MERMAG

Instrument User Manual

	Bepi Colombo - MPO
Instrument:	MERMAG
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CHANGE RECORD

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1	0	2010-09-27	All	N/A
1	1	2010-10-18		
1	2	2011-05-09		Update for ICDR
1	3	2012-09-20		ICDR Rids
1	4			Changed typos TC acceptance/execution failures for TM 1,8
				MICDs, TICDs updated for FM New Calmodes SensorSetFindPhase Command updated HK limits defined
1	5	2013-06-04		FM PSR Rids
1	6	2013-03-26		New HK Packets, status messages, compression TC
1	7	2014-08-13	All	Parameter name changes based on Astrium comments, HK limit updates, ...
1	8	2014-10-16	5.1.2.3.4.1	TM parameter names added
1	9	2015-07-08	5.1.2.2.10.5	Sensor Science Report Calibration – packet length changed
			6.3.1.6	use redundant power supply unit by default
			5.1.2.4.4.1	time
			5.1.2.4.2	MERMAG primary current monitoring
1	10	2015-08-04	Table 5-98	HK Limit for +8V-OB current changed
1	11	2015-09-03	Table 5-98	HK Limit for +8V IB current changed
			Table 5-92	Spacewire main/redundant calibration exchanged
			various	Implemented changes from DB comments 2015-09-01
1	12	2015-09-17	5.1.2.4.2	Switch on from ground if PSU trip-off is detected
1	13	2015-09-18	Table 5-92	Nominal/Redundant calibration parameter naming
1	14	2015-12-17	Table 5-98 Table 5-78 Section 5.1.7	HK Limits for 3.3V OB+IB voltage changed Name of Range set for Surveillance Param ID changed Added software default settings
1	15	2017-01-13	5.1.2.4.1.1 5.1.2.4.5 5.1.2.4.2 5.1.3.3 5.1.2.2.4.4	Not applicable anymore Removed offered HK from service 20 Added current parameters for service 12 Added chapter with generation rate for non-science packets Action added for YME51817
1	16	2017-11-29	All	IFAR RID actions implemented
1	17	2018-09-27	5.1.2.1.2 5.1.3.2.22	Removed unavailable modes for sensorsetraw
1	18	2022-04-05	1.2.1,6.1,6.2	IR: Operation strategy updated

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1. INTRODUCTION

1.1 Scope

This document explains the implementation and operation of the MERMAG instrument and its use to exploit the DC and low AC magnetic field investigation on BepiColombo MPO.

1.2 Documentation

1.2.1 APPLICABLE DOCUMENTATION

No.	Title	Doc. ID	Issue	Date
AD-1	EID-A	BC-EST-RS-01140-EIDA	I2R4	2014-11-03
AD-2	Sensor HK Cal	BC-MAG-TN-00011	I1R1	2012-14-11
AD-3	MPO-MAG-IPOD	BC-SGS-TN-066	I1R1	2021-11-17
AD-4	TMX-Editor	http://bepicolombo/esac.esa.int/tmx/	2.4.0	2022-03-24

1.2.2 REFERENCE DOCUMENTATION

No.	Title	Doc. ID	Issue	Date
RD-1	EID-B	BC-EST-RS-02514	2.0	2014-08-31
RD-2	Resource Budget TN	BC-MAG-TN-00004	I1R8	2012-09-26

1.3 Acronyms

AC	Alternating Current
ASIC	Application Specific Integrated Circuit
CLK	Clock
CPU	Central Processing Unit
DAC	Digital to Analog Converter
DMA	Direct Memory Access
DPU	Data Processing Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EID	Event ID
EM	Evaluation Module
ESA	European Space Agency
FDIR	Failure Detection Isolation and Recovery
FID	Failure ID
FIFO	First in First Out
FM	Flight Module
FPGA	Field Programmable Gate Array
GSE	Ground Support Equipment
GPIO	General Purpose Input / Output
HICDS	Highly Integrated Control and Data System
HOOD	Hierarchical Object Oriented Design
IB	Inboard
ICU	Instrument Controller Unit
IGEP	Institut für Geophysik und extraterrestrische Physik

IP	Intellectual Property
IRQ	Interrupt Request
ISAS	Institute for Space and Astronautical Science
IWF	Institut für Weltraumforschung
JAXA	Japan Aerospace eXploration Agency
LCL	Latching Current Limiter
LVDS	Low Voltage Differential Signalling
MAG	Magnetometer
MAGE	Magnetometer Electronics Box
MAGIB	Magnetometer Inboard Sensor
MAGOB	Magnetometer Outboard Sensor
MAGE-I	Magnetometer Inboard Sensor Electronics
MAGE-O	Magnetometer Outboard Sensor Electronics
MAGE-C	Magnetometer Interface Control Unit
MAGE-P	Magnetometer Power Supply (DC/DC Converter)
MERMAG	Mercury Magnetometer
MERMAG-P	Mercury Planetary Magnetometer
MTL	Mission Time Line
MMO	Mercury Magnetospheric Orbiter
MPO	Mercury Planetary Orbiter
OB	Outboard
OBCP	Onboard Computer Program
PEO	Programmable Even/Odd Phase
PI	Principal Investigator
PID	Process ID
PROM	Programmable Read Only Memory
PSU	Power Supply Unit
RAM	Random Access Memory
RTAX	Radiation Tolerant Accelerator (FPGA)
RTC	Remote Terminal Controller
RS-422	Serial communication standard
SEU	Single Event Upset
SID	Structure ID
STP	System Interface Temperature Point
T/C	TeleCommand
TBC	To Be Confirmed
TBD	To Be Defined
TRP	Temperature Reference Point
URF	Unit Reference Frame

2. GENERAL DESCRIPTION

2.1 Scientific Objectives

2.1.1 General Scientific Objectives

The primary objective of the proposed Magnetic Field Investigation on the BepiColombo Mercury Planetary Orbiter mission (MERMAG-P) is to provide the magnetic field measurements that will lead to the detailed description of Mercury's planetary magnetic field, and thereby constrain models of the evolution and current state of the planetary interior. This objective can be interpreted as the unambiguous determination of the coefficients g_l^m and h_l^m to the highest possible order in the expansion of the magnetic potential of the internal field:

$$T_l^i = \sum_{m=0}^{l} P_l^m(\cos\theta)\left[g_l^m \cos(m\phi) + h_l^m \sin(m\phi)\right]$$

This objective will be achieved using accurate magnetic field measurements on the low orbit BepiColombo MPO, but will be supported by measurements made on the MMO, both to distinguish the effects of the magnetosphere on the MPO measurements and to use the MMO measurements directly to augment the data base for the determination of the internal terms.

The secondary objectives of the investigation relate to the interaction of the solar wind with the Hermean magnetic field and the planet itself, the formation and dynamics of the magnetosphere as well as to the processes that control the interaction of the magnetosphere with the planet. In particular, measurements close to the planet on the MPO will allow the determination of the conditions for access of the solar wind to the planetary surface and assessing the role and importance of different current systems, including subsurface induction currents and the conductivity of the regolith. These objectives will be greatly assisted by the planned close association with the magnetic field investigation on the Mercury Magnetospheric Orbiter.

2.1.2 Instrument Scientific Performances

The proposed MERMAG MPO MAG instrument will meet the requirements stated in the BC Science Requirements Document as follows:

To determine Mercury's magnetic field to the targeted accuracy of harmonic coefficients up to order ~10, and to separate the external and internal sources of the magnetic field, the following quantities need to be determined:

- *Magnetic field vector along MPO orbit (accuracy: 0.1-0.3 nT/0.5) at variable rates up to 10 vectors/s. Full orbit coverage (operation in eclipse) is required on selected orbits.*

These performance requirements are placed on the MAG instrument. The proposed instrument is fully compliant with these requirements. The final performance of the investigation is also dependent on the achieving the system-level requirement on magnetic cleanliness at the location of the MAG sensors and the attitude determination of the spacecraft with respect to the planet.

2.2 Measurement Principle

The measurement of magnetic fields in space science is constrained by environmental factors such as temperature and radiation, and also by restrictions on resources available for the instrument such as weight and power. The fluxgate magnetometer principle has emerged as the optimum compromise method for magnetic field measurement in space, since such instruments are rugged, low-in power and mass and offer high precision. The basic operating principle of the fluxgate magnetometer is well known and documented. A soft-magnetic core, usually toroidal in shape, is wound with a coil and driven into saturation with an AC excitation current. The external magnetic field (which is to be measured) distorts the symmetry of the magnetic flux in the core, which generates a signal at even harmonics of the excitation frequency. This signal is picked-up by a sense coil wound around the core. By feeding back a current into the sense coil proportional to the measured signal, the ambient field is backed-off and the sensor operates in null-mode, thereby improving linearity.

Typically, the second harmonic of the drive frequency is notch-filtered, amplified, synchronously-detected, integrated, and used to drive the feedback current. It is this current which is proportional to the ambient magnetic field. The output of a traditional analogue magnetometer is a voltage which may be digitised by an analogue-to-digital converter. In such a design, the signal processing to extract the second-harmonic signal is performed by an analogue circuit. This is an efficient and well-developed method, however the filtering and synchronous detection stages all show temperature dependencies. By replacing the analogue processing with a digital system, this signal processing is performed as a software function in the digital domain. As well as eliminating some of the temperature effects, this provides an inherent flexibility in the design, since the processing parameters can be modified by software. The basic design of the digital technique magnetometer is presented in MAG-4268, which also shows a comparison with the traditional analogue design. The fluxgate sensor output current is digitised immediately after the sense signal current is amplified and converted to a voltage; this stage is the same for both designs. Subsequently, the filtering, synchronous detection and integration is performed by software, resulting in a calculated value for the feedback current which is used to null the ambient field. The feedback current is generated by a digital-to-analogue converter. This calculated value is therefore the field-proportional output of the magnetometer, and this value can be transmitted directly to the instrument controller.

Such digital fluxgates have some space heritage (e.g. Rosetta Lander, Venus Express and Themis magnetometers). These developments have validated the basic principles of the technique, and demonstrated enhanced temperature stability. There are a number of temperature-dependent error parameters associated with traditional analogue designs that can, in principle, be mitigated by the digital processing. The goal for the BepiColombo MAG team is to equal or surpass the performance of the traditional analogue design, whilst reducing the overall mass and power requirements of the instrument. It is for a combination of these reasons that a digital-technique fluxgate instrument is proposed for the BepiColombo mission.

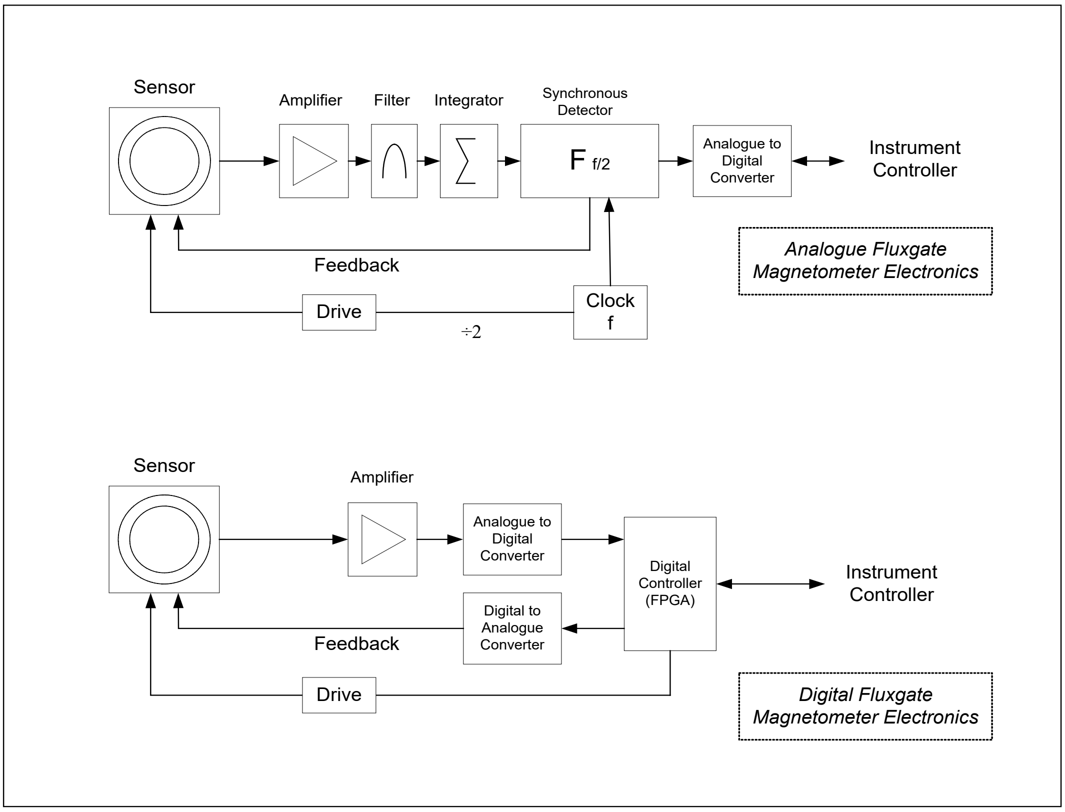


Figure 2.2-1: Digital versus Analogue Technique Fluxgate Magnetometer

2.3 Instrument Description

The overall instrument design is depicted in the Figure 2.3-1. Two identical magnetometers are used, each with their own dedicated electronics. Using two sensors, the so-called 'dual-magnetometer' technique will be applied in order to help determine the magnetic influence of the spacecraft. Due to the thermal extremes of the MPO orbit, each sensor includes a heater which will help to maintain the expected high operating temperature during the eclipses. The instrument electronics is responsible for the heater control.

In addition to the sensors front end electronics, the instrument includes an Instrument Controller Unit (ICU), and a redundant power supply for provision of secondary Voltages to the sensor electronics, ICU and sensor heaters. Functionally, the MAG instrument is largely autonomous in operation, requiring a minimum of commanding only for selecting from a set of science operations modes and corresponding telemetry bit-rates.

The instrument controller will be based on the ESA-provided RTC ASIC.

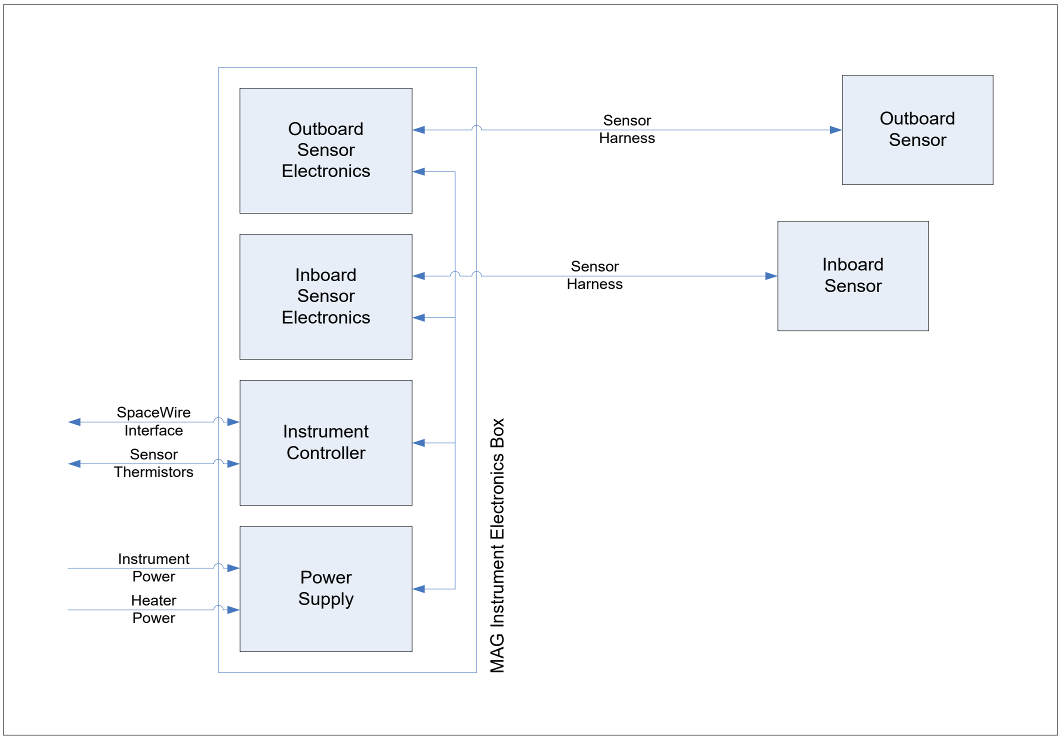


Figure 2.3-1: Instrument Block Diagramme

2.3.1 Fault Tolerance Design

The instrument design does not implement redundancy. For detecting magnetic field disturbances from the S/C, both sensors must be operating.

The Spacewire telemetry interface and the power interface to the S/C are redundant. The DC/DC power conversion within the MAG instrument (MAG-P) is redundant.

2.3.2 Safety Concept

Not applicable for the MERMAG instrument.

2.3.3 Materials

For the list of materials please refer to the instrument's declared materials list (BC-MAG-LI-00003).

2.3.4 Lifetime Sensitive Items

The MERMAG instrument has no lifetime sensitive item.

2.3.5 Radiation Tolerance Requirements

2.3.5.1 Sensitive Areas

The MERMAG electronics box contains radiation sensitive components. The sensors are not containing active components and are not sensitive to radiation.

2.3.5.2 Acceptable Limits

According to the latest values presented in the Radiation Analysis document (BC-ASD-TN-00027, I4R1), the nominal radiation design case for the MERMAG electronics box is 74.82 kRad including a safety factor of 2.

All components inside the MERMAG electronics box can withstand total dose radiation levels of >= 75kRad.

The electronics box does not contain latchup-sensitive components.

2.3.5.3 Protection Concept

No separate radiation shielding is necessary for the MERMAG electronics box. Furthermore MERMAG electronics does not use latchup-sensitive components.

2.3.5.4 Micro-meteorite

The sensors will be covered by a thermal protection hut (OSR at the outside, MLI at the inside) which also has excellent micro-meteorite dissipation properties. The micro-meteorite fluence predicted for the overall BepiColombo mission shall be taken into account when designing the thermal protection for the sensors. Also, exposed sensor harness area shall be minimised by optimising the protection afforded by spacecraft structure and the boom. These parts of the sensor harness that are directly exposed to space conditions are covered by a micro-meteorite protection surface.

3. INSTRUMENT INTERFACES

3.1 Mechanical Interface

3.1.1 Instrument Mechanical and Structural Design

The instrument electronics is housed in a box mounted internal to the spacecraft. The sensors are mounted to a spacecraft provided boom. The sensors are thermally isolated from the boom mounting interface by an insulating stand-off, which is also the mounting fixation for the sensors. Sensor thermal hardware will be composed of a structure that is covered with OSRs at the outside and MLI on the inside.

This thermal hardware will be designed to fit around all exposed surfaces of the sensor , including the mounting stand-off and the sensor harness (until such point as it is covered by boom MLI).

3.1.1.1 Mechanical and Structural Concept

Electronics Box

The electronics is housed in a basic six-sided, flat mounted box fabricated from Aluminium alloy type Al6061-T651. Each panel is machined individually according to a detailed design for stiffness and strength but minimising mass by cutting down to a web thickness of 0.3mm between ribs. Flatness is maintained during machining using a vacuum chuck. This process has been used with excellent results on many previous missions, and the BepiColombo design bears direct heritage from the Venus Express magnetometer box. Electronics card are fixed to the inside of the box by machined Aluminium beams fixed along each side of the PCB and then fixed to the box panel by means of screws from the outside of the box.

The box contains five electronics cards. To save weight, they are connected together by a cable tree that is located outside of the box. This type of cable tree was sucessfully used for the Rosetta RPC magnetometer.

The general design of the box is shown on the Figure 3.1-1 and Figure 3.1-2.

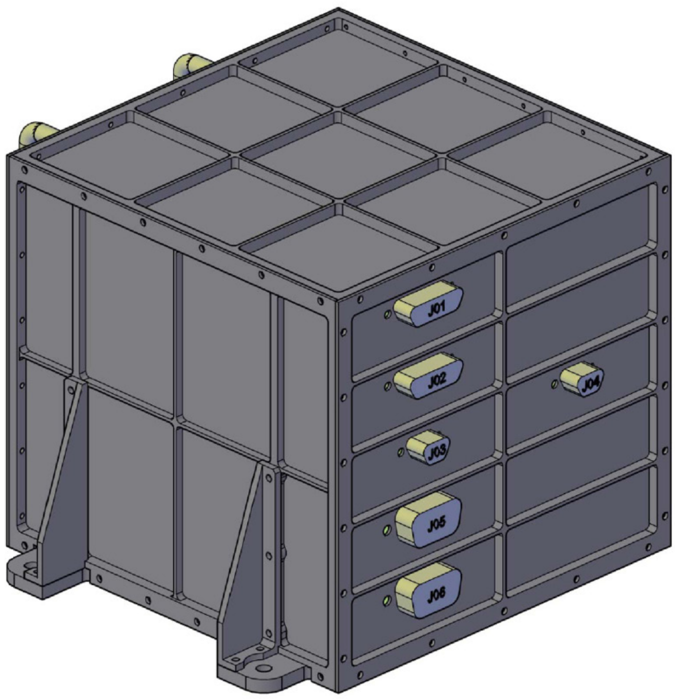


Figure 3.1-1: Electronics Box structure - External Harness Side

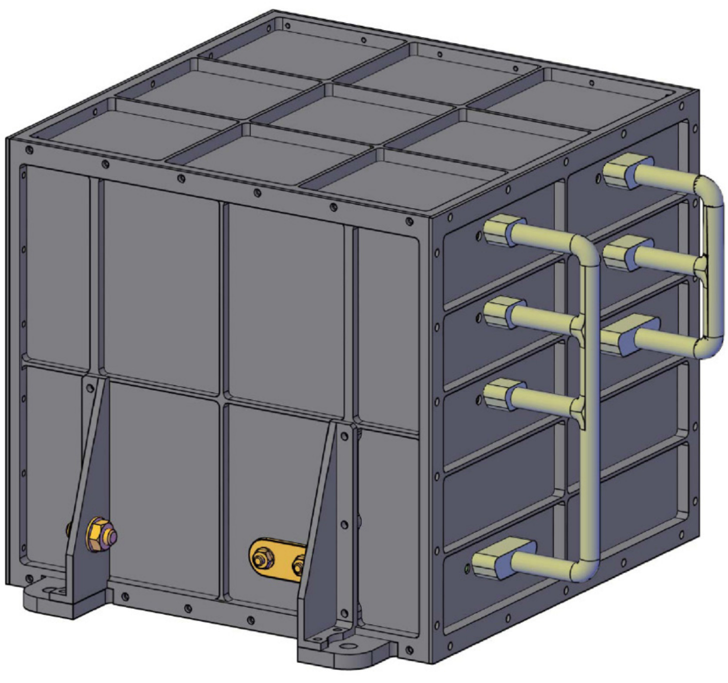


Figure 3.1-2: Electronics Box structure - Internal Harness Side

Sensors

Two crossed ringcores made by 6-81-Mo Permalloy band are used for three components. The magnetic field in the third-direction is measured by a coil surrounding both single sensors (see Figure 3.1-3). The ringcores have been tested under extreme environmental conditions aboard numerous space missions as well as in applied geophysics. The excellent low noise and stability behaviour of the ringcores has especially been proven aboard Equator-S. The pickup coil systems is made by Cu wire isolated by polyesterimid and covered by bond coat (polyamid). The feedback coil system consists of three Helmholtz pairs fabricated with the same technology as the pickup coils. About 0.5mA is necessary to generate the maximum compensation field of 5000nT. The thermal extension coefficient of the coil system is about 22ppm/°C.

The image in Figure 3.1-6 shows one sensor with stand-off, thermal shielding and indicated sensor harness. The sensor is mounted onto an interface plate that is attached to the boom and is under responsibility of the boom contractor.

Figure 3.1-3: Ringcores with pick up coil system and sensor with feedback Helmholtz system

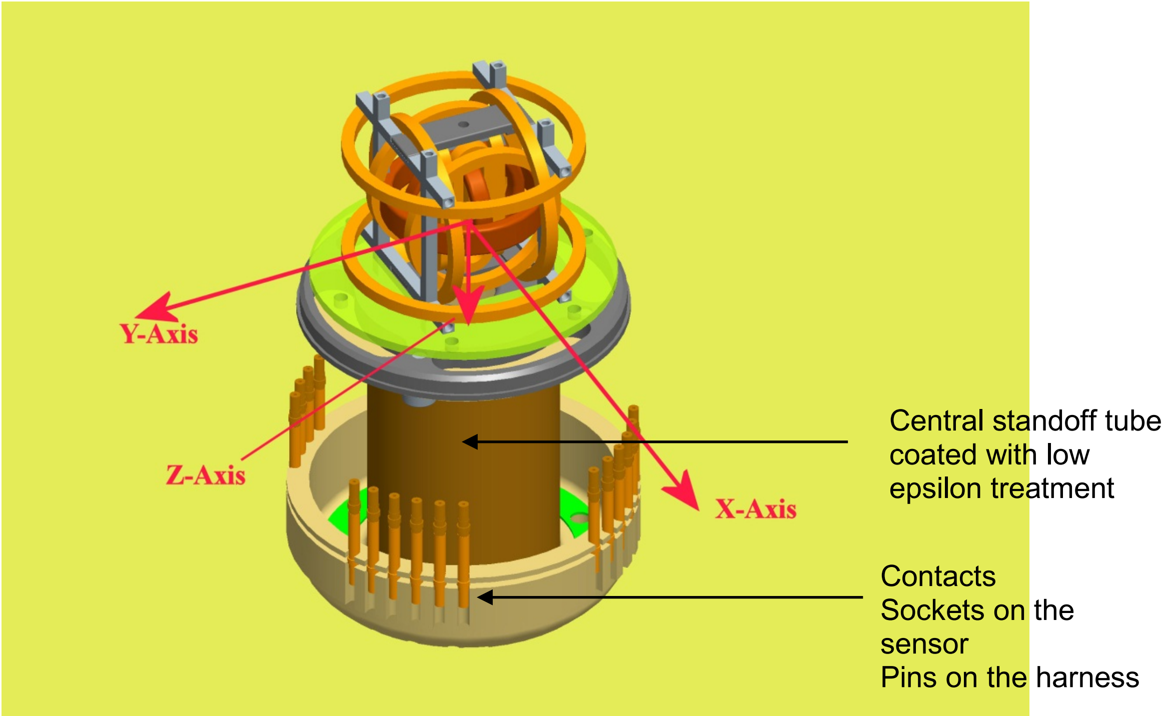


Figure 3.1-4: Sensor and standoff

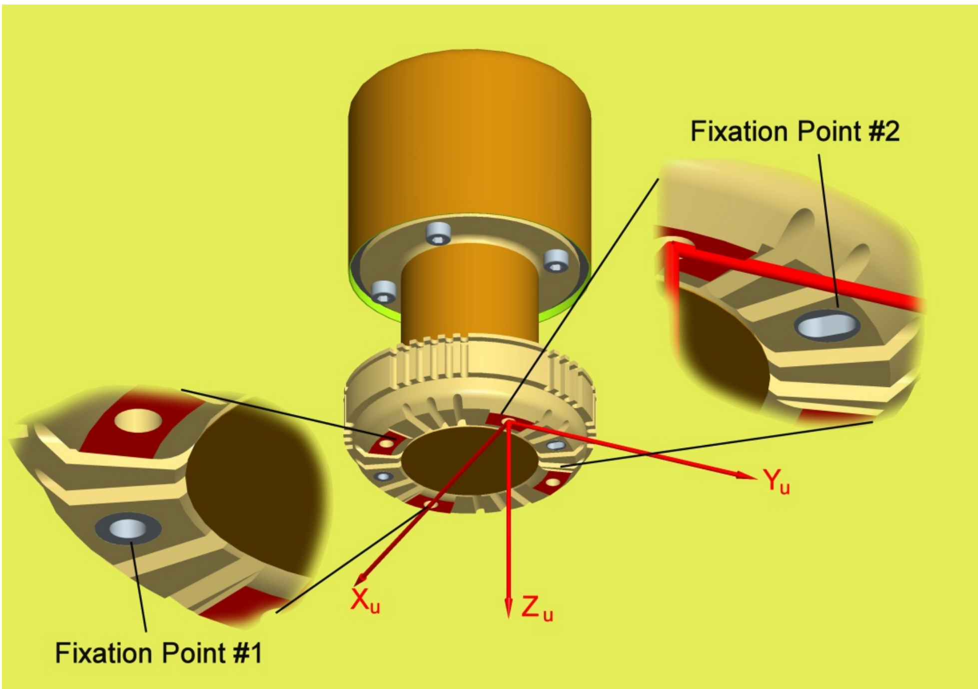


Figure 3.1-5: Sensor alignment

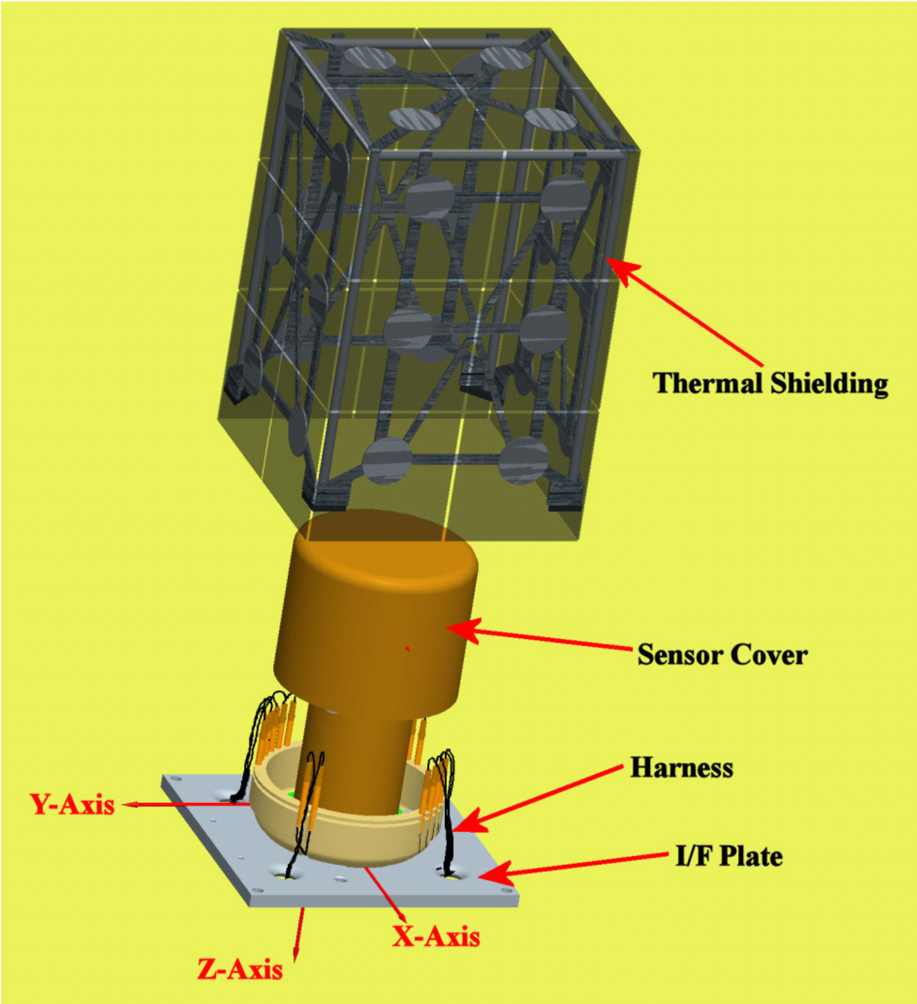


Figure 3.1-6: Sensor with thermal shielding and stand-off

3.1.1.2 Unit Eigenfrequencies

Electronics Box (MAGE)

The electronics box has space heritage, it is very similar to the electronics box used for VenusExpress.

The box will have a first global resonant frequency above 120Hz, and therefore will be in compliance with EID-A stiffness requirement (EIDA-1669/R).

The accurate Eigenfrequency will be investigated during the vibration tests.

Sensors (MAGOB, MAGIB)

The sensor configuration has space heritage, it is very similar to the sensors used for VenusExpress.

The sensors will have a first global resonant frequency far above 200Hz, and therefore will be in compliance with EID-A stiffness requirement (EIDA-3432/R).

The accurate Eigenfrequency will be investigated during the vibration tests.

3.1.1.3 Instrument Mechanisms

The MERMAG instrument has no mechanisms.

The MERMAG instrument has no aperture cover.

3.1.1.4 Pressurized Items

The MERMAG instrument has no pressurized items.

3.1.1.5 Red- and Green-Tag items List

The red-tag items as listed in the Table 3.1-1 will be provided for MERMAG.

Unit	Red-Tag Item	MICD Reference	Delivered for Model	Comment
OB Sensor (MAGOB)	Sensor Protection Cap	MAGOB-IF-002-DUMMY	FM	Mechanical Protection
IB Sensor (MAGIB)	Sensor Protection Cap	MAGOB-IF-002-DUMMY	FM	Mechanical Protection
OB and IB Sensor	Labels	BC-MAG-IC-00007	STM, FM	Label
OB and IB Thermal Hardware	Labels	BC-MAG-IC-00007	STM, FM	Label

Table 3.1-1: Red-Tag Item List

Because of sensitivity of the surface of the sensors and the thermal hardware, the labeling of these items will be performed in the following manner:

The labels are fixed to the units by a string. After mounting of the units onto the S/C, the labels are removed and stored. If the units are dismounted from the S/C, the labels are fixed to the units again. For avoiding unintentional swapping of the OB and IB units, they will be marked with colored dots.

3.1.2 Unit Co-ordinate systems

3.1.2.1 Unit Reference Frame

The sensors, interface plates and the thermal hardware are mounted on a deployable boom that is located on the -X side in the plane of the radiator and tilted 10° to nadir.

Refer to the MICD in annex 1 for the orientation and origin of the URF axes for the Sensors and the Electronics Unit.

3.1.2.2 Unit Optical Alignment Frame

Not applicable for MERMAG.

3.1.3 Instrument Accommodation Requirements and Constraints

3.1.3.1 General Accommodation Constraints

- *The MERMAG sensors shall be accommodated on a spacecraft provided boom.*
- *The distance between the Out-board Sensor reference hole and the In-Board Sensor reference hole shall be 800 mm +/- 50 mm.*
- *The MERMAG in-board and out-board sensors shall be mounted on the Boom such that their Xurf axis is parallel to the Boom tube symmetry axis and oriented in a positive direction towards the Boom tip.*
- *The MERMAG in-board and out-board thermal hardware shall be mounted on the Boom such that their Xurf axis is parallel to the Boom tube symmetry axis and oriented in a positive direction towards the Boom tip.*

3.1.3.2 Intra-Experiment Harness Constraints

There is no constraint on the intra-experiment cables length other than mass.

The first part of the sensor harness is going from the Electronics Box to the boom root where a it is attached to a connector bracket. The length of this piece of harness is depending on the cable routing at the S/C.

The second part of the sensor harness is going, preferably inside the boom, from the connector bracket to the sensor interface plate at the boom, where it is routed through 4 holes in plate to the pins at the sensor standoff.

The harness should be fixed securely to the boom structure below the interface plate to avoid that is slides into the boom tube.

The sensor harness minimum bending radius is 2 cm.

3.1.3.3 Sensitivity to Sun, Planetary Albedo and Infra-Red Illumination

MERMAG is not sensitive to Sun illumination, planetary albedo or infra-red illumination.

For thermal reasons, the preferred mounting side of the sensors on the boom is the anti-nadir side.

3.1.3.4 Magnetic and Electrostatic Cleanliness

The MERMAG out-board sensor shall be accommodated according to the requirement specified in para 3.6.2.2.

MERMAG has no requirement on electrostatic cleanliness.

3.1.4 Mechanical Interface Control Drawings

The MERMAG MICDs as listed in Table 3.1-2 are provided in the annex.

Unit	MICD Reference	Iss.	Pages	Issue date	3D-Model Reference
O-B and IB Sensors	MAGOB-I/F-001	Rev. H	1	08 Feb 2013	Magob-001_2011-11-28.stp
O-B and IB Sensor Thermal Shields	MAGOB-I/F-002	Rev. I	1	08 Feb 2013	Magob-osr_asm_2011-11-28.stp
Electronics Box	BC-ORTHO-01	Rev. 10	1	18 Feb 2013	BC-STEP-ORTHO-01Rev7.stp 02.07.09
Sensor Harness Cable Clamp	CableClamp	I1R0	1	31.01.2011	Cable_clamp_BC_I1R0.stp

Table 3.1-2: Actual MICDs references

3.1.5 Physical Properties

Note: all values listed in this section are not marked as requirement if they are indicated on the MICD. The MICD is the formal requirement.

3.1.5.1 Instrument's units envelope

The Table 3.1-3 gives the overall envelope of each instrument's unit including the envelope of movable parts.

Unit	X_{urf}	Y_{urf}	Z_{urf}
Out-Board sensor(defined by Thermal Shielding)	86.6mm	86.6mm	123.8mm
In-Board Sensor (defined by Thermal Shielding)	86.6mm	86.6mm	123.8mm
Electronics Box	169mm (-20mm to 149mm)	162mm (-7mm to 155mm)	119.6mm (0 to 119.6mm)

Table 3.1-3: Units envelope including external mechanisms envelope

Refer to the MICD in the annex.

3.1.5.2 Mass in Flight Configuration

The Table 3.1-4 gives the mass of each unit in flight configuration including eventual green-tag items.

Unit	Current Best Estimates (g)	Margin (%)	Total (g)
Out-Board Sensor incl. Thermal Hardware	300	3	309
In-Board Sensor incl. Thermal Hardware	300	3	309
Electronics	1220	3	1257
Total	1820		1875
Harness Electronics to OB Sensor	363	10	399
Harness Electronics to IB Sensor	313	10	344

Table 3.1-4: Instrument mass in launch configuration

Refer to the MICD in the annex.

3.1.5.3 Centre of Mass

The Table 3.1-5 gives the position of the centre of mass of each instrument unit in operational configuration. MERMAG has no moving part.

Unit	X_{urf}	Y_{urf}	Z_{urf}
OB- Sensor, IB-Sensor	20 mm	0.03 mm	-55.4 mm
OB-Thermal Hardware, IB-Thermal Hardware	37.5 mm	-37.5 mm	-64.7 mm
Electronics	47 mm	73.5 mm	57.5 mm

Table 3.1-5: Units centre of mass in operational configuration

Refer to the MICD in the annex.

3.1.5.4 Moments of Inertia

The Moments of Inertia (MoI) and Cross Products of Inertia for MERMAG are shown in the Table 3.1-6.

Unit	I_{xx} (kgxmm²)	I_{yy} (kgxmm²)	I_{zz} (kgxmm²)	I_{xy} (kgxmm²)	I_{xz} (kgxmm²)	I_{yz} (kgxmm²)
OB-Sensor, IB-Sensor	128	128	70	0	0	0
OB-Thermal HW, IB-Thermal HW	$3.8*10^2$	$3.8*10^2$	$3.0*10^2$	0	0	0
Electronics	13871.2	9673.1	12758.7	4029.8	3056.5	5016.5

Table 3.1-6: Instrument's units moment of inertia (wrt URF @ CoG)

Refer to the MICD in the annex.

3.1.6 Mounting Attachment and Handling

3.1.6.1 Attachment Concept and Foot pattern

Electronics box:

The electronics box is flat-mounted by four attachment points for M4 screws close to the box corners. There are no special mounting or handling requirements. For details refer to the MICD in annex 1.

Sensors:

The sensors are mounted to the boom interface plate by four non-magnetic M3 screws. The required hole pattern of the interface plate is defined in the MICD in annex 1 and is under responsibility of the boom contractor.

The Thermal Hardware are mounted to the boom interface plate by four non-magnetic M3 screws. The required hole pattern of the interface plate is defined in the MICD in annex 1 and is under responsibility of the boom contractor.

The fixation of the interface plate to the boom is left open and is subject to agreement with the boom contractor.

The Figure 3.1-6 (chapter 3.1.1.1) shows the sensor mounted onto the boom interface plate.

3.1.6.2 Reference Hole

The units reference holes are shown on their respective MICD in the annex.

3.1.6.3 Thermal Contact

The thermal coupling between the different MERMAG units and the spacecraft the is specified in the TICD's in annex 3:

- The Electronics box shall be flat mounted to the spacecraft panel.
- The Sensors are mounted to the boom interface plate via an isolating stand-off. The sensor is defined to contain the stand-off.
- The Sensors Thermal Hats are thermally coupled to the boom interface plate.

3.1.6.4 Attachment Loads

The attachment loads have been computed by the spacecraft structure supplier and the insert types have been selected to have positive margins of safety.

3.1.6.5 Handling Provisions

There will be no special handling provisions provided by the MERMAG PI.

Handling of the sensor thermal hat, which is covered with OSRs, has to be done always with gloves and only under clean room conditions. Any contact to the OSR has to be avoided. The storage of the thermal cover has to be done in a dedicated box provided by the MERMAG team.

3.1.7 Baffle, MLI and Cold Finger Mechanical Interfaces

The sensor thermal shielding interface is mounted onto the sensor interface plate and is defined in the MICD in annex 1.

3.1.8 Purging Interfaces

Not applicable for MERMAG.

3.1.9 Alignment and Pointing

The magnetometer instrument has no pointing requirements, however accurate knowledge of the alignment is required, to meet the science requirement of measurement of the magnetic field vector to an accuracy of 1°.

The principle sources of error in field vector measurement are budgeted for as follows:

- The magnetic axes of each sensor with respect to the alignment holes are determined with an accuracy of 0.1° by the pre-flight calibration procedure.
- With the boom in the deployed configuration, the orientation of the sensor mounting planes with respect to the spacecraft Mechanical Reference Frame, shall be known and repeatable to better than 0.2°. Experience has shown that this is readily achievable through good mechanical design practice and accurate measurement of sensor alignment to the boom.
- An allowance of 0.4° is factored into the analysis due to magnetic contamination from the spacecraft.

This gives an overall error in magnetic field vector measurement of 0.8°, leaving a 0.2° contingency.

3.1.9.1 Boresight and Field of View

Not applicable for MERMAG.

3.1.9.2 Pointing Requirements

The MERMAG instrument needs knowledge of the attitute with an accuracy of +/- 0.2°.

Unit	Pointing Required of the Boresight wrt S/C axis	Absolute Pointing Error	Absolute Measurement Accuracy	Relative Pointing Error
OB-Sensor	N.A.	N.A.	± 0.2°	N.A.
IB-Sensor	N.A.	N.A.	± 0.2°	N.A.

Table 3.1-7: Pointing Requirements

3.1.9.3 Alignment and Co-Alignment Requirements

The alignment requirements of the MERMAG sensors with respect to the spacecraft are shown on Table 3.1-8.

Unit	Accuracy wrt S/C		Knowledge wrt S/C		Stability wrt S/C	
	Azimuth	Elevation	Azimuth	Elevation	Azimuth	Elevation
IB Sensor	N.A	N.A	± 0.2 °	± 0.2 °	<± 0.2°	<± 0.2°
OB Sensor	N.A	N.A	± 0.2 °	± 0.2 °	<± 0.2°	<± 0.2°

Table 3.1-8: Alignment Requirements

The co-alignment requirements with respect to other units are shown in Table 3.1-9.

Unit $_m$ -	Unit $_n$ -	Accuracy		Knowledge		Stability	
		Azimuth	Elevation	Azimuth	Elevation	Azimuth	Elevation
IB Sensor	OB Sensor	± 0.1 °	± 0.1 °	± 0.1 °	± 0.1 °	± 0.1 °	± 0.1 °

Table 3.1-9: Co-Alignment Requirements

3.1.9.4 Method of On-Ground Alignment

Both sensors shall be mounted on the boom baseplates during integration. No removal of the sensor is foreseen during transportation between facilities as well as during electrical and qualification tests. The alignment of the sensor on the boom is realised by alignment holes in baseplate and sensor standoff. Tools for alignment (see Figure) are provided by the MERMAG team. The magnetic axes of each sensor with respect to the alignment holes are determined with an accuracy of 0.1° by the pre-flight calibration procedure. The co-alignment of both sensor (requirement also 0.1°) has to be provided by the precision of the alignment holes in both baseplates. (responsibility: boom provider).

The alignment pins shall be accessible from the top (sensor side) for their installation and removal.

