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IGEP
TU Braunschweig

*Institut für
Geophysik und
extraterrestrische
Physik*

**ROSETTA PLASMA CONSORTIUM
USERS' MANUAL**

RO-RPC-UM

Issue 2.08

10 April2006

Prepared by: Ingo Richter (MAG-TM), Emanuele Cupido-(RPC-TM)

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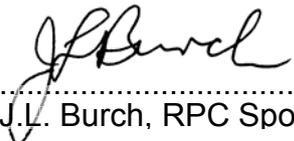
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J.L. Burch, RPC Spokesman

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Useful documents

Title	Number	Version	Date	Author
General				
RPC IST Procedure	RO-ALS-PR- 4037	1	25.01.01	Claudio Prato
RPC I&T - UFT Procedure for EM/EQM	RO-ALS-PR- 4051	2	07.08.00	Claudio Prato
RSDB Naming Convention	RO-ALS-TN-4002	4	25.07.00	M.C. Ostorero
RSDB TM / TC DATA	RO-DSS-LI-1018	1.3	09.05.00	R.Eilenberger
RPC Experiment OBCPs URD	RO-DSS-RS-1032	2B	12.12.02	Stephane Osipenco
ROSETTA Service 19 "Information Distribution Service"	RO-DSS-TN-1138			
Data Delivery Interface Document	RO-ESC-IF-5003	B5	27.03.03	Rosetta GST
RMCS CRID	RO-ESC-IF-5004	A6	10.03.00	Rosetta GST
FOP	RO-ESC-PL-5000	5.1	26.07.05	ROS-FCT
Rosetta DDS Test Plan	RO-ESC-PL-5305	1	27.03.02	Fabienne Delhaise
System Validation Test Plan	RO-ESC-PR-5130			
Asteroid Flyby Ops	RO-ESC-TN-5017	1	01.12.00	Elsa Montagnon
Planet Flyby Ops	RO-ESC-TN-5018	1	01.12.00	Elsa Montagnon
Near Sun Cruise Ops	RO-ESC-TN-5019	1	15.12.00	Elsa Montagnon
Commissioning Operations	RO-ESC-TN-5022	1	15.03.01	Mark Sweeney
Mission Calendar	RO-ESC-TN-5026	1.0	24.05.05	Elsa Monttagnon
The Near Comet Drift Phase: A Strategy For Possible Early Comet Detection And Arrival	RO-ESC-TN-5506	1	30.11.99	Ruaraidh Mackenzie
EIDA	RO-EST-RS-3001/EID A	2.2	01.10.03	
EIDC	RO-EST-RS-3001/EID C	1.4	15.12.00	
EIDB	RO-EST-RS-3012/EID B	2	15.05.01	
Mission scenarios - Close encounter	RO-EST-TN-3027	0.7	20.03.00	Detlef Koschny
PI to RSOC I/F Test	RO-EST-TP-3051	1	23.05.02	A. Hulsbosch
Experiment_UM_Iss1_Planning		1	01.04.01	Mark Sweeney
Consolidated Report on Mission Analysis Churyumov-Gerasimenko 2004	RO-ESC-RP-5500	5.0	1.8.03	Canabal/Perez/Otero
Rosetta Mission Calendar	RO-ESC-PL-5026	1	01.05.05	
Rosetta Far Thermal Analysis Report	RO-MMB-TN-3134	9.1	12.11.02	S.Tuttle

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RPC TM/TC PACKET Definition & DSDB		http://www.rssd.esa.int/llink/livelink?func=ll&objId=17079&objAction=browse&sort=name			
Archiving					
Planetary Science Archive PVV User Manual		SOP-RSSD-UM-004	3.1	12.05.05	D.Heather
Planetary Data System Standards Reference		JPL D-7669, part 2	3.6	01.08.03	JPL
Planetary Data System Data Preparation Workbook		JPL D-7669, part 1	3.1	17.02.95	JPL
Planetary Science Data Dictionary Document		JPL D-7116	Rev. E	28.08.02	JPL
Rosetta Archive Generation, Validation and Transfer Plan		RO-EST-PL-5011	2.2	01.09.05	K.Wirth
Planetary Science Archive Experiment Data Release Concept		SOP-RSSD-TN-15	1.16	12.05.05	J.Zender
RPC					
RPC Operations Planning Document		RO-RPC-MA-6002	0.3	16.02.04	Chris Lee
RPC Commissioning Plan		RO-RPC-MA-6004	1.4	31.01.03	Chris Lee
RPC Cruise Phase Plan		RO-RPC-MA-6005	0.1	29.10.02	Chris Lee
RPC Operational Concept Note: incorporated into RPC-UM		RO-RPC-MA-6006	2.0	07.12.05	Emanuele Cupido
PIU Magnetometer Processing Software Overview		RO-RPC-MA-6007	1.0	07.05.02	Chris Lee
RPC System Validation Test (SVT)		RO-RPC-TS-6006	0.3	29.11.01	Chris Lee
RPC_FCP_Definitions			1.4	16.08.04	Chris Lee
RPC Bench Test and SFT			1.1	22.05.00	Michael Ludlam
RPC Guide to filling in the RSDB			1	07.02.00	Paul Howarth
RPC DSDB //pegasus.sp.ph.ic.ac.uk/RpcOpsXfer.php		Current_RSDB_26_07_2002.xls		26.07.02	Chris Lee
ROSETTA RPC dds2rpc User and Reference Manual			1.3	09.05.04	Lybekk, Lee
ROSETTA RPC rpsServer User and Reference Manual			0.7	09.05.04	Lybekk, Lee
ICA					
ICA SVT Procedure Definition			0.1	23.11.01	Hans Borg
ICA-TmTc Data Formats and related s/w aspects			0	07.04.02	Hans Borg
ICA_FCP_Definitions_1_4			1.4	09.12.04	Emanuele Cupido

ICA_SVT_0_1		0.1	23.11.01	Chris Lee
ICA Command Description		1.4	07.04.02	Hans Borg
ICA – RPC : The Ion Composition Analyser in the RPC				Ole Norberg
IES				
IES Commands			07.02.02	Charles Zinsmeyer
IES FCP Definitions		1.8	14.12.04	Emanuele Cupido
IES Interface Document	8182-SID-01	0	01.11.01	John Hanley
IES SVT Procedure Definition		0	29.11.01	Chris Lee
LAP				
LAP_FCP_Definitions.doc		2.0	16.08.04	Emanuel.e Cupido
LAP_SVT_Procedure_Definition		0.6	19.02.02	Chris Lee
RPC LAP Intrument UM	IRFU-RPC-LAPUM	0	08.11.00	Reine Gill
LAP Command & Telemetry Description	RO-IRFU-LAPCTM	1.5	06.06.02	Reine Gill
LAP Macros in PROM & Flash Flight Software Version 11.0	IRFU-ROS-LAPMPF		07.04.03	Reine Gill
MAG				
Protocol and Analysis of Magnetic Measurements during Strayfield & CS Test	RO-IGM-TR-0001	1.1	23.05.01	Ingo Richter
Fluxgate Magnetometer Calibration for ROSETTA: Report on the Flight Unit and Flight Spare Unit Calibration	RO-IGM-TR-0002	2.2	10.10.01	Ingo Richter
Fluxgate Magnetometer Calibration for ROSETTA: Analysis of the FGM Calibration	RO-IGM-TR-0003	1.1	12.10.01	Ingo Richter
Sample Rate and Frequency Response Analysis of Rosetta RPC-MAG	RO-IWF-TR0001	1.1	23.01.02	Hans Eichelberger
MAG SVT Procedure Definition.doc		0	26.11.01	Chris Lee
The Building and Operation of the MAG_FPGA in the Fluxgate Magnetometer Electronics		1.1	11.04.02	Janos Sulivan
MAG_FCP_Definitions		1.2	06.11.02	Chris Lee
MAG_Packet_definition_last		1	11.04.02	Özer Aidogar
RPC MAG GSE UM		1.3	20.02.02	Özer Aidogar
RPC-MAG Knowledge Management			1.08.03	Richter, Diedrich,Glaßmeier
Flight Reports of RPC_MAG Report of the COMMISIONING PART 1	RO-IGEP-TP0006	5.1	08.04.05	Richter, Diedrich,Glaßmeier
RPC-MAG Software: DDS2PDS User Manual	RO-IGEP-TR0007	1.8	21.09.05	Ingo Richter

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Flight Reports of RPC_MAG Report of the COMMISIONING PART 2	RO-IGEP-TR0008	4.1		08.04.05	Richter, Diedrich,Glaßmeier
ROSETTA-RPC-MAG to planetary Science Archive Interface Control Document EAICD	RO-IGEP-TR0009	1.7		26.09.05	Ingo Richter
Flight Reports of RPC_MAG Report of the COMMISIONING PART 3	RO-IGEP-TR0010	3.1		08.04.05	Richter, Diedrich,Glaßmeier
Flight Reports of RPC_MAG Report of the INTERFERENCE CAMPAIGN	RO-IGEP-TR0011	3.0		08.04.05	Richter, Diedrich,Glaßmeier
Flight Reports of RPC_MAG MCCR , Mission Commissioning Results Review	RO-IGEP-TR0013	1.0		10.11.04	Ingo Richter
Flight Reports of RPC_MAG Report of the Earth Flyby (EAR1)	RO-IGEP-TR0014	2.0		03.08.05	Richter, Diedrich,Glaßmeier
Flight Reports of RPC_MAG Anomaly Report & Analysis of the MAG-OB failure in June 2005	RO-IGEP-TR0015	1.2		03.08.05	Richter, Diedrich,Glaßmeier
ROSETTA RPC-Magnetometerexperiment FK:50QP9702/5, Abschlußbericht				01.03.05	Richter, Diedrich,Glaßmeier
RPCMAG Internal Packet Definitions	RO-IGEP-TN0001	1.0		15.12.05	Richter, Diedrich,Glaßmeier
MIP					
MIP SVT Procedure Definition		0		26.11.01	Chris Lee
MIP_FCP_Definitions		1.9		06.09.05	Emanuele Cupido
Manuel d'Utilisation du F.S.	RPC-MIP-OP-1-020125-LPCE	1.0		15.03.02	Jean-Louis Michau
MIP/PIU Data Handling Interface	RPC-MIP-RP-126-990253-LPCE	3.3		23.05.01	D.Lagoutte
MIP Onboard Data Handling	RPC-MIP-RP-13-980317-LPCE	3.4		20.09.00	D.Lagoutte
PIU					
PIU RPC ICD		2.2		06.10.00	
PIU SVT Procedure Definition		1.5		15.02.02	Chris Lee
PIU_FCP_Definitions		1.4		18.08.04	Emanuele Cupido

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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
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

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BDU	Batery 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

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CMO	Configuration Management Officer	
CMP	Configuration Management Plan	
CNES	Centre Nationale d'Etude Spatiale	
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 Suszeptibility	
CSG	Centre Spatiale Guyanaise	
CSM	Communication Switching Matrix	
CSME	Communication Switching Matrix Element	
CSP	Carge Senisitive Preamplifier	
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 Cocine Transform	
D&D	Design and Development	
DDD	Detailed Design Document	
DDID	Data Delivery Interface Document	
DDS	Data Distribution System	
DDV	Design Development and Verification	
DFMS	Double Focusing Mass Spectrometer	
DIB	DPU Interface Board	
DISR	Descent Imager/Spectral Radiometer	
D/L	Down Link	

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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	Datra 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
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 Subsyste
EQM	Electrical Qualification Model
ERF	Event Reporting Function
ESA	European Space Agency
ESA	Electrostatic Analyzer
ESANET	European Space Agency's communications Network

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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
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

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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)
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
GSIR	Ground Segment Implementation Review
GSIS	Ground Station Interface Specification
GSM	Ground Segment Manager
GSMP	Ground Segment Management Plan
GSOC	German Space Operations Centre
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	Hight Power Command
HPCM	HPC Module
HPD	High Performance Demodulator
HRM	Holddown & Release Mechnism
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'Astrophysipue Spatiale
IAS-CNR	Istituto di Astrofisica Spaziale/Consiglio Nazionale delle Richerche
IB	Inboard
I-BOB	Intelligent Break Out Box
ICA	Ion Composition Analyser (RPC)

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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

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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
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

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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

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OBEM	On-Board Event Monitoring
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, integer packets only, LAP)
PAIP	Product Assurance Implementation Plan
PALASIM	Parallel Access Large Silicon Memory
PC	Project Control
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

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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

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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
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

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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 Latchup
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	Scaleable 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

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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

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TLC	Telcommand
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	Verical 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

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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	

Table 1.0-2: Acronym List

Documentation Change Record

Issue	Rev.	Sect.	Date	Changes	ECR No.
Draft	0.93	All	16.11.00	First draft issue	N/A
Draft	0.94	All	28.11.00	LAPUM implemented; EIDB update implemented	N/A
Draft	0.95	All	20.12.00	UM Meeting partially added & changed	N/A
Draft	0.96	All	15.03.01	EIDB Changes partially implemented	N/A
Draft	0.97	All	06.07.01		N/A
Draft	0.987	All	20.02.02	SOWG comments added, etc..	N/A
Draft	0.99	All	30.05.02	EFOR comments implemented	N/A
Draft	0.992	All	21.06.02	Flyby Scenarios added	N/A
Draft	0.994	All	28.10.02	Minor Improvements	N/A
Draft	0.995	All	21.11.02	RSDB reference, minor improvements	N/A
1	0	All	01.12.03	Minor changes	N/A
2	07	All	22.12.05	Various changes	N/A

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2   08   10.04.06   Action on dEFOR Comments   N/A

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1.0 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 Probe (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 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

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investigate this interaction. Furthermore, the planned observations will allow us to study the magnetic and electric conductivity properties of the asteroid.

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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
Figure 1.2-3

The accommodation of the sensors and interfaces are indicated in Figure 1.2-1 and Figure 1.2-2.

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LAP	two sensors, each mounted at the tip of an about 1.5m boom, 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 x-boom, i.e. the boom 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
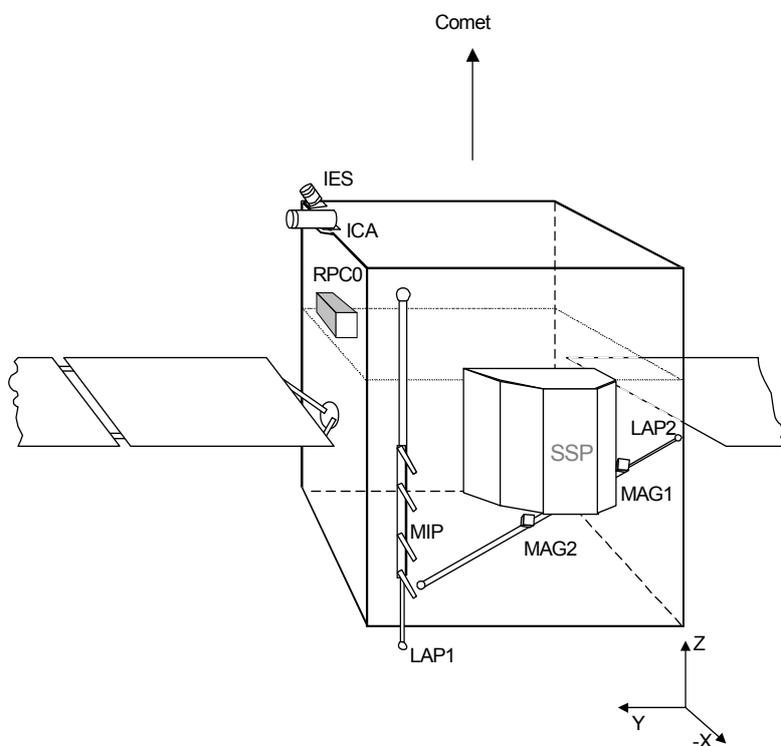
Figure 1.2-1: RPC Sensors Layout (stowed)

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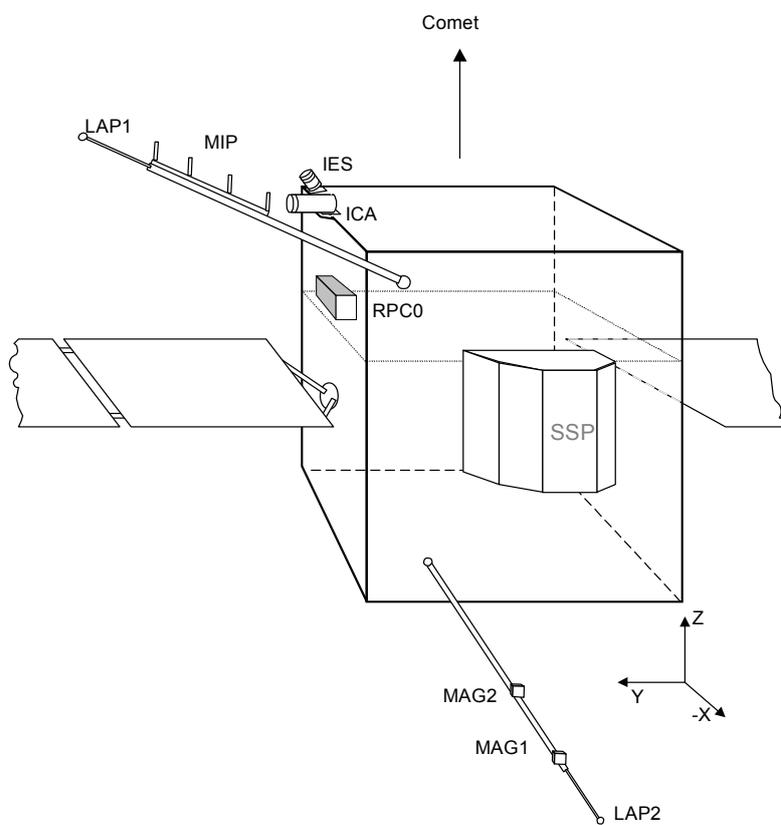
Figure 1.2-2: RPC Sensors Layout (deployed)

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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

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.

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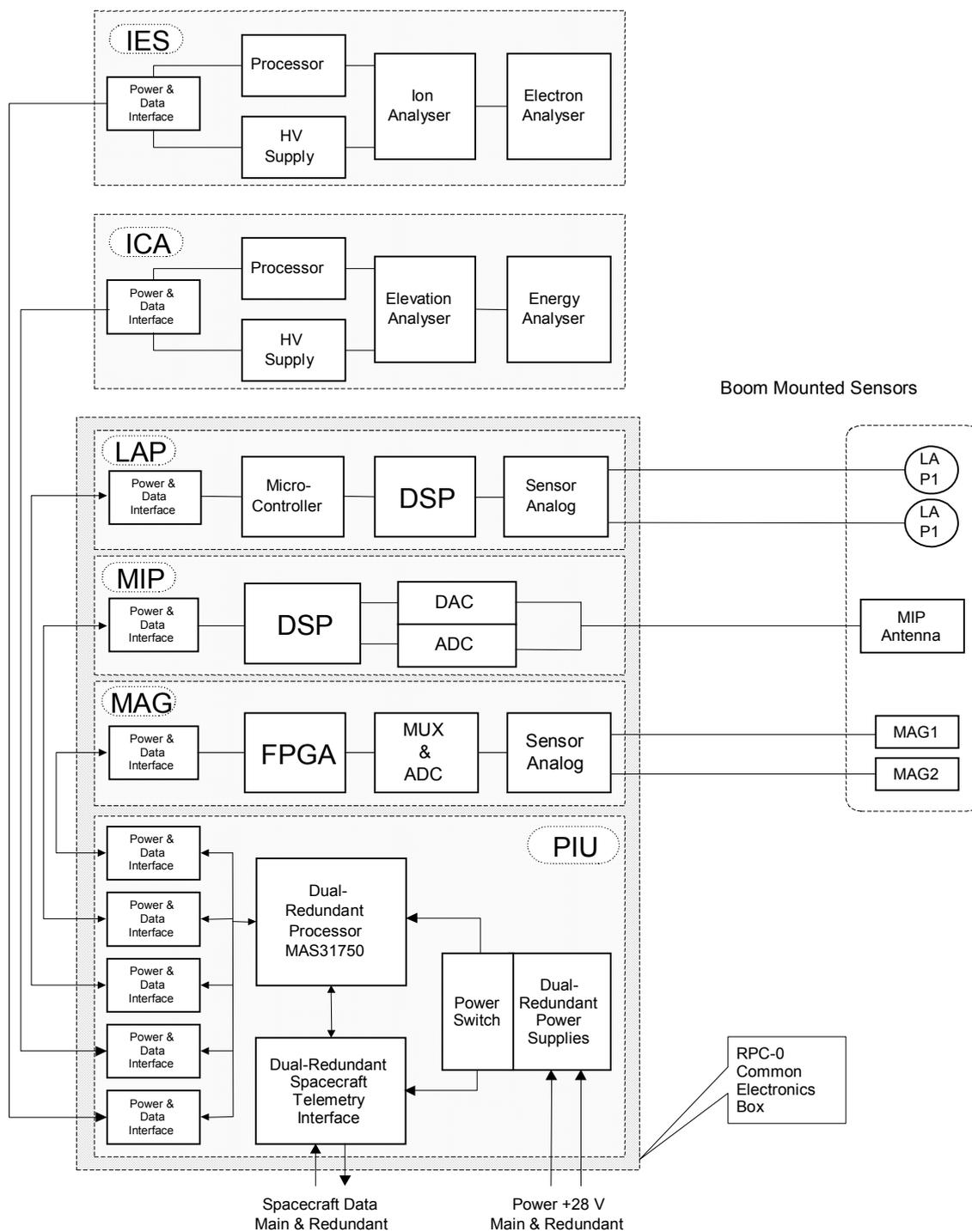
Figure 1.2-3: RPC Overall Block Diagram

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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:

1. 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.
2. 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.

1. 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.
2. 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.
3. 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:

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- 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. With a probe separation of 3 m, this amounts to the possibility to observe time shifts down to 0.3 ms. To do so, a sampling frequency of at least 10 ksamples/s is needed on two probes simultaneously.
- Estimate electric fields and spacecraft potentials as well as plasma density variations. This calls for the possibility to operate the probes in a fixed-bias-current mode as well as in the fixed-bias-voltage mode.
- Observe plasma wave fields up to 8 kHz, necessitating sampling at at least 20 ksamples/s.
- 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 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.
- Study dust by the electrostatic structure of the impacts.

From this list, it is obvious that LAP is characterised by a large number of different operational modes. When comparing the very limited telemetry rates available (nominally 1 bit/s, 5 bit/s or 2200 bit/s) to the data output (20 ksample/s from two probes with 16 bit samples implies 640 kbit/s), it is obvious that another characteristic of LAP is the need for extensive onboard data processing. It is also clear that the data processing needs are very different for different types of measurement. For the probe sweeps, some non-linear parameterisation process is called for. For wave studies Fourier or wavelet transforms may be used to reduce data. For time-of-flight measurements cross-correlation techniques will be useful, and so on. Finally, it is also clear that a data processing technique used for one type of measurement may be completely inapplicable to another type of measurement: taking the Fourier transform of sweep data or fitting a Langmuir sweep expression to pulsed propagation experiment data are two examples of such mismatches between measurement and data processing, each likely to have disastrous results for quality of the data. Therefore, all commanding of LAP has to take this close coupling of measurement and data processing into account.

LAP comprises a pair of classic Langmuir probes with sensors in the form of 5 cm diameter spheres on booms and multiple modes of operation (refer to the block diagram in Figure 1.2-4):

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1. *Electron collection mode.*
2. *Positive ion collection mode.*
3. *Two Langmuir probe mode.*
4. *Density fluctuations measurement.*
5. *Measurements of spacecraft potential with a current biased probe (voltage mode).*
6. *Detection of AC electric fields with one or two LAPs in voltage mode.*
7. *Active propagation experiment.*
8. *Measurements of solar UV integrated ionizing flux.*
9. *Measurements of micrometeoroid and dust impacts.*

One of the LAP sensors can also be used by the MIP instrument for signal transmission (see Sec.1.2.2.5). 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	0.001 – 10 eV
Plasma flow velocity	0 – 10 km/s
Electron/ion number density fluctuations	0.1 - 50 %
Spacecraft potential	±32 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

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Figure 1.2-4: Langmuir Probe (LAP) Block Diagram

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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 1 eV/e up to 30 keV/e, with a basic time resolution of 3 s. The angular resolution for electrons is 5º x 22.5º (9 azimuthal and 16 polar-angle sectors). For ions the angular resolution is 5º x 45º (9 azimuthal and 8 polar-angle sectors) with additional segmentation to 5º x 5º in the 45º polar-angle sector most likely to contain the solar wind (giving a total of 16 polar-angle sectors for ions).

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 azimuthal angle field of view to ±45º. With the typical top hat polar-angle 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 azimuthal 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 polar acceptance angles. The selected energy will correspond to a particular 5º azimuthal entrance angle, depending on the ratio of voltages on the angle deflectors and 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 (RTX20X10) 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.

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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	1 eV to 22 KeV
	Resolution	0.04
	Scan	mode-dependent
Angle:	Range (FOV)	90º x 360º (2.8 π sr)
	Resolution (electrons)	5º x 22.5º (18 azimuthal x 16 polar)
	Resolution (ions)	5º x 45º (5º x 5º for ions in one sector) (18 azimuthal x 16 polar)
Temporal resolution:		
	3D distribution	3 s
	downlink data	300 s
Geometric factor:		
	total (ions)	5×10^{-4} cm^2 sr eV/eV counts/electron
	per 45º sector (ions)	5×10^{-5} cm^2 sr eV/eV counts/electron
	total (electrons)	5×10^{-5} cm^2 sr eV/eV counts/electron
	per sector (electrons)	5×10^{-6} cm^2 sr eV/eV counts/electron

Table 1.2-4: Summary of expected IES performance

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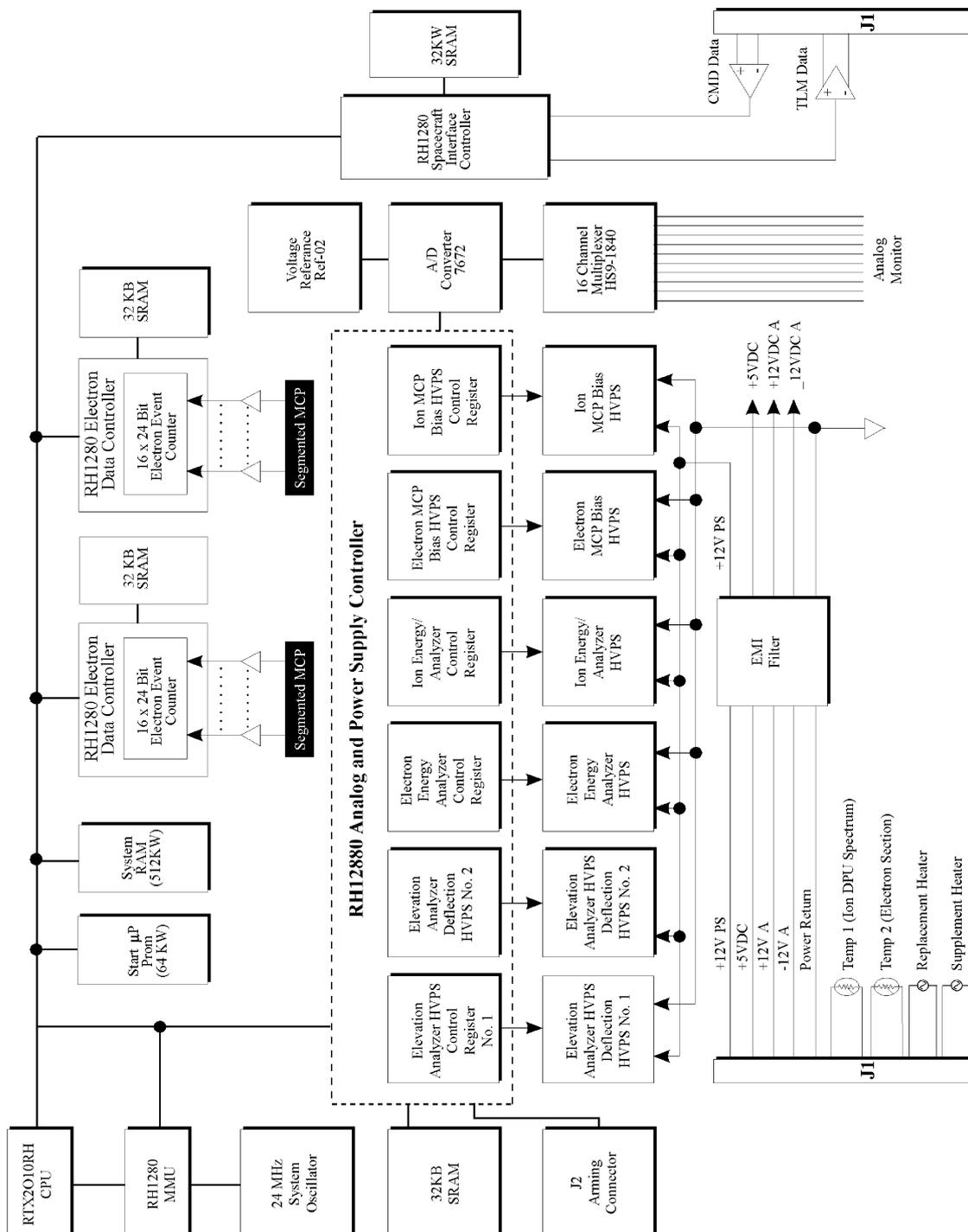
Figure 1.2-5: Ion and Electron Sensor (IES) Block Diagram

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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	1 eV to 40 KeV
	Resolution	$\Delta E/E = 0.07$
	Scan	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	4 s (solar wind mode) 12 s (normal mode)
	3D distribution	64 s (solar wind mode) 192 s (normal mode)
Geometric factor:		
	per 22.5º sector	6×10^{-4} cm^2 sr
	per 360º sector	1×10^{-2} cm^2 sr

Table 1.2-5: Summary of expected ICA performance

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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.

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Figure 1.2-6: Ion Composition Analyser (ICA) Block Diagram

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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 the document
The Building and Operation of the MAG_FPGA in the Fluxgate Magnetometer Electronics.

