of the 731 mode. This is represented by a Virtual Mode ID of 3731. Following the completion of this cycle, the standard processing sequence continues for the Standard Mode, 731.

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. A document describing the calibration procedure can be found at `DOCUMENT\GROUND_CALIB\8182-CALPFM-01_R0.PDF`.

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.

2.4.6 Calibration Software

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

2.4.7 Scientific Analysis Software

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.

2.4.8 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.

2.4.9 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.

2.4.10 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.)

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 with 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
CALIB/	Calibration directory
CATALOG/	Catalog directory
DATA/	Data directory
DOCUMENT/	Document directory
INDEX/	Index 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
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 Document Directory

Table 3: Document Directory Contents

File Name	File Contents
DOCINFO.TXT	A description of the contents of this directory and all subdirectories.
ANODES/	Directory containing the IES anode diagram
ANODES.PDF	IES anode diagram
ANODES.LBL	A PDS detached label that describes ANODES.PDF
GROUND_CALIB/	Directory containing the IES ground calibration procedure
8182-CALPFM-01_R0.PDF	IES ground calibration procedure
8182-CALPFM-01_R0.LBL	A PDS detached label that describes 8182-CALPFM-01_R0.PDF
IES_EAICD/	Directory containing the IES EAICD document
IES_EAICD/IES_EAICD-01.PDF	The IES Experiment-Archive Interface Control Document as a PDF document
IES_EAICD/IES_EAICD-01.TXT	The IES Experiment-Archive Interface Control Document in plain text
IES_EAICD/IES_EAICD-01.LBL	A PDS detached label that describes IES_EAICD.TXT and IES_EAICD.PDF
IES_MODES/	Directory containing IES mode definitions
IES_MODES/IES_MODES.PDF	IES mode definitions
IES_MODES/IES_MODES.LBL	A PDS detached label that describes IES_MODES.PDF

3.4.3.5 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.

3.4.3.6 Calib Directory

Table 4: Calib Directory Contents

File Name	File Contents
CALINFO.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

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"
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 elevation
      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 an 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
```