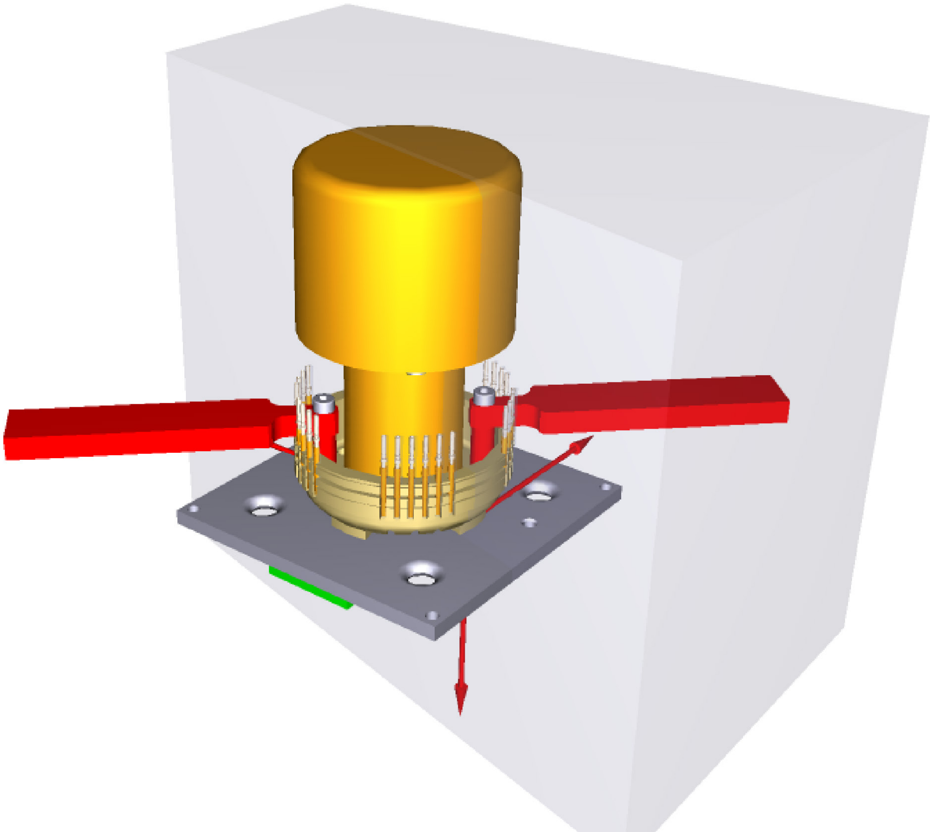


Figure 3.1-7: Sensors Alignment principle

The tolerances of the boom baseplates for the sensor alignment shall be according to DIN7168.

The surface finish of the base plate shall be blue anodized and the surface roughness shall be below 0.1.

3.1.10 Mechanisms Perturbations

The MERMAG instrument has no mechanism.

3.1.10.1 Description of disturbing mechanisms

Not applicable for MERMAG.

3.1.10.2 Disturbances levels

Not applicable for MERMAG.

3.2 Thermal Interface

3.2.1 Instrument Thermal Design

3.2.1.1 Thermal Design Description

The electronics box presents no particular thermal problems. It is fully compliant with the requirements for an internally mounted item. The sensor is designed to be a thermally isolated unit. A schematic diagram of the thermal concept is given in Figure 3.2-1. The sensor is isolated from the boom structure by an insulating stand-off, which also serve to mount the sensor to the boom.

The sensor is furthermore protected by a thermal shielding. This structure is covered with OSRs at the outside and MLI on the inside.

The sensor is isolated from the thermal shielding MLI as much as possible to have only radiative coupling to the MLI. This way the *alpha/epsilon*-ratio of the OSR dominates the equilibrium temperature while the *epsilon* of the sensor cap defines the reaction to temperature changes.

For the simulated scenario, the sensor was constructed principally from Aluminium.

In operation, the sensor dissipates electrical power Q_d. The heater dissipates Q_h. The sensor can be operated with the heater on or off. The sensor assembly is covered with a Gold (Au) coated aluminium cap for mechanical protection, which also contains the main heat capacity. As mentioned above, the whole sensor is covered with a thermal shielding, which give an overall leakage power into the sensor of Q_l. The sensor harness is attached to the boom, and therefore the (Copper) wiring makes a conductive path from the boom structure to the sensor, along with the stand-off (Q_{con}). To have the best thermal decoupling from the boom, the harness will be as long as possible thermally insulated from the boom structure.

An instrument controlled sensor heater will be used to maintain the sensor temperature within it's calibrated limits during the eclipse duration.

For heater temperature regulation the sensor temperature is measured at two locations. One temperature sensor is located at the sensor interface plate, the other sensor measured the temperature of the sensor itself. Both temperature values will be provided as HK values.

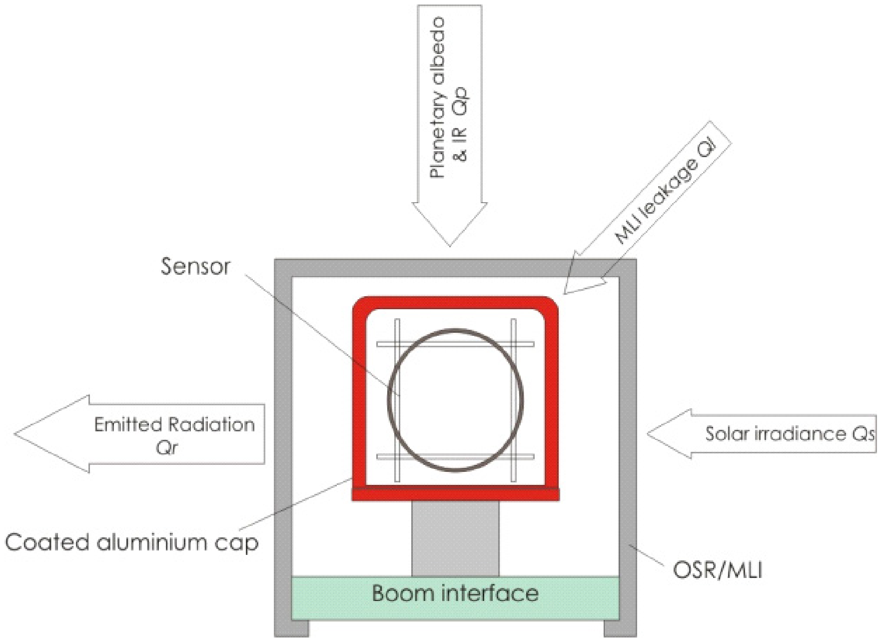


Figure 3.2-1: Sensor thermal design concept

The thermal concept of the sensor is such that when illuminated it will operate at a high temperature which is defined by the equilibrium

$$Q_d + Q_{con} + Q_l = Q_r \qquad \text{Equation. 3-1}$$

In eclipse, the heater will be powered to provide a partial replacement of the $Q_{con} + Q_l$ terms. The sensor will continue to operate in eclipse, which is a scientific requirement, reaching an equilibrium temperature defined by

$$Q_d + Q_{con} + Q_l + Q_h = Q_r \qquad \text{Equation. 3-2}$$

Where Q_{con} is the reduced or even negative heat input from the boom in eclipse, and Q_l is the radiated heat lost from the sensor through the MLI.

The sensor heater power shall be sized to maintain the sensor temperature within its calibrated limits during the eclipse duration.

Sensor Thermal Hardware

The sensor thermal blanket shall be MLI of a conventional type for high-temperature applications covered with OSRs.

To achieve optimal thermal isolation of the sensor, spacers are recommended. The precise number of layers of will be finalised during the thermal modelling stage. The alpha/epsilon ratios for both outer and inner layers will be selected so as to achieve the sensor design temperature range.

The Table 3.2-1 summarises the interfaces and principal thermal nodes of the sensor.

Name	Type	Location	Node (TMM)	Read-out	Control	TM Reference
OB +X Thermal Shield	**OSR + MLI**	Thermal HW OB Sensor	**62220**	**N/A**	**N/A**	
OB -X Thermal Shield	**OSR + MLI**	Thermal HW OB Sensor	**62215**	**N/A**	**N/A**	
OB +Y Thermal Shield	**OSR + MLI**	Thermal HW OB Sensor	**62210**	**N/A**	**N/A**	
OB -Y Thermal Shield	**OSR + MLI**	Thermal HW OB Sensor	**62205**	**N/A**	**N/A**	
OB -Z Thermal Shield	**OSR + MLI**	Thermal HW OB Sensor	**62225**	**N/A**	**N/A**	
OB Harness IF	**Custom**	Sensor I/F, OB Sensor	**62251**	**N/A**	**N/A**	
OB Harness Boom	**Custom**	**Sensor Harness on Boom, OB Sensor**	**62253**	**N/A**	**N/A**	
OB Sensor (TEMP-S1)	Custom	OB Sensor	62249	MAG	N/A	NME02200
OB Sensor Heater (TEMP-S2)	Custom	OB Sensor Heater	N/A	MAG	MAG	NME02201
OB Sensor Electronics	Custom	IB Sensor Electronics	N/A	MAG	N/A	NME02202
IB +X Thermal Shield	**OSR + MLI**	Thermal HW IB Sensor	**62120**	**N/A**	**N/A**	
IB -X Thermal Shield	**OSR + MLI**	Thermal HW IB Sensor	**62115**	**N/A**	**N/A**	
IB +Y Thermal Shield	**OSR + MLI**	Thermal HW IB Sensor	**62110**	**N/A**	**N/A**	
IB -Y Thermal Shield	**OSR + MLI**	Thermal HW IB Sensor	**62105**	**N/A**	**N/A**	
IB -Z Thermal Shield	**OSR + MLI**	Thermal HW IB Sensor	**62125**	**N/A**	**N/A**	
IB Harness IF	**Custom**	Sensor I/F, IB Sensor	**62151**	**N/A**	**N/A**	
IB Harness Boom	**Custom**	**Sensor Harness on Boom, IB Sensor**	**62153**	**N/A**	**N/A**	
IB Sensor (TEMP-S1)	Custom	IB Sensor	62149	MAG	N/A	NME02214
IB Sensor Heater (TEMP-S2)	Custom	IB Sensor Heater	N/A	MAG	MAG	NME02215
IB Sensor Electronics	Custom	IB Sensor Electronics	N/A	MAG	N/A	NME02216

Table 3.2-1: Principal Thermal Nodes and Interfaces

The MERMAG ITMM is provided in the annex.

<u>Sensor Thermistor Locations</u>:

There are two thermistors to monitor the temperatures of the sensors and the heater.

One, TEMP-S1, is situated on the upper side of the sensor-PCB at the –X-side of the sensor, as shown in Figure 3.2-2.

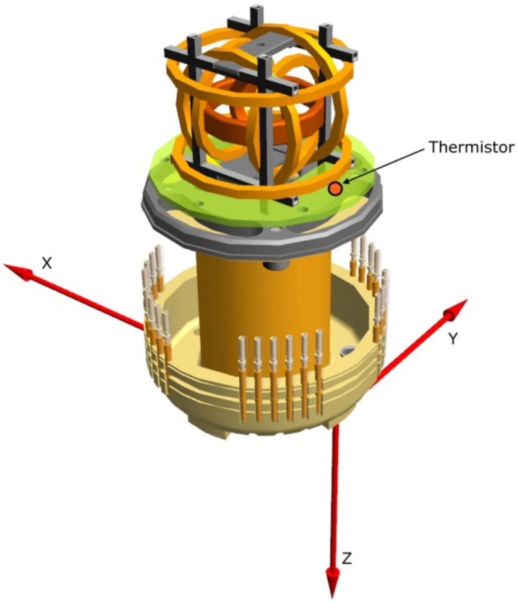


Figure 3.2-2: Thermistor TEMP-S1 monitors sensor temperature

The thermistor for the heater temperature, TEMP-S2, is located on the upper mounting of the heater tube close to the heater, as shown in Figure 3.2-3

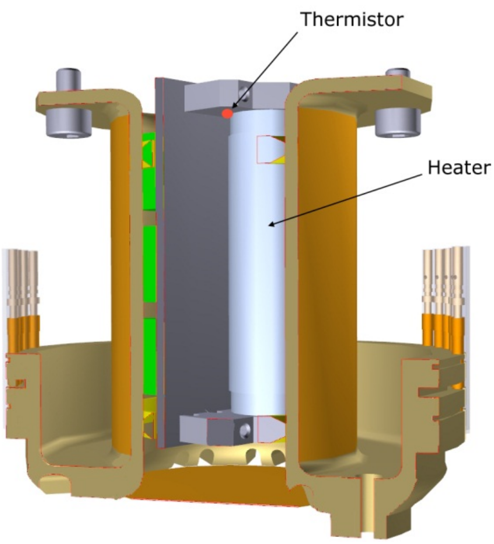


Figure 3.2-3: Thermistor TEMP-S2 monitors heater temperature

3.2.1.2 Thermal Control Category

The Table 3.2-2 indicates the thermal category of each instrument unit.

Unit	Thermal Category
Electronics Box	Internally mounted
IB Sensor	Externally mounted
OB Sensor	Externally mounted

Table 3.2-2: MERMAG Thermal Control Category

3.2.2 Thermal Interfaces

3.2.2.1 Temperature ranges

The TRP and STP temperature ranges for each unit are shown on Table 3.2-3.

The TRP defined on the Sensor Thermal ICD (annex) is also applicable to the thermal hat.

Unit	Operating Temperature (°C)		Non-operating Temperature (°C)		Switch-on Temperature (°C)		Temperature Stability
	Min	Max	Min	Max	Min	Max	-
Sensors	-120	+180	-155	+180	-155	+180	1.3°C/minute 1°C/minute (goal)
Electronics	-20	+50	-40	+60	-40	+60	N/A
Boom harness	-150	+200	-150	+200	-150	+200	N/A

Table 3.2-3: TRP/STP Temperature requirements

Note: the boom cables were tested up to 240°C.

3.2.2.2 Heat dissipation

The MERMAG units heat dissipation in the different instrument's operating modes are shown in the Table 3.2-4.

Unit	Non-Operating Mode	Heater Off	Heater On
OB sensor	0	0.05 W	0.05 W
OB Sensor heater	0	0	0.3 W
IB Sensor	0	0.05 W	0.05 W
IB Sensor heater	0	0	0.3 W
Electronics	0	5 W	5.75 W

Table 3.2-4: Units' steady state heat dissipation in the different operation modes

3.2.2.3 Cold Finger Interfaces

Not applicable for MERMAG.

3.2.2.4 Radiative Interface

For the thermal analysis purpose of internally mounted units, the spacecraft thermal environment shall be assumed as a black body cavity at a temperature TR equal to:

- cold case: -20 °C
- hot case: +40 °C

3.2.3 Thermal Interface Control Drawing

The TICDs as shown in the Table 3.2-5 are provided in the annex.

Unit	TICD Reference	Issue	Pages	Issue date
OB Sensor, IB Sensor	MAGOB-I/F-001	Rev. H	1	08 Feb 2013
OB Sensor, IB Sensor Thermal Shield	MAGOB-I/F-002	Rev. I	1	08 Feb 2013
Electronics	BC-ORTHO-01	Rev. 10	1	18 Feb 2013

Table 3.2-5: Actual MERMAG TICDs references

3.2.4 Thermal Control Interfaces

3.2.4.1 Heater Power Requirements

3.2.4.1.1 Spacecraft controlled heaters

MERMAG is not using any spacecraft controlled heaters.

3.2.4.1.2 Instrument internal operational heaters

MERMAG uses one internal controlled heater for each sensor.

The installed heater power in each sensor is 0.3 W.

3.2.4.2 Temperature Monitoring

3.2.4.2.1 Spacecraft Controlled Thermistors

MERMAG does not require any spacecraft controlled thermistor other than those provided to monitor the TRP.

3.2.4.2.2 Instrument Controlled Temperature Sensors

The 6 lists the instrument powered temperature sensors.

Unit	Instrument Powered Thermistors	Temperature range	Thermistor type	Location	Parameter Name
OB TEMP-S1	1	-200°C / +300°C	PT1000	OB sensor	NME02200
OB TEMP-S2	1	-200°C / +300°C	PT1000	OB sensor heater	NME02201
IB TEMP-S1	1	-200°C / +300°C	PT1000	IB sensor	NME02214
IB TEMP-S2	1	-200°C / +300°C	PT1000	IB sensor heater	NME02215
OB Electronics Temperature	1	-100°C /+150°C	PT1000	OB sensor electronics	NME02202
IB Electronics Temperature	1	-100°C /+150°C	PT1000	IB sensor electronics	NME02216

Table 3.2-6: Instrument Provided Temperature Sensors

The locations of the thermistors are shown on the TICD in the annex.

3.3 Electrical – Power Interface

3.3.1 Instrument Power Distribution and Redundancy Scheme

Power Conversion and Distribution Architecture

The MAG power supply unit (PSU) is a redundant unit which is located on two electronics cards at the bottom of the box. It provides the 6 secondary voltages required by the MAG instrument. The regulation of the spacecraft bus voltage of +28V, +1% -3% (EIDA #3443) is sufficient for the MAG instrument, so no additional regulation is performed on the MAG PSU.

The MAG instrument requires +5V, +3.3V, +2.5V and +1.8V supplies the digital electronics and a bipolar ±8V supply for the magnetometer excitation electronics.

The sensor heaters are supplied from the -8V voltage.

The MAG instrument will be able to safely survive any standing or fluctuation voltage in the full range 0V to 32V, or failure in the power subsystem resulting in a transient of 1ms and 33V as outlined in the EIDA (#2405).

The instrument supply is a switched-mode converter operating at nominally 65.5 kHz

The PSU will ensure correct transformer-isolation between primary and secondary lines, and also isolation of secondary from structure when the star-point bonding connection is removed.

Instrument Power Supply Block Diagram

The power supply and distribution block diagram is given in Figure 3.3-1.

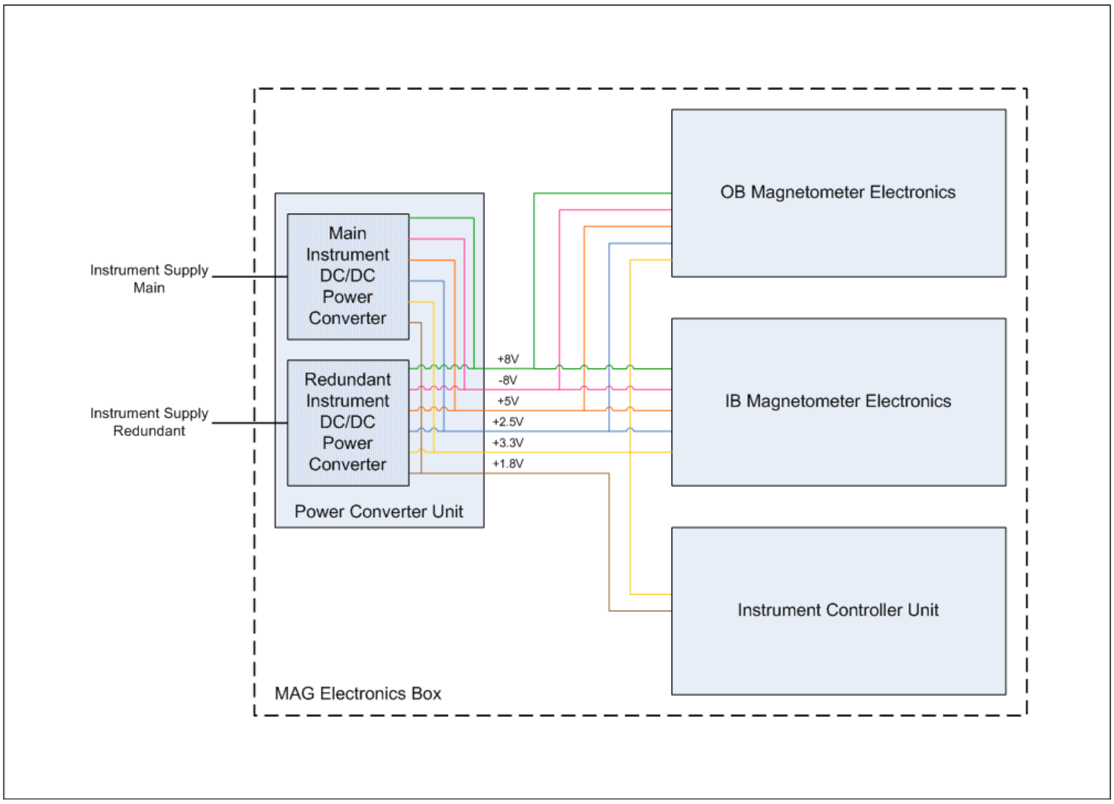


Figure 3.3-1: Power Supply and Distribution Block Diagram

3.3.2 Power Interface Description

The MERMAG primary power interfaces to the spacecraft are indicated in the Table 3.3-2.

Function	Main Interfaces	Redundant Interfaces	LCL Class
28V Main Power Bus	1	1	A
28 V S/C Powered Heaters	0	0	-
28 V Coolers	0	0	-

Table 3.3-2: MERMAG Power Supply Interface Requirements

3.3.3 Experiment Power Requirements

The Table 3.3- indicates the MERMAG primary power characteristics. The Table 3.3-44 indicates the average primary power consumption for various instrument's modes.

Function	Max Average Power		Long Peak Power (Bootup)		Short Peak power (Heating)	
	BoL	EoL	BoL	EoL	BoL	EoL
28 V Main Power	5 W	5 W	N/A	N/A	5.75 W	5.75 W

Table 3.3-3: MERMAG Main Bus Interfaces Power Requirements

Instrument Interface	Sensor in Sunlight (EOL/BOL) [W]	Sensor in Shadow (EOL/BOL) [W]
MERMAG	5 W	5.75 W

Table 3.3-4: +28V Main Power Consumption (average) for Various Instrument Modes

Note: It is anticipated that the heater will be operated whenever the sensor is not illuminated directly by sunlight; either by being shadowed by the spacecraft or when Mercury eclipses the spacecraft.

The Table 3.3-5 gives the instrument's units maximum power dissipation and its duration as well as the average units power dissipation over one orbit for different operational modes at EoL conditions.

Unit	Non-Operating Mode		Normal Operating Mode		Reduced Power Mode	
	Max/ duration	Average/ orbit	Max/ duration	Average/ orbit	Max/ duration	Average/ orbit
MERMAG instrument	N.A.	0	5.75 W/ 1 hr	5 W	5.75 W/ 1 hr	4.7 W

Table 3.3-5: Maximum and average power consumption (w) over an orbit (EoL)

3.3.4 Power Interface Circuits

The MAG PSU is redundant. The power lines from the main spacecraft LCL connect to the Main MAG DCDC converter and the redundant spacecraft LCL connects to the Redundant MAG DCDC converter.

On the output of the MAG PSU board, the individual voltage outputs (i.e. +8V, -8V etc.) are diode or'd together before being routed via connector J13 to the other MERMAG boards.

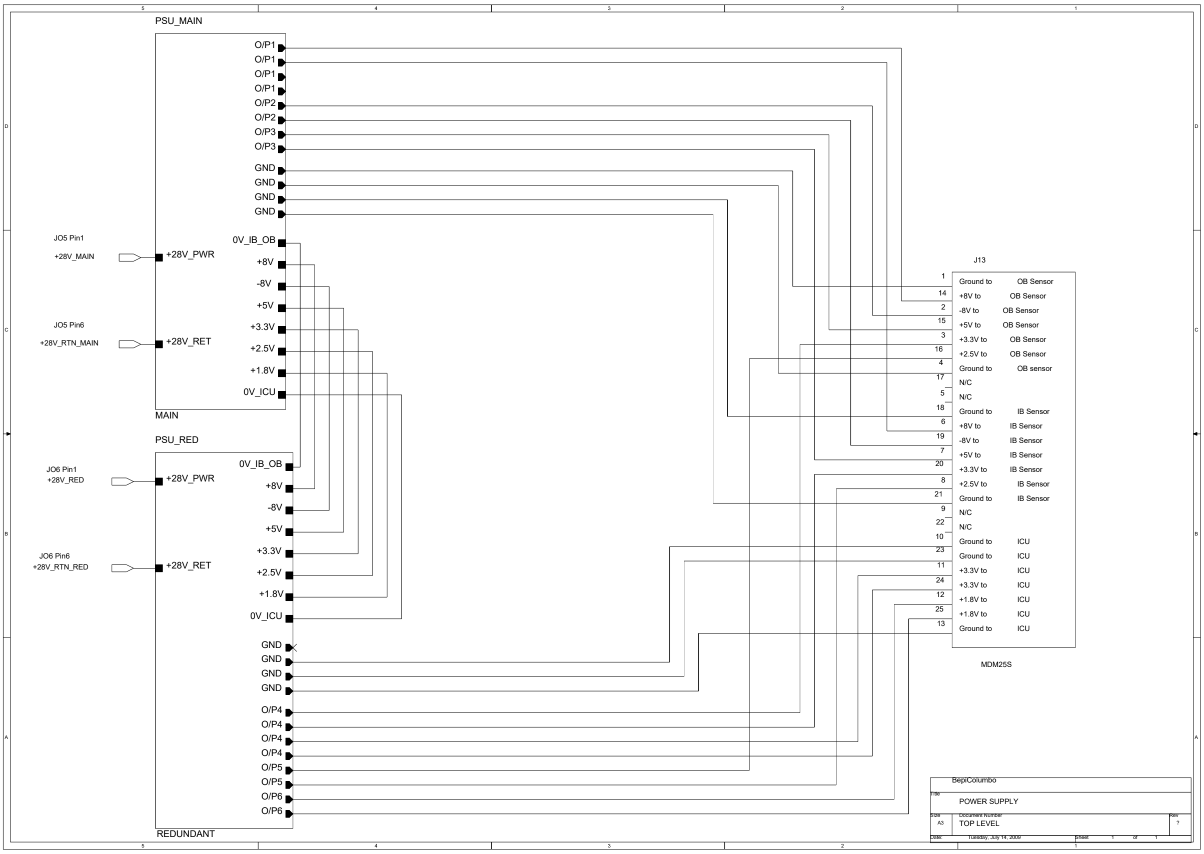


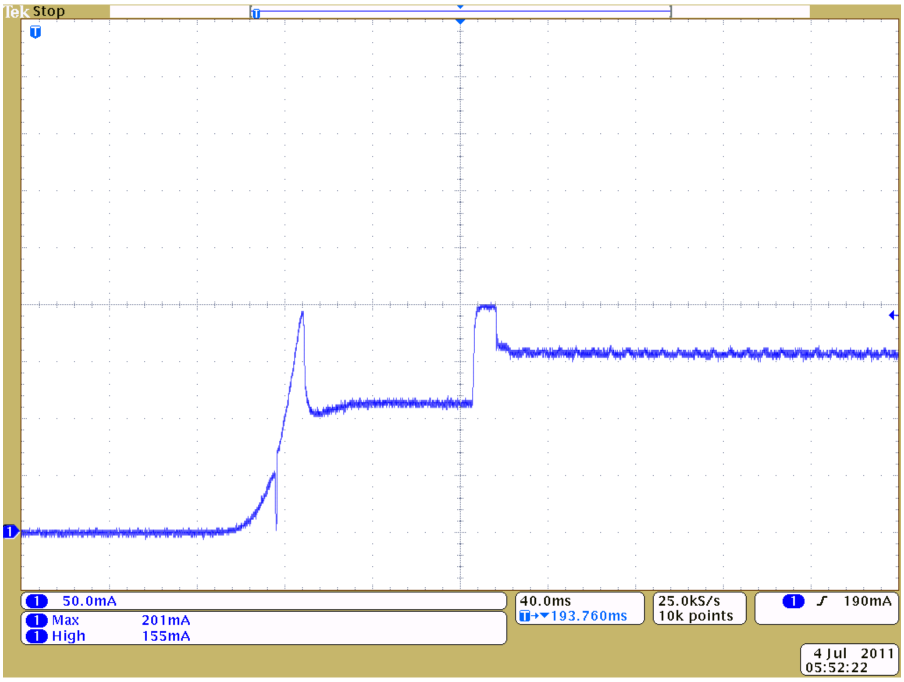
Figure 3.3-2: Electrical Power Interface Circuit

3.3.5 Electrical Power Interface Data Sheets

Test Step Description	Min. Limit	Max. Limit	Meas. Value	Phys. Unit
Inrush Current Main : J05 Pin 1 +28V_MAIN (Main Power) J05 Pin 6 +28V_RTN_MAIN (Main Power Return)				
Current di/dt	0.0	1.0	0.010	[A/ms]
Current peak	0.0	-	0.197 / 0.201	[A]
Input current settling time (switch-on peak duration)	0.0		40	[ms]
Maximum load current w/o heaters, sensors in GSE µ-metal shield	0.0	1.0	0.165	[A]
Maximum load current with 2 heaters (full power), sensors in GSE µ-metal shield	0.0	1.0	0.190	[A]
Supply voltage steady state (at MERMAG power supply)	27.16	28.28	28.28	[V]

Electrical Data Sheet 5: Inrush Current Profile	
Instrument:	MERMAG
Unit:	Electronics Box
Connector:	J05, J06
Power Input:	28V

The in-rush current profile with the primary power bus voltage present at the UNIT input is shown in the figure below:



3.3.6 Non Explosive Actuators Interfaces

Not applicable for MERMAG.

3.4 Electrical - Data Handling Interface

3.4.1 Instrument Signal and Data Handling Interface Description

The MAG instrument uses two independently addressed cold redundant SpaceWire interfaces connecting to the SSMM. These Interfaces are to be used for TM and TC. MERMAG will use the spacewire time service.

3.4.2 Interfaces Overview

The signal and data handling interface requirements from MERMAG to the spacecraft are summarized in the Table 3.4-1.

Interface	Signal Type or Function	Main	Red.	I/F Type	I/F Circuit
TM/TC	SpaceWire	1	1		
					Fehler! Verweisquelle konnte nicht gefunden werden.
Monitoring	Thermistors	n.a.	n.a.		
	Bi-Level	n.a.	n.a.	-	-
	Analogue	n.a.	n.a.	-	-
Discrete Cmd	High Power ON/OFF	n.a.	n.a.	-	-
Synchronisation		n.a.	n.a.	-	-

Table 3.4-1: Instrument Signal and Data Handling Interfaces

3.4.3 TM/TC

3.4.3.1 Bit Rate Requirements

The data signal rate is 10Mbit per second as agreed in EIDA Chapter 3.5.2.3.

3.4.4 Monitoring

MERMAG does not require descrete monitoring interfaces with the spacecraft..

3.4.5 Synchronisation

Time synchronisation of the MERMAG internal clock is provided via the SpaceWire interface using spacewire time service and TC as defined in EIDA chapter 3.7.5.8 as well as time format defined in EIDA Chapter 3.7.2.3.0.

3.4.6 Electrical Interface Circuits

The internal spacewire links of the ESA-provides RTC-ASIC will be used for TM/TC. Currently there are no final datasheets and application circuit diagrams available.

Refer to figure 3.9-3 for TM and TC interface circuits.

3.4.7 Electrical Signal Interface Data Sheets

The internal spacewire links of the RTC will be used for TM/TC. Currently there are no final datasheets and application circuit diagrams available.

3.5 Instrument Budgets

Please refer to the MERMAG Resource Budget Technote BC-MAG-TN-00004.

4. INSTRUMENT OPERATING MODES

See Chapter 5.1.1.2 and following.

5. INSTRUMENT ON-BOARD SOFTWARE

5.1.1 Software Concept

5.1.1.1 Software Architecture / Design overview

5.1.1.1.1 Software Partitions

The instrument software consists of several software partitions explained below

5.1.1.1.1.1 Boot Software

The boot software resides in PROM and contains basic functionality for science software selection, software maintenance and basic commanding.

5.1.1.1.1.2 Science Software

The science software resides in EEPROM and contains the full science software with functionality. The software is copied to RAM by the boot software and can be executed there. The software maintenance functionality of the science software has limited TC availaibility. Information available in both overview 5.1.2.1.2 and individiual TC descriptions.

5.1.1.1.1.3 Backup Science Software

The backup science software resides in PROM and provides basic science functionality with limited command set. It is executed in case of EEPROM software errors.

5.1.1.1.2 Redundancy/Security

All software is verified prior to execution using software checksums. There is no explicit hardware redundancy, some kind of redundancy can be reached using backup science software or using direct software upload at boot, so failures of EEPROM or RAM can be handled. This would require 600 TC of maximum length.

5.1.1.1.3 Data Compression

A data compression mode is available. Data from both sensors can be compressed using joint Golomb-Huffman Coding.

5.1.1.1.4 Internal Storage Capacity

The memories of the instrument will include

64 kbytes PROM

512 kbytes EEPROM

2 Mbytes RAM

An internal data buffer of about 1024 kbytes will be available in the RAM. In case of a SPW connection loss all data is buffered until the buffer is full, then buffer is frozen until reconnection.

Upon reconnection data is sent, the buffer is emptied and data is recorded as soon as there is space in buffer.

5.1.1.2 Instrument Modes

5.1.1.2.1 Available Modes

The software operation is defined by software operational modes, which define the current functionality and available commands. The current mode of operation is defined by the mode status byte, which is explained below:

Mode Number UInt4	Mode	Explanation
none	Off	Power off state
0	ROM Boot	**Objective:** Automatic boot mode. Software resides in PROM and uses only internal memory. Copies EEPROM software to external memory for booting second stage software. Software source is selectable via TC or automatic. **FDIR:** check all stored software and compare checksum, check internal and external RAM, stop automatic boot process on unrecoverable errors. **Supported services**: see 5.1.2.1.2. **Data Resources:** boot events and memory check success messages, HK SID 3 every 8192 sec
1	Boot Maintenance	**Objective:** Provide software maintenance in bootloader, software can be checked, patched, dumped and uploaded without having a working software in EEPROM. Modified software can be executed directly. **FDIR:** all software can be verified using checksums **Supported services**: see 5.1.2.1.2. **Data Resources:** mode change message, HK SID 3 every 8192 sec
2	Booting RAM	**Objective:** Transient mode to signal boot process of second stage to OBCP. Spacewire is disabled, instrument will switch to default science mode, which is Normal Science X (dual sensor), 4Hz, 2048nT range, uncompressed.. The science mode can instantly be changed after boot. In case a science packet has been started it is filled up with NaN values and the new mode starts with a new packet. Mode change status events will be sent upon entering and leaving this mode. Detectable errors will be sent after leaving this mode. **FDIR:** none **Supported Services:** none **Data Resources:** mode change event only
3	Normal Science X	**Objective:** This is the normal mode of science operation. Data volume is dependant on sensor activation state (inboard/outboard), data rate and compression mode/activation. Data is sent for X-Band transmission. This mode produces uncompressed, compressed and dual compressed science reports. **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported services**: see 5.1.2.1.2. **Data Resources:** science and housekeeping data, see 5.1.3.

4	Normal Science Ka	**Objective:** Science mode. Data volume is dependant on sensor activation state (inboard/outboard), data rate and compression mode/activation. Data is sent for Ka-Band transmission. This mode produces uncompressed, compressed and dual compressed science reports. **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported services**: see 5.1.2.1.2. **Data Resources:** science and housekeeping data, see 5.1.3.
5	Selective Science	**Objective:** This mode is used for selective downlink. 2 data products (selection support data and high rate selective data) are generated. Data volume is dependant on sensor activation state (inboard/outboard), data rate and compression mode/activation. Data is sent for X- and Ka-Band transmission. This mode produces uncompressed, compressed and dual compressed science reports. **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported services**: see 5.1.2.1.2. **Data Resources:** science and housekeeping data, see 5.1.3.
6	Science Standby	**Objective:** In this mode science data output is disabled, but sensor housekeeping data is still available. **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported services**: see 5.1.2.1.2. **Data Resources:** housekeeping data, HK SIDs 1,2,4,5, typically every 128 sec, see 5.1.3 .
7	Operational Maintenance	**Objective:** Provide software maintenance in operation, software can be checked, patched, dumped and uploaded, but not executed **FDIR:** all software can be checked using checksums **Supported services**: see 5.1.2.1.2. **Data Resources:** HK SID 3 every 8192 sec, see 5.1.3.
8	EEPROM Writing	**Objective:** Transient mode to signal eeprom writing. A single command is delayed until returning from this mode, further commands are discarded. Returns automatically to originating maintenance mode. No communication is possible due to timing requirements of EEPROM writing. Detectable error events are caught and signalled after leaving this mode. **FDIR:** Hardware watchdog, but set to several minutes to prevent accidental rebooting by to tight timing. **Supported Services:** none **Data Resources:** none

9	Calibration Science	**Objective:** provide calibration possibilities for the sensors. Data volume is dependant on sensor activation state (inboard/outboard), and data rate. No compression is available. Data is sent via X-Band **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported Services:** none **Data Resources:** see 5.1.3.
15	Backup Science Mode	**Objective:** Provide science functionality in boot PROM. Simplified extract of normal X science mode. This mode is only used in case of EEPROM or external RAM failure. Sensors are commanded directly using a raw command. **FDIR:** sensor temperature surveillance, hardware watchdog. **Supported services**: see 5.1.2.1.2. **Data Resources:** science and housekeeping data, see 5.1.3.

Table 5-1: Instrument Modes

5.1.1.2.2 Mode Transitions

Mode Transition Diagram

The MERMAG mode transition diagram is shown on Figure 5.1.1

TC	Transition via telecommand
A	Transition automatically
FDIR	Transition caused by FDIR
TC/A	Transition automatically with timeout or via telecommand possible
TC/FDIR	Transition can be caused by FDIR or TC

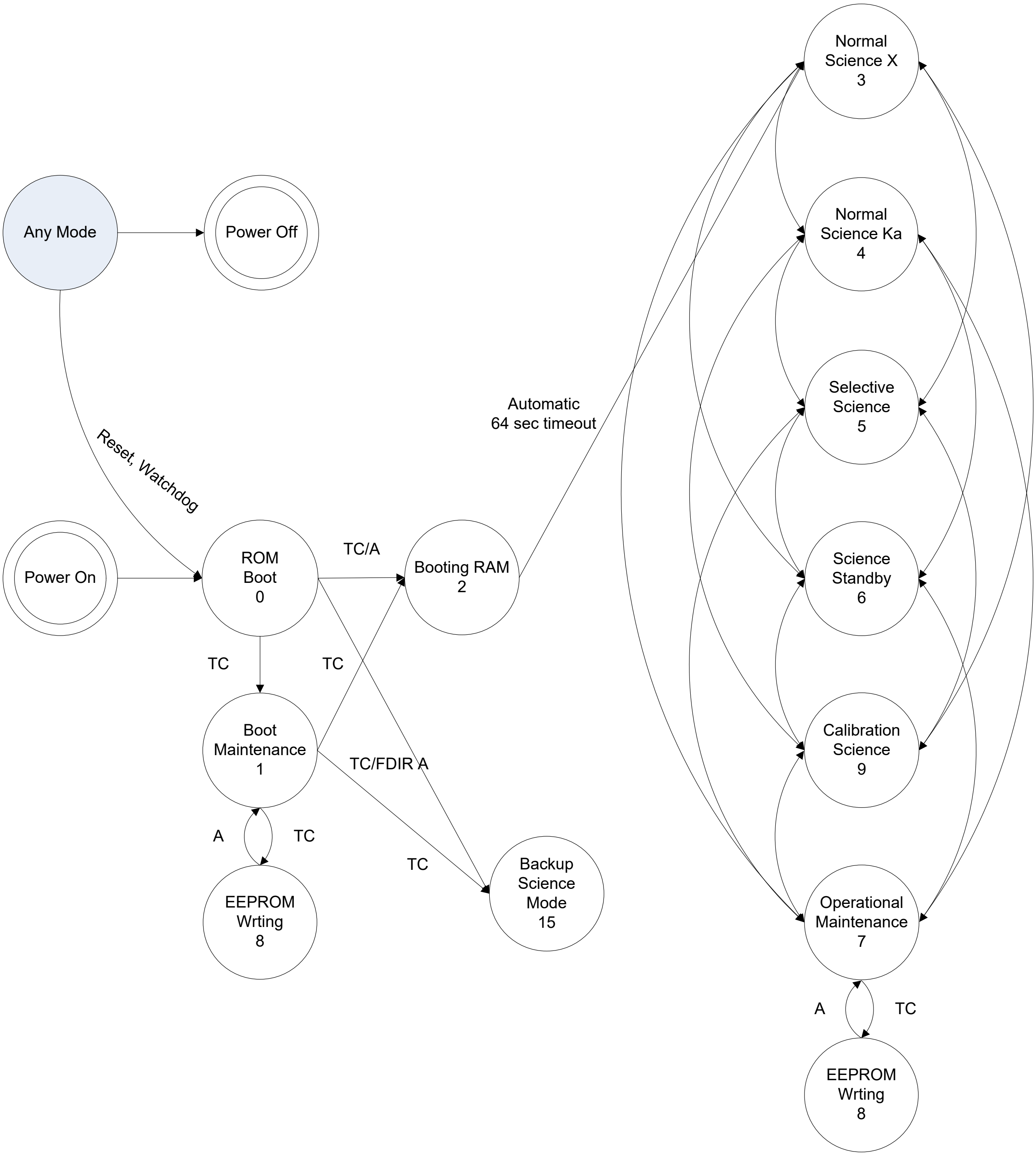


Figure 5-1: Mode Transition Diagram

Mode Transition Table

Table 5.1.2 shows the mechanisms for the transitions from one to another mode.

Originating Mode	Destination Mode	Transition Cause	Condition for Transition
Any	OFF	Power-Off	None
OFF	ROM Boot 0	Power-On	None
Any Mode	ROM Boot 0	Software Reset, Hardware Watchdog, Software watchdog	If in EEPROM writing mode, software reset is delayed
ROM Boot 0	RAM Boot 2	Automatic Timeout, 64 seconds No mode change TC received (manual/override boot select, backup mode received	IF RAM checksum is OK ELSE stay in ROM Boot mode, deactivate timeout
		TC Manual Boot Select	IF RAM Checksum is OK ELSE error message, stay in ROM Boot mode, deactivate timeout
		TC Override Boot Select	None
ROM Boot 0	Backup Science Mode 15	TC Manual Boot Select	If PROM Checksum is OK ELSE error message, stay in ROM Boot mode, deactivate timeout
		TC Override Boot Select	None
ROM Boot 0	Boot Maintenance 1	TC Enable Boot Maintenance	None
Boot Maintenance 1	RAM Boot 2	TC Manual Boot Select	IF RAM Checksum is OK ELSE error message, stay in Boot Maintenance mode, deactivate timeout
		TC Override Boot Select	None
		TC Execute memory Address	None
Boot Maintenance 1	Backup Science Mode 15	TC Manual Boot Select	If PROM Checksum is OK ELSE error message, stay in Boot Maintenance mode, deactivate timeout
		TC Override Boot Select	None
Boot Maintenance 1	EEPROM Writing 8	TC Write to EEPROM	None
Boot Maintenance 1	ROM Boot 0	TC Execute memory Address	None
EEPROM Writing 8	Originating Maintenance	Automatic after writing, independent of success	None
RAM Boot 2	Normal Science X 3 (can be changed to 3,4,5,6 using service 6 for parameter update or SW update	Automatically after boot	None
Science, any	Other Science	TC Science: Change Instrument Mode	None
Science, any	Operational Maintenance 7	TC Enable Operational Maintenance	None

Originating Mode	Destination Mode	Transition Cause	Condition for Transition
Operational Maintenance 7	Science	TC Science: Change Instrument Mode	None

Table 5-2: Mode Transition Table

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="12">To</th></tr>
<tr><th>Off</th><th>ROM Boot
0</th><th>Boot
Maintenance
1</th><th>RAM
Boot
2</th><th>Normal
Science
X
3</th><th>Normal
Science
Ka
4</th><th>Selective
Science
5</th><th>Science
Standby
6</th><th>Operational
Maintenance
7</th><th>EEPROM
Writing
8</th><th>Calibration
Science
9</th><th>Backup
Science
15</th></tr>
<tr><td rowspan="13">From</td><td>Off</td><td>Leave power off</td><td>Power on</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>ROM Boot
0</td><td rowspan="12">Power off</td><td>Watchdog
TC(208,2)</td><td>TC(209,5)</td><td>Automatic
TC(209,2)
TC(209,3)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2">Automatic
TC(209,2)
TC(209,3)</td></tr>
<tr><td>Boot
Maintenance
1</td><td>Watchdog
TC(208,2)
TC(209,10)</td><td>-</td><td>Automatic
TC(209,2)
TC(209,3)
TC(209,10)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>TC(209,7)</td><td>-</td></tr>
<tr><td>RAM Boot
2</td><td rowspan="10">Watchdog
TC(208,2)</td><td></td><td>-</td><td colspan="4">dependant on default science mode</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Normal
Science X
3</td><td>-</td><td>-</td><td colspan="4" rowspan="5">TC(207,5)</td><td rowspan="5">TC(209,6)</td><td>-</td><td rowspan="5">TC(207,5)</td><td>-</td></tr>
<tr><td>Normal
Science KA
4</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Selective
Science
5</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Science
Standby
6</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Operational
Maintenance
7</td><td>-</td><td>-</td><td>TC(209,7)</td><td>-</td></tr>
<tr><td>EEPROM
Writing
8</td><td>Automatic</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Automatic</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Calibration
Science
9</td><td>-</td><td>-</td><td colspan="4">TC(207,5)</td><td>TC(209,6)</td><td>-</td><td>TC(207,5)</td><td>-</td></tr>
<tr><td>Backup
Science
15</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Table 5-3: Allowed Mode Transitions

5.1.1.2.3 Magnetometer Measurement Rates and Calibration modes

Each science mode can operate at different sampling rates. Each sensor can be sampled independently, allowing up to 4 differently sampled data products (2 each for inboard/outboard sensor) in selective downlink mode. Also compression can be enabled independently for each of these 4 products. If 2 products of a process operate at same sampling frequency with enabled compression, a dual science report is sent to allow better compression. A sensor with standby (0) sampling rate still produces housekeeping data with normal rate.