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PIU - MAG Electronics

Boom mounted
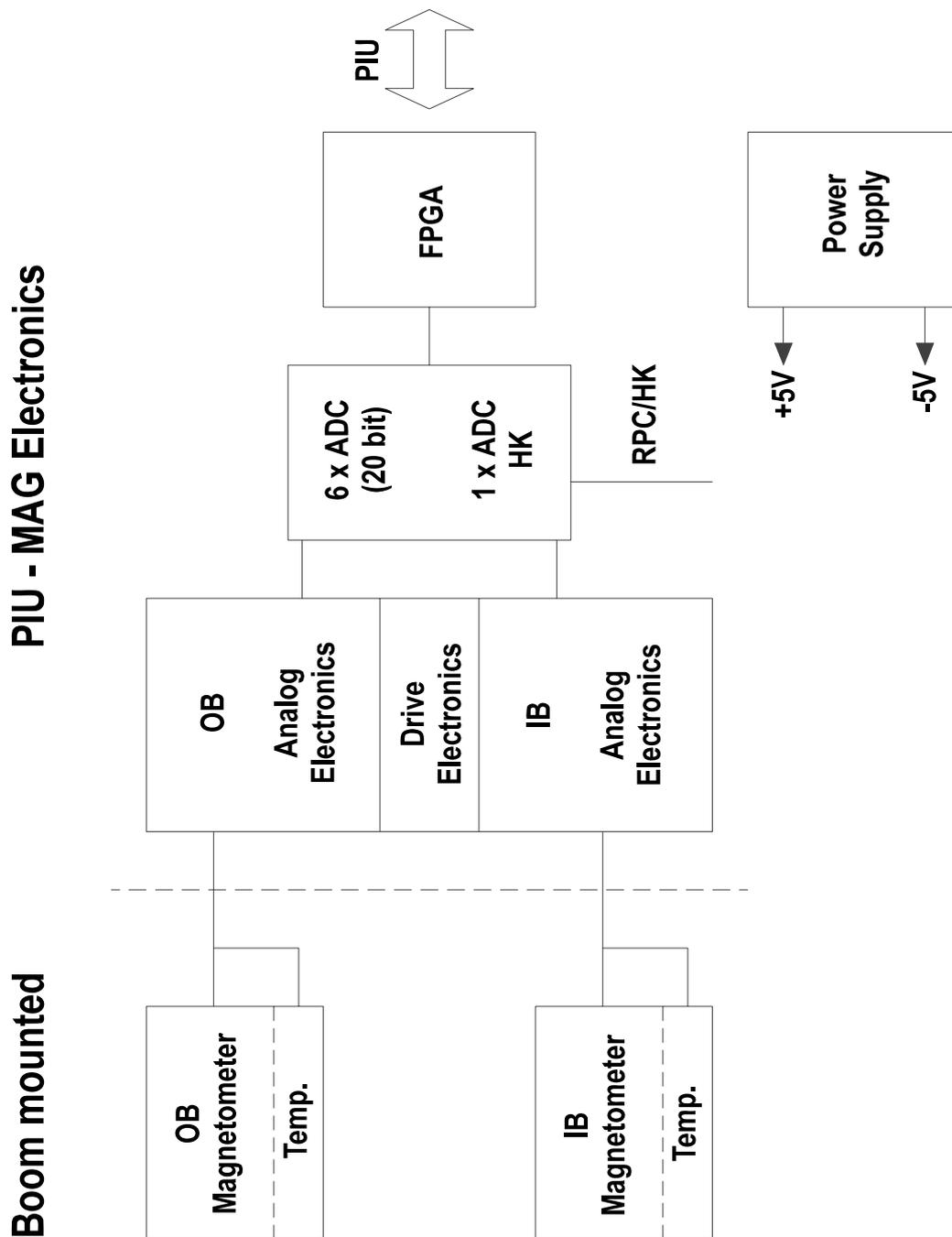
Figure 1.2-7: Fluxgate Magnetometer (MAG) Block Diagram

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1.2.2.5   Mutual Impedance Probe (MIP)

The MIP sensor (ref. Figure 1.2-8) 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

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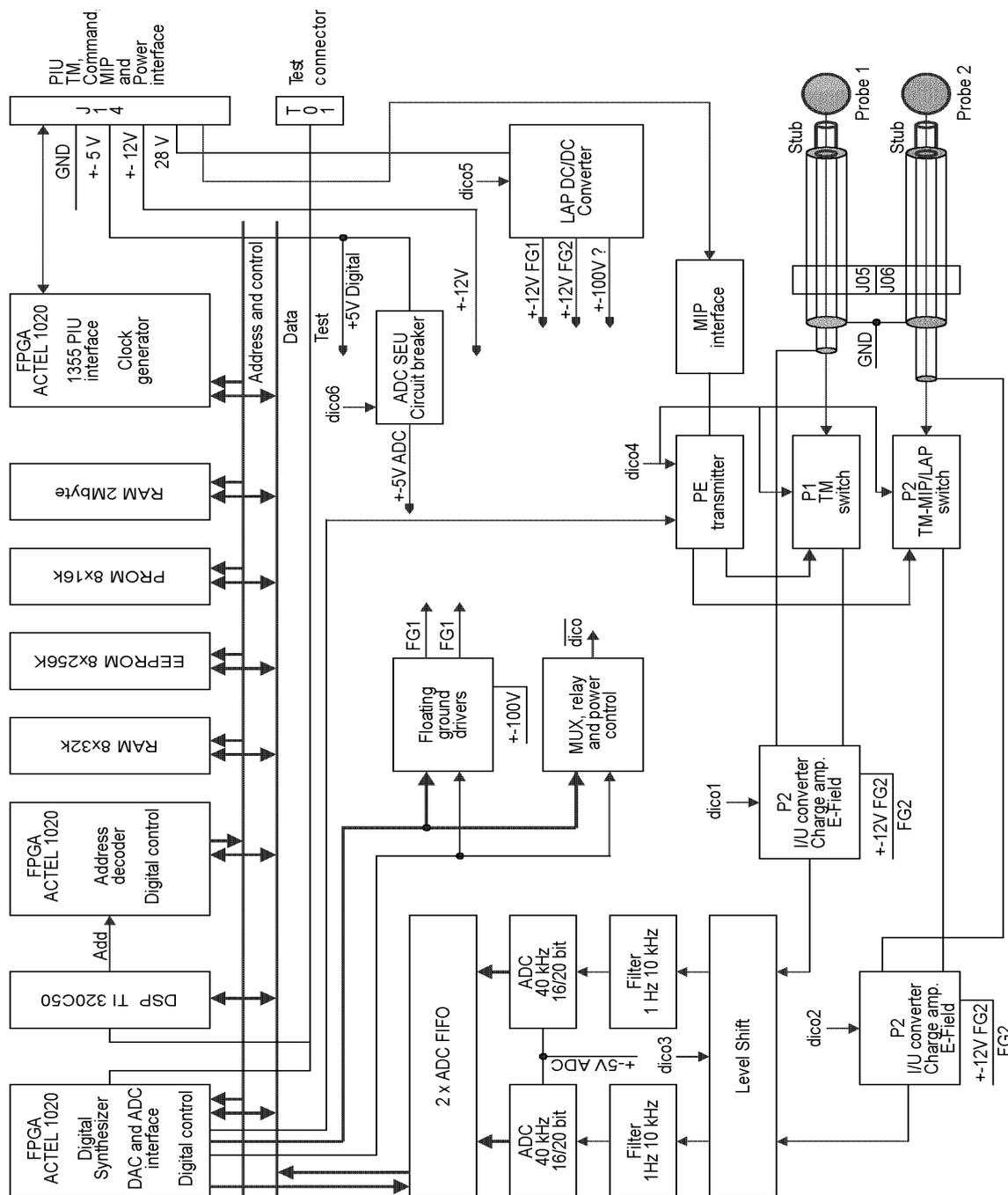Date : **April 10**, **2006**
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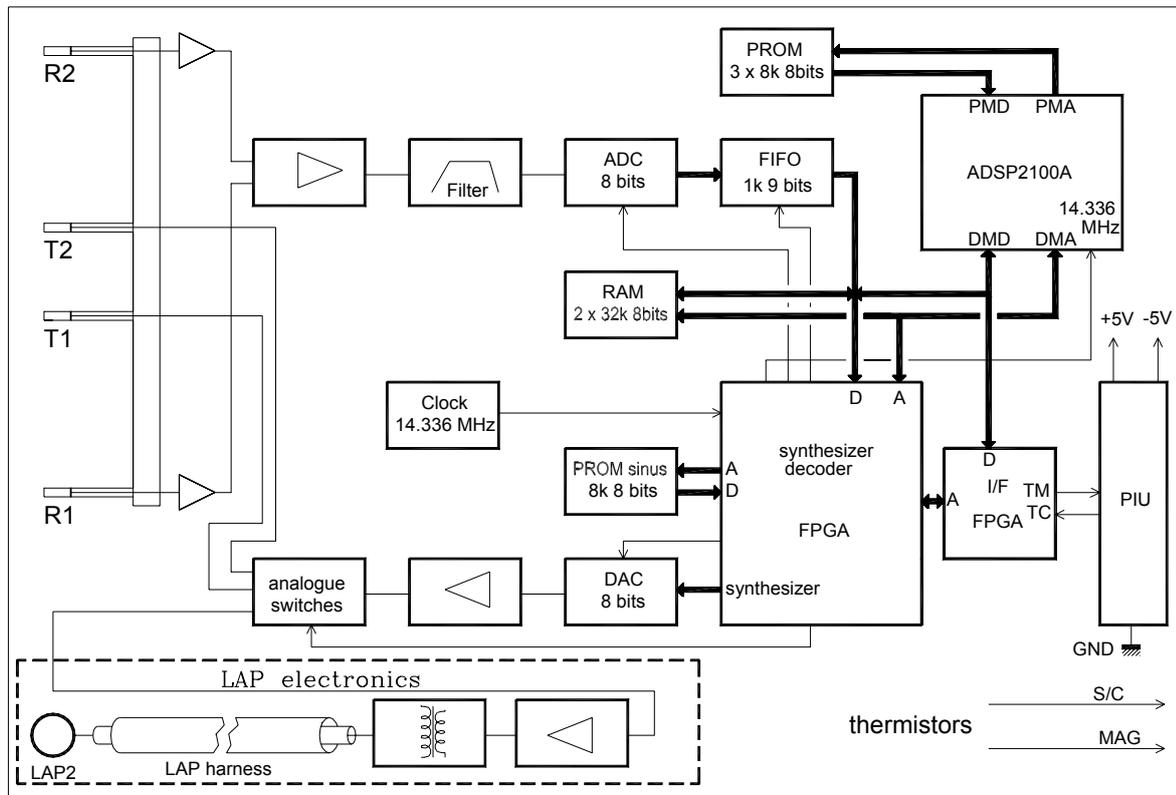
Figure 1.2-8: Mutual Impedance Probe (MIP) Block Diagram

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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 1.2-3) 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 1.2-9) 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.
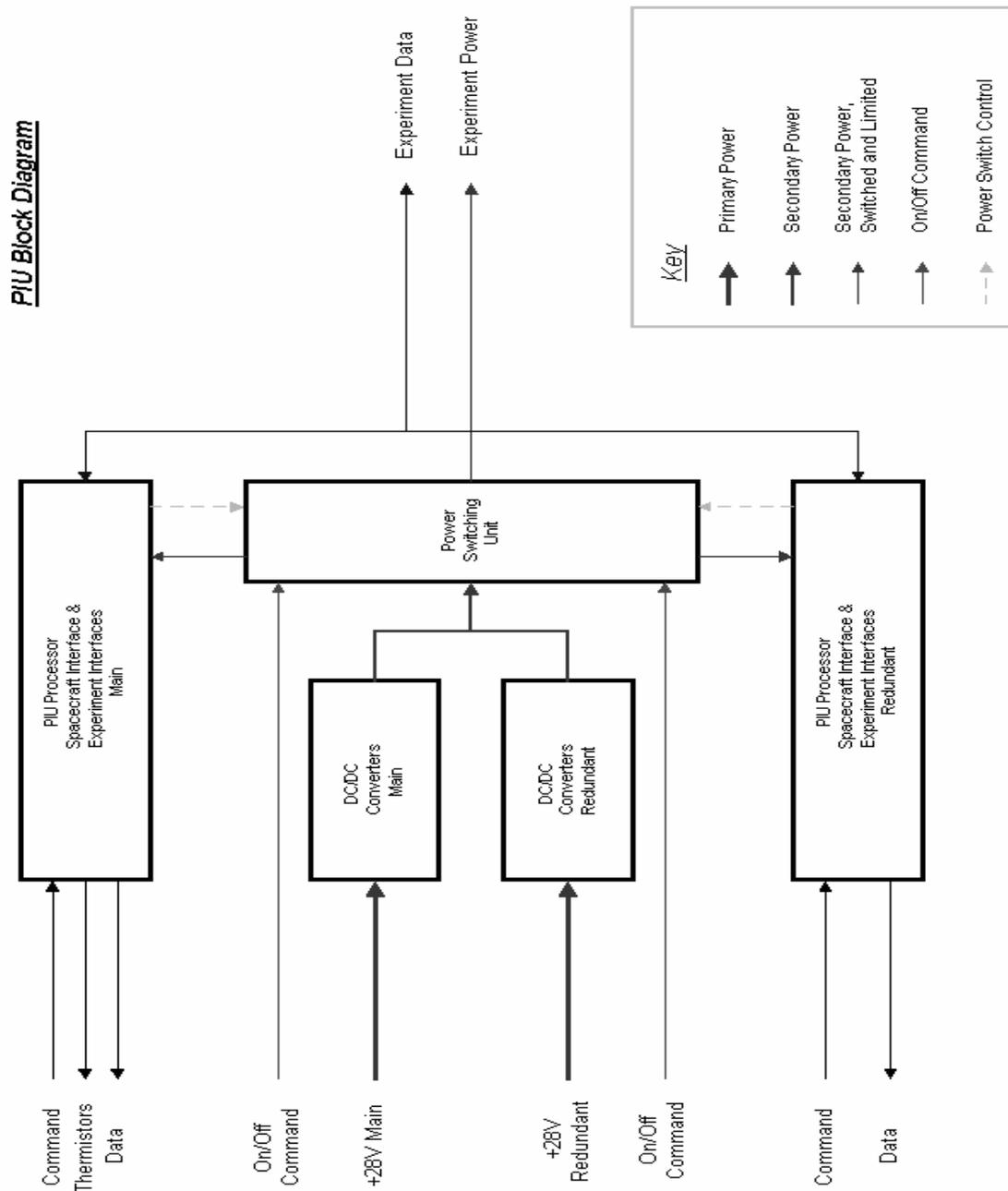
Figure 1.2-9: Plasma Interface Unit (PIU) Block Diagram

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2.0 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.
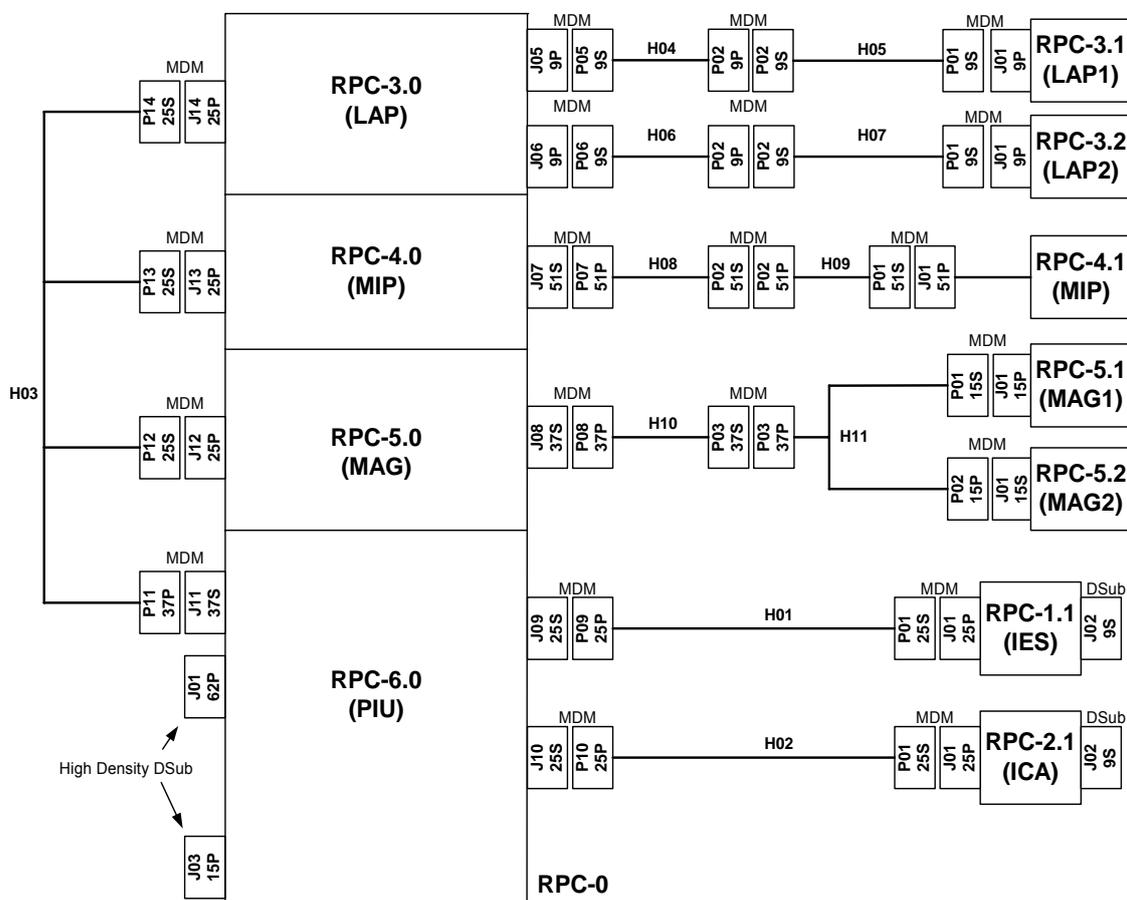
Figure 2.1-1: RPC Experiment Layout and Harness Diagram

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2.1.1   RPC-0

Figure 2.1-2: RPC-0 Mechanical Interface Drawing

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2.1.2 IES
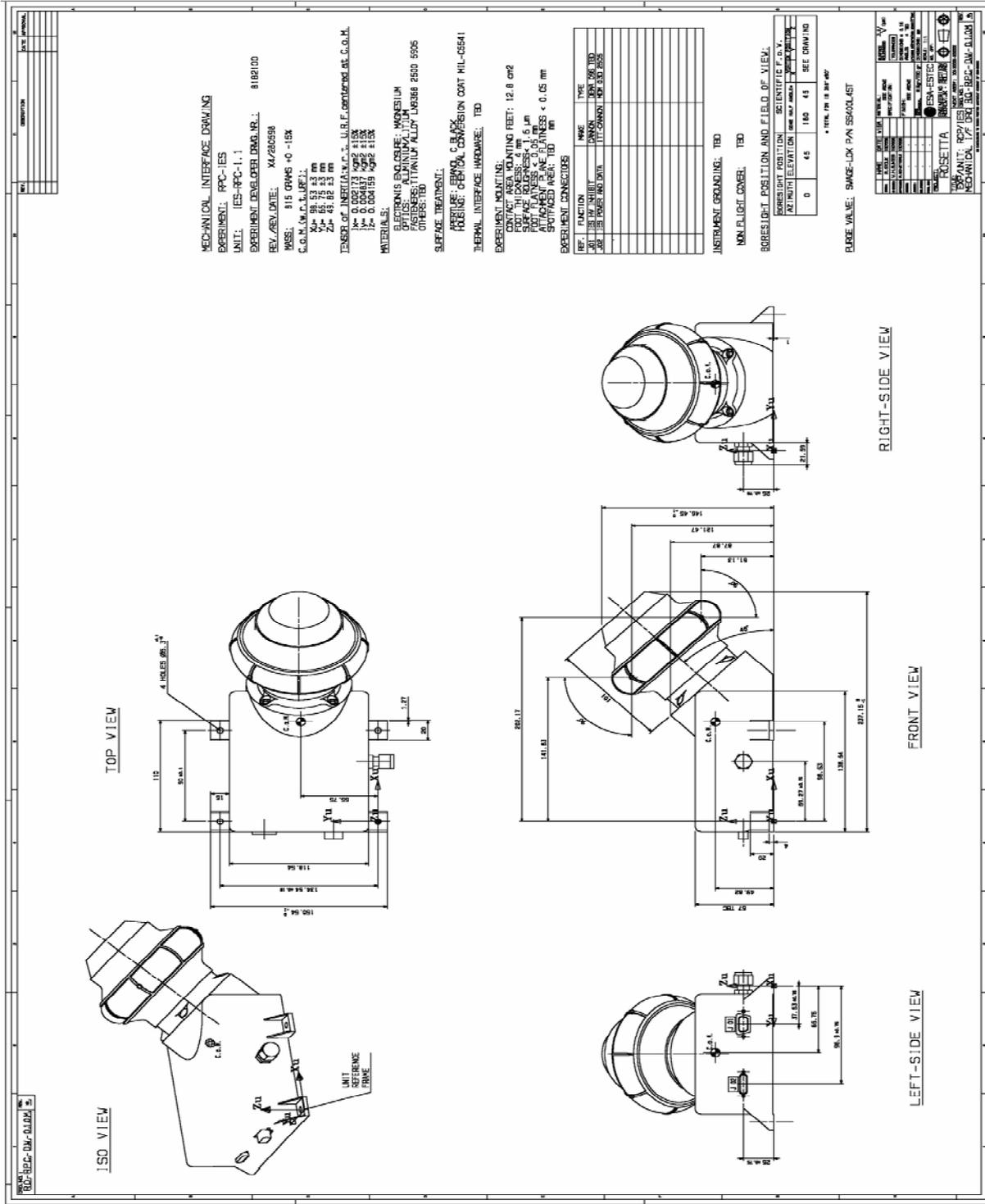
Figure 2.1-3: IES Mechanical Interface Drawing

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2.1.3   ICA

Figure 2.1-4: ICA Mechanical Drawing

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2.1.4   LAP
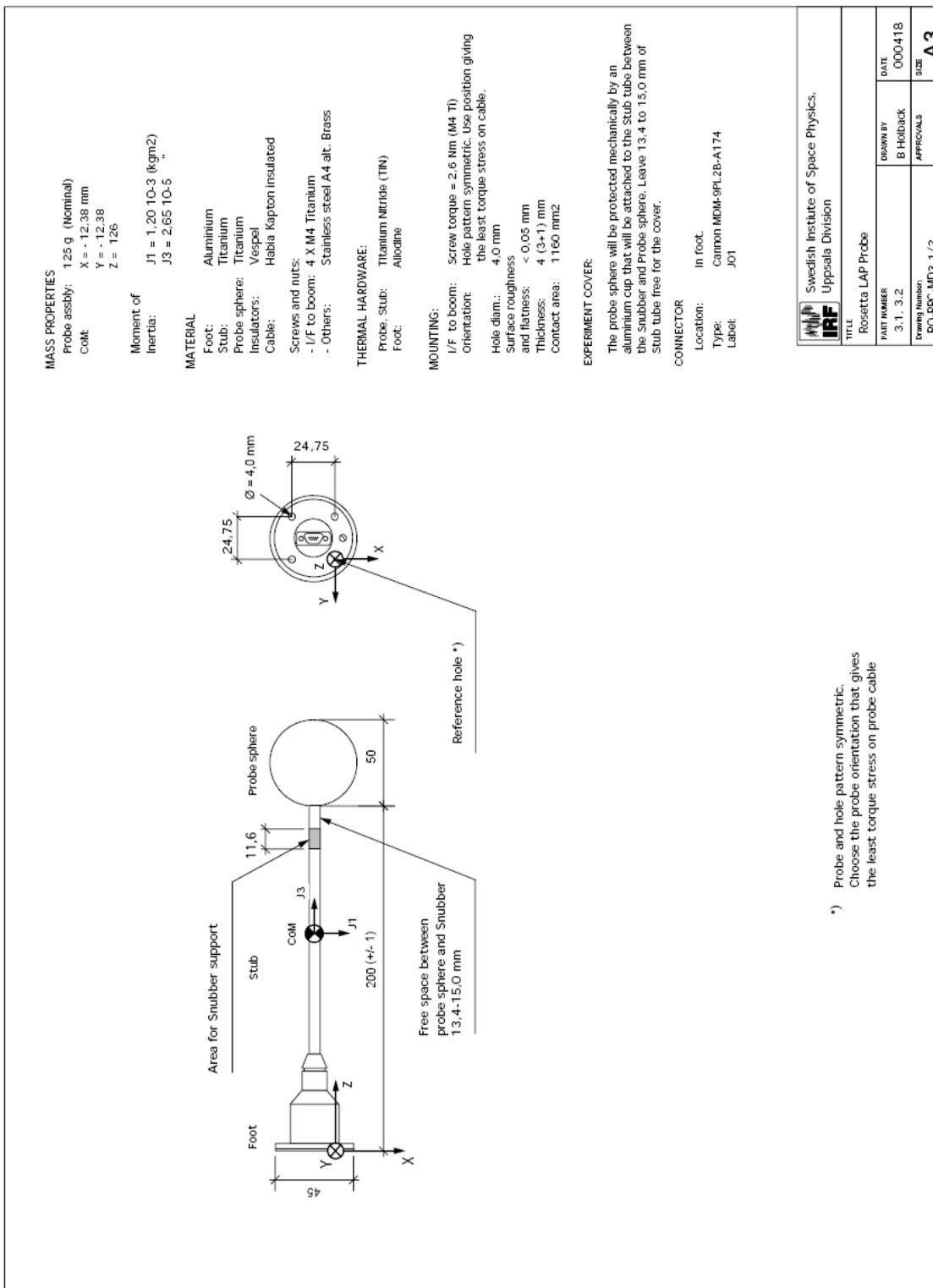
Figure 2.1-5: LAP Mechanical Interface Drawing

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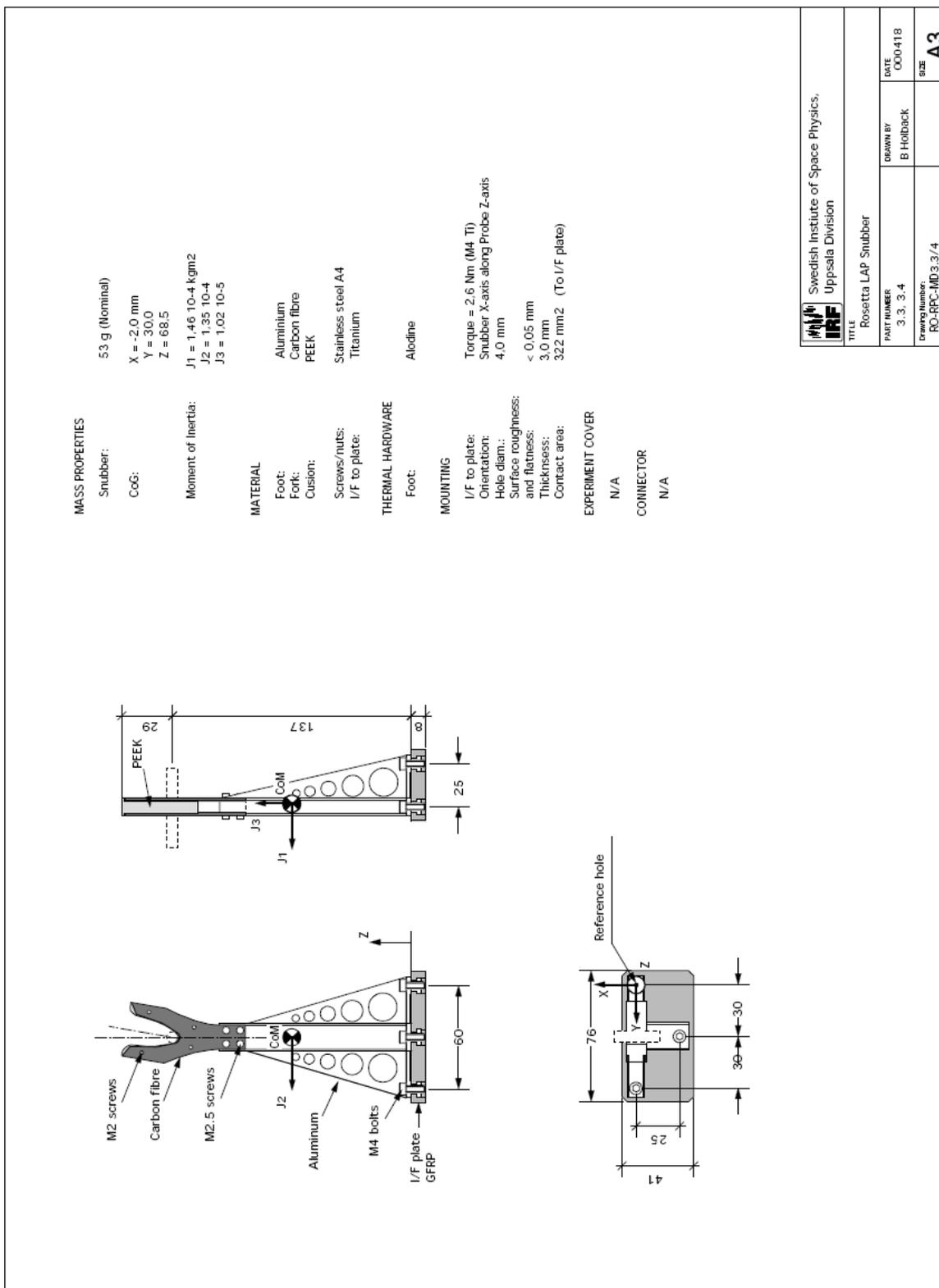
Figure 2.1-6: LAP Support Bracket Mechanical Interface Drawing

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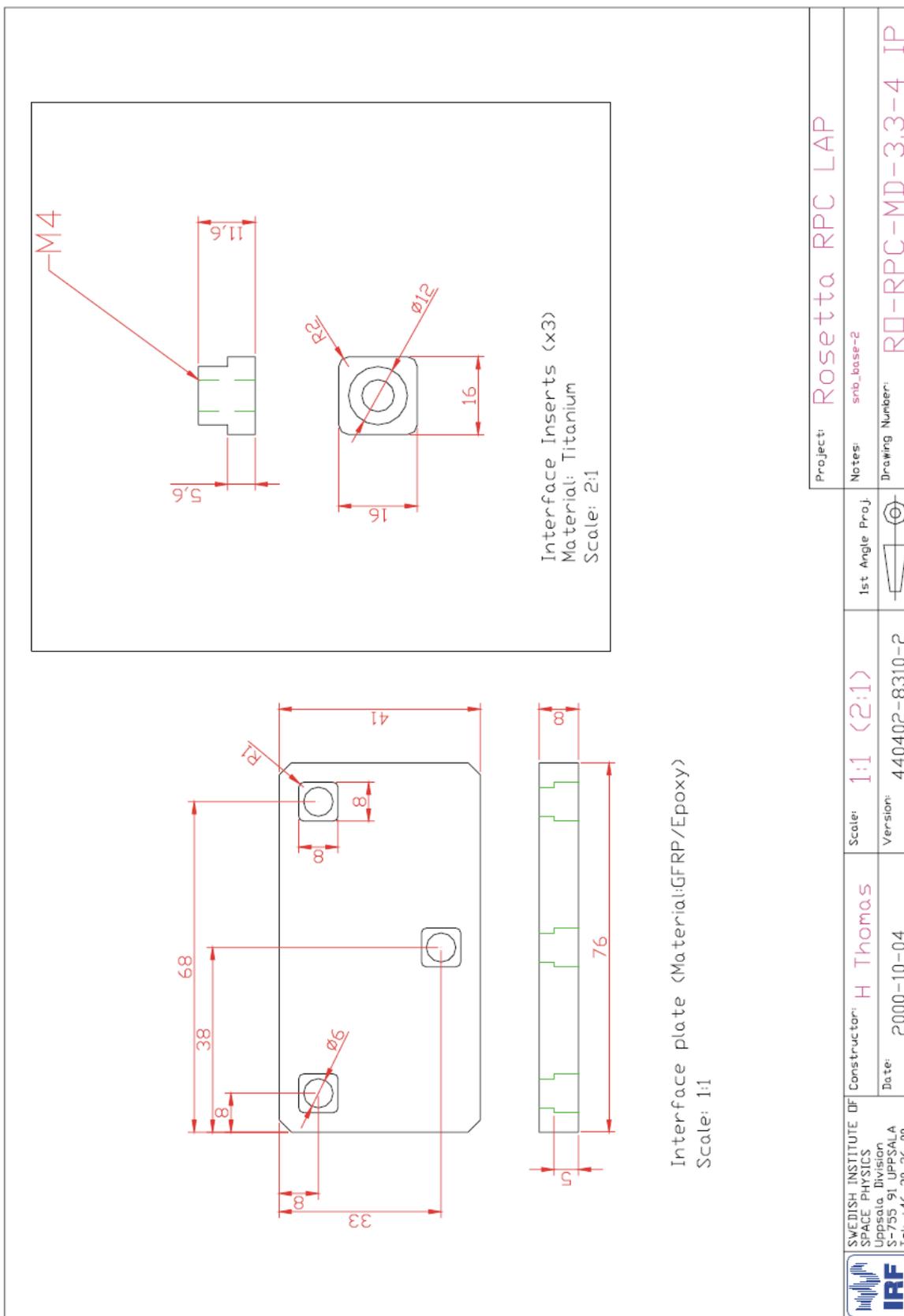
Figure 2.1-7: LAP Support Bracket (I/F Plate) MICD

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2.1.5 MIP
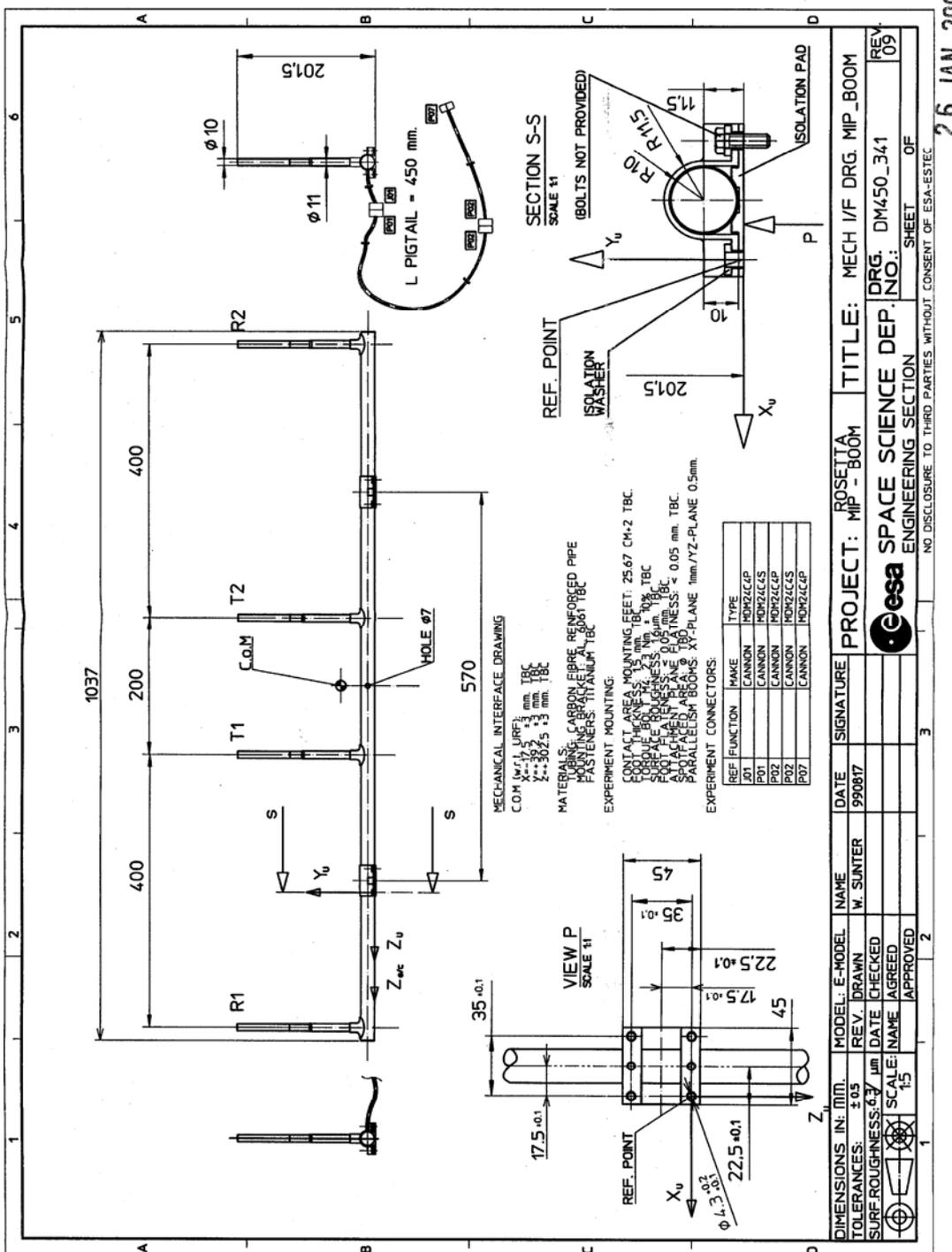
Figure 2.1-8: MIP Mechanical Interface Drawing

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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

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Figure 2.1-10: MAG Sensor Boom Interface

Figure 2.1-11: MAG Sensor Integrated System Test Configuration

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The MAG-URF U,V,W
refers to deployed
boom position.

MAG-URF

Mech.
S/C-URF

Special non-magnetic screws acc. to
DIN 84 M3x10 and washers acc. to
DIN 125 provided by MAG-Experiment.
Torque for Baseplate-screws:
EM (Plate: Phenol Hard Paper GFK laminated,
Screws: Brass): 0.4 Nm
FM/FS (Plate: CFK, Screws: Ti): 0.9 Nm

RPC-5.1 (OB):
MDM-15PSP

RPC-5.2 (IB):
MDM-15SSP

Material:
Material: EM: PC, Macor, Cu, Brass, Ti,
Phenol Hard Paper GFK laminated
FM/FS: CFK, Macor, Cu, Ti

Maßstab:
Scale:

All dimensions in mm

		Datum Date	Name Name	
		Bearb. Drawn	05.11.99	B.
		Gepr. Approved		B.
F	834	10.05.00	Norm Standard	DIN7168T1
E	829	24.03.00	B.	
D	822	23.02.00	B.	
C	816	06.01.00	B.	
B	805	01.12.99	B.	
Zust. Status	Änderung Revision	Datum Date	Name Name	

ROSETTA RPC/MAG EM,FM,FS
Magnetometer OB/IB Sensor
Dimensions, Interface

MARTIN PFEIL
TRAWID-GmbH

06.17.11.99.654

ROSETEQM\0617654F

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Figure 2.1-12: MAG Sensor Dimensions, Interface

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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 2.1-1: Boom Alignment, Reference Calculations

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	Deployed MAGinSC__nominal				Deployed [MAGinSC] measured			Error sources	[deg]	[arcmin]	OB & IB average plus offset
	SC_X	SX_Y	SC_Z		SC_X	SX_Y	SC_Z				
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 2.1-2: Boom Alignment, Deployed Configuration

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	Stowed MAGinSC__nominal				Stowed [MAGinSC] measured			Error sources	Deviation from Nominal SC		
	SC_X	SX_Y	SC_Z		SC_X	SX_Y	SC_Z		[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 2.1-3: Boom Alignment, Stowed Configuration

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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

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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.

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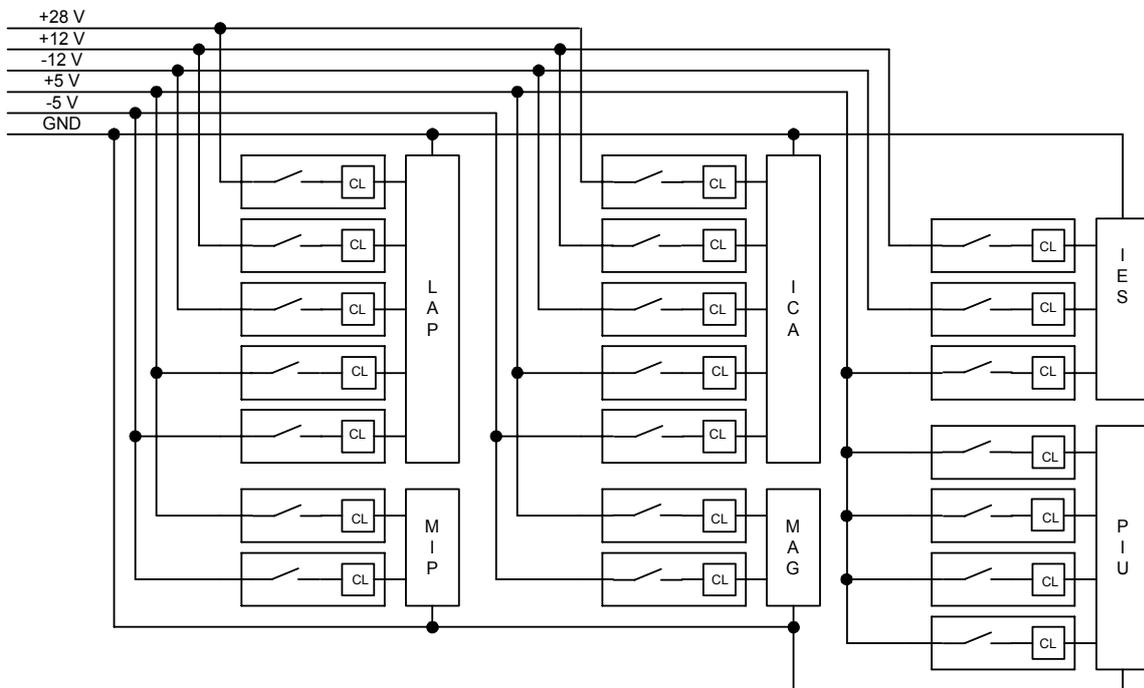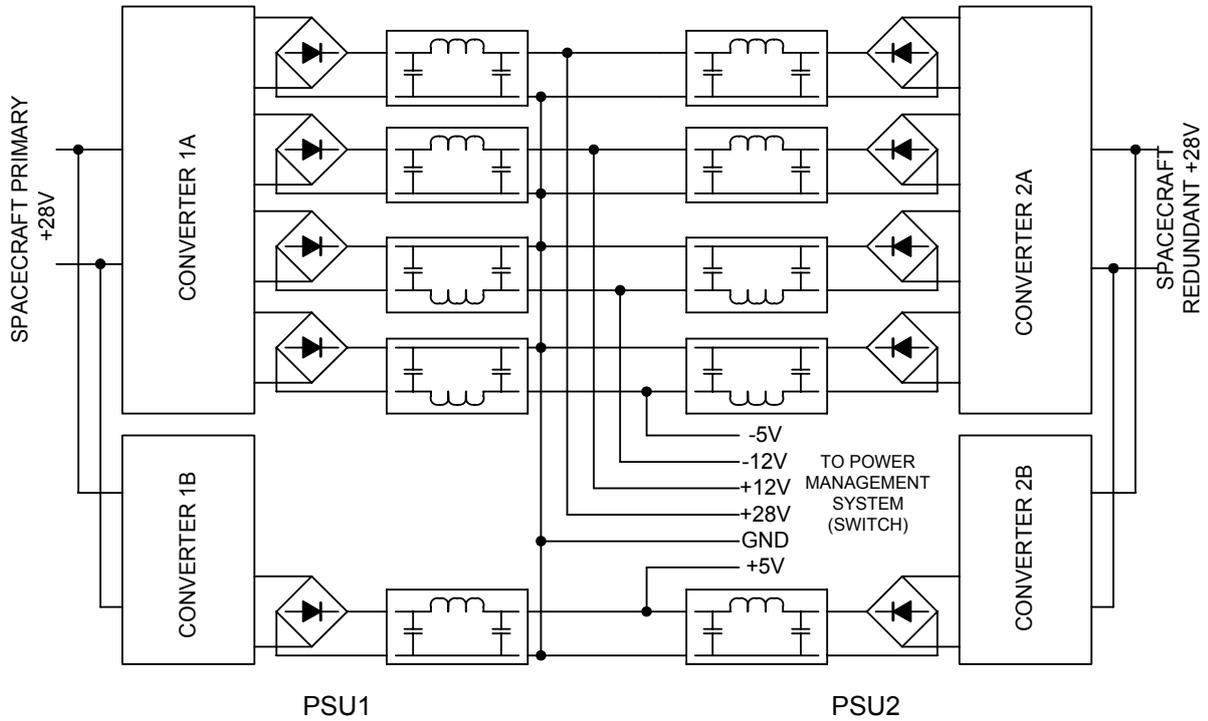
Figure 2.2-1: RPC Power Distribution Block Diagram

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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 the EID-A.

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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.

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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.

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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

Fehler! Verweisquelle konnte nicht gefunden werden. 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 EID-B section 2.6.4.

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2.2.2.5.3 SBDL Driver Circuit Specification

The driver interface circuit is given in **Fehler! Verweisquelle konnte nicht gefunden werden.**Figure 2.2-2.
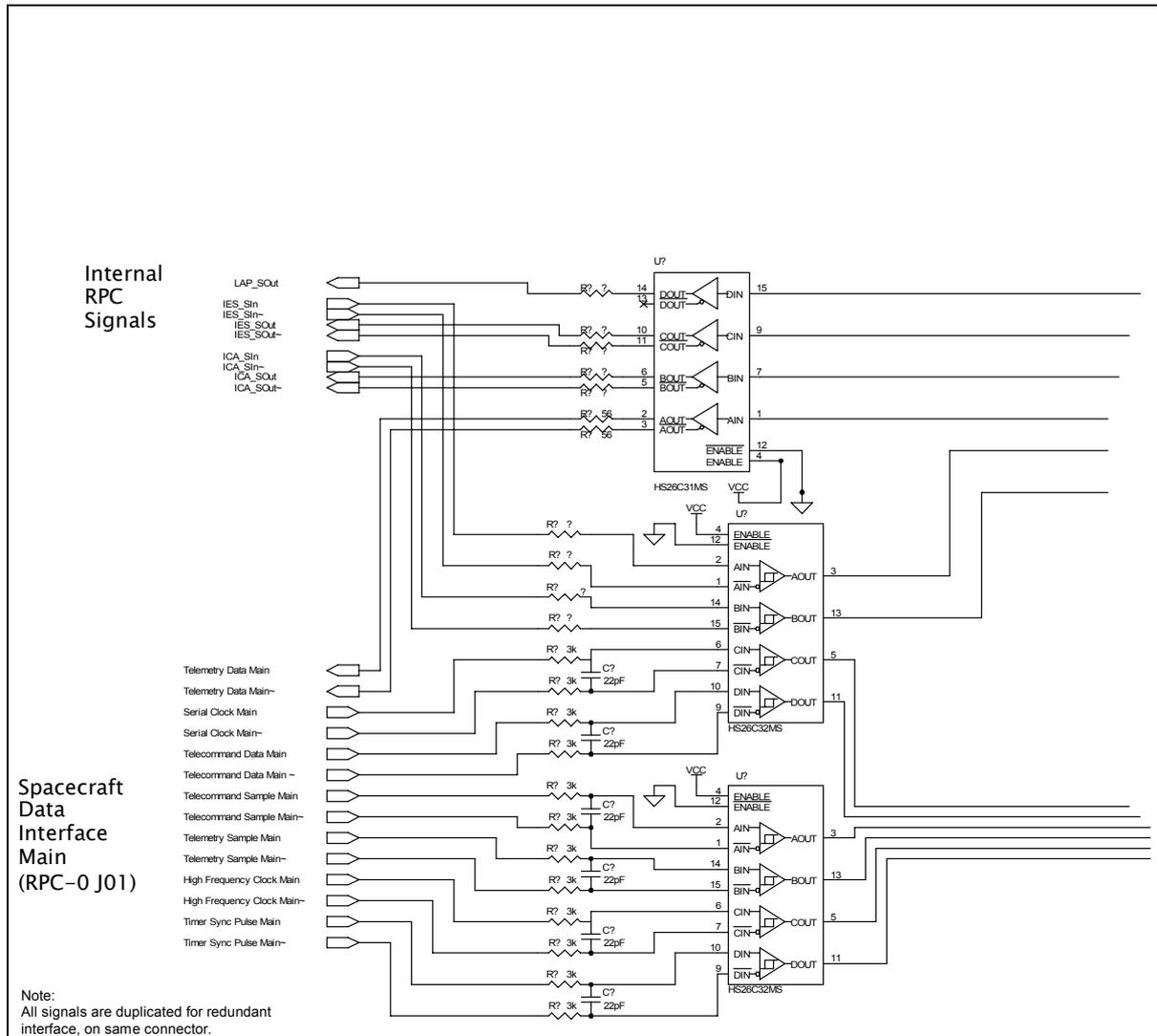
Figure 2.2-2: SDBL Interface Circuits

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2.2.2.5.4   Thermistors

Thermistors are of type A, refer to Table 2.5-11. The RPC internal thermistors are therefore all of type YSI 440907.

For the external ones refer to the information below, taken from the ASTRIUM datasheets.

NAME	LNAME	LIMS NAME	LNAME	RANK	SOFT_LO	SOFT_HI	HARD_LO	HARD_HI
NRPA5320	RPC-MAG-OB Temp	LRPA5320	Temp. 1	16	-130	75	-145	95
NRPA5330	RPC-MAG-IB Temp	LRPA5330	Temp. 2	16	-130	75	-145	95
NRPAT001	PAY429-Rpc Ies Temp	LRP00001	PAY429-Rpc Ies Temp Limits	1	-35	65	-40	70
NRPAT001	PAY429-Rpc Ies Temp	LRP00001	PAY429-Rpc Ies Temp Limits	16	-25	55	-30	60
NRPAT002	PAY430-Rpc Ica Temp	LRP00002	PAY430-Rpc Ica Temp Limits	1	-35	55	-40	60
NRPAT002	PAY430-Rpc Ica Temp	LRP00002	PAY430-Rpc Ica Temp Limits	16	-25	50	-30	55
NRPAT003	PAY431-Rpc Mip Temp	LRP00003	PAY431-Rpc Mip Temp Limits	1	-130	90	-160	100
NRPAT003	PAY431-Rpc Mip Temp	LRP00003	PAY431-Rpc Mip Temp Limits	16	-130	90	-160	100

Table 2.2-3: RPC Thermistors

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2.2.2.5.5 Heaters

unit identification		thermal TM data		Temperature limits [°C]							unit telemety data		
Instrument	**unit**	thermistor 1 (RTU A)	thermistor 2 (RTU B)			Up. NOP	Up. OP	Low OP	Sw - ON	Low NOP	thermal TM data (S/C powered)		
PAYLOADS				*TMT limits*				*to be used as basis for RSDB limits*				*TMT limits*	
		S/c TRP/STP Monitors		*(prom)*							*S/C powered interal T° (in P/L RTU)*	*(prom)*	
RPC	ICA	TCS056_ICA___TRP_P	TCS057_ICA___TRP_R	-25	55	-> 60	55	-30	-40	-40 <-		PAY430_ICA___1	-35	55
	STP	TCS055_ICA___STP		-35	60	-> 70	60	-30	N/A	-40				
	IES	TCS053_IES___TRP_P	TCS054_IES___TRP_R	-25	55	-> 65	55	-25	-20	-35 <-	PAY429_IES___1		-35	55
	LAP1					250	250	-150	-170	-150	none			
	STP (on boom)		TCS058_LAP1__STP	-35	60	-> 70	60	-30	N/A	-40				
	LAP2					250	250	-150	-170	-150	none			
	STP (on boom)	TCS096_LAP2_STP		-35	60	-> 70	60	-30	N/A	-40				
	MAG IB					150	120	-160	-150	-180	none			
	STP (on boom)	TCS062_MAGIB_STP		-35	60	-> 70	60	-30	N/A	-40				
	MAG OB					150	120	-160	-150	-180	none			
	MIP					100	100	-130	-160	-160 <-	PAY431_MIP___1		-55	90
	STP (on boom)	TCS059_MIP___STP		-35	60	-> 70	60	-30	N/A	-40				
	PIU	TCS051_RPCEL_TRP_P	TCS052_RPCEL_TRP_R	-25	55	-> 60	55	-20	-30	-30	-			

Table 2.2-4: Heater TM limits

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PL PDU	LCL No.	Power [W]	Circuit power [W]	Name for H/W heaters - for LCL branch A listed only - ON/OFF -	effectect units	no of heater circuits	HG THS	CG THS
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 2.2-5: Heater Budgets

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HW heater LCLs in PL PDU	Related thermistors	
LCL-10		
Rosina DPU	TCS041_RODPU_TRP_P TCS042_RODPU_TRP_R	
Cosima	TCS010_COSIM_TRP_P TCS011_COSIM_TRP_R	PAY406_COSIM_1 PAY407_COSIM_2
RPC PIU	TCS051_RPCEL_TRP_P TCS052_RPCEL_TRP_R	
LCL-18		
SSP ESS	TCS075_ESSEL_TRP	
RPC IES (TCS)	TCS053_IES___TRP_P TCS054_IES___TRP_R	PAY429_IES___1

Prime LCL-PL-10
Line 1 — hot guard T/S 0°C / 40°C — Rosina DPU 1.64W (470Ohm)
Line 2 — hot guard T/S 0°C / 40°C — Cosima 1.06W (721Ohm)
Line 3 — hot guard T/S 0°C / 40°C — RPC PIU 1.64W (470Ohm)
Line 4 — NC

Redundant LCL-PL-10
Line 1 — cold guard T/S -30°C / +5°C — Rosina DPU 1.64W (470Ohm)
Line 2 — cold guard T/S -30°C / +5°C — Cosima 1.06W (721Ohm)
Line 3 — cold guard T/S -30°C / +5°C — RPC PIU 1.64W (470Ohm)
Line 4 — NC

Prime LCL-PL-18
Line 1 — hot guard T/S 0°C / 40°C — SSP ESS Box 1.63W (470Ohm)
Line 2 — NC
Line 3 — NC
Line 4 — hot guard T/S 0°C / 40°C — RPC IES 2.74W (280Ohm)

Redundant LCL-PL-18
Line 1 — cold guard T/S -30°C / +5°C — SSP ESS Box 1.63W (470Ohm)
Line 2 — NC
Line 3 — NC
Line 4 — cold guard T/S -30°C / +5°C — RPC IES 2.74W (280Ohm)

Table 2.2-6: Heater Connections, LCL-10 & LCL-18

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HW heater LCLs in PL PDU	related thermistors									
LCL-41										
RPC ICA; SREM	TCS056_ICA___TRP_P TCS057_ICA___TRP_R TCS055_ICA___STP	PAY430_ICA___1								
	TCS065_SREM__TRP_P TCS064_SREM__STP	PAY432_SREM__1								

Prime LCL-PL-41
Line 1
hot guard T/S 0°C / 40°C
thermostat on ICA
RPC ICA / SREM 3.49W / 3.49W (220 / 220Ohm)
Line 2 — NC

Redundant LCL-PL-41
Line 1
cold guard T/S -30°C / +5°C
thermostat on ICA
RPC ICA / SREM 3.49W / 3.49W (220 / 220Ohm)
Line 2 — NC

Table 2.2-7:Heater Connections, LCL-41

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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.
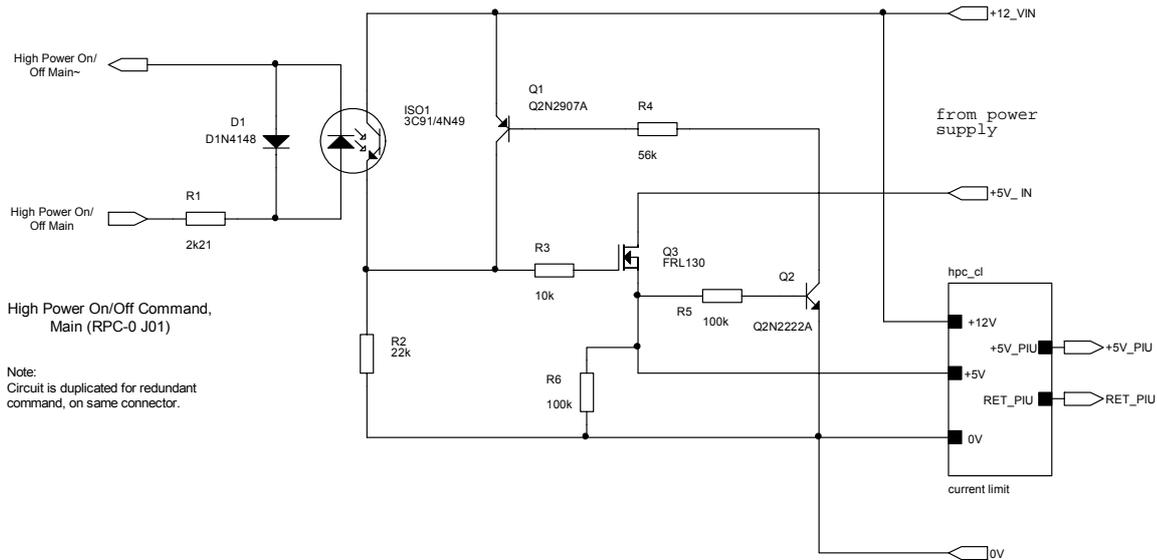
Figure 2.2-3: High Power Command Interface Circuit

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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.

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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, the 'Guide to applying software standards to small software projects', BSSC(96)2 is also applied.

2.3.1.1.2   LAP

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 2.3-1). 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 RO-IRFU-LAPCTM for a general description of macros and macro commands; see RO-IRFU-LAPMPF for existing macros.

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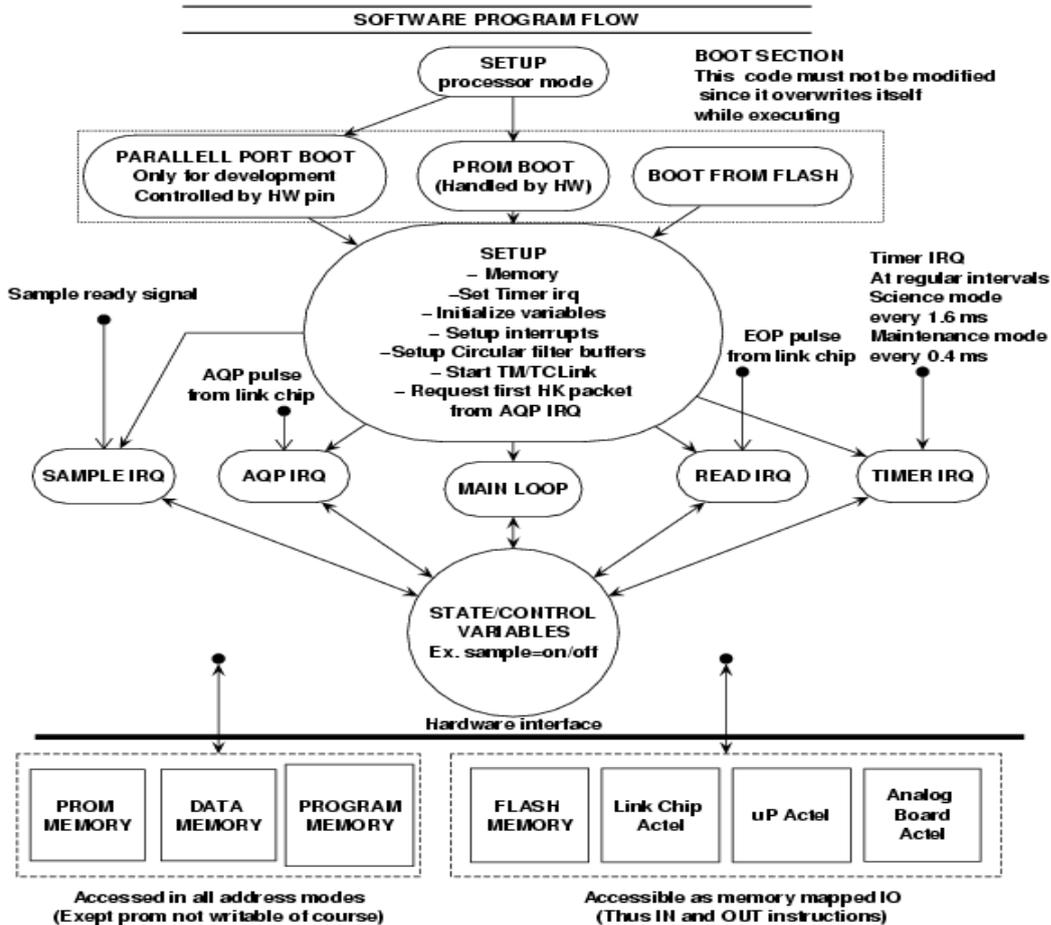
Figure 2.3-1: LAP Software Structure

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.

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- **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.

2.3.1.1.3   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

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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.

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.

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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

RPC uses the spacecraft mass memory for storing software. Sufficient software will be held in ROM within the instrument to support the basic operations. However, it is expected that some additional routines will be up-linked during flight. For this reason two uses for the mass memory are foreseen:

- firstly, as a temporary store for code up-linked while the payload is off;
- secondly, as a store for code transferred out of the instrument prior to a payload switch off.

Procedures will be devised for the transfer of software to and from the spacecraft mass memory.

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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

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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.

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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 the RSDB (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

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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 EID-A (section 2.7.3.3).

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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
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

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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

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2.3.2.1.2 IES Private Telecommand Service Definition

Subtype	Service Requests (TC)	Sub-type	Service Reports (TM)
Service 2xx – IES			
	IES commands: See IES Software Interface Document, 8182-SID-01, Appendix: Commands - 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

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2.3.2.1.6 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

http://www.rssd.esa.int/llink/livelink?func=ll&objId=17079&objAction=browse
&sort=name

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

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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 2.3-9: PIU HK TM Packet Definition

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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 2.3-10: RPC-IES TM Packet Definition

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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			

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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 2.3-11: RPC-ICA TM Packet Definition

For Details refer to the Document **ICA-TM /TC Data Formats and related s/w aspects**

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2.3.2.2.4   LAP TM Packet Definition

For more details on the LAP TM refer to the
RPC LAP Instrument User Manual   (IRFU-RPC-LAPCTM).

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 2.3-12: RPC-LAP TM Packet Definition

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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			

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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 2.3-13: 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.

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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 2.3-14: RPC-MAG TM Packet Definition

Details on the Structure of the internal MAG packets can be found in the Document RO-IGEP-TN00001: **RPCMAG Internal Packet Definitions**

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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		
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 2.3-15: RPC-PIU TC Packet Definition

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2.3.2.2.8   IES Telecommand Packet Definition

Telecommand Packet Information				
Packet Name		see below	**Instrument**	**RPC-IES**
Packet Function		IES Telecommand (ref. IES Software Document, 8182-SID-01, Appendix: Commands; see RSDB)		
Verification Rules		At any time		
Header Information				
Process ID	84	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	

Table 2.3-16: 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 telecommands (see UM and RSDB)		
Verification Rules		At any time		
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 bit telecommands (see UM and RSDB)		
Verification Rules		At any time		
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 2.3-17: ICA TC Packet Definition

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2.3.2.2.10 LAP Telecommand Packet Definition

Telecommand Packet Information				
Packet Name		see below	**Instrument**	**RPC-LAP**
Packet Function		LAP Telecommand (see RSDB)		
Verification Rules		At any time		
Header Information				
Process ID	86	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	

Table 2.3-18: 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 RSDB)		
Verification Rules		At any time		
Header Information				
Process ID	87	Packet Category	Private	
Service Type	**Subtype**	**Length**	**Name**	

Table 2.3-19: MIP TC Packet Definition

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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		
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 2.3-20: MAG TC Packet Definition

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2.3.2.3 Instrument Packet Content Description

- PIU
  Refer directly to the DSDB.

- IES
  Refer directly to the DSDB.
- ICA
  For the ICA TC parameter definition refer to the
  ICA-TMTC Data Formats and related S/W Aspects (Hans Borg,2002).

- LAP
  For the LAP TC parameter definition refer to the
  LAP Command and Telemetry Description (RO-IRFU-LAPCTM).

- MIP
  For the MIP TC parameter definition refer to the
  RPC MIP UM: Manuel D'UTILISATION DU F.M.

- MAG
  Refer directly to the RPC-DSDB.

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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	"

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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	"	

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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 2.3-21: RPC Data Volume in Different Mision Phases

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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

Table 2.3-22: RPC OBCPs

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

- **RPC Experiment OBCPs URD: RO-ESC-5632 (formerly known as :RO-DSS-RS-1032)**
- **Section 3.2.3**

- **Rosetta Flight Operations Plan: RO-ESC-PL-5000, 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 the Rosetta s/c UM.

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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 2.3-23: RPC Monitoring Requirements

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

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2.3.3.5 Information Distribution Requirements

RPC has a requirement to receive the following information:

- Environmental Pressure

This information is needed for the IES instrument and has to be distributed via the Service 19 from the DMS.
IES only requires the Rosina pressure, Rosina pressure alert and Giada dust flux information messages. If Rosina pressure, Rosina pressure gradient or Giada dust flux level as set by the IES-SAFETY-AMB-SET command are exceeded, the HV supplies will be brought down, an event message will be sent out and the IES instrument shall go to LVSCI-EEPROM mode, awaiting further instruction. IES response to the Giada the "no-data" message, 0xEEEE. This can be changed depending on mission operations. In general, this message should be benign and indicates that Giada is changing modes; however, by default, IES will turn off HV power supplies if this message is received. The IES-SAFETY-AMB-SET command can be used to make IES ignore the "no-data" message.

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.

- The auxilary data like

  o 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.

  o 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.

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2.4   Budgets

2.4.1   Telemetry

	Hk	SCIENCE					
		Min	Norm	Burst	SID 4	SID 5	SID 6
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	15,8	116,5	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	614,8	937,6	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

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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
	SID4	4	1024,0	335	15,7	2010	2020	2026	2019	15,8
	SID5	5	32,0	75	112,5	450	460	466	459	116,5
	Test	6	1,0	25	1200,0	150	160	166	159	1328,0
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

Table 2.4-3: RPC ScienceTelemetry Budget

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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 [Kgm²]		
		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

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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

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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 (estimate)		30	840
ICA	LV		70	1960
	HV (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 Radation 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)

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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

2.4.5 S/C Powered Thermistors

ICA: One thermistor PAY430_ICA__1 located at the ICA Thermal Reference Point (TRP) shown in Figure 2.5-2
IES: One thermistor PAY429_IES__1
MIP: One thermistor PAY431_MIP__1 (Th1), located in the sensor receiver 1, is monitored by the S/C.

Refer to Table 2.2-4 ,Table 2.2-5, Table 2.2-7

2.4.6 Pyro Lines

No pyro lines used for RPC.

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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 is used to aid in maintaining the temperature.

IES Sensor Body Temperature Ranges				
	Non-Operation Low	**Non-Operation High**	**Operation Low**	**Operation High**
Yellow Limit	-35C	+65C	-25C	+55C
Red Limit	-40C	+70C	-30C	+60C

Table 2.5-1: IES Temperature Ranges

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.

ICA Operation Temperature Ranges			
Instrument Element	**Operating**	**Non-Operating**	**Switch-On**
Sensor Top	-30to +55°C	-45 to +70°C	-30 to +50°C
Central Electronics	-30 to +55°C	-45 to +70°C	-30 to +50°C

Table 2.5-2: ICA Temperature Ranges

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LAP:

LAP has no special thermal requirements other than those listed below.

LAP Operation Temperature Ranges			
Instrument Element	**Operating**	**Non-Operating**	**Switch-On**
Sensor	-190 to 250°C	-190 to 250°C	-190 to 250°C

Table 2.5-3: LAP Temperature Ranges

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.

MIP Operation Temperature Ranges			
Instrument Element	**Operating**	**Non-Operating**	**Switch-On**
Sensor	-130 to 100°C	-160 to 100°C	-160 to 100°C

Table 2.5-4: MIP Temperature Ranges

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).

MAG Operation Temperature Ranges		
Instrument Element	**Operating**	**Non-Operating**
Sensor OB/IB	-160 to 120°C	-180 to 150°C
MAG - PIU Electronics	-20 to 50°C	-50 to 80°C

Table 2.5-5: MAG Temperature Ranges

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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.

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 will provide 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 of approximately 0.5 W is sufficient to protect the instrument during periods of dormancy.

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 will be 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 will be within their specified temperature ranges. Temperature ranges for the LAP units are specified in sec.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 will require one spacecraft powered thermistor to measure the sensor temperature when

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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.

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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 2.5-6: Thermal Control Category

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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.

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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 2.5-19 to Table 2.5-26.

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 2.5-27 to Table 2.5-34 **Fehler! Verweisquelle konnte nicht gefunden werden.**.

LAP:
See Table 2.5-35 to Table 2.5-40.

MIP:
See   Table 2.5-41**Fehler! Verweisquelle konnte nicht gefunden werden.** to Table 2.5-46.

MAG:
See Table 2.5-47 to Table 2.5-53.

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<u>**RPC-0:**</u>

The RPC-0 box is black anodised Aluminium with an area of 2200 cm^2.
See Table 2.5-14 to Table 2.5-18.

2.5.2.3   Heaters

<u>**IES:**</u>   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.

<u>**ICA:**</u>   2.7 W s/c powered non-operational heater.

<u>**MIP**</u>, <u>**LAP**</u>, <u>**MAG:**</u>   No heaters.

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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 (ε = 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 2.5-7: 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.

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2.5.2.5 Thermal Interface Control Drawing

IES: ref. Figure 2.5-1.

ICA: ref. Figure 2.5-2.

LAP: ref. Figure 2.5-3.

MIP: ref. Figure 2.5-4.

MAG: ref. Figure 2.5-5.

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

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Figure 2.5-1: Thermal Interface Control Drawing for IES

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Figure 2.5-2: Thermal Interface Control Drawing for ICA

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THERMAL INTERFACE DRAWING

HEAT CAPACITY: 73 J/K

MATERIALS:
Structural Items: Titanium, Duralumin
Screws, etc.: Autenitic SS
Others: Vespel

SURFACE TREATMENT:
Titanium: TiN
Duralumin: Alodine

THERMAL INTERFACE HARDWARE:
Boom end

EXPERIMENT MOUNTING:
Contact area: 1160 mm2
Foot thickness: 4 (3+1) mm
Surface roughness:mh.6
Foot flatness: 0.05 mm
Attach plane flatness: 0.1 mm

POWER DISSIPATION:
None

EXTERNAL
Epsilon = 0.05
Alpha = 0.2

EXTERNAL
Epsilon = 0.13
Alpha = 0.46

Project: Rosetta RPC LAP

Notes:

Drawing Number: RO-RPC-TD 3.1-2

1st Angle Proj.

Scale: 1:2

Version: 8310-2

Constructor: H. Thomas

Date: 2000-10-04

SWEDISH INSTITUTE OF
SPACE PHYSICS
Uppsala Division
S-755 91 UPPSALA
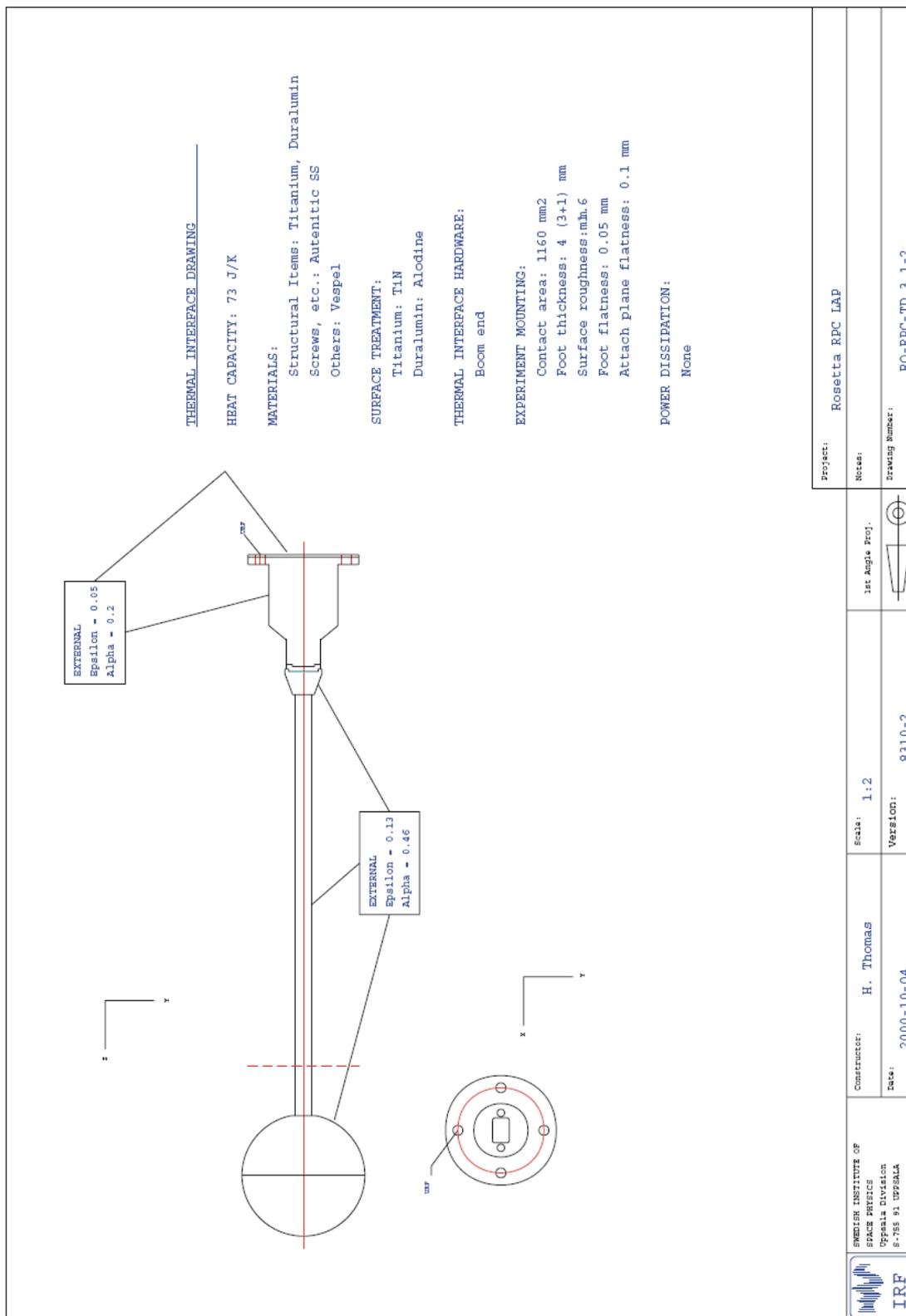Tel: +46 30 36 00

IRF

Figure 2.5-3: Thermal Interface Control Drawing for LAP

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Figure 2.5-4: Thermal Interface Control Drawing for MIP

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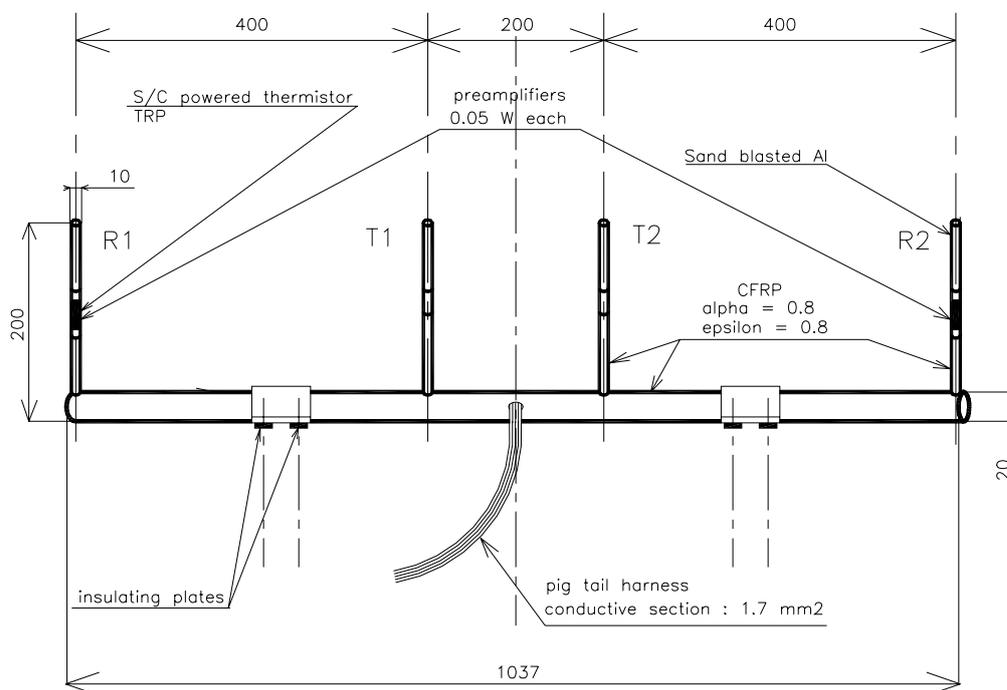Page : 139

Figure 2.5-5: Thermal Interface Control Drawing for MAG

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2.5.3   Temperatures and Thermal Control Budget

2.5.3.1   Temperatures Ranges

Ref. to Table 2.5-8 and **Fehler! Verweisquelle konnte nicht gefunden werden.** (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 2.5-8: 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 2.5-9: RPC Heater Power Requirements

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

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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 2.5-10: Heat Exchange

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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 2.5-11: 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 2.5-12: Temperature Sensors (RPC internal sensors)

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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 2.5-13: TMM Nodes

2.5.4.2 Interface Thermal Mathematical Models

2.5.4.2.1 PIU: RPC-0

(ref. RPC_8 in RO-EST-TN-1021)

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 2.5-14: PIU BOL / EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m²)	MCp (J/K)	Non-Op. Heater	TRP location
50740	Electronic	Al alloy 6061	0.220	2453.	HT	TRP

Table 2.5-15: PIU Node Properties

Node (-)	Op. (°C)	Non-Op. (°C)	Op. Stab. (°C/h)	Switch-On (°C)
50740	-20 / +55	-30 / +60	-	-30 / +50

Table 2.5-16: PIU TRP Design Temperature Ranges

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Mode	Node	BOL		EOL	
		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 2.5-17: PIU Power Dissipations

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

Table 2.5-18: PIU Interface Contact Conductances
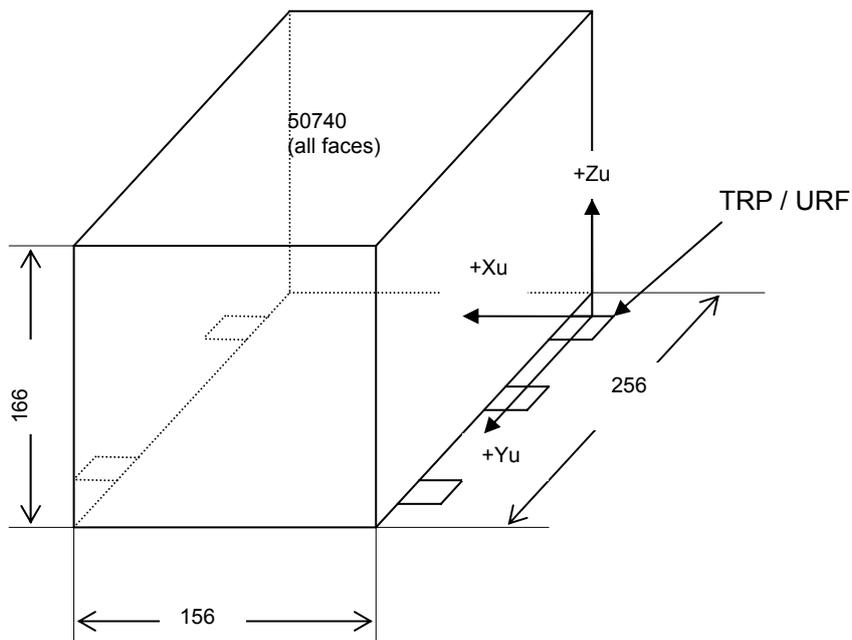
Figure 2.5-6: PIU Electronic Thermal Sketch

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2.5.4.2.2   IES: RPC-1.1

(ref. RPC_2 in RO-EST-TN-1021)

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 2.5-19: 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	aperture	Mg alloy ZK80A	ebanol C black	0.97	0.03	-	0.73	0.27	-
50625	MLI 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 2.5-20: IES EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m²)	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 2.5-21: IES Node Properties

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

Table 2.5-22: IES TRP Design Temperature Ranges

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		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 2.5-23: 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 2.5-24: 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 2.5-25: 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 2.5-26: IES Interface Contact Conductances

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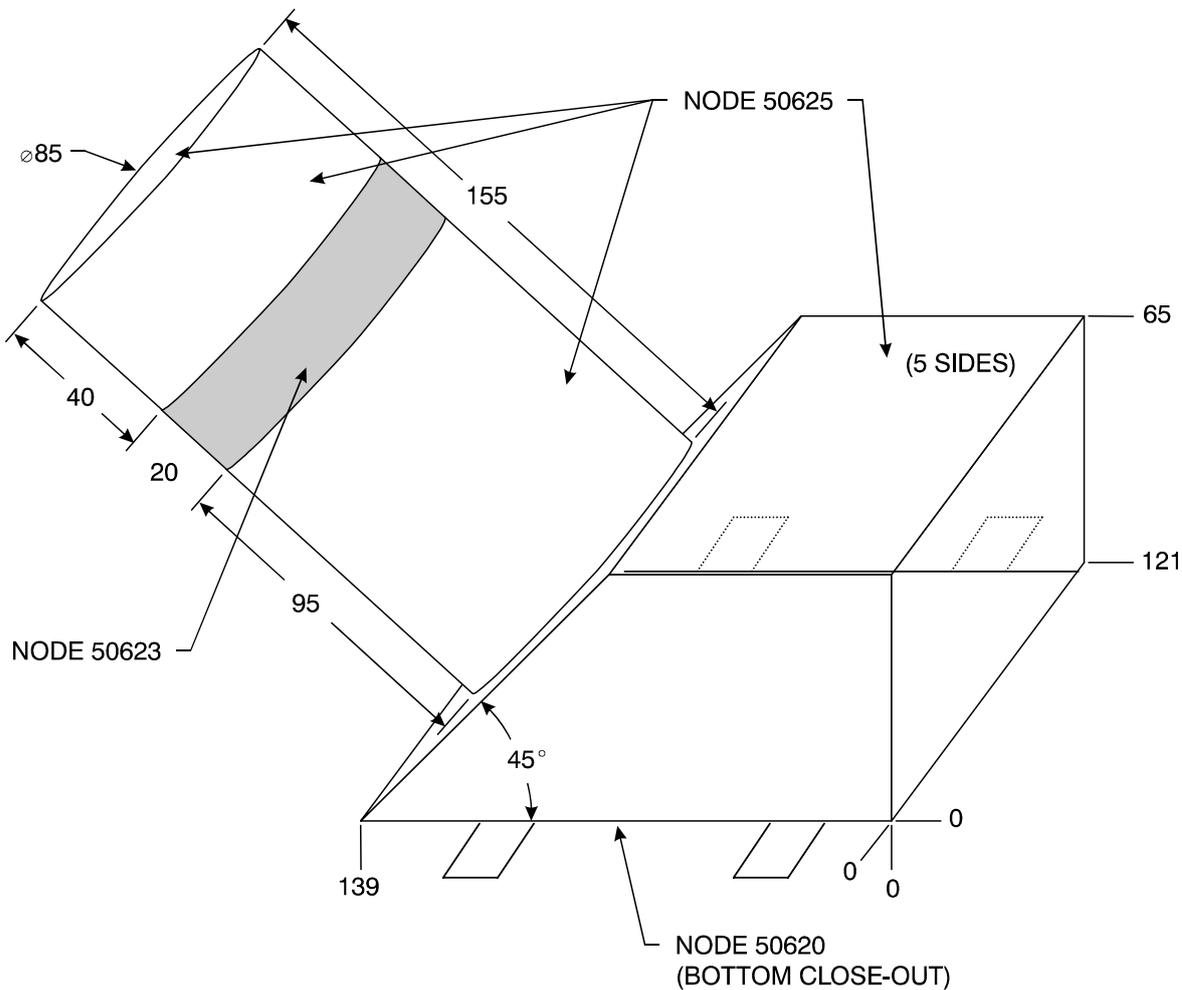
Figure 2.5-7: IES Thermal Sketch

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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 2.5-27: 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 2.5-28: 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 2.5-29: ICA Node Properties

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

Table 2.5-30: ICA TRP Design Temperature Ranges

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

Table 2.5-31: 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 2.5-32: ICA Internal Conductive Couplings

Node l (-)	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 2.5-33: ICA Internal Radiative Couplings

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

Table 2.5-34: ICA Interface Coductive Couplings

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Diameter 120
Length 60

Outer diameter 148
Inner diameter 120
Width 7.5

Diameter 120
Length 182

150

27.5

Height

154
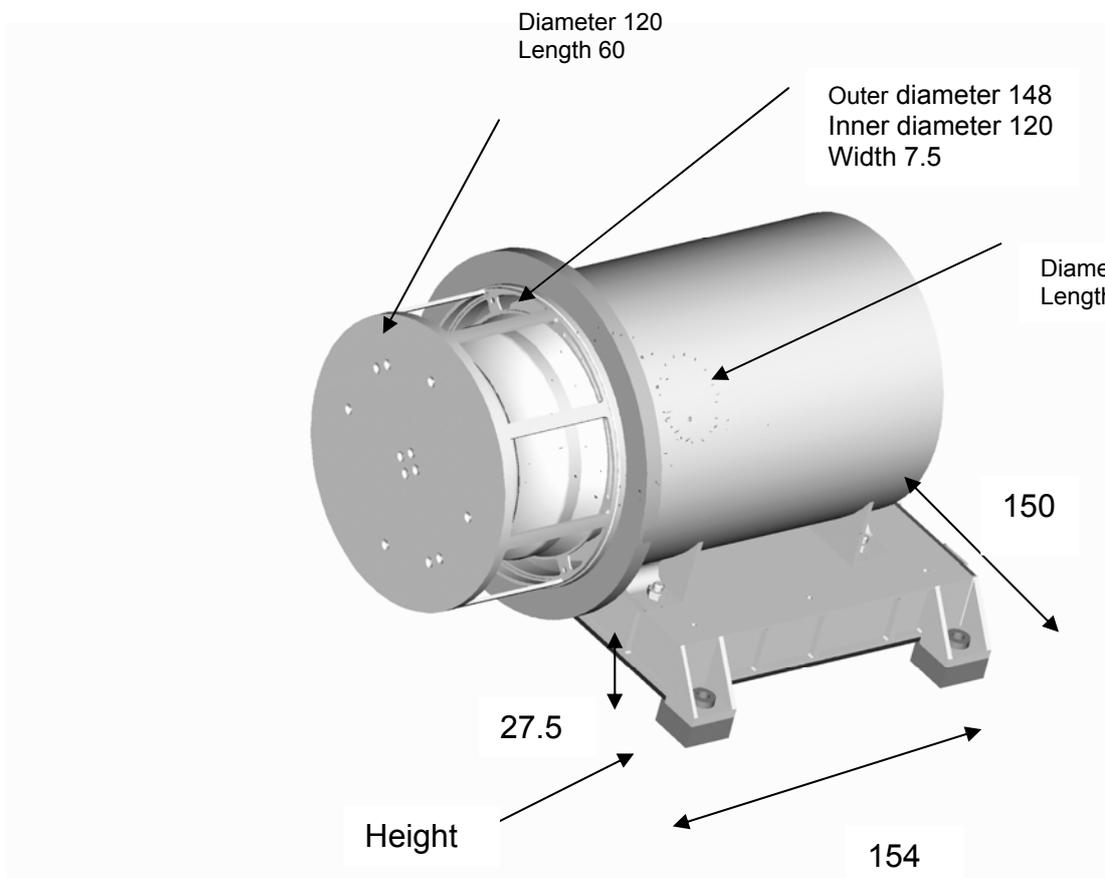
Figure 2.5-8: ICA Main Dimensions

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Node 50609 Iridite

Node 50601 Black paint

Node 50600 White paint

Node 50608 Front White paint Backside Black paint

Node 50606 **Sensor MLI**

Node 50602 Anodize black

Node 50605 Anodize black

Node 50607

+Z
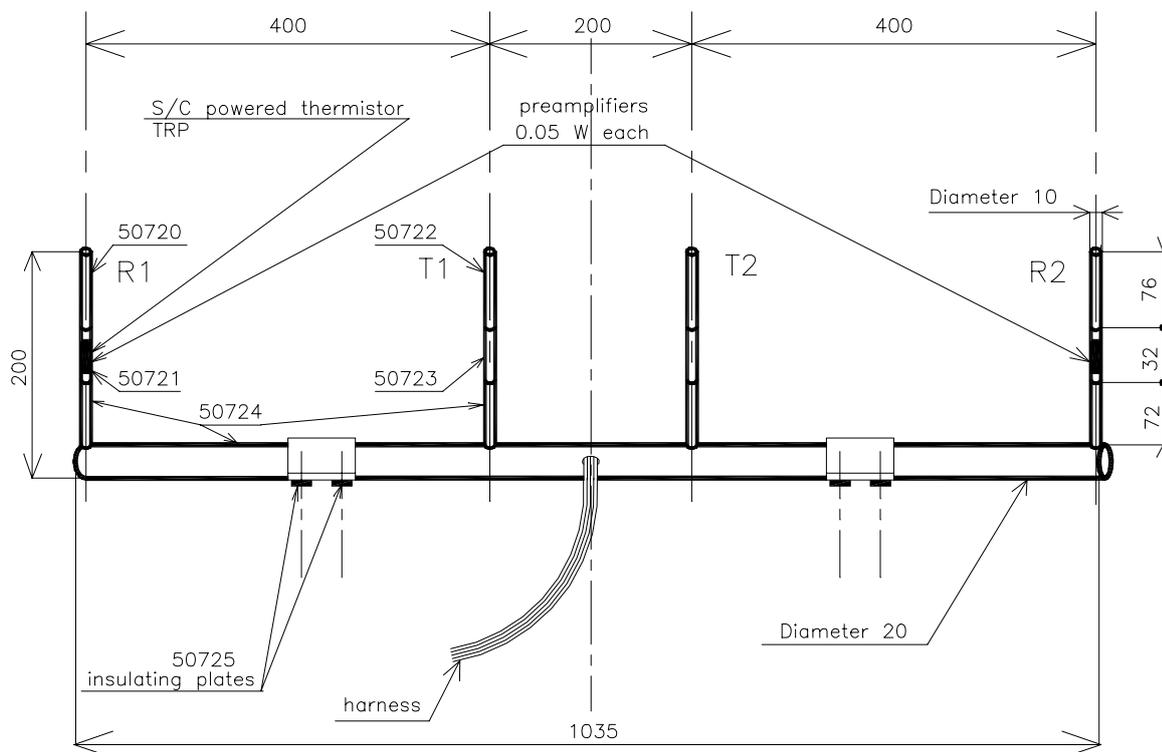
TRP/UR

+X

+Y

TRP location
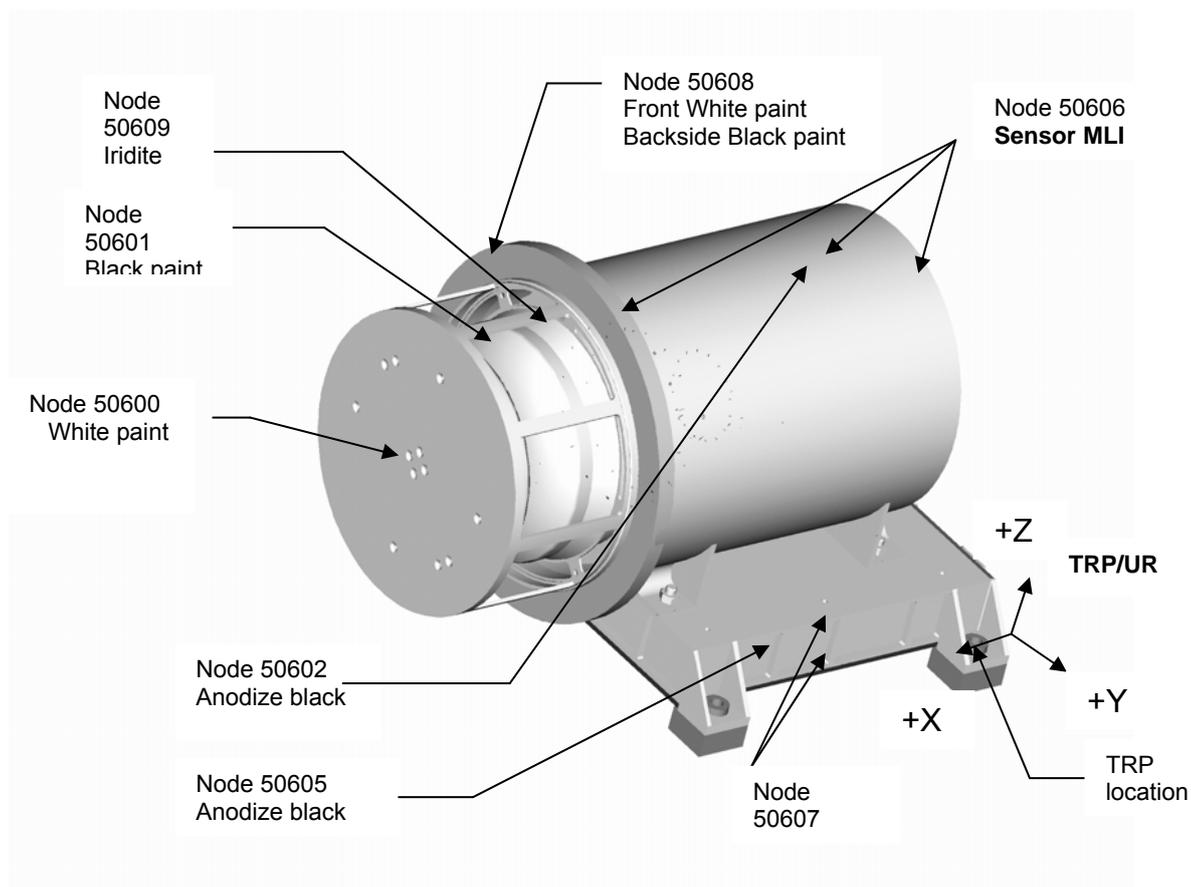
Figure 2.5-9: ICA Thermal Nodes

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2.5.4.2.4   LAP: RPC-3.1 and RPC-3.2

(ref. RPC_3 & 4 in RO-EST-TN-1021)

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 2.5-35: LAP BOL / EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m²)	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 2.5-36: 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 2.5-37: LAP TRP Design Temperature Ranges

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			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 2.5-38: LAP Power Dissipations

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

Table 2.5-39: 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 2.5-40: LAP Interface Contact Conductances
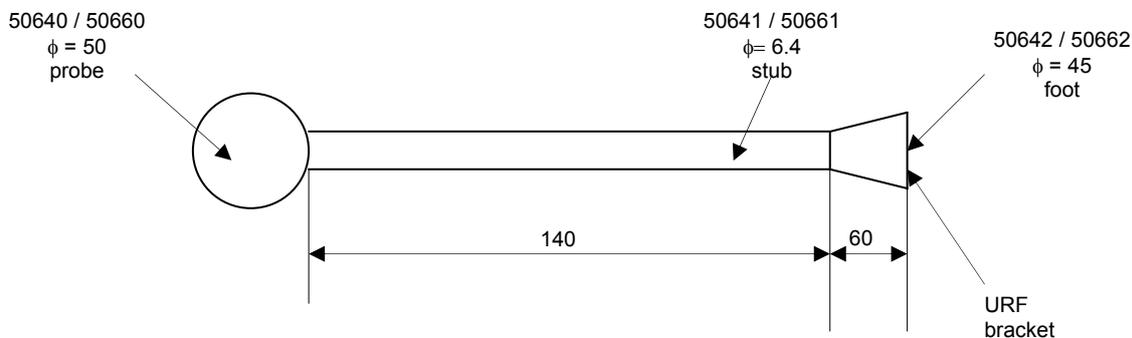
Figure 2.5-10: LAP1 and LAP2 Thermal Sketch

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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 2.5-41: 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 2.5-42: MIP Node Properties

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

Table 2.5-43: MIP TRP Design Temperature Ranges

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

Table 2.5-44: MIP Power Dissipations

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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 2.5-45: 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 2.5-46: MIP Interface Contact Conductances

Figure 2.5-11: MIP Sensor Thermal Sketch

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2.5.4.2.6   MAG: RPC-5.1 and RPC-5.2

(ref. RPC_5 & 6 in RO-EST-TN-1021)

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 2.5-47: 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 2.5-48: MAG EOL Surface Properties

Node (-)	Name (-)	Material (-)	A (m²)	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 2.5-49: MAG Node Properties

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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 2.5-50: MAG TRP Design Temperature Ranges

Unit (-)	Mode (-)	Node (-)	BOL / EOL	
			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 2.5-51: 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 2.5-52: 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 2.5-53: MAG: Interface Contact Conductances

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50705 / 50685
MLI
(6 faces)

35

35

35
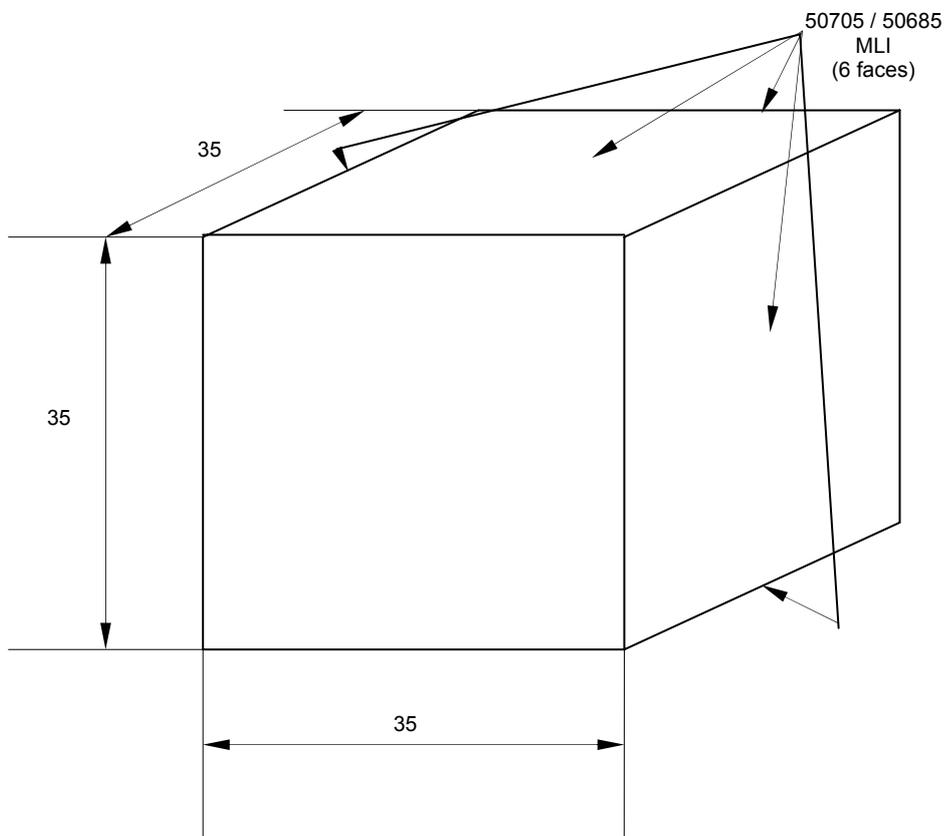
Note: The nodes 50701/50705 belong to the MAG OB (outboard) sensor),
whilst 50681/50685 belong to the MAG IB (inboard) sensor

Figure 2.5-12: MAG-OB and MAG-IB Thermal Sketch

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3.0 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.
- 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 **Fehler! Verweisquelle konnte nicht gefunden werden.**). They require pointing parallel to the plasma flow, plus the IES and the

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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.

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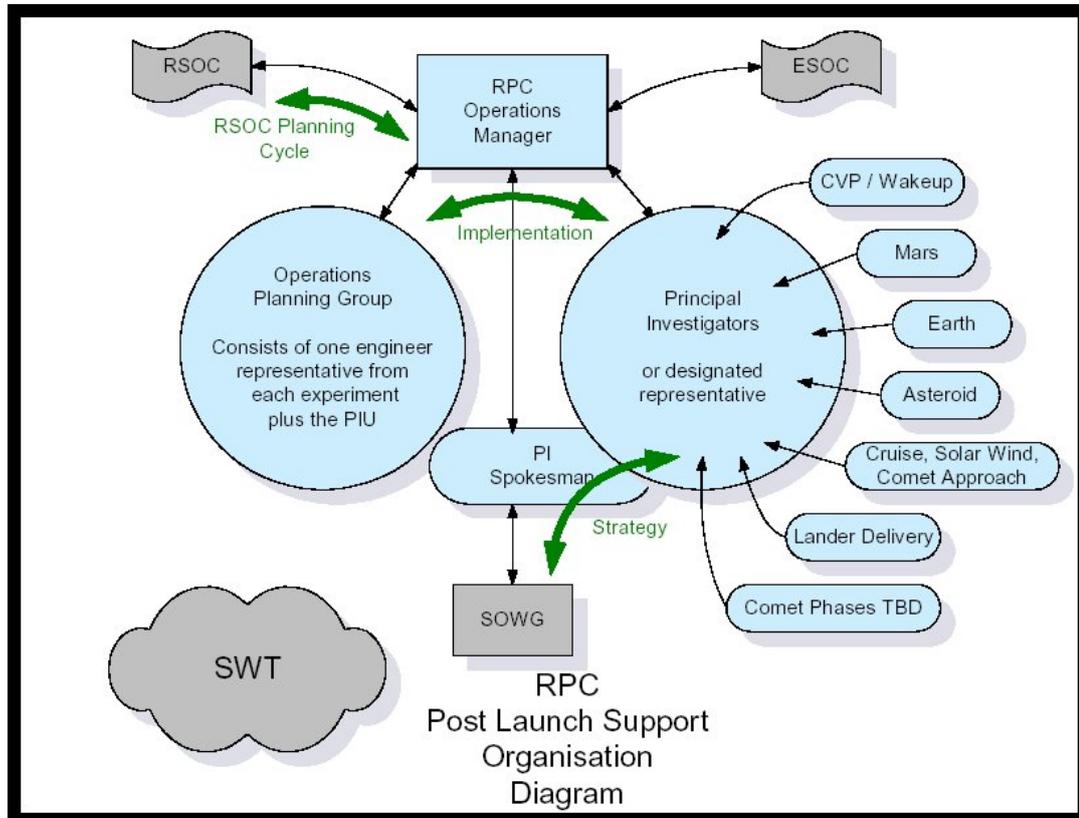
Figure 3.1-1: RPC Post Launch Support Organisation

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 **Fehler! Verweisquelle konnte nicht gefunden werden.**. 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.

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3.1.1.2 Data Flow

The RPC data will be retrieved from the ESOC DDS system, by a procedure, described in the **DDS2RPC User manual**. 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 the "**RO-IGEP-TR0016: RPC Archiving Guidelines**" 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.

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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 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 moving onto execute the EEPROM 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, right after bootup, 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.
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 is activated by telecommand (IES-DATA-ACQ-TABLE) 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 data packaging that is to take place and the duration of acquisition before the cycle repeats. Each acquisition table is closely coupled with one of the science telemetry rates: minimal, normal and burst. 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.

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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 RO-IRFU-LAPMPF 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

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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 the **LAP Instrument User manual IRFU-RPC-LAPCTM**.

3.1.2.5   MIP

No special care is required to switch on MIP (See **MIP/PIU Data Handling Interface, RPC/MIP/RP/126/990253/LPCE, Ed.3, Rev. 3, 23/5/2001**).
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.

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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 mis-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   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

3.2.2.1   IES Notes

The default power on procedure for normal flight operations should be out of location $c:0000 which is where the boot prom will automatically jump to without further commanding. For current testing only, we need to perform the special IES-INSTR-PROG-MODE PAUSE and IES-MEM-GO 0xE 0x0000.

3.2.2.2   ICA Notes

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).

3.2.2.3   LAP Notes

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).

3.2.2.4   PIU Notes

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.

3.2.3   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.

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3.2.3.1   RPC Power On

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

OBCP Title	RSDB Name	Function	Invocation	
PL_OBCP_5_RP.1 RPC POWER ON	KRPR8091	Powers on RPC. Parameters select Redundancy Configuration and Software Location.	Ground, MTL, other OBCP	
Parameter Name	**RSDB Name (Calibration)**	**Function**	**CAL**	**Actual**
PAR1	FSKD1000	Selects Redundancy Cfg: LCL & PIU (DPIU/PSU)	NOMINAL	LCLA & Main
			REDUNDANT	LCLB & Red
PAR2	FSK01250	PIU SW Configuration	RAM	No patch
			EEPROM_PATCH	Patch
			EEPROM_PATCH_REBOOT	Patch & reboot
PAR3	FSK01251	PIU E2prom Software Patch Location (0x00000-0x1ffff)	Specified at call-time	Specified at call-time

Table 3.2-1: OBCP Details: OBCP_5_RP.1

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.

This OBCP is invoked by (FOP issue 5.0):

- ARPF801A (RP-FCP-801) "RPC ON MAIN via OBCP" with parameters:

  PAR1 = NOMINAL
  PAR2 = EEPROM_PA_RE
  PAR3 = 12C00 <hex>

- ARPF802A (RP-FCP-802) "RPC ON RED via OBCP" with parameters:

  PAR1 = REDUNDANT
  PAR2 = EEPROM_PA_RE
  PAR3 = 12000 <hex>

- ARPE801A "RPC On Main OBCP EQM" with parameters:

  PAR1 = NOMINAL
  PAR2 = EEPROM_PA_RE
  PAR3 = None

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3.2.3.2 Power Off

OBCP Title	RSDB Name	Function	Invocation	
PL_OBCP_5_RP.2 RPC POWER OFF	KRPR8092	Powers off RPC.	Ground, MTL, other OBCP, DMS SW	
Parameter Name	RSDB Name (Calibration)	Function	CAL	Actual

Table 3.2-2: OBCP Details: OBCP_5_RP.2

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

This OBCP is invoked by:

- ARPF800A (RP-FCP-800) "RPC Power OFF via OBCP"
- ARPF806A (RP-FCP-806) "RPC OBCP Pwr-Off"

3.2.3.3 Mode Control

The RPC suite of instruments can be configured by running the two OBCPs below. The first one is for configuring IES and ICA and the second is for configuring LAP, MIP and MAG.

OBCP Title	RSDB Name	Function	Invocation
PL_OBCP_5_ RP.3 RPC Mode Control	KRPR8093	Configures IES & ICA experiments of RPC into standard configurations	Ground, MTL
Parameter Name	RSDB Name (Calibration)	Function	Allowable Values (See below for values & meaning)
ModeIES	FSK01260	Selects 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	Selects 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 3.2-3: OBCP Details: OBCP_5_RP.3

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Notes:
- The OBCP will power the experiment on if required.

This OBCP is invoked by:

- ARPS803A "IES-ICA Mode Change" (RP-SEQ-803).
  Parameters are to be specified at call-time.

- ARPF806A (RP-FCP-806) "IES-ICA Mode Change"
  with parameters:

    ModeIES = OFF
    ModeICA = OFF
    IESParam = 00ff
    ICAParam = 00ff

OBCP Title	**RSDB Name**	**Function**	**Invocation**
PL_OBCP_5_RP.6 RPC Mode Control	KRPR8096	Configures LAP, MIP, MAG experiments of RPC into standard configurations	Ground, MTL
Parameter Name	RSDB Name (Calibration)	Function	Allowable Values (See below for values & meaning)
ModeLAP	FSK01262	Selects LAP Mode	NoChange, OFF, SID1, SID2, SID3, Maintenance, Quiet
ModeMIP	FSK01263	Selects MIP Mode	NoChange, OFF, SID1, SID2, SID3, Quiet
ModeMAG	FSK01264	Selects 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	Selects LAP EEprom Bank to boot from	??? Default = 0x0003

Table 3.2-4: OBCP Details: OBCP_5_RP.6

Notes:
- The OBCP will power the experiment on if required.

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This OBCP is invoked by:

- ARPS804A (RP-SEQ-804) "IES-ICA Mode Change".
  Parameters are to be specified at call-time.

- ARPF806A (RP-FCP-806) "IES-ICA Mode Change"
  with parameters:
      ModeLAP = OFF
      ModeMIP = OFF
      ModeMAG = Quiet
      LAPParam = 00ff
      MIPParam =00ff

Meaning of 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.

The `ModeType` is 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	(ICA & IES only) Power on HV supplies
SID1_HV_On	0xA1	(ICA & IES only) Power on HV supplies, set telemetry rate to SID 1
SID2_HV_On	0xA2	(ICA & IES only) Power on HV supplies, set telemetry rate to SID 2
SID3_HV_On	0xA3	(ICA & IES only) Power on HV supplies, set telemetry rate to SID 3
SID4_HV_On	0xA4	(ICA & IES only) Power on HV supplies, set telemetry rate to SID 4
SID5_HV_On	0xA5	(ICA & IES only) Power on HV supplies, set telemetry rate to SID 5
TEST_HV_On	0xA6	(ICA & IES only) Power on HV supplies, set telemetry rate to TEST
HV_Off	0xC0	(ICA & IES only) Power off HV supplies
Maintenance	0x20	Set unit to maintenance mode
Quiet	0x30	Turn off Science generation

Table 3.2-5: Configuration Parameter: MODE_TYPE

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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 should be made 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 3.2-6: Configuration Parameter: ExpParam

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

LAPSWEEpromBank	LAP	????	Default value = 0x0003

Notes:

- The `LAPSWEEpromBank` is only used when switching LAP on (i.e. the first time the OBCP is run from a LAP-OFF condition). Successive instances of the OBCP which are meant to change LAP configuration will not make use of this parameter.

3.2.4   LDL Mode Control

LDL can be controlled with OBCP and FCP.

3.2.4.1   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 Montitoring, other OBCP
Parameter Name	RSDB Name (Calibration)	Function	Allowable Values Enumerated (raw)
Action	FSK01270	Selects which configuration to set LAP & MIP in	Resync (0x00) Disable (0x01) EnableNorm (0x02) EnableMixed (0x03)

Table 3.2-7: OBCP Details: OBCP_5_RP.4

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Notes:

- Within the LDL OBCP LAP runs the *current* (at call time) macro 6.
- 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.

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

This OBCP is invoked by:

- ARPS805A (RP-SEQ-805) " RPC LDL Mode ".
  Parameter is to be specified at call-time.

3.2.4.2   LDL Control with FCP

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

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

Table 3.2-8: LDLmode FCPs

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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.

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.

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3.3 Operational Requirements and Constraints

3.3.1 ICA Field-of-View

According to Table 1.2-5 the particles can enter the ICA sensor between 45° and 135° wrt. the vertical axis. The polar-angle FOV is 360°.

3.3.2 IES Field-of-View

According to Table 1.2-4 the IES FOV wrt. the vertical axis is ±45°. The polar-angle FOV is 360°.

3.3.3 LAP S/C Attitude Requirements

To enable the LAP experiment to perform low density ion measurements one or both of the LAP sensors should be occasionally in the shadow of the spacecraft, in sunlight or in solar wind. Therefore, it is necessary to know the s/c position & orientation with respect to the sun and the outlines & position of the s/c shadow zone with respect to the LAP sensors. It might happen that the s/c has to be turned to generate a shadow zone at the LAP sensors from time to time. The solar wind should come as close as possible towards the Z s/c – axis (Solar wind from -Zs/c – axis is excluded for measurement purposes).
More details can be found in the LAP User Manual IRFU-RPC-LAPCTM.

3.3.4 Environmental Pressure and dust??? for IES (DMS Service 19)

IES only requires the Rosina pressure, Rosina pressure alert and Giada dust flux information messages. If Rosina pressure, Rosina pressure gradient or Giada dust flux level as set by the IES-SAFETY-AMB-SET command are exceeded, the HV supplies will be brought down, an event message will be sent out and the IES instrument shall go to LVSCI-EEPROM mode, awaiting further instruction. IES response to the Giada "no-data" message, 0xEEEE, can be changed depending on mission operations. In general, this message should be benign and indicates that Giada is changing modes; however, by default, IES will turn off HV power supplies if this message is received. The IES-SAFETY-AMB-SET command can be used to make IES ignore the "no-data" message.

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.

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3.3.5 Thruster Warnings

TBD

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.
- IES and ICA must be off when a wheel offloading event takes place.

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.

3.4 Failure Detection and Recovery Strategy

3.4.1 Introduction

Failure detection occurs at three different levels:

- Spacecraft level i.e. DMS level (see section 3.4.3)
- PIU level (see section 3.4.4)
- Instrument level (see section 3.4.5)

Description of the strategy implemented by PIU to detect critical failures related to measurable physical quantities is described in section 3.4.2.

Detection of potentially dangerous conditions is performed on board the s/c by PIU or DMS monitoring physical parameters such as voltages and temperatures, that are vital to RPC.
In case of a potentially dangerous condition being detected, PIU and DMS will take autonomous action and put the offending unit in a safe condition (usually switch-off) and 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

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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 FOP RO-ESC-PL-5000.

3.4.2   Critical Failures Detection Strategy

Some of the parameters monitored by PIU are physical quantities such as voltages and temperatures. For this kind of parameters two operational limits have been set: a *warning* level and a *danger* level. PIU will react in case of a parameter reaching either level and the action taken depends on the offending unit (sub-unit or PIU) and on the nature of the failure.

The monitoring and contingency strategy implemented in PIU is explained below.

1. In case of a *warning* limit being reached:

    PIU will generate event YRP0AEC3 "EC_ParamMntrWrning" (regardless of the offending unit). The events parameters contains details of the event occurred.

2. In case of a parameter reaching *danger* level:

    PIU will generate event YRP0AEC4 "EC_ParamMntrDanger" and:
    i.   if the offending unit is ICA, IES, LAP, MIP or MAG:
        1.   PIU will switch the instrument off and generate the event YRP0AE84 "EC_AutoShutDown".
        2. The DMS will trap YRP0AEC4 and execute OBCP PL_OBCP_5_RP.5 KRPS8095. No action is performed by this OBCP if the offending unit is an instrument.
    ii.   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 and execute OBCP PL_OBCP_5_RP.5 KRPS8095 which will power PIU off.
3. In case of PIU detecting MIP watchdog being fired:
        PIU will power MIP down and generate event YRP0AE81 "EC_MipDogBarking".

3.4.3   DMS Monitoring of RPC

The DMS is in charge of monitoring the physical quantities and events

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that cannot be monitored directly by the PIU.
The table below lists the events monitored by DMS and upon which DMS will react.

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Event	Related RPC RSDB info	Action
LCL Current Trip	N/A	No immediate action required as events powers off all RPC units
Detection of event YRP0AEC4 "EC_ParamMntrDanger" being generated by PIU. i.e.: one of parameters monitored by PIU has reached *danger* level	NRPA0525	Event is always 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= 0x0003 (+5V danger level) 0x0006 (-5V danger level) 0x0009 (+12V danger level) 0x000B (-12V danger level) 0x000F (28V danger level) 0x0012 (Temperature danger level) • do nothing for all other values of NRPA0525.
Detection of event YRP0AEC1 "EC_BadLdlSync" being generated by PIU. i.e.: LDL is out of sync	None	Event is trapped by DMS which will run OBCP KRPS8094 with parameter Action = Resync
Onboard monitoring: RPC +5V level out-of-limits	YRP00325 NRPD0310	DMS will shut RPC down
Onboard monitoring: RPC -5V level out-of-limits	YRP00325 NRPD0317	DMS w shut RPC down

Table 3.4-1: Events monitored by the DMS

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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.

Event	Related RPC RSDB info	Action
PIU Voltage Level at Danger/Warning Level	Monitored Parameters NRPD0310 (+5V) NRPD0317 (-5V) NRPD0320 (+12V) NRPD0327 (-12V) NRPD0330 (28V) Events 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 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.

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Event	Related RPC RSDB info	Action
PIU Temperature at Danger/Warning Level	Monitored Parameters NRPD0306 Events 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 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 at Danger/Warning Level	Monitored Parameters NRPD2360 NRPD2368 Events 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 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	Monitored Parameters NRPD530C NRPA5310 Events 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	Monitored Parameters NRPD5306 Events Generated YRP0AEC3 (Warning)	When the warning level is reached PIU will raise the event YRP0AEC3 "EC_ParamMntrWrning".
MIP Watchdog Signal Received by PIU	Events 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

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3.4.5 Instrument-Specific Failure Detection Mechasnisms

IES
IES has the following failure detection and recovery strategies:

- 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.
  A check of the low-voltage power supplies (+5V, -5V, +12V, -12V)
  during LVSCI-EEPROM operation. Anomalous behavior is reported through housekeeping and event messaging.

- 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, an event message is sent out and IES goes to the safe, LVSCI-EEPROM mode awaiting further instruction.

- During HVSCI-EEPROM operation with HV supplies on, the electron and ion count rates are monitored for excessively high values.   If these values are exceeded on either the electron or ion detectors for a predetermined period as specified by the IES-SAFETY-ELC-THRESH and IES-SAFETY-ION-THRESH commands, the HV supplies are brought down, an event message is sent out and IES goes to the safe, LVSCI-EEPROM mode awaiting further instruction.

- During HVSCI-EEPROM operation with HV supplies on, the Rosina pressure and Giada dust messages are monitored for excessively high values.   If these values are exceeded as specified by the IES-SAFETY-AMB-SET commands, the HV supplies are brought down, an event message is sent out and IES goes to the safe, LVSCI-EEPROM mode awaiting further instruction.

ICA
ICA has the following failure detection mechanisms:

- A watchdog counter that is periodically reset. Failure to do so will raise a hardware reset.
- 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.
- 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.
- 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 can not 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.

LAP

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

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.

If no data are received during TBD consecutive sequences, PIU resets the link.

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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. **Recovery :** Proceed MAG Power on for 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 **suspiscious behaviour** the MAG **HK channels** should be **examined**. Especially the Reference Voltage U_{ref} should be checked. Addional information can be achieved by reading out the OB-analog signals fed into the HK channels. This analog 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 3.4-3: Actionlist for MOC

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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 and DMS level before execution, the

1. Manipulate the TML which is already on-board by removing the unwanted commands and modifying the relevant OBCP parameter values. The feasibility of this action must be negotiation with 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)

TBD

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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 3.4-4: Contingency Recovery Procedures

The Contingency Recovery Procedure RP-CRP-001 defined in the FOP (R-ESC-PL-5000, Volume 5.09) 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 the EID/A section 5.2.1, in which the EGSE can be used in 3 phases.

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- **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.

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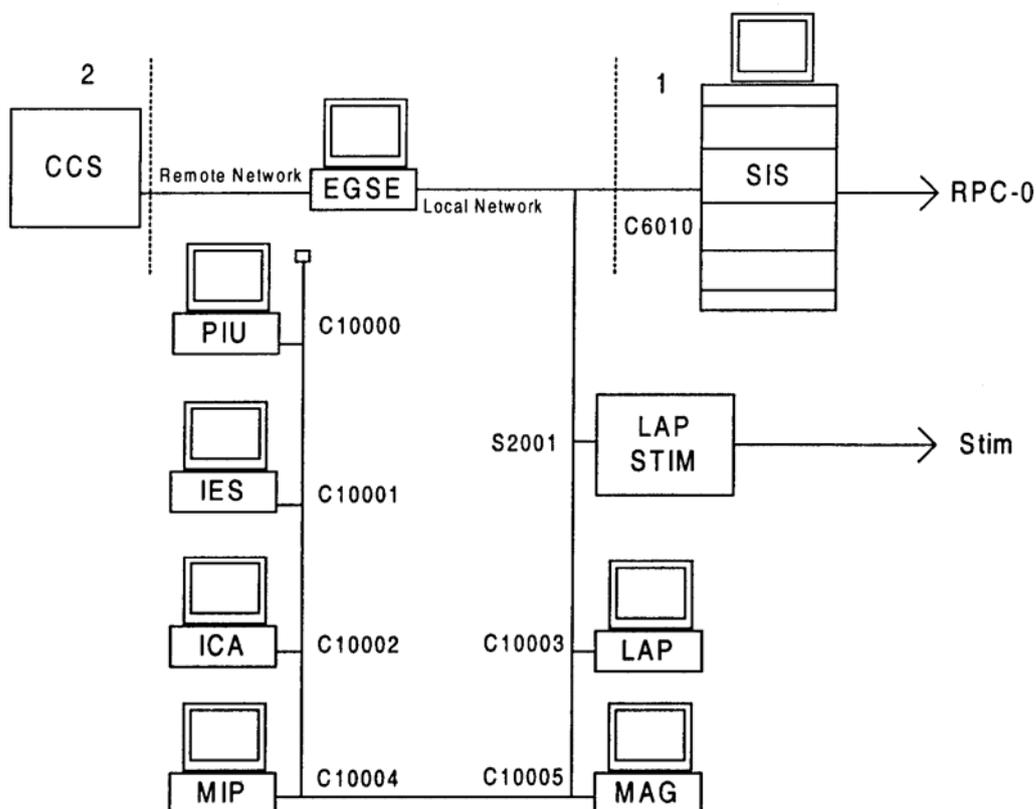
Figure 3.5-1: Overview of the RPC EGSE

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.

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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.

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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).
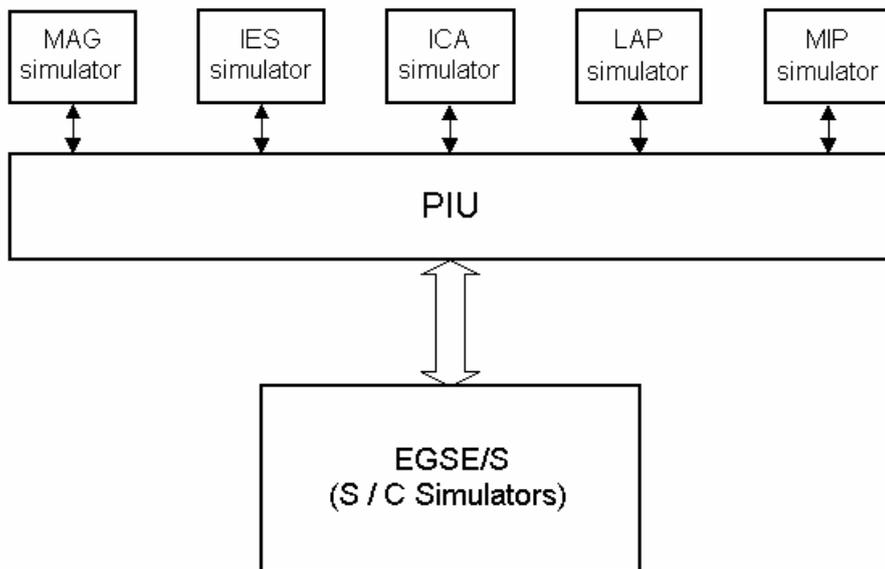
Figure 3.5-2: Autonomous Test of the PIU

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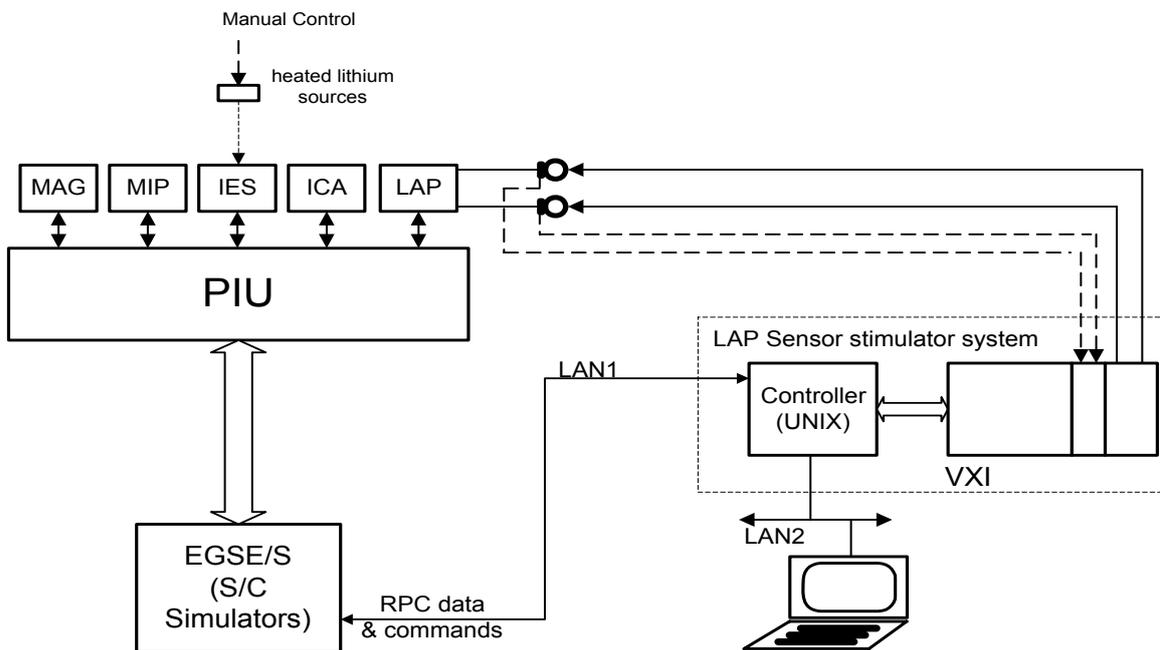
Figure 3.5-3: System Level Test of the Rosetta Plasma Package
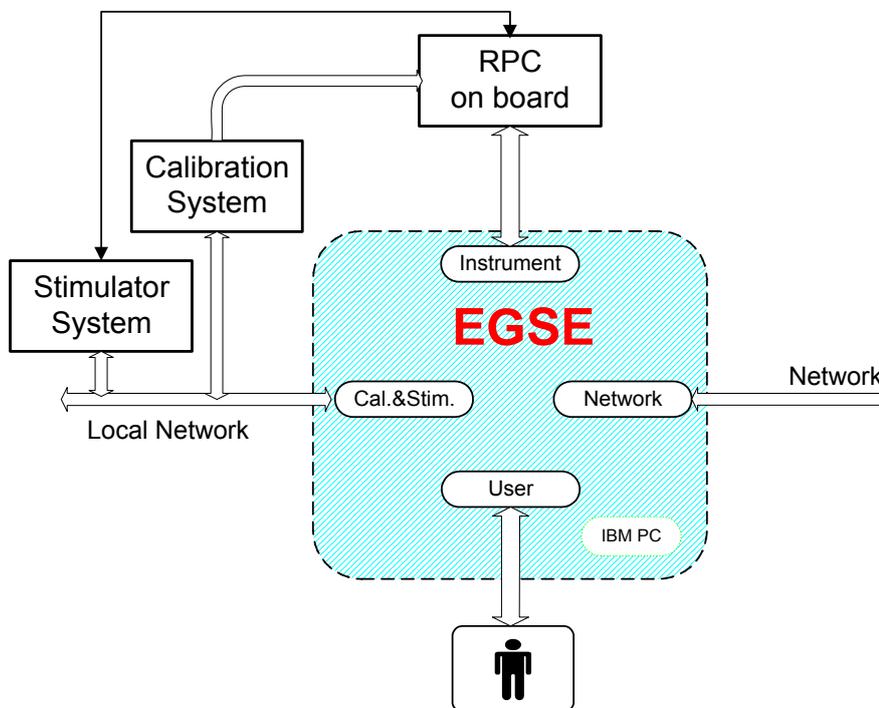
Figure 3.5-4: Logical Interfaces of the ICSTM EGSE

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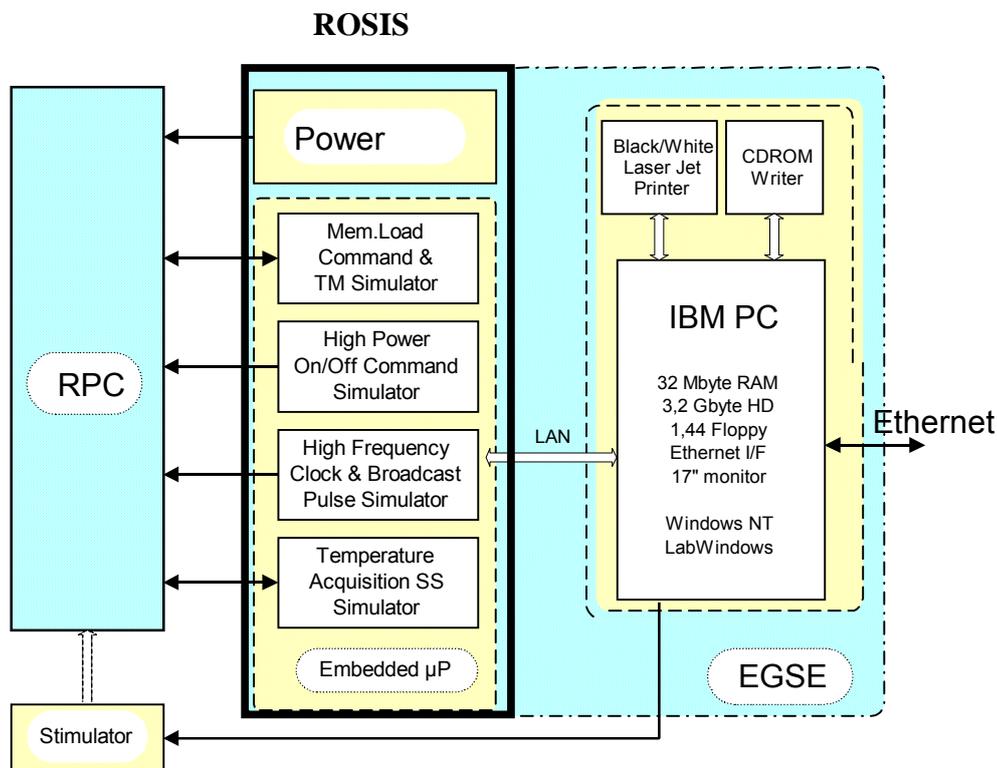
Figure 3.5-5: RPC Experiment Level testing with the ICSTM EGSE

3.5.2   In-orbit Commissioning Plan

For the In-orbit Commissioning Plan refer to the CVP document
RO-RPC-MA-6004 Commissioning Plan.

Details on the timeline and the procdures can be found in the FOP
RO-ESC-PL-5000

3.5.3   Flight Operations Plan for each Mission Phase

For the time schedule refer to **RO-ESC-TN-5026: Mission Calendar.**

Details about the overall mission can be found in the
**Consolidated Report on Mission Analysis Churyumov Gerasimenko
CreMA: RO-ESC-RP-5500.**

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.

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 (Jones et al. 2003, Astrophys. J., 597 :L61-64; Russell et al. 1984b, Science, 226, 43). Detailed calculations have been performed to investigate, whether ROSETTA will encounter a cometary

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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

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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 $\rightarrow$
  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 $\rightarrow$
  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).

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In Martian wake:

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

New plasma boundary:

- **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

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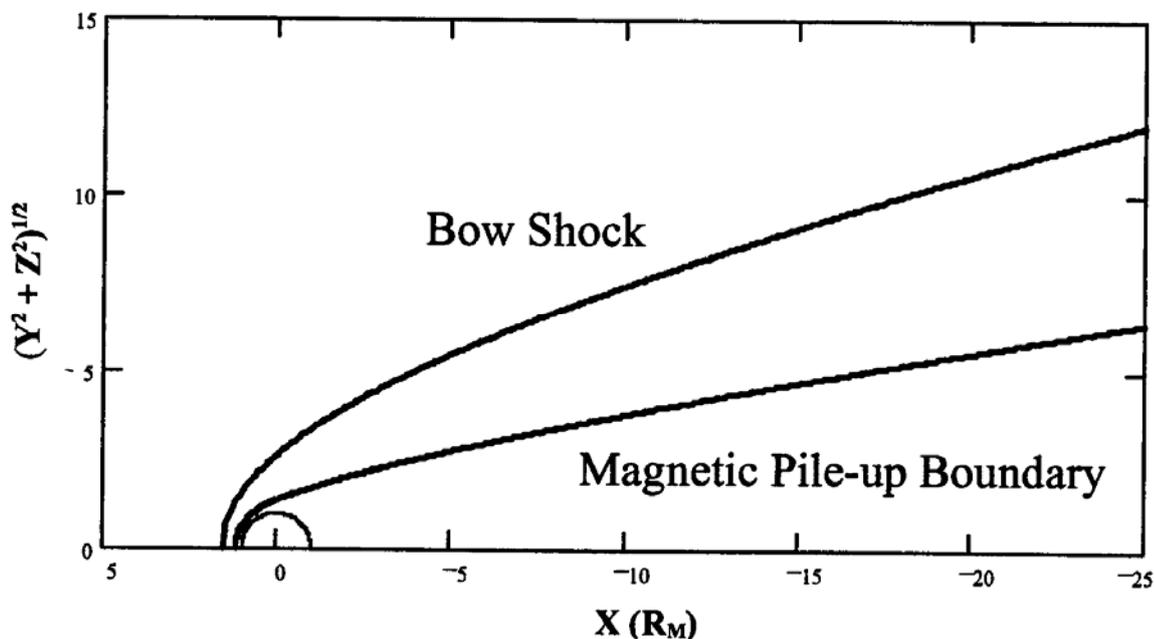
Figure 3.5-6: Martian Bow Shock and Pile-up Boundary

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

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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

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Figure 3.5-7: Mars Swing By - 1

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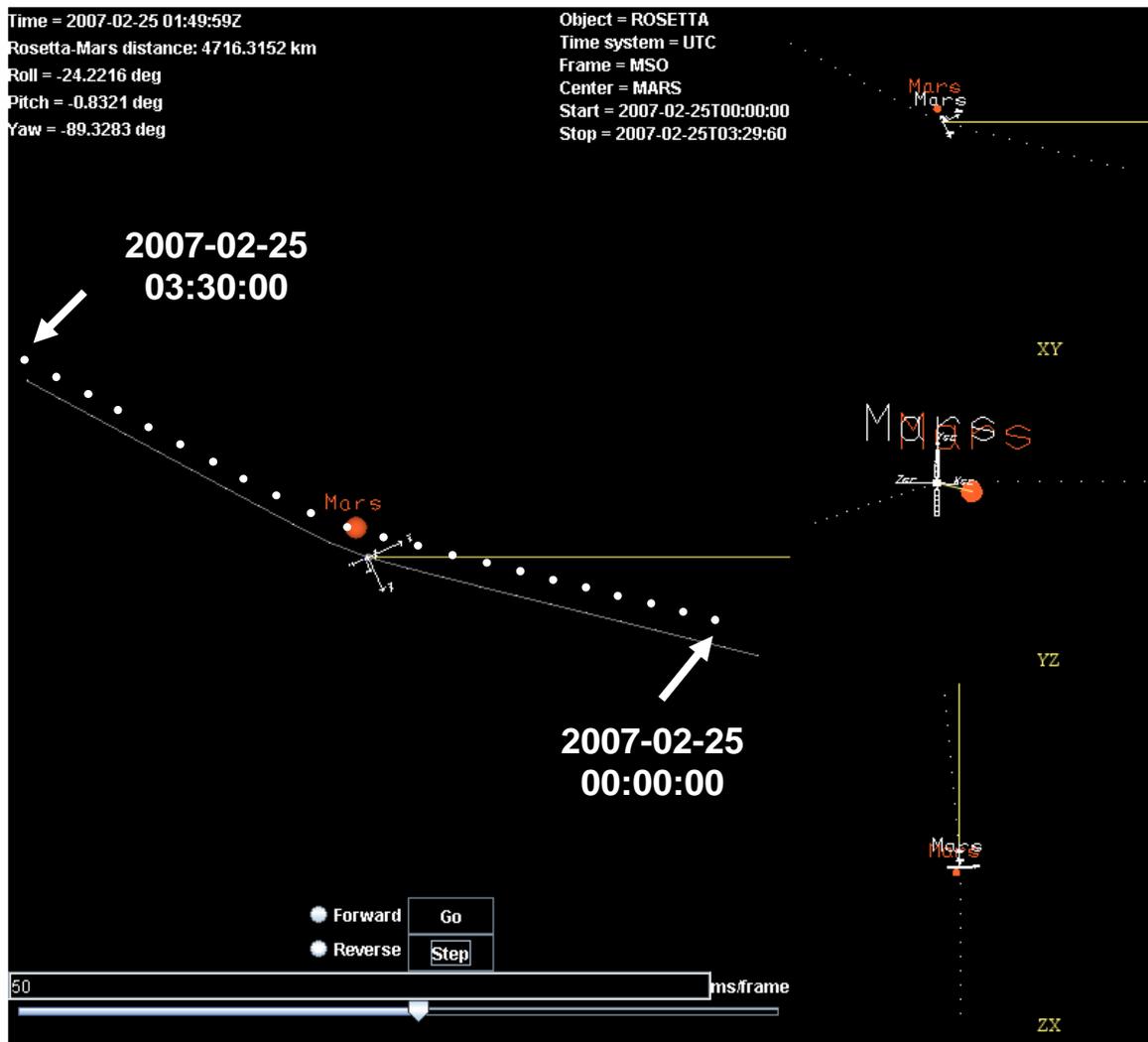
Figure 3.5-8: Mars Swing By - 2

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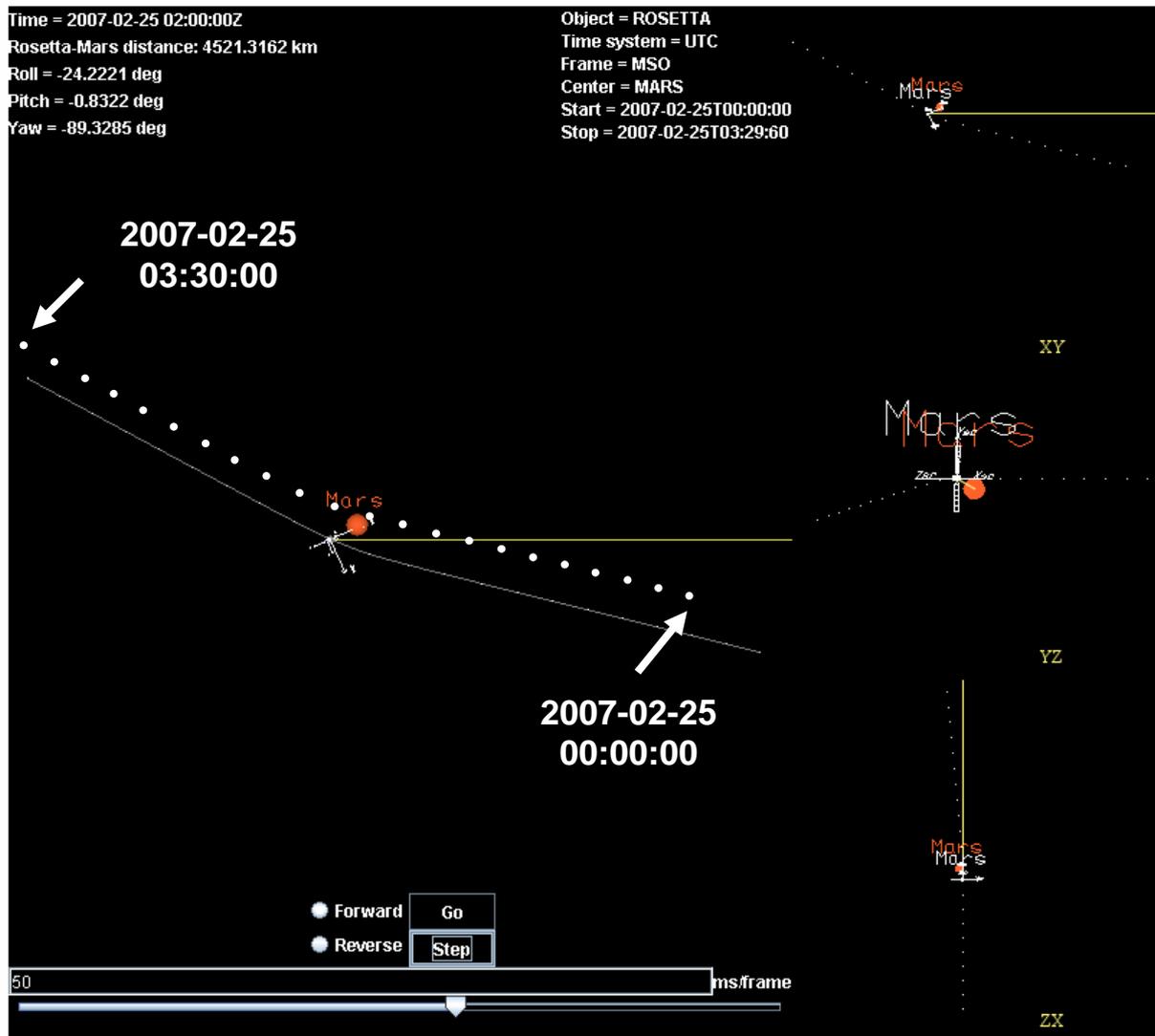
Figure 3.5-9: Mars Swing By - 3

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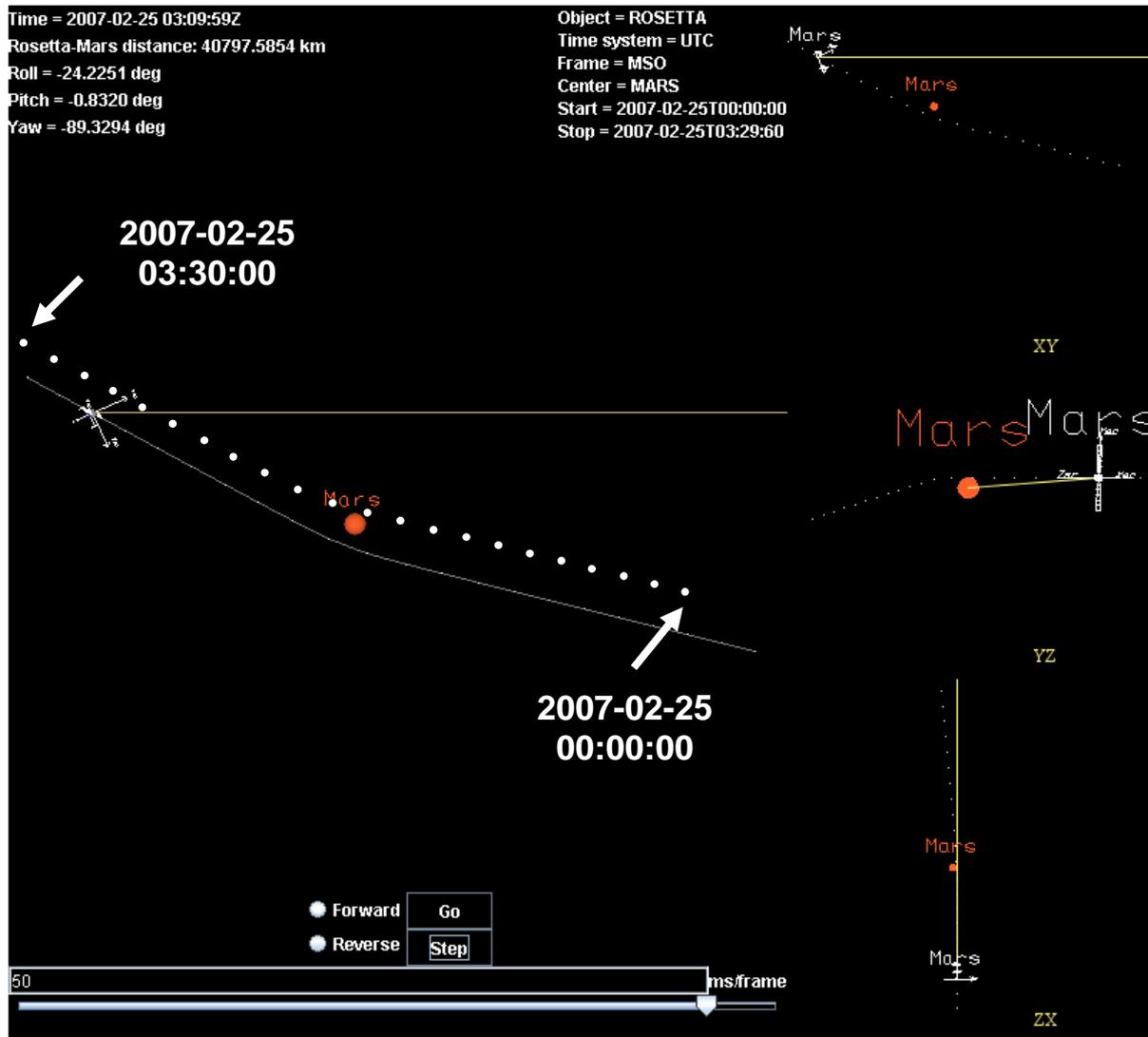
Figure 3.5-10: Mars Swing By - 4

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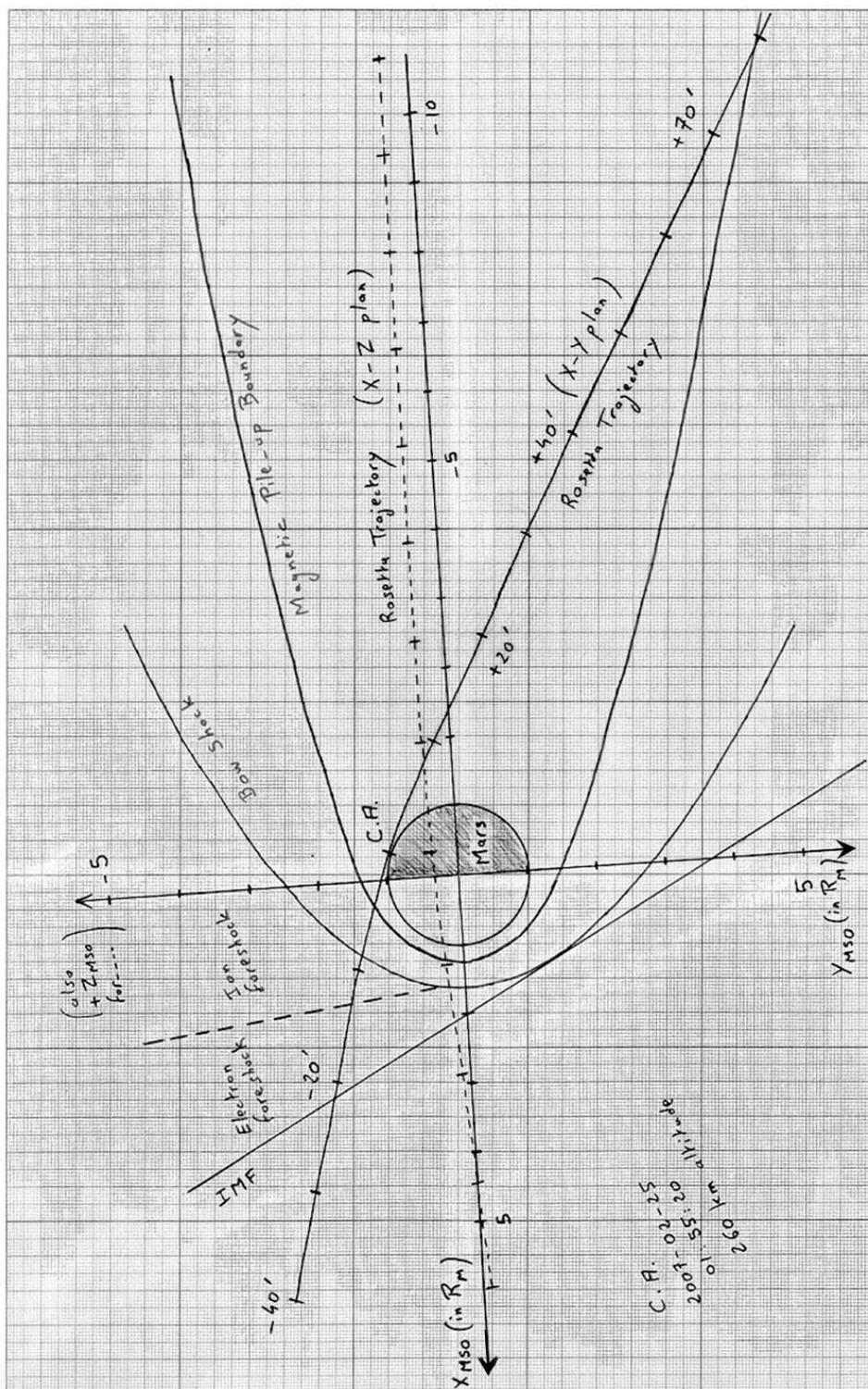
Figure 3.5-11: Mars Swing By Geometry, Plasmaphysical Situation

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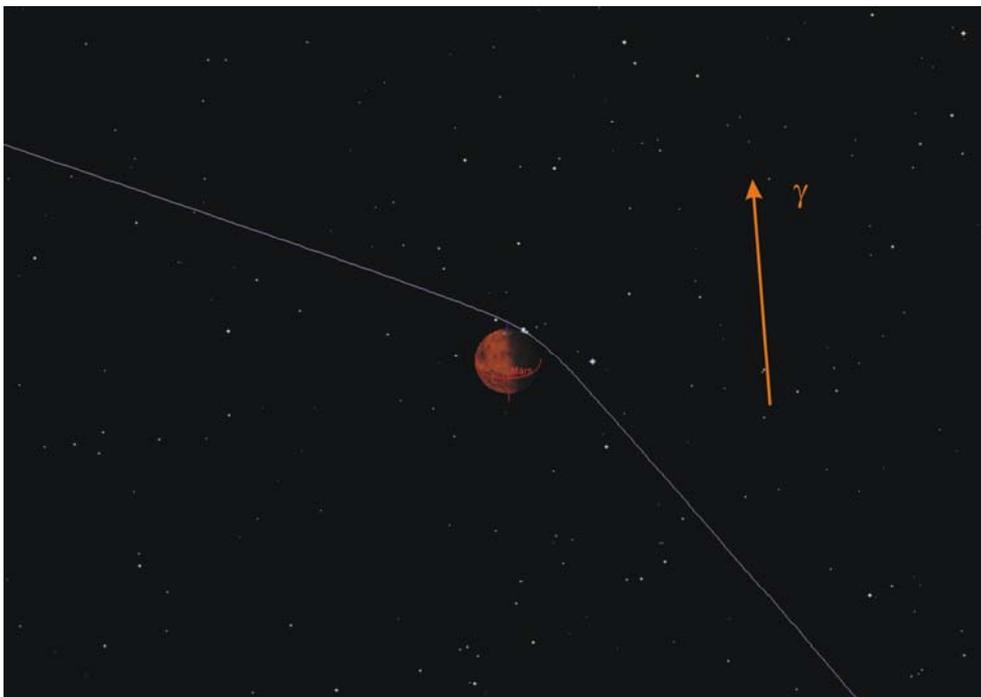
Figure 3.5-12: Mars Fly By Geometry , side view
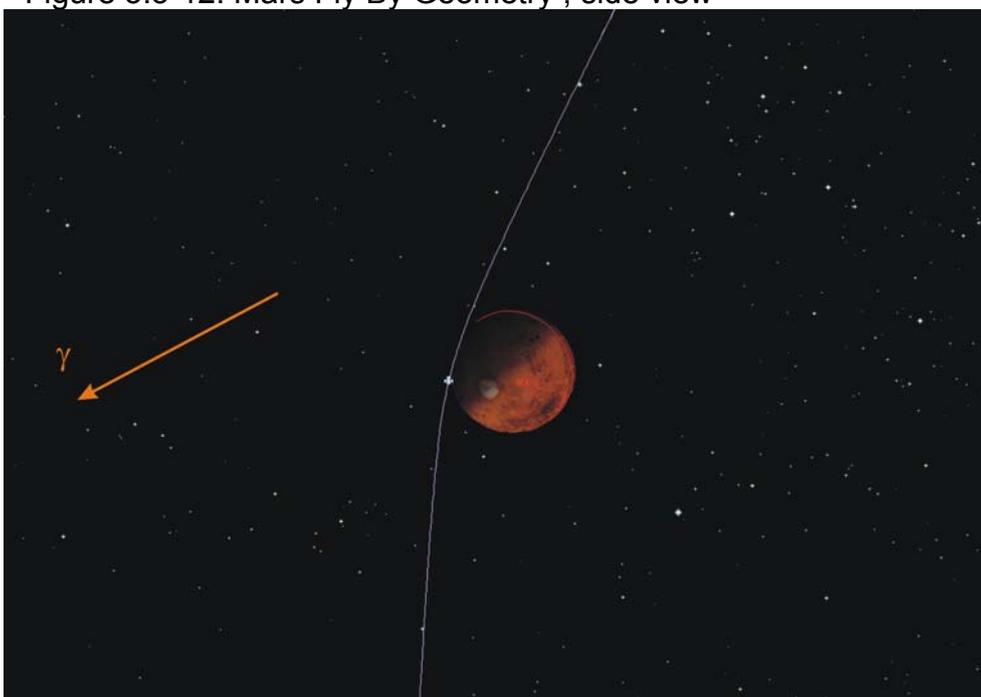
Figure 3.5-13: Mars Fly By Geometry , northern view

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X/Y

X/Z

Y/Z
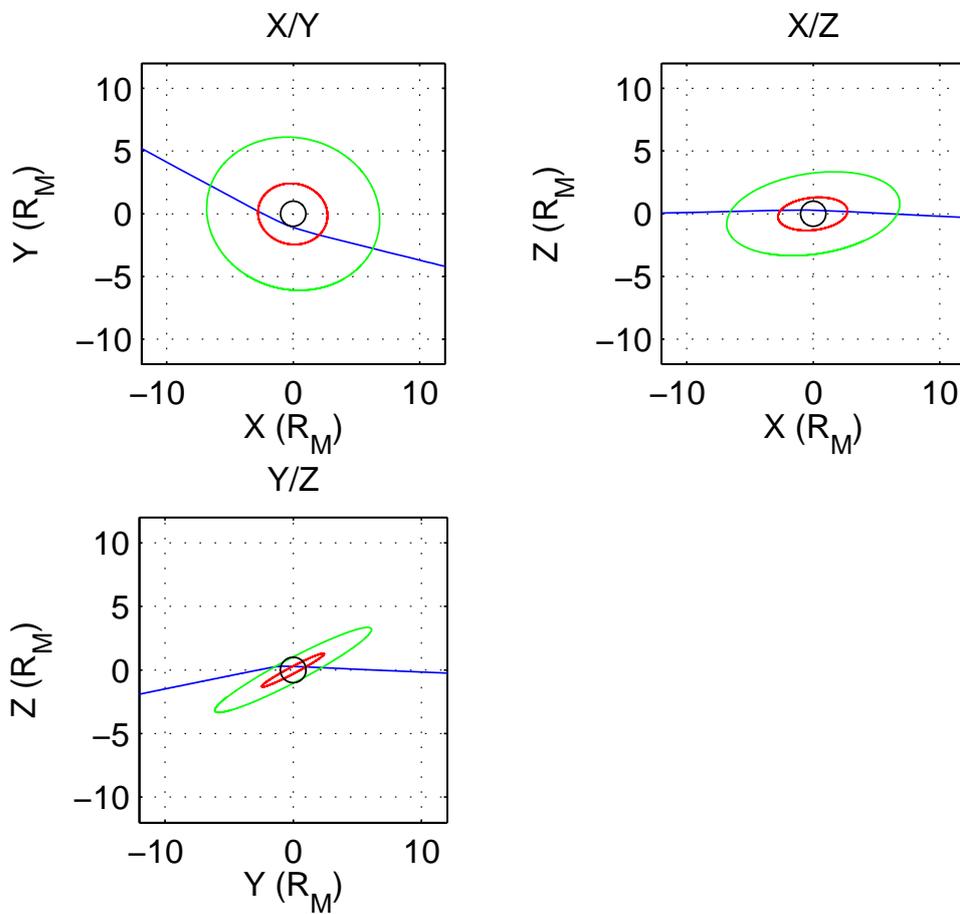
Figure 3.5-14: Mars Fly By Geometry , Projections

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Rosetta Mars flyby – 3D MSO plot
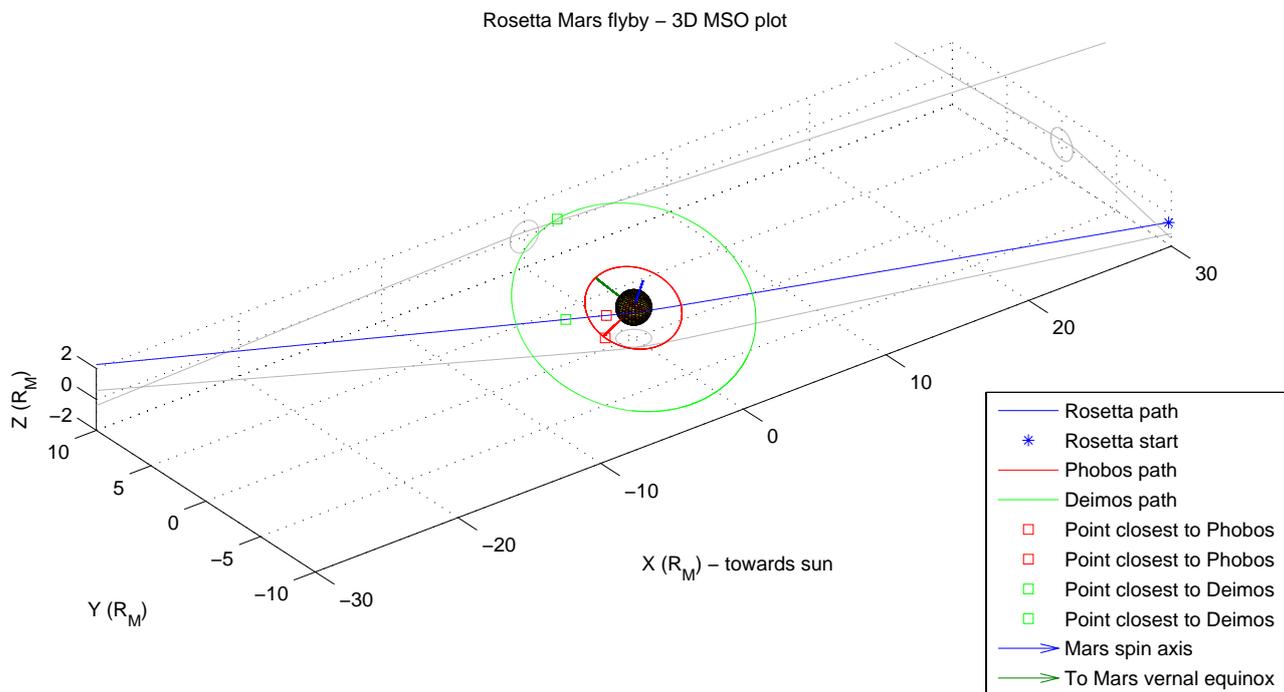
Figure 3.5-15: Mars Fly by , 3D Model
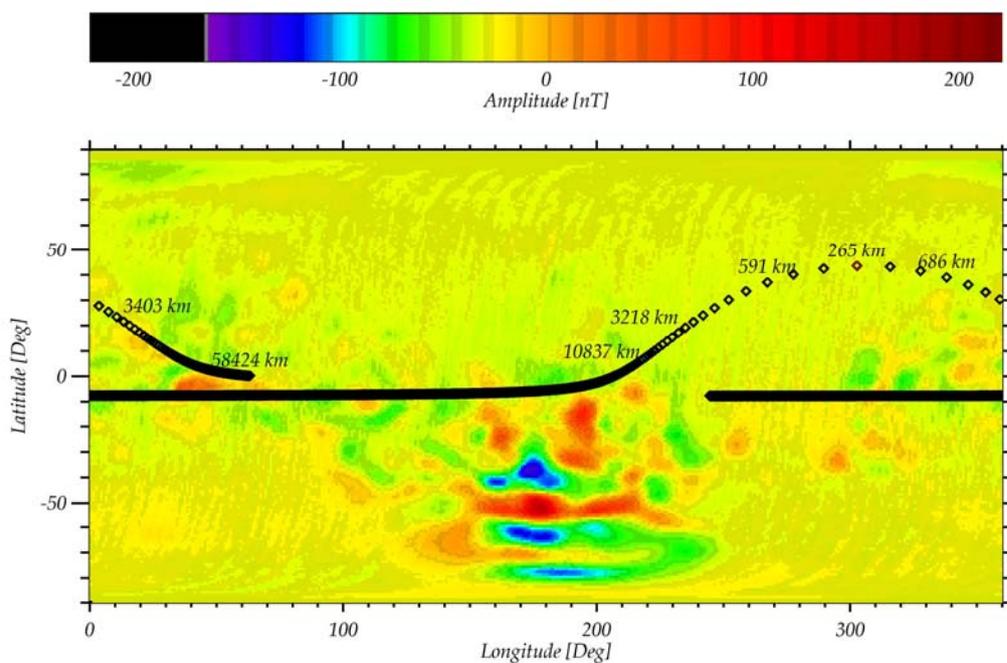
Figure 3.5-16: Mars Fly by with magnetic field model

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The Rosetta trajectory projected on the Martian magnetosphere, 25–feb–2007
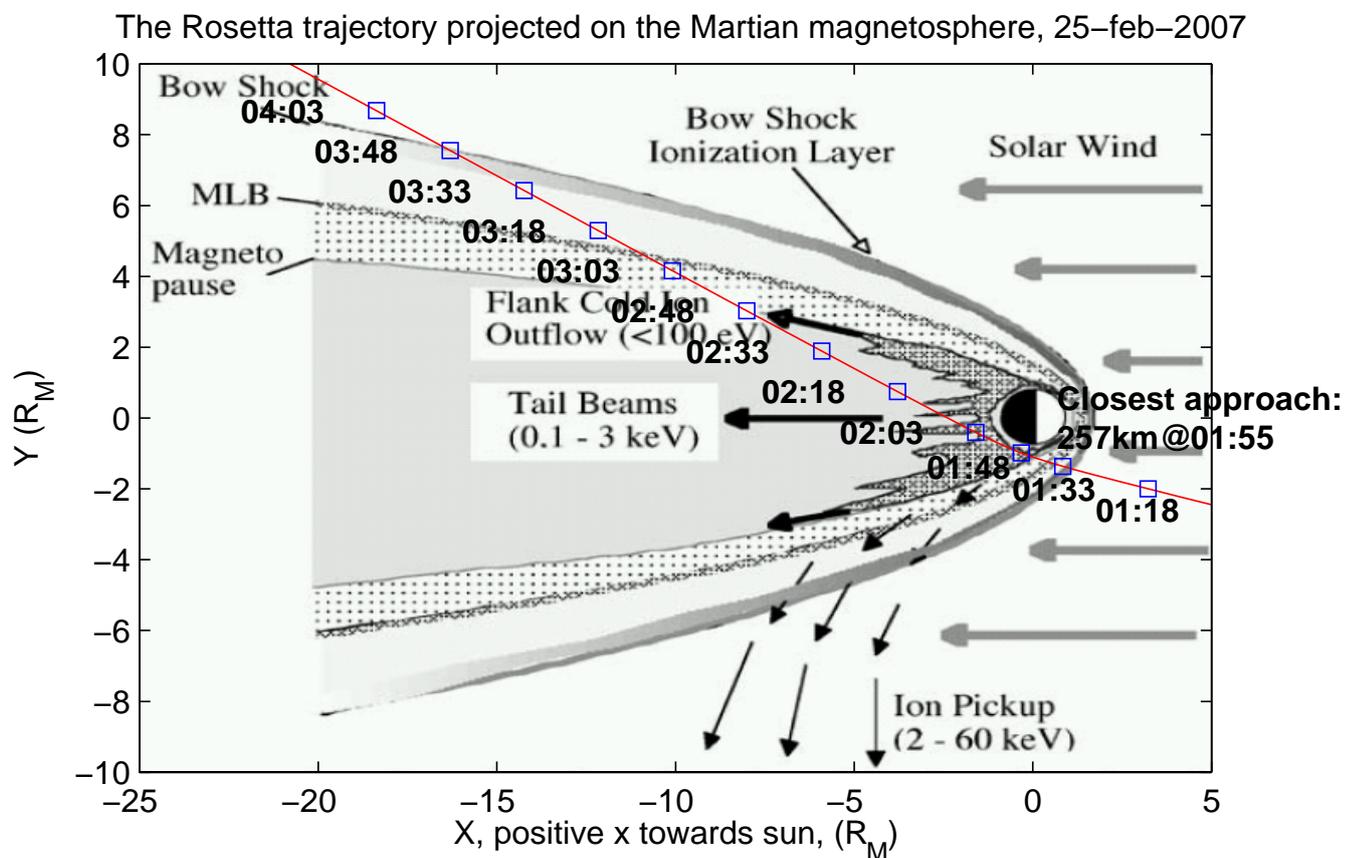
Figure 3.5-17: Mars Fly by & Martian Magnetosphere

Additional information can be found in the document:
RO-ESC-TN-5018 : Planet Flyby Ops

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 [AD-E1], Galileo [AD-E2], or more recently the CASSINI flyby at Earth [AD-E3] 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 (see Figs. 1 and 2). 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.

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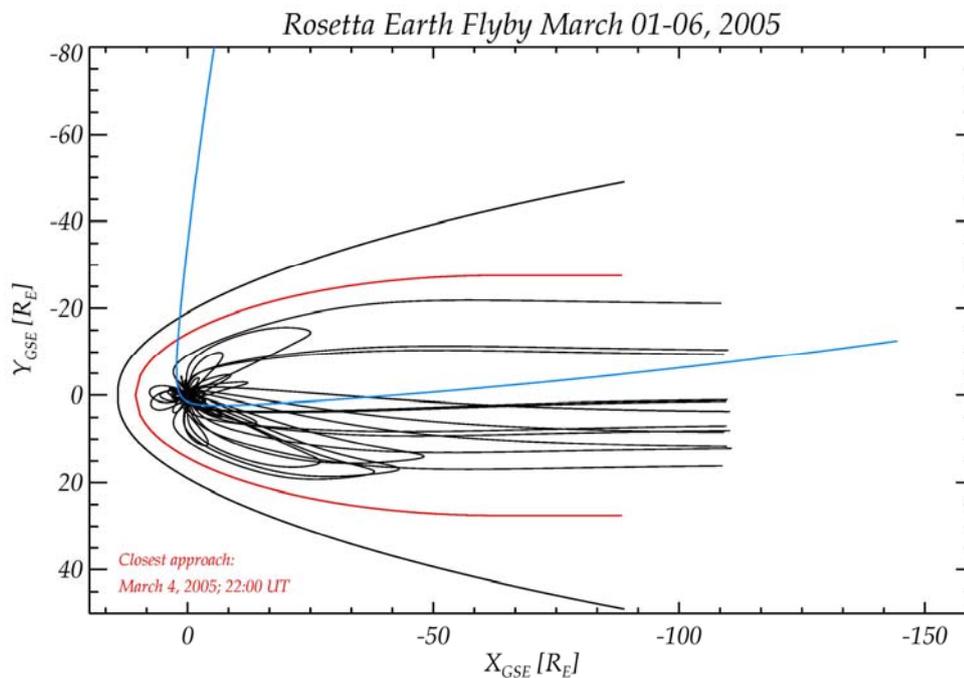
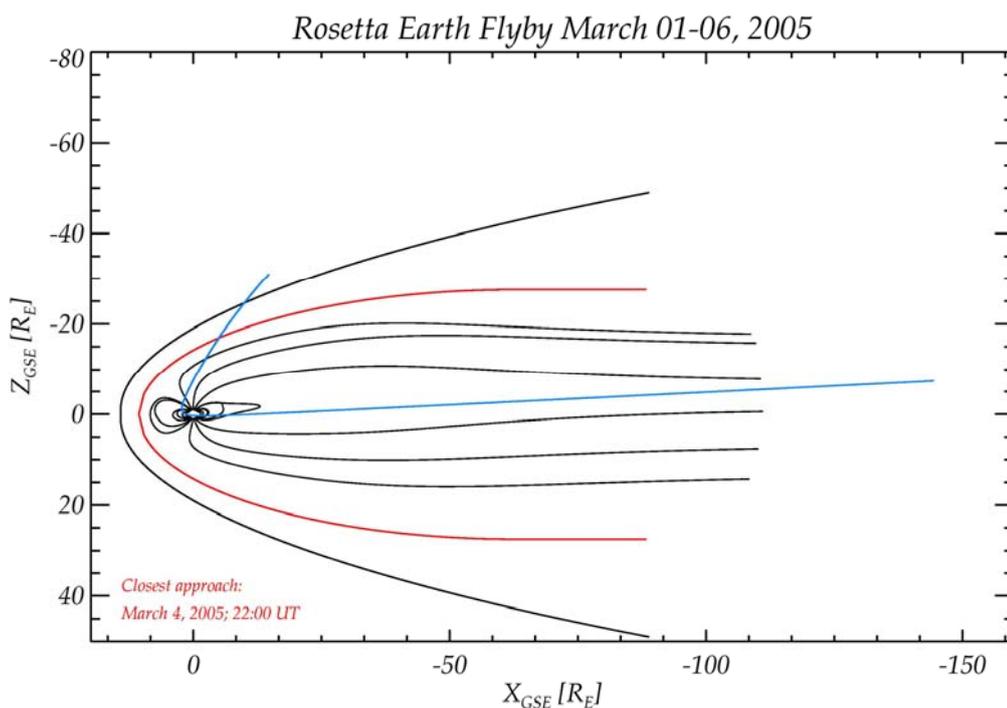Figure 3.5-18: The Rosetta trajectory (blue) during EF1: x-y plane.

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

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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 [AD-E3]. 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.

3.5.3.3.1 Applicibable Documents

[AD-E1] Glassmeier, K.-H., F.M. Neubauer, G. Brach, H. Marschall, M.H. Acuna, L.F. Burlaga, F. Mariani, G. Musmann, N.F. Ness, M.K. Wallis, E. Ungstrup, H.U. Schmidt, Giotto's mission to planet Earth, Geophys. Res. Lett., 18, 1663-1666, 1991.

[AD-E2] Kivelson, M.G., A. Prevost, F.V. Coroniti, K. K. Khurana, D. J. Southwood, Galileo flybys of Earth: the nature of the distant shock, Adv. Space Res. 16, 197, 1995.

[AD-E3] Special issue: Cassini's encounter with planet Earth, J. Geophys. Res.,106, 2001

[AD-E4] RO-ESC-TN-5018 : Planet Flyby Ops

[AD-E5] RO-EST-PL-3278: Earth Flyby #1

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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.
Every other parameter like spectral class etc. are unknow at the time of the UM release.

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	July 10, 2010
Distance	1700 km	3000 km
Flyby Velocity	~ 9 km/s	~ 15km/s

Table 3.5-5: Asteroidal FlyBy Parameter

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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.

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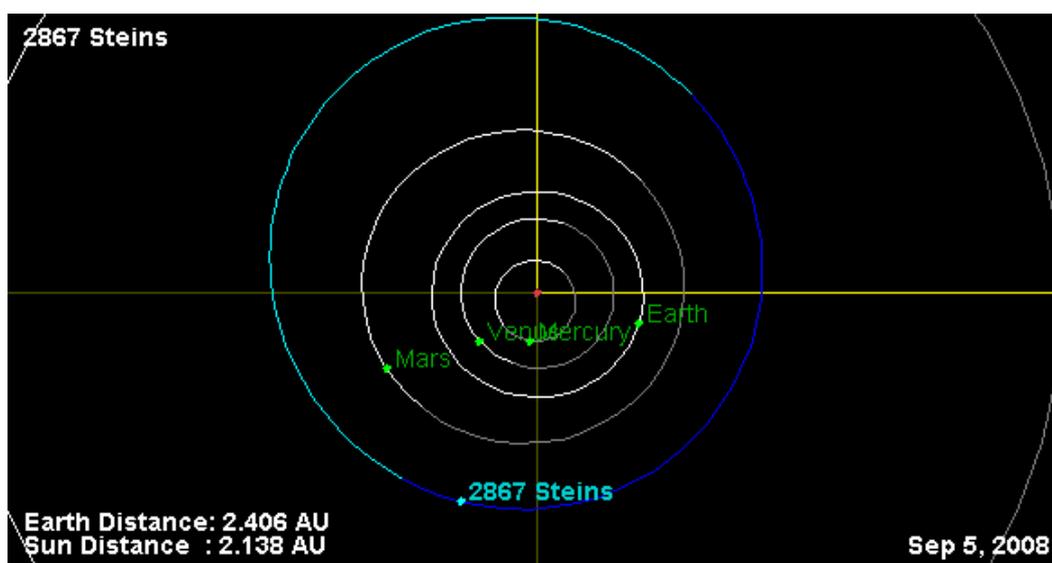Date : **April 10**, **2006**
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Flyby Trajectory:

STEINS:

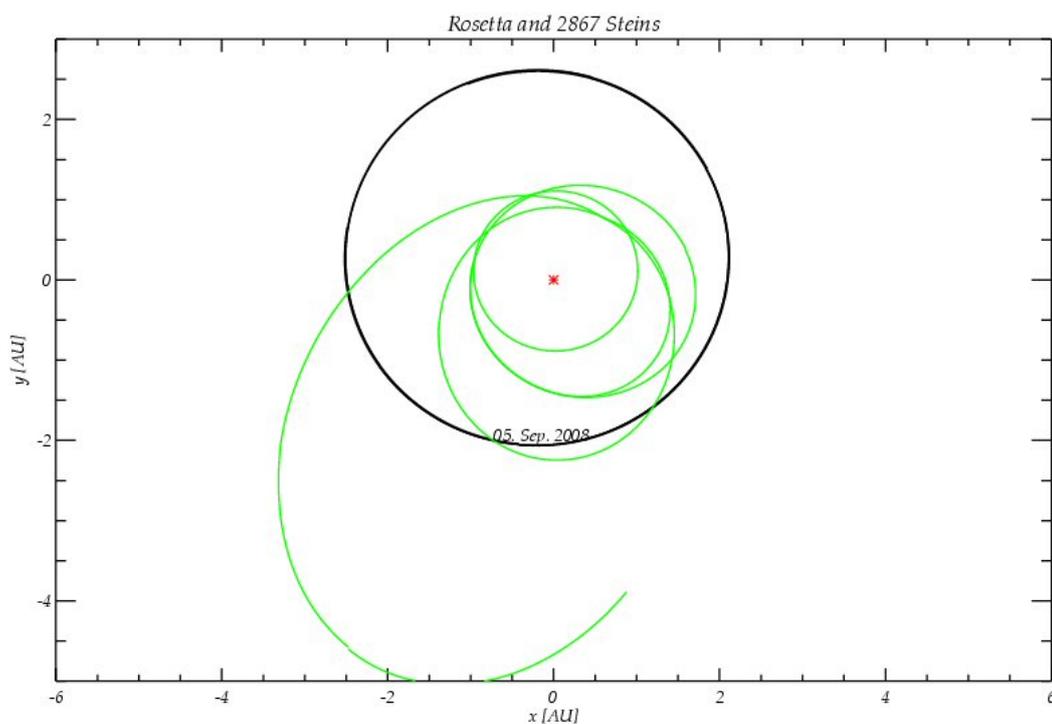Figure 3.5-20: The Orbit of Asteroid STEINS

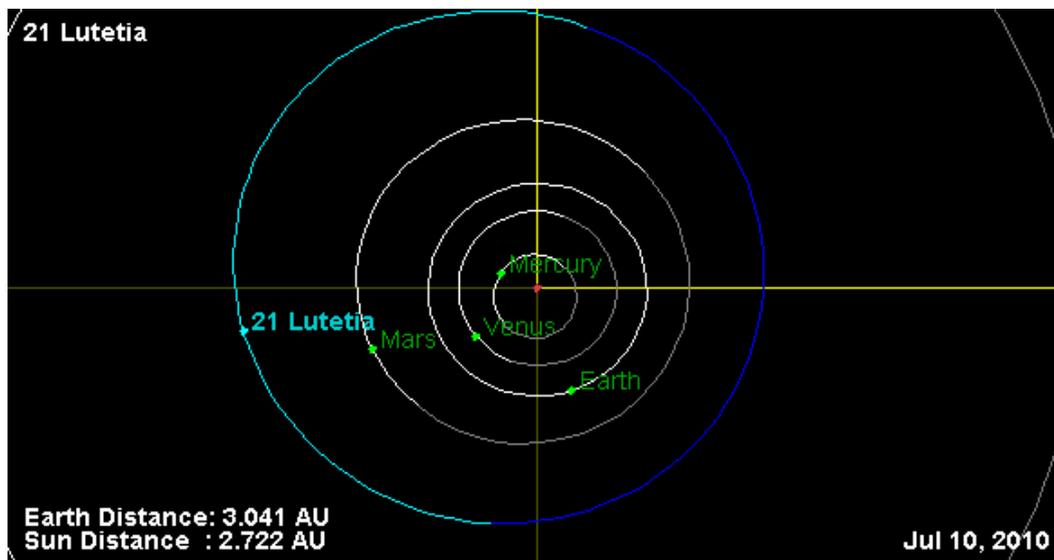Figure 3.5-21: Rosetta's flyby at Asteroid STEINS in September 2008

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LUTETIA:

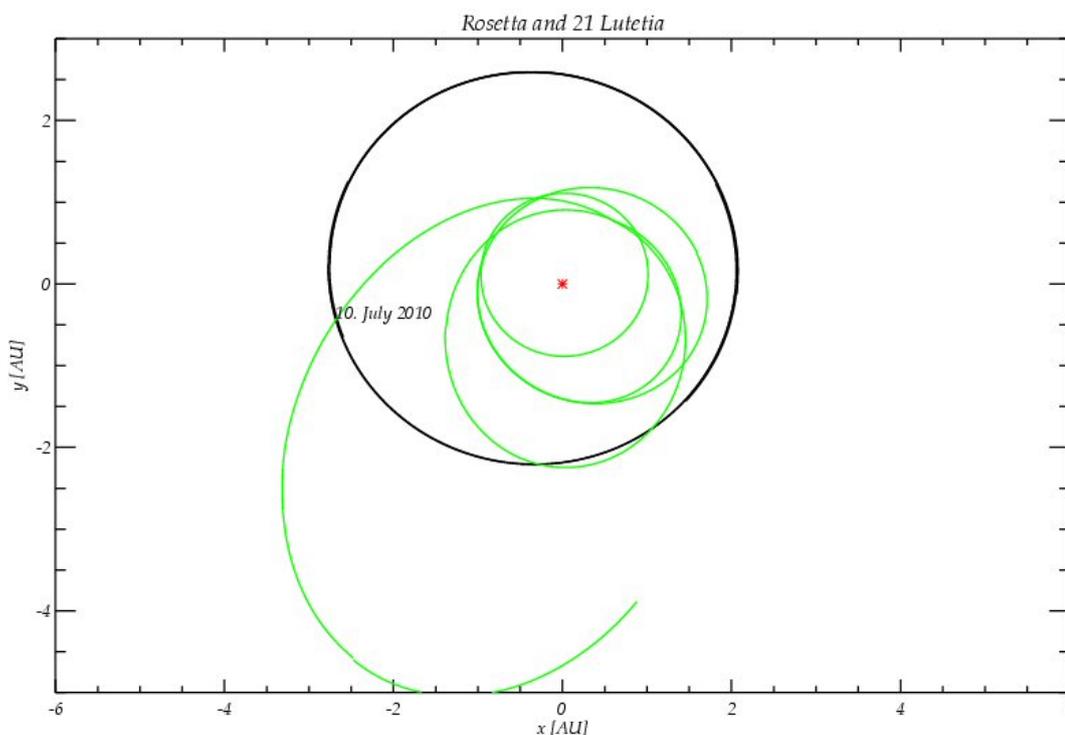Figure 3.5-22: The Orbit of Asteroid LUTETIA

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

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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 the document: **RO-ESC-TN-5017: Asteroid Flyby Ops**

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3.5.3.5   Comet Fly By

Additional information can be foud in the documents:
RO-EST-TN-3027: Mission scenarios - Close encounter
RO-ESC-TN-5506: The Near Comet Drift Phase

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4.0 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.
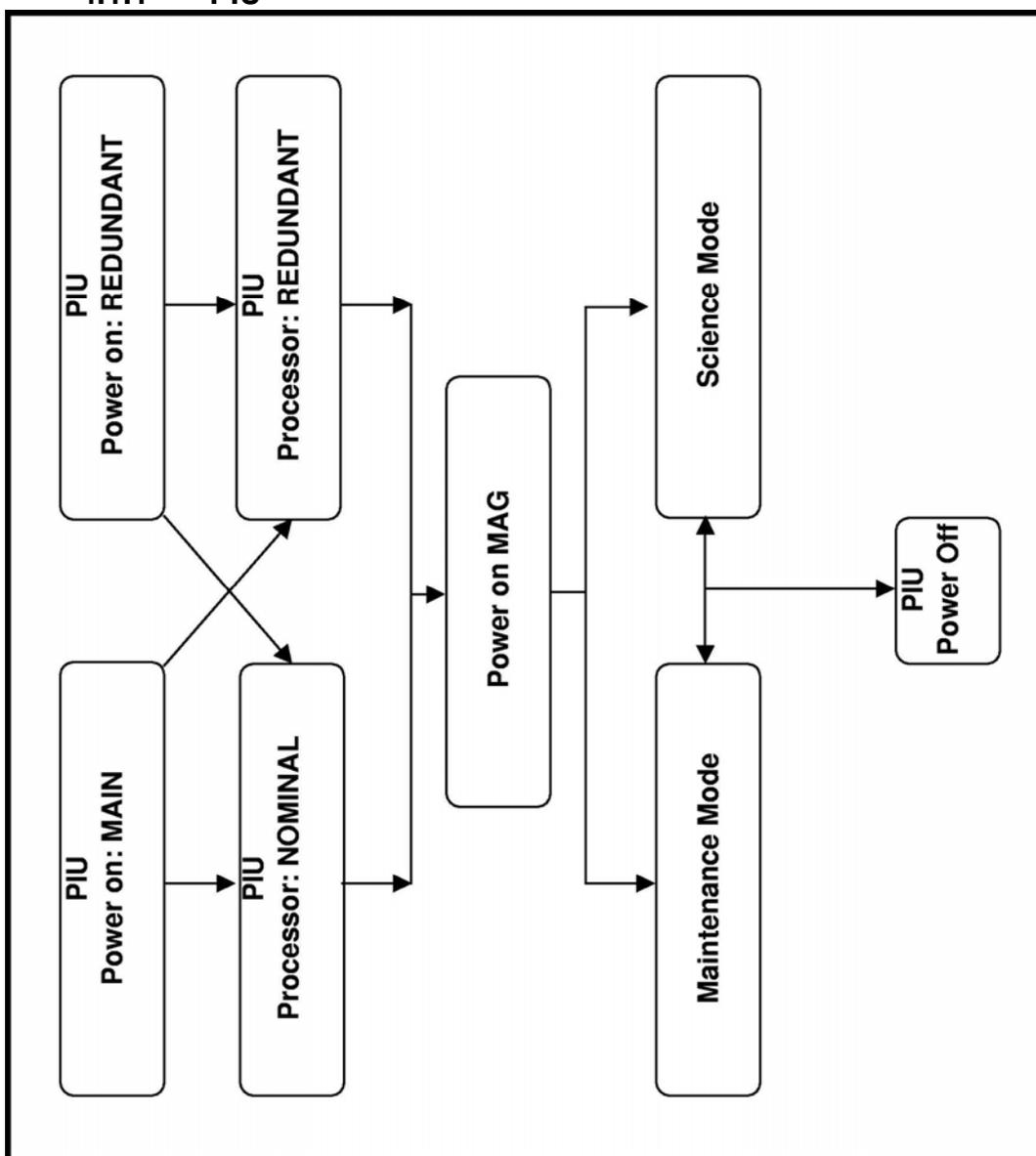
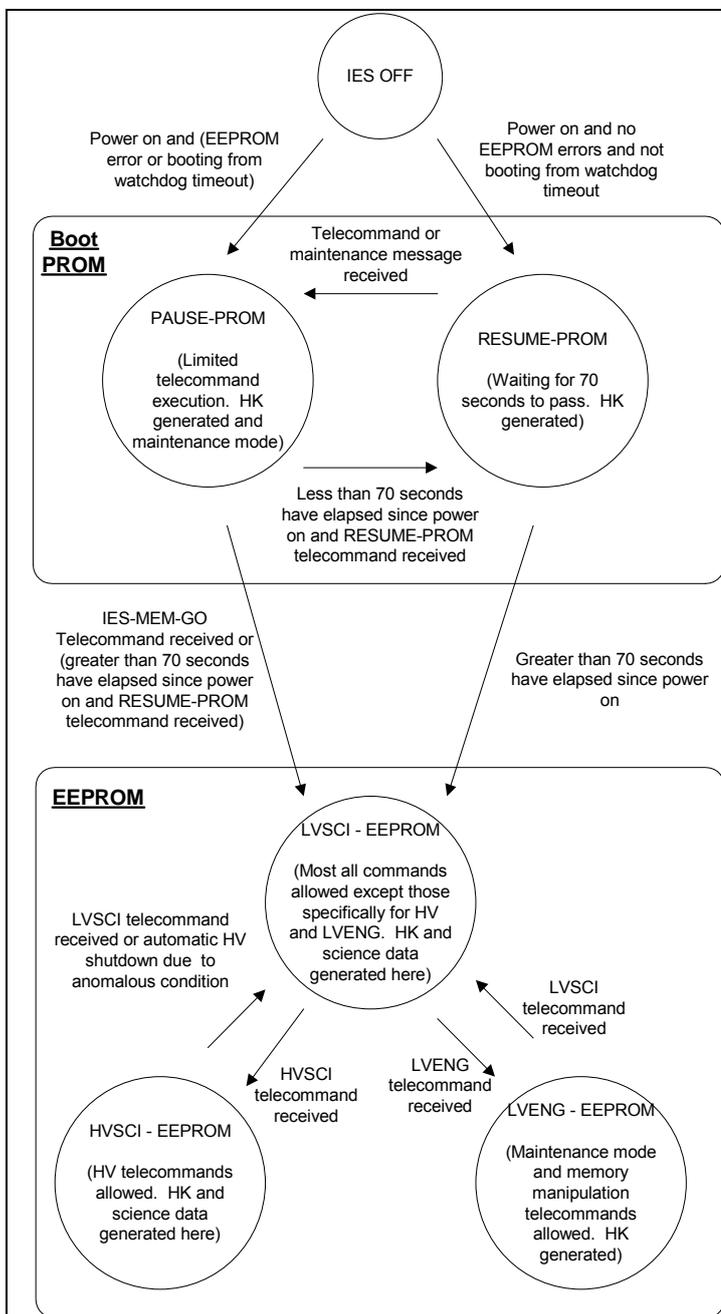### 4.1.1 PIU

Figure 4.1-1: PIU Mode Transition Diagram

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4.1.2 IES

Figure 4.1-2: IES Mode Transition Diagram.

