European Space Agency
Research and Science Support Department
Planetary Missions Division

SMART1-SPEDE

To Planetary Science Archive Interface Control Document

S1-SPE-ICD-3005

Version 2.4

5 June 2006

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Distribution List

Recipient	Organisation	Recipient

Change Log

Date	Sections Changed	Reasons for Change
8.4.2004 / v.1.1	All	
22.4.2004 / v.1.2	All	Moved to PSA EAICD template
17.6.2004 / v2.0	All	Added level 2 data descriptions Some changes in level 1 descriptions
18.5.2005 / v2.1	All	Wave measurement descriptions added. Some editorial changes.
26.9.2005 / v2.2	Chapters 2.4.9, 3.2.2, 4.n.n	S/C position and attitude information added to Level 2 datasets. S/C clock format changed.
26.1.2006 / v2.3	Chapters 4.n.n	More attitude information in Level 2 data products. More keywords in all data product labels.
5.6.2006 / v2.4	Chapters 3.1.1, 3.3, 3.4.4.9,4.2	Added dataset and release information, pvv version, typo correction, new dataset naming

TBD ITEMS

Section	Description

Section	Description

Table Of Contents

1 Introduction

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two fold. First it provides users of the SPEDE instrument with a detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between the SPEDE instrument team and SMART-1 archiving authority.

1.2 Archiving Authorities

ESA's Planetary Science Archive (PSA).

1.3 Contents

This document describes the data flow of the SPEDE instrument on SMART-1 from the s/c 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. Software that may be used to access the product is explained further on.

The design of the data set structure and the data product is given. Examples of these are given in the appendix.

1.4 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the SPEDE data.

1.5 Applicable and Reference Documents

[AD-01] Planetary Data System Data Preparation Workbook, February 17, 1995, Version 3.1, JPL, D-7669, Part 1

[AD-02] Planetary Data System Standards Reference, August 1, 2003, Version 3.6, JPL, D-7669, Part 2

[AD-03] SMART-1 Data Processing and Archive Plan, July 7, 2003, Issue 1, Rev. 5

[AD-04] Planetary Science Archieve Experiment Data Release Concept Technical Proposal, SOP-RSSD-TN-015

[RD-01] SPEDE User Manual, S1-SPE-MA-3001

1.6 Relationships to Other Interfaces

TBD

1.7 Acronyms and Abbreviations

APID	Application Identification
DDS	Data Distribution System
EP	Electric Propulsion
GSE	Ground Support Equipment
MJD2000	Modified Julian Date 2000
LEOP	Low Earth Orbit Period
PDS	Planetary Data System
PSA	Planetary Science Data Archive
SIS	Software Interface Specification
TBC	To Be Confirmed
TBD	To Be Defined
UTC	Coordinated Universal Time

1.8 Contact Names and Addresses

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2 Overview of Instrument Design, Data Handling Process and Product Generation

2.1 Science and Technology Objectives

The SPEDE (Spacecraft Potential, Electron and Dust Experiment) experiment, consisting of two electric sensors and an electronics unit, will measure the electron flux and wave electric fields. The cylindrical sensors are mounted on the tips of two 60-cm booms, located at the +X and -X faces of the spacecraft (see Figure 1.). The sensors are connected to the electronics unit via a single triaxial cable each without any active electronics outside the board; the SPEDE electronics is housed on two electronics boards, located in a box inside the spacecraft body.

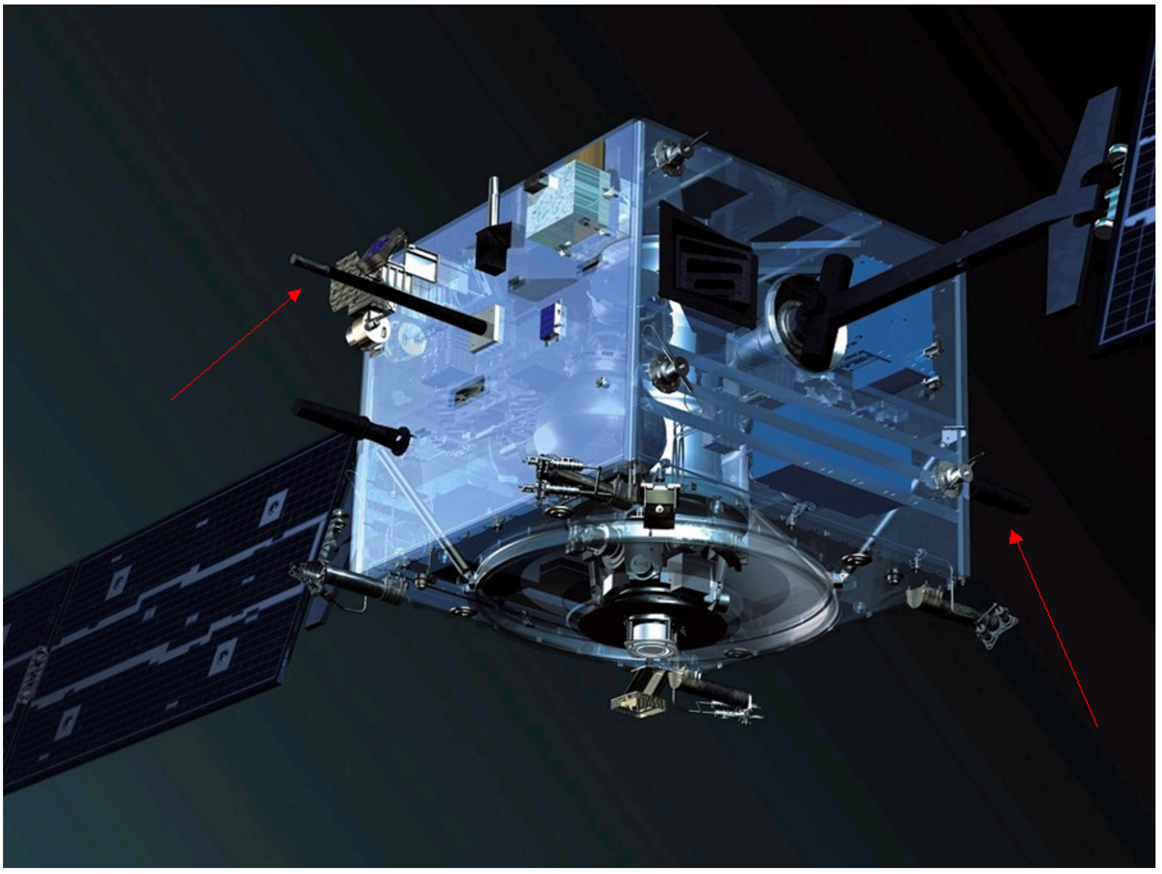

Figure 1. Smart-1 and SPEDE booms.

The mission of the SPEDE experiment is two-fold: it will monitor

- The disturbances (electron flux, wave electric fields, and spacecraft potential variations) induced by the propulsion system, and
- The variability of the electron density and wave electric fields during the Earth spiraling and cruise phases and during the Moon phase

1. Monitoring of disturbances produced by the SMART-1 propulsion system

Gas releases, most commonly from thrusters used to control the spacecraft velocity and attitude, can disturb observations of some instruments as well as contaminate the spacecraft structure. Because of possible interference effects and spacecraft contamination can be detrimental to sensitive instruments, it is important that the disturbances produced by the thruster operations in the spacecraft environment are monitored. This is especially important for the SMART-1 mission, for the first time using electrical propulsion on an ESA mission. Charged clouds expanding from the propulsion system may introduce a variety of phenomena when interacting with the ambient plasma and the spacecraft surface. These include

- variations in the spacecraft potential and electron flux,
- contamination of the spacecraft surfaces for an extended period of time, and
- generation of wave electric fields.

Especially, large effects in the spacecraft potential can be immediately observed if, for some reason, the exhaust ions are not properly neutralized by the cathode electron emitter. It is also important to gain knowledge of the reactions of the plasma environment to changes in EP engine parameters of operation.

2. Monitoring of electron density in the inner magnetosphere

In the first part of the SMART-1 mission, the Earth spiralling phase, the spacecraft will be accelerated by the ion propulsion engine and remain in the inner magnetosphere. In addition to monitoring the effects of the propulsion as described above, the SPEDE observations are used for measuring the distribution of thermal plasma of the plasmasphere whenever the EP is not operating. Particularly the measurements aim at detecting the position of its outer boundary, the plasmapause, usually located at a distance of 3-7 Earth's radii at the equator. As long as the perigee of the orbit is less than 3-4 Re (20 000 km), the plasmapause is crossed twice per orbit. When the perigee is between 20 000 and 40 000 km, the plasmapause is not always encountered, particularly so during magnetic storms, when the plasmasphere becomes smaller in size.

3. Monitoring of plasma density and waves in the Earth's magnetosphere and in the Solar Wind

After the perigee of the orbit is raised outside of the plasmasphere boundary (see above), SPEDE observations will concentrate on low-rate monitoring of the magnetospheric and solar wind plasma. These regions have been extensively investigated on earlier missions with plasma instrumentation optimised for tenuous plasmas, and no scientific break-throughs are expected. The measurements will consist of monitoring variations of plasma density by operating the instrument in a constant-bias low-sampling mode.

4. Monitoring of space weathering of the Moon

The target of the SMART-1 mission is the Moon, which has no magnetic field and atmosphere. Therefore, it is continuously exposed to the interplanetary space environment. The fast solar wind stream hits the dayside lunar surface and is possibly capable of lifting up small dust grains from the surface. Behind the moon, the solar wind produces a wake that is more tenuous than the solar wind.

On lunar orbit, SPEDE observations are used for studying solar wind - moon interaction processes. The uplifted dust particles can be detected as variations in the spacecraft potential, as the particles are ionised when hitting the spacecraft surface. A high sampling rate will be used at the region of the predicted wake boundary, to obtain the best data both for dust impact detection and studies of the plasma density and turbulence at the wake. Optimised modes initiated by time-tagged commands will be used.

2.2 Instrument description

SPEDE is a double-probe plasma instrument, measuring plasma parameters with two cylindrical Langmuir probes. The objectives of SPEDE are to measure 1) variations in the spacecraft potential and electron flux, caused by the electric propulsion, and 2) the variability of the electron density and wave electric fields of the natural plasma during Earth spiraling, cruise, and Moon phases. In addition, SPEDE will provide dust impact detection based on ionisation effects on the spacecraft surface.

SPEDE consists of two separate conical metallic sensor areas mounted each at the tip of a 60cm long carbon fiber sensor boom, and an electronics box on the inside of the -X face of the spacecraft. The booms are attached to the centers of the spacecraft's -X and +X face, respectively. Each is a 100 mm long metallic TiN foil glued around another slightly protruding150 mm long TiN foil, which is attached to the boom structure. The outer foil is the sensor area. The inner foil extends 25 mm outside of the probe area at both ends. The potential of the inner foil is kept actively at the sensor area's potential to compensate for capacitive coupling losses (guard). The booms are slightly conical, but the conical shape can be neglected in analysis, and the sensors can be considered cylindrical, with a radius of 12 mm and a length of 100 mm.

Due to the short boom length, measurements are strongly affected by photoelectrons from the spacecraft body, which need to be taken account when interpreting the measurements, especially in the electric field (voltage measurement) mode. During thruster operations, it is assumed that the plasma is dominated by charge-exchange ions from thruster outflow, and electrons from the neutralizing cathode, and photoelectron contribution is negligible.

SPEDE can operate in two different configurations: In Langmuir Probe (or Probe Current, PC) mode, a relay connects the output of a bias voltage generator via a small series resistor to the sensor. The probe current is measured as voltage drop across the resistor. The range of currents that can be measured is -470 microA to 240 microA with 5 nanoA resolution, positive sign corresponding to current from the probe (electron current with positive bias). Each sensor has its dedicated source for bias voltage, which can be controlled independently. Stabilized reference voltages and buffering amplifiers provide adjustable bias voltages between -13V and +13V with fine-tuning possibilities close to 0V. In Spacecraft Potential (or Probe Voltage, PV) mode the relays connect the sensors via 6MOhm resistors to ground. Voltage variations w.r.t. ground are measured directly before the series resistor. The range of voltages (probe to spacecraft ground) is +/- 3 volts, with 0.2 mV resolution.

The wave measurement, when activated, is performed at the end of a measurement sequence. The voltage difference between the two probes is sampled for one second at 10000 samples/s. The resulting data is analysed with on-board software Fast Wavelet Transform routine, with the number of logarithmically spaced frequency bins given in the command parameters.

The analog signals from the probes are translated into frequencies using a separate Voltage-to-Frequency-Converter (VFC) for each channel. The measurement frequencies in the range of 150Hz to 150kHz with about 50kHz for 0V (exact values for zero frequency at each bias code are given in the calibration data). Small values (low frequency) correspond to positive voltages and large values to negative voltages. The VFC readings are digitized by either defining a measurement time window inside which the frequency pulses are counted (frequency measurement), or by defining the number of frequency pulses whose total length is measured (pulse length measurement). The on-board 16-MHz clock is used as time reference. The probe data (frequencies) are saved as 20-bit data values in the telemetry.

The -X sensor chain includes additionally an 8-channel analog multiplexer, via which housekeeping parameters can be measured: -X and +X bias voltage, -X and +X reference voltage, ground reference, and temperature of electronics as measured inside the +X VFC chip.