Also during calibration each sensor can be operated independently. Compression is not available in calibration mode. Calibration is defined further by calibration sub-modes below. In calibration modes a calibration science report is generated.

5.1.1.2.3.1 Magnetometer Measurement Rates

Value UInt4	Measurement Rate	Report Rate
0	0	Standby
1	0.5 Hz	256 sec
2	1 Hz	128 sec
3	2 Hz	64 sec
4	4 Hz	32 sec
5	8 Hz	16 sec
6	16 Hz	8 sec
7	32 Hz	4 sec
8	64 Hz	2 sec
9	128 Hz	1 sec
Others	Invalid	Invalid

Table 5-4: Measurement Rates

5.1.1.2.3.2 Magnetometer Calibration Modes

Value UInt4	Measurement Mode	Explanation
0	Normal	Normal Operation for comparison purposes.
1	Calibration 1	The feedback DAC is operated using a step function.
2	Calibration 2	The sensor counts up in the data values. Used for filter verification.
3	Calibration 3	ADC measurement and feedback DAC Values are sent separately. To keep frame generation rate constant, each second ADC vector is replaced by the DAC value of the first vector.
4	Calibration 4	The magnetometer is operated in open loop, the feedback DAC is set to 0 by default and can be changed via TC.
5	Calibration 5	Meander Macro using Feedback DAC. The magnetometer is operated in open loop, feedback and compensation dac values are changed every 10 seconds using a lookup table .
6	Calibration 6	Meander Macro using Compensation DAC. The magnetometer is operated in open loop, feedback and compensation dac values are changed every 10 seconds using a lookup table .
7	Calibration 7	Findphase Macro using Feedback DAC. The magnetometer is operated in open loop, the feedback dac and phase values are changed in adjustable steps and time.
8	Calibration 8	Findphase Macro using Compensation DAC. The magnetometer is operated in open loop, the feedback dac and phase values are changed in adjustable steps and time.
Others	Invalid	

Table 5-5: Measurement Modes

5.1.1.3 Software memory allocation

5.1.1.3.1 Physical Memories

The memory area consists of the following physical memories:

PROM: 2x32Kbyte (8 bit wide)

EEPROM: 4x128Kbyte (8 bit wide)

RTC internal RAM: 64 KByte(32 bit wide)

external RAM: 2Mbyte (32 bit wide)

The PROM is used for boot and backup science mode software, the EEPROM is used for science software, the internal RAM is used for fast computation and the external RAM is used for slower computations and data buffering.

5.1.1.3.2 Alignment

The used CPU word length is 32 bits. To simplify software operation, memory accesses are only addressable in 32 bit units.

5.1.1.3.3 Memory Operations:

- Dump: Partially or full dump of the requested area
- Check: Checksum of the requested area with CRC16 algorithm
- Compare check: compare onboard stored checksum with checksum of area
- Patch: Load the requested area with new data

Dump, check and patch are service 6 commands, compare check is a private service 209 command. The external memory can be filled with 0/1 during boot maintenance mode to detect memory errors.

5.1.1.3.4 Memories and their ID's

Physical memories are represented as themselves as well as their logic partitions which are defined by their purpose.

Memory ID UInt16	Memory	Address Range	Services
190	Boot PROM	0x00000000-0x0000ffff	Dump Check
191	EEPROM0	0x10000000-0x1001ffff	Dump Check Patch Compare Check
192	EEPROM1	0x10020000-0x1003ffff	
193	EEPROM 2	0x10040000-0x1005ffff	
194	EEPROM 3	0x10060000-0x1007ffff	
195	BootImage	0x40100000-0x401fffff	
196	External RAM	0x40000000--0x401fffff	Dump Check Patch
197	Internal RAM	0xA0000000-0xA000ffff	
198	Complete addressable area	0x00000000-0xffffffff	Dependant on area
199	Backup Science Placeholder	0x00000000-0x0000ffff	Dump Check

Table 5-6: Memory IDs

The defined memory sections are sub-areas of the complete addressable area (198). Any TC that is using area 198 can therefore address all the subareas. The service restrictions are therefore applied to the memory range, not the memory ID.

5.1.1.3.5 Explanation of memories

- PROM: contains ROM boot software, maintenance commands and backup science mode software as well as the PROM checksum
- EEPROM: whole EEPROM area composed of EEPROM program and constants area and parameter update area. The last 512 bytes are reserved for parameter updates.

- BootImage: This area is used to store a program image before executing or writing to EEPROM. During normal science operation this area is used as science buffer.
- External RAM: Is used for RAM software, constants and slow but big data buffers
- Internal RAM: Is used for ROM boot, backup science software and fast buffer for data when RAM software is executed. A full RAM load is not possible, as it would influence the update software.
- Complete adressable Area: whole address range of the CPU including memory mapped hardware.

5.1.1.4 Boot Behaviour

The boot software in PROM executes the following functions:

- Check external RAM for stuck bits by writing and reading 0's and 1's, do an address check
- Check internal RAM using read with enabled EDAC
- Initialize clock
- Initialize Spacewire
- Report memory check errors
- Check software checksums
- auto select first working software, disable autoboot if no correct software is found
- copy to Boot Image, disable autoboot if check error after copy.
- Report checksum success/errors
- Sent Boot Success/Error Event
- Accept time updates
- Send Boot HK report after time update / 5 second timeout
- Auto boot first working software after 64 seconds if no backup mode or select boot TC is received or remain in boot mode if errors have happened.
- In case of auto boot go to default science mode

5.1.1.5 Software Maintenance Concept

Software maintenance can be done in all memories by using maintenance commands (services 6 and 209). For memory upload only TC (6,2) is used. The following update concepts are available:

- Write any memory area without verification
- Write any memory area with verification via TC (6,9)
- Write to boot image or EEPROMS TC(6,2) with checksum verification using TC (209,1)
- Write (updated) boot image to selected EEPROM using TC (209,7). The stored software checksum is compared before/after write and events are generated.
- Each area can be checked or dumped during maintenance modes.
- EEPROM write errors are reported using TM (5,2,52020)
- All EEPROM writes require TC (209,8) to provide the EEPROM unlocking keys.

- To ensure correct upload, also the checksum of the changed memory section should be updated, so the updated software can be verified using TC (209,1)
- A full software update contains its own checksum and can be directly verified using TC (209,1)
- Since the basic maintenance software resides in PROM and is not writeable, a failed upload can also be repeated any time later.
- Parameter updates are done using a partial software update to the parameter area. The positioning of individual parameters is instrument-internal and is subject to change. The instrument verifies that an installed parameter update fits to the current software version.
- If an onboard software is uploaded, it is normally executable as soon as the software checksum (part of the uploaded image) is correct.

5.1.1.5.1 Intended Update Workflows

5.1.1.5.1.1 Temporary Software Update

Prerequisites:

System is in Boot Maintenance Mode

Flow:

- Upload Software Packets in chunks of 224 Bytes to BootImage area using TC 6,2
- Compare Software Checksum of MemID 195 using TC (209,1)
- Wait for TM(5,1) EID 52022 and MemID 195
- If EID52022 is received, the software checksum is correct and the upload was successful.
- Execute program image

Problems:

One of the messages is not received.

5.1.1.5.1.2 Full Software Update

Prerequisites:

System is in Maintenance Mode

Flow:

- Upload Software Packets in chunks of 224 Bytes to BootImage area using TC 6,2
- Compare Software Checksum of MemID 195 using TC (209,1)
- Wait for TM(5,1) EID 52022 and MemID 195
- If EID52022 is received, the software checksum is correct and the upload was successful.
- Provide EEPROM keys using TC (209,8)
- Write RAM Software to EEPROM using TC (209,7)
- Revoke EEPROM keys using TC (209,9)
- Compare software checksum of EEPROM using TC (209,1)

- Wait for TM(5,1) EID 52022 and MemID of selected EEPROM
- If EID52022 is received, the software checksum is correct and the update was successful.

Problems:

One of the messages is not received.

5.1.1.5.1.3 Partial Software Update

Prerequisites:

System is in Maintenance Mode

Flow:

- Provide EEPROM keys using TC (209,8)
- Upload Software Packets to EEPROM using TC 6,2
- Revoke EEPROM keys using TC (209,9)
- Compare Software Checksum of MemID using TC (209,1)
- Wait for TM(5,1) EID 52022 and MemID 195

Problems:

One of the messages is not received.

5.1.1.6 Instrument internal Failure Detection, Isolation and Recovery (FDIR)

5.1.1.6.1 Software verification

5.1.1.6.1.1 Detection

All software is verified prior to execution using checksums. The first working software (EEPROM 0-3, Backup Science) is marked for automatic boot. If no working software is found or a memory test fails, automatic boot is dsabled. Manual boot (TC 209,2) of a software image with errors is denied, this can be done using override boot (TC 209,3) All checksum errors are reported using appropriate telemetry.

5.1.1.6.1.2 Action

Execute first working software or halt boot process

5.1.1.6.2 Software Monitoring

5.1.1.6.2.1 Detection

Software Traps are detected and can be reported. Reporting of software traps cannot be guaranteed.

A hardware watchdog is implemented.

5.1.1.6.2.2 Action

Triggering of the hardware watchdog causes a soft reboot.

Soft Reboot in this case means rebooting without power cycling the instrument.

5.1.1.6.3 DPU Memory

5.1.1.6.3.1 Detection

PROM error detection cannot be detected, since no software functionality can be guaranteed in case of prom errors (single point failure).

EEPROM errors can be detected using checksum. Non-permanent errors can be corrected using software update (overwrite), permanent errors can be avoided by executing from another EEPROM, using backup science mode software or by uploading the software each time at boot.

Internal RAM errors can be detected and corrected using EDAC. No EDAC scrub mechanism is implemented. An uncorrectable internal RAM failure is also a CPU failure and reporting cannot be guaranteed.

External RAM errors can be detected at boot (0/1 write test) and can be avoided using backup science mode (uses only internal RAM) or by reprogramming the EEPROM software to skip using defective RAM areas. EDAC is not available for the external RAM.

5.1.1.6.3.2 Action

No autonomous action.

5.1.1.6.4 Sensors

5.1.1.6.4.1 Detection

Sensor communication errors and timeouts can be detected and reported. Events and error messages see service 5.

5.1.1.6.4.2 Action

No autonomous action.

5.1.1.6.5 Power

5.1.1.6.5.1 Detection

All voltages and currents are monitored, exceedance of limits can be detected and reported.

5.1.1.6.5.2 Action

On exceedance of predefined or TC set limits (see 5.1.6 and 5.1.2.3.4.1) for more than N times (HKLimitCount) the instrument will request a poweroff.

Furthermore the internal PSU has a tripoff mechanism that limits the instrument current. See 5.1.2.4.2 .

5.1.1.6.6 Thermal Control

The instrument has no thermal control. The used heating mechanisms are only used to reduce temperature gradients/changes to improve science performance.

5.1.2 Service Implementation

5.1.2.1 General

5.1.2.1.1 PID Allocation

Operational modes (see 5.1.1.2) also define the types of processes started within the instrument. This means not every process and its according housekeeping data is available in every operational mode. (e.g. sensor science and housekeeping data is not available during boot or maintenance)

Process ID UInt7	Process	Available in Mode
85	Traditional science or support science (X-band)	3,15
86	Traditional science (Ka-band)	4
87	Selective high rate science (Ka-band)	5
88	Unused	
89	Instrument Management, Sensor Control and Housekeeping	1,3,4,5,6,7,9,15

Table 5-7: PID Allocation

5.1.2.1.1.1 Sensor ID

Several TC operate on the 2 instrument sensors. Commands can be applied to inboard, outboard or both sensors.

Sensor ID UInt8 CMET6030TC CMET6030TM	Affected Sensor
0	Outboard Sensor
1	Inboard Sensor
2	Both Sensors

Table 5-8: Sensor IDs

5.1.2.1.2 Service Table

The following lists give information about the application data area of the TC/TM packets. Each packet is of course enveloped by the general TC/TM packet structure.

All TC have to be sent to PID 89, all responses will therefore originate from PID 89.

Some of the following key words used in packet definition are defined below:

Database mnemonic: Name in Bepicolombo TM database

Availability: Service is available in the mentioned operational modes (see chapter 5.1.1.2.1)

PID: TC has to be addressed to the listed process IDs (see above) or TM is created by listed processes

SETY: Service type

SUTY: Service subtype

TY: Type (Telemetry/Telecommand)

Destination: Destination ID for TM

SETY	SUTY	TY	Description	Availability	PID	Chapter
Service 1: Telecommand Verification						
1	1	TM	Telecommand acceptance report	Any, except 2,8	89	5.1.2.2.1.1
1	2	TM	Telecommand acceptance failure report	Any, except 2,8	89	5.1.2.2.1.2
1	7	TM	Telecommand execution success report	Any, except 2,8	89	5.1.2.2.1.3
1	8	TM	Telecommand execution failure report	Any, except 2,8	89	5.1.2.2.1.4
Service 3: Housekeeping and Diagnostic Data Reporting						
3	5	TC	Enable housekeeping parameter report generation	Any, except 2,8 dependant on SID, see individual reports	89	5.1.2.2.3.1
3	6	TC	Disable housekeeping parameter report generation	Any, except 2,8 dependant on SID		5.1.2.2.3.2
3	25	TM	Housekeeping parameter report	Any, except 2,8 dependant on SID, see individual reports	89	5.1.2.2.3.3
3	129	TC	Define housekeeping parameter report collection interval	Any, except 0,2,8 Dependant on SID, see individual reports	89	5.1.2.2.3.4
Service 5: Event Reporting						
5	1	TM	Normal/progress report	Any, except 2,8	89	5.1.2.2.4.1
5	2	TM	Error/anomaly report	Any, except 2,8	89	5.1.2.2.4.2
5	3	TM	Error/anomaly report – ground action	Any, except 2,8	89	5.1.2.2.4.3
5	4	TM	Error/anomaly report – onboard action	Any, except 2,8	89	5.1.2.2.4.4
Service 6: Memory Management						
6	2	TC	Load data in memory using absolute addresses	1, 7	89	5.1.2.2.5.1
6	5	TC	Dump memory area using absolute addresses	1, 7	89	5.1.2.2.5.2
6	6	TM	Memory dump report using absolute addresses	1,7	89	5.1.2.2.5.3
6	9	TC	Check memory area using absolute addresses	1,7	89	5.1.2.2.5.4
6	10	TM	Memory check report	1,7	89	5.1.2.2.5.5
Service 9: Time Management						
9	129	TC	Accept time update	Any, except 2	89	5.1.2.2.7.1
Service 17: Test						
17	1	TC	Perform connection test	Any, except 2,8	89	5.1.2.2.8.1
17	2	TM	Connection test response report	Any, except 2,8	89	5.1.2.2.8.2
17	128	TC	Test telecommand of maximum length	Any, except 2,8	89	5.1.2.2.8.3
Service 21: Science Data Transfer						

21	1	TC	Enable/start science transfer from user	3,4,5,9,15	89	5.1.2.2.10.1
21	2	TC	Disable/stop science transfer from user	3,4,5,9,15	89	5.1.2.2.10.2
21	3	TM	Multiple packets, see Science Packet Identifier	3,4,5,9,15	85, 86, 87	5.1.2.2.10.3
21	128	TC	Reset output buffer	3,4,5,6,9	89	5.1.2.2.10.9
Service 205: Unused						
			Unused			
Service 206: Sensor Control						
206	1	TC	Set Sensor ADC Weighting values	3,4,5,6,9	89	5.1.2.3.2.1
206	2	TC	Set Sensor DAC Weighting Values	3,4,5,6,9		5.1.2.3.2.2
206	3	TC	Set Sensor Internal Feedback Factor	3,4,5,6,9		5.1.2.3.2.3
206	4	TC	Set Sensor Phase Value	3,4,5,6,9		5.1.2.3.2.4
206	5	TC	Set Sensor Sample Value	3,4,5,6,9		5.1.2.3.2.5
206	6	TC	Set Sensor Feedback Relay	3,4,5,6,9		5.1.2.3.2.6
206	7	TC	Set Sensor Excitation	3,4,5,6,9		5.1.2.3.2.7
206	8	TC	Set Sensor feedback DAC values	9		5.1.2.3.2.8
206	9	TC	Select Sensor ICU Filter	3,4,5,6,9		5.1.2.3.2.9
206	10	TC	Set Sensor Auto Compensation	3,4,5,6,9		5.1.2.3.2.10
206	11	TC	Set Sensor Manual Compensation Values	3,4,5,6,9		5.1.2.3.2.11
206	12	TC	Trigger Single Sensor Auto Compensation Cycle	3,4,5,6,9		5.1.2.3.2.12
206	13	TC	Set Sensor Auto Ranging	3,4,5,6,9		5.1.2.3.2.13
206	14	TC	Set Sensor Auto Heater	3,4,5,6,9		5.1.2.3.2.14
206	15	TC	Set Sensor Auto Heater Parameters	3,4,5,6,9		5.1.2.3.2.15
206	16	TC	Set Sensor Heater Value	3,4,5,6,9		5.1.2.3.2.16
206	17	TC	Activate / Deactivate Sensor	3,4,5,6,9		5.1.2.3.2.17
206	18	TC	Reset Sensor	3,4,5,6,9		5.1.2.3.2.18
206	19	TC	SetSensorPEO	3,4,5,6,9		5.1.2.3.2.19
206	20	TC	SensorSetFindPhase	9		5.1.2.3.2.20
206	21	TC	SensorSetClock	3,4,5,6,9		5.1.2.3.2.21
206	22	TC	SensorSetRaw	15		5.1.2.3.2.22
Service 207: Science Control						
207	1	TC	Science: Change Measurement Rate	3,4,5,9,15	89	5.1.2.3.3.1
207	2	TC	Science: Change Calibration Mode	9	89	5.1.2.3.3.2
207	3	TC	Science: Change Compression	3,4,5, 6	89	5.1.2.3.3.3
207	4	TC	Science: Change Measurement Range	3,4,5,6,9,15	89	5.1.2.3.3.4
207	5	TC	Science: Change Instrument Mode	3,4,5,6,7,9	89	5.1.2.3.3.5
Service 208: Surveillance						

208	1	TC	Surveillance Limit Change	3,4,5,6,7,9	89	5.1.2.3.4.1
208	2	TC	Software Reset	Any, except 2	89	5.1.2.3.4.2
Service 209: Boot and Maintenance						
209	1	TC	Compare Software Checksum	1,7	89	5.1.2.3.5.1
209	2	TC	Manual Boot Select	0, 1	89	5.1.2.3.5.2
209	3	TC	Override Boot Select	0, 1	89	5.1.2.3.5.3
209	4	TC	Memory Fill	1	89	5.1.2.3.5.4
209	5	TC	Enable Boot Maintenance Mode	0	89	5.1.2.3.5.5
209	6	TC	Enable Operational Maintenance Mode	3,4,5,6,7,9	89	5.1.2.3.5.6
209	7	TC	Write RAM Software to EEPROM	1,7	89	5.1.2.3.5.7
209	8	TC	Provide EEPROM Keys	1,7	89	5.1.2.3.5.8
209	9	TC	Revoke EEPROM Keys	1,7	89	5.1.2.3.5.9
209	10	TC	Execute Memory Address	1	89	5.1.2.3.5.10
209	11	TC	Execute Backup Science Mode	1	89	5.1.2.3.5.11
209	12	TC	Set SPW RX Timeout	3,4,5,6,7,9	89	5.1.2.3.5.12

Table 5-9: Service Overview Table

5.1.2.1.3 Backup Science Mode Restrictions

Backupmode ist highly limited in functionality to fit into PROM. It is just there in case everything else fails and is not part of normal operation.

Sensor commanding (Service 206) is just done by the Sensor Set Raw Command.

Science packets are automatically adjusted to the correct packet in case the sensor is put into calibration mode (dependant on sensor calibration settings NMED2237 and NMED2267)

Instrument surveillance and some FDIR (EDAC, runtime traps, sw watchdog, sensor communication and commands, sensor temperature) is not available.

Instrument feedback is limited (no sensor setup reports, no heater setup).

The list of available commands is given above (mode 15).

5.1.2.2 Standard Packet Services

5.1.2.2.1 Service 1: Telecommand Verification

5.1.2.2.1.1 Telecommand Acceptance Report

Telemetry Packet Description						
Database mnemonic			YME51900			
Database Description			MERM TC Acceptance Acknowledge			
Destination ID			Copy of source ID field of TC			
Description			Telecommand Acceptance Report			
Generation Rule			On arrival of a valid TC			
Header Information						
Process ID			89 (SYSMGT)		Packet Category	1
Service			1		Packet Cargo Length	4 bytes
Service Subtype			1		Packet Total Length	20 bytes
Data Field Information (Application Data)						
Offset		Format	Size	Database		
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Calibration
0		UInt	16	NME08000	TC Packet ID	-
2		UInt	16	NME08001	Packet Sequence Control	-

Table 5-10: TC Acceptance Report Structure

5.1.2.2.1.2 Telecommand Acceptance Failure Report

Telemetry Packet Description						
Database mnemonic			Dependant on FID			
Database Description			Dependant on FID			
Destination ID			Copy of source ID field of TC			
Description			Telecommand Acceptance Failure Report			
Generation Rule			On arrival of an invalid TC (static check failed)			
Header Information						
Process ID			89 (SYSMGT)		Packet Category	1
Service			1		Packet Cargo Length	Variable
Service Subtype			2		Packet Total Length	Variable
Data Field Information (Application Data)						
Offset		Format	Size	Database		
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Calibration
0		UInt	16	NME08000	TC Packet ID	-
2		UInt	16	NME08001	Packet Sequence Control	-
4		UInt	16	NME08002	FID	-
6	See below				Dependant on FID	-

Table 5-11: TC Acceptance Failure Report Structure

Possible Acceptance Failure IDs:

Packet Mnemonic	Packet Database Description	FID	Parameters							Failure Description	Autonomous Actions
			Offset		Format	Size	Database				
			[Byte]	[Bit]		[Bit]	mnemonic	description	Calibration		
YME51910	MERM Illegal APID	0	6		UInt	8	NME08010	TC Packet Type		Illegal APID (checks for APID,PID and PCAT)	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
YME51911	MERM incomplete or invalid Length	1	6		UInt	8	NME08010	TC Packet Type	-	Incomplete or Invalid length Packet	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
YME51912	MERM Incorrect Checksum	2	6		UInt	8	NME08010	TC Packet Type	-	Incorrect Checksum	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	16	NME08012	Received Checksum	-		
			10		UInt	16	NME08013	Computed Checksum	-		
YME51913	MERM Illegal Packet Type	3	6		UInt	8	NME08010	TC Packet Type	-	Illegal Packet Type	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
YME51914	MERM Illegal Packet Subtype	4	6		UInt	8	NME08010	TC Packet Type	-	Illegal Packet Subtype	None
			7		UInt	8	NME08011	TC Packet Subtype	-		

Table 5-12: Acceptance Failure IDs

5.1.2.2.1.3 Telecommand Execution Success Report

Telemetry Packet Description						
Database mnemonic			YME51901			
Database Description			MERM TC Execution Acknowledge			
Destination ID			Copy of source ID field of TC			
Description			Telecommand execution success report			
Generation Rule			On execution of a valid TC			
Header Information						
Process ID			89 (SYSMGT)		Packet Category	1
Service			1		Packet Cargo Length	4 bytes
Service Subtype			7		Packet Total Length	20 bytes
Data Field Information (Application Data)						
Offset		Format	Size	Database		
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Calibration
0		UInt	16	NME08000	TC Packet ID	-
2		UInt	16	NME08001	Packet Sequence Control	-

Table 5-13: TC Execution Success Report Structure

5.1.2.2.1.4 Telecommand Execution Failure Report

Telemetry Packet Description						
Database mnemonic			Dependant on FID			
Database Description			Dependant on FID			
Destination ID			Copy of source ID field of TC			
Description			Telecommand execution failure report			
Generation Rule			On execution error of a valid TC (execution error or content error)			
Header Information						
Process ID			89 (SYSMGT)		Packet Category	1
Service			1		Packet Cargo Length	variable
Service Subtype			8		Packet Total Length	variable
Data Field Information (Application Data)						
Offset		Format	Size	Database		
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Calibration
0		UInt	16	NME08000	TC Packet ID	-
2		UInt	16	NME08001	Packet Sequence Control	-
4		UInt	16	NME08002	FID	-
6		See below	-		Dependant on FID	

Table 5-14: TC Execution Failure Report Structure

Possible Execution Failure IDs:

Packet Mnemonic	Packet Database Description	FID	Parameters Offset [Byte]	[Bit]	Format	Size [Bit]	Database mnemonic	description	Calibration	Failure Description	Autonomous Actions
YME51915	MERM Inconsistent Data	5	6		Uint	8	NME08010	TC Packet Type	-	Illegal or inconsistent application data	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	8	NME08014	Position Inconsist Param	-		
			9		Var	8	NME08015	Value inconsist Param	-		
YME51917	MERM Cmd cannot be executed at this time	7	6		Uint	8	NME08010	TC Packet Type	-	Command cannot be executed at this time (service/subtype not available in mode)	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8	0	-	4		ZeroPad4	-		
			NMEG 2003	4	UInt	4	NMED2003	Instrument Mode	CMET6000TM		
			9		-	8	ZZPAD008	ZeroPadByte	-		
YME51920	MERM Illegal 16bit Parameter	52000	6		Uint	8	NME08010	TC Packet Type	-	Illegal 16 bit Parameter	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	8	NME08014	Position Inconsist Param	-		
			9		-	8	ZZPAD008	ZeroPadByte	-		
			10		Var	16	NME08016	Value Inconsist Param16	-		
YME51921	MERM Illegal 32bit Parameter	52001	6		Uint	8	NME08010	TC Packet Type	-	Illegal 32 bit Parameter	none
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	8	NME08014	Position Inconsist Param	-		
			9		-	8	ZZPAD008	ZeroPadByte	-		
			10		Var	32	NME08017	Value Inconsist Param32	-		
YME51922	MERM Unavailable HK SID	52003	6		Uint	8	NME08010	TC Packet Type	-	SID not available at this time	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	8	NME08003	SID	-		
			9		-	8	ZZPAD008	ZeroPadByte	-		
YME51923	MERM Not in CAL2 mode	52004	6	0	Enum	8	NME08020	Requested Sensor ID	CMET6030TM	Not in CAL2 mode	None
			7	0	-	4	ZZPAD004	ZeroPad4	-		
			NMEG 2003	4	Enum	4	NMED2003	Instrument Mode	CMET6000TM		
			8	0	-	4	NMED2100	OB Calibration Mode	CMET6101TM		
			NMEG 2100	4	Enum	4	NMED2101	IB Calibration Mode	CMET6101TM		
			9		-	8	ZZPAD008	ZeroPadByte	-		
YME51924	MERM Invalid Surveillance Parameter	52005	6		UInt	8	NME02150	Surveillance Param ID		Invalid Surveillance Parameter	None
			7			8	ZZPAD008	ZeroPadByte	-		
			8		UInt	32	NME02151	Surveillance Param Val			

YME51927	MERM EEPROM Write Error	52006								EEPROM write error during update	None
YME51925	MERM Memory Load Truncated	52007	6		Uint	8	NME08010	TC Packet Type		Received memory load to short	None
			7		UInt	8	NME08011	TC Packet Subtype	-		
			8		UInt	32	NME08018	Received Length Info	-		
			12		UInt	32	NME08019	Received Byte Count	-		
YME51926	MERM Defective SW	52009								Defective SW selected for normal boot	None

Table 5-15: Execution Failure IDs

5.1.2.2.2 Service 2: Device Command Distribution

No Telecommands and Telemetry are used in this service

5.1.2.2.3 Service 3: Housekeeping and Diagnostic Data Reporting

5.1.2.2.3.1 Enable housekeeping parameter report generation

Telecommand Packet Description								
Database mnemonic		ZME00305						
Database Description		MERM HK Report Enable						
Packet Function		Enable the generation of housekeeping reports with currently set rates for the selected structure ID. In case no rate has been selected the default rate is set.						
Attributes		none						
Verification rule		none						
Valid modes		Any, except 0,2,8, dependant on SID						
Header Information								
Process ID		89			Packet Category		12	
Service		3			Packet Cargo Length		2 bytes	
Service Subtype		5			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME08003	SID	1-9	-	-
1		-	8	ZeroPadByte	-	-	-	-

Table 5-16: Enable HK Parameter Report Generation TC StructureExceptions:

Invalid SID: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [3, 5, 0, received SID] is generated.

SID not available now: A Telecommand Acceptance Failure Report TM 1,2, FID 52003 and parameters [3, 5, received SID, system mode word (5.1.1.2.1)] is generated.

5.1.2.2.3.2 Disable housekeeping parameter report generation

Telecommand Packet Description								
Database mnemonic		ZME00306						
Database Description		MERM HK Report Disable						
Packet Function		Disable the generation of housekeeping reports for the selected structure ID.						
Attributes		None						
Verification rule		None						
Valid modes		Any, except 0,2,8, dependant on SID						
Header Information								
Process ID		89			Packet Category		12	
Service		3			Packet Cargo Length		2 bytes	
Service Subtype		6			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME08003	SID	1-9	-	-
1		-	8	ZeroPadByte	-	-	-	-

Table 5-17: Disable HK Parameter Report Generation TC Structure

<u>Exceptions:</u>

Invalid SID: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [3, 5, 0, received SID] is generated.

SID not available now: A Telecommand Execution Failure Report TM 1,8, FID 52003 and parameters [3, 6, received SID, system mode word (5.1.1.2.1)] is generated.

5.1.2.2.3.3 Housekeeping Parameter Report

Telemetry Packet Description			
Database mnemonic	Dependant on SID		
Database Description	Dependant on SID		
Destination ID	0		
Description	Magnetometer Housekeeping Report, reports housekeeping values of contained structure ID		
Generation Rule	If SID is available in current operational mode and generation of SID is enabled. SIDs are automatically disabled, if the generating PID is unavailable in a new mode. These SIDs have to be re-enabled then.		
Header Information			
Process ID	89	Packet Category	4
Service	3	Packet Cargo Length	SID dependant
Service Subtype	25	Packet Total Length	SID dependant

Table 5-18: HK Parameter Report

This report is available for several structure IDs. The report format for each structure is printed below. There are identical structures for inboard/outboard sensor housekeeping to allow enabling / disabling of these reports separately.

The PID column shows the process IDs which generate the housekeeping report. Note that PIDs are closely coupled to operational modes, since not every process is active in every mode.

Housekeeping Structures

Database		SID	PID		Parameters							Generation Cycle
Mnemonic	Description			Offset		Format	Size	Database				[sec]
				[Byte]	[Bit]		[Bit]	Mnemonic	Description	Calibration	Unit	
YME51001	MERM Sensor Temperature OB	1	89	0		Enum	8	NME08003	SID	-	-	16
				1		UInt	8	NME02081	OB Sensor Heater Value	-	-	
				2		UInt	16	NME02200	OB Sensor Temp 1	CMEP6200TM	degC	
				4		UInt	16	NME02201	OB Sensor Temp 2	CMEP6201TM	degC	
				6		UInt	16	NME02202	OB Electronics Temp	CMEP6202TM	degC	
				8		UInt	16	NME06020	Checksum16	-	-	
YME51000	MERM Sensor Temperature IB	2	89	0		Enum	8	NME08003	SID	-	-	16
				1		UInt	8	NME02082	IB Sensor Heater Value	-	-	
				2		UInt	16	NME02214	IB Sensor Temp 1	CMEP6214TM	degC	
				4		UInt	16	NME02215	IB Sensor Temp 2	CMEP6215TM	degC	
				6		UInt	16	NME02216	IB Electronics Temp	CMEP6216TM	degC	
				8		UInt	16	NME06020	Checksum16	-	-	
YME51002	MERM Instrument Controller HK Report	3	89	0		Enum	8	NME08003	SID	-	-	1280
				1		UInt	8	NME02275	BootImageSWVersion	-	-	
				2		Enum	16	NME02283	BootImageSWSource	CMET6060TM	-	
				4	0	-	4	ZZPAD004	ZeroPad4	-	-	
				NMEG2002	4	UInt	4	NMED2002	InstrumentMode	CMET6000TM	-	
				5		Enum	8	NME02001	Active SPW Link	CMET0003TM	-	
				6		Enum	8	NME02284	OBSensState	CMET6184TM	-	
				7		Enum	8	NME02285	IBSensState	CMET6184TM	-	
				8		Enum	8	NME02286	DualSensState	CMET6184TM	-	
				9		-	8	ZZPAD008	Spare	-	-	
				10		-	8	ZZPAD008	Spare	-	-	
				11		-	8	ZZPAD008	Spare	-	-	
				12		-	8	ZZPAD008	Spare	-	-	
				13		-	8	ZZPAD008	Spare	-	-	
				14		UInt	8	NME02287	Systemload	o/o	o/o	
				15		UInt	8	NME02288	Worstload	o/o	o/o	
				16		Uint	16	NME06020	Checksum16	-	-	
YME51004	MERM Sensor HK Report OB	4	89	0		Enum	8	NME08003	SID	-	-	64
				1		UInt	8	NME02081	OB Sensor Heater Value	-	-	
				2		UInt	16	NME02203	OB +8 Voltage	CMEP6203TM	V	
				4		Int	16	NME02204	OB +8 Current	CMEP6204TM	mA	

				6		UInt	16	NME02205	OB -8 Voltage	CMEP6205TM	V	
				8		Int	16	NME02206	OB -8 Current	CMEP6206TM	mA	
				10		UInt	16	NME02212	OB +5 Voltage	CMEP6212TM	V	
				12		Int	16	NME02213	OB +5 Current	CMEP6213TM	mA	
				14		UInt	16	NME02207	OB +3.3 Voltage	CMEP6207TM	V	
				16		UInt	16	NME02208	OB +1.8 Voltage	CMEP6208TM	V	
				18		UInt	16	NME02209	OB +2.5 Voltage	CMEP6209TM	V	
				20		Int	16	NME02210	OB +2.5 Current	CMEP6210TM	mA	
				22 NMEG2211	0	Enum	1	NMED2228	OBSensLatchADCX	CMET6180TM	-	
					1	Enum	1	NMED2250	OBSensLatchADCY	CMET6180TM	-	
					2	Enum	1	NMED2251	OBSensLatchADCZ	CMET6180TM	-	
					3	Enum	1	NMED2229	OBHeatEmergency	CMET6180TM	-	
					4	Enum	1	NMED2230	OBSensSyncSelect	CMET6152TM	-	
					5	Enum	1	NMED2231	OBSensSyncUsed	CMET6152TM	-	
					6	Enum	1	NMED2232	OBSensClkSelect	CMET6152TM	-	
					7	Enum	1	NMED2233	OBSensClkUsed	CMET6152TM	-	
					8	Enum	1	NMED2234	OBSensRelais1	CAAT0001TM	-	
					9	Enum	1	NMED2235	OBSensFBRelais	CAAT0001TM	-	
					10	Enum	1	NMED2236	OBSensExcitation	CAAT0001TM	-	
					11	Enum	2	NMED2237	OBSensCalBits	CMET6153TM	-	
					13	Enum	3	NMED2238	OBSensElecID	CMET6154TM	-	
				24		Uint	16	NME06020	Checksum16	-	-	
YME51003	MERMSensor HK Report IB	5	89	0		Enum	8	NME08003	SID	-	-	64
				1		UInt	8	NME02082	IB Sensor Heater Value	-	-	
				2		UInt	16	NME02217	IB +8 Voltage	CMEP6217TM	V	
				4		Int	16	NME02218	IB +8 Current	CMEP6218TM	mA	
				6		UInt	16	NME02219	IB -8 Voltage	CMEP6219TM	V	
				8		Int	16	NME02220	IB -8 Current	CMEP6220TM	mA	
				10		UInt	16	NME02226	IB +5 Voltage	CMEP6226TM	V	
				12		Int	16	NME02227	IB +5 Current	CMEP6227TM	mA	
				14		UInt	16	NME02221	IB +3.3 Voltage	CMEP6221TM	V	
				16		UInt	16	NME02222	IB +1.8 Voltage	CMEP6222TM	V	
				18		UInt	16	NME02223	IB +2.5 Voltage	CMEP6223TM	V	
				20		Int	16	NME02224	IB +2.5 Current	CMEP6224TM	mA	
				22 NMEG2225	0	Enum	1	NMED2256	IBSensLatchADCX	CMET6180TM	-	
					1	Enum	1	NMED2257	IBSensLatchADCY	CMET6180TM	-	
					2	Enum	1	NMED2258	IBSensLatchADCZ	CMET6180TM	-	
					3	Enum	1	NMED2259	IBHeatEmergency	CMET6180TM	-	
					4	Enum	1	NMED2260	IBSensSyncSelect	CMET6152TM	-	

					5	Enum	1	NMED2261	IBSensSyncUsed	CMET6152TM	-	
					6	Enum	1	NMED2262	IBSensClkSelect	CMET6152TM	-	
					7	Enum	1	NMED2263	IBSensClkUsed	CMET6152TM	-	
					8	Enum	1	NMED2264	IBSensRelais1	CAAT0001TM	-	
					9	Enum	1	NMED2265	IBSensFBRelais	CAAT0001TM	-	
					10	Enum	1	NMED2266	IBSensExcitation	CAAT0001TM	-	
					11	Enum	2	NMED2267	IBSensCalBits	CMET6153TM	-	
					13	Enum	3	NMED2268	IBSensElecID	CMET6154TM	-	
				24		UInt	16	NME06020	Checksum16	-	-	
YME51008	MERM Offered Magnetometer Data	6	89	0		Enum	8	NME08003	SID	-	-	Off
				1		-	24	ZZPAD024	ZeroPad24	-	-	
				4		Int	32	NME02020	FieldValXOB	-	-	
				8		Int	32	NME02021	FieldValYOB	-	-	
				12		Int	32	NME02022	FieldValZOB	-	-	
				16		Int	32	NME02023	FieldValXIB	-	-	
				20		Int	32	NME02024	FieldValYIB	-	-	
				24		Int	32	NME02025	FieldValZIB	-	-	
YME51010	MERM Boot HK Report	7	89	0		Enum	8	NME08003	SID	-	-	Once at boot, 8192 in mode 0,1, deactivated in other modes
				1		Enum	8	NME02001	Active SPW Link	CMET0003TM	-	
				2		UInt	8	NME02270	PROM SW Version	-	-	
				3		UInt	8	NME02271	EEPROM 0SW Version	-	-	
				4		UInt	8	NME02272	EEPROM 1SW Version	-	-	
				5		Uint	8	NME02273	EEPROM 2SW Version	-	-	
				6		UInt	8	NME02274	EEPROM 3SW Version	-	-	
				7		UInt	8	NME02275	BootImage SW Version	-	-	
				8		UInt	16	NME02276	PROM SW Checksum	-	-	
				10		UInt	16	NME02277	EEPROM0 SW Checksum	-	-	
				12		UInt	16	NME02278	EEPROM1 SW Checksum	-	-	
				14		UInt	16	NME02279	EEPROM2 SW Checksum	-	-	
				16		UInt	16	NME02280	EEPROM3 SW Checksum	-	-	
				18		UInt	16	NME02281	BootImage SW Checksum	-	-	
				20		Enum	16	NME02282	Rom Boot Error	-	-	
				22		Enum	16	NME02283	BootImage SW Source	CMET6060TM	-	
				24		UInt	16	NME06020	Checksum16	-	-	

YME51011	MERM HK Status	8	89	0		Enum	8	NME08003	SID	-	-	1280
				1		-	8	ZZPAD008	ZeroPadByte	-	-	
				2 NMEG2286 HKEnableGl ob	0	-	7	ZZPAD007	7bitZeroPad	-	--	
					7	Bool	1	NMED2294	SetupHKEn	CAAT0001TM		
					8	Bool	1	NMED2293	HKStatusEn	CAAT0001TM		
					9	Bool	1	NMED2292	BootHKEn	CAAT0001TM	-	
					10	Bool	1	NMED2291	SensOfferedEn	CAAT0001TM	-	
					11	Bool	1	NMED2290	SensHKIBEn	CAAT0001TM	-	
					12	Bool	1	NMED2289	SensHKOBEn	CAAT0001TM	-	
					13	Bool	1	NMED2288	ICUHKEn	CAAT0001TM	-	
					14	Bool	1	NMED2287	SensTempIBEn	CAAT0001TM	-	
					15	Bool	1	NMED2286	SensTempOBEn	CAAT0001TM	-	
				4		UInt	16	NME02294	SenstempOBRate	-	-	
				6		UInt	16	NME02295	SenstempIBRate	-	-	
				8		UInt	16	NME02296	ICUHKRate	-	-	
				10		UInt	16	NME02297	SensHKOBRate	-	-	
				12		UInt	16	NME02298	SensHKIBRate	-	-	
				14		UInt	16	NME02299	SensOfferedRate	-	-	
				16		UInt	16	NME02300	BootHKRate	-	-	
				18		UInt	16	NME02301	HKStatusRate	-	-	
				20		UInt	16	NME02302	SetupHKRate	-	-	
				22		UInt	16	NME06020	Checksum16	-	-	
YME51012	MERM Setup	9	89	0		Enum	8	NME08003	SID	-		1800
				1		-	16	ZZPAD016	ZeroPad16	-	-	
				3		-	8	NME06086	Spw RX Timeout	-	-	
				4 NMEG2073	0	-	4	ZZPAD004	4bitZeroPad	-		
					4	Bool	1	NMED2075	OBSensor ICU Filtertype	-		
					5	Bool	1	NMED2078	OBSensAutoHeatEnable	CAAT0001TM		
					6	Bool	1	NMED2076	OBSensAutoCompEnabl e	CAAT0001TM		
					7	Bool	1	NMED2077	OBSensAutoRangeEnabl e	CAAT0001TM		
					8	Bool	1	NMED2079	OBSens Clk used	CMET6152TM		
					9	Bool	1	NMED2080	OBSens Sync used	CMET6152TM		
					10	Bool	1	NMED2087	OBSens PEO	CMET6151TM		
					11	Bool	1	NMED2073	OBSensFBRelayEnable	CAAT0001TM		
					12	Enum	2	NMED2081	OBSens Calibration Bits	CMET6153TM		
					14	Bool	1	NMED2074	OBSens ExcitationEnable	CAAT0001TM		

					15	Bool	1	NMED2082	OBSens Active State	CAAT0001TM		
				6		UInt	16	NME02050	OBSens K1 X ADC	-		
				8		UInt	16	NME02051	OBSens K1 Y ADC	-		
				10		UInt	16	NME02052	OBSens K1 Z ADC	-		
				12		UInt	16	NME02053	OBSens K2 X DAC	-		
				14		UInt	16	NME02054	OBSens K2 Y DAC	-		
				16		UInt	16	NME02055	OBSens K2 Z DAC	-		
				18		UInt	8	NME02071	OBSens Phase Val	-		
				19		UInt	8	NME02072	OBSens Samples Val	-		
				20		Uint	8	NME02070	OBSens Internal Feedback	-		
				21		-	8	NMEPAD18	ZeroPadByte			
				22	0	-	4	ZZPAD004	4bitZeroPad	-		
				NMEG2074	4	Bool	1	NMED2091	IBSensor ICU Filtertype	-		
					5	Bool	1	NMED2094	IBSensAutoHeatEnable	CAAT0001TM		
					6	Bool	1	NMED2092	IBSensAutoCompEnable	CAAT0001TM		
					7	Bool	1	NMED2093	IBSensAutoRangeEnable	CAAT0001TM		
					8	Bool	1	NMED2095	IBSens Clk used	CMET6152TM		
					9	Bool	1	NMED2096	IBSens Sync used	CMET6152TM		
					10	Bool	1	NMED2088	IBSens PEO	CMET6151TM		
					11	Bool	1	NMED2089	IBSensFBRelayEnable	CAAT0001TM		
					12	Enum	2	NMED2097	IBSens Calibration Bits	CMET6153TM		
					14	Bool	1	NMED2090	IBSens ExcitationEnable	CAAT0001TM		
					15	Bool	1	NMED2098	IBSens Active State	CAAT0001TM		
				24		UInt	16	NME02056	IBSens K1 X ADC	-		
				26		UInt	16	NME02057	IBSens K1 Y ADC	-		
				28		UInt	16	NME02058	IBSens K1 Z ADC	-		
				30		UInt	16	NME02059	IBSens K2 X DAC	-		
				32		UInt	16	NME02060	IBSens K2 Y DAC	-		
				34		UInt	16	NME02061	IBSens K2 Z DAC	-		
				36		UInt	8	NME02074	IBSens Phase Val	-		
				37		UInt	8	NME02075	IBSens Samples	-		
				38		Uint	8	NME02073	IBSens Internal Feedback	-		
				39		-	8	NMEPAD28	ZeroPadByte	-		
				40		UInt	16	NME02240	OBSensTemp1HLim	CMEP6200TM		
				42		UInt	16	NME02241	OBSensTemp2HLim	CMEP6201TM		
				44		UInt	16	NME02242	IBSensTemp1HLim	CMEP6214TM		
				46		UInt	16	NME02243	IBSensTemp2HLim	CMEP6215TM		