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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.
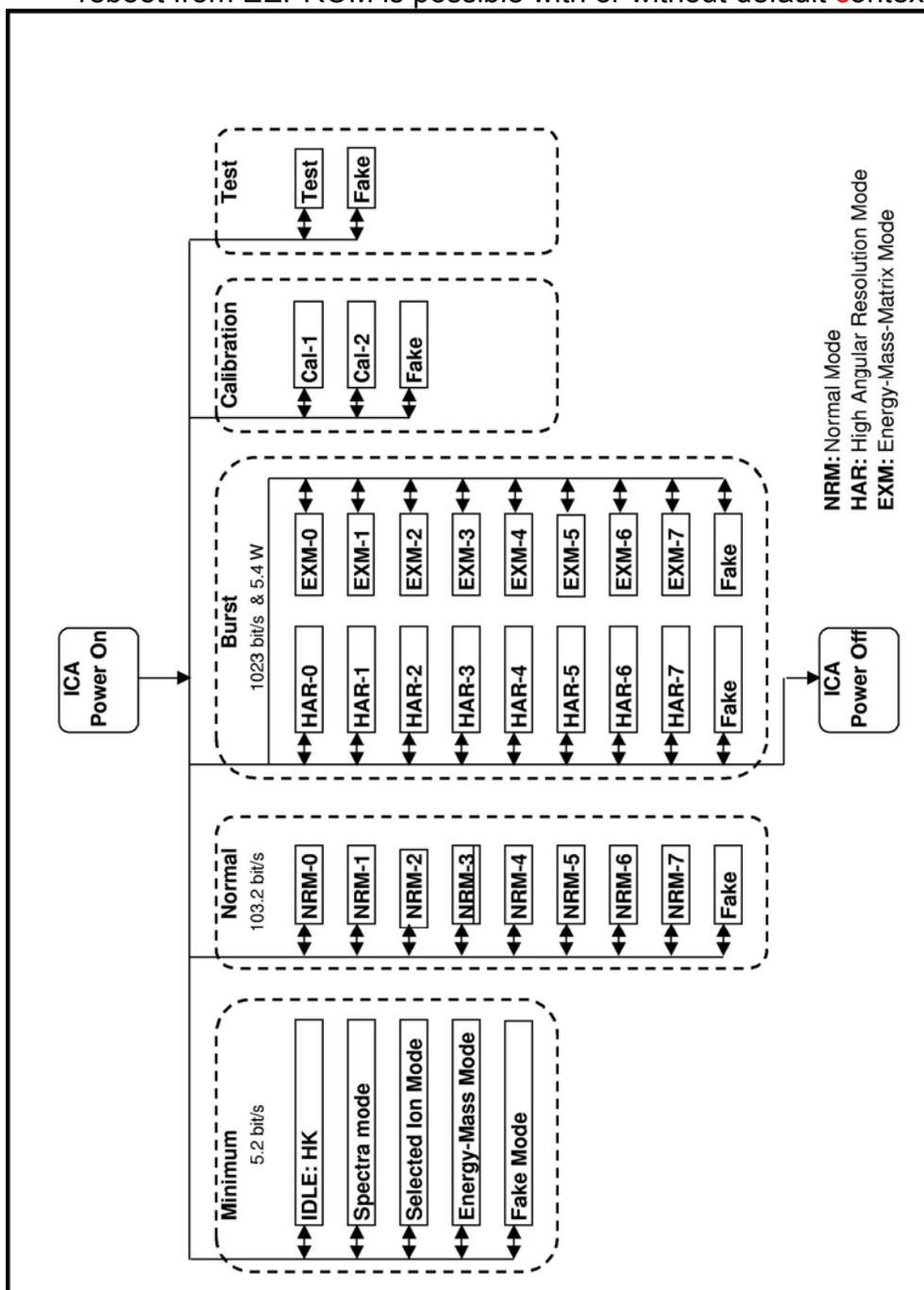

Figure 4.1-3: ICA Mode Tranisition Diagram

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4.1.4   LAP

Figure 4.1-4: LAP Mode Tranisition Diagram

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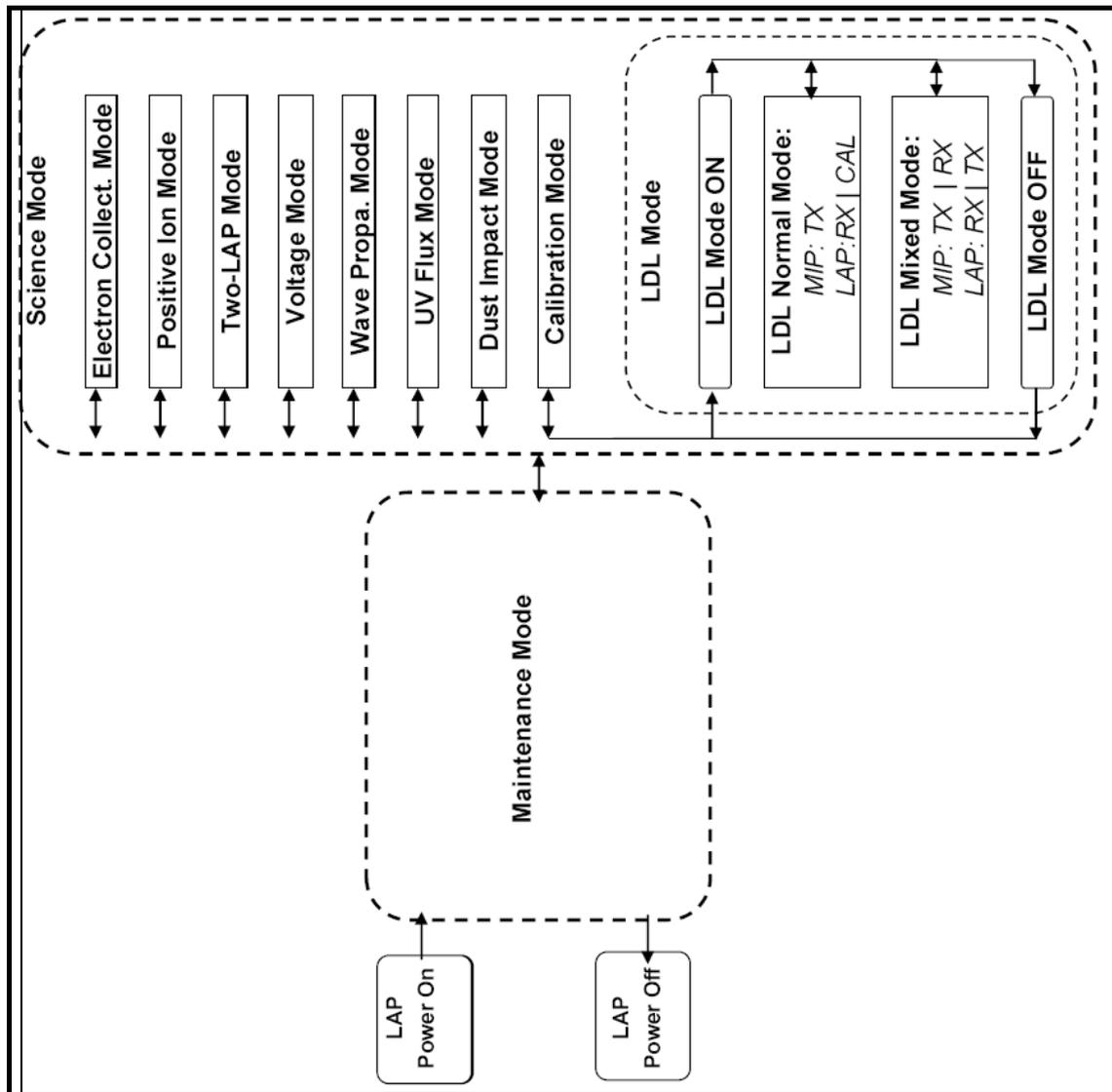
Reference : **RO-RPC-UM**
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4.1.5   MIP

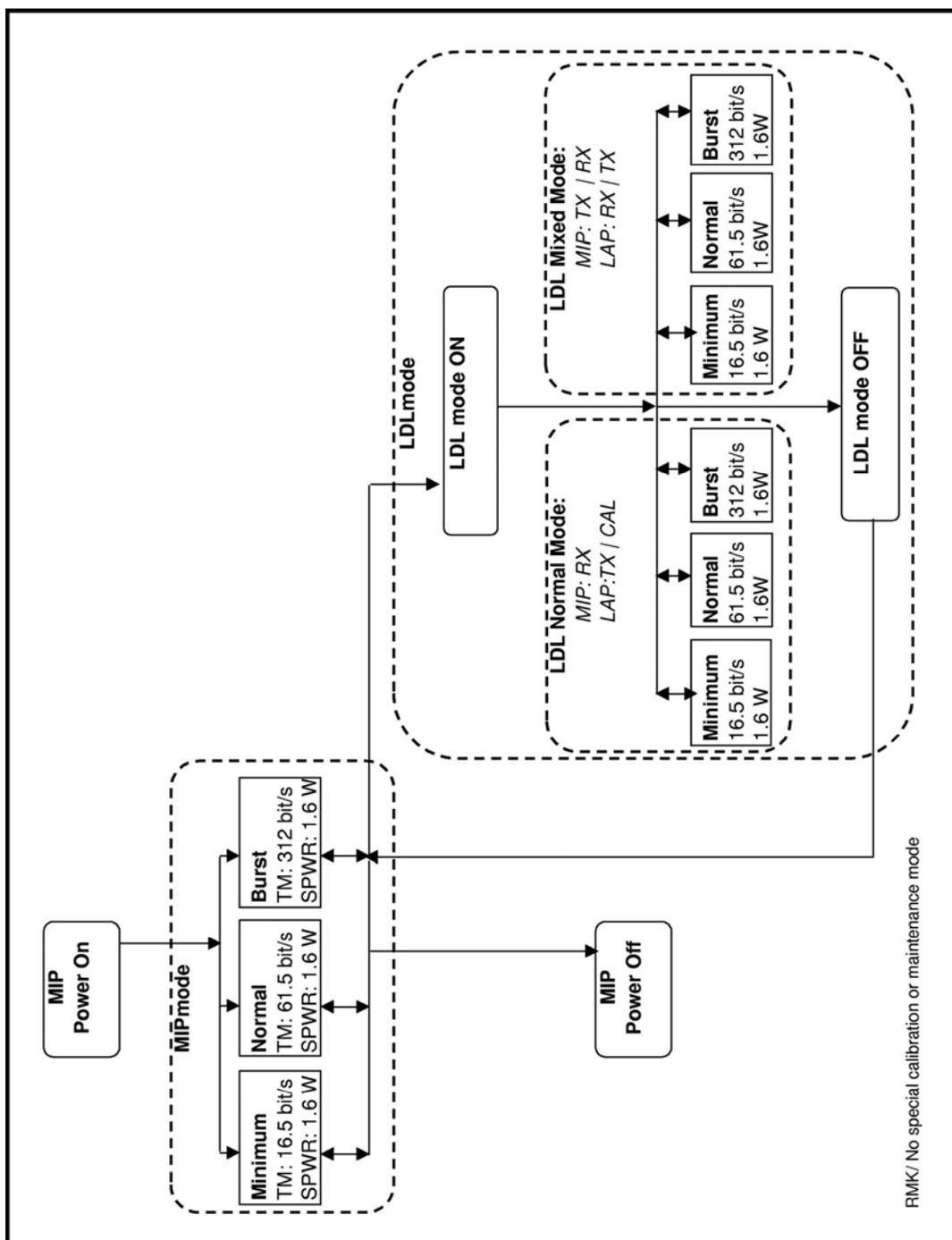*Sequence   definition   (See   Onboard   Data   Handling, RPC/MIP/RP/13/980317/LPCE, Ed. 3/4, 20/9/00)*

Figure 4.1-5: MIP Mode Transition Diagram

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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)

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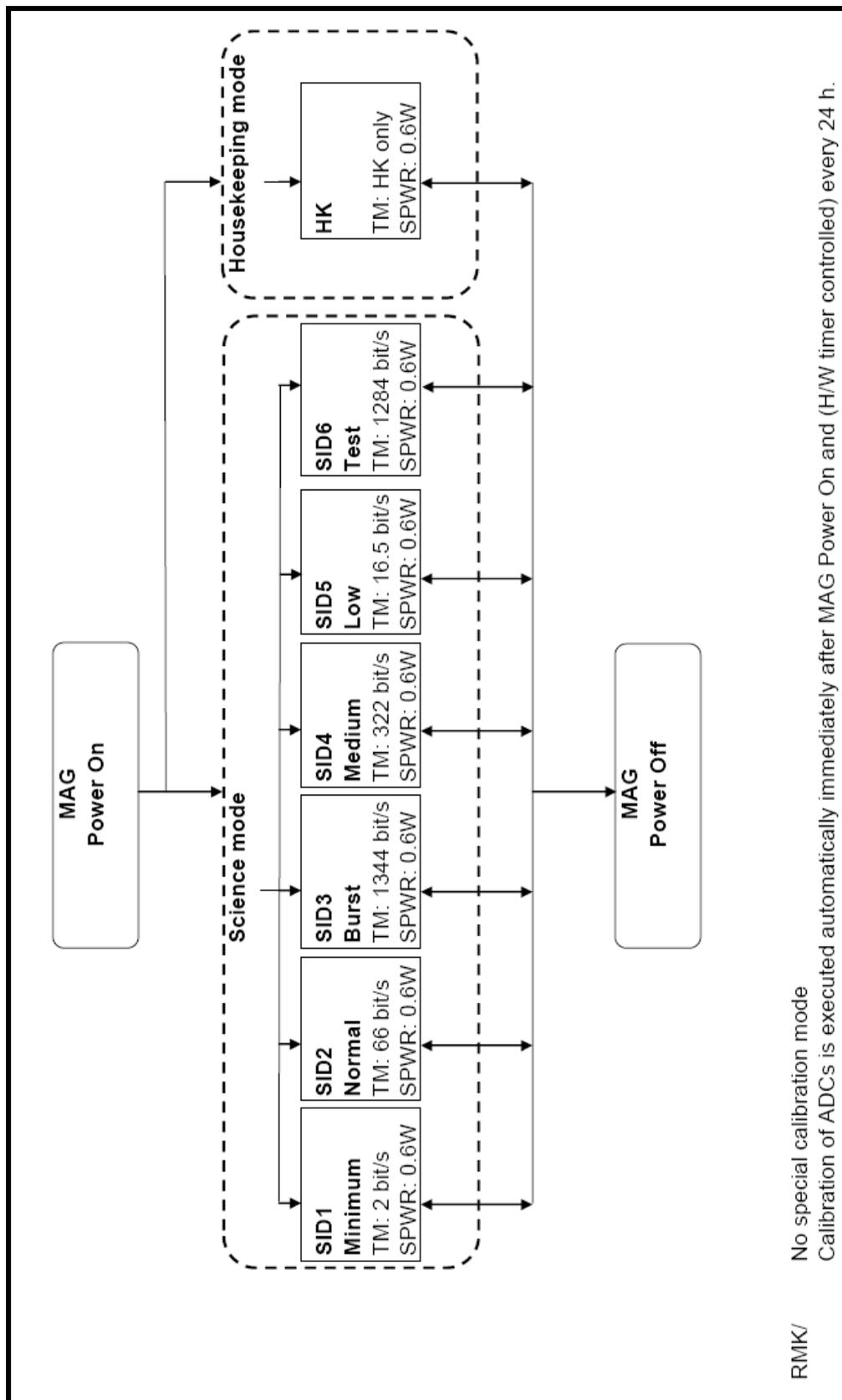Page : 224

Figure 4.1-6:MAG Mode Transition Diagram

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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 .

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.

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LVENG-EEPROM is used for executing maintenance commands and memory manipulation telecommands. Note that the EPROM 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.

A second diagram with science data details is shown in the following figure (note that science data are only generated in LVSCI-EEPROM and HVSCI-EEPROM modes. The acquisition table number corresponding to those data modes is also shown):
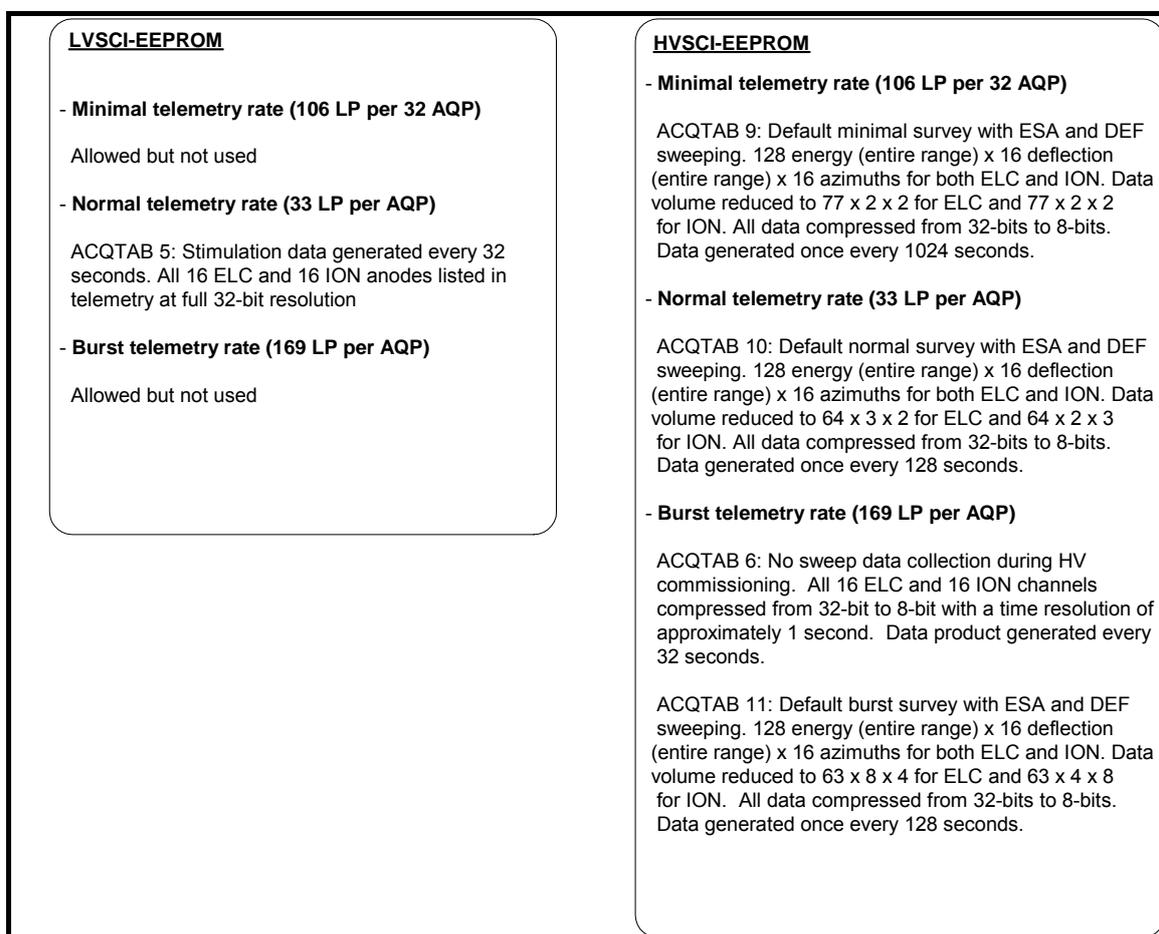
LVSCI-EEPROM

- **Minimal telemetry rate (106 LP per 32 AQP)**

  Allowed but not used

- **Normal telemetry rate (33 LP per AQP)**

  ACQTAB 5: Stimulation data generated every 32 seconds. All 16 ELC and 16 ION anodes listed in telemetry at full 32-bit resolution

- **Burst telemetry rate (169 LP per AQP)**

  Allowed but not used

HVSCI-EEPROM

- **Minimal telemetry rate (106 LP per 32 AQP)**

  ACQTAB 9: Default minimal survey with ESA and DEF sweeping. 128 energy (entire range) x 16 deflection (entire range) x 16 azimuths for both ELC and ION. Data volume reduced to 77 x 2 x 2 for ELC and 77 x 2 x 2 for ION. All data compressed from 32-bits to 8-bits. Data generated once every 1024 seconds.

- **Normal telemetry rate (33 LP per AQP)**

  ACQTAB 10: Default normal survey with ESA and DEF sweeping. 128 energy (entire range) x 16 deflection (entire range) x 16 azimuths for both ELC and ION. Data volume reduced to 64 x 3 x 2 for ELC and 64 x 2 x 3 for ION. All data compressed from 32-bits to 8-bits. Data generated once every 128 seconds.

- **Burst telemetry rate (169 LP per AQP)**

  ACQTAB 6: No sweep data collection during HV commissioning. All 16 ELC and 16 ION channels compressed from 32-bit to 8-bit with a time resolution of approximately 1 second. Data product generated every 32 seconds.

  ACQTAB 11: Default burst survey with ESA and DEF sweeping. 128 energy (entire range) x 16 deflection (entire range) x 16 azimuths for both ELC and ION. Data volume reduced to 63 x 8 x 4 for ELC and 63 x 4 x 8 for ION. All data compressed from 32-bits to 8-bits. Data generated once every 128 seconds.

Figure 4.2-1: IES TM Modes Overview

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

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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 (see §5.4).

For a more detailed description of the experiment see:
 ICA – RPC : the Ion Composition Analyser in the Rosetta Plasma Consortium. (Norberg,O. et al.).

4.2.2.1   Telemetry modes.

The experiments have to their disposal a number of telemetry modes (here named Sid, Science ID). The Sid defines 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.

For Details of the inernal mode defintions refer to the Document:
ICA-TmTc Data Formats and related s/w aspects

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Sid	Mnemonic	Exp. Pkt. size in bytes	ICA rate
0	Min (Minimum)	618	5.15 bps
1	Nrm (Normal)	2478	103.25 bps
2	Bst (Burst)	4092	1023 bps
3	Cal (Calibration)	1074	268.5 bps
4	Spc (Special)	3198	799.5 bps
5	Tst (Test)	600	75 bps
HK	Housekeeping	24	6 bps

Table 4.2-1: ICA Telemetry modes (Sid+HK).

4.2.3   LAP

The Langmuir probe can be operated in different modes:

4.2.3.1   Standard LAP Modes

1.   *Electron collection mode:*
A probe with positive voltage bias provides the measurements of $n_e (T_e)^{-1/2}$. If n_e is determined separately, then T_e can be accurately measured or conversely.

2.   *Positive ion collection mode:*
A probe with negative voltage bias provides the measurements of n_i / v_i. If the ion velocity is determined separately, then $n_i = n_e$ can be accurately measured or conversely.

3.   *Two Langmuir probe mode:*
Provides by a cross-correlation of probe current fluctuations (time-of-flight) the plasma velocity component in direction of probe separation ($v_p = v_i$). This velocity is assumed to equal the neutral gas velocity.

A sequence of measurements 1, 2, and 3 provides the three basic variables electron number density, electron temperature, and plasma drift velocity. The LAP probes can also be used for the following measurements:

4.   *Density fluctuations measurement:*
Study of turbulence in the plasma-neutral gas flow of the inner coma and study of low frequency plasma waves.

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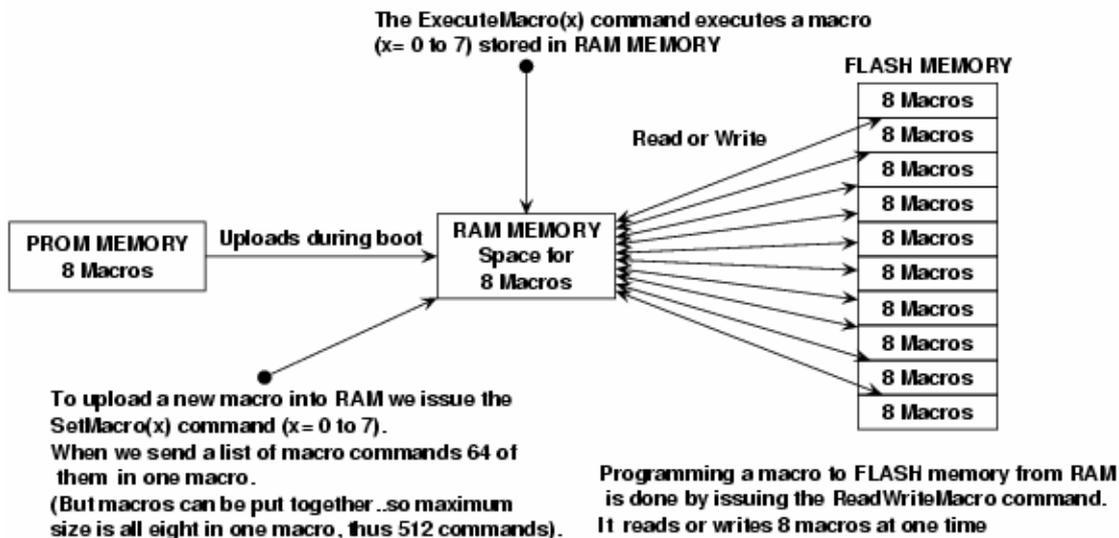Date : **April 10**, **2006**
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5.   *Measurements of spacecraft potential* :
   The probe is biased with a current (voltage mode): important for low-energy electron and ion measurements, possible reference for the other particle sensors.

6.   *Detection of AC electric fields with one or two LAPs in voltage mode.*

7.   *Active propagation experiment:*
   Propagation of artificial ion-acoustic pulses to determine the ion flow velocity, and measurement of transfer impedance to determine the electron density.

8.   *Measurements of solar UV integrated ionizing flux:*
   Measurements of photoelectron saturation current, a parameter of interest to understand the ionisation of cometary gases, especially if the innermost coma is optically thick.

9.   *Measurements of micrometeroid and dust impacts.*

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 RO-IRFU-LAPMPF for details about macros. For details about macros and commanding of macro execution see RO-IRFU-LAPCTM. 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.

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Figure 4.2-2: LAP Macro Storage and Operations

For currently (November 2005) implemented macros in LAP, see list in Table 4.2-2. Note that this list is to be seen as an example, as macros are intended to be updated to optimize science operations:

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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 4.2-2: List of LAP Macros

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).

A special description of the LDL mode can be found in the **LDL mixed-mode noise document** on the IC RPC server.

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 Onboard Data Handling, RPC/MIP/RP/13/980317/LPCE, Ed. 3/4, 20/9/00.

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.

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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.

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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 4.2-3: MAG Science Modes 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)
- **Housekeeping Mode:**
  1 packet every 32 s containing 8 words. (total 128 bits / 32 s)

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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).

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5.0 Operational Procedures

5.1 Ground Test Sequences / SVT

5.1.1 RPC

5.1.1.1 UFT

The procedure is defined in the Alenia Document RO-ALS-PR- 4051 **"RPC I&T - UFT Procedure for EM/EQM"**

5.1.1.2 IST

The procedure is defined in the Alenia Document RO-ALS-PR- 4037 **"RPC IST Procedure"**

5.1.1.3 SVT

For the procedure definitions refer to the following documents:

RO-ESC-PR-5130   **System Validation Test Plan**
RO-RPC-MA-6002   **RPC Operations Planning Document**
RO-RPC-TS-6006   **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 the
PIU SVT Procedure Definition.doc

5.1.2.2 IES

For further information refer to the
IES SVT Procedure Definition.doc

5.1.2.3 ICA

For further information refer to the
ICA SVT Procedure Definition.doc

5.1.2.4 LAP

For further information refer to the
LAP SVT Procedure Definition.doc

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5.1.2.5 MIP

The ground test sequences are described in **MIP/PIU Data Handling Interface**, RPC/MIP/RP/126/990253/LPCE, Ed.3, Rev. 3, 23/5/2001.

For further information refer to the
MIP SVT Procedure Definition.doc

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 **Fehler! Verweisquelle konnte nicht gefunden werden.**.

The detailed procedures are defined by the PIU-IC team; for further information refer to the **MAG SVT Procedure Definition.doc**

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5.2 Command Sequences

5.2.1 Summary of all RPC Command Sequences

Table missing

Taken from Reference Document RO-TBD:

5.2.2 OBCPs

For information about the OBCPs refer to
- o section 2.3.3.3 (List of OBCPs)
- o RO-ESC-Rs-5632, RPC OBCP User Requirements Document
- o Section 3.2.3.

5.2.3 FCPs

Latest FCP Definitions documents are

- RPC: RPC_FCP_Definitions_1_4.doc
- PIU: PIU_FCP_Definitions_1_4.doc
- IES: IES_FCP_Definitions_1_8.doc
- ICA: ICA_FCP_Definitions_1_4.doc
- LAP: LAP_FCP_Definitions_2_0.doc
- MIP: MIP_FCP_Definitions_1_9.doc
- MAG: MAG_FCP_Definitions_1_2.doc

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

The FCP's currently used can be found in the latest FOP.

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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 3.4-4.

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.

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6.0 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 available as MS-Access database on the IC-server

http://pegasus.sp.ph.ic.ac.uk/RpcOpsXfer.php

Filename: RPC_Replica_050302_Ver2000.mdb

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