The data processing part is based on a 16-bit RISC-processor, implemented directly in the same Field-Programmable-Gate-Array (FPGA) as the controller for the analog part. Several alternative software versions and operational configurations are stored in a 0.5MByte EEPROM, a 0.5MByte RAM is used as intermediate data storage.

Boot program, memory paging system, watchdog and real-time clock are also implemented inside the FPGA. An independent FPGA controls the low-level communications protocol with the spacecraft.

For each data acquisition and sensor the following parameters have to be defined: measurement type (Langmuir mode - current measurement/ Voltage measurement), bias voltage, digitalization principle (frequency / pulse length measurement) and duration of integration (long/short). When data acquisitions are completed for both probes, the software can retrieve the data. Data acquisitions can be defined either by the hardware access telecommand, returning directly a telemetry packet with the results, or under flight software control, where bias start and increment parameters and relative timing are defined in one of the 9 configuration tables. In each case the hardware configuration during each data acquisition is returned together with the measurement result inside the telemetry.

SPEDE has 10 operation modes:

- Stand-by (0) - Processor is in idle loop, interpreting telecommands, if any. No scientific measurements. This is the only mode where direct hardware control of the instrument is possible. Stand-by mode is entered on power low condition (spacecraft primary voltage < 45 V) or on telecommand.
- Housekeeping (1) - default mode. This mode is entered after reset, after automatic end of any other mode, or on telecommand. The housekeeping mode is controlled by configuration table 1. Default configuration is one Langmuir Probe (Probe Current) measurement with fixed bias voltage per minute, 30 measurements in one measurement vector.
- Science modes (2-9) - are controlled by related configuration tables 2-9. The instrument behavior depends on the table's contents. Science modes are entered on explicit telecommand. Each of the science modes 2-9 can be configured to run continuously until replaced by another mode, or to stop after a given number of telemetry blocks (measurement repetitions, 1-255), after which the instrument changes automatically to the housekeeping mode.

The parameters contained in mode configuration tables 1-9 are given in detail in chapter 4.3.3.

2.3 Data Handling Process

All PDS data products will be prepared at the Finnish Meteorological Institute (see chapter 1.8 for contact information). All data processing levels mentioned in this document are PSA-compliant, as defined in RO-EST-PL-5011.

Level 1a SPEDE data will be fetched from the SMART-1 Data Distribution System (DDS) by FMI, where it will be processed to Level 1b, and further to Level 2 products.

2.3.1 Level 1b products (raw data)

SPEDE science data is transmitted via ESOC ground stations and processed to level 1a by ESOC (processing levels are defined in [AD-01]). Level 1a data is made available to SPEDE team via FTP server (SMART-1 Data Distribution System (DDS)).

SPEDE team fetches level 1a data from the DDS. The telemetry packets are saved into FMI’s local database (still in DDS format).

Because SMART-1 payload telemetry packets do not have proper PUS headers, the supposed time of packet generation given by the DDS header is actually the time of packet reception on ground. The real time of packet generation is only saved as spacecraft clock value in the beginning of each SPEDE telemetry packet. When SPEDE telemetry packets are saved into local database, the packet generation times in DDS headers are fixed based on the spacecraft clock. Correlations between the spacecraft clock and UTC (the spacecraft clock was reset several times during the mission) are hardcoded into `epoch_data.conf` file, used by the database generation routine.

From the local database, SPEDE data can be retrieved by spacecraft orbit or date. Orbit division is made according to event files provided by ESOC.

The first step of SPEDE PDS product generation is to divide data by orbits (science data) or months (ancillary data). This is done automatically. A script fetches data from the local database and produces DDS-formatted files for each orbit (science data) or month (ancillary data).

DDS-formatted files are then processed by another script that produces 5 PDS-compliant level 1b data products:

- Raw probe current data – SPEDE-PC-RAW (science, Probe Current (Langmuir) mode)
- Raw probe voltage data – SPEDE-PV-RAW (science, Probe Voltage (E-field) mode)
- Raw wave electric field data – SPEDE-WEF-RAW (science, extracted from TM files also containing probe current or voltage data)
- Configuration table dumps (non-science, ancillary data)
- Software dumps of operation parameters (non-science, ancillary data)

Raw probe current data (Langmuir) and raw probe voltage data (E-field) are divided into product files according to combination of probe (-X = probe 1, +X = probe 2) and measurement vector length. Each combination is stored into its own file. Other products will also be gathered to their own files.

One science product file contains measurements from one spacecraft orbit. Configuration table dump and software dump files contain all dumps for one month.

Level 1b data are generally to be used only by SPEDE data producers. For other data users, Level 2 data will be provided.

2.3.2 Level 2 products (calibrated data)

Level 1b science data is further processed and calibrated using look-up tables. Also information about probe shadow status and S/C position is added. This results in 5 (TBC) PDS-compliant level 2 data products:

- Calibrated electron/ion flux data (SPEDE-EF-CAL) – originated from Langmuir probe data measured with constant voltage bias
- Calibrated plasma data (SPEDE-PD-CAL) – originated from Langmuir probe data measured with variable voltage bias (sweeps)
- Calibrated E-field data (SPEDE-EFF-CAL) – originated from Probe Voltage data. Details TBD.
- Calibrated wave electric field data (SPEDE-WEF-CAL) – originated from the wave measurements.
- Calibrated housekeeping values (ancillary data)

Calibrated data is divided into data files by products, probes (separate files for –X and +X), and spacecraft orbits.

2.4 Overview of Data Products

2.4.1 Pre-Flight Data Products

N/A

2.4.2 Sub-System Tests

N/A

2.4.3 Instrument Calibrations

Level 1b probe current (PC) data is calibrated to physical values using look-up tables, resulting in Level 2 data (EF and PD). The look-up tables contain for both probes (-X and +X):

- Physical values (Volts) corresponding to each raw bias control value
- Background values corresponding to each raw bias control value
- Calibration coefficients a_0, a_1, a_2, a_3, used in the polynomial that calculates currents (in Amperes) from frequencies (raw Langmuir measurements).
  The polynomial is: $I(V(b)) = a_3*f(b)^3 + a_2*f(b)^2 + a_1*f(b) + a_0$, where
  f(b) = Background(b) – Raw measurement(b), b = bias, f = frequency (Hz)

(Calibration of Probe voltage (S/C potential) measurements to physical values (Volts) TBD.)

There can exist several versions of the lookup tables. The versions used for a particular data product are given in its header as DATA_QUALITY_ID keyword.

Calibrated wave power data (WEF) is calculated from the raw wave data with the following formula:

$$P = w^2/(2*N^3),$$

where w = raw wave value, and $N = 2^{(10-n)}$, n = frequency bin number 0 … 9.

Before calibration to physical values, some of the measurement results obtained with pulse length measurement mode need to be corrected, because the pulse counter sometimes misses the last pulse of a measurement (resulting for example in 19 instead of 20 pulses in short pulse mode). Since the origin and result of this are known, this feature can be corrected during calibration to Level 2 data. If a pulse measurement result is corrected, this is indicated with a ‘P’ flag as described below.

Level 2 data contains status vectors associated with each measurement value. Their purpose is to give an overview of the measurement quality. A science data quality vector contains places for 16 flags. Currently 4 flags are used, the rest are placeholders marked with an underscore (_). Also flag downs are marked with an underscore.

The information currently given by a status vector is:

- 16th (LS) flag: 0 = the result is checked and found correct
  1 = the result is checked and possibly corrected, warnings concerning quality
  2 = the result is checked, and found unreliable (no corrections)
  9 = the result is unchecked
- 15th flag: F = frequency measurement, p = original pulse measurement, P = corrected pulse measurement, _ = not applicable (wave measurements)
- 14th flag: 1 = the first measurement in a measurement vector, _ = following measurements
- 13th flag: R = the reference voltage was fluctuating during this measurement, _ = the reference voltage was OK
  (the reference voltage value is obtained from ancillary housekeeping data;

fluctuation means that raw voltage value was outside nominal levels of 95-105)

A housekeeping data quality vector contains only two places: status check (as 16th flag above), and reference voltage fluctuation (as 13th flag above).

Calibration look-up tables and other information necessary for SPEDE raw data calibration are stored in /CALIB directory of the data archive. Bias and background look-up tables are given in file SPEDE_BIAS_CALIB.TAB, and polynomial coefficients in file SPEDE_CURRENT_CALIB.TAB.

Note! /CALIB directory is present only in the data archives containing Level 2 data.

2.4.4 Other Files written during Calibration

N/A

2.4.5 In-Flight Data Products

All archived SPEDE data products will be in-flight products of level 1b and 2. The products are described in chapter 2.3.

Level 1b products shall be used to produce level 2 products, by the FMI team only. **Level 2 calibrated data is intended for other users.**

See also chapter 2.4.9.2 for important information about SPEDE data interpretation!

2.4.6 Software

2.4.6.1 Data processing software

A local database for storing all DDS data. Data is added to the database by *generate_db* routine. This routine also removes any duplicate packets, and fixes telemetry packet generation times in DDS headers by calculating UTC times from spacecraft clock times.

Scripts to divide DDS data into files according to orbits or time slots (for science data), and months (for ancillary data): *get_orbit_dds, get_measurement* and *get_aux*.

Another script to generate PDS-compliant level 1b products from the DDS-formatted files already divided by orbit or month: *gen_tab.sh*.

A script to generate level 2 products from level 1b products: *pds2level2all.tcl*

Scripts to generate index files: *generate_index.sh* (level 1b) and *generate_2_index.sh* (level 2)

These scripts are used only by the data producers, and they are not included in PDS deliveries.

2.4.6.2 Scientific analysis software

No special software for scientific analysis is included. SPEDE data is in ASCII format and can be plotted for example with any spreadsheet software.

2.4.7 Documentation

The data archive contains the following documentation:

This EAICD

SPEDE paper describing the instrument

2.4.8 Derived and other Data Products

See chapter 2.3.2.

2.4.9 *Ancillary Data Usage*

2.4.9.1 SPEDE ancillary data

SPEDE measurements are controlled by configuration tables and operation parameters stored in the EEPROM. They can be changed by telecommands. The performance of SPEDE instrument depends on these settings.

Whenever a configuration table or an operation parameter is changed, its new value is returned in telemetry. These dumps are provided in Level 1b datasets as software dump and configuration table dump products. These non-science products are archived together with the science data.

In Level 2 datasets, calibrated housekeeping values (reference voltages and temperatures) are given as ancillary data records for reference purposes.

2.4.9.2 Spacecraft auxiliary data

SPEDE measurement results are affected by the status of the SMART-1 propulsion system (the Hall thruster), and the spacecraft's position and attitude. The results can only be interpreted if these are known. Level 2 data products contain Information about s/c position and attitude (probe shadow status). The status of the Hall thruster (ON, OFF, power level) is provided by the Smart-1 team in auxiliary data set with DATA_SET_ID = S1-L-ESOC-6-AUXILIARY-DATA-V1.0. The status is given in the file PRODUCT_ID = S1_EP_THRUST_LOG.TAB. This file is located in DATA/THRUST directory of the dataset.

SPEDE data users should also fetch this auxiliary data set before interpreting SPEDE results.

3 Archive Format and Content

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

The following dataset releases will be delivered

dataset	***release***	***orbits***	***dates***
LEOP-CALIBRATION	1	e3-e14	2003-09-29 - 2003-10-04
EE-EP-MONITORING	1	e15-e204,e228-e259	2003-10-04 – 2004-04-01
EE-EP-MONITORING	2	e260-e331	2004-04-01 – 2004-11-17
LP-EP-MONITORING	1	m1-m235	2004-11-17 – 2005-03-01
LP-EP-MONITORING	2	m978-m1252	2005-08-01 – 2005-09-27
SOLAR-WIND	1	e205-e227	2004-02-01 – 2004-02-25
MOON-PLASMA	1	m236-m977	2005-03-01 – 2005-08-01
MOON-PLASMA	2	m1253-m1999	2005-09-27 – 2006-03-01
MOON-PLASMA	3	m2000-	2006-03-01 -

Both the level 1b and level2 data will be produced. The datasets are split to distinct operational environments. On top of that, some of the datasets are divided to releases [SOP-RSSD-TN-015]. With the release concept, new data can be appended to an existing dataset, without repeating the supplementary data.

The first dataset, LEOP-CALIBRATION, contains the instrument commissioning in the low Earth orbit.

Both EP-MONITORING datasets, Earth escape and Lunar phase contain data, when the thruster has been operated. While the dataset contain orbit data, when thruster is not operated, it's needed to understand the data in the thruster on moments in the same orbit. The releases are separated from the natural operational border or from about 6 month worth of data. Note, that the first dataset contains a hole in time, during which the thruster was not operated and the data is given in a different dataset.

The SOLAR-WIND dataset contains data from the Earth orbits, when the thruster is not operated for a long period.

The MOON-PLASMA datasets contains data from the Moon orbit, when the thruster is not operated. The releases are splitted from the natural operational border or from about 6 month worth of data.