				48		UInt	32	NME02244	HWWatchdogTimeout	-		
				52		UInt	32	NME02245	SWWatchdogTimeout	-		
				56	0	-	-	ZZPAD007	ZeroPad7			
				NMEG2252	7	Bool	1	NMED2280	OBSensCommErrEn	CAAT0001TM		
					8	Bool	1	NMED2281	IBSensCommErrEn	CAAT0001TM		
					9	Bool	1	NMED2282	OBSensCmdErrEn	CAAT0001TM		
					10	Bool	1	NMED2283	IBSensCmdErrEn	CAAT0001TM		
					11	Bool	1	NMED2284	SensAsyncErrEn	CAAT0001TM		
					12	Bool	1	NMED2285	RequestPoweroffEn	CAAT0001TM		
					13	Bool	1	NMED2252	Mem EDAC Enable	CAAT0001TM		
					14	Bool	1	NMED2253	RuntimeTrapErrEn	CAAT0001TM		
					15	Bool	1	NMED2254	GlobalHKSurvEn	CAAT0001TM		
				58		UInt	16	NME02246	EDACUncorrTresh	-		
				60		UInt	16	NME02247	EDACCorrTresh	-		
				62		-	-	NMEPAD38	ZeroPadByte	-		
				63		UInt	8	NME02250	HKLimitCount	-		
				64		UInt	32	NME02248	SensErrRepeat	-		
				68		UInt	32	NME02249	ICUErrRepeat	-		
				72		UInt	16	NME02350	OB P8VU lower	CMEP6203TM	V	
				74		UInt	16	NME02351	OB P8VU upper	CMEP6203TM	V	
				76		Int	16	NME02352	OB P8VI lower	CMEP6204TM	mA	
				78		Int	16	NME02353	OB P8VI upper	CMEP6204TM	mA	
				80		UInt	16	NME02354	OB N8VU lower	CMEP6205TM	V	
				82		UInt	16	NME02355	OB N8VU upper	CMEP6205TM	V	
				84		Int	16	NME02356	OB N8VI lower	CMEP6206TM	mA	
				86		Int	16	NME02357	OB N8VI upper	CMEP6206TM	mA	
				88		UInt	16	NME02358	OB P5VU lower	CMEP6212TM	V	
				90		UInt	16	NME02359	OB P5VU upper	CMEP6212TM	V	
				92		Int	16	NME02360	OB P5VI lower	CMEP6213TM	mA	
				94		Int	16	NME02361	OB P5VI upper	CMEP6213TM	mA	
				96		UInt	16	NME02362	OB P3V3U lower	CMEP6207TM	V	
				98		UInt	16	NME02363	OB P3V3U upper	CMEP6207TM	V	
				100		UInt	16	NME02364	OB P1V8U lower	CMEP6208TM	V	
				102		UInt	16	NME02365	OB P1V8U upper	CMEP6208TM	V	
				104		UInt	16	NME02366	OB P2V5U lower	CMEP6209TM	V	
				106		UInt	16	NME02367	OB P2V5U upper	CMEP6209TM	V	
				108		Int	16	NME02368	OB P2V5I lower	CMEP6210TM	mA	
				110		Int	16	NME02369	OB P2V5I upper	CMEP6210TM	mA	
				112		UInt	16	NME02370	OB SensTemp1 lower	CMEP6200TM	degC	

				114		UInt	16	NME02371	OB SensTemp1 upper	CMEP6200TM	degC	
				116		UInt	16	NME02372	OB SensTemp2 lower	CMEP6201TM	degC	
				118		UInt	16	NME02373	OB SensTemp2 upper	CMEP6201TM	degC	
				120		UInt	16	NME02374	OB ElecTemp lower	CMEP6202TM	degC	
				122		UInt	16	NME02375	OB ElecTemp upper	CMEP6202TM	degC	
				124		Int	16	NME02376	OB HeaterStatic	-		
				126		Int	16	NME02377	OB HeaterDynamic	-		
				128		UInt	16	NME02378	IB P8VU lower	CMEP6217TM	V	
				130		UInt	16	NME02379	IB P8VU upper	CMEP6217TM	V	
				132		Int	16	NME02380	IB P8VI lower	CMEP6218TM	mA	
				134		Int	16	NME02381	IB P8VI upper	CMEP6218TM	mA	
				136		UInt	16	NME02382	IB N8VU lower	CMEP6219TM	V	
				138		UInt	16	NME02383	IB N8VU upper	CMEP6219TM	V	
				140		Int	16	NME02384	IB N8VI lower	CMEP6220TM	mA	
				142		Int	16	NME02385	IB N8VI upper	CMEP6220TM	mA	
				144		UInt	16	NME02386	IB P5VU lower	CMEP6226TM	V	
				146		UInt	16	NME02387	IB P5VU upper	CMEP6226TM	V	
				148		Int	16	NME02388	IB P5VI lower	CMEP6227TM	mA	
				150		Int	16	NME02389	IB P5VI upper	CMEP6227TM	mA	
				152		UInt	16	NME02390	IB P3V3U lower	CMEP6221TM	V	
				154		UInt	16	NME02391	IB P3V3U upper	CMEP6221TM	V	
				156		UInt	16	NME02392	IB P1V8U lower	CMEP6222TM	V	
				158		UInt	16	NME02393	IB P1V8U upper	CMEP6222TM	V	
				160		UInt	16	NME02394	IB P2V5U lower	CMEP6223TM	V	
				162		UInt	16	NME02395	IB P2V5U upper	CMEP6223TM	V	
				164		Int	16	NME02396	IB P2V5I lower	CMEP6224TM	mA	
				166		Int	16	NME02397	IB P2V5I upper	CMEP6224TM	mA	
				168		UInt	16	NME02398	IB SensTemp1 lower	CMEP6214TM	degC	
				170		UInt	16	NME02399	IB SensTemp1 upper	CMEP6214TM	degC	
				172		UInt	16	NME02400	IB SensTemp2 lower	CMEP6215TM	degC	
				174		UInt	16	NME02401	IB SensTemp2 upper	CMEP6215TM	degC	
				176		UInt	16	NME02402	IB ElecTemp lower	CMEP6216TM	degC	
				178		UInt	16	NME02403	IB ElecTemp upper	CMEP6216TM	degC	
				180		Int	16	NME02404	IB HeaterStatic	-		
				182		Int	16	NME02405	IB HeaterDynamic	-		
				184		Int	16	NME02079	OBHeatProportionalCoeff	-		
				186		Int	16	NME02080	OBHeatIntegralCoeff	-		
				188		Int	16	NME02089	OBHeatDifferentialCoeff	-		
				190		UInt	16	NME02094	OBHeatTargetTemp	CMEP6200TM	degC	

				192		Int	16	NME02096	IBHeatProportionalCoeff	-		
				194		Int	16	NME02097	IBHeatIntegralCoeff	-		
				196		Int	16	NME02098	IBHeatDifferentialCoeff	-		
				198		UInt	16	NME02095	IBHeaterTargetTemp	CMEP6214TM	degC	
				200		UInt	16	NME06020	Checksum16	-		

Table 5-19: Housekeeping Telemetry Structures

Structure ID 1,2: Sensor Temperature Housekeeping

Source Description	
Contains 6 equidistant samples of the sensor temperatures. Time distance is defined by housekeeping repetition rate.	
Available in Mode	
3,4,5,6,9	
Packet Cargo Length	10 bytes
Packet Total Length	26 bytes

Table 5-20: Sensor Temperature HK TM Structure

Structure ID 3: ICU Housekeeping Report

Source Description	
Contains ICU Boot status, originates from PID 89	
Available in Mode	
3,4,5,6,7,9	
Packet Cargo Length	18 bytes
Packet Total Length	34 bytes

Table 5-21: ICU HK TM Structure

Structure ID 4,5 Sensor Housekeeping Report

Source Description	
Contains sensor housekeeping data	
Available in Mode	
3,4,5,6,9	
Packet Cargo Length	22 bytes
Packet Total Length	38 bytes

Table 5-22: Sensor HK TM Structure

Structure ID 6: Offered MAG Data

Source Description	
Offers 32 second averaged precalibrated science data to other users. Dependant on mode inboard, outboard or dual sensor data is offered. If a sensor is offline, data is set to 0x80000000	
Available in Mode	
3,4,5	
Packet Cargo Length	28 bytes
Packet Total Length	44 bytes

Table 5-23: Offered MAG Data TM Structure

Structure ID 7: Boot Housekeeping Report

Source Description	
Offers housekeeping information in ROM boot mode. No sensor information is available at this time.	
Available in Mode	
0,1	
Packet Cargo Length	26 bytes
Packet Total Length	42 bytes

Table 5-24: Boot HK Report TM Structure

Structure ID 8: HK Status Report

Source Description	
Shows the enable/disable status and frequency of all HK reports	
Available in Mode	
3,4,5,6,7,9	
Packet Cargo Length	18 bytes
Packet Total Length	34 bytes

Table 5-25: HK Status Report TM Structure

Structure ID 9: Setup HK Report

Source Description	
Shows the enable/disable status and frequency of all HK reports	
Available in Mode	
3,4,5,6,7	
Packet Cargo Length	202 bytes
Packet Total Length	218 bytes

Table 5-26: Setup HK Report TM Structure

General HK Availability

SID	HK Report	Mnemonic	Mode
1	OB Sensor Temperature	YME51001	3,4,5,6,9
2	IB Sensor Temperature	YME51000	3,4,5,6,9
3	ICU	YME51002	3,4,5,6,7,9
4	OB Sensor	YME51004	3,4,5,6,9
5	IB Sensor	YME51003	3,4,5,6,9
6	Offered Data	YME51008	3,4,5,6
7	Boot	YME51010	0,1
8	HK Status	YME51011	3,4,5,6,7,9
9	SetupHK	YME51012	3,4,5,6,7

Table 5-27: HK Availability

5.1.2.2.3.4 Define housekeeping parameter report collection interval

Telecommand Packet Description								
Database mnemonic		ZME00329						
Database Description		MERM Set HK Report Rate						
Packet Function		Set the generation rate of housekeeping reports in 8 Hz cycle multiples for the selected structure ID. Generation rate is multiplied by 8						
Attributes		none						
Verification rule		none						
Valid modes		Any, except 0,2,8 dependant on SID						
Header Information								
Process ID		89			Packet Category		12	
Service		3			Packet Cargo Length		4 bytes	
Service Subtype		129			Packet Total Length		14 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME08003	SID	1-9	-	-
1		UInt	16	PME08004	HKReportRate	1-65535	-	-
3		-	8	ZeroPadByte	ZeroPadByte	-	-	-

Table 5-28: Define HK Parameter Report Collection Interval TC

Exceptions:
Invalid SID: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [3, 5, 0, received SID] is generated.
SID not available now: A Telecommand Execution Failure Report TM 1,8, FID 52003 and parameters [3, 29, received SID, system mode word (5.1.1.2.1)] is generated.
Invalid Report rate (0): A Telecommand Execution Failure Report TM 1,8, FID 52000 and parameters [206, 4, 1, received rate value] is generated.

5.1.2.2.4 Service 5: Event Reporting

5.1.2.2.4.1 Normal/Progress Report

Telemetry Packet Description						
Database mnemonic		Dependant on EID				
Database Description		Dependant on EID				
Destination ID		0				
Description		Normal/Progress Report				
Generation Rule		On Events				
Header Information						
Process ID		89		Packet Category		7
Service		5		Packet Cargo Length		EID dependant
Service Subtype		1		Packet Total Length		EID dependant
Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0		Enum	16		NME08501	EID
2						Parameters dependant on EID

Table 5-29: Normal/Progress Report TM Structure

5.1.2.2.4.2 Error/Anomaly Report

Telemetry Packet Description						
Database mnemonic		Dependant on EID				
Database Description		Dependant on EID				
Destination ID		0				
Description		Error / anomaly report				
Generation Rule		On errors/anomalies, if reporting of error is enabled				
Header Information						
Process ID		89		Packet Category		7
Service		5		Packet Cargo Length		FID dependant
Service Subtype		2		Packet Total Length		FID dependant
Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0		Enum	16		NME08502	FID
2						Parameters dependant on FID

Table 5-30: Error/Anomaly Report TM Structure

5.1.2.2.4.3 Error/Anomaly Report – Ground Action

Telemetry Packet Description						
Database mnemonic		Dependant on EID				
Database Description		Dependant on EID				
Destination ID		0				
Description		Error / anomaly report requiring ground action				
Generation Rule		On errors/anomalies, if reporting of error is enabled				
Header Information						
Process ID		89		Packet Category	7	
Service		5		Packet Cargo Length	FID dependant	
Service Subtype		3		Packet Total Length	FID dependant	
Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0		Enum	16		NME08503	FID
2						Parameters dependant on FID

Table 5-31: Error/Anomaly Report – Ground Action TM Structure

5.1.2.2.4.4 Error/Anomaly Report – Onboard Action

Telemetry Packet Description						
Database mnemonic		Dependant on EID				
Database Description		Dependant on EID				
Destination ID		0				
Description		Error / anomaly report requiring onboard action				
Generation Rule		On errors/anomalies, if reporting of error is enabled				
Header Information						
Process ID		89		Packet Category	7	
Service		5		Packet Cargo Length	FID dependant	
Service Subtype		4		Packet Total Length	FID dependant	
Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0		Enum	16		NME08504	FID
2						Parameters dependant on FID

Table 5-32: Error/Anomaly Report – Onboard Action TM Structure

List of Events / FIDs

Repetitive error events with specified rate share a common timer, the timeout can be set using parameter updates.
The occurence of an error event starts the timer, every error is just reported once for every timeout frame. Repetitive errors during the timeout frame are kept and will cause new error messages after the timeout.

Example:
Timeout is set to 64 seconds.
00:00:00 OB sensor communication error occurs, YME51814 is sent
00:00:15 OB sensor communication error occurs, no report due to timeout
00:00:16 OB sensor communication error occurs, no report due to timeout
00:00:30 IB sensor communication error occurs, YME51820 is sent
00:00:45 IB sensor communication error occurs, no report due to timeout
00:01:04 timeout expired, YME51814 and YME51820 are sent once due to an error repetition occuring in the timeout period. timer is restarted

Packet Mnemonic	Packet Database Description	EID FID	Packet / Event Sub-Type	PID	Parameters							Event Generation Condition	Autonomous Actions / Repetition Rate	Ground Actions
					Offset		Format	Size	Database					
					[Byte]	[Bit]		[Bit]	mnemonic	description	Calibration, unit			
YME51800	MERM EEPROM Write Address Fail	52020	2	89	2		Enum	16	NME06000	Memory ID	CMET6060TM	Upon EEPROM write error, gives detailed information of first write fail.		Contact PI wthin 48 hours, use as is until further notice
					4		UInt	32	NME08100	Written Address				
YME51801	MERM Invalid Checksum	52021	2	89	2		Enum	16	NME06000	Memory ID	CMET6060TM	Invalid Checksum at attempt to boot a memory		Contact PI wthin 48 hours, uase as is until further notice
					4		UInt	16	NME08101	Expected Checksum				
					6		UInt	16	NME08102	Computed Checksum				
YME51802	MERM Memory Checksum Success	52022	1	89	2		Enum	16	NME06000	Memory ID	CMET6060TM	Upon TC request, at boot once for every memory checked		-
					4		UInt	16	NME08101	Expected Checksum				
					6		UInt	16	NME08102	Computed Checksum				
YME51803	MERM Memory Checksum Error	52023	2	89	2		Enum	16	NME06000	Memory ID	CMET6060TM	Upon TC request, at boot once for every memory checked		Contact PI wthin 48 hours, use as is until further notice
					4		UInt	16	NME08101	Expected Checksum	-			
					6		UInt	16	NME08102	Computed Checksum	-			
YME51804	MERM RAM Check Error	52024	2	89	2		UInt	32	NME08103	Num Errors Stuck 0	-	Upon boot once, if bits are stuck or address test fails		Contact PI wthin 48 hours, use
					6		UInt	32	NME08104	Num Errors Stuck 1	-			
					10		UInt	32	NME08105	Num Errors Address	-			

														as is until further notice
YME51805	MERM RAM EDAC Error	52025	2	89	2		UInt	16	NME08109	Num EDAC Uncorrected	-	Upon EDAC error	64 seconds	Use as is
					4		UInt	16	NME08110	Num EDAC corrected	-			
YME51806	MERM ROM Boot Success	52050	1	89	-		-	-	-	-	-	Once after ROM Boot For OBCP		-
YME51807	MERM RAM Boot Success	52051	1	89	-		-	-	-	-	-	Once after RAM boot For OBCP		-
YME51808	MERM Backup Boot Success	52052	1	89	-		-	-	-	-	-	Once after Backup Science boot, for OBCP		-
YME51809	MERM ROM Boot Error	52053	2	89	-		-	-	-	-	-	Indicates an error during ROM Boot for OBCP. Error type is reported using other packets		Contact PI wthin 48 hours, use as is until further notice
YME51810	MERM Mode Change	52054	1	89	2	0	-	-	ZZPAD004	ZeroPad4	-	Once after mode change by TC or automatic (during boot)		-
					NMEG2000	4	UInt	4	NMED2000	Instrument Mode	CMET6000TM			
					3		-	8	ZZPAD008	ZeroPadByte				
YME51828	MERM Science Change	52055	1	89	2	0	Enum	4	NMED2100	OB Cal Mode	CMET6101TM	Once after boot, once upon change of contained parameters by TC or automatic change		-
					NMEG2100	4	Enum	4	NMED2101	IB Cal Mode	CMET6101TM			
					3	0	Enum	4	NMED2104	OB Rate Process 85	CMET6100TM			
					NMEG2104	4	Enum	4	NMED2105	IB Rate Process 85	CMET6100TM			
					4	0	Enum	4	NMED2106	OB Rate Process 86	CMET6100TM			
					NMEG2106	4	Enum	4	NMED2107	IB Rate Process 86	CMET6100TM			
					5	0	Enum	4	NMED2108	OB Rate Process 87	CMET6100TM			
					NMEG2108	4	Enum	4	NMED2109	IB Rate Process 87	CMET6100TM			
YME51829	MERM Range Change	52056	1	89	2	0	Enum	4	NMED2210	OB Range	CMET6103TM	Upon Change of Measurement Range		-
					NMEG2210	4	Enum	4	NMED2211	IB Range	CMET6103TM			
					3		-	8	ZZPAD008	ZeroPadByte	-			
YME51812	MERM Software Watchdog Exceeded	52401	2	89	2		UInt	32	NME02245	SW Watchdog Timeout Val	-	Once after SW Watchdog triggered		Contact PI wthin 48 hours, use as is until further notice
YME51813	MERM Runtime Trap	52402	2	89	2		UInt	8	NME08106	Software Trap Type	-	Once after trap occurred	64 seconds	Contact PI wthin 96 hours, use as is until further notice
					3		-	8		ZeroPadbyte	-			
					4		-	32		Spare32	-			

YME51814	MERM Sensor Communication Error OB	52500	2	89	2 NMEG8110	0	Enum	1	NMED8123	OB SensErr FloodFrame	CMET6180TM	Once after communication error has occurred	64 seconds	Contact PI wthin 96 hours, use as is until further notice
						1	Enum	1	NMED8124	OB SensErr LateFrame	CMET6180TM			
						2	Enum	1	NMED8125	OB SensErr Sensor Loss	CMET6180TM			
						3	Enum	1	NMED8110	OB SensErr Unexp Pointer	CMET6180TM			
						4	Enum	1	NMED8111	OB SensErr Illg Pointer	CMET6180TM			
						5	Enum	1	NMED8112	OB SensErr Double Frame	CMET6180TM			
						6	Enum	1	NMED8113	OB SensErr Inv Meas Mode	CMET6180TM			
						7	Enum	1	NMED8114	OB SensErr Miss Frame	CMET6180TM			
						8	Enum	1	NMED8115	OB Sens Err Slip Inv Pkt	CMET6180TM			
						9	Enum	1	NMED8116	OB Sens Err Slip Frm Ov	CMET6180TM			
						10	Enum	1	NMED8117	OB SensErr Slip Esc	CMET6180TM			
						11	Enum	1	NMED8118	OB SensErrr Slip Buf Ov	CMET6180TM			
						12	Enum	1	NMED8119	OB SensErr Serial Frm	CMET6180TM			
						13	Enum	1	NMED8120	OB SensErr Serial Par	CMET6180TM			
						14	Enum	1	NMED8121	OB SensErr Serial Ov	CMET6180TM			
						15	Enum	1	NMED8122	OB SensErrr Serial Bre	CMET6180TM			
					4	0	UInt	24	NME08107	OB Last Sent Sensor Cmd	-			
					7		-	8	ZZPAD008	ZeroPadByte	-			
					8		UInt	16	NME08111	OBSensConfWord				
YME51820	MERM Sensor Communication Error IB	52506	2	89	2 NMEG8130	0	Enum	1	NMED8143	IB SensErr FloodFrame	CMET6180TM	Once after communication error has occurred	64 seconds	Contact PI wthin 96 hours, use as is until further notice
						1	Enum	1	NMED8144	IB SensErr LateFrame	CMET6180TM			
						2	Enum	1	NMED8145	IB SensErr Sensor Loss	CMET6180TM			
						3	Enum	1	NMED8130	IB SensErr Unexp Pointer	CMET6180TM			
						4	Enum	1	NMED8131	IB SensErr Illg Pointer	CMET6180TM			
						5	Enum	1	NMED8132	IB SensErr Double Frame	CMET6180TM			
						6	Enum	1	NMED8133	IB SensErr Inv Meas Mode	CMET6180TM			
						7	Enum	1	NMED8134	IB SensErr Miss Frame	CMET6180TM			
						8	Enum	1	NMED8135	IB Sens Err Slip Inv Pkt	CMET6180TM			
						9	Enum	1	NMED8136	IB Sens Err Slip Frm Ov	CMET6180TM			
						10	Enum	1	NMED8137	IB SensErr Slip Esc	CMET6180TM			
						11	Enum	1	NMED8138	IB SensErrr Slip Buf Ov	CMET6180TM			
						12	Enum	1	NMED8139	IB SensErr Serial Frm	CMET6180TM			

						13	Enum	1	NMED8140	IB SensErr Serial Par	CMET6180TM			
						14	Enum	1	NMED8141	IB SensErr Serial Ov	CMET6180TM			
						15	Enum	1	NMED8142	IB SensErrr Serial Bre	CMET6180TM			
					4	0	UInt	24	NME08108	IB Last Sent Sensor Cmd	-			
					7		-	8	ZZPAD008	ZeroPadByte	-			
					8		UInt	16	NME08112	IBSensConfWord	-			
YME51815	MERM Sensor Command Error OB	52501	2	89	2		UInt	16	NME08111	OBSensConfWord	-	Once after command error occurred	64 seconds	Contact PI wthin 96 hours, uase as is until further notice
					4		UInt	24	NME08108	OB Last Sent Sensor Cmd	-			
					7 NMEG8150	0	Bool	1	NMED8150	OB SensCmd Serialtimeout	CMET6180TM			
						1	Bool	1	NMED8151	OB SensCmd Multiple	CMET6180TM			
						2	Bool	1	NMED8152	OB SensCmd Overflow	CMET6180TM			
						3	Bool	1	NMED8153	OB SensCmd NotFound	CMET6180TM			
						4	Bool	1	NMED8154	OB SensCmd NoEcho	CMET6180TM			
						5	Bool	1	NMED8155	OB SensCmd FrameError	CMET6180TM			
						6	Bool	1	NMED8156	OB SensCmd TimeoutError	CMET6180TM			
						7	Bool	1	NMED8157	OB SensCmd EscError	CMET6180TM			
YME51816	MERM Sensor Command Error IB	52502	2	89	2		UInt	16	NME08112	IBSensConfWord	-	Once after command error occurred	64 seconds	Contact PI wthin 96 hours, use as is until further notice
					4		UInt	24	NME08108	Last Sent Sensor Cmd IB	-			
					7 NMEG8160	0	Bool	1	NMED8160	IB SensCmd Serialtimeout	CMET6180TM			
						1	Bool	1	NMED8161	IB SensCmd Multiple	CMET6180TM			
						2	Bool	1	NMED8162	IB SensCmd Overflow	CMET6180TM			
						3	Bool	1	NMED8163	IB SensCmd NotFound	CMET6180TM			
						4	Bool	1	NMED8164	IB SensCmd NoEcho	CMET6180TM			
						5	Bool	1	NMED8165	IB SensCmd FrameError	CMET6180TM			
						6	Bool	1	NMED8166	IB SensCmd TimeoutError	CMET6180TM			
						7	Bool	1	NMED8167	IB SensCmd EscError	CMET6180TM			
YME51817	MERM Request Poweroff	52503	4	89	-	-	-	-	-	-	-	When exceeding any HK Limit	64 seconds Action: power off OBCP (see service 18)	Contact PI wthin 24 hours, keep instrumennt off.
YME51818	MERM HK Anomaly	52504	2	89	2		Enum	8	NME02030	Sensor ID	CMET6030TM	When exceeding HK Limit	64 seconds per unique channel	Contact PI wthin 24 hours, use
					3		Enum,	8	NME08113	HK Channel Num	CMET6113TM			
					4		UInt	8	NME08114	Trigger Num Tresh	-			

					5		UInt	8	NME08115	ErrorHeaterVal			(sensor ID+channel number)	as is until further notice
					6		UInt	16	NME08116	MeasValue	-			
					8		UInt	16	NME08117	Limit 1	-			
					10		UInt	16	NME08118	Limit 2	-			
					12		UInt	16	NME08119	DiagData1	-			
					14		UInt	16	NME08120	DiagData2	-			
YME51819	MERM Sensor Async Error	52505	2	89	2 NMEG8170	0	-	1	ZZPAD001	ZeroPad1Bit	-	When sensor produces async data. Only repeated if sensor changed back to sync mode again.	64 seconds	Contact PI wthin 96 hours, use as is until further notice
						1	Bool	1	NMED8184	Sync Loss IB	CMET6180TM			
						2	Bool	1	NMED8183	Sync Loss OB	CMET6180TM			
						3	Bool	1	NMED8182	ICU SoftSync Lost	CMET6180TM			
						4	Bool	1	NMED8175	Sens Clk ICU OB	CMET6152TM			
						5	Bool	1	NMED8172	Sens Sync ICU OB	CMET6152TM			
						6	Bool	1	NMED8170	Sens Sync Sel OB	CMET6152TM			
						7	Bool	1	NMED8171	Sens Sync Used OB	CMET6152TM			
						8	Bool	1	NMED8173	Sens Clk Sel OB	CMET6152TM			
						9	Bool	1	NMED8174	Sens Clk Used OB	CMET6152TM			
						10	Bool	1	NMED8181	Sens Clk ICU IB	CMET6152TM			
						11	Bool	1	NMED8178	Sens Sync ICU IB	CMET6152TM			
						12	Bool	1	NMED8176	Sens Sync Sel IB	CMET6152TM			
						13	Bool	1	NMED8177	Sens Sync Used IB	CMET6152TM			
						14	Bool	1	NMED8179	Sens Clock Sel IB	CMET6152TM			
						15	Bool	1	NMED8180	Sens Clk Used IB	CMET6152TM			
YME51821	MERM Sensor Setup OB	52700	1	89	2 NMEG2073	0	-	4	ZZPAD004	4bitZeroPad	-	Once after boot, once upon change of contained parameters by TC or automatic change by mode change		-
						4	Bool	1	NMED2075	OBSensor ICU Filtertype	-			
						5	Bool	1	NMED2078	OBSensAutoHeatEnable	CAAT0001TM			
						6	Bool	1	NMED2076	OBSensAutoCompEnable	CAAT0001TM			
						7	Bool	1	NMED2077	OBSensAutoRangeEnable	CAAT0001TM			
						8	Bool	1	NMED2079	OBSens Clk used	CMET6152TM			
						9	Bool	1	NMED2080	OBSens Sync used	CMET6152TM			
						10	Bool	1	NMED2088	OBSens PEO	CMET6151TM			
						11	Bool	1	NMED2073	OBSensFBRelayEnable	CAAT0001TM			
						12	Enum	2	NMED2081	OBSens Calibration Bits	CMET6153TM			
						14	Bool	1	NMED2074	OBSens ExcitationEnable	CAAT0001TM			
						15	Bool	1	NMED2082	OBSensor Active State	CAAT0001TM			
					4		UInt	16	NME02050	OBSens K1 X ADC	-			
					6		UInt	16	NME02051	OBSens K1 Y ADC	-			
					8		UInt	16	NME02052	OBSens K1 Z ADC	-			
					10		UInt	16	NME02053	OBSens K2 X DAC	-			
					12		UInt	16	NME02054	OBSens K2 Y DAC	-			

					14		UInt	16	NME02055	OBSens K2 Z DAC	-			
					16		UInt	8	NME02071	OBSens Phase Value	-			
					17		UInt	8	NME02072	OBSens Samples Value	-			
					18		Uint	8	NME02070	OBSens Internal Feedback	-			
					19		-	8	ZZPAD008	ZeroPadByte	-			
YME51823	MERM Sensor Setup IB	52702	1	89	2 NMEG2074	0	-	4	ZZPAD004	4bitZeroPad	-	Once after boot, once upon change of contained parameters by TC or automatic change by mode change		-
						4	Bool	1	NMED2091	IBSensor ICU Filtertype	-			
						5	Bool	1	NMED2094	IBSensAutoHeatEnable	CAAT0001TM			
						6	Bool	1	NMED2092	IBSensAutoCompEnable	CAAT0001TM			
						7	Bool	1	NMED2093	IBSensAutoRangeEnable	CAAT0001TM			
						8	Bool	1	NMED2095	IBSens Clk used	CMET6152TM			
						9	Bool	1	NMED2096	IBSens Sync used	CMET6152TM			
						10	Bool	1	NMED2088	IBSens PEO	CMET6151TM			
						11	Bool	1	NMED2089	IBSensFBRelayEnable	CAAT0001TM			
						12	Enum	2	NMED2097	IBSens Calibration Bits	CMET6153TM			
						14	Bool	1	NMED2090	IBSens ExcitationEnable	CAAT0001TM			
						15	Bool	1	NMED2098	IBSensor Active State	CAAT0001TM			
					4		UInt	16	NME02056	IBSens K1 X ADC	-			
					6		UInt	16	NME02057	IBSens K1 Y ADC	-			
					8		UInt	16	NME02058	IBSens K1 Z ADC	-			
					10		UInt	16	NME02059	IBSens K2 X DAC	-			
					12		UInt	16	NME02060	IBSens K2 Y DAC	-			
					14		UInt	16	NME02061	IBSens K2 Z DAC	-			
					16		UInt	8	NME02074	IBSens Phase Value	-			
					17		UInt	8	NME02075	IBSens Samples Value	-			
					18		Uint	8	NME02073	IBSens Internal Feedback	-			
					19		-	8	ZZPAD008	ZeroPadByte	-			
YME51831	MERM Heater Setup OB	52706	1	89	2		Int	16	NME02079	OBHeatProportionalCoeff	-	Upon change of contained parameters		-
					4		Int	16	NME02080	OBHeatIntegralCoeff	-			
					6		Int	16	NME02089	OBHeatDifferentialCoeff	-			
					8		UInt	16	NME02094	OBHeatTargetTemp	CMEP6200TM			
YME51832	MERM Heater Setup IB	52707	1	89	2		Int	16	NME02096	IBHeatProportionalCoeff	-	Upon change of contained parameters		-
					4		Int	16	NME02097	IBHeatIntegralCoeff	-			
					6		Int	16	NME02098	IBHeatDifferentialCoeff	-			
					8		UInt	16	NME02095	IBHeaterTargetTemp	CMEP6214TM			
YME51827	MERM SpW Link Change	52704	1	89	2	0	Enum	8	NME02001	Active SPW Link	CMET0003TM	Once up change or reconnection of spacewire link		-
					3	0	-	8	ZZPAD008	ZeroPadByte	-			

YME51830	MERM Request Time Sync	52057	4	89	-	-	-	-	-	-	-	Once after ROM boot. If no time update has occured until RAM or backup science boot, message is repeated. In case of HW watchdog a reboot happens and time sync request is repeated.	Autonomous Action: Send Time update to MERMAG	-

Table 5-33: List of Event/FIDs

5.1.2.2.5 Service 6: Memory Management

5.1.2.2.5.1 Load data in memory using absolute addresses

Telecommand Packet Description								
Database mnemonic			ZME00602					
Database Description			MERM Memory Load					
Packet Function			Load data into memory using absolute addresses Memory addresses and write length must be 4 byte aligned. ROM cannot be written.					
Attributes			Memory writing, recoverable function degradation possible					
Verification rule			None					
Valid modes			1					
Header Information								
Process ID			89			Packet Category		12
Service			6			Packet Cargo Length		variable
Service Subtype			2			Packet Total Length		variable
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	16	PME06061	Memory ID Write	191-199 VME06061	-	CMET6060TC
2		UInt	32	PME06065	Start Address	Full	-	-
6		UInt	32	PME06066	Length of Load Block	-	-	-
10		-	-	PME06069	Data Word	-	-	-
...								

Table 5-34: Load data in memory using absolute addresses TC structure

Exceptions:

Invalid memory ID or memory ID 190 (PROM): A Telecommand Execution Failure Report TM 1,8, FID 52000 and parameters [6, 2, 0, received memory ID] is generated.

Invalid start address (not in requested memory or not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 2, 2, received start address] is generated.

Invalid length (overflow of selected memory or not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 2, 6, received length] is generated.

Invalid received length (contained data does not fit to transmitted length information): A Telecommand Execution Failure Report TM 1,8, FID 52007 and parameters [6, 2, received length, byte count] is generated.

Write Error (e.g. EEPROM): A Telecommand Execution Failure Report TM 1,8, FID 52006 and an Error Event TM1,5, FID 52020 and parameters [32 bit address of first write error] are generated

5.1.2.2.5.2 Dump memory area using absolute addresses

Telecommand Packet Description			
Database mnemonic	ZME00605		
Database Description	MERM Memory Dump		
Packet Function	Dump data from memory using absolute addresses. Memory addresses and dump length must be 4 byte aligned Only Memory ID 198 is allowed for dump.		
Attributes	None		
Verification rule	None		
Valid modes	1,7		
Header Information			
Process ID	89	Packet Category	12
Service	6	Packet Cargo Length	10 bytes
Service Subtype	5	Packet Total Length	20 bytes

Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	16	PME06062	Memory ID Dump	198 VME06062	-	CMET6060TC
2		UInt	32	PME06065	Start Address	Full	-	-
6		UInt	32	PME06067	Length of Dump Block	-	-	-

Table 5-35: Dump memory area using absolute addresses

Reaction:

One or several packets (5.1.2.2.5.3) are generated, dependant on requested dump length

Exceptions:

Invalid memory ID: A Telecommand Execution Failure Report TM 1,8, FID 52000 and parameters [6, 5, 0, received memory ID] is generated

Invalid start address (not in requested memory or not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 5, 2, received start address] is generated.

Invalid length (overflow of selected memory not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 5, 6, received length] is generated.

5.1.2.2.5.3 Memory Dump Report Using Absolute Addresses

Telemetry Packet Description							
Database mnemonic		YME51606					
Database Description		MERM Memory Dump Report					
Destination ID		0					
Description		Memory dump report using absolute addresses					
Generation Rule		On request					
Header Information							
Process ID		89		Packet Category		9	
Service		6		Packet Cargo Length		variable	
Service Subtype		6		Packet Total Length		variable	
Data Field Information (Application Data)							
Offset		Format	Size	Unit	Database		
[Byte]	[Bit]		[Bit]		Mnemonic	Description	Calibration
0		Enum	16		NME06000	Memory ID	CMET6060TM
2		UInt	32		NME06001	Start Address	-
6		UInt	32		NME06002	Length	-
10		-	16		NME06003	Data	-
..							

Table 5-36: Memory Dump Report Using Absolute Addresses TM Structure

Description:
Explanation:

5.1.2.2.5.4 Check memory area using absolute addresses

Telecommand Packet Description								
Database mnemonic		ZME00609						
Database Description		MERM Memory Check						
Packet Function		Check data in memory using absolute addresses Memory addresses and check length must be 4 byte aligned						
Attributes		none						
Verification rule		none						
Valid modes		1,7						
Header Information								
Process ID		89		Packet Category		12		
Service		6		Packet Cargo Length		10 bytes		
Service Subtype		9		Packet Total Length		20 bytes		
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	16	PME06060	Memory ID	190-199 VME060 60	-	CMET6060 TC
2		UInt	32	PME06065	Start Address	Full	-	-
6		UInt	32	PME06068	Length of Check Block	Full	-	-

Table 5-37: Check memory area using absolute addresses TC

Notes:

Memory addresses and check length must be 4 byte aligned
Reaction:
A Memory Check Report
Exceptions:
Invalid memory ID: A Telecommand Execution Failure Report TM 1,8 FID 52000 and parameters [6, 9, 0, received memory ID] is generated.
Invalid start address (not in requested memory or not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 9, 2, received start address] is generated.
Invalid length (overflow of selected memory not aligned): A Telecommand Execution Failure Report TM 1,8, FID 52001 and parameters [6, 9, 6, received length] is generated.

5.1.2.2.5.5 Memory Check Report

Telemetry Packet Description							
Database mnemonic		YME51610					
Database Description		MERM Memory Check Report					
Destination		0					
Description		Memory Check Report					
Generation Rule		On request					
Header Information							
Process ID		89		Packet Category		9	
Service		6		Packet Cargo Length		12 bytes	
Service Subtype		10		Packet Total Length		28 bytes	
Data Field Information (Application Data)							
Offset		Format	Size	Unit	Database		
[Byte]	[Bit]		[Bit]		Mnemonic	Description	Calibration
0		Enum	16		NME06000	Memory ID	CMET6060TM
2		UInt32	32		NME06001	Start Adress	-
6		UInt32	32		NME06002	Length	-
10		UInt16	16		NME06004	Memory Checksum	-

Table 5-38: Memory Check Report TM Structure

5.1.2.2.6 Service 8: Function Management

No telecommands are supported within this context.

5.1.2.2.7 Service 9: Time Management

5.1.2.2.7.1 Accept time update

Telecommand Packet Description								
Database mnemonic			ZME00929					
Database Description			MERM Accept Time Update					
Packet Function			Onboard time at next spacewire synchronization pulse					
Attributes			none					
Verification rule			none					
Valid modes			All except 2, 8 and 14					
Header Information								
Process ID			89			Packet Category		12
Service			9			Packet Cargo Length		6 bytes
Service Subtype			129			Packet Total Length		16 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		CUCTime	48	PME08917	On Board Time	Full	-	-

Table 5-39: Accept Time Update TC

<u>Time Synchronization Requirements:</u>
range 5 to 60 min. Message is required twice at boot.
<u>Exceptions:</u>
No specials

5.1.2.2.8 Service 17: In-Flight Testing

5.1.2.2.8.1 Perform Connection Test

Telecommand Packet Description			
Database mnemonic	ZME01701		
Database Description	MERM Connection Test		
Packet Function	Perform connection test, a connection test response is generated		
Attributes	None		
Verification rule	None		
Valid modes	All except 0,2,8		
Header Information			
Process ID	89	Packet Category	12
Service	17	Packet Cargo Length	0 bytes
Service Subtype	1	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-40: Perform Connection Test TC

<u>Reaction</u>:

A Connection Test Response TM 17,2

<u>Exceptions</u>:

No specials

5.1.2.2.8.2 Connection Test Response Report

Telemetry Packet Description			
Database mnemonic	YME51972		
Database Description	MERM Connection Test Response		
Destination ID	Copy of source ID of respective TC(17,1)		
Description	Connection test response report		
Generation Rule	On request		
Header Information			
Process ID	89	Packet Category	7
Service	17	Packet Cargo Length	0
Service Subtype	2	Packet Total Length	16 bytes
Data Field Information (Application Data)			
none			

Table 5-41: Connection Test Response Report TM Structure

<u>Description</u>:

<u>Explanation</u>:

5.1.2.2.8.3 Test telecommand of maximum length

Telecommand Packet Description								
Database mnemonic			ZME01728					
Database Description			MERM Test TC max Length					
Packet Function			Perform acceptance test of TC with maximum length					
Attributes			None					
Verification rule			None					
Valid modes			All except 0,2,8					
Header Information								
Process ID			89		Packet Category		12	
Service			17		Packet Cargo Length		236 bytes	
Service Subtype			128		Packet Total Length		246 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		-	1888	-	Dummy236bytescommand	-	-	-

Table 5-42: Test telecommand of maximum length TC

<u>Exceptions:</u>

No specials

5.1.2.2.9 Service 20: Information Distribution DMS-User

No telecommands are supported within this context.

5.1.2.2.10 Service 21: Science Data Transfer

5.1.2.2.10.1 Enable/Start Science Transfer from User

Telecommand Packet Description								
Database mnemonic			ZME02101					
Database Description			MERM Enable Sci Data					
Packet Function			Using this command science output of a process can be started. This does not affect the instrument mode. It is not planned to use this command, since a better functionality can be reached by changing measurement rates to 0..					
Attributes			None					
Verification rule			None					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			21			Packet Cargo Length		2 bytes
Service Subtype			1			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0	0	-	9	ZeroPad9	ZeroPad9	-	-	-
1	1	-	7	PME08005	PID	85-87 CMET6005 TC	-	CMET6005TC

Table 5-43: Enable/Start Science Transfer from User TC

<u>Reaction</u>

A Normal/Progress Report TM 5,1 EID 52054 is generated to report the mode change.

<u>Exceptions:</u>

Different PID than in header: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [21,1,0,received byte] is generated.

5.1.2.2.10.2 Disable/Stop Science Transfer from User

Telecommand Packet Description								
Database mnemonic			ZME02102					
Database Description			MERM Disable Sci Data					
Packet Function			Using this command science output of a process can be stopped. This does not affect the instrument mode. It is not planned to use this command, since a better functionality can be reached by changing measurement rates to 0.					
Attributes			none					
Verification rule			none					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			21			Packet Cargo Length		2 byte
Service Subtype			2			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0	0	-	9	ZeroPad9	ZeroPad9	-	-	-
1	1	-	7	PME08005	PID	85-87 CMET6005 TC	-	CMET6005TC

Table 5-44: Disable/Stop Science Transfer from User TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52054 is generated to report the mode change.

Exceptions:

Invalid PID: A Telecommand Acceptance Failure Report TM 1,2, FID 5 and parameters [21,2,0,received byte] is generated.

5.1.2.2.10.3 Science Packet Identifier

Science packets are distinguishable by their packet identifier, which is always transmitted as first byte of the cargo. There are 2 identical packets for most types to allow identification of inboard/outboard sensor data. Compression is available for science packets. In case all settings (rate, range) are the same for both channels in a process, data of both channels is transmitted in a single packet exploiting the data redundance between inboard and outboard sensor.

For science packets a single packet for each process is defined in the database. A further discrimination can be done using the science packet identifier (NMED8004), but is not possible in database due to format restrictions there.

Telemetry Packet Description							
Database mnemonic		YME51100, YME51101, YME51102					
Database Description		MERM Science X Band MERM Science Ka Band MERM Science Selective					
Destination ID		0					
Description		Magnetometer Science Packets. Contains produced science data with source and format defined by science packet identifier.					
Generation Rule		Automatically in modes 3,4,5,9 if science report generation is enabled for this PID					
Header Information							
Process ID		85,86,87			Packet Category	12	
Service		21			Packet Cargo Length	Variable	
Service Subtype		3			Packet Total Length	Variable	
Data Field Information (Application Data)							
Offset		Format	Size	Unit	Database		
[Byte]	[Bit]		[Bit]		Mnemonic	Description	
0	0	Enum	4		NMED8004	SciencePacketIdentifier	
						Further definition dependant on identifier, see below.	

