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ROSETTA PLASMA CONSORTIUM USERS' MANUAL

RO-RPC-UM

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ROSETTA – RPC USER MANUAL

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Reference Documents

All the relevant documents listed below can be accessed at the RPC-WIKI,
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Acronym List

Acronym	Description
A/D	Analog/Digital
A/R	As Required
AAD	Attitude Anomaly Detector
AC	Alternate Current
ACID	Application Configuration Interface Data
ACK	Acknowledge
ACM	Active Cruise Mode
ACS	Avionics Computer System
ACS	Attitude Control System
ACU	Attitude Control Unit
AD	Applicable Document
ADC	Analog to Digital Converter
ADD	Architectural Design Document
ADP	Acceptance Data Package
AFM	Asteroid Flyby Mode
AIT	Assembly Integration Tests
AIU	AOCMS Interface Unit
AIV	Assembly, Integration and Verification
AIV	Activity of Integration and Validation
ALICE	ORBITER PAYLOAD INSTRUMENT
ALS	Alenia Spazio
AM	Activation Mode
AME	Absolute Measurement Error
AND	Alphanumeric Display
ANSI	American National Standards Institute
AO	Announcement of Opportunity
AOCMS	Attitude & Orbit Control Measurement System
AOCS	Attitude & Orbit Control System
AOS	Acquisition Of Signal
AOU	Astronomical Observatory Uppsala
APC	Active Payload Checkout
APD	Active Payload Data Dump
APE	Absolute Pointing Error
APID	Application Process Identifier
APM	Antenna Pointing Mechanism
APXS	LANDER PAYLOAD INSTRUMENT
AQP	Acquisition Period
AS	Address State (1750 Processor)
ASA	Austrian Space Agency
ASAP	As soon as possible
ASF	Additional Safety Factors
ASI	Agenzia Spaziale Italiana
ASIC	Application Specific Integrated Circuit
ATA	Alignment Test Adapter

ATP	Approach Transition Point
AU	Astronomical Unit
AWG	American Wire Gauge
BB	Broad Band
BC	Bus Controller
BCP1	Broadcast Command Pulse 1 (Pulse at 1/8 Hz on OBDH bus)
BCU	Battery Charge Unit
BDR	Battery Discharge Regulator
BDU	Battery Discharge Unit
BER	Bit Error Rate
BERENICE	ORBITER PAYLOAD INSTRUMENT
BFL	Back Focal Length
BIT	Build In Test
BL	Block Length, LAP
BMOS	Buckling Margin Of Safety
BOB	Break Out Box
BOL	Beginning of Life
BPS	Bits per second
BRU	Battery Regulator Unit, Battery Recharge Unit
BSM	Bus Support Module
C/C	Collectively Controlled
CA	Contract Authorisation
CADU	Channel Access Data Unit
CAP	Comet Acquisition Point
CAPS	Cassini Plasma Spectrometer
CAV	Command Acceptance Verification
CC	Cost Code
CCB	Configuration Control Board
CCCS	Common Checkout & Control System
CCD	Charged Coupled Device
CCDB	Configuration Control Database
CCE	Central Checkout Equipment
CCITT	Consultative Committee International Telegraph & Telephone
CCN	Change Contract Notice
CCR	Configuration Control Request
CCS	Central Check-out System
CCSDS	Consultative Committee for Space Data Systems
CCU	Central Computing Unit
CDC	Clock Drift Correction
CDMS	Central Data Management System
CDMS	Control and Data Management Subsystem (Sub-Assembly)
CDMU	Central Data Management Unit
CDR	Critical Design Review
CDV	Command Dispatch Verification
CE	Conducted Emission
CEPHAG/SA	Centre d'Etude des Phenomenes Aleatoires et Geophysiques/Service d'Aeronomie u CNES
CESR	Centre d'Etude Spatiale des Rayonnements
CEV	Command Execution Verification

CFRP	Carbon Fibre Reinforced Plastic
CGSE	Cryocooling Ground Support Equipment
CHAMPAGNE	LANDER PAYLOAD INSTRUMENT
CHF	Critical History File
CHL	Command History Log
CHM	Critical Housekeeping Unit
CI	Configuration Item
CIA	Communication Interface Adapter
CIDL	Configuration Item Data List
CISAS	Centro Interdipartimentale di Studi e Attività Spaziali
CIVA	Comet nucleus Infrared and Visibility Analyser (Lander Payload)
CLCW	Command Link Control Word
CLTU	Command Link Transmission Unit
CM	Configuration Management
CMD	Command
CMF	Configuration Management Facility
CMO	Configuration Management Officer
CMP	Configuration Management Plan
CNES	Centre Nationale d'Etude Spatiale
COB	Consolidated Obeservation Request
COG	Centre Of Gravity
Co-I	Co-Investigator
COM	Centre Of Mass
CONSERT	ORBITER & LANDER PAYLOAD INSTRUMENTs
COP	Command Operations Procedure
COSAC	LANDER PAYLOAD INSTRUMENT
COSIMA	ORBITER PAYLOAD INSTRUMENT
COTS	Commercial Off The Shelf
CPDU	Command Pulse Distribution Unit
CPU	Central Processing Unit
CR	Compression Ratio
CRAF	Comet Rendezvous and Asteroid Fly-by mission
CRB	CCD Readout Board
CRC	Cyclic Redundancy Code
CRF	Command Request Files
CRID	Command Request Interface Document
CRMA	Consolidated Report on Mission Analysis
CRP	Contingency Recovery Procedure
CRV	Command Station Reception Verification
CS	Conducted Susceptibility
CSG	Centre Spatiale Guyanaise
CSM	Communication Switching Matrix
CSME	Communication Switching Matrix Element
CSP	Charge Sensitive Preamplifier
CSPL	Consolidated Parameter Scenario List
CSV	Command Station Radiation Verification
CSY	Converter Synchronisation
CTC	Cost to Completion
CUC	CCSDS Unsegmented Time Code

CUV	Command Uplink Verification
CVP	Commissioning and Verification Phase
D/TOS	Directorate of Technical and Operational Support
DARA	Deutsche Agentur für Raumfahrtangelegenheiten
DAT	Digital Analog Tape
DAWG	Data Archiving Working Group
DB	Database
DBMS	Data Base Management System
DC	Data Centre
DC	Direct Current
DCA	Dedicated Control Area
DCL	Declared Components List
DCR	Document Change Request
DCR	Data Change Request
DCR	Dedicated Control Room
DCS	Dust Collector Subsystem (COSIMA)
DCT	Discrete Cosine Transform
D&D	Design and Development
DDD	Detailed Design Document
DDID	Data Delivery Interface Document
DDS	Data Distribution System
DDV	Design Development and Verification
DEF	Deflector
DFMS	Double Focusing Mass Spectrometer
DIB	DPU Interface Board
DISR	Descent Imager/Spectral Radiometer
D/L	Down Link
DLR	Deutsche Forschungsanstalt fuer Luft und Raumfahrt e.V.
DM	Dynamic Model
DMA	Direct Memory Access
DML	Declared Materials List
DML	Delayed Memory Load command
DMPL	Declared Mechanical Parts List
DMS	Data Management System
DMSS	Distributed Mission Support System
DoD	Depth of Discharge
DOF	Degree Of Freedom
DOP	Division Operating Procedures
DOR	Direct Operation Request
DPL	Declared Process List
DPSS	Data Packet Switching System
DPU	Data Processing Unit
DQE	Detector Quantum Efficiency
DRAM	Dynamic Random Access Memory
DRB	Delivery Review Board
DS	Digital Serial Aquisition
DSDB	Data Sheet Database
DSN	Deep Space Network
DSP	Digital Signal Processor

DSS	Dornier Space Systems
DST	Deep Space Transponder
DTMM	Detailed Thermal Mathematical Model
DWG	Drawing
DWT	Discrete Wavelet Transform
ECDR	Experiment Critical Design Review
ECF	Expedited Command File
ECP	Executable Control Procedures
ECR	Expedite Command Request
ECR	Engineering Change Request
EDAC	Error Detection And Correction
EDC	Error Detection Correction
E-DSF	Expedite - Detailed Schedule File
EE	External Entity (SCOE)
EEPROM	Electrically Erasable Programmable Read Only Memory
EFDR	Experiment Final Design Review
EFOR	Experiment Flight Operations Review
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EID	Event Identification
EIDR	Experiment Intermediate Design Review
EIRP	Equivalent Isotropic Radiated Power
ELC	Electron
EM	Engineering Model
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EOC	End of Cycle
EOL	End of Life
EOP	End of Packet
EPC	Electrical Power Conditioner
EPS	Electrical Power Subsystem
EQM	Electrical Qualification Model
ERF	Event Reporting Function
ESA	European Space Agency
ESA	Electrostatic Analyzer
ESANET	European Space Agency's communications Network
ESARAD	ESA RADiation
ESATAN	ESA Thermal Analyser
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
ESM	Earth Strobing Mode
ESOC	European Space Operations Centre
ESS	Electrical Support System
ESTEC	European Space Research and Technology Centre
ESTRACK	European Space Tracking Network
ETS	EMC Test Station
EUT	Equipment under Test
EUV	Extreme Ultra Violet
F/D	Flight Dynamics

FAR	Flight Acceptance Review
FAU	File Assembly Unit
FAT	Factory Acceptance Test
FCL	Fold-Back Current Limiter
FCP	Flight Control Procedure
FCS	Flight Control System
FCT	Flight Control Team
FCV	Flow Control Valve
FD	Flight Dynamics
FD	Frequency Domain
FDIR	Failure Detection, Isolation and Recovery
FDR	Flight Dynamics (Control) Room
FDR	Functional Design Review
FDR	Flight Dynamics Request
FDS	Flight Dynamics System
FE	Front End
FEC	Front End Controller
FEE	Front End Equipment
FE-LAN	Front-End Local Area Network
FEM	Finite Element Model
FF	Full Frame
FID	Function Identifier
FIFO	First In First Out
FITO	Fabrication and Test Outline
FM	Flight Model
FM	File Management
FMECA	Failure Mode Effect and Criticality Analysis
FMI	Finnish Meteorological Institute
FMS	Failure Management system
FMS	File Management System
FOD	Flight Operations Director
FOP	Flight Operations Plan
FOP	Flight Operation Procedure
FOV	Field Of View
FP	Formal Procedures
FPA	Focal Plane Assembly
FPGA	Field Programmable Gate Array
FRAP	Fine Pointing Accuracy Phase
FRR	Flight Readiness Review
FS	Flight Spare
FT	File Transfer
FTS	File Transfer System
FTA	Fault Tree Analysis
FTP	File Transfer Protocol
FUSE	Far Ultraviolet Spectrograph Experiment
FUV	Far Ultra Violet
FWM	Filter Wheel Mechanism
G/S	Ground Station
GFURD	Ground Facilities User Requirements Document

GH	Grand Heading
GIADA	Grain Impact Analyser and Dust Accumulator (Orbiter Payload)
GLEP	Pointing on Ephemeris Phase : Phase with gyroless stellar estimator
GMI	Global Mapping Injection point
GMI	Global Mapping Insertion
GMT	Greenwich Mean Time
GPIB	General Purpose Instrument Bus (IEEE 488-75)
GPR	Ground Penetrating Radar
GRD	Graphic Display
GRM	Ground Reference Model
GS	Ground Station
GSDR	Ground Segment Design Review
GSE	Ground Support Equipment
GSEP	Pointing on Ephemeris Phase : Phase with Gyro-stellar estimator
GSIR	Ground Segment Implementation Review
GSIS	Ground Station Interface Specification
GSM	Ground Segment Manager
GSMP	Ground Segment Management Plan
GSOC	German Space Operations Centre
GSP	Ground commanded Slew Phase
GSRQR	Ground Segment Requirements Review
GSRR	Ground Segment Readiness Review
GW	Gravitational Waves
H/W	Hardware
HDBK	Handbook
HDR	Hardware Design Review
HF	High Frequency
HFC	High Frequency Clock
HGA	High Gain Antenna
HGAPM	HGA Pointing Mechanism
HIB	Hibernation
HIPPS	Highly Integrated Pluto Payload System
HK	Housekeeping
HL	High Limit
HM	Hibernation Mode
HMC	Halley Multicolour Camera
HOOD	Hierarchical Object Oriented Design
HPA	High Power Amplifier
HPC	High Power Command
HPCM	HPC Module
HPD	High Performance Demodulator
HRM	Holddown & Release Mechanism
HSD	High Speed Data
HTCB	Handling Transport Clamp Band
HV	High Voltage
HVPS	High Voltage Power Supply
I/C	Individually Controlled
I/F	Interface

I/O	Input/Output
I&T	Integration & Testing
IAA	Instituto de Astrofisica de Andalucia
IAS	Institute d'Astrophysique Spatiale
IAS-CNR	Istituto di Astrofisica Spaziale/Consiglio Nazionale delle Richerche
IB	Inboard
I-BOB	Intelligent Break Out Box
ICA	Ion Composition Analyser (RPC)
IC	Imperial College, London
ICD	Interface Control Document
ID	Identifier
IDA	Institut für Datenverarbeitungsanlagen
IDR	Instrument Design Review
IEEE	Institute of Electric and Electronics Engineers
IES	Ion and Electron Sensor (RPC)
IF	Intermediate Frequency
IFEM	Interface Finite Element Model
IFOV	Intrinsic Field Of View
IMMM	Interface Mechanical Mathematical Model
IMP	Imager for Mars Pathfinder
INTA	Instituto Nacional de Tecnica Aerospacial
I/O	Input / Output
IQR	Internal Quality Report
IR	Infra Red
IS	Impact Sensor (GIADA)
ISO	International Standards Organisation
IST	Integrated System Test
IT	Integration Test
IT	Interruption
ITMM	Interface Thermal Mathematical Model
ITP	Integration Test Plan
ITR	Integration Test Report
ITT	Invitation To Tender
IUE	Internal Ultraviolet Explorer
IWF	Institut für Weltraumforschung, Graz
JPEG	Joint Photographics Experts Group
JPL	Jet Propulsion Laboratory
KAL	Keep Alive Line
KAU	Kilo Accounting Units
KBPS	Kilo-Bits Per Second
KFKI	Hungarian Research Institute for Particle and Nuclear Physics
KO	Kick Off
L	Launch (time)
LAN	Local Area Network
LAP	Langmuir Probe (RPC)
LAS	Laboratoire d'Astronomie Spatiale
LCB	Last Chance Bit
LCDA	Launcher Coupled Dynamic Analysis

LCL	Latching Current Limiter
LDL	Long Debye Length (LAP/MIP Mode)
LEOP	Launch and Early Orbit Phase
LESS	Lander Electrical Support System
LET	Linear Energy Transfer
LF	Low Frequency
LGA	Low Gain Antenna
LID	Lander Interface Document
LIFO	Last In First Out
LIGA	Lithographie, Galvanoformung und Abformung
LILT	Low Intensity Low Temperature
LISN	Line Impedance Stabilization Network
LIT	Listen-In Test
LL	Low Limit
LM	Launch Mode
LMSS	Lander Mechanical Support and Separation systems
LNA	Low Noise Amplifier
LO	Local Oscillator
LOR	Lander Operational Request
LOS	Loss Of Signal
LOS	Line Of Sight
LPCE	Laboratoire de Physique et Chimie de l'Environnement
LRR	Launch Readiness Review
LSB	Least Significant Bit
LSI	Large Scale Integration
LU	Latch Up
LV	Latch Valve
LVO	Label Value Object
LVPS	Low Voltage Power Supply
LW	Launch Window
LZ	Lander = SSP
M&C	Monitoring and Control
MAC	Model Assurance Criterion
MACS	Modular Attitude Control System
MAG	Fluxgate Magnetometer (RPC)
MAP	Multiplexing Access Point
MAS	Mission Analysis Section
MB	Measurement Block
MBS	Micro Balance Sensor (GIADA)
MC	Measurement Cycle
MCM	Monitoring and Control Module
MCM	Multi Chip Module
MC-OCF	Master Channel – Operational Control Field
MCP	Micro Channel Plate
MCR	Main Control Room
MCR	Memory Checksum Request
MCRR	Mission Commissioning Results Review
MCS	Mission Control System
MDR	Memory Dump Request

MGA	Medium Gain Antenna
MGM	Magnetometer
MGSE	Mechanical Ground Support Equipment
MICD	Mechanical Interface Control Document
MID	Memory Identifier
MIDAS	ORBITER PAYLOAD INSTRUMENT
MINT	Monitoring Interval
MIP	Mission Implementation Plan
MIP	Mutual Impedance Probe (RPC)
MIP	Mandatory Inspection Points
MIRD	Mission Implementation Requirements Document
MIRO	Microwave Instrument for the Rosetta Orbiter (Orbiter Payload)
ML	Memory Load, Medium Level
MLC	Memory Load Command
MLI	Multi Layer Insulation
MM	Mass Memory
MM	Memory Management
MMB	Mass Memory Board
MMD	Mimic Display
MMH	Mono Methyl Hydrazine, (MMH-LTO)
MMI	Man Machine Interface
MMS	Matra Marconi Space
MMS-B	Matra Marconi Space (Bristol)
MMS-H	Matra Marconi Space (Stevenage)
MMS-T	Matra Marconi Space (Toulouse)
MMU	Memory Management Unit
MOC	Mission Operations Centre
MOD	Mission Operations Department
MODULUS	LANDER PAYLOAD INSTRUMENT
MOI	Moment Of Inertia
MOP	Mission Operations Phase
MOS	Margin Of Safety
MOU	Memorandum Of Understanding
MPA	Mission Planning Area
MPAE	Max Planck Institut für Aeronomie
MPI	Max Planck Institut
MPIK	Max Planck Institut für Kernphysik
MPP	Multiple Phase Pinning
MPPT	Maximum Power Point Tracking
MPR	Memory Patch Request
MPS	Mission Planning System
MPTS	Multi Purpose Tracking System
MRB	Material Review Board
MRT	Mission Readiness Test
MSB	Most Significant Bit
MSDR	Mission System Design Review
MSP	Master Science Plan
MSS	Mechanical Support and Separation system
MST	Mission Simulation Test

MSSW	Mission Specific Software
MTL	Mission Timeline
MTTR	Mean Time To Repair
MUPUS	Multi Purpose Sensor experiment (Lander Payload)
MUSC	Microgravity User Support Centre
MUX	Multiplexer
N/A	Not Applicable
NAC	Narrow Angle Camera
NACK	Not Acknowledge
NASA	National Aeronautics and Space Administration
NASAPSCN	NASA Private System Communication Network
NASTRAN	NASA Structural Analysis Tool
NAVCAM	Navigation Camera
NB	Narrow Band
NC	Non Conformity
NCM	Near Comet Mode
NCR	Non Conformance Report
NCTRS	Network Control and Telemetry Receiver System
NDIU	Network Data Interface Unit
NDM	Neutral Dynamics Monitor
NF	Normal Frequency
NM	Normal Mode
NOCC	Network Operations Control Centre (JPL)
NRT	Near Real Time
NRZ-L	Never Return to Zero-Level
NTO	Nitrogen Tetroxide
OA	Operational Archive
OAP	Off Axis Paraboloid
OB	Onboard
OB	Outboard
OBC	On-Board Computer
OBC	On-Board Clock
OBCP	On-Board Control Procedure
OBDH	On-Board Data Handling
OBEM	On-Board Event Monitoring
OBR	Observation Request
OBS	On-Board Software
OBSM	On-Board Software Maintenance
OBSW	On-Board Software
OBT	On-Board Time
OC	Output Code
OC	Open Centre
OCC	Operations Control Centre
OCM	Orbit Control Mode
OCXO	Oven Controlled Crystal Oscillator
OD	Operations Director
OHP	Observatoire d'Haute Provence
OIOR	Orbiter Instrument Operational Request
OIP	Orbit Injection Point

OM	Operations Manager
OMM	Operational Macro Mode
OOL	Out Of Limits
OPI	Orbiter Payload Instrument
OPS	Operations
ORATOS	Orbit Attitude Operations System
ORS	Operation Request Structure
OSI	Open System Interconnection
OSIRIS	Optical, Spectroscopic and Infrared Remote Imaging System (Orbiter) Payload)
OU	Open University
P/B	Play Back (data from Solid State Recorder)
P/L	Payload
PA	Product Assurance
PAD	Padding (to a good block length modulo packet length, packets only, LAP) integer packets only, LAP)
PAIP	Product Assurance Implementation Plan
PALASIM	Parallel Access Large Silicon Memory
PC	Project Control
PC	Passive Checkout
PCA	Pressure Controlled Assembly
PCB	Printed Board Circuit
PCE	Power Controller Electronics
PCM	Pulse Code Modulation
PCM	Power Converter Module
PCS	Packet Check Sequence
PCU	Power Control Unit
PDF	Product Definition File
PDL	Pseudo Design Language
PDR	Preliminary Design Review
PDS	Planetary Data System
PDU	Power Distribution Unit
PEM	Project Element Manager
PEM	Plasma Environment Monitor
PES	Performance Evaluation System
PFC	Parameter Format Code
PFM	Proto Flight Model
PHD	Project History Documents
PI	Principal Investigator
PID	Parameter Identifier
PID	Process Identifier
PIR	Post Integration Review
PISA	Principal Investigators Support Area
PIU	Plasma Interface Unit (RPC)
PKT	Packet
PLM	Payload Module
PM	Project Manager
PM	Processing Module

PMD	Propellant Management Device
PMIS	Project Management Information System
PMP	Part Material and Process
PMU	Processor Module Unit
POR	Payload Operation Request
PPWR	Primary Power
PRNU	Pixel Response Non Uniformity
PROM	Programmable Read Only Memory
PRR	Propellant Refillable Reservoir
PS	Pass Schedule
PSA	Planetary Science Archive
PSF	Point Spread Function
PSK	Phase Shift Key
PSM	Payload Support Module
PSR	Project Support Room
PSR	Processor Status Registers
PSR	Project Status Review
PSRI	Planetary Science Research Institute
PSS	Portable Satellite Simulator
PSS	Procedures, Specifications and Standards
PSS	Programme System Standards
PSU	Power Supply Unit
PT	Product Tree
PTC	Parameter Type Code
PTR	Pointing Requirement File
PTT	Post, Telegraph and Telephone authority
PTV	Pre-Transmission Validation
PUS	Packet Utilisation Standard
PVNC	Pyro Valve Normally Closed
PVNO	Pyro Valve Normally Opened
QA	Quality Assurance
QAE	Quality Assurance Engineer
QAM	Quality Assurance Management
QAPM	Quality Assurance Procedures Manual
QC	Quality Control
QPM	Quality Policy Manual
QTR	Qualification Test Review
R&D	Research & Development
R/T	Real Time (system)
RAF	Return All Frames
RAL	Rutherford Appleton Laboratory
RAM	Random Access Memory
RAMS	Reliability, Availability, Maintainability and Safety
RBW	Resolution Band Width
RC	Responsibility Code
RC	Remote Computer
RCCCS	Rosetta Common Checkout & Control System
RCS	Reaction Control Subsystem
RD	Reference Document

RDB	Rosetta Database
RDDD	Rosetta Database Definition Document
RDDS	Rosetta Data Disposition System
RDM	Raw Data Medium
RDVM	Rendezvous Maneuvre
RE	Radiation Emission
RF	Radio Frequency
RF S/S	Radio Frequency Subsystem (TT&C S/S)
RFC	Request For Change
RFC	Radio Frequency Self Compatibility
RFD	Request for Deviation
RFDU	Radio Frequency Distribution Unit
RFI	Radio Frequency Interface
RFMU	Radio Frequency Mock-Up
RFW	Request For Waiver
RH	Radiation Hardened
RID	Review Item Discrepancy / Disposition
RIS	Remote Imaging System
RISC	Reduced Instruction Set Computer
RL	Register Load
RLA	Register Load Address
RLG	Ring Laser Gyro
RLGS	Rosetta Lander Ground Segment
RM	Reconfiguration Module
RMCS	Rosetta Mission Control System
RMOC	Rosetta Mission Operations Centre
RNCTRS	Rosetta Network Control & Telemetry Receiver System
ROIRD	ROSETTA Operations Interface Requirements Document
ROKSY	Rosetta Knowledgement System
ROLIS	LANDER PAYLOAD INSTRUMENT
ROM	Read Only Memory
ROMAP	Rosetta Magnetic Field and Plasma experiment (Lander Payload)
ROSINA	Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (Orbiter Payload)
ROSIS	ROSETTA Spacecraft Interface Simulator
RP	Rundown Phase
RPC	Rosetta Plasma Consortium (Orbiter Payload)
RPE	Relative Pointing Error
RPM	Remote Processing Module
RRP	Rate Reduction Phase
RPRO	ROSETTA Common Packetized Protocol
RSDB	ROSETTA System Database
RS	Radiated Susceptibility
RSI	Radio Science Investigation (Orbiter Payload)
RSOC	Rosetta Science Operations Centre
RSS	Root Sum Square
RT	Real Time
RT	Remote Terminal

RTC	Real Time Clock
RTM	Reduced Thermal Model
RTMM	Reduced Thermal Mathematical Model
RTOF	Reflectron Time Of Flight
RTU	Remote Terminal Unit
RWA	Reaction Wheel Assembly
RWL	Reaction Wheel
RX	Receiver
S/A	Solar Array
S/C	Spacecraft
S/HM	Safe / Hold Mode
S/S	Subsystem
S/W	Software
SA	Solar Array
SAA	Solar Aspect Angle
SADM	Solar Array Drive Mechanism
SAM Sun	Sun Aquisition Mode
SAP	Sun Aquisition Phase
SAP	Science Activity Plan
SAS	Sun Aquisition Sensor
SASW	Standard Application Software
SBDL	Standard Balanced Digital Link
SCET	Spacecraft Elapsed Time
SCL	Spacecraft Control Language
SCOE	Spacecraft Check Out Equipment
SCP	Sun Capture Phase
SDB	Satellite (Spacecraft) Data Base
SDD	System Design Document
SDE	Software Development Environment
SDID	Station Data Interchange Document
SDR	System Design Review
SE	System Engineer
SECDED	(16,22) Hamming Single bit for Error Correcting code
SEL	Single Event Latch-up
SEPAC	Space Experiment with Particule Accelerator
SESAME	LANDER PAYLOAD INSTRUMENT
SEU	Single Event Upset
SF	Safety Factor
SFDU	Standard Formatted Data Unit
SFT	System Functional Test
SGICD	Space Ground Interface Control Document
SGM	Safeguard Memory
SI	Silicon
SID	Structure Identifier
SIM	Simulator
SIMSAT	Software Infrastructure for Modelling SATellites
SIR	Simulation Room
SIS	Spacecraft Information System
SIS	Spacecraft Interface Simulator

SIV	Software Independent Validation
SKM	Sun Keeping Mode
SLE	Space Link Extension
SLI	Space wire Link I/F
SM	Structural Model
SMCS	Scalable Multi-Channel Communication Subsystem
SMD	Surface Mounted Device
SNR	Signal to Noise Ratio
SOC	Science Operations Centre
SOHO	Solar & Heliospheric Observatory
SOM	Spacecraft Operations Manager
SOR	Spacecraft Operation Request
SOT	Science Operations Team
SOW	Statement of Work
SOWG	Science operating working group
SPACON	Spacecraft Controller
SPB	Superpixel Binning
SPC	Science Programme Committee
SPD	Space Division
SPG	Single Point Ground
SPL	Scenario Parameter List
SPEVAL	Spacecraft Performance Evaluation System
SpM	Sin-up Mode
SPP	Sun Point Phase
SPR	Software Problem Report
SPT	Specific Performance Test
SPWR	Secondary Power
SQA	Terma Space Division Quality Assurance
SR	Software Requirements
SRD	Software Requirements Document
SREM	Standard Radiation Environment Model
SRR	Subsystems Requirements Review
SSC	Status Consistency Checking
SSD	Space Science Department
SSMM	Solid State Mass Memory
SSP	Surface Science Package
SSPA	Solid State Power Amplifier
SSR	Solid State Recorder
STC	Station Computer
STIL	Irish Space Technology Institute
STM	Structural Thermal Model
STN	Standard
STO	Soyuz Transfer Orbit
STP	System Temperature Point
STR	Star Tracker
STSP	Solar Terrestrial Science Programme
SUM	Software User Manual
SuM	Survival Mode
SVF	Software Validation Facility

SVM	Service Module
SVT	System Validation Test
SW	Software
SWG	Science Working Group
SWR	Standing Wave Ratio
SWRI	South West Research Institute
SWT	Science Working Team
TBC	To be confirmed
TBD	To Be Defined
TBI	To be Inserted
TBP	Time Broadcast Pulse
TBR	To be resolved
TBS	To be supplied
TBW	To be written
TC	Telecommand
TCDL	Test Configuration Data List
TCDP	Tele Command Detail Parameter
TCGP	Tele Command Global Parameter
TCM	Trajectory Correction Manoeuvre
TCP-IP	Transport Protocol-Internet Protocol
TCS	Test Control System
TCS	Thermal Control Subsystem
TCSL	Test Configuration Status List
TC S/S	Thermal Control Subsystem
TD	Time Domain
TER	Terma Elektronic A.S.
TF	Transfer Function
TFG	Transfer Frame Generator
THA	Transport Handling Adapter
TID	Task Identifier
TIDE	Thermal Ion Dynamics Explorer
TLC	Telecommand
TLM	Telemetry
TM	Telemetry
TMM	Thermal Mathematical Model
TMP	Telemetry Processing System (within ground station)
TOP	Transfer Orbit Phase
TR	Tone Ranging
TRB	Test Review Board
TRP	Test Report
TRP	Temperature Reference Point
TRR	Test Readiness Review
TRRB	Test Readiness Review Board
TSE	Test Support Equipment
TSP	Test Specification
TSY	Timer Synchronisation Pulse
TT&C	Tracking, Telemetry & Commanding
TT&C S/S	Telemetry, Telecommand and Communication Subsystem (RF S/S)

TTC	Tracking, Telemetry & Commanding
TUB	Technical University of Budapest
TUB	Technical University Braunschweig
TUBS	Technical University Braunschweig
TV	Thermal Vacuum
TWTA	Travellling Wave Tube Assembly
TWTL	Two Way Travelling Lighttime
TX	Transmitter
UARS	Upper Atmospheric Research satellite
UD	User Defined
UM	User Manual
UMOS	Ultimate Margin Of Safety
UFT	Unit Functional Test
U/L	Up Link
UPM	Universidad Politecnica de Madrid
URD	User Requirements Document
URF	Unit Reference Frame
USO	Ultra Stable Oscillator
UTC	Universal Time Coordinated
UTC	Universal Time Code
UV	Ultra Violet
UVD	Under Voltage Detector
UVSC	Ultra Violet Spectrometer Component
V&V	Verification & Validation
VC	Virtual Channel
VCA	Virtual Channel Assembler
VCM	Virtual Channel Multiplexer
VDC	Voltage Direct Current
VDU	Video Display Unit
VHDL	VHSIC Hardware Description Language
VHF	Very High Frequency
VHSIC	Very High Speed Integrated Circuit
VIS	Vertical Integration Stand
VIMS	Visual Infrared Mapping Spectrometer
VIRTIS	ORBITER PAYLOAD INSTRUMENT
VIS	Visual
VSWR	Voltage Standing Wave Ratio
VT	Validation Test
VTP	Validation Test Plan
VTR	Validation Test Report
W/S	Work Station
WAC	Wide Angle Camera
WAOSS	Wide Angle Optoelectric Stereo Scanner
WBS	Work Breakdown Structure
WBS	Workpackage Breakdown Structure
WCA	Worst Case Analysis
WD	Watch Dog
WDE	Wheel Drive Electronics
WDW	Window

WIU	Wave Guide Interface Unit
WP	Work Package
WPD	Work Package Description
WRT	With Respect To
WTC	Wavelet Transform Coding
WVR	Water Vapor Radiometer
WWW	World Wide Web
YMOS	Yield Margin Of Safety
ZOM	Zero Order Monitor

Documentation Change Record

Issue	Rev.	Sect.	Date	Changes	ECR No.
Draft	0.93	All	16.11.00	First draft issue	N/A
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Draft	0.97	All	06.07.01		N/A
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2	09		10.05.07	Action on dEFOR Comments	N/A
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2	18		6.10.11	Final Version after review acc. to RO-EST-LI-3383	N/A

1 General Description

1.1 Scientific Objectives

The Rosetta Orbiter Plasma Consortium (RPC) will consist of five sensors:

- Langmuir Probe (LAP)
- Ion and Electron Sensor (IES)
- Ion Composition Analyser (ICA)
- Fluxgate Magnetometer (MAG)
- Mutual Impedance Prob (MIP),

as well as a joint

- Plasma Interface Unit (PIU)

acting as instrument control, spacecraft interface, and power management unit.

The scientific objectives are far reaching and related to the overall scientific aims of the ROSETTA mission. It is intended to investigate the following scientific areas of interest:

- The physical properties of the cometary nucleus and its surface
  Special emphasis will be paid to determine the electrical properties of the crust, its remnant magnetization, surface charging and surface modification due to solar wind interaction, and early detection of cometary activity.

- The inner coma structure, dynamics, and aeronomy

  Charged particle observation as planned will allow a detailed examination of the aeronomic processes in the coupled dust-neutral gas-plasma environment of the inner coma, its thermodynamics, and structure such as the inner shocks.

- The development of cometary activity, and the micro- and macroscopic structure of the solar-wind interaction region as well as the formation and development of the cometary tail.

- The study of the cometary Ionopause
  The ionopause is one of the major boundaries and comet-solar wind interaction regions. It was theoretically predicted and first and only observed by the Giotto s/c at comet Halley. The structure and dynamics as well as the formation of the ionpause is largely unknown and therefore a major a science objective for RPC.

- The study of the plasma / gas composition & interaction
  Cometary dust, evolving from the cometary surface, gets partially be charged by UV-and collision processes. The charged dust particles interact with the plasma environment. Due to low m/q ratio its behavor differs from ionized gas. The interaction is one of the most fundamental process during the solar system and planet formation.

- Asteroid – Solar wind interaction
  The planned asteroid flybys of the ROSETTA spacecraft will provide an excellent opportunity to study in detail the physics of the solar wind - asteroid interaction. The proposed payload is also most suitable to investigate this interaction. Furthermore, the planned observations will allow us to study the magnetic and electric conductivity properties of the asteroid.

1.2 Experiment Overview

Our RPC plasma consortium consists of five different sensors and a common plasma interface unit (PIU) as a single interface between the package and the spacecraft. Such a highly integrated package saves spacecraft resources such as mass and power. Great care has been taken to provide robust sensors of proven technology that will operate and survive in a cometary environment. The sensors used bear heritage from many different space missions such as GEOS 2, ARCAD 3, Voyager, Giotto, CLUSTER, Viking, Freja, MARS-96, and Cassini.

1.2.1 Instrument Overview and Accomodation

Sensor etc.	Mnemonic	Responsible Group
LAngmuir Probe	LAP	IRF-U, Uppsala
Ion and Electron Sensor	IES	SwRI, San Antonio
Ion Composition Analyser	ICA	IRF-K, Kiruna
Fluxgate MAGnetometer	MAG	IGEP, TU Braunschweig
Mutual Impedance Probe	MIP	LPCE, Orleans
Plasma Interface Unit	PIU	ICSTM, London
Electrical Ground Support Equipment	EGSE	ICSTM, London

Table 1.2-1: RPC Instruments

The accommodation of the sensors and interfaces are indicated in Figure 1.2-2 and Figure 1.2-3.

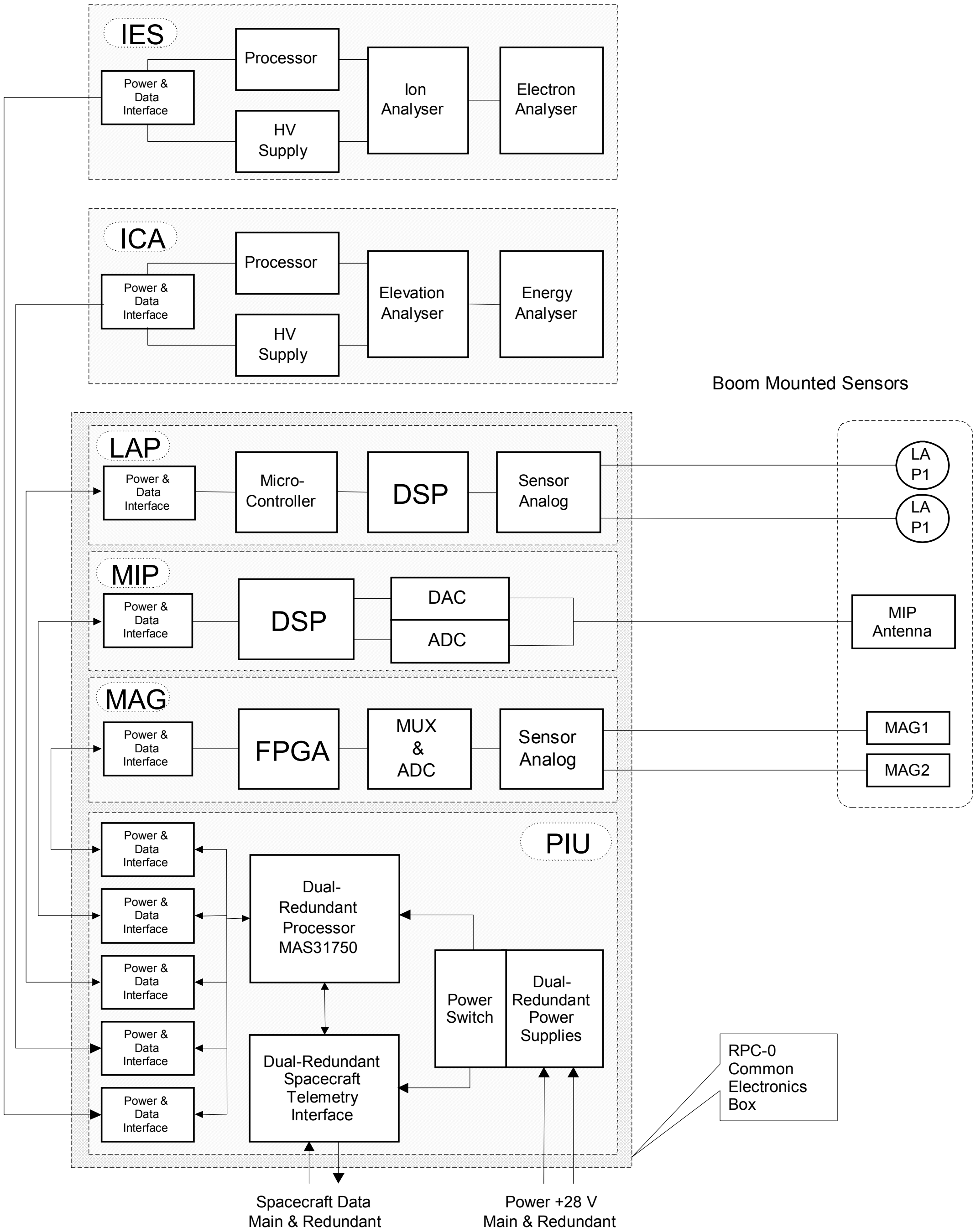


Figure 1.2-1: RPC Overall Block Diagram

LAP	two sensors, each mounted at the tip of about 1.5m long booms, separated > 1m in the direction towards the nucleus
IES	body mounted at the nucleus facing edge of the instrument platform
ICA	body mounted at the nucleus facing edge of the instrument platform
MAG	two sensors mounted at a distance of about 1.4 m and 1.55 m from the s/c and close to the tip of the MAG/LAP-boom. The boom points roughly in negative x-direction, hence pointing away from nucleus.
MIP	boom mounted: the four electrodes that make up the sensor are mounted at a minimal distance of 1m from the spacecraft structure, sensor pointing towards the comet direction (within 45º).
PIU	The PIU is contained within the RPC common electronic box, which also houses the MAG, MIP and LAP electronics

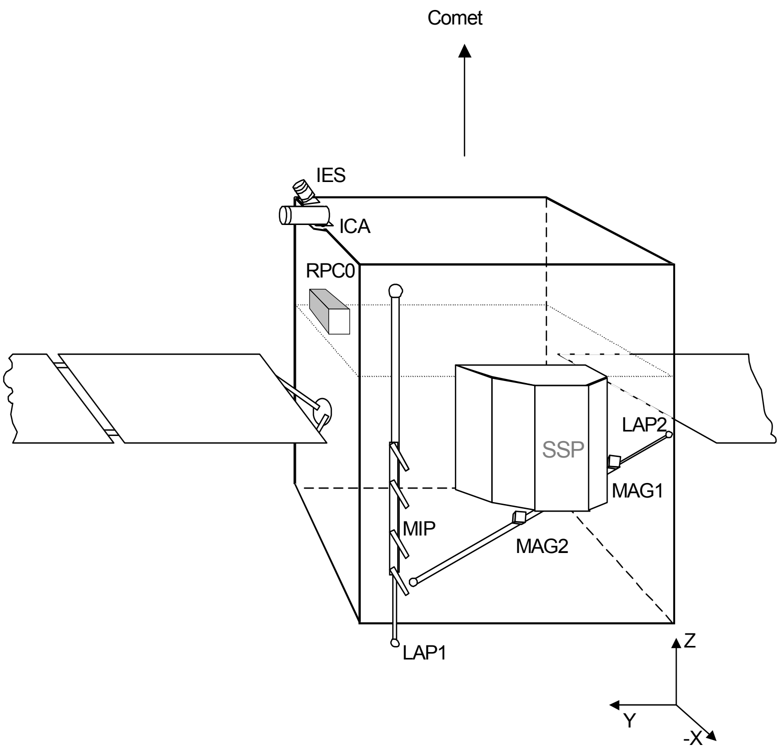


Figure 1.2-2: RPC Sensors Layout (stowed)

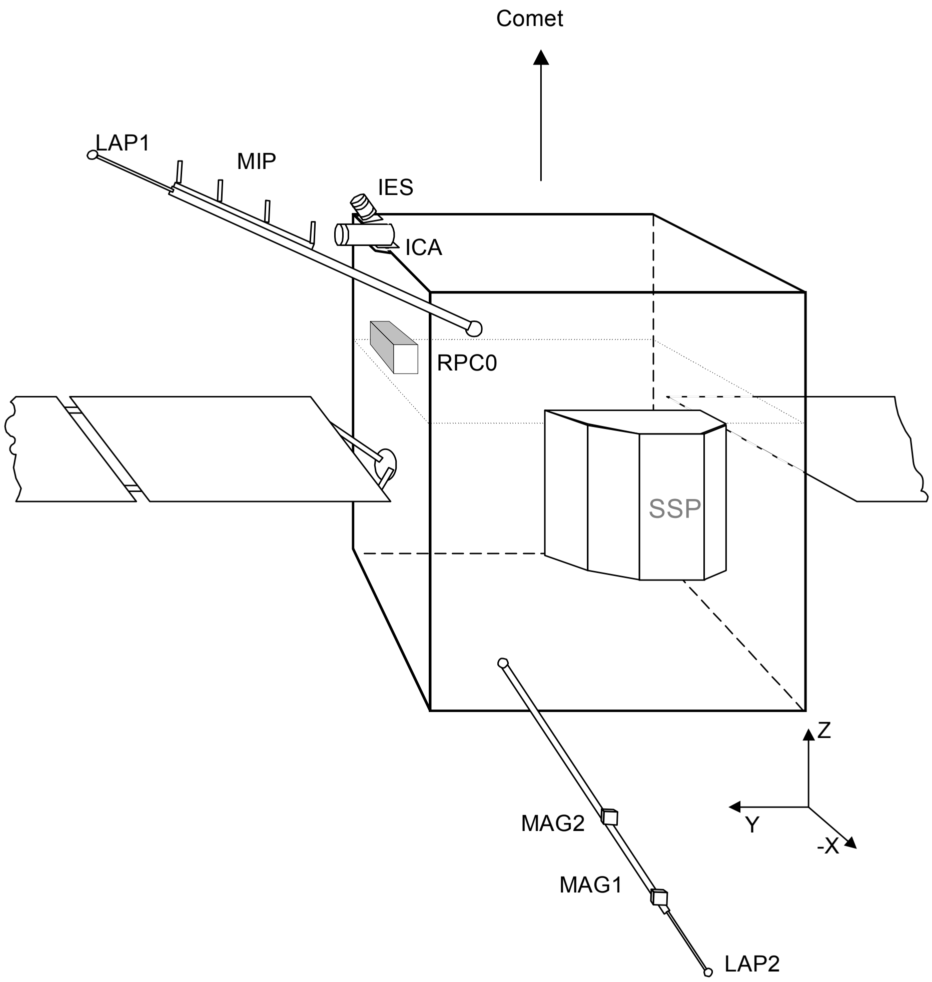


Figure 1.2-3: RPC Sensors Layout (deployed)

Units RPC-3.0, RPC-4.0 RPC-5.0 and RPC-6.0 are stacked in a single assembly referred to as RPC-0.

Experiment Unit	Experiment Name	Item Name	Process ID	Service Type Range
RPC-0		Common electronics box		
RPC-3.0		LAP control electronics		
RPC-4.0		MIP control electronics		
RPC-5.0		MAG control electronics		
RPC-6.0		PIU		
RPC-1	IES		84	210-219
RPC-1.1		IES sensor assembly		
RPC-2	ICA		85	220-229
RPC-2.1		ICA sensor assembly		
RPC-3	LAP		86	230-239
RPC-3.0		LAP control electronics		
RPC-3.1		LAP sensor 1		
RPC-3.2		LAP sensor 2		
RPC-3.3		LAP sensor support 1		
RPC-3.4		LAP sensor support 2		
RPC-4	MIP		87	240-249
RPC-4.0		MIP control electronics		
RPC-4.1		MIP sensor assembly		
RPC-5	MAG		88	250-255
RPC-5.0		MAG control electronics		
RPC-5.1		MAG OB sensor		
RPC-5.2		MAG IB sensor		
RPC-6	PIU		83	200-209
RPC-6.0		PIU		

Table 1.2-2: Experiment Assignment

1.2.2 Sensor Descriptions

1.2.2.1 Langmuir Probe (LAP)

The LAP sensors are two spherical Langmuir probes, one probe at the tip of each of the two solid booms. The probes are identified as RPC-3.1 and RPC-3.2 though the abbreviations P1 and P2 are often used. The probes can be independently operated in any of to bias modes:

A *bias voltage* can be applied to the probe. In this case the asic measured quantity is the current flowing from the probe to the plasma.
A *bias* current (including zero, corresponding to floating probes) can be applied to the probe. In this case, the basic quantity measured is the voltage of the probe with respect to the spacecraft.

Probe P2 may also be used by the MIP instrument for use in the LDL (Long Debye Length) mode. In general, voltage bias is to be used for determining the prime LAP science parameters of the plasma density, electron temperature, plasma flow speed, and the density fluctuation spectrum, while the bias current is applied to get measurements of spacecraft potential and electric (wave) fields. The bias can either be constant or ”swept”, i.e. varied in steps over some range of voltage or current. LAP also has the possibility to apply a square-wave voltage of up to a few kHz to one probe and observe the resulting signal on the other probe.
A variety of different measurements can be produced by this arrangement, producing different data types. The basic data types are listed above. However, it should be noted that the LAP flight s/w is very flexible, and functions can be defined for construction of other data types not listed here.

Time series data.
With the probes at constant bias, the time series, at some constant sampling frequency, from both or any of the probes, or derived time series like their sum or their average, can be transmitted.
Probe bias sweeps.
The bias voltage (or current) can be varied during a, brief interval, known as a sweep. While the samples acquired still constitute a time series, the basic assumption is that the plasma does not vary during the short sweep, and the sweep is treated as a set of instantaneous and simultaneous samples acquired at different bias.
Spectral data.
The LAP onboard software can also calculate frequency spectra from the time series data.

Within the fundamental restrictions of low power and mass figures, LAP must be able to perform among others the following tasks:

- Perform plasma diagnostics by Langmuir probe sweeps for a wide range of plasma parameters. This implies the possibility to vary the probe bias voltage, with the number, size and duration of the sweep steps optimised for the expected plasma parameters.

- Determine plasma flow velocities up to 10 km/s by a dual-probe time-of-flight technique. As the LAP probe separation is 5 m, this leads to the possibility to observe time shifts down to 0.5 ms, which is allowed by the 18.75 kHz sampling frequency of the LAP probes.
- Estimate electrical fields and spacecraft potentials as well as plasma density variations. This is implemented by the implementation of a fixed-bias-current mode in addition to the fixed-bias-voltage mode.
- Observe plasma wave fields at least up to the 7 kHz lower limit of RPC-MIP. This is possible by the inclusion of analog filters cutting at 8 kHz and fast sampling of two of the four ADCs at 18.75 kHz.
- Implement an active mode for investigation of the propagation of low frequency (up to a few kHz) waves. This implies the possibility to transmit a signal, with an adjustable frequency, amplitude and duration, from one probe and receive it at the other probe, with the possibility to interchange the Tx/Rx roles of the probes.
- Allow one of the probes to be used as a receiving antenna for the MIP instrument in its long-Debye length mode.
- Observe the electrostatic signature of dust impacts. This is possible using the 18.75 kHz sampling.

In addition to these fundamental capabilities, LAP also implements a limited propagation experiment, where square waves can be generated on any of the two probes and observed on the other, and also has the capability to observe the electrostatic signature of dust impacts using the 18.75 kHz sampling.

The functionality and general design of the LAP electronics are illustrated by the block diagrams in Figure 1.2-4, Figure 1.2-5 and Figure 1.2-6. Figure 1.2-4 shows the input stage to one of the two probes: the other one is similar. With switches in the position shown, the instrument is configured for current bias (E-field mode). Figure 1.2-5 shows the bias circuitry concept, and Figure 1.2-6 the digital electronics. More on the LAP design can be found in the published instrument description RD-LAP-6.
From the list above and the block diagrams, it should be clear that LAP is characterized by a large number of different operational modes. When comparing the very limited science telemetry rates available (1.6 bit/s, 62.5 bit/s or 2253 bit/s) to the data generated inside LAP (18.75 ksamples/s from two probes with 16 bit samples implies 600 kbit/s), it is obvious that another characteristic of LAP is the need for onboard data processing. This is achieved by digital filtering and sample selection mechanisms, controlled by the LAP macros. The flight software also includes provisions for onboard spectral calculations, though this is not implemented in present science modes. A summary of the expected LAP performance is given in Table 1.2-3.

Quantity	Range
Electron/ ion number density	1 – 10^6 cm^{-3}
Electron temperature	~10 meV – 10 eV
Plasma flow velocity	up to 10 km/s
Electron/ion number density fluctuations	0.05 - 50 %
Spacecraft potential	±30 V
Plasma Waves	0 – 8 kHz
Solar UV integrated ionizing flux (if $n_e < 3 \times 10^3 cm^{-3}$)	
Dust impacts (if d > 1mm, v > hundreds m/s)	

Table 1.2-3: Summary of expected LAP performance

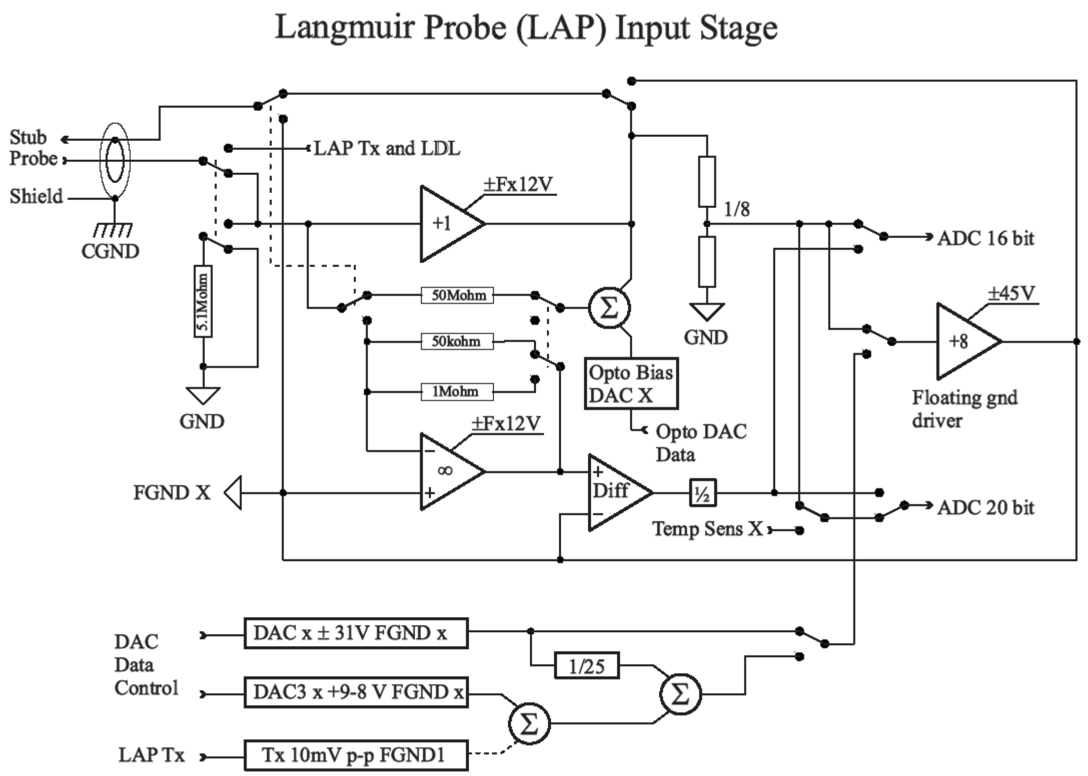


Figure 1.2-4 LAP diagram for the input stage of one of the two probes.

LAP Transmitter, Floating power supply and DAC converters

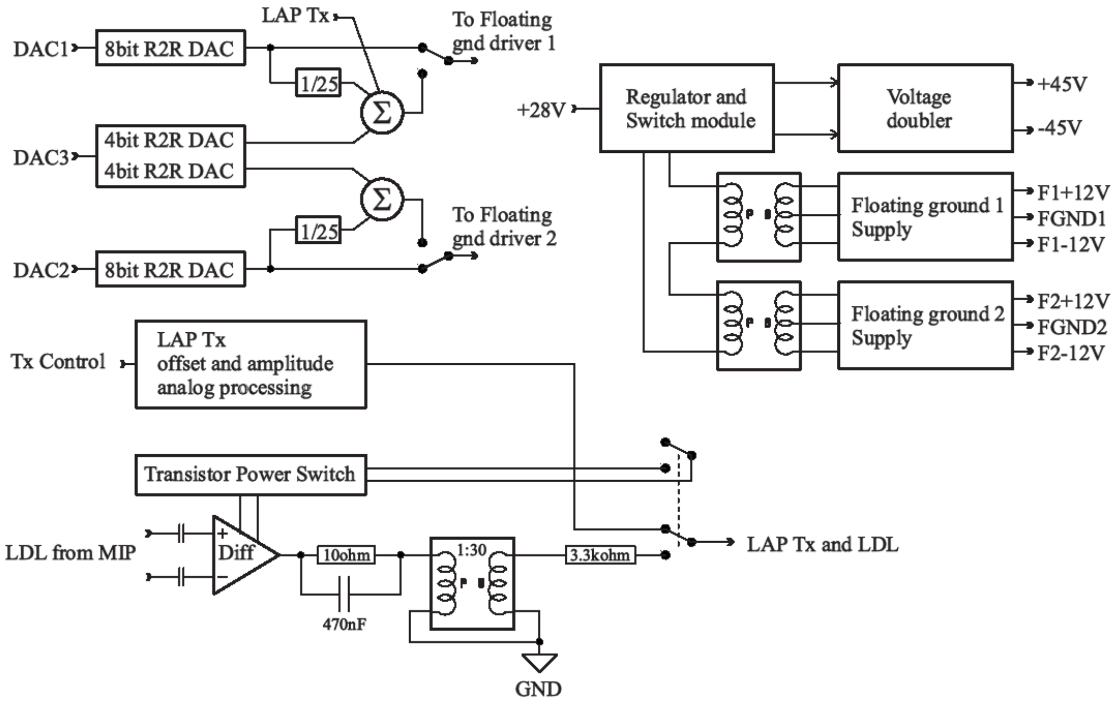


Figure 1.2-5 Langmuir probe (LAP) block diagram for the bias circuitry.

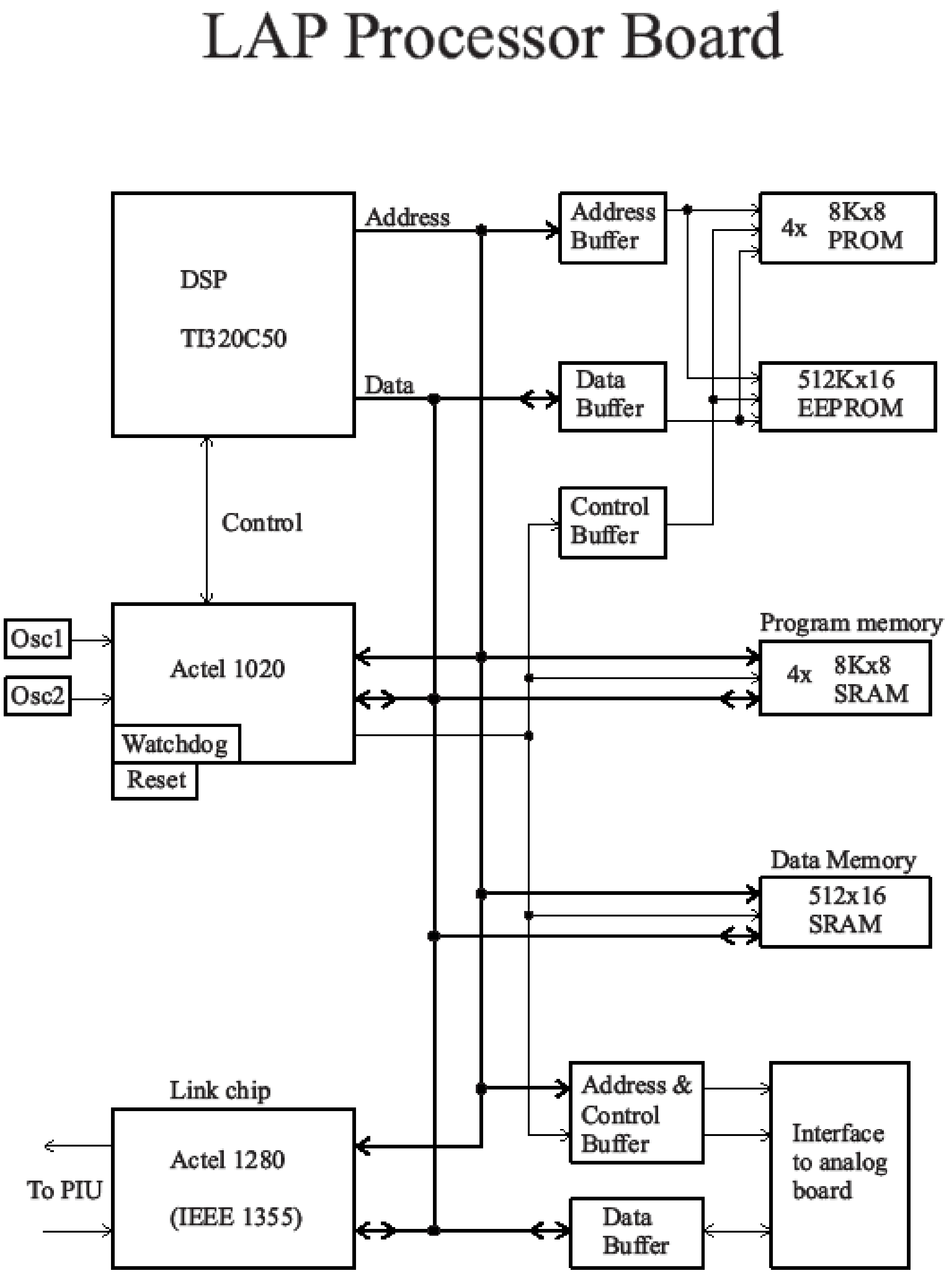


Figure 1.2-6: Langmuir Probe (LAP) Block Diagram for the digital electronics

1.2.2.2 Ion and Electron Sensor (IES)

The IES for ROSETTA is an electrostatic analyzer (ESA), featuring electrostatic angular deflection to obtain a field of view of 90º x 360º. The instrument objective is to obtain ion and electron distribution functions over the energy range extending from 4 eV/e up to17.7 keV/e, with a basic 3D time resolution of 1s. The angular resolution for electrons is 6º x 22.5º (16 elevation and 16 azimuthal sectors). For ions the angular resolution is 6º x 45º (16 elevation and 8 polar-angle sectors) with additional segmentation to nine 5º sectors in the 45º azimuthal sector most likely to contain the solar wind (giving a total of 16 azimuthal sectors for ions). A complete sweep of elevation angles and energies requires a minimum of 128 s. Table 1.2-4 lists the complete set of IES performance parameters and its resource requirements. The back-to-back top hat geometry of the IES electrostatic analyzer allows it to analyze both electrons and positive ions with a single entrance aperture. The IES top hat analyzers have toroidal geometry with a smaller radius of curvature in the deflection plane than in the orthogonal plane. This toroidal feature results in a flat deflection plate geometry at the poles of the analyzers and has the advantage that the focal point is located outside the analyzers rather than within them, as is the case with spherical top hat analyzers. In addition, the IES entrance aperture contains electrostatic deflection electrodes, which expand its elevation angle field of view to ±45º. With the typical top hat azimuthal field of view of 360º, the IES acquires a total solid angle of 2.8 π steradians.
Ions and electrons approaching the IES first encounter a toroidal-shaped grounded grid encircling the instrument. Once inside the grid the electric field produced by bipolar electrodes deflects ions and electrons with a range of energies and elevation angles into a field-free entrance aperture containing serrated walls to minimize scattering of ultraviolet light and charged particles into the instrument. The particles then enter the top hat region and the electric field produced by the flat electrostatic analyzer segments of the ion and electron analyzers. Particles within a narrow 4% energy pass band will pass through the analyzers and be focused onto the electron and ion MCPs, which produce charge pulses on 16 discrete anodes, which define the azimuthal acceptance angles. The selected energy will correspond to the voltages on the ESAs.
Pulses from the segmented MCPs are amplified by charge-sensitive preamplifiers (CSPs) and recorded in the 16 x 24 bit ion and electron counters. The data are buffered before being sent to the output serial register for transmission to the PIU as serial telemetry packets. The stepping sequences of the angle and energy deflection voltages of the instrument are determined by the modes of operation.
The IES instrument will contain a single micro-controller (RTX2010) as shown in. This micro-controller shall communicate with the PIU over the IEEE 1355 bus, transmit the collected science data, and monitor the instrument status. The flight software is written in the C and Forth programming languages.
The PIU shall store and re-transmit the data stream that the instrument produces. Other than data compression, no special data handling is required. The PIU shall store time-tagged commands so that a sequence of commands

can be performed between the times that ground stations are in direct contact with the satellite.

Parameter		Value	
Energy:	Range Resolution Scan	4 eV to 17.7 keV 0.04 mode-dependent	
Angle:	Range (FOV)	90º x 360º	(2.8 π sr)
	Resolution (electrons)	6º x 22.5º	(16 elevation x 16 azimuthal)
	Resolution (ions)	6º x 45º (6º x 5º for ions in one sector)	(16 azimuthal x 16 polar)
Temporal resolution:			
	3D distribution	1 s	
	downlink data	128 s	
Geometric factor:			
	total (ions)	5 x 10^{-4} cm^2 sr eV/eV counts/electron	
	per 45º sector (ions)	5 x 10^{-5} cm^2 sr eV/eV counts/electron	
	total (electrons)	5 x 10^{-5} cm^2 sr eV/eV counts/electron	
	per sector (electrons)	5 x 10^{-6} cm^2 sr eV/eV counts/electron	

Table 1.2-4: Summary of expected IES performance

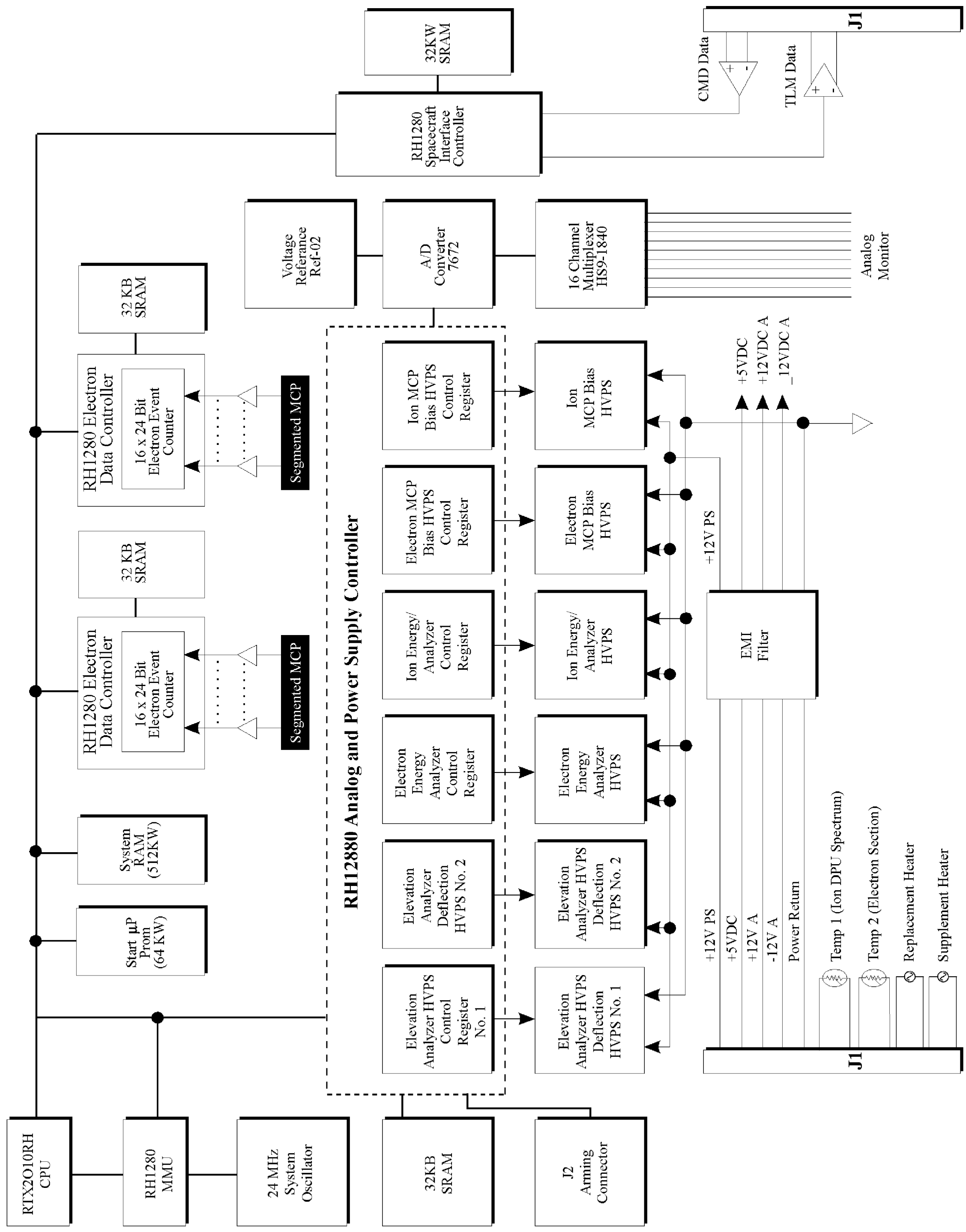


Figure 1.2-7: Ion and Electron Sensor (IES) Block Diagram

1.2.2.3 Ion Composition Analyser (ICA)

The ion composition analyser uses the same type of elevation analyser as the IES. Particles enter the analyser through an outer-grounded grid. Behind the grid is a deflection system whose purpose is to deflect particles coming from angles between 45º and 135º with respect to the vertical axis, into the electrostatic analyser. Ions within a swept energy pass band will pass the electrostatic analyser. The ions are then deflected in a cylindrical magnetic field set up by permanent magnets; the field deflects lighter ions more than heavier ions into the centre of the analyser. The ions finally hit an MCP and are detected by an anode system. Ions are analysed in both direction and mass per charge simultaneously. The magnet assembly can be biased with respect to the electrostatic analyser to post accelerate ions; this post acceleration enables a selection of both mass range and mass resolution.

Quantity		Range
Energy:	Range Resolution Scan	1 eV to 40 KeV ΔE/E = 0.07 Mode-dependent; normally 96
Angle:	Range (FOV); Resolution	90º x 360º (2.8 π sr) 5º x 22.5º (16 elevation steps x 16 sectors)
Temporal resolution:	2D distribution 3D distribution	4 s (solar wind mode) 12 s (normal mode) 64 s (solar wind mode) 192 s (normal mode)
Geometric factor:	per 22.5º sector per 360º sector	6×10^{-4} cm^2 sr 1×10^{-2} cm^2 sr

Table 1.2-5: Summary of expected ICA performance

The instrument contains the following high voltages:

- entrance deflection voltages for the upper and lower electrodes
- electrostatic analyser deflection voltage
- postacceleration voltage
- MCP bias voltage

The HV supplies is built providing MCP bias voltage and Main High voltage. Entrance deflection voltages for the upper and lower electrodes, electrostatic analyser deflection voltage, and post acceleration voltage is be obtained by the Main HVPS and HV optocouplers.