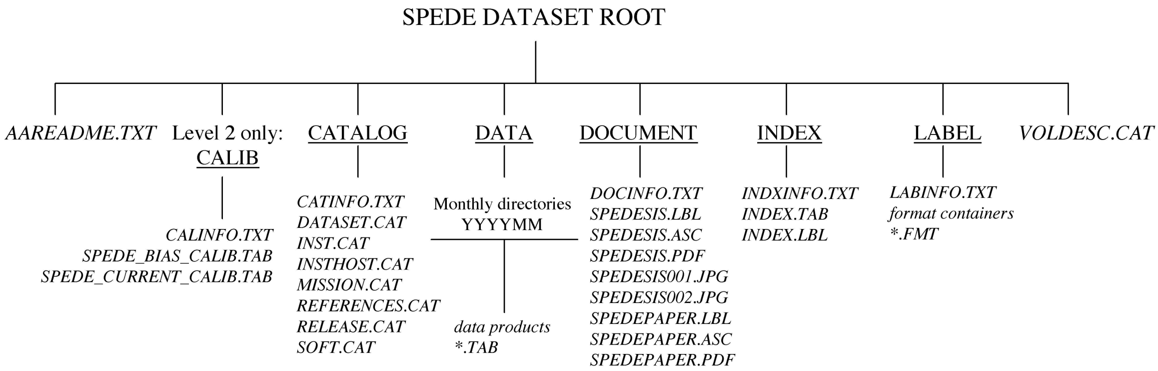

Figure 2. SPEDE dataset format.

3.1.2 Data Set ID Formation

Data set ID will be formed according to PDS standards. It will have the following components:

Instrument host: S1

Target: X (= other)

Instrument: SPEDE

Data processing level number (CODMAC): 2 for level 1b, 4 for level 2

Product type: EDR for level 1b, REFDR for level 2

Description = free description of the data set

Version number

Example:

"S1-X-SPEDE-4-REFDR-LEOP-CALIBRATION-V1.0"

3.1.3 Data Directory Naming Convention

Directories are named according to PDS standards.

DATA directory is divided into subdirectories each containing data products of one month. Format of the directory name are *YYYYMM*, for example 200310 for October 2003 data, 200311 for November 2003 data, etc.

If several datasets are present in one archive, the DATA directory is first divided into subdirectories for datasets, and only those are then divided to monthly subdirectories.

3.1.4 Filenaming Convention

3.1.4.1 Level 1b – raw data

Probe current and Probe voltage product types:

SP_*orbit*d*YYMMDD*_*x*_*tp*_*ll*_RAW.TAB, where

orbit = spacecraft orbit number, 5 digits
d = delimeter, Earth orbit: _, Moon orbit: M
YYMMDD = date of orbit start
x = sensor number, 1 = -X, 2 = +X
tp = product type, PC or PV
ll = vector measurement length

Wave electric field product type:

SP_*orbit*d*YYMMDD*_W_WA_*ll*_RAW.TAB, where

orbit, d, *YYMMDD*, *ll* as above.

Configuration table dump product type (non-science) are named:

SP_*YYYYMM*_CONFIG_RAW.TAB, where

YYYY = year*, MM* = month.

Software dump files (non-science) are named:

SP_*YYYYMM*_SWDUMP_RAW.TAB, where

YYYY = year*, MM* = month.

3.1.4.2 Level 2 – calibrated data

Electron/ion flux product:

SP_*orbit*d*YYMMDD*_*x*_EF_CAL.TAB

Plasma data product:

SP_*orbit*d*YYMMDD*_*x*_PD_*ll*_CAL.TAB

E-field product:

SP_*orbit*d*YYMMDD*_*x*_EFF_CAL.TAB

Wave electric field product:

SP_*orbit*d*YYMMDD*_W_WA_*ll*_CAL.TAB

Housekeeping data (ancillary):

SP_*orbit*d*YYMMDD*_HK_CAL.TAB

In all of the above:
orbit = spacecraft orbit number, 5 digits
d = delimeter, Earth orbit: _, Moon orbit: M
YYMMDD = date of orbit start
x = sensor number, 1 = -X, 2 = +X
ll = vector measurement length

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

PDS standard used is 3.6. All data processing levels mentioned in this document are PSA-compliant, as defined in SMART-1 Data Processing and Archive Plan [AD-03].

3.2.2 Time Standards

SPEDE data files use two time standards: Coordinated Universal Time (UTC) as ASCII string, and Modified Julian Date 2000 (MJD2000) as real number. MJD2000 counts days and day fractions since Jan 1, 2000.

The PDS header files also use S/C clock counts. Their format is 1/0001234567.89123, where the value before the '/' represents the partition number, which is increased by one for each clock reset on the spacecraft, and the rest is seconds and subseconds.

3.2.3 Reference Systems

3.2.4 Other Applicable Standards

3.3 Data Validation

Formats are checked with the PSA Validation and Verification Tool (PVV 2.6).

3.4 Content

3.4.1 Volume Set

3.4.2 Data Set

Data sets will be named according to PDS standards. Each component of the name will match the corresponding component of the data set ID.

Data set name components are:

Instrument host: SMART1

Target: PLASMA

Instrument name: SPEDE

Data processing level

Product type

Description

Version number

Example: "SMART1 PLASMA SPEDE 4 REFDR LEOP-CALIBRATION V1.0"

3.4.3 Directories

3.4.3.1 Root Directory

General archive description: AAREADME.TXT, VOLDESC.CAT

3.4.3.2 Calibration Directory

/CALIB directory contains information needed for SPEDE calibration (transfer from level 1b to level 2 data). The calibration files are look-up tables, as defined in chapter 2.4.3:

- SPEDE_BIAS_CALIB.TAB contains physical values (Volts) and background values for each raw bias value
- SPEDE_CURRENT_CALIB.TAB contains coefficients for the polynomial used to calculate currents from raw Langmuir measurements (frequencies).

/CALIB directory is included only in data archives containing level 2 data.

3.4.3.3 Catalog Directory

/CATALOG directory contains high-level catalog templates for SPEDE:

- INST.CAT – Instrument description
- INSTHOST.CAT – Instrument host description, provided by the Project
- MISSION.CAT – Mission description, provided by the Project
- DATASET.CAT – Data set description
- SOFT.CAT – Software description (empty for SPEDE archives)
- REFERENCES.CAT – References (empty for SPEDE archives)
- RELEASE.CAT – Release information

3.4.3.4 Index Directory

/INDEX directory contains index tables for SPEDE science data:

- INDEX.TAB – Tabular summary of all data files.
- INDEX.LBL – Detached label for the index file.

3.4.3.5 Browse Directory and Browse Files

N/A

3.4.3.6 Geometry Directory

N/A

3.4.3.7 Software Directory

N/A

3.4.3.8 Gazetter Directory

N/A

3.4.3.9 Label Directory

/LABEL directory contains format container files (*.FMT) used by SPEDE labels:

In level 1b archives:

- SPEDE_HEADER.FMT – Data objects definitions common to all products.
- SPEDE_CONFIGURATION.FMT – Data objects definitions for configuration table

dumps.

- o SPEDE_SWDUMP.FMT – Data object definitions for software dumps (operational parameters).
- o SPEDE_MEASURE_NN.FMT – Data objects definitions for measurement data with different vector lengths. NN = 20,30,40.

In level 2 archives:

- o SPEDE_FLUX.FMT – Data object definitions for electron/ion flux product.
- o SPEDE_PLASMA_NN.FMT – Data object definitions for plasma (sweep) data product. NN= 20,40
- o SPEDE_WAVE.FMT – Data object definitions for wave measurement data product.
- o SPEDE_HK.FMT – Data object definitions for housekeeping data product.

The labels themselves are always attached to the data files, so they do not appear in /LABEL directory.

Only necessary format containers are included in data sets. For example, if some data set does not include any software dumps, the corresponding format container will also not be included.

3.4.3.10 Document Directory

/DOCUMENT directory contains SPEDE documentation:

- o SPEDESIS.ASC – This document in ASCII format
- o SPEDESIS.PDF – This document in PDF format
- o SPEDESISxxx.JPG – Figures of this document in JPG format.
- o SPEDEPAPER.ASC – SPEDE paper in ASCII format
- o SPEDEPAPER.PDF – SPEDE paper in PDF format
- o Detached labels:
  - o SPEDESIS.LBL
  - o SPEDEPAPER.LBL

3.4.3.11 Extras Directory

N/A

3.4.3.12 Data Directory

/DATA directory contains subdirectories by month of data acquisition. For naming convention, see chapter 3.1.3.

Data products are stored in monthly subdirectories. If a product spans over two months, it is stored in the directory of the earlier month.

4 Detailed Interface Specifications

4.1 Structure and Organization Overview

/DATA directory will be divided into monthly subdirectories *YYYYMM*. The data products will be stored in these subdirectories. If some data product will span over two months, it will be stored in the subdirectory of the first month.

All SPEDE data products will be stored as TABLEs in ASCII format. The products will use attached labels. Parts of the labels will be stored in format files (*.FMT). The *.FMT files will be archived in the /LABEL directory.

4.2 Data Sets, Definition and Content

SPEDE data products will be divided into data sets as follows:

commissioning and ionospheric calibrations (LEOP, Earth orbits 3-14)

nominal EP monitoring, Earth escape phase (Earth orbits 15-204, 228-331)

nominal EP monitoring, Lunar phase (Moon orbits 1-235, 978-1252)

Monitoring of natural plasma with EP off (Earth orbits 205-227)

Moon science (Moon orbits 236-977, 1253-)

There will be own data sets for data with different processing level. Currently it is envisaged that for each mission phase defined above there will be two data sets supplied: one with level 1b data and one with level 2 data.

4.3 Data Product Design

4.3.1 Raw probe current (Langmuir) and probe voltage (S/C potential) data product

4.3.1.1 General description

Each measurement (row) of raw Probe current and Probe voltage data has the following components:

- Spacecraft time in UTC, ASCII format (time of the first measurement point)
- Spacecraft time in MJD2000
- TM packet APID
- TM packet sequence counter
- Spacecraft clock in seconds
- Spacecraft clock sub-seconds (1/256 sec)
- Probe –X reference voltage
- Probe +X reference voltage
- Temperature at +X
- Ground reference voltage
- Instrument mode number (1-9)
- Delta time between two measurement steps (stepping time)
- Probe: “1” = -X, “2” = +X, “W” = wave measurement
- Measurement vector length
- Bias type: Langmuir - Probe current (“I”) or Probe voltage (“V”)

- Measurement type: frequency (“F”) or pulse (“P”)
- Integration constant: integration time for frequency measurement, number of pulses for pulse measurement
- Repeated for each measurement point (number given by vector length):
    - Bias value
    - Measurement value

4.3.1.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 335
FILE_RECORDS                  = 431
LABEL_RECORDS                 =  9

/* POINTER TO DATA OBJECT */
^TABLE                        = 10

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_00189M050218_2_PV_20_RAW.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-2-EDR-EP-MONITORING2-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 2 EDR EP MONITORING2 V1.0"
PRODUCT_ID                    = "SP_00189M050218_2_PV_20_RAW.TAB"
PRODUCT_TYPE                  = "EDR"
PRODUCT_CREATION_TIME         = 2006-01-25
PROCESSING_LEVEL_ID           = 2
PROCESSING_LEVEL_DESC         = "Edited data, corrected for telemetry errors"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
INSTRUMENT_HOST_NAME          = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                   = "PLASMA ENVIRONMENT"
TARGET_NAME                   = "PLASMA"
TARGET_DESC                   = "Spacecraft potential and surrounding plasma"
START_TIME                    = 2005-02-18T06:43:34
STOP_TIME                     = 2005-02-18T12:58:15
SPACECRAFT_CLOCK_START_COUNT = "8/0030993731.23928"
SPACECRAFT_CLOCK_STOP_COUNT  = "8/0031016212.12239"
PRODUCER_ID                   = "FMI"
PRODUCER_INSTITUTION_NAME     = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME            = "Dr. Anssi Malkki"
INSTRUMENT_ID                 = "SPEDE"
INSTRUMENT_NAME               = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID            = "PV"
INSTRUMENT_MODE_DESC          = "Probe voltage (S/C potential)"
DATA_QUALITY_ID               = -1
DATA_QUALITY_DESC             = "-1=not checked"
INSTRUMENT_TYPE               = "PLASMA INSTRUMENT"
```