Packet Identifier UInt4	**Packet Type (Calibration CMET6104TM)**	**Packet Length**	**Chapter**
0 1	Sensor Science Report OB Sensor Science Report IB	778	5.1.2.2.10.4
2 3	Sensor Science Report Calibration OB Sensor Science Report Calibration IB	786	5.1.2.2.10.5
4 5	Sensor Science Report Compressed Single OB Sensor Science Report Compressed Single IB	Variable, 2 byte aligned	5.1.2.2.10.6
6	Magnetometer Science Report Compressed Dual	Variable, 2 byte aligned	5.1.2.2.10.7
7	Science Spectrum OB	Currently not implemented	
8	Science Spectrum IB	Currently not implemented	

Table 5-45: Science Packet IDs

5.1.2.2.10.4 Sensor Science Report Uncompressed

Telemetry Packet Description			
Description	Magnetometer Science Packet. Contains produced science data in uncompressed format for contained sensor (MAGOB or MAGIB). In dual science mode a packet is sent for each sensor.		
Generation Rule	Automatically in modes 3,4,5,9 • If science report generation is enabled for this PID • If compression is deactivated • If compression is activated and unsuccessful • In mode 9 with calibration mode 0,3,4,5 In mode 15, when sensor calibration bits are not set. • If science report generation is enabled for PID 85 Rate is dependant on measurement rate		
Header Information			
Process ID	85,86,87	Packet Category	12
Service	21	Packet Cargo Length	778 Bytes
Service Subtype	3	Packet Total Length	794 bytes

Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0	0	Enum	4		NMED8004	SciencePacketIdentifier
	4	UInt	4			MeasurementRange
1	0	UInt	4			MeasurementRate
	4	Bool	1			Clipping (range overflow)
	5	UInt	3			CalMode
2		Int	16			CompensationValX
4		Int	16			CompensationValY
6		Int	16			CompensationValZ
8		Int	16			FieldValX
10		Int	16			FieldValY
12		Int	16			FieldValZ
…		…				
770		Int	16			FieldValX
772		Int	16			FieldValY
774		Int	16			FieldValZ
776		UInt	16		NME06020	CheckSum16

Table 5-46: Sensor Science Report Uncompressed TM Structure

5.1.2.2.10.5 Sensor Science Report Calibration

Telemetry Packet Description						
Description		Magnetometer Science Packet. Contains produced calibration science data in uncompressed format for contained sensor (MAGOB or MAGIB). Data is interleaved calibration data.				
Generation Rule		Automatically in mode 9 • If science report generation is enabled for this PID In mode 15 (backup mode) if sensor calibration bits are set • If science report generation is enabled for PID 85				
Header Information						
Process ID		85		Packet Category	12	
Service		21		Packet Cargo Length	784 Bytes	
Service Subtype		3		Packet Total Length	800 bytes	
Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0	0	Enum	4		NMED8004	SciencePacketIdentifier
	4	UInt	4		-	MeasurementRange
1	0	UInt	4		-	MeasurementRate
	4	Bool	1		-	Clipping (range overflow)
	5	UInt	3		-	CalMode
2		Int	16		-	CompensationValX
4		Int	16		-	CompensationValY
6		Int	16		-	CompensationValZ
8		Int	16		-	CalibrationdataX
10		Int	16		-	CalibrationdataY
12		Int	16		-	CalibrationdataZ
…		…			-	
770		Int	16		-	CalibrationdataX
772		Int	16		-	CalibrationdataY
774		Int	16		-	CalibrationdataZ
776		Int	16		-	FeedBackDACVALX
778		Int	16		-	FeedBackDACVALY
780		Int	16		-	FeedBackDACVALZ
782		-	8		-	ZeroPadByte
783		UInt	8		-	Sensor Phase Value
784		UInt	16		-	CheckSum16

Table 5-47: Sensor Science Report Calibration 1 TM Structure

5.1.2.2.10.6 Sensor Science Report Compressed Single

<table>
<tr><td colspan="8">Telemetry Packet Description</td></tr>
<tr><td colspan="4">Description</td><td colspan="4">Compressed Magnetometer Science Packet from a single sensor (MAGOB or MAGIB dependant on PID), contains 128 vectors.</td></tr>
<tr><td colspan="4">Generation Rule</td><td colspan="4">Automatically in modes 3,4,5
• For PIDs available in mode
• If science report generation is enabled for this PID
• Compression is enabled
Rate is dependant on measurement rate
In case of unsuccessful compression (bigger than 778 bytes) an uncompressed science report is sent instead.</td></tr>
<tr><td colspan="8">Header Information</td></tr>
<tr><td colspan="3">Process ID</td><td colspan="2">85,86,87</td><td colspan="2">Packet Category</td><td>12</td></tr>
<tr><td colspan="3">Service</td><td colspan="2">21</td><td colspan="2">Packet Cargo Length</td><td>Variable, up to 778 Bytes, even length</td></tr>
<tr><td colspan="3">Service Subtype</td><td colspan="2">3</td><td colspan="2">Packet Total Length</td><td>Variable, up to 794 bytes, even length</td></tr>
<tr><td colspan="8">Data Field Information (Application Data)</td></tr>
<tr><td colspan="2">Offset</td><td rowspan="2">Format</td><td>Size</td><td rowspan="2">Unit</td><td colspan="3">Database</td></tr>
<tr><td>[Byte]</td><td>[Bit]</td><td>[Bit]</td><td>Mnemonic</td><td colspan="2">Description</td></tr>
<tr><td rowspan="2">0</td><td>0</td><td>Enum</td><td>4</td><td></td><td>NMED8004</td><td colspan="2">SciencePacketIdentifier</td></tr>
<tr><td>4</td><td>UInt</td><td>4</td><td></td><td>-</td><td colspan="2">MeasurementRange</td></tr>
<tr><td rowspan="3">1</td><td>0</td><td>UInt</td><td>4</td><td></td><td>-</td><td colspan="2">MeasurementRate</td></tr>
<tr><td>4</td><td>Bool</td><td>1</td><td></td><td>-</td><td colspan="2">Clipping (range overflow)</td></tr>
<tr><td>5</td><td>UInt</td><td>3</td><td></td><td>-</td><td colspan="2">Spare3</td></tr>
<tr><td>2</td><td></td><td>Int</td><td>16</td><td></td><td>-</td><td colspan="2">CompensationValX</td></tr>
<tr><td>4</td><td></td><td>Int</td><td>16</td><td></td><td>-</td><td colspan="2">CompensationValY</td></tr>
<tr><td>6</td><td></td><td>Int</td><td>16</td><td></td><td>-</td><td colspan="2">CompensationValZ</td></tr>
<tr><td>8</td><td></td><td></td><td>1-766</td><td></td><td>-</td><td colspan="2">CompressedData</td></tr>
<tr><td>N</td><td></td><td></td><td>0-15</td><td></td><td>-</td><td colspan="2">CompressPad</td></tr>
<tr><td>Max 776</td><td></td><td>UInt</td><td>16</td><td></td><td>-</td><td colspan="2">CheckSum16</td></tr>
</table>

Table 5-48: Sensor Science Report Compressed Single TM Structure

The packet length is already contained in the packet header, no length information is necessary for decoding, as the decoder just decodes 128 vectors.

5.1.2.2.10.7 Sensor Science Report Compressed Dual

Telemetry Packet Description			
Destination ID	0		
Description	Compressed Magnetometer Science Packet from both sensors, contains 128x2 vectors.		
Generation Rule	Automatically in mode 3,4,5 • If science report generation is enabled for this PID • compression is enabled • measurement rate of both sensor products in process is the same Rate is dependant on measurement rate. In case of unsuccessful compression (bigger than 1572 bytes) two uncompressed science reports are sent instead.		
Header Information			
Process ID	85,86,87	Packet Category	12
Service	21	Packet Cargo Length	Variable, up to 1572 Bytes, even length
Service Subtype	3	Packet Total Length	Variable, up to 1588 bytes, even length

Data Field Information (Application Data)						
Offset		Format	Size	Unit	Database	
[Byte]	[Bit]		[Bit]		Mnemonic	Description
0	0	Enum	4		NMED8004	SciencePacketIdentifier
	4	UInt	4		-	MeasurementRange
1	0	UInt	4		-	MeasurementRate
	4	Bool	1		-	Clipping OB (range overflow)
	5	Bool	1		-	Clipping IB (range overflow)
	6	UInt	2		-	Spare2
2		Int	16		-	MAGOBCompensationValX
4		Int	16		-	MAGOBCompensationValY
6		Int	16		-	MAGOBCompensationValZ
8		Int	16		-	MAGIBCompensationValX
10		Int	16		-	MAGIBCompensationValY
12		Int	16		-	MAGIBCompensationValZ
14			2-1556		-	CompressedData2
N			0-15		-	CompressPad
Max 1570		UInt	16		-	CheckSum16

Table 5-49: Sensor Science Report Compressed Dual TM Structure

The packet length is already contained in the packet header, no length information is necessary for decoding, as the decoder just decodes 128x2 vectors.

5.1.2.2.10.8 Science Spectrum Report

This packet reports some kind of spectral information about the field in OB and IB sensor. Content is used to support selective downlink and/or to detect regions of interest in non-selective mode. Packet structure and detailed content will follow as soon as Messenger data has been examined and a meaningful method for calculating this packet has been found. (state of 2017-01-27) Packet rate will be low (presumably one packet per 128 seconds) and will be on the expense of higher rate products, so the overall data budget will not increase. The size of the packet is presumed to be smaller than a current single packet. Further details will be added as soon as available. The introduction of this packet is based on ICDR suggestions.

5.1.2.2.10.9 Reset Output Buffer

Telecommand Packet Description			
Database mnemonic	ZME02128		
Database Description	MERM Reset Sci Buffer		
Packet Function	Reset Science Output Buffer, all buffer content of all science buffers is flushed.		
Attributes	None		
Verification rule	None		
Valid modes	3,4,5,6,9		
Header Information			
Process ID	89	Packet Category	12
Service	21	Packet Cargo Length	0 bytes
Service Subtype	128	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-50: Reset Output Buffer TC

Explanation:
This flushes the science buffer, which means that all contained packets are lost. This will cause a gap in science time stamps and sequence counters (SSC, those are not reset). Dependent on the amount of packets within the buffer the gap can be large. The worst case is if spacewire connection is lost for some time and the buffer is full, which could e.g. be up to 1320 uncompressed science packets.

Exceptions:

No Specials

5.1.2.2.11 Service 22: Context Saving

No TC and TM used.

5.1.2.3 Service 128 – 288 – Private Services

5.1.2.3.1 Private Service 205: Unused

5.1.2.3.2 Private Service 206: Sensor Control Private TC

5.1.2.3.2.1 Set Sensor ADC Weighting values

Telecommand Packet Description								
Database mnemonic		ZME02601						
Database Description		MERMSensorSetADCWeights						
Packet Function		Set sensor ADC weighting value of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet are set to the NaN value, a new packet is started						
Attributes		None						
Verification rule		None						
Valid modes		3,4,5,6,9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		8 bytes	
Service Subtype		1			Packet Total Length		18 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8		ZeroPadByte	-	-	-
2		UInt	16	PME02050	Sensor K1 X ADC	Full	-	-
4		UInt	16	PME02051	Sensor K1 YADC	Full	-	-
6		UInt	16	PME02052	Sensor K1 Z ADC	Full	-	-

Table 5-51: Set Sensor ADC Weighting values TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 1, 0, received sensor ID] is generated.

5.1.2.3.2.2 Set Sensor DAC Weighting Values

Telecommand Packet Description								
Database mnemonic			ZME02602					
Database Description			MERMSensorSetDACWeights					
Packet Function			Set sensor DAC weighting value of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started					
Attributes			None					
Verification rule			None					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			206			Packet Cargo Length		8 bytes
Service Subtype			2			Packet Total Length		18 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8		ZeroPadByte	-	-	-
2		UInt	16	PME02053	Sensor K2 X DAC	Full	-	-
4		UInt	16	PME02054	Sensor K2 Y DAC	Full	-	-
6		UInt	16	PME02055	Sensor K2 Z DAC	Full	-	-

Table 5-52: Set Sensor DAC Weighting values TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 2, 0, received sensor ID] is generated.

5.1.2.3.2.3 Set Sensor Internal Feedback Factor

Telecommand Packet Description								
Database mnemonic			ZME02603					
Database Description			MERMSensorSetIntFeedback					
Packet Function			Set sensor internal feedback factor of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started					
Attributes			none					
Verification rule			none					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			206			Packet Cargo Length		2 bytes
Service Subtype			3			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration

0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		UInt	8	PME02070	Sensor Internal Feedback	Full	-	-

Table 5-53: Set Sensor Internal Feedback Factor TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 3, 0, received sensor ID] is generated.

5.1.2.3.2.4 Set Sensor Phase Value

Telecommand Packet Description								
Database mnemonic			ZME02604					
Database Description			MERM Sensor Set Phase					
Packet Function			Set sensor sampling phase value of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started					
Attributes			none					
Verification rule			none					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			206			Packet Cargo Length		2 bytes
Service Subtype			4			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		UInt	8	PME02071	Sensor Phase Value	4-255 VME08171	-	-

Table 5-54: Set Sensor Phase Value TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 4, 0, received sensor ID] is generated.

Invalid phase value (range 4-255): A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 4, 0, received phase value] is generated.

5.1.2.3.2.5 Set Sensor Sample Value

Telecommand Packet Description								
Database mnemonic			ZME02605					
Database Description			MERM Sensor Set Samples					
Packet Function			Set Sensor number of samples to average for selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started					
Attributes			none					
Verification rule			none					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89		Packet Category		12	
Service			206		Packet Cargo Length		2 bytes	
Service Subtype			5		Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		UInt	8	PME02072	Sensor Samples Value	0-74 VME08172	-	-

Table 5-55: Set Sensor Sample Value TC

<u>Reaction:</u>

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

<u>Exceptions:</u>

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 5, 0, received sensor ID] is generated.

Invalid samples value: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 5, 0, received samples value] is generated.

5.1.2.3.2.6 Set Sensor Feedback Relay

Telecommand Packet Description									
Database mnemonic			ZME02606						
Database Description			MERM Sensor Set FB Relay						
Packet Function			Switch on/off feedback relay of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started						
Attributes			none						
Verification rule			none						
Valid modes			3,4,5,6,9						
Header Information									
Process ID			89			Packet Category		12	
Service			206			Packet Cargo Length		2 bytes	
Service Subtype			6			Packet Total Length		12 bytes	
Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC	
1	0	-	7		Pad7	-	-	-	
	7	Bool	1	PME02073	SensFeedbackRelayEnable	Full	-	CAAT0001TC	

Table 5-56: Set Sensor Feedback Relay TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 6, 0, received sensor ID] is generated.

5.1.2.3.2.7 Set Sensor Excitation

Telecommand Packet Description	
Database mnemonic	ZME02607
Database Description	MERM Sensor Set Excite
Packet Function	Switch on/off excitation of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started
Attributes	none
Verification rule	none
Valid modes	3,4,5,6,9

Header Information			
Process ID	89	Packet Category	12
Service	206	Packet Cargo Length	2 bytes
Service Subtype	7	Packet Total Length	12 bytes

Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	-	7		Pad7	-	-	-
	7	Bool	1	PME02074	SensorExcitationEnable	Full	-	CAAT0001TC

Table 5-57: Set Sensor Excitation TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 7, 0, received sensor ID] is generated.

5.1.2.3.2.8 Set Sensor feedback DAC values

Telecommand Packet Description								
Database mnemonic		ZME02608						
Database Description		MERMSensorSetCalFBDAC						
Packet Function		Set sensor feedback DAC values for calibration mode of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started						
Attributes		None						
Verification rule		None						
Valid modes		9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		8 bytes	
Service Subtype		8			Packet Total Length		18 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8		ZeroPadByte	-	-	-
2		Int	16	PME02056	Sensor FeedbackDACX	Full	-	-
4		Int	16	PME02057	Sensor FeedbackDACY	Full	-	-
6		Int	16	PME02058	Sensor FeedbackDACZ	Full	-	-

Table 5-58: Set Sensor feedback DAC values TC

Reaction:

none, is reported using science data

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 8, 0, received sensor ID] is generated.

Not in CAL 4,5,6 mode: A Telecommand Execution Failure Report TM 1,8, FID 52004 and parameters [Sensor ID,Instrument Mode, OB Cal Mode, IB Cal Mode] is generated

5.1.2.3.2.9 Select Sensor ICU Filter

Telecommand Packet Description			
Database mnemonic	ZME02609		
Database Description	MERMSensorSelectICUFilt		
Packet Function	Select sensor ICU Filter for both sensors. All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started		
Attributes	none		
Verification rule	none		
Valid modes	3,4,5,6,9		
Header Information			
Process ID	89	Packet Category	12
Service	206	Packet Cargo Length	2 bytes
Service Subtype	9	Packet Total Length	12 bytes

Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	-	7		Pad7	-	-	-
	7	Bool	1	PME02075	Sensor ICU FilterType	Full	-	-

Table 5-59: Select Sensor ICU Filter TC

The ICU filter type 0 is the only currently foreseen filter. The value of 1 is a placeholder for possible later use.

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 9, 0, received sensor ID] is generated.

5.1.2.3.2.10 Set Sensor Auto Compensation

Telecommand Packet Description									
Database mnemonic			ZME02610						
Database Description			MERMSensorSetAutoComp						
Packet Function			Enables Sensor auto compensation of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started						
Attributes			none						
Verification rule			none						
Valid modes			3,4,5,6,9						
Header Information									
Process ID			89			Packet Category		12	
Service			206			Packet Cargo Length		2 bytes	
Service Subtype			10			Packet Total Length		12 bytes	
Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC	
1	0	-	7		Pad7	-	-	-	
	7	Bool	1	PME02076	SensAutoCompEnable	Full	-	CAAT0001TC	

Table 5-60: Set Sensor Auto Compensation TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 10, 0, received sensor ID] is generated.

5.1.2.3.2.11 Set Sensor Manual Compensation Values

Telecommand Packet Description								
Database mnemonic			ZME02611					
Database Description			MERMSensorSetCompVal					
Packet Function			Sets manual compensation values of selected Sensor ID (MAGOB, MAGIB, BOTH). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started					
Attributes			none					
Verification rule			none					
Valid modes			3,4,5,6,9					
Header Information								
Process ID			89			Packet Category		12
Service			206			Packet Cargo Length		2 bytes
Service Subtype			11			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8		ZeroPadByte	-	-	-
2		Int	16	PME02059	SensManualCompValX	Full	-	-
4		Int	16	PME02060	SensManualCompValY	Full	-	-
6		Int	16	PME02061	SensManualCompValZ	Full	-	-

Table 5-61: Set Sensor Manual Compensation Values TC

Reaction:

None, data is contained in science packets

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 11, 0, received sensor ID] is generated.

5.1.2.3.2.12 Trigger Single Sensor Auto Compensation Cycle

Telecommand Packet Description									
Database mnemonic			ZME02612						
Database Description			MERMSensorSingleAutoComp						
Packet Function			Triggers a single sensor auto compensation cycle of selected Sensor ID (MAGOB, MAGIB, both). All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started						
Attributes			none						
Verification rule			none						
Valid modes			3,4,5,6,9						
Header Information									
Process ID			89			Packet Category		12	
Service			206			Packet Cargo Length		2 bytes	
Service Subtype			12			Packet Total Length		12 bytes	
Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC	
1		-	8		ZeroPadByte	-	-	-	

Table 5-62: Trigger Single Sensor Auto Compensation Cycle TC

<u>Exceptions</u>:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 12, 0, received sensor ID] is generated.

5.1.2.3.2.13 Set Sensor Auto Ranging

<table>
<tr><td colspan="9">Telecommand Packet Description</td></tr>
<tr><td colspan="3">Database mnemonic</td><td colspan="6">ZME02613</td></tr>
<tr><td colspan="3">Database Description</td><td colspan="6">MERMSensorSetAutoRange</td></tr>
<tr><td colspan="3">Packet Function</td><td colspan="6">Enables sensor auto ranging of selected Sensor ID (MAGOB, MAGIB, BOTH). The range of each packet is adjusted to fit to the contained vectors to avoid overflows.
All following science vectors of the current science packet(s) are set to the NaN value, a new packet is started upon reception of this TC</td></tr>
<tr><td colspan="3">Attributes</td><td colspan="6">none</td></tr>
<tr><td colspan="3">Verification rule</td><td colspan="6">none</td></tr>
<tr><td colspan="3">Valid modes</td><td colspan="6">3,4,5,6,9</td></tr>
<tr><td colspan="9">Header Information</td></tr>
<tr><td colspan="3">Process ID</td><td colspan="3">89</td><td colspan="2">Packet Category</td><td>12</td></tr>
<tr><td colspan="3">Service</td><td colspan="3">206</td><td colspan="2">Packet Cargo Length</td><td>2 bytes</td></tr>
<tr><td colspan="3">Service Subtype</td><td colspan="3">13</td><td colspan="2">Packet Total Length</td><td>12 bytes</td></tr>
<tr><td colspan="9">Data Field Information (Application Data)</td></tr>
<tr><td colspan="2">Offset</td><td rowspan="2">Format</td><td>Size</td><td colspan="5">Database</td></tr>
<tr><td>[Byte]</td><td>[Bit]</td><td>[Bit]</td><td>Mnemonic</td><td>Description</td><td>Range</td><td>Default</td><td>Calibration</td></tr>
<tr><td>0</td><td></td><td>Enum</td><td>8</td><td>PME02030</td><td>Sensor ID</td><td>0-2 CMET6030TC</td><td>-</td><td>CMET6030TC</td></tr>
<tr><td rowspan="2">1</td><td>0</td><td>-</td><td>7</td><td></td><td>Pad7</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>7</td><td>Bool</td><td>1</td><td>PME02077</td><td>SensAutoRangingEnable</td><td>Full</td><td>-</td><td>CAAT0001TC</td></tr>
</table>

Table 5-63: Set Sensor Auto Ranging TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 13, 0, received sensor ID] is generated.

5.1.2.3.2.14 Set Sensor Auto Heater

Telecommand Packet Description									
Database mnemonic			ZME02614						
Database Description			MERMSensorSetAutoHeater						
Packet Function			Enables sensor auto heating control of Sensor ID (MAGOB, MAGIB, BOTH). If heating is disabled, the heater is switched off. Also sets the target temperature for heating control (ignored if enable bit is set to off)						
Attributes			none						
Verification rule			none						
Valid modes			3,4,5,6,9						
Header Information									
Process ID			89			Packet Category		12	
Service			206			Packet Cargo Length		2 bytes	
Service Subtype			14			Packet Total Length		12 bytes	
Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		-	8	ZeroPadByte	Zero Padding	-		-	
1	0	-	6		Pad6	-	-	-	
	6	Bool	1	PME02078	OBSensAutoheater Enable	Full	-	CAAT0001 TC	
	7	Bool	1	PME02096	IBSensAutoheaterE nable	Full	-	CAAT0001 TC	
2	16	UInt	16	PME02094	OB HeaterTargetTemp	Full	-	CMEP6200 TC	
4	16	UInt	16	PME02095	IB HeaterTargetTemp	Full	-	CMEP6214 TC	

Table 5-64: Set Sensor Auto Heater

Description:

This command enables the heaters and gives the target temperatures for the heater control system (More details see ZME02615).

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated. A Normal/Progress Report TM 5,1, EID 52706 (MAGOB) or 52706 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 14, 0, received sensor ID] is generated.

5.1.2.3.2.15 Set Sensor Auto Heater Parameters

Telecommand Packet Description								
Database mnemonic		ZME02615						
Database Description		MERMSensSetAutoHeaterPar						
Packet Function		Set control parameters of sensor auto heating control						
Attributes		none						
Verification rule		none						
Valid modes		3,4,5,6,9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		8 bytes	
Service Subtype		15			Packet Total Length		18 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8	ZeroPadByte	ZeroPadByte	Full	-	-
2		Int	16	PME02079	HeaterProportional Coeff	Full	-	-
4		Int	16	PME02080	HeaterIntegralCoeff	Full	-	-
6		Int	16	PME02089	HeaterDifferentialCoeff	Full	-	-

Table 5-65: Set Sensor Auto Heater Parameters

Description:

Heater control is implemented using a PID-controller that calculates the new heater value dependent on the deviation from the heater target temperature.

Since heating power is limited to 0.5W, the effect of the heater is minimal and can only be used to either change the temperature in a small window (1-2 K) above regular thermal balance or to slow down temperature gradients in eclipse situations. Details of heater operation will be determined in Mercury orbit.

Reaction:

A Normal/Progress Report TM 5,1, EID 52706 (MAGOB) or 52706 (MAGIB) is generated.Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 15, 0, received sensor ID] is generated.

5.1.2.3.2.16 Set Sensor Heater Value

<table>
<tr><td colspan="9">Telecommand Packet Description</td></tr>
<tr><td colspan="3">Database mnemonic</td><td colspan="6">ZME02616</td></tr>
<tr><td colspan="3">Database Description</td><td colspan="6">MERMSensorSetHeaterValue</td></tr>
<tr><td colspan="3">Packet Function</td><td colspan="6">Sets sensor manual heater cycle value of Sensor ID (MAGOB, MAGIB, BOTH). Heating is switched off automatically, when the sensor temperature exceeds 180 °C. If auto heating is enabled, the set value is not persistent and will be overwritten by heating control.</td></tr>
<tr><td colspan="3">Attributes</td><td colspan="6">none</td></tr>
<tr><td colspan="3">Verification rule</td><td colspan="6">none</td></tr>
<tr><td colspan="3">Valid modes</td><td colspan="6">3,4,5,6,9</td></tr>
<tr><td colspan="9">Header Information</td></tr>
<tr><td colspan="3">Process ID</td><td colspan="3">89</td><td colspan="2">Packet Category</td><td>12</td></tr>
<tr><td colspan="3">Service</td><td colspan="3">206</td><td colspan="2">Packet Cargo Length</td><td>2 bytes</td></tr>
<tr><td colspan="3">Service Subtype</td><td colspan="3">16</td><td colspan="2">Packet Total Length</td><td>12 bytes</td></tr>
<tr><td colspan="9">Data Field Information (Application Data)</td></tr>
<tr><td colspan="2">Offset</td><td rowspan="2">Format</td><td>Size</td><td colspan="5">Database</td></tr>
<tr><td>[Byte]</td><td>[Bit]</td><td>[Bit]</td><td>Mnemonic</td><td>Description</td><td>Range</td><td>Default</td><td>Calibration</td></tr>
<tr><td>0</td><td></td><td>Enum</td><td>8</td><td>PME02030</td><td>Sensor ID</td><td>0-2
CMET6030TC</td><td>-</td><td>CMET6030TC</td></tr>
<tr><td>1</td><td></td><td>UInt</td><td>8</td><td>PME02081</td><td>Sensor Heater Value</td><td>0-128
VME08081</td><td>-</td><td>-</td></tr>
</table>

Table 5-66: Set Sensor Heater Value TC

Reaction:

None (Is contained in normal housekeeping packet)

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 16, 0, received sensor ID] is generated.

Invalid heater value: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 16, 0, received heater value] is generated.

5.1.2.3.2.17 Activate / Deactivate Sensor

Telecommand Packet Description									
Database mnemonic			ZME02617						
Database Description			MERMSensorSetActiveState						
Packet Function			This command enables/disables a complete sensor. Enable/Disable sensor commanding, data reception and error messages of Sensor ID (MAGOB, MAGIB, BOTH). The housekeeping enable state is adjusted accordingly. All following science vectors of the current science packet are set to the NaN value. Is used to suppress error messages of a defective sensor.						
Attributes			none						
Verification rule			none						
Valid modes			3,4,5,6,9						
Header Information									
Process ID			89			Packet Category		12	
Service			206			Packet Cargo Length		2 bytes	
Service Subtype			17			Packet Total Length		12 bytes	
Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC	
1	0	-	7		Pad 7	-	-	-	
	7	Bool	1	PME02082	Sensor Active State	Full	-	CAAT0001TC	

Table 5-67: Activate/Deactivate Sensor TC

<u>Reaction</u>:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

<u>Exceptions</u>:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 17, 0, received sensor ID] is generated.

5.1.2.3.2.18 Reset Sensor

Telecommand Packet Description	
Database mnemonic	ZME02618
Database Description	MERMSensorReset
Packet Function	Reset sensor electronics of Sensor ID (MAGOB, MAGIB, both). All following science vectors of the current science packet are set to the NaN value, a new packet is started when all activated sensors are online again. Reset sensors are then set to their previous settings
Attributes	none
Verification rule	none
Valid modes	3,4,5,6,9

Header Information			
Process ID	89	Packet Category	12
Service	206	Packet Cargo Length	2 bytes
Service Subtype	18	Packet Total Length	12 bytes

Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		-	8		ZeroPadByte	-	-	-

Table 5-68: Reset Sensor TC

Reaction:

None

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 18, 0, received sensor ID] is generated.

5.1.2.3.2.19 SetSensorPEO

Telecommand Packet Description								
Database mnemonic		ZME02619						
Database Description		MERM Sensor Set PEO						
Packet Function		Set Sensor phase orientation even/odd						
Attributes		None						
Verification rule		None						
Valid modes		3,4,5,6,9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		2 bytes	
Service Subtype		19			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	-	7		Pad 7	-	-	-
	7	Bool	1	PME02088	Sensor PEO	Full	-	CMET6151TC

Table 5-69: Set Sensor PEO TC

Reaction:

None

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 19, 0, received sensor ID] is generated.

5.1.2.3.2.20 SensorSetFindPhase

Telecommand Packet Description								
Database mnemonic		ZME02620						
Database Description		MERMSensorSetFindPhase						
Packet Function		Specify parameters for findphase calibration mode. Executed if calmode 6, otherwise values are just stored.						
Attributes		none						
Verification rule		none						
Valid modes		9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		8 bytes	
Service Subtype		20			Packet Total Length		18 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		-	8	-	ZeroPadByte		-	
1		UInt	8	PME02083	Sensor Cal StartPhase	4-255 VME08171	-	-
2		UInt	8	PME02084	Sensor Cal EndPhase	4-255 VME08171	-	-
3		UInt	8	PME02085	Sensor Cal PhaseStep	Full	-	-
4		UInt	16	PME02086	Sensor Cal JumpSize	Full	-	-
6		UInt	16	PME02087	Sensor Cal WaitPackets	Full	-	-

Table 5-70: Set Sensor Findphase TC

Reaction:

None

Exceptions:

Invalid start or end phase value: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 20, 0, received phase value] is generated

5.1.2.3.2.21 SensorSetClock

Telecommand Packet Description								
Database mnemonic		ZME02621						
Database Description		MERM Sensor Set Clock						
Packet Function		Select clock used for sensor sampling and synchronization (ICU provided, Internal)						
Attributes		none						
Verification rule		none						
Valid modes		3,4,5,6,9						
Header Information								
Process ID		89			Packet Category		12	
Service		206			Packet Cargo Length		2 bytes	
Service Subtype		21			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	UInt	6	-	Pad 6	-	-	-
	6	Bool	1	PME02090	Sensor Clk Select	0-1	-	CMET6152TC
	7	Bool	1	PME02091	Sensor Sync Select	0-1	-	CMET6152TC

Table 5-71: Set Sensor Clock TC

Reaction:

A Normal/Progress Report TM 5,1, EID 52700 (MAGOB) or 52702 (MAGIB) is generated.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 21, 0, received sensor ID] is generated.

5.1.2.3.2.22 SensorSetRaw

Telecommand Packet Description			
Database mnemonic	ZME02622		
Database Description	MERM Sensor Set Raw		
Packet Function	Send a direct command to the sensor in Backup Science mode.		
Attributes	none		
Verification rule	none		
Valid modes	15		
Header Information			
Process ID	89	Packet Category	12
Service	206	Packet Cargo Length	4 bytes
Service Subtype	22	Packet Total Length	14 bytes

Data Field Information (Application Data)

Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1		UInt	8	PME02092	Sensor Cmd ID	Full	-	CMET6153TC
2		UInt	16	PME02093	Sensor Cmd Param	Full	-	-

Table 5-72: Set Sensor Raw TC

Reaction:

None

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [206, 22, 0, received sensor ID] is generated.

Sensor Cmd Param: sensor commands and parameters are given in BC-MAG-IF-00006.

5.1.2.3.3 Private Service 207: Science Control Private TC

5.1.2.3.3.1 Science: Change Measurement Rate

Telecommand Packet Description								
Database mnemonic		ZME02701						
Database Description		MERMSetMeasurementRate						
Packet Function		Set magnetometer science data transfer rate of selected process and sensor as defined in 5.1.1.2.3						
Attributes		None						
Verification rule		None						
Valid modes		3,4,5,6,9,15						
Header Information								
Process ID		89			Packet Category		12	
Service		207			Packet Cargo Length		4 bytes	
Service Subtype		1			Packet Total Length		14 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0	0	-	1		ZeroPad1	-	-	-
	1	Enum	7	PME08005	PID	85-87 CMET6005TC	-	CMET6005TC
1		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
2	0	-	4		ZeroPad4	-	-	-
	4	UInt	4	PME02100	Measurement Rate	0-9 CMET6100TC	-	CMET6100TC
3		-	8		ZeroPadByte	-	-	-

Table 5-73: Change Measurement Rate TC

Reaction:

A Normal/Progress Report with EID 52054 is generated to report the mode change.

Notes:

All Rates are allowed in science and calibration. In calibration modes a data rate of 128 Hz is recommend for all calibration modes except NoCal, as lower rates may not provide useful results.

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 1, 0, received sensor ID] is generated.

Invalid rate selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 1, 1, received rate byte] is generated.

Invalid PID selected (other than 85-87): A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 1, 0, received pid] is generated.

5.1.2.3.3.2 Science: Change Calibration Mode

Telecommand Packet Description			
Database mnemonic	ZME02702		
Database Description	MERMSetCalibrationMode		
Packet Function	Set magnetometer calibration mode for selected sensor as defined in 5.1.1.2.3		
Attributes	None		
Verification rule	None		
Valid modes	9		
Header Information			
Process ID	89	Packet Category	12
Service	207	Packet Cargo Length	2 byte
Service Subtype	2	Packet Total Length	12 bytes

Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	-	4		ZeroPad4	-	-	-
	4	UInt	4	PME02101	Calibration Mode	0-8 CMET6101TC	-	CMET6101TC

Table 5-74: Change Calibration Mode TC

<u>Reaction:</u>

None (all data is available in science packets)

<u>Exceptions:</u>

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 2, 0, received sensor ID] is generated.

Invalid calibration mode: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 2, 1, received mode byte] is generated

Not in Calibration mode: A Telecommand Execution Failure Report TM 1,8, FID 51917 and parameters [207, 2, Instrument mode] is generated

5.1.2.3.3.3 Science: Change Compression

Telecommand Packet Description								
Database mnemonic			ZME02703					
Database Description			MERM Set Compression					
Packet Function			Enable/Disable Compression					
Attributes			None					
Verification rule			None					
Valid modes			3,4,5,6					
Header Information								
Process ID			89			Packet Category		12
Service			207			Packet Cargo Length		2 byte
Service Subtype			3			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0	0	-	1		ZeroPad1	-	-	-
	1	Enum	7	PME08005	PID	85-87 CMET6005 TC	-	CMET6005TC
1	0	-	5		Pad 5	-	-	-
	5	Bool	1	PME02105	EnableComp Dual	Full		CAAT0001TC
	6	Bool	1	PME02106	EnableComp 24Bit	Full		CAAT0001TC
	7	Bool	1	PME02102	Compression Enable	Full	-	CAAT0001TC

Table 5-75: Change Compression TC

Reaction:

None (data is available in science packets)

Exceptions:

Invalid PID selected (other than 85-87): A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 3, 0, received pid] is generated.

5.1.2.3.3.4 Science: Change Measurement Range

Telecommand Packet Description								
Database mnemonic			ZME02704					
Database Description			MERMSetMeasurementRange					
Packet Function			Set magnetometer measurement range (affects all data products)					
Attributes			None					
Verification rule			None					
Valid modes			3,4,5,6,9,15					
Header Information								
Process ID			89			Packet Category		12
Service			207			Packet Cargo Length		2 byte
Service Subtype			4			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02030	Sensor ID	0-2 CMET6030TC	-	CMET6030TC
1	0	-	4		ZeroPad4	-	-	-
	4	UInt	4	PME02103	Measurement Range	0-9 CMET6103TC	-	CMET6103TC

Table 5-76: Change Measurement Range TC

Reaction:

None (all data is available in science packets)

Exceptions:

Invalid sensor selected: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 4, 0, received sensor ID] is generated.

Invalid range: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 4, 1, received range value] is generated

5.1.2.3.3.5 Science: Change Instrument Mode

Telecommand Packet Description								
Database mnemonic		ZME02705						
Database Description		MERM Set Instr Sci Mode						
Packet Function		Set magnetometer instrument mode to one of the science or calibration modes						
Attributes		Mode Changing						
Verification rule		None						
Valid modes		3,4,5,6,7,9						
Header Information								
Process ID		89			Packet Category		12	
Service		207			Packet Cargo Length		2 byte	
Service Subtype		5			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02104	New Science Mode	3-6; 9 CMET6000TC	-	CMET6000TC
1		-	8		ZeroPadByte	-	-	-

Table 5-77: Change Instrument Mode TC

<u>Reaction:</u>

None (all data is available in science packets)

<u>Exceptions:</u>

Invalid mode selected (other than 3,4,5,6,9): A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [207, 5, 0, received mode] is generated.

5.1.2.3.4 Private Service 208: Surveillance and Error Recovery Private TC

5.1.2.3.4.1 Surveillance Limit Change

Telecommand Packet Description								
Database mnemonic		ZME02801						
Database Description		MERMSurveillLimitChange						
Packet Function		Change limits for anomaly triggers and recovery actions Each surveillance and recovery measure can be disabled by setting the limit to a predefined value as defined in the table below.						
Attributes		None						
Verification rule		None						
Valid modes		3,4,5,6,7,9						
Header Information								
Process ID		89			Packet Category		12	
Service		208			Packet Cargo Length		6 bytes	
Service Subtype		1			Packet Total Length		16 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	8	PME02150	Surveillance Param ID	0-75 CMET6150TC	-	CMET6150TC
1		-	8		ZeroPadByte	-	-	-
2		UInt	32	PME02151	Surveillance Param Value	-	-	-

Table 5-78: Surveillance Limit Change TC

<u>Reaction:</u>

A Normal/Progress Report TM 5,1, EID 52400 is generated.

<u>Exceptions:</u>

Invalid parameter: A Telecommand Execution Failure Report TM 1,8, FID 5 and parameters [208, 1, 1, received SurveillanceparamID] is generated.

Invalid parameter value: A Telecommand Execution Failure Report TM 1,8, with FID 52005 and parameters [received SurveillanceparamID, received SurveillanceparamVal] is generated

Parameter Interpretation:

All Parameters are masked to their data type (e.g. a Boolean is masked with 0x01)

Parameter Identifiers:

Parameter Identifier Enum8	TC Parameter Name	TM parameter name	Disable Value	Type	Description
0	OBSensTemp1HL	OBSensTemp1HL	0	UInt16	Sensor temperature hard limit, enforced by sensor. All heating commands (including autoheating) are ignored if these temperatures are exceeded.
1	OBSensTemp2HL	OBSensTemp2HL			
2	IBSensTemp1HL	IBSensTemp1HL			
3	IBSensTemp2HL	IBSensTemp2HL			
4	HWWatchdogTOVal	HWWdogTOVal	0	UInt32	Timeout for watchdog unit 1=15µsec
5	SWWatchdogTOVal	SWWdogTOVal			
6	OBSensCommErrEn	OBSensCommErrE	0	Bool	Enable sensor communication error messages
7	IBSensCommErrEn	IBSenscommErrE			
8	OBSensCmdErrEnable	OBSensCmdErrEn	0		Enable sensor command error messages
9	IBSensCmdErrEnable	IBSensCmdErrEn	0		
10	SensAsyncErrEnable	SensAsyncErrEn	0		Enable sensor synchronization error messages
11	RequestPoweroffEn	RequestPowerOE	0		Global switch to enable request power off via event YME51817 on exceedance of HK limits
12	Mem EDAC Enable	Mem EDAC En	0		Enable Memory EDAC error messages
13	EDACUncorrTresh	EDACUncorrTreh	0	UInt16	Treshold for number of errors until reporting
14	EDACCorrTresh	EDACCorrTreh			
15	RuntimeTrapErrEn	RuntimeTrapErE	0	Bool	Enable Runtime Trap messages
16	GlobalHKSurvEn	GlobalHKSurvEn	0		Global enable switch for all HK surveillance (Parameters 20 to 75)
17	HKLimitCount	HKLimitCount	-	UInt8	count for number of limit violations to trigger an error message
18	SensErrRepeat	SensErrRepeat	-	UInt32	Global error message repetition timeout for sensor related errors unit 1 = 1/19200 sec
19	ICUErrRepeat	ICUErrRepeat	-	UInt32	Global error message repetition timeout for all other errors unit 1 = 1/19200 sec
20	OB P8VU lower	OB P8VU low	0xFFFF	UInt16	OB Sensor +8V voltage lower limit
21	OB P8VU upper	OB P8VU high	0xFFFF	UInt16	OB Sensor +8V voltage upper limit
22	OB P8VI lower	OB P8VI low	0x8000	Int16	OB Sensor +8V current lower limit
23	OB P8VI upper	OB P8VI high	0x8000	Int16	OB Sensor +8V current upper limit
24	OB N8VU lower	OB N8VU low	0xFFFF	UInt16	OB Sensor -8V voltage lower limit
25	OB N8VU upper	OB N8VU high	0xFFFF	UInt16	OB Sensor -8V voltage upper limit
26	OB N8VI lower	OB N8VI low	0x8000	Int16	OB Sensor -8V current lower limit
27	OB N8VI upper	OB N8VI high	0x8000	Int16	OB Sensor -8V current upper limit
28	OB P5VU lower	OB P5VU low	0xFFFF	UInt16	OB Sensor +5V voltage lower limit
29	OB P5VU upper	OB P5VU high	0xFFFF	UInt16	OB Sensor +5V voltage upper limit
30	OB P5VI lower	OB P5VI low	0x8000	Int16	OB Sensor +5V current lower limit
31	OB P5VI upper	OB P5VI high	0x8000	Int16	OB Sensor +5V current upper limit
32	OB P3V3U lower	OB P3V3U low	0xFFFF	UInt16	OB Sensor +3.3V voltage lower limit
33	OB P3V3U upper	OB P3V3U high	0xFFFF	UInt16	OB Sensor +3.3V voltage upper limit

34	OB P1V8U lower	OB P1V8U low	0xFFFF	UInt16	OB Sensor +1.8V voltage lower limit
35	OB P1V8U upper	OB P1V8U high	0xFFFF	UInt16	OB Sensor +1.8V voltage upper limit
36	OB P2V5U lower	OB P2V5U low	0xFFFF	UInt16	OB Sensor +2.5V voltage lower limit
37	OB P2V5U upper	OB P2V5U high	0xFFFF	UInt16	OB Sensor +2.5V voltage upper limit
38	OB P2V5I lower	OB P2V5I low	0x8000	Int16	OB Sensor +2.5V current lower limit
39	OB P2V5I upper	OB P2V5I high	0x8000	Int16	OB Sensor +2.5V current upper limit
40	OB SensTemp1 low	OB SensT1 low	0xFFFF	UInt16	OB Sensor Sensor temp 1 lower limit
41	OB SensTemp1 upp	OB SensT1 high	0xFFFF	UInt16	OB Sensor Sensor temp 1 upper limit
42	OB SensTemp2 low	OB SensT2 low	0xFFFF	UInt16	OB Sensor Sensor temp 2 lower limit
43	OB SensTemp2 upp	OB SensT2 high	0xFFFF	UInt16	OB Sensor Sensor temp 2 upper limit
44	OB ElecTemp low	OB ElecT low	0xFFFF	UInt16	OB Sensor Electronics temp lower limit
45	OB ElecTemp upp	OB ElecT high	0xFFFF	UInt16	OB Sensor Electronics temp upper limit
46	OB HeaterStatic	OB HeaterStat	0x8000	Int16	OB Sensor -8V Heater static current
47	OB HeaterDynamic	OB HeaterDyn	0x8000	Int16	OB Sensor -8V Heater dynamic current
48	IB P8VU lower	IB P8VU low	0xFFFF	UInt16	IB Sensor +8V voltage lower limit
49	IB P8VU upper	IB P8VU high	0xFFFF	UInt16	IB Sensor +8V voltage upper limit
50	IB P8VI lower	IB P8VI low	0x8000	Int16	IB Sensor +8V current lower limit
51	IB P8VI upper	IB P8VI high	0x8000	Int16	IB Sensor +8V current upper limit
52	IB N8VU lower	IB N8VU low	0xFFFF	UInt16	IB Sensor -8V voltage lower limit
53	IB N8VU upper	IB N8VU high	0xFFFF	UInt16	IB Sensor -8V voltage upper limit
54	IB N8VI lower	IB N8VI low	0x8000	Int16	IB Sensor -8V current lower limit
55	IB N8VI upper	IB N8VI high	0x8000	Int16	IB Sensor -8V current upper limit
56	IB P5VU lower	IB P5VU low	0xFFFF	UInt16	IB Sensor +5V voltage lower limit
57	IB P5VU upper	IB P5VU high	0xFFFF	UInt16	IB Sensor +5V voltage upper limit
58	IB P5VI lower	IB P5VI low	0x8000	Int16	IB Sensor +5V current lower limit
59	IB P5VI upper	IB P5VI high	0x8000	Int16	IB Sensor +5V current upper limit
60	IB P3V3U lower	IB P3V3U low	0xFFFF	UInt16	IB Sensor +3.3V voltage lower limit
61	IB P3V3U upper	IB P3V3U high	0xFFFF	UInt16	IB Sensor +3.3V voltage upper limit
62	IB P1V8U lower	IB P1V8U low	0xFFFF	UInt16	IB Sensor +1.8V voltage lower limit
63	IB P1V8U upper	IB P1V8U high	0xFFFF	UInt16	IB Sensor +1.8V voltage upper limit
64	IB P2V5U lower	IB P2V5U low	0xFFFF	UInt16	IB Sensor +2.5V voltage lower limit
65	IB P2V5U upper	IB P2V5U high	0xFFFF	UInt16	IB Sensor +2.5V voltage upper limit
66	IB P2V5I lower	IB P2V5I low	0x8000	Int16	IB Sensor +2.5V current lower limit
67	IB P2V5I upper	IB P2V5I high	0x8000	Int16	IB Sensor +2.5V current upper limit
68	IB SensTemp1 low	IB SensT1 low	0xFFFF	UInt16	IB Sensor Sensor temp 1 lower limit
69	IB SensTemp1 upp	IB SensT1 high	0xFFFF	UInt16	IB Sensor Sensor temp 1 upper limit
70	IB SensTemp2 low	IB SensT2 low	0xFFFF	UInt16	IB Sensor Sensor temp 2 lower limit
71	IB SensTemp2 upp	IB SensT2 high	0xFFFF	UInt16	IB Sensor Sensor temp 2 upper limit
72	IB ElecTemp low	IB ElecT low	0xFFFF	UInt16	IB Sensor Electronics temp lower limit
73	IB ElecTemp upp	IB ElecT high	0xFFFF	UInt16	IB Sensor Electronics temp upper limit
74	IB HeaterStatic	IB HeaterStat	0x8000	Int16	IB Sensor -8V Heater static current
75	IB HeaterDynamic	IB HeaterDyn	0x8000	Int16	IB Sensor -8V Heater dynamic current

Others	Spare/Invalid				

Table 5-79: Surveillance Limit Parameter IDs

5.1.2.3.4.2 Software Reset

Telecommand Packet Description			
Database mnemonic	ZME02802		
Database Description	MERM Reset		
Packet Function	Reboot the instrument. If an EEPROM write is in progress, the command will be delayed to prevent a premature reboot. To enforce a reboot in this case, the instrument has to be power cycled. A lockup in this state would be detected using the hardware watchdog. Command is not available in RAM boot mode (as spacewire is reinitialized there)		
Attributes	Mode changing		
Verification rule	None		
Valid modes	All except 0,2 and 14		
Header Information			
Process ID	89	Packet Category	12
Service	208	Packet Cargo Length	0
Service Subtype	2	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-80: Software Reset TC

Exceptions:

No specials

5.1.2.3.5 Private Service 209: Boot and Maintenance Private TC

5.1.2.3.5.1 Compare Software Checksum

Telecommand Packet Description								
Database mnemonic		ZME02901						
Database Description		MERMCompareSWChecksum						
Packet Function		Compare Checksums of program in selected memory against the one stored in the checksum area of this memory						
Attributes		None						
Verification rule		None						
Valid modes		1,7						
Header Information								
Process ID		89			Packet Category		12	
Service		209			Packet Cargo Length		2 bytes	
Service Subtype		1			Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	16	PME06064	Memory ID Compare	190-194;199 VME06064	-	CMET6060TC

Table 5-81: Compare Software Checksum TC

Reaction:

In case of differences a Error/Anomaly Report TM 5,2, FID 52023 is generated,

otherwise a Normal/Progress Report TM 5,1, EID 52022.