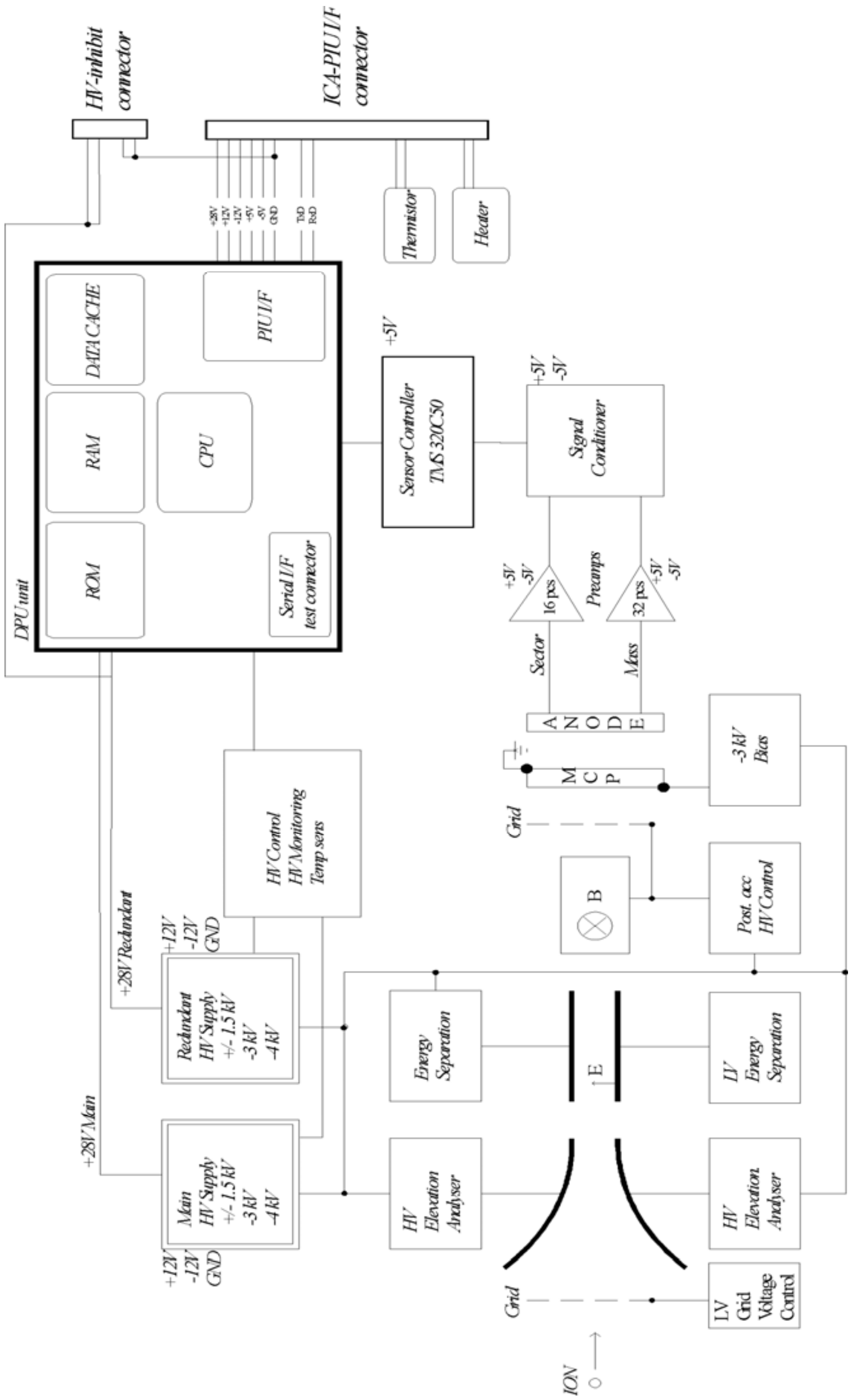


Figure 1.2-8: Ion Composition Analyser (ICA) Block Diagram

1.2.2.4 Fluxgate Magnetometer (MAG)

To measure the magnetic field a system of two ultra light triaxial fluxgate magnetometers (about 36 g each) is built, with the outboard (OB) sensor mounted close to the tip of the about 1.5 m long spacecraft boom pointing away from the comet nucleus and with the inboard (IB) sensor on the same boom about 15 cm closer to the spacecraft body. Two magnetometer sensors are required to minimise the influence of the rather complex spacecraft field on the actual measurements, and for redundancy purposes.
In order to meet the scientific requirements as discussed above the spacecraft magnetic DC-field requirement is about 25 nT at the outboard MAG sensor. To achieve this goal a magnetic cleanliness programme was necessary - conducted by the experimenter team, supported by the ROSETTA project.

To further eliminate spacecraft fields and zero-offsets the so called multi-magnetometer technique will be applied in conjunction with statistical in-flight techniques. To increase time resolution 6 A/D converters (one for each of the six sensor channels) will be used synchronously. The A/D converters have a resolution of 20 bits each. MAG will be operated with a high temporal resolution of about 20 vectors/sec outboard or inboard. The vector rate of transmitted vectors (burst mode, normal mode,…) will be adopted to the available data rate by vector averaging inside the PIU-DPU.

Quantity	**Range**
Range	+/- 16384 nT
Quantization steps	+/- 0.031 nT
Bandwidth	0-10 Hz
Time resolution OB/IB	20 vectors/sec

Table 1.2-6: Summary of expected MAG performances

For internal details of the MAG instrument refer to document RD-MAG-5.

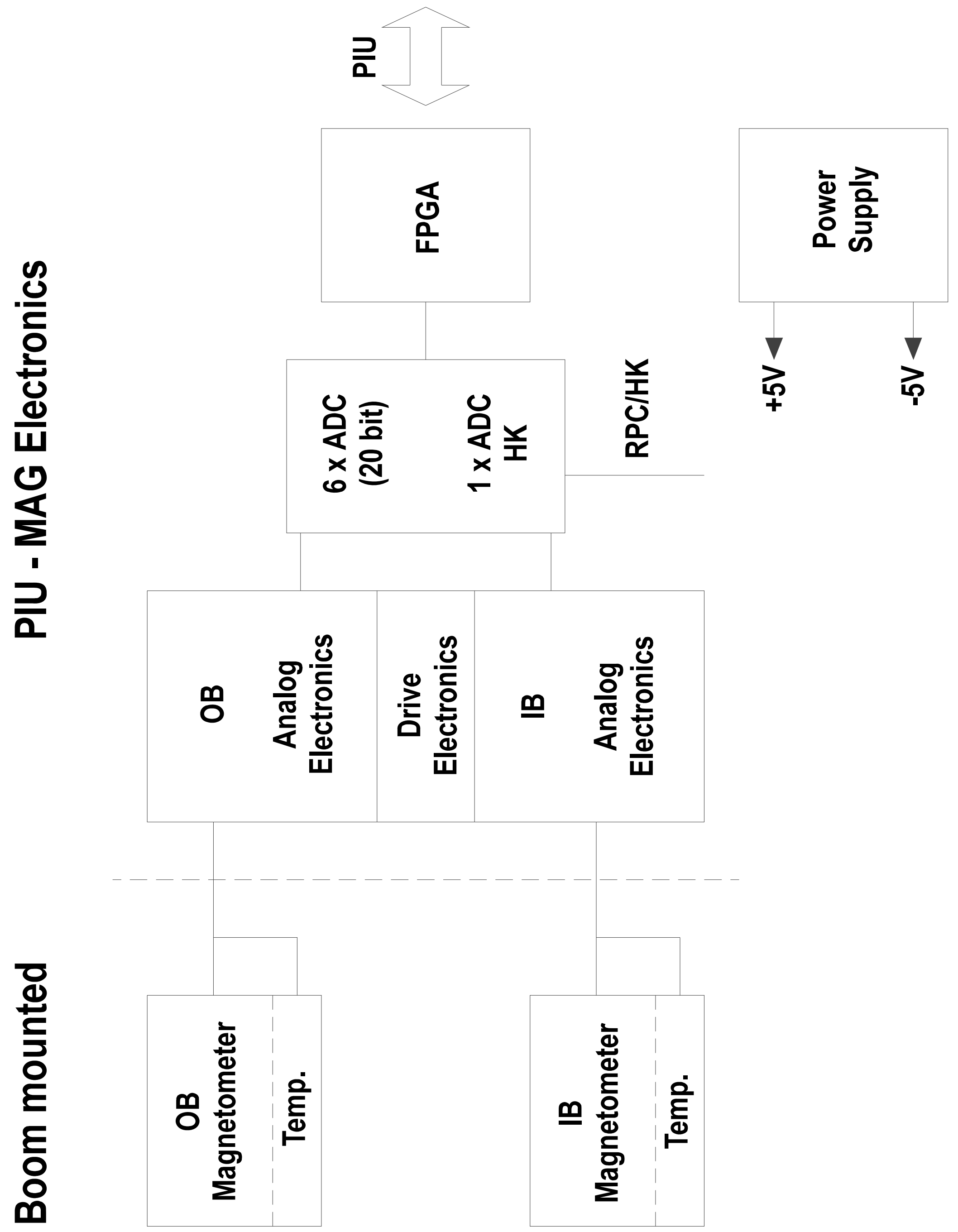


Figure 1.2-9: Fluxgate Magnetometer (MAG) Block Diagram

1.2.2.5 Mutual Impedance Probe (MIP)

The MIP sensor (ref. Figure 1.2-10) measures the electrical coupling of a transmitting antenna and a receiving antenna, and identifies the plasma density, temperature, and drift velocity from the features of the frequency response. No direct contact between the sensor and the plasma is required because the coupling is capacitive only. So, MIP performance is independent of the chemical composition and photoemissive properties of the probe. It is also immune to contamination by dust and ice deposits. Extremely low energetic plasmas can then be explored, an important advantage in a medium where temperatures as low as a few tens of Kelvin have been predicted.

In its passive mode, this instrument has also the capability of a plasma wave analyser. It is, therefore, proposed to detect the electric fields of electrostatic and electromagnetic waves associated with the interaction of the solar wind, with the charged dust, and ionized outgassing products of the nucleus, as well as the impulsive signals generated by individual dust particles impacting the spacecraft surface.

The characteristics of the MIP sensor are listed in Table 1.2-7.

Quantity	**Range**
Electron density	2 - 1.5 10^5 cm^{-3}; accuracy 5% 2 - 280 cm^{-3} for Long Debye Length Mode
Temperature	30 - 10^6 K; accuracy 10%
Drift velocity	100 – 1000 m/s; accuracy about 100 m/s
Frequency domain	7 kHz – 3.5 MHz
Wave – sensitivity - dynamic range	1.0 mV $m^{-1}Hz^{-1/2}$ at 100 kHz 60 dB
Debye length	0.5 - 20 cm 10 - 200 cm for Long Debye Length Mode
Time resolution	0.8 sec (burst mode, TBC) 10 sec (normal mode) 200 sec (survey mode)

Table 1.2-7: Summary of expected MIP performance

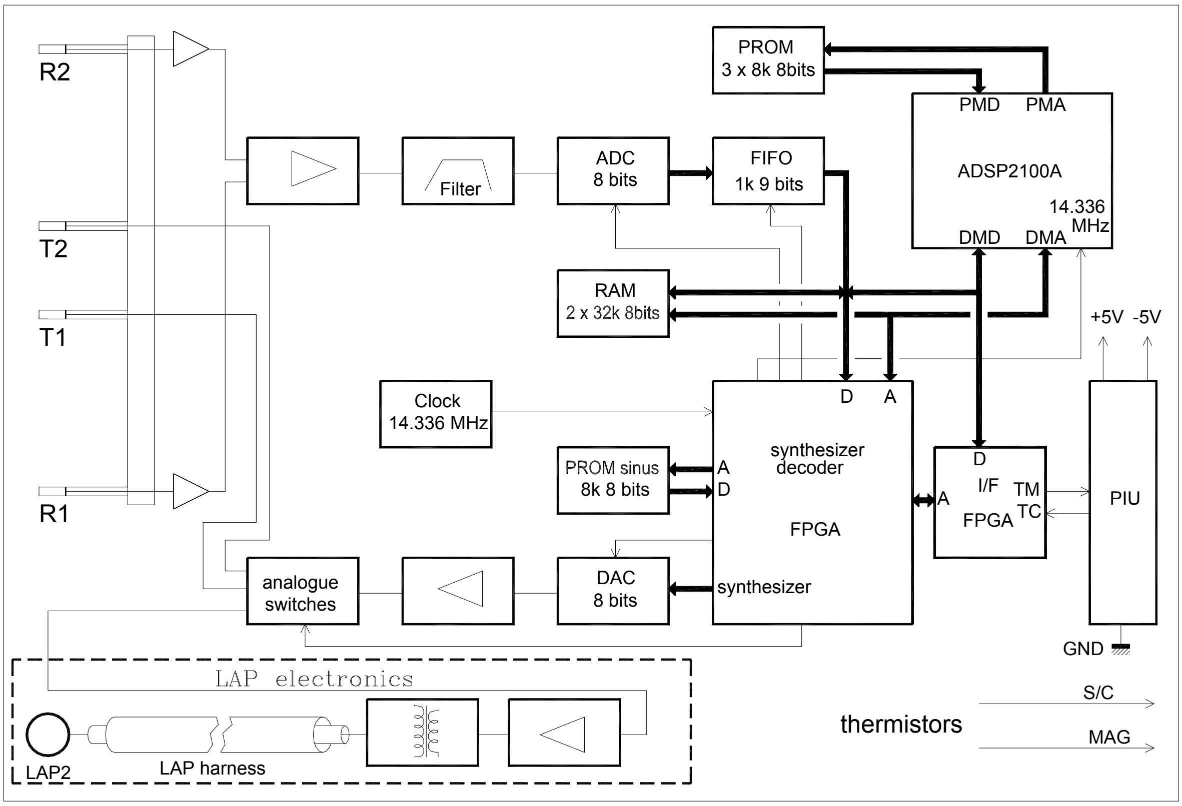


Figure 1.2-10: Mutual Impedance Probe (MIP) Block Diagram

1.2.2.6 The PIU and Common Electronics Box

The PIU is an interface and control unit that lies between the spacecraft and the five RPC sensors. The block diagram of RPC (Figure 1.2-1) shows the functional architecture of the package and indicates the role played by the PIU. The principal functions of PIU are as follows:

- Provision of power conversion from the s/c primary power system to the secondary voltages required by the sensor units.
- Provision of the power management system to switch, on ground command, the sensor units through power-switches which also provide over-current protection against failures in the sensor units.
- Control by command of the sensors' function; integration and packetisation of the data from the sensors.
- Provision of a data i/f to the s/c, which implements at least the minimum set of packet services required.
- On-board data processing for the MAG sensor unit, which has no processor incorporated in its own electronics.

No single point failure should disable PIU, and any single point failure should disable no more than one experiment unit (and should not affect the performance of any other). This requirement establishes that PIU must be designed to be tolerant of any single point failure, and should allow for graceful degradation in the event of multiple failures. The RPC is, therefore, provided with two independent connections to the spacecraft power, service signal, and data systems. These connections are managed by PIU to provide a single set of connections to each sub-experiment. The PIU provides, in a redundant configuration, data handling and power conversion. Each secondary voltage to each sub-experiment is individually switched and current limited.
A block diagram of the PIU (Figure 1.2-11) shows the dual-redundant processor and power supply configuration. The processor and interface units provide the data-handling interface between the spacecraft and the experiments, and also control the power switches which distribute power within RPC. The processor and DC/DC converter units are used in a 'cold redundant' fashion.
Embedded software operating in the PIU processor will handle the complex packet services and data management protocols required by the spacecraft. The PIU will also monitor the sub-experiments health and safety, and will take autonomous action in order to prevent damage from occurring.

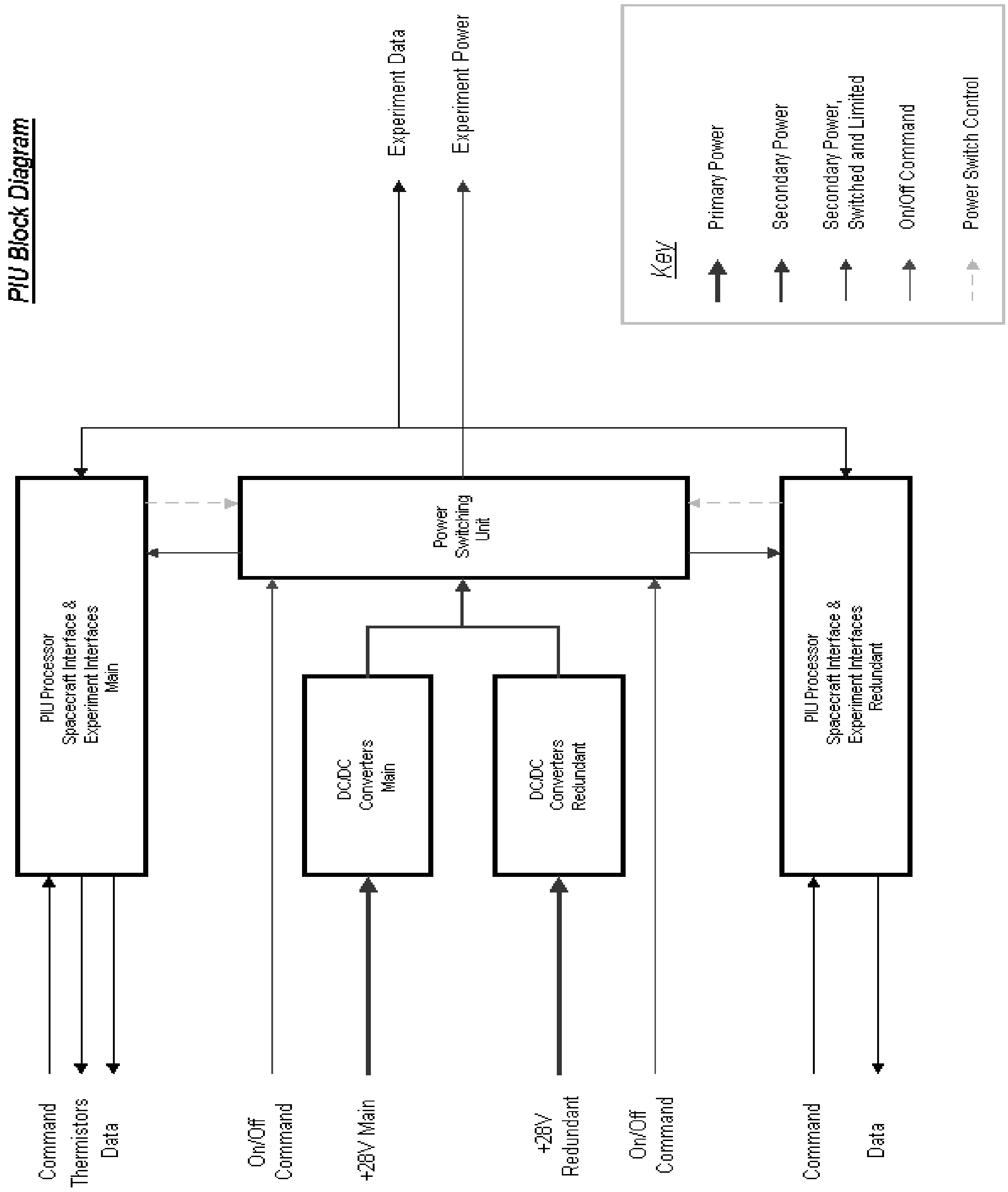


Figure 1.2-11: Plasma Interface Unit (PIU) Block Diagram

2 Experiment Configuration

2.1 Physical

The following diagram shows the layout of RPC and refers to Figure 1.2-1 and Figure 1.2-2 for the experiment accomodation on the satellite.

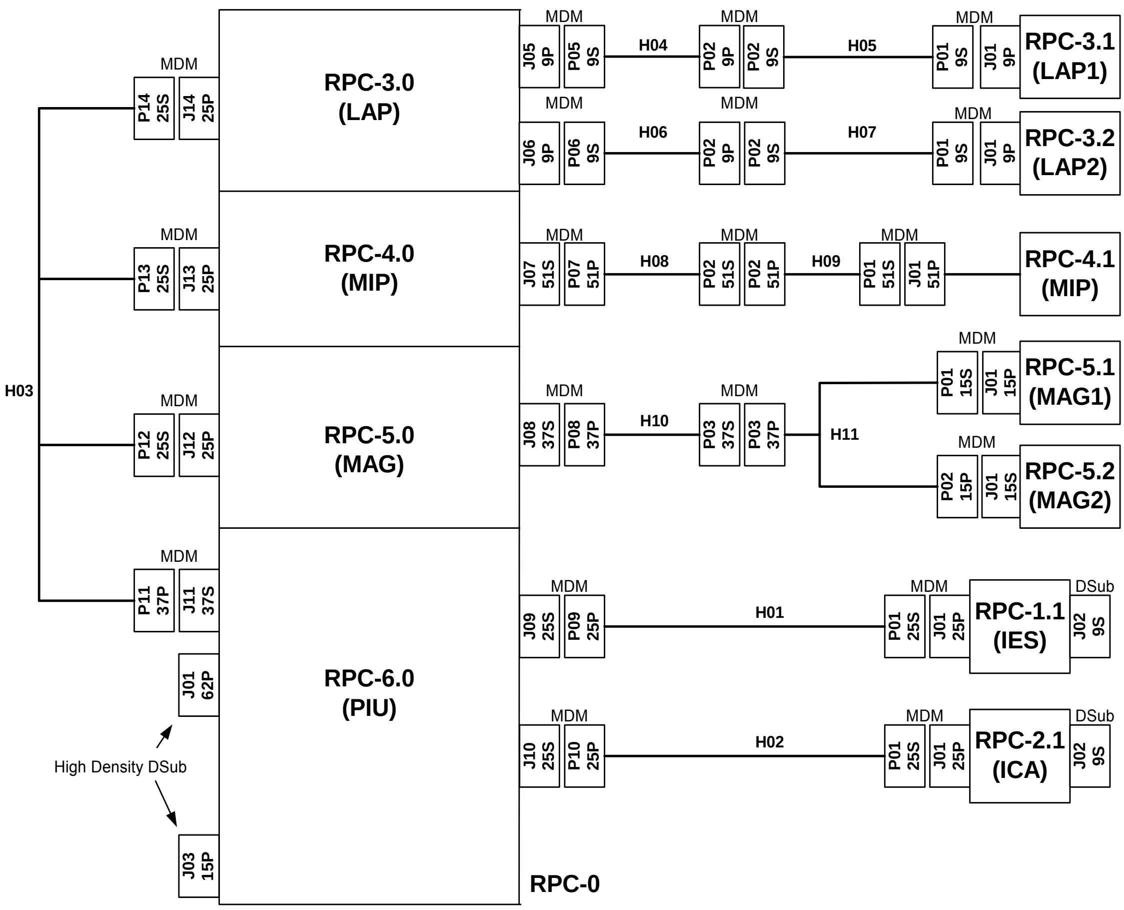


Figure 2.1-1: RPC Experiment Layout and Harness Diagram

2.1.1 RPC-0

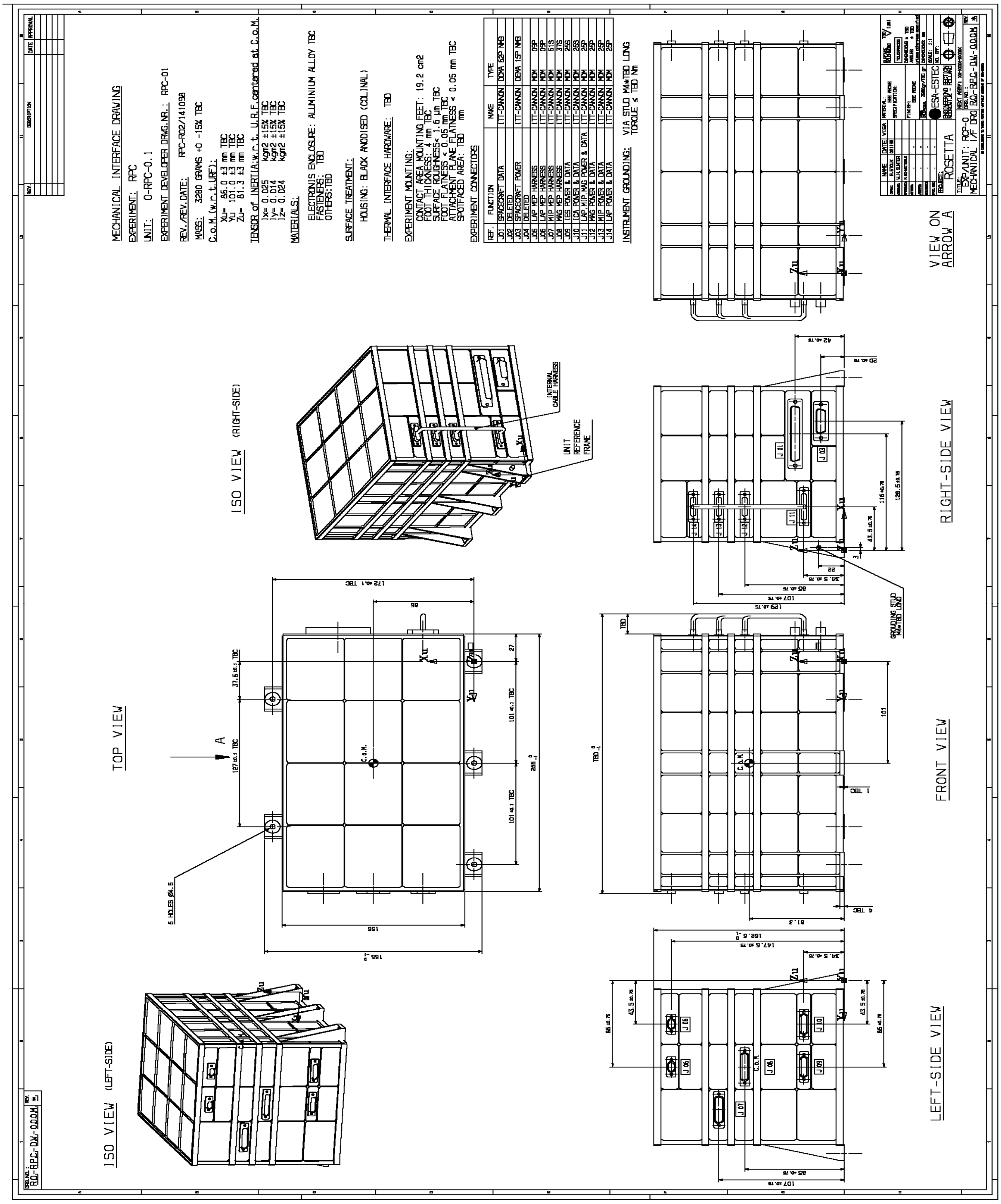


Figure 2.1-2: RPC-0 Mechanical Interface Drawing

2.1.2 IES

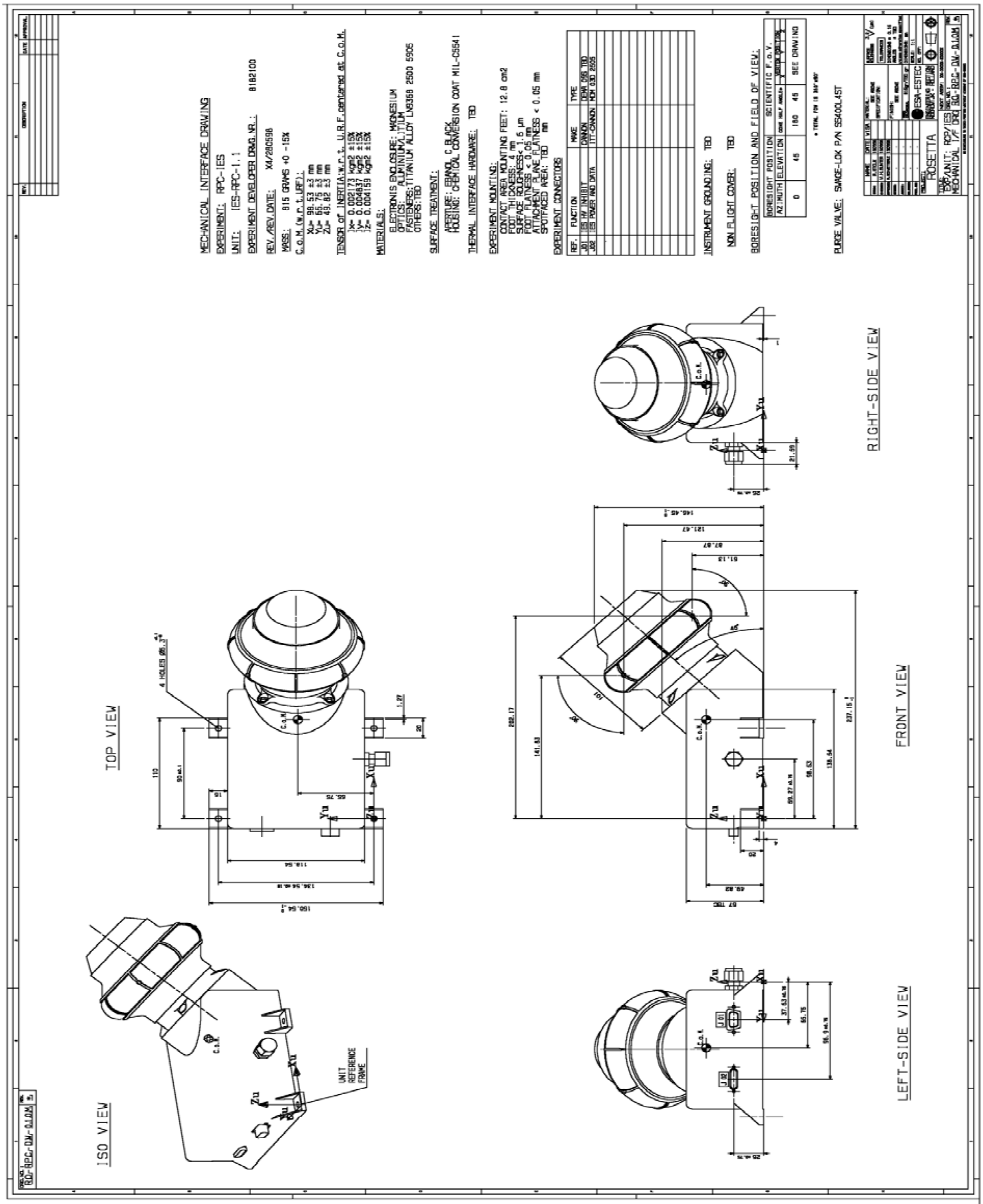


Figure 2.1-3: IES Mechanical Interface Drawing

2.1.3 ICA

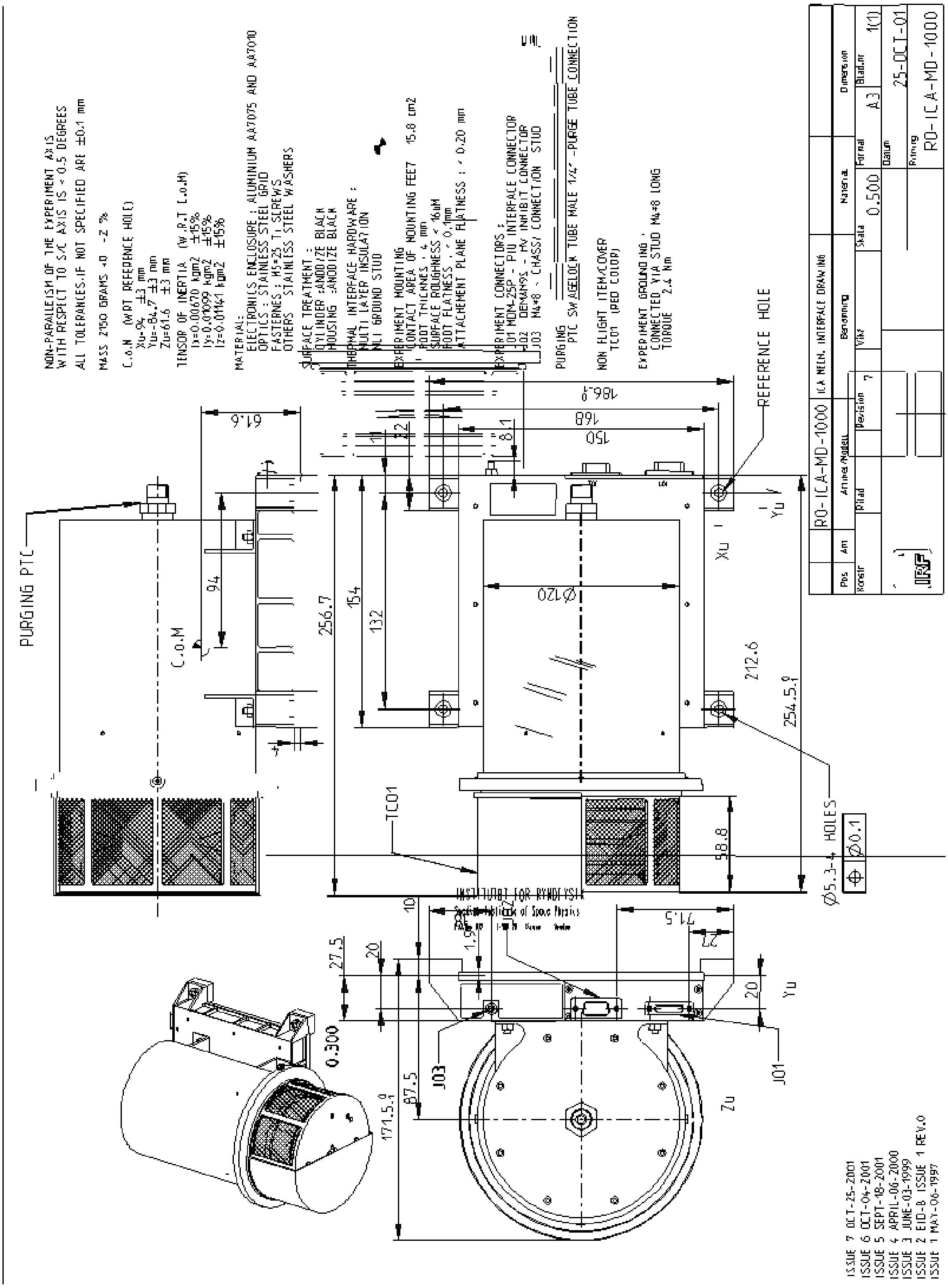


Figure 2.1-4: ICA Mechanical Drawing

2.1.4 LAP

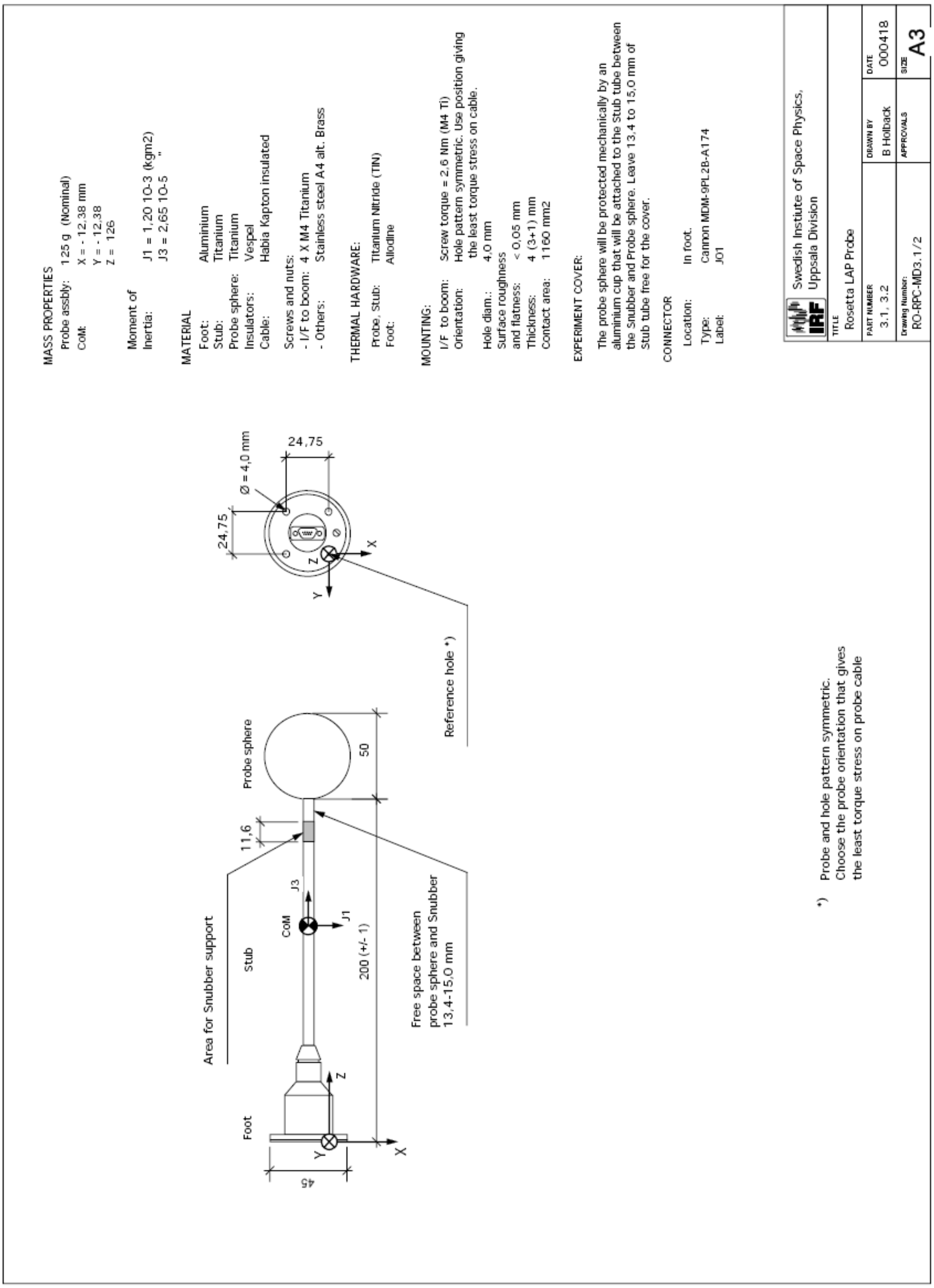


Figure 2.1-5: LAP Mechanical Interface Drawing

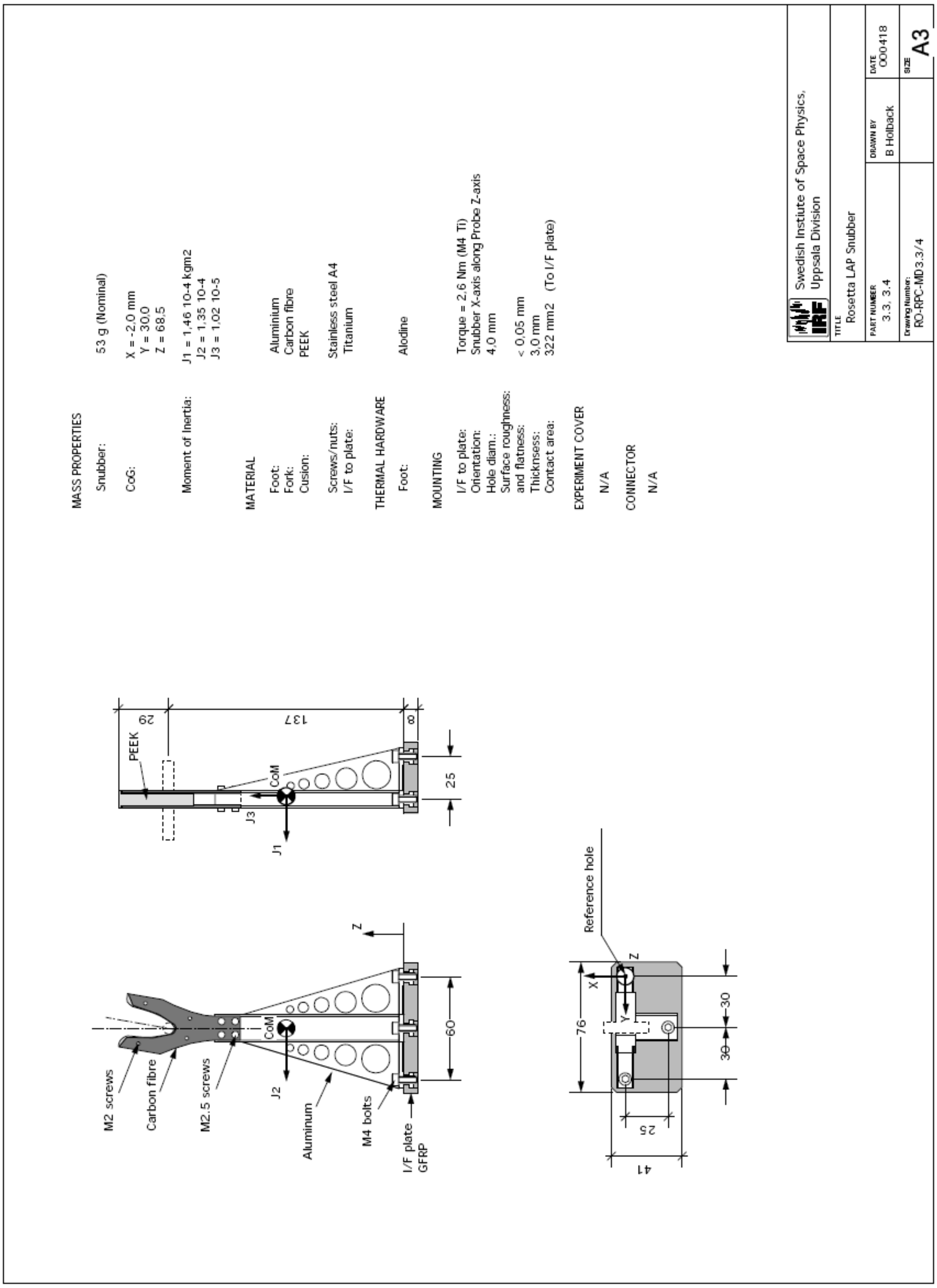


Figure 2.1-6: LAP Support Bracket Mechanical Interface Drawing

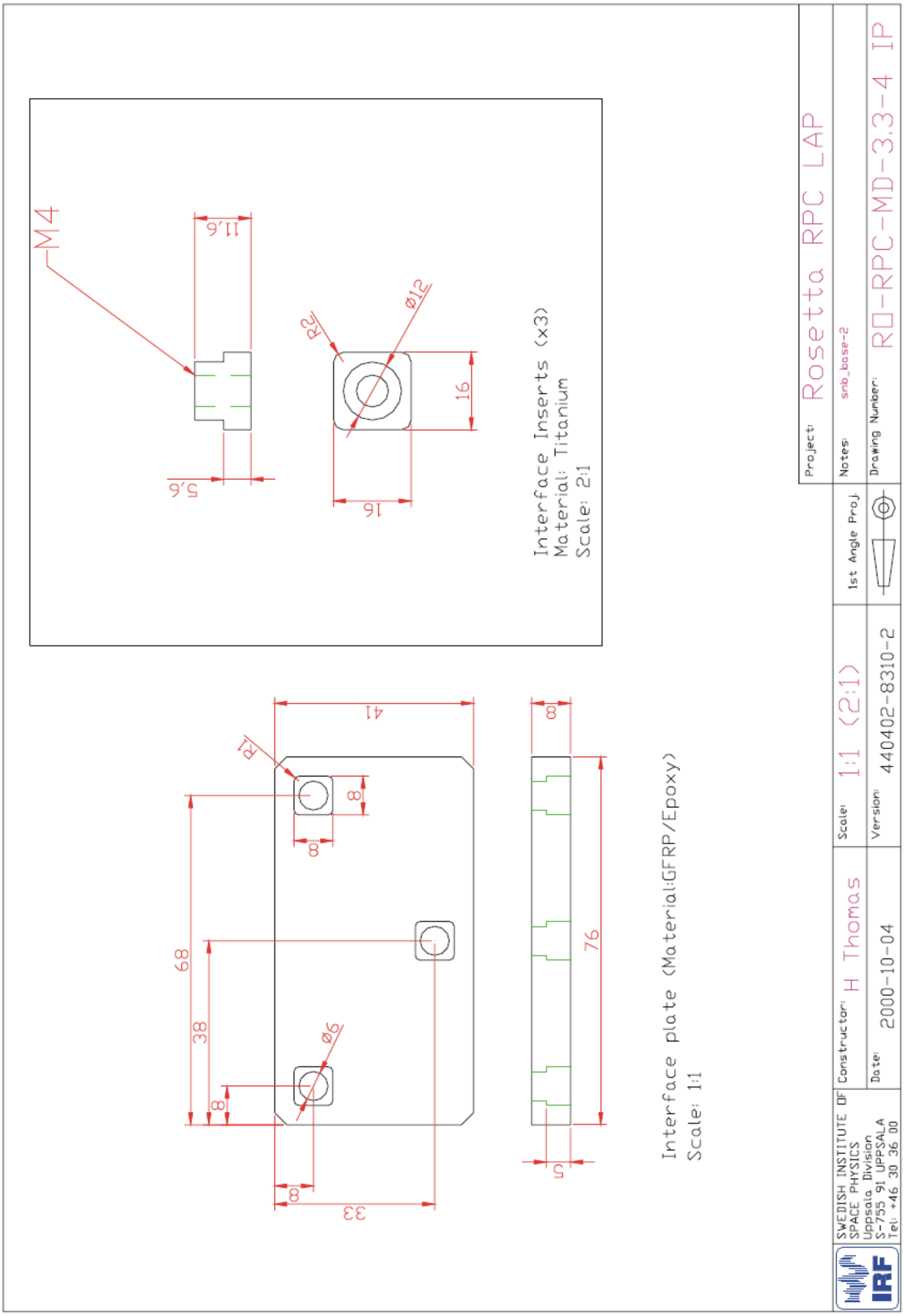


Figure 2.1-7: LAP Support Bracket (I/F Plate) MICD

	X [m]	Y [m]	Z [m]
LAP-1	-1.19	2.43	3.88
Hinge 1	-1.19	0.85	2.30
LAP-2	2.48	0.78	-0.65
Hinge 2	-1.19	0.65	0.30

Table 2.1-1: Positions of the LAP sensors and the hinges.

Table 2.1-1 shows the coordinates (in the s/c reference system) of the LAP sensors and the hinges at the boom roots.

2.1.5 MIP

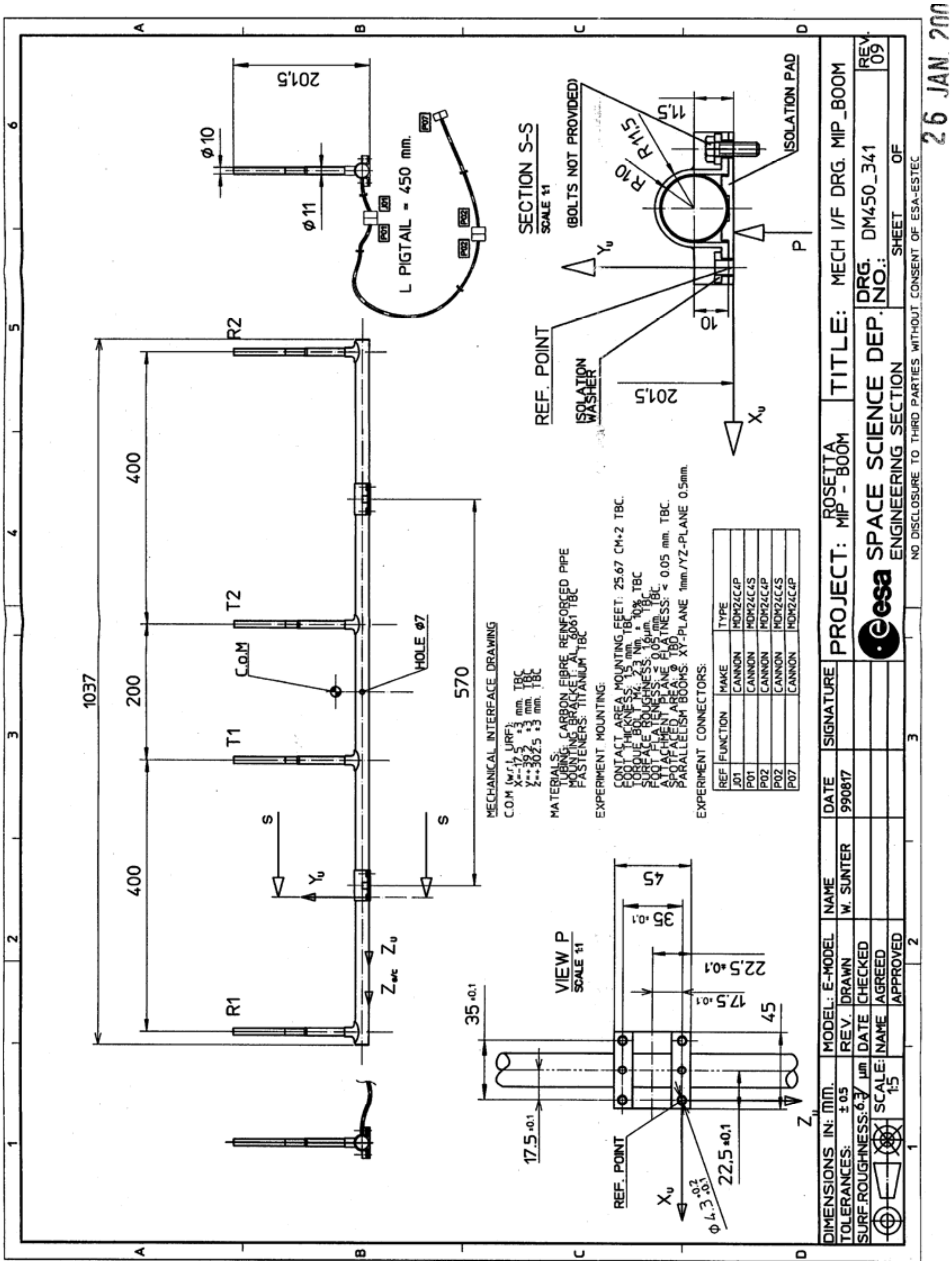


Figure 2.1-8: MIP Mechanical Interface Drawing

2.1.6 MAG

The following drawings show the MAG Inboard and Outboard sensors as well as the Mumetal Stimuli configuration and mirror location for ground alignment measurements (this is no flight item).

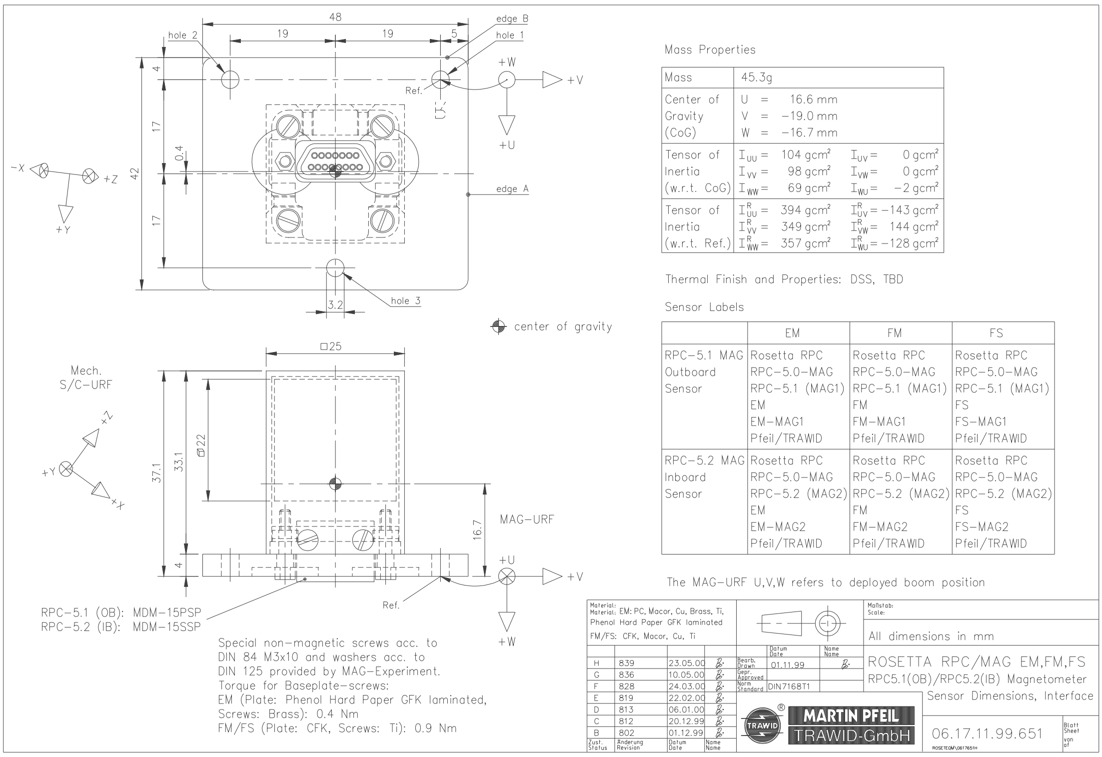


Figure 2.1-9: MAG Sensor Dimensions

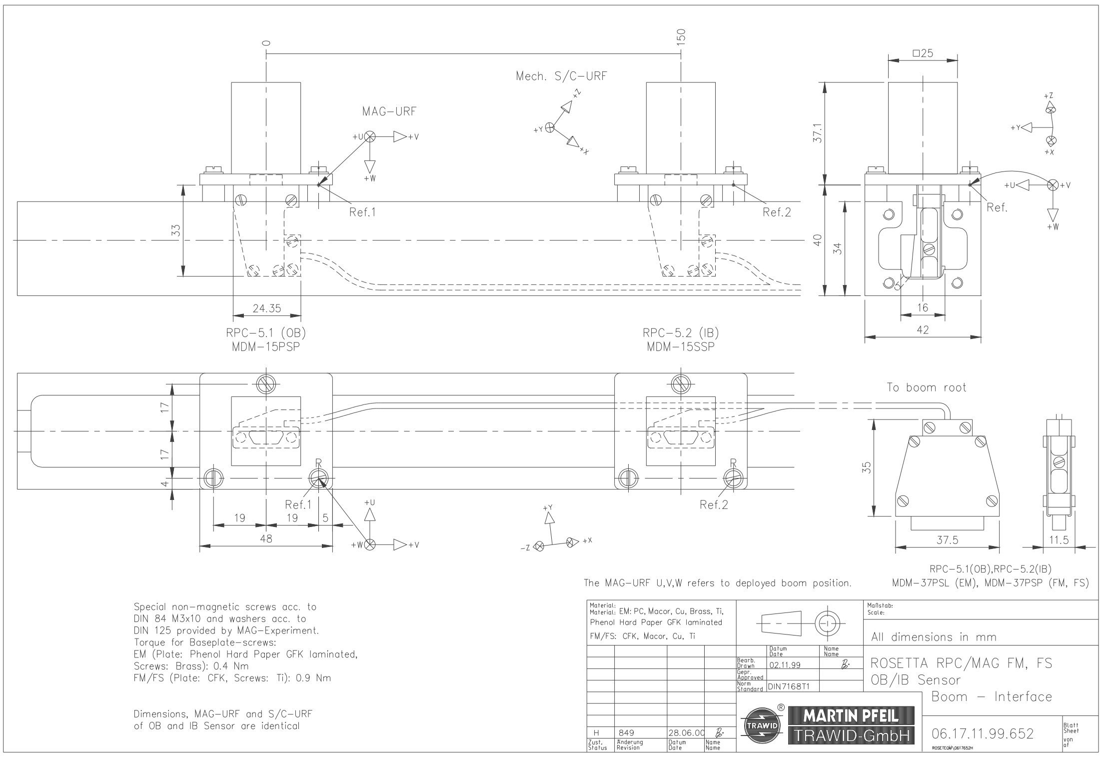


Figure 2.1-10: MAG Sensor Boom Interface

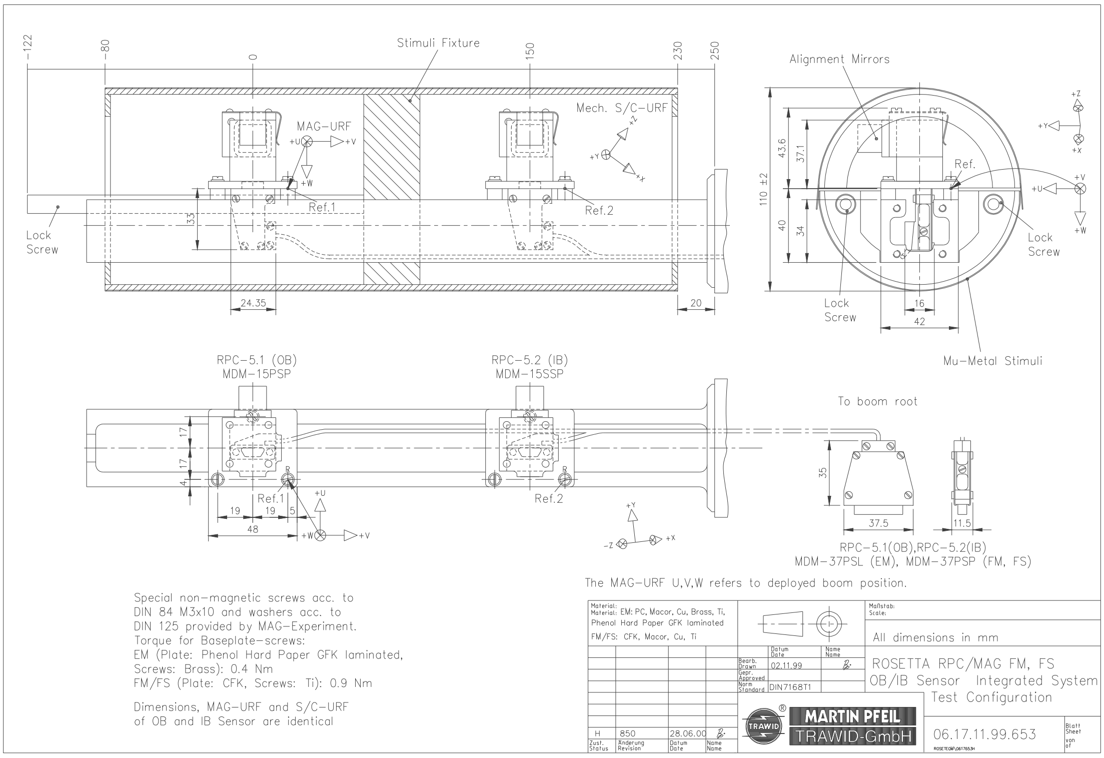


Figure 2.1-11: MAG Sensor Integrated System Test Configuration

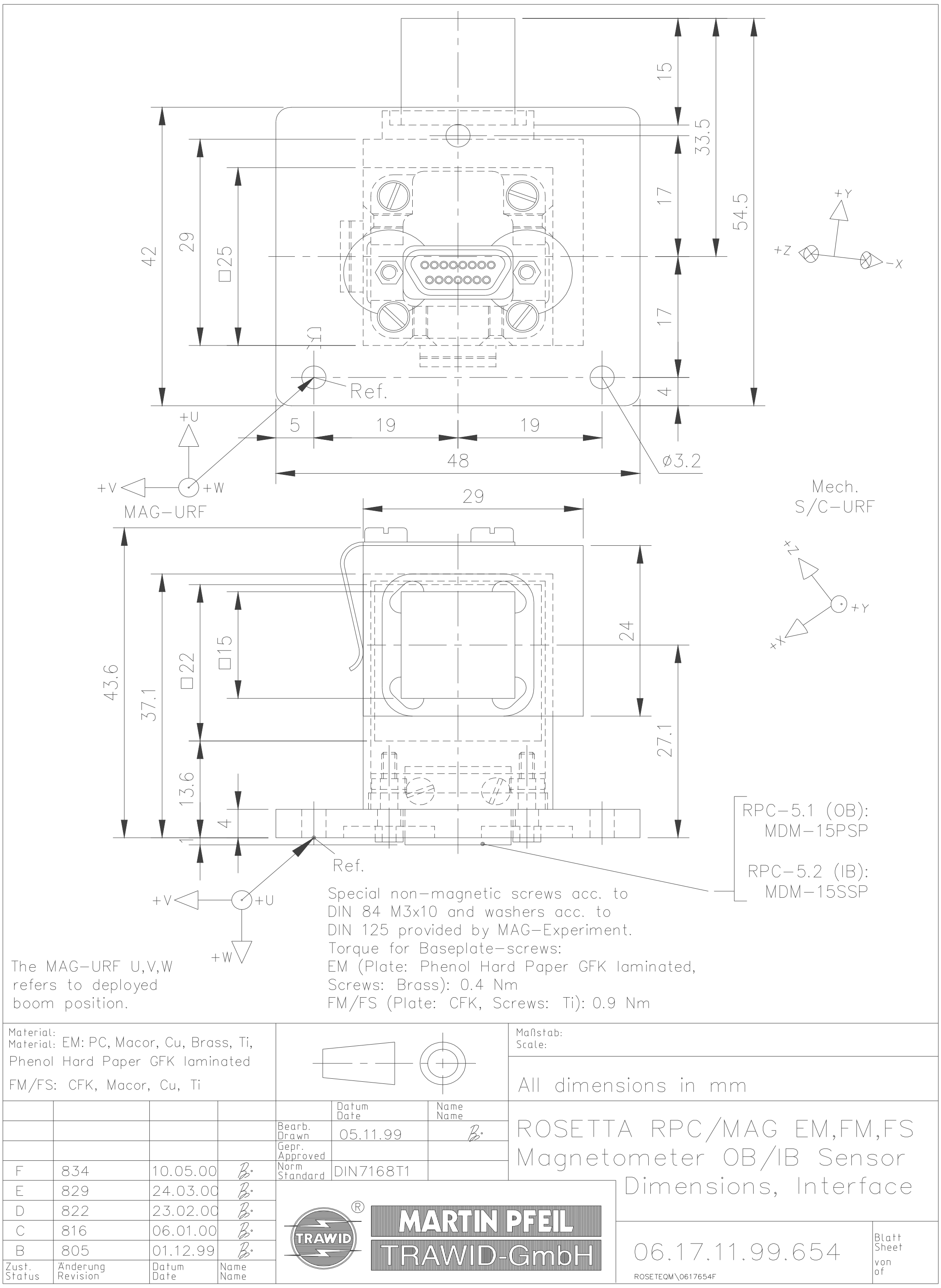


Figure 2.1-12: MAG Sensor Dimensions, Interface

2.1.6.1 Results of the Boom Alignment Measurement

MAG Boom Alignment Evaluation:									
[MAG in SC] = [MAGinTHEO] x [THEOinSC]									
[THEOinSC] = [THEOinMRC]x[MRCinSC]									
MRC during Deployed MAG-Boom			**MRC during Nominal Turn Table Measurement**						
Theo_in_MRC			**MRCinSC**	corrected by Ref.					
Nominal Cosines of Mirror Beam			Nominal Cosines of Mirror Beam				**[Theo_inMRC]*[MRCinSC] = [Theo_in_SC]**		
Cos(Xsc)	Cos(Ysc)	Cos(Zsc)	Cos(Xsc)	Cos(Ysc)	Cos(Zsc)				
0,99994966	**-0,00015882**	**-0,01003286**	**0,99995493**	**0,00000000**	**0,00949445**		**0,999999816**	**-0,000285091**	**-0,00053564**
0,00033541	**0,99984501**	**0,01760261**	**0,00011951**	**0,99992078**	**-0,01258673**		**0,000287776**	**0,999987364**	**0,005018821**
0,01002851	**-0,01760509**	**0,99979472**	**-0,00949370**	**0,01258730**	**0,99987571**		**0,000534203**	**-0,005018974**	**0,999987262**
					Deployed [MAGinTheo] measured				
					SC_X	**SX_Y**	**SC_Z**		
				O.B._u	**0,219583040714178**	**0,960668204776953**	**-0,169999672238927**		
				v	**0,792831952783288**	**-0,074175491152600**	**0,604909490054593**		
				w	**0,568507504679185**	**-0,267609037296758**	**-0,777936128663883**		
				I.B_u	**0,215552374952193**	**0,962688088601813**	**-0,163611789662776**		
				v	**0,792214219227469**	**-0,074444045803663**	**0,605685326632728**		
				w	**0,570906125826550**	**-0,260172496833484**	**-0,778701783345300**		

Table 2.1-2: Boom Alignment, Reference Calculations

	Deployed MAGinSC__nominal				Deployed [MAGinSC] measured				Deviation from Nominal SC		
	SC_X	SX_Y	SC_Z		SC_X	SX_Y	SC_Z	Error sources	[deg]	[arcmin]	OB & IB average plus offset
O.B. _u	0,214611970000000	0,965260430000000	-0,149043633238507	O.B. _u	0,219768642967342	0,961446688834391	-0,165293702534850	1),2),3), 4)	1,00	60,06	47.35'+12.7
v	0,787926219516248	-0,080929399621984	0,610428296260632	v	0,793133605262099	-0,077436608300837	0,604104838499749	2),3),4)	0,51	30,61	28.8' +1.75'
w	0,577160267977233	-0,248440605684821	-0,777922419342320	w	0,568014812986632	-0,263863290785682	-0,779573816904796	1),3)	1,03	61,90	49.37'+12'
I.B_ u	0,214611970000000	0,965260430000000	-0,149043633238507	I.B_ u	0,215741971645595	0,963435635624521	-0,158893604903554	1),2),3), 4)	0,58	34,66	47.3' - 12.7'
v	0,787926219516248	-0,080929399621984	0,610428296260632	v	0,792516208990562	-0,077708877352077	0,604879648250715	2),3),4)	0,45	27,12	28.8' -1.75'
w	0,577160267977233	-0,248440605684821	-0,777922419342320	w	0,570415164733284	-0,256423685312912	-0,780303423965860	1),3),4)	0,61	36,85	49.37'- 12.5'
									Deviation IB to OB		
v:	Along Boom Axis								[deg]	[arcmin]	
w:	MAG (Perpendicular to mounting plane)							u_IB w.r.t. OB	0,45	26,88	
	1) Tolerance of MAG I/F: O.B.: 0.22deg = 13.3arcmin and I.B. 0.184deg = 10.9arcmin							v	0,06	3,53	
	2) Tolerance of MAG OB or IB fixation max: 0.2deg =12arcmin (rotation in mounting plane)							w	0,45	26,99	
	3) Mounting Tolerance of Mirror : tbd										
	4) Boom I/F planarity error about max 10arcmin										
	5) Possible rotation of MAG bracket +/-0.82deg or 49arcmin										

Table 2.1-3: Boom Alignment, Deployed Configuration

	Stowed MAGinSC__nominal				Stowed [MAGinSC] measured				Deviation from Nominal SC		
	SC_X	SX_Y	SC_Z		SC_X	SX_Y	SC_Z	Error sources	[deg]	[arcmin]	OB & IB average & offset
O.B._u	-1,00	0,00	0,00	O.B._u	-0,999996321	-0,00253212	0,000973021	1),2),3),4)	0,16	9,33	47.35'+12.7
v	0,00	1,00	0,00	v	-0,002528122	0,999988449	0,004087938	2),3),4)	0,28	16,52	28.8' +1.75'
w	0,00	0,00	-1,00	w	-0,000983361	0,004085463	-0,999991171	1),3)	0,24	14,45	49.37'+12'
I.B_u	-1,00	0,00	0,00	I.B_u	-0,999986718	-0,001887027	0,004796146	1),2),3),4)	0,30	17,72	47.3' - 12.7'
v	0,00	1,00	0,00	v	-0,001868169	0,999990519	0,00393335	2),3),4)	0,25	14,97	28.8' -1.75'
w	0,00	0,00	-1,00	w	-0,004803523	0,003924337	-0,999980763	1),3),4)	0,36	21,32	49.37' - 12.5'
									Deviation IB to OB		
v:	Along Boom Axis								[deg]	[arcmin]	
w:	MAG (Perpendicular to mounting plane)							u_IB w.r.t. OB	0,22	13,33	
								v	0,04	2,33	
								w	0,22	13,14	
Remark:	The IB and OB Co-Alignment between stowd and deployed is fairly good along the S/C axis but different along u and w unit axis !										

Table 2.1-4: Boom Alignment, Stowed Configuration

2.2 Electrical

2.2.1 Power Interface Requirements

2.2.1.1 General Interface Description

The RPC low-voltage DC/DC converters are part of the PIU. The converters are fully redundant, the non-operating converter being held in cold redundancy. The non-synchronised PIU low-voltage converters will operate at a frequency of 65.5 kHz. +/- 5%.

RPC will not use the keep alive power interface provided by the spacecraft.

The interface to the spacecraft is designed to prevent any single point failure which could lead to a short circuit.
To further protect the spacecraft and the RPC, the converter includes a current limiting trip-out and slow turn on circuit at the input.

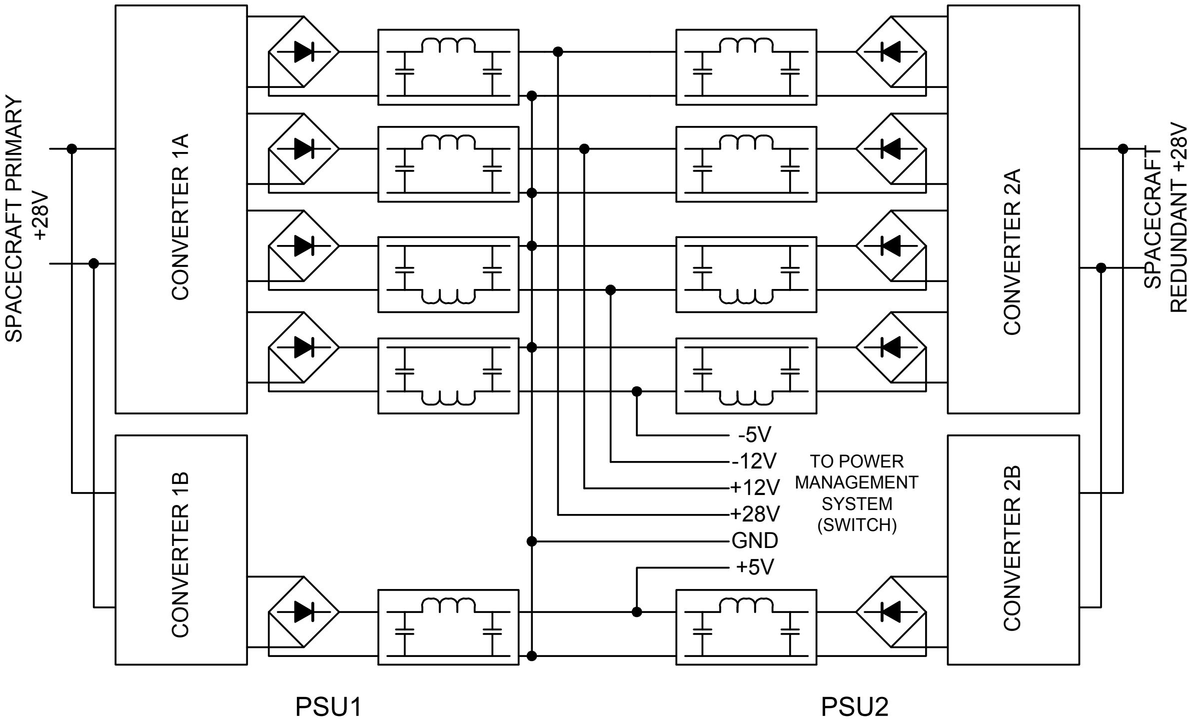
Function	Number of Main Lines Required	Number of Redundant Lines Required	LCL Class (place holder only, to be assigned by Project)
+ 28 V MAIN BUS RPC Experiment Supply (Switched and Current limited)	1	1	C (44 W / 1.6 A trip-off limit)
+ 28 V MAIN BUS Non-op. Heater Power For IES (Switched and Current limited)	1	1	A (11 W / 0.4 A trip-off limit)
Converter Synchronisation Signal (no longer baselined)	0	0	
Keep-Alive Supply	0	0	

Table 2.2-1: Power Supply Interface Requirements

2.2.1.2 Power Distribution Block Diagram and Redundancy

The RPC Power Supply Unit consists of two, identical pairs of DC/DC Converters in cold redundancy. Each PSU is capable of supplying the total power required for the functioning of the complete RPC instrument. Each PSU consists of two DC-DC converters, one to provide 4 secondary voltages: +28 V, ±12 V and -5 V, the other +5 V (all voltages nominal). The two PSUs receive raw +28 V (nominal) input voltages from the Prime and Redundant spacecraft power interfaces. Switching between the PSUs is performed by switching the input between the spacecraft Primary to Redundant supplies.