```
OBJECT                       = TABLE
        INTERCHANGE_FORMAT   = ASCII
        ROWS                 = 431
        ROW_BYTES            = 333
        ROW_SUFFIX_BYTES     = 2
        COLUMNS              = 19
        NAME                 = SPEDE_MEASUREMENT
        DESCRIPTION          = "SPEDE header and measurement"
        ^STRUCTURE           = "SPEDE_HEADER.FMT"
        ^STRUCTURE           = "SPEDE_MEASURE_20.FMT"
END_OBJECT                   = TABLE
END
```

SPEDE_HEADER.FMT:

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 1
        NAME            = DATE
        DATA_TYPE       = CHARACTER
        START_BYTE      = 1
        BYTES           = 23
        DESCRIPTION     = "S/C clock date in UTC"
        FORMAT          = A23
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 2
        NAME            = JULIAN_DATE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 25
        BYTES           = 14
        DESCRIPTION     = "S/C clock date in Modified Julian Date 2000"
        FORMAT          = "F14.8"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 3
        NAME            = APID
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 40
        BYTES           = 4
        DESCRIPTION     = "S/C application identification"
        FORMAT          = I4
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SEQ_CNT
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 45
        BYTES           = 5
        DESCRIPTION     = "SPEDE packet sequence count"
        FORMAT          = I5
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = SC_TIME
        DATA_TYPE       = ASCII_INTEGER
```

```
        START_BYTE      = 51
        BYTES           = 10
        DESCRIPTION     = "S/C clock in seconds"
        FORMAT          = I10
        UNIT            = "s"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = SC_SUBTIME
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 62
        BYTES           = 3
        DESCRIPTION     = "S/C clock in 1/256 subseconds"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = REF_VOLT_MINUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 66
        BYTES           = 3
        DESCRIPTION     = "2.5V -X reference voltage, data value with
                            frequency measurement using 4ms integration"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = REF_VOLT_PLUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 70
        BYTES           = 3
        DESCRIPTION     = "2.5V +X reference voltage, data value with
                            frequency measurement using 4ms integration"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = TEMP_PLUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 74
        BYTES           = 3
        DESCRIPTION     = "Temperature of +X channel electronics, data value
                           with frequency measurement using 20ms integration
                           -1280, resolution 3C degree"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = GROUND
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 78
        BYTES           = 3
        DESCRIPTION     = "Ground reference voltage, data value with frequency
                           measurement using 4ms integration"
```

```
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = MODE
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 82
        BYTES           = 5
        DESCRIPTION     = "Number of configuration table defining the
                           measurement for this data set"
        FORMAT          = I5
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
        NAME            = TIME_INC
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 88
        BYTES           = 6
        DESCRIPTION     = "Time difference between start of integration
                           periods of subsequent measurements in units
                           of 1/256 sec"
        FORMAT          = I6
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = PROBE
        DATA_TYPE       = CHARACTER
        START_BYTE      = 96
        BYTES           = 1
        DESCRIPTION     = "Sensor probe used for the data set:
                           1=probe on -X face of spacecraft,
                           2=probe on +X face of spacecraft,
                           W=wave measurement using the potential difference
                           between both probes"
        FORMAT          = A1
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = LENGTH
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 99
        BYTES           = 2
        DESCRIPTION     = " Length of measurement bias and data vectors"
        FORMAT          = I2
END_OBJECT              = COLUMN
```

<u>SPEDE_MEASURE_20.FMT</u>

```
OBJECT                  = COLUMN
        NAME            = BIAS_TYPE
        DATA_TYPE       = CHARACTER
        START_BYTE      = 2
        BYTES           = 1
        DESCRIPTION     = "I for Langmuir (current measurement),
                           V for voltage measurement"
```

```
        FORMAT          = A1
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        NAME            = MEASUREMENT_TYPE
        DATA_TYPE       = CHARACTER
        START_BYTE      = 6
        BYTES           = 1
        DESCRIPTION     = "F = frequency measurement,
                           P = pulse length measurement"
        FORMAT          = A1
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        NAME            = INTEGRATION_CONSTANT
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 9
        BYTES           = 4
        DESCRIPTION     = "For frequency measurement,
                           integration time in ms.
                           For pulse measurement,
                           number of VFC pulses used."
        FORMAT          = I4
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        NAME            = BIAS_VECTOR
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 14
        BYTES           = 79
        ITEM_BYTES      = 3
        ITEMS           = 20
        ITEM_OFFSET     = 4
        DESCRIPTION     = "Measurement bias"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        NAME            = MEASUREMENT_VECTOR
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 94
        BYTES           = 139
        ITEM_BYTES      = 6
        ITEMS           = 20
        ITEM_OFFSET     = 7
        DESCRIPTION     = "Measurement value"
        FORMAT          = I6
END_OBJECT              = COLUMN
```

4.3.2 Raw wave electric field data

4.3.2.1 General description

Each measurement vector (row) has the following components:

Spacecraft time in UTC, ASCII format (time of the first measurement point)

Spacecraft time in MJD2000

TM packet APID

TM packet sequence counter

- Spacecraft clock in seconds
- Spacecraft clock sub-seconds (1/256 sec)
- Probe –X reference voltage
- Probe +X reference voltage
- Temperature at +X
- Ground reference voltage
- Instrument mode number (1-9)
- Delta time between two measurement steps (stepping time)
- Probe: “W” = wave measurement
- Measurement vector length
- Wave data bias for –X
- Wave data bias for +X
- Repeated for each measurement point (number given by vector length):
    - o Wavelet coefficient

4.3.2.2 Label example

```
PDS_VERSION_ID                 = PDS3
LABEL_REVISION_NOTE            = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                     = 0001
REVISION_ID                    = 0000

/* FILE FORMAT */
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 180
FILE_RECORDS                   = 144
LABEL_RECORDS                  = 24

/* POINTER TO DATA OBJECT */
^TABLE                         = 25

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                      = "SP_00235M050228_W_WA_10_RAW.TAB"
DATA_SET_ID                    = "S1-X-SPEDE-2-EDR-EP-MONITORING2-V1.0"
DATA_SET_NAME                  = "SMART1 PLASMA SPEDE 2 EDR EP MONITORING2 V1.0"
PRODUCT_ID                     = "SP_00235M050228_W_WA_10_RAW.TAB"
PRODUCT_TYPE                   = "EDR"
PRODUCT_CREATION_TIME          = 2006-01-25
PROCESSING_LEVEL_ID            = 2
PROCESSING_LEVEL_DESC          = "Edited data, corrected for telemetry errors"
MISSION_ID                     = "SMART1"
MISSION_NAME                   = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME             = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                   = "N/A"
INSTRUMENT_HOST_ID             = "S1"
INSTRUMENT_HOST_NAME           = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                    = "PLASMA ENVIRONMENT"
TARGET_NAME                    = "PLASMA"
TARGET_DESC                    = "Spacecraft potential and surrounding plasma"
START_TIME                     = 2005-02-28T21:46:40
STOP_TIME                      = 2005-02-28T23:22:00
SPACECRAFT_CLOCK_START_COUNT = "8/0031911897.24132"
SPACECRAFT_CLOCK_STOP_COUNT  = "8/0031917617.12239"
PRODUCER_ID                    = "FMI"
PRODUCER_INSTITUTION_NAME      = "Finnish Meteorological Institute"
```

```
PRODUCER_FULL_NAME             = "Dr. Anssi Malkki"
INSTRUMENT_ID                  = "SPEDE"
INSTRUMENT_NAME                = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID             = "WA"
INSTRUMENT_MODE_DESC           = "Wave measurement (Voltage mode)"
DATA_QUALITY_ID                = -1
DATA_QUALITY_DESC              = "-1=not checked"
INSTRUMENT_TYPE                = "PLASMA INSTRUMENT"

OBJECT                         = TABLE
        INTERCHANGE_FORMAT     = ASCII
        ROWS                   = 144
        ROW_BYTES              = 178
        ROW_SUFFIX_BYTES       = 2
        COLUMNS                = 17
        NAME                   = SPEDE_MEASUREMENT
        OBJECT                 = CONTAINER
                NAME           = SPEDE_HEADER_DATA
                START_BYTE     = 1
                BYTES          = 100
                REPETITIONS    = 1
                DESCRIPTION    = "SPEDE header"
                ^STRUCTURE     = "SPEDE_HEADER.FMT"
        END_OBJECT             = CONTAINER
        OBJECT                    = COLUMN
                COLUMN_NUMBER     = 15
                NAME              = MINUS_X_BIAS
                DATA_TYPE         = ASCII_INTEGER
                START_BYTE        = 102
                BYTES             = 3
                DESCRIPTION       = "Wave data -X bias"
                FORMAT            = I3
        END_OBJECT                = COLUMN
        OBJECT                    = COLUMN
                COLUMN_NUMBER     = 16
                NAME              = PLUS_X_BIAS
                DATA_TYPE         = ASCII_INTEGER
                START_BYTE        = 106
                BYTES             = 3
                DESCRIPTION       = "Wave data +X bias"
                FORMAT            = I3
        END_OBJECT                = COLUMN
        OBJECT                    = COLUMN
                COLUMN_NUMBER     = 17
                NAME              = WAVE_COEFFICIENT_VECTOR
                DATA_TYPE         = ASCII_INTEGER
                START_BYTE        = 110
                BYTES             = 69
                ITEM_BYTES        = 6
                ITEMS             = 10
                ITEM_OFFSET       = 7
                DESCRIPTION       = "Wavelet coefficiens vector"
                FORMAT            = I6
        END_OBJECT                = COLUMN
END_OBJECT                     = TABLE
END
```

4.3.3 Raw configuration table dump (ancillary data)

4.3.3.1 General description

Each table dump (row) has the following components:

- Spacecraft time in UTC, ASCII format (time of the dump)
- Spacecraft time in MJD2000
- TM packet APID
- TM packet sequence counter
- Spacecraft clock in seconds
- Spacecraft clock sub-seconds (1/256 sec)
- Table number
- Table contents
    - Bias voltage start value for probe –X
    - Bias increment for probe –X
    - Number of bias steps for probe –X
    - Bias voltage start value for probe +X
    - Bias increment for probe +X
    - Number of bias steps for probe +X
    - Control byte for probe –X (in HEX)
    - Control byte for probe +X (in HEX)
    - Delta time between two measurement steps (stepping time)
    - Delta time between measurement repetitions (repetition time)
    - Number of measurement repetitions: 1-255, or 0 = infinite
    - Number of frequencies for wave measurement
    - Plasma wave measurement bias for probe +X
    - Plasma wave measurement bias for probe –X

4.3.3.2 Label example

```
PDS_VERSION_ID         = PDS3
LABEL_REVISION_NOTE    = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID             = 0001
REVISION_ID            = 0000

/* FILE FORMAT */
RECORD_TYPE            = FIXED_LENGTH
RECORD_BYTES           = 133
FILE_RECORDS           = 5
LABEL_RECORDS          = 19

/* POINTER TO DATA OBJECT */
^TABLE                 = 20

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                    = "SP_200310_CONFIG_RAW.TAB"
DATA_SET_ID                  = "S1-X-SPEDE-2-EDR-LEOP-CALIBRATION-V1.0"
DATA_SET_NAME                = "SMART1 PLASMA SPEDE 2 EDR LEOP CALIBRATION V1.0"
PRODUCT_ID                   = "SP_200310_CONFIG_RAW.TAB"
PRODUCT_TYPE                 = "ANCDR"
PRODUCT_CREATION_TIME        = 2006-01-25
PROCESSING_LEVEL_ID          = 2
PROCESSING_LEVEL_DESC        = "Edited data, corrected for telemetry errors"
MISSION_ID                   = "SMART1"
MISSION_NAME                 = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME           = "EARTH ESCAPE PHASE"
```

```
ORBIT_NUMBER                    = "N/A"
INSTRUMENT_HOST_ID              = "S1"
INSTRUMENT_HOST_NAME            = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                     = "PLASMA ENVIRONMENT"
TARGET_NAME                     = "PLASMA"
TARGET_DESC                     = "Spacecraft potential and surrounding plasma"
START_TIME                      = 2003-10-01T16:50:14
STOP_TIME                       = 2003-10-02T19:20:35
SPACECRAFT_CLOCK_START_COUNT = "4/0000010419.54255"
SPACECRAFT_CLOCK_STOP_COUNT  = "4/0000105840.54167"
PRODUCER_ID                     = "FMI"
PRODUCER_INSTITUTION_NAME    = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME           = "Dr. Anssi Malkki"
INSTRUMENT_ID                   = "SPEDE"
INSTRUMENT_NAME                 = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID              = "N/A"
INSTRUMENT_MODE_DESC            = "N/A"
DATA_QUALITY_ID                 = -1
DATA_QUALITY_DESC               = "-1=not checked"
INSTRUMENT_TYPE                 = "PLASMA INSTRUMENT"

OBJECT                  = TABLE
  INTERCHANGE_FORMAT   = ASCII
  ROWS                  = 5
  ROW_BYTES             = 131
  ROW_SUFFIX_BYTES      = 2
  COLUMNS               = 21
  NAME                  = SPEDE_CONFIGURATION
  ^STRUCTURE            = "SPEDE_CONFIGURATION.FMT"

END_OBJECT              = TABLE

END
```