Parameters are [Received Memory ID, expected checksum computed checksum].

Exceptions:

Invalid memory ID or memory ID not selectable: A Telecommand Execution Failure Report TM 1,8, FID 52000 is generated

5.1.2.3.5.2 Manual Boot Select

<table>
<tr><td colspan="9">Telecommand Packet Description</td></tr>
<tr><td colspan="3">Database mnemonic</td><td colspan="6">ZME02902</td></tr>
<tr><td colspan="3">Database Description</td><td colspan="6">MERMManualBootSelect</td></tr>
<tr><td colspan="3">Packet Function</td><td colspan="6">Boots selected Software.</td></tr>
<tr><td colspan="3">Attributes</td><td colspan="6">Mode changing</td></tr>
<tr><td colspan="3">Verification rule</td><td colspan="6">None</td></tr>
<tr><td colspan="3">Valid modes</td><td colspan="6">1,2</td></tr>
<tr><td colspan="9">Header Information</td></tr>
<tr><td colspan="3">Process ID</td><td colspan="3">89</td><td colspan="2">Packet Category</td><td>12</td></tr>
<tr><td colspan="3">Service</td><td colspan="3">209</td><td colspan="2">Packet Cargo Length</td><td>2 bytes</td></tr>
<tr><td colspan="3">Service Subtype</td><td colspan="3">2</td><td colspan="2">Packet Total Length</td><td>12 bytes</td></tr>
<tr><td colspan="9">Data Field Information (Application Data)</td></tr>
<tr><td colspan="2">Offset</td><td rowspan="2">Format</td><td>Size</td><td colspan="5">Database</td></tr>
<tr><td>[Byte]</td><td>[Bit]</td><td>[Bit]</td><td>Mnemonic</td><td>Description</td><td>Range</td><td>Default</td><td>Calibration</td></tr>
<tr><td>0</td><td></td><td>Enum</td><td>16</td><td>PME06063</td><td>Memory ID Boot</td><td>191-195 VME06063</td><td>-</td><td>CMET6060TC</td></tr>
</table>

Table 5-82: Manual Boot Select TC

Reaction:

If the software can be executed, a Normal/Progress Report TM 5,1, EID 52054 is generated to report the mode change (to RAM boot or backup science mode).

Exceptions:

Invalid memory ID or memory ID not selectable: A Telecommand Execution Failure Report TM 1,8, FID 52000 is generated

Software checksum of selected software is invalid: A Telecommand Execution Failure Report TM 1,8, FID 52009 and an Error Event Report TM 5,2, FID 52021 and parameters [209, 2, received MEMID, expected checksum, computed checksum] are generated.

5.1.2.3.5.3 Override Boot Select

Telecommand Packet Description	
Database mnemonic	ZME02903
Database Description	MERMOverrideBootSelect
Packet Function	Boots selected Software, ignores checksum errors
Attributes	Mode changing
Verification rule	None
Valid modes	1,2

Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	2 bytes
Service Subtype	3	Packet Total Length	12 bytes

Data Field Information (Application Data)									
Offset		Format	Size	Database					
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration	
0		Enum	16	PME06063	Memory ID Boot	191-195 VME06063	-	CMET6060TC	

Table 5-83: Override Boot Select TC

Reaction:

A Normal/Progress Report (5.1.2.2.4.1) with EID 52054 is generated to report the mode change (to RAM boot or backup science mode).

Exceptions:

Invalid memory ID or memory ID not selectable: A Telecommand Execution Failure Report TM 1,8, with FID 52000 is generated

Software checksum of selected software is invalid: An Error/Anomaly Report TM 5,2, FID 52021 and parameters [209, 3, received MEMID, expected checksum, computed checksum] is generated, but the software is executed nevertheless.

5.1.2.3.5.4 Memory Fill

Telecommand Packet Description			
Database mnemonic	ZME02904		
Database Description	MERM Memory Fill		
Packet Function	Fills external RAM area with 1's or 0's to check for stuck bits. RAM area can be dumped using 5.1.2.2.5.2 or checked using 5.1.2.2.5.4 To be able to boot RAM software afterwards, boot software 2 (repeat RAM copy and execute RAM) has to be selected		
Attributes	None		
Verification rule	None		
Valid modes	1		
Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	2 bytes
Service Subtype	4	Packet Total Length	12 bytes

Data Field Information (Application Data)

Offset [Byte]	Offset [Bit]	Format	Size [Bit]	Database Mnemonic	Description	Range	Default	Calibration
0	0	-	7		ZeroPad7	-	-	-
	7	Bool	1	PME02161	Memory Fill Value	Full	-	-
1		-	8		ZeroPadByte	-	-	-

Table 5-84: Memory Fill TC

Exceptions:

No Specials

5.1.2.3.5.5 Enable Boot Maintenance Mode

Telecommand Packet Description			
Database mnemonic	ZME02905		
Database Description	MERMEnableBootMainten		
Packet Function	Change Mode to Boot Maintenance to allow for maintenance operations. Boot Maintenance is left using manual or override boot select (5.1.2.3.5.2 or 5.1.2.3.5.3)		
Attributes	Mode changing		
Verification rule	None		
Valid modes	1		
Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	0
Service Subtype	5	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-85: Enable Boot Maintenance Mode TC

Reactions:

A Normal/Progress Report TM 5,1, EID 52054 is generated to report the mode change.

Exceptions:

No Specials

5.1.2.3.5.6 Enable Operational Maintenance Mode

Telecommand Packet Description			
Database mnemonic	ZME02906		
Database Description	MERMEnableMaintenance		
Packet Function	Change Mode to operational maintenance mode to allow for maintenance operations. Science and housekeeping processing is stopped. Maintenance is left using Science: Switch Science Mode (5.1.2.3.3.1)		
Attributes	Mode changing		
Verification rule	None		
Valid modes	3,4,5,6,9		
Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	0
Service Subtype	6	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-86: Enable Operational Maintenance Mode TC

Explanation:

This command switches to operational maintenance. To reserve space for maintenance operation, the complete output buffer for science data is flushed, i.e. packets that were already assigned a sequence counter may get lost, resulting in a sequence counter gap. Since software maintenance operation will typically be followed by an instrument reboot, this should not occur during regular operation. (This behavior was accepted by ESOC).

Reactions:

A Normal/Progress Report TM 5,1, EID 52054 is generated to report the mode change.

Exceptions:

No Specials

5.1.2.3.5.7 Write RAM Software to EEPROM

Telecommand Packet Description								
Database mnemonic			ZME02907					
Database Description			MERMWriteToEEPROM					
Packet Function			Writes the software from Start address to Memory ID, start address has to be inside memid 195, switches to mode 8 and returns to mode 2 after write success/error.					
Attributes			Mode changing, writes to memory, recoverable function degradation possible					
Verification rule			none					
Valid modes			1,7					
Header Information								
Process ID			89			Packet Category		12
Service			209			Packet Cargo Length		2
Service Subtype			7			Packet Total Length		12 bytes
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		Enum	16	PME06071	Memory ID EEPROM	191-194 VME06071	-	CMET6060TC
2		-	16		ZeroPad16	-	-	-
4		UInt	32	PME06065	Start Address	-	-	-

Table 5-87: Write RAM Software to EEPROM TC

Explanation:

This software writes a complete 128kByte software image placed in memory (using ZME00602) at the given start address from this memory to the EEPROM. This image is provided by MERMAG as one complete file.

Reaction:

The software at start address is checked, errors or success is reported using (5,1, EID 51802 or 5,2 51803). A Normal/Progress Report (5,1, EID 52054 is generated to report mode change to EEPROM write. After writing another report (5,1, EID 52054) is generated to report change back to maintenance. The written software is checked and a report (5,1, EID 51802 or 51803) is generated.

Exceptions:

No Specials

5.1.2.3.5.8 Provide EEPROM Keys

Telecommand Packet Description								
Database mnemonic		ZME02908						
Database Description		MERMProvideEEPROMKey						
Packet Function		Provide unlock keys for eeprom writing						
Attributes		None						
Verification rule		None						
Valid modes		1,7						
Header Information								
Process ID		89			Packet Category		12	
Service		209			Packet Cargo Length		16 bytes	
Service Subtype		8			Packet Total Length		26 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		UInt	32	PME06080	Key Address 1	Full	0x00005555	-
4		UInt	32	PME06081	Key Address 2	Full	0x00002AAA	-
8		UInt	32	PME06082	Key Address 3	Full	0x00005555	-
12		UInt	8	PME06083	Key 1	Full	0xAA	-
13		UInt	8	PME06084	Key 2	Full	0x55	-
14		UInt	8	PME06085	Key 3	Full	0xA0	-
15		-	8		ZeroPadByte	-	-	-

Table 5-88: Provide EEPROM Keys TC

Reaction:

In case the sent key is invalid, EEPROM writing will not work. The key is not stored onboard to prevent accidental overwriting. The provided default key addresses and values are the unlock key for the EEPROM. If other values are used, EEPROM writing will not take place and writing will just be simulated.

Exceptions:

No Specials

5.1.2.3.5.9 Revoke EEPROM Keys

Telecommand Packet Description			
Database mnemonic	ZME02909		
Database Description	MERMRevokeEEPROMKey		
Packet Function	Revoke unlock keys for eeprom writing		
Attributes	None		
Verification rule	None		
Valid modes	1, 7		
Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	0 bytes
Service Subtype	9	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-89: Revoke EEPROM Keys TC

Reaction:

None

Exceptions:

No Specials

5.1.2.3.5.10 Execute Memory Address

Telecommand Packet Description								
Database Mnenmonic		ZME02910						
Database Description		MERM Execute Address						
Packet Function		Execute contained memory address						
Attributes		None						
Verification rule		None						
Valid modes		1						
Header Information								
Process ID		89			Packet Category		12	
Service		209			Packet Cargo Length		4 bytes	
Service Subtype		10			Packet Total Length		14 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		UInt	32	PME06070	Execution Address	Full	-	-

Table 5-90: Execute Memory Address TC

Reaction:

None

Exceptions:

No Specials

5.1.2.3.5.11 Execute Backup Science Mode

Telecommand Packet Description			
Database mnemonic	ZME02911		
Database Description	MERM BackUp Sci Mode		
Packet Function	Execute Backup Science Mode		
Attributes	None		
Verification rule	None		
Valid modes	0,1		
Header Information			
Process ID	89	Packet Category	12
Service	209	Packet Cargo Length	0 bytes
Service Subtype	11	Packet Total Length	10 bytes
Data Field Information (Application Data)			
none			

Table 5-91: Execute Backup Science Mode TC

<u>Reaction:</u>

A Normal/Progress Report TM 5,1, EID 52054 is generated to report the mode change (to RAM boot or backup science mode). No execution acknowledge is sent.

<u>Exceptions:</u>

No Specials

5.1.2.3.5.12 Set Spacewire RX Timeout

Telecommand Packet Description								
Database mnemonic			ZME02912					
Database Description			MERMSetSpwRxTimeout					
Packet Function			Change the time window size that is used for receiving TC. After this time window an automatic buffer swap will happen that will block TC reception for a few microseconds.					
Attributes			None					
Verification rule			None					
Valid modes			3,4,5,6,7,9					
Header Information								
Process ID			89		Packet Category		12	
Service			209		Packet Cargo Length		2 byte	
Service Subtype			12		Packet Total Length		12 bytes	
Data Field Information (Application Data)								
Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		UInt	8	PME06086	Spw Rx Timeout	full	24	none
1		-	8		ZeroPadByte	-	-	-

Table 5-92: Change Instrument Mode TC

<u>Explanation:</u>

<u>Spacewire reception is handled using DMA buffering. The used buffers need to be swapped before TCs can start or before a buffer becomes full. This swapping causes a small gap in spacewire reception and TC might get lost (this is an architectural restriction of the used processor). As the</u>

number of TC received within a 125 ms cycle of the OBC is unknown and also timing information is limited, the length of the open window (waiting for additional TC to arrive within this cycle) is programmable. At the end of the cycle this information is swapped. The commanded value is the number of milliseconds (exact: 1.041ms) to wait after reception of a TC before swapping the buffer.

Reaction:

None. Please note that this TC was not foreseen in PROM software and illegal usage in Modes 0 and 1 will therefore cause an illegal subtype error event rather than "not excecutable now".

Exceptions:

None

5.1.2.3.6 Calibration

	Value	Alias
CAAT0001TC CAAT0001TM Generic On/Off	0	Off
	1	On
CMET6000TC CMET6000TM Instrument Mode	0	ROMBoot
	1	BootMaint
	2	BootingRAM
	3	ScienceX
	4	ScienceKa
	5	SelectScience
	6	ScienceStandby
	7	OpMaint
	8	EEPROMWrite
	9	CalScience
	15	BackupScience
CMET6005TC PID	85	ScienceX
	86	ScienceKa
	87	ScienceSel
CMET6030TC CMET6030TM Sensor ID	0	MAGOB
	1	MAGIB
	2	BothSensors
CMET6060TM CMET6060TC Memory ID	190	PROM
	191	EEPROM0
	192	EEPROM1
	193	EEPROM2
	194	EEPROM3
	195	BootImage
	196	EXRAM
	197	IRAM
	198	All
	199	BackupSci
CMET6100TC CMET6100TM Measurement Rate	0	0
	1	0.5
	2	1
	3	2
	4	4
	5	8
	6	16
	7	32
	8	64
	9	128
CMET6101TM CMET6101TC Calibration Mode	0	Norm
	1	Cal1Step
	2	Cal2Count
	3	Cal3ADAC
	4	Cal4OL

	5	Cal5Meander
	6	Cal6MeanderC
	7	Cal7Findphase
	8	Cal8FindphaseC
CMET6103TC CMET6103TM Measurement Range	0	2048
	1	1024
	2	0512
	3	0256
	4	0128
	5	0064
	6	0032
	7	0016
	8	0008
	9	0008Dummy
CMET6150TC CMET6150TM Surveillance Parameter ID		See Service ZME02801
CMET6151TC CMET6151TM SensPEO	0	Even
	1	Odd
CMET0003TM Nominal_Redundant	0	Nominal
	1	Redundant
CMET6152TM CMET6152TC Int / Ext Sensor Clock	0	Ext
	1	Int
CMET6153TM Sensor Calibration Bits	0	Standard
	1	OpenLoop
	2	ADAC
	3	Step
CMEP6200TM to CMEP6224TM CMEP6226TM CMEP6227TM CMEP6200TC CMEP6214TC Sensor Housekeeping	Sensor Housekeeping Calibrations, calibration varies with model See BC-MAG-TN-00011	
CMET6154TM Sensor Electronics ID	0-7	0-7
CMET6180TM ErrorState	0	Normal
	1	Error
CMET6153TC Sensor Cmd ID	0	ConfigRegister
	1	Phase
	2	Samples
	3	K1X
	4	K1Y
	5	K1Z
	6	K2X
	7	K2Y
	8	K2Z
	9	FBDacX
	10	FBDacY
	11	FBdacZ
	12	CompDacX
	13	CompDacY
	14	CompDacZ
	15	Internal FB
	16	HeaterVal
	17	Temp1Limit
	18	Temp2Limit
	19	SWSync
CMET6104TM ScienceStructureID	0	ScienceOB
	1	ScienceIB
	2	ScienceCalOB
	3	ScienceCalIB
	4	ScienceCompOB
	5	ScienceCompIB
	6	ScienceCompDua

	7	ScienceSpectOB
	8	ScienceSpectIB
CMET6153TC Sensor Cmd ID	0	ConfigRegister
	1	Phase
	2	Samples
	3	K1X
	4	K1Y
	5	K1Z
	6	K2X
	7	K2Y
	8	K2Z
	9	FBDacX
	10	FBDacY
	11	FBDacZ
	12	CompDacX
	13	CompDacY
	14	CompDacZ
	15	Internal FB
	16	HeaterVal
	17	Temp1Limit
	18	Temp2Limit
	19	SWSync
CMET6113TM HKSurvChannels	0	P8VU
	1	P8VI
	2	N8VU
	3	N8VI
	4	P5VU
	5	P5VI
	6	P3V3U
	7	P1V8U
	8	P2V5U
	9	P2V5I
	10	SensTemp1
	11	SensTemp2
	12	ElecTemp
	13	HeaterDynI
	14	TempHardL
CMET6184TM SensorStateMachine	0	OFF
	1	ErrorOff
	2	WiatFirstHK
	3	InitReady
	4	Init1
	5	Init2
	6	SoftSyncWait
	7	SoftSyncReady
	8	Running

Table 5-93: Calibrations

5.1.2.4 On-board offered services

5.1.2.4.1 Parameter Extraction

5.1.2.4.1.1 Housekeeping Packets

Not Applicable, as no onboard magnetic field data distribution is requires (see service 20).

5.1.2.4.1.2 Events

Several event messages are required for OBCP control. Only the EID of these messages is relevant for control.

5.1.2.4.2 Service 12: On-Board Monitoring

Beyond power consumption, the MERMAG primary current shall be monitored by the spacecraft.

The MERMAG PSU contains a trip-off for over-current situations. The MERMAG nominal operating current is between 150 mA and 200 mA, the trip-off value is at about 400mA. Herewith both current limiters (LCL and MERMAG PSU) cannot become active at the same time. The primary supply current in tripped condition is below 10 mA. Because there is no specific indication that the MERMAG PSU has tripped, we request monitoring of the primary current. The current monitoring should start 10 seconds after the instrument is powered up.

If a PSU trip-off is detected, MERMAG should be switched off autonomously via service 12/19. To reduce science data outage to a minimum,. MERMAG should be switched back ON at the next ground contact after PI was analyzing available data before the event to understand what led to the abnormal power consumption and concluding that it is safe to perform the switch ON.

Parameter	Lower Limit [mA]	Upper Limit [mA]	Filter value / Occurances	Recovery action
NPWU2404 (MERMAG-A ON-CT)	20	500	5	Switch the instrument OFF
NPWU2806 (MERMAG-B ON-CT)	20	500	5	Switch the instrument OFF

Table 5-94: MERMAG supply current monitoring parameters

5.1.2.4.3 Service 18: OBCP Management

5.1.2.4.3.1 Boot OBCP

Command

BootObcpCommand(BootType,MemID)

Parameters

Offset		Format	Size	Database				
[Byte]	[Bit]		[Bit]	Mnemonic	Description	Range	Default	Calibration
0		UInt	8		Boot Type	0-3	0	-

1		Enum	16	PME06063	Memory ID Boot	191-195 VME06063	191	CMET6060TC

Table 5-95: Boot OBCP Command

Flow

- Power on Instrument
- Wait for ROM boot success message; a Normal/Progress Report (see 5.1.2.2.4.1) with EID 52050 or an Error/Anomaly Report (see 5.1.2.2.4.2) with FID 52053. Time update is handled via event/action service
- Dependant on value of BootType
  - Normal Boot (0)
    - Continue to next step
  - Selected Boot (1)
    - Software Manual Boot Select (see 5.1.2.3.5.2) with Parameter MemID (within 63 seconds)
  - Override Boot (2)
    - Software Override Boot Select (see 5.1.2.3.5.3) with Parameter MemID (within 63 seconds)
  - Maintenance (3)
    - Enable Boot Maintenance Mode (see 5.1.2.3.5.5)
    - Wait 1 second for mode change to complete
    - quit
- Wait for RAM boot success message; a Normal/Progress Report (see 5.1.2.2.4.1) with EID 52051 or Backup science boot success message; a Normal/Progress Report (see 5.1.2.2.4.1) with EID 52052

Errors:

Timeout 1: If no message is received within 24 seconds, the instrument shall be powered off, all received messages shall be forwarded to ground and the OBCP shall be left in error state. All further commands on the mission time line shall be disabled.

Timeout 2: If no message is received within 96 seconds, the instrument shall be powered off, all received messages shall be forwarded to ground and the OBCP shall be left in error state. All further commands on the mission time line shall be disabled.

Explanation:

The instrument automatically boots the ROM software and reports errors if possible. In case no message is received within timeout 1, the instrument can be considered as defective and is powered off. The instrument will then boot its default (or first error free) software with an automatic timeout of 64 seconds. A manual boot can speed up this time (or change the selected software), since software is executed immediately in this case. In case of ROM boot errors or a defective software both manual and automatic boot will be rejected. In all these error cases no RAM boot or Backup boot success message is sent, so the instrument will then be powered off after timeout 2.

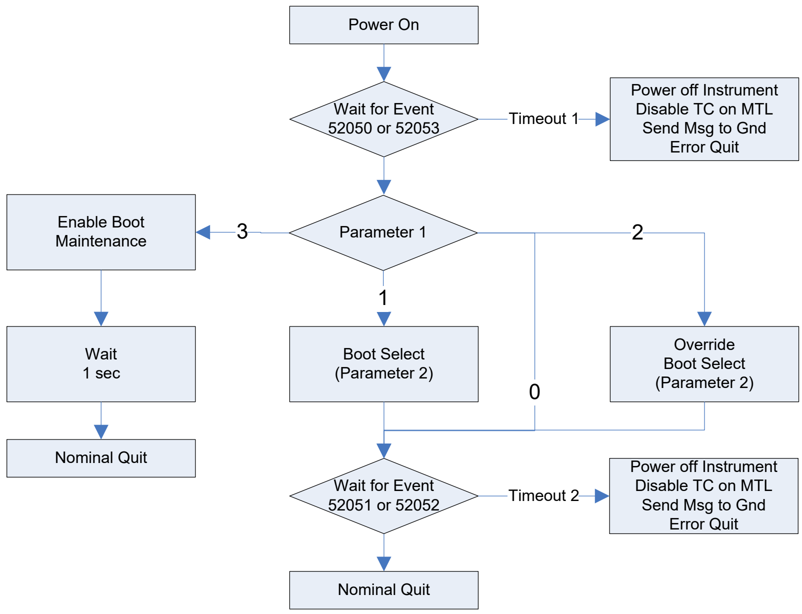


Figure 5-2: Boot OBCP

5.1.2.4.3.2 Nominal Poweroff OBCP

Poweroff is not desirable during EEPROM writing (software update) but will not cause permanent damage. Since software update is done under ground control, this should not happen anyway.

No other constraints

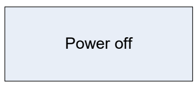


Figure 5-3: Poweroff OBCP

5.1.2.4.4 Service 19: Event Action Services

5.1.2.4.4.1 Time Sync Request

MERMAG request time synchronisation after all reboots. This is done to ensure time sync at the right moments during boot as well as to prevent unsynchronized time in case a reboot is triggered by the hardware watchdog. During normal operation a time sync is requested 1-2 times during a normal boot process. MERMAG expects to receive a time sync message within 5 seconds from when the time sync was requested. When time sync message is not received within this periode, the instrument continues with unsynchronized time until the next time sync is receivd.

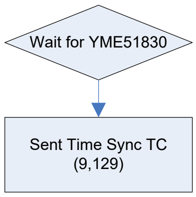


Figure 5-4: Time Sync Request

Database		EID	Event Subtype	Action			Condition
Mnemonic	Description	FID		mnemonic	description	parameters	
YME51830	MERM Request Time Sync	52057	4	ZME00929	MERM Accept Time update	OBT	Instrument is on.

5.1.2.4.4.2 Power off Request

On HK limit violation the instrument will request a power off if this is enabled in surveillance. This automatic action is only enabled in ScienceX, ScienceKa, ScienceSel and NoScience. Handling starts only 60 seconds after reaching one of this modes for the first time to allow disabling of this action after instrument boot. Upon reception of this message the instrument shall be switched off.

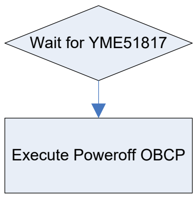


Figure 5-5: Request Poweroff

Database		EID	Event Subtype	Action			Condition
Mnemonic	Description	FID		mnemonic	description	parameters	
YME51817	MERM Request Poweroff	52503	4	OBCP	Power Off	none	Instrument is on.

5.1.2.4.5 Service 20: Information Distribution Offered

Not applicable.

MERMAG offers a HK packet (YME51008) with magnetic field data for onboard distribution to other instruments, but this packet is currently not used and therefore not added to service 20.

5.1.3 TM/TC Traffic Cases

5.1.3.1 TM Traffic

All values are dependent on the final strategy for selective downlink, which is still in discussion.
The given nominal scenario assumes a 16 Hz secondary sampling rate for nominal mode and a 64 Hz secondary sampling rate for peak operation.
In case compression is used (which is most likely the case) a data rate reduction of about 50% can be reached for science data.

5.1.3.1.1 Nominal Peak Scenario

Instrument Mode: Dual Science
Data Rate: 128 Hz for both sensors
Selective Product Rate 16 Hz
Temperature Housekeeping: 10 sec
Sensor Housekeeping: 64 sec
Compression: off

With selective downlink
Packet Rate: 2.6 / sec
Data Rate: 14370 bit/sec

Without selective downlink
Packet Rate: 2.3 / sec
Data Rate: 12750 bit/sec

5.1.3.1.2 Absolute Peak Scenario

Instrument Mode: Dual Science
Data Rate: 128 Hz for both sensors
Selective Product Rate 64 Hz
Temperature Housekeeping: 0.25 sec
Sensor Housekeeping: 0.25 sec
Compression: off

With selective downlink
Packet Rate: 18 / sec
Data Rate: 16850 bit/sec

Without selective downlink
Packet Rate: 19 / sec
Data Rate: 23200 bit/sec

5.1.3.1.3 TM Rate Overview

Sampling Rate	Rate [bps]					
	Normal Science		Selective data product		Calibration	
	Active Sensors		Active Sensors		Active Sensors	
	Single	Both	Single	Both	Single	Both
128	6352	12704	6352	12704	6384	12768
64	3176	6352	3176	6352	3192	6384
32	1588	3176	1588	3176	1596	3192
16	794	1588	794	1588	798	1596
8	397	794	397	794	399	798
4	198.5	397	198.5	397	199.5	399
2	99.25	198.5	99.25	198.5	99.75	199.5
1	49.625	99.25	49.625	99.25	49.875	99.75
0.5	24.8125	49.625	24.8125	49.625	24.9375	49.875

Table 5-96: TM Rate Overview Table

In case of selective Science mode both the normal science and the selective data product are generated with individually selected rates.

HK structure ID	Rate Multiplicator Bits @ 1Hz (1 sec)	Typical generation rate [sec]	Typical TM rate [bps]
1, 2	208	2 per 16 sec	26
3	272	1280	0.2125
4, 5	336	2 per 64 sec	10.5
6	336	Off	0
7	336	8192	0.041
8	272	1280	0.2125
9	1744	1800	0.969

Table 5-97: HK Rate Overview Table

5.1.3.2 TC Traffic

Due to its limited calculation power the controller can handle telecommands at a maximum speed of about 16000 bit/sec during normal science operation.

5.1.3.3 TM Generation Rate of Non-Science Packets

The only critical non-science TM generation in terms of data rate are the memory dump packets (YME51606).

The generation of these memory dump packet is unrestricted in Boot Maintenance (PROM software) and limited to a rate of one per 500ms in operational Maintenance (EEPROM SW).

This restriction is only applied for dumps of contiguous memory areas that exceed the size of one packet and are therefore dumped using multiple packets.

In case a longer dump is required in PROM mode, it has to be requested using multiple TC separated by enough time not to exceed the maximum desired non-science TM rate.

In case multiple memory dumps are requested via multiple TC, no restrictions are applied and packets are released at full rate, dependent on incoming TC speed.

5.1.4 Instrument requirements on Onboard Autonomy

None.

5.1.5 Reduced Power Mode

In reduced power mode only one sensor is operated, the other one is disabled using TC (206,17) activate/deactivate sensor. Most likely the inboard sensor will be deactivated, only in case the outboard sensor is disfunctional, this one will be deactivated. Generally this means that the science data rates are reduced to the one for single mode, also houskeeping will be available only for one sensor (only one of hk structure ID 1,2 and 4,5). In terms of power excitation and heating of one sensor is deactivated, see chapter 3.4.

5.1.6 Housekeeping Limits

Parameter (NAME)	***Name***	***Number of violations allowed (NBCHK)***	***Calibrated (C) / Uncalibrated(U) (INTER)***	***Limit Type (TYPE)***	***Unit***	***Lower Limit (LVALU) PFM***	***Upper Limit (HVALU) PFM***	***Lower Limit (LVALU) ETB***	***Upper Limit (HVALU) ETB***
NME02203	*OB +8 Voltage*	*3*	*C*	*H / Red*	*V*	*7*	*9*	*7*	*9*
NME02204	*OB +8 Current*	*3*	*C*	*H / Red*	*mA*	*50*	*120*	*0*	*120*
NME02205	*OB -8 Voltage*	*3*	*C*	*H / Red*	*V*	*-9*	*-7*	*-9*	*-7*
NME02206	*OB -8 Current*	*3*	*C*	*H / Red*	*mA*	*-140*	*-10*	*-145*	*18*
NME02212	*OB +5 Voltage*	*3*	*C*	*H / Red*	*V*	*4.5*	*5.5*	*4.5*	*5.8*
NME02213	*OB +5 Current*	*3*	*C*	*H / Red*	*mA*	*10*	*50*	*5*	*50*
NME02207	*OB +3.3 Voltage*	*3*	*C*	*H / Red*	*V*	*3*	*3.8*	*3*	*3.8*
NME02208	*OB +1.8 Voltage*	*3*	*C*	*H / Red*	*V*	*1.65*	*2.05*	*1.65*	*2.05*
NME02209	*OB +2.5 Voltage*	*3*	*C*	*H / Red*	*V*	*2.25*	*2.75*	*2.25*	*2.75*
NME02210	OB +2.5 Current	3	C	H / Red	mA	100	160	100	260
NME02217	IB +8 Voltage	3	C	H / Red	V	7	9	7	*9*

NME02218	IB +8 Current	3	C	H / Red	mA	50	120	*0*	*120*
NME02219	IB -8 Voltage	3	C	H / Red	V	-9	-7	*-9*	*-7*
NME02220	IB -8 Current	3	C	H / Red	mA	-140	-10	*-145*	*18*
NME02226	IB +5 Voltage	3	C	H / Red	V	4.5	5.5	*4.5*	*5.8*
NME02227	IB +5 Current	3	C	H / Red	mA	10	50	*5*	*50*
NME02221	IB +3.3 Voltage	3	C	H / Red	V	3	3.8	*3*	*3.8*
NME02222	IB +1.8 Voltage	3	C	H / Red	V	1.65	2.05	*1.65*	*2.05*
NME02223	IB +2.5 Voltage	3	C	H / Red	V	2.25	2.75	*2.25*	*2.75*
NME02224	IB +2.5 Current	3	C	H / Red	mA	100	160	100	260

Table 5-98: Housekeeping Limits

On triggering of any red limit the emergency off procedure should be executed and PI should be informed.
The limits for the ETB are delivered in a separate database ASCII file (ocp_ETB.dat).

5.1.7 Instrument Bugs and Features

BUG	NCR	Affected Models
On loss of Spacewire link the instrument fills a buffer with error messages (max. 9216 bytes or 490 packets). These packages are released as soon as the spacewire link is reconnected. The number of packets created is dependent on the duration of the disconnect. This only affects the fixed part of the software in PROM, which is deactivated during normal operation. The bug is fixed in the EEPROM software.	BC-MAG-NCR-00019 (FM) BC-MAG-NCR-00027 (EM)	FM PROM software EM PROM software
The instrument process 89 accepts commands from all source IDs and returns acceptance/acknowledge messages. Additionally the sequence counter for outgoing messages in direction of source ID ground is increased for each acceptance message. This only affects the fixed part of the software in PROM, which is deactivated during normal operation. The bug is fixed in the EEPROM software.	BC-MAG-NCR-00020 (FM) BC-MAG-NCR-00024 (EM)	FM PROM software EM PROM software
Housekeeeping SID 0 and 8 are accepted for enable/disable HK and HK set rate (TC (3,5), (3,6) and (3,129), so in this case no illegal parameter message is returned. This only affects the fixed part of the software in PROM, which is deactivated during normal operation. The bug is fixed in the EEPROM software.	BC-MAG-NCR-00021 (FM) BC-MAG-NCR-00025 (FM)	FM PROM software EM PROM software
In case a TC fails checks error messages (TM 1,2) and TM(1,8) are sent always, even if the acknowledge bits of the TC are not set. This only affects the fixed part of the	BC-MAG-NCR-00022 (FM) BC-MAG-NCR-00026 (FM)	FM PROM software EM PROM software

software in PROM, which is deactivated during normal operation. The bug is fixed in the EEPROM software.		

Table 5-99: Instrument Bugs and Features

5.1.8 Instrument Software Default Settings

Process 85 rate in Science X	4 Hz	
Process 86 rate in Science Ka	4 Hz	
Process 85 rate in ScienceSel	4 Hz	
Process 87 rate in ScienceSel	128Hz	
Compression	Disabled for all PIDs	
Dual Compression	Disabled for all PIDs	
24 bit compression	Disabled for all PIDs	

Table 5-100: Software Default Settings 1

NMED2075	OBSensor ICU Filtertype	0
NMED2078	OBSensAutoHeatEnable	OFF
NMED2076	OBSensAutoCompEnable	OFF
NMED2077	OBSensAutoRangeEnable	OFF
NMED2079	OBSens Clk used	EXT
NMED2080	OBSens Sync used	EXT
NMED2087	OBSens PEO	ON
NMED2073	OBSensFBRelayEnable	ON
NMED2081	OBSens Calibration Bits	Standard
NMED2074	OBSens ExcitationEnable	ON
NMED2082	OBSens Active State	ON
NME02050	OBSens K1 X ADC	40402 (FM, model dependent)
NME02051	OBSens K1 Y ADC	22671 (FM, model dependent)
NME02052	OBSens K1 Z ADC	55926 (FM, model dependent)
NME02053	OBSens K2 X DAC	32756 (FM, model dependent)
NME02054	OBSens K2 Y DAC	32378 (FM, model dependent)
NME02055	OBSens K2 Z DAC	32986 (FM, model dependent)
NME02071	OBSens Phase Val	146
NME02072	OBSens Samples Val	68
NME02070	OBSens Internal Feedback	102
NMED2091	IBSensor ICU Filtertype	0
NMED2094	IBSensAutoHeatEnable	OFF
NMED2092	IBSensAutoCompEnable	OFF
NMED2093	IBSensAutoRangeEnable	OFF
NMED2095	IBSens Clk used	EXT
NMED2096	IBSens Sync used	EXT
NMED2088	IBSens PEO	ON
NMED2089	IBSensFBRelayEnable	ON
NMED2097	IBSens Calibration Bits	Standard
NMED2090	IBSens ExcitationEnable	ON
NMED2098	IBSens Active State	ON
NME02056	IBSens K1 X ADC	24927 (FM, model dependent)
NME02057	IBSens K1 Y ADC	14331 (FM, model dependent)
NME02058	IBSens K1 Z ADC	56105 (FM, model dependent)
NME02059	IBSens K2 X DAC	32763 (FM, model dependent)
NME02060	IBSens K2 Y DAC	32383 (FM, model dependent)
NME02061	IBSens K2 Z DAC	32986 (FM, model dependent)
NME02074	IBSens Phase Val	146 (FM, model dependent)
NME02075	IBSens Samples	68 (FM, model dependent)
NME02073	IBSens Internal Feedback	102 (FM, model dependent)
NME02240	OBSensTemp1HLim	51650 (FM, model dependent)
NME02241	OBSensTemp2HLim	51663 (FM, model dependent)
NME02242	IBSensTemp1HLim	51557 (FM, model dependent)

NME02243	IBSensTemp2HLim	0 (FM, model dependent)
NME02244	HWWatchdogTimeout	614400
NME02245	SWWatchdogTimeout	19660800
NMED2280	OBSensCommErrEn	ON
NMED2281	IBSensCommErrEn	ON
NMED2282	OBSensCmdErrEn	ON
NMED2283	IBSensCmdErrEn	ON
NMED2284	SensAsyncErrEn	ON
NMED2285	RequestPoweroffEn	OFF
NMED2252	Mem EDAC Enable	OFF
NMED2253	RuntimeTrapErrEn	OFF
NMED2254	GlobalHKSurvEn	ON
NME02246	EDACUncorrTresh	0
NME02247	EDACCorrTresh	0
NME02250	HKLimitCount	3
NME02248	SensErrRepeat	1228800
NME02249	ICUErrRepeat	1228800
NME02350	OB P8VU lower	45956 (FM, model dependent)
NME02351	OB P8VU upper	59086 (FM, model dependent)
NME02352	OB P8VI lower	840 (FM, model dependent)
NME02353	OB P8VI upper	2012 (FM, model dependent)
NME02354	OB N8VU lower	35014 (FM, model dependent)
NME02355	OB N8VU upper	39391 (FM, model dependent)
NME02356	OB N8VI lower	-781 (FM, model dependent)
NME02357	OB N8VI upper	-37 (FM, model dependent)
NME02358	OB P5VU lower	45345 (FM, model dependent)
NME02359	OB P5VU upper	55422 (FM, model dependent)
NME02360	OB P5VI lower	260 (FM, model dependent)
NME02361	OB P5VI upper	1288 (FM, model dependent)
NME02362	OB P3V3U lower	39365 (FM, model dependent)
NME02363	OB P3V3U upper	49862 (FM, model dependent)
NME02364	OB P1V8U lower	21650 (FM, model dependent)
NME02365	OB P1V8U upper	26899 (FM, model dependent)
NME02366	OB P2V5U lower	29543 (FM, model dependent)
NME02367	OB P2V5U upper	36108 (FM, model dependent)
NME02368	OB P2V5I lower	1050 (FM, model dependent)
NME02369	OB P2V5I upper	1681 (FM, model dependent)
NME02370	OB SensTemp1 lower	0x80000000 (FM, model dependent)
NME02371	OB SensTemp1 upper	0x80000000 (FM, model dependent)
NME02372	OB SensTemp2 lower	0x80000000 (FM, model dependent)
NME02373	OB SensTemp2 upper	0x80000000 (FM, model dependent)
NME02374	OB ElecTemp lower	3355 (FM, model dependent)
NME02375	OB ElecTemp upper	53805 (FM, model dependent)
NME02376	OB HeaterStatic	0x80000000 (FM, model dependent)
NME02377	OB HeaterDynamic	0x80000000 (FM, model dependent)
NME02378	IB P8VU lower	45864 (FM, model dependent)
NME02379	IB P8VU upper	58968 (FM, model dependent)
NME02380	IB P8VI lower	839 (FM, model dependent)
NME02381	IB P8VI upper	2008 (FM, model dependent)
NME02382	IB N8VU lower	34944 (FM, model dependent)
NME02383	IB N8VU upper	39312 (FM, model dependent)
NME02384	IB N8VI lower	-766 (FM, model dependent)
NME02385	IB N8VI upper	-31 (FM, model dependent)
NME02386	IB P5VU lower	45255 (FM, model dependent)
NME02387	IB P5VU upper	55311 (FM, model dependent)
NME02388	IB P5VI lower	259 (FM, model dependent)
NME02389	IB P5VI upper	1285 (FM, model dependent)
NME02390	IB P3V3U lower	39286 (FM, model dependent)
NME02391	IB P3V3U upper	49762 (FM, model dependent)
NME02392	IB P1V8U lower	21607 (FM, model dependent)
NME02393	IB P1V8U upper	26845 (FM, model dependent)

NME02394	IB P2V5U lower	29484 (FM, model dependent)
NME02395	IB P2V5U upper	36036 (FM, model dependent)
NME02396	IB P2V5I lower	1048 (FM, model dependent)
NME02397	IB P2V5I upper	1677 (FM, model dependent)
NME02398	IB SensTemp1 lower	0x80000000 (FM, model dependent)
NME02399	IB SensTemp1 upper	0x80000000 (FM, model dependent)
NME02400	IB SensTemp2 lower	0x80000000 (FM, model dependent)
NME02401	IB SensTemp2 upper	0x80000000 (FM, model dependent)
NME02402	IB ElecTemp lower	3304 (FM, model dependent)
NME02403	IB ElecTemp upper	53823 (FM, model dependent)
NME02404	IB HeaterStatic	0x80000000 (FM, model dependent)
NME02405	IB HeaterDynamic	0x80000000 (FM, model dependent)
NME02079	OBHeatProportionalCoeff	0 (FM, model dependent)
NME02080	OBHeatIntegralCoeff	4096 (FM, model dependent)
NME02089	OBHeatDifferentialCoeff	0 (FM, model dependent)
NME02094	OBHeatTargetTemp	40000 (FM, model dependent)
NME02096	IBHeatProportionalCoeff	0 (FM, model dependent)
NME02097	IBHeatIntegralCoeff	4096 (FM, model dependent)
NME02098	IBHeatDifferentialCoeff	0 (FM, model dependent)
NME02095	IBHeaterTargetTemp	40000 (FM, model dependent)

Table 5-101: Software Default Settings 2

5.1.9 Data Compression Algorithm

The principles of the data compression algorithm have been published:

Fischer, D., Berghofer, G., Magnes, W. and Zhang, T.L.: A lossless compression method for data from a spaceborne magnetometer, IEEE, doi: 10.1109/CSNDSP.2008.4610829

The compression is baded on a combination of Golomb-Rice and Huffman coding that is applied per packet. The first data sample of each axis is used uncompressed, all further samples are only transmitted as difference to the previous sample.

- Step 1: (Only for dual compressed data): Calculate the difference between inboard and outboard sensor, store this difference.
- Step 2: Keep the first sample of each axis, store all further samples as diffference to the respective previous sample
- Step 3: Select a power of two divisor that is roughly equal to the average difference sample
- Step 4: Store sign bit of each difference sample, divide absolute value by the divisor, store quotient using truncated huffman coding, store remainder with the necessary number of bits. Repeat for each difference sample
- Step 5: (Only for dual compressed data): Repeat step 2 to 4 with the calculated inboard-outboard difference from step 1.
- Step 6: If the compressed data size is too large, transmit an uncompressed packet instead.

The target of this algorithm is to create data words with only small values (difference stages), allowing to reduce the needed number of bits. The application of the division algorithm can catch small outliers (at the cost of a few additional bits), but is still able to compress the average value as long as it is small enough.

Truncated huffman coding is using codewords with increasing size to a certain point and adds the uncompressed quotient for all quotients larger than this value. This way small quotients use less bits than large quotients, but the codebook alphabet size (= memory space) is still limited.

The compression algorithm will most probably be updated in orbit once data properties are known. In simulations with Venus Express Data a remaining volume of 30-50% was achieved.

The current code uses a quotient codebook size of 7 (0,10,110,1110,11110,111110,111111xxx). The last word uses the code prefix and then adds the uncompresseded coefficient.

Dual compression of data as well as a 24 bit mode (using the full data set resolution without range) can be selected via TC. 24 bit works exactly the same way, it is just the resolution of input data that is different.

