ROSETTA-NAVCAM

to

Planetary Science Archive Interface Control Document

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Table 1: Distribution List.

Recipient	Organisation	Contact
Rosetta SGS	ESA/ESAC	rsgs_dev@sciops.esa.int

Table 2: Document Change Log.

Date of Update	Update to Document	New Version	Name
2010 Oct 20	Creation of document	V 1.0	Colin Archibald
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2013 Aug 30	Corrections in Sections 2.6.1, 3.1.2	V 3.1	Bernhard Geiger

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List of Acronyms

A/D Analogue-to-Digital

AIU Avionics Interface Unit

AOCMS Attitude and Orbit Control Measurement System

AOCS Attitude and Orbit Control System

APID Application Process Identifier

ASIC Application Specific Integrated Circuit

BIOS Basic Input/Output System

CAM-BAF Camera Baffle

CAM-EU Camera Electronic Unit

CAM-OH Camera Optical Head

CCD Charge Coupled Device

CDS Correlated Double Sampling

CMOS Complimentary Metal Oxide Semiconductor

CODMAC Committee On Data Management, Archiving, and Computation

DDS Data Distribution System

DMS Data Management System

DNA Defocused imaging with No Attenuation

DSP Digital Signal Processing

EAICD Experimenter to (Science) Archive Interface Control Document

ESA European Space Agency

ESAC European Space Astronomy Centre

ESOC European Space Operations Centre

EU Electronic Unit

FA Focused imaging with Attenuation

FIFO First In / First Out

FNA Focused imaging with No Attenuation

FOV Field of View

ftp file transfer protocol

GSE Ground Support Equipment

HC Health-check

HK Housekeeping

I/F Interface

I/O Input / Output

JPEG Joint Photographic Experts Group

LED Light Emitting Diode

MOS Metal Oxide Semiconductor

MSPS Mobilisation Stationing and Planning System

NASA National Aeronautics and Space Administration

NavCam Navigation Camera

OBT On-Board Time

OH Optical Head

PDS Planetary Data System

PSA Planetary Science Archive

PSA-DH Planetary Science Archive Data Handler

RAM Random Access Memory

RH reference hole

RL Rosetta Lander

RMOC Rosetta Mission Operations Centre

RO Rosetta Orbiter

ROM Read Only Memory

RSSD Research and Scientific Support Department

S/C Spacecraft

S/W Software

SCIOPS Science Operations Department

SEU Single Event Upset

SSMM Solid State Mass Memory

STR Autonomous Attitude Star Tracker

TC Telecommand

TM Telemetry

TTL Transistor-Transistor Logic

UTC Coordinated Universal Time

1 Introduction

1.1 Purpose and Scope

This Experimenter to (Science) Archive Interface Control Document (EAICD) has two main purposes. Firstly, it gives users of the Navigation Camera (NavCam) instrument data a detailed description of the product and how it was generated, including data sources and destinations. Secondly, it acts as an interface between the NavCam data producers and the data archiving authority. One point of note is that there are two identical NavCams installed on the Rosetta Spacecraft (S/C), however, for the purposes of this document the singular is generally referred to when discussing the NavCams.

1.2 Archiving Authorities

The Planetary Data System (PDS) standard is used as the archiving standard by:

- the National Aeronautics and Space Administration (NASA) for U.S. Planetary Missions, implemented by PDS;
- the European Space Agency (ESA) for European Planetary Missions, implemented by the Science Operations Department (SCIOPS) of ESA.

ESA implements an on-line science archive, the Planetary Science Archive (PSA), for several reasons:

- to support and ease data ingestion;
- to offer additional services to the scientific user community and science operations teams, such as, e.g.:
    1. search queries that allow searches across instruments, missions and scientific disciplines;
    2. several data delivery options, such as:
        - direct download of data products, linked files and data sets;
        - file transfer protocol (ftp) download of data products, linked files and data sets.

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

1.3 Contents

This document describes the data flow of the NavCam instrument on Rosetta from the Spacecraft (S/C) until the insertion into the PSA by ESA. It includes information on how data were processed, formatted, labelled and uniquely identified; along with discussing the general naming schemes for NavCam data volumes, data sets, data and label files. The standards used to generate such products are explained and the design of the data set structure and data products are also given within this document.

1.4 Intended Readership

The staff of the archiving authority (PSA, ESA, Research and Scientific Support Department (RSSD), SCIOPS and operations team) along with any potential user of the NavCam data.

1.5 Applicable Documents

- AD1: Rosetta Archive Generation, Validation and Transfer Plan, January 10, 2006, RO-EST-PL-5011
- AD2: Rosetta Archive Conventions, Mar 25, 2010, RO-EST-TN-3372

1.6 Reference Documents

- RD1: Rosetta Navigation Camera User's Manual, January 2002, RO-GAL-MA-2008
- RD2: Rosetta Navigation Camera Design Description, January 2002, RO-GAL-RP-2007
- RD3: Navigation Camera TM/TC and Software ICD, November 2001, RO-MMT-IF-2007
- RD4: Rosetta SPICE Frame Kernel, ROS_V18.TF

1.7 Contact Names and Addresses

Table 3: List of contacts for the NavCam instrument archive.

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

In order to fully satisfy the requirements and objectives regarding navigation and attitude control, Galileo Avionica developed a mission-specific Navigation Camera for Rosetta by building on the heritage of existing models. Table 4 provides an overview of some of the physical and operational parameters of the NavCam.

Table 4: Overview of NavCam properties.

Parameter	**Value**	**Comment**
Mass CAM-OH	6.050 kg	
Mass CAM-EU	2.700 kg	
Mass CAM-BAF	1.408 kg	
Total Mass	10.158 kg	
Total Power	16.8 W	
Field of View	$5° \times 5°$	
Sensor Type	CCD	
Number of Pixels	1024×1024	
Focal Length	152.5 mm	
Pixel Size	13 μm	
Pixel Angular Size	17 arcsec	
Aperture	70 mm 30 mm	Non-Attenuated Modes Attenuated Mode
F/Number	f/2.2 f/5.1	Non-Attenuated Modes Attenuated Mode
Limit Magnitude	$M_v = 11$	Exposure time 5 s, SNR $\geq$ 5
Saturation Magnitude	$M_v = 1.6$ $M_v = 0.8$	Whole spectral range, G2 Class; exposure time = 10ms
Integration time	10 ms 30 s	Minimum, maximum
Bias error (1 σ)	0.2 pixels	$M_v = 11$, exposure time = 5 s, Defocused mode
NEA (1 σ)	0.1 pixels	$M_v = 11$, exposure time = 5 s, Defocused mode
Commanded window size	20×20 1024×1024	Minimum pixel array Maximum pixel array
CCD Operative temp. range	-50° +50°	Minimum Maximum
CCD Performance Temp. Range	-25° 0°	Minimum Maximum

2.1 Architectures and Configurations

The NavCam comprises a Camera Optical Head (CAM-OH), a Camera Electronic Unit (CAM-EU) and a Camera Baffle (CAM-BAF).

2.1.1 CAM-OH

The CAM-OH for the Rosetta NavCam consists of a Charge Coupled Device (CCD) detector and a set of electronics, including:

- PROXIMITY ELECTRONICS:
  1. CCD drivers;
  2. CCD bias and phase voltage regulators;
  3. the analogue signal processor:
     - the pre-amplifier;
     - the amplifier with variable gain; and,
     - the Correlated Double Sampling (CDS) amplifying circuit.
  4. two multiplexers;
  5. the Analogue-to-Digital (A/D) converter; and,
  6. the interfaces for:
     - the temperature transducers; and,
     - the Light Emitting Diodes (LEDs) and photodiodes for the cover / attenuation mechanism control.
- TIMING SEQUENCER and CONTROL LOGIC:
  1. CCD sequencer and analogue channel control; and,
  2. data interface.
- DIGITAL SIGNALS and POWER INTERFACES:
  1. digital lines Interface (I/F);
  2. command I/F; and,
  3. data I/F.

All the logic operations that need to be carried out by the optical head are commanded via the Application Specific Integrated Circuit (ASIC); these include the CCD timing control and digital data and the commanded interfaces of the Optical Head (OH) with the Electronic Unit (EU).

The CAM-OH supports the attenuation / cover mechanism in front of the optics. This includes three exchangeable optical elements in order to make possible the following functions, the second line of each provides the reader with the Rosetta mission specific keyword for ROSETTA:CAM_COVER_POSITION (Summarised in Table 16):

- Defocused imaging with No Attenuation (DNA)
  Specific keyword value DEFOC_NATT;
- Focused imaging with Attenuation (FA)
  Specific keyword value FOC_ATT; and,
- Focused imaging with No Attenuation (FNA)
  Specific keyword value FOC_NATT.

All three positions of the mechanism provide protection to the internal section of the NavCam from debris in the space environment.

Configuration

The CCD enables the NavCam to image objects in the camera Field of View (FOV) and perform the image readout out line-by-line. As the first line of pixels are interrogated and read into the EU each following line is moved pixel-by-pixel to occupy the space of the first line, thus, freeing the row of pixels at the opposing end. By operating in such a manner the NavCam can begin the next image before the first one has completed the read-out process and, hence, reduce the image lag. This can be particularly useful when having to perform a sequence of quickly resolved images, e.g. during navigation for the Rosetta Lander (RL) descent.

The ***CCD drivers*** translate Transistor-Transistor Logic (TTL) signals, produced via the timing sequencer, to the Metal Oxide Semiconductor (MOS) levels, required by the CCD, to operate correctly over the correct time-scale and drive the relatively high capacitive load presented.

Charge-shifting rates of 2 μsec are used for the vertical (parallel) transfers, while 250 nsec and 3.6 μsec rates are used for the non-processed and A/D converted pixels in the horizontal (serial) transfers respectively.

The ***CCD bias and phase voltage regulators*** supply the voltage levels to bias the CCD and the levels to which the timing signals must be translated.

The ***analogue signal processor*** uses two gain levels and again the second line gives the values for the Rosetta mission specific keyword related to this parameter - ROSETTA:CAM_GAIN (Table 16):

1. G_high - increases the grey signal level resolution when faint targets are imaged
   Specific keyword value HIGH; and,

2. G_low - used when bright targets are imaged
   Specific keyword value LOW.

The ***two multiplexers*** (8-channel Complimentary Metal Oxide Semiconductor (CMOS) HS-508A chips) are used to acquire the CCD data and all the needed Health-check (HC) signals. The CCD sequencer block of the OH ASIC selects, with a given sequence, the various channels to perform the readout of a given signal. The readout of all HC signals is performed before the readout of the CCD data.

The ***A/D converter*** is a high speed monolithic 12-bit, 1.25 Mobilisation Stationing and Planning System (MSPS), with an on-chip sample-and-hold amplifier.

The ***CCD sequencer and analogue channel control block*** produces CCD timings and (simultaneously) drives a First In / First Out (FIFO) control system for pixel storage and direct interfacing with all processor buses. It is this block that constructs the signals for the following operations:

- CCD clocking; and,
- analogue channel control:
  - clamp;
  - sample;
  - gain switch; and,
  - A/D conversion.

The sequencer opens CCD windows, selects the window gain, and, commands the CCD operations and pixel grouping. Within the OH electronics a separate sub-block is incorporated to, solely, deal with HC signal acquisition and conversion from different sources.

The sequencer can be completely re-configured by means of an external Read Only Memory (ROM); designed to store all waveforms that drive the CCD and analogue signal controls. Re-loading the external ROM and running a complete waveform sequence via the ASIC occurs at every CCD scan cycle; by doing so the possibility of a Single Event Upset (SEU) is minimized. The logic is completely synchronous and uses a single port for waveform storage in the form of a static Random Access Memory (RAM) chip with a total size of 16 Kbits.

The ***data interface*** is a small FIFO based serial link, for command outputting and pixel data inputting, general purpose bus interfacing consisting of two sub-blocks:

- Command I/F; and,
- Pixel input I/F.

The command I/F serialises a command stream (written in a small FIFO 32 by 32 processor) and sends it to the CCD sequencer. The pixel input I/F will accept the serial stream originating from the CCD sequencer and write the data in a large FIFO (1 Kb by 24 word) location, ready for reading by a microprocessor.