SPEDE_CONFIGURATION.FMT:

```
OBJECT                   = COLUMN
        COLUMN_NUMBER    = 1
        NAME             = DATE
        DATA_TYPE        = CHARACTER
        START_BYTE       = 1
        BYTES            = 23
        DESCRIPTION      = "S/C clock date in UTC"
        FORMAT           = A22
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 2
        NAME             = JULIAN_DATE
        DATA_TYPE        = ASCII_REAL
        START_BYTE       = 25
        BYTES            = 14
        DESCRIPTION      = "S/C clock date in Modified Julian Date 2000"
        FORMAT           = "F14.8"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
```

```
        COLUMN_NUMBER   = 3
        NAME            = APID
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 40
        BYTES           = 4
        DESCRIPTION     = "S/C application identification"
        FORMAT          = I4
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SEQ_CNT
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 45
        BYTES           = 5
        DESCRIPTION     = "SPEDE packet sequence count"
        FORMAT          = I5
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = SC_TIME
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 51
        BYTES           = 10
        DESCRIPTION     = "S/C clock in seconds"
        FORMAT          = I10
        UNIT            = "s"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = SC_SUBTIME
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 62
        BYTES           = 3
        DESCRIPTION     = "S/C clock in 1/256 subseconds"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = CONFIGURATION_TABLE
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 66
        BYTES           = 3
        DESCRIPTION     = "SPEDE configuration table number, range 1-9"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = MINUS_X_LP_BIAS_START
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 70
        BYTES           = 3
        DESCRIPTION     = "First bias control value for -X probe in
                           Langmuir mode"
        FORMAT          = I3
```

```
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = MINUS_X_LP_BIAS_INCREMENT
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 74
        BYTES           = 3
        DESCRIPTION     = "If not zero, defines a Langmuir sweep:
                           difference between subsequent measurement points.
                           The related bias voltages are not linearily
                           related to the control values."
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = MINUS_X_STEPS
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 78
        BYTES           = 3
        DESCRIPTION     = "Number of measurement points in one measurement.
                           In Langmuir mode with INCREMENT > 0 this is the
                           number of bias voltages used in an upward sweep.
                           If the bias code value would become larger than the
                           largest allowed value 255, the value will be 255
                           for those measurements. If hysteresis measurements
                           are defined (see CONTROL_MINUS_X/_PLUS_X below)
                           another sequence will be performed with same number
                           of measurements and reversed stepping starting from
                           end value of first measurement. The total
                           measurement vector length will then be twice the
                           given number here."
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = PLUS_X_LP_BIAS_START
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 82
        BYTES           = 3
        DESCRIPTION     = "First bias control value for +X probe in
                           Langmuir mode"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
        NAME            = PLUS_X_LP_BIAS_INCREMENT
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 86
        BYTES           = 3
        DESCRIPTION     = "If not zero, defines a Langmuir sweep:
                           difference between subsequent measurement points.
                           The related bias voltages are not linearly
                           related to the control values."
        FORMAT          = I3
END_OBJECT              = COLUMN
```

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = PLUS_X_STEPS
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 90
        BYTES           = 3
        DESCRIPTION     = "Number of measurement points in one measurement.
                           In Langmuir mode with INCREMENT > 0 this is the
                           number of bias voltages used in an upward sweep.
                           If the bias code value would become larger than the
                           largest allowed value 255, the value will be 255
                           for those measurements. If hysteresis measurements
                           are defined (see CONTROL_MINUS_X/_PLUS_X below)
                           another sequence will be performed with same number
                           of measurements and reversed stepping starting from
                           end value of first measurement. The total
                           measurement vector length will then be twice the
                           given number here."
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = CONTROL_MINUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 94
        BYTES           = 3
        DESCRIPTION     = "Decimal representation of the control bit pattern
                           for -X probe. The different powers of 2 and groups
                           thereof have the following meaning:
                           V*2^0: V=0: Voltage mode,
                                  V=1: Langmuir (current) mode
                           F*2^1: F=0: Frequency measurement,
                                  F=1: Pulse length measurement
                           H*2^2: H=0: no hysteresis measurement,
                                  H=1: Hysteresis measurement
                           I*2^3: I=0: large integration constant,
                                  I=1: small integration constant
                           2^4  2^6 are only relevant if
                                  H=1 (hysteresis measurement activated)
                           V2*2^4:
                               V2=0 Voltage mode in second measurement phase,
                               V2=1: Langmuir mode
                           F2*2^5: F2=0: Frequency measurement,
                                   F2=1: pulse length measurement
                           I2*2^6: I2=0: large integration constant,
                                   I2=1: short integration constant
                           W*2^7:  W=0: No wave measurement,
                                   W=1: wave measurement included"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 15
        NAME            = CONTROL_PLUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 98
        BYTES           = 3
```

```
        DESCRIPTION     = "Decimal representation of the control bit pattern
                           for +X probe. The different powers of 2 and groups
                           thereof have the following meaning:
                           V*2^0: V=0: Voltage mode,
                                  V=1: Langmuir (current) mode
                           F*2^1: F=0: Frequency measurement,
                                  F=1: Pulse length measurement
                           H*2^2: H=0: no hysteresis measurement,
                                  H=1: Hysteresis measurement
                           I*2^3: I=0: large integration constant,
                                  I=1: small integration constant
                           2^4  2^6 are only relevant if
                                  H=1 (hysteresis measurement activated)
                           V2*2^4:
                               V2=0 Voltage mode in second measurement phase,
                               V2=1: Langmuir mode
                           F2*2^5: F2=0: Frequency measurement,
                                   F2=1: pulse length measurement
                           I2*2^6: I2=0: large integration constant,
                                   I2=1: short integration constant
                           W*2^7:  W=0: No wave measurement,
                                   W=1: wave measurement included"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 16
        NAME            = STEPPING_INTERVAL
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 102
        BYTES           = 6
        DESCRIPTION     = "Time interval between start of integration times
                           in units of 1/256s"
        FORMAT          = I6
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 17
        NAME            = REPETITION_INTERVAL
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 109
        BYTES           = 7
        DESCRIPTION     = "Time interval between start of telemetry packets
                           in units of 1/16s"
        FORMAT          = I7
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 18
        NAME            = REPETITIONS
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 117
        BYTES           = 3
        DESCRIPTION     = "Number of automatic telemetry packet repetitions.
                           0=infinte (continuous measurement)."
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
```

```
        COLUMN_NUMBER   = 19
        NAME            = FREQUENCY_BANDS
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 121
        BYTES           = 3
        DESCRIPTION     = "If wave measurements are activated:
                           number for frequency bins"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 20
        NAME            = WAVE_BIAS_MINUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 125
        BYTES           = 3
        DESCRIPTION     = "Bias voltage on -X probe.
                           If =0, probe is set to voltage"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 21
        NAME            = WAVE_BIAS_PLUS_X
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 129
        BYTES           = 3
        DESCRIPTION     = "Bias voltage on +X probe.
                           If =0, probe is set to voltage"
        FORMAT          = I3
END_OBJECT              = COLUMN
```

4.3.4 Raw operation parameters (software dumps) product (ancillary data)

4.3.4.1 General description

Level 1b software dump files will contain certain operation parameters (listed below) that affect SPEDE measurements.

Each row of the software dump file will contain the time of the dump in UTC and JMD2000, and placeholders for 12 SPEDE operation parameters:

- Long frequency integration time in EEPROM
- Short frequency integration time in EEPROM
- Long pulse measurement value for –X in EEPROM
- Short pulse measurement value for –X in EEPROM
- Long pulse measurement value for +X in EEPROM
- Short pulse measurement value for +X in EEPROM
- Long frequency integration time in RAM
- Short frequency integration time in RAM
- Long pulse measurement value for –X in RAM
- Short pulse measurement value for –X in RAM

- Long pulse measurement value for +X in RAM
- Short pulse measurement value for +X in RAM

Each row of the dump contains parameters returned in one telemetry packet. Parameter values not present in a certain memory dump are marked as “N/A”.

4.3.4.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 198
FILE_RECORDS                  = 10
LABEL_RECORDS                 = 13

/* POINTER TO DATA OBJECT */
^TABLE                        = 14

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_200309_SWDUMP_RAW.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-2-EDR-LEOP-CALIBRATION-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 2 EDR LEOP CALIBRATION V1.0"
PRODUCT_ID                    = "SP_200309_SWDUMP_RAW.TAB"
PRODUCT_TYPE                  = "ANCDR"
PRODUCT_CREATION_TIME         = 2006-01-25
PROCESSING_LEVEL_ID           = 2
PROCESSING_LEVEL_DESC         = "Edited data, corrected for telemetry errors"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
INSTRUMENT_HOST_NAME          = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                   = "PLASMA ENVIRONMENT"
TARGET_NAME                   = "PLASMA"
TARGET_DESC                   = "Spacecraft potential and surrounding plasma"
START_TIME                    = 2003-09-29T17:08:01
STOP_TIME                     = 2003-09-29T17:14:21
SPACECRAFT_CLOCK_START_COUNT = "2/0000064482.42013"
SPACECRAFT_CLOCK_STOP_COUNT  = "2/0000064862.47974"
PRODUCER_ID                   = "FMI"
PRODUCER_INSTITUTION_NAME     = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME            = "Dr. Anssi Malkki"
INSTRUMENT_ID                 = "SPEDE"
INSTRUMENT_NAME               = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID            = "N/A"
INSTRUMENT_MODE_DESC          = "N/A"
DATA_QUALITY_ID               = -1
DATA_QUALITY_DESC             = "-1=not checked"
INSTRUMENT_TYPE               = "PLASMA INSTRUMENT"

OBJECT                        = TABLE
```

```
  INTERCHANGE_FORMAT          = ASCII
  ROWS                        = 10
  ROW_BYTES                   = 196
  ROW_SUFFIX_BYTES            = 2
  COLUMNS                     = 18
  NAME                        = SPEDE_PARAMETERS
  ^STRUCTURE                  = "SPEDE_PARAMETERS.FMT"

END_OBJECT                    = TABLE

END
```

SPEDE_PARAMETERS.FMT

```
OBJECT                   = COLUMN
        COLUMN_NUMBER    = 1
        NAME             = DATE
        DATA_TYPE        = CHARACTER
        START_BYTE       = 1
        BYTES            = 23
        DESCRIPTION      = "S/C clock date in UTC"
        FORMAT           = A23
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 2
        NAME             = JULIAN_DATE
        DATA_TYPE        = ASCII_REAL
        START_BYTE       = 25
        BYTES            = 14
        DESCRIPTION      = "S/C clock date in Modified Julian Date 2000"
        FORMAT           = "F14.8"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 3
        NAME             = APID
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 40
        BYTES            = 4
        DESCRIPTION      = "S/C application identification"
        FORMAT           = I4
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 4
        NAME             = SEQ_CNT
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 45
        BYTES            = 5
        DESCRIPTION      = "SPEDE packet sequence count"
        FORMAT           = I5
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 5
        NAME             = SC_TIME
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 51
```

```
        BYTES           = 10
        DESCRIPTION     = "S/C clock in seconds"
        FORMAT          = I10
        UNIT            = "s"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = SC_SUBTIME
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 62
        BYTES           = 3
        DESCRIPTION     = "S/C clock in 1/256 subseconds"
        FORMAT          = I3
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = FREQ_LONG_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 66
        BYTES           = 10
        DESCRIPTION     = "Number of 16-MHz clock pulses defining the long
                           integration time. This value is used after each
                           instrument reboot"
        FORMAT          = I10
        UNIT            = "ms"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = FREQ_SHORT_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 77
        BYTES           = 10
        DESCRIPTION     = "Number of 16-MHz clock pulses defining the short
                           integration time. This value is used after each
                           instrument reboot. EEPROM store."
        FORMAT          = I10
        UNIT            = "ms"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = PULSE_LONG_MINUS_X_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 88
        BYTES           = 10
        DESCRIPTION     = "Number of pulses from -X sensor VFC used to
                           determine the pulselength by comparision
                           with 16-MHz clock (long). EEPROM store."
        FORMAT          = I10
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = PULSE_SHORT_MINUS_X_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 99
```

```
        BYTES           = 10
        DESCRIPTION     = "Number of pulses from -X sensor VFC used to
                           determine the pulselength by comparision
                           with 16-MHz clock (short). EEPROM store."
        FORMAT          = I10
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = PULSE_LONG_PLUS_X_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 110
        BYTES           = 10
        DESCRIPTION     = "Number of pulses from +X sensor VFC used to
                           determine the pulselength by comparision
                           with 16-MHz clock (long). EEPROM store."
        FORMAT          = I10
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
        NAME            = PULSE_SHORT_PLUS_X_EEPROM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 121
        BYTES           = 10
        DESCRIPTION     = "Number of pulses from -+ sensor VFC used to
                           determine the pulselength by comparision
                           with 16-MHz clock (short). EEPROM store."
        FORMAT          = I10
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = FREQ_LONG_RAM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 132
        BYTES           = 10
        DESCRIPTION     = "Number of 16-MHz clock pulses defining the long
                           integration time. This value is used after each
                           instrument reboot. RAM store."
        FORMAT          = I10
        UNIT            = "ms"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = FREQ_SHORT_RAM
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 143
        BYTES           = 10
        DESCRIPTION     = "Number of 16-MHz clock pulses defining the short
                           integration time. This value is used after each
                           instrument reboot. RAM store."
        FORMAT          = I10
        UNIT            = "ms"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 15
```

```
        NAME             = PULSE_LONG_MINUS_X_RAM
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 154
        BYTES            = 10
        DESCRIPTION      = "Number of pulses from -X sensor VFC used to
                            determine the pulselength by comparision
                            with 16-MHz clock (long). RAM store."
        FORMAT           = I10
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 16
        NAME             = PULSE_SHORT_MINUS_X_RAM
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 165
        BYTES            = 10
        DESCRIPTION      = "Number of pulses from -X sensor VFC used to
                            determine the pulselength by comparision
                            with 16-MHz clock (short). RAM store."
        FORMAT           = I10
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 17
        NAME             = PULSE_LONG_PLUS_X_RAM
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 176
        BYTES            = 10
        DESCRIPTION      = "Number of pulses from +X sensor VFC used to
                            determine the pulselength by comparision
                            with 16-MHz clock (long). RAM store."
        FORMAT           = I10
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 18
        NAME             = PULSE_SHORT_PLUS_X_RAM
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 187
        BYTES            = 10
        DESCRIPTION      = "Number of pulses from +X sensor VFC used to
                            determine the pulselength by comparision
                            with 16-MHz clock (short). RAM store."
        FORMAT           = I10
END_OBJECT               = COLUMN
```

4.3.5 Calibrated electron/ion flux data product

4.3.5.1 General description

Each measurement point (row) of calibrated electron/ion flux data has the following components:

- Spacecraft time in UTC, ASCII format (time of the measurement)
- Spacecraft time in MJD2000
- -X probe shadow status flag (S/C shadow, Earth or Moon umbra, etc.)
- Angles between S/C –X, -Y and -Z axis and Sun

- Angle between S/C +Z axis and solar array +Z axis
- S/C position in GSE coordinates: X, Y, Z
- S/C position in LSE coordinates: X, Y, Z
- Instrument bias voltage in Volts
- Measurement value representing the flux in Amperes
- Status flag for the measurement point. Details of the flag as in the label example below.