The source code of the compression and decompression algorithm was provided to SGS and is also available from the MERMAG team on request.

6. INSTRUMENT OPERATIONS

6.1 Operating Principles

The MPO-MAG should be turned-on as much as possible in order to fulfil its science objectives. The sampling rate of the sensors is commandable via TC depending on actual downlink capabilities or state of the SSMM.
MPO-MAG is an instrument delivering timeseries of the magnetic field. Therefore, it is essential to operate quasi permanently in order to be able to distribute complete timeseries. The instrument needs at least 6 h to stabilize due to increasing sensor temperatures. Therefore, higher frequent on/off cycles - as maybe possible for other instruments - do not make sense for the magnetometer. Furthermore, the magnetometer is not only used for scientific purposes, but is also intensively used as diagnosis and surveillance instrument for the s/c at all. It can provide precious data for the analysis of the ion engine thrusters (SEPS), for the solar array investigation, the reaction wheel signatures and a general analysis of s/c currents. The knowledge of all these and similar effects is needed to provide proper science data in the very Mercury phase. Therefore a quasi permanent operation already during cruise is highly desired.

There are no environmental (thermal, illumination) constraints for MPO-MAG. Also there are no constraints relating to the spacecraft, nor any dependencies on other instruments. However, it might be beneficial to characterise the individual interferences from other instruments (in order to improve the cleaning of the interferences from the measurements).

MPO-MAG does not require any special pointing. Furthermore there is no preference for any special scheduling of WOL.

6.2 Operations Plan per Mission Phase

6.2.1 NEAR-EARTH COMMISSIONING PHASE (NECP)

In this phase the magnetometer will be turned-on and the boom carrying the magnetometers will be deployed. The magnetometer (both sensors) will be turned-on for functional test and calibration. The offsets of the magnetometer can be determined in the solar wind with a quiet interplanetary magnetic field which can not be foreseen. For calibration purposes, it is desired to determine the offsets at all boom configurations.

6.2.1.1 Power-On and Software Functional Test

After power-on, as a first functional test, the instrument passes through the modes 0,2,3,9 (ROM-Boot, RAM-Boot, Normal Science X, Calibration Science) described in section 5.1.1.2 . The first two mode transition happen automatically after power-on and the last must be initiated by TC. The data from the magnetometer in Calibration Science Mode is not compressed.

After the first functional test, the magnetometer software makes every allowed mode transition defined and eventually returns to Science Standby Mode (6)

6.2.1.2 Before Boom Deployment

The offsets of the magnetometer can be determined in the solar wind. The minimum measuring time is one day which suffices to collect enough data of the magnetometer in the solar wind.

6.2.1.3 During Boom Deployment

The magnetometer needs to be turned-on in high-resolution mode in order to characterize magnetic behaviour of the satellite.

6.2.1.4 After Boom Deployment

The offsets of the magnetometer can be determined in the solar wind. The minimum measuring time is one day which suffices to collect enough data of the magnetometer in the solar wind.

After the boom is deployed the functionality of the heater will be checked.

6.2.2 INSTRUMENT CHECK-OUT PLAN DURING CRUISE

For MPO-MAG the checkout phase are mainly regarded as “instrument still alive” – checks. During cruise the sensor temperature with and without heating will be checked at intervals of 0.1 astronomical units. Also, the sensor temperature should be checked for the verification of the thermal behaviour if the illumination conditions change.

For the cruise check-out, the MERMAG instrument is activated and configured for producing science data. The instrument-internal outboard and inboard sensor heaters are activated for specific intervals. The total instrument operating time during the cruise check-out will be 10-12 hours.

For details please refer to the cruise check-out procedure defined in chapter 7.4.

It would also be desirable to have longer (e.g. 10 days) and more regular operating phases to measure the interplanetary field in the inner solar system. If such a possibility exists, details need to be examined.

6.2.3 NEAR-MERCURY COMMISSIONING PHASE (MCP)

In this phase the spacecraft will be inserted into orbit around Mercury, the apoherm is lowered and the instruments become active. This offers a unique opportunity to measure magnetospheric processes at higher altitudes above the planet than throughout the final orbit.

6.2.4 Calibration Needs during CRUISE

If “fast”calibration rolls become feasible in the future, MPO-MAG would request at least one per year.

6.2.5 MERCURY ROUTINE PHASE

6.2.5.1 Calibrations in Mercury Orbit

The objective of the in-flight calibration is
(a) determine and monitor the actual spacecraft-induced magnetic background at the magnetometer sensors
(b) to verify to what extent the ground calibration remains valid
(c) to monitor and quantify any changes in the calibration parameters.

The in-flight calibration of magnetometers is a challenging problem, it is particularly so on three-axis stabilised spacecraft. A spacecraft-induced magnetic background is expected at the location of the MPO-MAG sensors. This is the primary and crucially important reason that the proposed MPO-MAG instrument has two boom-mounted sensors.
We propose to use the dual-magnetometer technique for in-flight calibration. This technique was first developed by Ness et al., 1970 with the purpose of correcting magnetic field measurements on a spacecraft that produced a significant magnetic disturbance at the location of the magnetometer sensors. The technique has been rarely used in practice as most spacecraft achieved either an adequately low level of magnetic cleanliness or had a long enough boom, in other cases when a single magnetic sensor was used, a significant doubt remained concerning the accuracy of the measurements.
The dual magnetometer technique has been successfully applied recently to the CSSAR/ESA Double Star spacecraft. Due to inadequate compensation of the currents generated by the spacecraft, a significant magnetic disturbance was found after launch at the location of the two magnetometer sensors. The dual magnetometer technique has been applied to the data. The disturbance field due to the spacecraft has been identified and quantified and the ensuing in-flight calibration algorithm and procedure ensured that the measurements can be used to generate scientifically usable data.
In addition to the dual magnetometer technique, more standard calibration procedures will be used through a built-in calibration mode and by the use of the statistical properties of the magnetic field data when the MPO may be in the solar wind.

If “fast”calibration rolls become feasible in the future, MPO-MAG would request at least one per year.

6.2.5.2 Mercury Routine Science Phase (MSP)

The operations of MPO-MAG during the MSP are described in detail in the In-Orbit Payload Operation Document [AD-3] MPO-MAG IPOD, BC-SGS-TN-066 and will not be listed here again in order to avoid any versioning confusion,

All operatios will be planned in accordance to the BepiColombo science tracibility matrix TMX. The TMX editor [AD-4], which lists all science objectives and related scientific questions can be found at http://bepicolombo.esac.esa.int/tmx.

6.3 Instrument Operation Constraints

6.3.1 INTERNAL CONSTRAINTS

6.3.1.1 TC Data Rate

Due to its limited calculation power the controller can handle telecommands at a maximum speed of about 16000 bit/sec during normal science operation.

6.3.1.2 TC Execution Timing Information

Minimum TC execution time	100 µsec
Maximum TC execution time	Up to 100 msec (workload dependant)

Typical TC execution time	8 msec
TC(6,2) execution time for normal memory writing	Up to 100 msec
TC(6,2) execution time for EEPROM writing	Up to 300 msec
TC(209,7) Write to EEPROM	Acceptance Acknowledge: up to 100 msec Execution Acknowledge: up to 15 seconds
Time for mode transition TC	10 µsec to 100 msec
Upload of complete memory image	180 seconds, if writing directly to EEPROM 60 seconds, if writing to BootImage Area in RAM (+ possibly another 15 seconds if data is copied to EEPROM from BootImage using TC209,7). This time is multiplied by the number of memories (EEPROM 0 to 3) that is updated.
Time for measurements	Instrument is measuring continuously, data time stamping is done for measurement time, so no processing delay is introduced. Delay from measurement to data output is dependant on data rate, as data is downsampled to selected frequency and delivered in 128 vector blocks.
Time from power on to boot success report	5 sec
Time from boot success to initial HK report	Up to 5 sec, dependant on reception of initial time synchronization (= EID-A 7258 and 7261)
Time until science mode is selected automatically	64 sec

Table 6-1: Housekeeping Limits

6.3.1.3 Other Inferface Constraints

Not all commands are available during every mode for security reasons (maintenance) or due to limited functionality (backup science mode). Also mode transitions are limited. For more information on individual TCs, please refer to chapter 5.

6.3.1.4 FDIR Constraints

The instrument prohibits selecting a software with illegal checksum for boot using “normal boot select” (TC 209,2).

The instrument also prohibits heating, if heaters are above the selected heater switchoff temperature.

6.3.1.5 Time Synchronisation

From the current point of view time synchronization is only required at startup, as the rest is done using spacewire time ticks. However, a synchronization is desirable e.g. every 1-5 hours.

6.3.1.6 Power Supply Interface

Because the instrument science data noise characteristics is better when MERMAG is operated from the redundant power supply unit (PSU) in the electronics box, the redundant PSU shall be used by default.

The reason is that the distance from the sensitive sensor electronics boards to the redundant PSU board is larger than to the nominal PSU board. Therefore the noise coupling from the redundant PSU to the sensor electronics boards is is lower.

6.3.2 ENVIRONMENTAL CONSTRAINTS

6.3.2.1 Thermal Constraints

We do not have thermal constraints. Even if the temperature exceeds the operation limits the sensor shall be switched on. Even if the sensor operation ceased there is no threat for the S/C operation.
OOL will trigger contingency procedures. When high temperature limits are exceeded, instrument shall stay on in order to receive TM and allow on-ground diagnostics. Sensors dissipation is negligible (50 mW) and will not impact operational temperatures.
If low temperature limits are exceeded, instrument shall stay on (MERMAG has heaters, which are part of the MPO thermal control system and can be commanded to recover OOL). Sensors have been tested down to LN2 temperatures, if a damage will occur below these temperatures cause will be mechanical stress, independently on the ON/OFF status of the instrument.

6.3.2.2 Illumination Constraints

We do not have illumination constraints.

6.3.3 SPACECRAFT RELATED CONSTRAINTS

We do not have spacecraft related constraints. For calibration purposes we need to know the operational status of the s/c and its subsystems.

6.3.4 OPERATIONAL CONSTRAINTS WITH OTHER INSTRUMENTS

Interference of any other electrical instrument or other electrical satellite part is expected but should be minimal as possible. The interferences can be partly cleaned by the dual-magnetometer approach of MERMAG.

7. INSTRUMENT FLIGHT OPERATIONS PROCEDURES

All currently given procedures are stubbs only and will be filled later. Procedures only cover frequently used operations, other procedures will be added if used more frequently.

7.1 Nominal Flight Control Procedures (FCP)

Procedure Title	Procedure Name	Type	Priority	Remark
MERMAG Boot	KMER0000BOOT	Routine	Normal	
MERMAG Power Off	KMEL0001POFF	Low-Level	Normal	

For procedure details, please refer to the MERMAG OBCP URD (BC-MAG-TN-00012)

7.1.1 Set Science

Sets science mode, rates, range and autoranging for all processes

7.1.2 Set Autoheater

Enables / Disables Autoheater and sets target temperature

7.1.3 Set Compression

Enables / Disables Compression for given processes

7.2 Engineering Flight Control Procedures (ENG)

7.2.1 Software Upload

Uploads software to BootImage area and verifies checksum

7.2.2 Software Permanent Update

Writes the BootImage software to EEPROMs given by parameter

7.2.3 SoftwareCheck

Retrieve software version information, build date memory dumps, check all software vs. internal checksums

7.2.4 Parameter Update

Upload a new parameter set to given memory.

7.3 Contingency Recovery Procedures (CRP)

7.3.1 Emergency Off

Switches off MERMAG in emergency cases (housekeeping red limits, spacecraft safe mode)

7.3.2 Disable Science Output

Disables Science output

7.3.3 Reset Output Buffer

Flushes Science output buffer

7.3.4 Software Reset

Reset the instrument software

7.3.5 Reception of TM(5,2)

Inform instrument team on any reception of TM(5,2). Please note, there is currently no TM(5,4) that requires any action – the only TM(5,4) is used to signal a request for time synchronization

7.4 Flight Test Procedures (TST)

7.4.1 Functional Test

Full functional test, e.g. used for commissioning

7.4.2 Short Functional Test

Shorter version of functional test

7.4.3 Connection Test

Service 17 tests

7.4.4 Cruise Checkout

Used for cruise phase checkouts

7.4.5 Boom Deployment

Set science mode to verify boom deployment

7.4.6 Calibration

General Calibration Macro

8.

9. APPENDIX A INSTRUMENT DATA SHEETS

Name / Acronym	Magnetometer / MAG
Objectives	To measure DC Magnetic Field (0 to 64 Hz)
General description	Dual-sensor digital technique Fluxgate Magnetometer

Table 7.4-1: Instrument Identification Table

Parameter	Units	Value/Description	Remarks
General			
Reference P/L	N/A	ROMAP, VEX Magnetometer	
Technology	N/A	Fluxgate	
Technique	N/A	Dual sensor	Digital Processing

Table 7.4-2: General Instrument Data Sheet

Parameter	Units	Value/Description	Remarks
Sensor			
Type	N/A	Tri-axial Fluxgate	2 ring core design
Sensor intrinsic noise performance	pT/□Hz	< 10	at 1 Hz
Sensor Offset (3 axes)	nT	< 6	
Sensor Offset Stability (3 axes)	nT	< 0.5	in 100 hours
Offset Temperature coefficient	nT/°C	< 0.05	
Scale Factor Error (linearity)	%	< 0.052	
Axis-to-Axis Alignment Error	°	< 0.5	known better than 0.1°
Operating Temperature Range	°C	-120 to +180	
Non-operating temperature range	°C	-155 to +180	
Sensor Harness Opterating Temperature Range	°C	-150 to +200	Was tested up to 240°C

Table 7.4-3: Instrument performances

Parameter	Units	Value/Description	Remarks
Resolution			
Digital resolution	pT	1.96	21 bit
Measurement Range	nT	+/-2048	
Compensation Range	nT	+/- 5000	
Data reduction		6 ranges	By selecting 16 bit of 21 bit for transmission

Table 7.4-4: Instrument resolution

Parameter	Units	Value/Description	Remarks
Orbit			
Inclination	°	Polar	
Type of orbit	N/A	Near-Circular	
Altitude	Km	As low as possible	
Pericenter precession	°	No requirement	
Periapsis longitude change	°/orbit	No requirement	
Phase angle	°	No requirement	

Table 7.4-5: Orbit parameter

Parameter	Units	Value/Description	Remarks
Configuration			
Units	N/A	7	
Layout	N/A	1 x Electronics Box 2 x Sensor 2 x Sensor Thermal Shielding 2 x Sensor Harness	
Preferred location	N/A	Boom mounted sensors	
Sensitivity to shocks	N/A	No particular sensitivity	

Table 7.4-6: Instrument configuration

Parameter	Units	Value/Description	Remarks
Physical			
Mass, total	Kg	2.5	margin: 3%
Mass, sensors, thermal hardware	Kg	0.6	margin: 3%
Mass, electronics	Kg	1.22	margin: 3%
Mass, harness	Kg	0.675	margin: 3%
Dimension, sensor incl. Thermal Shielding	mm	86.6 x 86.6 x 123.8	Envelope including sensor thermal shielding
Dimension, electronics	mm	162 x 169 x 119.6	

Table 7.4-7: Instrument physical properties

Parameter	Units	Value/Description	Remarks
Power			
Average operating power (heaters off)	W	5	Heaters off Primary power
Electronics Box Power Dissipation	W	4.87	Dissipation
Sensors Power Dissipation (heaters off)	W	2 x 0.065	Dissipation
Sensors Power Dissipation (heaters on)	W	2 x 0.375	Dissipation
Instrument Operating Power (heaters on)	W	5.75	Maximum Primary Power

Table 7.4-8: Instrument power requirements

Due to the very limited power resources aboard BepiColombo MPO, the MAG instruments implements a **reduced power mode**. In reduced power mode only one sensor is operated, the other one is disabled. Most likely the inboard sensor will be deactivated, only in case the outboard sensor is disfunctional, this one will be deactivated. Generally this means that the science data rates are reduced to the one for single mode, also houskeeping will be available only for one sensor (only one of hk structure ID 1,2 and 4,5). In terms of power, excitation and heating of one sensor is deactivated.

Since operating the instrument in reduced power mode means also reduced science, this mode should only be used in mission cases where the power budget is very narrow.

Parameter	Units	Value/Description	Remarks
Data Rate/Volume			
Sample Rate	1/s	0.5 to 128 Vector/sec	per sensor
Data rate to HICDS	bps	max: 23200 min: 70 typ: 450	including HK
Data volume/orbit	Mbit	3	Typical
Data downlink rate	bps	max: 23200 min: 70 typ: 450	including HK
Total mass memory	Gbit	No requirement	
Compression factor	-	No requirement	

Table 7.4-9: Instrument Data requirements

Parameter	Units	Value/Description	Remarks
Pointing			
Pointing	N/A	No requirement	
Attitude reconstruction	arcsec	720	
Pointing stability	□/s	No requirement	
Alignment knowledge	arcsec	720	
Co-Alignment w.r.t. other sensor	arcsec	360	

Table 7.4-10: Instrument pointing requirements

Parameter	Units	Value/Description	Remarks
Thermal			
Sensor	°C	-155 to +180 non op./ -120 to +180 operating	STP interface temperature
Electronics	°C	-40 to +60 non op. / -20 to +50 operating	TRP interface temperature

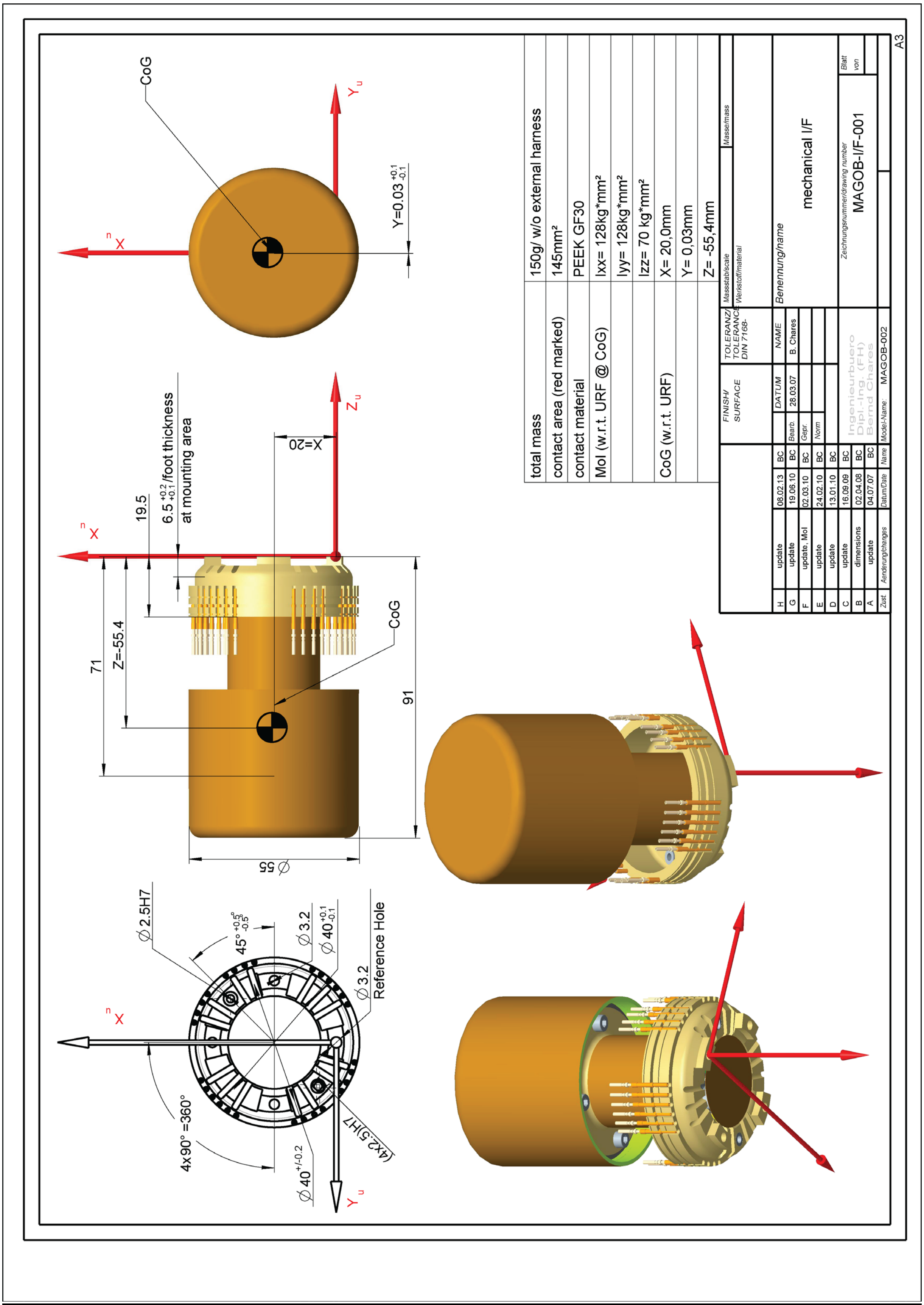
Table 7.4-11: Instrument Thermal requirements

Parameter	Units	Value/Description	Remarks
Contamination			
EMC requirements		No particular requirements	
DC magnetic		< 160nT at Outboard Sensor	design goal: < 100nT at Outboard Sensor
LF AC Magnetic		< 2% of DC field at Outboard Sensor	10mHz to 64 Hz
Particulate/chemical		No particular requirements	

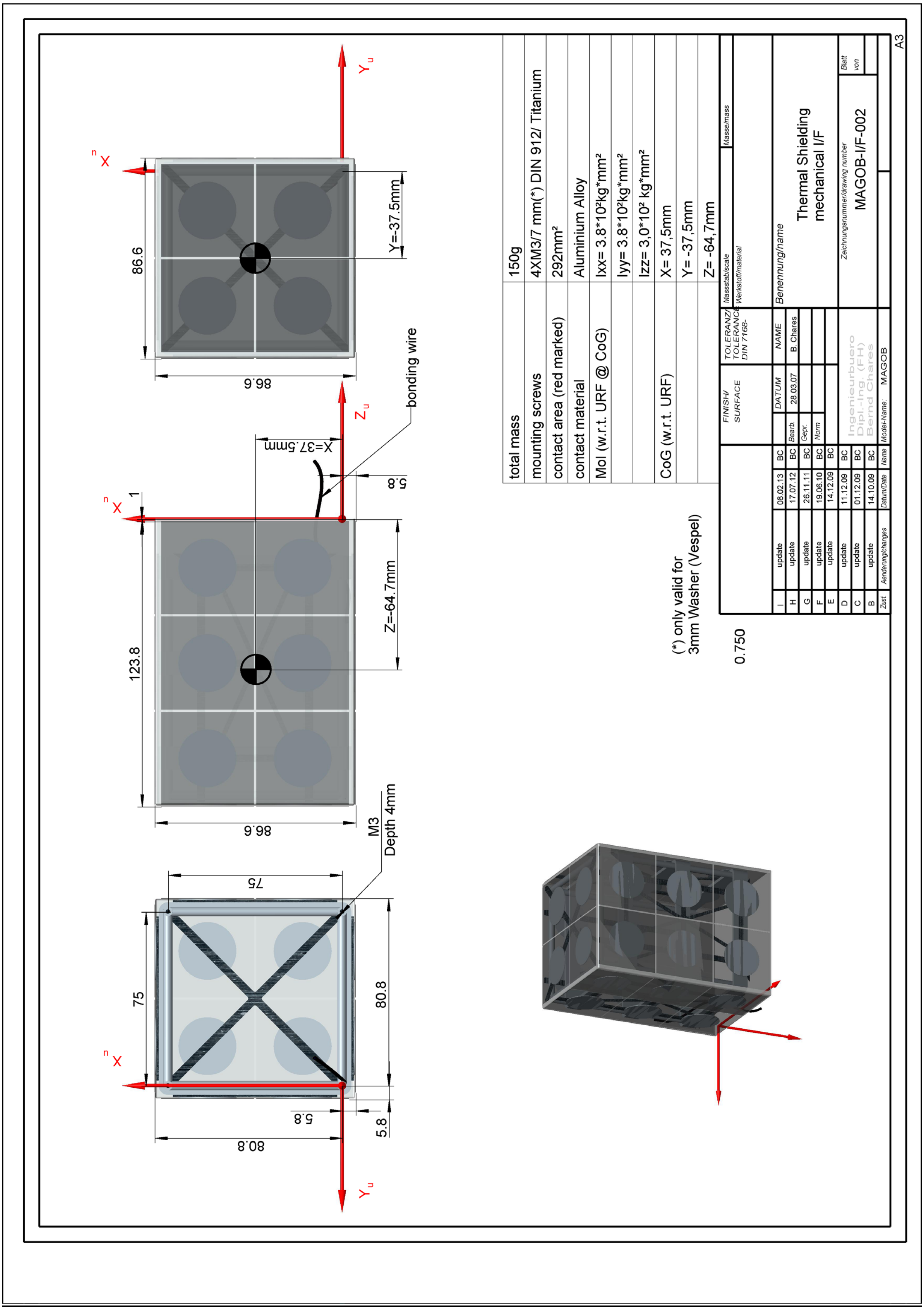
Table 7.4-12: Instrument contamination requirements

10. APPENDIX B MECHANICAL INTERFACE CONTROL DRAWINGS

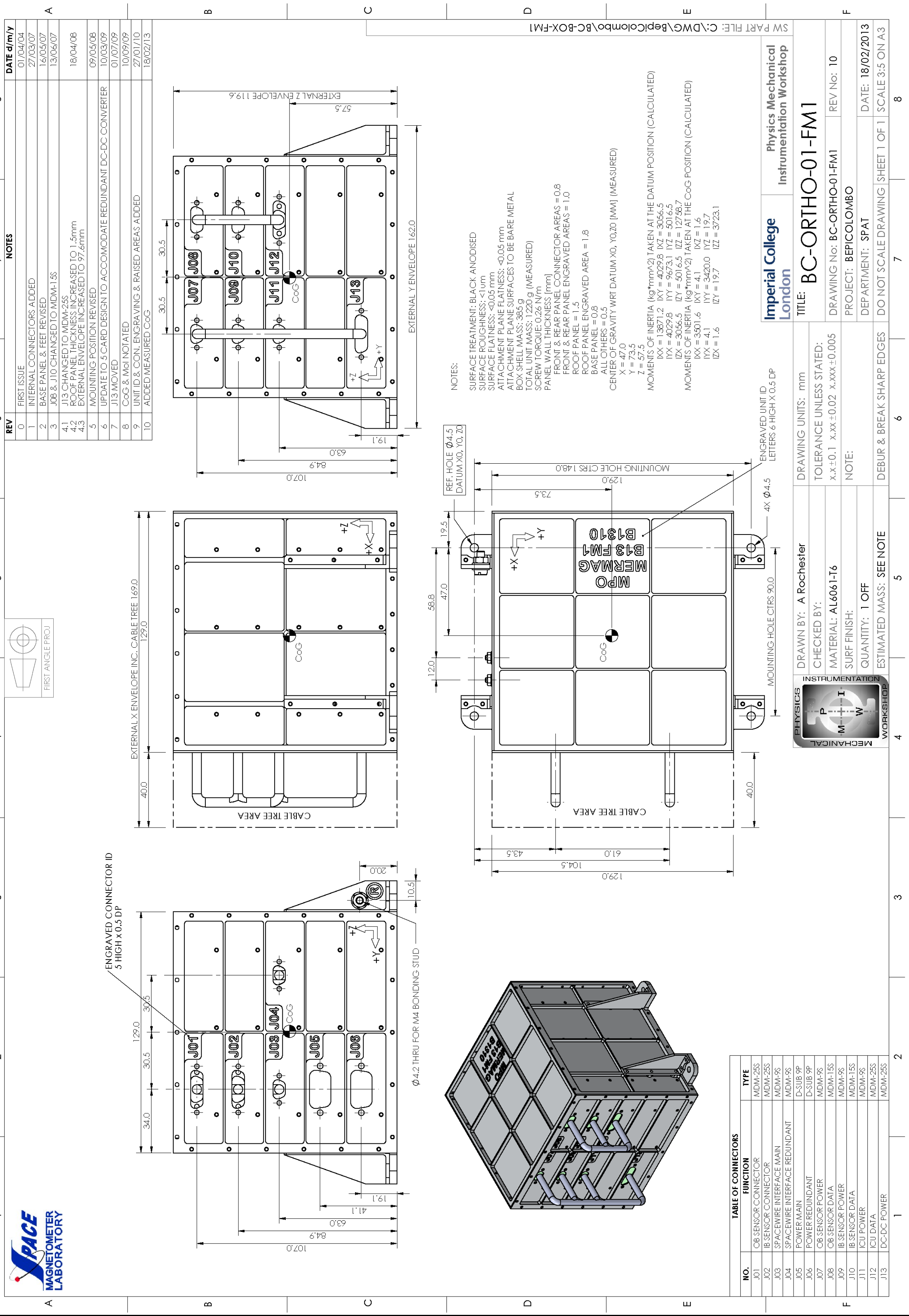
Out-Board and In-Board Sensors MICD



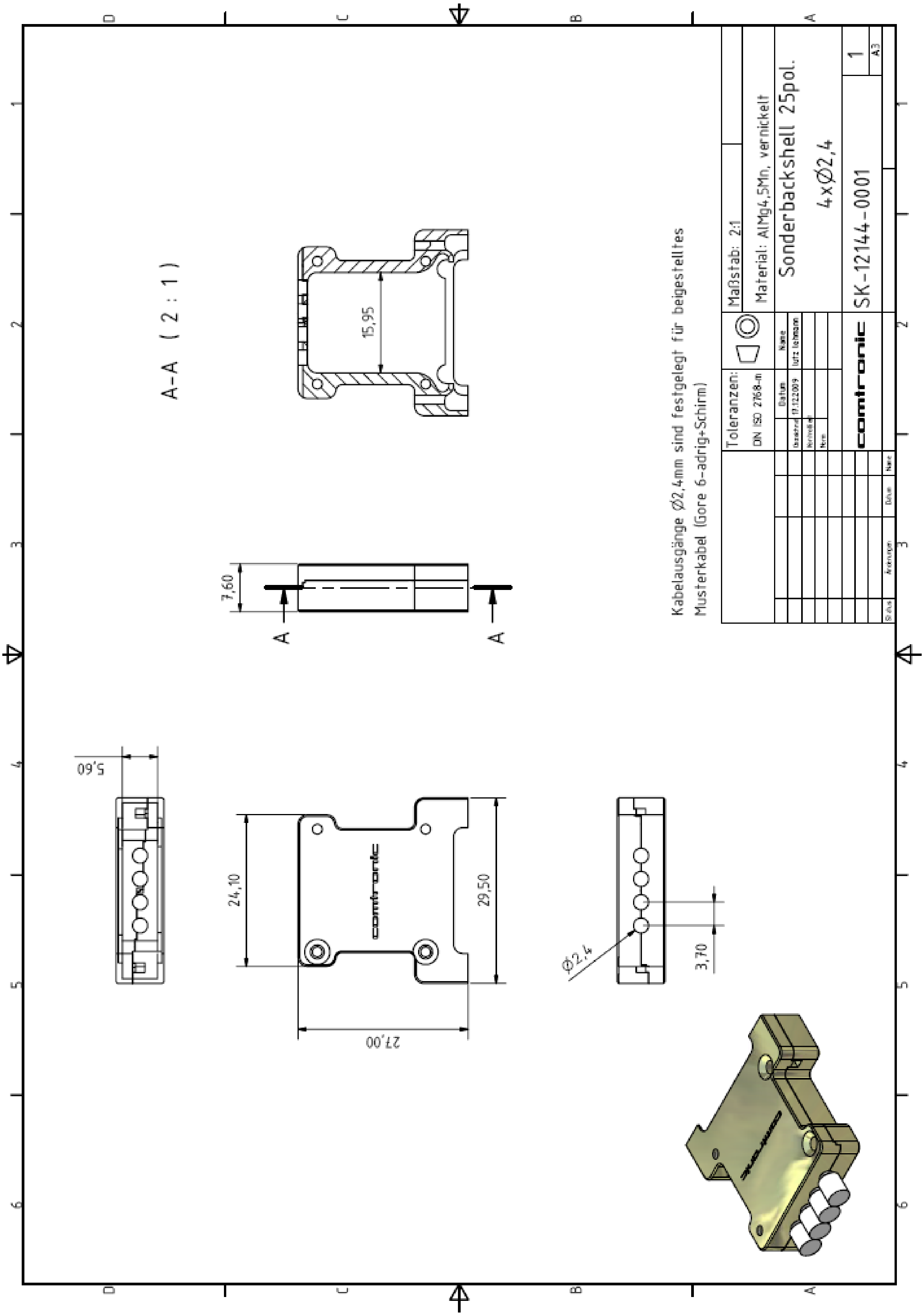
Sensors Thermal Shields MICD

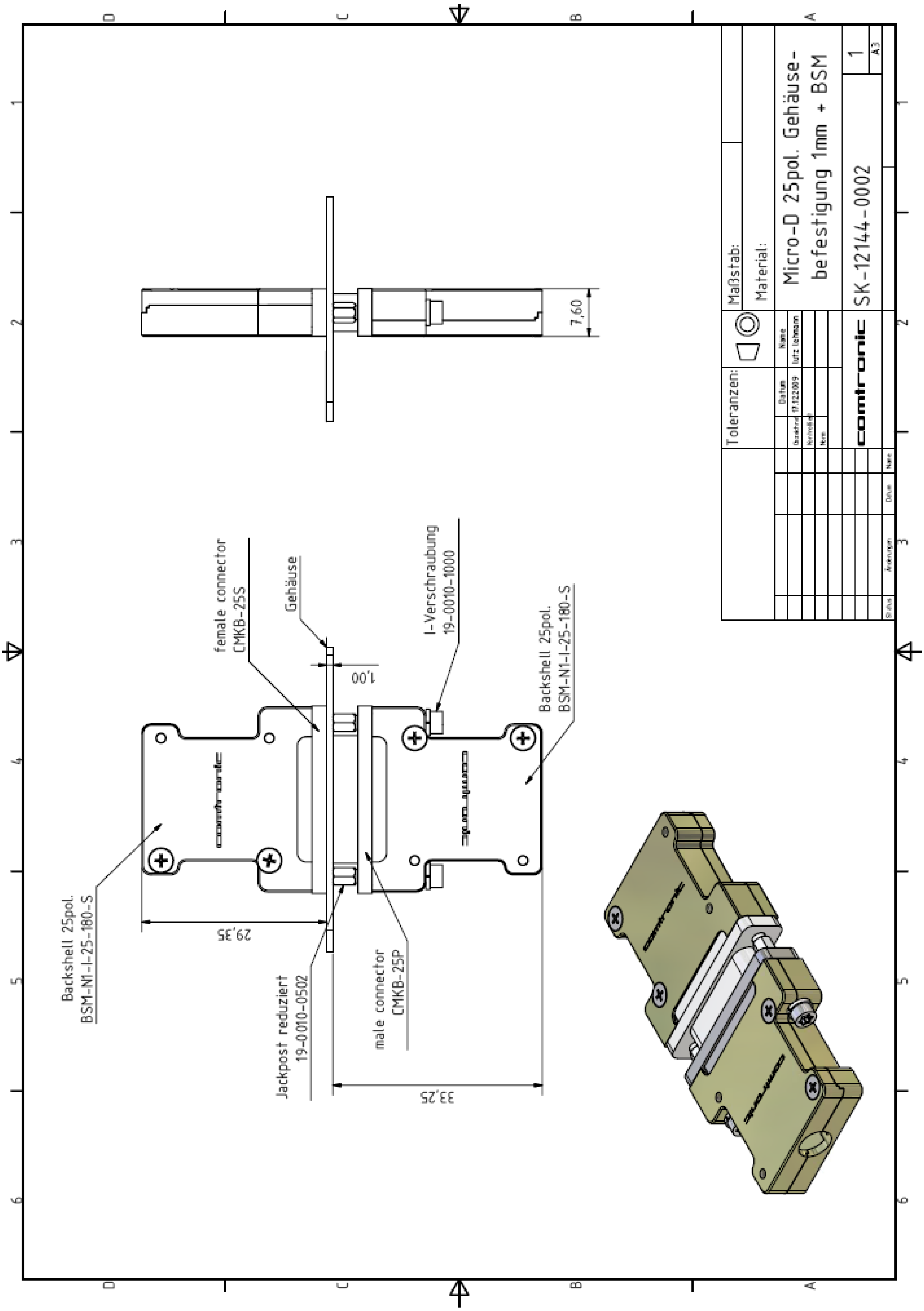


Electronics Box MICD

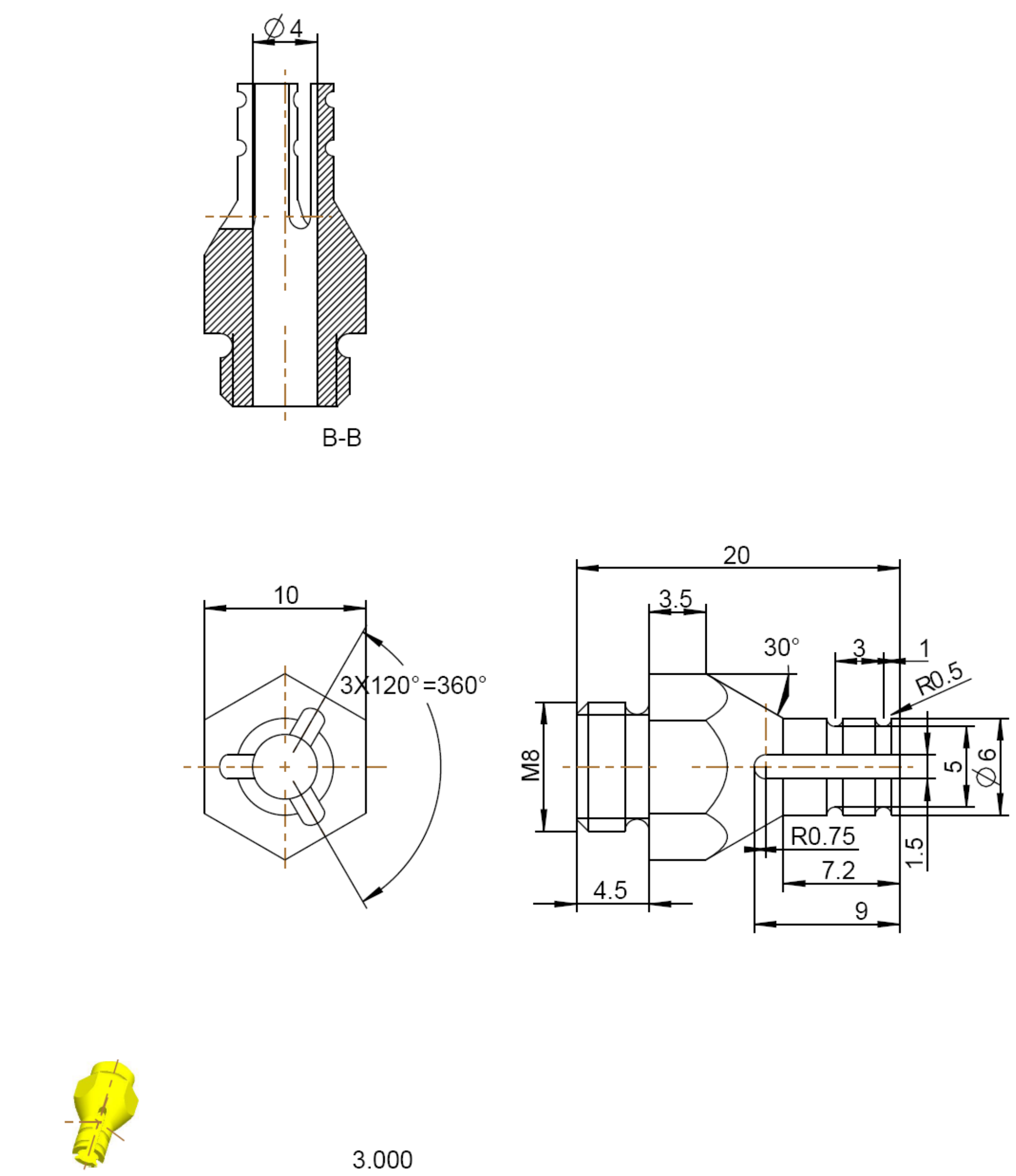


Boom Hinge Connectors Back-shells MICD



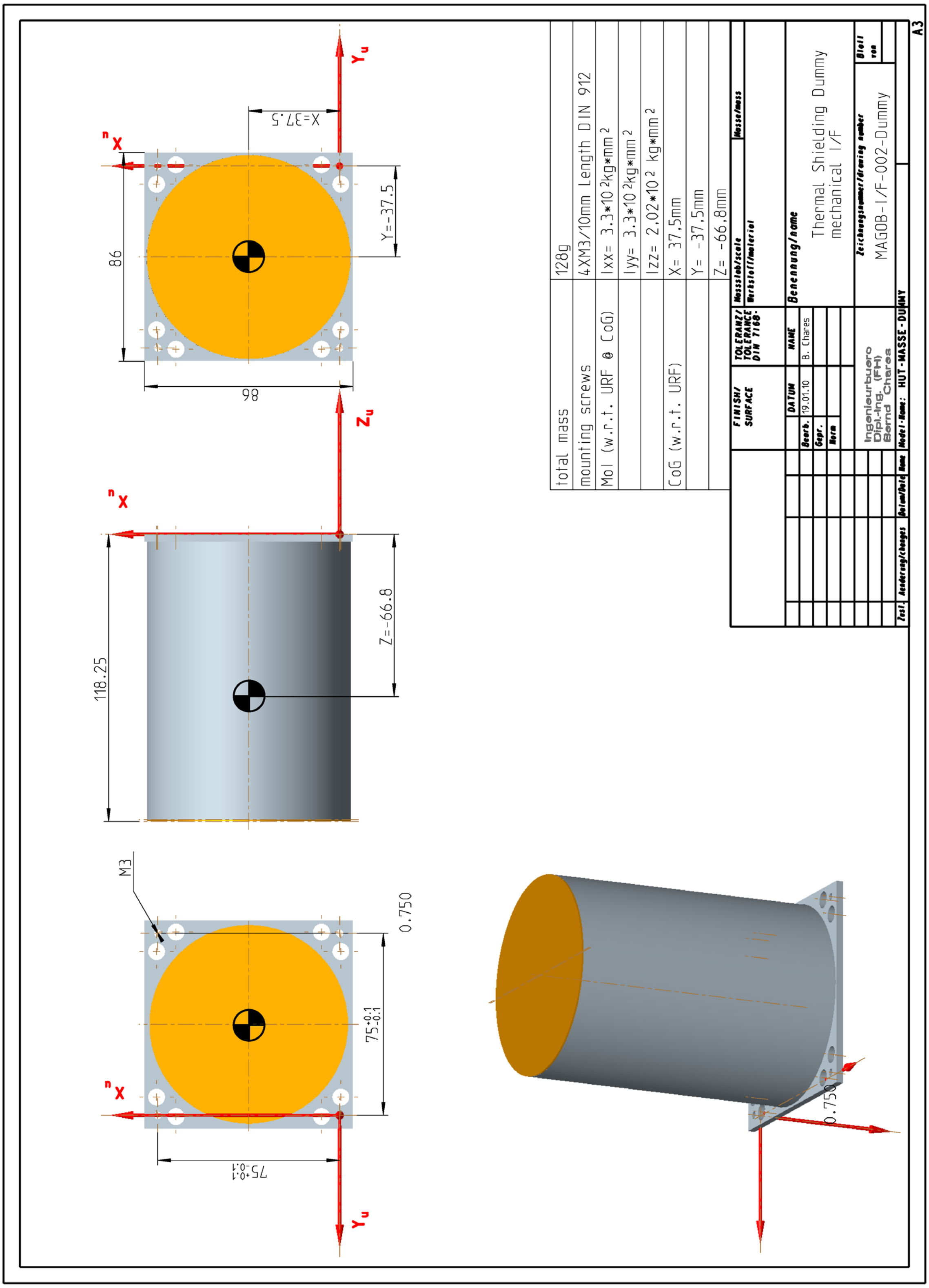

7,60
female connector
CMKB-25S
Gehäuse
I-Verschraubung
19-0010-1000
1,00
Backshell 25pol.
BSM-N1-I-25-180-S
Backshell 25pol.
BSM-N1-I-25-180-S
29,35
Jackpost reduziert
19-0010-0502
male connector
CMKB-25P
33,25
Maßstab:
Material:
Toleranzen:
Micro-D 25pol. Gehäuse-
befestigung 1mm + BSM
SK-12144-0002
1
A3
comtronic

