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DOCUMENT

Science User Guide for the ROSETTA HK Engineering data

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1 INTRODUCTION

1.1 Purpose and Scope

This is the science user guide for the Rosetta Spacecraft Engineering data. It is intended to introduce users to the data that is in the archive and how they may use it to its full advantage.

The details of the data formats, directory structure etc are provided in the EAICD which is a separate document located in the document folder.

1.2 Archiving Authorities

The Planetary Data System Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the SCI-O Department

1.3 The Rosetta Mission and Instruments

Rosetta Mission overview

The main objective of the Rosetta mission, which was approved in November 1993 as the Planetary Cornerstone mission of ESA's Horizon 2000 long-term program, was to rendezvous with a comet. In-situ investigation of a cometary nucleus was regarded as of the utmost scientific interest.

The original target comet of Rosetta was 46P/Wirtanen, but after the failure of the Ariane 5 ECA in December 2002, the Ariane 5 P1+ was not ready to launch Rosetta in January 2003. In February 2003 the Science Working Team (SWT) approved the preparation for a mission to be launched in February-March 2004. This alternative mission would rendezvous with comet 67P/Churyumov-Gerasimenko in 2014.

The Rosetta satellite was launched in March 2004 and after a 10 year journey which included two flybys of asteroids as well as a deep space hibernation phase, it was woken up on the 20th of January 2014.

Rosetta Mission Phases

Between this date and its arrival at the comet on the 6th of August 2014, the instruments were successfully commissioned and began to generate science data already at a significant distance from the comet. The mission phase was called "Prelanding" (PRL) in that all data taken up to the Philae Lander delivery had an objective to support the landing site selection process. The prelanding phase ended approximately 5 days after the landing itself. At this



point, the comet escort phase (ESC) kicked off whereby the spacecraft accompanied the comet through its perihelion passage and beyond. The nominal mission was due to end on the 31st of December 2015 but was approved for a mission extension (EXT) until the end of September 2016.

The Rosetta orbiter carried a significant set of scientific instruments – the following represents a list of those instruments and the science investigations being performed by each:

Remote sensing:

- OSIRIS (VIS and NIR imaging)
- VIRTIS (VIS and NIR mapping spectroscopy)
- ALICE (UV mapping spectroscopy)
- MIRO (microwave spectroscopy)

Composition analysis:

- ROSINA (neutral gas and ion mass spectrometry)
- COSIMA (dust mass spectrometry)

Dust physical properties:

- MIDAS (dust grain morphology)
- GIADA (dust velocity, impact momentum, mass flow)

Nucleus large-scale structure:

- CONSERT (radiowave sounding, nucleus tomography) – also on Philae Lander
- RSI (radio science)

Comet plasma environment and solar wind interaction:

- RPC (Rosetta plasma consortium)
 - > ICA (ion composition analyser)
 - > IES (ion and electron sensor)
 - > LAP (Langmuir probe)
 - > MAG (fluxgate magnetometer)
 - > MIP (mutual impedance probe)
- SREM Radiation Monitor Data

Engineering Datasets

- Rosetta Housekeeping Engineering Data

Data Coverage

The data provided in the datasets covers all mission phases from launch until end of mission.



1.4 Acronyms

For more acronyms refer to Rosetta Project Glossary [RO-EST-LI-5012]

AFM	Asteroid Flyby mode
AIU	AOCMS Interface Unit (AIU)
AOCMS	Attitude & Orbit Management System
APM	Antenna Pointing Mechanism
BCR	Battery Charge Regulator
BDR	Battery Discharge Regulator
BSM	Bus Support Module
CAM	Navigation Camera
CAP	Comet Acquisition Point
CAT	Close Approach Trajectory
CDMU	Control and Data Management Unit
CDMS	Central Data Management System
C-G	67P/Churyumov-Gerasimenko
CM	Control Module
CODMAC	Committee on Data Management and Computation
COP	Close Observation Phase
CR1...6	Mission phase: Cruise 1...6
CVP1/2	Mission phase: Commissioning and verification phase part 1/2
DDOR	Delta Differential One-way Range
DLR	German Aerospace Center
DMS	Data Management Subsystem
DSHM	Deep Space Hibernation Mode
DSM	Deep Space Manoeuvre
DSN	Deep Space Network
EAICD	Experiment to Planetary Science Archive Interface Control Document
EAR1/2/3	Mission phase: Earth swing-by 1/2/3
EDAC	Error Detection & Correction
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMC	Electromagnetic Compatibility
EOM	End of Mission
ESA	European Space Agency
ESC	Mission Phase : Escort phase
ESD	Electro Static Discharge
ESAC	European Space Astronomy Centre
ESOC	European Space Operations Center
ESTEC	European Space Research and Technology Center
EXT	Mission phase: Extended mission



FAT	Far approach trajectory
FCL	Fold-back Current Limiters
FDIR	Failure Detection Isolation and Recovery
F/D	Focal Diameter
FITS	Flexible Image Transport System
FOV	Field Of View
GCMS	Gas Chromatography / Mass Spectrometry
GMP	Global Mapping Phase
GSE	Ground Support Equipment
HDRM	Hold-Down and Release Mechanism
HGA	High Gain Antenna
HGAPE	High Gain Antenna Pointing Electronics
HGAPM	High Gain Antenna Pointing Mechanism
HPA	High Power Amplifier
HPCM	High Power Command Module
HK	HouseKeeping
H/W	Hard/Ware
I/C	Individually Controlled
I/F	InterFace
IMP	Inertial Measurement Packages
IMU	INERTIAL MEASUREMENT UNITS
KAL	Keep Alive Lines
LCC	Lander Control Center
LCL	Latching Current Limiters
LEOP	Launch and Early Orbit Phase
LGA	Low Gain Antenna
MC	Memory Controller
MGA	Medium Gain Antenna
MGAS	MGA S-band
MGAX	MGA X-band
MLI	Multi Layer Insulation
MM	Memory Module
MMH	MonoMethylHydrazine
MPPT	Maximum Power Point Trackers
MS	Microscope
NAVCAM	Navigation Cameras
NM	Normal Mode



NNO	New Norcia ground station
NSHM	Near Sun Hibernation Mode
NTO	Nitrogen TetrOxide
OBCP	On-Board Control Procedures
OBDH	On-Board Data Handling
OCM	Orbit Control Mode
PCU	Power Conditioning Unit
PDU	Power Distribution Unit
PDS	Planetary Data System
PI	Principal Investigator
P/L	PayLoad
PL-PDU	Payload Power Distribution Unit
PM	Processor Module
PRL	Prelanding Phase (S/c wakeup Jan 2014 to week after lander delivery – Mid-Nov 2014)
PSA	Planetary Science Archive
PSM	Payload Support Module
PSS	Power SubSystem
PVV	PSA Validation and Verification Tool
RAM	Random Access Memory
RCS	Reaction Control System
RF	Radio Frequency
RFDU	RF Distribution Unit
RJ	Rotary Joints
RMOC	Rosetta Mission Operations Center
RO	Rosetta Orbiter
RPM	Revolutions per minute
RSGS	Rosetta Science Ground Segment
RTU	Remote Terminal Unit
RVM	Rendez-vous Manouver
RW	Reaction Wheel
RWA	Reaction Wheel Assembly
SA	Solar Array
SADE	Solar Array Drive Electronics
SADM	Solar Array Drive Mechanism
SAM	Sun Acquisition Mode
SAS	Sun Acquisition Sensors
SBM	Stand-By Mode
SBN	Small Bodies Node
SHM	Safe/Hold Mode
SAS	Sun Acquisition Sensor
S/C	SpaceCraft
SI	Silicon



SINC	Sharp Increase Phase (Escort Phase)
SKM	Sun Keeping Mode
SpM	Spin-up Mode
S/S	SubSystem
SSMM	Solid State Mass Memory
SSP	Surface Science Package (another name for the Philae Lander)
SS-PDU	Subsystems Power Distribution Unit
STP	System Interface Temperature point
STR	Star Tracker
S/W	Software
SWT	Science Working Team
TC	Telecommand
TC	Telecommunications
TCS	Thermal Control Subsystem
TFG	Transfer Frame Generator
TGM	Transition to global mapping
TM	Telemetry
TRP	Temperature Reference Point
TRSP	Transponder
TTC	Tracking, Telemetry and Command
TTM	Thruster Transition Mode
TWTL	Two Way Travelling Lighttime
TWTA	Travelling Wave Tube Amplifiers
USO	Ultra Stable Oscillator
VC	Virtual Channel
WDP	Wheel Damping Phase
WG	WaveGuide
WIU	Waveguide Interface Unit
WOL	Wheel Offloading

1.5 Contents

This document describes the data flow of the Rosetta Spacecraft engineering data 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. The design of the data set structure and the data product is given.



1.6 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, PDS) and any potential user of the Rosetta Spacecraft Engineering data.

1.7 Scientific Objectives

The engineering data are not considered as pure scientific data however there is no doubt that some of this data can support science investigations e.g. Star tracker data, manoeuvre data.

Examples of scientific publications that have made use of this data are provided in the user guide.



1.8 Applicable Documents

- [1] Rosetta Archive Generation, Validation and Transfer Plan, RO-EST-PL-5011, Issue 2.3, 10 Jan 2006.
- [2] Rosetta Archive conventions document, RO-EST-TN-3372, Issue 8.0, 20 Apr 2015
- [3] Planetary Data System Standards Reference, JPLD-7669, Part 2, Version 3.6, 1 Aug 2003.
- [4] European Cooperation for Space Standardization, ECSS Internal Procedures, ECSS/SEC(2004)35

1.9 Reference Documents

- [5] PDS Standards Reference, JPL-D-7669, Part 2, version 3.7, 2006 March 20
- [6] Rosetta EAICD
- [7] Rosetta User Manual, Issue 5, 31st October 2003

1.10 Contact Names and Addresses

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2 OVERVIEW OF ROSETTA SPACECRAFT DESIGN, DATA HANDLING PROCESS AND PRODUCT GENERATION

2.1 Overview of Spacecraft Design

A high level drawing is provided below in Figure 1(a) showing the Rosetta spacecraft in its launch configuration and an “exploded” view of what is inside in Figure 1(b).

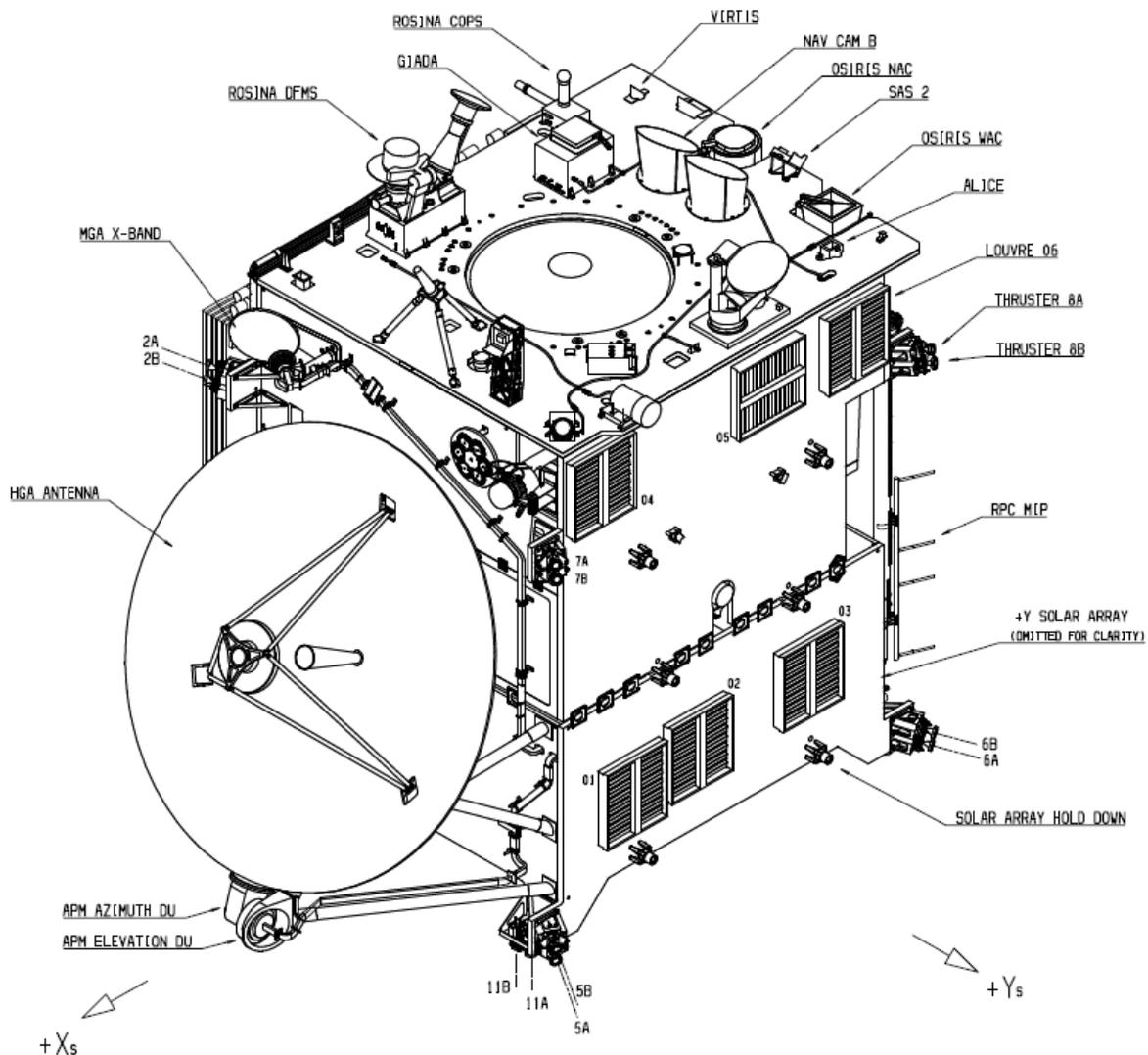
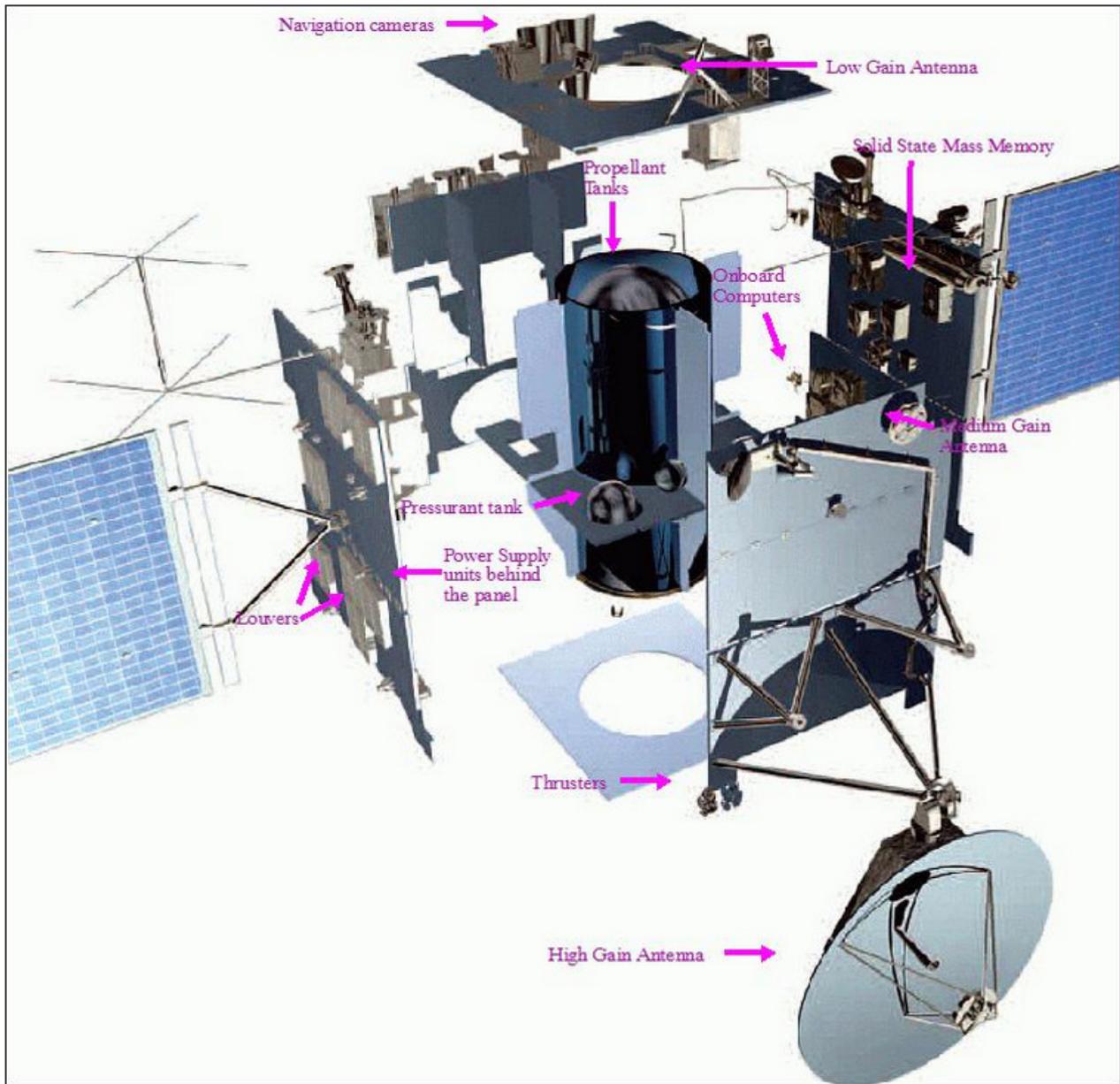


Figure 1(a) - Rosetta in Launch Configuration (+X face)



Exploded view of major spacecraft components (image credit: ESA, AOES Medialab)

Figure 1(b)

The following drawing of the on-board avionics provides a high level summary of the main subsystems on-board the spacecraft – Figure 2.

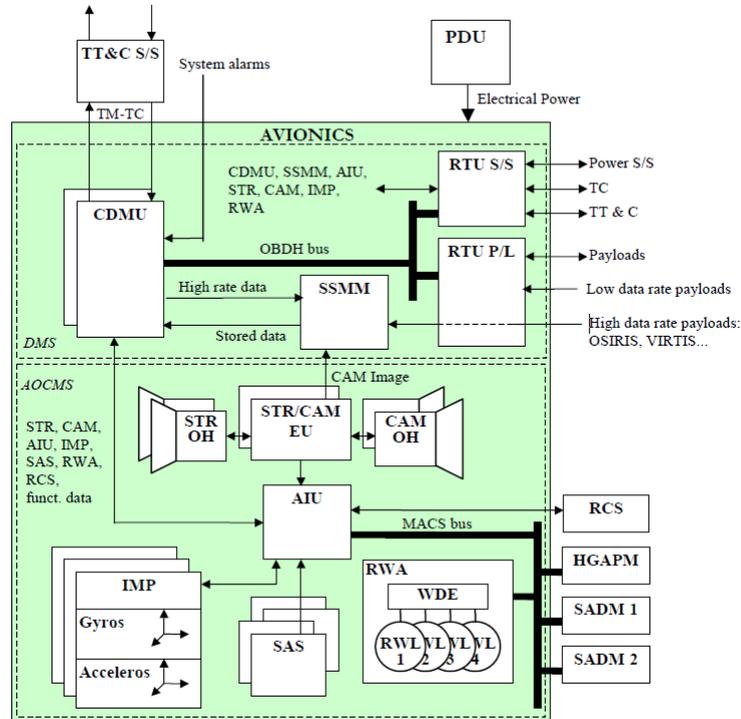


Figure 2 - Rosetta Avionics Subsystem Breakdown

The Subsystem breakdown relevant to the provided datasets is the following:

- Reaction Control Subsystem (RCS)
- Star Trackers (STR)
- Navigation Cameras (CAM)
- Inertial Measurement Package (IMP)
- Reaction Wheel Assembly (RWA)
- High Gain Antenna & Antenna Pointing Mechanism (HGA & APM)
- Radio Frequency Communication subsystem (TT&C)
- Power Distribution Unit (PDU)
- Solar Arrays and Solar Array Drive Mechanism (SA & SADM)
- Thermal Control System (TCS)

2.2 How was the data selected

Of the telemetry data belonging to the subsystems and the instruments that were available from the Mission Operations Centre Database (MUST), only a select few set of parameters have made it into these datasets.

There are in fact 16322 parameters that are not used. The selection was done on the basis of performing a review of the full set of data and extracting those which it was believed provided the most relevant information for the user.

This extraction was feasible primarily because the author of this science user guide had worked previously in the Mission Operations Centre for Rosetta and had experience in using the data from the spacecraft subsystems.

It's important to flag that the data provided does not include internal telemetry data from the instruments. These are provided by the instrument teams in their own data deliveries to the Planetary Science Archive.

The full database containing all data has been saved in a legacy repository at ESAC. If a user believes that there is a parameter that has been identified by him/her to be key to generating a science or technical publication that is not present here then the user is recommended to contact the PSA helpdesk to ask if it is feasible to get this specific data extracted.

2.3 Product Generation

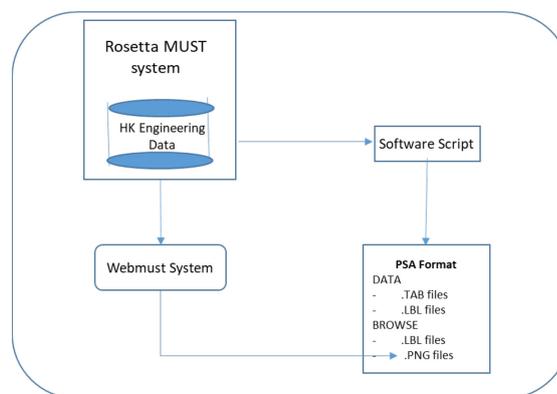


Figure 3 - Overview of the data generation process.

Figure 3 summarizes all the processes involved in the data flow from the Rosetta MUST system which contains the calibrated housekeeping engineering data to the ESA Planetary Science Archive.



The telemetry data coming from the spacecraft was stored in the MUST system at the Rosetta Mission Operations Centre. This is a database which provides calibration against the Spacecraft DB for all telemetry parameters. The MUST system was transferred to ESAC in the post-operations phase.

The data is extracted from the MUST DB in two ways:

- Via a software script retrieves the selected TM parameter values and creates the required PDS Label files and associated .DAT (for binary contents) or .TAB (for ascii contents). The software script creates the required directory structure and places these files there. The software script also produces the directory structure & .LBL files for the browse images.
- Via the Webmust system which allows the user to create plots from selected TM parameters. These files are saved as .PNG files and placed into the browse directories.



2.4 Overview of the datasets & products provided

2.4.1 Datasets provided

See the EAI CD for the details. The following are the list of datasets provided.

Dataset name: ROSETTA ATTITUDE & ORBIT CONTROL SYSTEM ENGINEERING DATA
Dataset ID: RO-X-HK-3-AOCGEN-V1.0

Dataset name: ROSETTA ORBIT CONTROL MANOEUVRE ENGINEERING DATA
Dataset ID: RO-X-HK-3-OCMRCS-V1.0

Dataset name: ROSETTA INERTIAL MEASUREMENT PACKAGE ENGINEERING DATA
Dataset ID: RO-X-HK-3-IMP-V1.0

Dataset name: ROSETTA RADIATION DATA CORRECTION ENGINEERING DATA
Dataset ID: RO-X-HK-3-EDAC-V1.0

Dataset name: ROSETTA REACTION WHEEL ENGINEERING DATA
Dataset ID: RO-X-HK-3-RWL-V1.0

Dataset name: ROSETTA HIGH GAIN ANTENNA ENGINEERING DATA
Dataset ID: RO-X-HK-3-HGAAPM-V1.0

Dataset name: ROSETTA NAVIGATION CAMERA ENGINEERING DATA
Dataset ID: RO-X-HK-3-NAVCAM-V1.0

Dataset name: ROSETTA STARTRACKER ENGINEERING DATA
Dataset ID: RO-X-HK-3-STARTRACKER-V1.0

Dataset name: ROSETTA SOLAR ARRAY & POWER ENGINEERING DATA
Dataset ID: RO-X-HK-3-SOLARARRAY-V1.0

Dataset name: ROSETTA RF ANTENNA ENGINEERING DATA
Dataset ID: RO-X-HK-3-ANTENNASTATUS-V1.0



Dataset name: ROSETTA THERMAL CONTROL SYSTEM ENGINEERING DATA
Dataset ID: RO-X-HK-3-TCS-V1.0

2.4.2 Binary & ASCII data tables

In quite a significant number of cases, the data contained in the MUST system is provided also in binary format in the EXTRAS folder. To convert this data to ASCII tables does lead to a loss in precision which has to be taken into account by the user of the data. The description of the precision applied is provided below (Section 2.4.4).

2.4.3 Engineering Data Calibrations & Timing

All data has been provided with the calibration performed via the MUST system. The calibration curves, polynomials etc applied are not included in the delivery as they are not an output of the MUST system.

With that said, there are a number of parameters where a calibration table is provided to derive the value provided in the ASCII table with a specific status. The calibration tables are provided at the back of the Science User guide.

The first field (in the provided **binary** files) is the **timestamp** of the parameter sample expressed as the number of milliseconds from the epoch of 1970-01-01T00:00:00Z (As stored in the MUST database).

The first field (in the provided ASCII files) is the nominal timestamp in UTC.

The second field is the **value** of the parameter sample (if the “**unit**” is available in MUST, it is indicated in the column definition). One can also see the units in the thumbnail drawings beside the relevant HK parameter.

2.4.4 In-Flight Data Products

The In-flight data includes data generated since launch until the end of the mission.

The data products can be provided as tables (ext: .TAB) with two columns: Time (UTC) and engineering data, or in Binary data again with time in UTC and data. There is one table per parameter.



The precision in use to perform the conversion from ASCII to Binary is via the PDS3 format "**E20.6**". This format is commonly used in instrument's datasets and is believed to be flexible enough for the values stored.

The E specifier is for the exponential form of decimal real data items. The form is:

Ew.d

where: w indicates that the field to be edited occupies w positions and d indicates that the fractional part of the number (the part to the right of the decimal point) has d digits.

The output field for the E **w.d** edit specifier has the width **w**. The value is right-justified in that field. The field consists of zero or more leading blanks followed by either a minus if the value is negative, or an optional plus, followed by a zero, a decimal point, the magnitude of the value of the list item rounded to **d** decimal digits, and an exponent.

The software used to process the data at ESOC is not archived.

2.4.5 Documentation

The following documentation will be provided, in order to support the data analysis:

- The EAI CD (WORD and PDF format)
- Science User Guide (PDF format) : This document



2.4.6 Derived and other Data Products

The data set contains calibrated data.

Further calibration tables for specific TM parameters are provided later in this Science User Guide.

The format is as follows : using the example below

Calibration parameters for NAWDoVo5

2262	0	0	SBM
2262	1	1	SAM
2262	2	2	SHM
2262	3	3	SKM
2262	4	4	NSH
2262	5	5	NM
2262	6	6	AFM
2262	7	7	TTM
2262	8	8	OCM
2262	9	9	SPM

The first column shows the calibration id number as defined in the Satellite DB. The second/third columns show the values that appear in the dataset tables. The values match with a status as defined in the fourth column.

2.4.7 Browse Products

The BROWSE directory contains PNG thumbnail files for browsing the data provided in the DATA directory. Each file comes with a detached PDS label. Note that there is **not** a one to one correspondence between the DATA products and the BROWSE products. Instead, BROWSE products are provided either as yearly, quarterly or monthly overviews.

BROWSE products are also only provided for a selected set of parameters in the data sets, carefully chosen as being of most interest to have as thumbnails to help browse through the data sets and select data and periods of interest.

For most of the datasets, browse products have been produced solely for the comet phase of the mission. They begin when the satellite comes out of hibernation in Jan 2014 and continue on a 3 monthly basis until 30th Sept 2016.

For a select set of datasets e.g. radiation monitoring (EDAC data for the AOCS & DMS computers), Thermal control system data, the browse images have been provided for the full period of the mission.



Further details on how the selection is made for each data type can be found in each of the dataset “BROWINFO.TXT” that are provided in the Browse directories.

In addition, the user is recommended to have a look at the “How to use the data” sections provided in this science user guide in order to get a better understanding of how the data provided can be used.



3 SPACECRAFT SUBSYSTEMS & LINK TO DATA PRODUCTS

3.1 The Spacecraft Avionics (AOCS & DMS)

Avionics General Overview

The ROSETTA Avionics consists of the Data Management Subsystem (DMS) and the Attitude and Orbit Control and Measurement Subsystem (AOCMS) functions.

Data Management Subsystem (DMS)

The data management subsystem is in charge of telecommand distribution to other spacecraft subsystems and payload, of telemetry data collection from spacecraft subsystems and payload and formatting, and of overall supervision of spacecraft and payload functions and health.

The DMS is based on a standard OBDH bus architecture enhanced by high rate IEEE 1355 serial data link between the different Avionics processors and the SSMM, STR and CAM. The OBDH bus is the data route for data acquisition and commands distribution via the RTUs (Remote Terminal Units). Payload Instruments are accessed via a dedicated Payload RTU. Subsystems are accessed via a dedicated Subsystem RTU.

DMS includes 4 identical Processor Modules (PM) located in 2 CDMUs. Any of the processor modules can perform either the DMS or the AOCMS processing. The PM selected for the DMS function acts as the bus master. It is also in charge of Platform subsystem management (TT&C, Power, Thermal). The one selected as the AOCMS computer is in charge of all sensors, actuators, HGA & SA drive electronics.

A TC decoder and a Transfer Frame Generator (TFG) are included in each CDMU. Telemetry can be downlinked via the TFG using the real time channel (VCo) or in form of retrievals from the SSMM (VC1).

The Solid State Mass Memory (SSMM) is used for data storage including 25 Gbit of memory. It is capable of file management capability. It is coupled to the 4 processors, the TFG, VIRTIS, OSIRIS and the Navigation Camera. It stores CAM images, science and telemetry packets as well as software data. It is able of data compression allowing lossy (for CAM image) and lossless (for HK and science data) compression.

Attitude and Orbit Control Measurement System (AOCMS)

The AOCMS is in charge of attitude and orbit measurement and control and uses sensors and actuators for autonomous attitude determination and control as well as pre-programmed manoeuvring.

The AOCMS subsystem is built around the AOCMS Interface Unit (AIU) which is used by the AOCMS-SW to exchange functional data with:

- **the sensors:** 2 Navigation Cameras (CAM) and 2 Star Trackers (STR), 4 Sun Acquisition Sensors (SAS) and 3 Inertial Measurement Packages (IMP), each IMP includes 3 gyros + 3 accelerometers,
- **the actuators:** the Reaction Wheel Assembly (RWA) belonging to the Avionics, and the Reaction Control System (RCS), the High Gain Antenna Pointing Mechanism (HGAPM), and the 2 Solar Array Drive Mechanisms (SADM) belonging to the Platform.

The AOCMS avionics system is shown in Figure 4 below.

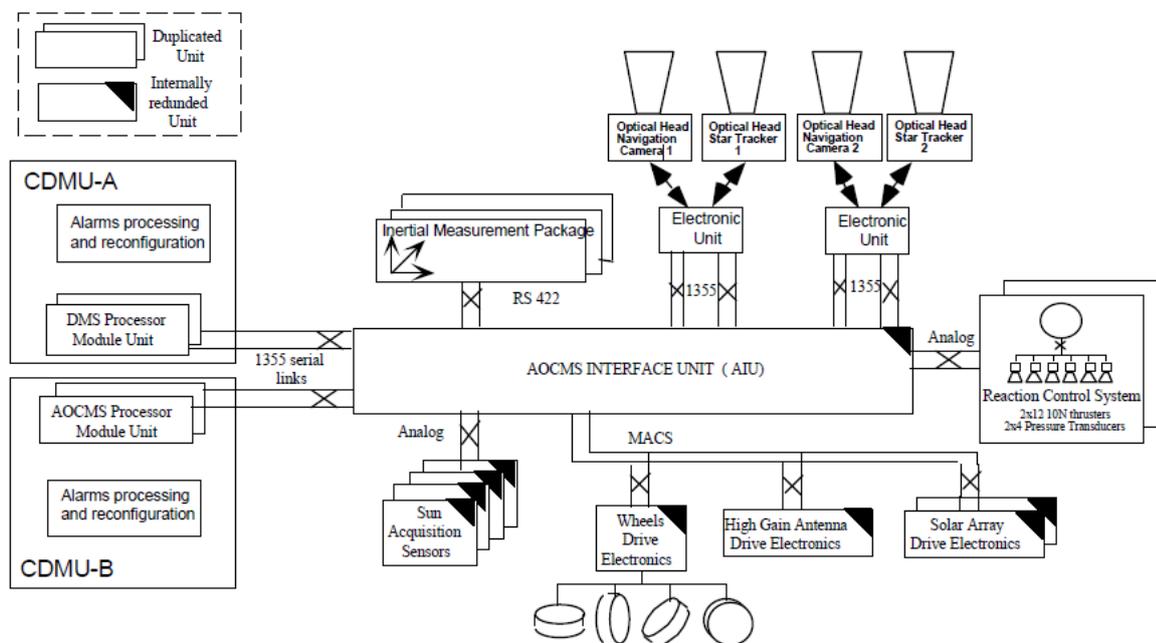


Figure 4 : AOCMS Avionics Overview



3.2 Attitude & Orbit Control System Operating Modes - Datasets

3.2.1 AOCMS – General modes

The Rosetta Spacecraft has numerous AOCMS modes which are used at different stages of the mission. For example, during hibernation, the Near Sun Hibernation Mode (NSHM) was used. During the Asteroid Flybys then the Asteroid Flyby Mode was used (AFM). Normally however, the key mode in use by the Spacecraft was “Normal Mode” (NM) which had a range of sub-modes that were applied depending on the specific activities being carried out. For very stable pointing, the spacecraft used NM-FPAP (Fine Pointing Accuracy Phase), when the spacecraft was dumping the momentum of the wheels then it was in the Wheel Damping Phase (NM-WDP) which involved the use of thrusters.

Figure 5 below shows the numerous modes in use on the spacecraft (including the ones above) and how transitions between them took place.

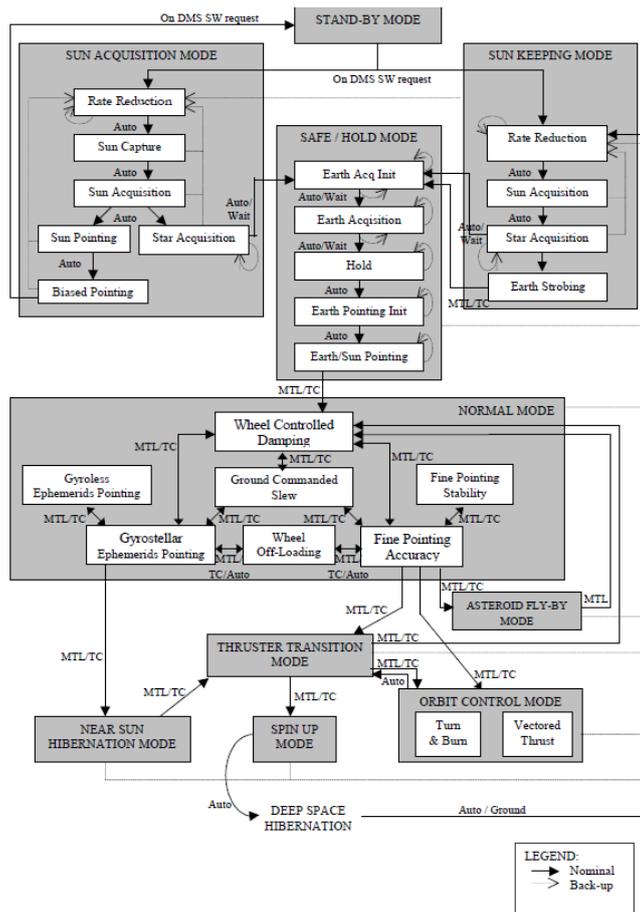


Figure 5 : Spacecraft Avionics Modes



The Avionics modes derived from the AOCMS modes (shown in the figure above) are the following:

Stand-By Mode (SBM)

The SBM is used in Pre-launch and Launch Modes for general check supervision. Only DMS functions are activated. It is possible to command thrusters through AIU for RCS Priming.

Sun Acquisition Mode (SAM)

This mode is used during Separation Sequence to perform rate reduction (if necessary), Sun acquisition and Sun pointing. SAM is also used as second level back-up mode to recover Sun pointing attitude in case of an unsuccessful Sun Keeping Mode.

Safe/Hold Mode (SHM)

The SHM follows the Sun Acquisition Mode / Sun Keeping Mode to achieve a 3-axis attitude based on star trackers, gyros and reaction wheels, with solar arrays pointing towards the Sun and Medium and High Gain Antennae (i.e. S/C Xaxis) pointing towards the Earth and the Y-axis normally pointing to the north of the ecliptic plane.

In some mission phases (i.e. defined by the minimum earth distance), S/C X-axis pointing towards the Earth is forbidden because of thermal constraints. Then, +X axis is pointed towards the Sun, and the High Gain Antenna is pointed towards the Earth.

Normal Mode (NM)

The NM is used in Active Cruise and Near Comet phases for nominal longterm operations, for comet observation and SSP delivery. Reaction wheel off-loading is a function of the Normal Mode. The Normal Mode has the following Sub-modes :

- NM-GSEP : Gyrostellar Ephemeris Pointing
- NM-WDP : Wheel Damping Phase
- NM-FPAP : Fine Pointing Accuracy Phase
- NM-FPSP : Fine Pointing Stabilisation Phase
- NM-WOL : Wheel Off-loading Phase
- NM-GSP : Gyrostellar Phase
- NM-GLEP : Gyroless Phase

Of the above, NM-GSEP was the standard day to day mode in use.



Thruster Transition Mode (TTM)

The TTM is used for transition from Normal Mode to operational thruster Modes, and vice-versa, for control tranquillisation.

Orbit Control Mode (OCM)

The OCM is used in Active Cruise Mode for trajectory and orbit corrections.

Asteroid Fly-By Mode (AFM)

The AFM mode is dedicated to asteroid observation.

Near Sun Hibernation Mode (NSHM)

The NSHM is a 3-axis controlled mode (with the attitude estimation based on the use of STR only, and no gyro), with a dedicated thruster control (i.e. single sided) to minimise the fuel consumption.

Spin-up Mode (SPM)

The SpM is necessary to spin up the spacecraft at hibernation entry (spin down at hibernation exit is achieved by Sun Keeping Mode). The attitude control concept is a completely passive inertial spin during the deep space hibernation phase. There is no AOCMS Deep Space Hibernation Mode.

Sun Keeping Mode (SKM)

The Sun Keeping Mode is used nominally at wake-up after Deep Space hibernation, and as first level back-up mode to recover Sun pointing attitude in case of a failure involving the Avionics and for which a local reconfiguration on redundant units is not efficient. In case the autonomous entry to Safe / Hold Mode is disabled or not successful Earth Strobing Mode is established leading to Aa slow spin motion around the Sun direction.

Then the + X-axis is pointed towards the expected earth direction (i.e. using the actual Sun/spacecraft/Earth angle). The rotation along the Sun line is maintained therefore the Earth crosses once per revolution the + X-axis which will allow communication with the MGA



System Level Modes

A basic configuration of the system level modes is given below:

Pre-launch Mode	Only DMS on, AOCMS PM on, external power supply
Launch Mode	Initially: DMS on, SSMM in standby with 1 MM, AOCMS PM on, separation sequence program running, power supply from batteries Finally: DMS on, AOCMS in Sun Acquisition Mode, TTC S-band downlink on, power supply from solar arrays, X-axis and solar arrays Sun pointing.
Activation Mode	DMS on, AOCMS in Normal Mode, TTC S- or X-band downlink via HGA (initially in S-band via LGA), 3-axis stabilised, SA Sun pointing attitude
Active Cruise Mode	DMS on, AOCMS in Normal Mode or Orbit Control Mode TTC S- or X-band downlink via HGA, 3-axis stabilised, SA Sun pointing attitude
Deep Space Hibernation Mode	CDMU on, AOCMS in SBM mode, inertial spin stabilisation mode, wake-up timers on, thermostat control of heaters
Near Sun Hibernation Mode	DMS on, AOCMS in NSHM, 3-axis active control mode with 2 PMs, star tracker, thrusters, X-axis Sun or Earth pointing
Asteroid Fly-by Mode	DMS on, TTC X-band downlink via HGA, SA Sun pointing, payload on, AOCMS in AFM mode: closed loop asteroid tracking with navigation camera, during Near Fly-by: HGA tracking stopped
Near Comet Mode	DMS on, TTC X-band downlink via HGA, navigation camera and payload on, AOCMS in Normal Mode: 3-axis stabilised, SA Sun pointing, instruments comet pointing;
Safe Mode	DMS on, AOCMS in Safe/Hold Mode; SA Sun pointing, X-axis Sun or Earth pointing, 3-axis stabilised using gyros, star tracker, RWs(if enabled by ground); TTC S-Band downlink via HGA; RXs on HGA/LGA; payload off



Survival Mode DMS on, AOCMS in SKM submode 'MGA Strobing' (or in SKM if this submode is disabled), SA Sun pointing with offset from +X-axis = SSCE angle, fixed small residual rate around Sun vector; control by thrusters, Sun sensors, gyros; S-Band carrier downlink via MGA, RXs on MGA/LGA, load off



3.2.2 Dataset Description

Dataset name: ROSETTA ATTITUDE & ORBIT CONTROL SYSTEM ENGINEERING DATA

Dataset ID: RO-X-HK-3-AOCCGEN-V1.0

/RO-X-HK-3-AOCCGEN-V1.0

/DATA

/CURRENT_AOCS_MODE

/WOL_MANAGER

/WOL_PHASE_DURATION

Parameters contained in the Dataset

In the following table, parameter IDs that have an asterisk have an additional calibration table provided later in this section.

General	Dataset Directory name	Parameter ID (Unit)	Unit	Parameter description
Current AOCS mode	CURRENT_AOCS_MODE	NAWDoV05*	n/a	Current AOCS mode being executed on board
Wheel Offloading Manager	WOL_MANAGER	NACPo435*	n/a	Wheel offloading manager status
Wheel offloading duration	WOL_PHASE_DURATION	NACW1Go2	sec	Wheel offloading duration

Calibration parameters for NAWDoV05

See section 2.3.5 for an explanation of format.

2262	0	0	SBM
2262	1	1	SAM
2262	2	2	SHM
2262	3	3	SKM
2262	4	4	NSH
2262	5	5	NM
2262	6	6	AFM
2262	7	7	TTM
2262	8	8	OCM
2262	9	9	SPM

Calibration parameters for NACPo435



See section 2.3.5 for an explanation of format.

3104	5	5	Damping
3104	6	6	Active
3104	8	8	Off

3.2.3 How to use the data

(a) Looking at what mode was used when on the spacecraft during a specific time period

The parameter data that comes with the current AOCS mode is a key input to understand at what time was a specific activity taking place on the Spacecraft.

The figure below from 2015_04 (April 2015) shows three main modes that were performed on the spacecraft during that month. NM (Normal Mode) which is the general mode in use.

TTM is the intermediate mode between Normal Mode and OCM (Orbit Control Manoeuvre). In that respect, you can see from the drawing when the manoeuvres took place on the spacecraft.

By downloading the file, the exact time when the Manoeuvre starts and ends can be found.

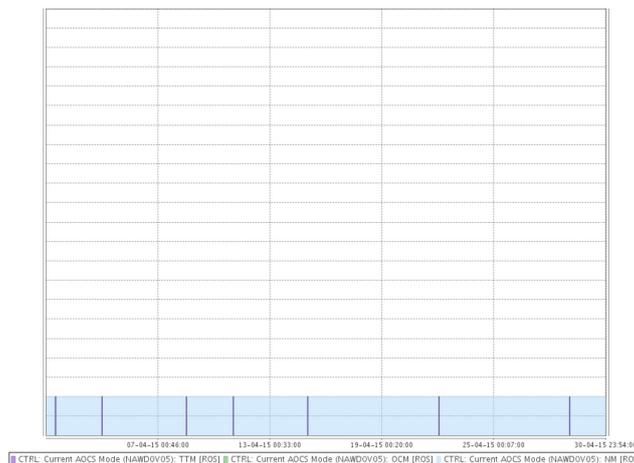


Figure 6 : modes from April 2015

(b) Looking at Wheel Off-loadings and how long they took

The four reaction wheels on the Rosetta Spacecraft helped to maintain the attitude of the spacecraft when the thrusters were not in use. As the momentum increases on these wheels there comes a time where in order to reduce the momentum i.e. dampen it, and reduce the wheel speed, a wheel offloading was required to take place. In a wheel off loading, the thrusters are fired to dampen the wheel momentum.



The AOCS modes in use in this phase therefore would be a transition from the standard NM-GSEP to NM-WDP where the thrusters are fired.

In the datasets provided, the software module which was responsible for the wheels being offloaded was called the Wheel Off loading Manager. If we take an example of one of the browse images for April 2015, one can see three different states for this manager :

- WOL Manager is OFF i.e. no wheel offloading taking place
- WOL Manager is Active – thrusters are being fired
- WOL Manager is damping – damping of the wheels as a result of the thrusters being fired.

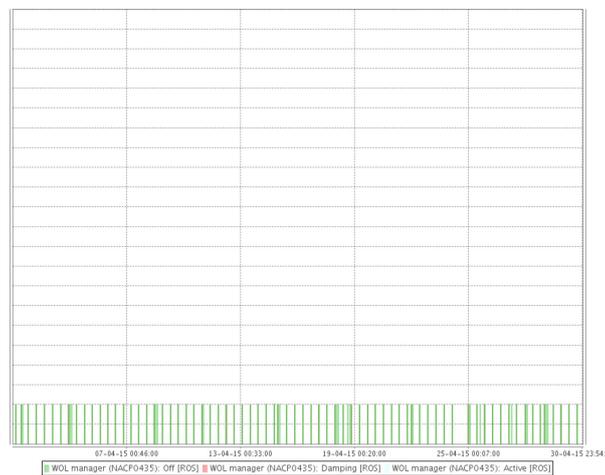


Figure 7 : Wheel Offloading modes from April 2015

The duration of the wheel offloading can be found by studying the data corresponding to the WOL duration. A plot from the same month is shown below.

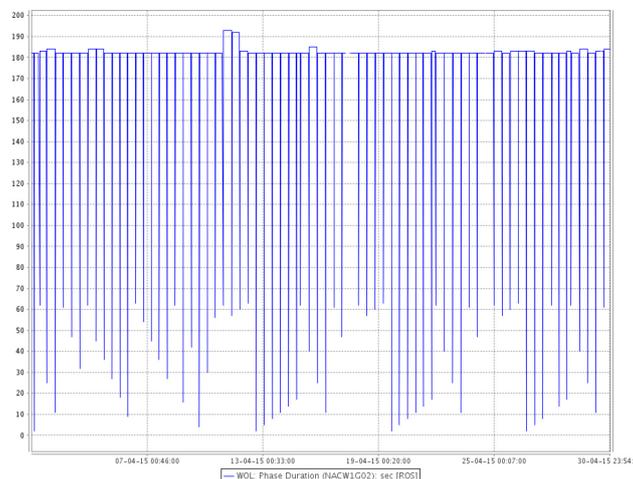


Figure 8 : Wheel Offloading duration – April 2015

3.3 Orbit Control Manoeuvre & Propulsion Dataset

3.3.1 Overview

The RCS subsystem comprises tanks, thrusters and the associated valves and pipework. The main tanks are accommodated within the central tube while the helium pressurisation tanks are mounted on the internal deck. Most of the valves and pipework are located on the +X BSM, panel which becomes permanently attached to the BSM once RCS assembly is completed. Sixteen of the twenty-four thrusters are located at the four lower corners of the BSM. The remaining thrusters are located in 4 groups near the top corners of the S/C. They are installed as part of the BSM, but are attached to the PSM after PSM/BSM mating.

The propulsion subsystem is based on a pressure fed bipropellant type using MMH and NTO. It is capable to operate in both regulated and in blow-down mode and provides a delta v of more than 2100 m/s plus attitude control. It is able to operate in three axis and in spin stabilised mode (about the x-axis) provided that the spin rate does not exceed 1 rpm. The subsystem provides a high degree of redundancy in order to cope with the special requirements of the ROSETTA mission.

The materials used in the propulsion subsystem are proven to be compatible with the propellants and their vapours the wetted area being mainly made of titanium or suitable stainless steel alloys.

The components and most of the pipework are installed on the spacecraft -X panel by means of supporting brackets made of material with low thermal conductance. The subsystem has 24 10 N thruster for attitude and orbit control. They are located such that they can provide pure forces and pure torques to the spacecraft. The 24 thrusters are grouped in pairs on the brackets, one of each pair being the main and one the redundant thruster. The subsystem allows the operation of 8 thrusters simultaneously.

The subsystem will be maintained within the temperature limits of the components. The mixture ratio may be adjusted by tank temperature (i.e. pressure) manipulation in order to enhance thruster performance.

RCS Subsystem Sections

The RCS subsystem consists of two main sections; a high pressure gas section and a low pressure gas/liquid propellant section.

The high pressure section provides storage, control & supply of helium to the low pressure section. The low pressure section provides propellant storage & delivery to a set of 24 10 Newton dual valve thrusters used for attitude and orbit control. The system is capable of operating in both regulated and blowdown modes. Redundancy of function is provided.



The subsystem will be able to operate when the spacecraft is three axis or spin stabilised provided the spin rate does not exceed 1 RPM . Beyond the specified spin rate propellant pumping within the tank may fail depending on amount of propellant remaining at the time. Firing of thrusters would still be possible from the reserves within the refillable reservoir but this supply is finite. If more than 1 RPM is not planned then the reserve is a contingency.

All materials that are used within the subsystem will be compatible with the propellants or vapours where they are exposed for the duration of the mission. Titanium alloy will constitute the majority of the wetted area with some suitable stainless steels and small amounts of Teflon for valve seats.

The subsystem will be maintained within a temperature range such that the components do not exceed their temperature limits .Temperature manipulation can be used to aid thruster performance (adjusting tank pressure to manipulate mixture ratio) during blowdown phases.

Keeping the temperature of the propellant within the tanks lower than the temperature of the pressurant feed pipework will promote propellant vapour condensation in the tank rather than the pressurant pipe-work .The pipework and components will be supported on brackets made of material with a low thermal conductance.

Thruster Accommodation

The 24 thrusters are grouped in pairs of two, one of each pair being the main and one the redundant one. The nominal thruster coordinates and thrust axis directions with respect to the spacecraft axes are given in the table below and are shown in the figure below (also in Figure 1).

Thruster	Co-ordinates in S/C axes			Direction Cosines w.r.t S/C axes			Thrust
	X	Y	Z	X	Y	Z	
1A	-1231.9	-1139.5	2176.8	0.4698	0.8660	-0.1710	10
2A	1231.9	-1139.5	2176.8	-0.4698	0.8660	-0.1710	10
3A	-1231.9	-1139.5	-84.252	0.4698	0.8660	0.1710	10
4A	1231.9	-1139.5	-84.252	-0.4698	0.8660	0.1710	10
5A	1231.9	1139.5	-84.252	-0.4698	-0.8660	0.1710	10
6A	-1231.9	1139.5	-84.252	0.4698	-0.8660	0.1710	10
7A	1231.9	1139.5	2176.8	-0.4698	-0.8660	-0.1710	10
8A	-1231.9	1139.5	2176.8	0.4698	-0.8660	-0.1710	10
9A	-1160	-903	-199.2	0.0000	0.0000	1.0000	10
10A	1160	-903	-199.2	0.0000	0.0000	1.0000	10
11A	1160	903	-199.2	0.0000	0.0000	1.0000	10
12A	-1160	903	-199.2	0.0000	0.0000	1.0000	10
Thruster	Co-ordinates in S/C axes			Direction Cosines			Thrust
	X	Y	Z	X	Y	Z	
1B	-1238	-1150.9	2101.9	0.4698	0.8660	-0.1710	10
2B	1238	-1150.9	2101.9	-0.4698	0.8660	-0.1710	10
3B	-1238	-1150.9	-9.371	0.4698	0.8660	0.1710	10
4B	1238	-1150.9	-9.371	-0.4698	0.8660	0.1710	10
5B	1238	1150.9	-9.371	-0.4698	-0.8660	0.1710	10
6B	-1238	1150.9	-9.371	0.4698	-0.8660	0.1710	10
7B	1238	1150.9	2101.9	-0.4698	-0.8660	-0.1710	10
8B	-1238	1150.9	2101.9	0.4698	-0.8660	-0.1710	10
9B	-1160	-827	-199.2	0.0000	0.0000	1.0000	10
10B	1160	-827	-199.2	0.0000	0.0000	1.0000	10
11B	1160	827	-199.2	0.0000	0.0000	1.0000	10
12B	-1160	827	-199.2	0.0000	0.0000	1.0000	10

Table 1 : Thruster coordinates and corresponding thrust cosine directions

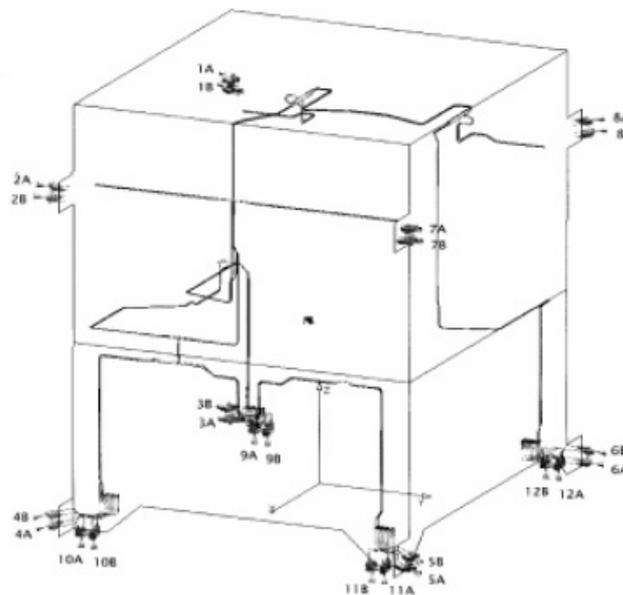


Figure 9 : Thruster location (see also Figure 1)

3.3.2 Dataset Description

Dataset name: ROSETTA ORBIT CONTROL MANOEUVRE ENGINEERING DATA

Dataset ID: RO-X-HK-3-OCMRCS-V1.0

/RO-X-HK-3-OCMRCS-V1.0

/DATA

/OCM_IMPULSE_MEAS

/OCM_ACCEL_MEAS

/OCM_ESTIM_TRANS_VEL

/OCM_EST_DIST_TORQUES

/RCS_THRUST_ON_CYCLES_1_TO_8

/RCS_THRUST_ON_CYCLES_9_TO_12

/RCS_CUM_THRUST_CONS_1_TO_8

/RCS_CUM_THRUST_CONS_9_TO_12

/RCS_CUM_FUEL_THRUST_CONS

Parameters contained in the Dataset

General	Directory name	Parameter ID	Unit	Description
OCM Impulse Meas Approach	OCM_IMPULSE_MEAS	NACW1D0A	Ns	OCM Impuls Estim Velocity
OCM Impulse Meas Approach	OCM_IMPULSE_MEAS	NACW1D07	Ns	OCM: Impulse Cmd delta-V
OCM Acceleration Meas approach	OCM_ACCEL_MEAS	NACW1D05	m/s	OCM: Accel Cmd delta-V
OCM Acceleration Meas approach	OCM_ACCEL_MEAS	NACW1D09	m/s	OCM Accel Estim Velocity
OCM Estim Transverse Vel	OCM_ESTIM_TRANS_VEL	NACW1D0E	m/s	OCM Estim Transverse Vel
OCM Estim Disturbance Torques	OCM_EST_DIST_TORQUES	NACW1D0O	Nm	OCM Estim Dist Torque X1
OCM Estim Disturbance Torques	OCM_EST_DIST_TORQUES	NACW1D0P	Nm	OCM Estim Dist Torque X2



OCM Disturbance Torques	Estim	OCM_EST_DIST_TORQUES	NACW1D0Q	Nm	OCM Estim Dist Torque X3
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0J	n/a	RCS Nb ON Cycles Thr1
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0K	n/a	RCS Nb ON Cycles Thr2
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0L	n/a	RCS Nb ON Cycles Thr3
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0M	n/a	RCS Nb ON Cycles Thr4
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0N	n/a	RCS Nb ON Cycles Thr5
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0O	n/a	RCS Nb ON Cycles Thr6
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0P	n/a	RCS Nb ON Cycles Thr7
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_1_TO_8	NACW0M0Q	n/a	RCS Nb ON Cycles Thr8
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_9_TO_12	NACW0M0R	n/a	RCS Nb ON Cycles Thr9
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_9_TO_12	NACW0M0S	n/a	RCS Nb ON Cycles Thr10
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_9_TO_12	NACW0M0T	n/a	RCS Nb ON Cycles Thr11
RCS Number	Thruster On Cycles	RCS_THRUST_ON_CYCLES_9_TO_12	NACW0M0U	n/a	RCS Nb ON Cycles Thr12
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M0V	gr	RCS Cum Consumption Thr1
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M0W	gr	RCS Cum Consumption Thr2
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M0X	gr	RCS Cum Consumption Thr3
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M0Y	gr	RCS Cum Consumption Thr4
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M0Z	gr	RCS Cum Consumption Thr5
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M10	gr	RCS Cum Consumption Thr6
RCS Consumption	Cum Thruster	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M11	gr	RCS Cum Consumption Thr7



RCS Cum Thruster Consumption	RCS_CUM_THRUST_CONS_1_TO_8	NACW0M12	gr	RCS Consumption Thr8 Cum
RCS Cum Thruster Consumption	RCS_CUM_THRUST_CONS_9_TO_12	NACW0M13	gr	RCS Consumption Thr9 Cum
RCS Cum Thruster Consumption	RCS_CUM_THRUST_CONS_9_TO_12	NACW0M14	gr	RCS Consumptn Thr10 Cum
RCS Cum Thruster Consumption	RCS_CUM_THRUST_CONS_9_TO_12	NACW0M15	gr	RCS Consumptn Thr11 Cum
RCS Cum Thruster Consumption	RCS_CUM_THRUST_CONS_9_TO_12	NACW0M16	gr	RCS Consumptn Thr12 Cum
RCS Cum Thruster Consumption	RCS_CUM_FUEL_THRUST_CONS	NAWG0060	gr	RCS Cum Fuel Consumption

3.3.3 How to use the data

(a) Relevant properties of an Orbit Control Mode manoeuvre

A wide range of HK parameters are provided to allow the user to understand the actual performance of the RCS system during an Orbit Control Manoeuvre.

For example, the figure below shows a thumbnail from Q1 in 2015 which gives an idea of when OCMs have taken place when this measurement method was used. To know exactly when an OCM happened, one can see the mode change in the AOCS general parameters described earlier.

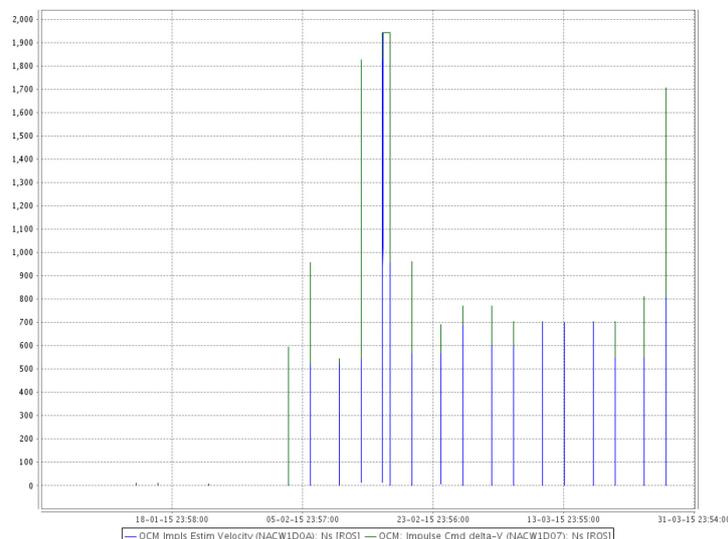


Figure 10 : OCM Impulse measurement approach



With different HK parameters, one can measure the disturbance torques on the different S/C axes during the manoeuvre.

(b) Looking at when thrusters were fired and which ones were used

The thrusters are used in a number of different Spacecraft modes. The key ones are the TTM (Thruster Transition Mode) and the Orbit Control Mode (OCM).

For certain scientific reasons e.g. contamination, there is a need to understand which thrusters were firing and when exactly did the fire. This is the information that can be derived from the # of on cycles of each of the thrusters e.g Figure 11 from 2016 Q2. When a thruster is used, then the on cycle value increments.

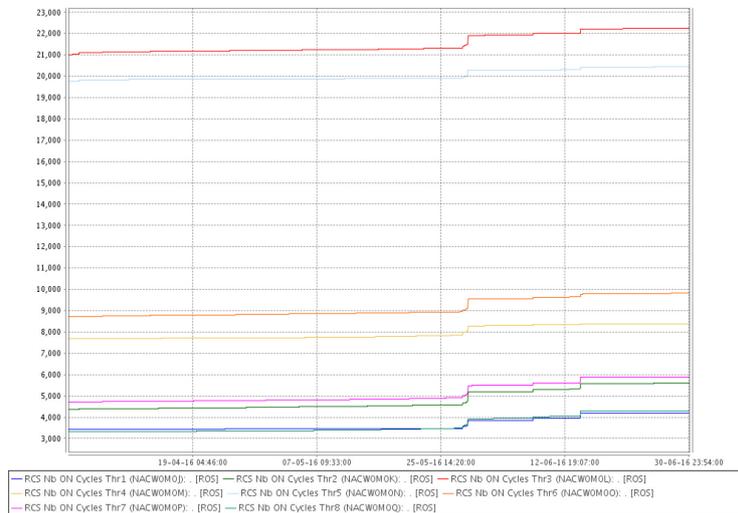


Figure 11 : Thrusters 1-8 on-cycles

Further to this, one can look at the cumulative consumption in grams derived from each of the thrusters or indeed as a whole.

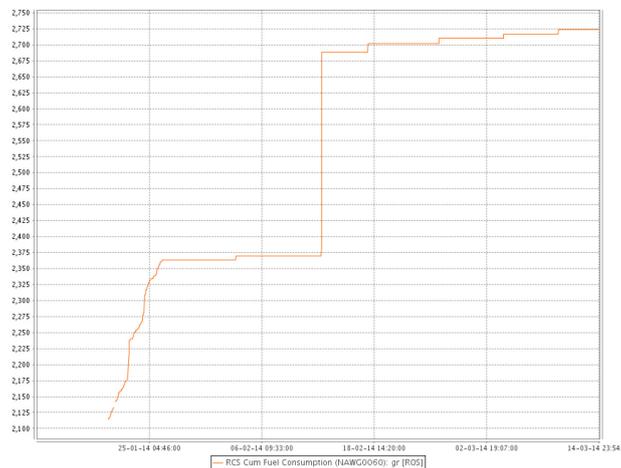


Figure 12 : Cumulative Fuel consumption (grams)

(c) Science publications that have used this data

The following science publication used the HK data from the thruster system to understand better the contamination on the spacecraft :

- Thruster Plumes: Sources for High Pressure and Contamination at the Payload Location, 2018, Graf, S. **Article** in *Journal of Spacecraft and Rockets* · January 2008 DOI: 10.2514/1.30600

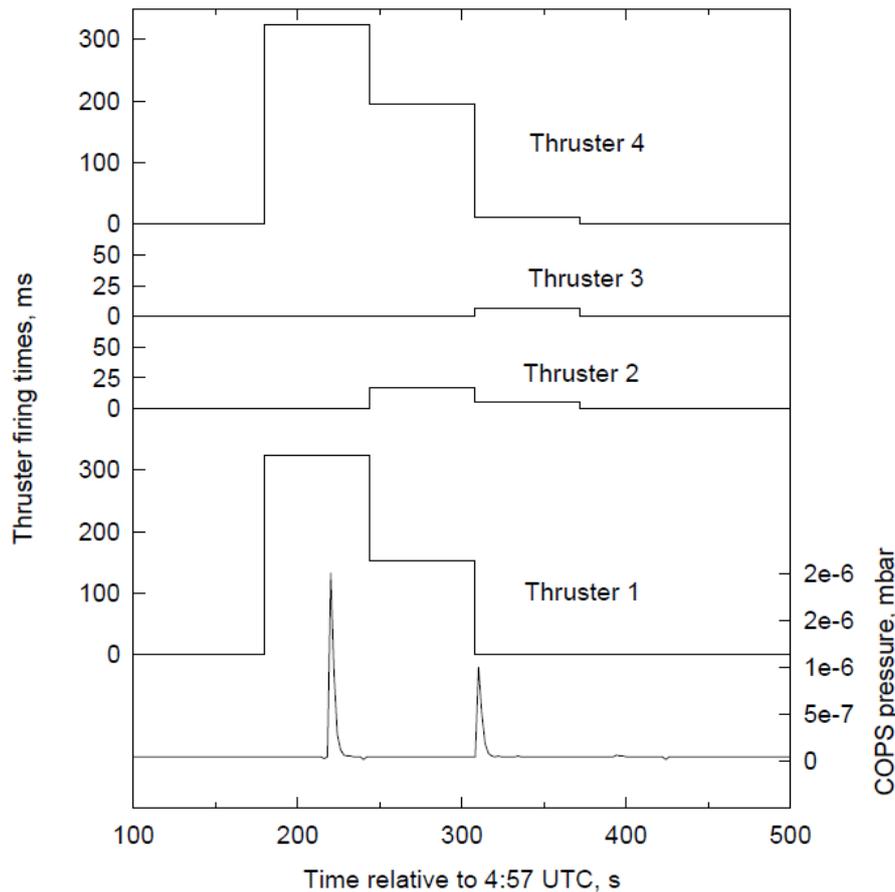


Figure extracted from paper above : Thruster firing from September 19, 2004. The thruster firing times are superimposed over the COPS pressure data set. The S/C data channel recorded the thruster operation times every 64 s. Please note, that the thruster firing time scales for thruster 2 and thruster 3 are enhanced by a factor of two.

- The influence of spacecraft outgassing on the exploration of tenuous atmospheres with in situ mass spectrometry,
- An interesting blog post : <http://blogs.esa.int/rosetta/2014/07/02/rosetta-smells-its-exhaust>

3.4 Inertial Measurement Package (IMP) Dataset

3.4.1 Overview

The AOCMS subsystem is built around the AOCMS Interface Unit (AIU) which is used by the AOCMS-SW to exchange functional data with:

- **the sensors:** 2 Navigation Cameras (CAM) and 2 Star Trackers (STR), 4 Sun Acquisition Sensors (SAS) and 3 Inertial Measurement Packages (IMP), each IMP includes 3 gyros + 3 accelerometers,
- **the actuators:** the Reaction Wheel Assembly (RWA) belonging to the Avionics, and the Reaction Control System (RCS), the High Gain Antenna Pointing Mechanism (HGAPM), and the 2 Solar Array Drive Mechanisms (SADM) belonging to the Platform.

The Inertial Measurement Packages (IMP): The IMP function provides roll rate and velocity measurements along 3 orthogonal axes.

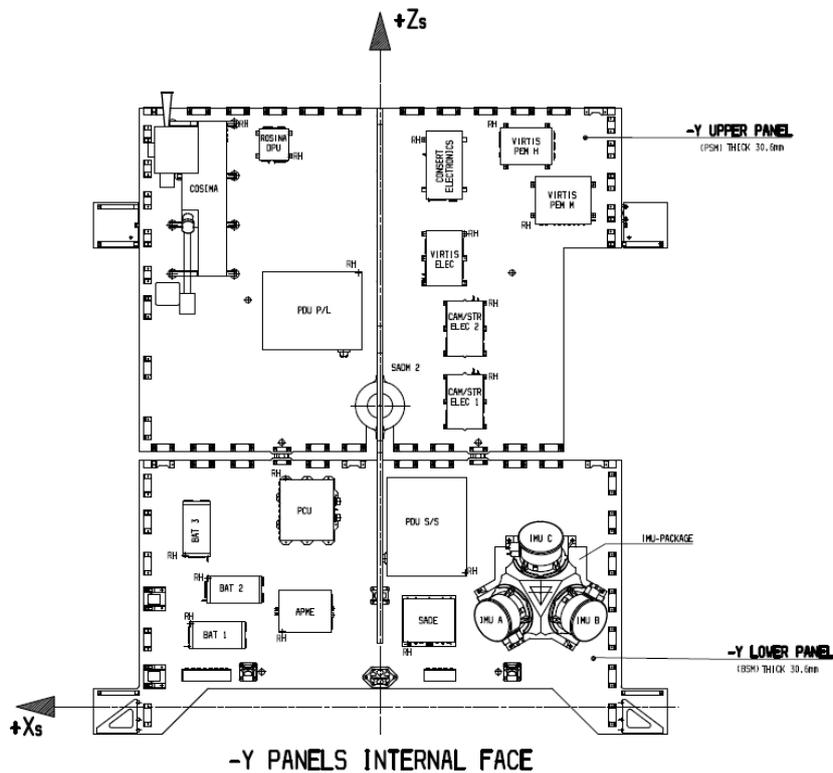


Figure 13 : Location of the Inertial Measurement Packages (IMU in this figure)



3.4.2 Dataset Description

Dataset name: ROSETTA INERTIAL MEASUREMENT PACKAGE ENGINEERING DATA

Dataset ID: RO-X-HK-3-IMP-V1.0

/RO-X-HK-3-IMP-V1.0

/DATA

/IMP_RATE

/IMP_A_GYRO

/IMP_B_GYRO

/IMP_C_GYRO

/GYRO_CONS_ERR

General	Directory name	Parameter ID	Unit	Description
IMP Rate Measurements	IMP_RATE	NACX0001	Deg/sec	IMP Rate Measurement X
IMP Rate Measurements	IMP_RATE	NACX0002	Deg/sec	IMP Rate Measurement Y
IMP Rate Measurements	IMP_RATE	NACX0003	Deg/sec	IMP Rate Measurement Z
IMP A Gyro Measuremnt	IMP_A_GYRO	NACWoE00	Rad/sec	IMP A Gyro Measuremnt X1
IMP A Gyro Measuremnt	IMP_A_GYRO	NACWoE01	Rad/sec	IMP A Gyro Measuremnt X2
IMP A Gyro Measuremnt	IMP_A_GYRO	NACWoE02	Rad/sec	IMP A Gyro Measuremnt X3
IMP B Gy ro Measuremnt	IMP_B_GYRO	NACWoE0A	Rad/sec	IMP B Gyro Meas. X
IMP B Gy ro Measuremnt	IMP_B_GYRO	NACWoE0B	Rad/sec	IMP B Gyro Meas. Y
IMP B Gy ro Measuremnt	IMP_B_GYRO	NACWoE0C	Rad/sec	IMP B Gyro Meas. Z
IMP C Gy ro Measuremnt	IMP_C_GYRO	NACWoE0K	Rad/sec	IMP C Gyro Measuremnt X1
IMP C Gy ro Measuremnt	IMP_C_GYRO	NACWoE0L	Rad/sec	IMP C Gyro Measuremnt X2
IMP C Gy ro Measuremnt	IMP_C_GYRO	NACWoE0M	Rad/sec	IMP C Gyro Measuremnt X3



Gyro consistency Error	GYRO_CONS_ERR	NACWoPoB	n/a	gyro consistency error
------------------------	---------------	----------	-----	------------------------

3.4.3 How to use the data

Looking at general gyro measurements for attitude monitoring

The key HK data to use to look at the attitude of the spacecraft at any one time is the IMP Rate (NACX0001 to 0003 – unit degrees/sec). Whether a manoeuvre is ongoing, or the spacecraft is going through turbulence due to gas, then this shows the stability of the spacecraft. The figure below comes from Q1 2016.

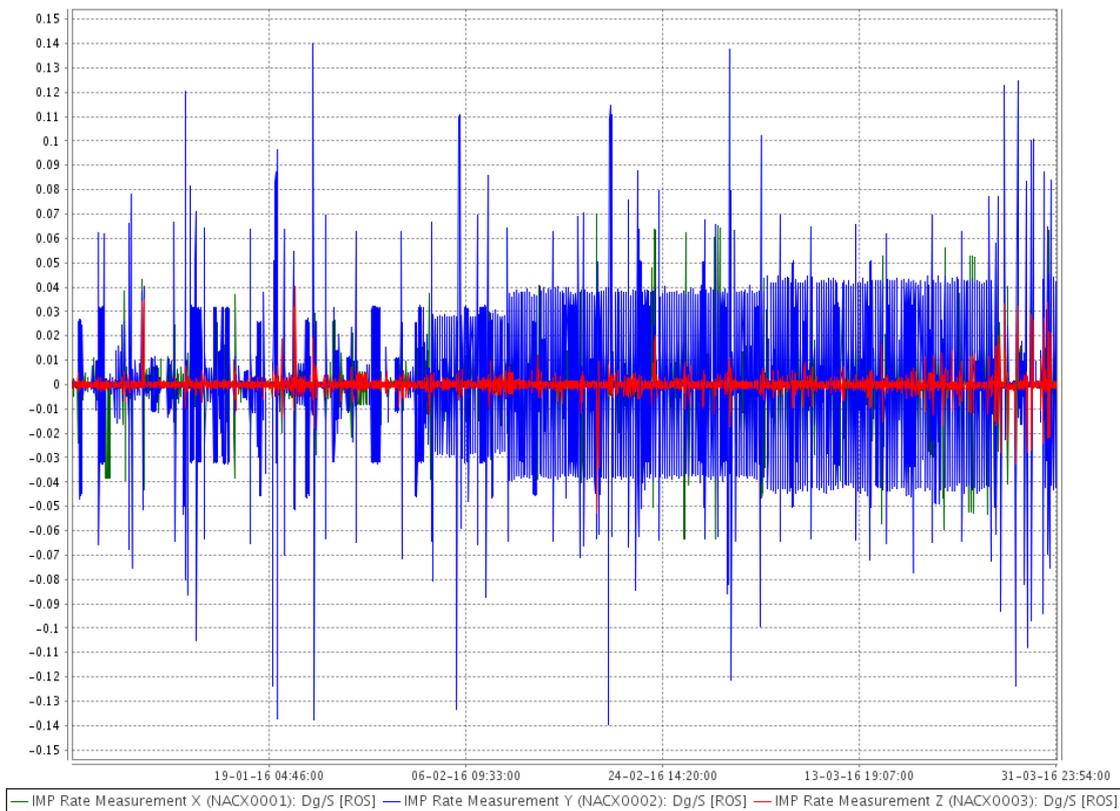


Figure 14 : Gyro information from Q1 2016

3.5 Radiation Data Corrections (EDAC) Dataset

3.5.1 Overview

The contents of this dataset represents measured housekeeping values provided by different computers on board the Rosetta spacecraft relating to corrections by the software on those computers of radiation bit-flips (single event upsets). The EDAC counter shows how many times the software has had to correct for a bit flip. EDAC stands for Error Detection & Correction.

This dataset provides EDAC values from the AOCMS computer, DMS computer, Startrackers and the Navigation Cameras. In addition, the single event upset values measured by the Star Tracker is provided.

In the case of the AOCMS & DMS EDAC datasets, the values provided were observed to reset a number of times during the course of the mission. A check with the Mission Operations Centre did not provide a reason for this reset although it is believed to be most likely due to a full software upload being made on these computers whereby a reset was needed in order to use the most recent software.

To aid the user in understanding where the above are located on the spacecraft two drawings are provided below :

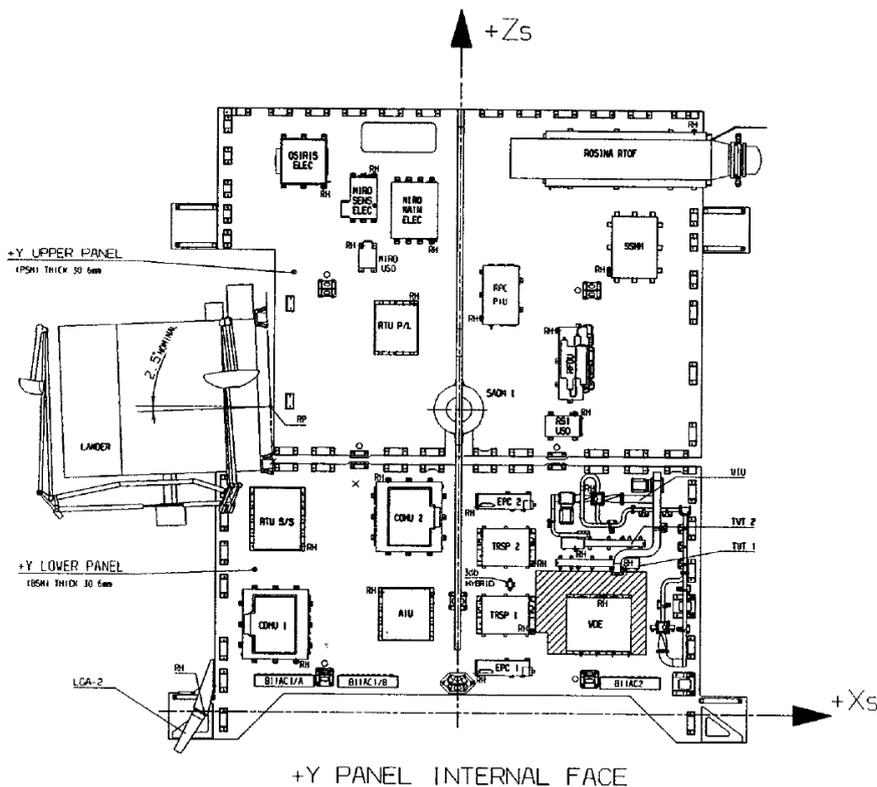


Figure 15 : Positions of the AOCMS (AIU) & DMS (CDMS) computers – bottom left

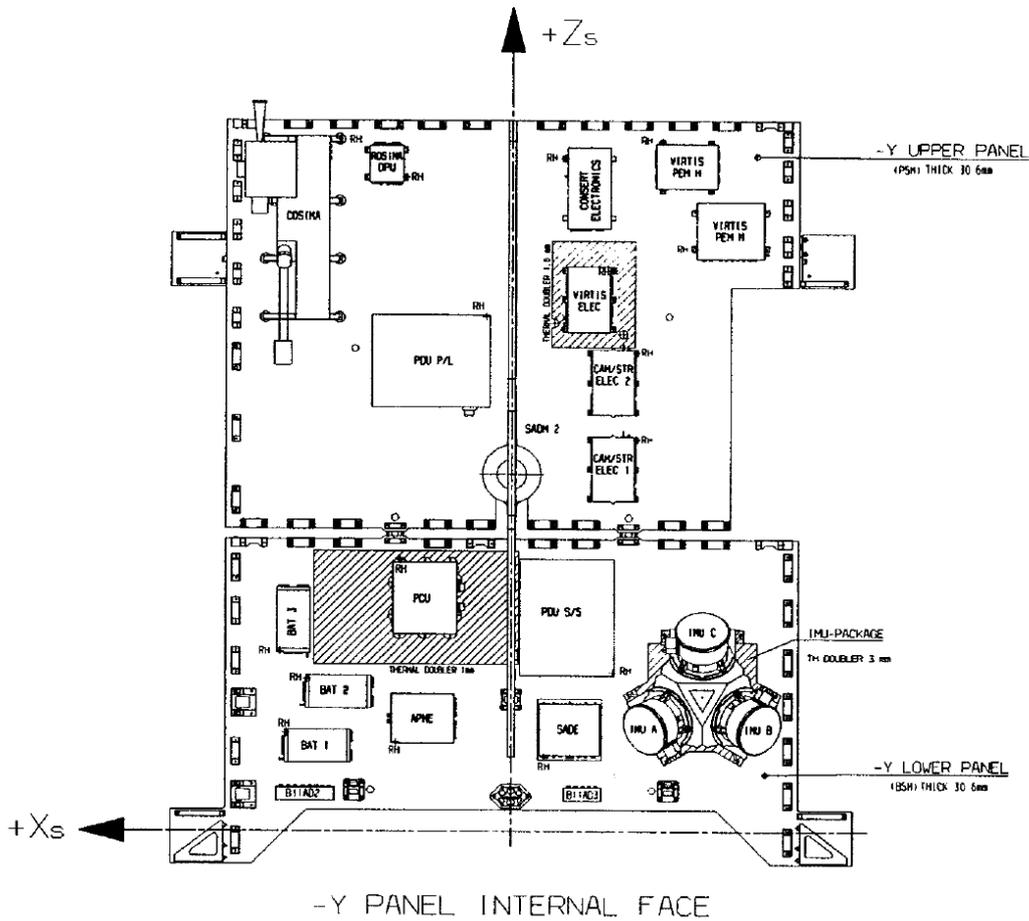


Figure 16 : Positions of the CAM & STR electronic computers 1 & 2 (middle right)

3.5.2 Dataset Description

Dataset name: ROSETTA RADIATION DATA CORRECTION ENGINEERING DATA

Dataset ID: RO-X-HK-3-EDAC-V1.0

/RO-X-HK-3-EDAC-V1.0

/DATA

/AOCS_AND_DMS_EDAC_CNTR

/NAVCAM_A_EDAC_CNTR

/NAVCAM_B_EDAC_CNTR

/STR_A_EDAC_CNTR

/STR_B_EDAC_CNTR

/STR_NB_SEU_FOUND



General	Directory name	Parameter ID	Unit	Description
AOCS and DMS EDAC Counters	AOCS_AND_DMS_EDAC_CNTR	NACWoDoA	n/a	BTSTP: EDAC Counter
AOCS and DMS EDAC Counters	AOCS_AND_DMS_EDAC_CNTR	NDMWoDoA	n/a	EDAC counter
NAVCAMA EDAC Counters	NAVCAM_A_EDAC_CNTR	NACP1801	n/a	CAM A DRAM EDAC Sec Cntr
NAVCAMA EDAC Counters	NAVCAM_A_EDAC_CNTR	NACW1RoR	n/a	CAM A Dt RAM EDAC Cntr
NAVCAMA EDAC Counters	NAVCAM_A_EDAC_CNTR	NACW1RoQ	n/a	CAM A Pr RAM EDAC Cntr
NAVCAMA EDAC Counters	NAVCAM_A_EDAC_CNTR	NACP1800	n/a	CAM A PRAM EDAC Sec Cntr
NAVCAMB EDAC Counters	NAVCAM_B_EDAC_CNTR	NACP2801	n/a	CAM B DRAM EDAC Sec Cntr
NAVCAMB EDAC Counters	NAVCAM_B_EDAC_CNTR	NACW1R1L	n/a	CAM B Dt RAM EDAC Cntr
NAVCAMB EDAC Counters	NAVCAM_B_EDAC_CNTR	NACW1R1K	n/a	CAM B Pr RAM EDAC Cntr
NAVCAMB EDAC Counters	NAVCAM_B_EDAC_CNTR	NACP2800	n/a	CAM B PRAM EDAC Sec Cntr
STR A EDAC Counters	STR_A_EDAC_CNTR	NACP1301	n/a	STR A DRAM EDAC Sec Cntr
STR A EDAC Counters	STR_A_EDAC_CNTR	NACW1LoQ	n/a	STR A Dt RAM EDAC Cntr
STR A EDAC Counters	STR_A_EDAC_CNTR	NACW1LoP	n/a	STR A Pr RAM EDAC Cntr
STR A EDAC Counters	STR_A_EDAC_CNTR	NACP1300	n/a	STR A PRAM EDAC Sec Cntr
STR B EDAC Counters	STR_B_EDAC_CNTR	NACP2301	n/a	STR B DRAM EDAC Sec Cntr
STR B EDAC Counters	STR_B_EDAC_CNTR	NACW1LiJ	n/a	STR B Dt RAM EDAC Cntr
STR B EDAC Counters	STR_B_EDAC_CNTR	NACW1LiI	n/a	STR B Pr RAM EDAC Cntr
STR B EDAC Counters	STR_B_EDAC_CNTR	NACP2300	n/a	STR B PRAM EDAC Sec Cntr
STR Nb SEU found	STR_NB_SEU_FOUND	NACW1KoH	n/a	STR A Nb SEU Found
STR Nb SEU found	STR_NB_SEU_FOUND	NACW1K2X	n/a	STR B Nb SEU Found



3.5.3 How to use the data

Looking at EDAC (Error Detection and Correction) counts

An example is provided below which shows the EDAC counts from the AOCMS & DMS computers during Q1 2015.

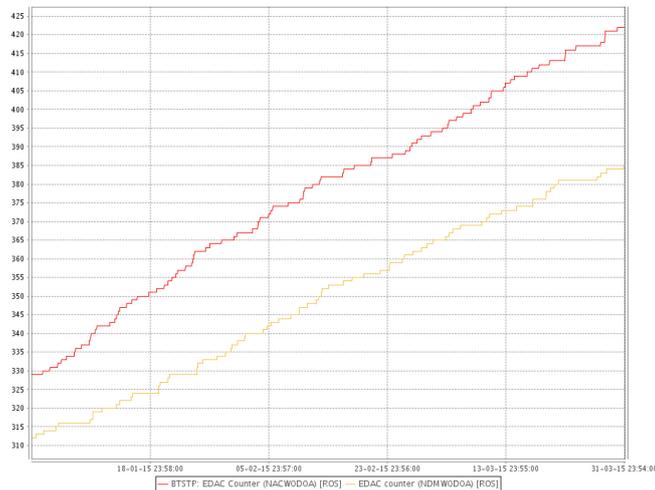


Figure 17 : EDAC counts for Q1 2015 for the AOCMS & DMS computers

This data can be used/combined with similar data coming from other satellites to help understand when e.g. the output of solar storms, are registered by Rosetta – taking into account its location with respect to the sun at that time.

3.6 Reaction Wheels (RWL) Dataset

3.6.1 Overview

The AOCMS subsystem is built around the AOCMS Interface Unit (AIU) which is used by the AOCMS-SW to exchange functional data with:

- **the sensors:** 2 Navigation Cameras (CAM) and 2 Star Trackers (STR), 4 Sun Acquisition Sensors (SAS) and 3 Inertial Measurement Packages (IMP), each IMP includes 3 gyros + 3 accelerometers,
- **the actuators:** the Reaction Wheel Assembly (RWA) belonging to the Avionics, and the Reaction Control System (RCS), the High Gain Antenna Pointing Mechanism (HGAPM), and the 2 Solar Array Drive Mechanisms (SADM) belonging to the Platform.

The reaction wheels are located on the internal deck which provides them with a thermo-elastically stable location.

There are 4 Reaction Wheels: they are arranged in a tetrahedral configuration about the S/C Y-axis in order to enhance the torque and momentum capacity about that axis for the asteroid fly-by.

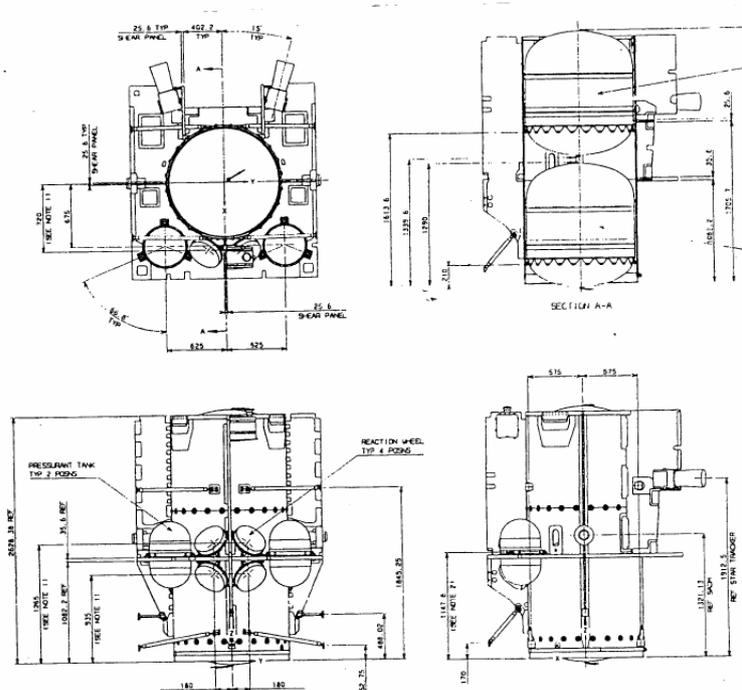


Figure 18 : Reaction wheel assembly & orientation on the s/c

The dataset provided gives specific information on the actual use and performance of the 4 reaction wheels. In this respect, the measured wheel speed & angular momentum provide



information on how fast the wheels themselves are running & associated momentum. Similarly the wheel direction is useful to understand when the wheel crosses the zero point and changes direction in its spin.

Two other parameters are provided, namely the friction torque and the friction coefficient. The friction torque of the bearings measured as well as the friction coefficient aid in understanding the long term performance of the reaction wheel bearings & lubricant.

The RW bearing friction is directly linked to the time needed by the wheels to slow down from 35 *N.m.s* (which is consistent with the FDIR threshold of the RW estimated angular momentum Surveillance) to a complete stop, when no control torque is applied. This duration was monitored at each maintenance test, and compared to the previous results.

The evolution of the wheels speed during this spin-down can also be used to derive the bearing friction level from a viscous / Coulomb model for example.

3.6.2 Dataset Description

Dataset name: ROSETTA REACTION WHEEL ENGINEERING DATA

Dataset ID: RO-X-HK-3-RWL-V1.0

/RO-X-HK-3-RWL-V1.0

/DATA

/RWL_FRICT_COEFF

/RWL_EST_FRICT_TORQUE

/RWL_MEAS_ANG_MOM

/RWL_WHEEL_SPEED

/RWL_WHEEL_DIRECTION

General	Directory name	Parameter ID	Unit	Description
RWL Friction Coefficient	RWL_FRICT_COEFF	NAAG0005	Nms	RW A fric coeff.
RWL Friction Coefficient	RWL_FRICT_COEFF	NAAG0006	Nms	RW B fric coeff.
RWL Friction Coefficient	RWL_FRICT_COEFF	NAAG0007	Nms	RW C fric coeff.
RWL Friction Coefficient	RWL_FRICT_COEFF	NAAG0008	Nms	RW D fric coeff.
RWL Est Friction Torque	RWL_EST_FRICT_TORQUE	NACW0G05	Nm	RW A Est Friction Torque
RWL Est Friction Torque	RWL_EST_FRICT_TORQUE	NACW0G0H	Nm	RW B Est Friction Torque



RWL Est Friction Torque	RWL_EST_FRICT_TORQUE	NACW0GoT	Nm	RW C Est Friction Torque
RWL Est Friction Torque	RWL_EST_FRICT_TORQUE	NACW0G15	Nm	RW D Est Friction Torque
RWL Measured Ang Momentum	RWL_MEAS_ANG_MOM	NACG0010	Nms	RW A Real Measured Ang M
RWL Measured Ang Momentum	RWL_MEAS_ANG_MOM	NACG0011	Nms	RW B Real Measured Ang M
RWL Measured Ang Momentum	RWL_MEAS_ANG_MOM	NACG0012	Nms	RW C Real Measured Ang M
RWL Measured Ang Momentum	RWL_MEAS_ANG_MOM	NACG0013	Nms	RW D Real Measured Ang M
RWL Wheel Speed	RWL_WHEEL_SPEED	NACG0014	Rpm	RW A Real Wheel Speed
RWL Wheel Speed	RWL_WHEEL_SPEED	NACG0015	Rpm	RW B Real Wheel Speed
RWL Wheel Speed	RWL_WHEEL_SPEED	NACG0016	Rpm	RW C Real Wheel Speed
RWL Wheel Speed	RWL_WHEEL_SPEED	NACG0017	Rpm	RW D Real Wheel Speed
RWL Wheel Direction	RWL_WHEEL_DIRECTION	NAAD6011	n/a	RW A Wheel direction
RWL Wheel Direction	RWL_WHEEL_DIRECTION	NAAD6021	n/a	RW B Wheel direction
RWL Wheel Direction	RWL_WHEEL_DIRECTION	NAAD6031	n/a	RW C Wheel direction
RWL Wheel Direction	RWL_WHEEL_DIRECTION	NAAD6041	n/a	RW D Wheel direction

3.6.3 How to use the data

Checking for a wheel offloading using Reaction Wheel ang momentum

In an earlier section, how to find out the timing of a wheel offloading was explained. With the above parameters, one can find out also when a wheel offloading is taking place as one can see the change in wheel speeds.

In the example below from Q1 2014, one can see the commissioning of the reaction wheels after the spacecraft exited from the Deep Space Hibernation.



Figure 19 : Reaction wheel angular momentum

3.7 High Gain Antenna (HGA) Dataset

3.7.1 Overview

A 2.2m diameter HGA is stowed face-outwards for launch against the S/C +X face (so it would be partially usable even in the event of a deployment failure). After deployment, the HGA can be rotated in two axes around a pivot point on a tripod assembly some distance clear of the lower corner of the S/C. This provides the HGA with greater than hemispherical pointing range.

HGA Antenna Pointing Mechanism (APM)

The APM is a two-axes mechanism which allows motion of the HGA in both azimuth and elevation. The control authority rests with the AOCMS subsystem, which always 'knows' the actual attitude and Earth direction and is therefore in the position to determine the required orientation of the antenna. The positioning commands are routed from the AOCMS I/F Unit via the APM-E (APM-Electronics) to the APMM.

HGA elevation rotation is physically limited to +30 degrees/ -165 degrees from the reference position (after deployment). Before and during deployment the range is -207° and +30°. The HGA azimuth rotation is physically limited to +80 to -260 degrees from the reference position.

The main functions of the APM are:

- Allow accurate and stable pointing of the antenna dish through controlled rotation about azimuth and elevation axes.
- Minimise stresses on the waveguides by acting as load transfer path between the HGA and the spacecraft.

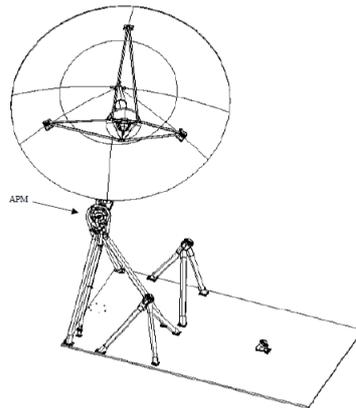


Figure 20 : HGA In deployed state

3.7.2 Dataset Description

Dataset name: ROSETTA HIGH GAIN ANTENNA ENGINEERING DATA

Dataset ID: RO-X-HK-3-HGAAPM-V1.0

/RO-X-HK-3-HGAAPM-V1.0

/DATA

- /HGA_EARTH_AZ_ELEV
- /HGA_MEAS_AZ_ELEV
- /HGA_A_ABSANG_ERR_AZ_EL
- /HGA_A_DISP_ERR_AZ_EL
- /HGA_B_ABSANG_ERR_AZ_EL
- /HGA_B_DISP_ERR_AZ_EL

General	Directory name	Parameter ID	Unit	Description
HGA Earth Az and Elev	HGA_EARTH_AZ_ELEV	NACX0009	Deg	APME: Earth Azimuth
HGA Earth Az and Elev	HGA_EARTH_AZ_ELEV	NACX0008	Deg	APME: Earth Elev
HGA Measured Azimuth & Elevation	HGA_MEAS_AZ_ELEV	NACX0011	Deg	APME: Measured Azi



HGA Measured Azimuth & Elevation	HGA_MEAS_AZ_ELEV	NACX0010	Deg	APME: Measured Elev
HGA A Abs ang Error	HGA_A_ABSANG_ERR_AZ_EL	NACW1218	Rad	APME A Abs Ang Error Az
HGA A Abs ang Error	HGA_A_ABSANG_ERR_AZ_EL	NACW1217	Rad	APME A Abs Ang Error El
HGA A Displacement Error	HGA_A_DISP_ERR_AZ_EL	NACW120B	Rad	APME A Dispment Error Az
HGA A Displacement Error	HGA_A_DISP_ERR_AZ_EL	NACW120A	Rad	APME A Dispment Error El
HGA B Abs ang Error	HGA_B_ABSANG_ERR_AZ_EL	NACW121D	Rad	APME B Abs Ang Error Az
HGA B Abs ang Error	HGA_B_ABSANG_ERR_AZ_EL	NACW121C	Rad	APME B Abs Ang Error El
HGA B Displacement Error	HGA_B_DISP_ERR_AZ_EL	NACW120V	Rad	APME B Dispment Error Az
HGA B Displacement Error	HGA_B_DISP_ERR_AZ_EL	NACW120U	Rad	APME B Dispment Error El

3.7.3 How to use the data

Checking where the HGA is pointing

The figure below plots the azimuth & elevation of the HGA during Q1 2014 where one can see the rotation of the HGA (Antenna Pointing mechanism – APM) point to the Earth once the spacecraft woke up from the hibernation.



Figure 21 : APME Earth Az & Elevation (degrees)

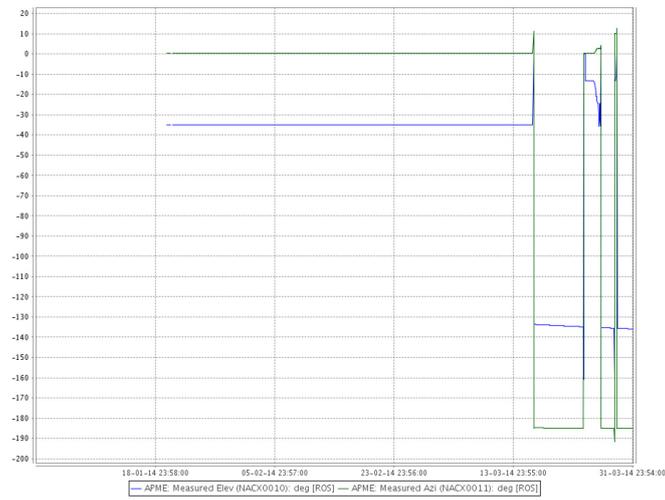


Figure 22 : APME actual measured Elevation & Azimuth

Other data provided is used to understand the errors in the measurements of the HGA positioning system.

3.8 Navigation Camera (NAVCAM) Dataset

3.8.1 Overview

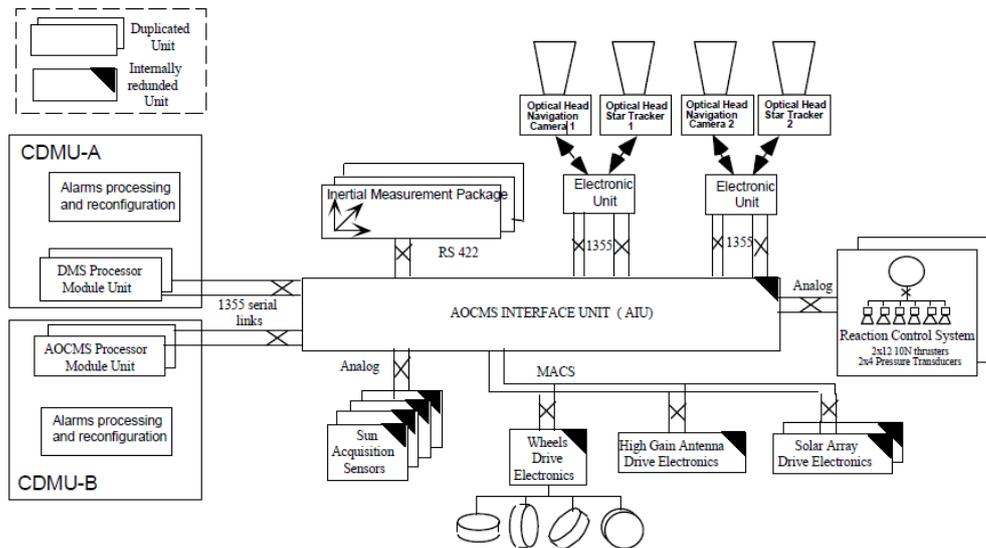


Figure 23 : AOCMS Units – showing the NAVCAMs

The AOCMS subsystem is built around the AOCMS Interface Unit (AIU) which is used by the AOCMS-SW to exchange functional data with:

- **the sensors:** 2 Navigation Cameras (CAM) and 2 Star Trackers (STR), 4 Sun Acquisition Sensors (SAS) and 3 Inertial Measurement Packages (IMP), each IMP includes 3 gyros + 3 accelerometers,
- **the actuators:** the Reaction Wheel Assembly (RWA) belonging to the Avionics, and the Reaction Control System (RCS), the High Gain Antenna Pointing Mechanism (HGAPM), and the 2 Solar Array Drive Mechanisms (SADM) belonging to the Platform.

Other equipment interfacing with the AOCMS: the Navigation Camera is used in the AOCMS control loop only during the Asteroid Near Fly-by Phase



3.8.2 Dataset Description

Dataset name: ROSETTA NAVIGATION CAMERA ENGINEERING DATA

Dataset ID: RO-X-HK-3-NAVCAM-V1.0

/RO-X-HK-3-NAVCAM-V1.0

/DATA

/NAVCAM_A_OP_MODE

/NAVCAM_B_OP_MODE

General	Directory name	Parameter ID	Unit	Description
NAVCAM A Operation mode	NAVCAM_A_OP_MODE	NACX0502	n/a	CAM A Current Operative
NAVCAM B Operation mode	NAVCAM_B_OP_MODE	NACX0503	n/a	CAM B Operative Mode

Calibration parameters for NACX0502 & NACX0503

See section 2.3.5 for an explanation of format.

```

2269 0 0 INIT
2269 1 1 STAND_BY
2269 2 2 SELF_TEST
2269 3 3 POINTTRACKIN
2269 4 4 ASTERTRACKIN
2269 5 5 IMAGING
    
```



3.8.3 How to use the data

Checking the mode of the NAVCAM

The Navigation Camera was not in use all of the time but rather during specific periods when images were taken. The figure below gives an example of how the NAVCAM was used during 2014 with the three main modes shown – Standby, Imaging and Asteroid Tracking (although this last mode was not used).

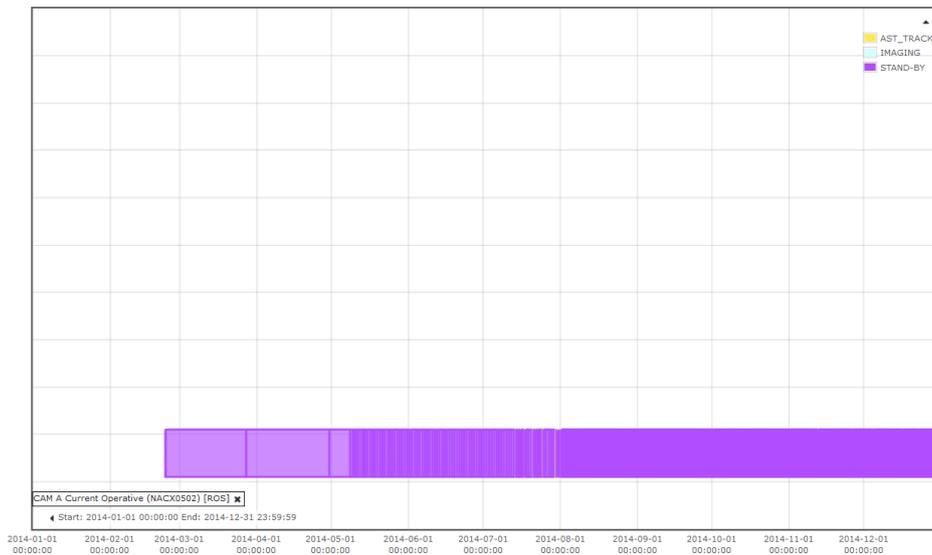


Figure 24 : NAVCAM A operating modes during 2014

3.9 Startracker (STR) Dataset

3.9.1 Overview

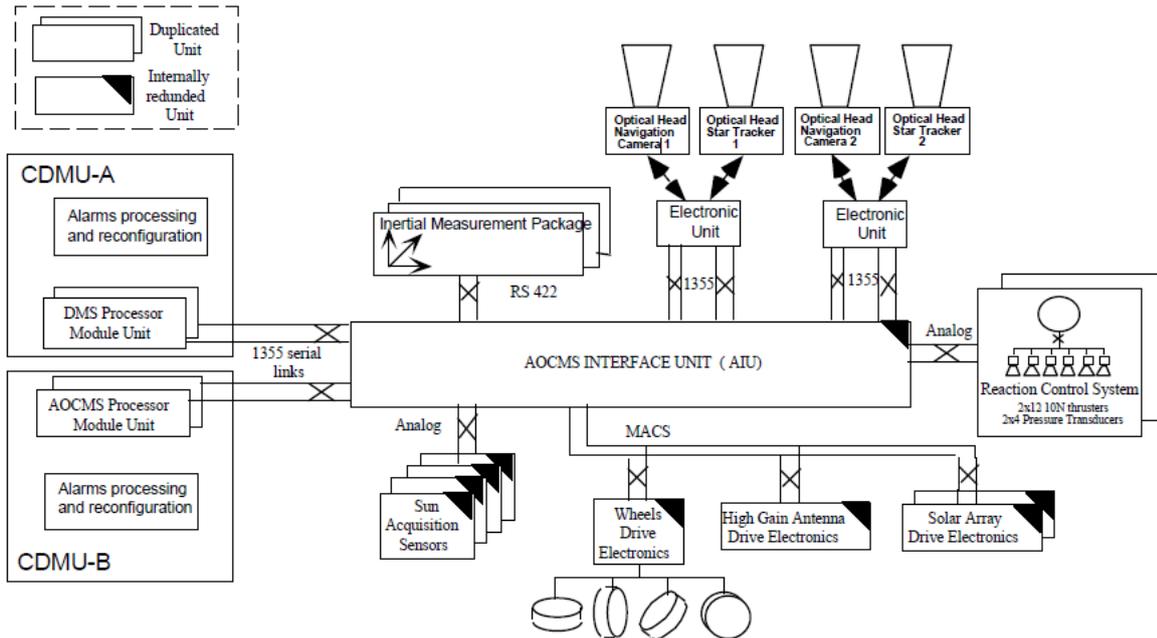


Figure 25 : Avionics subsystems showing the star trackers

The Star Trackers are mounted on the –X shearwalls. The STR B is rotated by additional 10 degrees towards the -Z direction compared to STR A to avoid the VIRTIS radiator rim to be seen in its FOV. This location of the STRs is both thermally stable and mechanically close to the –X PSM panel which accommodates the instruments requiring high pointing accuracy.

3.9.2 Dataset Description

Dataset name: ROSETTA STARTRACKER ENGINEERING DATA

Dataset ID: RO-X-HK-3-STARTRACKER-V1.0

```

/RO-X-HK-3-STARTRACKER-V1.0
  /DATA
    /STR_A_CURRENT_OP_MODE
    /STR_B_CURRENT_OP_MODE
    /STR_A_B_TRACKED_STARS
    /STR_A_ANG_VELOCITY
    
```



/STR_B_ANG_VELOCITY
 /STR_A_B_MODE
 /STR_A_B_INTEGRATION_TIME
 /STR_A_B_MEAN_BACKGRND
 /STR_A_B_STD_DEV_BACKGRND
 /STR_A_B_NO_OF_STARS_FOUND
 /STR_A_B_NO_OF_LARGE_OBJECTS
 /STR_A_STARS_1_TO_9_SXYZ_COORD
 /STR_A_STARS_1_TO_9_XY_COORD
 /STR_B_STARS_1_TO_9_SXYZ_COORD
 /STR_B_STARS_1_TO_9_XY_COORD
 /STR_A_B_STAR_QUALITY_STAT
 /STR_A_STARS_1_TO_9_MAGNITUDE
 /STR_A_STARS_1_TO_9_MAGNITUDE
 /STR_B_STARS_1_TO_9_MAGNITUDE
 /STR_A_STARS_1_TO_9_ID_NO
 /STR_B_STARS_1_TO_9_ID_NO

In the following table, parameter IDs that have an asterisk have an additional calibration table provided later in this section.

General	Directory name	Parameter ID	Unit	Description
STR A Current Operating mode	STR_A_CURRENT_OP_MODE	NACX0500*	n/a	STR A Current Operative
STR B Current Operating mode	STR_B_CURRENT_OP_MODE	NACX0501*	n/a	STR B Current Opern Mode
STR A and B- tracked stars	STR_A_B_TRACKED_STARS	NACW1KoK	n/a	STR A Nb Tracked Stars
STR A and B- tracked stars	STR_A_B_TRACKED_STARS	NACW1K30	n/a	STR B Nb Tracked Stars
STR A Angular Velocity	STR_A_ANG_VELOCITY	NACW1KoD	Deg/s	STR A angular velocity X
STR A Angular Velocity	STR_A_ANG_VELOCITY	NACW1KoE	Deg/s	STR A angular velocity Y



STR Angular Velocity	A	STR_A_ANG_VELOCITY	NACW1K0F	Deg/s	STR angular velocity Z
STR Angular Velocity	B	STR_B_ANG_VELOCITY	NACW1K2T	Deg/s	STR angular velocity X
STR Angular Velocity	B	STR_B_ANG_VELOCITY	NACW1K2U	Deg/s	STR angular velocity Y
STR Angular Velocity	B	STR_B_ANG_VELOCITY	NACW1K2V	Deg/s	STR angular velocity Z
STR A and B Mode		STR_A_B_MODE	NACW1K05*	n/a	STR A Mode
STR A and B Mode		STR_A_B_MODE	NACW1K2L*	n/a	STR B Mode
STR A and B Integration time		STR_A_B_INTEGRATION_TIME	NACW1K06	Sec	STR A Integration Time
STR A and B Integration time		STR_A_B_INTEGRATION_TIME	NACW1K2M	Sec	STR B Integration Time
STR A and B Mean Background		STR_A_B_MEAN_BACKGRND	NACW1K0L	n/a	STR A Mean Background
STR A and B Mean Background		STR_A_B_MEAN_BACKGRND	NACW1K31	n/a	STR B Mean Background
STR A and B Standard Deviation Background		STR_A_B_STD_DEV_BACKGRND	NACW1K0M	n/a	STR A Stdv Background
STR A and B Standard Deviation Background		STR_A_B_STD_DEV_BACKGRND	NACW1K32	n/a	STR B Stdv Background
STR A & B Number of Stars found		STR_A_B_NO_OF_STARS_FOUND	NACW1K0J	n/a	STR A Nb Stars Found
STR A & B Number of Stars found		STR_A_B_NO_OF_STARS_FOUND	NACW1K2Z	n/a	STR B Nb Stars Found



STR A & B Number of Large Objects found	STR_A_B_NO_OF_LARGE_OBJECTS	NACW1KoI	n/a	STR A Nb Large Objects
STR A & B Number of Large Objects found	STR_A_B_NO_OF_LARGE_OBJECTS	NACW1K2Y	n/a	STR B Nb Large Objects
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoQ	n/a	STR A Star 1 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoR	n/a	STR A Star 1 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoS	n/a	STR A Star 1 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoX	n/a	STR A Star 2 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoY	n/a	STR A Star 2 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1KoZ	n/a	STR A Star 2 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K14	n/a	STR A Star 3 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K15	n/a	STR A Star 3 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K16	n/a	STR A Star 3 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1B	n/a	STR A Star 4 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1C	n/a	STR A Star 4 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1D	n/a	STR A Star 4 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1I	n/a	STR A Star 5 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1J	n/a	STR A Star 5 : SY coord



STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1K	n/a	STR A Star 5 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1P	n/a	STR A Star 6 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1Q	n/a	STR A Star 6 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1R	n/a	STR A Star 6 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1W	n/a	STR A Star 7 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1X	n/a	STR A Star 7 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K1Y	n/a	STR A Star 7 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K23	n/a	STR A Star 8 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K24	n/a	STR A Star 8 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K25	n/a	STR A Star 8 : SZ coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K2A	n/a	STR A Star 9 : SX coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K2B	n/a	STR A Star 9 : SY coord
STR A - Star 1 to 9 - SXYZ Coordinates	STR_A_STARS_1_TO_9_SXYZ_COORD	NACW1K2C	n/a	STR A Star 9 : SZ coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1KoT	mm	STR A Star 1 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1KoU	mm	STR A Star 1 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1o	mm	STR A Star 2 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K11	mm	STR A Star 2 : Y coord



STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K17	mm	STR A Star 3 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K18	mm	STR A Star 3 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1E	mm	STR A Star 4 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1F	mm	STR A Star 4 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1L	mm	STR A Star 5 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1M	mm	STR A Star 5 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1S	mm	STR A Star 6 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1T	mm	STR A Star 6 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K1Z	mm	STR A Star 7 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K20	mm	STR A Star 7 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K26	mm	STR A Star 8 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K27	mm	STR A Star 8 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K2D	mm	STR A Star 9 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_A_STARS_1_TO_9_XY_COORD	NACW1K2E	mm	STR A Star 9 : Y coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K36	n/a	STR B Star 1 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K37	n/a	STR B Star 1 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K38	n/a	STR B Star 1 : SZ coord



STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3D	n/a	STR B Star 2 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3E	n/a	STR B Star 2 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3F	n/a	STR B Star 2 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3K	n/a	STR B Star 3 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3L	n/a	STR B Star 3 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3M	n/a	STR B Star 3 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3R	n/a	STR B Star 4 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3S	n/a	STR B Star 4 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3T	n/a	STR B Star 4 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3Y	n/a	STR B Star 5 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K3Z	n/a	STR B Star 5 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K40	n/a	STR B Star 5 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K45	n/a	STR B Star 6 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K46	n/a	STR B Star 6 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K47	n/a	STR B Star 6 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4C	n/a	STR B Star 7 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4D	n/a	STR B Star 7 : SY coord



STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4E	n/a	STR B Star 7 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4J	n/a	STR B Star 8 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4K	n/a	STR B Star 8 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4L	n/a	STR B Star 8 : SZ coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4Q	n/a	STR B Star 9 : SX coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4R	n/a	STR B Star 9 : SY coord
STR B - Star 1 to 9 - SXYZ Coordinates	STR_B_STARS_1_TO_9_SXYZ_COORD	NACW1K4S	n/a	STR B Star 9 : SZ coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K39	mm	STR B Star 1 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3A	mm	STR B Star 1 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3G	mm	STR B Star 2 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3H	mm	STR B Star 2 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3N	mm	STR B Star 3 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3O	mm	STR B Star 3 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3U	mm	STR B Star 4 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K3V	mm	STR B Star 4 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K41	mm	STR B Star 5 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K42	mm	STR B Star 5 : Y coord



STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K48	mm	STR B Star 6 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K49	mm	STR B Star 6 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4F	mm	STR B Star 7 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4G	mm	STR B Star 7 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4M	mm	STR B Star 8 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4N	mm	STR B Star 8 : Y coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4T	mm	STR B Star 9 : X coord
STR A - Star 1 to 9 - XY Coordinates	STR_B_STARS_1_TO_9_XY_COORD	NACW1K4U	mm	STR B Star 9 : Y coord
STR A and B - Star Quality Status	STR_A_B_STAR_QUALITY_STAT	NAWD1Ko4*	n/a	STR A Star Quality stat
STR A and B - Star Quality Status	STR_A_B_STAR_QUALITY_STAT	NAWD1KoA*	n/a	STR B Star Quality stat
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1KoV	Mi	STR A Star 1 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K12	Mi	STR A Star 2 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K19	Mi	STR A Star 3 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K1G	Mi	STR A Star 4 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K1N	Mi	STR A Star 5 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K1U	Mi	STR A Star 6 : magnitude



STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K21	Mi	STR A Star 7 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K28	Mi	STR A Star 8 : magnitude
STR A - Star 1 to 9 - magnitudes	STR_A_STARS_1_TO_9_MAGNITUDE	NACW1K2F	Mi	STR A Star 9 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K3B	Mi	STR B Star 1 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K3I	Mi	STR B Star 2 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K3P	Mi	STR B Star 3 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K3W	Mi	STR B Star 4 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K43	Mi	STR B Star 5 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K4A	Mi	STR B Star 6 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K4H	Mi	STR B Star 7 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K4O	Mi	STR B Star 8 : magnitude
STR B - Star 1 to 9 - magnitudes	STR_B_STARS_1_TO_9_MAGNITUDE	NACW1K4V	Mi	STR B Star 9 : magnitude
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1KoP	n/a	STR A Star 1 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1KoW	n/a	STR A Star 2 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K13	n/a	STR A Star 3 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1KiA	n/a	STR A Star 4 : id number



STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K1H	n/a	STR A Star 5 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K1O	n/a	STR A Star 6 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K1V	n/a	STR A Star 7 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K22	n/a	STR A Star 8 : id number
STR A - Star 1 to 9 - ID number	STR_A_STARS_1_TO_9_ID_NO	NACW1K29	n/a	STR A Star 9 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K35	n/a	STR B Star 1 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K3C	n/a	STR B Star 2 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K3J	n/a	STR B Star 3 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K3Q	n/a	STR B Star 4 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K3X	n/a	STR B Star 5 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K44	n/a	STR B Star 6 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K4B	n/a	STR B Star 7 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K4I	n/a	STR B Star 8 : id number
STR B - Star 1 to 9 - ID number	STR_B_STARS_1_TO_9_ID_NO	NACW1K4P	n/a	STR B Star 9 : id number

Calibration parameters for NACX0500 & NACX0501

See section 2.3.5 for an explanation of format.

```

987  0    0    INIT
987  1    1    STAND-BY
987  10   10   Unknown

```



987	2	2	SELF-TEST
987	3	3	CARTOGR
987	4	4	CMD_STAR_TRK
987	5	5	AA&CAD
987	6	6	AT&FAD
987	7	7	CCD_HEAL_ST

Calibration parameters for NACW1Ko5 & NACW1K2L

See section 2.3.5 for an explanation of format.

1046	0	0	INIT
1046	1	1	STAND_BY
1046	2	2	SELF_TEST
1046	3	3	CARTOGRAPHY
1046	4	4	CMDSTARTRACK
1046	5	5	AUTONOM_ACQ
1046	6	6	AUTONOMTRACK
1046	7	7	CCDHEALTHST

Calibration parameters for NAWD1Ko4 & NAWD1KoA

See section 2.3.5 for an explanation of format.

2264	0	0	MAXSTARS
2264	1	1	LESSMAXGUIDE
2264	2	2	LESSMAXSTARS

3.9.3 How to use the data

(a) Looking at the number of stars being tracked by STR A & B

The nominal number of stars that the star tracker should be tracking at any one time is 8-9 stars. At some stages, the # of stars can reduce to 6 but lower than this is unusual. The figures below shows the difficulties that existed with the star tracker in achieving this tracking level while flying around the comet. Figure 24 shows the # of tracked stars when the spacecraft had not yet arrived to the comet. Figure 25 shows the situation while orbiting the comet whereby there were occasions when 0 stars could be tracked due to dust conditions. One can see that there were switches occurring between STR A & B as a result of the spacecraft reconfigurations that occurred.

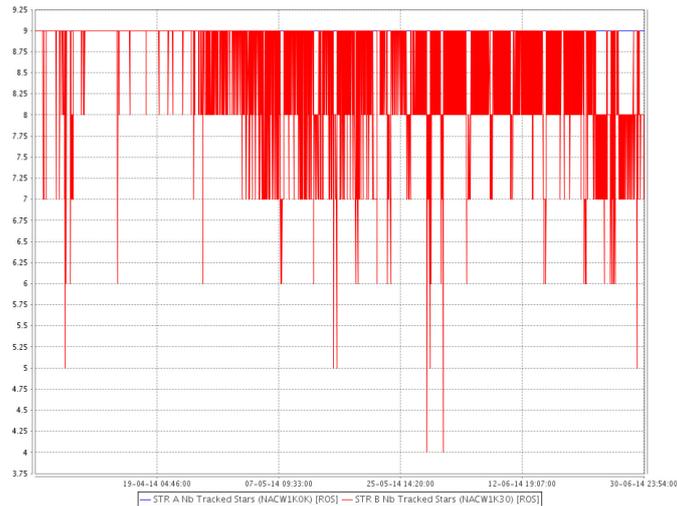


Figure 26 : # of tracked stars in Q2 2014 when far from the comet. STR B was in use

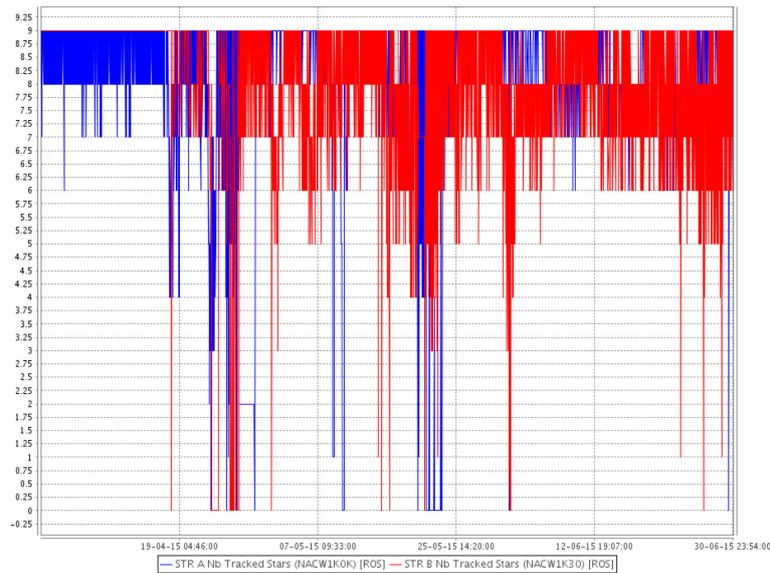


Figure 27 : # of tracked stars in Q2 2015 when in orbit around the comet

(b) Star Tracker Operating Mode – STR A and STR B

Figures 26 & 27 shows Q1 2024 for both STR A and for STR B. If one star tracker is in Standby then in the equivalent figure for the other star tracker, one can see it is in AT&FAD.

The modes of the star tracker move from Standby to Autonomous Acquisition (AA&CAD) to Autonomous Tracking (AT&FAD).

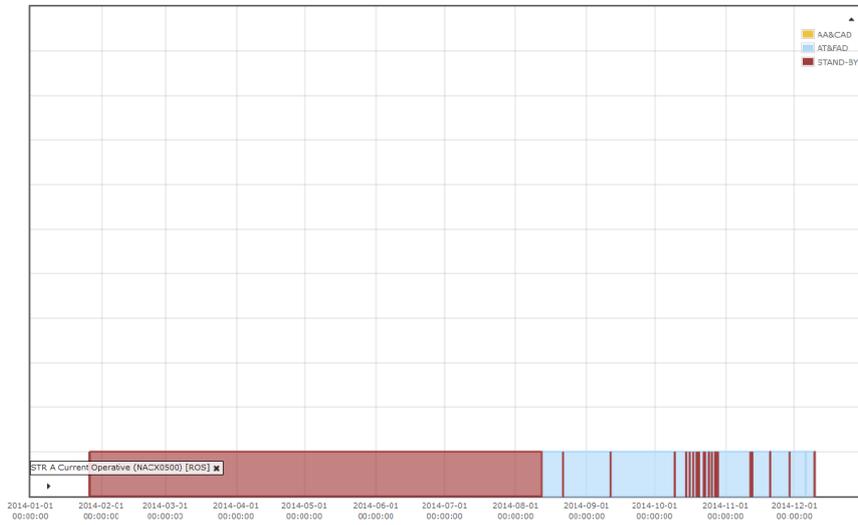


Figure 28 : Star Tracker A operating modes – Q1 2014

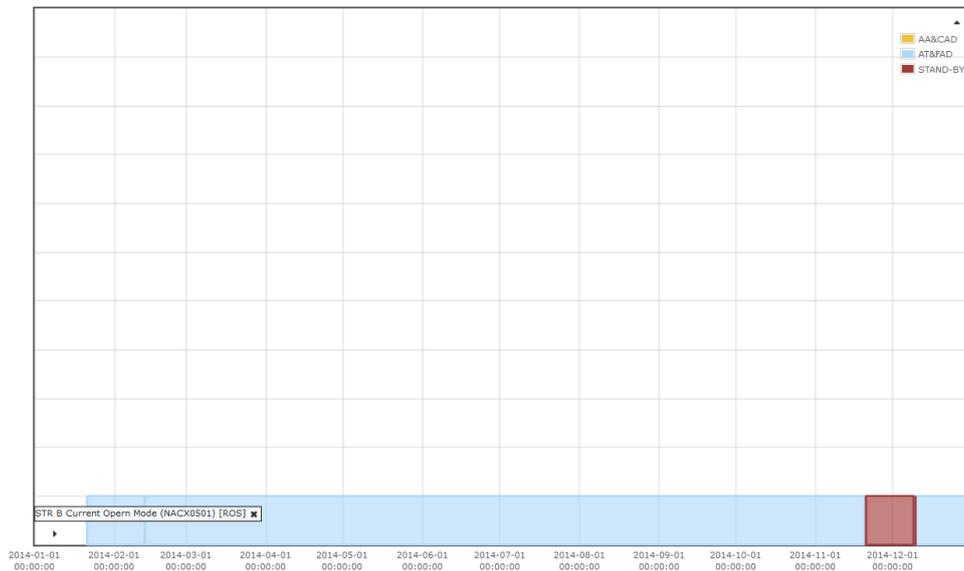


Figure 29 : Star Tracker B operating modes – Q1 2014

(c) Science publications that have used this data

The following science publications used the HK data from the star trackers of the Rosetta spacecraft. In particular, it is worth flagging the use of the data during cometary outbursts.

- Evidence of sub-surface energy storage in comet 67P from the outburst of 2016 July 03; 2017, Agarwal, J. et al. *Monthly Notices of the Royal Astronomical Society*, Volume 469, Issue Suppl_2, July 2017, Pages s606–s625, <https://doi.org/10.1093/mnras/stx2386>

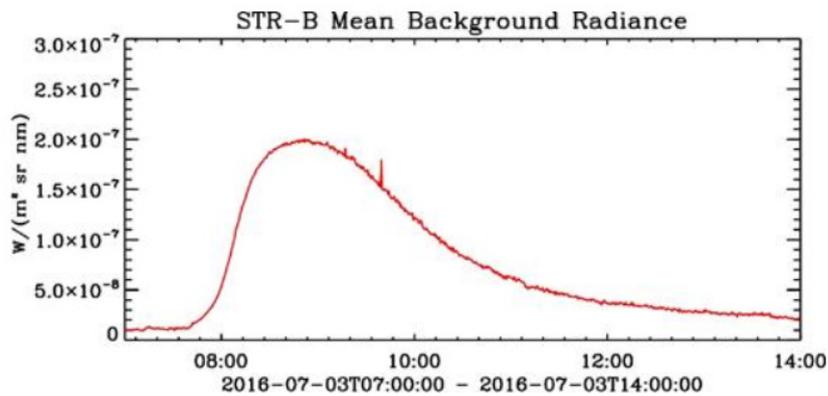


Figure 30 : Surface brightness in the FOV of the STR-B as a function of time

- The 2016 Feb 19 outburst of comet 67P/CG: an ESA Rosetta multi-instrument study, 2016, Grun, E. et al, *MNRAS* **462**, S220–S234 (2016) doi:10.1093

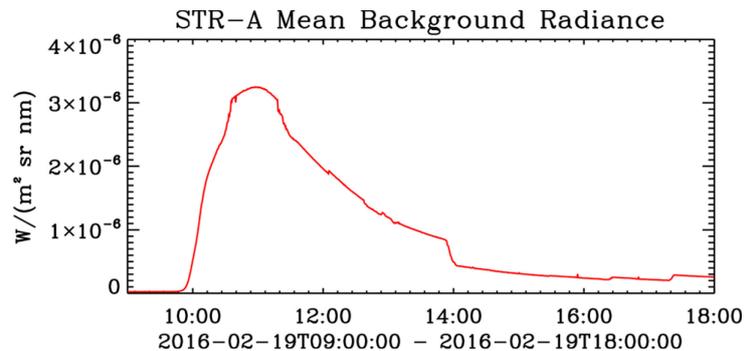


Figure 31 : Temporal evolution of the mean background radiance measured by StarTracker A (STR-A) during the outburst event. The results are derived from a housekeeping telemetry parameter which reports the mean background signal in 20 × 20 pixel windows around the (up to nine) tracked stars.

3.10 Solar Array & Power (SA) Dataset

3.10.1 Overview

The solar array comprises two 5-panel wings folded against the Y faces of the S/C for launch. Because the arrays are sized to operate at aphelion, the outwards facing outer panel can also generate useful power before array deployment.

Solar Array Drive Mechanism (SADM)

The SADM performs the positioning of the Solar Array w.r.t. the Sun by rotation of the panels around the spacecraft Y-axis. There are two identical SADMs on both sides of the spacecraft, which can be individually controlled. The control authority rests with the AOCMS subsystem, which always ‘knows’ the actual attitude and Sun direction and is therefore in the position to determine the required orientation of the solar panels. The positioning commands are routed from the AOCMS I/F Unit via the SADE (SADM-Electronics) to the SADM.

The Solar Array rotation is limited to plus and minus 180 degrees to the reference position. The array zero position is as defined in the figure below. At zero (reference) position the array wing is aligned such that the array surface is in the spacecraft Y-Z plane, with the face (cells) aligned such that the array normal is parallel to the +X axis of the spacecraft.

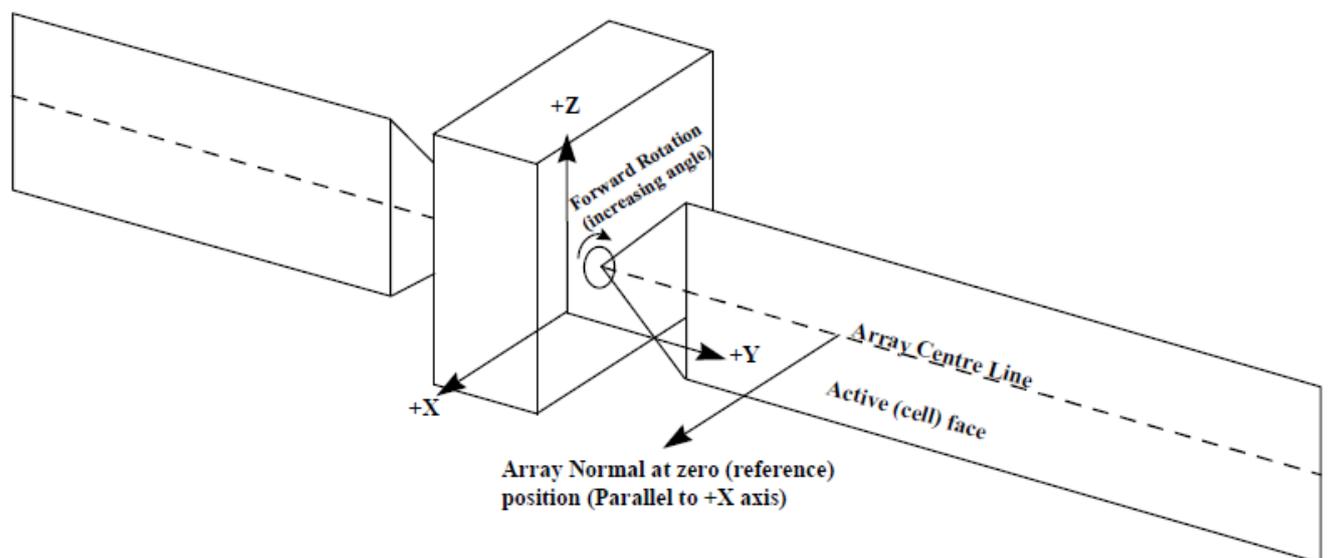


Figure 32 : +Y Solar Array Drive Reference Axis

Design of the Power Subsystem

The Power Subsystem (PSS) conditions, regulates and distributes all the electrical power required by the spacecraft throughout all phases of the mission. Distribution involves the switching and protection of power lines to all users, including the Avionics units and the Payload instruments, and includes equipment power, thermal power and keep-alive-lines. The PSS also switches, protects and distributes power for the pyrotechnics and the thermal knives of the various release mechanisms of the spacecraft.

The block diagram in figure 30 shows the elements of the Rosetta Power Subsystem :

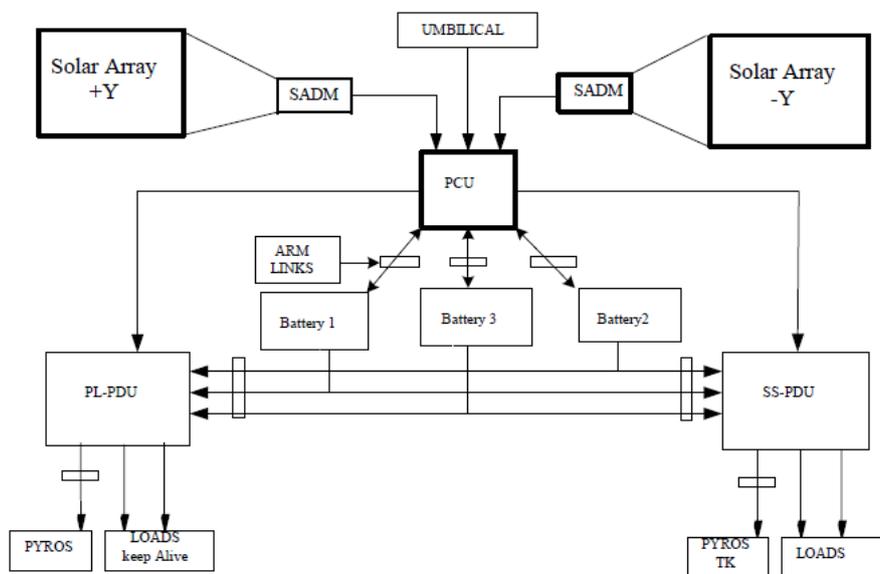


Figure 33 : Power Subsystem Main components

The main power source for Rosetta is provided by the SI solar cells mounted on 2 identical solar array wings, which are deployed from the +Y and -Y faces of the spacecraft and can be rotated to track the sun. The solar cells on the outer panel of each wing are outward facing when in the launch (stowed) configuration in order to provide power input to the PSS for loads and battery recharge following separation from the launcher and prior to array deployment.

Batteries provide power for launch and post-separation support until the solar arrays are fully deployed and sun aligned, and thereafter support the main power bus as necessary to supply peak loads and special situations during Safe Mode where the sun might not be fully oriented towards the sun.



One special feature of the power supply is the Maximum Power Point Tracker (MPPT), which operates the solar array in its maximum power point in case of power shortage.

The power generators (the batteries and the solar array) supply power to the Power Control Unit. The PCU provides regulated power to the two Power Distribution Units (PDU) which then supply power to the equipments needing it.

During almost all of the mission, except for short periods of peak power demands, the Power Control Unit (PCU) operates in nominal mode, i.e. the PCU takes only the power required by the satellite from the solar array. The delta power remains in the solar array. Because of this feature the actual performance of the array can only be assessed by utilising “performance strings” which operate some cells in short circuit current mode and others in open circuit voltage mode.

From the data obtained from these cells the performance of the solar generator can be determined.

Batteries are also the main power source for the pyrotechnics, although pyrotechnic power is also available from the main bus as a back-up in case there is no battery power. The subsystem is designed in accordance to the ESA Power Standard PSS-02-10.

The PSS comprises 34 units (i.e. PCU and 2 PDUs) plus the batteries, but excludes the solar arrays which are part of the Solar Array Subsystem.

3.10.2 Dataset Description

Dataset name: ROSETTA SOLAR ARRAY & POWER ENGINEERING DATA

Dataset ID: RO-X-HK-3-SOLARARRAY-V1.0

```

/RO-X-HK-3-SOLARARRAY-V1.0
  /DATA
    /POWER_DIST_UNIT_PRIME_CURRENT
    /POWER_DIST_UNIT_SECONDARY_VOLTAGE
    /MASTER_BUS_VOLTAGE_CM_A_B
    /SOLAR_ARRAY_DISPL_ERROR
    /SOLAR_ARRAY_MEAS_ANG_POS_DEG
    /SOLAR_ARRAY_MEAS_ANG_POS_RAD
    /SOLAR_ARRAY_MISALIGNMENT
    /SOLAR_ARRAY_INCIDENCE_ANGLE

```



/POWER_CONTROL_UNIT_CM_A_B
/POWER_CONTROL_UNIT_CM_A_CURR

General	Directory name	Parameter ID	Unit	Description
Power Distribution unit - Primary Current	POWER_DIST_UNIT_PRIMARY_CURRENT	NPWD2260	A	SS-PDU PRIMARY CURRENT A
Power Distribution unit - Primary Current	POWER_DIST_UNIT_PRIMARY_CURRENT	NPWD2920	A	SS-PDU PRIMARY CURRENT B
Power Distribution unit - Secondary Voltage	POWER_DIST_UNIT_SECONDARY_VOLTAGE	NPWD2268	V	SS-PDU SEC VOLTAGE A
Power Distribution unit - Secondary Voltage	POWER_DIST_UNIT_SECONDARY_VOLTAGE	NPWD2928	V	SS-PDU SEC VOLTAGE B
Master Bus Voltage - Power Control Unit	MASTER_BUS_VOLTAGE_CM_A_B	NPWD1024	V	MBUS VOLTAGE - PCU CM-A
Master Bus Voltage - Power Control Unit	MASTER_BUS_VOLTAGE_CM_A_B	NPWD102B	V	MBUS VOLTAGE - PCU CM-B
Solar Array Displacement Error	SOLAR_ARRAY_DISPL_ERROR	NACX0017	Deg	SADE Displ Error Y+
Solar Array Displacement Error	SOLAR_ARRAY_DISPL_ERROR	NACX0016	Deg	SADE Displ Error Y-
Solar Array measured angular position - Degrees	SOLAR_ARRAY_MEAS_ANG_POS_DEG	NACX0021	Deg	SADE Meas Ang Pos Y+
Solar Array measured angular position - Degrees	SOLAR_ARRAY_MEAS_ANG_POS_DEG	NACX0020	Deg	SADE Meas Ang Pos Y-
Solar Array measured angular position	SOLAR_ARRAY_MEAS_ANG_POS_RAD	NACW1307	Rad	SADE Measured Ang Pos YM
Solar Array measured angular position	SOLAR_ARRAY_MEAS_ANG_POS_RAD	NACW1306	Rad	SADE Measured Ang Pos YP
Solar Array misalignment	SOLAR_ARRAY_MISALIGNMENT	NACX0022	Deg	SADE SA Misalignment



Solar Incidence Angle	SOLAR_ARRAY_INCIDENCE_ANGLE	NAWG0026	Deg	YM Solar Incidence Angle
Solar Incidence Angle	SOLAR_ARRAY_INCIDENCE_ANGLE	NAWG0025	Deg	YP Solar Incidence Angle
Power Control Unit - Control Module Voltage	POWER_CONTROL_UNIT_CM_A_B	NPWD1044	V	CM A AUX SUPP VOLT CM-A
Power Control Unit - Control Module Voltage	POWER_CONTROL_UNIT_CM_A_B	NPWD104B	V	CM A AUX SUPP VOLT CM-B
Power Control Unit - Control Module Current	POWER_CONTROL_UNIT_CM_A_CURR	NPWD1104	A	CM SUPPLY CUR CM-A
Power Control Unit - Control Module - Volt	POWER_CONTROL_UNIT_CM_A_VOLT	NPWD1704	V	CM B AUX SUPP VOLT CM-A

3.10.3 How to use the data

What is the main bus voltage & how does it vary?

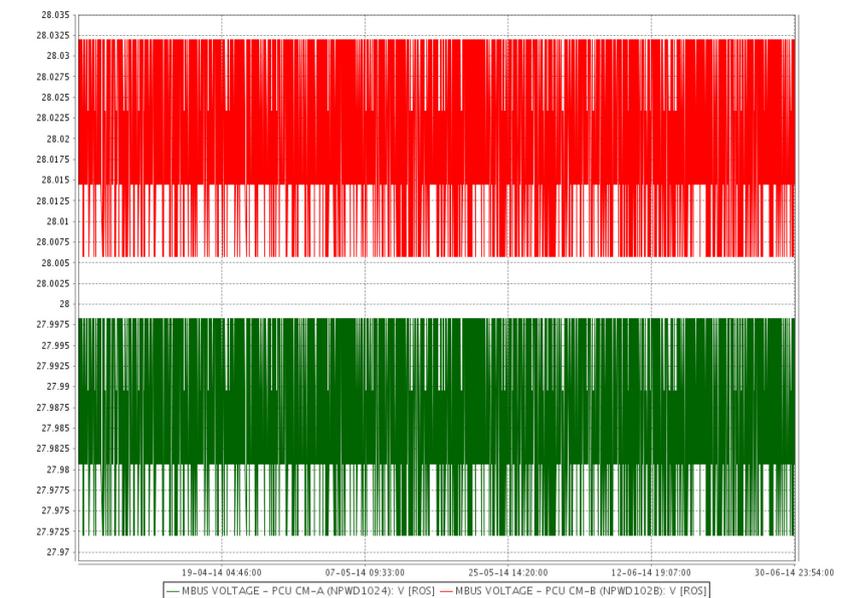


Figure 34 : Main bus voltage

What is angle of the solar panels w.r.t. zero position



Figure 35 : Measured angular position of the solar panels – Q4 2014

Checking the ageing of the solar panels towards end of mission

In the closing stages of the mission tests were performed to check the aging of the solar panels.

- A solar array test using batteries at hibernation exit confirmed no degradation between hibernation entry and exit.
- To characterise the power available for end of mission, first a battery test was done on 27/04. The test concluded that the three batteries were fully functional.
- A solar array test was then conducted on 12/07/2016. The solar arrays were rotated for 30 minutes and 60 degrees away from the Sun line. A degradation between 0 and 2 % compared to January 2014 was measured.



This concluded the solar array testing. From these numbers, it could be derived how much power was available to share among the instruments until end of mission.

It is believed that the data delivered here should provide the user with sufficient inputs to be able to see when these tests have taken place and understand what was measured e.g. checking the solar incidence angle of the solar panels (as the panels were offset from the sun during the tests) and taking note of the measured current/voltage provided to the main power distribution unit as a result.

3.11 RF Communication Dataset

3.11.1 Overview

A 2.2m diameter High Gain Antenna (HGA) is stowed face-outwards for launch against the S/C +X face (so it would be partially usable even in the event of a deployment failure). After deployment, the HGA can be rotated in two axes around a pivot point on a tripod assembly some distance clear of the lower corner of the S/C. This provides the HGA with greater than hemispherical pointing range.

The two Medium Gain Antennas (MGAs) are fixed mounted on the S/C +X face, oriented in the +Xsc direction, as this is the most useful direction for a fixed MGA.

The Low Gain Antennas (LGAs) are located at the +Z and –Z ends of the S/C but angled at 30 degs to the Z axis. This accommodation provides spherical coverage with minimum need for switching.

Figures 1(a) and 1(b) show the position of the above antennae.

Telecommunication Design

The Tracking, Telemetry and Command (TT & C) communications with the Earth over the complete Rosetta mission is ensured by three antenna concepts, operating at various stages throughout the overall programme, combined with a number of electrical units performing certain functions. The Telecommunication Subsystem is required to interface with the ESA ground segment in normal operational mode and with the NASA Deep Space Network during emergency mode.

The TT&C subsystem comprises a number of equipment whose descriptions appear below:

- Two Transponders interfacing with the S-Band RF Distribution Unit (RFDU), with the High Power Amplifiers - in this case Travelling Wave Tube Amplifiers (TWTA's) -, and with the Data Management System (DMS). The Transponders modulate and transmit the Telemetry stream coming from both parts of the redundant Data Management System either in S or X-Band or both simultaneously without any interference and transpond the ranging signal in S and X-Band. The Transponders provide hot redundancy for the receiving functions and cold redundancy for transmitting functions. The receivers can receive telecommands in S-Band or X-Band (selectable per command), but not simultaneously in both frequency bands. The configuration is such that both receivers can receive, demodulate and send the Telecommand signal to the DMS simultaneously. The transmitters are also able to receive the telemetry stream from both parts of the redundant DMS. Each transponder is capable of operating in a coherent or non-coherent mode depending on the lock status of the receiver.



- An RF Distribution Unit (RFDU) providing an S-Band transmit/receive switching function between the antennas and the two Transponder units via two diplexers.
- Two TWTA's providing >28W of power at X-Band to the MGA or HGA via the Waveguide Interface Unit (WIU). The input to the TWTA HPA's is supplied by the Transponder X-Band modulators via a 3dB passive hybrid.
- A Waveguide Interface Unit (WIU) comprising of diplexers, two transfer switches and high power isolators so that it is possible to switch between antennas without turning off the TWTA.
- The transmit frequency (and receiver rest frequency) can also be derived from an external Ultra Stable Oscillator (USO) on request by Telecommand which may be used any time during the mission. This USO has a superior performance compared to the Transponder internal oscillator such that it is used for one-way ranging as part of the Radio Science Investigations (RSI).
- Two Low Gain Antennas (LGA) providing a quasi omni directional coverage for any attitude of the satellite which may be used for: the near earth mission phase at S-Band for uplink telecommand and downlink telemetry. the telecommand Up Link at S-Band during emergency and nominal communications over large ranges up to 6.25 AU.
- A 2.2m High Gain Antenna (HGA) providing the primary communication for Uplink at S/X-band and Downlink at S/X-Band.
- Two Medium Gain Antennas (MGA) providing emergency Up and Downlink default communication after sun pointing mode of the S/C is reached. The S-Band MGA is realised as a flat patch antenna whereas the X-Band MGA is an offset-type 0.31m reflector antenna. The MGAs also perform some mission communications functions at various phases throughout their lifetime due to their much larger coverage area.

3.11.2 Dataset Description

Dataset name: ROSETTA RF ANTENNA ENGINEERING DATA

Dataset ID: RO-X-HK-3-ANTENNASTATUS-V1.0

/RO-X-HK-3-ANTENNASTATUS-V1.0

/DATA

/TRSP_1_2_RX_BITRATE_SELECTION

/TRSP_1_X_S_BAND_TX_STATUS

/TRSP_2_X_S_BAND_TX_STATUS

/TRSP_1_2_LOCK_STATUS
 /X_BAND_TWTA_1_2_STATUS
 /S_BAND_TX_1_2_STATUS
 /USO_STATUS
 /HGA_MGA_X_BAND_STATUS
 /TRSP_1_2_S_TX_ON_STATUS
 /TRSP_1_2_X_TX_ON_STATUS

General	Directory name	Parameter ID	Unit	Description
Transponder 1 & 2 - Receiver Bit rate & selection	TRSP_1_2_RX_BITRATE_SELECTION	NTTD1020*	bps	TRSP1 RX Bit Rate
Transponder 1 & 2 - Receiver Bit rate & selection	TRSP_1_2_RX_BITRATE_SELECTION	NTTD102A*	bps	TRSP1 RX Selection
Transponder 1 & 2 - Receiver Bit rate & selection	TRSP_1_2_RX_BITRATE_SELECTION	NTTD2020*	bps	TRSP2 RX Bit Rate
Transponder 1 & 2 - Receiver Bit rate & selection	TRSP_1_2_RX_BITRATE_SELECTION	NTTD202A*	bps	TRSP2 RX Selection
Transponder 1 - X and S band transmitter status	TRSP_1_X_S_BAND_TX_STATUS	NTTD1069*	n/a	TRSP1 X-TX Status
Transponder 1 - X and S band transmitter status	TRSP_1_X_S_BAND_TX_STATUS	NTTD106A*	n/a	TRSP1 S-TX Status
Transponder 2 - X and S band transmitter status	TRSP_2_X_S_BAND_TX_STATUS	NTTD2069*	n/a	TRSP2 X-TX Status
Transponder 2 - X and S band transmitter status	TRSP_2_X_S_BAND_TX_STATUS	NTTD206A*	n/a	TRSP2 S-TX Status
Transponder 1 & 2 - Lock status	TRSP_1_2_LOCK_STATUS	NTTD1027*	n/a	TRSP1 SC Lock Status
Transponder 1 & 2 - Lock status	TRSP_1_2_LOCK_STATUS	NTTD2027*	n/a	TRSP2 SC Lock Status

X-band Antenna - TWTA 1 & 2	X_BAND_TWTA_1_2_STATUS	NTTX4023*	n/a	TWTA 1 X BAND Antenna
X-band Antenna - TWTA 1 & 2	X_BAND_TWTA_1_2_STATUS	NTTX5023*	n/a	TWTA 2 X BAND Antenna
S band Antenna - Transmitter 1 & 2	S_BAND_TX_1_2_STATUS	NTTX4011*	n/a	TX 1 S BAND Antenna
S band Antenna - Transmitter 1 & 2	S_BAND_TX_1_2_STATUS	NTTX5011*	n/a	TX 2 S BAND Antenna
Ultra Stable Oscillator Status	USO_STATUS	NDMWO20L*	n/a	USO status
			n/a	
X-band - High Gain Antenna	HGA_MGA_X_BAND_STATUS	NTTX0023	n/a	X BAND High GA
X-band - Medium Gain Antenna	HGA_MGA_X_BAND_STATUS	NTTX0022	n/a	X BAND Medium GA
Transponder 1 & 2 - S band transmitter ON status	TRSP_1_2_S_TX_ON_STATUS	NTTDX101	n/a	TRSP1 S-TX ON/OFF STATUS
Transponder 1 & 2 - S band transmitter ON status	TRSP_1_2_S_TX_ON_STATUS	NTTDX201	n/a	TRSP2 S-TX ON/OFF STATUS
Transponder 1 & 2 - X band transmitter ON status	TRSP_1_2_X_TX_ON_STATUS	NTTDX102	n/a	TRSP1 X-TX ON/OFF STATUS
Transponder 1 & 2 - X band transmitter ON status	TRSP_1_2_X_TX_ON_STATUS	NTTDX202	n/a	TRSP2 X-TX ON/OFF STATUS

Calibration parameters for NTTD1020 & NTTD2020

See section 2.3.5 for an explanation of format.

```
1565 0 0 7.8125
1565 1 1 15.625
```



1565	2	2	250
1565	3	3	1000
1565	4	4	2000

Calibration parameters for NTTD102A and NTTD202A

See section 2.3.5 for an explanation of format

1557	0	0	S-Band
1557	1	1	X-Band

Calibration parameters for NTTD1069 and NTTD106A

See section 2.3.5 for an explanation of format

1559	0	0	TX Off
1559	1	1	TX On

Calibration parameters for NTTD2069 and NTTD206A

See section 2.3.5 for an explanation of format

1559	0	0	TX Off
1559	1	1	TX On

Calibration parameters for NTTD1027 and NTTD2027

See section 2.3.5 for an explanation of format

1555	0	0	Not Locked
1555	1	1	Locked

Calibration parameters for NTTX4023 and NTTX5023

See section 2.3.5 for an explanation of format

2683	0	0	High GA
2683	1	1	Medium GA
2683	2	2	High GA
2683	3	3	Medium GA

Calibration parameters for NTTX4011



See section 2.3.5 for an explanation of format

2681	0	0	Medium GA
2681	1	1	Medium GA
2681	10	10	LGA Rear
2681	11	11	LGA Rear
2681	12	12	High GA
2681	13	13	High GA
2681	14	14	LGA Rear
2681	15	15	LGA Rear
2681	16	16	Medium GA
2681	17	17	Medium GA
2681	18	18	LGA Front
2681	19	19	LGA Front
2681	2	2	LGA Front
2681	20	20	High GA
2681	21	21	High GA
2681	22	22	LGA Front
2681	23	23	LGA Front
2681	24	24	Medium GA
2681	25	25	Medium GA
2681	26	26	LGA Rear
2681	27	27	LGA Rear
2681	28	28	High GA
2681	29	29	High GA
2681	3	3	LGA Front
2681	30	30	LGA Rear
2681	31	31	LGA Rear
2681	4	4	High GA
2681	5	5	High GA
2681	6	6	LGA Front
2681	7	7	LGA Front
2681	8	8	Medium GA
2681	9	9	Medium GA

Calibration parameters for NTTX5011

See section 2.3.5 for an explanation of format

2685	0	0	High GA
2685	1	1	LGA Rear
2685	10	10	High GA
2685	11	11	LGA Front
2685	12	12	Medium GA
2685	13	13	LGA Front
2685	14	14	Medium GA
2685	15	15	LGA Front
2685	16	16	High GA



2685	17	17	LGA Rear
2685	18	18	High GA
2685	19	19	LGA Rear
2685	2	2	High GA
2685	20	20	Medium GA
2685	21	21	LGA Rear
2685	22	22	Medium GA
2685	23	23	LGA Rear
2685	24	24	High GA
2685	25	25	LGA Front
2685	26	26	High GA
2685	27	27	LGA Front
2685	28	28	Medium GA
2685	29	29	LGA Front
2685	3	3	LGA Rear
2685	30	30	Medium GA
2685	31	31	LGA Front
2685	4	4	Medium GA
2685	5	5	LGA Rear
2685	6	6	Medium GA
2685	7	7	LGA Rear
2685	8	8	High GA
2685	9	9	LGA Front

Calibration parameters for NDMWO2oL

See section 2.3.5 for an explanation of format

1818	0	0	Off
1818	1	1	mute
1818	2	2	enabled

Calibration parameters for NTTX0023

See section 2.3.5 for an explanation of format

2679	0	0	RX2 - TWTA1
2679	1	1	RX2 - TWTA2
2679	2	2	RX1 - TWTA1
2679	3	3	RX1 - TWTA2

Calibration parameters for NTTX0022

See section 2.3.5 for an explanation of format



2678	0	0	RX1 - TWTA2
2678	1	1	RX1 - TWTA1
2678	2	2	RX2 - TWTA2
2678	3	3	RX2 - TWTA1

Calibration parameters for NTTDX101 & NTTDX201

See section 2.3.5 for an explanation of format

1548	0	0	Off
1548	1	1	On

Calibration parameters for NTTDX102 & NTTDX202

See section 2.3.5 for an explanation of format

1548	0	0	Off
1548	1	1	On

3.11.3 How to use the data

Checking the bit rate in use

The figure below shows a combined view of the two transponders Receiver status and bit rate. For example, the Transponder 1 is assigned to S-Band and has a bit rate of 7.8125bps, while Transponder 2 is assigned to X-Band and has a bit rate of 2000bps.

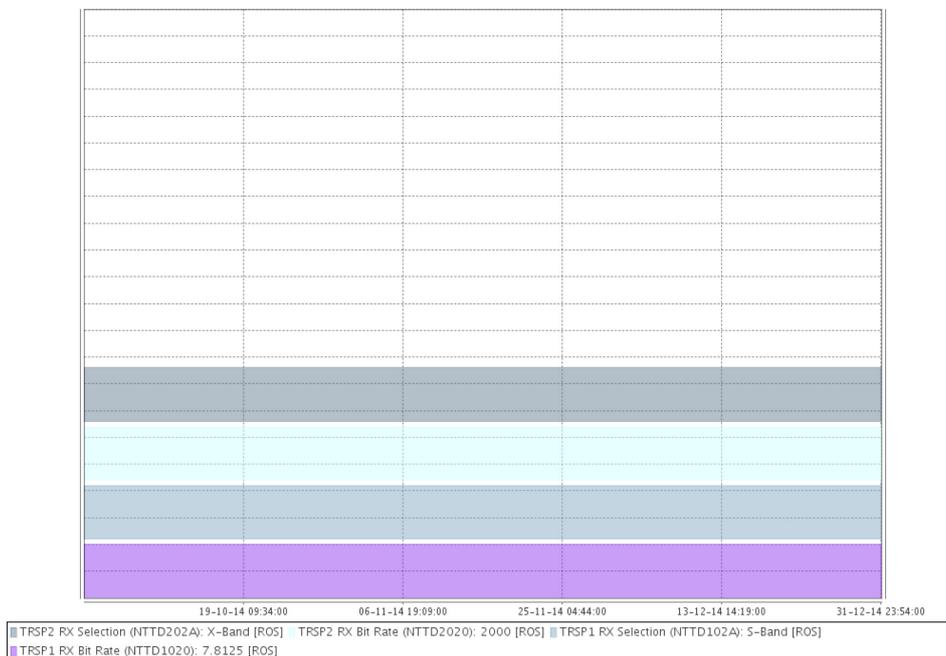


Figure 36 : T ransponder X/Sband allocation and bit rate– Q3 2014

3.12 Thermal Control System (TCS) Dataset

3.12.1 Overview

General Overview

The objective of the Thermal Control subsystem is to maintain the thermal environment of the spacecraft and equipment within defined limits throughout the mission life.

The two methods used in meeting this objective are:

Passive Means

- Multi Layer Insulation (MLI)
- Thermal control Paints
- Conductive interfillers
- Insulating washers
- Radiators
- Louvres

Active Means

- Heaters
- Thermistors

For the case of the data placed in the archive, focus is on the measurement of the temperatures at specific locations on the spacecraft. The measurement is performed using thermistors.

Thermistors are used for monitoring the performance of the TCS and as input information to control the software heaters. The design includes 3 control thermistors sited next to each other and using the middle temperature reading to control the heater switching. This method is used in order to maximise the reliability of thermistor controlling temperature and to ensure that no single thermistor failure affects heater switching accuracy. The upper switch off temperature for the thermistors shall nominally be 20 degrees C higher than the switch on temperature. This ensures little thermal cycling and therefore no problems with reliability of software heater circuit elements over the 10.5 year mission. The thermistor limit set points may, of course, be updated to whatever is required as they are software controlled and therefore may be updated from the ground as required.

There is also a requirement to monitor the temperature at each unit's temperature reference point (TRP) and at the System Interface Temperature Points (STP), so at least one thermistor will be used at these points. YellowSpring thermistors have been baselined for use throughout the thermal subsystem.



NOTE : The Thermal Parameter values provided in the dataset correspond to the STP thermistor measurements only.

For spacecraft hibernation modes, it is necessary that the heater circuits operate without any external support. Prime heater lines will be on permanently and redundant heaters will be thermostatically controlled. These thermostats, as with the thermistors, are locally bonded at pre-defined controlling points. The use of thermostatically controlled heater circuits on Rosetta will be maximised in order to help produce a simple, autonomous TCS design.

Thermostat switching ranges are set to produce little or no cycling of the hardware heaters. This produces a stable temperature platform and also improves the reliability of the hardware heater circuits. The thermostats selected for use in the Rosetta TCS are COMEPA Type 47.

Detailed description of the Rosetta TCS

The thermal control subsystem (TCS) design is optimised for the enveloping design cases of the end of life comet operations and the aphelion hibernation. From the overall mission point of view the deep space hibernation heater power request is the most critical thermal design case. This heater power request is dependent on the radiator sizing, which need to be performed for worst case end of mission conditions. The very strong heater power limitation implies that to a certain extent constraints in the operation and/or attitude need to be accepted for hot case.

The TCS uses a combination of selected surface finishes, heaters, multi-layer insulation (MLI) and louvres to control the units in the allowable temperature ranges. The units are mostly mounted on the main +/- Y panels of the spacecraft (and +Z for experiments), with interface fillers to enhance the conductive link to the panel for the collectively controlled units. The individually controlled experiments are thermally decoupled from the structure.

Generated heat by the collectively controlled units is then rejected via conduction into the panel and subsequent radiation from the external surface of the panel to space. These surfaces are covered with louvers over white painted radiators minimising any absorbed heat inputs and heat losses in cold mission phases. The louvers are selected as baseline being the best solution (investigated during phase B) for flexibility, qualification status and reliability.

VIRTIS and OSIRIS cameras are located at the top of the -X (anti-sun face) so that their radiator may view deep space. The top floor is extended over the top as a sunshield to prevent any direct solar illumination of these instruments, while the sun angle on the -Z side has to be limited to 80° for the same reason.

Any external structural surface not required as a radiator, (or experiment aperture) is covered with a high performance MLI blanket. The bottom of the bus module, which is not enclosed with a structural panel, is covered with a high performance MLI blanket used also as an EMC screen. In the areas around thrusters, a high temperature version of the MLI are implemented. All blankets are adequately grounded and vented.

The bi-propellant propulsion subsystem needs to be maintained between 0° to +45° throughout the mission. This is far warmer than some units, particularly when the spacecraft is in deep space hibernation mode. The tanks and RCS are therefore well isolated from the rest of the spacecraft to allow their specific thermal control. The antennae and experiment booms are passively thermally controlled by the use of appropriate thermo-optical surface finishes and MLI. The mechanism for the HGA has similar appropriate passive control but also needs heaters to prevent the mechanism from freezing. It is thermally decoupled from the rest of the spacecraft to allow its dedicated thermal control.

The chosen solution for thermal control subsystem design uses well known and proven technologies and concepts.

The thermal control concept mainly utilises conventional passive components supported by active units like heaters and controlled radiative areas, using well proven methods and classical elements. An overview of the concept is shown in the Figure below.

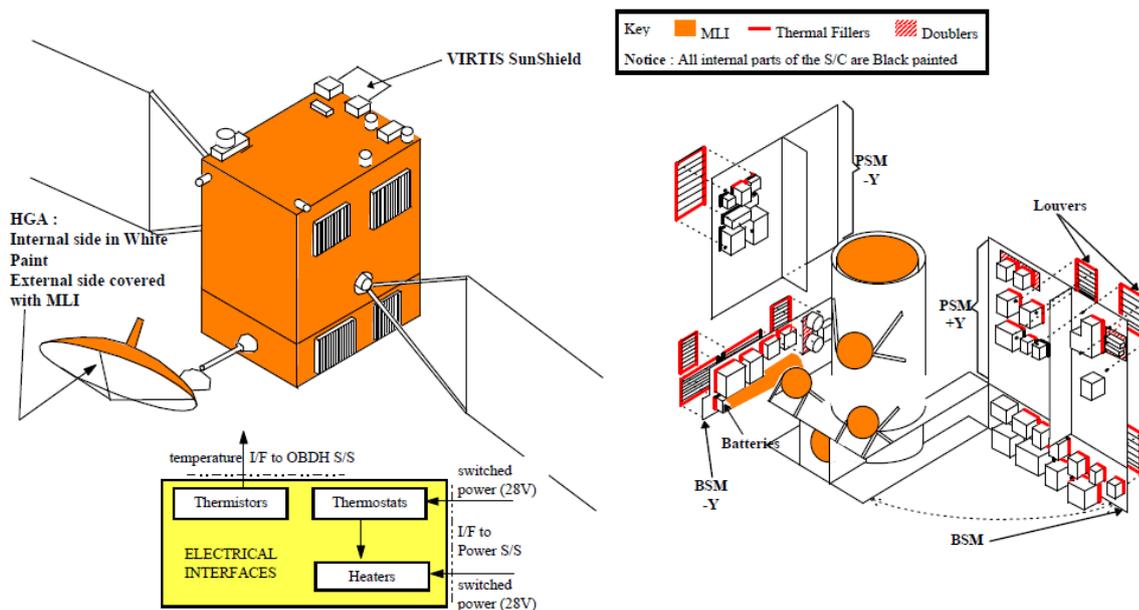
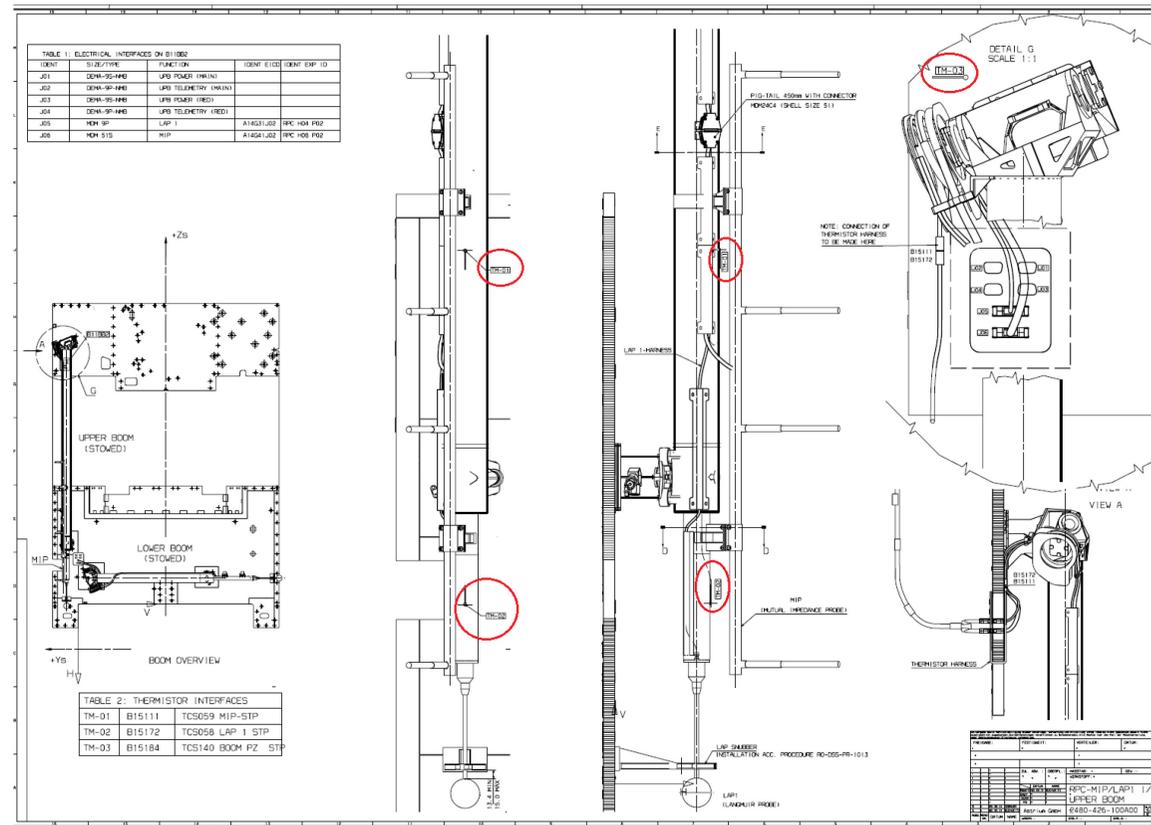


Figure 37 : Thermal Control configuration – exploded view

This concept can be characterised as follows :



- Heat flows from and to the external environment are minimised using high performance Multi-Layer Insulation (MLI).
- Most unit heat is rejected through dedicated white paint radiator, actively controlled by louvers, located on very low Sun-illuminated +/-Y panels.
- High internal emissivity compartments reduce structural temperature gradients.
- Individually controlled instruments and appendages (booms, antennas,...) are mounted thermally decoupled from the structure.
- High temperature MLI is used in the vicinity of thrusters.
- Optimised heaters, dedicated to operational, and hibernation modes, are monitored and controlled to judiciously compensate the heat deficit during cold environment phases.



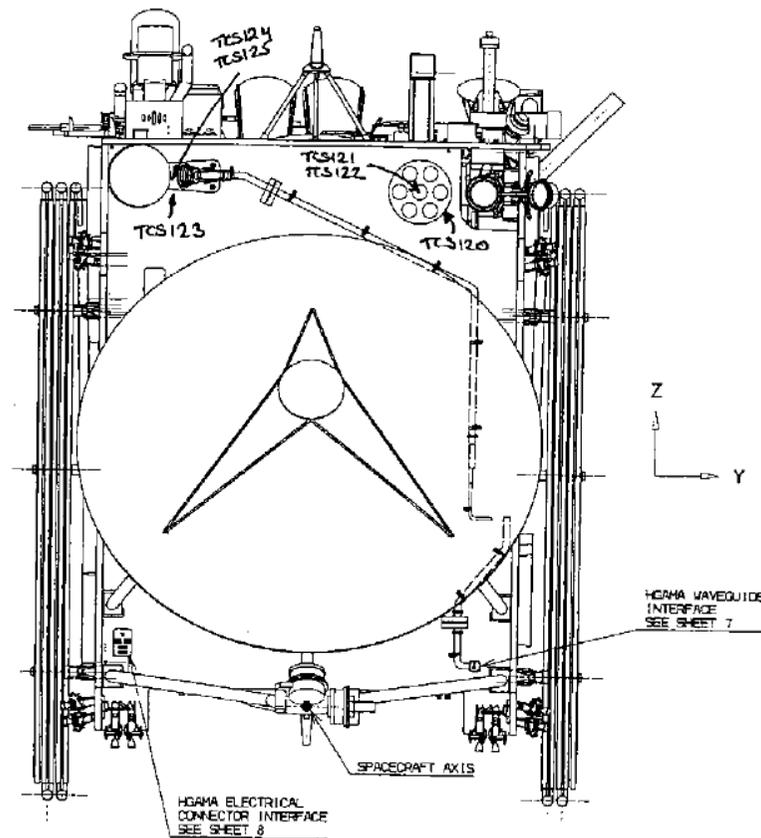


Figure 39: Location of STP points for MGAS and X (see section 3.12.2)

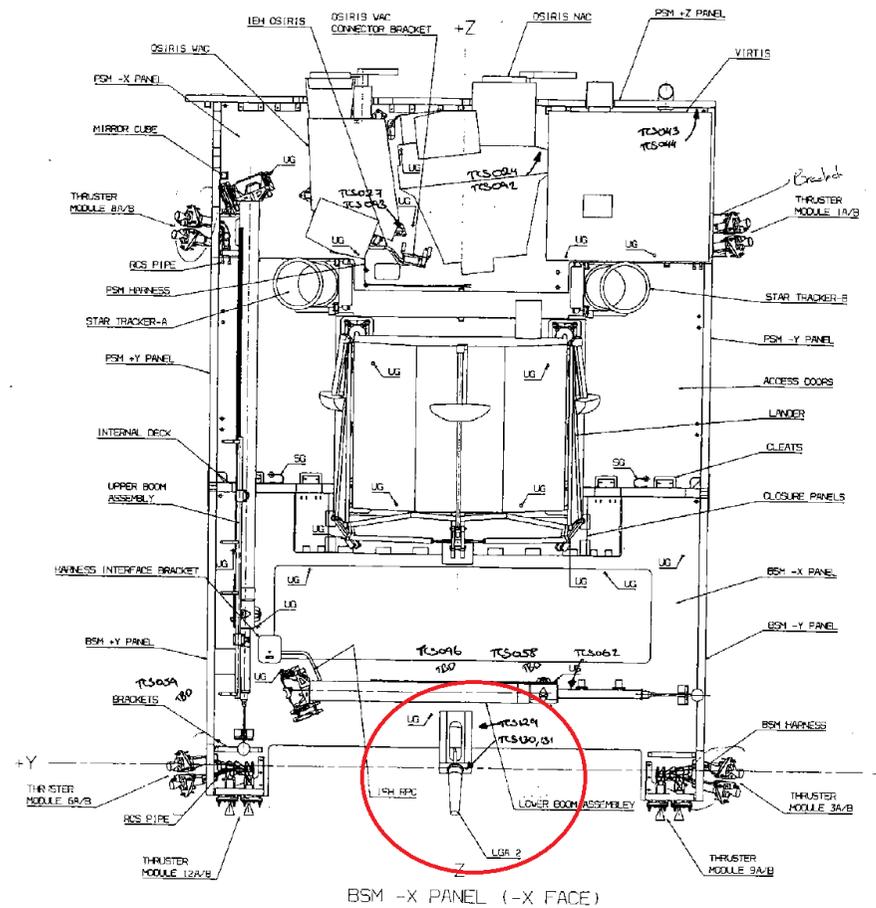


Figure 40: Location of STP points for OSIRIS WAC, LGA Mz, RPC, VIRTIS (see section 3.12.2)

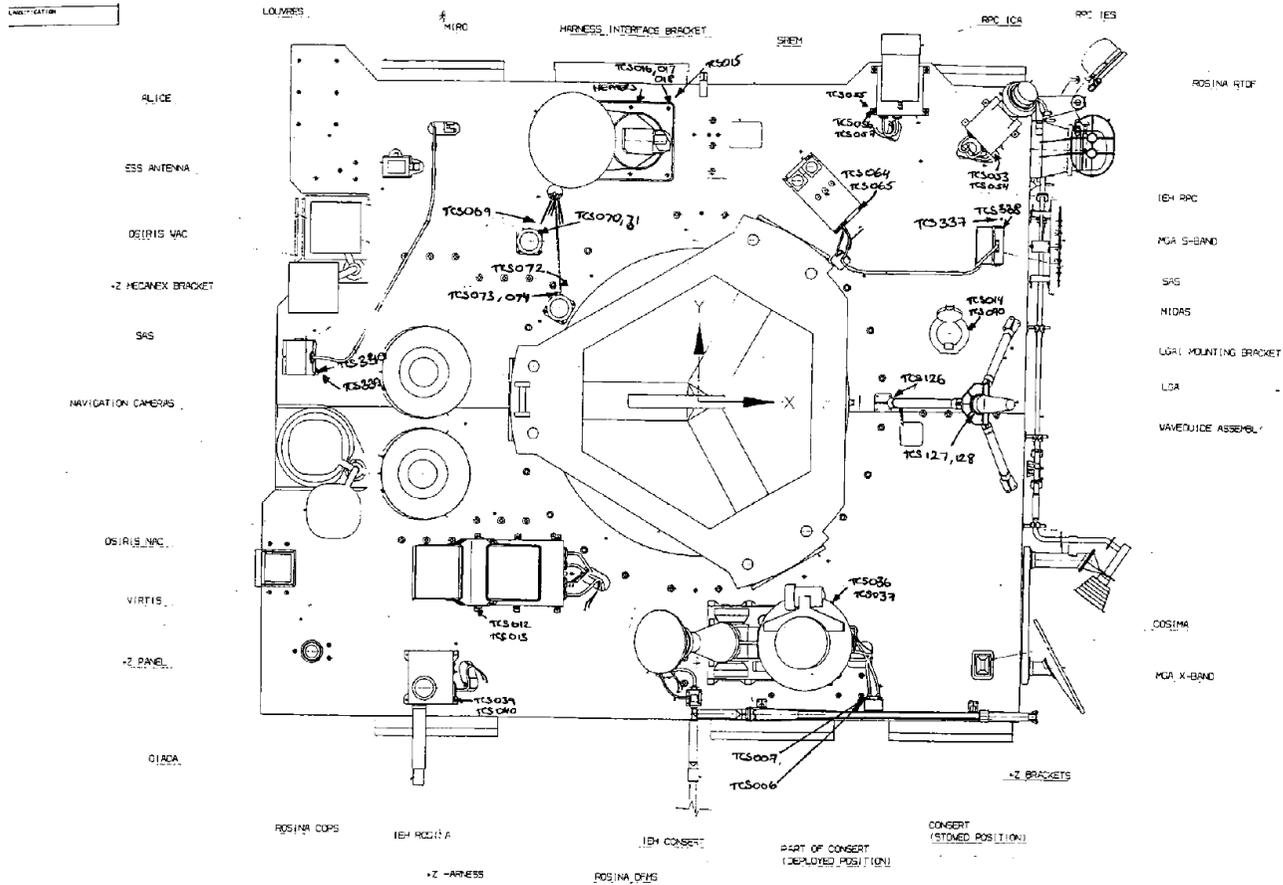


Figure 41 : Location of STP points for Consert, GIADA, MIDAS, MIRO, LGA Lz, ROSINA, RPC, SAS, SREM and SSP units (see section 3.12.2)

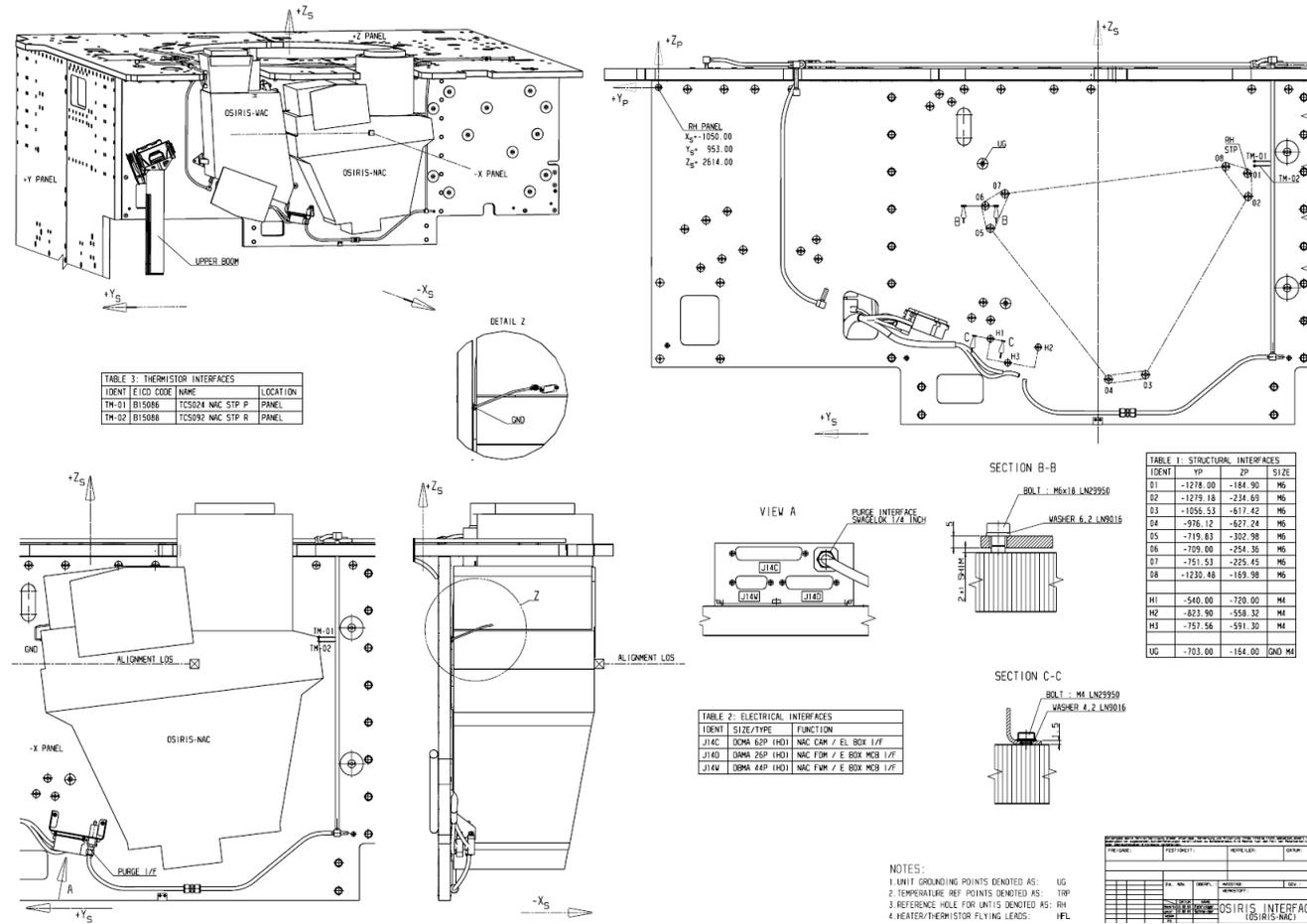


Figure 42: Location of STP points for OSIRIS NAC (see section 3.12.2)

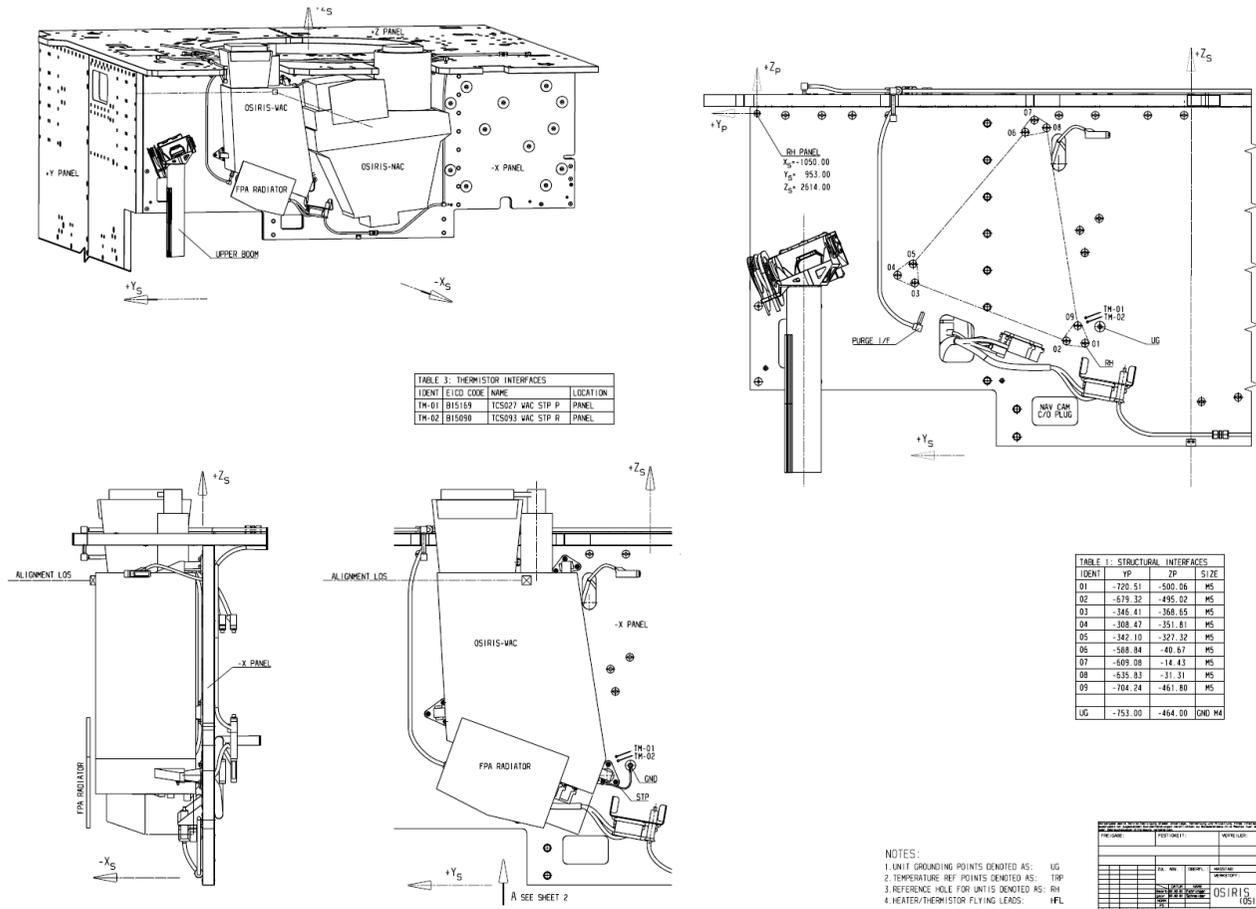


Figure 43 : Location of STP points for OSIRIS WAC & CRB (see section 3.12.2)

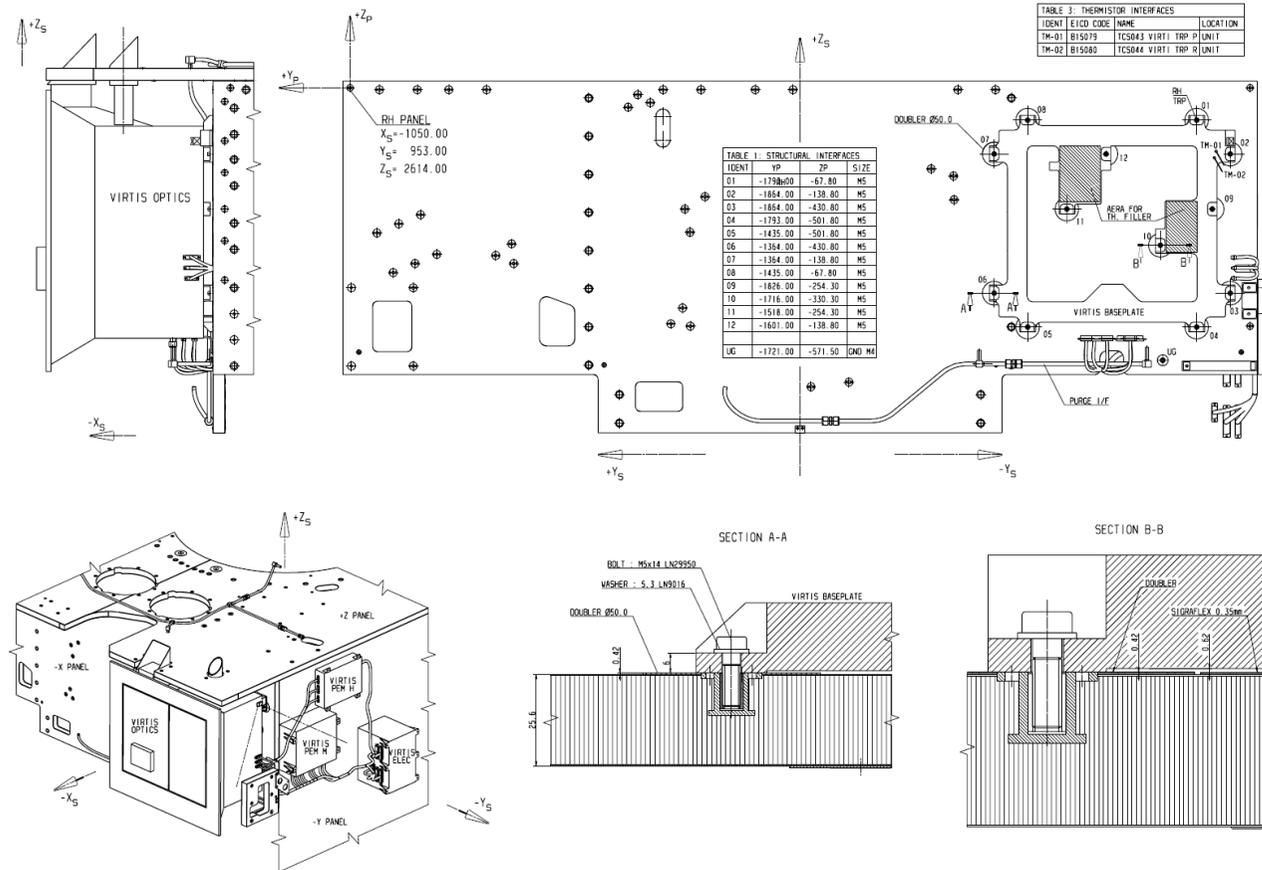


Figure 44: Location of STP points for VIRTIS (see section 3.12.2)

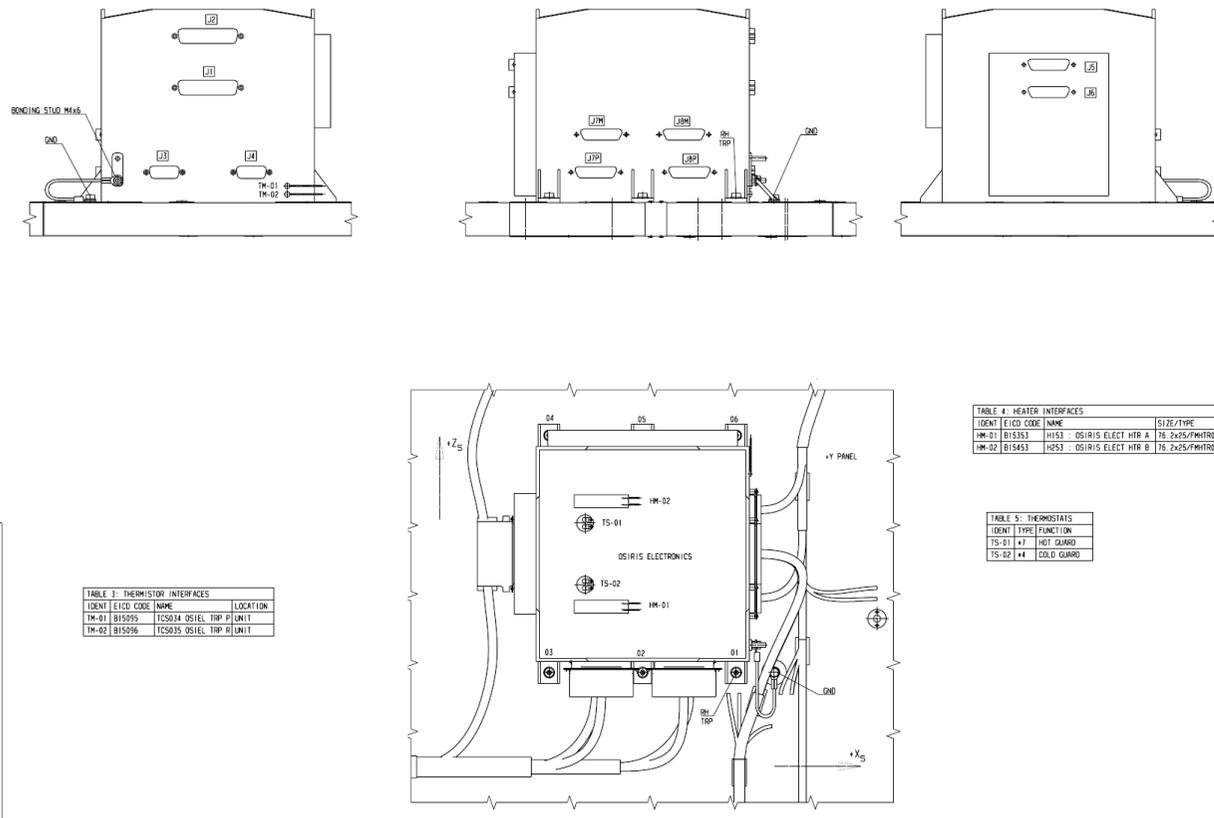


Figure 45: Location of STP points for OSIRIS electronics (see section 3.12.2)



3.12.2 Dataset Description

Dataset name: ROSETTA THERMAL CONTROL SYSTEM ENGINEERING
DATA

Dataset ID: RO-X-HK-3-TCS-V1.0

/RO-X-HK-3-TCS-V1.0

/DATA

/CONCERT_ANT_TEMP

/GIADA_TEMP

/MIDAS_TEMP

/MIRO_TEMP

/OSIRIS_TEMP

/RF_ANTENNA_TEMP

/ROSINA_TEMP

/RPC_BOOM_TEMP

/RPC_ICA_TEMP

/RPC_IES_TEMP

/SAS_TEMP

/SREM_TEMP

/SSP_ANT_TEMP

/VIRTIS_TEMP

The data provided covers the full duration of the Rosetta mission. Browse images are only provided for the RPC boom dataset.



3.12.3	General	3.12.4	Directory Name	3.12.5	Instrument / Subsystem	3.12.6	Description	3.
3.12.10	Consert Antenna Temperature	3.12.11	CONSERT_ANT_TEMP	3.12.12	Consert Antenna	3.12.13	TCS006_CONAN_STP-C36	3.
3.12.17	Consert Antenna Temperature	3.12.18	CONSERT_ANT_TEMP	3.12.19	Consert Antenna	3.12.20	TCS007_CONAN_TRP_P-C31	3.
3.12.24	GIADA Temperature	3.12.25	GIADA_TEMP	3.12.26	Giada	3.12.27	TCS012_GIADA_TRP_P-C34	3.
3.12.31	GIADA Temperature	3.12.32	GIADA_TEMP	3.12.33	Giada		TCS013_GIADA_TRP_R-C34	3.
3.12.37	MIDAS Temperature	3.12.38	MIDAS_TEMP	3.12.39	Midas	3.12.40	TCS014_MIDAS_TRP_P-C30	3.
3.12.44	MIDAS Temperature	3.12.45	MIDAS_TEMP	3.12.46	Midas	3.12.47	TCS090_MIDAS_TRP_R-C30	3.
3.12.51	MIRO Temperature	3.12.52	MIRO_TEMP	3.12.53	Miro Telescope	3.12.54	TCS015_MIRTE_STP-C35	3.
3.12.58	MIRO Temperature	3.12.59	MIRO_TEMP	3.12.60	Miro Telescope		TCS016 MIRTE TRP P-C37	3.
3.12.64	MIRO Temperature	3.12.65	MIRO_TEMP	3.12.66	Miro Telescope	3.12.67	TCS017_MIRTE_TRP_R-C37	3.
3.12.70	MIRO Temperature	3.12.71	MIRO_TEMP	3.12.72	Miro Optical bench	3.12.73	TCS018_MIROB_TRP-C35	3.
3.12.77	OSIRIS Temperature	3.12.78	OSIRIS_TEMP	3.12.79	Osiris NAC	3.12.80	TCS024_NAC__STP_P-C44	3.



3.12.3 General	3.12.4 Directory Name	3.12.5 Instrument / Subsystem	3.12.6 Description	3.
3.12.84 OSIRIS Temperature	3.12.85 OSIRIS_TEMP	3.12.86 Osiris WAC	3.12.87 TCS027_WAC__STP_P-C45	3.
3.12.91 OSIRIS Temperature	3.12.92 OSIRIS_TEMP	3.12.93 Osiris NAC CRB	3.12.94 TCS030_NACRB_TRP_P-C46	3.
3.12.97 OSIRIS Temperature	3.12.98 OSIRIS_TEMP	3.12.99 Osiris NAC CRB	3.12.100 TCS031_NACRB_TRP_R-C46	3.
3.12.104 OSIRIS Temperature	3.12.105 OSIRIS_TEMP	3.12.106 Osiris WACCRB	3.12.107 TCS032_WACRB_TRP_P-C47	3.
3.12.111 OSIRIS Temperature	3.12.112 OSIRIS_TEMP	3.12.113 Osiris WACCRB	TCS033 WACRB TRP R-C47	3.
OSIRIS Temperature	3.12.117 OSIRIS_TEMP	3.12.118 Osiris Main Electronic (ME)	3.12.119 TCS034_OSIEL_TRP_P-C48	3.



3.12.3	General	3.12.4	Directory Name	3.12.5	Instrument / Subsystem	3.12.6	Description	3.
3.12.123	OSIRIS Temperature	3.12.124	OSIRIS_TEMP	3.12.125	Osiris Main Electronic (ME)	3.12.126	TCS035_OSIEL_TRP_R-C48	N
3.12.129	OSIRIS Temperature	3.12.130	OSIRIS_TEMP	3.12.131	Osiris NAC	3.12.132	TCS092_NAC__STP_R-C44	3.
3.12.136	OSIRIS Temperature	3.12.137	OSIRIS_TEMP	3.12.138	Osiris WAC	3.12.139	TCS093_WAC__STP_R-C45	3.
3.12.143	RF Antenna Temperature	3.12.144	RF_ANTENNA_TEMP	3.12.145	MGA S	3.12.146	TCS120_MGAS_STP-C89	3.
3.12.149	RF Antenna Temperature	3.12.150	RF_ANTENNA_TEMP	3.12.151	MGA S	3.12.152	TCS121_MGAS_TRP_P-C67	3.
3.12.156	RF Antenna Temperature	3.12.157	RF_ANTENNA_TEMP	3.12.158	MGA S	3.12.159	TCS122_MGAS_TRP_R-C67	3.
3.12.163	RF Antenna Temperature	RF_ANTENNA_TEMP		3.12.164	MGA X	3.12.165	TCS123_MGAX_STP-C89	3.
3.12.169	RF Antenna Temperature	3.12.170	RF_ANTENNA_TEMP	3.12.171	MGA X	3.12.172	TCS124_MGAX_TRP_P-C68	3.
RF Antenna Temperature		3.12.176	RF_ANTENNA_TEMP	3.12.177	MGA X	3.12.178	TCS125_MGAX_TRP_R-C68	3.



3.12.3	General	3.12.4	Directory Name	3.12.5	Instrument / Subsystem	3.12.6	Description	3.
3.12.182	RF Antenna Temperature	3.12.183	RF_ANTENNA_TEMP	3.12.184	LGA PZ	3.12.185	TCS126_LGAPZ_STP-C90	3.
3.12.189	RF Antenna Temperature	3.12.190	RF_ANTENNA_TEMP	3.12.191	LGA PZ	3.12.192	TCS127_LGAPZ_TRP_P-C69	3.
3.12.196	RF Antenna Temperature	3.12.197	RF_ANTENNA_TEMP	LGA PZ		3.12.198	TCS128_LGAPZ_TRP_R-C69	3.
3.12.202	RF Antenna Temperature	3.12.203	RF_ANTENNA_TEMP	3.12.204	LGA MZ	3.12.205	TCS129_LGAMZ_STP-C90	3.
3.12.209	RF Antenna Temperature	3.12.210	RF_ANTENNA_TEMP	3.12.211	LGA MZ	3.12.212	TCS130_LGAMZ_TRP_P-C70	3.
3.12.216	RF Antenna Temperature	3.12.217	RF_ANTENNA_TEMP	3.12.218	LGA MZ	3.12.219	TCS131_LGAMZ_TRP_R-C70	3.
3.12.222	ROSINA Temperature	3.12.223	ROSINA_TEMP	3.12.224	Rosina DFMS	3.12.225	TCS036_DFMS_TRP_P-C49	3.
3.12.229	ROSINA Temperature	3.12.230	ROSINA_TEMP	3.12.231	Rosina DFMS	3.12.232	TCS037_DFMS_TRP_R-C49	3.
3.12.236	ROSINA Temperature	3.12.237	ROSINA_TEMP	Rosina Cops		3.12.238	TCS039_COPS_TRP_P-C50	3.
3.12.242	ROSINA Temperature	3.12.243	ROSINA_TEMP	3.12.244	Rosina Cops	3.12.245	TCS040_COPS_TRP_R-C50	3.
3.12.248	RPC Boom Temperature	3.12.249	RPC_BOOM_TEMP	3.12.250	RPC LAP1	3.12.251	TCS058_LAP1_STP-C58	3.



3.12.3 General	3.12.4 Directory Name	3.12.5 Instrument / Subsystem	3.12.6 Description	3.
3.12.255 RPC Boom Temperature	3.12.256 RPC_BOOM_TEMP	RPC MIP	3.12.257 TCS059_MIP__STP-C56	3.
3.12.261 RPC Boom Temperature	3.12.262 RPC_BOOM_TEMP	RPC MAGIB	3.12.263 TCS062_MAGIB_STP-C57	3.
3.12.267 RPC Boom Temperature	3.12.268 RPC_BOOM_TEMP	3.12.269 RPC LAP2	3.12.270 TCS096_LAP2_STP-C86	3.
3.12.274 RPC ICA Temperature	3.12.275 RPC_ICA_TEMP	3.12.276 RPC ICA	3.12.277 TCS055_ICA__STP-C86	3.
3.12.281 RPC ICA Temperature	3.12.282 RPC_ICA_TEMP	3.12.283 RPC ICA	3.12.284 TCS056_ICA__TRP_P-C55	3.
3.12.288 RPC ICA Temperature	3.12.289 RPC_ICA_TEMP	3.12.290 RPC ICA	TCS057_ICA_TRP_R-C55	3.
3.12.294 RPC IES Temperature	3.12.295 RPC_IES_TEMP	3.12.296 RPC IES	3.12.297 TCS053_IES__TRP_P-C54	3.
3.12.301 RPC IES Temperature	3.12.302 RPC_IES_TEMP	3.12.303 RPC IES	3.12.304 TCS054_IES__TRP_R-C54	3.
Solar Aspect Sensor Temperature	3.12.308 SAS_TEMP	3.12.309 SAS 1 (+X)	3.12.310 TCS337_SASPX_STP-C121	3.



3.12.3 General	3.12.4 Directory Name	3.12.5 Instrument / Subsystem	3.12.6 Description	3.
3.12.314 Solar Aspect Sensor Temperature	3.12.315 SAS_TEMP	3.12.316 SAS 1 (+X)	3.12.317 TCS338_SASPX_TRP-C121	3.
3.12.321 Solar Aspect Sensor Temperature	SAS_TEMP	3.12.322 SAS 2 (-X)	3.12.323 TCS339_SASMX_STP-C122	3.
3.12.327 Solar Aspect Sensor Temperature	3.12.328 SAS_TEMP	3.12.329 SAS 2 (-X)	3.12.330 TCS340_SASMX_TRP-C122	3.
3.12.333 SREM Temperature	3.12.334 SREM_TEMP	3.12.335 SREM	3.12.336 TCS064_SREM_STP-C87	3.
3.12.340 SREM Temperature	3.12.341 SREM_TEMP	3.12.342 SREM	3.12.343 TCS065_SREM_TRP_P-C59	3.
3.12.347 (Philae) Antenna Temperature	3.12.348 SSP_ANT_TEMP	3.12.349 SSP Antenna 1	3.12.350 TCS069_ESSAA_STP-C87	3.
3.12.354 (Philae) Antenna Temperature	3.12.355 SSP_ANT_TEMP	3.12.356 SSP Antenna 1	3.12.357 TCS070_ESSAA_TRP_P-C61	3.
3.12.361 (Philae) Antenna Temperature	3.12.362 SSP_ANT_TEMP	3.12.363 SSP Antenna 1	3.12.364 TCS071_ESSAA_TRP_R-C61	3.
3.12.368 (Philae) Antenna Temperature	3.12.369 SSP_ANT_TEMP	3.12.370 SSP Antenna 2	3.12.371 TCS072_ESSAB_STP-C88	3.
3.12.375 (Philae) Antenna Temperature	3.12.376 SSP_ANT_TEMP	3.12.377 SSP Antenna 2	3.12.378 TCS073_ESSAB_TRP_P-C62	3.



3.12.3 General	3.12.4 Directory Name	3.12.5 Instrument / Subsystem	3.12.6 Description	3.
3.12.382 (Philae) Antenna Temperature	3.12.383 SSP_ANT_TEMP	3.12.384 SSP Antenna 2	3.12.385 TCS074_ESSAB_TRP_R-C62	N
3.12.388 VIRTIS Temperature	3.12.389 VIRTIS_TEMP	3.12.390 Virtis Optical Module (Sensor)	3.12.391 TCS043_VIRTI_TRP_P-C40	3.
3.12.395 VIRTIS Temperature	3.12.396 VIRTIS_TEMP	3.12.397 Virtis Optical Module (Sensor)	3.12.398 TCS044_VIRTI_TRP_R-C40	3.

3.12.402 How to use the data

Looking at the temperature of the RPC booms

Only one set of browse images have been generated from the TCS datasets and these are for the RPC booms which are in a deployed state and pointing out from the body of the spacecraft.

The intention in providing these images is purely to help the user recognize the benefits of being able to make use of temperature data from the different locations on the surface (and booms) of Rosetta.

An example of the RPC boom browse image from 2015 is provided below.

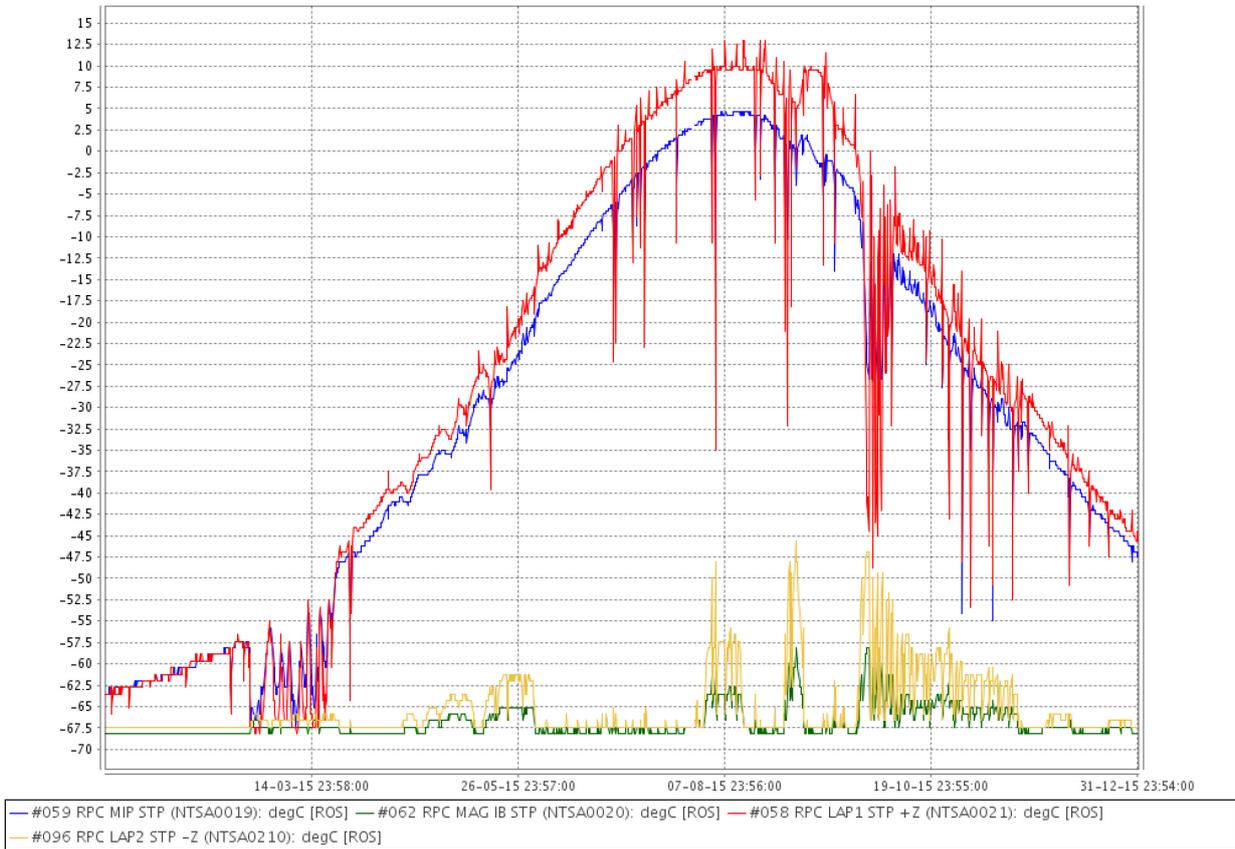


Figure 46 : RPC boom temperature profile in 2015