4.3.5.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 173
FILE_RECORDS                  = 480
LABEL_RECORDS                 = 16

/* POINTER TO DATA OBJECT */
^TABLE                        = 17

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_00135M050201_1_EF_CAL.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-4-REFDR-EP-MONITORING2-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 4 REFDR EP-MONITORING2 V1.0"
PRODUCT_ID                    = "SP_00135M050201_1_EF_CAL.TAB"
PRODUCT_TYPE                  = "REFDR"
PRODUCT_CREATION_TIME         = 2006-01-26
PROCESSING_LEVEL_ID           = 4
PROCESSING_LEVEL_DESC         = "Calibrated data"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
INSTRUMENT_HOST_NAME          = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                   = "PLASMA ENVIRONMENT"
TARGET_NAME                   = "PLASMA"
TARGET_DESC                   = "Spacecraft potential and surrounding plasma"
START_TIME                    = 2005-02-01T05:04:34
STOP_TIME                     = 2005-02-01T13:03:34
SPACECRAFT_CLOCK_START_COUNT = " 8/0029518991.10547"
SPACECRAFT_CLOCK_STOP_COUNT  = " 8/0029547731.31640"
PRODUCER_ID                   = "FMI"
PRODUCER_INSTITUTION_NAME     = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME            = "Dr. Anssi Malkki"
INSTRUMENT_ID                 = "SPEDE"
INSTRUMENT_NAME               = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID            = "PC"
INSTRUMENT_MODE_DESC          = "Probe current (Langmuir)"
```

```
DATA_QUALITY_ID              = -1
DATA_QUALITY_DESC            = "-1 = not checked
                                Calibration tables: bias 1.0 background 1.0
                                frequency_to_current 1.0"
INSTRUMENT_TYPE              = "PLASMA INSTRUMENT"

OBJECT                       = TABLE
        INTERCHANGE_FORMAT   = ASCII
        ROWS                 = 480
        ROW_BYTES            = 171
        ROW_SUFFIX_BYTES     = 2
        COLUMNS              = 14
        NAME                 = SPEDE_ELECTRON_FLUX
        DESCRIPTION          = "SPEDE calibrated electron flux data"
        ^STRUCTURE           = "SPEDE_FLUX.FMT"
END_OBJECT                   = TABLE
END
```

SPEDE_FLUX.FMT:

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 1
        NAME            = DATE
        DATA_TYPE       = TIME
        START_BYTE      = 1
        BYTES           = 23
        DESCRIPTION     = "S/C clock date in UTC"
        FORMAT          = A22
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 2
        NAME            = JULIAN_DATE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 25
        BYTES           = 14
        DESCRIPTION     = "S/C clock date in Modified Julian Date 2000"
        FORMAT          = "F14.8"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 3
        NAME            = SHADOW
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 40
        BYTES           = 1
        DESCRIPTION     = "Status flag, if the SPEDE -X probe is in shadow
                           or not:
                           0 = in sun
                           1 = in S/C shadow
                           2 = in Earth or Moon umbra
                           3 = in S/C and Earth or Moon umbra
                           4 = in Earth or Moon penumbra
                           5 = in S/C shadow and Earth or Moon penumbra
                           9 = unknown situation"
        FORMAT          = "I1"
END_OBJECT              = COLUMN
```

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SC_MX_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 42
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -X-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SC_MY_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 50
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Y-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SC_MZ_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 58
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Z-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = SC_SA_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 66
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           +Z-axis and the solar array +Z-axis."
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = GSE_X
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 74
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in GSE coordinates"
```

```
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = GSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 84
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = GSE_Z
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 94
        BYTES           = 9
        DESCRIPTION     = "S/C position Z-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = LSE_X
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 104
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = LSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 114
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = LSE_Z
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 124
        BYTES           = 9
```

```
        DESCRIPTION     = "S/C position Z-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
        NAME            = BIAS
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 134
        BYTES           = 6
        DESCRIPTION     = "Bias voltage"
        UNIT            = "V"
        FORMAT          = "F6.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = MEASUREMENT
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 141
        BYTES           = 12
        DESCRIPTION     = "Measurement value"
        UNIT            = "A"
        FORMAT          = "E12.5E3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = FLAGS
        DATA_TYPE       = CHARACTER
        START_BYTE      = 155
        BYTES           = 16
        DESCRIPTION     = "16th (LS) flag:
                             0 = the result is checked and found correct
                             1 = the result is checked and possibly corrected,
                                 warnings concerning quality
                             2 = the result is checked, and found unreliable
                                 (no corrections)
                             9 = the result is unchecked
                           15th flag:
                              F = frequency measurement,
                              p = original pulse measurement,
                              P = corrected pulse measurement
                           14th flag:
                              1 = the first measurement in an
                                  measurement vector,
                              _ = following measurements
                           13th flag:
                              R = the reference voltage was
                                  fluctuating during this measurement,
                              _ = the reference voltage was OK
                                  (the reference voltage value is obtained
                                  from the housekeeping data)"
        FORMAT          = "A16"
END_OBJECT              = COLUMN
```

4.3.6 *Calibrated plasma data product*

4.3.6.1 General description

Each row of calibrated plasma data has the following components:

- Spacecraft time in UTC, ASCII format (time of the first measurement point of the sweep)
- Spacecraft time in MJD2000
- -X probe shadow status flag (No shadow, S/C shadow, Earth or Moon umbra, etc.)
- Angles between S/C –X, -Y and -Z axis and Sun
- Angle between S/C +Z axis and solar array +Z axis
- S/C position in GSE coordinates: X, Y, Z
- S/C position in LSE coordinates: X, Y, Z
- Time increment in seconds: Delta time between two measurement points of the sweep
- Vector containing instrument bias voltages of the sweep in Volts
- Vector containing measurement values of the sweep in Amperes
- Vector containing status flags for each measurement point. Details of the flag as in the label example below.

The length of the sweeps can vary. Currently 20 and 40 points are used. In the label example below, 20 points are used.

4.3.6.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 1705
FILE_RECORDS                  = 8
LABEL_RECORDS                 =  2

/* POINTER TO DATA OBJECT */
^TABLE                        =  3

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_00205_040201_1_PD_40_CAL.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-4-REFDR-BKGRPLASMA-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 4 REFDR BKGRPLASMA V1.0"
PRODUCT_ID                    = "SP_00205_040201_1_PD_40_CAL.TAB"
PRODUCT_TYPE                  = "REFDR"
PRODUCT_CREATION_TIME         = 2006-01-26
PROCESSING_LEVEL_ID           = 4
PROCESSING_LEVEL_DESC         = "Calibrated data"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
```

```
INSTRUMENT_HOST_NAME         = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                  = "PLASMA ENVIRONMENT"
TARGET_NAME                  = "PLASMA"
TARGET_DESC                  = "Spacecraft potential and surrounding plasma"
START_TIME                   = 2004-02-01T23:46:27
STOP_TIME                    = 2004-02-02T22:39:53
SPACECRAFT_CLOCK_START_COUNT = " 6/0008779952.84375"
SPACECRAFT_CLOCK_STOP_COUNT  = " 6/0008862358.22656"
PRODUCER_ID                  = "FMI"
PRODUCER_INSTITUTION_NAME    = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME           = "Dr. Anssi Malkki"
INSTRUMENT_ID                = "SPEDE"
INSTRUMENT_NAME              = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID           = "PC"
INSTRUMENT_MODE_DESC         = "Probe current (Langmuir)"
DATA_QUALITY_ID              = -1
DATA_QUALITY_DESC            = "-1 = not checked
                                Calibration tables: bias 1.0 background 1.0
                                frequency_to_current 1.0"
INSTRUMENT_TYPE              = "PLASMA INSTRUMENT"

OBJECT                       = TABLE
        INTERCHANGE_FORMAT   = ASCII
        ROWS                 = 8
        ROW_BYTES            = 1703
        ROW_SUFFIX_BYTES     = 2
        COLUMNS              = 15
        NAME                 = SPEDE_PLASMA
        DESCRIPTION          = "SPEDE calibrated plasma data"
        ^STRUCTURE           = "SPEDE_PLASMA_40.FMT"
END_OBJECT                   = TABLE
END
```

SPEDE_PLASMA_40.FMT:

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 1
        NAME            = DATE
        DATA_TYPE       = TIME
        START_BYTE      = 1
        BYTES           = 23
        DESCRIPTION     = "S/C clock date in UTC"
        FORMAT          = A22
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 2
        NAME            = JULIAN_DATE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 25
        BYTES           = 14
        DESCRIPTION     = "S/C clock date in Modified Julian Date 2000"
        FORMAT          = "F14.8"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 3
```

```
        NAME            = SHADOW
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 40
        BYTES           = 1
        DESCRIPTION     = "Status flag, if the SPEDE -X probe is in shadow
                           or not:
                           0 = in sun
                           1 = in S/C shadow
                           2 = in Earth or Moon umbra
                           3 = in S/C and Earth or Moon umbra
                           4 = in Earth or Moon penumbra
                           5 = in S/C shadow and Earth or Moon penumbra
                           9 = unknown situation"
        FORMAT          = "I1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SC_MX_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 42
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -X-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = SC_MY_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 50
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Y-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = SC_MZ_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 58
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Z-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = SC_SA_ANGLE
        DATA_TYPE       = ASCII_REAL
```

```
        START_BYTE      = 66
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           +Z-axis and the solar array +Z-axis."
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = GSE_X
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 74
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = GSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 84
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = GSE_Z
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 94
        BYTES           = 9
        DESCRIPTION     = "S/C position Z-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = LSE_X
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 104
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
```

```
        NAME            = LSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 114
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = LSE_Z
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 124
        BYTES           = 9
        DESCRIPTION     = "S/C position Z-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = TIME_INCREMENT
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 134
        BYTES           = 7
        UNIT            = "s"
        DESCRIPTION     = "Time difference between start of integration
                           periods of subsequent measurements in units
                           of seconds"
        FORMAT          = "F7.3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 15
        NAME            = BIAS
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 142
        BYTES           = 280
        ITEM_BYTES      = 6
        ITEMS           = 40
        ITEM_OFFSET     = 7
        DESCRIPTION     = "Bias voltage"
        UNIT            = "V"
        FORMAT          = "F6.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 16
        NAME            = MEASUREMENT
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 422
        BYTES           = 520
        ITEM_BYTES      = 12
        ITEMS           = 40
        ITEM_OFFSET     = 13
        DESCRIPTION     = "Measurement value"
```

```
        UNIT            = "A"
        FORMAT          = "E12.5E3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 17
        NAME            = FLAGS
        DATA_TYPE       = CHARACTER
        START_BYTE      = 943
        BYTES           = 760
        ITEM_BYTES      = 16
        ITEMS           = 40
        ITEM_OFFSET     = 19
        DESCRIPTION     = "16th (LS) flag:
                              0 = the result is checked and found correct
                              1 = the result is checked and possibly corrected,
                                  warnings concerning quality
                              2 = the result is checked, and found unreliable
                                  (no corrections)
                              9 = the result is unchecked
                            15th flag:
                               F = frequency measurement,
                               p = original pulse measurement,
                               P = corrected pulse measurement
                            14th flag:
                               1 = the first measurement in an
                                   measurement vector,
                               _ = following measurements
                            13th flag:
                               R = the reference voltage was
                                   fluctuating during this measurement,
                               _ = the reference voltage was OK
                                   (the reference voltage value is obtained
                                   from the housekeeping data)"
        FORMAT          = "A16"
END_OBJECT              = COLUMN
```

4.3.7 Calibrated electric field data product

N/A. No electric data field products are included in the present datasets.

4.3.8 Calibrated wave data

4.3.8.1 General description

Each row of calibrated wave data has the following components:

- Spacecraft time in UTC, ASCII format (time of the first measurement point of the wave measurement)
- Spacecraft time in MJD2000
- -X probe shadow status flag (No shadow, S/C shadow, Earth or Moon umbra, etc.)
- Angles between S/C –X, -Y and -Z axis and Sun
- Angle between S/C +Z axis and solar array +Z axis
- S/C position in GSE coordinates: X, Y, Z

- S/C position in LSE coordinates: X, Y, Z
- Time increment in seconds: Delta time between two measurement points of the measurement
- Wave data –X bias voltage
- Wave data +X bias voltage
- Wave power vector: wave power at steps 5000 Hz, 2500 Hz, 1250 Hz, 625 Hz, 313 Hz, 156 Hz, 78 Hz, 39 Hz, 20 Hz, 10 Hz.
- Vector containing status flags for each measurement point. Details of the flag as in the label example below.

4.3.8.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 305
FILE_RECORDS                  = 144
LABEL_RECORDS                 =  9

/* POINTER TO DATA OBJECT */
^TABLE                        = 10

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_00235M050228_W_WA_10_CAL.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-4-REFDR-EP-MONITORING2-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 4 REFDR EP-MONITORING2 V1.0"
PRODUCT_ID                    = "SP_00235M050228_W_WA_10_CAL.TAB"
PRODUCT_TYPE                  = "REFDR"
PRODUCT_CREATION_TIME         = 2006-01-26
PROCESSING_LEVEL_ID           = 4
PROCESSING_LEVEL_DESC         = "Calibrated data"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
INSTRUMENT_HOST_NAME          = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                   = "PLASMA ENVIRONMENT"
TARGET_NAME                   = "PLASMA"
TARGET_DESC                   = "Spacecraft potential and surrounding plasma"
START_TIME                    = 2005-02-28T21:46:40
STOP_TIME                     = 2005-02-28T23:22:00
SPACECRAFT_CLOCK_START_COUNT = " 8/0031911897.44531"
SPACECRAFT_CLOCK_STOP_COUNT  = " 8/0031917617.48047"
PRODUCER_ID                   = "FMI"
PRODUCER_INSTITUTION_NAME     = "Finnish Meteorological Institute"
PRODUCER_FULL_NAME            = "Dr. Anssi Malkki"
INSTRUMENT_ID                 = "SPEDE"
INSTRUMENT_NAME               = "SPACECRAFT POTENTIAL, ELECTRON AND
```

```
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID            = "WA"
INSTRUMENT_MODE_DESC          = "Wave measurement (Voltage mode)"
DATA_QUALITY_ID               = -1
DATA_QUALITY_DESC             = "-1 = not checked
                                 Calibration tables: bias 1.0 background 1.0
                                 frequency_to_current 1.0"
INSTRUMENT_TYPE               = "PLASMA INSTRUMENT"

OBJECT                        = TABLE
        INTERCHANGE_FORMAT    = ASCII
        ROWS                  = 144
        ROW_BYTES             = 303
        ROW_SUFFIX_BYTES      = 2
        COLUMNS               = 16
        NAME                  = SPEDE_WAVE_MEASUREMENT
        DESCRIPTION           = "SPEDE power spectrum"
        ^STRUCTURE            = "SPEDE_WAVE.FMT"
END_OBJECT                    = TABLE
END
```

SPEDE_WAVE.FMT

```
OBJECT                   = COLUMN
        COLUMN_NUMBER    = 1
        NAME             = DATE
        DATA_TYPE        = TIME
        START_BYTE       = 1
        BYTES            = 23
        DESCRIPTION      = "S/C clock date in UTC"
        FORMAT           = A22
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 2
        NAME             = JULIAN_DATE
        DATA_TYPE        = ASCII_REAL
        START_BYTE       = 25
        BYTES            = 14
        DESCRIPTION      = "S/C clock date in Modified Julian Date 2000"
        FORMAT           = "F14.8"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 3
        NAME             = SHADOW
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 40
        BYTES            = 1
        DESCRIPTION      = "Status flag, if the SPEDE -X probe is in shadow
                            or not:
                            0 = in sun
                            1 = in S/C shadow
                            2 = in Earth or Moon umbra
                            3 = in S/C and Earth or Moon umbra
                            4 = in Earth or Moon penumbra
                            5 = in S/C shadow and Earth or Moon penumbra
                            9 = unknown situation"
```

```
        FORMAT          = "I1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = SC_MX_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 42
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -X-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = SC_MY_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 50
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Y-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = SC_MZ_SUN_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 58
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           -Z-axis and the sun direction"
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = SC_SA_ANGLE
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 66
        BYTES           = 7
        DESCRIPTION     = "The angular separation between the spacecraft
                           +Z-axis and the solar array +Z-axis."
        UNIT            = "Deg"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 8
        NAME            = GSE_X
        DATA_TYPE       = ASCII_REAL
```

```
        START_BYTE      = 74
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 9
        NAME            = GSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 84
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 10
        NAME            = GSE_Z
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 94
        BYTES           = 9
        DESCRIPTION     = "S/C position Z-component in GSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 11
        NAME            = LSE_X
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 104
        BYTES           = 9
        DESCRIPTION     = "S/C position X-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 12
        NAME            = LSE_Y
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 114
        BYTES           = 9
        DESCRIPTION     = "S/C position Y-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 13
        NAME            = LSE_Z
```

```
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 124
        BYTES           = 9
        DESCRIPTION     = "S/C position Z-component in LSE coordinates"
        UNIT            = "km"
        MISSING_CONSTANT= "1.E32"
        FORMAT          = "F9.1"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 14
        NAME            = TIME_INCREMENT
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 134
        BYTES           = 7
        UNIT            = "s"
        DESCRIPTION     = "Time difference between start of integration
                           periods of subsequent measurements in units
                           of seconds"
        FORMAT          = "F7.3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 15
        NAME            = MINUS_X_BIAS
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 142
        BYTES           = 6
        DESCRIPTION     = "wave data -X bias voltage"
        UNIT            = "V"
        FORMAT          = "F6.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 16
        NAME            = PLUS_X_BIAS
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 149
        BYTES           = 6
        DESCRIPTION     = "wave data +X bias voltage"
        UNIT            = "V"
        FORMAT          = "F6.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 17
        NAME            = WAVE_POWER
        DATA_TYPE       = ASCII_REAL
        START_BYTE      = 156
        BYTES           = 130
        ITEM_BYTES      = 12
        ITEMS           = 10
        ITEM_OFFSET     = 13
        DESCRIPTION     = "Wave power at the frequency step,
                           starting from 5 kHz, then decreasing
                           by half in each step:
                           item  1: 5000 Hz
                           item  2: 2500 Hz
                           item  3: 1250 Hz
```

```
                              item  4:  625 Hz
                              item  5:  313 Hz
                              item  6:  156 Hz
                              item  7:   78 Hz
                              item  8:   39 Hz
                              item  9:   20 Hz
                              item 10:   10 Hz.
                              The power is calculated from the raw data with
                              the formula p = raw^2/(2*N^3)"
        FORMAT              = "E12.5E3"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
        COLUMN_NUMBER       = 18
        NAME                = FLAGS
        DATA_TYPE           = CHARACTER
        START_BYTE          = 287
        BYTES               = 16
        DESCRIPTION         = "16th (LS) flag:
                                0 = the result is checked and found correct
                                1 = the result is checked and possibly corrected,
                                    warnings concerning quality
                                2 = the result is checked, and found unreliable
                                    (no corrections)
                                9 = the result is unchecked
                              15th flag:
                                 F = frequency measurement,
                                 p = original pulse measurement,
                                 P = corrected pulse measurement,
                                 _ = not applicaple (as in wave measurement)
                              14th flag:
                                 1 = the first measurement in an
                                     measurement vector,
                                 _ = following measurements
                              13th flag:
                                 R = the reference voltage was
                                     fluctuating during this measurement,
                                 _ = the reference voltage was OK
                                     (the reference voltage value is obtained
                                     from the housekeeping data)"
        FORMAT              = "A16"
END_OBJECT                  = COLUMN
```

4.3.9 Calibrated housekeeping data (ancillary product)

4.3.9.1 General description

Each row of calibrated housekeeping data product has the following components:

- Spacecraft time in UTC, ASCII format (time of the measurement)
- Spacecraft time in MJD2000
- Reference voltage of –X probe in Volts (nominal value ≈ 2.5 V)
- Reference voltage of +X probe in Volts (nominal value ≈ 2.5 V)
- Temperature of +X channel electronics in Celcius degrees
- Ground reference voltage in Volts

- Status flag vector:
  1st flag: R = reference fluctuation, _ = no fluctuation (fluctuation means that raw value was outside nominal values of 95-105).
  2nd (LS) flag: 0 = the result is checked and found correct
  1 = the result is checked and possibly corrected, warnings concerning quality 2 = the result is checked, and found unreliable (no corrections)
  9 = the result is unchecked

Fluctuation of a reference voltage can be clearly seen in abnormally high or low reference voltage values. Also the scientific measurements performed at that time with the fluctuating probe cannot be trusted. In case of probe +X, fluctuating reference voltage also affects temperature measurement.

Reference fluctuation flags ('R') in status vectors of Level 2 scientific products (electron/ion flux and plasma data) are obtained from ancillary housekeeping data.

4.3.9.2 Label example

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2006-01-03, Jouni Ryno, FMI, initial release"
RELEASE_ID                    = 0001
REVISION_ID                   = 0000

/* FILE FORMAT */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 74
FILE_RECORDS                  = 16
LABEL_RECORDS                 = 36

/* POINTER TO DATA OBJECT */
^TABLE                        = 37

/* GENERAL DATA DESCRIPTION PARAMETERS */
FILE_NAME                     = "SP_00135M050201_HK_CAL.TAB"
DATA_SET_ID                   = "S1-X-SPEDE-4-REFDR-EP-MONITORING2-V1.0"
DATA_SET_NAME                 = "SMART1 PLASMA SPEDE 4 REFDR EP-MONITORING2 V1.0"
PRODUCT_ID                    = "SP_00135M050201_HK_CAL.TAB"
PRODUCT_TYPE                  = "ANCDR"
PRODUCT_CREATION_TIME         = 2006-01-26
PROCESSING_LEVEL_ID           = 4
PROCESSING_LEVEL_DESC         = "Calibrated data"
MISSION_ID                    = "SMART1"
MISSION_NAME                  = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
INSTRUMENT_HOST_ID            = "S1"
INSTRUMENT_HOST_NAME          = "SMALL MISSIONS FOR ADVANCED RESEARCH
 AND TECHNOLOGY"
TARGET_TYPE                   = "PLASMA ENVIRONMENT"
TARGET_NAME                   = "PLASMA"
TARGET_DESC                   = "Spacecraft potential and surrounding plasma"
START_TIME                    = 2005-02-01T05:04:34
STOP_TIME                     = 2005-02-01T12:34:34
SPACECRAFT_CLOCK_START_COUNT = " 8/0029518991.10550"
SPACECRAFT_CLOCK_STOP_COUNT  = " 8/0029545991.31640"
PRODUCER_ID                   = "FMI"
PRODUCER_INSTITUTION_NAME     = "Finnish Meteorological Institute"
```

```
PRODUCER_FULL_NAME            = "Dr. Anssi Malkki"
INSTRUMENT_ID                 = "SPEDE"
INSTRUMENT_NAME               = "SPACECRAFT POTENTIAL, ELECTRON AND
 DUST EXPERIMENT"
INSTRUMENT_MODE_ID            = "N/A"
INSTRUMENT_MODE_DESC          = "Not applicable"
DATA_QUALITY_ID               = -1
DATA_QUALITY_DESC             = "-1 = not checked
                                 Calibration tables: bias 1.0 background 1.0
                                 frequency_to_current 1.0"
INSTRUMENT_TYPE               = "PLASMA INSTRUMENT"

OBJECT                        = TABLE
        INTERCHANGE_FORMAT    = ASCII
        ROWS                  = 16
        ROW_BYTES             = 72
        ROW_SUFFIX_BYTES      = 2
        COLUMNS               = 7
        NAME                  = SPEDE_HK
        ^STRUCTURE    = "SPEDE_HK.FMT"
END_OBJECT                    = TABLE
END
```

SPEDE_HK.FMT:

```
OBJECT                   = COLUMN
        COLUMN_NUMBER    = 1
        NAME             = DATE
        DATA_TYPE        = TIME
        START_BYTE       = 1
        BYTES            = 23
        DESCRIPTION      = "S/C clock date in UTC"
        FORMAT           = A22
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 2
        NAME             = JULIAN_DATE
        DATA_TYPE        = ASCII_REAL
        START_BYTE       = 25
        BYTES            = 14
        DESCRIPTION      = "S/C clock date in Modified Julian Date 2000"
        FORMAT           = "F14.8"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
        COLUMN_NUMBER    = 3
        NAME             = REF_VOLT_MINUS_X_CAL
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 40
        BYTES            = 6
        DESCRIPTION      = "2.5V -X reference voltage, data value with
                             frequency measurement using 4ms integration.
                            Calculated from:
                               (REF_VOLT_MINUS_X-GROUND)*250/-10039.6"
        UNIT             = "V"
        FORMAT           = "F6.3"
END_OBJECT               = COLUMN
```

```
OBJECT                  = COLUMN
        COLUMN_NUMBER   = 4
        NAME            = REF_VOLT_PLUS_X_CAL
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 47
        BYTES           = 6
        DESCRIPTION     = "2.5V +X reference voltage, data value with
                            frequency measurement using 4ms integration
                           Calculated from:
                              (REF_VOLT_PLUS_X-GROUND)*250/-10039.6"
        UNIT            = "V"
        FORMAT          = "6.3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 5
        NAME            = TEMP_PLUS_X_CAL
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 54
        BYTES           = 6
        DESCRIPTION     = "Temperature of +X channel electronics, data value
                           with frequency measurement using 20ms integration
                           -1280, resolution 3C degree.
                           Calculated from:
                             -3.18314*(TEMP_PLUS_X-7.8*(GROUND-200))+603.51"
        UNIT            = "DegC"
        FORMAT          = "7.2"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 6
        NAME            = GROUND_CAL
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 62
        BYTES           = 6
        DESCRIPTION     = "Ground reference voltage, data value with frequency
                           measurement using 4ms integration
                           Calculated from:
                              (GROUND-200)*250/-10033.0"
        UNIT            = "V"
        FORMAT          = "6.3"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
        COLUMN_NUMBER   = 7
        NAME            = STATE
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 70
        BYTES           = 2
        DESCRIPTION     = "2nd (LS) flag:
                             0 = the result is checked and found correct
                             1 = the result is checked and possibly corrected,
                                 warnings concerning quality
                             2 = the result is checked, and found unreliable
                                 (no corrections)
                             9 = the result is unchecked
                           1st flag:
                              R = the reference voltage was
                                  fluctuating during this measurement,
```