2.1.2 CAM-EU

The CAM-EU contains: all of the digital electronics, interfaces for data Input / Output (I/O) with the Avionics Interface Unit (AIU) and Solid State Mass Memory (SSMM), and finally, the DC/DC power converter. The ASIC used in the OH for CCD timing is designed to implement, by a dedicated section, the interfaces from the EU in the direction of the OH. Therefore, two identical ASICs are utilised in the NavCam system; one in the OH and one in the EU; to provide interfacing in both directions. The EU sends the control commands required by the OH and processes the digital signals coming from the OH to realise the target detection and tracking capabilities. In general the EU provides overall control of the instrument and comprises three main blocks, including two Digital Signal Processing (DSP) boards:

- the DSP board with NavCam processor and related interfaces;
- the DSP board with Autonomous Attitude Star Tracker (STR) processor and related interfaces; and,
- the power section.

Configuration

The common ***DC/DC converter*** module provides functioning for: conditioning, switching, conversion and distribution of the power supply from the EU and CAM-OH. It provides a common functionality that implements primary power conditioning functions and separate DC/DC conversions for both the NavCam and STR modules, including both DSPs.

Another major function of this module is to provide the programmable constant-current driver for, both, the heater in the OH and the stepper motor that actuates the NavCam attenuation / cover mechanism.

The *NavCam* ***DSP board*** controls the processing of the data from the NavCam and incorporates the following modules:

- the DSP itself;
- the memory banks;
- the DSP peripherals;
- the interfacing between the AIU, SSMM and the OH; and,
- the instrument control function, including:
  - the thermal control for the OH; and,
  - the cover / attenuation mechanism position controls.

2.1.3 CAM-BAF

The CAM-BAF provides protection against stray light produced by the sun and reflected from the planetary bodies and the satellite. This level of protection allows the tracking of faint objects.

Configuration

The CAM-BAF is mechanically supported by the S/C structure so as to avoid mechanical stress of the OH. This is done due to the required high pointing stability of the CAM-OH to its boresight in order to achieve the desired accuracies from the NavCam.

2.2 Objectives and Operating Modes

The Rosetta NavCam does not have any *scientific* objectives, as such, to speak of. Instead, the aims of this instrument are to provide the Rosetta S/C with several capabilities through a series of operating modes. In general the camera has three major functions:

1. Point Tracking;
2. Asteroid (or Extended Object) Tracking; and,
3. Imaging

and, more precisely, seven operational modes:

- OFF Mode;
- Initialisation;
- Stand-by;
- Imaging;
  — INSTRUMENT_MODE_ID = "IMAGING";
- Point-Target Tracking;
- Asteroid (Extended Object) Tracking;
  — INSTRUMENT_MODE_ID = "ASTEROID_TRACKING"; and
- Self Test.

Science data (i.e., images) can only be generated and downlinked to ground in the Imaging and Asteroid (Extended Object) Tracking modes. In the archived data sets, the used mode is indicated by the INSTRUMENT_MODE_ID keyword of the label files as indicated above (also see Table 15).

The following sections give a description of each of the operational modes and the multiple abilities they provide.

2.2.1 OFF Mode

In this mode the camera is dormant and devoid of all power.

2.2.2 Initialisation Mode

In this mode the NavCam autonomously loads and runs the bootstrap into a devoted section of the RAM at switch-on, activates the interfaces and awaits a Telecommand (TC) from the AIU. The content of *all* RAM is left unchanged - except that of the RAM location devoted to the initialisation and Software (S/W) maintenance modes - so that it may be fully tested following a specific TC being sent from the AIU. Finally, the switch to stand-by mode (start application S/W) is commanded by the AIU.

2.2.3 Stand-by Mode

In this mode the instrument achieves and maintains the nominal operating conditions, e.g. the CCD operating temperature, in order to rapidly react to the Attitude and Orbit Control Measurement System (AOCMS) commands. While operating in stand-by mode the power consumption is minimised and S/W services can be commanded quickly and easily.

2.2.4 Imaging Mode

Allows the camera to operate as a standard camera, targeting and resolving images of: the star-field in the camera FOV, extended sources such as asteroids, comets or planets in the camera FOV, or, features of the comet 67P/Churyumov-Gerasimenko during the orbits and finally the descent of the RL. This mode can be operated independently or as a sub-mode of the Asteroid (Extended Object) Tracking mode.

2.2.5 Point Target Tracking Mode

The Point Target Tracking mode has several applications when addressing the Rosetta NavCam objectives:

- *Autonomous Acquisition of a Star-Field*

This will allow the NavCam to, firstly, recognise and then lock a star-field and is accomplished by the collection and processing of images in the entire FOV without *priori* knowledge being gained from the use of other sensors. By operating in this way the NavCam / STR can perform the coarse attitude determination and evaluate manoeuvres that may need to be performed to ensure the correct pointing of the satellite is maintained.

Following from this operation is the method of Autonomous Star-Tracking.

- *Autonomous Tracking of Stars*

Autonomous Star-Tracking allows the NavCam to collect images of stars locked in the FOV (or from new stars entering the FOV) and evaluate fine attitude control manoeuvres (pitch, roll and yaw) that may need to be performed.

- *Commanded Star-Tracking*

Upon being provided with the coordinates, motion rate and magnitude of (up to) five selected stars, the NavCam can autonomously track these within the camera's FOV.

- *Provide the AIU with Position and Magnitude measurements*

The NavCam shall also be able to provide the AIU with the position and magnitude measurements of the ten brightest objects within the camera FOV. This mode can be used to provide information along with the images of deep-space; so as to allow a comparison against a catalogue of stars for determination of position and pointing direction of the Rosetta S/C.

2.2.6 Asteroid (Extended Source) Tracking Mode

The objectives to be satisfied here are essentially the same as for the autonomous star-field acquisition and tracking modes:

- *Autonomous Acquisition of Extended Sources*

This will allow the NavCam to, firstly, recognise and then lock an extended source and is accomplished by the collection and processing of images in the entire FOV without *priori* knowledge being gained from the use of other sensors. By operating in this way the NavCam / STR can perform the coarse attitude determination and evaluate manoeuvres that may need to be performed to ensure the correct pointing of the satellite is maintained.

Following from this operation is the method of Autonomous Extended Source Tracking.

- *Autonomous Tracking of Extended Sources*

Autonomous Extended Source Tracking allows the NavCam to collect images of asteroids, comets or planets locked in the FOV and evaluate fine attitude control manoeuvres (pitch, roll and yaw) that may need to be performed. The secondary outcome of this operational mode allows the instrument to evaluate rates of motion with a specified repetition rate.

2.2.7 Self-Test

This mode operates by providing, upon request, the health-check Housekeeping (HK)-Telemetry (TM) without destroying the contents of any memory locations.

2.2.8 Summary of the Operating Modes

Table 5 demonstrates a summary of each of the operating modes and provides a brief description of the scope for each.

Table 5: Summary of NavCam Operating Modes.

Mode	**Description**
OFF Mode	The NavCam is completely off and devoid of power.
Initialisation	Switch-on of NavCam.
Stand-by	Minimise power consumption and prepare for S/W commanding.
Imaging	Produces and transmits a solid image.
Point Target Tracking Mode	To recognise, lock and autonomously track a (point like) star-field providing coarse and fine attitude corrections to the AOCMS respectively. Provide position and magnitude measurements to the AIU. Track up to five stars within the FOV of given coordinates.
Asteroid (Extended Object) Tracking Mode	To recognise, lock and autonomously track an extended object, providing both coarse and fine attitude corrections to the AOCMS. Provide position and magnitude measurements to the AIU along with observed rates of motion with a specified repetition rate.
Self-test (Trouble-shooting)	Provide the HK-TM upon request.

2.3 Software for Camera Control

The camera software makes it possible to either command the NavCam from the ground or autonomously control it on board the S/C. These commands are first routed by the Data Management System (DMS) TC router then by the Attitude and Orbit Control

System (AOCS) TC router to the NavCam based on the Application Process Identifier (APID) value. The on-board instrument S/W consists of the following:

1. Application Management S/W:
    - Initialisation S/W; and,
    - Application S/W.
2. Basic Input/Output System (BIOS) and Auxiliary Functions:
    - Power-on and initialisation function (Start-up);
    - device drivers (library);
    - EU self-test functions (library);
    - EU overall self-test program (library/function); and,
    - S/W services (library).

In addition to this autonomously commanded S/W there is also a full set of TCs that can be executed by the AOCS. The initialisation S/W is used immediately after power-on (from OFF mode) and is only used during the initialisation mode. While the application S/W can be used in stand-by mode to access another mode state as well as being operated, in some instances, to transfer from one mode state to the next (if applicable). This is summarised in Table 6.

Both the initialisation and application S/W can execute the following operations:

- S/W program control;
- Communication handling;
- S/W maintenance; and,
- Board handling.

While the initialisation S/W can also perform the default readout sequence and the application S/W performs the specific tasks of:

- Housekeeping (HK) (including: thermal control, HC and memory scrubbing);
- On-Board Time (OBT) and OH handling.

Table 6: NavCam operating modes and state transitions

Mode	Event and Transition From	Event and Transition To
OFF	←***All Operative Modes:*** OFF command	→***Initialisation:*** ON command from RTU
Initialisation	←***OFF:*** ON command from RTU	→***Initialisation:*** after bootstrap completion after RAM check completion after S/W loading to RAM
	←***All Operative Modes:*** S/W reset TC	→***Stand-by:*** start application S/W TC
Stand-by	←***Initialisation:*** start application S/W TC	
	←***Imaging:*** Stand-by entering command	→***Imaging:*** Image entering command
	←***Point Target Tracking:*** stand-by entering command all targets lost	→***Point Target Tracking:*** Point target tracking entering command
	←***Asteroid Tracking:*** Stand-by entering command	→***Asteroid Tracking:*** Asteroid tracking entering command
	←***Self-Test:*** Test completion	→***Self-Test:*** Self-test entering command
Imaging	←***Stand-by:*** Imaging entering command	→***Stand-by:*** Stand-by entering command
	←***Imaging:*** Imaging entering command	→***Imaging:*** Imaging entering command
Point Target Tracking	←***Stand-by:*** Point target tracking entering/ updating command	→***Stand-by:*** Stand-by entering command All targets lost
	←***Point Target Tracking:*** Point target tracking entering/ updating command	→***Point Target Tracking:*** Point target tracking entering/ updating command
Asteroid Tracking	←***Stand-by:*** Asteroid tracking entering/ updating command	→***Stand-by:*** Stand-by entering command
	←***Asteroid Tracking:*** Asteroid tracking entering/ updating command	→***Asteroid Tracking:*** Asteroid tracking entering/ updating command
Self-Test	←***Stand-by:*** Self-test entering command	→***Stand-by:*** Self-test completion

2.4 Data Handling Process

The NavCam data will be primarily used by the Rosetta Mission Operations Centre (RMOC) team at European Space Operations Centre (ESOC), Germany, where the data will be used to help ensure the S/C's position, pointing and attitude are correct. However, to offer data to the scientific community, products produced under the imaging mode have been collated into relevant data sets. The data products are prepared by Bernhard Geiger and Michael Küppers at the European Space Astronomy Centre (ESAC), Spain. The production of the documentation to accompany and explain these products is carried out by the PSA at ESAC. The data levels (according to both PSA and Committee On Data Management, Archiving, and Computation (CODMAC) definition) considered in this documentation are described in Table 7.

Table 7: Data Processing Levels for the NavCam Data.

PSA	CODMAC	Description
1a	1	The level 1 data that have been separated by instrument. This is the level which is distributed by the DDS.
1b	2	Level 1a data that have been sorted by instrument data types and instrument modes. Data are in scientifically useful form, e.g. as images. These data are still uncalibrated.
2	3	Level 1b with calibration and corrections applied to yield data in scientific units.
3	5	Higher level data products developed for specific scientific investigations.

2.5 Telemetry Data

For generating the product files the following telemetry data are processed:

- Science Data Report: TM APID 460 (CAM1) and 476 (CAM2), Type 20, Subtype 13. This set of telemetry data contains the images as well as a number of meta data parameters. The latter are included in the label files of the generated data products.
- Housekeeping and Health-Check Report: TM APID 452 (CAM1) and 468 (CAM2), Type 3, Subtype 25. From the set of available housekeeping parameters only the

CCD temperature and the optics temperature are extracted and included in the label files of the generated data products.

2.6 Overview of Data Products

2.6.1 Expected Releases

Due to the inherent nature of the NavCam instrument there will be no reason to produce any CODMAC level 5 data sets and only levels 2 and 3 (see Table 7) will become available for release. The scientific community should expect to have made available to them data products from the Imaging Mode - including images produced while operating under the Asteroid (Extended Object) Tracking mode. These images will include some basic header information. Each released volume will follow the format and structure outlined in Chapter 3. Full explanations of the parameters found in the label files and headers, along with an explanation of the camera readout frame, are provided in Chapter 4.

Uncalibrated Data

Raw data sets are made available, which contain meta-information on the used instrument modes and geometry in the product label files of the images. The data result from multiple mission phases (see Table 10) and include images of star-fields and extended objects: Earth, Mars, Asteroid 21-Lutetia, Asteroid 2867-Steins and Comet 67P/Churyumov-Gerasimenko.

Calibrated Data (Not Yet Available)

From the raw data sets the calibration software will allow for necessary adjustments to be made to the images for the production of the CODMAC level 3 data via a calibration pipeline. The data sets expected for release will be calibrated versions of all the data releases for the raw data sets.

3 Archive Format and Conventions

This chapter contains general rules for the NavCam data sets. The format and convention used for naming directories and files are specified below.

3.1 Format and Conventions

The directory tree must be compatible, in terms of directory organisation and naming and file organisation, with the PDS standards and such that:

- each logical archive volume shall contain one NavCam PDS data set;
- data sets will contain data from both NavCams;
- one data set shall be created for each separate mission phase;
- a different data set shall be created for each processing level;
- the top level directory of each logical archive volume shall match that of the NavCam data set ID; and,
- the volume set name shall be as that of the data set.

3.1.1 Data Set ID Formation

The data set ID formation shall be done according to the following rule:

DATA_SET_ID = <INST_HOST>-<TARGET_ID>-<INST>-<CODMAC_LEVEL>-<MISSION_PHASE_ABBREVIATION>-<VERSION>

Each of the components are described, briefly, in Table 8, with a full list of options for TARGET_ID and MISSION_PHASE being given in Tables 9 and 10 respectively. Examples include:

- RO-E-NAVCAM-2-EAR1-V1.0
- RO-A-NAVCAM-2-AST1-V1.0

In some instances it can be viewed that there are several TARGET_ID terms in the DATA_SET_ID naming formation. These terms come together in a list, separated by hyphens, between the <INST_HOST> and <INST> terms in the data set name. Examples include:

- RO-A-CAL-NAVCAM-2-AST2-V1.0
- RO-E-X-NAVCAM-2-CR1-V1.0

Table 8: Description of Components of the DATA_SET_ID.

Component	Examples	Description
INST_HOST	RO	Rosetta Orbiter
TARGET_ID	A, C, E, M	Asteroid, Comet, Earth, Mars
INST	NAVCAM	Navigation Camera
CODMAC_LEVEL	2, 3, 5	See Table 7
MISSION_PHASE_ ABBREVIATION	AST1, EAR3, CR4B, MARS	Asteroid 1 Flyby, Earth Swingby 3, Cruise 4-B, Mars Swingby
VERSION	Vx.y e.g. V1.0, V1.1, V2.0	x and y are numerical values indicating the version level and revision number

Table 9: Full list of TARGET_ID values for Rosetta.

Abbreviation	TARGET_TYPE	TARGET_NAME
A	Asteroid	(21) Lutetia (2867) Steins
C	Comet	C/LINEAR 9P/TEMPEL 1 67P/Churyumov-Gerasimenko
CAL	Calibration	
E	Planet	Earth
J	Planet	Jupiter
M	Planet	Mars
N/A	Satellite	Moon
X	N/A	Checkout

3.1.2 File Naming Convention

Each data product found in the /DATA/ directory is presented in the form of a *.IMG file, each of which has an associated *.LBL file of the same name that points to the image

Table 10: MISSION_PHASE_NAME and ABBREVIATION.

Phase Name	Abbr.	Phase Name	Abbr.
STEINS FLY-BY	AST1	COMMISSIONING 2	CVP2
LUTETIA FLY-BY	AST2	EARTH SWING-BY 1	EAR1
CRUISE 1	CR1	EARTH SWING-BY 2	EAR2
CRUISE 2	CR2	EARTH SWING-BY 3	EAR3
CRUISE 3	CR3	GROUND	GRND
CRUISE 4-1	CR4A	LAUNCH	LEOP
CRUISE 4-2	CR4B	MARS SWING-BY	MARS
CRUISE 5	CR5	RENDEZVOUS MANOEUVRE 1	RVM1
CRUISE 6	CR6	RENDEZVOUS MANOEUVRE 2	RVM2
COMMISSIONING 1	CVP1		

file. Each *.LBL file contains the camera operating parameters in the header. Every data product has a browse version in the form of a *.JPG file with an associated *.LBL located in the /BROWSE/ directory. These are provided so as to allow an easier browsing of the data. The naming formation for each *.IMG, *.JPG and *.LBL is as follows:

<MISSION>_<CAM#>_<YYYYMMDDThhmmss>.<EXT>

Table 11 demonstrates the definitions of each part:

Table 11: File naming parameters.

Variable	Possible Values	Description
MISSION	ROS	Demonstrates which mission the NavCam is being flown on.
CAM#	CAM1, CAM2	Denotes which NavCam produced the data.
EXT	IMG, JPG, LBL	Denotes the file type in question.

The parameter <YYYYMMDDThhmmss> is the Coordinated Universal Time (UTC) without the fractional seconds (explained in *Standards Used in Data Product Generation: Time Standards*) and provides the date and time at which the image was taken on-board the S/C.

3.2 Standards Used in Data Product Generation

This section describes the fundamental standards used for the Rosetta NavCam data production.

3.2.1 PDS Standards

Each complete volume produced will be able to pass both the PDS and PSA standards. In general each individual file will be created using standards of the PDS and more specifically Version 3. The PDS format uses the ISO 9660 level 2 standard for the file names. Hence, no complete file name shall be longer than 31 characters and the "27.3" structure will be obeyed, that is, a maximum of 27 characters before the "." for the file name and 3 characters after for the extension type.

3.2.2 Time Standards

Two time standards are used in the production of the NavCam data. Firstly, the standard UTC is used in the time stamping of the data products for the following properties:

- PRODUCT_CREATION_TIME;
- IMAGE_TIME;
- START_TIME; and,
- STOP_TIME

Where the START_TIME = IMAGE_TIME - 0.5 ×EXPOSURE_DURATION and STOP_TIME = IMAGE_TIME + 0.5×EXPOSURE_TIME. The other time standard is found in the following keywords:

- SPACECRAFT_CLOCK_START_COUNT; and,
- SPACECRAFT_CLOCK_STOP_COUNT.

Where these time standards are defined to be:

- Coordinated Universal Time (UTC):
  - YYYYMMDDThhmmss.fff
    where YYYYMMDD provides the calendar format (year, month and day) of production; T indicates the time at which the event occurred in hhmmss.fff (hours, minutes, seconds and fractions of a second).

- SPACECRAFT_CLOCK_START/STOP_COUNT:
  - <reset number>/<time counter high value>.<time counter low value>
    <time counter high value> spacecraft clock counts (approximately one second) since initialisation.
    <time counter low value> counted in 1/65536 second ticks.
    Example:
    - 1/123772074.26377

3.2.3 Camera Reference Frames

For data processing and analysis purposes the NavCam reference frames are defined as follows:

- The +Z axis points along the camera boresight (optical axis).
- The +X axis is parallel to the apparent image columns. It is nominally co-aligned with the S/C +X axis.
- The +Y axis completes the right hand frame. It is nominally parallel to the apparent image lines and co-aligned with the S/C +Y axis.
- The origin of the frame is located at the camera focal point.

The actual alignment of the boresights with respect to the spacecraft reference frame as determined by in-flight calibration is given in the Rosetta SPICE frame-kernel [RD4].

3.2.4 Image Orientation

The images in the data product files are oriented such that the CCD columns (and therefore the X axis) appear in vertical direction and the lines (and therefore the Y axis) in horizontal direction. The binary files start with the first byte of the first line read out from the CCD. This first line corresponds to the bottom of the image in the orientation mentioned above. Accordingly, the relevant keywords in the image description section of the product label files are specified as SAMPLE_DISPLAY_DIRECTION = "RIGHT" and LINE_DISPLAY_DIRECTION = "UP".
The orientation of the X and Y axes is such that line and column number counts increase with increasing coordinate value. However, the optics of the instrument introduces an

inversion of the image. This means that the signs of both coordinate values need to be reversed when transforming the position of an object in space into image coordinates. Or in other words, the image needs to be rotated by 180 degrees in order to match the orientation of the imaged scene.

3.2.5 Window Size and Position

The camera software allows the user to specify sub-frames in order to reduce the data volume for downlink. In the product label files the size of the images is indicated by the standard keywords LINES and LINE_SAMPLES of the image description section. The specific keywords
ROSETTA:CAM_WINDOW_POS_ALONG_ROW
and
ROSETTA:CAM_WINDOW_POS_ALONG_COL,
respectively, indicate the central column and row numbers of the commanded sub-images (see Table16). For full images with 1024×1024 pixels the value of both of these keywords is set to 511, which corresponds to the centre of the CCD.

3.3 Data Quality

When considering the data quality for the uncalibrated NavCam images there are two levels, as presented in Table 12:

Table 12: Data quality level and description.

DATA_QUALITY_ID	DATA_QUALITY_DESC	Comment
0	COMPLETE	Image Complete
1	INCOMPLETE	Lines Missing

Additional values for this keyword, e.g. indicating image saturation, may be added in later product releases. The number of missing lines can be seen in Table 16 under the Rosetta mission specific keyword ROSETTA:CAM_MISSING_LINES. The keyword ROSETTA:CAM_DATA_VALID with the possible values OK or NOT_OK reports the result of a periodic instrument health check which is included in the science telemetry data. This error flag is set, for example, if the instrument temperature is not within the operating range.

3.4 Content

This section contains information that is data product independent and is common to all data sets produced for the Rosetta NavCam.

3.4.1 Volume Set

The following conditions shall remain true for the NavCam data sets at all times:

- Each logical archive volume shall contain one NavCam data set.
- Necessary documentation for the logical archive volumes shall be provided by the Planetary Science Archive Data Handlers (PSA-DHs). Any other non-data file necessary for the logical archive volume will be provided by the PSA-DHs.
- It shall be possible to modify and implement the structure of the directory tree with new sub-directories, whenever needed. The creation and management of the directories shall be performed by the PSA-DHs.

The keywords mandatory for the VOLUME object of the Rosetta mission are presented in Table 13:

Table 13: Mandatory keywords and standard values for the VOLUME object.

Keyword	**Required**	**Max. Length**	**Standard Value(s)**
DATA_SET_ID	yes	40	see Section 3.1.1
DESCRIPTION	yes	N/A	"N/A"
MEDIUM_TYPE	yes	30	"ELECTRONIC"
PUBLICATION_DATE	yes	10	YYYY-MM-DD
VOLUME_FORMAT	yes	20	"ANSI"
VOLUME_ID	yes	12	"N/A"
VOLUME_NAME	yes	60	"N/A"
VOLUME_SERIES_NAME	yes	60	"N/A"
VOLUME_SET_NAME	yes	60	"N/A"
VOLUME_SET_ID	yes	40	"N/A"
VOLUME_VERSION_ID	yes	12	"N/A"
VOLUMES	yes	N/A	"UNK"

3.4.2 Data Set Naming

The data set naming for the Rosetta NavCam follows the following formation rule:

DATA_SET_NAME =
<INSTRUMENT_HOST_NAME>-<TARGET>(-<OPTIONAL>)-<INST>-
<CODMAC_LEVEL>-<MISSION_PHASE_ABBREVIATION>-<VERSION>

Where each of these parameters are defined in Table 14:

Table 14: Data set naming parameters.

Parameter	**Value(s)**
INSTRUMENT_HOST_NAME	ROSETTA-ORBITER
TARGET	see Table 9
INST	NAVCAM
CODMAC_LEVEL	see Table 7
MISSION_PHASE_ABBREVIATION	see Table 10
VERSION	e.g. V1.0, V2.4 etc.

Examples include:

- "ROSETTA-ORBITER-EARTH-NAVCAM-2-EAR1-V1.0"
- "ROSETTA-ORBITER-MARS-CALIBRATION-2-MARS-V1.0"

3.4.3 Directories

Root Directory

The top-level structure of the ROOT directory of a data archive volume corresponds to chapter 19 of the PDS Standards Reference (summarised here):

- **AAREADME.TXT**: This file describes the complete volume. It provides an overview of what can be found in the volume including the organisational attributes and general instructions for use along with contact information.
- **VOLDESC.CAT**: This file contains the VOLUME object, which gives a high-level description of the volume contents.

Sub-directories (except the DATA directory) include a file, **xxxxINFO.TXT**, that briefly describes the contents of that directory. In case that an important instrument characteristic cannot be described with an existing PDS keyword, the information will be supplied in a separate parameter file.

BROWSE Directory

This directory contains two directories (CAM1 and CAM2) with a set of thumbnail images in *.JPG format (one corresponding to each *.IMG file in the DATA directory) and an associated *.LBL for each one. Other files that are included here are:

- **BROWINFO.TXT**: This file describes the contents of the directory.
- ***.LBL**: Detached label files for the browse products.
- ***.JPG**: Browse products in JPEG format

CATALOG Directory

This directory contains the catalogue object files for the complete volume. Files include:

- **CATINFO.TXT**: A description of the contents of the CATALOG directory.
- **MISSION.CAT**: Contains PDS mission catalogue information about the Rosetta Mission (provided by ESA).
- **INSTHOST.CAT**: Contains PDS instrument host catalogue information about the Rosetta S/C and the mounting relationship of the instruments within the S/C (provided by ESA).
- **NAVCAM_INST.CAT**: Contains PDS instrument catalogue information about the instrument (likely to be the same in all deliveries, unless updates are needed).
- **DATASET.CAT**: Contains PDS data set catalogue information about the data set currently being submitted.
- **REF.CAT**: PDS reference catalogue information about every journal article, book or other published reference mentioned in the above catalogue objects or their components.

- **SOFTWARE.CAT**: PDS software catalogue information about the software submitted in the data set.
- **TARGET.CAT**: Contains PDS target catalogue information about the observation targets, i.e. comet, asteroid, Earth or Mars (provided by ESA).
- **NAVCAM_PERS.CAT**: Contains PDS personnel catalogue information about the instrument team responsible for generating the data products.

It should be noted here that the last two files are optional and may not be found in the volume.

DATA Directory

This directory contains two sub directories CAM1 and CAM2 with the data products in the form of *.IMG files each with a corresponding detached *.LBL (label) file.

DOCUMENT Directory

Included here is a copy of all the documentation relative to the data production and the volume as a whole, specific files are:

- **DOCINFO.TXT**: A description of the contents of the document directory.
- **RO-SGS-IF-0001.PDF**: The Experimenter to (Science) Archive Interface Control Document (EAICD) (this document) for the NavCam instrument.
- **RO-SGS-IF-0001.TXT**: The ASCII version of the above file.
- **RO-SGS-IF-0001.LBL**: The label of the above files.

INDEX Directory

Contains index files that summarise all of the data products in the volume by mode, key instrument parameters or mission phase. The files are organised in such a manner to facilitate finding specific data of interest related to a particular *scientific* question. Information about the observation geometry is included in the data products (e.g., spacecraft position and attitude, illumination conditions, etc.). Information that is not accurately known at the time of delivery and thus will probably be updated later shall be stored in the index files rather than in the data product labels. Particular files include:

- **INDXINFO.TXT**: A description of the contents of the directory.
- **INDEX.LBL**: The detached label file for the file INDEX.TAB. The INDEX_TABLE specific object should be used to identify and describe the columns of the index table.
- **INDEX.TAB**: Includes the index of the volume in a tabular format.
- **BROWSE_INDEX.LBL**: The detached label for BROWSE_INDEX.TAB.
- **BROWSE_INDEX.TAB**: This file includes an index of the browse products in tabular format.

4 Detailed Interface Specifications

4.1 Data Product Design

According to the PDS formatting standard, each data product must be accompanied by a descriptive *.LBL to describe the content. For the NavCam these label files shall be in the detached form and will appear as a separate file (see Section 3.1.2).

4.1.1 Content of *.LBL Files

The following shall remain true for all label files in all volumes for the Rosetta NavCam:

- The format follows PDS standards for formatting and character usage.
- The labels shall use only valid keywords that appear in both the PDS and PSA dictionaries.
- The character set used shall be that of ASCII 7 bit; specifically characters within and including the code range 001 to 127.
- The characters <CR> and <LF> shall be used and shall be present at the end of each line of every label file.
- Each label file shall not exceed a maximum 80-character limit; including the <CR> <LF> characters.
- Where possible, every line that is less than the permitted 80 character maximum shall be padded out to be of a length equal to 80.

Table 15 provides the list of keywords used in label files within the NavCam volumes; Table 16 signifies Rosetta mission specific dictionary entries.

Table 15: Keywords used in NavCam label files.

Keyword	Max. Length	Value(s)
PDS_VERSION_ID	6	PDS3
FILE_NAME	N/A	filename
RECORD_TYPE	20	FIXED_LENGTH
RECORD_BYTES	N/A	bytes per image line
FILE_RECORDS	N/A	number of image lines
INTERCHANGE FORMAT	6	BINARY
DATA_SET_ID	40	see Section 3.1.1
DATA_SET_NAME	60	see Section 3.4.2
PRODUCT_ID	40	filename without extension
PRODUCT_CREATION_TIME	24	YYYY-MM-DDThh:mm:ss.fff
PRODUCT_TYPE	30	EDR
PROCESSING_LEVEL_ID	N/A	"2"
IMAGE_TIME	24	YYYY-MM-DDThh:mm:ss.fff
START_TIME	24	YYYY-MM-DDThh:mm:ss.fff
STOP_TIME	24	YYYY-MM-DDThh:mm:ss.fff
SPACECRAFT_CLOCK_START _COUNT	30	see Section 3.2.2
SPACECRAFT_CLOCK_STOP _COUNT	30	see Section 3.2.2
MISSION_ID	N/A	ROSETTA
MISSION_NAME	60	"INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_NAME	60	"ROSETTA-ORBITER"
INSTRUMENT_HOST_ID	6	RO
TARGET_NAME	30	see Table 9
TARGET_TYPE	20	see Table 9
TARGET_DESC	N/A	text description of target
MISSION_PHASE_NAME	30	see Table 10

PRODUCER_INSTITUTION _NAME	60	"EUROPEAN SPACE AGENCY-ESAC"
PRODUCER_ID	20	"ESA-ESAC"
PRODUCER_FULL_NAME	60	"BERNHARD GEIGER"
NOTE	N/A	list of SPICE kernels used
INSTRUMENT_ID	12	NAVCAM
INSTRUMENT_NAME	60	"NAVIGATION CAMERA"
INSTRUMENT_TYPE	30	"CCD CAMERA"
CHANNEL_ID	4	"CAM1" or "CAM2"
EXPOSURE_DURATION	N/A	sss.fff <s>
DATA_QUALITY_ID	3	0 or 1
DATA_QUALITY_DESC	N/A	"0: Image Complete, 1: Lines Missing."
INSTRUMENT_MODE_ID	20	"IMAGING" or "ASTEROID TRACKING"
INSTRUMENT_MODE_DESC	N/A	"Value of OPERATING MODE param. in TM data"
INSTRUMENT_TEMPERATURE	N/A	CCD and optics temperature retrieved from HK TM
INSTRUMENT_TEMPERATURE _POINT	60	("CCD_T1", "OPTICS_T7")
SUN_POSITION_VECTOR	N/A	spacecraft position in ECLIPJ2000 coordinates
RIGHT_ASCENSION	N/A	right ascension of boresight direction (J2000)
DECLINATION	N/A	declination of boresight direction (J2000)

Table 16: Rosetta mission specific dictionary entries.

Keyword	**Value(s)**
ROSETTA:CAM_ABSOLUTE_FRAME_NUMBER	frame number since instrument start-up
ROSETTA:CAM_MODE_FRAME_NUMBER	frame number in current mode
ROSETTA:CAM_COVER_POSITION	FOC_NATT, FOC_ATT , or DEFOC_NATT, see p.6
ROSETTA:CAM_GAIN	LOW or HIGH, see p.7
ROSETTA:CAM_DATA_VALID	OK or NOT_OK, see p.23
ROSETTA:CAM_WINDOW_POS_ALONG_ROW	see p.23
ROSETTA:CAM_WINDOW_POS_ALONG_COL	see p.23
ROSETTA:CAM_MISSING_LINES	number of missing image lines, see p.23

The following example is that of a label file that can be found for one of the data products:

```
PDS_VERSION_ID                = PDS3

/***      FILE CHARACTERISTICS                                        ***/
FILE_NAME                     = "ROS_CAM1_20040926T073116.LBL"
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 2048
FILE_RECORDS                  = 1024
INTERCHANGE_FORMAT            = BINARY

/***      POINTERS TO DATA OBJECTS                                    ***/
^IMAGE                        = ("ROS_CAM1_20040926T073116.IMG",1)

/***      IDENTIFICATION DATA ELEMENTS                                ***/
DATA_SET_ID                   = "RO-CAL-NAVCAM-2-CVP2-V1.0"
DATA_SET_NAME                 = "ROSETTA-ORBITER-CAL-NAVCAM-2-CVP2-V1.0"
PRODUCT_ID                    = "ROS_CAM1_20040926T073116"
PRODUCT_CREATION_TIME         = 2013-05-20T12:40:46
PRODUCT_TYPE                  = EDR
PROCESSING_LEVEL_ID           = "2"
```

```
IMAGE_TIME                    = 2004-09-26T07:31:16.423
START_TIME                    = 2004-09-26T07:31:16.418
STOP_TIME                     = 2004-09-26T07:31:16.427
SPACECRAFT_CLOCK_START_COUNT  = "1/54804659.34474"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/54804659.35129"
MISSION_ID                    = "ROSETTA"
MISSION_NAME                  = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_NAME          = "ROSETTA-ORBITER"
INSTRUMENT_HOST_ID            = RO
TARGET_NAME                   = "CALIBRATION"
TARGET_TYPE                   = "CALIBRATION"
TARGET_DESC                   = "ALPHA GRU"
MISSION_PHASE_NAME            = "COMMISSIONING 2"
PRODUCER_INSTITUTION_NAME     = "EUROPEAN SPACE AGENCY-ESAC"
PRODUCER_ID                   = "ESA-ESAC"
PRODUCER_FULL_NAME            = "BERNHARD GEIGER"
NOTE                          = "SPICE KERNELS USED:
                                NAIF0009.TLS
                                ROS_100903_STEP.TSC
                                ORHR_______________00109.BSP
                                ROS_V16.TF
                                ATNR_P040302093352_00109.BC"

/***      INSTRUMENT RELATED PARAMETERS                                      ***/
INSTRUMENT_ID                 = NAVCAM
INSTRUMENT_NAME               = "NAVIGATION CAMERA"
INSTRUMENT_TYPE               = "CCD CAMERA"
CHANNEL_ID                    = "CAM1"
EXPOSURE_DURATION             =  0.01 <s>
DATA_QUALITY_ID               = "0"
DATA_QUALITY_DESC             = "0: Image Complete, 1: Lines Missing."
INSTRUMENT_MODE_ID            = IMAGING
INSTRUMENT_MODE_DESC          = "Value of OPERATING MODE param. in TM data"
INSTRUMENT_TEMPERATURE        = (  -12.57 <degC>,    8.66 <degC> )
INSTRUMENT_TEMPERATURE_POINT  = (       "CCD_T1",    "OPTICS_T7" )
```

```
/***      ROSETTA MISSION SPECIFIC DATA DICTIONARY ENTRIES                ***/
ROSETTA:CAM_ABSOLUTE_FRAME_NUMBER    = 9420
ROSETTA:CAM_MODE_FRAME_NUMBER        = 8935
ROSETTA:CAM_COVER_POSITION           = FOC_NATT
ROSETTA:CAM_GAIN                     = LOW
ROSETTA:CAM_DATA_VALID               = OK
ROSETTA:CAM_WINDOW_POS_ALONG_ROW     = 511
ROSETTA:CAM_WINDOW_POS_ALONG_COL     = 511
ROSETTA:CAM_MISSING_LINES            = 0

/***   SPACECRAFT POSITION (ECLIPJ2000) AND INSTRUMENT POINTING (J2000)   ***/
SC_SUN_POSITION_VECTOR          = (    138352393.70 <km>,
                                        80450030.08 <km>,
                                         -833729.07 <km>   )
RIGHT_ASCENSION                 =   22.117464 <h>
DECLINATION                     = -46.593084 <deg>

/***      IMAGE DESCRIPTION                                               ***/
OBJECT                          = IMAGE
   DERIVED_MAXIMUM              = 968
   DERIVED_MINIMUM              = 174
   LINES                        = 1024
   LINE_SAMPLES                 = 1024
   SAMPLE_TYPE                  = LSB_UNSIGNED_INTEGER
   SAMPLE_BITS                  = 16
   SOURCE_SAMPLE_BITS           = 12
   SAMPLE_DISPLAY_DIRECTION     = "RIGHT"
   LINE_DISPLAY_DIRECTION       = "UP"
END_OBJECT                      = IMAGE

END
```