The PSU secondary voltages are distributed to the user subsystems (ICA, IES, LAP, MAG, MIP, PIU) through the Power Management System. This consists of individual current-limited voltage switches switched on or off by ground command through H/W configuration commands received and decoded in the spacecraft interface units.



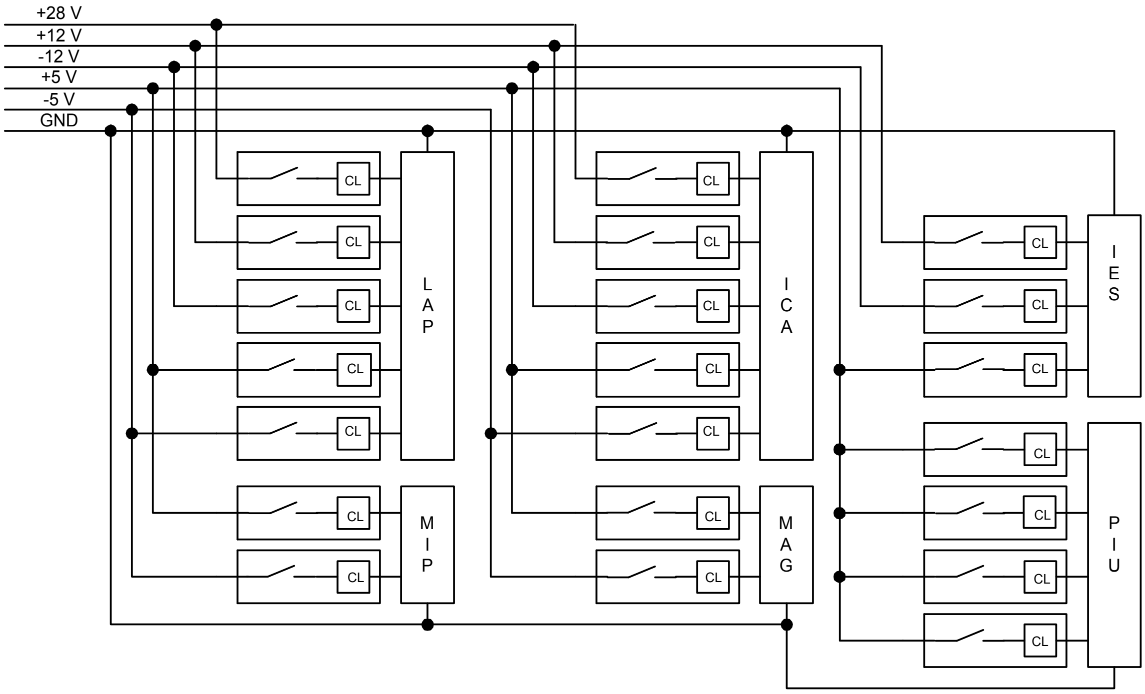


Figure 2.2-1: RPC Power Distribution Block Diagram

2.2.1.3 Experiment Power Requirements

The Power Requirements are listed in section 2.4.3.

2.2.1.4 Interface Circuits

Each of the RPC PSUs has an interface to the spacecraft which is designed to prevent short circuit under any single-point failure. This interface also features a current limited trip-out switch to protect the RPC, and a slow turn on circuit which will comply with the inrush current and current slew specifications of the spacecraft LCL.

The interface is also compliant in respect of reverse-current generation, and will operate safely under any of the over/under voltage situations as detailed in RD-GEN-18.

2.2.2 OBDH Interface Requirements

2.2.2.1 Channel Allocation

Interface Channels	Signal Type or Function	Main	Redundant
Telecommand Channels	Memory Load Commands	1	1
	High Power ON/OFF Commands	1	1
Telemetry Channels	16 Bit Serial Digital Channel	1	1
Monitor Channels	Spacecraft Powered Thermistors	3	0
	Bi-level Channels	0	0
	Analogue Channels	0	0
Timing Channels	High Frequency Clock	1	1
	Broadcast Pulse	1	1
Special Synchronisation Channels	Converter Synchronisation Signal	0	0

Table 2.2-2: Experiment OBDH Interface Channels/Functions

Note:
The high power On/Off channel will be used to select either the main or redundant PIU data-processing unit. This is independent of the main or redundant LCL selection.

2.2.2.2 Bit Rate Requirements

Refer to section 2.4.1 for a detailed description of the RPC telemetry requirements.

2.2.2.3 Timing

RPC requires the following timing channels/services:

- High Frequency Clock (redundant channel)
- Timer Synchronisation Pulse (redundant channel)
- Telecommand Time Packet

For the Timer Synchronisation Pulse, a repetition rate of 8 seconds is required. The time Packet will be required after PIU power-on, and thereafter approximately every day.

Timing information received from the spacecraft will be decoded in the PIU and distributed to the sub-experiment units to be used for time stamping of science telemetry data.

RPC has no special requirements on timing. A correlation of on-board time to UTC to within 100 ms is acceptable.

2.2.2.4 Monitoring

The PIU monitors specified internal voltages, temperatures, and digital status of all sensor units. Logic for corrective action and safe shut-down of sensors is built into the PIU. Refer to section 3.4.4 for details.

The spacecraft is required to monitor three spacecraft powered thermistors for sensor units IES, ICA and MIP. Heaters are provided for IES and ICA, operable by the spacecraft according to limit-set.

The PIU monitors and verifies correct reception for all TCs. Correct execution of a TC can be verified either by a change of state in the HK or the transmission of an execution acknowledge.

2.2.2.5 Electrical Interface Circuits

2.2.2.5.1 General

As indicated in section 2.2.2.1, the PIU digital electronics are fully redundant, with the redundant branch being powered off whilst the nominal branch is operational (and vice-versa). Branch selection is made with the high power ON/OFF command. Internally, PIU will implement no cross-over between the main and redundant receiver/driver circuits.

RPC Thermistor interfaces are not redundant.

Digital interface circuits comply with the Standard Balanced Digital Link specification. SBDL interface circuits within PIU are designed such that unpowered circuits maintain a high impedance to the spacecraft.

2.2.2.5.2 SBDL Receiver Circuit Specification

Figure 2.2-2 shows the SBDL interfaces, main side only. All circuits are replicated for the redundant interface, according to the pin-out of the J01 connector given in RD-GEN-20 section 2.6.4.

2.2.2.5.3 SBDL Driver Circuit Specification

The driver interface circuit is given in Figure 2.2-2.

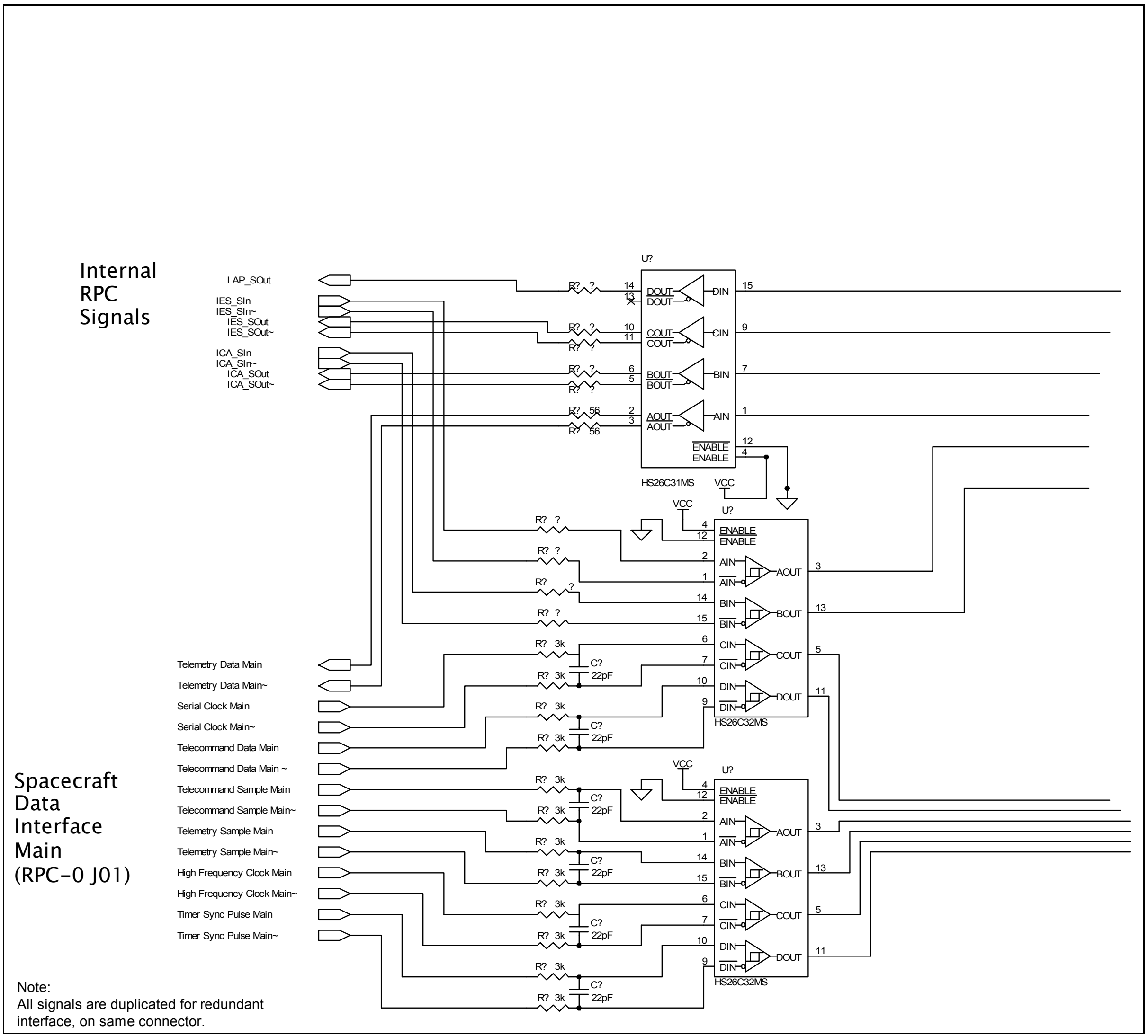


Figure 2.2-2: SDBL Interface Circuits

2.2.2.5.4 Thermistors

Thermistors are of type A, refer to Table 2.5-7. The RPC internal thermistors are therefore all of type YSI 440907.

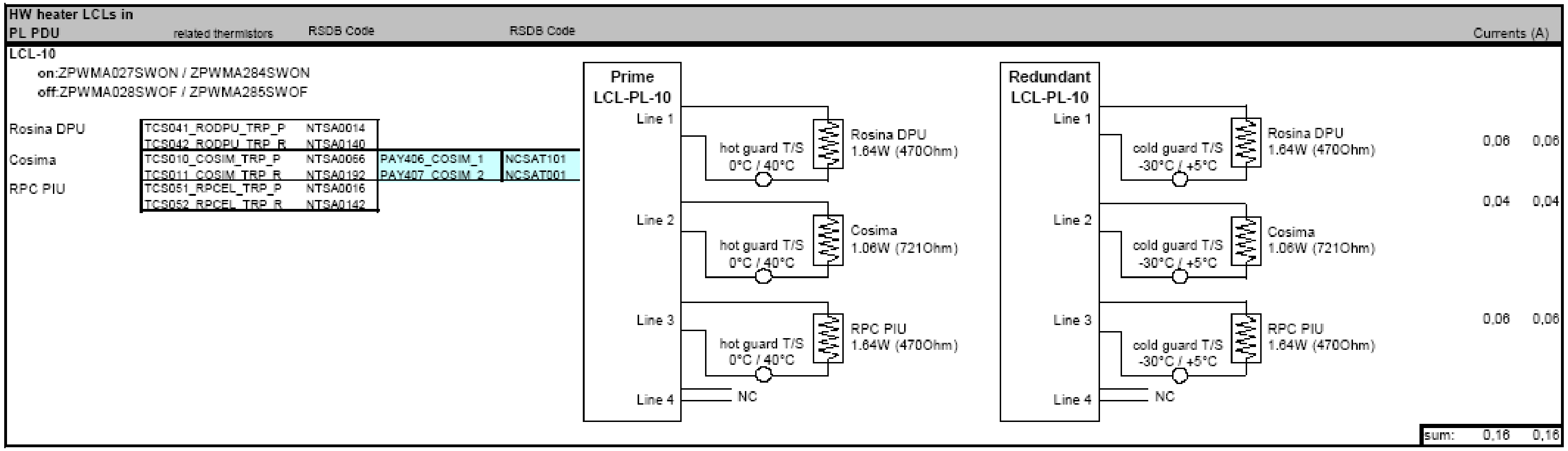
Information about the external ones has been digged out of the Spacecraft User Manual (RD-GEN-30).

All necessary information including parameter names, limits and location is summarized in Table 2.5-1.

2.2.2.5.5 Heaters

PL PDU	LCL No.	Power [W]	Circuit power	Name for H/W heaters	effectect units	no of heater	HG THS	CG THS
			[W]	- for LCL branch A listed only - ON/OFF -		circuits		
X	**10**	4.33		ROS/COS/RPC/ , LCL 10A ON, PDU-P/L-A/B	Ro DPU, CosEU, PIU	3	0 / 40	-30 / +5
				ROS/COS/RPC/ , LCL 10A OFF, PDU-P/L-A/B				
X	**18**	4.37		SSP ESS/ RPC IES, LCL 18A ON, PDU-P/L-A/B	ESS, IES	2	0 / 40	-30 / +5
				SSP ESS/ RPC IES, LCL 18A OFF, PDU-P/L-A/B				
X	**40**	0.5		RPC IES HTR, LCL 40A ON, PDU-P/L-A/B	IES	1	no	No
				RPC IES HTR, LCL 40A OFF, PDU-P/L-A/B				
X	**41**	6.98		RPC ICA A/SREM/L, LCL 41A ON, PDU-P/L-A/B	ICA, SREM	1	0 / 40	-30 / +5
				RPC ICA A/SREM/L, LCL 41A OFF, PDU-P/L-A/B				
			27.7	*main bus voltage*				

Table 2.2-3: Heater Budgets



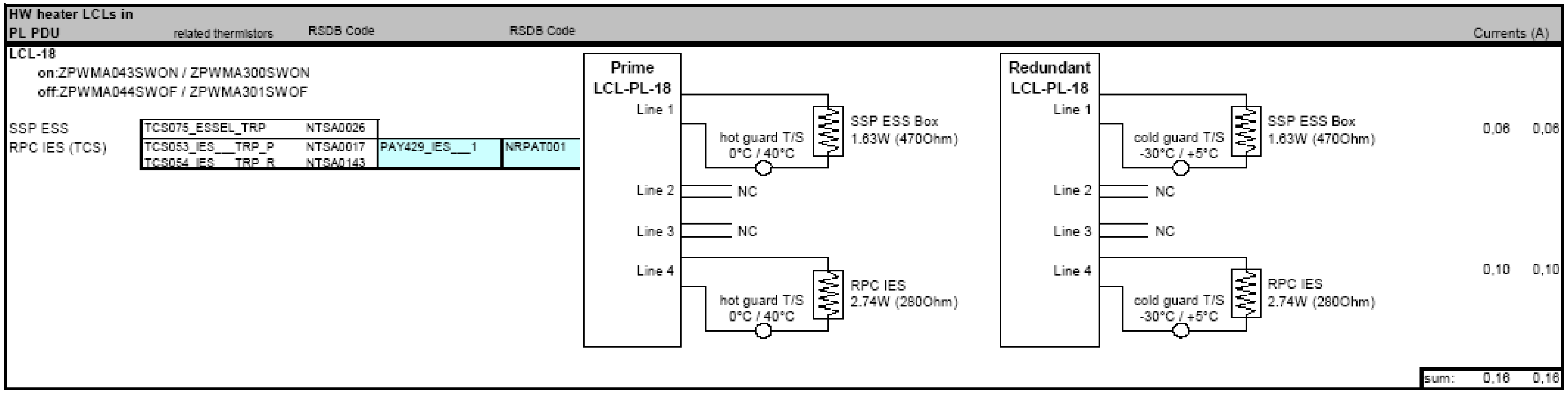
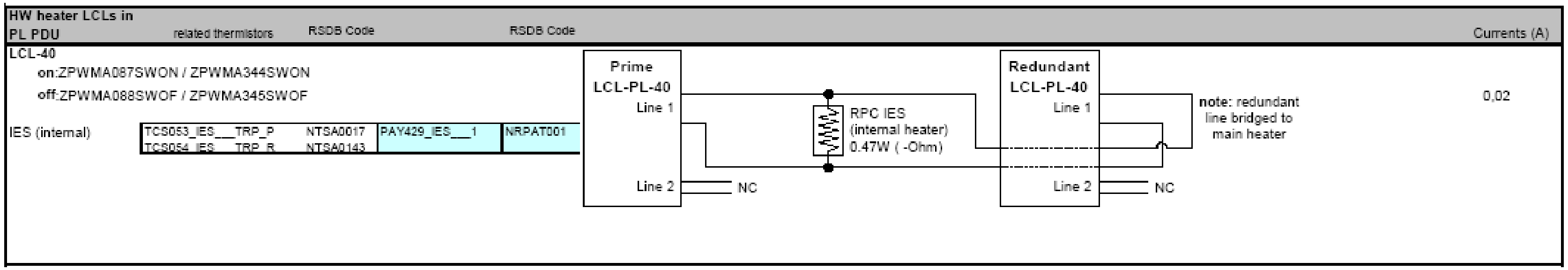


Table 2.2-4: Heater Connections, LCL-10 & LCL-18



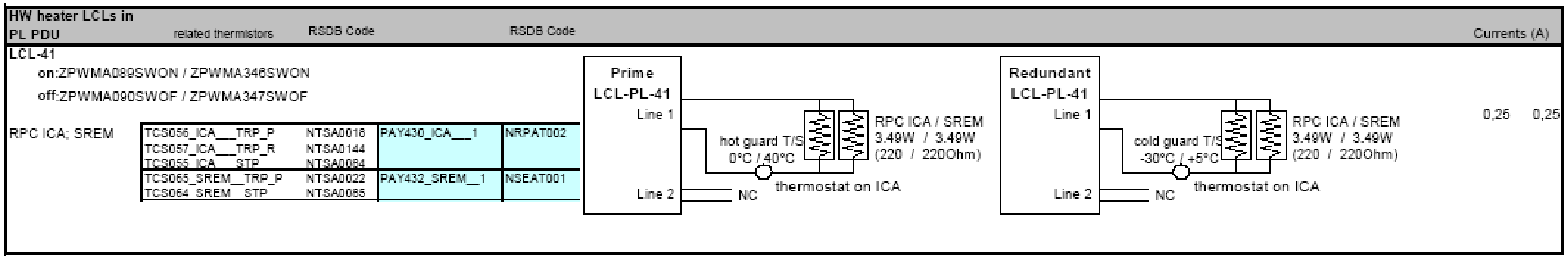


Table 2.2-5: Heater Connections, LCL-40 & LCL-41

2.2.2.5.6 High Power On/Off Command Interface

Figure 2.2-3 shows the High Power On/Off Command interface, main side only. The circuit is replicated for the redundant interface.

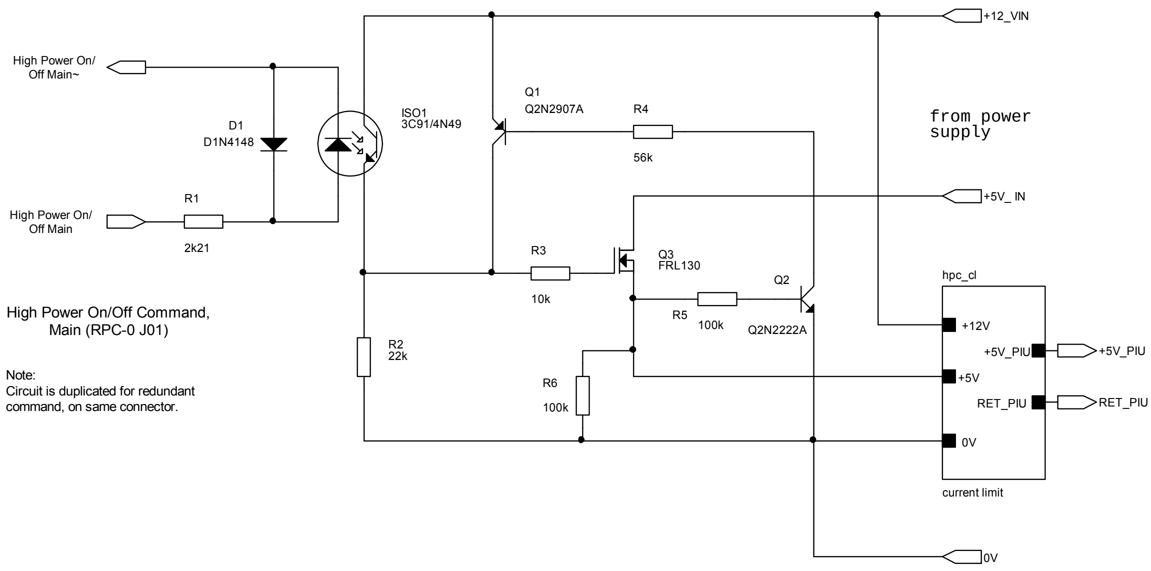


Figure 2.2-3: High Power Command Interface Circuit

2.3 Software

2.3.1 Software Concept and Functional Requirements

2.3.1.1 Software Overview

2.3.1.1.1 PIU

The PIU unit provides the interface between the five RPC experiments and the spacecraft for telecommanding and telemetry data. The RPC experiments IES, ICA, LAP and MIP contain micro-processors or micro-controllers, and operate semi-independently of the PIU; the MAG experiment contains no micro-processor – it delivers digital samples to the PIU, which is responsible for the processing and filtering of the data.

All the functionality of the packet services is the responsibility of the PIU. The PIU contains real-time code written in the 'C++' and assembler language of approximately 32 kWords in length. The software is dedicated to serving the interfaces to the spacecraft and the experiments as it's highest priority. Data transmitted to the spacecraft is double-buffered, to provide a seamless flow to the spacecraft at the highest possible rate, whilst still taking telemetry from the experiments. Commands received from the spacecraft are also buffered such that they may be received from the spacecraft at the fastest rate allowed on the OBDH bus.

The PIU software functions may be summarised as follows:

- Receive and buffer commands from the spacecraft; remove packet formatting and forward command data to experiments.
- Receive and buffer science data from the experiments; packetise data and transmit to the spacecraft.
- Manage the packet services interface with the spacecraft.
- Control the status of the power switches which distribute secondary power within the RPC.
- Process and filter the MAG experiment data.
- Maintain a pool of experiments' housekeeping parameters, packetise and transmit these to the spacecraft.
- Monitor the status of the experiments, and perform any autonomous functions necessary to ensure health and safety.

The RPC has a variety of operating modes, and not all the experiments are necessarily powered on at the same time. Furthermore, the experiments may switch between their minimum, normal and burst data rates independently of each other. The RPC must therefore be considered as providing six independent data streams, and as six independent units for telecommanding. A separate Process ID is, therefore, requested for each unit in section 2.3.1.5

All PIU software complies with the ESA software standard PSS-05-0. In addition RD-GEN-28 is also applied.

2.3.1.1.2 IES

The IES software runs on the Harris/Intersil RTX-2010 16-bit microcontroller. The base clock frequency on IES is 15.2 MHz, so the maximum number of instruction rate is half that, or 7.6 MIPS. The software can also run at slower rates if needed by changing a hardware register. The code is written predominantly in C, with a little RTX-2010 assembler code for areas that benefit from optimization. The hardware configuration consists of 8kwords of PROM (where each word is 16-bits) for the boot image, 256kwords of SRAM and 128kwords of EEPROM. The software versions at launch were 1.0 for PROM and 1.5 for EEPROM.
At bootup, code is initially fetched directly from PROM during a check of memory resources. The PROM code is then copied to SRAM and executed from SRAM. The PROM code is primarily for initial diagnostics and maintenance activities – it contains no science code. Code that resides in EEPROM is copied to SRAM before it is executed. For both PROM v1.0 and EEPROM v1.5 code, the underlying architectures are similar:

- Interrupts
  - AQP to signal when a 32-second acquisition period from PIU has been reported
  - Timer interrupts to control sampling of science data and measure the fine passage of time
  - Link chip interrupts to control TC and TM flow
  - Software interrupt to execute TCs once they are passed on from the link chip front end software that processes incoming messages

- Main loop

  - o Performs IES system initialization (one time)
  - o Controls science data processing
  - o Controls science telemetry production
  - o Controls housekeeping telemetry production
  - o Maintains coarse one-second time passage
  - o Checks A/D monitors
  - o Stroke the watchdog

The IES flight software employs a double buffer (called "PING" and "PONG") to manage science acquisition and telemetering. Each buffer is capable of storing up to 128 kB of data, which corresponds to 32768 data values since each value is stored as a four-byte value to eliminate number saturation during acquisition. The data acquisition time cycles in burst and normal telemetry modes can have the following settings:

- o 128 seconds
- o 256 seconds
- o 512 seconds
- o 1024 seconds

This allows for tailoring the acquisition and collapsing over a range of tradeoffs, between sampling quickly but with the lower energy-angular phase space resolution (128 seconds); and sampling slowly (1024 seconds) but with the higher energy-angular phase space resolution. Data are collected and accumulated during the data acquisition time window, then telemetered over an amount of time that is equal to the data acquisition time. These modes are specified by tables; with thirteen slots available for use in page D of the EEPROM.

As an example, science acquisition data flow for the 128 seconds cycle is illustrated in a series of four figures.

Figure 2.3-1 shows the sweeping of the ESA and DEF power supplies as a function of AQP and 128-second time passage. The processing is performed in the subsequent 128 seconds while another acquisition is taking place. The processing is typically quick and the first telemetry data to be transmitted can be started during the first 32 seconds of the next 128 second period. A total of four packet sets are output (one packet set per 32 seconds) during the 128 seconds. Note that each packet set is a CCSDS packet.

Figure 2.3-2 illustrates the time detail for the ESA steps relative to the DEF steps, relative to the fine interrupt-driven timing to acquire the data at the 62.5 ms step period. This period includes a power supply rise time of 30 ms and a science acquisition and integration time that depends on the cycle length as follows:

- o 32.5 ms integration for a 128 s cycle
- o 95 ms integration for a 256 s cycle
- o 220 ms integration for a 512 s cycle
- o 470 ms integration for a 1024 s cycle

Note that there is a unit timer interrupt running every 2.5 ms that sets the pace for all of the science acquisition.

Figure 2.3-3 shows an example of how data acquired every 62.5 ms is collapsed (i.e., summed) within the ELC science data acquisition buffer organization. The method of collapse can be reconfigured using the ELC remapping vectors in the figure. These remapping vectors are described in the acquisition tables.
Figure 2.3-4 shows the final processing from acquisition buffer, to processing, to data product, and finally to science data telemetry transmission.

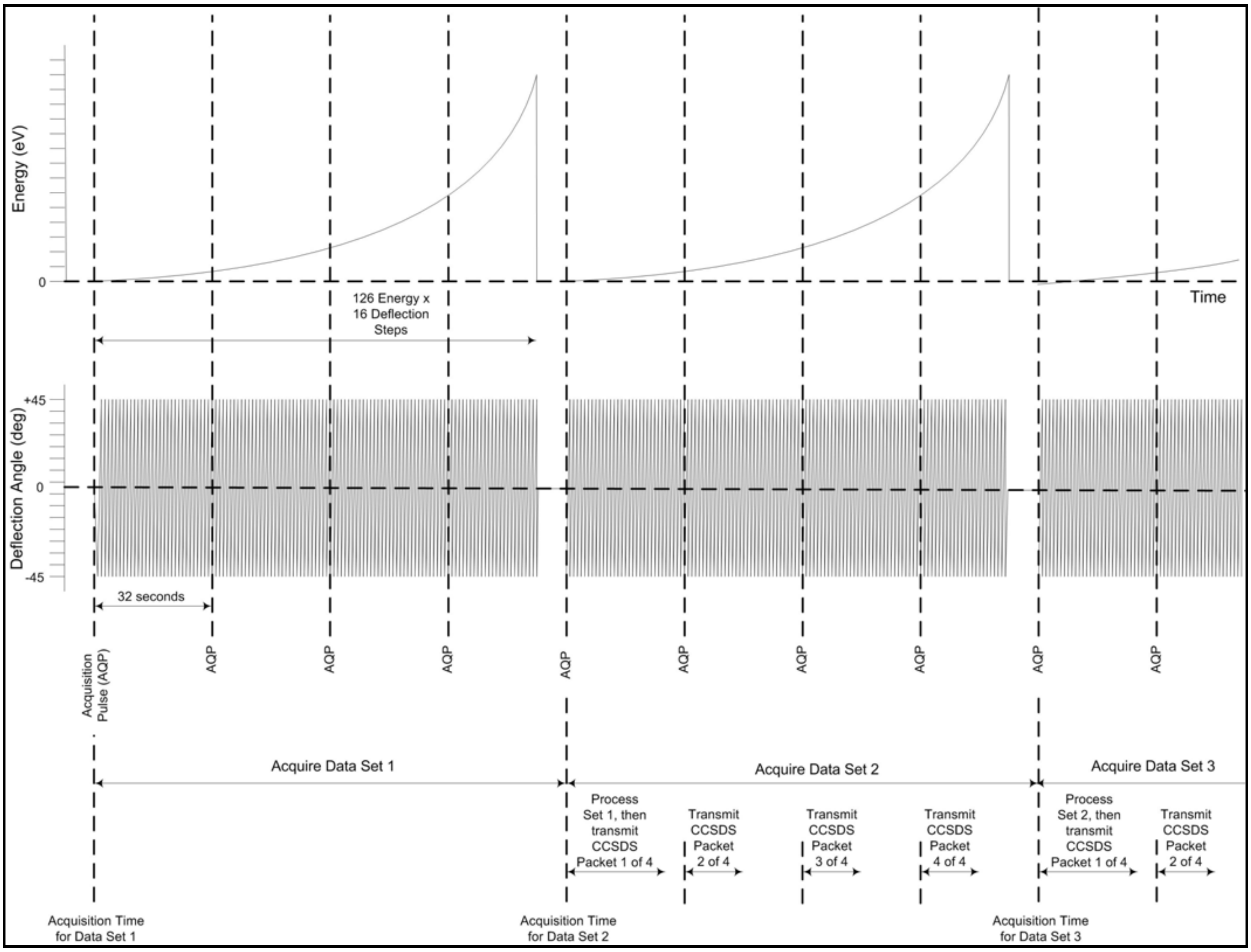


Figure 2.3-1: IES Science Acquisition Time Overview for a 128 s Cycle

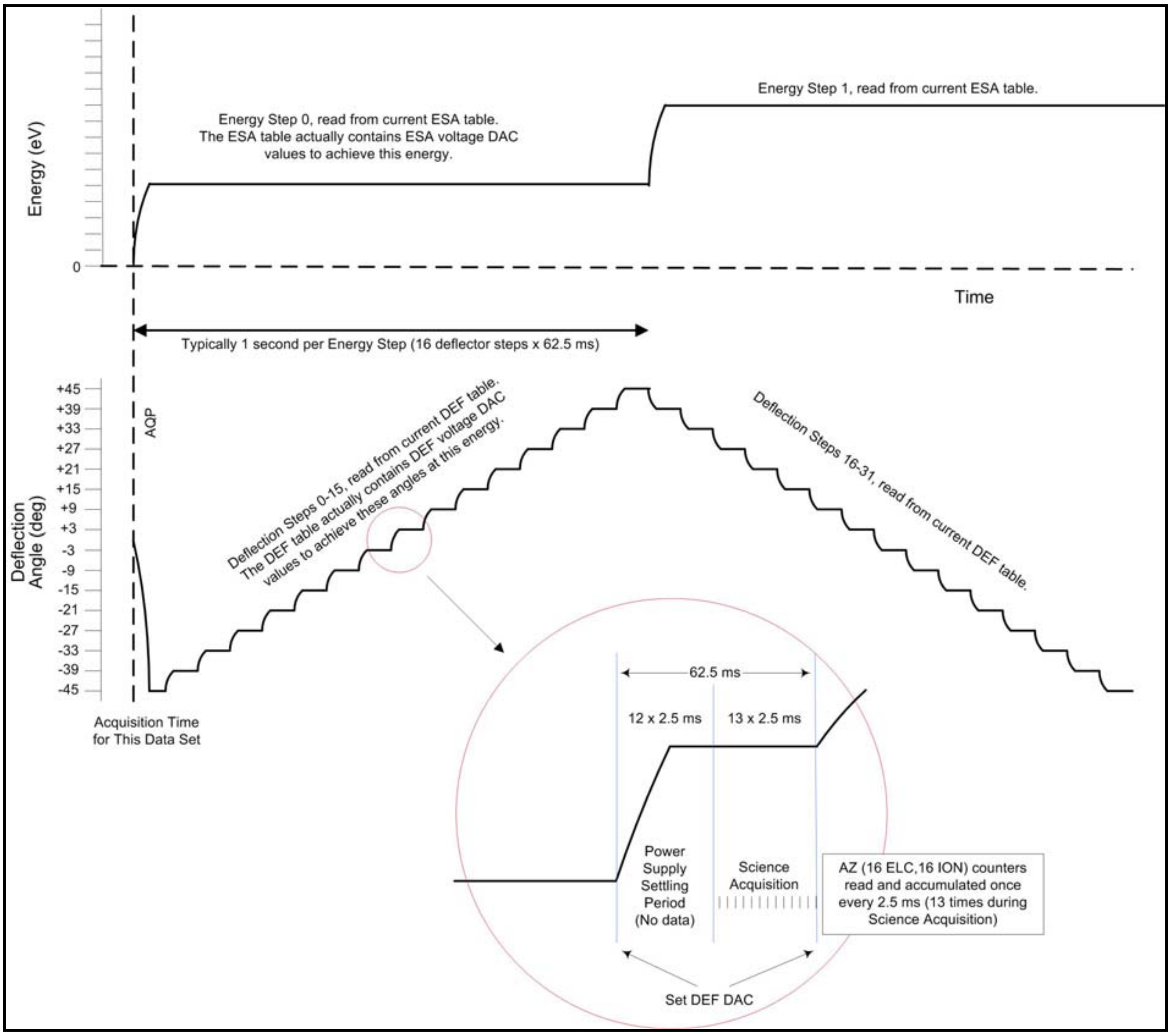


Figure 2.3-2: IES Science Acquisition Timing Detail for a 128 s Cycle

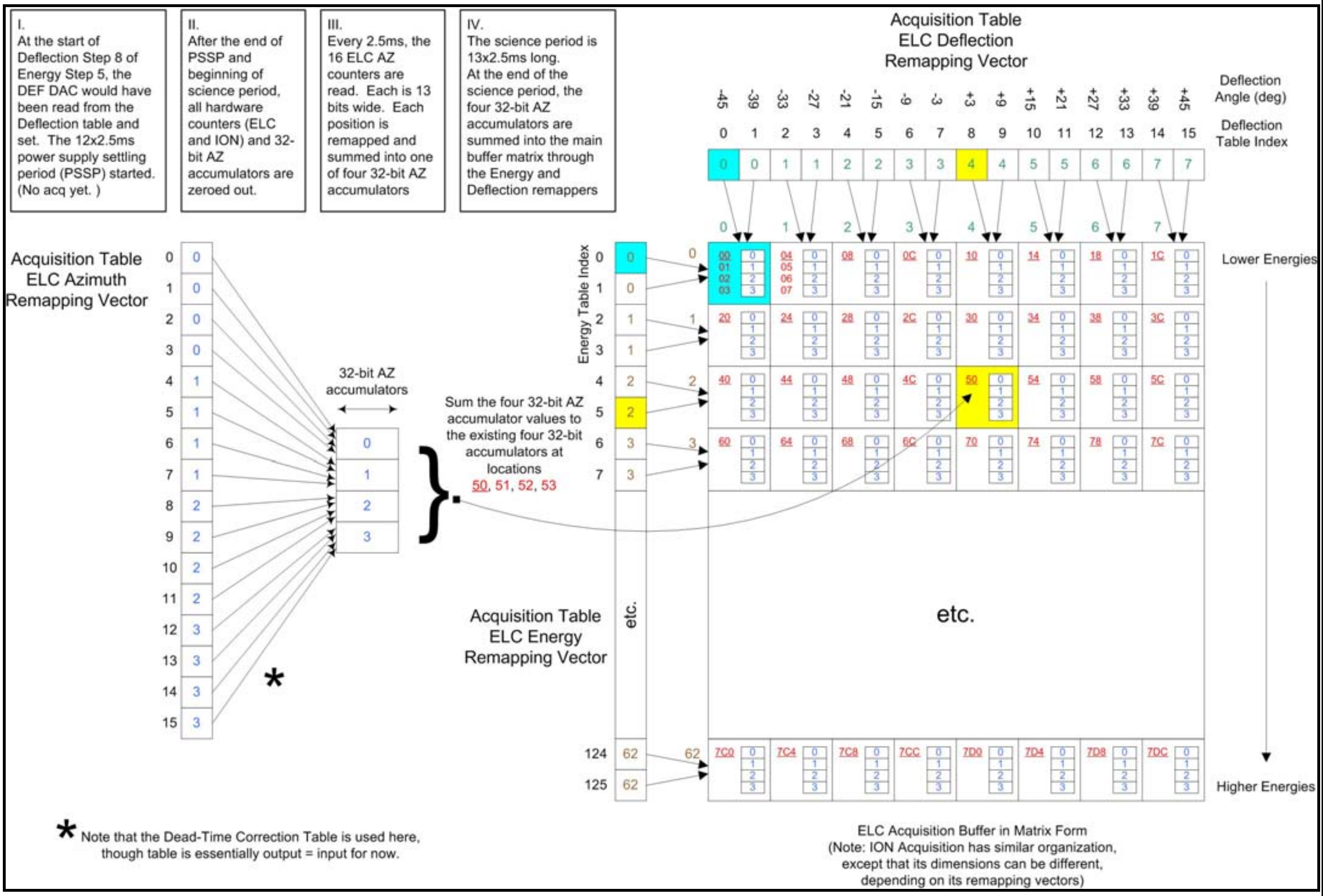


Figure 2.3-3: IES Science Acquisition Collection Detail for a 128 s Cycle

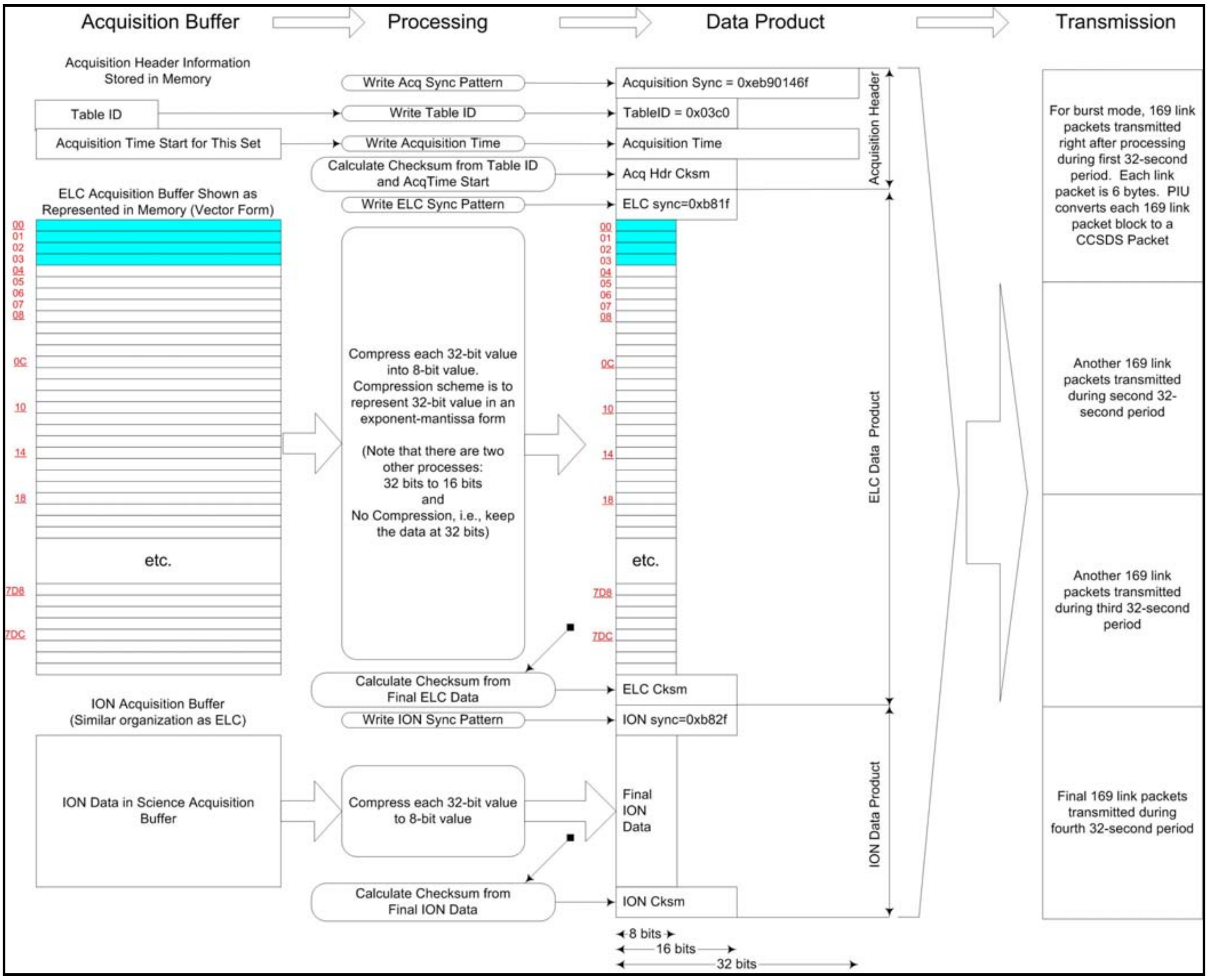


Figure 2.3-4: IES Science Acquisition, Processing Detail for a 128 s Cycle

The flight software can accommodate changes in acquisition time window lengths without stopping acquisition, such that collection time is continuous.

Figure 2.3-5 is an illustration showing the interaction between acquisition (green) and telemetering (yellow) for the PING and PONG buffers over time that includes transitions between acquisition cycle lengths. "STATE" is an internal flight software state that tracks what each buffer is doing at a moment in time.

The beginning of the graph shows alternating PING and PONG buffer usage for 128 second cycle, with acquisition taking 128 seconds, and the subsequent telemetering of that data taking 128 seconds. When there is a transition to the 256 second cycle, while the 256-second cycle data are being acquired by PONG, the PING buffer is simultaneously telemetering data over only the first 128 seconds of that 256 second time window. When the transition is from a longer cycle to a shorter cycle (as in the 512 second cycle to 128 second example in the figure), the shorter acquisition time is repeated (in this case four times) and summed (i.e., accumulated) until the telemetering of the longer time window data has completed. Subsequently, it takes 128 seconds to telemeter that data out. This arrangement allows for transitions without gaps.

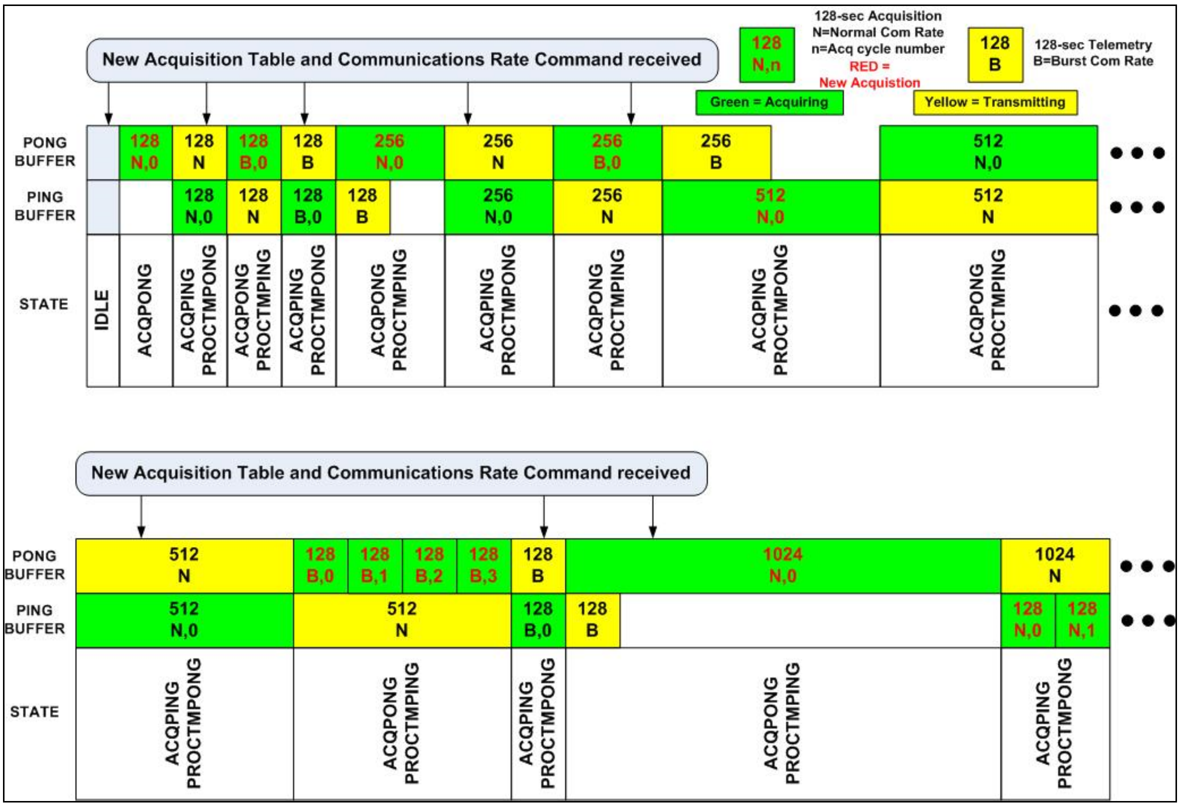


Figure 2.3-5: IES Ping Pong Buffer Interaction for Different Cycle Lengths

2.3.1.1.3 ICA

The ICA commands, TM format and related software aspects are described in the documents RD-ICA-5, RD-ICA-2.
The latter also contains a flow diagram of the onboard software processes.

2.3.1.1.4 LAP

The software managing the LAP instrument is developed for enabling scientific operations by use of macros, which are sequences of commands, stored in EEPROM, which are run repeatedly and thereby completely defines the scientific operations of LAP until the macro is stopped. In addition, the software allows detailed operations by single commands, and patching and maintenance activities. While macros as well as the main LAP flight software are stored in EEPROM (default versions of both reside in PROM), only software upgrades requires memory management services (see Sections 2.3.1.3 and 3.1.2.4.1). In contrast to patching, uploading new macros is considered a quasi -regular activity for tuning the instrument to new environments, perhaps to be used a dozen of time during the mission (for example, new macros where uploaded for the Mars swing-by as well as for the two first Earth swing-bys). Macro uploads are therefore handled by normal instrument commands. The LAP operations concept is further described in Section 3.1.2.4.

The LAP software is written in assembler and runs on the Texas Instruments DSP TMS320C50. The software can be divided into four interrupts and the main execution loop (see Figure 2.3-6). The DSP is made for signal processing and we do continuous real time digital filtering and resampling using circular hardware buffers in the DSP.

Main loop

Initializes the instrument, executes macro commands. Analysis is also performed in the main loop, controlled by the macro commands. The macros can be viewed as small programs that control what the instrument does. See RD-LAP-4 for a general description of macros and macro commands; see RD-LAP-5 for existing macros.

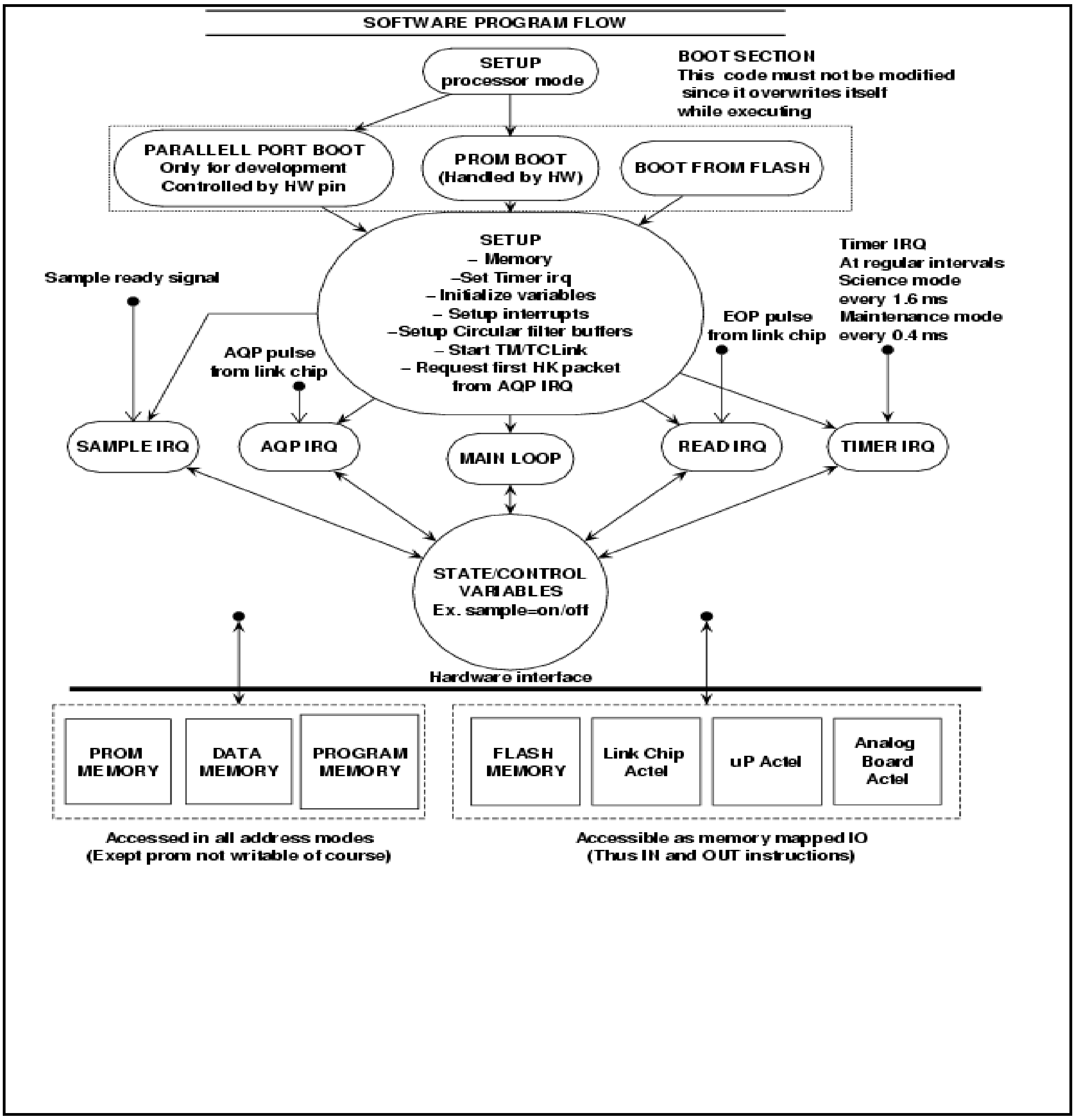


Figure 2.3-6: LAP Software Structure

There are four interrupts used for the following tasks:

- Sample interrupt

  The sampling interrupt handles the sampling signal and determines what ADC caused it. It also handles switching of memory banks, sweeping (strobing of DACs), updates cyclic filter buffers and handles resampling.

- AQP interrupt

  The AQP interrupt handles LDL, delays HK packets, updates status of double buffering buffers, reinitializes sweeps, checks telemetry rate and sets telemetry packet identity.

- Read interrupt

  The read interrupt handles all incoming telecommands and handles the communication link.

- Timer interrupt

  The timer interrupt times writing to the relays, if needed it strobes DACs, tests if patches are to be activated, in which case it computes and checks CRCs and burns to flash memory, kicks the watchdog, parses incoming commands, differentiates between different packet types, executes commands, programs macros, returns memory dumps, assemble HK output, handles double buffering and TM data output.

2.3.1.1.5 MIP

All the MIP management and processing tasks are done by the onboard DSP Analog Devices 2100. The MIP software contains real-time code of 8 kwords in length (24-bit word). The processing activities are written in DSP assembly language and the management ones in C language.

The main tasks of the MIP software are :

- receive and decode the configuration table,
- generate the signal for the transmission electrodes (synthesizer function),
- perform the data acquisition from the sensor in active and passive modes,
- process the data (Fourier analysis),
- run the 32 s sequence (combination of active and passive modes),
- create the HK packets,.
- packetise the science data (with MIP status header) before sending to PIU

The data time stamp is made by the PIU (inside the CCSDS format header) every acquisition period, for science and HK packets.

The initialization of the MIP data handling is made using a configuration table of 6-byte length. The individual commands sent from the ground are combined by PIU to update the current MIP table. Then, PIU sends the table to MIP.

All the elementary modes (Survey, Sweep, Passive and LDL) are independent. They are arranged into pre-programmed sequences. The selection of the type of sequence (type of mode combination) is done through the configuration table.
The first sequence running when MIP is turned on is a special Control sequence. It contains all the necessary information to make a rapid diagnosis of the health of the experiment (memory test, TX/RX checking, input/output verification, command return). After a table reception (new command), MIP runs a Table sequence which has the same goal and the same output information as a Control one except the memory test information.
The LDL mode is common to MIP and LAP. It has to be managed and synchronized by PIU.

Special functions

MIP has an internal watchdog. In case of alarm, the alarm signal is transmitted to PIU to immediately switch off MIP.

Details of the MIP OBSW can be found in RD-MIP-6.

2.3.1.1.6 MAG

Major aspects of the MAG S/W can be found in RD-MAG-5.

2.3.1.2 RPC Autonomy Concept

The principal mode of operation of the RPC is the execution of OBCPs initiated from the mission timeline. This approach maximises the flexibility of the RPC operational concept by removing autonomous operations from the experiments' hard-coded PROM software and placing the responsibility on the DMS (where it is assumed that the procedures may be 'fine-tuned' as the mission progresses). This approach should also enhance the safety and reliability of autonomous operations.

The PIU monitor specified fields within each experiments HK data. If a parameter goes out of bounds then the PIU will generate a PIU event packet identifying the unit and the parameter which is out of bounds. Two sets of limits may be defined for each parameter – a warning level and a danger level. Each level will generate a different EID. Monitor functions within the DMS shall detect either of these EIDs and use its data to trigger the correct OBCP to perform corrective or make-safe actions.

The PIU monitors the experiments' housekeeping data. Anomalies are reported to the DMS by event packets. Monitor functions within the DMS shall trigger the execution of RPC defined OBCPs in order to perform corrective or make-safe actions.

For fault conditions where the response time via the DMS is too long, the PIU may take autonomous actions to ensure that no damage occurs to the experiment. The action will typically be to power the experiment off. For example, in the event that the MIP watchdog detects a processor latch-up, the watchdog will send a signal to the PIU which will immediately power-off the MIP experiment.

Any such autonomous actions will be immediately signalled to the DMS by a PIU event packet identifying unit. In the case of the MIP example, the action taken by the spacecraft will then be to initiate the MIP power-on sequence.

2.3.1.3 Software Maintenance Approach

The PIU and the experiments LAP, IES, and ICA have a software patching capability. This is handled via the Memory Management service. In the case of the PIU, a contiguous block of the processor's SRAM or EEPROM may be loaded, dumped or checked (by a checksum) by the action of a single telecommand packet. For the LAP, IES and the ICA, this capability is available via the PIU, and the PIU provides the Memory Management service to the DMS for these experiments. The destination unit (either PIU, LAP, IES or ICA) for a load, dump or check telecommand is given by the packet's process ID. The response packet will also be identified by the unit's Process ID.

MIP has no software maintenance possibility : no dump, no patch.
MAG does not have its own s/w. All changes are done via PIU.

2.3.1.4 Software Storage

The Software is stored in the individual instruments. RPC does not use the SSMM for software storing.

2.3.1.5 Data Delivery Concept

2.3.1.5.1 Process ID Requirements

The RPC package requires six Process IDs. The requested allocation is as follows (ref. to Table 1.2-2 and Table 2.8.1-1 in the EID-A):

USER	PROCESS ID	PACKET CATEGORY	PACKET TYPE	USAGE
PIU	83	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		7	TM	Event Packets
		12	TC	Memory Load
		12	TC	Memory Dump Request
		9	TM	Memory Dump
		12	TC	Memory Check Request
		7	TM	Memory Check Report
		12	TC	Time Update
		12	TC	Private TC
IES	84	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		7	TM	Event Packets
		12	TC	Memory Load
		12	TC	Memory Dump Request
		9	TM	Memory Dump
		12	TC	Memory Check Request
		7	TM	Memory Check Report
		12	TM	Science TM
		12	TC	Private TC
ICA	85	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		7	TM	Event Packets
		12	TC	Memory Load
		12	TC	Memory Dump Request
		9	TM	Memory Dump
		12	TC	Memory Check Request
		7	TM	Memory Check Report
		12	TM	Science TM
		12	TC	Private TC
LAP	86	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		7	TM	Event Packets
		12	TC	Memory Load
		12	TC	Memory Dump Request
		9	TM	Memory Dump
		12	TC	Memory Check Request
		7	TM	Memory Check Report
		12	TM	Science TM
		12	TC	Private TC
MIP	87	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		12	TM	Science TM
		12	TC	Private TC
MAG	88	1	TM	Acknowledge
		4	TM	Housekeeping – 1 sid
		7	TM	Event Packets
		12	TM	Science TM
		12	TC	Private TC

Table 2.3-1: RPC Telemetry Identifier

2.3.1.5.2 Science Data Delivery Concept

For each of the experiments which is powered and operating in 'normal' rate telemetry, RPC generates one science telemetry packet per 32 second Acquisition Period. The Acquisition Period is a common data gathering interval for the experiments and PIU; the start of each period is signalled to each of the experiments by a hardware pulse which is generated from the Timer Synchronisation Pulse divided by four. Each packet carries the Process ID of the generating unit. The packet category 'science' will be used for all science packets.

Each experiment will operate in one of six modes (independently of any other experiment). The following three modes are supported by all experiments:

- Minimum
- Normal
- Burst

The other three modes may be implemented as required by each instrument.

Since the data volume generated by some of the experiments in minimum mode is very small, transmission every 32 seconds is inefficient (due to the packet header overhead), therefore the data will be buffered and transmitted at a multiple of the Acquisition Period. Thus the packet generation period for IES, ICA, LAP and MAG minimum mode data is 1024 seconds, and for MIP it is 256 seconds. Conversely burst rate data for LAP & MAG will be fitted into 3 packets and 2 packets per AQP respectively. This is due to the large volume of data which is unable to fit into a single TM packet. All normal rate data is transmitted at a 32 second period.

2.3.1.5.3 Housekeeping Data Delivery Concept

For each RPC unit (i.e. 5 experiments plus the PIU) the PIU collects HK data and stores it in an internal HK data base. At the start of the RPC Acquisition period the PIU generates a single HK packet for each unit identified by the unit's housekeeping APID. The HK packet contains the latest data received from the experiments. The generation of the unit's housekeeping packets may be controlled using the standard service 3 TCs.

2.3.1.5.4 Use of Event Packets

The PIU uses the Event Reporting service to report both normal progress action as well as warnings which are detected during the operation of the RPC package.
An event may also be generated by the PIU monitoring system which monitors all the RPC. These events will be monitored by the DMS so that they may trigger

OBCPs. The possible events may be any of the following:

- Parameter Out of bounds (OOL) Warning
- Parameter Out of bounds (OOL) Danger
- Autoshutdown occurrence

Each of the three EIDs will identify the related unit in its parameters.

MIP does not create event packets, they are created directly by PIU. They have the word MIP in but get the PIU APID.

The full list of events is generated by RPC and can be found in RD-RPC-10 (Table: C_TMPCK)

2.3.1.5.5 Timing Requirements

The RPC has no specific requirements on timing accuracy beyond that given in the EID-A. The RPC uses the Timer Synchronisation Pulse and the Time Packet to synchronise with spacecraft elapsed time. Within 20 seconds of the PIU power-on procedure, the PIU expects a time update by the Time Management service. This must be completed before any telemetry packets are sent. On receipt of the time update, the PIU shall load the time value into a 'coarse time' register. On each subsequent Timer Synchronisation Pulse the coarse time register will be incremented by 8 seconds. The PIU also receives the high frequency clock, which is used to drive the PIU's tick timer. A PIU tick is defined as 2^{-7} seconds or 2^{10} cycles of the HF clock and is used for the internal timing of PIU actions.
In order to maintain timing synchronisation throughout the RPC, each experiment receives a simultaneous hardware pulse every 32 seconds. This pulse is derived from the Timer Synchronisation Pulse divided by 4. Each pulse signifies the start of a new Acquisition Period to the experiment. Each experiment will time-stamp events in its data relative to the start of the Acquisition Period in which the data will be transmitted from the experiment, and will send this relative time-stamp to the PIU contained within the experiment's data. The PIU will then transmit the experiment's data to the DMS, and the time code of the packet will be the start of the Acquisition Period when the data was received. Ground processing software will reconstitute the event time by adding the relative time stamp to the packet time.

Note*:*
An exception to this protocol is the MAG experiment, as the processing of the MAG data is done with in the PIU science TM of the MAG experiment with the time of when the first vector was converted on the MAG board. By using the coarse time register, the current tick, and the tick timer register the time stamp for these packets will be to a resolution to an accuracy of greater than 1 ms.

For all other packets, including acknowledgements and events, the time stamp will be generated by the coarse time registers and the current PIU tick. These packets will therefore be marked to the accuracy of 2^{-7}s.

The ability of the RPC to maintain synchronisation with spacecraft elapsed time is dependent on the accuracy of the Timer Synchronisation Pulse interval. Given the stated jitter on the TSY is 2 μs, RPC time should be synchronised with the spacecraft to within 100 ms over a period exceeding 100 hours, however in practice a time update should be scheduled every 24 hours. The accuracy of the TSY is related to the Time synchronization Protocol definition in the RD-GEN-18 (section 2.7.3.3).

2.3.1.6 Context Files

RPC does not use any Context files.

2.3.2 Packet Definitions

2.3.2.1 Packet Services Compliance

The table below gives all the packet services (mandatory and optional) with which RPC will be compliant.

Sub-type	**Service Requests (TC)**	**Sub-Type**	**Service Reports (TM)**
Service 1 – TC Acknowledge			
		1	Acceptance Success
		2	Acceptance Failure
		7	Execution Success
		8	Execution Failure
Service 3 – Housekeeping Reporting			
5	Enable HK Report for SID		
6	Disable HK Report for SID		
		25	HK Report for SID
Service 5 – Event Reporting			
		1	Normal Progress Report
		2	Anomaly Report – Warning
		3	Anomaly Report – Ground action
		4	Anomaly Report – Onboard action
Service 6 – Memory Management			
2	PATCH ABS		
5	DUMP ABS	6	DUMP ABS Report
9	CHECK ABS	10	CHECK ABS Report
Service 9 – Time Management			
1	Accept Time Update		
Service 13 – Large Data Transfer Service			
Not supported by RPC.			
Service 17 – Test Service			
1	Connection Test Request		
		2	Connection Test Report
Service 18 – Context Transfer			
1	Context Request		
		2	Context Report

Sub-type	Service Requests (TC)	Sub-Type	Service Reports (TM)
3	Accept Context		
Service 19 – Information Distribution			
10	ROSINA Pressure Info		
11	ROSINA Pressure Alert		
12	GIADA Dust Info		
Service 20 – Science Data Transfer			
1	Enable Science Report		
2	Disable Science Report		
		3	Science Report

Table 2.3-2: RPC Packet Services

2.3.2.1.1 PIU Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 192 – PIU Power Commands			
1	Set IES Power		
2	Set ICA Power		
3	Set LAP Power		
4	Set MIP Power		
5	Set MAG Power		
Service 193 – PIU Reset Commands			
1	Reset IES Link		
2	Reset ICA Link		
3	Reset LAP Link		
4	Reset MIP Link		
5	Reset MAG Link		
6	Reset DPIU		
7	Reset SCAT TC Channel		
8	Reset SCAT TM Channel		
Service 194 – PIU Software Control			
1	Reset Software TM FIFO		
2	Revert RAM Map (Undo Invert)		
3	Invert RAM Map		
4	Set Software Location		
5	Set to Maintenance Mode		
6	Set to Normal Mode		
7	Patch from EEPROM		
8	Set Keyhole Word Address		
9	Report Last Aq. Period Time		
10	Control Parameter Monitor		
Service 195 – PIU Link Control			
1	Set IES Link		
2	Set ICA Link		
3	Set LAP Link		
4	Set MIP Link		
5	Set MAG Link		
Service 196 – PIU Test Commands			
1	IES Test		
2	ICA Test		

3	LAP Test		
4	MIP Test		
5	MAG Test		

Table 2.3-3: PIU TC Services

2.3.2.1.2 IES Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 2xx – IES			
	see RSDB		

Table 2.3-4: IES TC Services

2.3.2.1.3 ICA Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 2xx – ICA			
	see RSDB		

Table 2.3-5: ICA TC Services

2.3.2.1.4 LAP Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 2xx – LAP			
	see RSDB		

Table 2.3-6: LAP TC Services

2.3.2.1.5 MIP Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 2xx – MIP			
	see RSDB		

Table 2.3-7: MIP TC Services

MAG Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 250 – MAG Select Sensor			
1	Select Outboard		
2	Select Inboard		
Service 251 – MAG Select SID			
1	Select SID 1		
2	Select SID 2		
3	Select SID 3		
4	Select SID 4		
5	Select SID 5		
6	Select SID 6		

Table 2.3-8: MAG TC Services

2.3.2.2 Instrument Packet Definitions

The definition of the RPC TM and TC packets and parameters can be
can be found in the DSDB at RD-GEN-27.

The structure of the RPC packets for a selected subset of TM/TC packets is given in the following chapters.

The next table summarizes the packet periods and bit rates of the science and Housekeeping modes of all RPC instruments.

Instrument	Mode ID	Mode Name	Packet Generation Period [s]	Packet Length [Bits]
IES	SID1	Minimum	1024	5088
	SID2	Normal	32	1584
	SID3	Burst	32	8112
	SID4			
	SID5			
	SID6	Maintenance	32	32000
	HK		32	192
ICA	SID1	Minimum	960	4944
	SID2	Normal	192	19824
	SID3	Burst	32	32736
	SID4	Calibration	32	8592
	SID5	Special	32	25584
	SID6	Test	64	4800
	HK	HK	32	192
LAP	SID1	Minimum	1024	1408
	SID2	Normal	32	1856
	SID3	Burst	10.66	23968
	SID4			
	SID5			
	SID6			
	HK	HK	32	96
MIP	SID1	Minimum	32	144
	SID2	Normal	32	1584
	SID3	Burst	32	9600
	SID4			
	SID5			
	SID6			
	HK	HK	32	96
MAG	SID1	Minimum	1024	2112
	SID2	Normal	32	2112
	SID3	Burst	16	21504
	SID4	Medium	32	10304
	SID5	Low	128	2112
	SID6	Test	16	20544
	HK	HK	32	128

Table 2.3-9: RPC Packet Generation Summary

2.3.2.2.1 PIU TM HK Packet Definition

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-PIU
Packet Function	PIU Housekeeping Report		
Generation Rules	Every 32 seconds		
Header Information			
Process ID	83	Packet Category	HK
Service Type	3	Service Subtype	25
Structure ID	1	Packet Length	29
Data Field Information (Bit 15 – LSB)			
Word 0, Bits 6-15	PSUTemperature		
Word 0, Bit 5	MAG Power Switch Status		
Word 0, Bit 4	MIP Power Switch Status		
Word 0, Bit 3	LAP Power Switch Status		
Word 0, Bit 2	LAP HV Power Switch Status		
Word 0, Bit 1	ICA Power Switch Status		
Word 0, Bit 0	IES Power Switch Status		
Word 1, Bits 8-15	-5V Level		
Word 1, Bits 0-7	+5V Level		
Word 2, Bits 8-15	-12V Level		
Word 2, Bits 0-7	+12V Level		
Word 3, Bits 8-15	TC Count		
Word 3, Bits 0-7	+28V Level		
Word 4	Keyhole Word		
Word 5	Broadcast Pulse Count		
Word 6, Bits 5-15	Priority FIFO Level		
Word 6, Bit 4	RAM Map Flag		
Word 6, Bit 3	Normal / Maintenance Mode Flag		
Word 6, Bit 2	Main / Redundant Flag		
Word 6, Bits 0-1	System ID		
Word 7, Bits 2-15	Normal FIFO Level		
Word 7, Bits 0-1	Spare		
Word 8, Bit 15	MAG HK 1 Flag		
Word 8, Bit 14	MIP HK 2 Flag		
Word 8, Bit 13	MIP HK 1 Flag		
Word 8, Bit 12	LAP HK 2 Flag		
Word 8, Bit 11	LAP HK 1 Flag		
Word 8, Bit 10	ICA HK 4 Flag		
Word 8, Bit 9	ICA HK 3 Flag		
Word 8, Bit 8	ICA HK 2 Flag		
Word 8, Bit 7	ICA HK 1 Flag		
Word 8, Bit 6	IES HK 4 Flag		
Word 8, Bit 5	IES HK 3 Flag		
Word 8, Bit 4	IES HK 2 Flag		
Word 8, Bit 3	IES HK 1 Flag		
Word 9	Spare		

Table 2.3-10: PIU HK TM Packet Definition

2.3.2.2.2 IES TM Packet Definition

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-IES
Packet Function	Science Report		
Generation Rules	Every 1024 seconds when enabled		
Header Information			
Process ID	84	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	1	Packet Length	648
Data Field Information			
IES science data in Minimum telemetry mode			

Telemetry Packet Information			
Packet Name	Normal Science	Instrument	RPC-IES
Packet Function	Science Report		
Generation Rules	**Every 32 seconds when enabled**		
Header Information			
Process ID	84	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	2	Packet Length	208
Data Field Information			
IES science data in Normal telemetry mode			

Telemetry Packet Information			
Packet Name	Burst Science	Instrument	RPC-IES
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	84	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	3	Packet Length	1008
Data Field Information			
IES science data in Burst telemetry mode			

Table 2.3-11: RPC-IES TM Packet Definition

2.3.2.2.3 ICA TM packet Definition

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 960 seconds (average) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	1	Packet Length	618
Data Field Information			
ICA science data in Minimum telemetry mode			

Telemetry Packet Information			
Packet Name	Normal Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 192 seconds (average) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	2	Packet Length	2478
Data Field Information			
ICA science data in Normal telemetry mode			

Telemetry Packet Information			
Packet Name	Burst Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 32 seconds (max) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	3	Packet Length	4092
Data Field Information			
ICA science data in Burst telemetry mode			

Telemetry Packet Information			
Packet Name	Calibration Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 32 seconds (max) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	4	Packet Length	1074
Data Field Information			
ICA science data in Calibration telemetry mode			

Telemetry Packet Information			
Packet Name	Special Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 32 seconds (max) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	5	Packet Length	3198
Data Field Information			
ICA science data in Special telemetry mode			

Telemetry Packet Information			
Packet Name	Test Science	Instrument	RPC-ICA
Packet Function	Science Report		
Generation Rules	Every 32 seconds (max) when enabled		
Header Information			
Process ID	85	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	6	Packet Length	600
Data Field Information			
ICA science data in Test telemetry mode			

Table 2.3-12: RPC-ICA TM Packet Definition

For Details refer to the Document RD-ICA-2.

2.3.2.2.4 LAP TM Packet Definition

For more details on the LAP TM refer to RD-LAP-3 and RD-LAP-4.

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-LAP
Packet Function	Science Report		
Generation Rules	Every 1024 seconds when enabled		
Header Information			
Process ID	86	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	1	Packet Length	176
Data Field Information			
LAP science data in Minimum telemetry mode			

Telemetry Packet Information			
Packet Name	Normal Science	Instrument	RPC-LAP
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	86	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	2	Packet Length	232
Data Field Information			
LAP science data in Normal telemetry mode			

Telemetry Packet Information			
Packet Name	Burst Science	Instrument	RPC-LAP
Packet Function	Science Report		
Generation Rules	Every 10.66 seconds (on average) when enabled		
Header Information			
Process ID	86	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	3	Packet Length	2996
Data Field Information			
LAP science data in Burst telemetry mode			

Table 2.3-13: RPC-LAP TM Packet Definition

2.3.2.2.5 MIP TM Packet Definition

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-MIP
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	87	Packet Category	Private
Service Type	20	Service Subtype	3
Structure ID	1	Packet Length	28*
Data Field Information			
MIP science data packet in minimum telemetry rate			

Telemetry Packet Information			
Packet Name	Normal Science	Instrument	RPC-MIP
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	87	Packet Category	Private
Service Type	20	Service Subtype	3
Structure ID	2	Packet Length	208*
Data Field Information			
MIP science data packet in normal telemetry rate			

Telemetry Packet Information			
Packet Name	Burst Science	Instrument	RPC-MIP
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	87	Packet Category	Private
Service Type	20	Service Subtype	3
Structure ID	3	Packet Length	1210*
Data Field Information			
MIP science data packet in burst telemetry rate			

Telemetry Packet Information			
Packet Name	Housekeeping	Instrument	RPC-MIP
Packet Function	MIP Housekeeping Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	87	Packet Category	4
Service Type	3	Service Subtype	25
Structure ID	1	Packet Length	26*
Data Field Information			
MIP HK packet			

Telemetry Packet Information			
Packet Name	TC Verification	Instrument	RPC-MIP
Packet Function	Telecommand Verification Report		
Generation Rules	Every telecommand sent		
Header Information			
Process ID	87	Packet Category	1
Service Type	1	Service Subtype	1
Structure ID	1	Packet Length	14*
Data Field Information			
TC Verification			

Table 2.3-14: RPC-MIP TM Packet Definition

MIP-Note*: The cell ‘Packet Length’ is filled up with the effective value of the packet data field length, i.e. the experiment data length + 10 bytes of the data field header length (without the 6 bytes of the packet header).

HK data characteristics

The HK data transmitted to PIU every acquisition period (32 seconds) are :
1 HK type I packet of 6 bytes in length,
1 HK type II packet of 6 bytes in length.

The 2 HK packets, the temperature value managed by MAG/PIU and a 2 byte identifier are combined to create an telemetry HK packet of 16 bytes in length.

2.3.2.2.6 MAG TM Packet Definition

Telemetry Packet Information			
Packet Name	Minimum Science	Instrument	RPC-MAG
Packet Function	Science Report		
Generation Rules	Every 256 seconds when enabled		
Header Information			
Process ID	88	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	1	Packet Length	40
Data Field Information			
MAG science data packet in minimum telemetry rate			

Telemetry Packet Information			
Packet Name	Normal Science	Instrument	RPC-MAG
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	88	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	2	Packet Length	208
Data Field Information			
MAG science data packet in normal telemetry rate			

Packet Name	Burst Science	Instrument	RPC-MAG
Packet Function	Science Report		
Generation Rules	Every 32 seconds when enabled		
Header Information			
Process ID	88	Packet Category	Private
Service Type	20	Service Subtype	2
Structure ID	3	Packet Length	4104
Data Field Information			
MAG science data packet in burst telemetry rate			

Table 2.3-15: RPC-MAG TM Packet Definition

Details on the Structure of the internal MAG packets can be found in RD-MAG-23.

2.3.2.2.7 PIU Telecommand Packet Definition

Telecommand Packet Information			
Packet Name	See below	**Instrument**	**RPC-PIU**
Packet Function	PIU Telecommand		
Verification Rules	At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information			
Process ID	83	Packet Category	Private
Service Type	**Subtype**	**Length**	**Name**
3	5	11	Enable HK Data
3	6	11	Disable Hk Data
6	2	Variable	Memory Load
6	5	Variable	Memory Dump
6	9	Variable	Memory Check
9	1	15	Update Time
17	1	9	Test Service
192	1	11	Set IES Power
192	2	11	Set ICA Power
192	3	11	Set LAP Power
192	4	11	Set MIP Power
192	5	11	Set MAG Power
193	1	9	Reset IES Link
193	2	9	Reset ICA Link
193	3	9	Reset LAP Link
193	4	9	Reset MIP Link
193	5	9	Reset MAG Link
193	6	9	Reset DPIU
193	7	9	Reset SCAT TC Channel
193	8	9	Reset SCAT TM Channel
194	1	9	Reset Software TM FIFO
194	2	9	Revert RAM Map (Undo Invert)
194	3	9	Invert RAM Map
194	4	11	Set Software Location
194	5	9	Set to Maintenance Mode
194	6	9	Set to Normal Mode
194	7	13	Patch from EEPROM
194	8	13	Set Keyhole Word Address
194	9	9	Report Last Aq. Period Time
194	10	11	Control Parameter Monitor
195	1	11	Set IES Link
195	2	11	Set ICA Link
195	3	11	Set LAP Link
195	4	11	Set MIP Link
195	5	11	Set MAG Link
196	1	15	IES Test
196	2	15	ICA Test
196	3	15	LAP Test
196	4	15	MIP Test
196	5	15	MAG Test

Table 2.3-16: RPC-PIU TC Packet Definition

2.3.2.2.8 IES Telecommand Packet Definition

Telecommand Packet Information					
Packet Name		see below		**Instrument**	**RPC-IES**
Packet Function		IES Telecommand (ref. RD-IES-3, Appendix: Commands; and RD-GEN-27)			
Verification Rules		At any time. For details refer to Chapter 2.8.3.1.3 EID-A.			
Header Information					
Process ID	84	Packet Category		Private	
Service Type	**Subtype**		**Length**		**Name**

Table 2.3-17: IEC TC Packet Definition

2.3.2.2.9 ICA Telecommand Packet Definition

Telecommand Packet Information				
Packet Name		see below	**Instrument**	**RPC-ICA**
Packet Function		ICA 16 bit TCs (see RD-ICA-2 and RD-GEN-27)		
Verification Rules		At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information				
Process ID	85	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	
		2		
Data Field Information				
A 16 bit command code				

Telecommand Packet Information				
Packet Name		see below	**Instrument**	**RPC-ICA**
Packet Function		ICA 32 TCs (see RD-ICA-2 and RD-GEN-27)		
Verification Rules		At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information				
Process ID	85	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	
		4		
Data Field Information				
A 16 bit command code followed by a 16 bit security lock (0xFEED				

Table 2.3-18: ICA TC Packet Definition

2.3.2.2.10 LAP Telecommand Packet Definition

Telecommand Packet Information			
Packet Name	see below	**Instrument**	**RPC-LAP**
Packet Function	LAP Telecommand (see RD-GEN-27)		
Verification Rules	At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information			
Process ID	86	Packet Category	Private
Service Type	**Subtype**	**Length**	**Name**

Table 2.3-19: LAP TC Packet Definition

2.3.2.2.11 MIP Telecommand Packet Definition

Telecommand Packet Information			
Packet Name	see below	**Instrument**	**RPC-MIP**
Packet Function	MIP Telecommand (see RD-GEN-27))		
Verification Rules	At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information			
Process ID	87	Packet Category	Private
Service Type	**Subtype**	**Length**	**Name**

Table 2.3-20: MIP TC Packet Definition

2.3.2.2.12 MAG Telecommand Packet Definition:

Telecommand Packet Information			
Packet Name		see below	**Instrument**	**RPC-MAG**
Packet Function		MAG Telecommand		
Verification Rules		At any time. For details refer to Chapter 2.8.3.1.3 EID-A.		
Header Information				
Process ID	88	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	
3	5	11	Enable HK Data	
3	6	11	Disable HK Data	
20	1	9	Enable Science	
20	2	9	Disable Science	
250	1	11	Select Outboard	
250	2	11	Select Inboard	
251	1		Select SID 1	
251	2		Select SID 2	
251	3		Select SID 3	
251	4		Select SID 4	
251	5		Select SID 5	
251	6		Select SID 6	

Table 2.3-21: MAG TC Packet Definition

2.3.2.3 Instrument Packet Content Description

PIU
Refer directly to the RD-RPC-10.

IES
Refer directly to the RD-RPC-10.
ICA
For the ICA TC parameter definition refer to RD-ICA-2.

LAP
For the LAP TC parameter definition refer to RD-LAP-4.

MIP
For the MIP TC parameter definition refer to RD-MIP-3

MAG
Refer directly to RD-RPC-10.

2.3.3 DMS Resource Requirements

2.3.3.1 SSMM Allocation

The available SSMM is 104.9 MB for RPC.

2.3.3.2 SSMM Utilisation

The tables below give, for each mission phase with different SSMM requirements, the estimated (average) amount of data which will be generated in a 7 day period. Note that some of the mission phases given last less than 7 days, therefore the total data taken will be less than the figures given.

The data space required for context storage is constant over all mission phases. The space required for patches is estimated, and will also be constant assuming that the patches will be held constantly in the SSMM for the largest part of the mission.

Non-Science Telemetry includes the following RPC-specific data types:

- Housekeeping Data
- Event Report Data
- Memory Dumps

but does not include data provided under the spacecraft mandatory packet services such as Telecommand reception reports.

Mission Phases:	Commissioning, Far Approach, Relay.	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	0.41	Active time typically 10%
Science Telemetry	Burst	37	“
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	All Cruise Phases	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	0.005	Active time typically <1%
Science Telemetry	Normal	0.25	
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	Near Comet Drift	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	0.16	Active time typically 5%
Science Telemetry	Burst	19	
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	Earth Swing-by, Asteroid Encounters, Mars Fly-by	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	4.1	Active time 100%
Science Telemetry	Burst	374	“
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	Close Approach, Global Mapping	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	1.8	Active time typically 50%
Science Telemetry	Burst	187	“
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	Transition, Close Observation, Extended Monitoring, Ext. Mission	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	1	Active time typically 30%
Science Telemetry	Normal	8.3	“
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Mission Phases:	SSP Delivery	**Instrument:**	RPC
Data Type	**Description**	**Volume Mb.**	**Operational Usage**
Non-Science Telemetry	Housekeeping, Event Reports, Memory Dumps	4.1	Active time 100%
Science Telemetry	Burst	374	“
Context	Context	0.1	At RPC Power-on
Software Patches	PIU and Exp. Patches	0.2	“

Table 2.3-22: RPC Data Volume in Different Misison Phases

2.3.3.3 On-Board Control Procedures

OBCP Name, Number	Function	Usage
PL_OBCP_5_RP.1, #8091	PIU Power On	Power On of RPC
PL_OBCP_5_RP.2, #8092	PIU Power Off	Power Off of RPC
PL_OBCP_5_RP.3, #8093	RPC Mode Control	During any reconfiguration of RPC IES and ICA
PL_OBCP_5_RP.4, #8094	LDL no synchronization	When LDL sync event is generated
PL_OBCP_5_RP.5, #8095	Parameter Monitor Danger value	When Danger event is generated
PL_OBCP_5_RP.6, #8096	RPC Mode Control 2	During any RPC reconfiguration of MIP, MAG, LAP
PL_OBCP_5_RP.7, #8097	IES Mode Control	Change Mode of IES
PL_OBCP_5_RP.8, #8098	ICA Mode Control	Change Mode of ICA
PL_OBCP_5_RP.9, #8099	LAP Mode Control	Change Mode of LAP
PL_OBCP_5_RP.10, #809A	MIP Mode Control	Change Mode of MIP
PL_OBCP_5_RP.11 #809B	MAG Mode Control	Change Mode of MAG

Table 2.3-23: RPC OBCPs

More information about the OBCPs can be found in the documents:

- RPC Experiment OBCPs URD: RD-GEN-5, Section3.2.4.
- Rosetta Flight Operations Plan: RD-GEN-9,
- Volume 2, Annex 3, Chapter 2

2.3.3.4 DMS Monitoring of RPC

The DMS shall perform periodic and event driven monitoring of the RPC status. Periodic monitoring shall be performed on parameters defined within the RPC Housekeeping Report, delivered every 32 seconds. According to a limit-set for each parameter, the DMS may be required to execute an OBCP for ‘make-safe’ action. The RPC shall also generate discrete Event Packets which shall trigger the execution of an OBCP.

For the external thermistors to be monitored refer to section 2.2.2.5.4 or to RD-GEN-30.

Instrument	**RPC**		
Monitored Entity	**RSDB Mnemonic**	**Monitoring Requirements**	**Action On Error, FCP/OBCP**
Parameters			
RPC +5V	NRPD0310	According to Limit Set in RSDB	RPC Off
RPC –5V	NRPD0317	According to Limit Set in RSDB	RPC Off
LCL Current Trip			
S/C controlled Thermistors			
PIU – LCL-10	TCS051_RPCEL_TRP_P TCS052_RPCEL_TRP_R	Ref. ROS-ESS-S/C-UM	RPC Off, RPC_FCP_000
IES -LCL -18 / LCL- 40	TCS053_IES___TRP_P TCS054_IES___TRP_R	Ref. ROS-ESS-S/C-UM	IES Off, RPC_FCP_010
ICA – LCL-41	TCS056_ICA___TRP_P TCS057_ICA___TRP_R TCS055_ICA___STP	Ref. ROS-ESS-S/C-UM	ICA Off, RPC_FCP_020
Events			
PIU Monitor Danger	YRP0AEC4	Parameter: Unit ID	Run OBCP PL_OBCP_5_RP.5 Contact RPC
MIP Dog barking	YRP0AE81	None	Contact RPC

Table 2.3-24: RPC Monitoring Requirements

More details of DMS monitoring of RPC can be found in section 3.4.3.

2.3.3.5 Information Distribution Requirements

RPC has a requirement to receive the following information:

- Environmental Pressure
- IES requires the Rosina Pressure, Rosina Pressure Gradient and the Giada Dust Flux information messages to be delivered via Service 19 from the DMS.

The IES software has an algorithm to monitor these values and take actions to either turn off the high voltage or to autorecover and return the high voltage to nominal levels.
The safety and autorecovery mechanisms are described in detail in section 3.4.5, Instrument-Specific Failure Detection Mechanisms.

Environment Pressure may be delivered to RPC as either a periodic parameter (approx. once per minute).

The auxiliary data like

Attitude Data

- These data shall provide the position (3 coordinates) of the s/c in a convenient celestial coordinate system as well as the orientation of the s/c (2 angles). This information is needed with a temporal resolution of 1 s.
- Thruster Warnings

are distributed to RPC via the standard s/c TM.

2.3.3.6 DMS TM Packetisation Requirements

RPC has no discrete telemetry, and no specific requirements on DMS packetisation.

2.4 Budgets

2.4.1 Telemetry

		SCIENCE					
	Hk	Min	Norm	Burst	SID4	SID5	SID6
PIU	9.0	n/a	n/a	n/a	n/a	n/a	n/a
MAG	8.5	2.2	70.5	1353.0	326.5	17.6	1293.0
MIP	8.0	8.5	53.5	304.0	n/a	n/a	n/a
LAP	7.5	1.6	62.5	2253.0	n/a	n/a	n/a
IES	10.5	5.1	53.5	257.5	n/a	n/a	n/a
ICA	10.5	5.3	103.9	1027.0	272.5	803.5	154.0
Total	54.0	22.7	343.9	5194.5	599.0	821.1	1447.0

Table 2.4-1: RPC Telemetry Rates Summary

Housekeeping NB Application data includes SID word

	Sid ID	Period	No Of Link Packets	Actual Data Bit rate	Application Data	Packet Data Field Size	Total Packet Size (Packet header + data field)	ESA Packet Length	Total Data Rate
		Secs		Bit/sec	Octets	Octets	Octets	Octets	bits/s
PIU	Default	32,0	3,00	4,5	20	30	36	29	9,0
MAG	Default	32,0	2,67	4,0	18	28	34	27	8,5
MIP	Default	32,0	2,33	3,5	16	26	32	25	8,0
LAP	Default	32,0	2	3,0	14	24	30	23	7,5
IES	Default	32,0	4	6,0	26	36	42	35	10,5
ICA	Default	32,0	4	6,0	26	36	42	35	10,5
								Total Hk Data Rate	54,0

Table 2.4-2: RPC HousekeepingTelemetry Rate

Science									ESA Packets		
	Sid Name	Sid ID	Period	No Of Link Packets	Actual Data Bit rate	Application Data	Packet Data Field Size	Total Packet Size (Packet header + data	ESA Packet Length	Total Data Rate
			Secs		Bit/sec	Octets	Octets	Octets	Octets	bits/s
MAG	Min	1	1024.0	44	2.1	266	276	282	275	2.2
	Norm	2	32.0	44	66.5	266	276	282	275	70.5
	Burst	3	16.0	448	1345.0	2690	2700	2706	2699	1353.0
	Sid 4	4	32.0	215	322.5	1290	1300	1306	1299	326.5
	Sid 5	5	128.0	44	16.6	266	276	282	275	17.6
	Sid 6	6	16.0	428	1285.0	2570	2580	2586	2579	1293.0
MIP	Min	1	32.0	3	4.5	18	28	34	27	8.5
	Norm	2	32.0	33	49.5	198	208	214	207	53.5
	Burst	3	32.0	200	300.0	1200	1210	1216	1209	304.0
LAP	Min	1	1024.0	32	1.5	192	202	208	201	1.6
	Norm	2	32.0	39	58.5	234	244	250	243	62.5
	Burst	3	10.7	498	2241.0	2988	2998	3004	2997	2253.0
IES	Min	1	1024.0	106	5.0	636	646	652	645	5.1
	Norm	2	32.0	33	49.5	198	208	214	207	53.5
	Burst	3	32.0	169	253.5	1014	1024	1030	1023	257.5
ICA	Min	1	960.0	103	5.2	618	628	634	627	5.3
	Norm	2	192.0	413	103.3	2478	2488	2494	2487	103.9
	Burst	3	32.0	682	1023.0	4092	4102	4108	4101	1027.0
	Cal	4	32.0	179	268.5	1074	1084	1090	1083	272.5
	Spec	5	32.0	533	799.5	3198	3208	3214	3207	803.5
	Test	6	32.0	100	150.0	600	610	616	609	154.0
	Housekeeping					NB Application data includes SID word				

Table 2.4-3: RPC ScienceTelemetry Budget

2.4.2 Mass & Moments of Inertia

RPC Total Unit Mass : 7.5 kg
RPC Harness Mass: 1.5 kg

2.4.2.1 Sensors

Experiment Unit	Mass [Kg]	Dimensions wrt URF axes [mm]			Center of Mass wrt URF axes centered at RP [mm]			Moment of Inertia wrt URF axes centered at COM [Kgm^2]		
		X	Y	Z	X	Y	Z	Ix	Iy	Iz
RPC-1.1 (IES)	1.300	249	157	160	109.3	68.9	53.1	0.00280	0.00663	0.00637
RPC-2.1 (ICA)	2.150	257	186	171	94	-84.7	61.6	0.0067	0.01099	0.01141
RPC-3.1 (LAP Sensor 1)	0.125	50	50	280	12,4	12,4	126	0.00120	0.00120	0.000027
RPC-3.2 (LAP Sensor 2)	0.125	50	50	280	12,4	12,4	126	0.00120	0.00120	0.000027
RPC3.3 (LAP Bracket 1)	0.053	45	76	166	-2	30	68.5	0.000146	0.000135	0.000010
RPC-3.4 (LAP Bracket 2)	0.053	45	76	166	-2	30	68.5	0.000146	0.000135	0.000010
RPC-4.1 (MIP Sensor)	0.270	45	201.5	1037	-17.5	39.2	302.5	0.02690	0.02660	0.000371
RPC-5.1 (MAG Sensor 1)	0.045	48	42	38	19	17	17	9E-6	7E-6	8E-6
RPC-5.2 (MAG Sensor 2)	0.045	48	42	38	19	17	17	9E-6	7E-6	8E-6
RPC-0 Electronics of PIU,LAP, MIP &	3.280	186	256	163	80	101	80	0.02500	0.01400	0.02400
RPC-H01	0.180	1830	N/A	N/A						
RPC-H02	0.089	1435	N/A	N/A						
RPC-H03	0.094	95	400	N/A						
RPC-H04	0.120	2962	N/A	N/A						
RPC-H05	0.125	2700	N/A	N/A						
RPC-H06	0.150	3600	N/A	N/A						
RPC-H07	0,120	2495	N/A	N/A						
RPC-H08	0.140	3004	N/A	N/A						
RPC-H09	0.110	1830	N/A	N/A						
RPC-H10	0.210	3750	7	7						
RPC-H11	0.195	2295/ 2440	5-7	5-7						

Table 2.4-4: RPC Mass & Moments of Inertia

2.4.2.2 Electronic Boards

PIU: DPIU: 442g
TSU: 355g
PSU: 463g (est)

ICA: Electronicboard mass included in ICA total mass of 2150 g, outside RPC-0

LAP: N/A

IES: Electronicboard mass included in IES total mass of 1170 g, outside RPC-0

MAG: (with stiffeners,without Alu panels): 436.7 g
(with stiffeners,with Alu panels): 519.1 g

MIP: 377 g

2.4.3 RPC Power Consumption

The following 2 tables show the RPC consumed power:

RPC Power Consumption Figures during System TBTV February 2002

		LCL Current (mA @ 28V)	Power (mW)
IES	**LV**	56	1568
	HV (additive ,estimate)	30	840
ICA	**LV**	70	1960
	HV (additive, estimate)	30	840
LAP		74	2072
MIP		70	1960
MAG		30	840
PIU	**DPIU**	35	980
	PSU	35	980
	Total	**430**	**12040**

Notes LCL Current measurement not better than +- 5mA
IES/ICA HV current estimated
Current expected to increase during life due to Radiation Damage

Table 2.4-5: RPC Power Consumption (overview)

RPC Power Requirements
Issue 2 Rev 4 of 15/3/2001

	mA @ +5V		***ma @ -5V***		***mA @ +12V***		***mA @ -12V***		***mA @ +28V***		***Sec Pwr /mW***		***Pri Pwr /mW***	
Unit	*Nom.*	*Max.*	*Nom.*	*Max.*	*Nom.*	*Max.*	*Nom.*	*Max.*	*Nom.*	*Max.*	*Nom.*	*Max.*	*Nom.*	*Max.*
IES	200	200	40	40	45	45	40	40			2220	2220	2960	2960
ICA	400	462	75	75	15	28	15	27	30	30	3575	4185	4767	5580
LAP	105	170	10	10	10	35	10	10	15	18	1235	1944	1647	2592
MIP	280	300	45	45							1625	1725	2167	2300
MAG	83	86	59	62							710	740	946,7	986,7
PIU	210	235									1050	1175	1400	1567
Total mA	1278	1453	229	232	70	108	65	77	45	48				
Total mW	6390	7265	1145	1160	840	1296	780	924	1260	1344	10415	11989	13887	15985

Table 2.4-6: RPC power consumption (detailed)

Note: MIP
During each 32 s sequence (acquisition period) MIP works in two regimes:

- active regime which consumes 1645 mW (secondary)
- stand-by regime (processor idle) which consumes 1035 mW (secondary).

The duration of these two regimes inside a 32 s frame depends on the bit telemetry rate. Thus we have:

- normal or burst rate: 1625 mW (secondary)
- minimum rate: 1190 mW (secondary)

2.4.4 Non-Operational Heaters Power Consumption

PIU: A S/C controlled non-operating heater of 1.6 W. LCL-10
ICA: A S/C controlled non-operating heater of 3.5 W. LCL-41
IES: A S/C controlled non-operating heater of 0.5 W. LCL-40
A S/C controlled non-operating heater of 2.7 W. LCL-18

Refer to **Fehler! Verweisquelle konnte nicht gefunden werden.** --- Table 2.2-5.

2.4.5 S/C Powered Thermistors

ICA: One thermistor PAY430_ICA__1 (NRPAT002) located at the ICA Thermal Reference Point (TRP) shown in Figure 2.5-3.

IES: One thermistor PAY429_IES__1 (NRPAT001)

MIP: One thermistor PAY431_MIP__1 (Th1)(NRPAT003), located at the sensor Receiver 1, is monitored by the S/C (ref. to Figure 2.5-5).

Refer to **Fehler! Verweisquelle konnte nicht gefunden werden.** --- Table 2.2-5.

2.4.6 Pyro Lines

No pyro lines used for RPC.

2.5 Thermal

2.5.1 Thermal Design

2.5.1.1 Thermal Design Requirements

IES:
Thermal management of IES is accomplished using passive blankets to protect the instrument against contamination resulting from cold-trapping early in flight. To monitor IES's temperature, a total of four thermistors are employed, monitored by the Rosetta spacecraft. The non-operation temperature limits for IES are given in Table 2.5-1.
IES has no radiator, and therefore has no special requirements for radiator field-of-view. A 0.5 W non-operational heater (PL-LCL 40) is used to aid in maintaining the temperature. It is located at the top of the sensor and is controlled by means of thermistor NRPAT001, switching on if the temperature drops below -10° C and off if it subsequently rises to +5° C. A second heater (2.7 W, PL-LCL 18), inside the instrument box, switches on at 0° C. Refer to Figure 2.5-1 for the locations of thermistors and heaters.

ICA:
ICA is mounted externally on the comet facing platform. The instrument is thermally de-coupled from the spacecraft, i.e. individually controlled. The thermal design requirements are driven by temperature constraints on electronics components and the micro-channel plates. A S/C provided non-operational heater is required.

LAP:
LAP has no special thermal requirements besides those listed in Table 2.5-1.

MIP:
The sensor contains 2 preamplifiers which cannot be located in the RPC-0 electronics box without an important loss of sensitivity and bandwidth reduction. A wide range of heliocentric distances must be considered for the thermal design (0.9 to 5.2 AU non-operating, 1 to 4.1 AU operating). A model has been established with the help of the ROSETTA Project and ESTEC/SSD, to define the temperature range at the MIP sensor location. The adopted solution is to use electronics and mechanical components which support the wide range of temperatures.

MAG:
The MAG OB/IB sensors will be exposed to a wide temperature range down to about -140°C and up to +100°C. Extreme temperatures of
-180°C / +120°C can be tolerated by specific sensor material (Macor).

PIU and Sensor Common Electronics (RPC-0):
The main electronics box for the RPC package is located under spacecraft supplied blankets on the payload platform, to which it is thermally conducting. The box thermal control will therefore be dictated by the spacecraft environment.

The following table summarizes all parameters, RSDB names, Temperature Soft & Hard limits and loactions of all thermistors used by RPC. The locations of the RPC controlled sensors can be found in TICDs in section 2.5.2.5.

The locations of the s/c controlled thermistors can be found in Annex9/ Thermal and Annex9/Payload of the Spacecraft Users Manual RO-DSS-MA-1001 (RD-GEN-30).

Unit	Description	RSDB Name	powered by	TM	Condition	SOFT (Yellow) Limits		HARD (Red) Limits		Limit Name	Location
						Low	High	Low	High		
IES	PAY429-Rpc IES Temp	NRPAT001	s/c	RPC	Non OP	-35 °C	+65°C	-40 °C	+70 °C	LRP00001	Inside top end of “neck” of electron sensor board
					Operation	-25 °C	+55 °C	-30 °C	+60 °C		
IES	TCS053_IES_TRP_P-C54, RPC IES TRP	NTSA0017	s/c	s/c	NRPD0300:RV=0, Non OP	-25°C	+55°C	-30°C	+60°C	LTS00053	Back surface of IES box, not Reference Foot
					Operation	-20°C	+50°C	-25°C	+55°C		
IES	TCS054_IES_TRP_R-C54, RPC IES TRPP	NTSA0143	s/c	s/c	NRPD0300:RV=0, Non OP	-25°C	+55°C	-30°C	+60°C	LTS00054	Back surface of IES box, not Reference Foot
					Operation	-20°C	+50°C	-25°C	+55°C		
ICA	PAY430-Rpc ICA Temp	NRPAT002	s/c	RPC	Non OP	-35 °C	+55°C	-40 °C	+60 °C	LRP00002	TRP
					Operation	-25 °C	+50 °C	-30 °C	+55 °C		
ICA	Sensor Temperature	NRPD2360	RPC	RPC	NRPD0301:RV=1	-25 °C	+50 °C	-30 °C	+55 °C	LRPD2360	Sensor Top
ICA	DPU Temperature	NRPD2368	RPC	RPC	NRPD0301:RV=1	-25 °C	+50 °C	-30 °C	+55 °C	LRPD2368	Central Electronics
ICA	TCS056_ICA_TRP_P-C55, RPC IES TRPP	NTSA0018	s/c	s/c	NRPD0301:RV=0, Non OP	-35°C	+55 °C	-40 °C	+60 °C	LTS00056	Reference Foot
					Operation	-30°C	+55°C	-35°C	+60°C		
ICA	TCS057_ICA_TRP_R-C55, RPC ICA TRPP	NTSA0144	s/c	s/c	NRPD0301:RV=0 Non OP	-35°C	+55°C	-40°C	+60 °C	LTS00057	Reference Foot
					Operation	-50°C	+60°C	-55°C	+70°C		
ICA*	TCS055_ICA_STP-C86 ?#55 Thrurter12 HT1 H381	NTSA0084	s/c	s/c							STP nearby Structure
LAP	TCS096_LAP2_STP-C58	NTSA0210	s/c	s/c	TRUE	-130°C	+90°C	-150°C	+100°C	LTS00096	STP on Boom-Z

LAP	TCS058_LAP1_STP-C86	NTSA0021	s/c	s/c	TRUE	-130°C	+90°C	-150°C	+100°C	LTS00058	STP on Boom +Z
LAP	Processor Temperature	NRPD3360	RPC	RPC	NRPD0303:RV=1	-300°C	+80°C	-300°C	+110°C	LRPD3350	LAP Electronics
MIP	PAY431-Rpc MIP Temp	NRPAT003	s/c	s/c	TRUE	-130 °C	+90°C	-160 °C	+100 °C	LRP00003	Antenna, R1
MIP	Thermistor #2, NRPA4370	NRPD4370/MSB NRPD4378/LSB	RPC	RPC	NO LIMITS associated with this thermistor						Antenna, R2
MIP	TCS059_MIP_STP-C56	NTSA0019	s/c	s/c	TRUE	-130 °C	+90°C	-150 °C	+100 °C	LTS00059	STP on boom
MAG	TEMP1 (OB-Sensor)	NRPA5320	RPC	RPC	NRPD0305:RV=1	-130 °C	+75°C	-145 °C	+95 °C	LRPA5320	Inside OB-Sensor
MAG	TEMP2 (IB-Sensor)	NRPA5330	RPC	RPC	NRPD0305:RV=1	-130 °C	+75°C	-145 °C	+95 °C	LRPA5330	Inside IB-Sensor
MAG	TCS062_MAGIB_STP-C57	NTSA0020	s/c	s/c	TRUE	-75 °C	+60°C	-75 °C	+70°C	LTS00062	STP on boom, at IB Sensor
PIU	PSU TEMPERATURE	NRPD0306	RPC	RPC	NRPD038F:RV=1	-35 °C	55 °C	-40°C	85 °C	LRPD0306	on PIU - PCB
PIU	TCS051_RPCEL_TRP_P-C53, RPC PIU TRPP	NTSA0016	s/c	s/c	Non OP	-25°C	55°C	-30 °C	60 °C	LTS00051	Reference Foot
					Operation	-20°C	55°C	-25°C	60°C		
PIU	TCS052_RPCEL_TRP_R-C53	NTSA0142	s/c	s/c	Non OP	-25°C	55°C	-30 °C	60 °C	LTS00052	Reference Foot
					Operation	-20°C	55°C	-25°C	60°C		

Table 2.5-1: Overview of RPC related Thermistors & Temperature Limits.

The MIP Thermistor #2 is asscociated with the parameter NRPA4370. This splits up in the detailed parameters NRPD4370 for the MSB and NRPD4378 for the LSB.

* Neither on RPC-ICA side nor on ESOC side consistent information for TCS055_ICA_STP-C86 / NTSA0084 does exist.
It might be possible that this entry is still an relict from the EM Database.

2.5.1.2 Thermal Design Description

IES:
The thermal design of the IES is based on a totally passive thermal maintenance approach. Since the operating temperature range of the instrument is so broad, it presents no special thermal problem. The sensor is covered with thermal blankets except for the entrance aperture. Conduction through the mechanical interface to the spacecraft provides a large thermal capacitance to the sensor's design. We do not require any radiator surfaces since the instrument draws so little power and can sink heat into the structure of the spacecraft or dissipate through the exposed aperture. A small survival heater (PL-LCL-40) of approximately 0.5 W is sufficient to protect the instrument during periods of dormancy. This heater is switched on when the temperature gets down -10°C, well before it gets near the cold limit. However, the temperature shall not get too high, so the heater will turn off when the temperature warms up to -5 C.
Remark: The project was confused by this behaviour because they thought IES tries to control the temperature within the very narrow 5 deg band, which might cause many on/off cycles. But that is not the intention of this implementation. Finally there was an agreement with all concerned (including Paolo Ferri) that IES is allowed to keep this scheme.

The second part, the main electronics box, is in thermal contact with the+Z deck and carries 2 TRP thermistors (TCS053_IES, TCS054_IES) on the back surface. The box also has a 2.7 W heater (PL-LCL-18) on the surface as well as 2 thermostats that control the heaters. The thermostats turn on at 0 C. This arrangement is supposed to take care of maintaining the temperature of the electronics box.

ICA:
ICA is an individually controlled instrument. ICA is covered by electrically conducting MLI except for the aperture opening and a radiator surface to space. ICA is thermally de-coupled from S/C by using 10 mm high fibreglass isolators attache to the four mounting feets. A non-operatinal heater of 2.7 W is used to keep the instrument above the non-operational temperature limit when ever it is switched off.

LAP:

Tests were used to verify that all electronics and mechanical parts are within their specified temperature ranges. Temperature ranges for the LAP units are specified in section 2.5.1.

MIP:
The MIP sensor is thermally and electrically insulated from the boom. Due to the weak power dissipated by the sensor electronics, the thermal exchange is always from the spacecraft to the sensor. MIP requires one spacecraft powered thermistor to measure the sensor temperature when PIU is off, and one experiment powered thermistor working when PIU is on. To simplify and to save mass and cables, no redundant thermistor is required.

MAG:
The MAG sensors are located on the MAG/LAP boom in the anti-comet direction (lower boom). For better thermal conductivity the baseplate is made of CFC in order to cope with the internal 50 mW power dissipation. The calibrated temperature range is –160 to +120 °C using extrapolation and flight calibration techniques.
The sensor assembly is made of MACOR with little mass of copper and sensor core magnetic material and a cover made of LEXAN. The heat capacity can be determined by the mass of the sensor structure (12 g) and its specific heat of 1.47 J/gK and the cover (10 g) with a specific heat of 1.17 J/gK. The power dissipation in the sensor is 50 mW each with small variations. The thermal design of the sensors is dominated by conductive heat loss through the 3 feet (total area is 0.6 cm^2) and a factor 20 higher heat loss through the harness consisting of 16 wires (1.2 mm^2 total, thermal conductivity 380 W/mK, copper), and by the radiative and conductive heat loss to the CFC mounting bracket. An experiment powered thermistor (PT 1000) is built into each sensor with a range from -180 °C to +120 °C. Due to the very small size, the MLI for the RPC-5.1 & RPC-5.2 sensors are provided by the s/c. The harness along the outer boom and the sensor feet (bottom, bracket) is covered by the S/C provided boom MLI (assuming an α=0.41 and ε=0.5). The maximum and minimum solar radiation input onto the sensors can be estimated to be: 2 W at 0.9 AU and only 0.06 W at 5.2 AU each. The heat capacity for each sensor is 29.3 J/K. The total protruding surface (without bottom) of each sensor is 61cm^2 MLI.

RPC-0:
The RPC Main Electronics Box, being conductively and radiatively coupled to the spacecraft structure, is collectively controlled.

2.5.1.3 Thermal Control Category

Experiment Unit	Category
RPC-0 (Complete Box)	Collectively Controlled
RPC-1.1 (IES)	Collectively Controlled
RPC-2.1 (ICA)	Individually Controlled
RPC-3.1 (LAP)	Individually Controlled
RPC-3.2 (LAP)	Individually Controlled
RPC-3.3 (LAP Bracket)	Individually Controlled
RPC-3.4 (LAP Bracket)	Individually Controlled
RPC-4.1 (MIP)	Individually Controlled
RPC-5.1 (MAG)	Individually Controlled
RPC-5.2 (MAG)	Individually Controlled

Table 2.5-2: Thermal Control Category

2.5.2 Thermal Interfaces

2.5.2.1 Conductive Interface

IES:
IES has a thermally conductive interface to the S/C through the mounting feet.The conductive interface of the harness is 18 AWG 26 wires of 1.8 m.

ICA:
ICA has 10 mm high fibreglass insulators between S/C platform and the mounting feet to keep the conductive coupling to a minimum.
The conductive interface of the harness is 18 wires of 8.6 mm^2 cross-section including shielding.

LAP:
Each LAP sensor has a thermally conducting interface to the top of the boom through the sensor mounting feet.
The conductive interface of the harness is 1 Triax cable of 1.1 mm^2 for the probe and 10 mm^2 for the stub.

MIP:
The conductive I/F of the MIP RPC-4.1 sensor is 7 wires of 0.14 mm^2 cross-section each. The bracket is thermally and electrically isolated from the boom.

MAG:
The conductive interface of each MAG sensor is 16 wires of cross-section 1.2 mm^2 each sensor. The interface to the boom is conductive through the CFC base plate.

RPC-0:
The conductive interface of the RPC-0 box is as follows:

- Five mounting feet, total area 21.6 cm^2. The foot thickness is 4mm.
- 52 wires interfacing to the spacecraft via AWG 28.

Conduction through the box feet are less than 0.5 Wcm^{-2}. The mating faces of the feet is not anodised.

2.5.2.2 Radiative Interface

IES:

The bottom face of the IES box faces the S/C platform. This face of the box is surface treated with optical black DOW 9 on magnesium. The IES aperture does not directly face any S/C platform surfaces. The remainder of the IES instrument is covered with MLI to reduce radiative coupling.

See Table 2.3-15 to Table 2.5-22.

ICA:
The radiator on the ICA cylinder is facing away from the S/C (towards space) and will thus not provide any radiative coupling

See Table 2.5-23 to Table 2.5-30.

LAP:
See Table 2.5-31 to Table 2.5-36.

MIP:
See Table 2.5-37 to Table 2.5-42.

MAG:
See Table 2.5-43 to Table 2.5-49.

RPC-0:
The RPC-0 box is black anodised Aluminium with an area of 2200 cm^2.
See Table 2.5-10 to Table 2.5-14.

2.5.2.3 Heaters

IES:	0.5 W non-operation S/C powered on the TopHat, 2.7 W on the electronics box s/c powered (operation or non-operational) to maintain TRP. PAY429_IES_1
ICA:	2.7 W s/c powered non-operational heater. PAY430_ICA_1.
MIP, LAP, MAG:	No heaters.

2.5.2.4 Coatings and Finishes

IES:
The housing exterior surface finish is a gold plate over magnesium. This is a low emissivity finish (0.11). In addition, multilayer insulation blankets cover all exposed surfaces of IES exclusive of aperture clear field of view. The exposed aperture is finished with high emissivity ($\varepsilon = 0.73$) Ebanol C black.

ICA:

ICA surface	Area [m^2]	Coating
Bottom of the electronics box, facing the s/c platform	0.023	Electrically conducting MLI
Elevation analysers	0.018	Dag 213.
+x cylinder end	0.011	PCB-Z
All other ICA surfaces	0.11	Electrically conducting MLI

Table 2.5-3: ICA Coating

LAP:
The LAP spheres and stubs have a TiN surface with a small exposed area of Vespel for electrical insulation. The foot (bracket for sensor interface to boom) is made of Al with Alodine coating. The equilibrium temperature at Earth orbit is expected to be below 129 C.

MIP:
CRFP boom for sensor and lower antenna stub, sandblasted Al for antenna tips.

MAG:
Lexan housing with thermal blankets. The baseplate is made of CFRP.

RPC-0:
The RPC-0 surface finish is Black-Anodised Aluminium.

2.5.2.5 Thermal Interface Control Drawing

IES: ref. Figure 2.5-1

ICA: ref.Figure 2.5-3.

LAP: ref.Figure 2.5-4.

MIP: ref. Figure 2.5-5.

MAG: ref. Figure 2.5-6.

RPC-0: ref. MICD Figure 2.1-2.

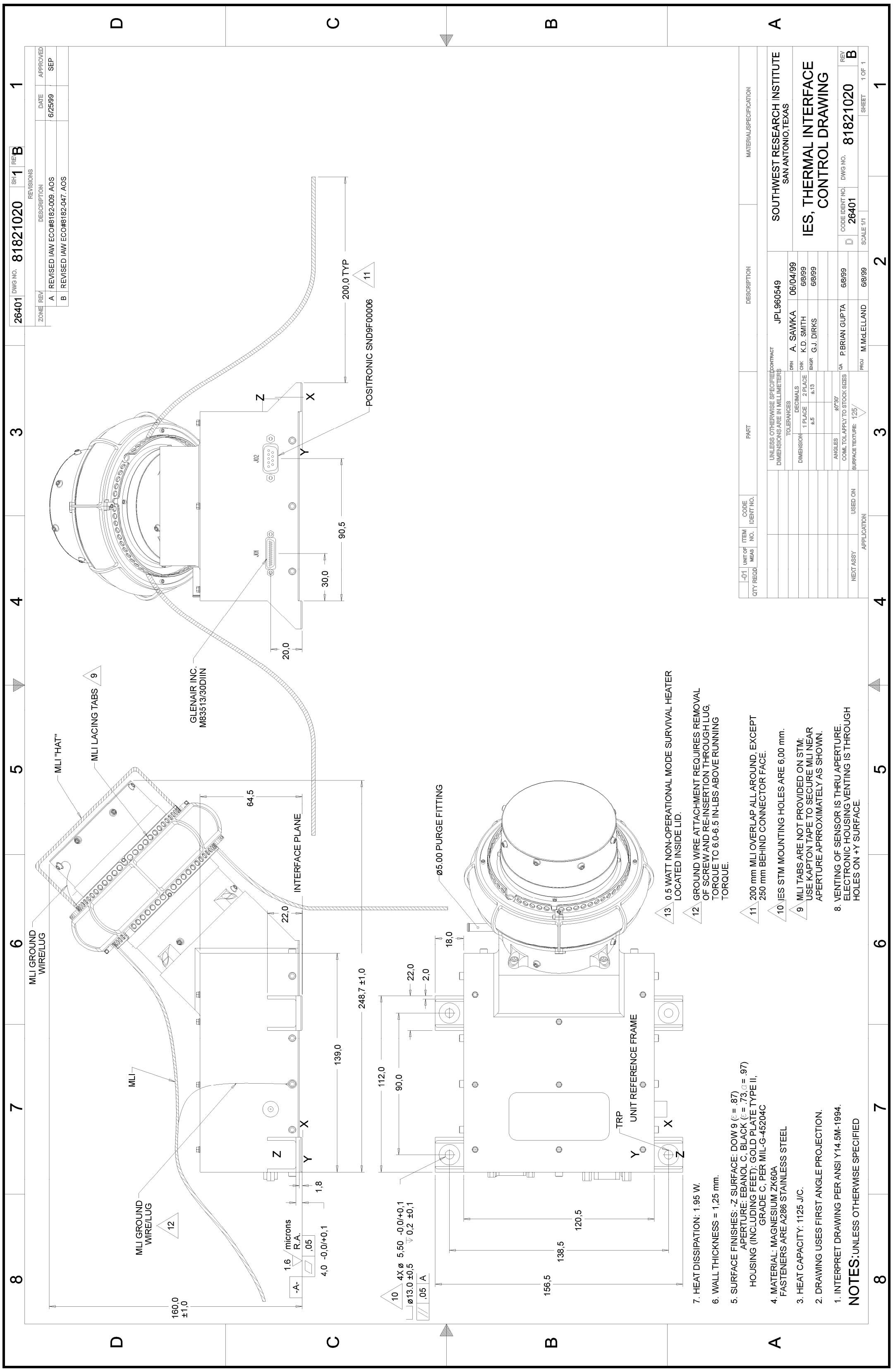


Figure 2.5-1: Thermal Interface Control Drawing for IES

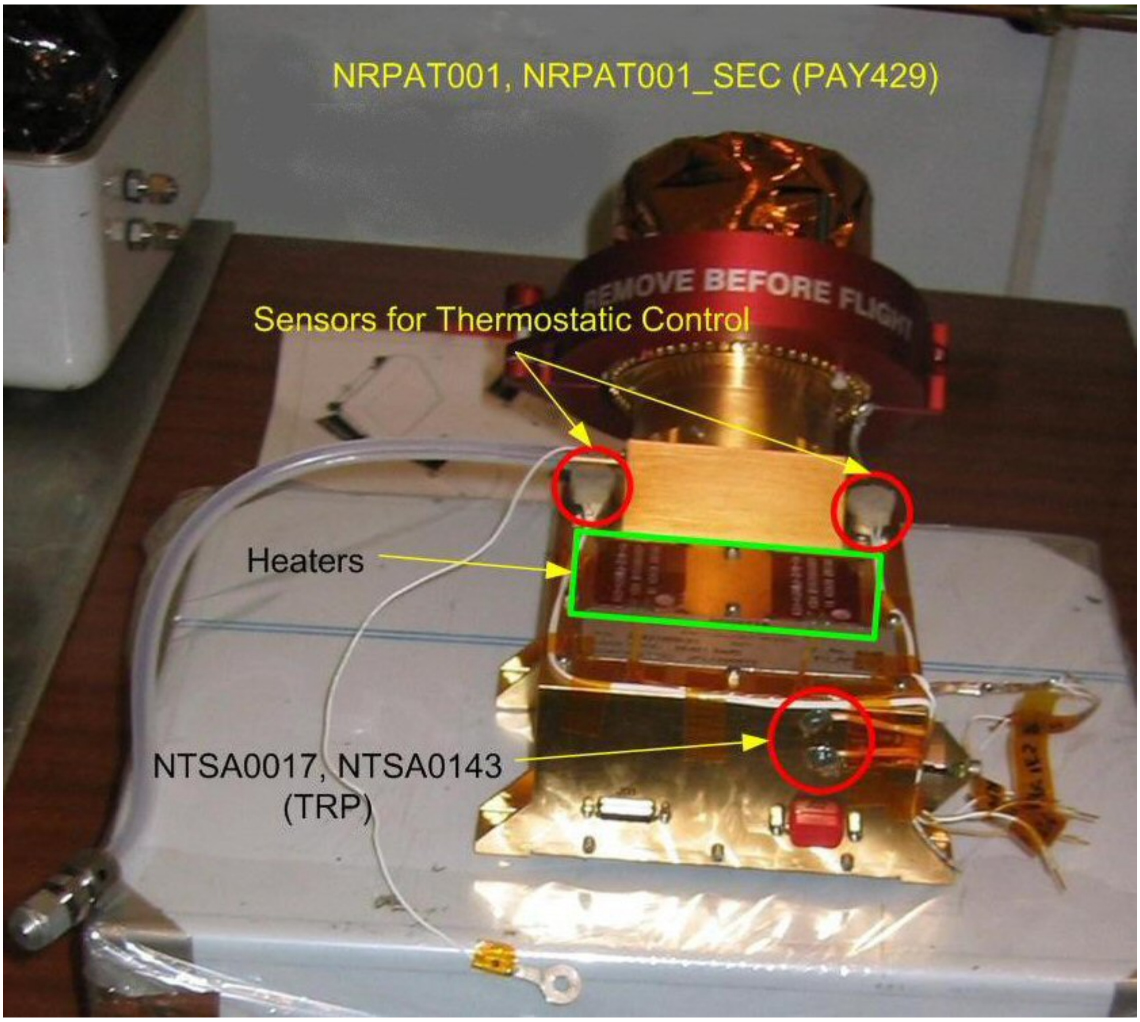


Figure 2.5-2: IES sensor (at CSG Kourou) with labeled Thermistors.

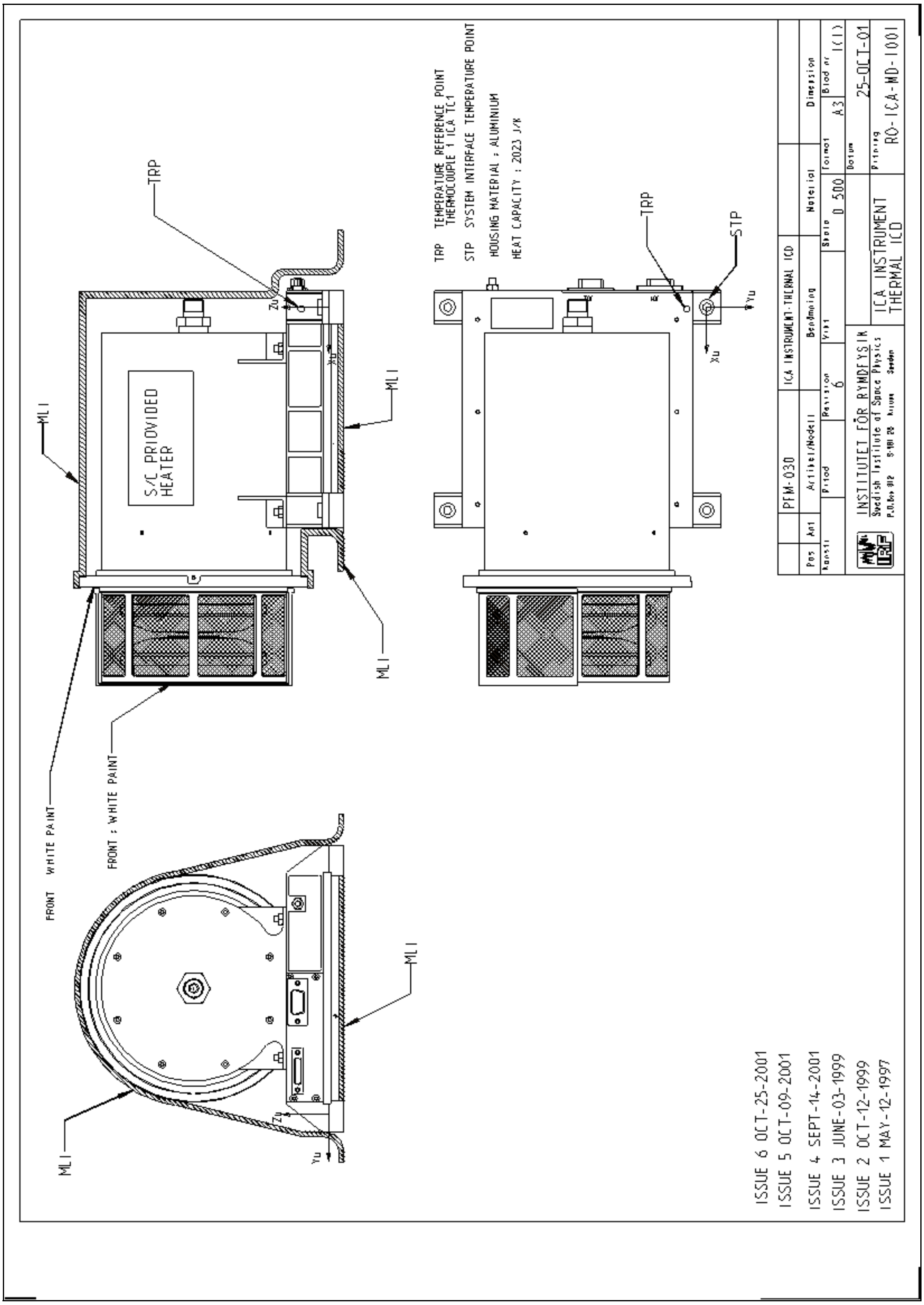


Figure 2.5-3: Thermal Interface Control Drawing for ICA

The ICA Thermistor PAY430_ICA (NRPAT002) is located at the indicated TRP.

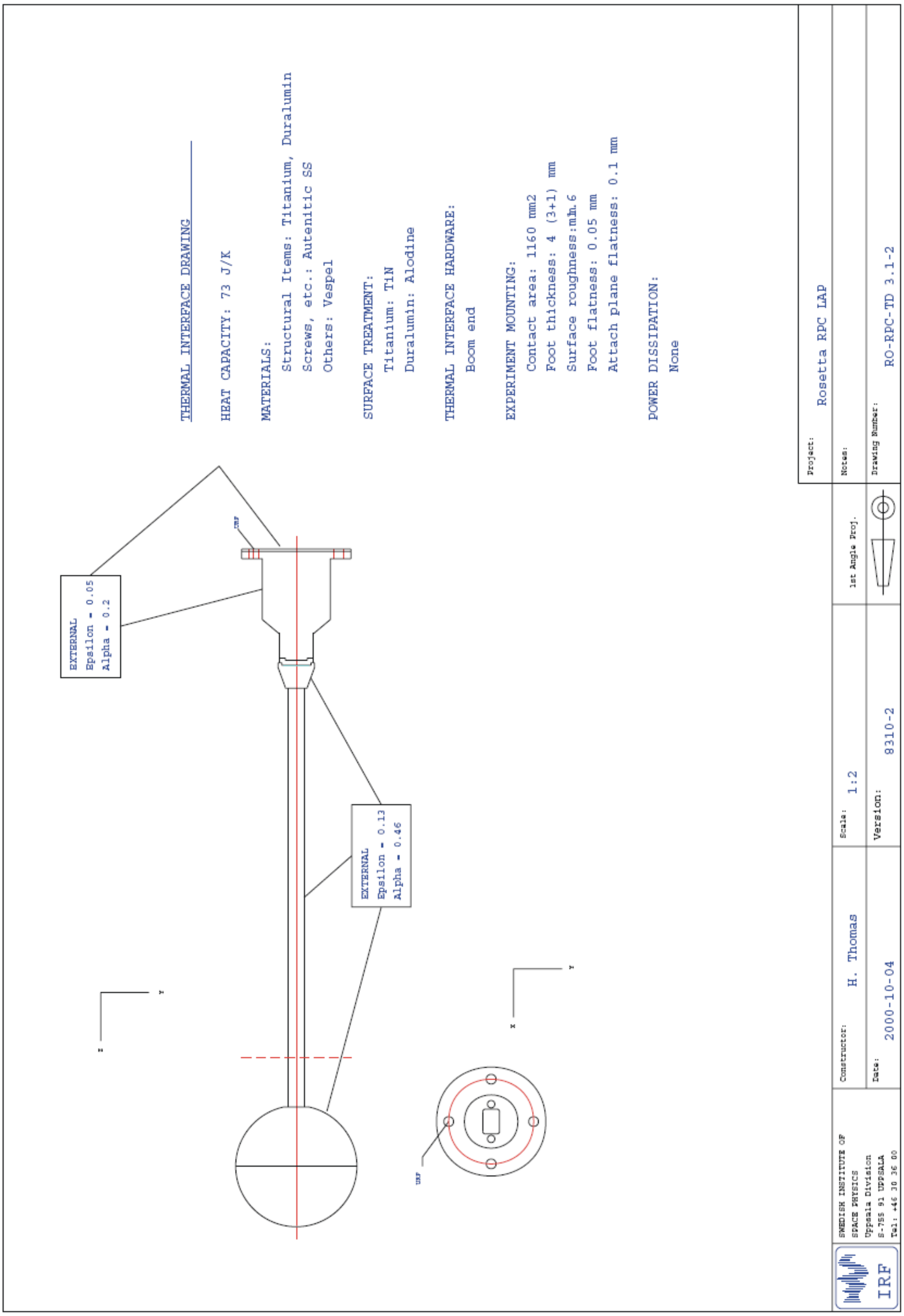


Figure 2.5-4: Thermal Interface Control Drawing for LAP

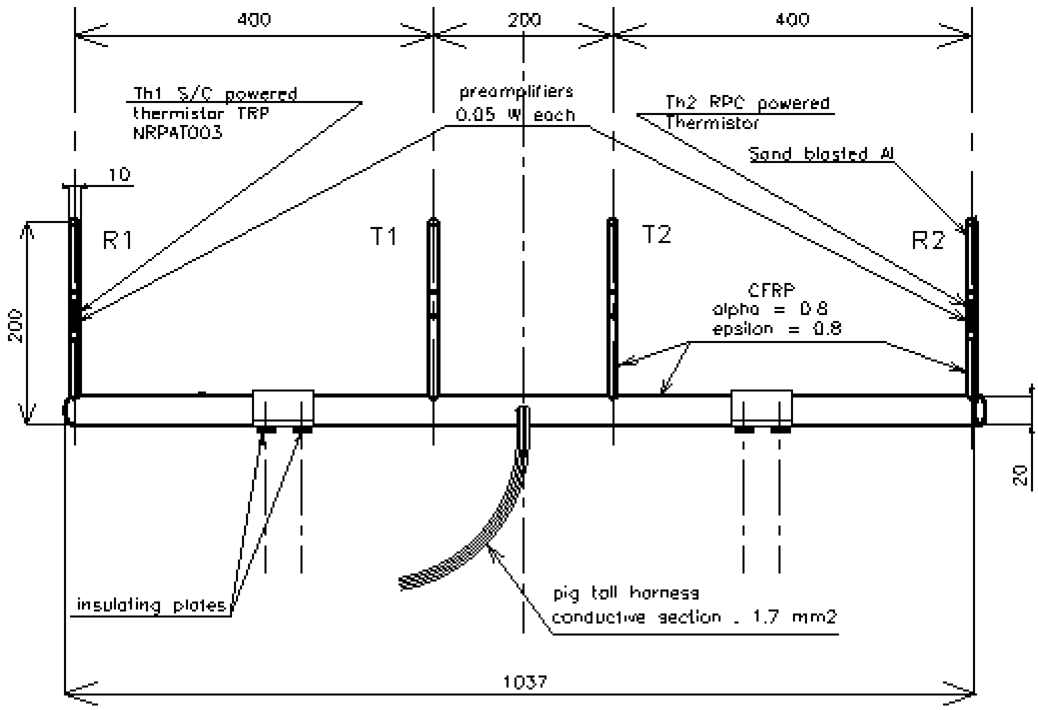


Figure 2.5-5: Thermal Interface Control Drawing for MIP

The two thermistors are shown at the left (NRPAT003, S/C-powered) and at the right side (NRPD4370 /MSB, NRPD4378 / LSB, RPC-powered) in the middle of R1 and R2.

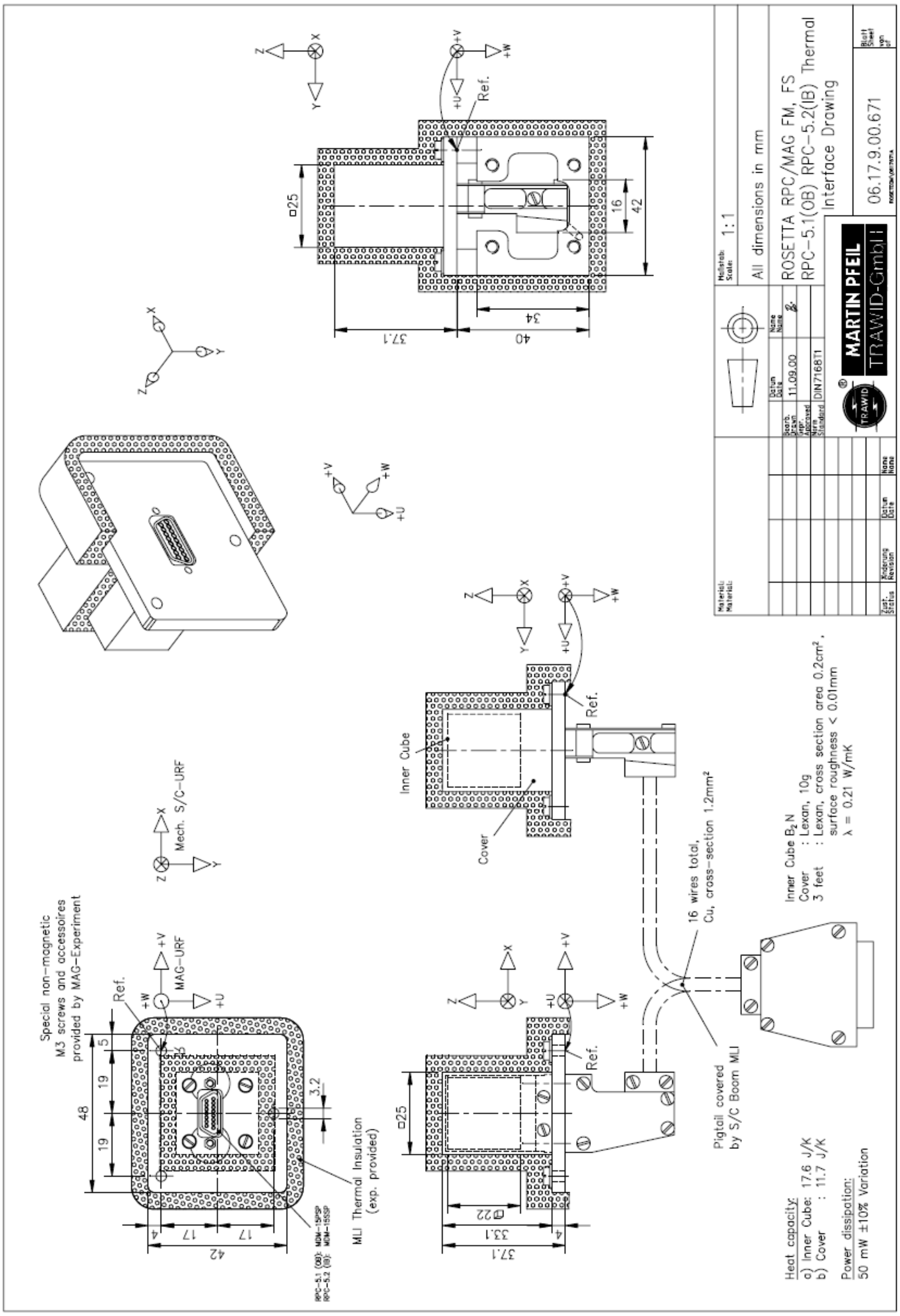


Figure 2.5-6: Thermal Interface Control Drawing for MAG

The MAG Thermistors are located in the middle of the lower part of front side of each sensor. It can be seen below the “M” of “FM-MAG” in the following picture. There is one thermistor for the OB (NRPA5320) and one for the IB (NRPA5330) sensor.

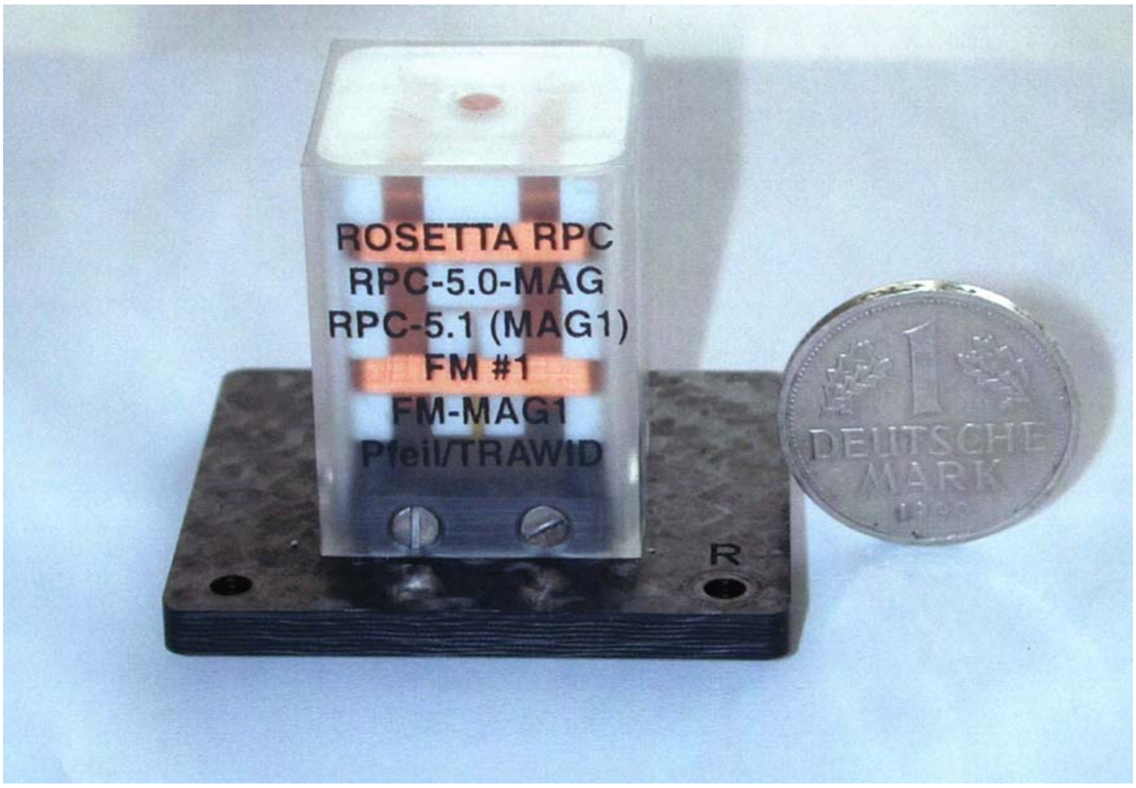


Figure 2.5-7: MAG Sensor with Thermistor
(located at the bottom of the front side behind the “M” of “-MAG1”)

2.5.3 Temperatures and Thermal Control Budget

2.5.3.1 Temperatures Ranges

The RPC Temperatures Ranges are listed in Table 2.5-4 (temperatures are referred to the TRP at the interface to the S/C).

Experiment Unit	Operating Temperature		Non-operating Temperature		Switch-on Temperature	
	Min	max	Min	Max	min	max
RPC-0	-30 ºC	65 ºC	-40 ºC	65 ºC	-30 ºC	55 ºC
RPC-1.1	-30 ºC	60 ºC	-40 ºC	70 ºC	-25 ºC	55 ºC
RPC-2.1	-30 ºC	55 ºC	-45 ºC	60 ºC	-30 ºC	50 ºC
RPC-3.1	-190 ºC	250 ºC	-190 ºC	250 ºC	-190 ºC	250 ºC
RPC-3.2	-190 ºC	250 ºC	-190 ºC	250 ºC	-190 ºC	250 ºC
RPC-4.1	-130 ºC	100 ºC	-160 ºC	100 ºC	-160 ºC	100 ºC
RPC-5.1	-160 ºC	120 ºC	-180 ºC	150 ºC	-150 ºC	100 ºC
RPC-5.2	-160 ºC	120 ºC	-180 ºC	15 ºC	-150 ºC	100 ºC

Table 2.5-4: TRP temperature range, space environment

2.5.3.2 Heater Power Requirements

Experiment Unit	Power (W)
IES ICA	0.5+2.7* 2.7

Table 2.5-5: RPC Heater Power Requirements

*S/C also provided a second heater to ensure IES temperature range.

2.5.3.3 Heat Exchange Budget

Phase 1 is at 0.9 AU, Phase 2 is at 5.3 AU;
Mode 1 is ON, Mode 2 is OFF.

Experiment Unit	**Mission Phase 1 Heat Exchange [W]**						**Mission Phase 2 Heat Exchange [W]**					
	Mode 1		**Mode 2**		**Mode 3**		**Mode 1**		**Mode 2**		**Mode 3**	
	cond	**rad**	**Cond**	**rad**	**cond**	**Rad**	**cond**	**rad**	**cond**	**rad**	**cond**	**rad**
RPC-0	7.3**	0	0	0			7.3**	0	0	0		
RPC-1.1(***)												
RPC-2.1 (*)	2.46	0.03	-0.55	-0.01			1.86	0.02	-1.34	-0.02		
RPC-3.1	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A		
RPC-3.2	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A		
RPC-4.1	0.05	TBD	0.05	TBD			0.1	TBD	0.15	TBD		
RPC-5.1	0.05	2	0	2			0.05	0.05	0	0.05		
RPC-5.2	0.05	2	0	2			0.05	0.05	0	0.05		

(*) Mission Phase 1: ICA in full sun and TRP at +50ºC
Mission Phase 2: ICA in shadow and TRP at - 30ºC
(**) Long term average operating heat exchange.
Peak dissipation of 7.3 W corresponds to highest power mode for RPC

Table 2.5-6: Heat Exchange

2.5.3.4 Temperature Monitoring

Experiment Unit	S/C Powered Thermistors	Temperature Range	Location
ICA	1	-50 to 90ºC	RPC-2.1
IES	1	-50 to 90ºC	RPC-1.1
LAP	0	N/A	RPC-3.1
LAP	0	N/A	RPC-3.2
MIP	1	-50..+90°C	RPC-4.1
MAG	0	N/A	RPC-5.1
MAG	0	N/A	RPC-5.2
PIU	0	TBD	RPC-4.1

Table 2.5-7: Temperature Sensors (s/c powered thermistors)

Experiment Unit	Experiment Powered Thermistors	Temperature Range	Location
ICA	2	-50 to 70°C	RPC-2.1
IES	3	-50 to 90°C	RPC-1.1
LAP	0	N/A	RPC-3.1
LAP	0	N/A	RPC-3.2
MIP	1	-50 to +90°C	RPC-4.1
MAG	1	-150 to +150°C	RPC-5.1
MAG	1	-150 to +150°C	RPC-5.2
PIU	1	TBD	RPC-6.0

Table 2.5-8: Temperature Sensors (RPC internal sensors)

2.5.4 Mathematical Model

2.5.4.1 Thermal Mathematical Model

Experiment Unit	No. Of Nodes in Design TMM	No. Of Nodes in InterfaceTMM
RPC-0 (PIU)	1	1
RPC-1.1 (IES)	5	5
RPC-2.1 (ICA)	17	10
RPC-3.1 (LAP)	3	3
RPC-3.2 (LAP)	3	3
RPC-3.3 (LAP Bracket)	N/A	N/A
RPC-3.4 (LAP Bracket)	N/A	N/A
RPC-4.1 (MIP)	7	6
RPC-5.1 (MAG)	3	1
RPC-5.2 (MAG)	3	1

Table 2.5-9: TMM Nodes

2.5.4.2 Interface Thermal Mathematical Models

2.5.4.2.1 PIU: RPC-0

(ref. RPC_8 in RD-GEN-31)

Node (-)	Name (-)	Material (-)	Thermal Finish (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50740	Electronic	Al alloy 6061	ban colinal 3100	-	-	-	0.85	0.15	-

Table 2.5-10: PIU BOL / EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m^2)	MCp (J/K)	Non-Op. Heater	TRP location
50740	Electronic	Al alloy 6061	0.220	2453.	HT	TRP

Table 2.5-11: PIU Node Properties

Node	Op.	Non-Op.	Op. Stab.	Switch-On

(-)	(°C)	(°C)	(°C/h)	**(°C)**
50740	-20 / +55	-30 / +60	-	-30 / +50

Table 2.5-12: PIU TRP Design Temperature Ranges

		BOL		**EOL**	
Mode (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)	**Op. QI** (W)	**Non-Op. QR** (W)
min/max	50740	2.3 / 9.4 (*)	S/C	2.3/9.4 (*)	S/C
1 AU w. c.	50740	-	-	5.	-

R (50740) = S/C Ω
(*) typically 7.3 W

Table 2.5-13: PIU Power Dissipations

Type (-)	**Number** (-)	**Ac** (cm^2)	**Node** (-)	**Conductive I/F Node** (-)
5 feet - 5*M4	5	5 * 3.36	50740	60740

Table 2.5-14: PIU Interface Contact Conductances

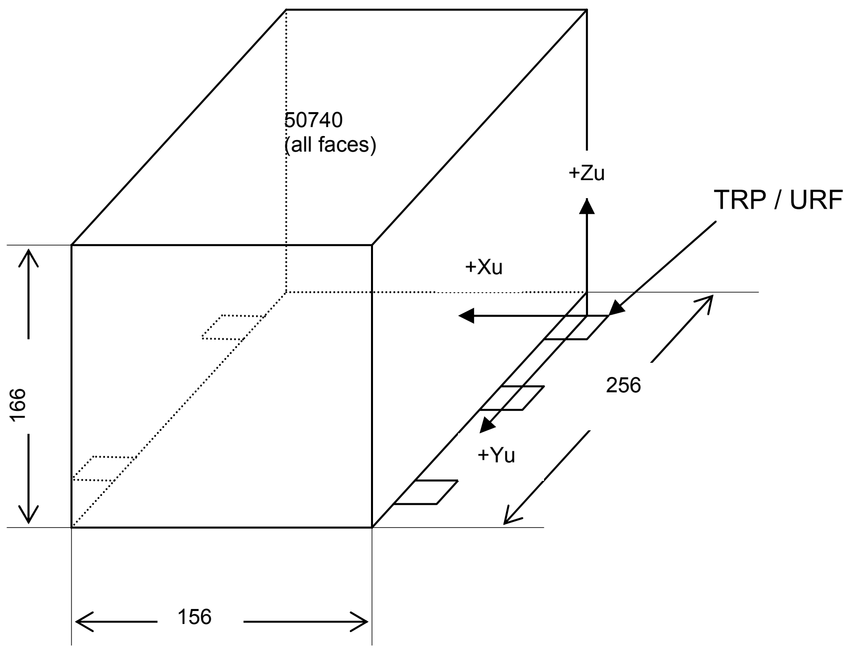


Figure 2.5-8: PIU Electronic Thermal Sketch

2.5.4.2.2 IES: RPC-1.1

(ref. RPC_2 in RD-GEN-31)

Node (-)	**Name** (-)	**Material** (-)	**Thermal Finish** (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50620	foot	Mg alloy ZK80A	Au plated	0.23	0.77	-	0.03	0.97	-
50623	aperture	Mg alloy ZK80A	ebanol C black	0.97	0.03	-	0.73	0.27	-
50625	MLI DPU	MLI	vka (*	0.41	0.59	-	0.72	0.28	-
50625	MLI ion	MLI	vka (*	0.41	0.59	-	0.72	0.28	-
50625	MLI electron	MLI	vka (*	0.41	0.59	-	0.72	0.28	-
50625	MLI top	MLI	vka (*	0.41	0.59	-	0.72	0.28	-

(*2 2 mils VDA kapton ITO

Table 2.5-15: IES BOL Surface Properties

Node (-)	**Name** (-)	**Material** (-)	**Thermal Finish** (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50620	foot	Mg alloy ZK80A	Au plated	0.23	0.77	-	0.03	0.97	-
50623	apertureMLI	Mg alloy ZK80A	ebanol C black	0.97	0.03	-	0.73	0.27	-
50625	DPU	MLI	vka (*	0.55	0.45	-	0.72	0.28	-
50625	MLI ion	MLI	vka (*	0.55	0.45	-	0.72	0.28	-
50625	MLI electron	MLI	vka (*	0.55	0.45	-	0.72	0.28	-
50625	MLI top	MLI	vka (*	0.55	0.45	-	0.72	0.28	-

(*2 2 mils VDA kapton ITO

Table 2.5-16: IES EOL Surface Properties

Node (-)	**Name** (-)	**Material** (-)	**A** (m^2)	**mCp** (J/K)	**Non-Op. Heater**	**TRP location**
50620	foot	Mg alloy ZK80A	0.0168	45.	-	TRP
50621	DPU	Mg alloy ZK80A	0.0361	750.	HT	-
50622	ion	Mg alloy ZK80A	0.0254	130.	-	-
50623	aperture	Mg alloy ZK80A	0.0053	30.	-	-
50624	electron	Mg alloy ZK80A	0.0164	130.	HT	-
50625	MLI	kapton	0.0779	40.	-	-

Table 2.5-17: IES Node Properties

Node (-)	**Op.** (°C)	**Non-Op.** (°C)	**Op. Stab.** (°C/h)	**Switch-On** (°C)
50620	-20 / +50	-30 / +60	-	-20 / +50

Table 2.5-18: IES TRP Design Temperature Ranges

		BOL / EOL	
Mode (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)
science	50621	1.62	S/C
	50624	0.23	0.5 (max)

R (50620)= S/C Ω

Table 2.5-19: IES Power Dissipations

Node i (-)	**Node j** (-)	**GL** (W/K)
50620	50621	2.30
50621	50622	0.48
50622	50623	0.17
50623	50624	0.17

Table 2.5-20: IES Internal Conductive Couplings

Node i (-)	**Node j** (-)	**GR** (m^2)
50621	50625	0.0011
50622	50625	0.0008
50624	50625	0.0005

NOTE: coupling between 50620 -Zu face and S/C has to be calculated by the S/C with the optical properties taken from Table 2.3.4.2.2-1.1

Table 2.5-21: IES Internal Radiative Couplings

Type (-)	**Number** (-)	**Ac** (cm^2)	**Node** (-)	**Conductive I/F Node** (-)
4 feet - 4*M5	4	4 * 3.1	50620	71066

Table 2.5-22: IES Interface Contact Conductances

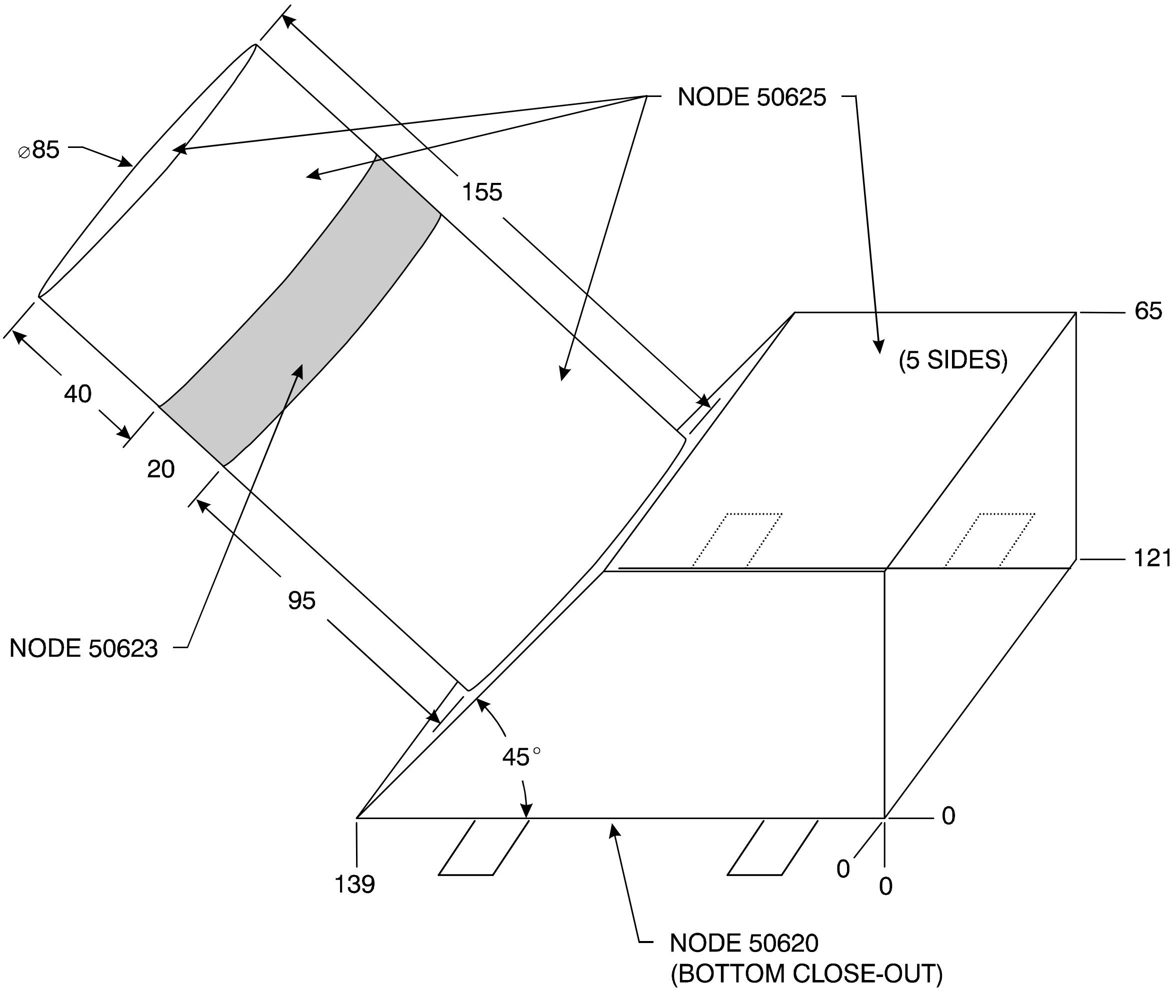


Figure 2.5-9: IES Thermal Sketch

2.5.4.2.3 ICA: RPC-2.1

Node (-)	Name (-)	Material (-)	Thermal Finish (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50600	Sensor structure	Al 6062	Dag213	0.89	0.11	-	0.91	0.09	-
50601	Elevation analysers	Al 6062	misc	0.35	0.65	-	0.77	0.23	-
50606	Sensor MLI	MLI	bka	0.85	0.15	-	0.81	0.19	-
50607	MLI Electronics box	MLI	bka	0.85	0.15	-	0.81	0.19	-
50608	Radiator	Al 6062	PCB-Z	0.23	0.77	-	0.80	0.20	-

Table 2.5-23: ICA BOL Surface Properties

Node (-)	Name (-)	Material (-)	Thermal Finish (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50600	Sensor structure	Al 6062	Dag 213	0.89	0.11	-	0.91	0.09	-
50601	Elevation analysers	Al 6062	misc	0.35	0.65	-	0.77	0.23	-
50606	Sensor MLI	MLI	bka	0.79	0.21	-	0.81	0.19	-
50607	MLI Electronics box	MLI	bka	0.79	0.21	-	0.81	0.19	-
50608	Radiator	Al 6062	PCB-Z	0.31	0.69	-	0.80	0.20	-

Table 2.5-24: ICA EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m²)	mCp (J/K)	Non-Op. Heater	TRP Location
50600	Sensor structure	Al 6062	0.00259	61.4	-	-
50601	Elevation analysers	Al 6062	0.002	8.4	-	-
50602	Sensor housing	Al 6062	-	913	HT	-
50603	Sensor electronics	Misc.	-	420.8	-	-
50604	DPU electronics	Misc.	-	310	-	-
50605	DPU electronics box	Al 6062	-	320.4	-	TRP
50606	Sensor MLI	MLI	0.0216	97.5	-	-
50607	MLI DPU Electronics box	MLI	0.0075	45.8	-	-
50608	Radiator	Al 6062	-	49.8	-	-
50609	Ring	Al 6062	-	954	-	-

Table 2.5-25: ICA Node Properties

Node (-)	Op. (°C)	Non-Op. (°C)	Op. Stab. (°C/h)	Switch-On (°C)
50605	-30 / +55	-45 / +60	-	-30 / +50

Table 2.5-26: ICA TRP Design Temperature Ranges

		BOL / EOL	
Mode (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)
min/max	50603	2.2	-
	50604	2.01	-
	50605	-	S/C

Table 2.5-27: ICA Power Dissipations

Node i (-)	Node j (-)	GL (W/K)
50600	50601	0.054
50600	50608	0.20
50602	50609	0.20
50602	50603	0.287
50602	50605	1.69
50602	50606	0.00755
50602	50608	0.55
50605	50604	0.20
50605	50607	0.00315

Table 2.5-28: ICA Internal Conductive Couplings

Node I (-)	Node j (-)	GR (m^2)
50600	50601	1.00e-10/5.67e-8
50601	50608	1.16e-10/5.67e-8
50602	50609	2.48e-10/5.67e-8
50602	50603	8.67e-10/5.67e-8
50602	50605	7.17e-10/5.67e-8
50600	50609	0.80e-12/5.67e-8
50605	50604	38.30e-10/5.67e-8
50606	50607	1.24e-10/5.67e-8

Table 2.5-29: ICA Internal Radiative Couplings

Node i (-)	Node j (-)	GL (W/K)
50605	S/C	0.058

Table 2.5-30: ICA Interface Coductive Couplings

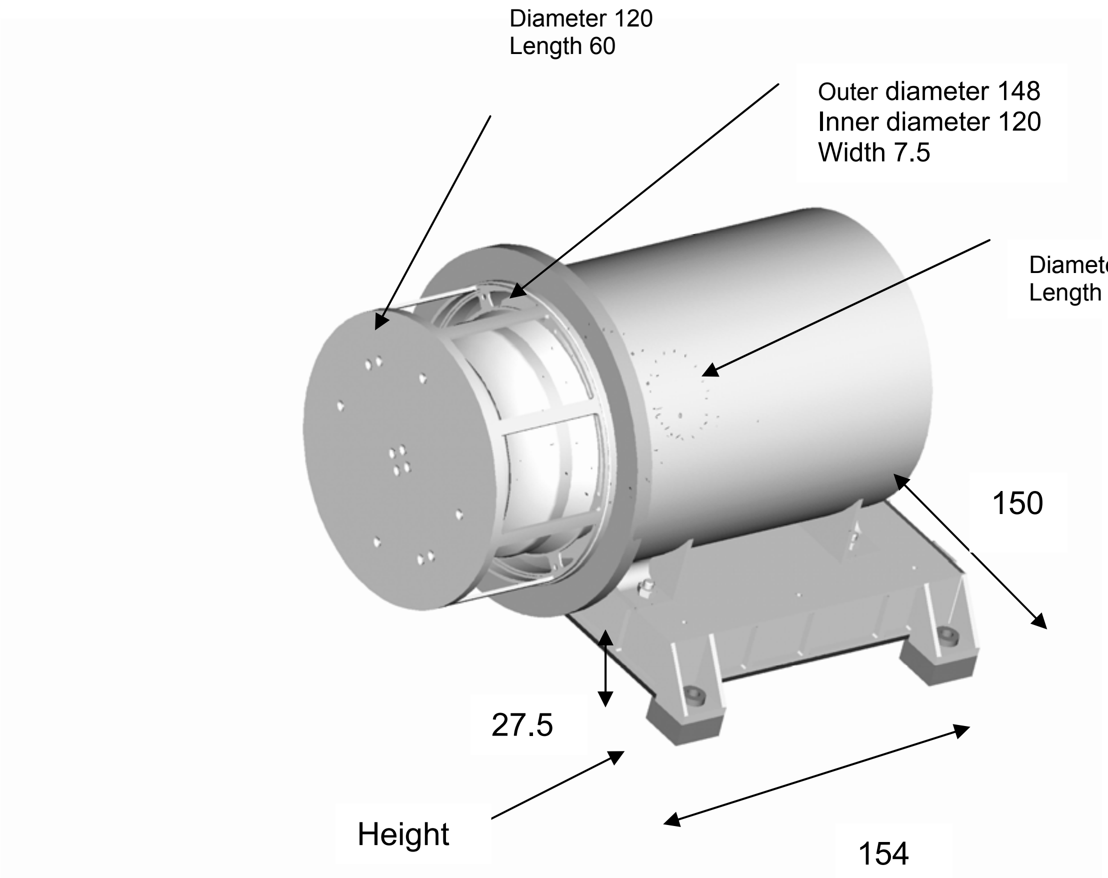


Figure 2.5-10: ICA Main Dimensions

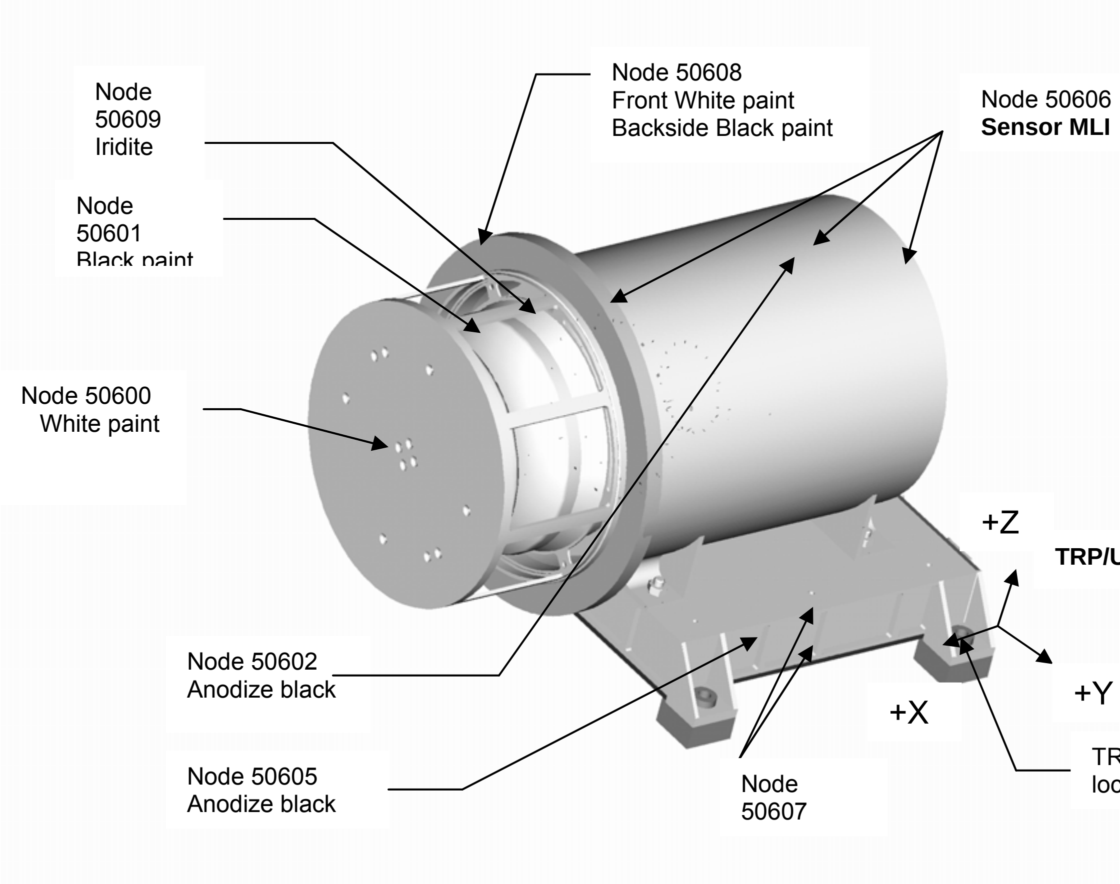


Figure 2.5-11: ICA Thermal Nodes

2.5.4.2.4 LAP: RPC-3.1 and RPC-3.2

(ref. RPC_3 & 4 in RD-GEN-31)

Node (-)	Name (-)	Material (-)	Thermal Finish (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50640	LAP1 probe	Ti alloy	Ti Nitride	0.46	0.54	-	0.13	0.87	-
50641	LAP1 stub	Ti alloy	Ti Nitride	0.46	0.54	-	0.13	0.87	-
50642	LAP1 foot	Al alloy	Alodine	TBD	TBD	-	TBD	TBD	-
50660	LAP2 probe	Ti alloy	Ti Nitride	0.46	0.54	-	0.13	0.87	-
50661	LAP2 stub	Ti alloy	Ti Nitride	0.46	0.54	-	0.13	0.87	-
50662	LAP2 foot	Al alloy	Alodine	TBD	TBD	-	TBD	TBD	-

Table 2.5-31: LAP BOL / EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m^2)	mCp (J/K)	Non-Op. Heater	TRP location	Op. Heater
50640	LAP1 probe	Ti alloy	7.9e-3	21.	-	-	-
50641	LAP1 stub	Ti alloy	3.4e-3	11.	-	-	-
50642	LAP1 foot	Al alloy	5.2e-3	41.	-	-	-
50660	LAP2 probe	Ti alloy	7.9e-3	21.	-	-	-
50661	LAP2 stub	Ti alloy	3.4e-3	11.	-	-	-
50662	LAP2 foot	Al alloy	5.2e-3	41.	-	-	-

Table 2.5-32: LAP Node Properties

Unit (-)	Node (-)	Op. (°C)	Non-Op. (°C)	Op. Stab. (°C/h)	Switch-On (°C)
LAP1	50640	-190 / +250	-190 / +250	-	-170 / +250 -
LAP2	50660	-190 / +250	-190 / +250	-	-170 / +250

Table 2.5-33: LAP TRP Design Temperature Ranges

			BOL / EOL	
Unit (-)	**Mode** (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)
LAP1	no power	50640	0. / 0.	no heater
LAP2	no power	50660	0. / 0.	no heater

Table 2.5-34: LAP Power Dissipations

Unit (-)	**Node I** (-)	**Node j** (-)	**GL** (W/K)
LAP1	50641	50642	0.1
LAP2	50661	50662	0.1

Table 2.5-35: LAP Internal Conductive Couplings

Unit (-)	**Type** (-)	**Number** (-)	**C** (W/K)	**Node** (-)	**Conductive I/F Node** (-)
LAP1	flat - 4*M3	1	0.24	50642	S/C (S/C boom)
LAP2	flat - 4*M3	1	0.24	50662	S/C (S/C boom)

Table 2.5-36: LAP Interface Contact Conductances

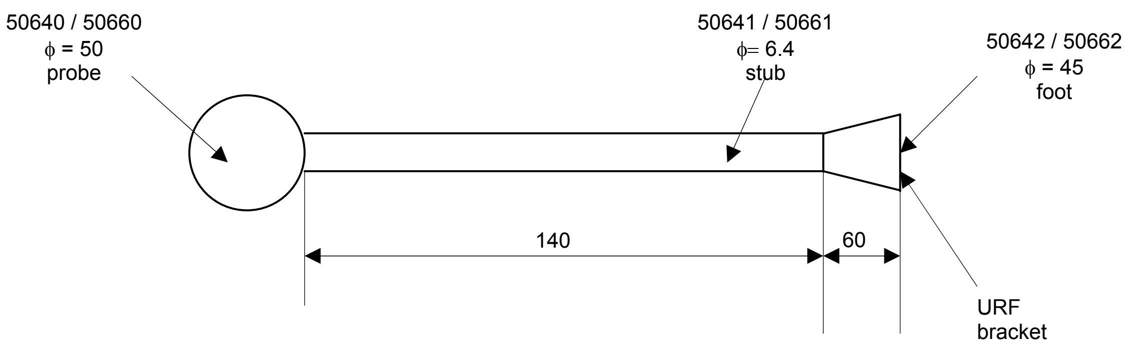


Figure 2.5-12: LAP1 and LAP2 Thermal Sketch

2.5.4.2.5 MIP: RPC-4.1

Node (-)	**Name** (-)	**Material** (-)	**Thermal Finish** (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50720	receiving electrode	Al alloy	bead blasted	0.50	0.50	-	0.20	0.80	-
50721	receiving insulated section	peek	as is	0.64	0.36	-	0.90	0.10	-
50722	transmitting electrode	Al alloy	bead blasted	0.50	0.50	-	0.20	0.80	-
50723	transmitted insulated section	peek	as is	0.64	0.36	-	0.90	0.10	-
50724	bar middle section	CFRP	as is	0.80	0.20	-	0.80	0.20	-

Table 2.5-37: MIP BOL / EOL Surface Properties

Node (-)	**Name** (-)	**Material** (-)	**A (*** (m²)	**mCp (**** (J/K)	**Non-Op. Heater**	**TRP location**
50720	receiving electrode	Al alloy	4.78e-3	5.5	-	-
50721	receiving insulated section	peek	2.01e-3	4.5	-	TRP (**
50722	transmitting electrode	Al alloy	4.78e-3	5.5	-	-
50723	transmitted insulated section	peek	2.01e-3	4.5	-	-
50724	bar middle section	CFRP	7.50e-2	66.6	-	-

* Values given for both symmetrical parts
** Monitoring thermistor

Table 2.5-38: MIP Node Properties

Node (-)	**Op.** (°C)	**Non-Op.** (°C)	**Op. Stab.** (°C/h)	**Switch-On** (°C)
50721	-130 / +100	-160 / +100	-	-160 / +100

Table 2.5-39: MIP TRP Design Temperature Ranges

BOL / EOL

Mode (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)
ON	50721	0.1 / 0.1	-

Table 2.5-40: MIP Power Dissipations

Node I (-)	Node j (-)	GL (W/K)
50720	50721	4.6e-3
50721	50724	5.0e-3
50722	50723	4.5e-3
50723	50724	5.0e-3
50724	50725	0.06

Table 2.5-41: MIP Internal Conductive Couplings

Type (-)	Number (-)	C (W/K)	Node (-)	Conductive I/F Node (-)
bracket 1	1	0.15	50725	30108 (TBC)
backet 2	1	0.15	50725	30109 (TBC)
cables	1	1.05e-3 (*	50724	50740 (PIU)

(* Cu cross section is 1.64 mm^2, estimated effective length 0.50 m

Table 2.5-42: MIP Interface Contact Conductances

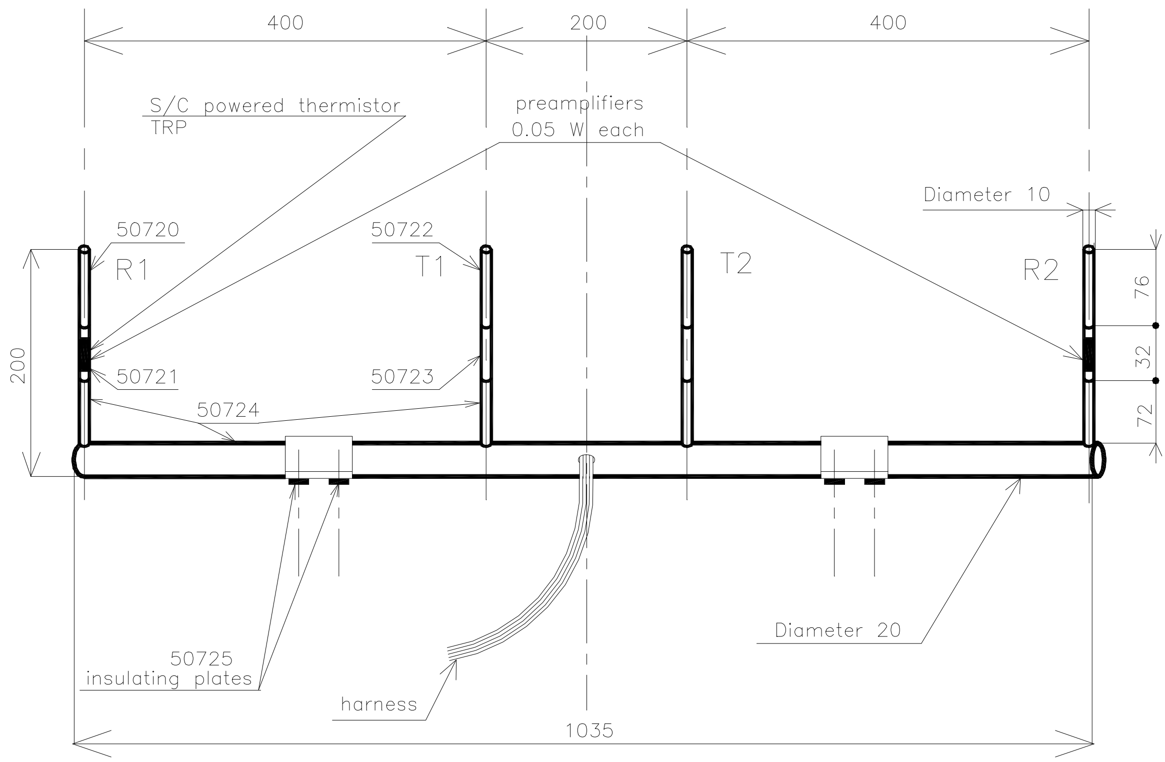


Figure 2.5-13: MIP Sensor Thermal Sketch

2.5.4.2.6 MAG: RPC-5.1 and RPC-5.2

(ref. RPC_5 & 6 in RD-GEN-31)

Node (-)	**Name** (-)	**Material** (-)	**Thermal Finish** (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50701	MAG-OB MLI	MLI 2mils	vka	0.42	0.53	-	0.65	0.35	-
50704	MAG-OB inner cube	Boronnitride	-	-	-	-	-	-	-
50705	MAG-OB baseplate	CFRP	as is	-	-	-	0.80	0.20	-
50681	MAG-IB MLI	MLI 2mils	vka	0.42	0.53	-	0.65	0.35	-
50684	MAG-IB inner cube	Boronnitride	-	-	-	-	-	-	-
50685	MAG-IB baseplate	CFRP	as is	-	-	-	0.80	0.20	-

Table 2.5-43: MAG BOL Surface Properties

Node (-)	**Name** (-)	**Material** (-)	**Thermal Finish** (-)	α_s (-)	ρ_s^d (-)	ρ_s^s (-)	ε_h (-)	ρ_h^d (-)	ρ_h^s (-)
50701	MAG-OB MLI	MLI 2mils	Vka	0.62	0.38	-	0.65	0.35	-
50704	MAG-OB inner cube	Boronnitride	-	-	-	-	-	-	-
50705	MAG-OB baseplate	CFRP	as is	-	-	-	0.80	0.20	-
50681	MAG-IB MLI	MLI 2mils	vka	0.62	0.38	-	0.65	0.35	-
50684	MAG-IB inner cube	Boronnitride	-	-	-	-	-	-	-
50685	MAG-IB baseplate	CFRP	as is	-	-	-	0.80	0.20	-

Table 2.5-44: MAG EOL Surface Properties

Node (-)	**Name** (-)	**Material** (-)	**A** (m^2)	**mCp** (J/K)	**Non-Op. Heater**	**TRP location**
50701	MAG-OB MLI	MLI 2mils	6.125e-3	0.	-	-
50704	MAG-OB inner cube	Boronnitride	-	29.0	-	TH
50705	MAG-OB baseplate	CFRP	1.225e-3	2.3	-	-
50681	MAG-IB MLI	MLI 2mils	6.125e-3	0.	-	-
50684	MAG-IB inner cube	Boronnitride	-	29.0	-	TH
50685	MAG-IB baseplate	CFRP	1.225e-3	2.3	-	-

Table 2.5-45: MAG Node Properties

Unit (-)	**Node** (-)	**Op.** (°C)	**Non-Op.** (°C)	**Op. Stab.** (°C/h)	**Switch-On** (°C)
MAG-OB	50704	-80 / +80	-170 / +120	5	-170 / +100
					-
MAG-IB	50684	-80 / +80	-170 / +120	5	-170 / +100

Table 2.5-46: MAG TRP Design Temperature Ranges

			BOL / EOL	
Unit (-)	**Mode** (-)	**Node** (-)	**Op. QI** (W)	**Non-Op. QR** (W)
MAG-OB	Deployed	50704	0.081 / 0.081	-
MAG-OB	Stowed	50704	0. / 0.	-
MAG-IB	Deployed	50684	0.081 / 0.081	-
MAG-IB	Stowed	50684	0. / 0.	-

Table 2.5-47: MAG Power Dissipations

Unit (-)	**Node I** (-)	**Node j** (-)	**GR** (m^2)
MAG-OB	50704	50705	1.608e-3
MAB-IB	50684	50685	1.608e-3

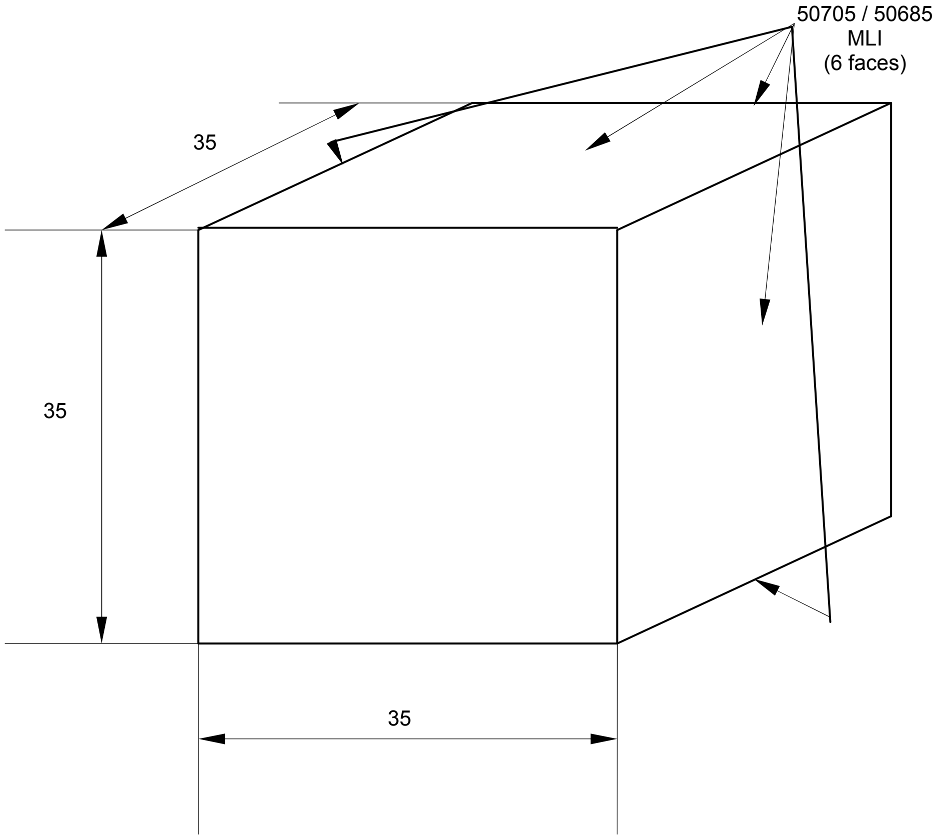
Assuming inner cube side=20 mm

Table 2.5-48: MAG Internal Radiative Couplings

Unit (-)	**Type** (-)	**Number** (-)	**C** (W/K)	**Node** (-)	**Conductive I/F Node** (-)
MAG-OB	3 feet - 3*M3	3	0.0162	50704	86003 (S/C boom) (*
MAG-IB	3 feet - 3*M3	3	0.0162	50684	86003 (S/C boom) (*

(*node of the S/C boom

Table 2.5-49: MAG: Interface Contact Conductances



Note: The nodes 50701/50705 belong to the MAG OB (outboard) sensor), whilst 50681/50685 belong to the MAG IB (inboard) sensor

Figure 2.5-14: MAG-OB and MAG-IB Thermal Sketch

3 Experiment Operations

3.1 Operating Principles

3.1.1 RPC

The Rosetta mission presents a number of new challenges with regard to payload operations. Due to the complex on-board data-handling systems required to realise the mission objectives, the cost constraints requiring a large degree of on-board autonomy, and the physical difficulties of operating such a mission in deep space, the on-board operations allow much flexibility to maximise the data return. The particular capability which affects payload planning is that the Rosetta spacecraft does not operate in a deterministic and fully pre-planned manner, rather the data gathering and transmission can be commanded at a late stage or even dynamically in real-time on-board the spacecraft. This is necessary due to the uncertain nature of the comet observation possibilities, and the limited bandwidth for telemetry downlink. The central resource which is available to the experiments is the 'Solid State Mass Memory' (SSMM), which contains all payload data stored on-board for later downlink. In order to maximise use of this resource, the project will allocate space in the SSMM to each payload per mission phase. It is up to the payload team to decide how to fill this volume. In the case of RPC, this is no easy task; there are five sensor units producing science and housekeeping data, plus housekeeping data from the PIU. Moreover, any sensor unit may be powered on or off for power budgeting reasons or telemetry saving. When operating, each sensor unit may be generating data at up to six different data rates. It therefore becomes clear that RPC can not be operated as a 'classical' instrument with a limited set of modes. In fact, the possible number of modes for RPC is many thousands, and the associated data rates and power requirements are commensurately large. It is also clear, that given the capabilities of the Rosetta spacecraft, this flexibility can be used to optimise the scientific return from RPC.

There are of course a large number of constraints placed on payload operations, and these include specific constraints for RPC:

- Power availability
  RPC can operate from 2 to 16 W, and RPC operations will at times be constrained to an allowed maximum of 11 W.
  For details on the power consumption refer to section 2.4.3.

- Spacecraft pointing
  The orientation of s/c with respect to the sun due to the s/c shadow covering the instruments is only relevant for LAP and MIP (refer to section 3.3). They require pointing parallel to the plasma flow, plus the IES and the ICA sensors which require to have the plasma flow in their field of view, with the added requirement that IES likes to view the solar wind direction.

- On-board operations constraints,
  such as the availability of OBCP slots (which are dynamic programs run on the spacecraft system which control the operation of the payload – the possibility to execute these is a limited resource);

- Space available in the SSMM.

- Additionally for the magnetometer (MAG) experiment,
  the operation of other payload, subsystems (particularly the reaction wheels) and the Lander must be taken into account, since these are a significant cause of magnetic interference.

For the fly-by phases of the mission (Mars and Asteroids), the mission timeline will be rather pre-determined and well suited to advance planning. This is also the case for the Earth swing-by, which can be well used by RPC for sensor calibration purposes. RPC also anticipates significant possibilities to take data in the solar wind during the cruise, where meaningful science can be done, and has already requested that the sensors be operated when possible. Although there are times when all the payload must be switched off, it is likely the RPC can be operated during significant parts of the cruise, since the resource hungry imaging instruments will be off. For any scientificically promising phase during cruise RPC will submit operation requests well in advance offically to ESA to allow an analysis of feasibiltiy.
During comet operations, however, the situation will be rather more complex, with all the instruments requesting resources. Moreover, the planning during comet operations will be rather dynamic, with the spacecraft and science operations being tailored to the evolution of the cometary activity, and driven by events and observations. Whilst there will be a baseline plan, it is expected that this will be iterated and modified heavily during this phase of the mission, often on a short timescale.

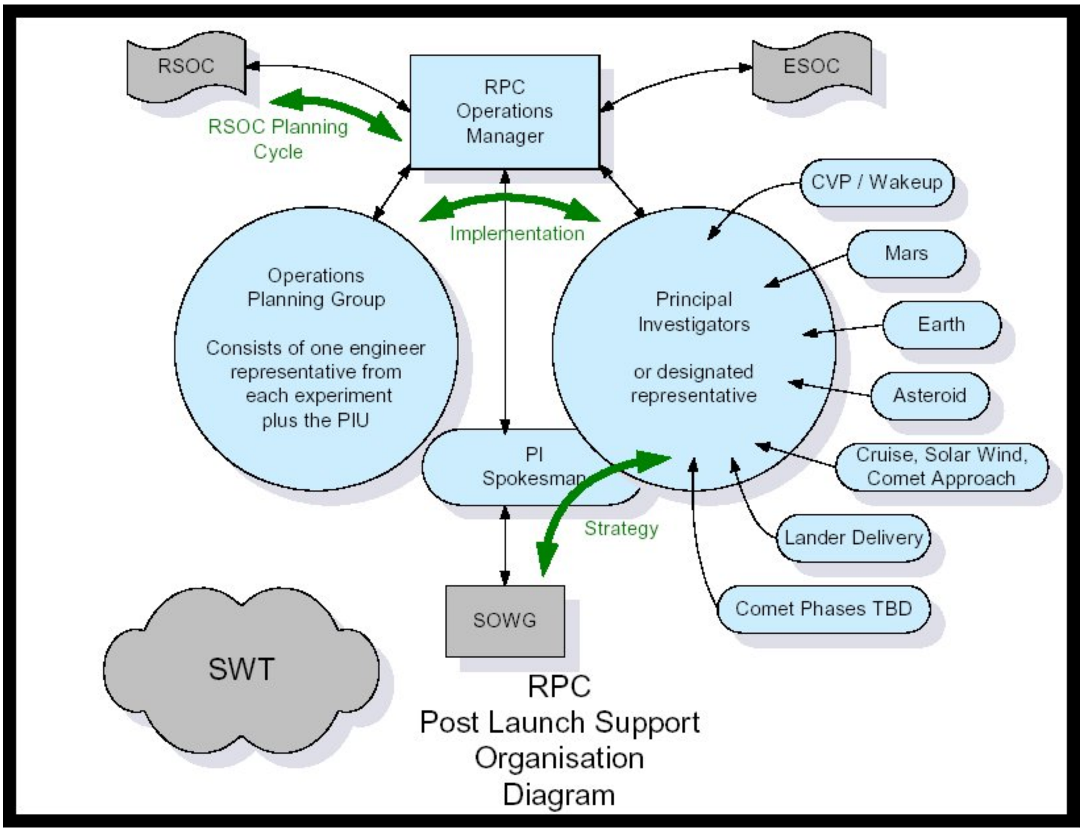


Figure 3.1-1: RPC Post Launch Support Organisation

3.1.1.1 Operational Concept

The choice of the mode is due to mission phase, available power and telemetry as well as scientific requirements. Appropriate instrument commanding is required. The selection and initiation of the modes and sub-modes are under the control of the RPC PI-spokesman after consultation with the RPC team.

A more detailed preferred operational concept is described in section 4.2. The sequence of sub-modes during operational phases will be defined during the preparation of the specific phases and depends on power and telemetry available. In any case the preferred mode is the one, where all units are powered on and operating at a high data rate). Especially in phases, when both the orbiter and the lander magnetometers are required to operate simultaneously, the data rate should me as high as possible.

3.1.1.2 Data Flow

The RPC data will be retrieved from the ESOC DDS system, by a procedure, described in the RD-RPC-11. The data from each instrument are unpacked from the RPC science telemetry by individual procedures for each expereiment team. On a common RPC level, the data consists of housekeeping and science data and possible common data products, i.e. event data. Each instrument team is responsible for the decoding, calibration, validation and archiving of the data from their instrument. The common RPC data products are based on calibrated data either directly provided by the individual instrument teams or produced by s/w provided by them. At the end of the data flow chain data will be stored in PDS/PSA compliant data format. For the RPC archiving guidelines refer to RD-ARC-7 and the individual instrument EAICDs.

3.1.2 Experiments

3.1.2.1 PIU

All electrical, telemetry and telecommand interfaces between the RPC group of instruments and the spacecraft are handled by the PIU. This unit distributes secondary power within the group of instruments, it provides the first level of command decoding and it controls the packaging of data for transmission to the spacecraft.

When PIU is powered the nominal mode shall be to have MAG powered on (one MAG ADC is needed for the PIU HK) as well, but not producing any Science. The PIU HK will be automatically produced at power on. Once spacecraft time update has been received PIU will send an “alive” event and the first packet of housekeeping. MAG should then be powered on and only after the ADC’s in MAG have started to send voltage and thermistor values will all of PIU Housekeeping be valid.
In order for any other experiment in the package be powered PIU and MAG must be powered (ref. section 3.1.2.6). Commands to any other experiment in the package are sent to PIU which distributes these to the correct experiment. PIU collects all Housekeeping and Science from the experiments and passes it on to the Spacecraft.

3.1.2.2 IES

The main interface of the IES instrument to the S/C is through the PIU. The PIU provides +5 V, -5 V, +12 V and -12 V power to IES as well as the sole command and telemetry interface. The power supplies are essentially turned on simultaneously with a single command to PIU from the S/C.

Once IES is on, it begins execution from its boot PROM in RESUME-PROM or if commanded, PAUSE-PROM mode; and generates housekeeping packets I, II, III and IV every 32 seconds, synchronized with the AQP. Event messages can be generated asynchronously by IES if non-HK information must be conveyed or an anomaly has been detected. Maintenance operations are allowed during this time, notably the uploading of data and writing to EEPROM if updates are needed.

The boot PROM performs diagnostics checks of PROM, RAM and EEPROM before waiting for 70 seconds and copying code from EEPROM to RAM and then executing the newly copied RAM code. Since the HV commands will be rejected by the boot PROM code, the high-voltage power supplies cannot be turned on during this time.

By default, IES initializes with science data generation off and high supplies off. Typically, during commissioning, stimulation pulsers and science data generation will be commanded on in low-voltage science (LVSCI-EEPROM) mode so that data flow can be checked through all subsystems except for the HV supplies. Diagnostic checks can be performed by commanding IES to low-voltage engineering (LVENG-EEPROM) mode.

In order to use the HV supplies, IES must be commanded to the high-voltage science (HVSCI-EEPROM) mode. This is also the mode that IES acquires its science data. When the HV supplies are brought up, the micro-channel plates (MCP) are immediately capable of collecting electron and ion data. During regular operation (i.e., not during commissioning), it is then possible to start plasma data collection. An acquisition table and the telemetry rate are activated by telecommands (IES-DATA-ACQ-TABLE and IES-COMM-RATE-MODE) to choose the voltage sweep tables for the electrostatic (ESA) and deflection (DEF) analyzers, the number of steps to use in each of the sweep tables, the science integration time, the data packaging that is to take place and the duration of acquisition before the cycle repeats and the science telemetry rates. Because of telemetry rate limitations, the data packaging is used to reduce the amount of data through spatial averaging and data compression.

At a minimum, IES has a table to perform a survey data acquisition which sweeps the entire energy and deflection angle range possible for the instrument and collects data across all azimuthal anodes. Note that this data are greatly reduced in volume for telemetry but provides an image of the entire phase space of IES.

To reduce the number of commands stored by the S/C, IES stores scripts in its EEPROM and has the ability to run them by a single telecommand (IES-SEQ-TRIGGER). The scripts consist of a common series of commands for performing stimulation tests, bringing up HV supplies and acquiring science data in each of the three telemetry rates.

3.1.2.3 ICA

When ICA is powered it will enter its default telemetry and data reduction mode but high voltages will not be switched on. Full high voltage operation will require 3 commands.
The basic operation consists of stepping through a number of energy levels (32 or 96) for 16 different elevation angles. For each energy level (held for 202.9 milliseconds) a mass-angle matrix (32x16) is produced by the imaging system. Except for some special modes the data are fed through various integration modules to reduce the amount of data, then converted to an 8-bit floating code and finally compressed by a loss less method. All data are stored in a telemetry FIFO for transmission. Due to the compression the experiment formats will vary in length and will therefore be floating in the telemetry packets.

3.1.2.4 LAP

3.1.2.4.1 General Operation

RPC has an operational concept for all the instruments in the consortium. In principle one command is needed to configure all the instruments inside RPC. The information we provide, when operating the instrument in this way, is what macro to run and in what macro bank in LAP flash memory it can be found (see RD-LAP-5 for details about existing macros). A number of FCPs have been defined for LAP, as shown in detail in the Flight Operations Plan (FOP).

Maintenance is done after the instrument has been turned into safe mode or directly after power on. This includes software uploading (patching), memory dumps, debugging and macro programming. Software uploading and memory dumps use the memory services. Macro programming and some debugging are done using normal instrument commands.

During scientific operation (when LAP produces scientific data), LAP always executes a macro. A macro consists of a list of commands telling the instrument what to do. The list usually contains a GOTO command as the last command that jumps back into the list repeating a certain section in a cyclic manner. The instrument has several predefined macros stored in prom memory and flash memory. Each macro is designed to achieve a different scientific objective and also to keep the constraints such as telemetry and power consumption. New macros can be uploaded into the instrument flash memory, currently there is space for about 80 macros in flash memory. The instrument can also upload and run new macros without storing them in flash memory; this mode is intended for use in case of flash memory failure. Two generic macros reside in prom memory and can be used for simple tasks but need to be configured with additional commands to produce useful science; their use is not recommended. Some instrument parameters can be modified during the execution of a macro. What can be modified and not is dependent of the running software version. The prom software version has limited abilities to modify parameters when running a macro. For further details refer to RD-LAP-4.

3.1.2.5 MIP

No special care is required to switch on MIP (See RD-MIP-4).
A parameter table (Table 3.1-1) of 6 bytes is required for software initialization and configuration. This table contains :

internal parameters (transmitter selection, transmission level, ...)
commands for selection of working modes and telemetry rates.

The size of 6 bytes corresponds to one link-packet between PIU and MIP.

	bit7	bit6	Bit5	bit4	bit3	bit2	bit1	bit0
Byte0	Interference frequency n°1							
Byte1	Interference frequency n°2							
Byte2	Interference frequency n°3							
Byte3	Transmission_level		Transmitter_odd_sweeps		Transmitter_even_sweeps		Extremum_threshold	
Byte4	Sweep_mode_bandwidth			Survey_mode_bandwidth			Ampl_pas	Autoloop
Byte5	Watchdog	Science_sequence_number			LDL_type	Mode	TM_rate	

Table 3.1-1: MIP Description of the configuration table.

A default table is stored in a MIP PROM. This default table cannot be updated. It will only be used in case of transmission problems between PIU and MIP.
The default table is : 0x00 00 00 45 02 00;
The type of table ‘PIU_update' or ‘MIP_default' and its contents are sent back in the CONTROL or TABLE sequence as data. The table ‘PIU_update' is sent back in the HK packet type II as execution acknowledgement.

3.1.2.6 MAG

As written in section 3.1.2.1 there is a hard constraint to power on MAG (both sensors) as soon as PIU has sent the first housekeeping packet. The two reasons are the following:
MAG provides HK for PIU, LAP, and MIP.
With MAG powered on before the other RPC experiments, there is the possibility to detect any interexperimental interference.

There is only one single command to power RPCMAG on completely with all 7 ADCs starting to convert the two times 3 magnetometer components and the housekeeping channels (voltages and thermistors). Also the sampling rate is fixed to 20 vectors per second. All other handling on the data like packetizing and changing the vector rate is done under control of the PIU, depending on actual downlink capabilities.

3.2 Operating Instructions

3.2.1 Introduction

For routine science operations the RPC instruments will be primarily operated via OBCPs whereas the use of FCPs will be limited to the accomplishment of those tasks which cannot be suitably fulfil via OBCP.
This modus operandi aims to minimize miss-commanding and other operator-related errors by relying on the OBCP built-in “intelligence” for checking on instrument status and command parameters validity.

3.2.2 Simultaneous commanding of RPC instruments

Tests on the S/C EQM have demonstrated that PIU can correctly handle simultaneous operation of all the five RPC instruments. More specifically, the test was designed to release individual commands simultaneously to al the RPC units. In practical terms this means that no special care needs to be taken to avoid timing conflicts between commands belonging to different instruments.

3.2.3 RPC Instrument Configuration

A brief description of the start-up state of the RPC instruments is given in this section. As a general rule:

1. Subunit will boot up with code from E2PROM as default.
2. Maintenance of the subunit will be performed from a state of power off and return to power off

3.2.3.1 Instrument-specific notes

IES
At power on, IES initially runs PROM code. This code is run until AQP’s are detected, 70 seconds have passed since power on, no commands have been received and no anomalies were detected. At that point, control is passed to EEPROM as part of the default power on procedure for normal flight operations which should be out of location $c:0000. This is where the boot prom will automatically jump to without further commanding.

ICA
On power on ICA loads code from PROM to RAM and runs for RAM. E2PROM code is loaded and run using command Boot EEP (ZRP22113/

ZRP22111).

LAP
On power-on LAP runs from PROM. E2PROM code may be selected using EE Boot command (ZRP23023). The default EEPROM bank is 4. EEPROM/PROM may be turned off and watchdog timers switched on then using DOG PROM command (ZRP23007).

PIU
PIU starts up running from PROM code. It transfers an image of the PROM code to RAM automatically and it is possible to switch to RAM by command. Code from EEPROM may be loaded into RAM by command and then it may be started by using the “Software location: Boot from RAM” command.

3.2.4 Operation with OBCP

A description of the function, prerequisites and other information on the behaviour of the OBCPs, as well as detailed explanation of the invocation parameters, is given in this section.

For detailed description of OBCPs see RD-GEN-5.

The following two tables contain the list of RPC OBCPs.

OBCP Title	RSDB Name
PL_OBCP_5_RP.1 RPC POWER ON	KRPR8091
PL_OBCP_5_RP.2 RPC Power OFF	KRPR8092
PL_OBCP_5_RP.3 RPC Mode Control	KRPR8093
PL_OBCP_5_RP.6 RPC Mode Control 2	KRPR8096
PL_OBCP_5_RP.4 RPC LDL Mode	KRPR8094
PL_OBCP_5_RP.7 IES Mode Control	KRPR8097
PL_OBCP_5_RP.8 ICA Mode Control	KRPR8098
PL_OBCP_5_RP.9 LAP Mode Control	KRPR8099
PL_OBCP_5_RP.10 MIP Mode Control	KRPR809A
PL_OBCP_5_RP.11 MAG Mode Control	KRPR809B

Table 3.2-1: List of RPC OBCPs for routine operations.

OBCP Title	RSDB Name
PL_OBCP_5_RP.5 RPC Parameter Monitoring OBCP	KRPR8095

Table 3.2-2: List of RPC OBCPs for special operations.

The OBCPs “RPC Mode Control” and “RPC Mode Control 2” are used to set and command groups of instruments. “RPC Mode Control” controls IES and ICA whereas “RPC Mode Control 2” controls LAP, MIP and MAG. These OBCPs restricts flexibility of operations because the same OBCP cannot be invoked while it is still running. This means that IES and ICA (the same is true for LAP, MIP and MAG) cannot be controlled independently without paying attention to the commands timing.

To overcome this problem, a set of instrument-specific OBCP was created which guarantee a truly independent control of the instruments. They are:

- IES Mode Control

- ICA Mode Control
- LAP Mode Control
- MIP Mode Control
- MAG Mode Control

The use of “RPC Mode Control” and “RPC Mode Control 2” is **discouraged** in favor of the instrument-specific OBCPs:

3.2.4.1 RPC Power On

This OBCP configures the Spacecraft interfaces and powers on PIU and then the MAG unit for HK generation only.

Notes:

- From the parameters you can select either nominal or redundant configuration (Nominal being LCL-A, main PSU and main DPIU), and what code (patch address) the PIU should use.
- Selecting RAM uses the code stored in PROM but transferred to RAM. The other two options require PAR3 to be defined with a valid patch address.

•

<table>
<tr><td>OBCP Title</td><td>RSDB Name</td><td colspan="2">Function</td><td>Invocation</td></tr>
<tr><td rowspan="6">PL_OBCP_5_RP.1
RPC POWER ON</td><td>KRPR8091</td><td colspan="2">Power on RPC.
Parameters will select redundancy configuration and software location</td><td>Ground, MTL, other OBCP</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="2">Invoked by sequence</td><td colspan="2">With parameter values</td></tr>
<tr><td colspan="2">ARPF801A (RP-FCP-801)
“RPC ON MAIN via OBCP”</td><td colspan="2">PAR1 = NOMINAL
PAR2 = EEPROM_PA_RE
PAR3 = 14C00 <hex> (Correct at time of writing. Will run ver. 5.12 build 524)</td></tr>
<tr><td colspan="2">ARPF802A (RP-FCP-802)
“RPC ON RED via OBCP”</td><td colspan="2">PAR1 = REDUNDANT
PAR2 = EEPROM_PA_RE
PAR3 = 12000 <hex> (Current at time of writing. Will run ver. 5.9 build 519)</td></tr>
<tr><td colspan="2">ARPE801A (no procedure defined)
“RPC On Main OBCP EQM”</td><td colspan="2">PAR1 = NOMINAL
PAR2 = EEPROM_PA_RE
PAR3 = None</td></tr>
</table>

<table>
<tr><td>Parameter Name</td><td>RSDB Name (Calibration)</td><td>Function</td><td>CAL</td><td>Actual</td></tr>
<tr><td rowspan="2">PAR1</td><td rowspan="2">FSKD1000</td><td rowspan="2">Select redundancy cfg. LCL & PIU (DPIU/PSU)</td><td>NOMINAL</td><td>LCLA & Main</td></tr>
<tr><td>REDUNDANT</td><td>LCLB & Red</td></tr>
<tr><td rowspan="3">PAR2</td><td rowspan="3">FSK01250</td><td rowspan="3">PIU SW Configuration</td><td>RAM</td><td>No patch</td></tr>
<tr><td>EEPROM_PATCH</td><td>Patch</td></tr>
<tr><td>EEPROM_PATCH_REBOOT</td><td>Patch & reboot</td></tr>
<tr><td>PAR3</td><td>FSK01251</td><td>PIU E2prom Software Patch</td><td>Specified at call-time</td><td>Specified at call-time</td></tr>
</table>

Table 3.2-3: OBCP Details: OBCP_5_RP.1

3.2.4.2 Power Off

This OBCP turns RPC off.

Notes:
1) This OBCP powers off RPC on both LCL's and takes no parameters.
2) This OBCP **will not** put instruments in safe mode before executing.

OBCP Title	**RSDB Name**	**Function**	**Invocation**	
PL_OBCP_5_RP.2 RPC POWER OFF	KRPR8092	Power off RPC	Ground, MTL, other OBCP, DMS SW	
	Invoked by sequence		With parameter values	
	ARPF800A (RP-FCP-800) "RPC Power OFF via OBCP"		**n/a**	
	ARPF806A (RP-FCP-806) "RPC OBCP Pwr-Off"		**n/a**	
Parameter Name	RSDB Name (Calibration)	Function	CAL	Actual
n/a	**n/a**	**n/a**	**n/a**	**n/a**

Table 3.2-4: OBCP Details: OBCP_5_RP.2

3.2.4.3 IES and ICA Mode Control

This OBCP configures and operates IES and ICA.

Notes:
1) The OBCP will power the experiments on if required.
2) This OBCP **cannot be re-invoked** while it is still running, as it may be the case if you want to set control IES and ICA at two different times. The use of this OBCP is discouraged in favour of the instrument-specific ones.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.3 RPC Mode Control	KRPR8093	Configure IES and ICA experiments	Ground, MTL
	Invoked by sequence	With parameter values	
	ARPS803A (RP-SEQ-803) "IES-ICA Mode Change"	ModeIES = specified at call-time ModeICA = specified at call-time IESParam = specified at call-time ICAParam = specified at call-time	
	ARPF806A (RP-FCP-806) "RPC OBCP Pwr-Off"	ModeIES = OFF ModeICA = OFF IESParam = 00ff <hex> ICAParam = 00ff <hex>	

Parameter Name	RSDB Name (Calibration)	Function	Allowed values (See below for values & meaning)
ModeIES	**FSK01260**	**Select IES Mode**	NoChange, OFF, SID1, SID2, SID3, TEST, HV_ON, SID1_HV_ON, SID2_HV_ON, SID3_HV_ON, HV_OFF, Maintenance, Quiet
ModeICA	**FSK01261**	**Select ICA Mode**	NoChange, OFF, SID1, SID2, SID3, SID4, SID5, TEST,HV_ON, SID1_HV_ON, SID2_HV_ON, SID3_HV_ON, SID4_HV_ON, SID5_HV_ON, TEST_HV_ON, HV_OFF, Maintenance, Quiet
IESParam	**FSK01265**	**Execute IES Sequence (see below)**	0xff (Do nothing), 0x05-0xFE.
ICAParam	**FSK01266**	**Set ICA Operational mode (see below)**	0xff (Do nothing), 0x00-0x27

Table 3.2-5: OBCP Details: OBCP_5_RP.3

3.2.4.4 LAP, MIP and MAG Mode Control

This OBCP configures and operates LAP, MIP and MAG.
Notes:

1) The OBCP will power the experiment on if required.
2) This OBCP **cannot be re-invoked** while it is still running, as it may be the case if you want to set control LAP, MIG in different times. The use of this OBCP is discouraged in favour of the instrument-specific ones.

OBCP Title	RSDB Name	Function		Invocation
PL_OBCP_5_RP.6 RPC Mode Control 2	KRPR8096	Configure LAP, MIP and MAG experiments		Ground, MTL
	Invoked by sequence	With parameter values		
	ARPS804A (RP-SEQ-804) "IES-ICA Mode Change"	**ModeLAP = specified at call-time ModeMIP = specified at call-time ModeMAG = specified at call-time LAPParam = specified at call-time MIPParam = specified at call-time**		
	ARPF806A (RP-FCP-806) "RPC OBCP Pwr-Off"	**ModeLAP = OFF ModeMIP = OFF ModeMAG = Quiet LAPParam = 00ff <hex> MIPParam =00ff <hex>**		

Parameter Name	RSDB Name (Calibration)	Function	Allowed values (see below for values & meaning)
ModeLAP	**FSK01262**	**Select LAP Mode**	NoChange, OFF, SID1, SID2, SID3, Maintenance, Quiet
ModeMIP	**FSK01263**	**Select MIP Mode**	NoChange, OFF, SID1, SID2, SID3, Quiet
ModeMAG	**FSK01264**	**Select MAG Mode**	NoChange, OFF, SID1, SID2, SID3, SID4, SID5, Quiet
LAPParam	**FSK01267**	**Execute LAP Macro (see below)**	0xff (Do nothing), Upper nibble 0x0-0xa, Lower nibble 0x0-0x7
MIPParam	**FSK01268**	**Select MIP predefined table (see below)**	0xff (Do nothing), 0x00-0x0f
LAPSWEEpromBank	**FSK01268**	**Select LAP EEprom Bank to boot from**	??? Default = 0x0003

Table 3.2-6: OBCP Details: OBCP_5_RP.6

REMARK: The TEST-mode for RPCMAG which is mentioned in the mode control diagrams, will never be used in flight.

3.2.4.5 IES Mode Control

The objective of this OBCP is to set the operating mode of the IES sensor. The OBCP takes invocation parameters to set the operation mode of IES.

Notes:
1) The OBCP will power IES experiment on if required.
2) This OBCP is an instantiation of OBCP 8093 “Mode Control OBCP”, for which ICA invocation parameters are fixed to “NoChange” at sequence level. Therefore, only IES related actions will be executed by the OBCP.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.7 IES Mode Control	KRPR8097	Configure IES experiment	Ground, MTL
	Invoked by sequence	With parameter values	
	ARPS807A "IES Mode Control”	ModeIES = specified at call-time IESParam = specified at call-time	
Parameter Name	RSDB Name (Calibration)	Function	Allowed values (See below for values & meaning)
ModeIES	**FSK01260**	**Select IES Mode**	NoChange, OFF, SID1, SID2, SID3, TEST, HV_ON, SID1_HV_ON, SID2_HV_ON, SID3_HV_ON, HV_OFF, Maintenance, Quiet
IESParam	**FSK01265**	**Execute IES Sequence (see below)**	0xff (Do nothing), 0x05-0xFE.

Table 3.2-7: OBCP Details: OBCP_5_RP.7

3.2.4.6 ICA Mode Control

The objective of this OBCP is to set the operating mode of the ICA sensor. The OBCP takes invocation parameters to set the operation mode of ICA.

Notes:
1) The OBCP will power ICA experiment on if required.
2) This OBCP is an instantiation of OBCP 8093 “Mode Control OBCP”, for which IES invocation parameters are fixed to “NoChange” at sequence level. Therefore, only ICA related actions will be executed by the OBCP.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.8 ICA Mode Control	KRPR8098	Configure ICA experiment	Ground, MTL
	Invoked by sequence	With parameter values	
	ARPS808A "ICA Mode Control”	ModeICA = specified at call-time ICAParam = specified at call-time	
Parameter Name	RSDB Name (Calibration)	Function	Allowed values (See below for values & meaning)
ModeICA	**FSK01261**	**Select ICA Mode**	NoChange, OFF, SID1, SID2, SID3, SID4, SID5, TEST,HV_ON, SID1_HV_ON, SID2_HV_ON, SID3_HV_ON, SID4_HV_ON, SID5_HV_ON, TEST_HV_ON, HV_OFF, Maintenance, Quiet
ICAParam	**FSK01266**	**Set ICA Operational mode (see below)**	0xff (Do nothing), 0x00-0x27

Table 3.2-8: OBCP Details: OBCP_5_RP.8

3.2.4.7 LAP Mode Control

The objective of this OBCP is to set the operating mode of the LAP sensor. The OBCP takes invocation parameters to set the operation mode of LAP.

Notes:
1) The OBCP will power LAP experiment on if required.
2) This OBCP is an instantiation of OBCP 8096 “Mode Control OBCP 2”, for which MIP and MAG invocation parameters are fixed to “NoChange” at sequence level. Therefore, only LAP-related actions will be executed by the OBCP.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.9 LAP Mode Control	KRPR8099	Configure LAP experiment	Ground, MTL
	Invoked by sequence	With parameter values	
	ARPS809A "LAP Mode Control”	ModeLAP = specified at call-time LAPParam = specified at call-time LAPSWEEpromBank = specified at call-time - default value = 0x0003	
Parameter Name	RSDB Name (Calibration)	Function	Allowed values (see below for values & meaning)
ModeLAP	**FSK01262**	**Select LAP Mode**	NoChange, OFF, SID1, SID2, SID3, Maintenance, Quiet
LAPParam	**FSK01267**	**Execute LAP Macro (see below)**	0xff (Do nothing), Upper nibble 0x0-0xa, Lower nibble 0x0-0x7
LAPSWEEpromBank	**FSK01268**	**Select LAP EEprom Bank to boot from**	??? Default = 0x0003

Table 3.2-9: OBCP Details: OBCP_5_RP.9

3.2.4.8 MIP Mode Control

The objective of this OBCP is to set the operating mode of the MIP sensor. The OBCP takes invocation parameters to set the operation mode of MIP.

Notes:
1) The OBCP will power MIP experiment on if required.
2) This OBCP is an instantiation of OBCP 8096 “Mode Control OBCP 2”, for which LAP and MAG invocation parameters are fixed to “NoChange” at sequence level. Therefore, only MIP-related actions will be executed by the OBCP.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.10 MIP Mode Control	KRPR809A	Configure MIP experiment	Ground, MTL

	Invoked by sequence		With parameter values
	ARPS810A "MIP Mode Control"		ModeMIP = specified at call-time MIPParam = specified at call-time
Parameter Name	RSDB Name (Calibration)	Function	Allowed values (see below for values & meaning)
ModeMIP	**FSK01263**	**Select MIP Mode**	NoChange, OFF, SID1, SID2, SID3, Quiet
MIPParam	**FSK01268**	**Select MIP predefined table (see below)**	0xff (Do nothing), 0x00-0x0f

Table 3.2-10: OBCP Details: OBCP_5_RP.10

3.2.4.9 MAG Mode Control

The objective of this OBCP is to set the operating mode of the MAG sensor. The OBCP takes invocation parameters to set the operation mode of MAG.

Notes:

1) The OBCP will power MAG experiment on if required.
2) This OBCP is an instantiation of OBCP 8096 "Mode Control OBCP 2", for which LAP and MIP invocation parameters are fixed to "NoChange" at sequence level. Therefore, only MAG-related actions will be executed by the OBCP.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.11 MAG Mode Control	KRPR809B	Configure MAG experiment	Ground, MTL
	Invoked by sequence		With parameter values
	ARPS811A "MAG Mode Control"		ModeMAG = specified at call-time
Parameter Name	RSDB Name (Calibration)	Function	Allowed values (see below for values & meaning)
ModeMAG	**FSK01264**	**Select MAG Mode**	NoChange, OFF, SID1, SID2, SID3, SID4, SID5, Quiet

Table 3.2-11: OBCP Details: OBCP_5_RP.11

3.2.4.10 Meaning of OBCP invocation parameters

Each individual instrument is configured using two parameters, `ModeType` and `ExpParam` (both 8 bits in length). The default value for both is 0xff which will cause the OBCP to take no action.

`ModeType` is an enumerated variable which controls the operation of each experiment. The values and meanings are as follows:

Value		Function
Enumerated	Raw	
NoChange	0xff	Do not change the state of the experiment
Off	0x00	Power off experiment
SID1	0x01	Set experiment to SID 1 Telemetry Rate
SID2	0x02	Set experiment to SID 2 Telemetry Rate
SID3	0x03	Set experiment to SID 3 Telemetry Rate
SID4	0x04	Set experiment to SID 4 Telemetry Rate
SID5	0x05	Set experiment to SID 5 Telemetry Rate
TEST	0x06	Set experiment to Test Telemetry Rate
HV_On	0xA0	Power on HV supplies (ICA & IES only)
SID1_HV_On	0xA1	Power on HV supplies, set telemetry rate to SID1 (ICA & IES only)
SID2_HV_On	0xA2	Power on HV supplies, set telemetry rate to SID2 (ICA & IES only)
SID3_HV_On	0xA3	Power on HV supplies, set telemetry rate to SID3 (ICA & IES only)
SID4_HV_On	0xA4	Power on HV supplies, set telemetry rate to SID4 (ICA & IES only)
SID5_HV_On	0xA5	Power on HV supplies, set telemetry rate to SID5 (ICA & IES only)
TEST_HV_On	0xA6	Power on HV supplies, set telemetry rate to TEST (ICA & IES only)
HV_Off	0xC0	Power off HV supplies (ICA & IES only)
Maintenance	0x20	Set unit to maintenance mode
Quiet	0x30	Turn off Science generation

Table 3.2-12: Configuration Parameter: Mode_Type

The second parameter, `ExpParam`, has a different meaning for each experiment. It is not required for MAG. The parameter controls a further configuration of an experiment. In all cases the value 0xff has a null action and is the default value. The meaning of each parameter is as follows:

Parameter Name	Unit	Valid Values	Description
IesParam	IES	Any although 0x05-0xff will be used in reality	The OBCP utilises IES command sequencer. There are a possible TBD sequences with the first 5 defined for specific functions. These are selected when the parameter is set to 0xff and using the standard enumeration of the ModeTypes parameter. Seq 0 IES LVSCI STIM mode (selected using TEST) Seq 1 IES IES Normal HV turn on Seq 2 Default Minimum mode Seq 3 Default Normal mode Seq 4 Default Maximum mode Values other than 0xff will command the numerically related sequence to be run.
IcaParam	ICA	0xff,0x00-0x27	Selects operational mode unless set to 0xFF. Usually operational mode must be set with the telemetry rate.
LapParam	LAP	Upper nibble: 0xf,0x0-0xa Lower nibble: 0xf,0x0-0x7	Lower nibble runs the specified macro unless the value is 0xf. There 8 available unless the macros are loaded from one of 11 banks as defined by the upper nibble. If the upper nibble is set to 0xf then no macros are transferred from the memory bank. Usually the parameter must be correctly defined for a given telemetry rate
MipParam	MIP	0xff,0x00-0x0f	Values 0x0-0x0f will select a predefined configuration table in PIU memory to be loaded into the command buffer. The tm rate will then be adjusted according to ModeTypes parameter. Value 0xff prevents any table being loaded.

Table 3.2-13: Configuration Parameter: ExpParam

LAP requires the additional parameter `LAPSWEEpromBank` which specifies the memory boot bank allowing running different versions of the software stored in different memory banks.

Parameter Name	**Unit**	**Valid Values**	**Description**
LAPSWEEpromBank	LAP	TBD	Default value = 0x0003

Notes:

1) The parameter LAPSWEEpromBank is only used when switching LAP on. Successive instances of the OBCP which are meant to change LAP configuration **do not** require the use of this parameter which will be ignored if present.

3.2.5 LDL Mode Control

LDL can be controlled with OBCP and FCP.

3.2.5.1 LDL Control with OBCP

The LDL OBCP controls both the initialisation and termination of LDL mode but also any resynchronisation of the LDL mode that may be required. The resynchronisation occurs automatically. If resynchronisation is necessary, PIU will generate event YRP0AEC1 "EC_BadLdlSync" which will be trapped by DMS (event is registered with Service 12) and trigger execution of "PL_OBCP_5_RP.4 RPC LDL Control" with parameter Action = Resync.

This OBCP shall not be started again if it is already running. This will be avoided by the OBCP Manager.

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.4 RPC LDL Control	KRPR8094	Configures LAP/MIP LDL Mode	Ground, MTL, OB Monitoring, other OBCP
	Invoked by sequence		With parameter values
	ARPS805A (RP-SEQ-805) " RPC LDL Mode "		Action = specified at call-time
Parameter Name	RSDB Name (Calibration)	Function	Allowed values enumerated / raw
Action	**FSK01270**	**Selects LAP and MIP configurations**	Resync / 0x00 Disable / 0x01 EnableNorm / 0x02 EnableMixed / 0x03

Table 3.2-14: OBCP Details: OBCP_5_RP.4

Notes:
1) Within the LDL OBCP LAP runs the *current* (at call time) macro 6.
2) Before starting LDL it is necessary to ensure that the correct bank of macro's is loaded into LAP's memory and that the *current* macro 6 is compatible with LDL mode.

   Currently the following macros are defined in LAP:
   Bank 7, macro 6: Minimum rate LDL mode.
   Bank 8, macro 6: Normal rate LDL mode.
   Bank 9, macro 6: Burst rate LDL mode.

   For full list see:
   http://rpc.sp.ph.ic.ac.uk/wiki/pub/Documents/LapDocs/LAP_MacroTable_100910.pdf

3) It is also necessary to ensure that MIP is operating in the correct configuration. This may be done by using the MIP Mode Control OBCP.

3.2.5.2 LDL Control with FCP

LDL Mode is controlled by the following FCP's and corresponding ARPFs:

Sequence & Procedure	Name	Function	Notes
ARPF901A RP-FCP-901	Set LDL Normal Mode	Turn LDL ON in Normal Mode	LAP Macro 0 bank 1 executed. LAP Telemetry rate should be selected as required
ARPF902A RP-FCP-902	Set LDL Mixed Mode	Turn LDL ON in Mixed Mode	LAP Macro 6 bank 1 executed. LAP telemetry rate should be selected as required
ARPF903A RP-FCP-903	Stop LDL Mode	Turn LDL OFF	LAP End Macro command executed

Table 3.2-15: LDLmode FCPs.

Notes:

1) Prior to LDL Start
   - Before running an "ON" procedure, MIP should be configured in the required mode. The default procedure for doing this is MIP Active (RPC_FCP_420).
   - LAP should not be running a macro before starting LDL. This can be accomplished by running End Macro Procedure (RPC_FCP_399).
   - LAP's telemetry rate during LDL mode is selected by the specified parameter in power on procedures.
2) After LDL Stop
   - When LDL mode is turned off (RP-FCP-903) MIP is left in its pre-LDL mode.
   - LAP is left with its macro's terminated but it may still generate telemetry for 8 AQP's.

3.3 Operational Requirements and Constraints

The following FOV constraints for ICA,IES and LAP are input parameters for RD-GEN-38.

3.3.1 ICA Field-of-View

The nominal ICA FOV according to Table 1.2-5 is

- 360° in the azimuthal direction (spacecraft yz –plane) with a resolution of 22.5° (16 sectors)
- -45°…+45°(elevation angle) wrt. sensor XY-plane (s/c-ZX-plane) with a nominal resolution of 5.625°in elevation. The calibration revealed an actual FOV from -39°…+41°wrt. sensor XY plane. The actual resolution in the elevation angle according to the calibration is about 4.5°... 5°.

Figure 3.3-1 shows the sectors and elevation numbering. Note that the sector numbering is based on the physical location of the sector anode. The particles actually detected by those sectors come from the opposite direction. Note furthermore that the coordinates are given in the instrument coordinate system
(Y_urf=-Z s/c, Z_urf= Ys/c)

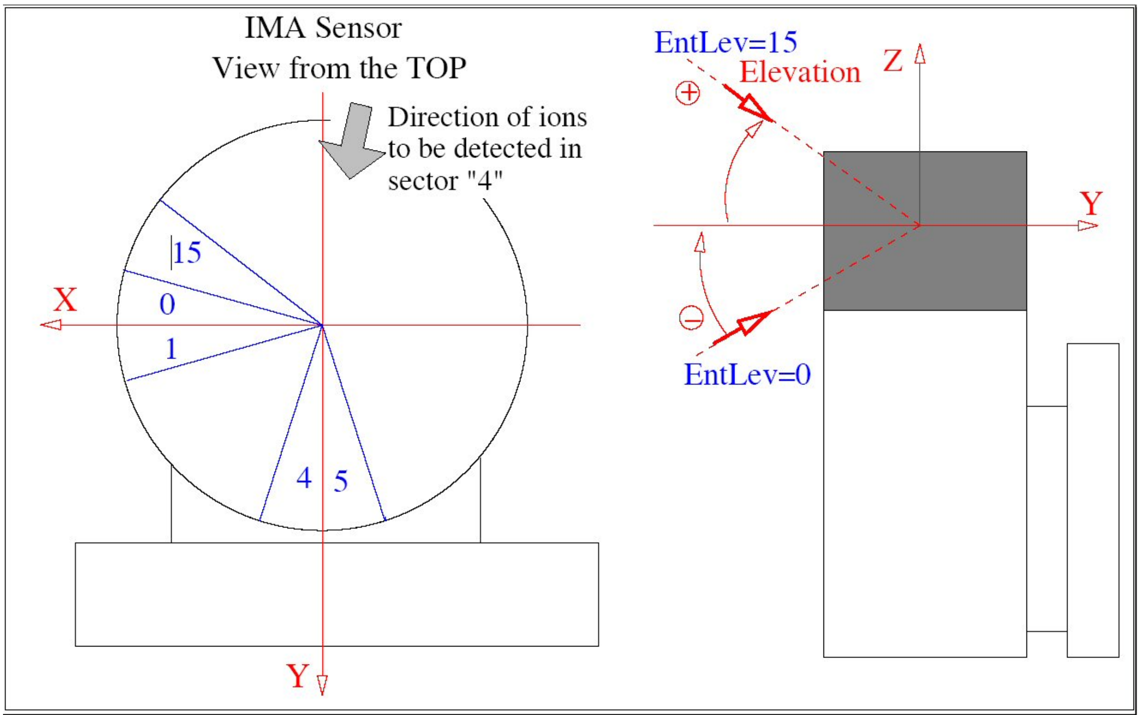


Figure 3.3-1: ICA Sector and Elevation numbering for ICA.

Elevation Index 0 relates to -39° elevation and index 15 relates to 41°.

The location of ICA on Rosetta is shown schematically inFigure 3.3-2. The spacecraft coordinate system is shown so that sector and elevation angles (from Figure 3.3-1) can be related to the spacecraft coordinate system. This Figure also shows the sectors (10 - 15 and 0) which are shadowed by the spacecraft for some elevation angles (index 0-7) .

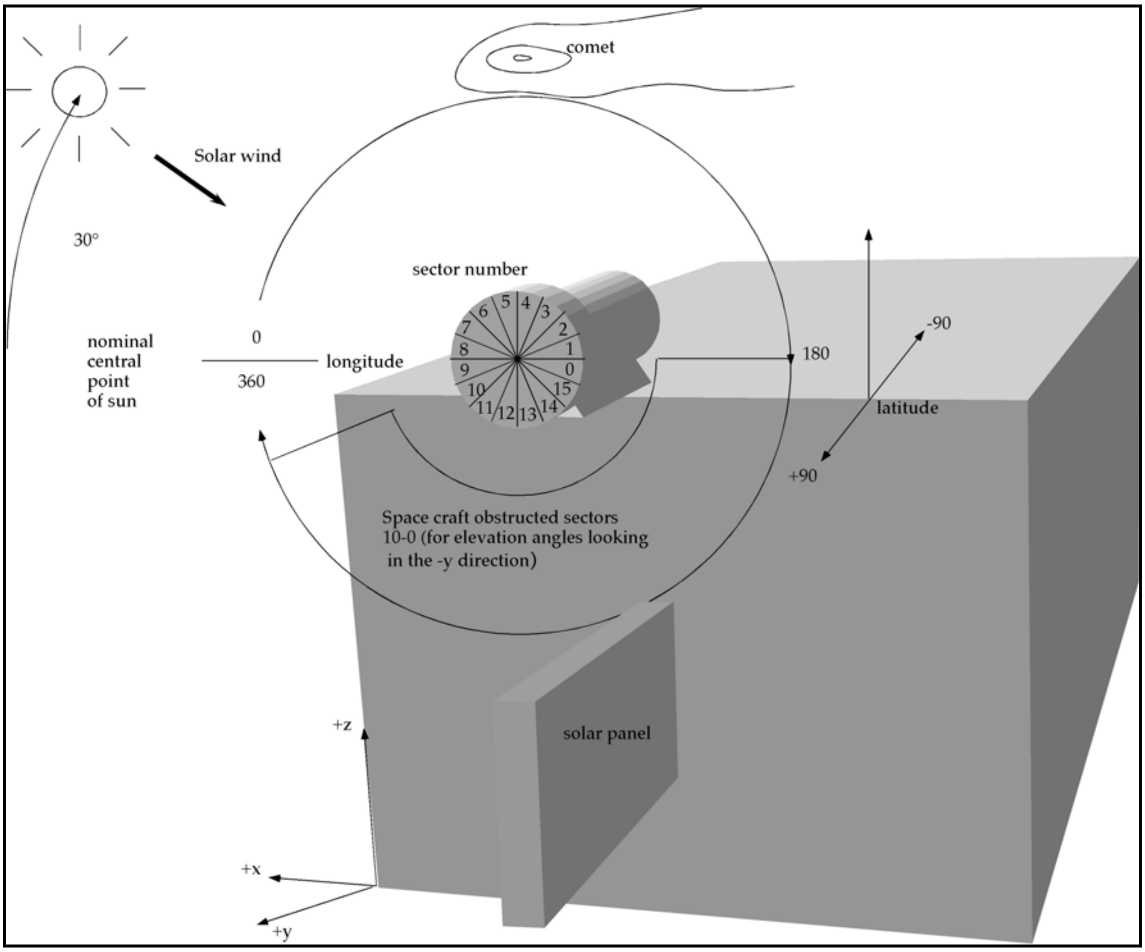


Figure 3.3-2: Location of ICA on the spacecraft.

The field-of-view of the ICA can also be shown using the latitude and longitude definitions shown in Figure 3.3-2, which is done in Figure 3.3-3. Latitude and longitude are defined in Figure 3.3-2. Note that this handwritten figure is not exact, it is intended as an indication where the spacecraft and solar panels are within the ICA field-of-view. The spot at 90° longitude, 0° latitude is the nominal position of the comet. Note also that –90 and 270 degrees in Figure 3.3-3 are the same. In nominal comet-pointing position the comet will be at 90° longitude, 0° latitude. The approximate angles which can be affected by the solar panels can be seen. The region between –10° and 180° is the free field-of-view of ICA. Longitudes below –10° and above 180° are totally blocked by the spacecraft for negative latitude.

The FOV definition is implemented in the SPICE instrument Kernel file RD-RPC-13.

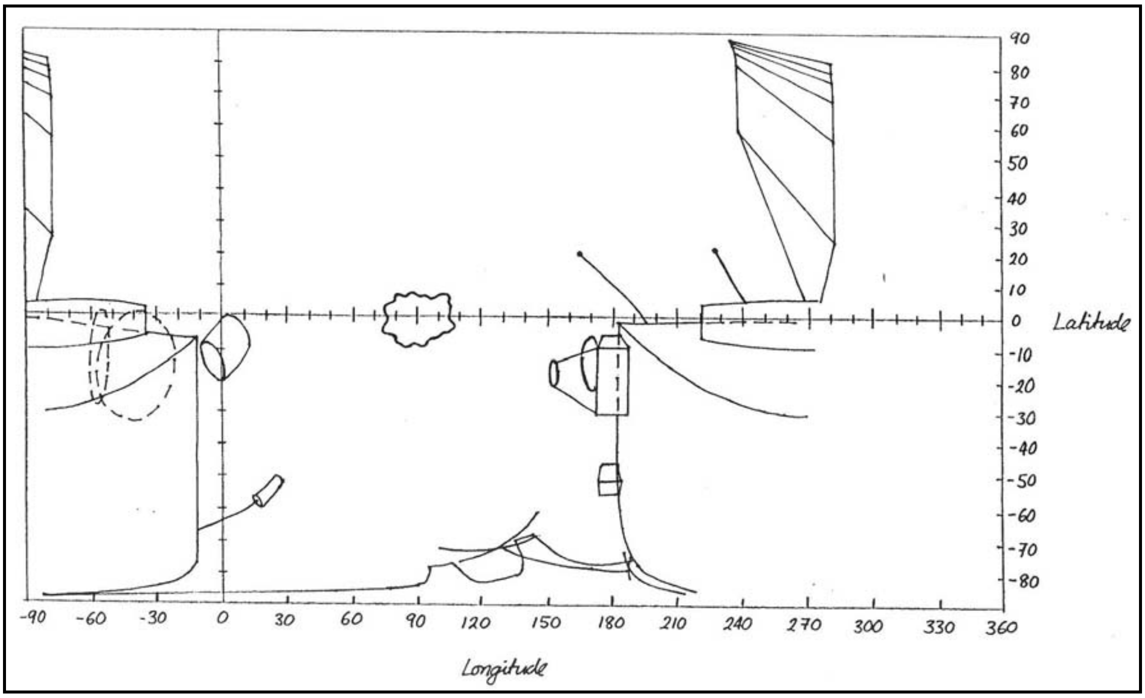


Figure 3.3-3: Rosetta seen from the ICA point-of-view.

3.3.2 IES Field-of-View

The IES instrument is oriented on the +Z deck of the Rosetta S/C at such an angle so as to avoid as little field of view (FOV) interference from other parts of the S/C as possible. Measuring the solar wind plasma is a critical science objective of IES. Since the solar wind ions generally flow as a very narrow beam it is necessary for IES to point its high angular resolution anodes as directly toward the sun as possible. Figure 3.3-4 shows the layout of the ion and electron MCP anodes.

The result is that in order for such pointing to occur the S/C SAA must be between the angles 70º and 100º. This is a soft operational constraint that needs to be met to acquire nominal solar wind data. This angle range was experimentally determined in flight by having
the S/C perform a roll through a large SAA range.

The FOV definition is implemented in the SPICE instrument Kernel file RD-RPC-13

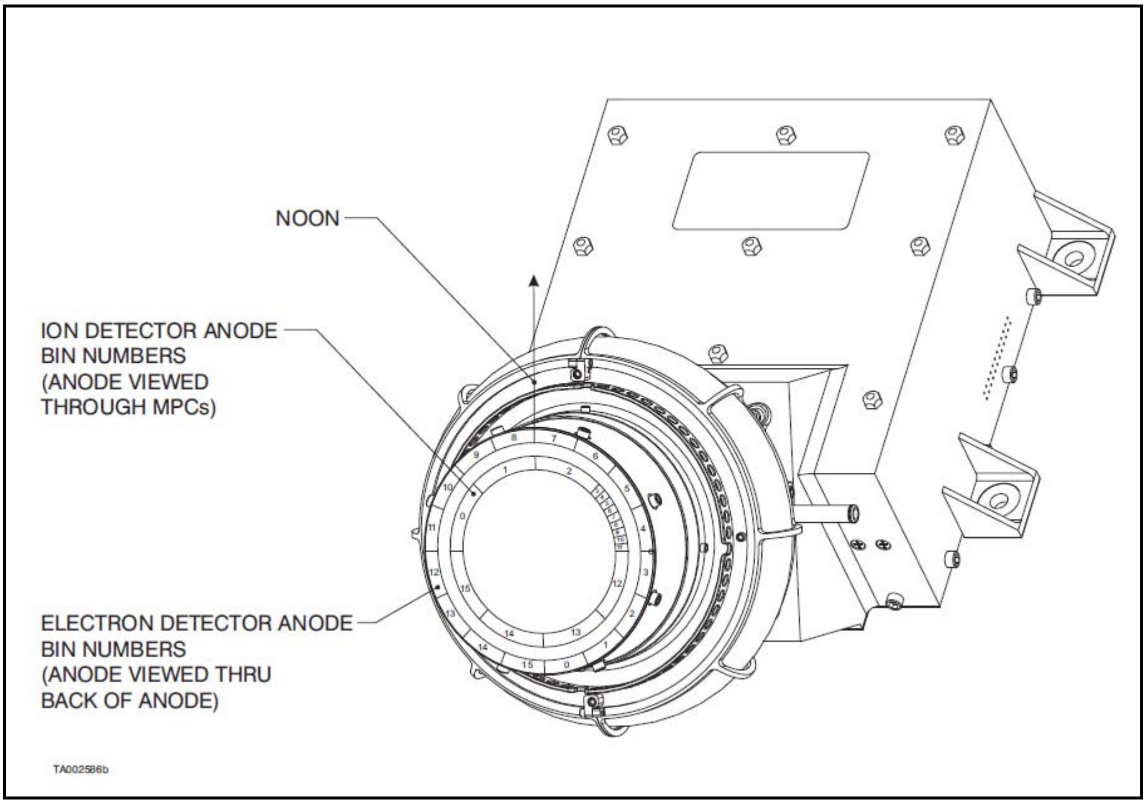


Figure 3.3-4: IES ion and electron MCP anodes layout

3.3.3 S/C Attitude Requirements

Some of the RPC Plasma instrument need a proper pointing to operation in the right attitude wrt. the Sun , the Comet are any other actual celestial body. The different pointing scenarios for the comet phase are defined in the RPC-Wiki at

http://rpc.sp.ph.ic.ac.uk/wiki/bin/view/Science/RpcPointings

These scenarios are based on the following detailed attitude constraints:

3.3.3.1 ICA S/C Attitude Requirements

To guarantee nominal performance of the instrument the following operational constraint on the FOV must be met:

The s/c solar aspect angle (SAA) must be between -90° and +90°. This corresponds to the constraint that the Sun is within a range of +/-40° from the s/c-XZ-plane and the Sun is in the X/+Z octant.

Type of constraint: soft, performance
Active is ICA is switched on

3.3.3.2 IES S/C Attitude Requirements

To guarantee nominal performance of the instrument the following operational constraint on the FOV must be met:

The s/c solar aspect angle (SAA) must be between +70° and +100°.
IES can see the solar wind in the azimuth and elevation angles only in this range.

Type of constraint: soft, performance
Active is ICA is switched on

3.3.3.3 LAP S/C Attitude Requirements

The LAP requirements on s/c attitude vary with operational mode and plasma environment. As a general rule, the probes do not provide good data if in a wake, formed by e.g. the s/c or the solar panels.

In the tenuous plasma in the solar wind (presumably relevant for the early comet phase as well), LAP measurements obtained using voltage bias (sweeps or fixed bias) are generally dominated by photoelectrons from the spacecraft, and are thus less useful for most purposes. In such environments, the electric field mode (bias current) is more useful, as this allows monitoring of the s/c potential from which the plasma density may be inferred. However, this mode is less useful if the probe is in eclipse: hence, a sunlit probe is preferable in these circumstances. In addition, the probe should be as far away from the solar panels as possible.

On the other hand, in the dense plasmas seen in the Earth's plasmasphere during the swing-bys and anticipated in the developed cometary coma, where the random thermal current due to electrons dominates over the photoemission current, the voltage bias mode will be more useful, and any photoemission will only complicate the data. In this situation, it can be an advantage if the probe avoids sunlight, though sunlight exposure is better than having the probe in the wake.

Interferometric measurements of flow speed require that the line between the two probes is as parallel to the plasma flow direction as possible. They are impossible if the plasma flow to any of the probes is blocked, i.e. if the probe is in a wake.

What attitude is optimal for LAP will thus have to be decided on a case-by-case basis. Nevertheless, given the very different positions of the two LAP probes, attitudes so bad that no useful data can be obtained from at least one of the two probes will be rare. It will almost always be possible for LAP to obtain some useful data on the plasma environment, though particular investigations will certainly require specific attitude ranges.

More details can be found in the RD-LAP-4.

3.3.4 Environmental Pressure and dust level for IES (DMS-Service19)

IES requires the ROSINA Pressure, ROSINA PressureGradient and the GIADA Dust Flux information messages to be delivered via Service 19 from the DMS. This service is required only at the comet. For the other phases it is nice to have but not necessary.

The IES software has an algorithm to monitor these values and take actions to either turn off the high voltage or to autorecover and return the high voltage to nominal levels. The safety and autorecovery mechanisms are described in detail in section 3.4.5, Instrument-Specific Failure Detection Mechanisms.

Environment Pressure may be delivered to RPC as either a periodic parameter (approx. once per minute) or as an ‘event’ when the pressure exceeds a pre-defined value.

ICA requires the ROSINA gas pressure information messages to be delivered via Service 19 from DMS. This service is only required at the comet. The ICA software has a command to enable automatic control of the high-voltage based on ROSINA pressure data. The commands are described in section 3.4.5.

LAP, MIP and MAG
do not use Service 19.

For details on Service 19 refer to RD-GEN-6.

3.3.5 Thruster Warnings

Gas pressure warning is needed at the comet and any time unplanned thruster firings are expected while IES HV is on.

3.3.6 Operational Constraints

The following operational constraints are to be met at all times during operations in order to guarantee integrity of the RPC instruments:

- IES and ICA must be off when a thrusters firing event takes place.
- Thruster firings give interference in LAP data, but are harmless and their signature is easily identifiable in the data. There is therefore no operational constraint on thruster firings, though their timing should be made available to us afterwards for assisting the removal of bad data.
- IES and ICA must be off when a wheel offloading event takes place.

Additional ICA Constraints:

- If the gas pressure in the vicinity of the comet is too high, the high voltage of ICA should be switched off. This is also true if the ionospheric electron density is too high. This may happen late in the mission phase and must be judged by the PI team. Electron/ion densities can be judged by the ICA, IES and LAP instruments of RPC. It is not an operational constraint which ESOC needs to consider.

- Apart from the ordinary sensor temperature constraints listed in table Table 2.5-1, ICA does have another specific operating temperature constraint. When the sensor temperature exceeds about 37 degrees an on-board FPGA is likely to latch-up. Such temperatures were observed at least as often at Mars orbit as at Earth orbit, despite the significantly different sun distances. From spacecraft housekeeping data it seems that the spacecraft operated heater was switched on during instrument operations at Mars distance and beyond, possibly explaining why such high temperatures were observed at Mars and Lutetia. Therefore, if possible, once the instrument is turned on, the spacecraft operated heater should be turned off, at least for sun distances corresponding to Lutetia and closer. At Lutetia the instrument was auto-switched off when the temperature threshold was exceeded, but this was not due to the rapid rise of temperature caused by a latch-up. See Figure Figure 3.3-5 which describes the evolution of temperatures and currents during 3 latch-up events and at the Lutetia encounter. One can see that the temperature increase at Lutetia is rapid at first, but is then gradually reaching a high steady state temperature before it is shut off at about 30 minutes after the temperature started to increase. During the latch-ups there was a surge of current to the PIU when the temperature of the ICA sensor increased, but this was not the case at Lutetia. Therefore we must learn from in situ operations how to operate ICA. Hopefully switching the spacecraft operated heater off during operations can solve the problem. Otherwise we will have to schedule regular switch-ons/offs of ICA, to re-start the instrument after a switch-off.

- The reaction wheels of the ROSETTA s/c generate magnetic disturbance. To get rid of these dynamically changing structures a special elimination s/w has been developed for cleaning the measured magnetic field data. This elimination works best if the RPCMAG instrument is operated in Burst mode (SID3).

- Additional interference is generated by the RPCLAP instrument causing monofrequent signatures seen by RPCMAG. Refer to RD-MAG-34 for details. Again, data cleaning works best if RPCMAG is operated in Burst mode (SID3).

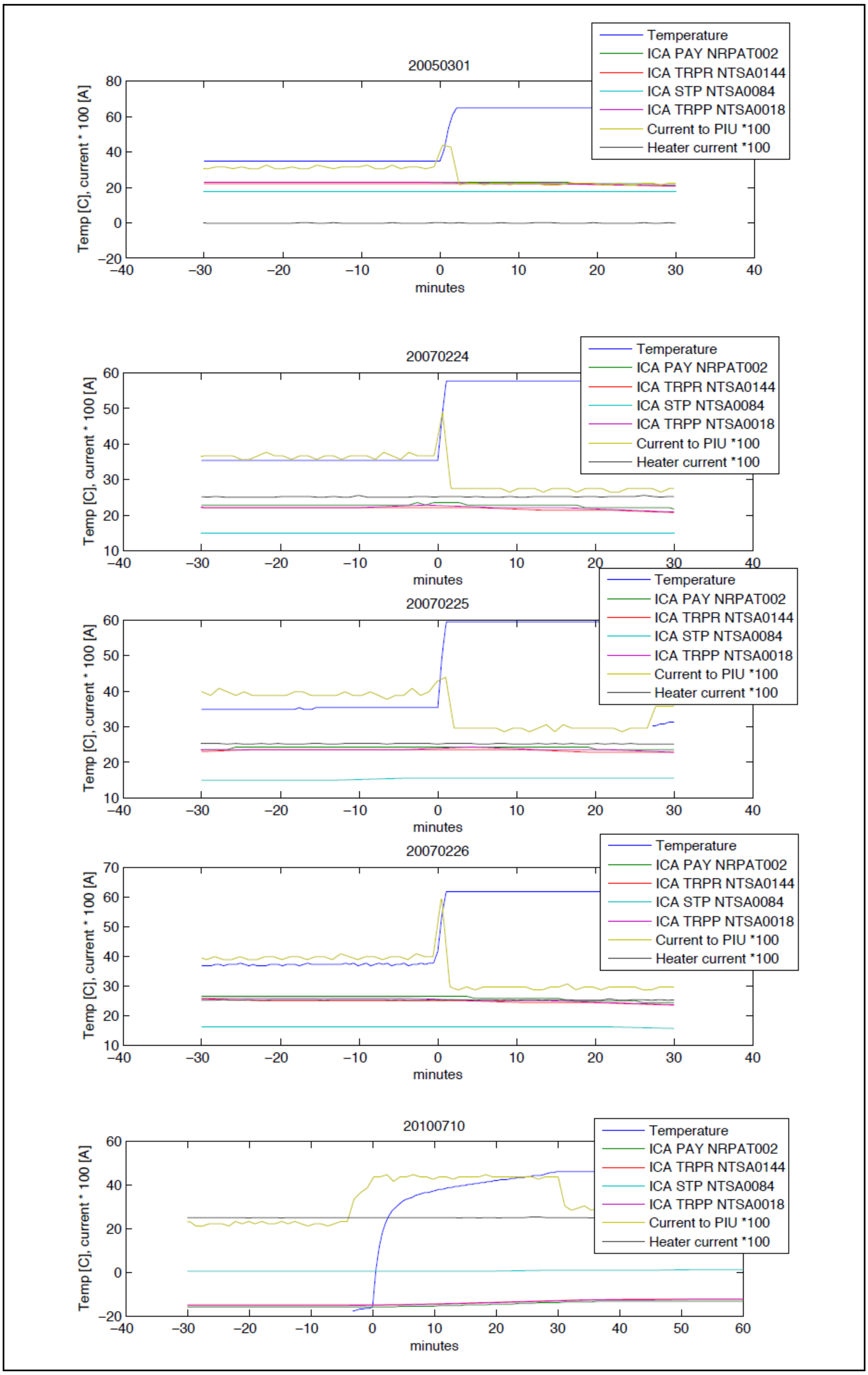


Figure 3.3-5: ICA, Thermal behavior

3.3.7 Thermal Constraints

The temperature limits listed in section 2.5.1.1 may not be exceeded in any phase of the mission.

IES: One part of IES consists of the ESAs, MCPs, and preamps attached to the neck. These components are not well connected thermally to the box because of the construction, especially due to the toroidal grounded grid that surrounds the top-hat aperture. There is thus a thermistor (PAY429_IES_1) inside the electron portion of this arrangement as well as a 0.5 W heater (PL-LCL-40). This heater has to be turned on when the temperature gets down to -10 C, well before it gets near the cold limit. However, we don't want the temperature to get too high so the heater should turn off when the temperature warms up to -5 C.

The second part, the main electronics box, is in thermal contact with the +Z deck and carries 2 TRP thermistors (TCS053_IES, TCS054_IES) on the back surface. The box also has a 2.7 W heaters (PL-LCL-18) on the top surface as well as 2 thermostats that control the heaters. The thermostats turn on at 0 C. This arrangement is supposed to take care of maintaining the temperature of the electronics box.

3.4 Failure Detection and Recovery Strategy

3.4.1 Introduction

The term *failure* is used in this section to indicate an out-of-limit situation i.e. the non compliance of a measurable physical quantity with its pre-defined limits.

RPC failure detection occurs at three different levels:

1) Spacecraft (DMS) level (see section3.4.3)
2) PIU level (see section 3.4.4)
3) Instrument level (see section 3.4.5)

A combination of actions from all three levels make up RPC's detection and recovery strategy, as described in section 3.4.2.

Detection of potentially dangerous conditions is performed by the PIU or the DMS monitoring physical parameters that are vital to RPC, such as voltages and temperatures. In case of a potentially dangerous condition being detected, PIU and DMS will take autonomous action and put the endangered unit in a safe condition (usually switch-off). No contingency detection is intended to be performed on ground.

Only non-critical events and faults related to parameters which are not measurable or detectable on-board are intended to be diagnosed on ground upon reception and analysis of telemetry data.

Notification to RPC of reception of event packets which might require intervention from ground will be performed by the MOC according to instructions given in SY-CRP-000. More information can be found in section 3.4.6.

The System Contingency Recovery Procedure SY-CRP-000 is fully defined and can be found in the RD-GEN-9.

3.4.2 Failure Detection and Recovery Strategy

Some of the parameters monitored by PIU are physical quantities such as voltages and temperatures for which two operational limits have been set: a w*arning* level and a *danger* level. PIU will react in case of a parameter reaching either level and the action taken depends on whether the offending unit is PIU itself or one of the instruments and on the nature of the violation. The list of parameters monitored by PIU and their limits can be found in Table 3.4-3.

The monitoring and recovery strategy is explained below.

a) If PIU detects that a **warning** limit has been violated, PIU will generate event YRP0AEC3 “EC_ParamMntrWrning”. The event’s parameters contains details of the event occurred such as the ID of the offending unit and the violated parameter.

b) If PIU detects that a **danger** limit has been violated, PIU will generate event YRP0AEC4 “EC_ParamMntrDanger” and:
   - if the offending unit is ICA, IES, LAP, MIP or MAG:
     1. PIU will switch the unit off and generate event YRP0AE84 “EC_AutoShutDown”.
     2. The DMS will trap YRP0AEC4 the reception of which will trigger execution of OBCP PL_OBCP_5_RP.5 KRPS8095. The OBCP will perform no action in the case of the offending unit being an instrument.
   - if the offending unit is PIU:
     1. PIU will switch off any powered sub-unit;
     2. PIU will generate YRP0AE84 “EC_AutoShutDown”
     3. The DMS will trap YRP0AEC4 the reception of which will trigger execution of OBCP PL_OBCP_5_RP.5 KRPS8095 which in this case will power PIU off.

c) In case of PIU detecting MIP **watchdog** being fired, PIU will power MIP down and generate event YRP0AE81 “EC_MipDogBarking”.

d) Other quantities such LDL current and PIU +5V and -5V are monitored and acted upon by the DMS alone.

3.4.3 DMS Monitoring of RPC

The DMS is in charge of monitoring the physical quantities and events that cannot be monitored or be acted upon directly by the PIU. Those events are listed in the table below.

LCL Current Trip	
Description	**Action**
The DMS has detected an LCL current trip	No immediate action required as events powers off all RPC units
Detection of event YRP0AEC4	
Description	**Action**
DMS has detected that event YRP0AEC4 EC_ParamMntrDanger" was generated by PIU – this means that one of the parameters monitored by PIU has violated the *danger* limit.	Event is trapped by DMS which will run OBCP KRPS8095. OBCP will analyse event parameter NRPA0525 and will: • shutdown RPC if offending unit is PIU which is indicated by NRPA0525 being 0x0003 (+5V danger level) 0x0006 (-5V danger level) 0x0009 (+12V danger level) 0x000C (-12V danger level) 0x000F (28V danger level) 0x0012 (Temperature danger level) • do nothing for all other values of NRPA0525.
Detection of event YRP0AEC1	
Description	**Action**
DMS has detected that event YRP0AEC1 "EC_BadLdlSync" was generated by PIU – this means that the LDL mode is out of sync	Event is trapped by DMS which will run OBCP KRPS8094 with parameter Action = Resync
PIU +5V level out-of-limits	
Description	**Action**
RPC +5V level out-of-limits Monitored parameter = NRPD0310 YRP00325	DMS will shut RPC down
PIU +5V level out-of-limits	
Description	**Action**
RPC -5V level out-of-limits Monitored parameter = NRPD0317 YRP00325	DMS will shut RPC down

Table 3.4-1: Events monitored by the DMS.

3.4.4 PIU monitoring of RPC

PIU is capable of detecting a certain number of fault conditions related to the experiments. The PIU *monitoring system* monitors specific fields within each

experiment's housekeeping data packet and action is taken autonomously by PIU in case the value of a monitored parameter is found to be out of the allowed boundaries or in case a failure being detected.
The action taken by PIU depends on the type of failure. Failures that might harm the integrity of an instrument, such as an over temperature condition, will trigger an action by the PIU which will put the instrument in a safe condition (instrument powered off), whereas failures that are not considered dangerous are reported to ground by generating an event packet and will be dealt with at a suitable stage.

PIU also monitors power supply voltages and PIU temperature. In case of a value being out-of-limit the whole RPC will be switched off. This will be done by DMS which will act upon request of PIU via the S/C service 12.

In addition to housekeeping parameters, PIU monitors a hardware MIP Watchdog.

The table below reports the parameters monitored by the PIU and the action PIU will take in case the parameter is found to be out of the preset limits.

PIU Voltage reached danger / warning level	
Description	**Action**
Monitored parameters: NRPD0310 (+5V) NRPD0317 (-5V) NRPD0320 (+12V) NRPD0327 (-12V) NRPD0330 (28V) Event pkts generated: YRP0AEC3 (Warning) YRP0AEC4 (Danger)	When the ***warning*** level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning". When the ***danger*** level is reached for two consecutive samples, PIU will turn off any powered subunit and then raise event YRP0AEC4 "EC_ParamMntrDanger". Offending parameter and its current level are reported in the event packet's parameters. DMS will trap the event and execute OBCP KRPS8095 which will shut the PIU down.
PIU Temperature reached danger / warning level	
Description	**Action**
Monitored parameters: NRPD0306 Event pkts generated: YRP0AEC3 (Warning) YRP0AEC4 (Danger)	When the **warning** level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning". When the **danger** level is reached for two consecutive samples, PIU will turn off any powered subunit and then raise event YRP0AEC4 "EC_ParamMntrDanger". Offending parameter and its current level are reported in the event packet's parameters. DMS will trap the event and execute OBCP KRPS8095 which will shut the PIU down.
ICA Temperature reached danger / warning level	
Description	**Action**

Monitored parameters: NRPD2360 NRPD2368 Event pkts generated: YRP0AEC3 (Warning) YRP0AEC4 (Danger)	When the **warning** level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning". When the **danger** level is reached for two consecutive samples, PIU will turn off ICA before raising YRP0AEC4 "EC_ParamMntrDanger" event indicating the offending parameter and its current level. DMS will trap the event and execute OBCP KRPS8095 which will do nothing.

MAG Reference Voltage out of specification	
Description	**Action**
Monitored parameters: NRPD530C NRPA5310 Event pkts generated: YRP0AEC4 (Danger) YRP0AEC3 (Warning)	When the **warning** level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning". When the **danger** level is reached for two consecutive samples, PIU will turn off MAG before raising YRP0AEC4 "EC_ParamMntrDanger" event indicating the offending parameter and its current level. DMS will trap the event and execute OBCP KRPS8095 which will do nothing.

MAG Sensor Temperature Difference out of bounds	
Description	**Action**
Monitored parameters: none (internal calculation performed by PIU) Event pkts generated: YRP0AEC3 (Warning)	When the **warning** level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning".

MIP Watchdog Signal Received by PIU	
Description	**Action**
Event pkts generated: YRP0AE81	When this hardware is signal is received from MIP, PIU will shutdown MIP and raise the event EC_MipDogBarking

Table 3.4-2: Parameters monitored by PIU

Description	**Warning Level**		**Danger Level**		**Parameter Name**	**NRPA0525 Value**
	Low	**High**	**Low**	**High**		
PIU +5 V	4.85 V	5.42 V	4.54 V	5.68 V	NRPD0310	0x0003
PIU -5 V	-5.25 V	-4.78 V	-5.50 V	-4.53 V	NRPD0317	0x0006
+12 V	10.88 V	13.75 V	9.67 V	15.00 V	NRPD0320	0x0009
-12 V	-13.45 V	11.27 V	-14.68 V	10.01 V	NRPD0327	0x000B
+28 V	25.12 V	31.28 V	22.33 V	34.12 V	NRPD0330	0x000F
PIU Temperature	-28.89°C	75.59°C	-38.22°C	91.23°C	NRPD0306	0x0012

Danger						
ICA Sensor Temp	-25.29°C	+44.84°C	-30.31°C	+45.84°C	NRPD2360	n/a
ICA DPU Temp	-25.29°C	+44.84°C	-30.31°C	+45.84°C	NRPD2368	n/a
MAG ref voltage	16220 *	16548 *	15565 *	17203 *	NRPD530C (MS nibble) NRPA5310 (LS word)	n/a
MAG sensor temp difference	-12288 *	12288 *	n/a	n/a	none	n/a

Table 3.4-3: Limits of Parameters monitored by PIU.

These limits are hard-coded in PIU s/w and may differ from the limit for the same parameter set in RSDB.

Description	SOFT Limits		HARD Limits		Parameter Name	Limit Name
	Low	High	Low	High		
PIU +5 V	+4.84 V	+5.39 V	+4.59 V	+5.65 V	NRPD0310	LRPD0310
PIU -5 V	-5.42 V	-4.87 V	-5.68 V	-4.62 V	NRPD0317	LRPD0317
+12 V	11.32 V	13.88 V	10.06 V	15.15 V	NRPD0320	LRPD0320
-12 V	-13.84 V	-11.49 V	-15.09 V	-10.21 V	NRPD0327	LRPD0327
+28 V	+25.4 V	+31.19 V	+22.58 V	+34.03 V	NRPD0330	LRPD0330
Temperature Danger	-35 °C	+55 °C	-40°C	+85°C	NRPD0306	LRPD0306
ICA Sensor Temp	-25 °C	50 °C	-30 °C	55 °C	NRPD2360	LRPD2360
ICA DPU Temp	-25 °C	50 °C	-30 °C	55 °C	NRPD2368	LRPD2368
MAG ref voltage	n/a	n/a	n/a	n/a	NRPD530C (MS nibble) NRPA5310 (LS word)	n/a
MAG sensor temp difference	n/a	n/a	n/a	n/a	n/a	n/a

Table 3.4-4: Limits set in RSDB.

3.4.5 Instrument-Specific Failure Detection Mechanisms

IES :

IES has the following failure detection and recovery strategies:

- Internal watchdog timer

An internal watchdog timer that must be stroked a minimum of every 0.5 seconds. If this is not performed, the IES instrument reboots to PAUSE-PROM mode awaiting further instruction. This could occur if there is e.g a bad opcode fetch or if there is instability in program execution. TLM point NRPD1342 would indicate that the watchdog timer had expired.
A check of the low-voltage power supplies (+5V, -5V, +12V, -12V) is performed during operation. Anomalous behavior is reported through housekeeping (TLM points NRPD132C, NRPD132E, NRPD1328 and NRPD132A respectively) and event messaging (e.g. YRPB161 for bad monitor and YRP0B163 for +/-5V problem or YRP0B164 for +/-12V problem to report the bad reading).

- HV Monitors:

During HVSCI-EEPROM operation with HV supplies on, the electron MCP, the ion MCP and high-voltage bulk supply monitors are all sampled and checked to be within the commanded range. If these criteria are not met, the HV supplies are brought down by the flight software – this is performed in one step by turning off the HVPS (observed at TLM point NRPD131C), event messages (YRP0B161 for bad monitor and then one of YRP0B106 for bad ELC MCP, YRP0B107 for bad ION MCP or YRP0B108 for bad HVMON) are sent out and IES goes to the safe, LVSCI-EEPROM mode awaiting further instruction.

- Safing and Autorecovery for high electron counts, ion counts, Rosina pressure, ROSINA pressure gradient and Giada dust count:

A safing and autorecovery mechanism has been implemented in the IES flight software. It is triggered by excessive counts in the ion or electron MCP's and/or Service 19 messages from Rosina or Giada.

Figure 3.4-1 shows a state diagram of this mechanism. The beginning state is INIT for initializing the mechanism upon entry into HVSCI mode. IES spends all of its science operation time monitoring the trigger mechanisms at a 1 Hz rate in the CHECKING state, unless ion or electron counts exceed their threshold levels, or if Rosina or Giada values exceed their threshold levels for their particular readings. If any of these conditions are detected, the state machine transitions to the SAFED state where the HVPS is immediately turned off and remains off for a predetermined time and until a safe condition is detected. The duration of the HV off state and the autorecovery thereafter depends on the recent history of safing. The more frequent the safings, the longer the wait time before autorecovery is initiated. A FINAL_WAIT state provides additional time before turning the HVPS back on. If the number of safings is too frequent, the WAITING FOR GROUND INTERVENTION state is entered, where new instructions must be provided from the ground for further action. Note that science acquisition is still executing in order to simplify the logic of the state machine - only the HVPS is being turned on and off.

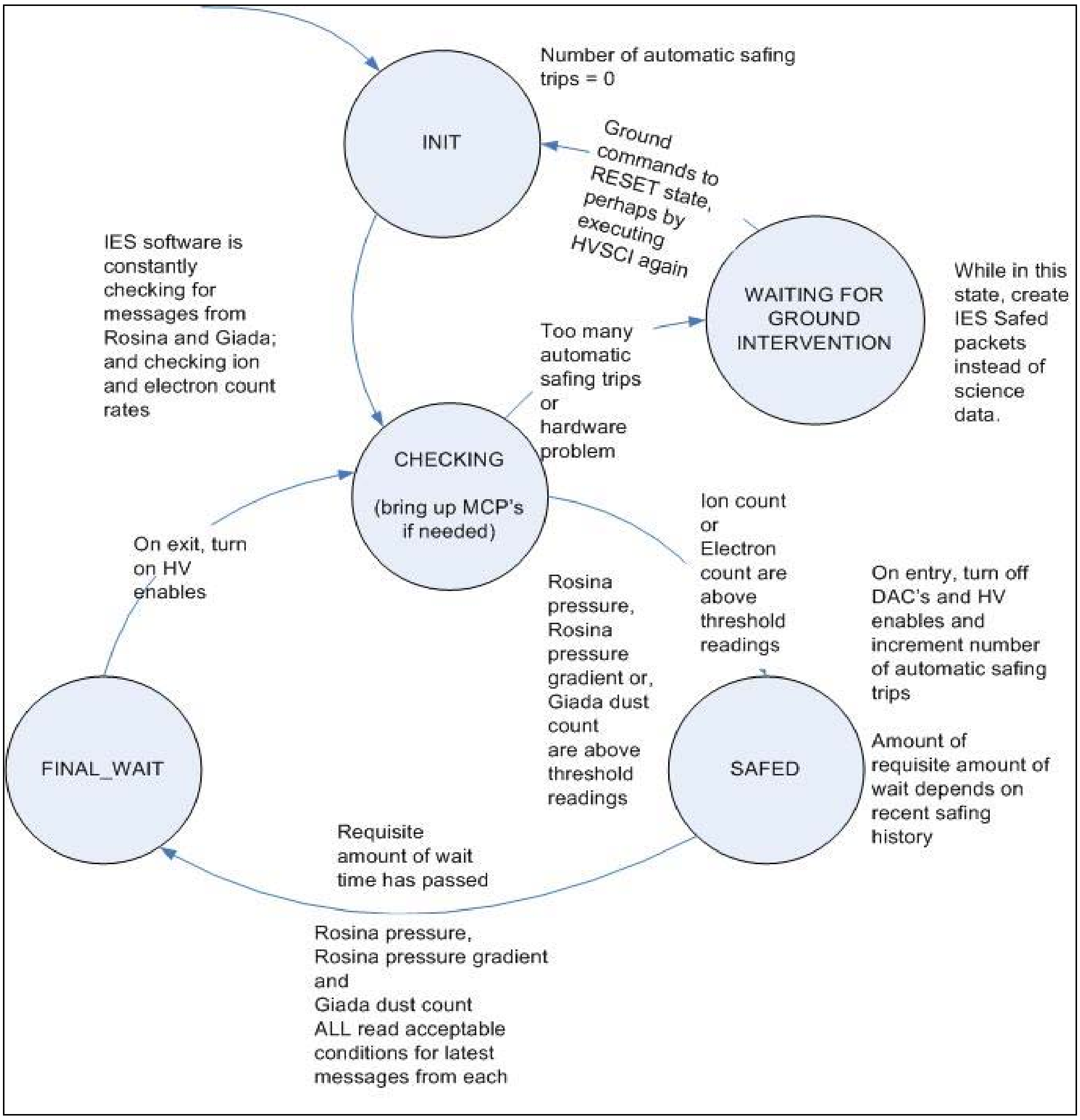


Figure 3.4-1: IES Safing and Autorecovery State Diagram

Table 3.4-5Table 3.4-5 shows the default list of parameters stored in an IES-internal EEPROM table. These include the threshold levels and the wait times. The values can be updated with an existing table upload procedure.

Parameter Name	Setting
bFirstTimeWaitForAcceptableRosinaGiada	0
bElcEnabled	1
wElcThreshold	1000
wElcViolations	5
bIonEnabled	1
wIonThreshold	1000
wIonViolations	5
bRosinaPressEnabled	1
wRosinaPressSafeThresh	0x0016
wRosinaPressRcovrThresh	0x0057
bRosinaPressGradEnabled	0
wRosinaPressGradSafeThresh	0
wRosinaPressGradRcovrThresh	0
bRosinaAlertEnabled	0
bGiadaReadingEnabled	1
wGiadaReadingSafeThresh	150
wGiadaReadingRcovrThresh	75
wElcMcpOpDacValue	0
wElcMcpDacIncrement	4
wIonMcpOpDacValue	0
wIonMcpDacIncrement	4
wCheckingCountdown	3600
awSafeIonElcWaitingCountdown[0]	3600
awSafeIonElcWaitingCountdown[1]	7200
awSafeIonElcWaitingCountdown[2]	14400
awSafeIonElcWaitingCountdown[3]	14400
awSafeIonElcWaitingCountdown[4]	14400
awSafeRosinaGiadaWaitingCountdown[0]	3600
awSafeRosinaGiadaWaitingCountdown[1]	7200
awSafeRosinaGiadaWaitingCountdown[2]	14400
wFinalWaitingCountdown	900

Table 3.4-5: IES Safing and Autorecovery Parameters

ICA has the following failure detection mechanisms:

1) A watchdog counter that is periodically reset. Failure to do so will raise a hardware reset.

2) The RAM memory has an error detection and correction mechanism. If it fails to correct a signal will be raised with a subsequent watchdog reset.

3) The code memory part is protected by low and high address limits. Any attempt to write into that area by an unprivileged software module will raise an exception with a subsequent watchdog reset.

4) Other exceptions like illegal instructions, reading instructions from outside the code memory are handled as under 3.

When the microprocessor is restarted by a watchdog all program code will be reset and initialised data will be reloaded except for the context area. The context area exists in three copies well spread in memory. The context is error checked by comparing the three areas and if possible corrections are made. If corrections cannot be made the default value is loaded. After correction a feasibility of the context is made. This way ICA should in most cases be able to recover completely to the state before the failure.

ROSINA gas pressure handling:

The ICA commands to control high voltages using ROSINA pressure data are:

ZRP22011 PRPG2011=1
Enables (1) gas pressure control of high voltage.
Default is off (0)

ZRP22204 PRPG22204= low level gas pressure in format
delivered by ROSINA

ZRP22205 PRPG22205= high level gas pressure in format
delivered by ROSINA

The automatic control of high voltage by ROSINA gas levels must be turned on. A low level where the high voltage is automatically switched on must be defined. A high level where the high voltage is automatically switched off must be defined. Without these commands no action will be taken by ICA upon receipt of ROSINA gas levels.

Appropriate gas pressure levels for switch on and off are currently not known, but should be similar for ICA and IES.

LAP has an internal watchdog that is started by a command (embedded in OBCP 804). The instrument resets itself if the watchdog is not updated periodically. A race condition (reset upon reset….) will not occur since the watchdog is started by a command. After a reset the instrument will start running the default software in prom: this can be used as an indicator of a reset (in addition to link reset events) since the software version in HK will drop down to the default (version 7). When OBCP 804 starts a software version in flash using the EEBoot command a checksum is computed on the software. A failure of the EEBoot command indicates a bit error in the flash memory, other software banks shall then be tested. A backup of the current software may or may not exist in another software bank, depending on what has been programmed into them. A checksum of all internal macros in the flash memory is returned in HK (Calibration A & B) upon booting a software version above 12. LAP has no critical parameters in housekeeping. Failures are detected by observing the science and HK together. For instance, loss of science data (something that occurred during Earth Flyby) usually indicate miscommanding. LAP does not use any recovery service, so after a power cycle new commands have to be issued to restart the instrument.

MIP has a watchdog which consists of a counter periodically reset. If the watchdog is not refreshed, an alarm signal is sent to PIU (through the link). PIU immediately powers off MIP after reception of an alarm signal.

The MIP watchdog can be inhibited with a command (Set_Wd [1]).

The alarm protocol has been simplified; no retry to be switched on after an alarm signal has occurred:
- PIU powers MIP off at ‘alarm' and ‘over-current detection';
- The status of this alarm signal is put into an event reporting;
- MIP stays off until the next on command.

In case of data receiving failure PIU resets the link according to procedure listed in RD-PIU-4.

MAG: In the unlikely case of a failure or delay during the power on sequence the MAG instrument might not be able to execute the calibration of all the ADCs in the right way. This can cause erratic readings (saturation or a two level oscillation) on the MAG readings. In this case the recovery strategy consists in power on MAG several times.
In the case of an obvious misreading of one sensor triple a recovery can be achieved by toggling the IB – OB sensors.

In any case of suspicious behaviour the MAG HK channels should be examined. Especially the reference voltage U_{ref} should be checked. Additional information can be obtained by reading the OB analogue signals fed into the HK channels. These analogue voltages are always the voltages of the physical OB sensor, independent of the OB-IB toggling.

3.4.6 Ground-based Analysis of Telemetry

Events and fault conditions which are not measurable on-board and/or impossible to predict deterministically will be diagnosed on ground upon reception of telemetry data.
A list of the event packets which indicate non-normal activity of the RPC is given in SY-CRP-000. Reception of those events requires an action to be taken by the MOC and/or RPC.
Possible actions to be taken by the MOC upon reception events reported in SY-CRP-000 are reported here:

Action	Notes
Log as expected in daily report	It is used for non-normal events which are expected (usually at instrument start-up).
Inform RPC by email	It is used for event packets that relate to: • A malfunction of an instrument which is not dangerous. Instrument power cycle might be required to restore functionality. • A dangerous condition which has occurred and doesn't need to be prevented from re-occurring. • A condition which only effects data quality.
Contact RPC representative immediately	It is used for event packets that relate to: • A potentially dangerous condition which might re-occur before the end of operations and must be prevented from re-occurring. Deletion of all RPC commands from MTL might be necessary. • A condition that might require the whole RPC to be switched off (for instance PIU malfunction).

Table 3.4-6: Actionlist for MOC

3.4.7 Recovery Strategy

3.4.7.1 What to do after an emergency switch off of PIU or a subunit

In case of PIU (i.e. the whole RPC) or a subunit being switch off due to a contingency, either by the on-board monitoring systems or from ground, it is necessary to prevent the instrument from being switched back on again by commands which might already be in the MTL.
Due to the fact that RPC instruments are switched on by OBCP and to the impossibility of filtering out single commands at DMS level before execution, the following options are available:

1. Manipulate the MTL which is already on-board by removing the unwanted commands and modifying the relevant OBCP parameter values. The feasibility of this action must be in negotiation with ESOC on an ad hoc basis.

2. In case option 1 is not viable, then the whole RPC must be switched off by running RP-FCP-806 “Switch RPC off Safely” and all RPC commands must be removed from the MTL.

3.4.7.2 What to do after IES switch off due to unsuitable environmental condition (pressure or dust)

The same options as listed in section 3.4.7.1 apply.

3.4.7.3 Contingency procedures

The FCPs listed in this section can be used in case of contingency, previous agreement with RPC representative.

Name	Description	Notes
RP-FCP-000	Power Off LCL A & B	Precondition: All experiments must be shut down
RP-FCP-010	Power Off IES Unit	Precondition: IES in safe mode – HV off
RP-FCP-020	Power Off ICA Unit	Precondition: ICA in safe mode – HV off
RP-FCP-030	Power Off LAP Unit	-
RP-FCP-040	Power Off MIP Unit	-
RP-FCP-050	Power Off MAG Unit	-
RP-FCP-800	OBCP Power RPC Emergency Power Off	All experiments should be shut down first unless in emergency situation.
RP-FCP-806	OBCP Power RPC Power Off	Safe shutdown; all experiments are powered off before switching LCL off.

Table 3.4-7: Contingency Recovery Procedures

The Contingency Recovery Procedure RP-CRP-001 defined in RD-GEN-9 can be used as emergency power off procedure.

3.5 Nominal Operating Plans

3.5.1 Ground Test Plan

3.5.1.1 System Ground I/F & OPS Requirements

3.5.1.1.1 EGSE

3.5.1.1.1.1 Concept

The Electrical Ground Support Equipment (EGSE) is the collective name given to the tools required for electrical testing of all the RPC instruments. The general concept follows the design baseline given in RD-GEN-18, section 5.2.1, in which the EGSE can be used in 3 phases.

- **Phase 1 – RPC Experiment Level Testing**
  The EGSE is used to control and monitor RPC instruments via an I/F to the project specified interface simulator (ROSIS). Also the central unit of the EGSE directly controls the stimulator for the LAP experiment.

- **Phase 2 – S/C System Level Testing**
  The EGSE is used to monitor TM sent from the CCS. Commanding is controlled by the CCS using inputs from the RSDB. The LAP stimuli can be controlled by the EGSE or by the CCS.

- **Phase 3 – Flight OPS**
  The EGSE will be used to monitor TM from S/C using the same I/F as previously used with the CCS.

3.5.1.1.1.2 Hardware Description

The EGSE system consists of a RPC EGSE PC, 6 experiment EGSE PCs and the LAP stimulator controller PC. They are connected via a local Ethernet network with each PC. A second network card is used to connect to the ROSIS or CCS. This card connects to the network via twisted-pair cable and an RJ-45 connector.

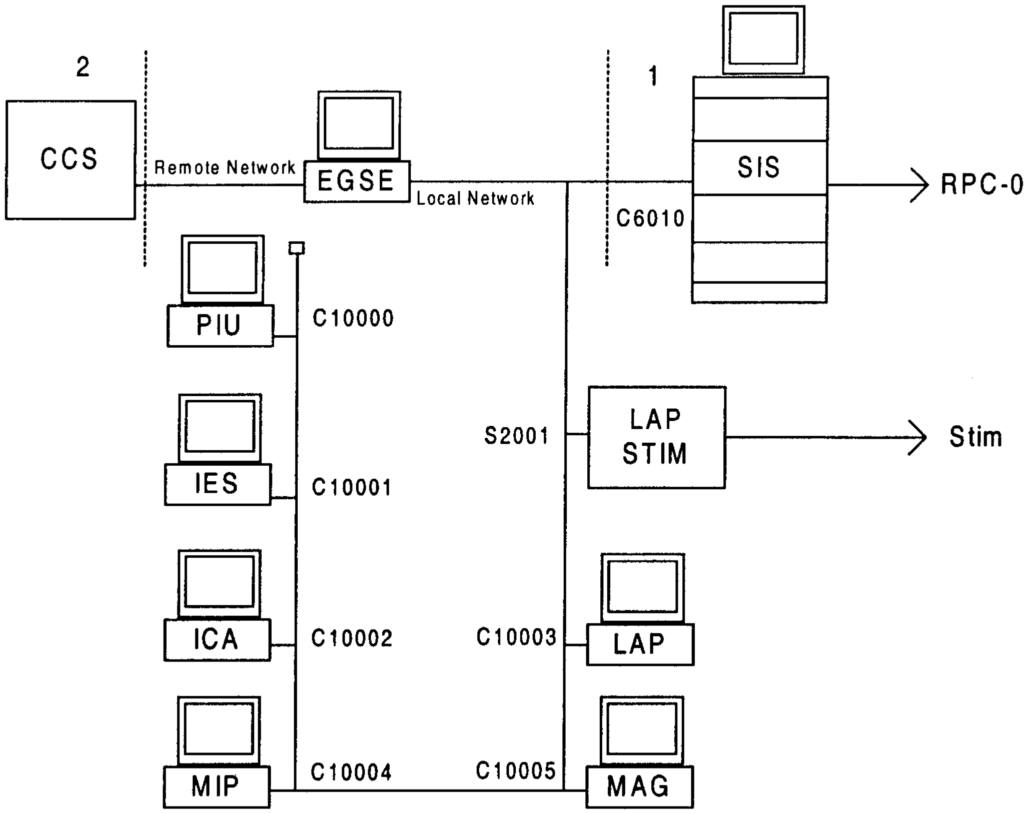


Figure 3.5-1: Overview of the RPC EGSE

In Figure 3.5-1, C represents Client and S represents Server towards the main EGSE and the number following is the TCP/IP port number. This arrangement means the system can run without changing the network settings for various testing facilities (in Phase 1). Also system level tests require only a single change of IP address when the SIS socket is replaced by a socket to the CCS (Phase 2). For certain tests the experiment EGSEs can also be connected to the remote network (e.g. tests with the instrument at IC and the experiment team at a remote institute).

There are 2 RPC EGSEs, one to remain with the S/C for system level tests and one for using development with the ROSIS. The system level EGSE is a desktop PC, the development EGSE is a laptop. This portability is useful for RPC testing away from IC.
The RPC EGSE archives all the RPC data as it arrives during a test on the local harddisk. After a test is completed the files can be copied onto CD using the built-in CD writer on the system level EGSE and via a shared CD writer on the network when using the development EGSE.

3.5.1.1.1.3 Software Description

The S/W for the RPC EGSE is written with National Instruments' LabVIEW S/W (V6.0) running under Windows NT/2000.

The S/W design is based on a state machine with the subsequent state generally determined by a user action or the type of TM received. Running in parallel with the state machine is a loop that listens on the network sockets for new TCP/IP connections. The network connection to the LAP stimuli rack can be opened at any time from a control on the GUI.

The EGSE S/W carries out the following main functions:

1. To communicate with the ROSIS/CCS using the ROSETA Common Packetised Protocol (RPRO) and display RPRO level information.
2. To receive TM from the ROSIS/CCS and distribute this in CCSDS format over LAN to the relevant instruments' EGSE.
3. To log the TM to archive files on the local hard drive. The files contain TM in CCSDS packet format (therefore individually time stamped with the on-board time). The files are in binary format and represent a fixed time bin during a test. This bin can be set as part of an archive setup screen that appears after starting the EGSE program.
4. To decode and display TM on the GUI and notify the user of unexpected or erroneous results. The last 30 TM packets received by the EGSE are displayed. Packets that arrived before this can be viewed by 'freezing' the display window and scrolling up the display (up to a maximum of 1000 packets). Events are shown in a separate display with the event ID decoded into text using a look-up table. In addition, the parameters of all the RPC experiments' housekeeping packets are decoded and displayed in a separate section.
5. To allow the user to control the ROSIS and send commands to RPC when testing at experiment level (this can take the form of discrete commands or scripts of up to several hundred commands). The experiment EGSEs are also able to command their own instrument via the network.
6. To control the LAP stimuli and display the command acknowledgements.

An extra utility program called *RPC Telemetry Replay V1.1* is used for displaying archived data and can distribute TM to single or multiple experiment EGSEs over the network. The TM rate can be set to:

1. Single step through packets, one at a time.
2. Replay TM in real time, as if connected to the CCS.
3. Continuous (download data to experiment EGSEs at fastest rate).

The utility program can also filter TM to display/distribute only packets with a certain PID or category.

3.5.1.1.1.4 Compliance

The EGSE I/F to the CCS conforms with the SCOE state table and functions correctly with the ROSIS (acting as a CCS simulator to the EGSE).

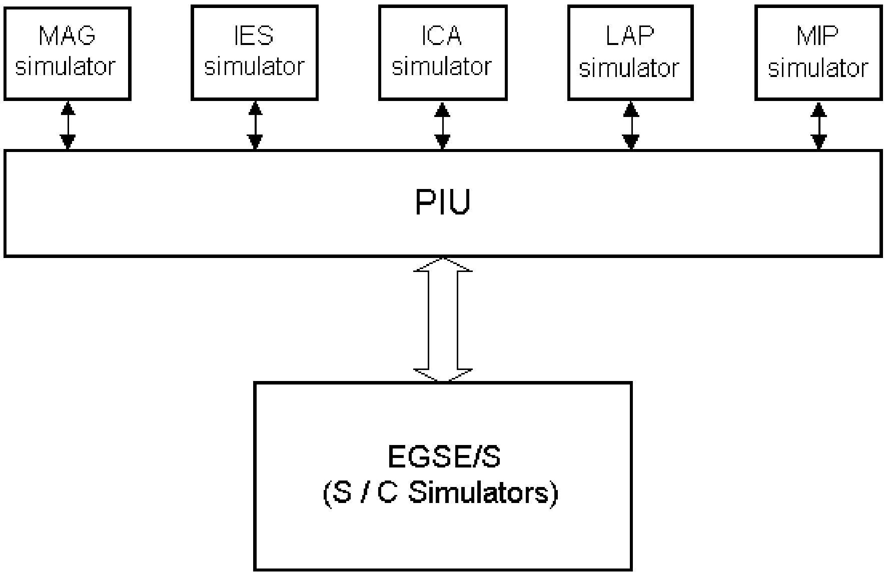


Figure 3.5-2: Autonomous Test of the PIU

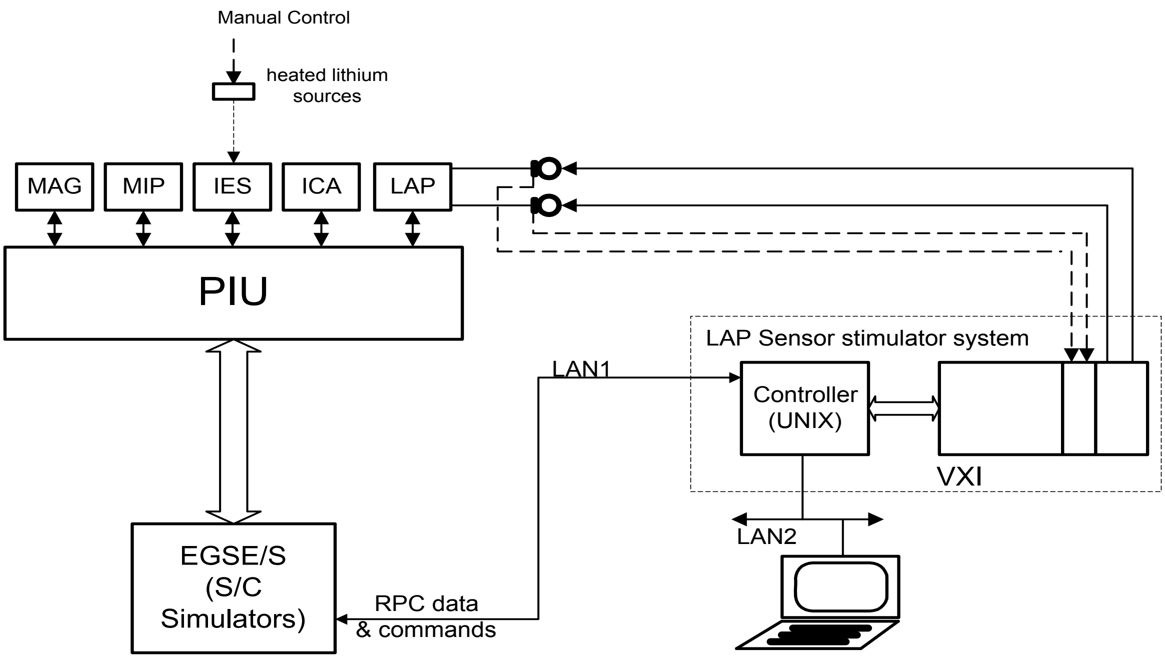


Figure 3.5-3: System Level Test of the Rosetta Plasma Package

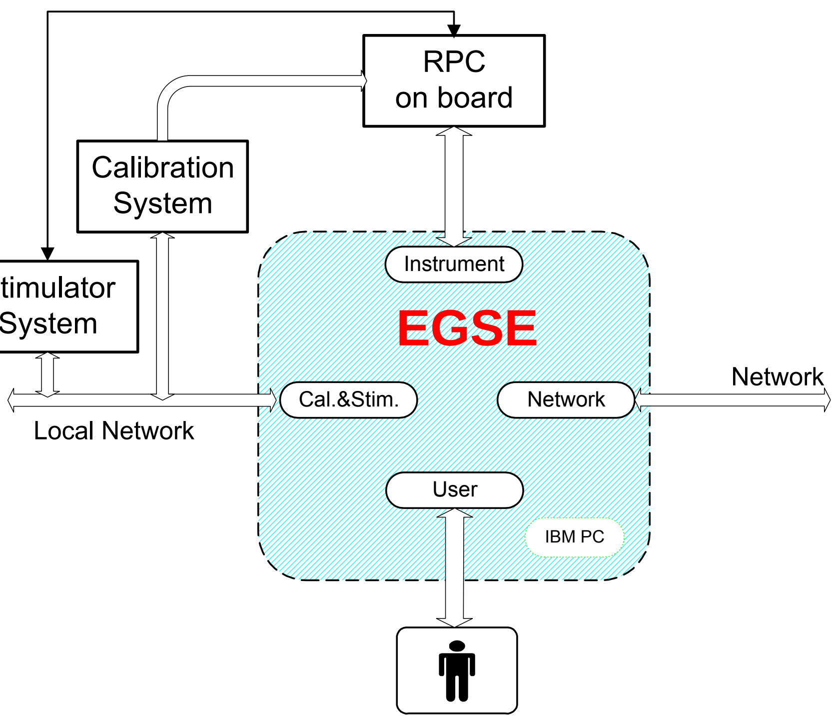


Figure 3.5-4: Logical Interfaces of the ICSTM EGSE

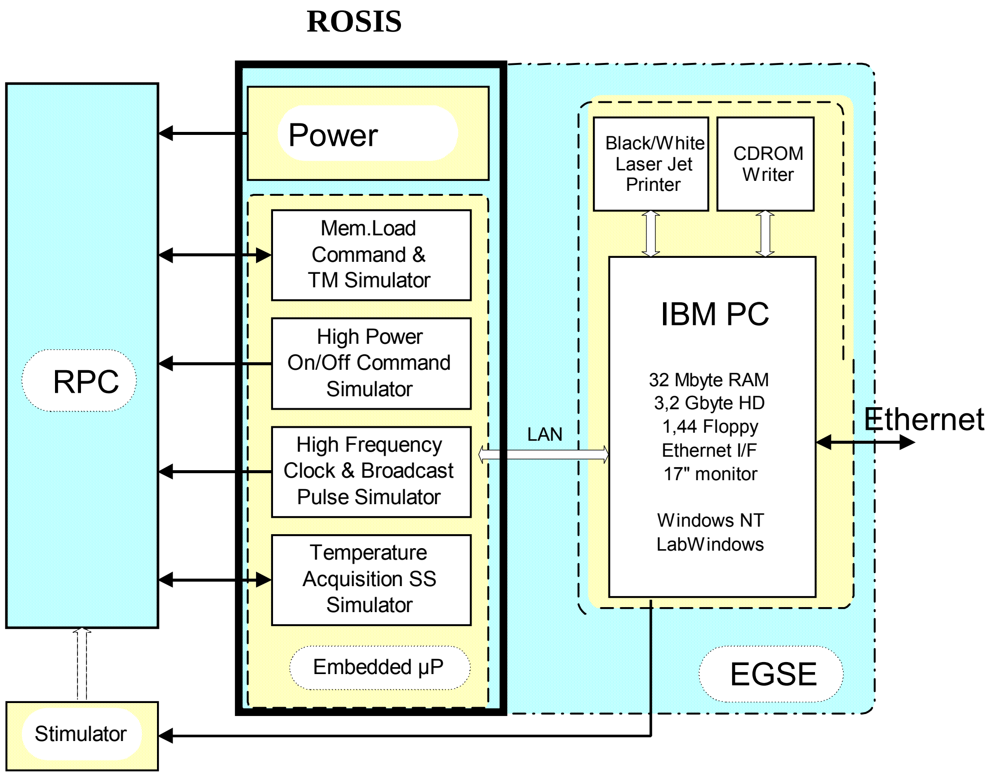


Figure 3.5-5: RPC Experiment Level testing with the ICSTM EGSE

3.5.2 In-orbit Commissioning Plan

3.5.2.1 Post-launch commissioning

For the post-launch commissioning refer to the document RD-RPC-2.

3.5.2.2 Post-hibernation activities

High-level description of RPC instruments commissioning activity after hibernation.

3.5.2.2.1 IES

Pointing: Sun in ES FOV i.e. SAA between 70 and 100 deg.
Total duration: Estimated 6 to 9 hours / 1 day (dependent on light time)

Low Voltage Checkout
Power on IES in PROM mode
EEPROM readout and dump
RAM patch to generate event message indicating counts (see HV below)
High Voltage Checkout
Turn MCP high voltage on (ESA and DEF sweeping disabled) and get sum of counts using event message
Full HV on with sweeping
Functional test - table and mode changes
MCP Gain Test
EEPROM Patch to update housekeeping fields
Functional Test

3.5.2.2.2 ICA

The ICA post-hibernation commissioning activity serves two purposes: to verify that the instrument is functioning properly after hibernation and to determine the sensor operating temperature characteristics. The latter is related to the overheating issue that has affected ICA on several occasions. If possible we want to interact with the spacecraft to adjust the operation of the spacecraft ICA non-operational heater. We therefore divide the post-hibernation commissioning activities into three steps.

1. Low-voltage commissioning
2. High voltage commissioning
3. Instrument temperature analysis: high voltage tests and measurements with / without spacecraft heater and possibly different solar illumination.

Step 1 is simple; does not require pointing and does not need to last very long.

Step 2 requires the Sun to be in ICA's field-of-view for some time, and preferably some variation of the pointing (of the order of 20 degrees solar aspect angle).

Step 3 is intended to determine whether ICA can improve the reliability of the operation of ICA by having the spacecraft operated heater off, and to learn about the temperature as function of solar illumination for the initial comet mission conditions. This requires somewhat more extended run time, preferably more variation of the illumination of the instrument and possibly tests with the spacecraft-operated heater on and off. The precise pointing is not important, as long as the angle of the sunlight hitting the instrument is varied within the limits expected during the nominal mission. This test is based on our understanding that the spacecraft-powered heater was on during Mars swing by and Lutetia, whereas it was off during Earth swing-by, as indicated by our interpretation of spacecraft housekeeping data (Heater current LCL41A).

Command sequences

1. Low voltage commissioning:
   Instrument on in test mode, fake mode and finally ordinary measurement mode but without high voltage. About 10 minutes of data from each stage is enough to see that the instrument is alive and delivers data. These operations can be performed via OBCP.

2. High voltage commissioning:
   Instrument on in measurement mode, preferably burst (EXM). Sun in ICA's field of view for 20 minutes or longer, and preferably some variation of the position of the sun within the instrument field-of-view. Measurement time as long as feasible. Instrument can be switched to NRM mode after a while if telemetry data volume is constraint. At least one hour burst data desired. OBCP are sufficient. If time is available, then an additional test where the instrument is booted from the EEPROM bank with an alternative energy table should be done. Procedures used during ESB 3 will then be used.

3. Instrument temperature analysis:
   If instrument temperatures were low and solar illumination of the instrument varied during high voltage commissioning then this step may not be necessary. Otherwise the instrument should be run while the spacecraft-operated heater is off. If possible the spacecraft-operated heater should be switched off just as the instrument is turned on. The instrument should then be run in the normal measurement mode. If telemetry data volume is a constraint then normal mode may be used. After at least 20 minutes with constant solar illumination angle, the angle should be varied significantly (exact angle is not important). The instrument should be run for at least an hour, preferably a few hours, to see how the temperature of the sensor changes. All commands can be done by OBCP.

3.5.2.2.3 LAP

LAP's post-hibernation commissioning is divided in three parts:

Part 1. Basic verification.
The instrument will be powered on and it will run several standard science macros. Duration will be 3 hours, of which half is in BM. This procedure is to be repeated twice, with the instrument turned off in between runs, in order not to suffer from possible glitches (like the one experienced during ESB1). Time between reruns is arbitrarily long: 5 minutes is as good as 5 days. No requirements on pointing or other instrument operations.

Part 2. Solar wind observation at large heliocentric distance.
To be ready for the early comet phase, LAP should gather comparison data at this large heliocentric distance using a standard science macro. Duration will be at least 24 hours with NM telemetry. Pointing should preferably be variable, but need not be tailored to us: we are happy to ride along on anybody else's pointing (surely the cameras will want to point to various sources). Part 2 can follow at any time after part 1, or between the two re-runs of part 1.

Part 3. Macro upload and testing (already known as CPPCR request R_RP032)
While there are already macros in place for the first operations at the comet, there are no suitable macros for the denser plasma in the fully developed coma. This is probably the best time to upload such macros, so as to be done with this before normal science operations start. Duration will be 6 hours of which up to half may be BM. Part 3 can be executed at any time after Step 1.

3.5.2.2.4 MIP

Post-hibernation commissioning consists of 9 sequences divided in three tests which should be run for 10 minutes each.

Transmission & level test
Normal mode, SDL, transmitter mono with E1, nominal level (divided by 2).
Sequence: ARPS496A 2600 0045 0201

Normal mode, SDL, transmitter mono with E1, full level.
Sequence: ARPS496A 2600 0005 0201

Normal mode, SDL, transmitter mono with E2, nominal level (divided by 2).
Sequence: ARPS496A 2600 0051 0201

Normal mode, SDL, transmitter mono with E2, full level.
Sequence: ARPS496A 2600 0011 0201

Normal mode, SDL, transmitter stereo with E1-E2 phased, nominal level (divided by 2).
Sequence: ARPS496A 2600 0069 0201 (a verifier, cf. commissioning)

Normal mode, SDL, transmitter stereo with E1-E2 antiphased, nominal level (divided by 2).
Sequence: ARPS496A 2600 007D 0201 (a verifier, cf. commissioning)

BM test
Nominal sequence.
Sequence: ARPS496A 2600 0045 0203

LDL test
Nominal sequence, nominal level (divided by 2).
Sequence: ARPS496A 2600 0045 0205

Nominal sequence, full level,
Sequence. ARPS496A 2600 0005 0205

3.5.2.2.5 MAG

MAG's post-hibernation commissioning sequence:

Switch on MAG

Switch the OB sensor to be PRIMARY
Switch to SID 2
Warm up 6 hours
Switch to SID 1 and collect data for at least 3h
(minimum 10 packet = 10*1024s = 10240s ~ 3hours)
Switch to SID 2 and collect data for at least 1hour
Switch to SID 3 and collect data for at least 1hour
Switch to SID 4 and collect data for at least 1hour
Switch to SID 5 and collect data for at least 1hour

Switch the OB sensor to be SECONDARY
Switch to SID 1 and collect data for least 3h
Switch to SID 2 and collect data for at least 1hour
Switch to SID 3 and collect data for at least 1hour
Switch to SID 4 and collect data for at least 1hour
Switch to SID 5 and collect data for at least 1hour

Switch off MAG

3.5.2.3 Routine operations

Details on the timeline and the procedures can be found in the FOP RD-GEN-9.
Active rehearsals of any planned, previously untested command sequences are necessary for any single-event such as a flyby. These will be individual for each event. Also for well tried sequences an active health check gathering at least a small amount of data is preferable.
The only commissioning activity that may be required for IES prior to swing-bys, fly-bys, and comet phase to commission the instrument would be to perform a new table upload to change the science acquisition configuration. Depending on the tables already in IES, this may not be needed. Otherwise, no other commissioning activity is anticipated.
For MIP & MAG no particular commissioning activities are required before active phases. This goes also for LAP, though uploads of new macros may occasionally be needed (done by normal telecommands). LAP operations for an active phase will typically start and end with internal calibration and photoemission determination activities controlled by ordinary OBCPs.

3.5.3 Flight Operations Plan for each Mission Phase

For the time schedule refer to **Mission Calendar** (RD-GEN-16)**.**

Details about the overall mission can be found in the Crema (RD-GEN-24)**.**
Operating procedures include Commissioning, Switch-on, Switch-off, and Cruise Phase Checkout. Each procedure is described in terms of 'command sequences' to be executed. 'Command sequences' are listed separately to 'Procedures'.

Each mode transition will be triggered by a single command sequence. Any contingency conditions within a mode transition will be handled by the software of the PIU.

Activities for the Checkout Phases:

- A cross calibration with IES, ICA, LAP & ROSINA during the checkout phases is anticipated.
- Upload improved Flight Software, re-examine interference, upload new Lookup tables
- MAG and ROMAP aim at cross calibrations between them.

.

No passive checkouts are needed for ICA. Active checkouts will be requested before all active mission phases and consist of running the instrument in test mode for preferably 20 minutes and then at the highest SID rate as possible for another 20-40 minutes.
No interesting observations are expected from Passive or Active checkout phases for MIP.
For MAG and MIP the checkout phases are mainly regarded as “instrument still alive” – checks.
For LAP, the periodic checkouts are means to monitor variation of probe photoemission (from probe bias sweeps) and internal offsets (from open calibration sweeps) over long times, as well as to verify the continued integrity of the complete operations chain from command preparation to data archive generation. In addition, the active checkouts can be used for maintenance activities.

3.5.3.1 Cruise Phase

The Rosetta Mission will have almost 10 years of cruise, interspersed with a total of 6 planet and asteroid flybys. Science observations during this cruise is not a primary objective of the mission but frequent measurements in the interplanetary medium by the RPC instruments can produce valuable scientific information. In addition, the periodic exercise of the instruments will provide valuable instrument operational experience as well as assurance of their health by the time of comet rendezvous. This approach has proved important during the Cassini mission long cruise. Another aspect of cruise phase operation will be the opportunity for cross-calibration of the instruments.

The primary measurement objective will be the characterization of the solar wind (temperature, density, velocity, and composition) as well as the interplanetary magnetic field and plasma waves as function of heliospheric distance and longitude. At those times during which the Rosetta spacecraft will be appropriately aligned with other interplanetary spacecraft (e. g., SOHO, ACE, Cassini) coordinated multipoint measurements of structures such as coronal mass ejections (CMEs) will be important for the understanding of the evolution of such structures during their transit through the heliosphere.

Other than the predicted occurrences of such alignments, we suggest continuous RPC measurements over a 2-week period every 6 months.

Additionally there will be very interesting chances to investigate cometary dust trails and their interaction with the interplanetary magnetic field from time to time as already indicated by measurements of the spacecrafts Ulysses and Pioneer (RD-GEN-36, RD-GEN-37). Detailed calculations have been performed to investigate, whether ROSETTA will encounter a cometary orbit during its long journey to comet C-G. The trajectory of ROSETTA has been compared with the orbits of all known short-periodic comets listed in the JPL DASTCOM. Thus, Table 3.5-1 displays these encounters for the whole mission. An encounter here is defined as the ROSETTA s/c passing a comets orbit within a distance of smaller than 0.01 AU.

We strongly recommend to switch on the RPC-MAG a few days before the encounter takes place. This would provide us the data needed to estimate, whether the solar wind is disturbed, or not.

Secondly we propose to switch on the Lander magnetometer ROMAP as well, to conduct combined measurements, which will improve the possibility to minimize any s/c generated noise and to get more information about the s/c field.

We will perform a detailed analysis of the other encounters as well.

Comet	Date	Minimum distance to orbit [AU]
21P/Giacobini-Zinner	09.09. 2004	0.0036
P/Linear 2000 G1	25.03.2005	0.0088
P/Linear 2000 G1	04.11.2006	0.0091
112P/Urata-Niijima	07.05.2006	0.0048
126P/IRAS	10.02.2006	0.0069
103P/Hartley	04.11.2007	0.0070
45P/Honda-Mrkos-Pajdusakova	17.04.2007	0.0083
88P/Howell	03.06.2008	0.0042
P/Linear 2003 O2	30.05.2009	0.0049
63P/Wild	06.04.2010	0.0065
P/Scotti 2001 X2	01.04.2011	0.0094
P/Lagerkvist 1996 R2	01.08.2011	0.0073
P/Mueller 1998 U2	28.06.2012	0.0022

Table 3.5-1: ROSETTA'S Encounters with short periodic Comets

3.5.3.2 Mars Fly By

Key Elements of the Solar Wind-Mars Interaction

Compared with the Earth:
Mars is **smaller** (~1/2);
gravity is **lower** (3 times);
a little bit **farther** from the Sun (1.5 AU);
and mostly no significant **planetary B-field**, but multiple
B-anomalies of small spatial scale in the crust.

Consequence of absence of intrinsic B-field:

solar wind - Mars interaction is probably a **Venus-like ionospheric interaction** rather than an Earth - like magnetospheric one;
low gravitational field →
neutral exosphere deeply interacts with solar wind. Comet-like features expected.

Ionosphere presents an obstacle to solar wind flow:

bow shock ahead of the planet;
smaller planet size & lack of substantial planetary B-field →
bow shock **closer to planet** centre than at Earth (1.6 R_M at Mars, 13 R_E at Earth in subsolar direction;1 R_M = 3390 km,1 R_E = 6371 km).

Bow shock preceded by electron and ion foreshocks:

plasma waves;
suprathermal particles;
B-field fluctuations.

Behind bow shock, in Martian sheath:

solar wind slowed, compressed, heated, & diverted (draped) around upper part of **ionosphere** before filling the **wake**.

Inside ~ 1 000 km altitude:

ion plasma, mainly **O^+**, of ionospheric origin *&* **photo electrons**;
O^+ plasma forms a **mantle** over the ionospheric «obstacle»;
flows in anti-sunward direction as in neighbouring sheath, but **at a lower velocity** (mantle is **mass loaded** by O^+ planetary ions).

In Martian wake:

- **Heavy ions** (O^+,O_2^+, CO^+...);
- move together with **light ions** (H^+ & probably He^+).

<u>New plasma boundary:</u>

- **Proton** fluxes (solar wind included) **drop out** in wake, **planetary O^+** fluxes **increase**;
- thermal plasma, E-field, B-field **signatures**.

→ **new plasma boundary** (planetopause, magnetopause, ion-composition boundary, protonopause or magnetic pile-up boundary)
actually exists at Mars;
is highly likely the **real obstacle** to solar wind flow (instead of ionosphere).

Bow shock and Planetopause Modellings

The best fits to the Martian shock and the planetopause crossings identified from the PWS data onboard PHOBOS-2 are shown below:

Terminator altitudes:

Shock::	5540 km (2.63 R_M)
Magnetic pile-up boundary :	1250 km (1.37 R_M)
Ionospheirc N_e peak (30000 cm^{-3}) :	170 km
Ionopause (not observed):	should be~1000 km

Subsolar altitudes:

Shock::	1950 km (1.57 R_M)
Magnetic pile-up boundary :	660 km (1.19 R_M)
Ionospheirc N_e peak (100000 cm^{-3}) :	125 km
Ionopause (not observed):	should be ~ 300 km

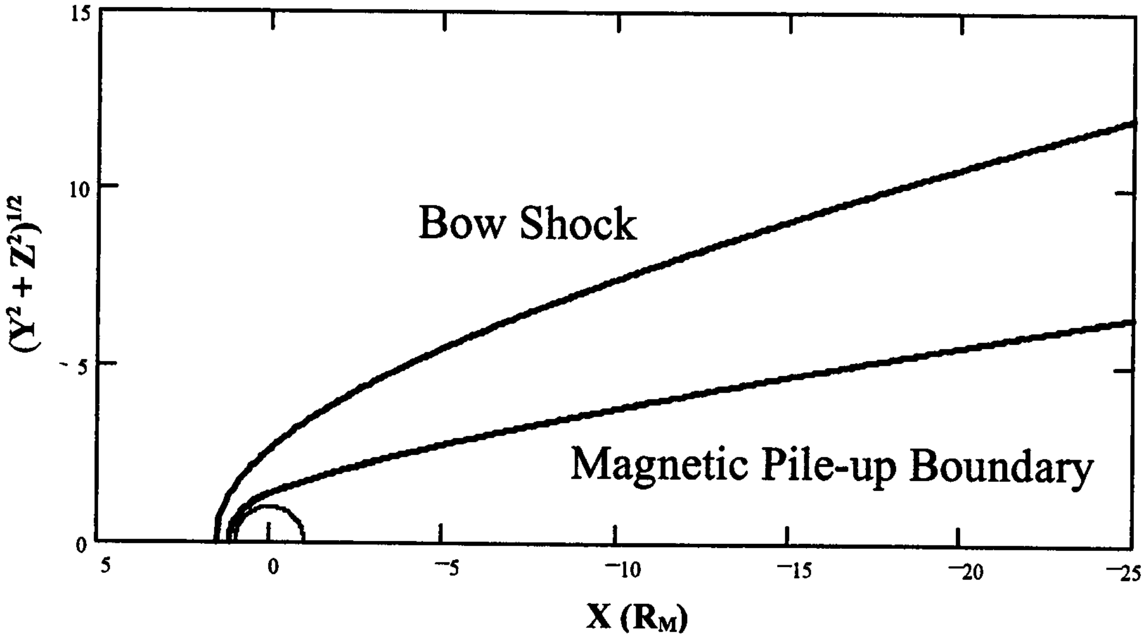


Figure 3.5-6: Martian Bow Shock and Pile-up Boundary

Electron Density and Temperature, Debye-Length, and Electron Plasma Frequency expected near Planet Mars

VIKING 1 &2 Observations for 35°- 55° Solar Zenith Angles and 69 – 76 Solar Radio Fluxes, $F_{10.7}$ (Hanson et al, 1977)

Altitude, km	N_e, cm^{-3}	T_e, K	λ_D, cm	F_{pe}, MHz
130	$2.4 * 10^5$	150	0.2	4.4
200	$\sim 10^4$	350	1.3	0.9
300	~ 400	$3 * 10^3$	19	0.18

Table 3.5-2: Martian Plasma Parameter observed by VIKING

Typical Solar Wind Values

Ram Pressure, dyn cm^{-2}	N_e, cm^{-3}	T_e, K	λ_D, cm	F_{pe}, MHz
$1.0 – 1.5 * 10^{-8}$	4	10^5	1090	0.018

Table 3.5-3: Solar Wind Parameter in vicinity of Mars

Electron Density (cm^{-3}) for two Solar Zenith Angles and two Solar Radio Fluxes, $F_{10.7}$: Empirical Model (Nielsen et al, 1995)

Altitude, km	Solar Radio Flux, $F_{10.7}$			
	50		100	
130	130000	38000	205000	52000
200	8000	4500	51000	24000
300	-	-	5500	2200
	20	80	20	80
	Solar Zenith Angle, deg			

Table 3.5-4: Electron and Radio Fluxes at Mars

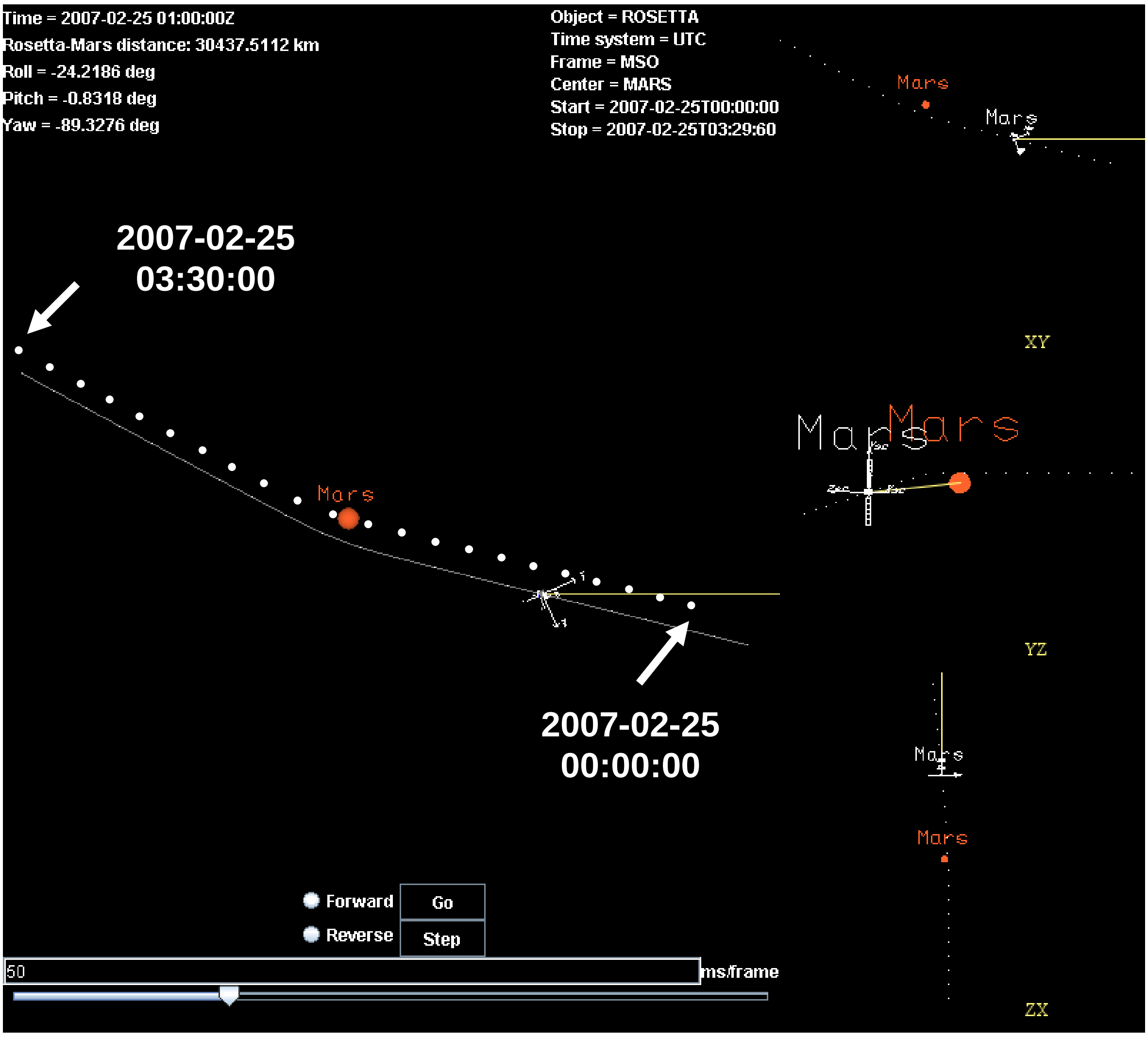


Figure 3.5-7: Mars Swing By - 1

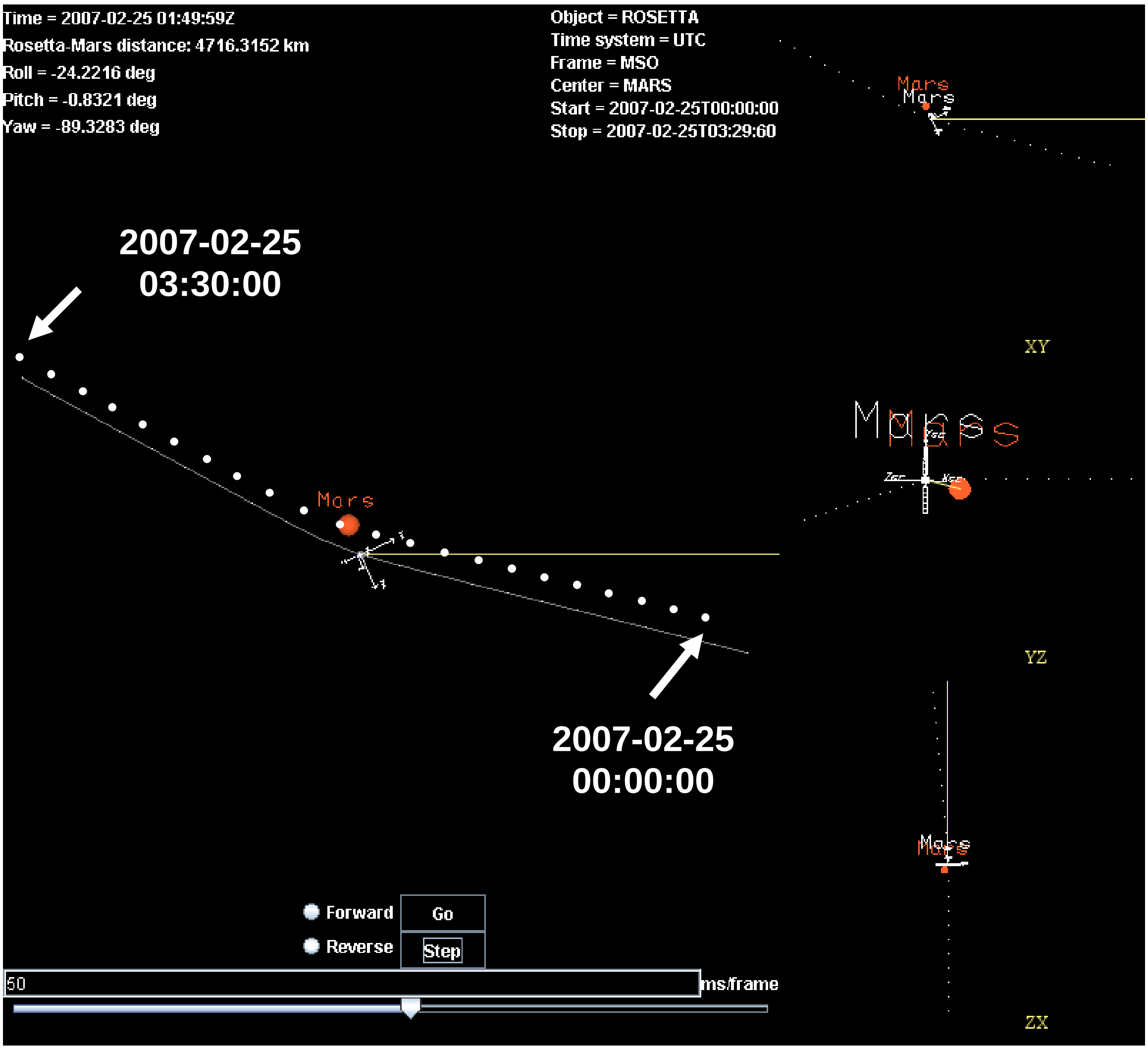


Figure 3.5-8: Mars Swing By - 2

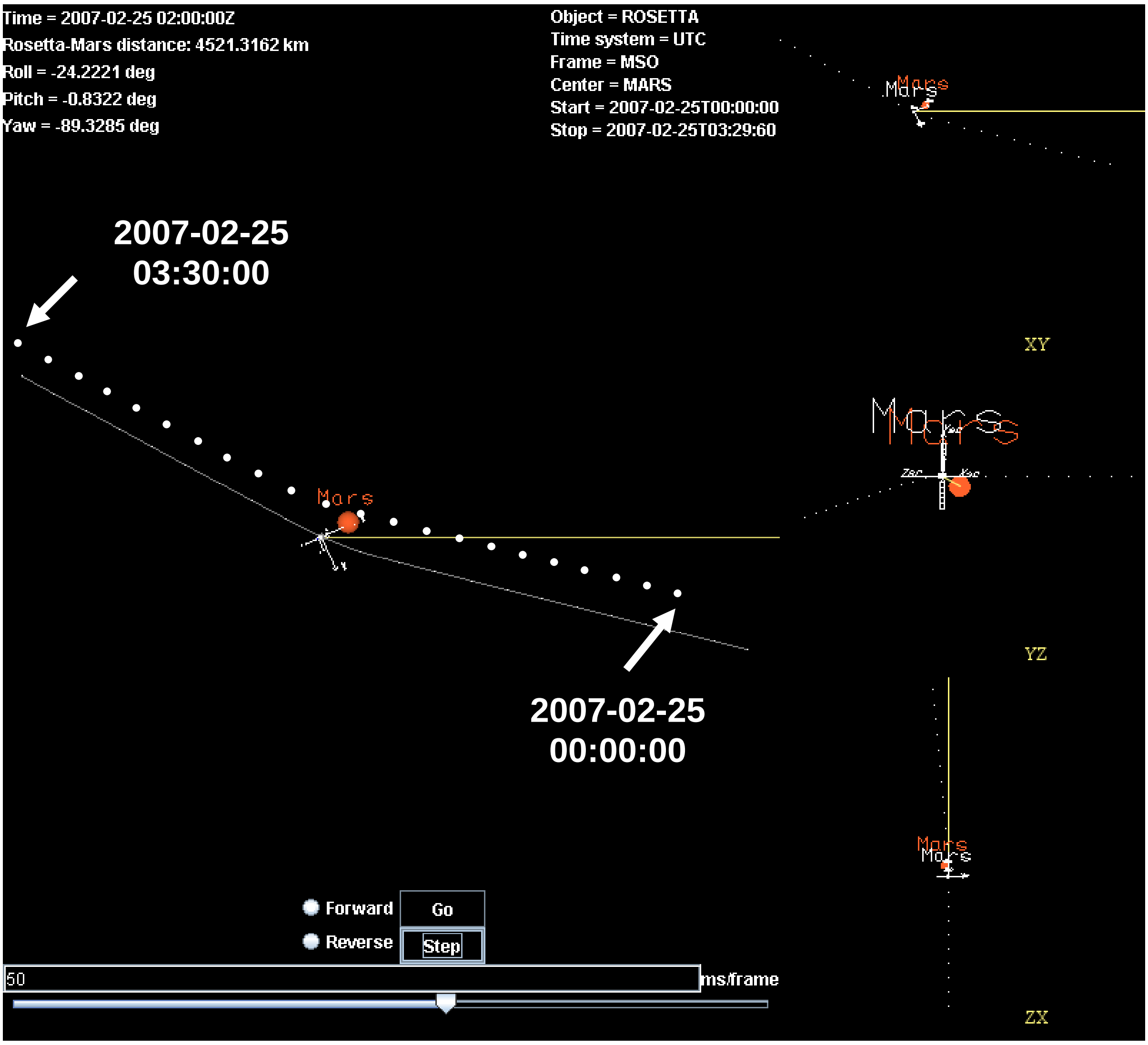


Figure 3.5-9: Mars Swing By - 3

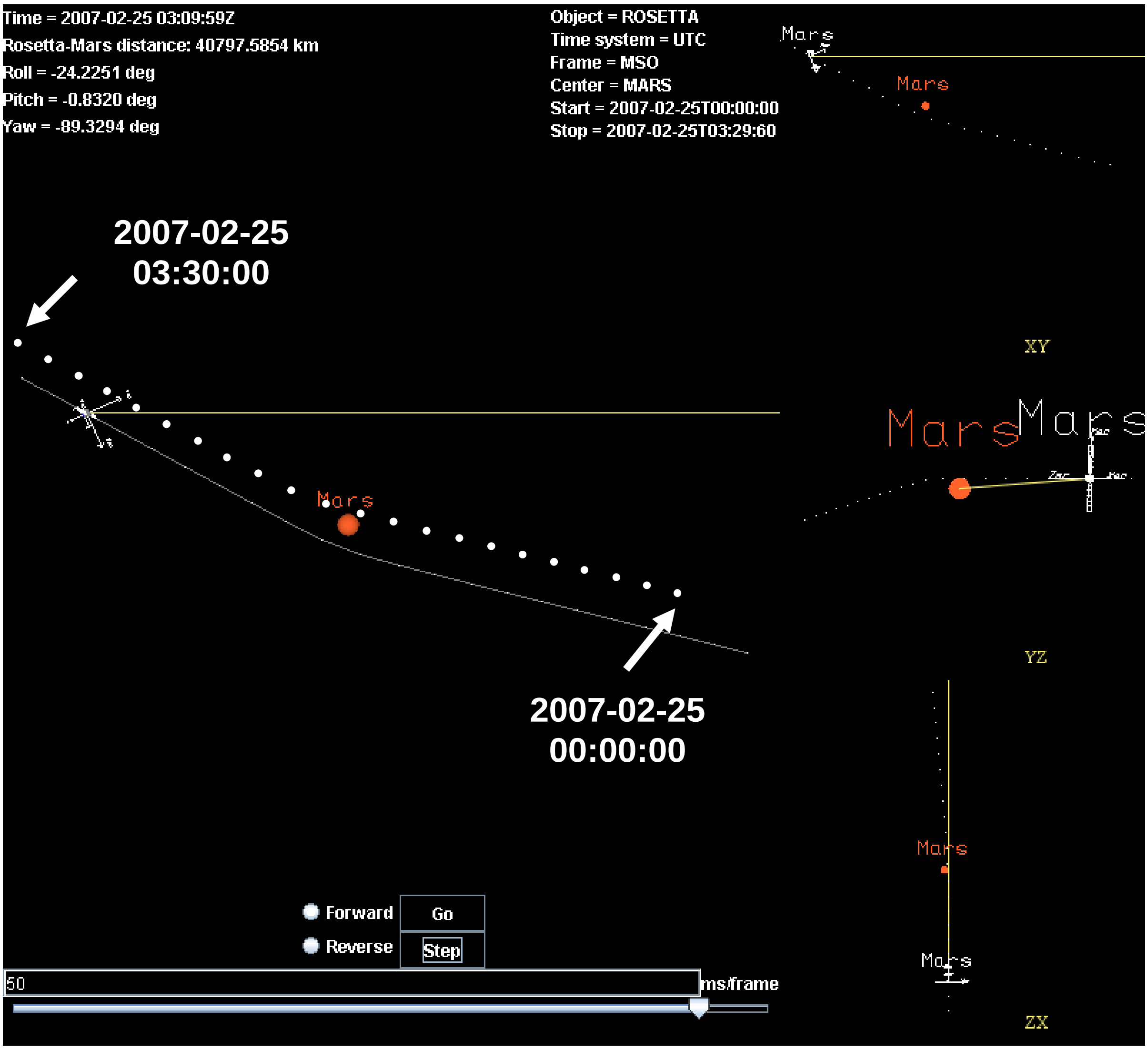


Figure 3.5-10: Mars Swing By - 4

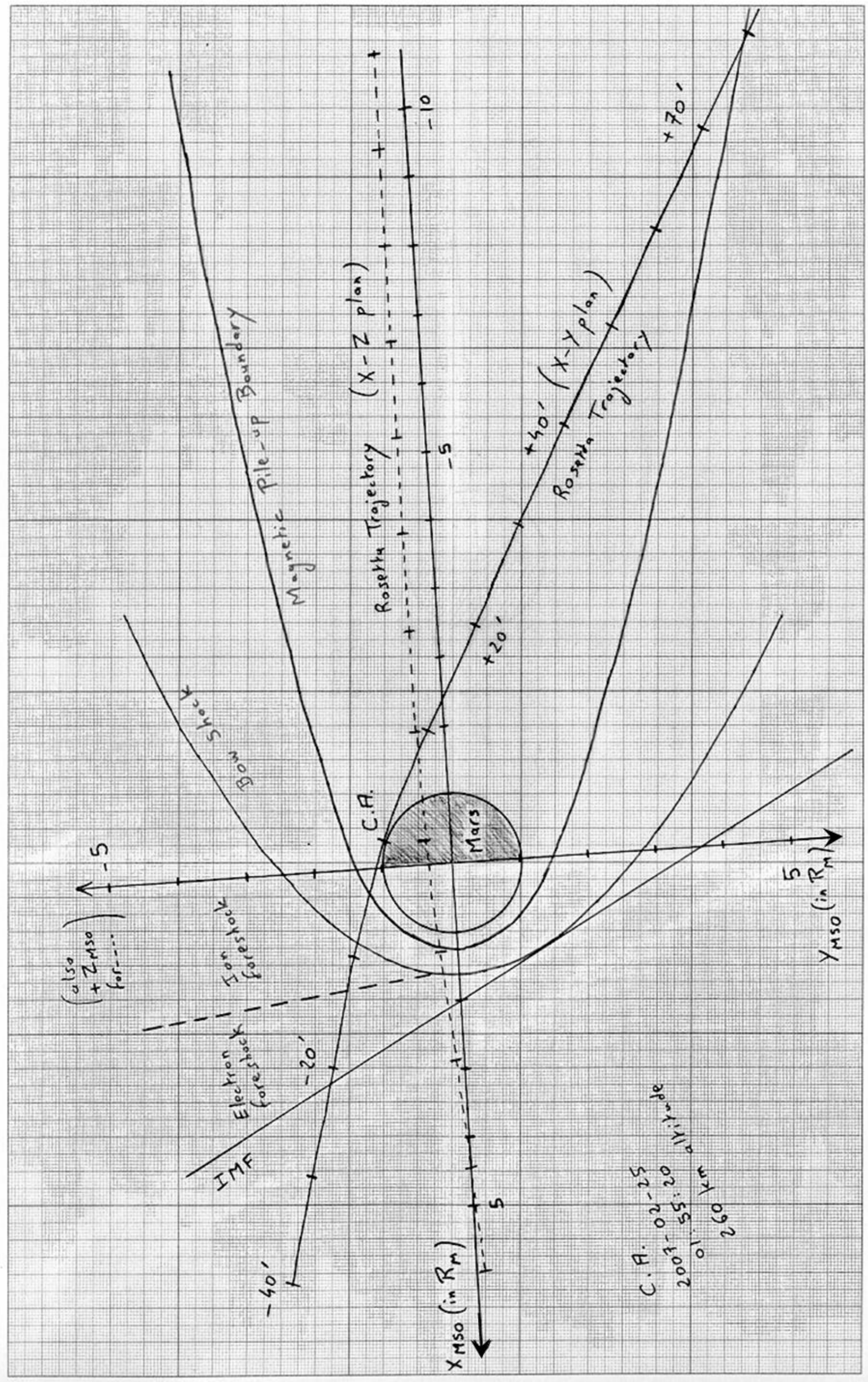


Figure 3.5-11: Mars Swing By Geometry, Plasmaphysical Situation

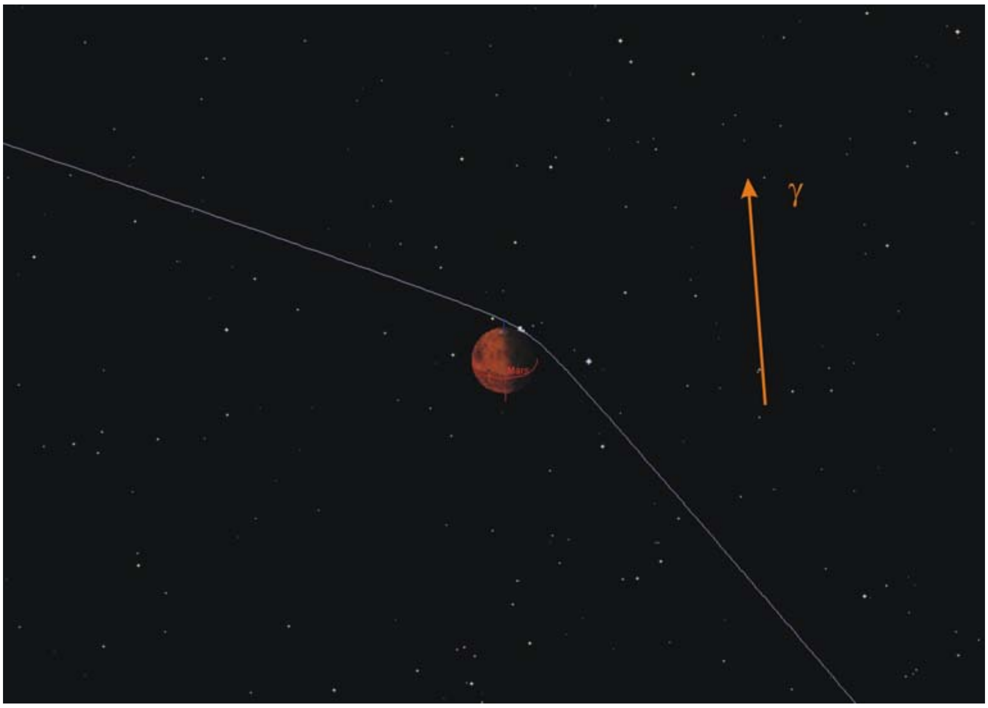


Figure 3.5-12: Mars Fly By Geometry , side view

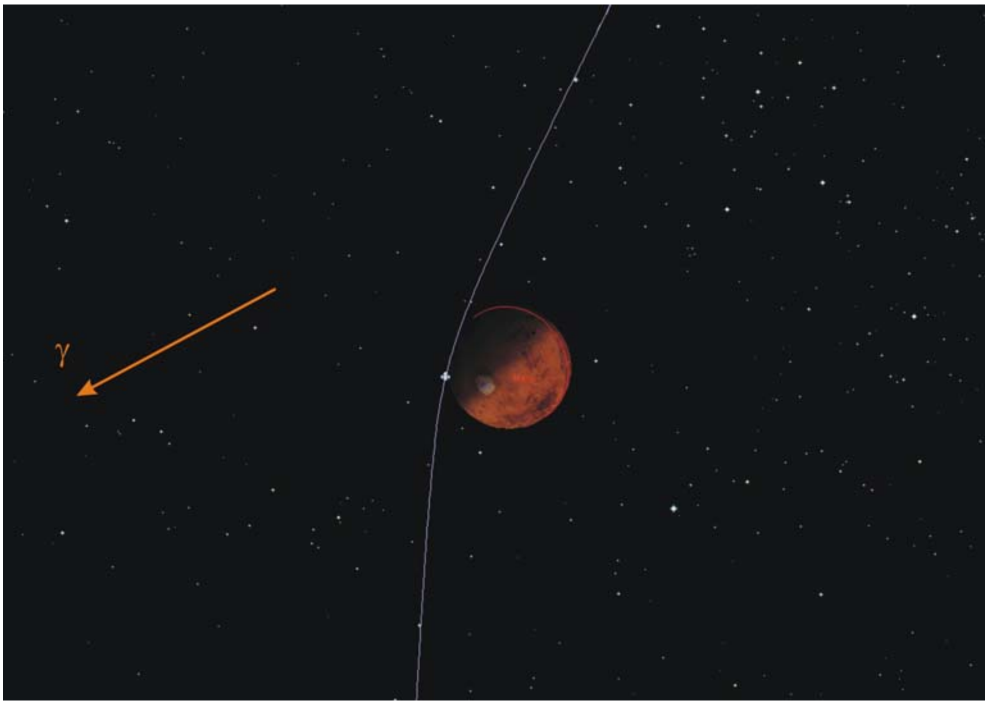


Figure 3.5-13: Mars Fly By Geometry, northern view

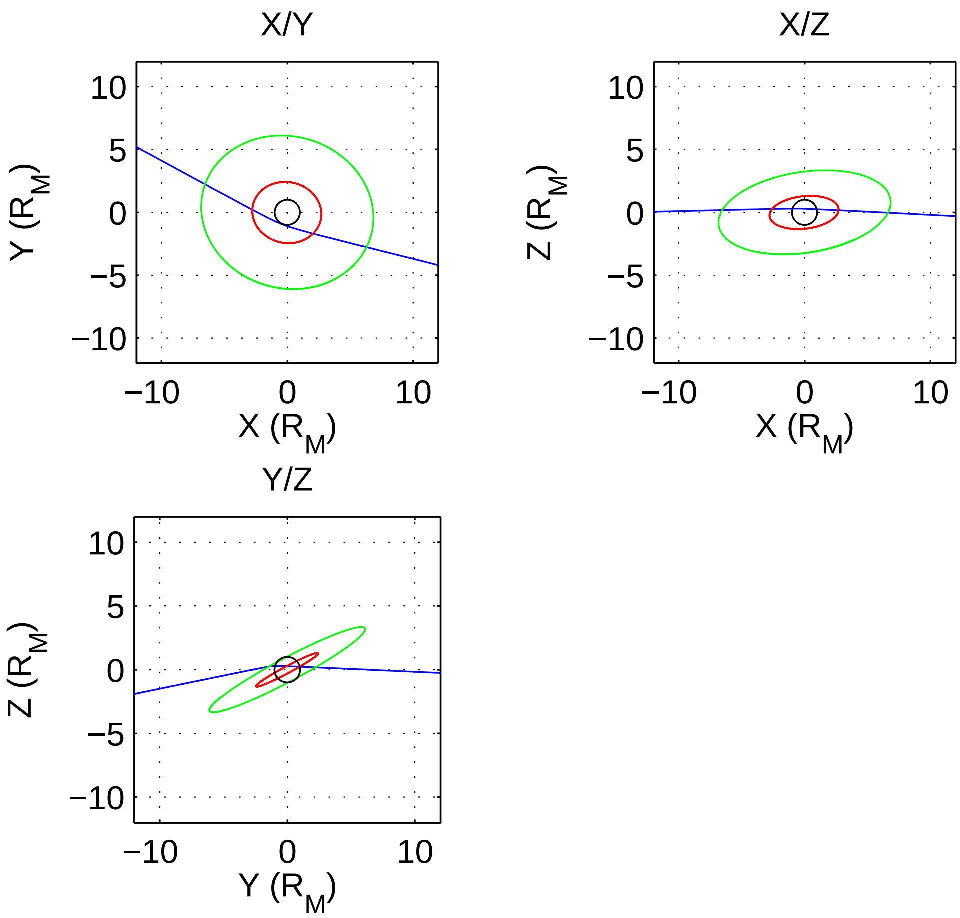


Figure 3.5-14: Mars Fly By Geometry, Projections

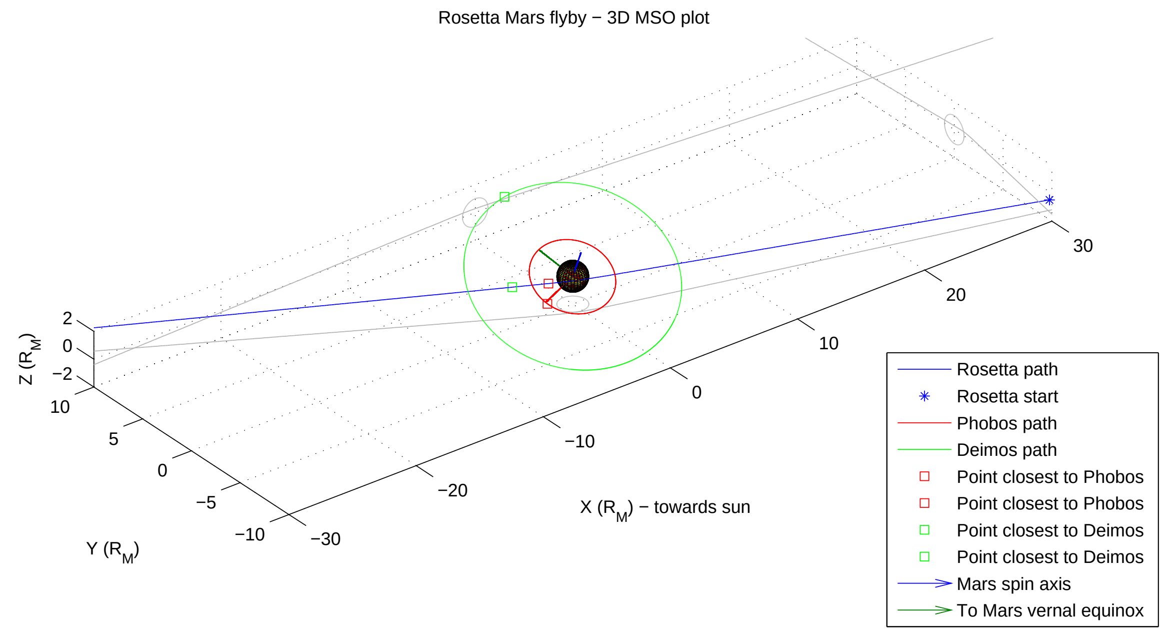


Figure 3.5-15: Mars Fly by , 3D Model

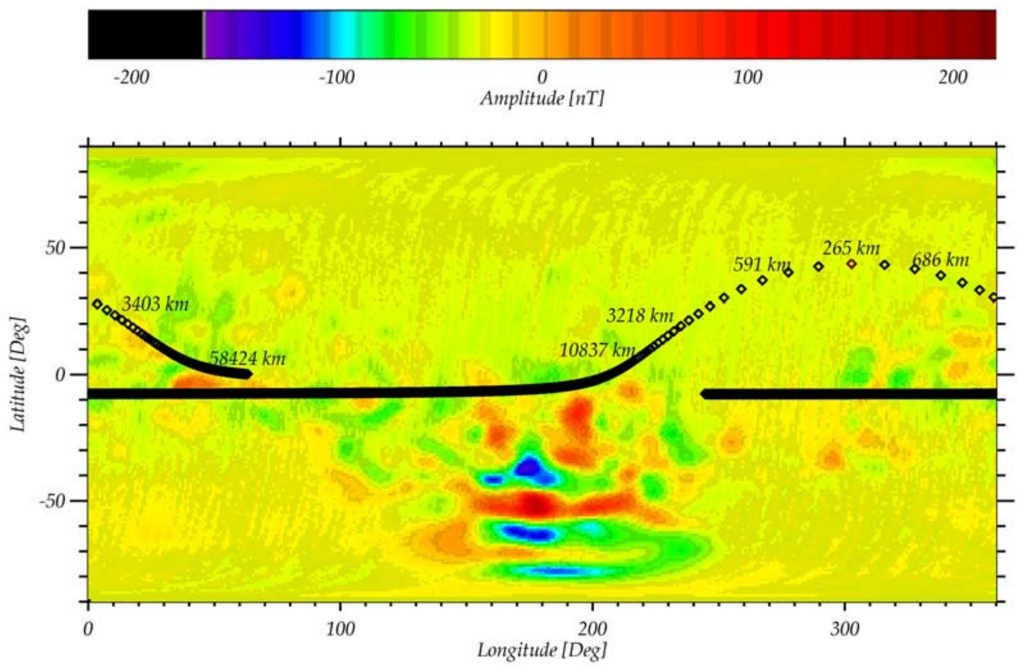


Figure 3.5-16: Mars Fly by with magnetic field model

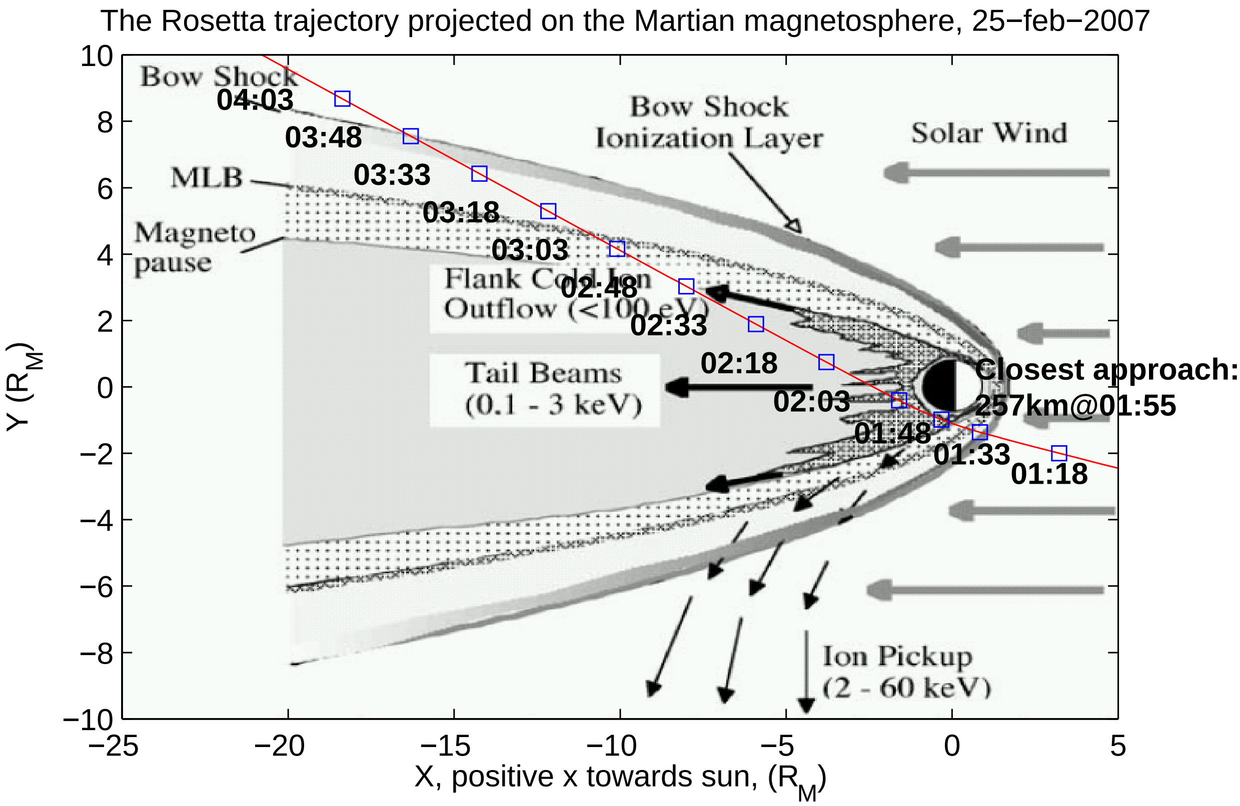


Figure 3.5-17: Mars Fly by & Martian Magnetosphere

Additional information can be found in RD-GEN-13.

3.5.3.3 Earth Fly By

Scientific Objectives of the RPC Instruments during the ROSETTA Earth Flyby:

- **Sensor Calibration**

The commissioning campaigns verified the technical integrity of the RPC instruments and their basic scientific performances. However, as measurements have been made only in the tenuous solar wind plasma with its weak interplanetary magnetic field and only low amplitude wave fields the close flyby of Rosetta at planet Earth will provide the RPC sensors with an environment ideal for a full check out of the science performance of the RPC sensors with special emphasize paid to calibration issues.

- **Magnetospheric physics**

The Earth encounter of a spacecraft coming out of deep space is a very valuable tool to do in particular magnetospheric studies. Previous encounters such as that one of the GIOTTO space in 1990 [RD-GEN-32], Galileo [RD-GEN-33], or more recently the CASSINI flyby at Earth [RD-GEN-34] have proven this statement.

In case of the Rosetta Earth flyby EF1 at March 04, 2005 a very special situation emerges as Rosetta flew almost along the nightside magnetotail before it reaches its perigee at a distance of about 2000 km in the dayside plasmasphere. The input magnetopause crossing occured early on March 4, 2005 at a distance 0f 40-50 R_E from Earth. Rosetta exits the magnetosphere at around 12:00 on March 5, 2004 at the dusk side of the magnetosphere.

Figure 3.5-18 and Figure 3.5-19 show the Rosetta trajectory (blue) during EF1 in the y-x plane and the z-x plane. A Tsyganenko model has been used to model the terrestrial magnetic field. Bow shock (black) and magnetopause (red) are also indicated.

This special trajectory of the Rosetta spacecraft allows a very detailed analysis of any magnetotail activity occurring during the flyby. In particular, the time history of any substorm activity can be observed. If conditions are favourable, for example, plasmoid motion along the magnetotail can be observed and studied in detail. Also, as the entry into the magnetotail will occur at a rather large distance a length axis cut of the magnetic tail close to the neutral sheet can be studied.

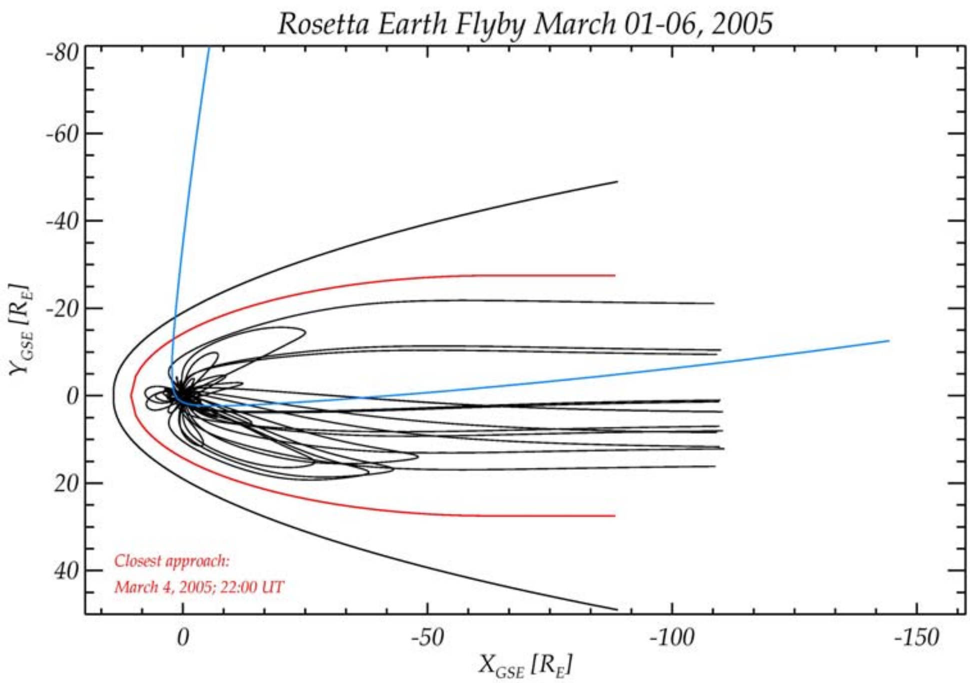


Figure 3.5-18: The Rosetta trajectory (blue) during EF1: x-y plane.

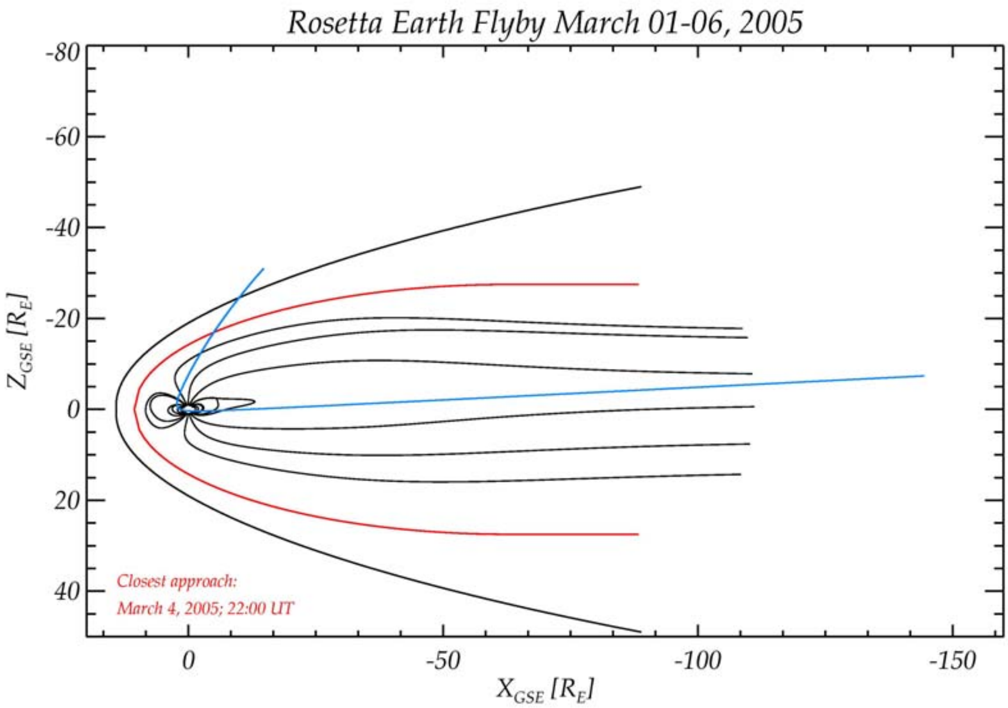


Figure 3.5-19: The Rosetta trajectory (blue) during EF1: z-x plane.

Furthermore, at the time of the flyby ESAs CLUSTER fleet is located in the near-Earth solar wind regime which enables one to use Rosetta (CLUSTER) as a downstream (upstream) monitor for CLUSTER (Rosetta). This situation promises a richness of magnetospheric observations, comparable to the CASSINI Earth flyby results summarized in [RD-GEN-34]. Also, the Double Star s/c was located close to the sub-solar point, crossing the magnetopause while Rosetta is in the terrestrial magnetosphere.

An international observational campaign including the Cassini, CLUSTER, Double Star, ACE, and Polar satellites as well as ground based observations will be organized to make Rosetta's first Earth encounter a highlight in the scientific career of this cometary explorer.

- **Rosetta Mars Flyby Preparations**

The Earth flyby also provides the only opportunity to verify the science operations modes for the Mars flyby in a realistic environment.

3.5.3.4 Asteroid Fly By

The mission planning envisages flybys at two flybys. This chapter will give a small overview about the target Asteroids STEINS and LUTETIA.

Target Asteroids:

2867 STEINS is a very small asteroid of only 10 km diameter. Its semi-major axis is 2.36 AU, the encounter takes place at 2.4 AU. Steins needs 3.63 years to orbit the sun. The excentricity is about 0.145 and the inclination 9.94°. The Rotational Period is about 6.05 h. The last Perihel passage happened at 2001-11-03. Steins is an E-Type asteroid.

21 LUTETIA with a diameter of ~100 km is one of the largest asteroids ever visited by a spacecraft. With a semi-major axis of 2.43 AU and an eccentricity of 0.16 Lutetia orbits the Sun in 3.8 years. The excentricity is about 0.16 and the inclination 3.06°. The rotational period is about 8.1h.
The last Perihle passage happened at 2004-04-14. Results of spectral analyses yield that Lutetia is a M-Type asteroid . Thus, it will be the first M-Type Asteroid ever visited by a s/c!

Flyby Parameter:

Asteroid	2867 Steins	21 Lutetia
Date	Sep 05, 2008,18:30	July 10, 2010
Distance	~800 km	3000 km
Flyby Velocity	~ 8.62 km/s	~ 15km/s

Table 3.5-5: Asteroidal FlyBy Parameter

Estimated Magnetic Field

With equation

$$B_{CA}(r_{CA}, r_{body}) = \mu_0 \frac{M}{3} (\frac{r_{body}}{r_{CA}})^3$$

r_{CA}	Flyby Distance at Closest Approach
r_{body}	Radius of Celestial Body
B_{CA}	Magnetic Field at Closest Approach
M	Magnetization

and an estimated magnetization of 110 A/m (which is an estimate of the magnetization of Asteroid Braille) a magnetic field at a distance of 3000 km for **LUTETIA** results of only **B_{CA}=0.21 nT**. Table 3.5-6 shows the results for other flyby distances:

Flyby Distances [km]	**B_{CA} [nT] STEINS**	**B_{CA} [nT] LUTETIA**
4000		0.09
3500		0.13
3000		0.21
2500		0.37
2000		0.72
1700	0.001	1.17
1000	0.01	5.76
500	0.05	46.0
100	5.76	7666

Table 3.5-6: Asteroid Magnetic Fields & Encounter Distance Relation

An estimation for STEINS seems rather useless. Due to its small diameter and the large flyby distance the expected fields are too small to be investigated.

Flyby Trajectory:

STEINS:

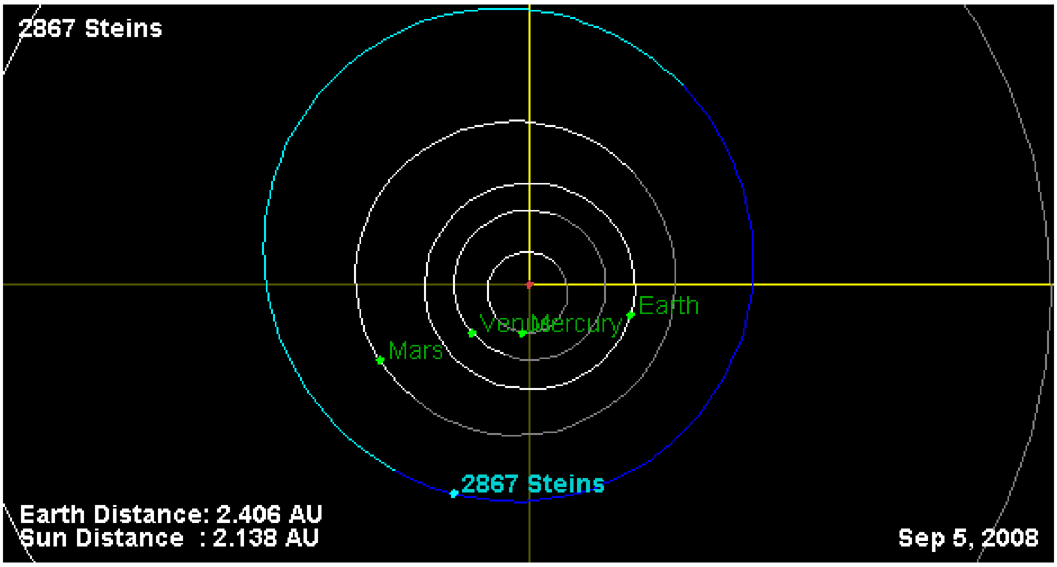


Figure 3.5-20: The Orbit of Asteroid STEINS

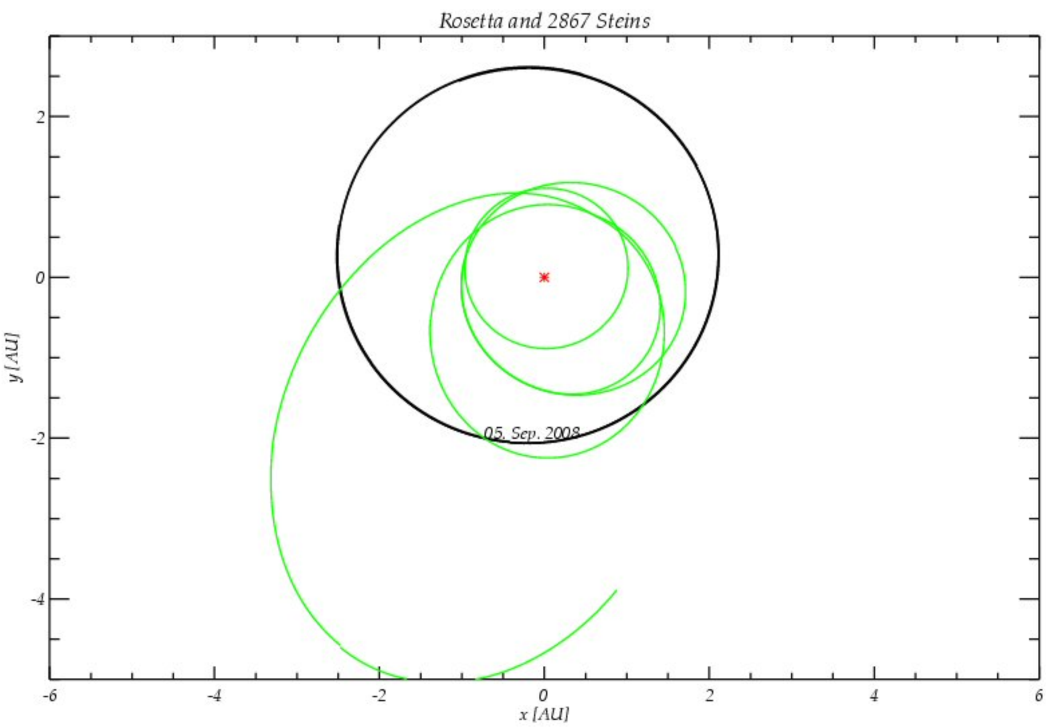


Figure 3.5-21: Rosetta’s flyby at Asteroid STEINS in September 2008

LUTETIA:

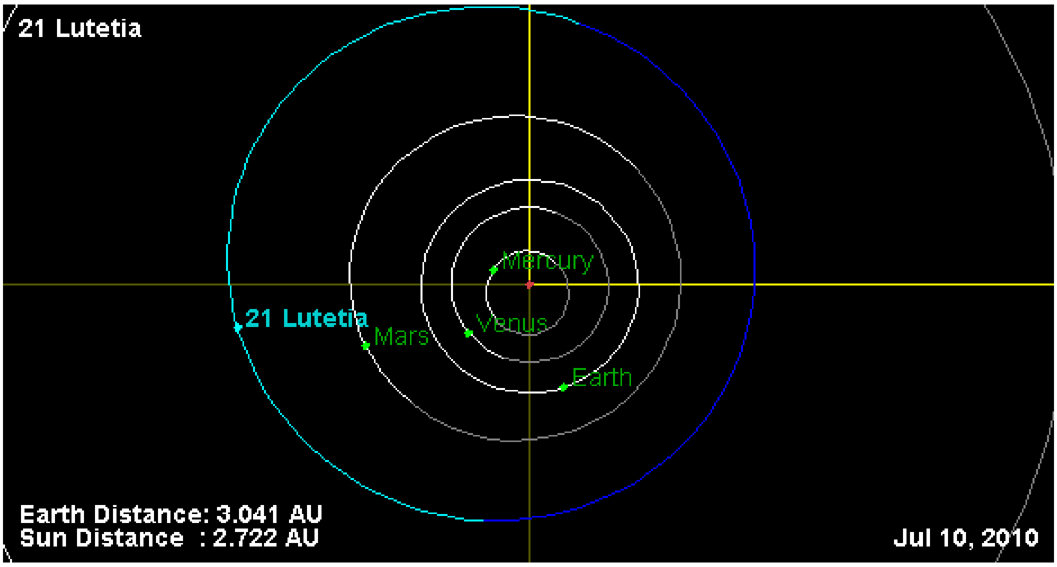


Figure 3.5-22: The Orbit of Asteroid LUTETIA

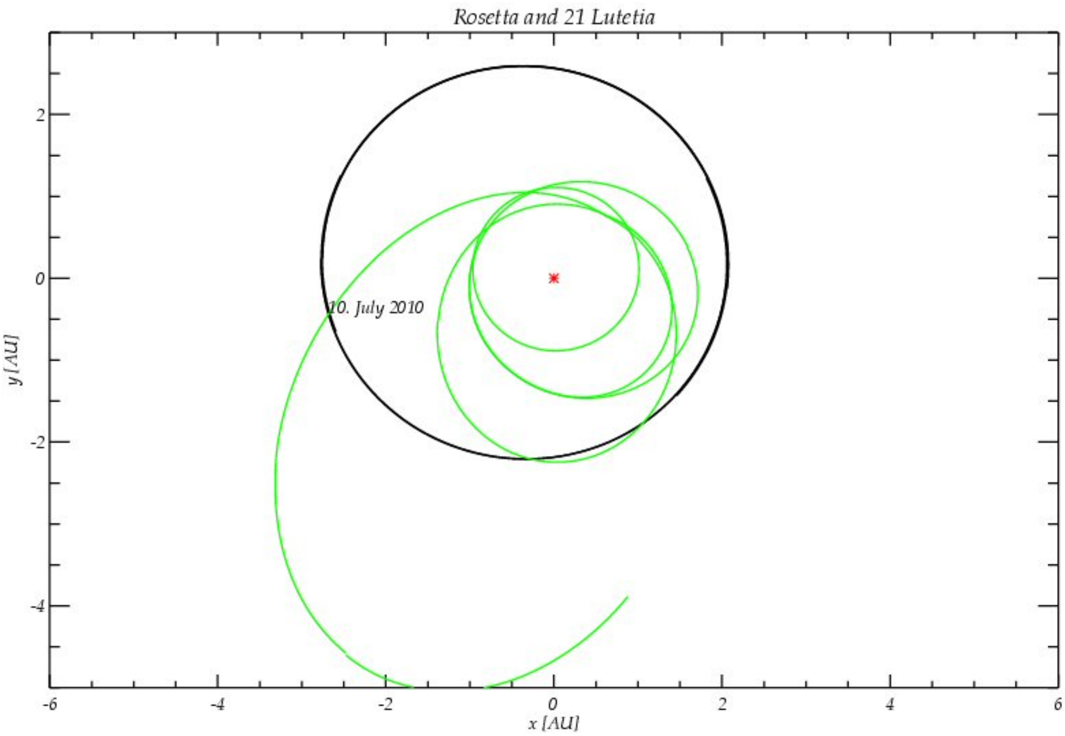


Figure 3.5-23 Rosetta's flyby at Asteroid LUTETIA in July 2010

Operational Mode:

To get a maximum amount of information, instruments should be set to Burst Mode during the encounters.

Evidence of a magnetosphere:

	Lutetia	Steins
Estimated Surface field @110 A/m	92000 nT	92000 nT
Stopping field @MP	31 nT	39 nT
Minimum required surface field	37 nT	131 nT
Required surface field for lateral stability	4880 nT	2990000 nT
Magnetosphere	***possible***	***Not possible***

Lutetia: A calculation of Greenstadt´s conditions for asteroidal magnetospheres yields the assumption that Siwa could build up a magnetosphere. A surface field of about 4880 nT would be enough to provide lateral stability. With an estimated magnetization of 110 A/m the resulting B_{sur} is 92000 nT, about a factor of 20 higher than necessary.

Steins: Although the first and the second condition could be met, the required surface field to fulfill the third condition is too large to be realised. Unless Otwara is a burnt out Borg Cube...

Additional information concerning the Asteroid Flybys can be found in RD-GEN-12

3.5.3.5 Comet Fly By

Information can be found in RD-GEN-21 and RD-GEN-17.

3.5.4 Interferences

IES: Nothing significant for IES here

ICA: Nothing to add for ICA

LAP: LAP observes several non-physical narrowband emissions at frequencies below 8 kHz. None of them is so severe as to constitute a problem. The only clear interference observed from other instruments is the obvious case when we hand over one of the probes to MIP in LDL mode. This is well understood and is handled within RPC. In addition, thruster firings give a very clear signature in LAP data, but this is easily identified and causes no operational constraint (Section 3.3.6).

MIP:

Interferences observed by MIP are :

266 kHz (50 mV/m), not due to RPC instruments
49 kHz, 98 kHz (13 mV/m) and some upper harmonics (6.5 mV/m), due to RPC instruments
154 kHz (6.5 mV/m), not permanent.

MAG:

During all the checkout and flyby phases lots of noise and disturbance has been recognized. Due to the huge level of activities on the s/c it can not clearly be stated where the disturbance is originated. Two sources, however, could be definitely identified:

- Reaction Wheels
  The comparison of the Reaction Wheel frequencies and the measured dynamic spectra of the magnetic field proofs that the rotating wheels can definitely be seen in the magnetic field data. For this analysis the actual wheel frequencies stored in NAAD6014, NAAD6024, NAAD6034 & NAAD6044 were folded down to the frequency range (wrt. the current Nyquist frequency) scanned by the magnetometer. Result: The disturbance is seen in the Burst mode (SID3) and from time to time in the normal mode (SID2) with amplitudes in the order of 2nT. A dynamic disturbance elimination algorithm has been developed and is applied to generate RW corrected LEVEL_H data.

- Heaters
  During the most time of ESB1 the SSP heaters were operated autonomously. The current fed into these heaters generated a

disturbing magnetic field in the order of 1nT at the RPCMAG sensors. These disturbance was eliminated semi-manually leading to Heater corrected LEVEL_K data. We hope that these heaters will never be switched on again while the SSP is connected to the orbiter and MAG is operated.

- LAP→MAG Interference
  During the PC10/LAP-MAG Interference test in November 2009 we identified a new source of disturbance: RPCLAP is generating a signal which is seen by RPCMAG at constant frequencies. The signal appears at 3.25 Hz or 3.65 Hz and their second harmonics (6.5 Hz and 7.3 Hz) in the MAG data. It seems to be independent of a LAP mode change. The frequency of this disturbance seems to vary randomly between the both values by switching on/off the LAP instrument. Details can be found in RD-MAG-34. As the disturbance occurs at constant frequencies only, it can be eliminated easily by the RPCMAG analysis software.
- COSAC,PTOLEMY Interference
  During the LUTETIA flyby the Lander instruments COSAC and PTOLEMY were operating in parallel with RPCMAG and ROMAP. Switching on/off PTOLEMY or COSAC could be seen in the RPCMAG data as jumps of about 4 nT. Also the sniff mode of PTOLEMY caused additional disturbance in the order of a few nT.
  The impact to the ROMAP instrument was significantly higher (in the order of a few hundred nT) due to the closer position of COSAC and PTOLEMY to ROMAP.
  Elimination of these disturbance signals is almost not possible.
  However, after the delivery of the Lander this problem will have been vanished for RPCMAG.
  Details can be found in RD-MAG-37.

4 Mode Descriptions

4.1 Mode Transition Diagram

The following diagrams show the mode transitions of the individual experiment modes. A combination of all these specific instrument modes is possible on RPC level. A detailed overview of the required power and needed TM budget is given in section 2.4. The following diagrams show only some indicative numbers.

4.1.1 PIU

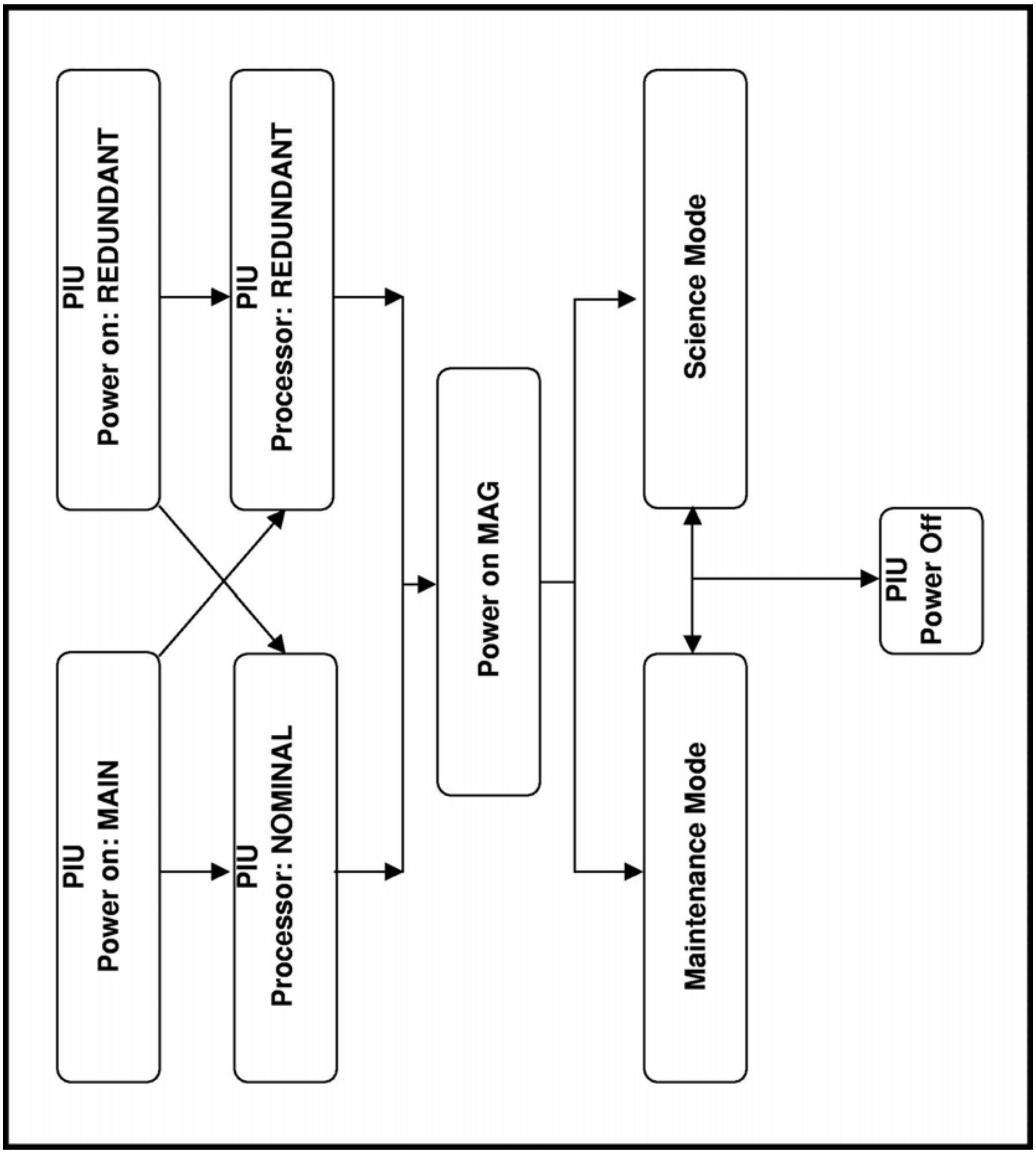


Figure 4.1-1: PIU Mode Transition Diagram

4.1.2 IES

A detailed mode description of the IES modes is given in 4.2.1. The functions and commanding of IES are described in detail in section 3.1.2.2.

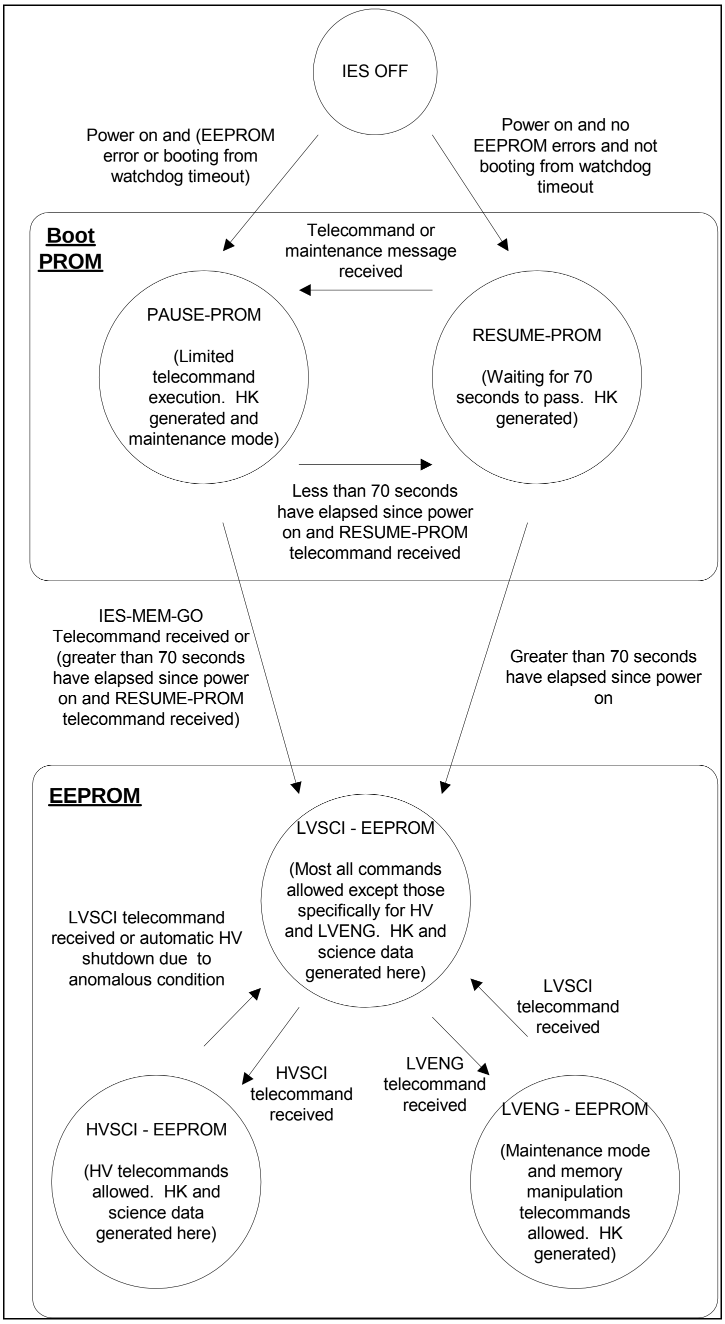


Figure 4.1-2: IES Mode Transition Diagram.

4.1.3 ICA

The ICA experiment can switch from any telemetry/data reduction mode combination to any other by means of commands. The ICA can be switched to any TM/data reduction mode combination by a single 16-bit combination command. Switching high voltages ON and reboot from EEPROM is possible with or without default context.
The modes listed in Figure 4.1-3 are all modes available for ICA. The mode names in Table 3.2-4 are specific for the onboard control procedure (OBCP) only. Maintenance and quiet are both IDLE mode, the names in the OBCP are used for consistency with IES. The HV_ON OBCP modes indicate that high voltage is switched on by the OBCP.

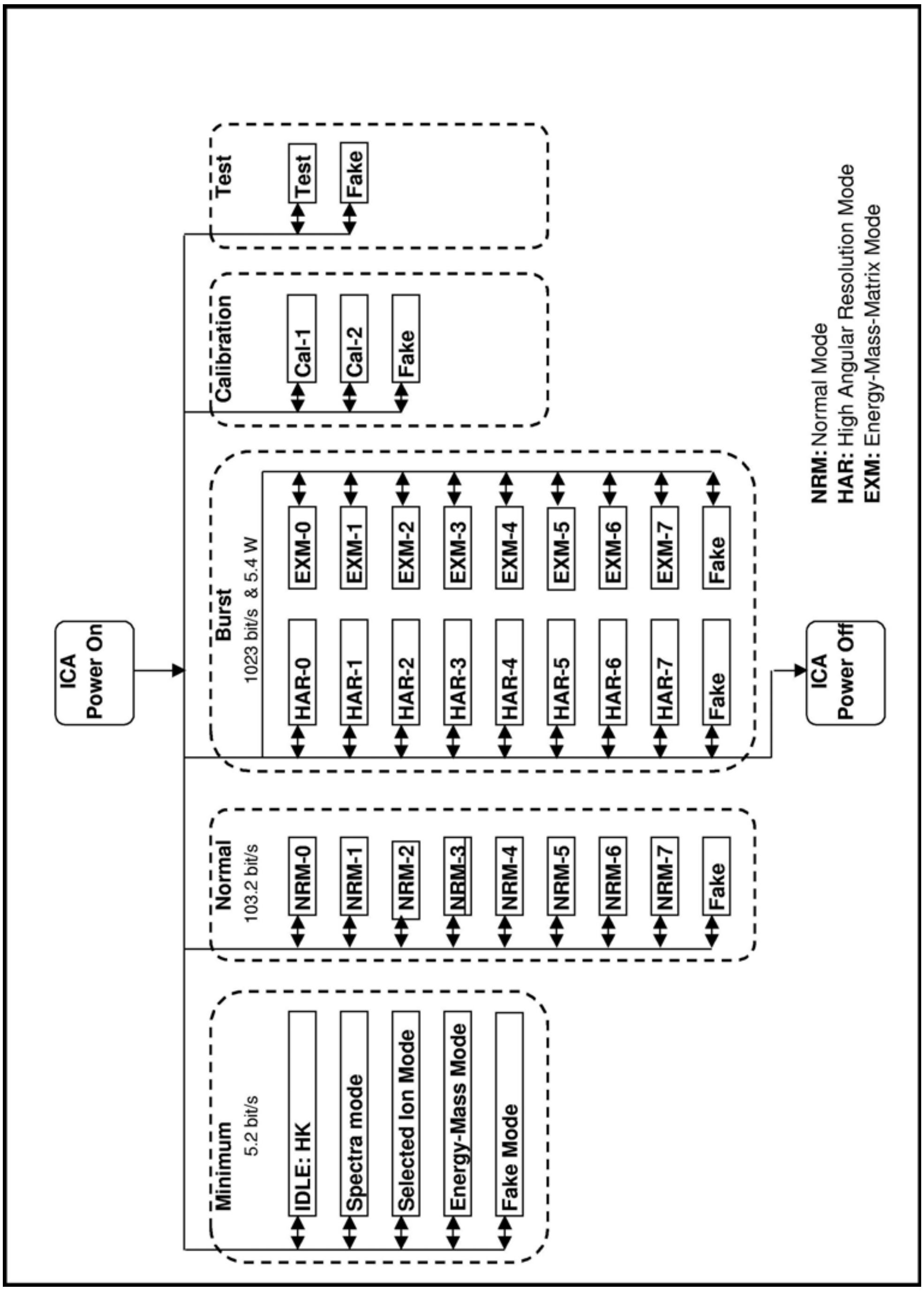


Figure 4.1-3: ICA Mode Transition Diagram

4.1.4 LAP

The fundamental LAP mode transition concept can be illustrated as in Figure 4.1-4. At boot, LAP is started in maintenance mode. Transition to any science mode is achieved by starting the relevant macro. To go to another science mode, the running macro is stopped, which returns LAP to maintenance mode, and the new macro is started.

In practice, the user finds an even simpler situation for ordinary science operations, as these are normally controlled by use of OBCP 804. For a user of this OBCP, it appears that LAP is started directly into the scientific mode corresponding to the macro selected by the user as an argument to the OBCP. Transit to other science modes is achieved by calls to the same OBCP with other macro identifiers as argument, and all transitions in and out of maintenance mode and/or power on/off are handled by the OBCP. Even the limited complexity of Figure 4.1-4 is thus simplified to the user.

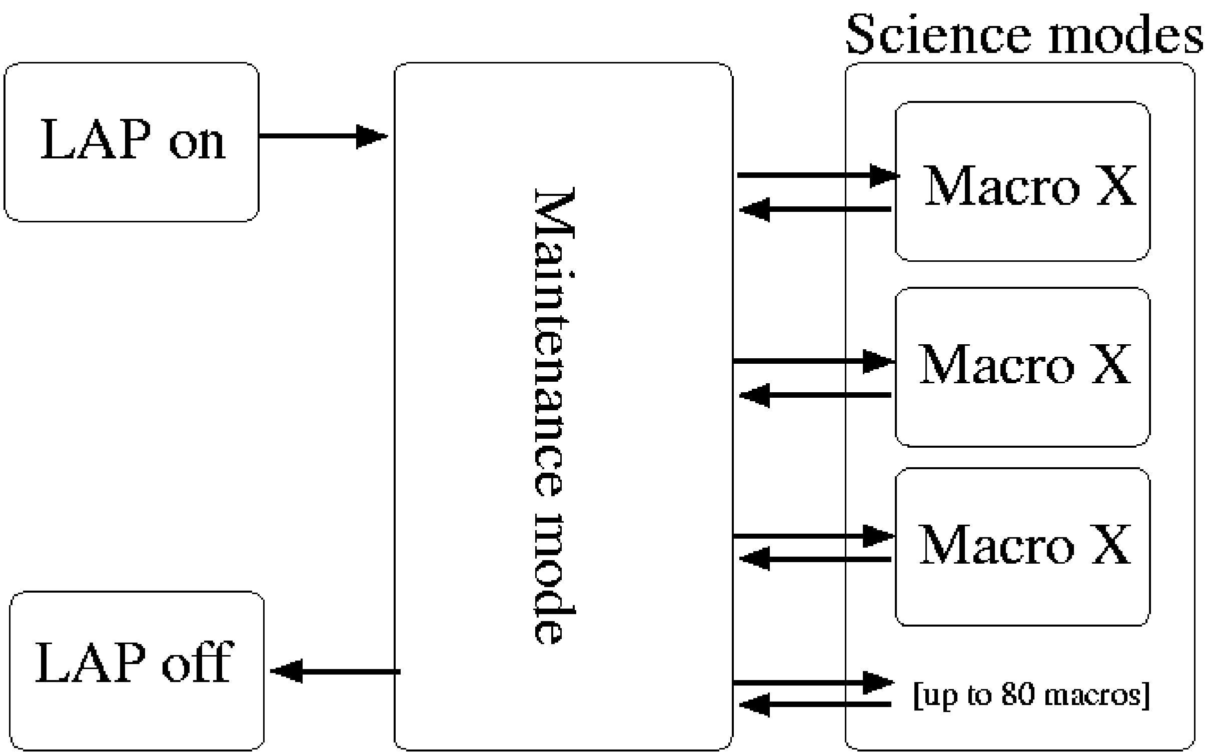


Figure 4.1-4: LAP Mode Transition Diagram

4.1.5 MIP

For the Sequence definition refer to RD-MIP-5.

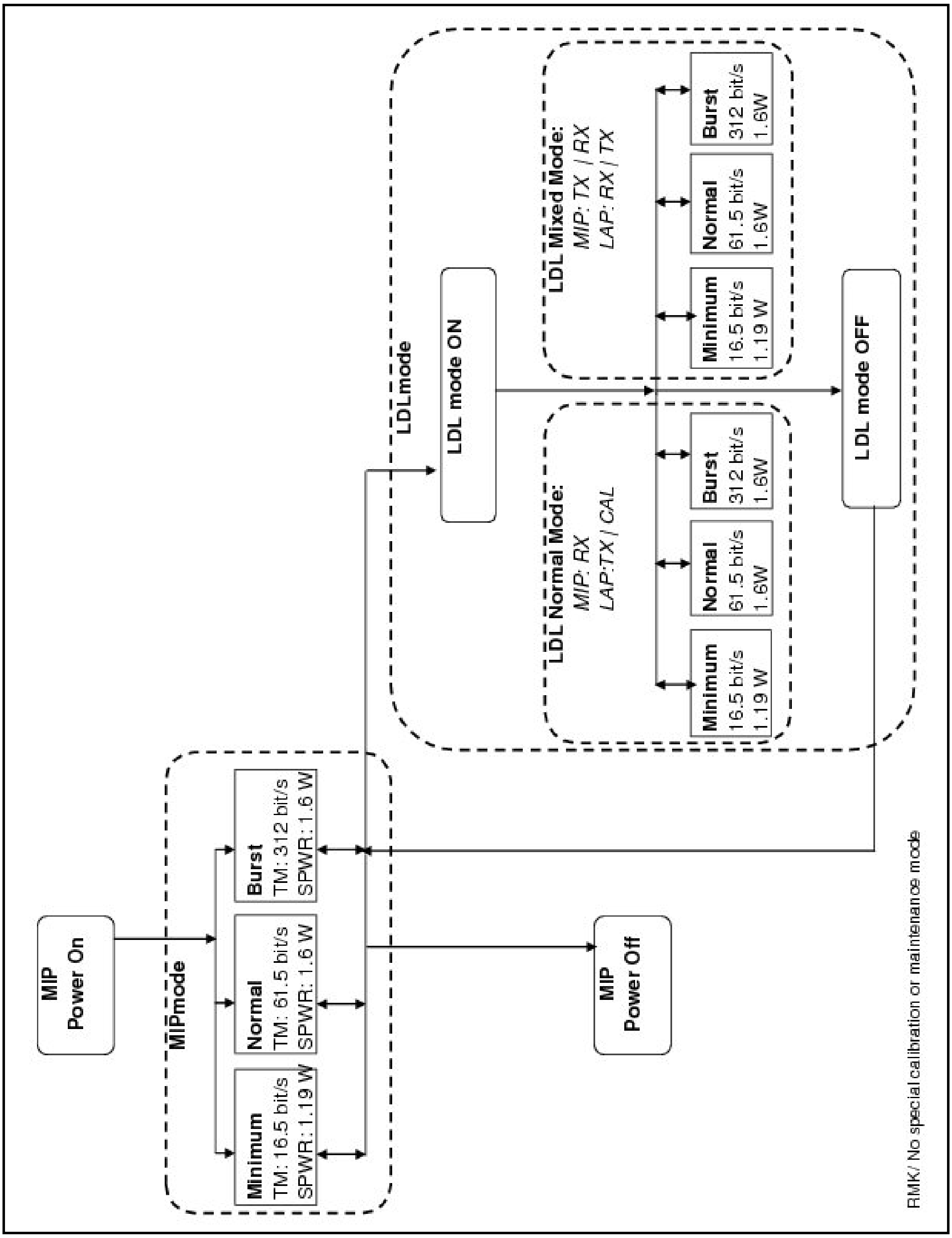


Figure 4.1-5:MIP Mode Transition Diagram

Figure 4.1-5 shows the two MIP main modes, the MIP science mode, and LDL mode, with the three TM rates available. From this point of view this diagram is complete. The quiet mode is a particular configuration of MIP science mode in which the antenna is not transmitting (passive). In OBCP operations it is given by table 00 or table 01 (parameter VRPD1268).

4.1.6 MAG

There is only one fixed mode of operation for MAG which is 20 vectors per second for both sensors. MAG wakes up in this mode just after power MAG on. (No other command, no range switching!)

Only depending on bit rate capabilities the PIU can reduce the MAG bit rate just by decimating and filtering down these 20 vectors per second (ref. Section 4.2.5 for the detailed mode description)

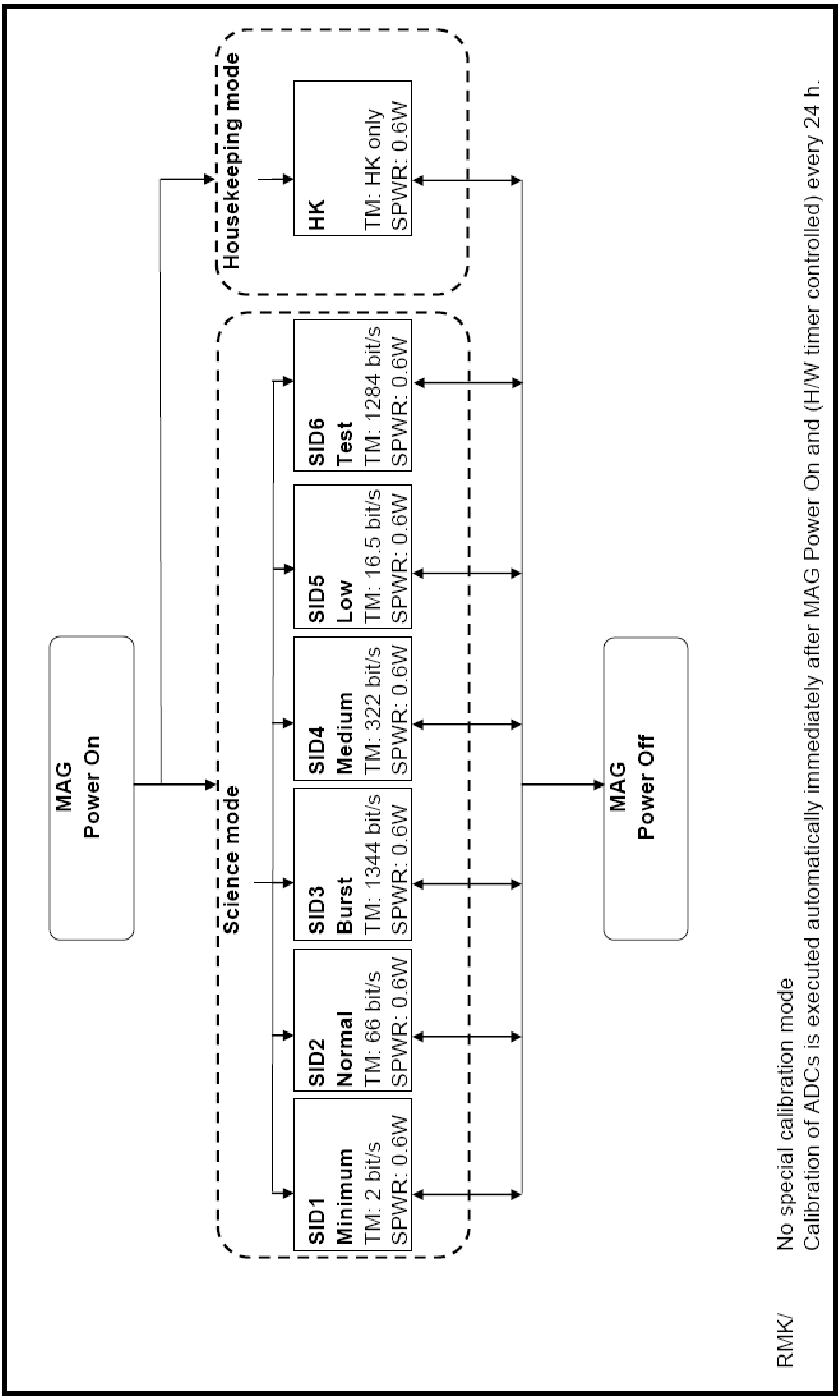


Figure 4.1-6: MAG Mode Transition Diagram

4.2 Detailed Mode Description

4.2.1 IES

The operating modes of IES are grouped according to the commands that are allowed to be executed and which telemetry types can be output. The IES state diagram is shown in Figure 4.1-2.

When powered on, the IES instrument runs its boot PROM code. The boot PROM, by default, checks all RAM, EEPROM and PROM resources within the IES instrument and reports their status in housekeeping. Whether the PAUSE-PROM or RESUME-PROM mode is entered depends on the conditions shown in the diagram.

PAUSE-PROM prevents the PROM from going automatically into the EEPROM code so that telecommanding or maintenance mode telecommands can be executed. The boot PROM can execute the entire suite of maintenance mode commands but only a limited set of telecommands. In order to program the EEPROM using the activate patch function in maintenance mode, IES must be running from the boot PROM. This is because the boot PROM code runs using a lower clock frequency which is amenable to the EEPROM write timing. The EEPROM code is run at a faster clock frequency to accommodate all the tasks that must be executed during science data acquisition. Housekeeping is generated every 32 seconds. Maintenance and event messages are possible from this mode.

RESUME-PROM is a waiting mode to allow telecommands or maintenance mode commands to be received by IES before automatically going to the EEPROM code. Housekeeping is generated every 32 seconds. Event messages are possible from this mode.

LVSCI-EEPROM is the first EEPROM mode entered and many of the IES commands to be executed. This is the mode used for low-voltage stimulation operation. Housekeeping is generated every 32 seconds. Science and event messages are possible from this mode.

HVSCI-EEPROM is entered if an IES-INSTR-PROG-MODE HVSCI telecommand is received. Here, high-voltage telecommands can be executed to turn on the HV supplies and manipulate their settings. All plasma science data are acquired in this mode. Housekeeping is generated every 32 seconds. Science and event messages are possible from this mode. The science telemetry modes are described in Table 4.2-1.

LVENG-EEPROM is used for executing maintenance commands and memory manipulation telecommands. Note that the EEPROM cannot be written in this mode due to the timing constraints mentioned in the PAUSE-PROM description. Housekeeping is generated every 32 seconds. Maintenance and event messages are possible from this mode.

Telemetry Mode	Sample Rate	Packet Period	Raw Packet Length (No header)	Raw Bit Rate (No header)	Name
SID1 (Science)	This mode, while still supported, is not expected to be used. Science data are acquired and collapsed to reduce volume. HK acquired over 32-s period	Science: One packet per 1024 s HK: 32 s	Science packet: 5088 bits HK: 192 bits	Science: 5 bps HK: 6 bps	Minimal
SID2 (Science)	Science data acquired in 128-s to 1024-s cycles with sample periods from 62.5 ms up to 500 ms. Data are collapsed to reduce volume. HK acquired over 32-s period	Science: One packet per 32 seconds. Data are telemetered over the same amount of time that the data were originally acquired HK: 32 s	Science packet: varies according to data acquisition cycle time HK: 192 bits	Science: 50 bps HK: 6 bps	Normal
SID3 (Science)	Science data acquired in 128-s to 1024-s cycles with sample periods from 62.5 ms up to 500 ms. Data are collapsed to reduce volume. HK acquired over 32-s period	Science: One packet per 32 seconds. Data are telemetered over the same amount of time that the data were originally acquired. HK: 32 s	Science packet: varies according to data acquisition cycle time HK: 192 bits	Science: 250 bps HK: 6 bps	Burst
Maintenance	HK acquired over 32 s period Memory dump packets are also possible if they are commanded.	HK: One packet per 32 s MD: One packet per 32 s Maximum number of 16-bit words per packet is approximately 2000	HK: 192 bits MD: 32000 bits	HK: 6 bps MD: 1000 bps	Maintenance

Table 4.2-1: IES Modes (SID+HK) and data rates

The power for IES is about 0.5 W when first booting up (no high-voltage power supply), but can be on the order of 2W for all science modes, which is its normal mode of operation.

Constraints:
No special constraints apply to any mode besides the ones listed in section 3.3.6

4.2.2 ICA

The basic operation consists of stepping through 32 or 96 energy HV deflection steps for each of 16 entrance HV deflection steps (polar angles). A complete cycle (scan) takes 64 seconds (32 levels) or 192 seconds (96 levels) respectively. The sampling time is 102.9 milliseconds. Each sample produces an imager matrix of 32 mass bins times 16 sectors (azimuth angles).
The data acquisition and transmission is synchronized to an acquisition (start) pulse. For ICA that pulse is received once per 32 seconds and for IMA once per 16 seconds.
All data to and from the experiment is transmitted over a serial 1355-link from/to a central unit that in turn interfaces to the spacecraft systems.

Each format starts with a 16-byte long standard header with a 3-byte long synchronization pattern.

Except for the header and some data in the special modes all data is by default converted to an 8-bit hybrid floating code (F8) followed by a loss less bit data compression.
Thus, most ICA-IMA data formats will float in the ESA telemetry packets. Some may, however, be synchronized.

4.2.2.1 Telemetry modes.

The experiments have to their disposal a number of telemetry modes (here named SID, Science ID). The SID efines the TM rate available. The SID numbers below are the internal ICA-IMA numbers that is also used in commanding. Note that direct (near real time) TM is mostly not available. The TM data is buffered onboard the S/C. The TM rate below then describes the reasonable amount to create to stay within the buffer allowance allocated for the planned S/C session before tapping to a ground S/C tracking station. Different ICA modes are different data reduction schemes to fit available TM.

For Details of the internal mode defintions refer to the Documents RD-ICA-2 , RD-ICA-7 and RD-ICA-8.

Telemetry Mode	Sample Rate	Packet Period	Raw Packet Length (No header)	Raw Bit Rate (No header)	Name
SID1 (000)	Scan of 32 or 96 Energies per 16min, details Table 4.2-6	One packet per 960 seconds.	618 bytes	5.3 bps	Minimum, **Min**
SID2 (001)	Scan of 96 Energies per 192 s details Table 4.2-10	One packet per 192 seconds.	2478 bytes	103.9 bps	Normal, **Nrm**
SID3 (010)	Scan of 96 Energies per 192 s details Table 4.2-11	One packet per 32 seconds.	4092 bytes	1027.0 bps	Burst, **Bst**
SID4 (011)		One packet per 32 seconds.	1074 bytes	272.5 bps	Calibration,**Cal**
SID5		One packet per 32 seconds.	3198 bytes	803.5 bps	Special, **Spc**
SID6		One packet per 32 seconds.	600 bytes	154 bps	Test, **TST**
HK		One packet per 32 seconds.	24 bytes	10.5 bps	Housekeeping

Table 4.2-2: ICA Telemetry modes

Mode	Index	Masses	Azimuth angles	Energies	Max sets
Idle	0				
Mspo	2	2	1	32	15
Msis	4	6	1	96	5
Mexm	5	32	1	96	5

Table 4.2-3: Characteristics of the different MINIMUM modes

Mode	Index	Masses	Azimuth angles	Energies	Polar angles
Nrm-0	8	6	16	96	16
Nrm-1	9	6	16	96	8
Nrm-2	10	6	16	96	4
Nrm-3	11	6	16	96	2
Nrm-4	12	6	8	96	2
Nrm-5	13	6	4	96	2
Nrm-6	14	3	4	96	2
Nrm-7	15	3	4	96	1

Table 4.2-4: Characteristics of the different NORMAL modes

Mode	Index	Masses	Azimuth angles	Energies	Polar angles
Har-0	16	16	16	96	16
Har-1	17	16	16	96	8
Har-2	18	16	16	96	4
Har-3	19	8	16	96	4
Har-4	20	4	16	96	4
Har-5	21	2	16	96	4
Har-6	22	2	8	96	4
Har-7	23	2	8	96	2
Exm-0	24	32	16	96	16
Exm-1	25	32	16	96	8
Exm-2	26	32	16	96	4
Exm-3	27	32	16	96	2
Exm-4	28	32	8	96	2
Exm-5	29	32	4	96	2
Exm-6	30	32	2	96	2
Exm-7	31	32	2	96	1

Table 4.2-5: Characteristics of the different BURST modes.

The Burst mode is split into High Angular Resolution (HAR) and Burst Mass Matrix modes (EXM).

Constraints:
No special constraints apply to any mode besides the ones listed in section 3.3.6

4.2.3 LAP

The Langmuir probe can be operated in different modes.

Constraints:
No special constraints apply to any mode besides the ones listed in section 3.3.6

4.2.3.1 Standard LAP Modes

When LAP starts it always begins in maintenance mode. From maintenance mode the instrument is commanded into several different scientific modes. Now each scientific mode is characterized by the underlying macro that is executed, so to simplify things we can view a macro as a mode. See RD-LAP-5 for details about macros. A complete table is listed in RD-LAP-7. For details about commanding of macro execution see RD-LAP-4. Note that all necessary commanding is embedded in OBCP 804 and for LDL OBCP 805.

Below is a figure describing how macros are stored in memory and how they are executed, a maximum of 80 macros can be stored in the flash memory. In addition, 8 default macros reside in the prom memory.

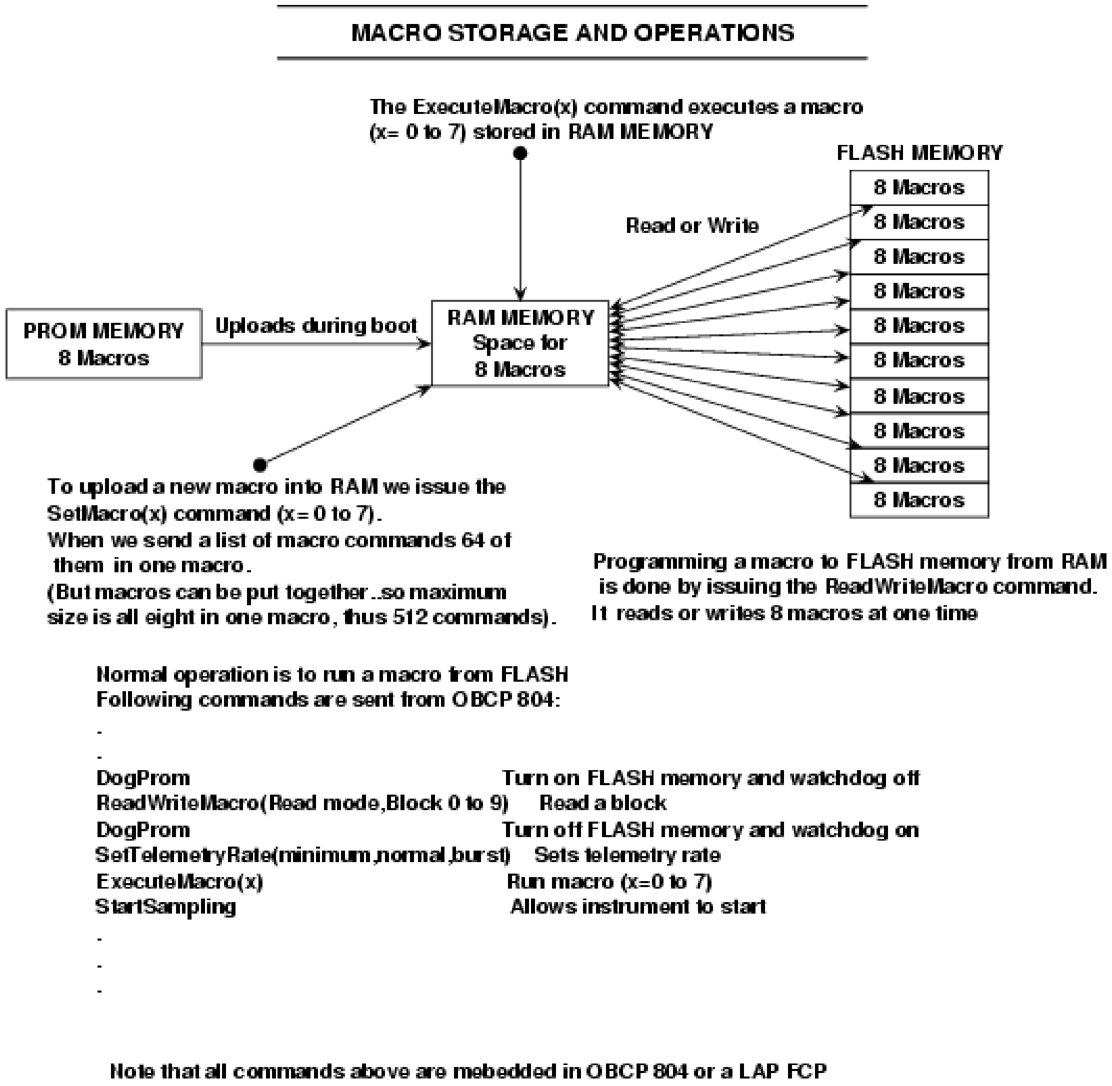


Figure 4.2-1: LAP Macro Storage and Operations

For currently (November 2005) implemented macros in LAP, see list in Table 4.2-6. Note that this list is to be seen as an example, as macros are intended to be updated to optimize science operations:

DESCRIPTION	MODE ID
Transmitting Probe 1 5 KHz	MCID0X100
Transmitting Probe 2 5 KHz	MCID0X101
Transmitting Probe 1 6.7 KHz	MCID0X102
Transmitting Probe 2 6.7 KHz	MCID0X103
Open Sweep Test Calibration	MCID0X104
Internal Resistor Sweep calibration	MCID0X105
Transmitting Probe 1	MCID0X106
Transmitting Probe 2	MCID0X107
Generic macro not for LDL	MCID0X200
Density mode, 20 Bit ADCs truncated, downsampled to 0.83Hz	MCID0X201
Density, normal mode alternating sweeps and time series.	MCID0X212
NE mode Sweeping on sensor 1. E-field using 20 bit ADC's on sensor 2 truncated to 16 bits	MCID0X203
Density, Burst mode alternating sweeps and time series.	MCID0X204
Density, Full 20 bit data time series	MCID0X205
Generic macro for LDL	MCID0X206
E-field mode, 16 Bit ADC's downsampled 4 times	MCID0X207
EE Mode, 20 Bit ADC's FULL AQP E-Field	MCID0X300
EN Mode, E-Field P1, Density Sweep P2	MCID0X301
Density P1,E-field P2, Fix Dbias 10 V 8KHz Filt. (Sensitive passive mode)	MCID0X302
EE Mode, 16 Bit ADC's 8KHz Filt	MCID0X303
Alternating fine sweeps P1 & P2, Offset 5, Otherwise as Prom Macro 2	MCID0X304
Alternating fine sweeps P1 & P2, Offset 7, Otherwise as Prom Macro 2	MCID0X305
Alternating fine sweeps P1 & P2, Offset 9, Otherwise as Prom Macro 2	MCID0X306
Alternating fine sweeps P1 & P2, Offset 11, Otherwise as Prom Macro 2	MCID0X307
16 Bit ADC's P1 & P1 Down sampling 2 times	MCID0X400
16 Bit ADC's P1 & P1 Down sampling 4 times	MCID0X401
16 Bit ADC's P1 & P1 Down sampling 8 times	MCID0X402
16 Bit ADC's P1 & P1 Down sampling 16 times	MCID0X403
20 Bit AD''s P1 & P2 Down sampling 30 times	MCID0X404
16 Bit ADC's Density Mode P1 & P2 long records 4096*2 samples for Interferometry	MCID0X405
Empty	MCID0X406
Empty	MCID0X407
Alternating Log Compressed sweeps P1 & P2, Fix density bias on non sweeping probes	MCID0X500
Alternating Log Compressed sweeps P1 & P2	MCID0X501
Density Difference P1-P2	MCID0X502
Not incl. in LAP_FCP_Definitions_0.9	
Minimum TM,Normal LDL or mixed LDL *	MCID0X806
Normal TM,Normal LDL or mixed LDL *	MCID0X906
Burst TM,Normal LDL or mixed LDL *	MCID0XA06

Table 4.2-6: List of LAP Macros

Telemetry Mode	Sample Rate	Packet Period	Raw Packet Length (No header)	Raw Bit Rate (No header)	Name
SID1		One packet per 1024 seconds.	192 bytes	1.5 bps	Minimum
SID2	Details: Table 4.2-8	One packet per 32 seconds.	234 bytes	58.5 bps	Normal
SID3	Details Table 4.2-9	One packet per 10.7 seconds.	2988 bytes	2241,0 bps	Burst

Table 4.2-7: LAP Telemetry modes

Macro	Purpose	Sample	Samples	Cadency

		Frequency		
0x104	Calibration			
0x212	Swp, HF		256	256 s
0x503	Vsc, HF	0.9 Hz	272	160 s
0x505	LDL, HF,N	0.45 Hz	96	160 s
0x506	N,HF,Swps	0.45 Hz	96	160 s
0x600	HF,Swp		256	256 s
0x700	Vsc,HF	0.9 Hz	160	96 s
0x701	Vsc,HF	0.9 Hz	160	96 s
0x702	Vsc,HF	0.9 Hz	160	96 s
0x703	LDL,Vsc,HF	1.8 Hz	160	96 s
0x705	Vsc,HF	0.9 Hz	272	160 s
0x803	LDL,N,HF	1.8 Hz	160	96 s

Table 4.2-8: Characteristics of the different LAP Normal modes

Macro	Purpose	Sample Frequency	Samples	Cadency
0x504	Vsc, HF	57.8 Hz	432	32 s
0x604	N, HF,swps	28.9 Hz	1840	96 s
0x704	LDL,Vsc,Wave	57.8 Hz	2416	32 s
0x706	Vsc, HF	57.8 Hz	2624	96 s
0x804	LDL,N,HF	57.8 Hz	2416	32 s

Table 4.2-9: Characteristics of the different LAP Burst modes

4.2.3.1.1 LDL MODE

Together with the MIP instrument LAP will enter a common mode, the Long Debye Length mode (LDL Mode). In this mode the MIP instrument will have full access to one of the LAP probes. Two variants of the LDL mode are defined, the LDL Normal (see Section 4.2.3.1.2) and LDL Mixed (see Section 4.2.3.1.3).

4.2.3.1.2 LDL Normal Mode

In the LDL Normal mode LAP simply lends one probe to MIP. During this period LAP does essentially nothing with the other probe, this means LAP does nothing that is interfered or interferes with MIP transmitting or measuring. How to set up and synchronise the two instruments are described in Section 4.2.3.1.4.

4.2.3.1.3 LDL Mixed Mode

In the LDL Mixed mode LAP does mixed measurements, thus MIP uses the probe in every second AQP and LAP does nothing. Interleaved between the times MIP uses the lent probe and LAP uses the other probe and MIP does nothing, (LAP could also use the probe lent out to MIP, but LAP wants to minimise relay switches). How to set up and synchronise the two instruments is described in Section 4.2.3.1.4.

4.2.3.1.4 MIP & LAP Synch.

To get the two instruments to interact smoothly with each other some kind of synchronisation is necessary. This is particularly important in the mixed mode, since if there is a shift in the AQP period with respect to the other the LAP measurement is performed when MIP sends, which is a bad timing.
The synchronisation and set up of the two instruments is best handled by the S/C DMS. This method requires that the DMS can check HK and branches depending on the result. Furthermore two bits are needed in both MIP and LAP HK to achieve synchronisation. If the acknowledge in HK is negative it retries several times (about 3 times). As soon as an instrument (LAP or MIP) enters LDL mode it should set one bit to indicate this in the MIP_LDL and the LAP_LDL. It should also set a toggle bit MIP_LDL_SYNC and LAP_LDL_SYNC. The instruments toggle the synchronisation bits every AQP making it possible to synchronise the instruments by comparing these two bits.
If we are out of sync for an even number of AQPs, we are again in sync afterwards. Therefore only one bit is needed.
The instruments will be out of sync when one instrument starts up in one AQP and the other in the next, happening if commands are received at a boundary of an AQP.

4.2.4 MIP

The modes are described in details in RD-MIP-5.

A sequence is a series of elementary working modes run during an acquisition period (32 seconds). Four types of sequences have been defined :

MIP science sequence
LDL science sequence
Control sequence
Table sequence.
For one science type, several sub-sequences will be defined with different series of elementary modes. The MIP science sequences correspond to the nominal operating order of the experiment around the comet when the Debye length is greater than a few millimeters and lower than ~20 cm. Transmission and reception are done with the MIP antenna. Combination of elementary modes „Survey", „Sweep" and „Passive" are run.
The LDL science sequences correspond to the nominal operating mode with MIP and LAP experiments when the Debye length is greater than ~20 cm. The Langmuir probe LAP2 is used as a long distance transmitter and MIP antenna is used for reception. Combination of modes „LDL" and „Passive" are run.
The Control sequence is a special sequence used to check the working state of the experiment when MIP is set on. It is automatically run once, before the science sequences. Its tasks are the reception and decoding of the commands coming from the PIU (configuration table) and a check-out of the experiment.
The Table sequence is defined to decode the commands which arrive during a science MIP or LDL sequence. This case occurs for example when MIP is set first in MIP modes and then in LDL mode. This sequence is like a Control sequence without experiment check-out.
Each LDL mode has to be preceded by MIP science mode.

MIP has only two operating modes :
MIP mode,
LDL mode(together with LAP)

Each operating mode can be set with one of the 3 telemetry rates.
MIP has no special test or calibration mode.

MIP has three science data rates :
minimum with a 18-byte packet per 32s sequence,
normal with a 198-byte packet per 32s sequence,
burst with a 1200-byte packet per 32s sequence.

MIP transmits to PIU one science packet every AQP (32 seconds).

The total telemetry data, **HK + science**, transmitted to the S/C (CCSDS formatted) are :
in minimum rate : 66 bytes every 32 s, rate of 16.5 b/s,
in normal rate : 246 bytes every 32 s, rate of 61.5 b/s,
in burst rate : 1248 bytes every 32 s, rate of 312 b/s.

The nominal power consumption (secondary) is :
in minimum rate: 1190 mW
in normal and burst rates: 1625 mW.

The operational modes are defined within RPC.

Science Mode (Binary)	**Sample Rate**	**Packet Period**	**Packet Length**	**Bit Rate**	**Spectrum Rate**	**Name**
SID1 (000) SCIENCE	N/A	32 s	18 bytes	4.5 bits/s	N/A	Minimum Rate
SID 2 (001) SCIENCE	1/16 Hz	32 s	198 bytes	49.5 bits/s	0.0625 spec/s	Normal Rate
SID 3 (010) SCIENCE	13/32 Hz	32 s	1200 bytes	300 bits/s	0.40625 spec/s	Burst Rate
HK	N/A	32 s	12 bytes	3 bits/s	N/A	House Keeping

Table 4.2-10: MIP Modes (SID+HK) and vector rates

Constraints:

The only constraint for MIP concerns the LDL mode :

- it has to be agreed by MIP and LAP experimenters
- it starts when MIP and LAP are already on and running in their own modes.

4.2.5 MAG

The MAG Data Modes are defined as follows:

Mode (Binary)	***Sample Rate***	***Packet Period***	***Packet Length***	***Bit Rate***	***Vector Rate***	***Name***	***File Ext.***
SID 1 (000) SCIENCE	1/32 Hz	1024 s	32 OB vec 1 IB vec	2 bits/s 0.0625 bits/s	0.03125 vec/s 0.000976 vec/s	Minimum Mode	_DID275
SID 2 (001) SCIENCE	1 Hz	32 s	32 OB vec 1 IB vec	64 bits/s 2 bits/s	1 vec/s 0.03125 vec/s	Normal Mode	_DID275
SID 3 (010) SCIENCE	20 Hz	16 s	320 OB vec 16 IB vec	1280 bits/s 64 bits/s	20 vec/s 1 vec/s	Burst Mode	_DID2699
SID 4 (011) SCIENCE	5 Hz	32 s	160 OB vec 1 IB vec	320 bits/s 2 bits/s	5 vec/s 0.033125 vec/s	Medium Mode	_DID1299
SID 5 (100) SCIENCE	¼ Hz	128 s	32 OB vec 1 IB vec	16 bits/s 0.5 bits/s	0.25 vec/s 0.007812 vec/s	Low Mode	_DID275
SID 6 (101) SCIENCE	20 Hz	16 s	320 OB vec 1 IB vec	1280 bits/s 4 bits/s	20 vec/s 0.0625 vec/s	Test Mode	_DID275
HK	1280 Hz Internal	32 s	8 words	4 bits/s		House Keeping	_DID27

Table 4.2-11: MAG Modes (SID+HK) and vector rates

The magnetometer vector rates for IB and OB (main) correspond to the above defined modes as follows:

- **Minimum Mode:**
  1 packet every 1024 s containing 32 vectors from OB sensor and 1 from IB sensor. (total 2112 bits/1024 s)
- **Normal Mode**:
  1 packet every 32 s containing 32 vectors from OB sensor and 1 vector from IB sensor. (total 2112 bits/ 32 s)
- **Burst Mode**:
  1 packet every 16 s containing 320 vectors from OB sensor and 16 vectors from IB sensor. (total 21504 bits/16 s)
- **Medium Mode:**
  1 packet every 32 s containing 160 vectors from OB sensor and 1 vector from IB sensor. (total 10304 bits/ 32 s)
- **Low Mode:**
  1 packet every 128 s containing 32 vectors from OB sensor and 1 vector from IB sensor. (total 2112 bits / 128 s)
- **Test Mode:**
  1 packet every 16 s containing 320 vectors from OB sensor and 1 vector from IB sensor. (total 20544 bits / 16 s)
  Remark: The Test Mode will never be used in flight

- **Housekeeping Mode:**
  1 packet every 32 s containing 8 words. (total 128 bits / 32 s)

Each vector consisting of three components XOB,YOB,ZOB or XIB,YIB,ZIB is sampled by a 20 bit A/D converter. 4 bits of identification per vector are added to get 8 bytes per vector (64 bits).

Constraints:
No special constraints apply to any mode.

4.3 RPC Operation Macro Modes (ROMM)

During the past years of the ROSETTA mission and during the detailed science planning for the comet phase it turned out, that most of the tests and most of the relevant plasma investigations can be performed with a small set of instrument mode combinations.
Therefore, 9 RpcOperationMacroModes (ROMM) were defined in the following way.

RpcOperationMacroMode	ICA	IES	LAP	MAG	MIP
ROMM1	n	n	n	n	n
ROMM2	b	b	b	b	b
ROMM3	b	b	n	n	n
ROMM4	n	n	b	b	b
ROMM5	n	b	b	b	b
ROMM6	b	b	n	b	n
ROMM7	n	b	n	n	n
ROMM8	x	x	x	b	x
ROMM9	n	n	n	b	n

Table 4.3-1: RPC Operation Macro Modes

Here (*n)* means *normal mode*, (*b*) means *burst mode* and (*x*) means don’t *don’t care* (=leave instrument in the current state).

Using these 9 ROMMs, each RPC instrument can be set to the right telemetry mode optimized for the related science objective at the regarded mission phase. Refer to Table 4.3-2 for details.

The ROMMs define only the telemetry modes of each instrument. Therefore, a ROMM is related to the telemetry budget needed at the desired phase. This provides an optimal means for budget planning. Besides this, an instrument can have different submodes under the given telemetry mode, which define specific intrument settings but do not change the overal TM needed.
The different submodes – if existent – are not listed here but can be found in the related specific instrument user manuals, as the submode definitons are of internal interest only.

The ROMMs will act as default modes. This means that there is a standard sequence associated with each ROMM which sets the instrument (all parameters of each instrument) in a state which is perfect for the related science objective. Thus even if there is no further action available (PI on holiday,….) the instrument will work in a proper way.

Measurement Objective	Science Objective	ICA	IES	LAP	MAG	MIP	RpcOperation MacroMode
BowShock Dynamics	SO 03	b	b	b	b	b	**ROMM2**
BowShock Monitoring	SO 03	n	n	n	n	n	**ROMM1**
ComaCompositionDetermination	SO 23	b	b	n	n	n	**ROMM3**
ComaDevelopment	SO 09	n	b	n	n	n	**ROMM7**
CometarySurvey	SO 20	n	n	n	n	n	**ROMM1**
DiamagneticCavityInvestigation	SO 04	n	b	b	b	b	**ROMM5**
DustPlasmaInteractionStudy	SO 21	n	b	b	b	b	**ROMM5**
FarApproachPhasePickupIons	SO 01	n	n	n	n	n	**ROMM1**
InsituPlasmaSurfaceInteraction	SO 02	b	b	b	b	b	**ROMM2**
InternalRPCCrossCalibration	SO 16	b	b	b	b	b	**ROMM2**
IonTailDevelopmentAndEvolution	SO 07	n	n	n	n	n	**ROMM1**
IonopauseNightSideStructure	SO 04	n	n	b	b	b	**ROMM4**
IonopauseStability	SO 04	n	n	b	b	b	**ROMM4**
LateralIonopauseStructureProbing	SO 04	n	b	b	b	b	**ROMM5**
MagneticFieldDraping	SO 07	n	n	n	n	n	**ROMM1**
MagneticFieldDrapingDuringInactivePhase	SO 08	n	n	n	b	n	**ROMM9**
NegativeIonPickUpDetection	SO 14	b	b	n	n	n	**ROMM3**
NonGyrotropicDistribution	SO 15	b	b	n	n	n	**ROMM3**
NucleusActiveRegionsMapping	SO 09	b	b	b	b	b	**ROMM2**
PickUpofCOIons	SO 07	b	b	n	b	n	**ROMM6**
PickupIonInvestigation	SO 12	b	b	n	b	n	**ROMM6**
PileUpBoundary	SO 13	n	n	n	n	n	**ROMM1**
ROSINARPCCrossCalibration	SO 17	b	b	b	b	b	**ROMM2**
RPCROMAPCalibrationPhaseA	SO 18	x	x	x	b	x	**ROMM8**
RPCROMAPCalibrationPhaseB	SO 18	x	x	x	b	x	**ROMM8**
RPCROMAPCalibrationPhaseC	SO 18	x	x	x	b	x	**ROMM8**
RPCROMAPCalibrationPhaseD	SO 18	x	x	x	b	x	**ROMM8**
RPCROMAPCalibrationPhaseE	SO 18	x	x	x	b	x	**ROMM8**
RadialIonopauseStructureProbing	SO 04	n	n	b	b	b	**ROMM4**
StriationStructureByOpticalImaging	SO 19	n	n	n	n	n	**ROMM1**
UpstreamWavesInvestigation	SO 11	n	n	n	n	n	**ROMM1**
WakeDevelopment	SO 22	n	n	n	n	n	**ROMM1**

Table 4.3-2: Macro Modes used for different Science Objectives in the Comet Phase

5 Operational Procedures

5.1 Ground Test Sequences / SVT

5.1.1 RPC

5.1.1.1 UFT

The procedure is defined RD-GEN-2**.**

5.1.1.2 IST

The procedure is defined in RD-GEN-1**.**

5.1.1.3 SVT

For the procedure definitions refer to the following documents:

RD-GEN-11, System Validation Test Plan
RD-RPC-1, RPC Operations Planning Document
RD-RPC-6, SVT Test Script

5.1.2 Experiments

The detailed individual procedures are defined in the documents

RO-RPC-TS-6006 **SVT Test Script**
RO-ESC-PL-5000 Flight Operations Plan

5.1.2.1 PIU

For further information refer to RD-PIU-2.

5.1.2.2 IES

For further information refer to RD-IES-4.

5.1.2.3 ICA

For further information refer to RD-ICA-1.

5.1.2.4 LAP

For further information refer to RD-LAP-2.

5.1.2.5 MIP

The ground test sequences are described in RD-MIP-4.
For further information refer to RD-MIP-1.

5.1.2.6 MAG

There is the same procedure for the Bench Test, the UFT, and the IST:

- For the functional test in the RPC integrated configuration it must be assured that the Mumetal can is installed properly on the boom according to installation procedure (see MAG ADP).
- Check that MAG EGSE (notebook) is connected via network to the IC-London RPC-EGSE.
- Power MAG on.
- Wait for 3 minutes and check MAG sensors to be in range (all 6 components). If out of range tune sensor position/orientation, respectively move the Mumetal can slightly in boom axis direction until all sensor components are in range.
- Check housekeeping channels versus nominal values including sensor temperatures.
- Run test about 5 minutes and control sensor reading stability.
  (Due to the LAB environment this stability will be in the order of several 10 nT per second or minute with excursions to several 100 nT, if H/W is moved close to the S/C.) Easiest control is to take the first science data packets as reference and compare al following data with these packets. There is no fixed value that can be given and no known stability of the magnetic field in the LAB; the Mumetal can just reduces ambient field by a factor of 5 – 10 and the technical noise in the LAB.
- The HK parameters have to be checked against the values listed in Table 2.1-1 in document RD-MAG-23.

The detailed procedures are defined by the PIU-IC team; for further information refer to RD-MAG-4.

5.2 Command Sequences

5.2.1 Summary of all RPC Command Sequences

A summary of all RPC Command Sequences can be found in RD-RPC-7.
The actual commanding Sequences can be found on the RPC WIKI located at

http://rpc.sp.ph.ic.ac.uk/wiki/bin/view/Commanding/WebHome

5.2.2 OBCPs

For information about the OBCPs refer to

- Section 2.3.3.3 (List of OBCPs)
- RD-GEN-5Section
- Section 3.2.4

5.2.3 FCPs

Latest FCP Definitions documents are

RPC: RD-RPC-7
PIU: RD-PIU-3
IES: RD-IES-2
ICA: RD-ICA-3
LAP: RD-LAP-1
MIP: RD-MIP-2
MAG: RD-MAG-6

These documents are RPC internal documents and they are maintained by IC.

The FCP's currently used can be found in the latest FOP, RD-GEN-9.

5.2.4 Contingency Recovery Procedures

We have a few sequences in place which deals with powering instruments and RPC (i.e. PIU) off but none of them might be suitable for a real emergency power off, as all the procedures state preconditions. For details refer to Table 3.4-7.

The listed procedures are part of the complete RPC FCP list and are no additional ones.

RPC vital parameters such as voltages and temperatures are monitored by PIU (and DMS) and actions are taken autonomously on board in case of an out-of-limit parameter.

The emergency procedures we are dealing with at this stage are procedures which are meant for handling contingencies from ground, should there be the necessity.

5.3 Usage of the EQM

PIU:

All the command RPC command sequences used for the EQM will be coordinated by the RPC TM. EQM usage is planned only for testing new command sequences before running them on ROSETTA. The time and personnel budget for this can hardly be assessed. However, the only task for the ESOC operators, will be the uploading of the desired commands to the EQM which will not consume much time.

IES:

From the IES point-of-view, we have a digital simulator (no high-voltage power supply or optics) at SwRI for testing initial scripts. If there are issues that require PIU interaction, an IES simulator at Imperial College can be used for RPC-level testing. This simulator has the same configuration as the one at SwRI.

The IES team also has an EM unit at ESOC onboard the EM S/C at ESOC. Functionally, this unit is the same as the simulators at SwRI and IC; however, it is part of a testbed that can be used with real S/C scripts and is valuable from that standpoint. The EM S/C is required whenever new IES scripts are developed, especially to uncover S/C commanding, scripting and timing issues.

Typically, because the scripts would have been run beforehand (albeit “by hand” rather then with real S/C commanding or scripting), testing of IES-specific issues by ESA personnel should be minimal.

When the scripts have been translated by S/C personnel, the IES team should have reviewed it prior to it running on the EM S/C. The overall flow is viewed to be:

- A new IES activity is required, so the requirements for it must be expressed. In particular, what output is expected, volume of output and amount of on-time.
- IES team contacts Imperial College and ESA regarding intent for planning purposes.
- The series of commands and the timing required to accomplish the requirements are written to a test plan, typically into an Excel spreadsheet.
- The Excel spreadsheet is run “by-hand” on the IES simulator at SwRI, and if RPC interaction is needed, the test should be run at IC.
- The Excel spreadsheet is passed onto ESA for translation into a S/C script.
- The generated S/C script is reviewed by SwRI and IC and updated if necessary.
- The S/C script is run on the EM S/C.
- ESA, SwRI and IC review the results.
- The S/C script is then ready for actual use on the Rosetta S/C.

Given the above series of steps, the need for ESA personnel on the EM S/C itself (aside from the script generation) does not appear to be very great.

ICA:

ICA may have use of EQM to try out some new command combinations and try patches before applying them to the spacecraft. Expected to be rather infrequent.

LAP:

The EQM might be used to test new commands and patches before the uplink to the spacecraft. Expected to be used seldom.

MIP:

The EQM is electrically conform with the FM. The EQM might be used to test some new commands and to try patches before applying them to the spacecraft. Expected to be rather infrequent.

MAG:

Tests on the MAG experiment apart from the s/c can be done on two instruments:
The EQM electronics connected to the FS sensors.
This instrument is located at Imperial College.
The FM = PFM connected to EM sensors.
This instrument has been installed on the EM S/C at ESOC.

Both instruments are completely compatible (electrically, software) to the flying unit onboard ROSETTA.

It is not planned to change the any MAG commands. So there is in principle no need to run any MAG related sequence on the EQM. Nevertheless MAG will be switched on in case that PIU is operating, as MAG provides PIU HK data. However, this will not cause any more workload to the ESOC operators.

6 Data Operations Handbook

All the RSDB TC/TM tables which have been listed here in earlier versions of the User Manual have been cancelled at this place.
For a detailed reference to all commands, parameters and descriptions refer to the RPC DSDB RD-GEN-27 and RD-RPC-10 available as MS-Access database on the IC-server .