```
                          _ = the reference voltage was OK"
        FORMAT          = "A2"
END_OBJECT              = COLUMN
```

4.4 Indices – summary tables of data products

Each data set has an index that summarizes the data products (files). The index table contains parameters that identify each product found in the archive and describes the observation / instrument state and its related information.

4.4.1 Level 1b

The parameters chosen for the index tables describe the product type (science, configuration table dump, or software dump), start and end time of the product in UTC and spacecraft clock seconds, and for science also: measurement orbit number, probe (1,2, or W), and bias type (probe current, or probe voltage).

Parameters not applicable to the non-science products are set to N/A in the index table. Details of the parameters are given in the index label below:

```
PDS_VERSION_ID              = PDS3

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 229
FILE_RECORDS                = 79
^INDEX_TABLE                = "INDEX.TAB"

DATA_SET_ID                 = "S1-X-SPEDE-2-EDR-LEOP-CALIBRATION-V1.0"
PRODUCT_ID                  = "INDEX"
VOLUME_ID                   = "N/A"
PRODUCT_CREATION_TIME       = 2005-08-15
MISSION_ID                  = "SMART1"
INSTRUMENT_HOST_ID          = "S1"
INSTRUMENT_ID               = "SPEDE"

OBJECT                      = INDEX_TABLE
       INTERCHANGE_FORMAT   = ASCII
       ROWS                 = 79
       COLUMNS              = 12
       ROW_BYTES            = 227
       INDEX_TYPE           = SINGLE
       DESCRIPTION          = "The index table contains parameters that
                               identify each product found in the archive
                               and describes the observation/instrument
                               state and related information for it."

    OBJECT                  = COLUMN
        NAME                = FILE_SPECIFICATION_NAME
        COLUMN_NUMBER       = 1
        DATA_TYPE           = "CHARACTER"
        START_BYTE          = 2
        BYTES               = 52
        FORMAT              = "A52"
        DESCRIPTION         = "Complete file name."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
```

```
        NAME                   = PRODUCT_ID
        COLUMN_NUMBER          = 2
        DATA_TYPE              = "CHARACTER"
        START_BYTE             = 57
        BYTES                  = 31
        FORMAT                 = "A31"
        DESCRIPTION            = "Product ID."
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
        NAME                   = PRODUCT_TYPE
        COLUMN_NUMBER          = 3
        DATA_TYPE              = "CHARACTER"
        START_BYTE             = 91
        BYTES                  = 7
        FORMAT                 = "A7"
        DESCRIPTION            = "Product type, either SCIENCE, CONFIG or
                                  SWDUMP"
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
        NAME                   = START_TIME
        COLUMN_NUMBER          = 4
        DATA_TYPE              = TIME
        START_BYTE             = 101
        BYTES                  = 19
        FORMAT                 = "A19"
        DESCRIPTION            = "Start time of the product."
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
        NAME                   = STOP_TIME
        COLUMN_NUMBER          = 5
        DATA_TYPE              = TIME
        START_BYTE             = 123
        BYTES                  = 19
        FORMAT                 = "A19"
        DESCRIPTION            = "Stop time of the product."
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
        NAME                   = SPACECRAFT_CLOCK_START_COUNT
        COLUMN_NUMBER          = 6
        DATA_TYPE              = TIME
        START_BYTE             = 145
        BYTES                  = 19
        FORMAT                 = "A19"
        DESCRIPTION            = "Start time of the product presented as
                                  on-board clock."
    END_OBJECT                 = COLUMN

    OBJECT                     = COLUMN
        NAME                   = SPACECRAFT_CLOCK_STOP_COUNT
        COLUMN_NUMBER          = 7
        DATA_TYPE              = TIME
        START_BYTE             = 167
        BYTES                  = 19
        FORMAT                 = "A19"
        DESCRIPTION            = "Stop time of the product presented as
```

```
                                on-board clock."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = ORBIT
        COLUMN_NUMBER       = 8
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 189
        BYTES               = 5
        FORMAT              = "A5"
        DESCRIPTION         = "Spacecraft orbit number"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PRODUCT_CREATION_TIME
        COLUMN_NUMBER       = 9
        DATA_TYPE           = TIME
        START_BYTE          = 197
        BYTES               = 10
        FORMAT              = "A10"
        DESCRIPTION         = "Time when the product was created."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PROBE
        COLUMN_NUMBER       = 10
        DATA_TYPE           = CHARACTER
        START_BYTE          = 210
        BYTES               = 3
        DESCRIPTION         = "1 = -X probe, 2 = +X probe,
                               W = wave measurement"
        FORMAT              = A3
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = BIAS_TYPE
        COLUMN_NUMBER       = 11
        DATA_TYPE           = CHARACTER
        START_BYTE          = 216
        BYTES               = 3
        DESCRIPTION         = "I = probe current, V = probe voltage"
        FORMAT              = A3
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = LENGTH
        COLUMN_NUMBER       = 12
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 222
        BYTES               = 3
        DESCRIPTION         = "Measurement vector length"
        FORMAT              = I3
    END_OBJECT              = COLUMN
END_OBJECT                  = INDEX_TABLE
END
```

4.4.2 Level 2

The parameters chosen for level 2 index tables describe the product type (electron/ion flux, plasma data (sweep) or housekeeping), start and end time of the product in UTC and spacecraft clock seconds, measurement orbit number, and probe (1,2, or W).

Details of the parameters are given in the index label below:

```
PDS_VERSION_ID              = PDS3

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 213
FILE_RECORDS                = 56
^INDEX_TABLE                = "INDEX.TAB"

DATA_SET_ID                 = "S1-X-SPEDE-4-REFDR-LEOP-CALIBRATION-V1.0"
PRODUCT_ID                  = "INDEX"
VOLUME_ID                   = "N/A"
PRODUCT_CREATION_TIME       = 2005-09-09
MISSION_ID                  = "SMART1"
INSTRUMENT_HOST_ID          = "S1"
INSTRUMENT_ID               = "SPEDE"

OBJECT                      = INDEX_TABLE
       INTERCHANGE_FORMAT   = ASCII
       ROWS                 = 56
       COLUMNS              = 10
       ROW_BYTES            = 213
       INDEX_TYPE           = SINGLE
       DESCRIPTION          = "The index table contains parameters that
                               identify each product found in the archive
                               and describes the observation/instrument
                               state and related information for it."

    OBJECT                  = COLUMN
        NAME                = FILE_SPECIFICATION_NAME
        COLUMN_NUMBER       = 1
        DATA_TYPE           = "CHARACTER"
        START_BYTE          = 2
        BYTES               = 52
        FORMAT              = "A52"
        DESCRIPTION         = "Complete file name."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PRODUCT_ID
        COLUMN_NUMBER       = 2
        DATA_TYPE           = "CHARACTER"
        START_BYTE          = 57
        BYTES               = 31
        FORMAT              = "A31"
        DESCRIPTION         = "Product ID."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PRODUCT_TYPE
        COLUMN_NUMBER       = 3
        DATA_TYPE           = "CHARACTER"
        START_BYTE          = 91
```

```
    BYTES                   = 5
    FORMAT                  = "A5"
    DESCRIPTION             = "Product type, either
                               FLUX for the electron flux data,
                               SWEEP for the plasma data,
                               WAVE for wavelet data or
                               HK for the housekeeping data."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = START_TIME
    COLUMN_NUMBER           = 4
    DATA_TYPE               = TIME
    START_BYTE              = 99
    BYTES                   = 19
    FORMAT                  = "A19"
    DESCRIPTION             = "Start time of the product."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = STOP_TIME
    COLUMN_NUMBER           = 5
    DATA_TYPE               = TIME
    START_BYTE              = 121
    BYTES                   = 19
    FORMAT                  = "A19"
    DESCRIPTION             = "Stop time of the product."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_START_COUNT
    COLUMN_NUMBER           = 6
    DATA_TYPE               = TIME
    START_BYTE              = 143
    BYTES                   = 19
    FORMAT                  = "A19"
    DESCRIPTION             = "Start time of the product presented as
                               on-board clock."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_STOP_COUNT
    COLUMN_NUMBER           = 7
    DATA_TYPE               = TIME
    START_BYTE              = 165
    BYTES                   = 19
    FORMAT                  = "A19"
    DESCRIPTION             = "Stop time of the product presented as
                               on-board clock."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = ORBIT
    COLUMN_NUMBER           = 8
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 187
    BYTES                   = 5
    FORMAT                  = "A5"
    DESCRIPTION             = "Spacecraft orbit number"
```

```
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PRODUCT_CREATION_TIME
        COLUMN_NUMBER       = 9
        DATA_TYPE           = TIME
        START_BYTE          = 195
        BYTES               = 10
        FORMAT              = "A10"
        DESCRIPTION         = "Time when the product was created."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        NAME                = PROBE
        COLUMN_NUMBER       = 10
        DATA_TYPE           = CHARACTER
        START_BYTE          = 208
        BYTES               = 3
        DESCRIPTION         = "1 = -X probe, 2 = +X probe,
                               W = wave measurement"
        FORMAT              = A3
    END_OBJECT              = COLUMN
END_OBJECT                  = INDEX_TABLE
END
```

5 Appendix: Available Software to read PDS files

No software is included in present datasets.

6 Appendix: Example of Directory Listing of Data Set: S1-X-SPEDE-4-REFDR-LEOP-CALIBRATION-V1.0

```
TOP-LEVEL DIRECTORY
|
|- AAREADME.TXT                       README document for the dataset.
|
|- VOLDESC.CAT                        Description of the data volume
|
|
|- [CALIB]                            Calibration data directory.
|      |
|      |- CALINFO.TXT                 Info about CALIB directory contents.
|      |
|      |- SPEDE_BIAS_CALIB.TAB        Lookup table for bias calibration.
|      |
|      |- SPEDE_CURRENT_CALIB.TAB     Coefficients for current calibration.
|
|
|- [CATALOG]                          The directory containing information
|       |                             about SPEDE LEOP calibration data set.
|       |
|       |- CATINFO.TXT                Info about CATALOG directory contents.
|       |
|       |- MISSION.CAT                SMART-1 mission description, provided
|       |                             by SMART-1 project.
|       |
|       |- INSTHOST.CAT               SMART-1 spacecraft description,
|       |                             provided by SMART-1 project.
|       |
|       |- INST.CAT                   SPEDE instrument description.
|       |
|       |- DATASET.CAT                Data set description.
|       |
|       |- SOFT.CAT                   Software description. Empty.
|
|       |- REFERENCES.CAT             References. Empty.
|       |
|       |- RELEASE.CAT                Release information.
|
|
|- [DATA]                             The directory for instrument data
|      |                              products.
|      |
|      |- [200309]                    September 2003 data products.
|      |      |
|      |   data products
|      |
|      |- [200310]                    October 2003 data products.
|             |
|         data products
|
|
|- [DOCUMENT]                         The directory containing documentation.
|       |
|       |- DOCINFO.TXT                Info about DOCUMENT directory contents.
|       |
```

```
|       |- SPEDESIS.ASC                 SPEDE PDS interface description in
|       |                               ASCII format.
|       |
|       |- SPEDESISXXX.JPG              Pictures to SPEDESIS document in JPG.
|       |
|       |- SPEDESIS.PDF                 SPEDE PDS interface description in
|       |                               PDF format (including pictures).
|       |
|       |- SPEDESIS.LBL                 PDS detached label for SPEDESIS doc.
|       |
|       |- SPEDEPAPER.ASC               SPEDE paper in ASCII format.
|       |
|       |- SPEDEPAPER.PDF               SPEDE paper in PDF format.
|       |
|       |- SPEDEPAPER.LBL               PDS detached label for SPEDE paper.
|
|
|
|- [INDEX]                             The directory for INDEX files.
|     |
|     |- INDEX.LBL                      A PDS detached label describing
|     |                                 INDEX.TAB
|     |- INDEX.TAB                      Tabular summary of data files.
|     |
|     |- INDXINFO.TXT                   Info about INDEX directory contents.
|
|
|- [LABEL]                             The directory for formatting containers
|      |                                used by attached labels.
|      |
|      |- LABINFO.TXT                   Info about LABEL directory contents.
|      |
|      |- SPEDE_FLUX.FMT                Format file used by electron/ion flux
|      |                                data product label.
|      |- SPEDE_HK.FMT                  Format file used by housekeeping
|      |                                data product labels.
|      |- SPEDE_PLASMA_20.FMT           Format file for 20-point SPEDE
|      |                                plasma data product labels.
|      |- SPEDE_PLASMA_40.FMT           Format file for 40-point SPEDE
|      |                                plasma data product labels.
```