Cable strain reliefs at interface bracket MICD

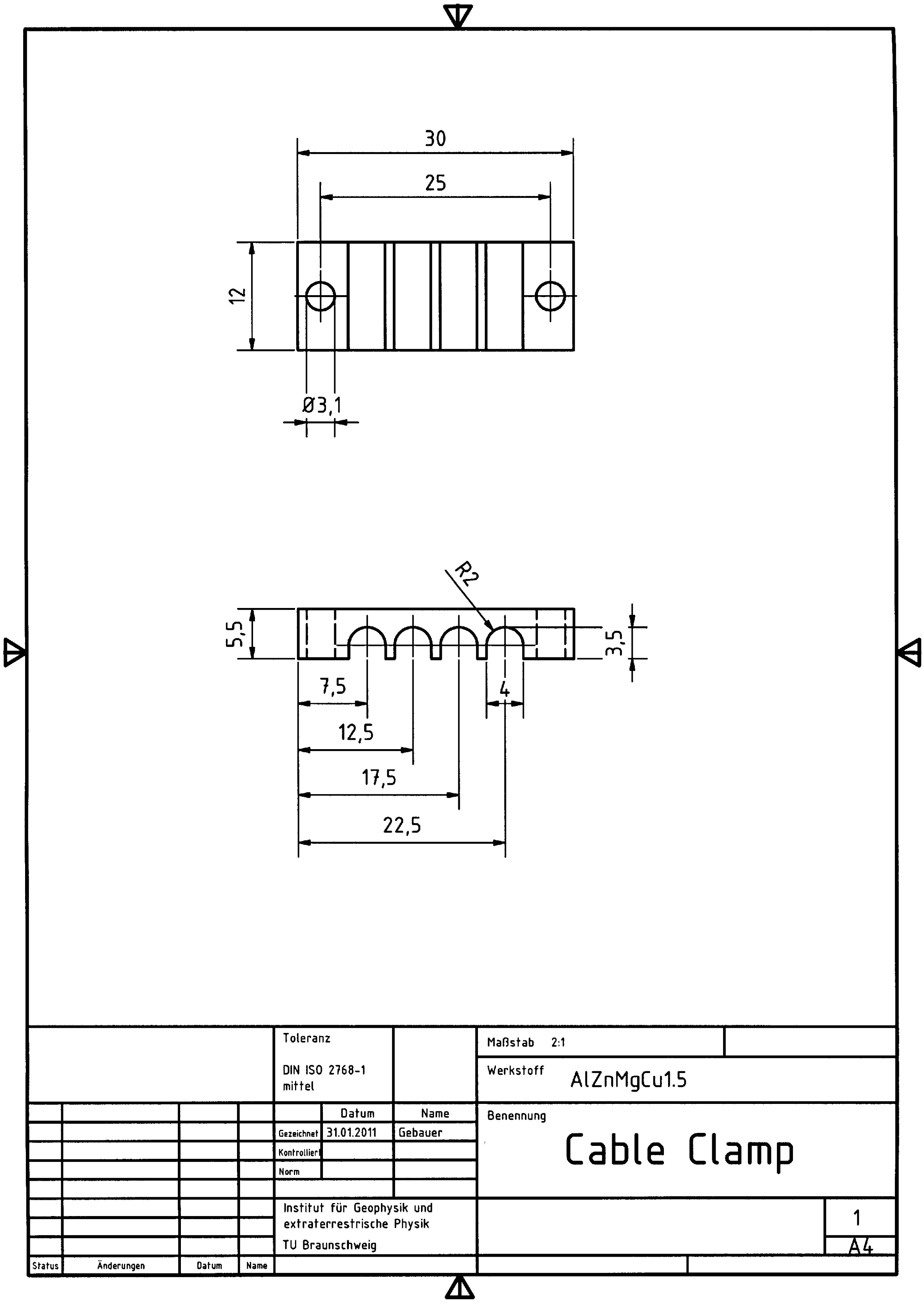


				FINISH/ SURFACE	TOLERANZ/ TOLERANCE DIN 7168-	Massstab/scale	Masse/mass
						Werkstoff/material PEEK GF30	
				DATUM	NAME	Benennung/name	
			Bearb.	01.12..09	B. Chares		
			Gepr.				
			Norm			Kabelentlastung	
			Ingenieurbuero Dipl.-Ing. (FH) Bernd Chares			Zeichnungsnummer/drawing number magob-020	Blatt von
Zust.	Aenderung/changes	Datum/Date	Name	Model-Name: MAGOB-020			

Sensors Protection caps MICD

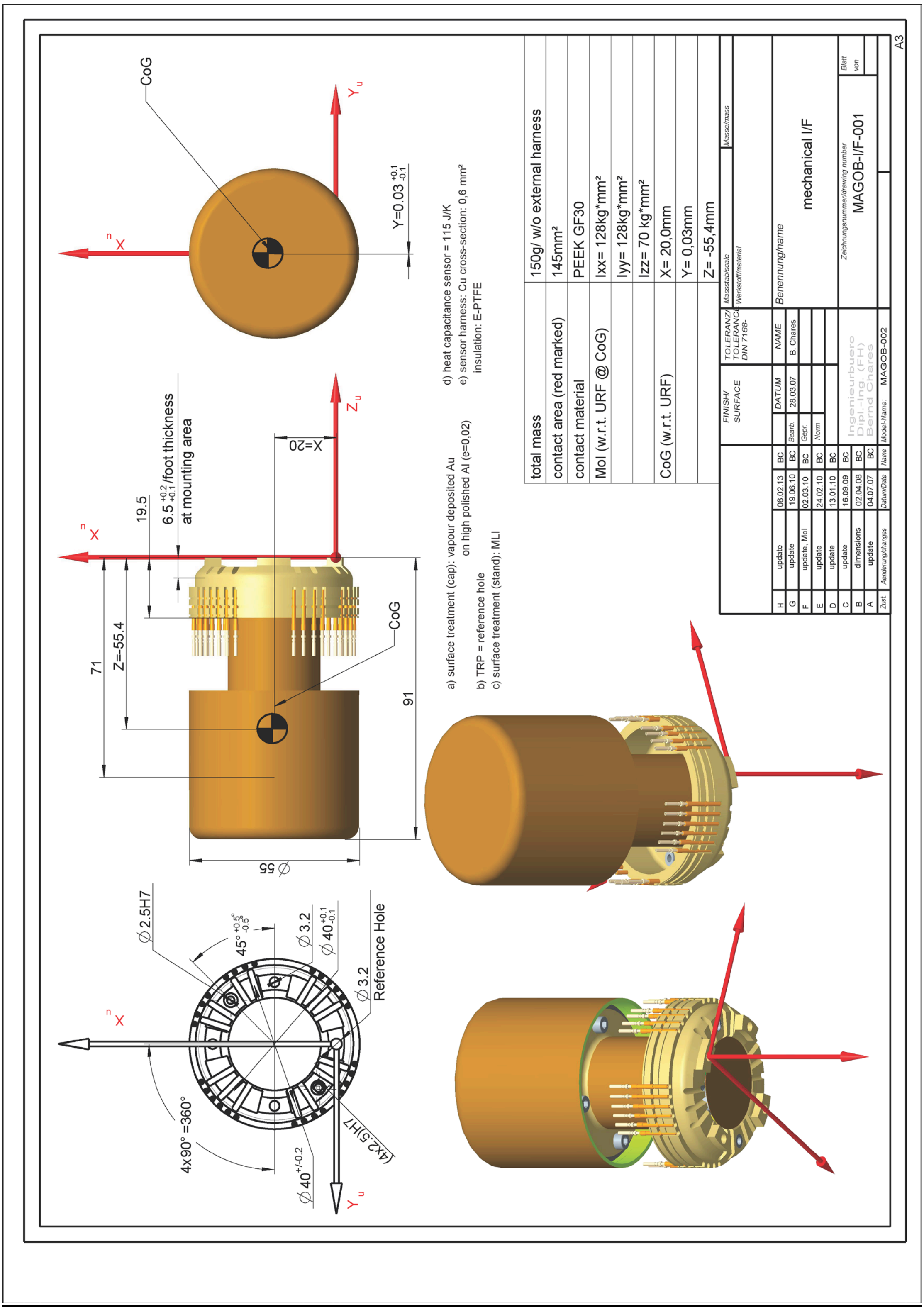


Cable Clamp MICD

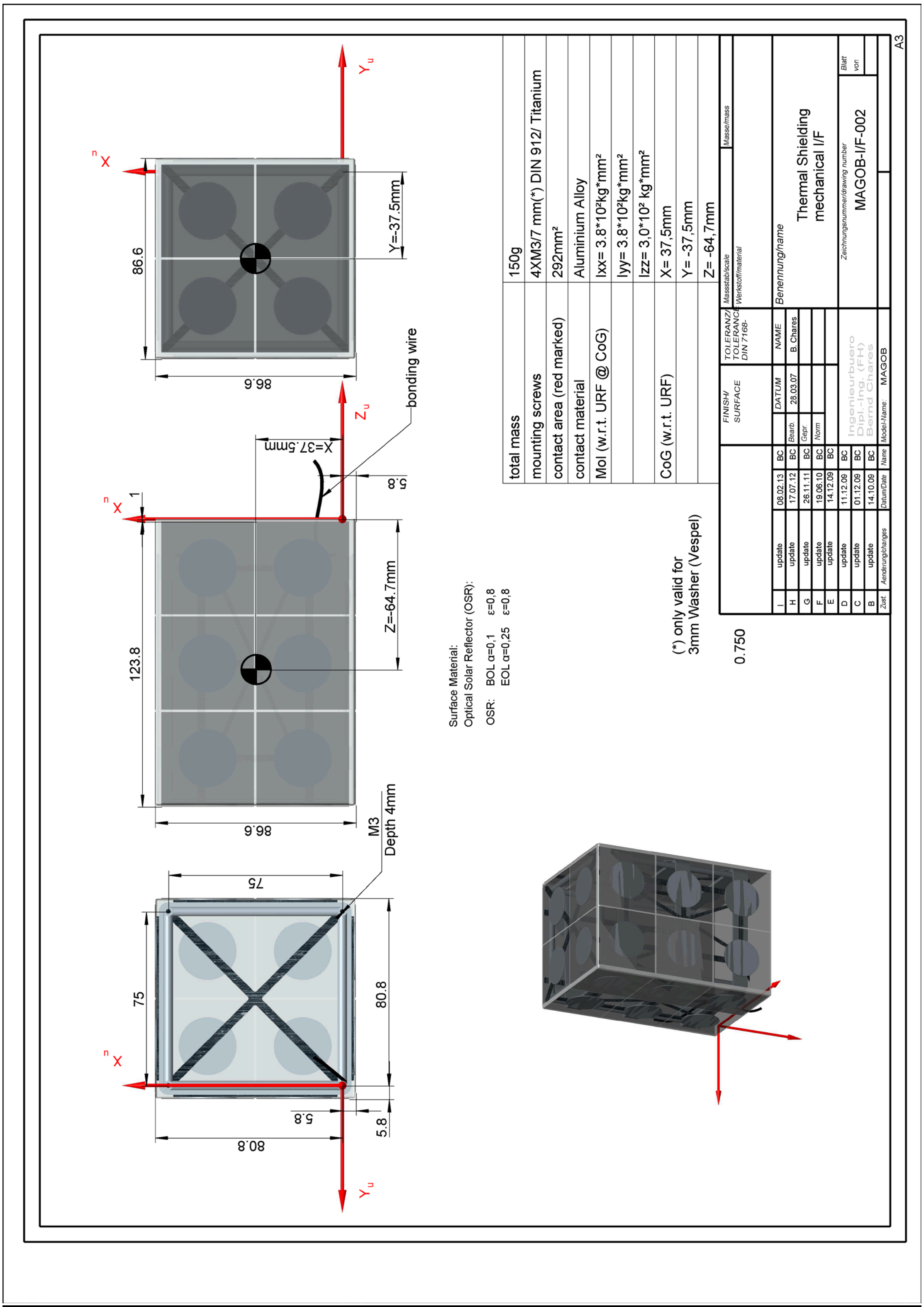


11. APPENDIX C THERMAL INTERFACE CONTROL DRAWINGS

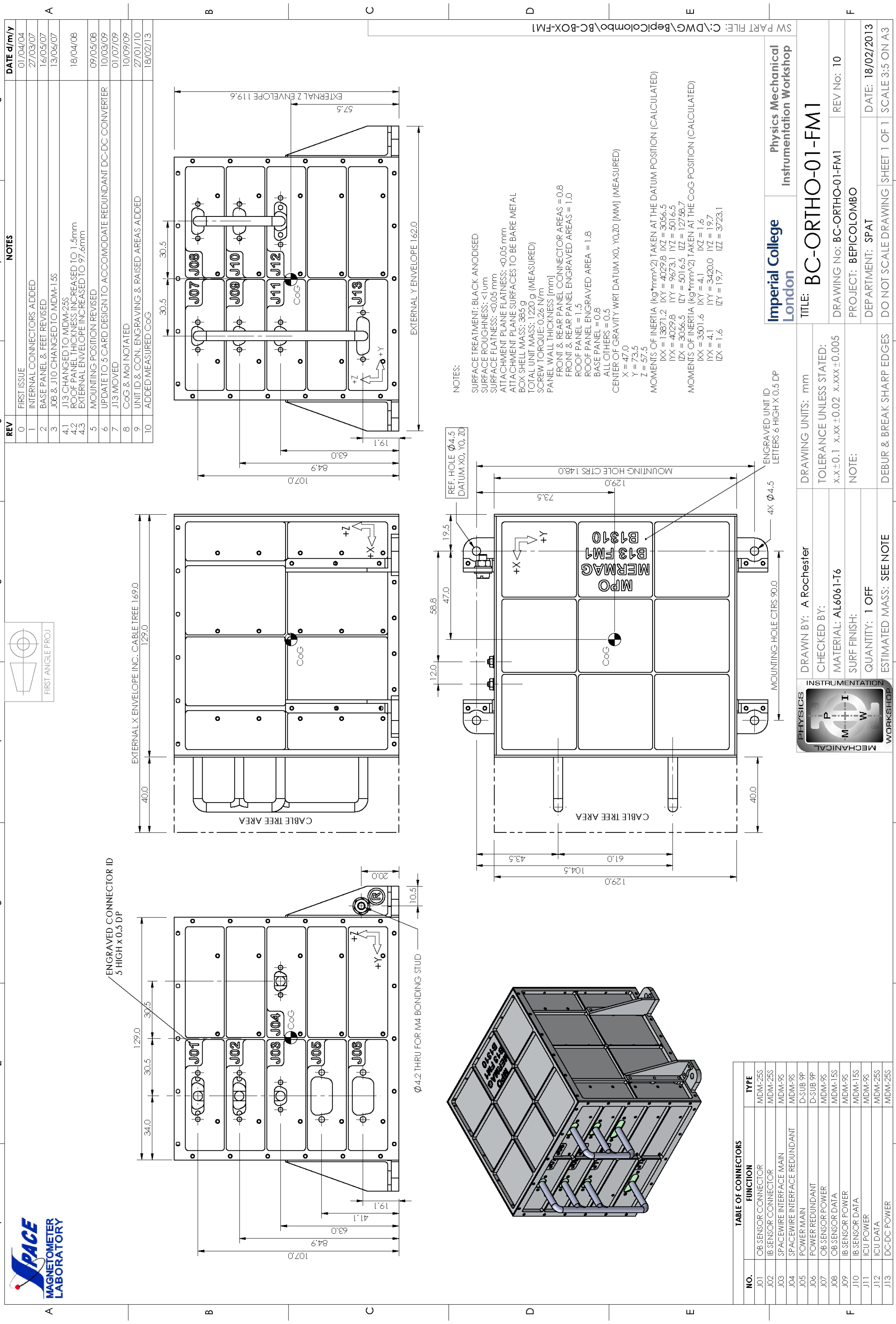
Out-Board and In-Board Sensors TICD



Sensors thermal Shields TICD

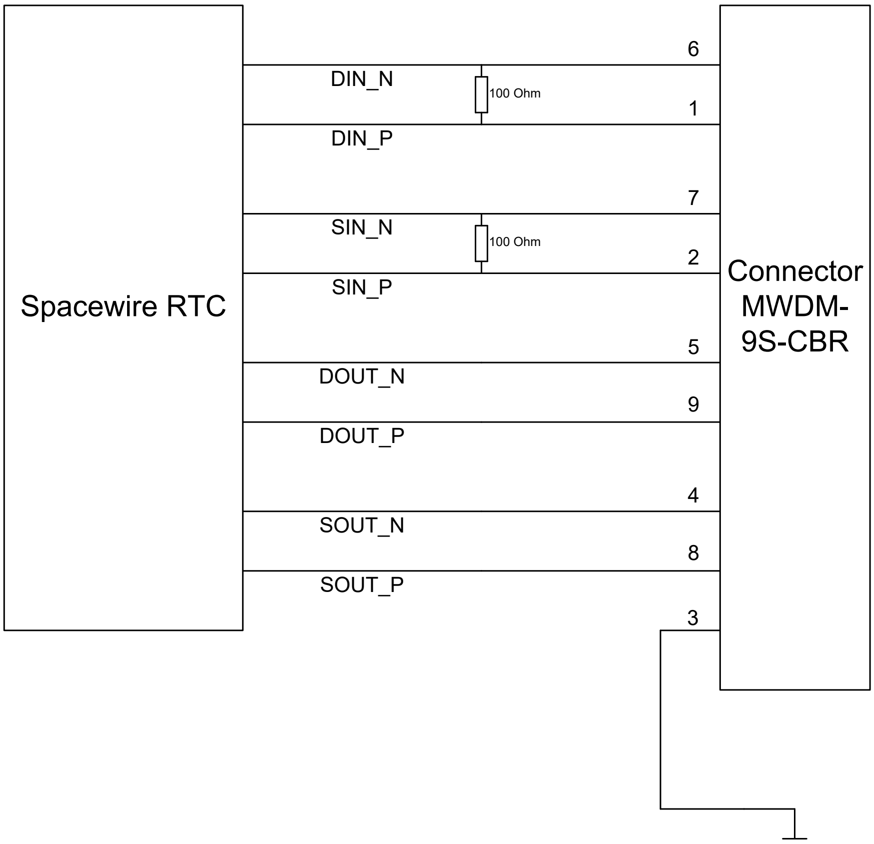


Electronics Box TICD

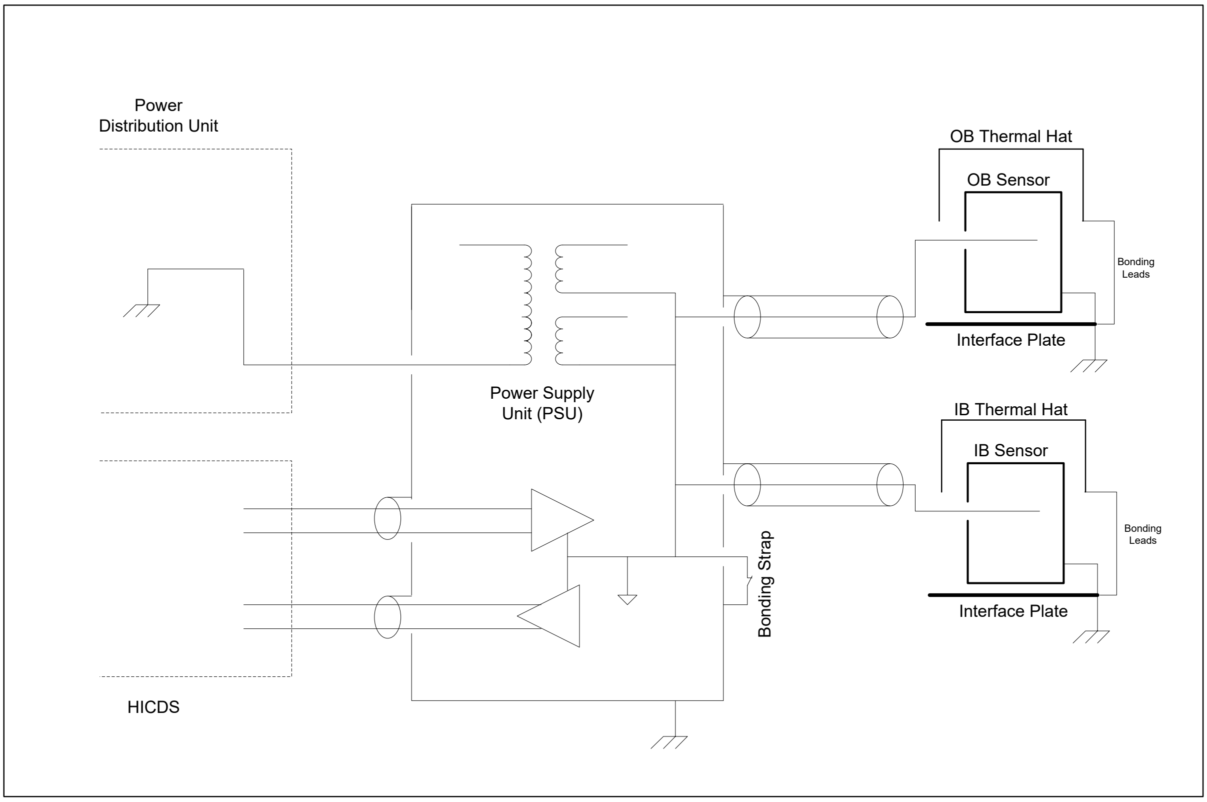


12. APPENDIX D ELECTRICAL INTERFACE CONTROL DRAWINGS

TM/TC Interface Circuit



Grounding Diagram



MERMAG Connectors List

Electrical Data Sheet 1: Unit Connector List

Instrument: MERMAG

Unit name	Conn. name	Connector type	Connector function/content	Specific requirements	Ch. in issue
E-Box	J01	MDM 25 S	OB Sensor Cable		
E-Box	J02	MDM 25 S	IB Sensor Cable		
E-Box	J03	MDM 9 S	SpaceWire Interface Main		
E-Box	J04	MDM 9 S	SpaceWire Interface Red.		
E-Box	J05	D-SUB 9 P	Power Main		
E-Box	J06	D-SUB 9 P	Power Redundant		
E-Box	J07	MDM 9 S	OB Sensor Power		
E-Box	J08	MDM 15 S	OB Sensor Data		
E-Box	J09	MDM 9 S	IB Sensor Power		
E-Box	J10	MDM 15 S	IB Sensor Data		
E-Box	J11	MDM 9 S	ICU Power		
E-Box	J12	MDM 25 S	ICU Data		
E-Box	J13	MDM 25 S	DC/DC Power		
OB Sensor Harness 01	P01	MDM 25 P	OB Sensor Cable		
OB Sensor Harness 01	J01	MDM 25 S	OB Sensor Cable		
OB Sensor Harness 02	P01	MDM 25 P	OB Sensor Cable		
OB Sensor Harness 02	P01	Pin-Socket	OB Sensor Cable		
IB Sensor Harness 01	P02	MDM 25 P	IB Sensor Cable		
IB Sensor Harness 01	J02	MDM 25 S	IB Sensor Cable		
IB Sensor Harness 02	P02	MDM 25 P	IB Sensor Cable		
IB Sensor Harness 02	P01	Pin-Socket	IB Sensor Cable		
OB Sensor	J01	Pin-Socket	OB Sensor Cable		
IB Sensor	J01	Pin-Socket	IB Sensor Cable		

MERMAG Pin Allocation List, Elec Box, Connector J01

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J01	1	EXCITATION									
E-Box	J01	2	EXCITATION-SCREEN									
E-Box	J01	3	HEATER(+)									
E-Box	J01	4	TEMP-S1									
E-Box	J01	5	TEMP-S2									
E-Box	J01	6	SENSE-SCREEN									
E-Box	J01	7	SENSE-X-(+)									
E-Box	J01	8	SENSE-Y-(+)									
E-Box	J01	9	SENSE-Z-(+)									
E-Box	J01	10	FEEDBACK-SCREEN									
E-Box	J01	11	FEEDBACK-X-(+)									
E-Box	J01	12	FEEDBACK-Y-(+)									
E-Box	J01	13	FEEDBACK-Z-(+)									
E-Box	J01	14	EXCITATION-RTN									
E-Box	J01	15	HEATER(-)									
E-Box	J01	16	TEMP-S1-RTN									
E-Box	J01	17	TEMP-S2-RTN									
E-Box	J01	18	HEATER-SCREEN									

Electrical Data Sheet 2: Pin Allocation List

Instrument: MERMAG

Unit name	Conn. name	Pin	Signal name	Sig. Ext.	IF-Drwg	S/L	Remarks	Wiring	Target-Unit	Target-Con	T-Pin	Ch. in issue
								Equipment deliverable unit-unit harness definition				
E-Box	J01	19	SENSE-X-(-)									
E-Box	J01	20	SENSE-Y-(-)									
E-Box	J01	21	SENSE-Z-(-)									
E-Box	J01	22	CHASSIS									
E-Box	J01	23	FEEDBACK-X-(-)									
E-Box	J01	24	FEEDBACK-Y-(-)									
E-Box	J01	25	FEEDBACK-Z-(-)									

MERMAG Pin Allocation List, Elec Box, Connector J02

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J02	1	EXCITATION									
E-Box	J02	2	EXCITATION-SCREEN									
E-Box	J02	3	HEATER(+)									
E-Box	J02	4	TEMP-S1									
E-Box	J02	5	TEMP-S2									
E-Box	J02	• 6	• SENSE-SCREEN									
E-Box	J02	• 7	• SENSE-X-(+)									
E-Box	J02	• 8	• SENSE-Y-(+)									
E-Box	J02	• 9	• SENSE-Z-(+)									
E-Box	J02	• 10	• FEEDBACK-SCREEN									
E-Box	J02	• 11	• FEEDBACK-X-(+)									
E-Box	J02	• 12	• FEEDBACK-Y-(+)									
E-Box	J02	• 13	• FEEDBACK-Z-(+)									
E-Box	J02	• 14	• EXCITATION-RTN									
E-Box	J02	• 15	• HEATER(-)									
E-Box	J02	• 16	• TEMP-S1-RTN									
E-Box	J02	• 17	• TEMP-S2-RTN									
E-Box	J02	• 18	• HEATER-SCREEN									

Electrical Data Sheet 2: Pin Allocation List

Instrument: MERMAG

Equipment deliverable unit-unit harness definition

Unit name	Conn. name	Pin	Signal name	Sig. Ext.	IF-Drwg	S/L	Remarks	Wiring	Target-Unit	Target-Con	T-Pin	Ch. in issue
E-Box	J02	• 19	• SENSE-X-(-)									
E-Box	J02	• 20	• SENSE-Y-(-)									
E-Box	J02	• 21	• SENSE-Z-(-)									
E-Box	J02	• 22	• CHASSIS									
E-Box	J02	• 23	• FEEDBACK-X-(-)									
E-Box	J02	• 24	• FEEDBACK-Y-(-)									
E-Box	J02	• 25	• FEEDBACK-Z-(-)									

MERMAG Pin Allocation List, Elec Box, Connector J03

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J03	1	Din+_MAIN									
E-Box	J03	6	Din-_MAIN									
E-Box	J03	2	Sin+_MAIN									
E-Box	J03	7	Sin-_MAIN									
E-Box	J03	3	Inner_shield_MAIN									
E-Box	J03	8	Sout+_MAIN									
E-Box	J03	4	Sout-_MAIN									
E-Box	J03	9	Dout+_MAIN									
E-Box	J03	5	Dout-_MAIN									

MERMAG Pin Allocation List, Elec Box, Connector J04

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J04	• 1	• Din+_RED									
E-Box	J04	• 6	• Din-_RED									
E-Box	J04	• 2	• Sin+_RED									
E-Box	J04	• 7	• Sin-_MAIN									
E-Box	J04	• 3	• Inner_shield_RED									
E-Box	J04	• 8	• Sout+_RED									
E-Box	J04	• 4	• Sout-_RED									
E-Box	J04	• 9	• Dout+_RED									
E-Box	J04	• 5	• Dout-_RED									

MERMAG Pin Allocation List, Elec Box, Connector J05

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J05	• 1	• +28V_MAIN									
E-Box	J05	• 6	• +28V_RTN_MAIN									
E-Box	J05	• 2	• not connected									
E-Box	J05	• 7	• not connected									
E-Box	J05	• 3	• not connected									
E-Box	J05	• 8	• not connected									
E-Box	J05	• 4	• not connected									
E-Box	J05	• 5	• not connected									
E-Box	J05	• 9	• Chassis									

MERMAG Pin Allocation List, Elec Box, Connector J06

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J06	• 1	• +28V_RED									
E-Box	J06	• 6	• +28V_RTN_RED									
E-Box	J06	• 2	• not connected									
E-Box	J06	• 7	• not connected									
E-Box	J06	• 3	• not connected									
E-Box	J06	• 8	• not connected									
E-Box	J06	• 4	• not connected									
E-Box	J06	• 5	• not connected									
E-Box	J06	• 9	• Chassis									

MERMAG Pin Allocation List, Elec Box, Connector J07

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J07	1	GND_OB									
E-Box	J07	6	+8V_OB									
E-Box	J07	2	-8V_OB									
E-Box	J07	7	+5V_OB									
E-Box	J07	3	+3.3V_OB									
E-Box	J07	8	+2.5V_OB									
E-Box	J07	4	GND_OB									
E-Box	J07	9	Not connected									
E-Box	J07	5	CHASSIS									

MERMAG Pin Allocation List, Elec Box, Connector J08

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J08	1	CLK+_OB									
E-Box	J08	9	CLK-_OB									
E-Box	J08	2	GND									
E-Box	J08	10	SYNC+_OB									
E-Box	J08	3	SYNC-_OB									
E-Box	J08	11	GND									
E-Box	J08	4	SE_TX+_OB									
E-Box	J08	12	SE_TX-_OB									
E-Box	J08	5	GND									
E-Box	J08	13	SE_RX+_OB									
E-Box	J08	6	SE_RX-_OB									
E-Box	J08	14	GND									
E-Box	J08	7	Not Connected									
E-Box	J08	15	Not Connected									
E-Box	J08	8	CHASSIS									

MERMAG Pin Allocation List, Elec Box, Connector J09

Electrical Data Sheet 2: Pin Allocation List Instrument: MERMAG								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J09	1	GND_IB									
E-Box	J09	6	+8V_IB									
E-Box	J09	2	-8V_IB									
E-Box	J09	7	+5V_IB									
E-Box	J09	3	+3.3V_IB									
E-Box	J09	8	+2.5V_IB									
E-Box	J09	4	GND_IB									
E-Box	J09	9	Not Connected									
E-Box	J09	5	CHASSIS									

MERMAG Pin Allocation List, Elec Box, Connector J10

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J10	1	CLK+_IB									
E-Box	J10	9	CLK-_IB									
E-Box	J10	2	GND									
E-Box	J10	10	SYNC+_IB									
E-Box	J10	3	SYNC-_IB									
E-Box	J10	11	GND									
E-Box	J10	4	SE_TX+_IB									
E-Box	J10	12	SE_TX-_IB									
E-Box	J10	5	GND									
E-Box	J10	13	SE_RX+_IB									
E-Box	J10	6	SE_RX-_IB									
E-Box	J10	14	GND									
E-Box	J10	7	Not Connected									
E-Box	J10	15	Not Connected									
E-Box	J10	8	CHASSIS									

MERMAG Pin Allocation List, Elec Box, Connector J11

Electrical Data Sheet 2: Pin Allocation List Instrument: MERMAG								Equipment deliverable unit-unit harness definition				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J11	1	CHASSIS									
E-Box	J11	6	Not Connected									
E-Box	J11	2	GND_ICU									
E-Box	J11	7	GND_ICU									
E-Box	J11	3	+3.3V_ICU									
E-Box	J11	8	+3.3V_ICU									
E-Box	J11	4	+1.8V_ICU									
E-Box	J11	9	+1.8V_ICU									
E-Box	J11	5	GND_ICU									

MERMAG Pin Allocation List, Elec Box, Connector J12

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J12	1	CLK+_OB									
E-Box	J12	14	CLK-_OB									
E-Box	J12	2	GND_ICU									
E-Box	J12	15	SYNC+_OB									
E-Box	J12	3	SYNC-_OB									
E-Box	J12	16	GND_ICU									
E-Box	J12	4	ICU_RX+_OB									
E-Box	J12	17	ICU_RX-_OB									
E-Box	J12	5	GND_ICU									
E-Box	J12	18	ICU_TX+_OB									
E-Box	J12	6	ICU_TX-_OB									
E-Box	J12	19	GND_ICU									
E-Box	J12	7	CLK+_IB									
E-Box	J12	20	CLK-_IB									
E-Box	J12	8	GND_ICU									
E-Box	J12	21	SYNC+_IB									

E-Box	J12	9	SYNC-_IB									
E-Box	J12	22	GND_ICU									
E-Box	J12	10	ICU_RX+_IB									
E-Box	J12	23	ICU_RX-_IB									
E-Box	J12	11	GND_ICU									
E-Box	J12	24	ICU_TX+_IB									
E-Box	J12	12	ICU_TX-_IB									
E-Box	J12	25	GND_ICU									
E-Box	J12	13	CHASSIS									

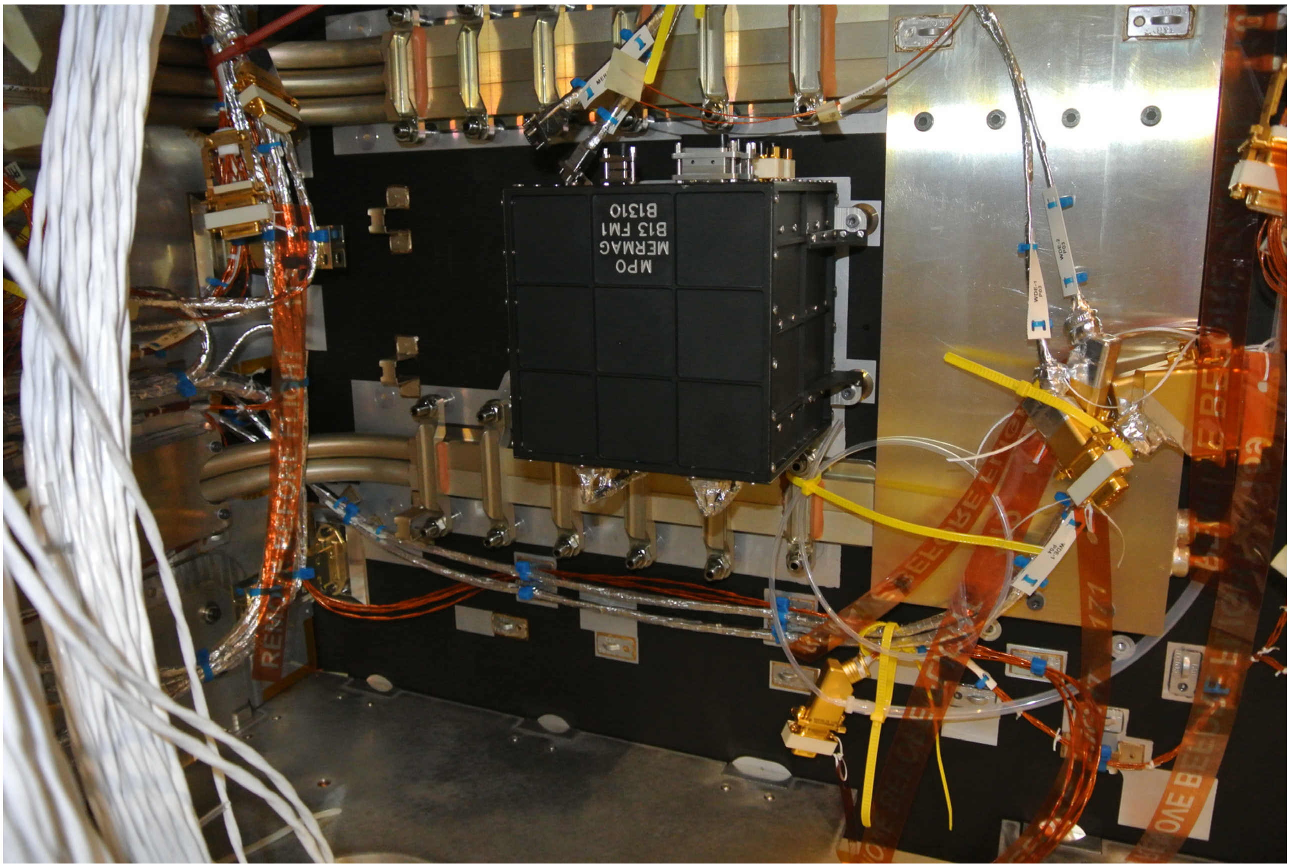
MERMAG Pin Allocation List, Elec Box, Connector J13

Electrical Data Sheet 2: Pin Allocation List **Instrument: MERMAG**								**Equipment deliverable unit-unit harness definition**				
Unit name	**Conn. name**	**Pin**	**Signal name**	**Sig. Ext.**	**IF-Drwg**	**S/L**	**Remarks**	**Wiring**	**Target-Unit**	**Target-Con**	**T-Pin**	**Ch. in issue**
E-Box	J13	1	GND_OB									
E-Box	J13	14	+8V_OB									
E-Box	J13	2	-8V_OB									
E-Box	J13	15	+5V_OB									
E-Box	J13	3	+3.3V_OB									
E-Box	J13	16	+2.5V_OB									
E-Box	J13	4	GND_OB									
E-Box	J13	17	Not connected									
E-Box	J13	5	NC									
E-Box	J13	18	GND_IB									
E-Box	J13	6	+8V_IB									
E-Box	J13	19	-8V_IB									
E-Box	J13	7	+5V_IB									
E-Box	J13	20	+3.3V_IB									
E-Box	J13	8	+2.5V_IB									
E-Box	J13	21	GND_IB									
E-Box	J13	9	NC									

E-Box	J13	22	CHASSIS									
E-Box	J13	10	GND_ICU									
E-Box	J13	23	GND_ICU									
E-Box	J13	11	+3.3V_ICU									
E-Box	J13	24	+3.3V_ICU									
E-Box	J13	12	+1.8V_ICU									
E-Box	J13	25	+1.8V_ICU									
E-Box	J13	13	GND_ICU									

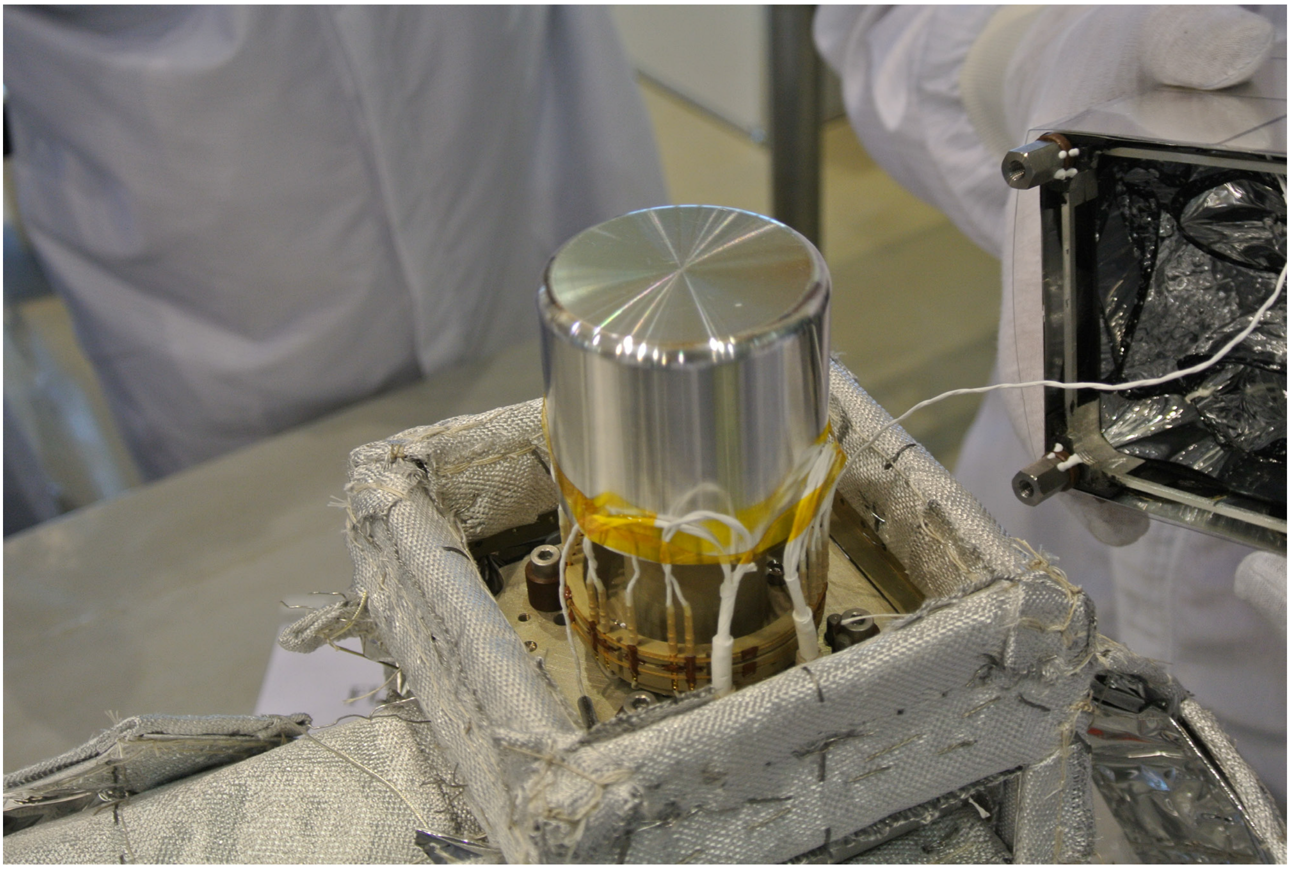
13. APPENDIX E INSTRUMENT PICTURES

Electronics Box:

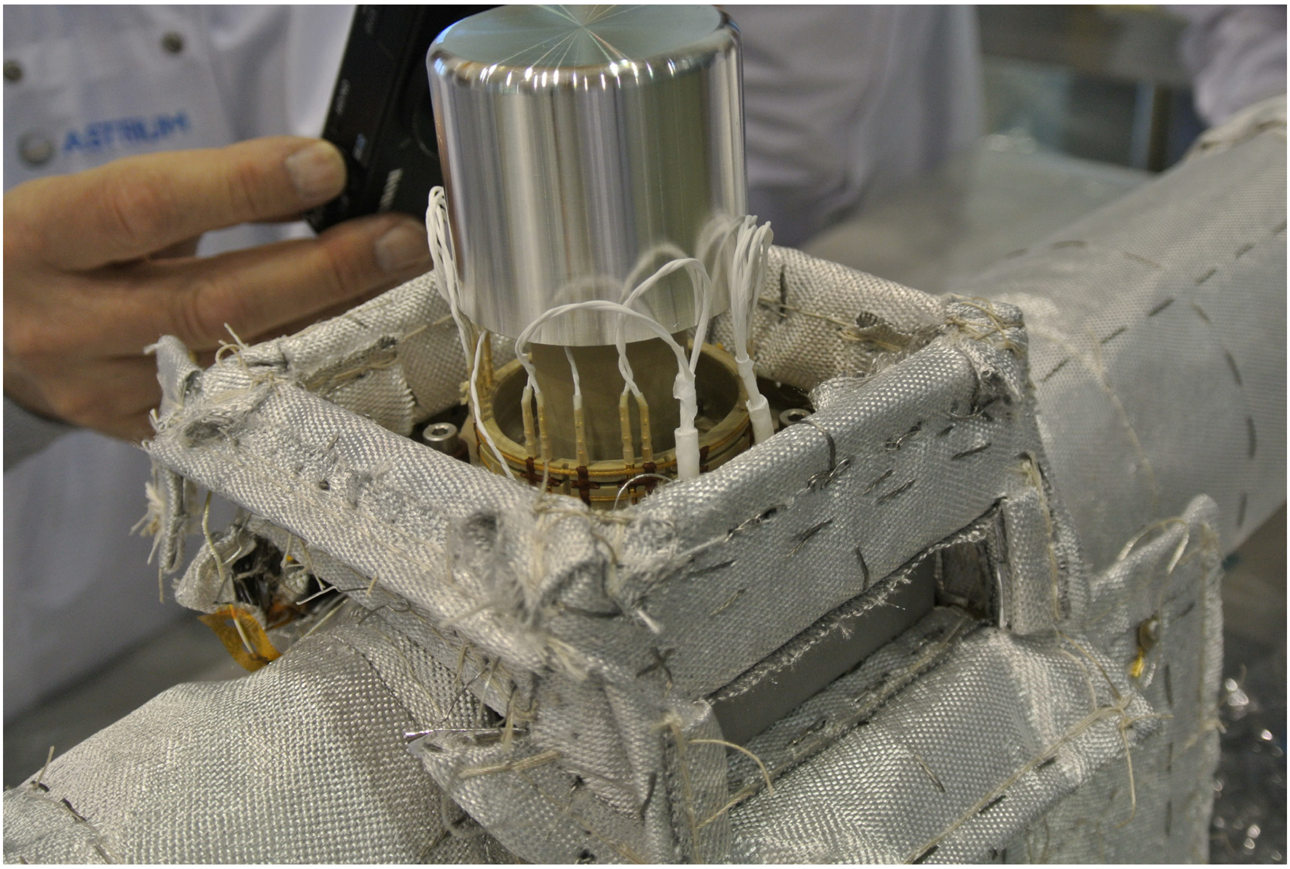


OB sensor (with attached magnetic shielding) and IB Sensor mounted on the boom:

OB Sensor:



IB Sensor:



IB Sensor with attached Thermal Shielding: