VIRTIS
EXPERIMENT USER MANUAL
ProtoFlight Model

Issue 3
(Working Copy)

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DOCUMENTATION CHANGE RECORD

Issue	Revision	Section	Date	Changes
1Draft	0	ALL	15/09/00	First Draft Issue
1Draft2			27/07/01	Preliminary revision
2		ALL	7/5/2002	Full revision
3				1. Paragraph 3.3 removed 2. Fig. 3.2. State Transitions changed 3. Added NCR induced constraints 4. Updated Mass Budget (metrology reports from PFM_ADP) 5. Updated Power Budget 6. Chapters 5.4 and 5.3 exchanged 7. Updated Flight Operation Sequences 8. Chapters 4.4 and 5.2. Recovery OBCP removed. Updated description of Failure On-Board Actions 9. Added AD : RSOC ICD 10. Updated Attachment List 11. Updated In-Flight Calibration sequence description for M and H

Da aggiungere:

- aggiungere considerazioni su “h slice lost event” (vedi mail di semery)
- aggiornare S/W version pag 76
- aggiornare contingency recovery procedures cap 5.6.
- aggiornare tabella 1.1 con valori post-calibrazione (spectral sampling…)
- aggiungere capitolo su come preparare una osservazione; considerare summing on spot and by binning
- aggiungere capitolo su come scaricare e spacchettare i dati dal dds.
- SCAN MIRROR: boresight definition and general usage: how to make images
- H/K errato relativo all’alimentazione della EEPROM (vedi mail Claudio/Gisbert)
- Pointing constraints wrt to S/C pointing
- Correggere Data Rates nella tabella modi VIRTIS-M (ricontrollarli con la formula data dopo)
- Filter location

RELATED DOCUMENTS

Applicable Documents

AD1	RO-EST-RS-3001/EID-A Issue2 rev.1, October 2000	
AD2	RO-EST-RS-3015/EID-B Issue 2 rev.0, March 2001	
AD3	RO-EST-RS-3001/EID-C Issue1 rev.3 December 1999	
AD4	RO-ESC-TN-5022 Issue 1, March 2001	Commissioning Operations
AD5	RO-ESC-TN-5018 Issue 1, December 2000	Planets swing-by Operations
AD6	RO-ESC-TN-5019 Issue 1, December 2000	Near Sun Cruise Operations
AD7	RO-ESC-TN-5017 Issue 1, December 2000	Asteroids Fly-By Operations
AD8	RO-DSS-RS-1024 Issue1, December 2001	VIRTIS OBCP URD
AD9	VIR-GAL-IC-028, Issue 7,July 2001	VIRTIS S/W Internal ICD
AD10	VIR-GAL-UR-040, Issue 5, July 2001	VIRTIS S/W User Req.
AD11	RO-ESC-PL-5000, Issue 4.3, 10/02/2004	Flight Operation Plan
AD12	RO-EST-IF-5010, Issue 1, February 2002	RSOC to PI ICD

Abbreviations

ANC	Condition Analog T/M
CCD	Charged Coupled Device
CCE	Cooler Controller Electronics
CE	Close Encounter
DHSU	Data Handling and Support Unit
DMS	Data Management System (the on board computer)
ECA	Emergency Cover Actuator
EGSE	Electrical Ground Support Equipment
HRD	High Speed Link
IRFPA	InfraRed Focal Plane Assembly
ME	Main Electronic Module
MLC	Memory Load Commands
OBCP	On-Board Control Procedure
OBDH	On-Board Data Handling
OTS	DMS Timing & Syncro Signal
PDU	Power Distribution Unit
PEM-H	Proximity Electronics Module H
PEM-M	Proximity Electronics Module M
PFM	Proto-Flight Model
PS	Power Supply
ROIC	Read-Out Interface Circuit
RTU	Remote Terminal Unit
SCET	Space Craft Elapsed Time
SDT	Serial 16 bit Digital Telemetry
SSMM	Solid State Mass Memory
VIRTIS	Visual, InfraRed and Thermal Imaging Spectrometer
VIRTIS-H	High Spectral Resolution Optical Head
VIRTIS-M	Mapping Spectrometer Optical Head

1 General Description

1.1 Scientific Objectives

VIRTIS is a sophisticated imaging spectrometer that combines three unique data channels in one compact instrument. Two of the data channels are committed to spectral mapping and are housed in the Mapper (**-M**) optical subsystem. The third channel is devoted solely to spectroscopy and is housed in the High resolution (**-H**) optical subsystem.

The nature of the solid compounds of the comets (silicates, oxides, salts, organics and ices) is still largely unknown. These chemical compounds can be identified by infrared spectroscopy using high spatial resolution imaging to map the heterogeneous parts of a *nucleus* and high spectral resolution spectroscopy to determine the composition unambiguously. The visual and infrared spectrum of the comet *coma* is characterised by a number of components comprising both gas emission bands and a dust continuum. Ground-based visual spectroscopy has detected various atomic, radical and ionic species formed through photo-dissociation by solar ultraviolet radiation of the so-called "parent" molecules which are sublimated from the nucleus and possibly from a halo of volatile grains. Previous IR comet observations have shown that various hydrocarbons show emission bands between 3 and 4 μm.

A Multispectral Imager - covering the range from the near UV (0.25 μm) to the near IR (5.0 μm) and having moderate to high spectral resolution and imaging capabilities - is an appropriate instrument for the determination of the comet global (size, shape, albedo, etc.), and local (mineralogical features, topography, roughness, dust and gas production rates, etc.) properties.
The VIRTIS instrument shall be capable of achieving the VIRTIS Rosetta Science Team objectives outlined below.

1.1.1 VIRTIS Science Objectives

The primary scientific objectives of the VIRTIS during the Rosetta mission are:

- to study the cometary nucleus and its environment,
- determine the nature of the solids of the nucleus surface,
- identify the gaseous species,
- characterise the physical conditions of the coma,
- measure the temperature of the nucleus.

Secondary objectives include helping with the selection of landing sites and providing support to other instruments.

Tertiary objectives include the detection and characterisation during flybys of the asteroids Steins and Lutetia.

1.1.2 VIRTIS-M Nucleus Science Objectives

- Identify different ices and ice mixtures and determine their spatial distribution for an albedo ranging from 0.02 to 0.4. This requires sensors (in the Vis and IR) with good dynamics and high sensitivity at low photon numbers . *The Vis and IR sensors procured for VIRTIS are designed in order to satisfy the previous requirements.*
- Identify the carbonaceous materials and determine the overall continuum slopes of the spectra. This requires S/N> 100. The characteristics of the thermal design of VIRTIS are such to guarantee that a reduced background noise; the characteristics of the optical design of VIRTIS guarantee a low stray light.
- Determine the physical microstructure and nature of the surface grains by measuring the spectrophotometric phase curve with a relative radiometric accuracy of 1%. *The thermal stability of the instrument obtained by design, permits to achieve this goal. The calibration p rocedures defined both for in-flight and ground calibration will permit to reach this goal.*
- Identify the silicates, hydrates and other minerals with a spectral resolution of $\lambda/\Delta\lambda >$ 100 in the full spectral band. *The selected sensor and the optical design of the instrument are optimised in order to achieve these objectives.*
- With a spatial resolution of a few tens of meters, globally map the nucleus and determine the spatial distribution of the various mineralogical types and their mixtures using both the spectral features and the overall brightness. *The procured sensorand the optical design are optimised in order to achieve these objectives. Moreover the presence of the scanning mirror in VIRTIS M will permit to map specific areas on the surface and, if needed in order to achieve a higher S/N, to compensate the relative motion S/C – surface on specific regions of the comet nucleus.*
- Detect and monitor active areas on the comet surface, such as gas volcanism, to understand the physical processes operating and identify the associated material types. *The presence of the scanning mirror in VIRTIS M will permit to follow the evolution of active areas on the surface.*

1.1.3 VIRTIS-M Coma Science Objectives

- With a resolving power of 100, determine the global distribution of gas and dust in the inner coma with to absolute and relative radiometric accuracy < 20% and 1% relative. *The procured sensor and the optical design are optimised in order to achieve these objectives. The presence of the scanning mirror in VIRTIS M will permit to map a larger part of the coma.*
- Determine the thermal properties of the dust.
- Identify and map the strong molecular emissions in the near ultraviolet and visible spectral band including the main water dissociation product OH at 0.28 mm and 0.31 mm, CN,C3, NH, CH and CO^+ ions, and the neutral radicals CN and C_2. With a high spatial resolution of 250 μrad and a moderate spectral resolution of 500, correlate the evolution of radicals with that of their parent molecules. *The procured sensor and the optical design are optimised in order to achieve these objectives The presence of the scanning mirror in VIRTIS M will permit to map a larger part of the coma.*
- Correlate the results of these measurements with ground based telescopic observations.

- Map the composition and evolution of gas and dust jets in the coma and correlate it with the mineralogical composition and spatial morphology of active regions on the nucleus surface. *The presence of the scanning mirror in VIRTIS M will permit to follow the evolution of active areas on the surface.*

1.1.4 VIRTIS-H Nucleus & Coma Science Objectives

- With a S/N > 100 and resolving power higher than 1000, determine the composition of ices on the nucleus surface by resolving the absorption bands of condensed molecules between 2 and 3 microns
- In the 2 to 5 micron band, identify molecules in the gas, and measure rotational temperature. With a resolving power of 1500 at 3.5 micron, identify the hydrocarbon emission in the 3 to 4 micron band. *The needed spectral resolving power is achieved by the design and thanks to the characteristics of the procured IR sensor.*
- Determine the composition of the dust grains in the coma by observing emission features in the fundamental bands between 2.5 and 5 microns at less than 2 A.U.

1.1.5 VIRTIS Asteroid Science Objectives

The asteroid part of Rosetta mission includes the encounter with two asteroids. The present selection of the Rosetta target-asteroids has been agreed by ESA with the support of the scientific community. It should be stressed out the selection of two asteroids different in size and in composition like 2867 Steins and 21Lutetia will strongly increase the scientific return.
VIRTIS should allow the determination of the global and local properties of the target asteroids. The scientific goals achievable with a minor planet encounter are:
The characterisation of global shape of the asteroid and the knowledge of its physical properties: size, shape, pole and rotational period, dimension, density.
The study of the morphological characteristics (local features, craters distribution, evidence of possible regolith) and mineralogical composition (heterogeneity of the surface, identification of local chemical provinces, first layer texture).
The analysis of the asteroid environment to detect the presence of dust or gas.
The characteristics of the optical and thermal design of the two channels as well as the characteristics of the 3 FPAs of VIRTIS guarantee the achievement of the previously listed scientific requirements.
The scanning mirror of VIRTIS M will be particularly useful in order to map different areas on the asteroid surface and , if needed , to point particularly interesting zones compensating the S/c motion during the 2 fly-bys.

1.2 Experiment Overview

In table 1.1 are reported the main characteristics of the VIRTIS instruments along with the required radiometric performances.

1.2.1 General Instrument Description

VIRTIS is an imaging spectrometer that combines three data channels in one compact instrument. Two of them are devoted to spectral mapping (Mapper optical subsystem: -M). The third channel is devoted to spectroscopy (High resolution optical subsystem:-H).
As shown in the functional block diagram of Figure 1.1, VIRTIS is made of 5 Modules: an Optics Module containing the –M and –H Optical Heads, the two Proximity Electronics Modules for –M and –H and the Main Electronic Module.
The Optics Module is externally mounted to the -X panel of the spacecraft with the -M and -H Optical Heads co-aligned and boresighted in the positive Z direction. Both optical systems have their slits parallel to the Y axis; the -M has the ability to point and scan by rotating the primary mirror around the Y axis. Two views of the Optics Module are given in figures 1.2 and 1.3.
The -M utilises a silicon charge coupled device (CCD Thomson TH7896) to image from .25 um to 1 μm and a mercury cadmium telluride (HgCdTe) infrared focal plane array (IRFPA from Raytheon) to image from 1 μm to 5 μm. The -H uses the same HgCdTe IRFPA to perform spectroscopy in selected bands from 2 μm to 5 μm (see table 1.1).
The Optics Module is electrically connected by the Inter-Unit Harness to the -M and -H Proximity Electronics Modules and to the Main Electronics Module, which are internally mounted to the spacecraft on its -Y panel.
The electronics boards required to drive the CCD and the two IRFPAs and to acquire H/K information from the optical heads are housed inside the Proximity Electronics Modules, while the Main Electronics Module takes care of the control of the interfacing with the PEMs and with the S/C, of the control of the cryocoolers, of the power conditioning and distribution, and performs all the digital data analysis.

The infrared detectors require active cooling to minimise the detector dark current (thermally generated Johnson noise). Their operative temperature is 70K. To minimise the thermal background radiation seen by these two IRFPAs, the Optics Module is divided in two parts:

- The Pallet which is directly interfaced to the warm S/C (i.e. thermally controlled by the S/C) and contains the two cryocoolers.
- The Cold Box which is a structure rigidly mounted to the much warmer Pallet while remaining thermally insulated from it. The Cold Box contains the cold detectors and the two Optical Heads and is thermally disconnected from the S/C and passively cooled to 130 K by radiating one of its surfaces toward cold space. The optical heads are mounted on the Cold Box Ledge

VIRTIS MAIN CHARACTERISTICS AND REQUIREMENTS			
	VIRTIS – M Visible	**VIRTIS – M InfraRed**	**VIRTIS – H**
Spectral Range (nm)	220.1 – 1046.0	952.8 – 5059.2	*Order* 0 4.05-5.03 *Order* 1 3.47-4.32 *Order* 2 3.04-3.78 *Order* 3 2.70-3.37 *Order* 4 2.43-3.03 *Order* 5 2.21-2.76 *Order* 6 2.03-2.53 *Order* 7 1.88-2.33
Spectral Resolution $\lambda/\Delta\lambda\lambda$	100 – 380	70 – 360	1300-3000
Spectral Sampling (nm) (1)	1.89	9.44	0.6
Field of View (mrad x mrad)	63.6 (slit) x 64.2 (scan)	63.6 (slit) x 64.2 (scan)	0.49X1.47
Max Spatial Resolution (μrad)	248.6 (slit) x 250.8 (scan)		
Pointing	+Zsc and Boresighted with Osiris, NavCam		
Telescope	Shafer Telescope	Shafer Telescope	Off axis parabolic mirror
Pupil Diameter (mm)	47.5		32
Imaging F#	5.6	3.2	2.04
Etendue (m^2 sr)	4.6×10^{-11}	7.5×10^{-11}	$.8 \times 10^{-9}$
Slit Dimension (mm)	0.038 x 9.53		0.029 x 0.089
Spectrometer	Offner Relay	Offner Relay	Echelle spectrometer
Detectors	Thomson TH7896 CCD	CdHgTe (2)	CdHgTe (2)
Sensitivity Area Format	508 x 1024	270 x 436	270 x 436
Pixel Pitch (μm)	19	38	38
Operating temp. (K)	150 to 190	65 to 90	65 to 90
Spectral range (μm)	0.25 to 1.05	0.95 to 5.0	0.95 to 5.0
Mean Dark Current	< 1 e^{-1}/s	< 10 fA @ 70K	< 10 fA @ 70K
Radiometric Resolution SNR	> 100	> 100	> 100 @ 3.3 μm
Radiometric Accuracy Absolute Relative	 < 20% < 1 %	 < 20% < 1 %	 < 20% < 1 %

(1) Depends on selected mode of operation; here is reported the maximum value (no pixel summing)
(2) VIRTIS-M and –H use identical IR detectors.

Table 1.1 - VIRTIS characteristics and Performances Overview

Two cold fingers connect the two active coolers inside the Pallet to their corresponding IRFPAs inside the Cold Box; they must maximise the thermal pathway from the coolers to the IRFPAs while remaining mechanically pliant; in contradistinction, the stand-off insulators (eight Titanium rods) connecting the Cold Box to the baseplate of the Pallet must minimise the thermal pathway between the warm spacecraft and the cold optical subsystems while remaining mechanically rigid. In this way the structure and the delicate subsystems that it supports are not only guaranteed to survive launch vibrations, but the structure can also help in minimising the usual thermal gradients that adversely affect the alignment of low temperature optical systems.

Since the CCD is a frame transfer device, and the IRFPAs are direct injection devices, exposure times can be controlled electronically. However, measurement of the detector dark current plus background radiation requires calibration shutters to be placed at the entrance light limiting slit of each spectrometer (telescope background contribution is negligible because of its low temperature and the narrow width of the slit).

The M and H channels are equipped with a protective cover to protect the instrument from dust contamination and damage when not operational. The covers are located between the baffles and the entrance borehole; they are commanded by the ME and controlled by S/W. Each cover is also equipped with an emergency actuator to force open the cover in case of malfunctions.
The covers have an additional use as they are machined as retro-reflectors for the in-flight spectral calibration. The instrument with he cover close shall then be calibrated in-flight. This features comes useful also for the on ground testing of the instrument.

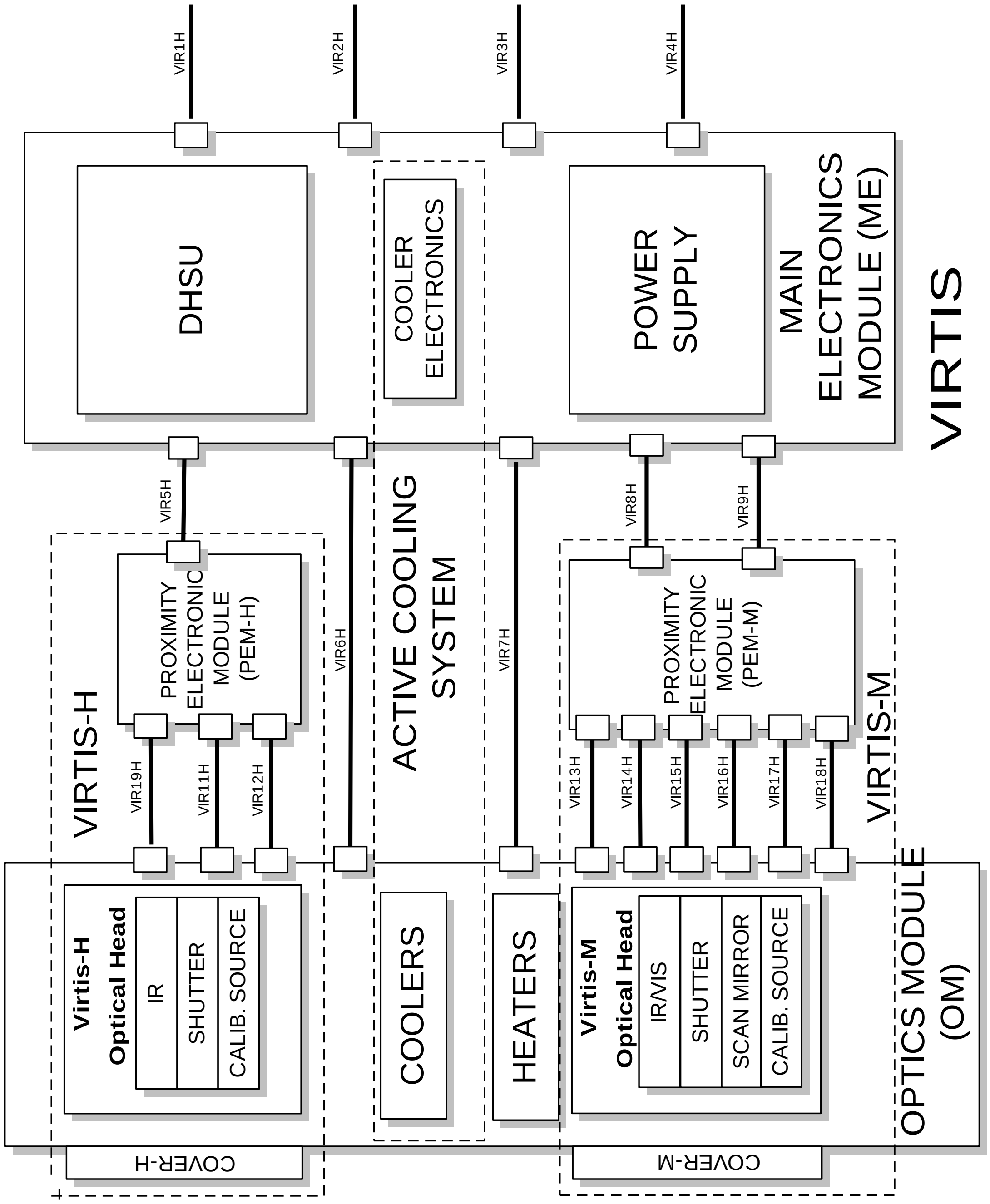


Figure 1.1 VIRTIS Functional Block Diagram

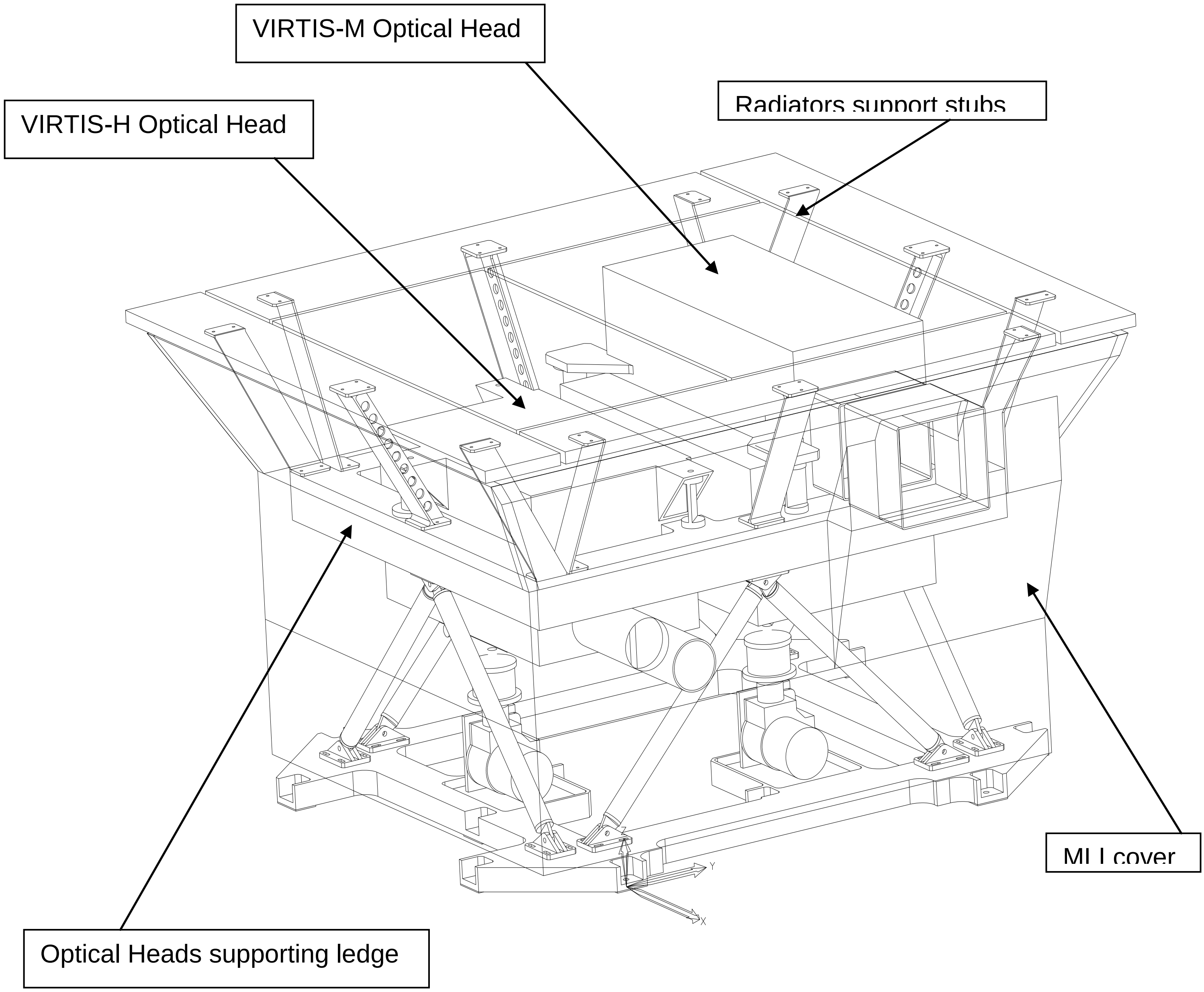


Figure 1.2: VIRTIS Optics Module

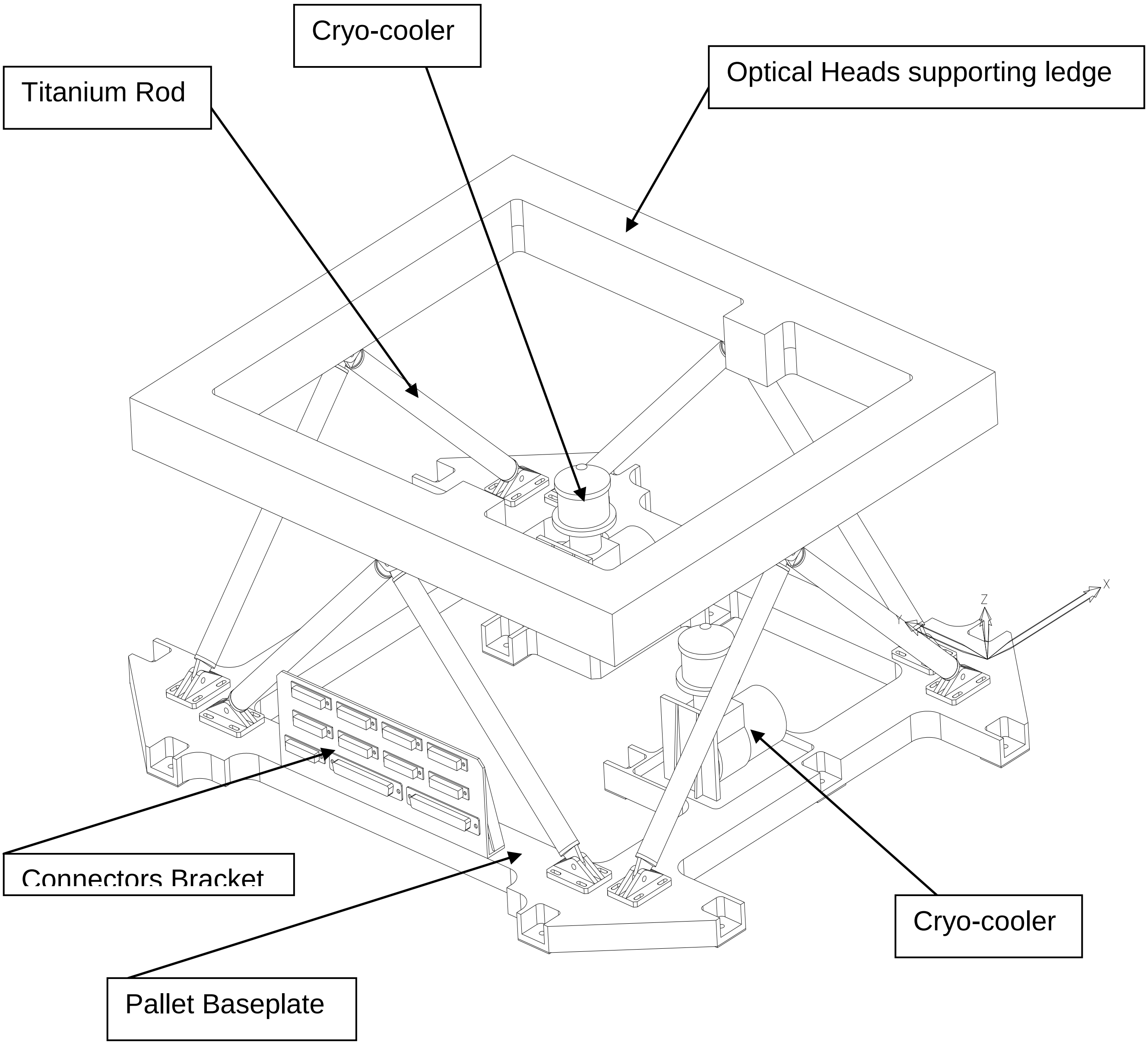


Figure 1.3: VIRTIS Frame showing : a) the baseplate pallet with the two cryocoolers and the connector bracket; b) the 8 titanium rods used to fix the Cold Box mounting Ledge on the baseplate; c) the empty ledge to which the two Optical Heads are rigidly connected.

2 Experiment Configuration

2.1 Physical I/F

The VIRTIS mechanical interfaces drawing (MICD) for the Proto Flight Model (PFM) are given in attachment 1.
To improve the mechanical description of the instrument in attachment 1 are also given the top level assembly drawings describing the various experiment modules.

2.2 Electrical I/F

2.2.1 Power Interface Circuit

The primary power (+28 V) will be received from the S/C power bus via a main and redundant interface. This voltage supplies the VIRTIS main components (ME, VIRTIS-M, VIRTIS-H) using the architecture shown in Figure 2.1
The main and redundant input lines are directly connected to the Main/Redundant DHSU converter without cross-coupling. In accordance with the VIRTIS reliability approach, only the power converter for the DHSU is redundant, while non redundant power converters are used to provide power to both optical modules (-H and -M subassemblies) and Cooler Control Electronics (CCE).
VIRTIS is switched on by applying a voltage higher than 25V to the main/redundant bus.
The DC/DC converters frequency is 131 KHz ± 5%.
In addition to the primary power interface 2 heaters are requested;

- Two for the Decontamination Heaters located in proximity of each optical Head (VIRTIS-H and VIRTIS-M) for optics decontamination and/or de-icing of radiators and covers (TBC). Two different heater circuits are implemented and are directly connected to LCL switches located in the S/C PCU, that will be ON simultaneously. **For design reasons one of the heaters is located on the main power bus line and the other on the redundant one, but they shall be on at the same time**.
- Two for the CCD non-ops heater which shall be used to control the CCD temperature during the hybernation phases.

The required power interfaces for VIRTIS are shown in table 2.1

Function	Main Lines	Redundant Lines	LCL Class
+ 28V Main Bus	1	1	F
+ 28V Decontamination Heater Line(1)	1	1	D
+28V CCD non-ops heater line (1)	1	1	A
Keep-Alive Supply	N/A	N/A	N/A

(1) The two decontamination heaters are located on the main and redundant lines but is intended that they must be on at the same time to achieve the required heat input to perform their required function.

Table 2.1 Power Supply Interface Requirements

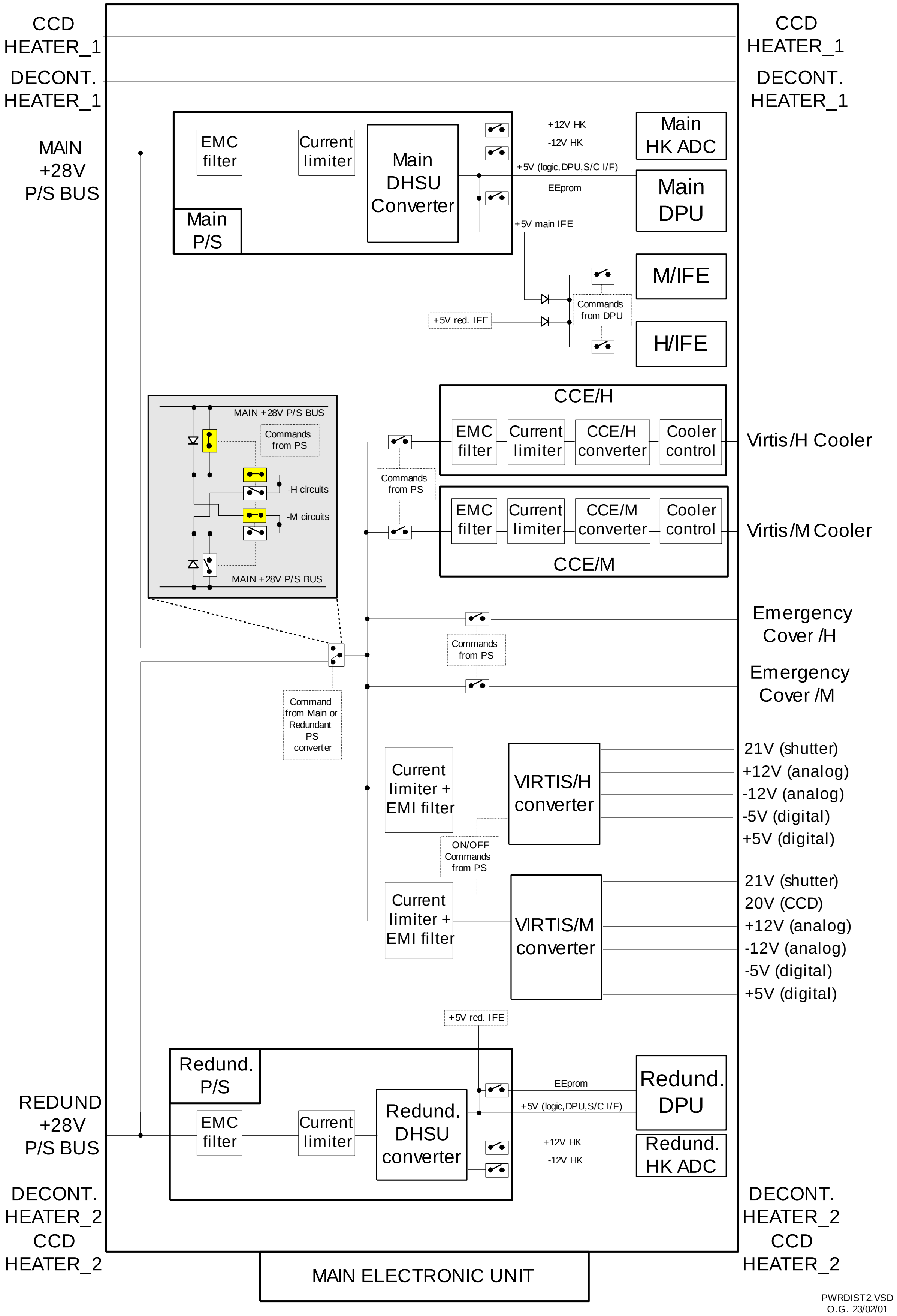


Figure 2.1 Power switching and Distribution block diagram.

The internal power distribution shown in figure 2.1 contains 6 DC/DC converters with their own current limiters and EMI filters:

- Main and Redundant DHSU. Generate the ME internal voltages in cold redundancy. These converters are switched on exclusively by the S/C power I/F
- VIRTIS-M and VIRTIS-H converters. Generate all voltages for VIRTIS-M and VIRTIS-H subsystems
- CCE-H and CCE-M converters. Generate all voltages for cooler control circuit voltages.

DHSU and VIRTIS-M/H converters are located in the PS unit while the CCE-M and CCE-H are located in two independent Cooler Control Boards (one for H one for M).

All converters can be on at the same time, however at power on (from the S/C) only the DHSU (Main or Redundant) shall be active. All others converters shall be powered by DHSU, via power switches controlled by the DHSU on the primary voltage side.

The characteristics of the power line is summarised in table 2.2

POWER LINE CHARACTERISTICS	
Maximum Average Input current (@28V)	
Nominal Operations	2.35 A
Occasional Decontamination	2.8 A
Inrush Characteristics	
Peak Current @28V for t < 8 ms measured on the EQM	5.8 A
Current for 8 ms < t < 65 ms measured on the EQM	4 A
Isolation	
Primary power from structure	> 1 MΩ
Primary from secondary power	> 1 MΩ
EMI Characteristics	Power converters are internally synchronised at 131 kHz +/- 5 %

Table 2.2 Operational Power Interface Characteristics

2.2.2 Pyrotechnic Interface Circuits

VIRTIS does not uses pyrotechnic devices.

2.2.3 OBDH Interface Circuits

The communication interfaces with the S/C are reported in table 2.3 along with their type and functions. All interfaces are connected to the Remote Terminal Unit of the S/C (RTU) , while the High Speed Data are directly delivered through a special link to the SSMM.

INTERFACE	SIGNAL TYPE OR FUNCTION	MAIN	REDUNDANT
Telecommand Channels	Memory Load Commands	1	1
	High Power ON/OFF Commands	0	0
Telemetry Channels	16bit serial digital channel	1	1
	High Speed telemetry channel	1	1
Monitor Channels	S/C powered thermistors	2	2
	Bi-level channels	0	0
	Analogue channels	0	0
Timing Channels	High frequency clock	1	1
	Broadcast pulse	1	1

Table 2.3 Experiment OBDH Interface Channels/Functions

In the following figures (from 2.2 through 2.10) and tables (from 2.4 through 2.8) are reported the interface circuits for Memory Load Commands (MLC), Serial 16 bit Digital Telemetry (SDT), High Speed Link (HRD), DMS Timing & Synchro Signal (OTS) and for the Conditioned Analog T/M (ANC).

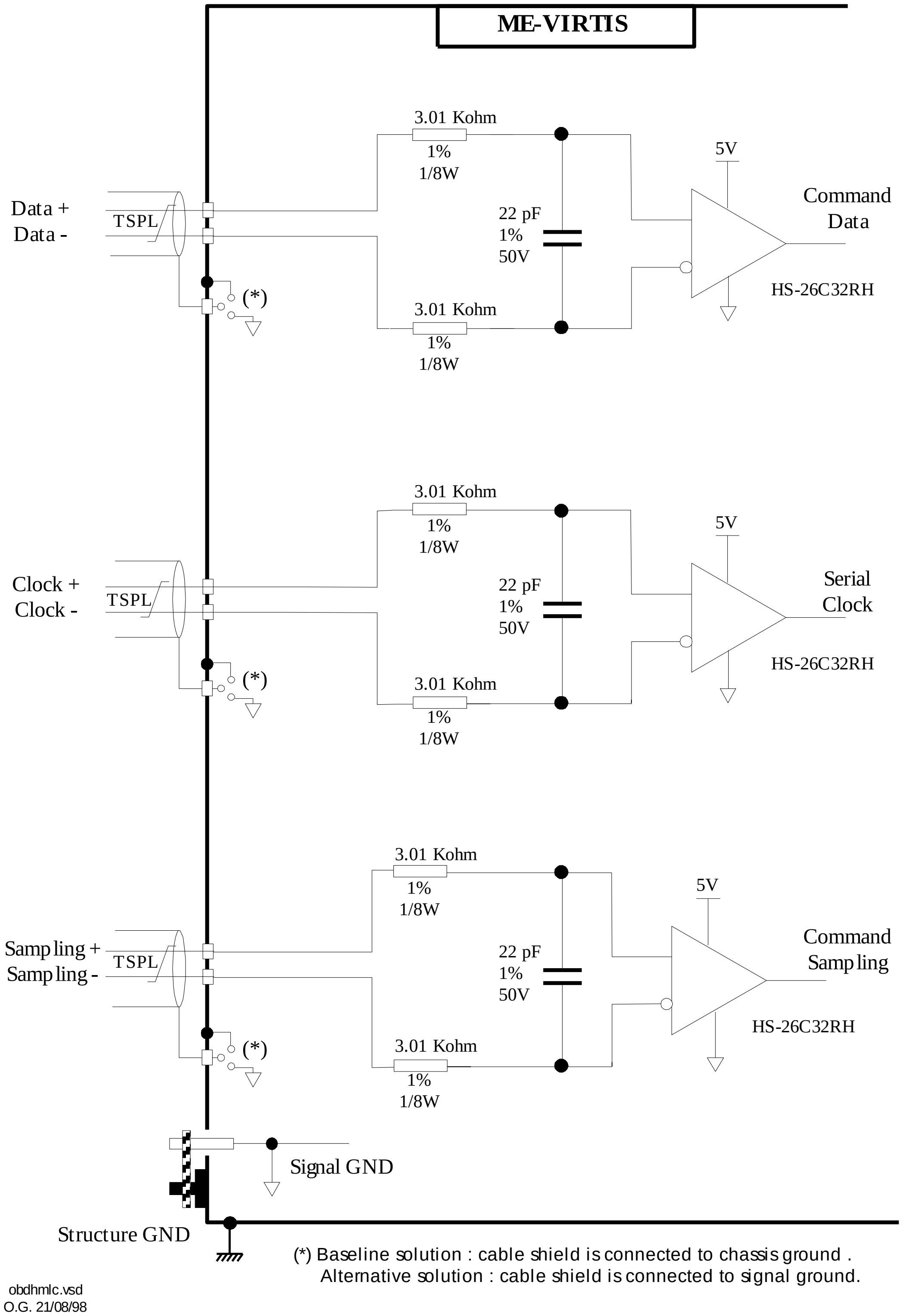
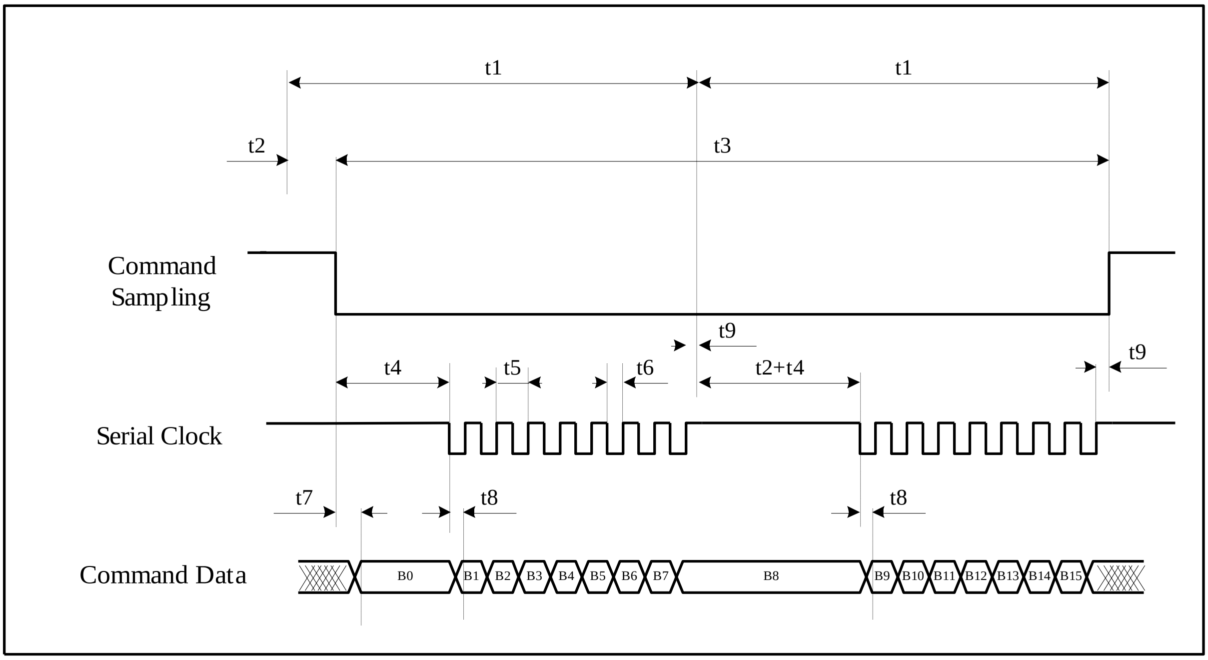


Figure 2.2 MLC (Memory Load Command) interface circuit



Acquisition rate		131 Kbps
t1		61.0us
t2		3.8us+1.5us/-1.0us
t3		118.3us+1.0us/-1.5us
t4		26.7us+1.0us/-1.5us
t5		3.8us
t6		1.9us+/-0.5us
t7		</= 3.8us
t8		1.4us+.5us/-0.6us
t9		>/= 1.4us
Sample	tr	< 700ns
	tf	< 700ns
Serial Clock	tr	< 700ns
	tf	< 700ns
Command Data	tr	< 700ns
	tf	< 700ns

Serial Clock / High Frequency Clock relationship

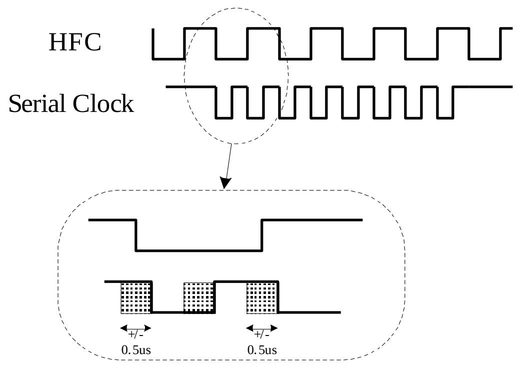


Figure 2.3 MLC (Memory Load Command) timing characteristics

I/F Designation	Memory Load Command (MLC)		1 of 1
The interfaces comprises the following three circuits : • MLD - memory load command data receiver • STC - serial data transfer clock receiver • MLS - memory load command sampling receiver			
Receiver Specification			
Circuit Type	differential receiver , CMOS compatible		
Transfer	DC coupled		
Differential Input Voltage ($-1V \geq V_{cm} \leq +1V$)	Low : <= -1V (bit logic value 0) High : <=+1V (bit logic value 1)	(1)	
Quiescent state	MLD true line = Low level (0V)	(2)	
	STC true line = High level (5V)	(2)	
	MLS true line = High level (5V)	(2)	
Hysteresis	N/A		
Common Mode Isolation	In accordance with par. 2.9.2.1.3 of AD1		
Diff. Input Impedance	>= 10 KΩ	(3)	
Noise Rejection	In accordance with par. 2.9.4.2.4 of AD1		
Maximum Fault Voltage	Tolerance : –0.5V to +7V	(4)	
	Emission : -0.0V to 5.5 V	(5)	
Operating frequency	262 KHz (burst)		
Harness Specification			
Wiring Type	Twisted Shielded Pair - Low Capacitance		
Core to Core Cap.	< 700 pF		
Core to Shield Cap.	< 1 nF		
Shield Connection	connected to chassis ground		
Notes			
(1) At experiment connector level. (2) Outside of the memory load data transfer. (3) Considering minimum input resistance of HS-26C32RH = 4 Kohm (-7V < VCM < +7V) (4) With input current limited to 1.5mA (5) Digital supply voltage designed to be below 7.0V in case of fault.			

Table 2.4 MLC (Memory Load Command) interface characteristics

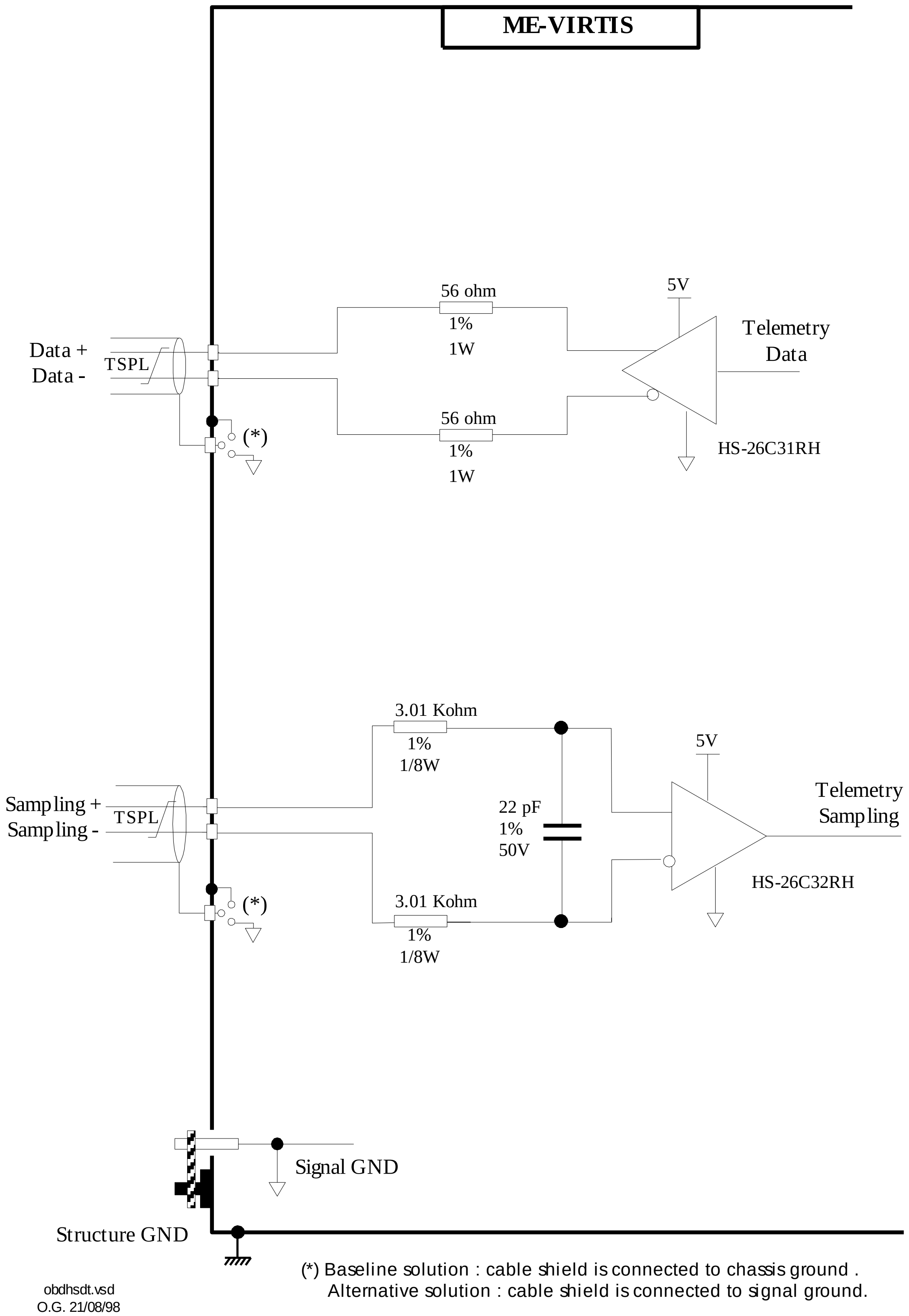
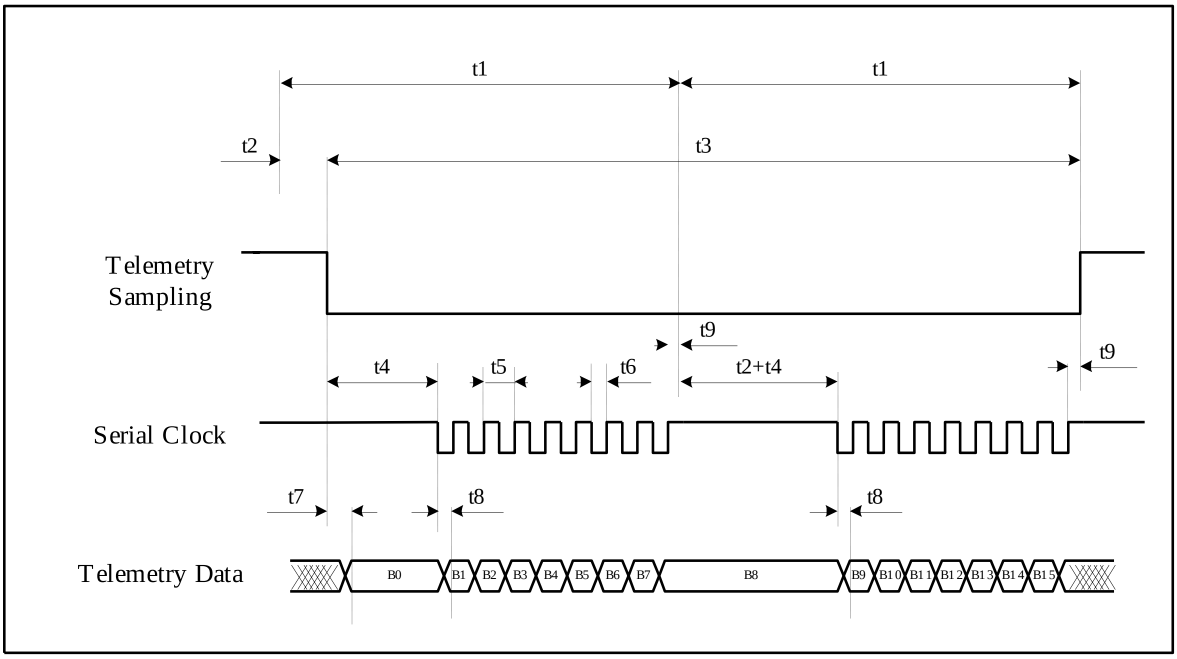


Figure 2.4 16Bit Serial Digital Telemetry (SDT) interface circuit



Acquisition rate		131 Kbps
t1		61.0us
t2		3.8us+/-1us
t3		118.3us+/-1us
t4		26.7us+/-1us
t5		3.8us
t6		1.9us+/-0.5us
t7		</= 15.3us
t8		</= 1.1us
t9		>/= 1.4us
Sample	tr	< 700ns
	tf	< 700ns
Serial Clock	tr	< 700ns
	tf	< 700ns
Command Data	tr	< 700ns
	tf	< 700ns

Serial Clock / High Frequency Clock relationship

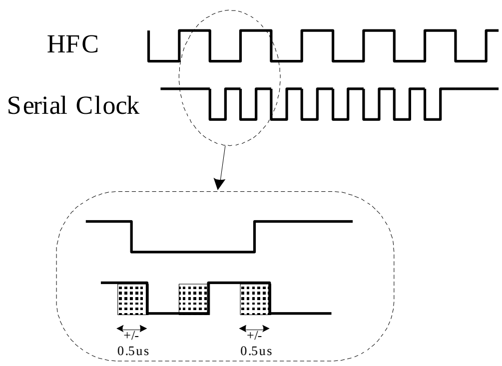


Figure 2.5 16Bit Serial Digital Telemetry (SDT) timing

I/F Designation	Serial 16 Bit Digital TeleMetry (SDT)	1 of 2
The interfaces comprises the following three circuits : • SDD - serial 16 bit digital TeleMetry data transmitter • STC - serial data transfer clock receiver • SDS - serial 16 bit digital TeleMetry sampling receiver		
Source Specification		
Circuit Type	balanced CMOS driver	
Transfer	DC coupled	
Zero Reference	signal ground	
Coding	NRZ-L	
Bit Rate	262 Kbps (burst)	
Low level output voltage	$0\ V \leq V_{OL} \leq 0.5\ V$	(1)
High level output voltage	$2.5\ V \leq V_{OL} \leq 5.5\ V$	(1)
Differential output Voltage	Low (bit logic value 0) : -5.5V <= V_{OD} <= -2.0 V High (bit logic value 1) : 2.0 V<= V_{OD} <= 5.5 V	
Rise and Fall Times	tr < 400ns tf < 400ns	(3)
Spurious noise	In accordance with character 2.9.4.1.6 of AD1	
Current Drive and Sink Capability	Sufficient to drive 1.2nF within fall/rise time below 400nsec. , and resistor limited.	
Short Circuit Current	90 mA	(2)
Max fault Voltage	Tolerance : –0.5V to +7.0V	9
	Emission : –0.0V to 5.5V	(5)
Quiescent state	SDD true line = High level	(6)
Receiver Specification		
Circuit Type	differential receiver , CMOS compatible	
Transfer	DC coupled	
Differential Input Voltage ($-1V \geq V_{cm} \leq +1V$)	Low : <= -1V (bit logic value 0) High : <=+1V (bit logic value 1)	(7)
Quiescent state	STC true line = High level (5V)	(6)
	SDS true line = High level (5V)	(6)
Hysteresis	N/A	
Common Mode Isolation	In accordance with par. 2.9.2.1.3 of AD1	
Diff. Input Impedance	>= 10 Kohm	(8)
Noise Rejection	In accordance with character 2.9.4.2.4 of AD1	
Maximum Fault Voltage	Tolerance : –0.5V to +7V	(4)
	Emission : –0.0V to 5.5V	(5)
Operative frequency	262 Khz (Typ.)	

I/F Designation	Serial 16 Bit Digital TeleMetry (SDT)	2 of 2
Harness Specification		
Wiring Type	Twisted Shielded Pair - Low Capacitance	
Core to Core Cap.	< 700 pF	
Core to Shield Cap.	< 1 nF	
Shield Connection	Connected to chassis ground	
Notes		
(1) true and comp line with ref. to signal ground. (2) Short circuit to ground (3) when loaded with differential 1.2 nF (4) with input current limited to 1.5mA (5) Digital supply voltage designed to be below 7.0V in case of fault. (6) Outside of the load data transfer. (7) At experiment connector level. (8) Considering minimum input resistance of HS-26C32RH = 4 Kohm (-7V < VCM < +7V) (9) with power off, 0.5V to 5.5V with power on.		

Table 2.5 16Bit Serial Digital Telemetry (SDT) interface characteristics

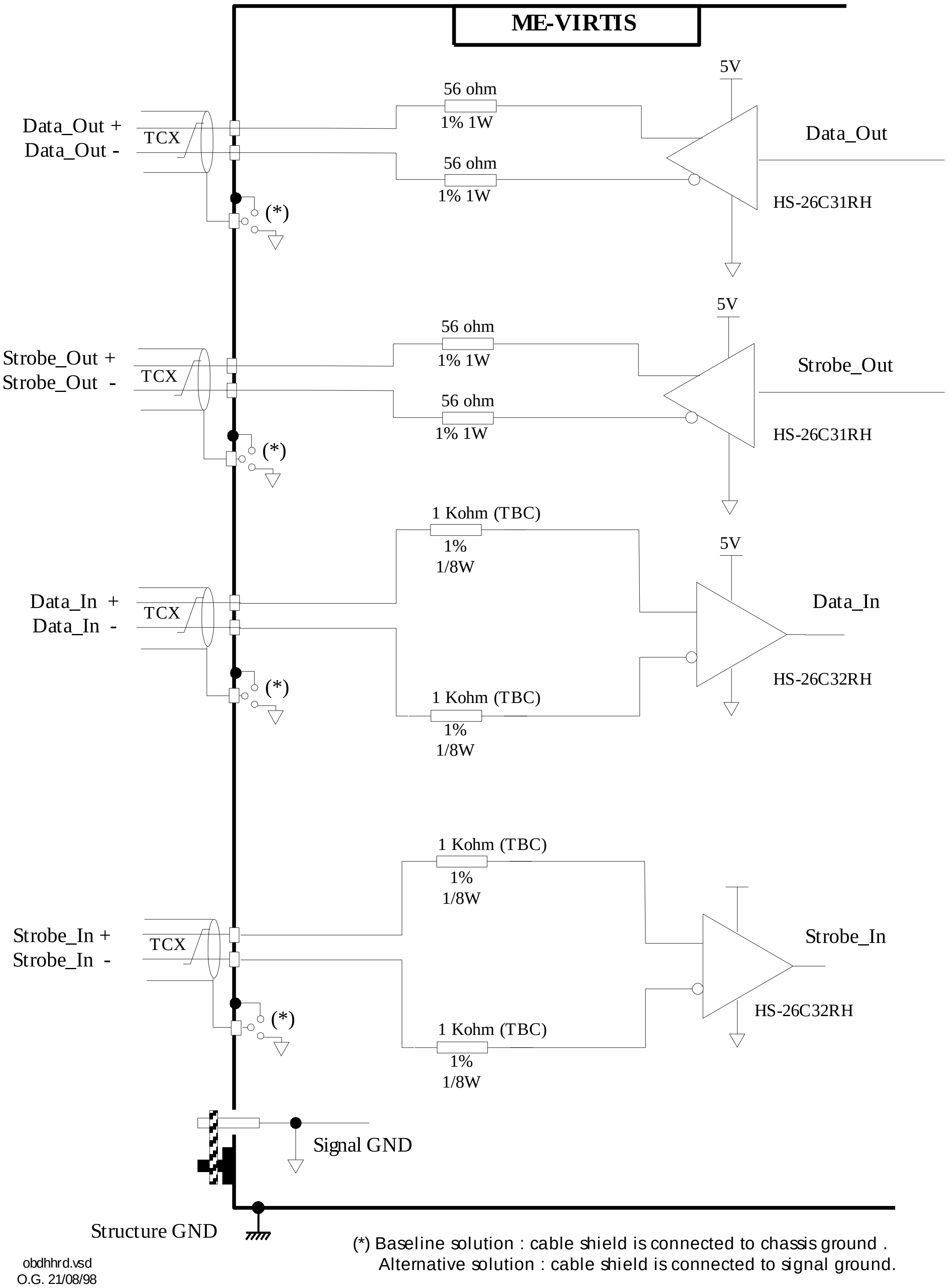
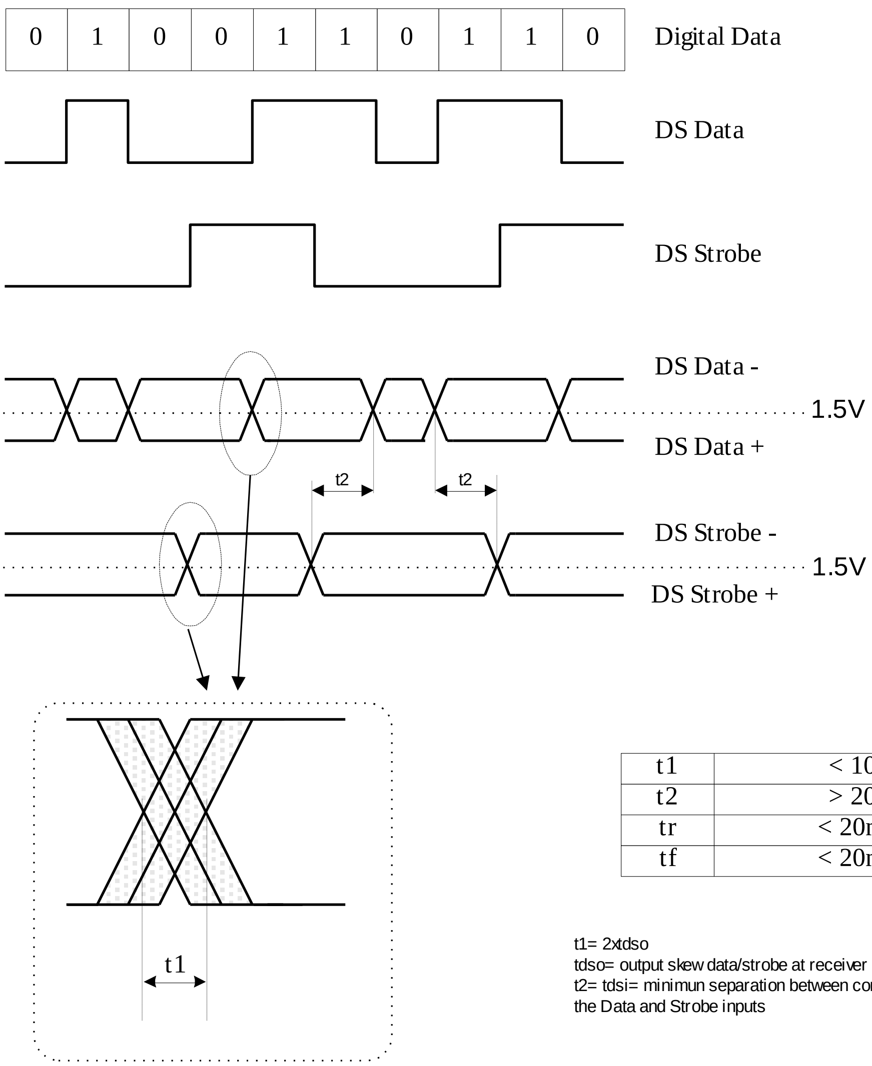


Figure 2.6 High Rate Data (HRD) link interface circuit



t1	< 10ns
t2	> 20ns
tr	< 20ns
tf	< 20ns

t1= 2xtdso
tdso= output skew data/strobe at receiver side
t2= tdsi= minimun separation between consecutive edges on the Data and Strobe inputs

Figure 2.7 High Rate Data (HRD) Timing

I/F Designation	High Rate Data Link (HRD)		1 of 2
The interfaces comprises the following four circuits : • HDO - DS_Data_Out transmitter • HSO - DS_Strobe_Out transmitter • HDI - DS_Data_In receiver • HSI - DS_Strobe_In receiver			
Source Specification			
Circuit Type	balanced CMOS driver		
Transfer	DC coupled		
Zero Reference	signal ground		
Coding	TBD		
Bit Rate	<= 10 Mbps , nominal 5 Mbps		
Low level output voltage	0 V <= V_{OL} <= 0.55 V	(1)	
High level output voltage	2.45 V <= V_{OH} <= 5.45 V	(1)	
Differential output Voltage	Low (bit logic value 0) : -5.45 V <= V_{OD} <= -1.9V High (bit logic value 1) : 1.9 V<= V_{OD} <= 5.45 V		
Rise and Fall Times	tr < 40 ns tf < 40 ns	(2)	
Output to Output Skew	toos <= ±20ns (TBC)	(2) (3)	
Spurious noise	In accordance with character 2.9.4.1.6 of AD1		
Current Drive and Sink Capability	Sufficient to drive 125 ohms TCX cable with the required rise/fall times.		
Short Circuit Current	<90 mA	(10)	
Max fault Voltage	Tolerance : +0.5V to +7V	(11)	
	Emission : -0.5 V to 7V	(5)	
Quiescent state	High impedance	(6)	

I/F Designation	**High Rate Data Link (HRD)**	**2 of 2**
Receiver Specification		
Circuit Type	differential receiver , CMOS compatible	
Transfer	DC coupled	
Differential Input Voltage	Low : <= -0.6V (bit logic value 0) (TBC) High : <=+0.6V (bit logic value 1) (TBC)	(7)
Hysteresis	N/A	
Common Mode Isolation	In accordance with par. 2.9.2.1.3 of AD1	
Diff. Input Impedance	>= 5 Kohm	(8)
Noise Rejection	In accordance with character 2.9.4.2.4 of AD1	
Maximum Fault Voltage	Tolerance : +0.5V to +7V	(4)
	Emission : 0V to +5.5V	(5)
Harness Specification		
Wiring Type	125 Ohm TwinAx (TCX)	(9)
Shield Connection	External harness : connected to chassis ground	
Notes		

(1) true and comp line with ref. to signal ground at output current of 1mA.
(2) at receiver input when loaded with cable of TBD length
(3) difference in propagation delay time between complementary outputs at 50% point
(4) With input current limited to 1.5mA
(5) Digital supply voltage designed to be below 7.0V in case of fault .
(6) Outside of the data transfer.
(7) At experiment connector level.
(8) Considering minimum input resistance of HS-26C32RH = 4 Kohm (-7V < VCM < +7V)
(9) Cable to be used : GORE GSC 6509 , Rev. 6 or space qualified equivalent.
(10) Short circuit to ground
(11) With power off; -0.5V to +5.5V with power on

Table 2.6 High Rate Data (HRD) Interface characteristics

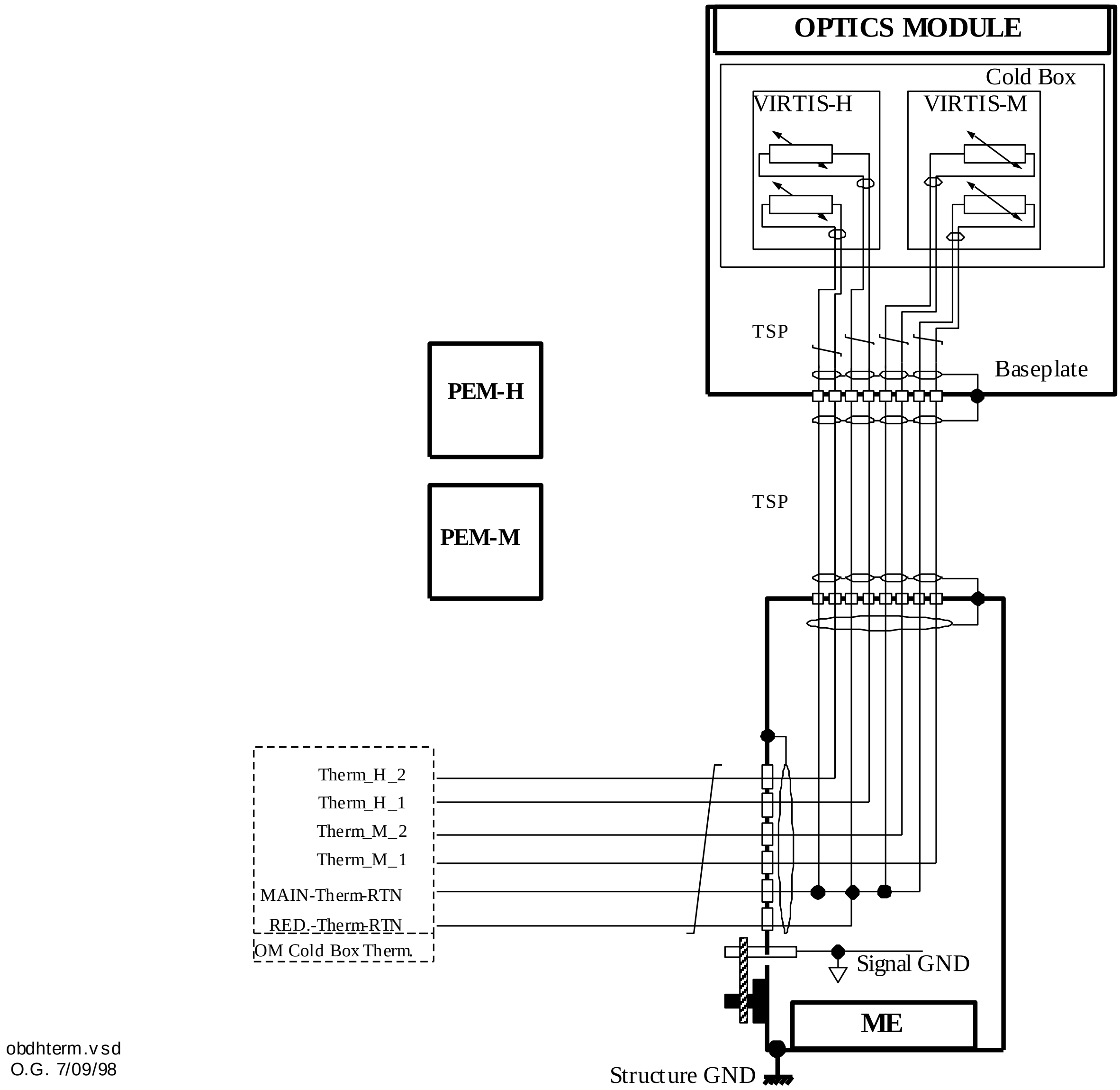


Figure 2.8 Conditioned Analogue Telemetry (ANC) interface circuit

I/F Designation	**Conditioned Analogue T/M (ANC)**	**1 of 1**
The interface comprises the following circuit : • OM Cold Box thermistors		
Source Specification		
Circuit Type	Thermistor	
Transfer	DC coupled	
Thermistor Type	Rosemount 118MF 2000 Ohm	
Operating temperature Range	from 100 K to 360 K	
Isolation	to signal ground : >1Mohm to chassis ground : >1 Mohm isolated load	
Max fault Voltage	Tolerance : N/A	
	Emission : N/A	
Harness Specification		
Wiring Type	Twisted 6 tuple(T6)	(1)
Notes		
(1) Minimum of 2 common returns for channel.		

Table 2.7 Conditioned Analogue Telemetry (ANC) interface characteristics

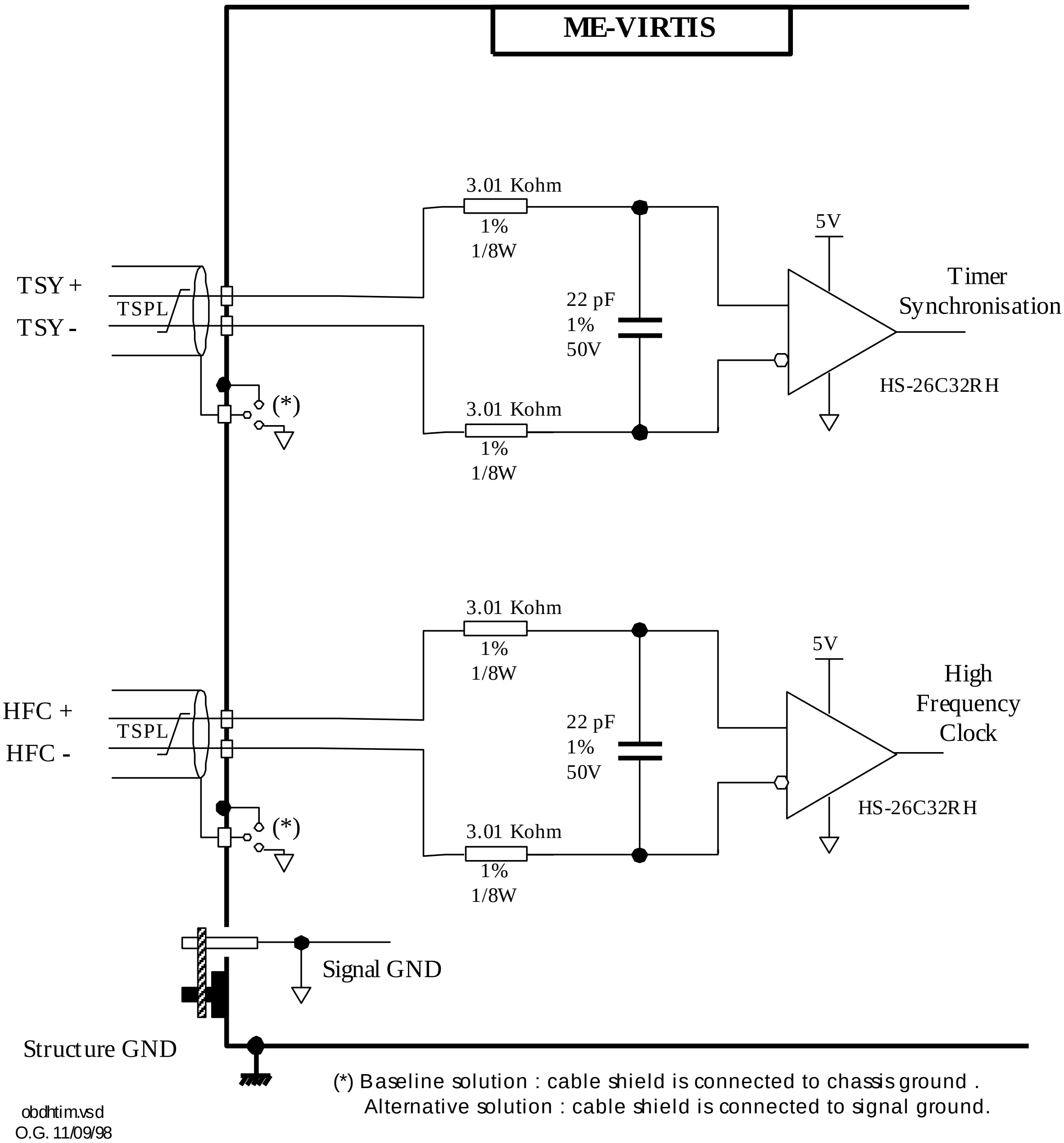
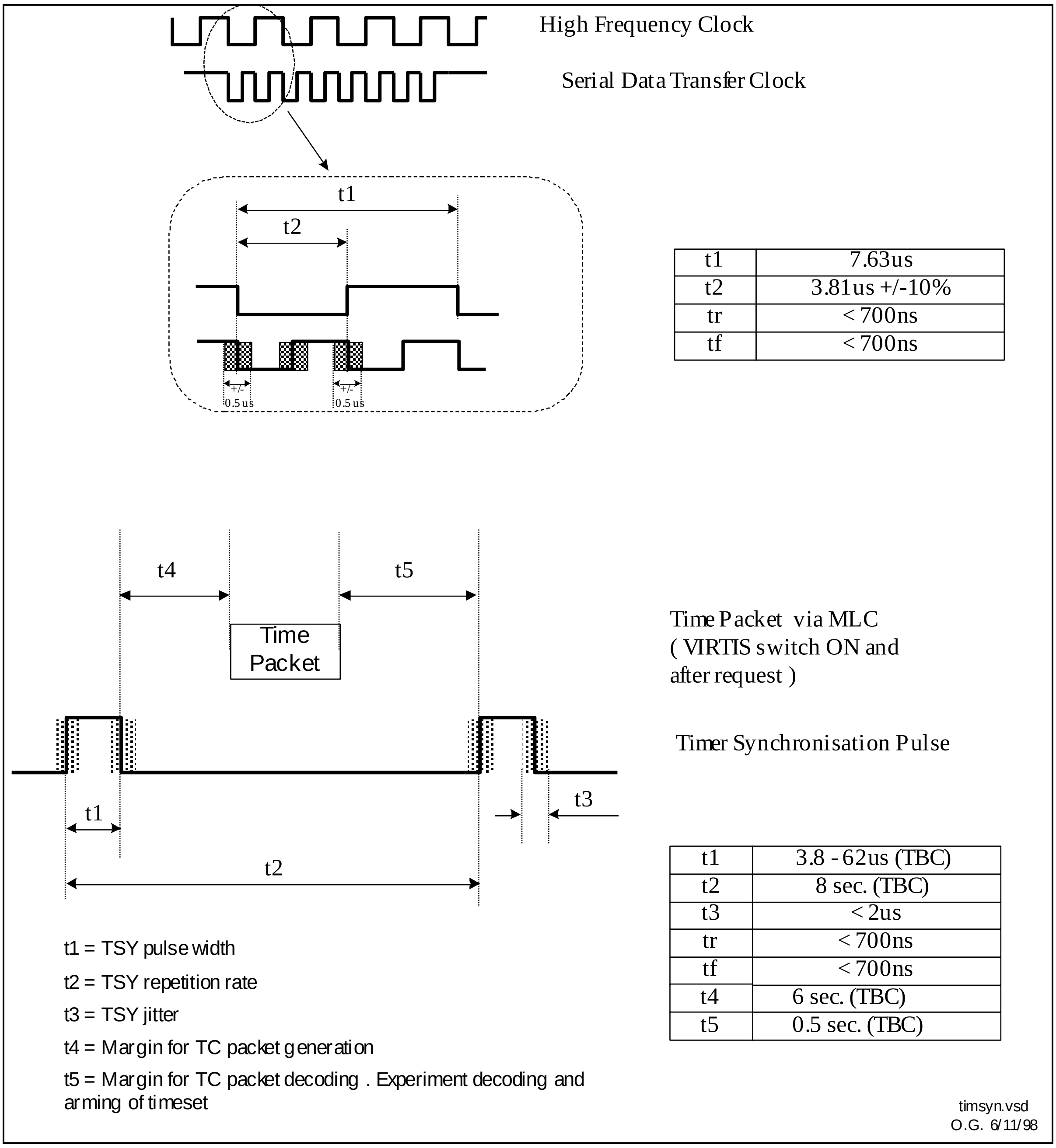


Figure 2.9 DMS timing & synchronisation signal (OTS) interface circuit



t1	7.63us
t2	3.81us +/-10%
tr	< 700ns
tf	< 700ns

t1	3.8 - 62us (TBC)
t2	8 sec. (TBC)
t3	< 2us
tr	< 700ns
tf	< 700ns
t4	6 sec. (TBC)
t5	0.5 sec. (TBC)

Figure 2.10 DMS timing & synchronisation signal (OTS) timing

I/F Designation	**DMS Timing & Sync. Signals (OTS)**	**1 of 1**
The interface comprises the following Two circuits : • HFC - High Frequency Clock receiver • TSY - Timer Synchronization Pulse receiver		
Receiver Specification		
Circuit Type	differential receiver , CMOS compatible	
Transfer	DC coupled	
Differential Input Voltage (-1V $\geq V_{cm} \leq$ +1V)	Low : <= -1V (bit logic value 0) High : <=+1V (bit logic value 1)	(1)
Hysteresis	N/A	
Common Mode Isolation	In accordance with par. 2.9.2.1.3 of AD1	
Diff. Input Impedance	>= 10 Kohm	(2)
Noise Rejection	In accordance with character 2.9.4.2.4 of AD1	
Maximum Fault Voltage	Tolerance : –0.5V to +7V	(3)
	Emission : 0V to +5.5V	(4)
Harness Specification		
Wiring Type	Twisted Shielded Pair - Low Capacitance	
Core to Core Cap.	< 700 pF	
Core to Shield Cap.	< 1 nF	
Shield Connection	Connected to chassis ground	
Notes		
(1) At experiment connector level. (2) Considering minimum input resistance of HS-26C32RH = 4 Kohm (-7V < VCM < +7V) (3) With Input current limited to 1.5mA (4) Digital supply voltage designed to be below 7.0V in case of fault.		

Table 2.8 DMS timing & synchronisation signal (OTS) interface characteristics

2.3 Software

In the following is given a general description of VIRTIS S/W. Full details on the mode definitions, mode transitions, TC/TM detailed description is given in chapters 3 and 4 and in attachments 2 and 3.

2.3.1 Software Functions.

The main purposes of the VIRTIS software are the control of the VIRTIS instrument, specifically of the two VIRTIS sub-systems (VIRTIS-H and VIRTIS-M) and the handling of the scientific data.
From the Software design point of view, the software is divided in two parts (i.e. two separate executables), the PROM software and the EEPROM software. The PROM software (also called Primary Boot software) is active after VIRTIS ME power-on. The EEPROM software (also called Secondary Boot software) is started by a special TC, given in Safe mode (i.e. VTC_Enter_Idle_Mode).

2.3.1.1 Specific PROM / Primary Boot Software Functions

The PROM software provides low level functionality and is the ‘BIOS’ of VIRTIS with the following functions:

- Initialization of the ME DPU and ME Power Supply (PS) after power-on
- Power-up, reset management and SCET synchronization
- Entering the Safe mode (default for VIRTIS operation) or Development mode (only for EEPROM S/W development purposes)
- Collection and providing Default HK TM
- Low level TC receipt (via MLC interface), verification, acceptance and execution
- TM packing, buffering and transfer to S/C via SDT interface
- ME DPU Memory Management including upload, dump and check of memory (i.e. RAM, EEPROM and PORTs) performed by separate TCs via MLC interface
- Boot and start of Secondary Boot software in RAM by IEEE-1355 interface (Boot loader provided by ASTRIUM)
- Maintenance of up to 8 different secondary boot executables in EEPROM
- Health check and error/event handling incl. failure override function
- Test display control for displaying Safe mode status and HK information

Note: In Safe mode (i.e. with PROM software) it is never possible for the user to have access to the –M and –H sub-system. Only the memory upload/dump to/from memory ports allows (i.e. very low level) to have access on all H/W interfaces, also to –M and –H.

2.3.1.2 Specific EEPROM / Secondary Boot Software Functions

The EEPROM software provides partially the same functionality as the PROM software and additionally all VIRTIS-M and -H control functions. These are:

- Initialization of the ME M- and/or H-Interface Electronics as well as the –M and –H sub-system after power-on
- Low level and high level TC verification, acceptance and execution
- TM packing, buffering and transfer to S/C
- SCET re-synchronization
- Collection and providing of VIRTIS Default, General and PEM science HK
- Interfacing the M-PEM, H-PEM, coolers and ECAs
- Control and monitoring of –M and –H control, calibration and science sequences
- Entering the ME IDLE mode, instrument control modes and Science modes
- Science data acquisition, TM packing and transfer to the S/C via IEEE-1355 HS link or via SDT interface
- -M and –H science data handling, processing and compression
- Health check and error/event handling incl. failure override function of several error categories
- Test display control for displaying instrument status and HK information

2.3.2 Software Design

The PROM software is hard coded in the Main Electronics/DPU and the EEPROM software is stored in EEPROM and is changeable by memory upload (memory management service).
The PROM software is written in Assembler, the V2.0-1 has a size of 5139 48bit instructions and consists of 66 modules.

After Primary Boot the PROM software runs always in Program Memory (PM) for safety reasons. Primary Boot is performed by the DPU Board and Boot Controller (BBC) after +28V power-on. The PM has a very good Single Event Upset (SEU) performance (almost SEU free) while the Data Memory (DM) is SEU sensitive. Therewith a safe behaviour of all PROM software functions can be assumed.

The EEPROM software is stored in EEPROM as PM and DM segments with segment checksum for verification during upload and start (i.e. Secondary Boot from EEPROM in RAM). It runs in PM and DM RAM.

The EEPROM software is mainly written in C with low level functions in Assembler for speed and code optimization. The Real Time Operating System (RTOS) VIRTUOSO is used and 51 processes can be active simultaneously (FM software). The Secondary Boot software consists of about 200 functions, excluding VIRTUOSO functions/library.

The size of V3.6 is 83Kwords with 68K Instructions and 15K Program data/parameter. The compressed (mem21k) code stored in EEPROM is 354Kbyte (about 60Kwords). That means 2 FM executables are able to store in EEPROM from the size point of view. Generally about 170K Instructions can be stored in EEPROM as maximum and up to 8 different executables.

2.3.3 Data handling

On-board **data compression** for VIRTIS is important to maximise the scientific return of VIRTIS. Both reversible (lossless) and lossy compression algorithms are implemented. The reversible algorithm is derived from that developed for the OMEGA and VIMS imaging spectrometers. It takes advantage of spatial / spectral correlations for pre-processing, then a Rice coding is applied on the residuals. This algorithm shall be used for validation purposes early in the mission but also during real observations whenever the data rate and available data volume shall allow. The loss-less algorithm provides typical compression ratios of 2 to 3 depending on the entropy content of the data.

The lossy algorithm is based on ***wavelet*** transforms. There is a specific compression mode for coma observations by VIRTIS-H, which implements very long observation times (up to 1 hour). In this case, a one dimension wavelet transform is applied, followed by coefficients entropy coding. This provides a minimum compression ratio of 4 within the acceptable distortion limits.
The compression strategy based on wavelet transforms of spectral / spatial rectangles of data, works either on VIRTIS-M detectors data (frames) or on accumulated time series of VIRTIS-H spectra. These rectangles are divided in sub-units of typically 64 pixels x 144 spectrals, hence 4 steps of transform in each direction. Each sub-unit provides a self-consistent telemetry stream, so that a SEU can only result in the loss of a small fraction of the data. The result of the transform is coded using a version of the Said-Perlman tree coding algorithm which has been optimised for speed on a TSC21020E. The processing power obtained with the breadboard is 500 Kdata/s, which is adequate for VIRTIS.
With the implemented algorithm, the compression ratio can easily be modified as a TC parameter. Tests on AVIRIS, ISM and VIMS data show that compression ratios of 8 to 12 provide distortion levels of less than 2 DN.

We have implemented 4 compression schemes shown in table 2.9

Algorithm	**Compression Factor**	**Comments**
Reversible (lossless)	2…3	Varies according to the entropy of the data
Wavelet – F1	8	2bit per pixel /16bit
Wavelet – F2	10.67	1.5bit per pixel / 16
Wavelet – F3	16	1bit per pixel /16bit

Table 2.9 Compression schemes adopted for both VIRTIS-M and VIRTIS-H

2.3.4 Software Concept and Functional Requirements

2.3.4.1 Software Overview

This section contains all the SW related information about the interface between the VIRTIS experiment and the ROSETTA Spacecraft. Interface functional aspects and data formats are described for either DMS/RTU channel as well High Speed link (see Figure 2.11). As VIRTIS is a 3 data channel spectrometer, science data from each channel are

formatted in separate science TM packets transmitted on the HS link while other TM packets (e.g. H/K, event) are transmitted to the RTU.
The electrical requirements of the interface are defined for all ROSETTA instruments in AD1 while the derived VIRTIS implementation is described in AD2. In the same way, the functional requirements of the interface are defined for all ROSETTA instruments in AD1 while this section specifies VIRTIS derived definitions.
Unless explicitly specified, all TM and TC data between VIRTIS and OBDH described in the current document is aligned on 16-bit words, with the following bit numbering convention:

Bit 0 = MSB = first transmitted bit;
Bit 15 = LSB = last transmitted bit.

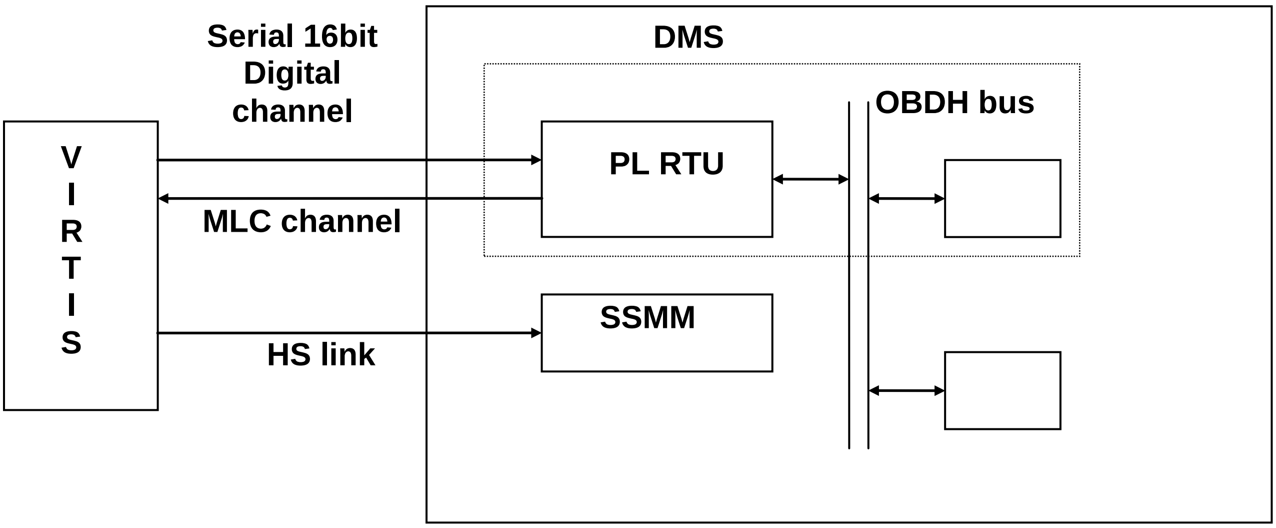


Figure 2.11 VIRTIS - S/C Interface

2.3.4.2 Autonomy Concept

The VIRTIS software will detect Anomalous Events, related to malfunctions, and will perform recovery, safing and reporting actions. The recovery / safing actions can be inhibited by the VTC_Override TC.
Anomalous Events have been classified according to AD1 as:

Internal Category	**S/C TM Event Report**
Category I	Anomaly Warning – subtype 2
Category II	Anomaly Warning – subtype 2
Category III	Anomaly Warning – subtype 2
Category IV	Anomaly Warning – subtype 2
Category V	On Board Action – subtype 4
Category VI	On Ground Action – subtype 3

However, a further refinement of the definition has been introduced to suit it to VIRTIS autonomous S/W needs:

Event Category	Description	Action	Number	TM report type (subtype)
Category I	Do not prevent operation	None	134	Warning (2)
Category II	“retry” type	ME resend TC	2	Warning (2)
Category III	Subsystem “reset” type	ME shall autonomously perform a reset of the H/W which shows the malfunction	19	Warning (2)
Category IV	events which prevent operations of PEM-H or PEM-M but allows to continue with other channel	PEM-H or PEM-M autonomously powered off by ME	5	Warning (2)
Category V	Prevent further operations	ME Reset, enter Safe Mode	63	On-Board Action (4)
Categories 0, IX	Normal progress events	None	24	

A full list of the Events is available in Attachment III (Appendix 12, page 159 onward)

VIRTIS ME is capable of entering a safe condition whenever a malfunction is encountered, from this point of view can be considered fully autonomous. For this reason no special recovery OBCP has been envisaged. A category V events shall stop any instrument operations (rejection of TC from MTL), however, for category IV events for instance operation with a single channel is still allowed (if compatible with MTL TCs).

2.3.4.3 Software Maintenance Approach

Except for the PROM, all VIRTIS memories (EEPROM, RAM) can be uploaded by the Load_Memory TC.
This means that it is possible to upload the software in EEPROM, if needed; moreover, in case e.g. the EEPROM fails, it is possible to load the Program Memory content and start execution directly from it.

The software is physically divided into segments, and each segment can be uploaded separately; this allows to patch the software by uploading only one segment and not the whole software.
The segment approach also allows to manage the case in which one or more of the 8 EEPROM chips fails, while the other ones are still working, by uploading the segments in the failed chips into other ones (assuming of course that enough free EEPROM is available).

2.3.4.4 Data Delivery Concept

VIRTIS will produce the following types of TM data :

- TC verification reports;
- H/K data reports;
- Event reports;
- Memory reports;
- Science reports.

They are transmitted to the S/C DMS through the RTU I/F except the Science reports that are transmitted on the High Speed I/F. If this is not available (e.g. failure) the instrument can be commanded to start a degraded Science mode which does not use the HS link. In this case the Science reports are transferred via the RTU I/F like the other TMs.

Data delivery is performed according to AD1. As explained below, packets are internally collected in TM blocks (one TM block is 512 words or 1024 octets) that are put in a H/W FIFO (size :4096 words) and transferred to the DMS when requested by it.

Data Collection for RTU link (non degraded mode)

TC verification, H/K, Memory and Event packets are collected in a SW buffer to form TM blocks (i.e. a group of whole packets plus one word with the block length in words) . A block is considered formed if:

- the size is not more than but near by the maximum of the allowed block size, i.e. it is not possible to add one more packet because the block size would exceed the maximum, or
- a predefined collection period (16 sec) is expired, or
- for TC requiring an Acceptance Report, 2 sec after TC receipt.

Usually blocks will be formed for collection period expiration only, as the first criterion will apply only for memory dump (in Safe Mode) and for degraded Science mode (in both cases, the produced data volume on the RTU link could be quite high). Therefore if the mode is neither Safe nor Degraded Science, the max block size is less than 1k word assuming that:

- each H/K packet size = less than 100 word;
- collection period = 10 sec;
- margin for TC verification and Event reports = 200 words;

in one collection period there are:

- ME H/K packets (default and general);
- 2 H/K packets for each of the 3 channels (5 sec min. repetition time).

When a block is formed, its length is written as first word of the block and data are transferred to the I/F FIFO. If its length exceed the FIFO size or its free area, the words that cannot be accommodated in the FIFO are kept in the SW buffer and are written in the FIFO only later. Note that the writing of one word in the H/W FIFO is about 100 times faster (<1μsec) than the reading by the DMS (min. 122 μsec). After closing one block, a new one is prepared on the SW buffer to accommodate the new packets.

Science Data Delivery on RTU link (degraded link mode)

When the HS link is not available, a Degraded Science Mode can be commanded in order to transfer Science data on the RTU link. As a smaller data rate can be sustained on this link, less data are prepared and transmitted to the DMS.
In the degraded mode a budget of 600 bps and 900 bps have been allocated for M and H respectively, giving a data rate of 1.5 kbps for the overall VIRTIS.

H/K packets

They contain data required both for monitoring the operational aspects of the instrument and for interpreting science data. H/K parameters are self standing (i.e. not require data from other packets or TC history to be interpreted) and have the same structure and interpretation in all TM packets in which they appear.

SID	H/K description	Generation Conditions	Generation rate	
			Science Modes	*All other Modes*
1	ME Default H/K	At power on	Every 10 s	
2	ME/M general H/K	If M/Cooler and/or M/ECA are on	Every 10 s	
3	ME/H general H/K	If H/Cooler and/or H/ECA are on	Every 10 s	
4	V-M-VIS H/K	Only if PEM-M is On	M repetition rate	Every 10 s
5	V-M-IR H/K	Only if PEM-M is On	M repetition rate	Every 10 s
6	V-H H/K	Only if PEM-H is On	H repetition rate	Every 10 s

Table 2.9: VIRTIS House-Keepings

NOTE: it must be pointed out that validity of periodic SID6 H/K is not guaranteed. Read-out of the multiplexer is performed only during Science Modes.

There are 6 H/K packet types identified by means of their Structure Identification (SID) included in the packet and used on ground together with APID, Service Type and Sub-Type, to identify the report and its content . The packet types, their generation conditions and generation rates are given in table 2.9. They are automatically enabled when the generation conditions are met, however, they can be disabled by a specific TC.

<u>Event packets</u>

Event reports represent an higher level of information than H/K reports, therefore they are the preferred method to perform monitoring activities. They report to ground or DMS unambiguous operational information such as:

- failures and/or anomalies detected on-board;
- autonomous on-board actions;
- normal progress of payload operation/activities.

Event packets :

- include an unique identifier of the event, its occurrence time and related data;
- are generated only once per event occurrence and are concise;
- includes the nature/severity of the event;
- are self standing (i.e. not require data from other packets or TC history to be interpreted);

Each event report type has its Event Identifier (like H/K reports have their SID) derived from a selected list controlled by the project. Event reports have fixed structure per EID. Definition of Event Category is given in chapter 2.3.4.2

PID	Packet Category	Packet Type	Usage
51	12	TC	For ALL telecommand packets to VIRTIS
51	1	TM/ 1	Telecommand acknowledge packets
51	4	TM/ 3	Housekeeping data reporting from VIRTIS (note that there will be 6 SIDs within this App

			Id)
51	7	TM/ 17	Event reporting from VIRTIS (note that there will be N TBD EIDs within this App Id)
51	7	TM/ 5	Test reporting from VIRTIS
51	9	TM/ 6	Memory download from VIRTIS
52	12	TM/ 20	Science data from unit VIRTIS M-VIS and VIRTIS M-IR(1)
53	12	TM/ 20	Science data from unit VIRTIS H (1)

Table 2.10: VIRTIS Application Process Ids

NOTES TO Table 2.10:
(1) Two Process Id are requested for VIRTIS science data as independent on-board and ground processing is necessary for the two independent data streams from the units V-M and V-H.

2.3.4.5 Timing Requirements

Time references in TCs, TMs and on-board procedures are in SCET, i.e. the time the DMS will maintain and distribute on the OBDH bus. This time value is transmitted to the experiment as 6 octets, (32 bit unit seconds, 16 bit fractional seconds, see RD1, 2.8.1.8) and has a resolution of 15,3µs (1/65536 sec) while the experiment time-stamps its TM packets with a time reference whose MS bit is usually set to 0 unless for any reason synchronisation is missing (e.g. no time update from the S/C) or lost (e.g. payload failure). Note that the distributed SCET has ALWAYS the MS bit =0.

To perform a correct synchronisation of the user internal timer to the SCET, the user complies with the Timer Synchronisation Protocol defined in 2.7.3.3. and 2.8.1.8. and 2.8.1.9 of RD1, specifically using both TSY (period 8 sec) and HFC lines as follows:

- the user is able to receive the first Time Update TC Packet with a delay from power-on of min. 20 sec and max. 60 sec (RD1, Sec. 2.8.1.9); if no time update is received within 60 sec, the user starts anyway sending its TM using a non-synchronised value i.e. with the MS bit set to 1;
- the frequency of Time Update is in the order of several hours (≈1.8 TBC);
- the Packet is decoded in a short time less than the margin of 0.5 sec that will be included by DMS for the experiment to process this type of packet before the following TSY is received;
- with the next rising (first) edge of TSY pulse an interrupt is generated and the received time value is written into the 48 bit internal timer (in the OBDH FPGA on DPU extension). The HFC clocks this FPGA timer (as well all other H/W timers);
- the internal timer is used to time stamp VIRTIS TM Packets (e.g. for Science data time stamp, the timer is read out in the interrupt routine which transfers the science data out from the -M or -H IFE FIFO and the value is written in the related Science data TM packets);
- if for any reason (e.g. instrument failure) the synchronisation is lost, the user time-stamps its TM with a non-synchronised value (i.e. MS bit =1).

The update will be performed in all operative modes when the TSY is received, by overwriting the VIRTIS internal timer with the SCET. Additionally, if the difference between these timers is found greater than 20 ms, a warning event is issued (see 2.8.3.2.1, Event Reporting TMs).

The loss of accuracy due to the possible time drift is anyway very small (e.g. 0,1 msec if the time update were performed once in 1000 days) and the VIRTIS-ME time stamp accuracy for Science TM would result still better than 8.2 ms as described in what follows (all values are worst case estimations):

- S/C HFC drift: 0,1 ms (1000 days * 0,1 µs/day, see RD1);
- S/C TSY jitter: 2µs (see RD1);
- TSY interrupt acceptance time (incl. C call int. dispatcher, 112 Instr.): 5,6 µs;
- TSY interrupt routine run time until the timer is started: 1 µs;
- -M/-H data receipt interrupt acceptance time: 56 µs (Science mode) (10 Interrupts at the same time x 8,1µs (162instr.)/interrupt);
- -M/-H data receipt interrupt routine (first FIFO interrupt, during one of the Science mode) run time until the timer is read: 4 ms (as the 3 channels can issue an interrupt at the same time, the worst case is when two channels have to be read out before the 3d. channel data are read out i.e. 10Instr x 50ns/Instr x 4000bytes (half FIFO) x 2channels = 4,1672 ms (+ 100% margin).

2.3.5 Safety

The software for **Safe Mode** is stored in the radiation-hard PROM and executed after primary boot by the BBC hardware only in the PM RAM which is radiation-hard too and has a low SEU sensitivity.

The PROM software contains all functionality for the safe operation of the instrument, especially for:

- Execution of a reduced list of TCs (timer synchronisation, memory up- and download, failure override and “Enter_IDLE” TC)
- Health check including acquisition of a small list of timer triggered HK and TM packet transmission
- Execution of the secondary boot either from EEPROM or from S/C to -RAM
- Start of the ME IDLE mode

Before executing of the secondary boot from EEPROM a check of EEPROM content will be performed by using of the stored checksums.
Severe errors detected by the instrument control software leads to entering of the **Safe Mode.**
Error/event handling can be avoided by a special “failure override” TC.

2.3.6 Reliability

There is a **watch-dog** implemented for detecting of lock-ups and endless loops which can be caused by i.e. an Single Event Upset (SEU).

The program code and parameter of the EEPROM are stored with **checksum** in order to verify the content before using.
The software for the **Safe Mode** which contains up- and download functionality is stored in the radiation-hard PROM and is always executed in the radiation-hard PM RAM.
In case of detection of severe failures VIRTIS enters into the **Safe Mode.** It provides the possibility for **verification** of the program code or parameter by downloading or a **correction** by uploading.

2.3.7 Maintainability

The VIRTIS software (code + parameter) is organised in **segments**
The segments or patches can be uploaded by transferring of TC packets and will be permanently stored in the EEPROM or directly written into the RAM (if the EEPROM fails).
An EEPROM error will be detected by means of the stored checksum.

2.3.8 Verifiability

The whole EEPROM content can be checked for validity of the content by the checksum stored for each EEPROM segment
The PROM software provides periodically Default HK TM packets which contains the operational status of VIRTIS, e.g. the current active instrument mode.

2.3.9 H/K and Events to be monitored by DMS

Several H/K and events are used during power ON and power OFF OBCPs, however no continuous monitoring is performed by the DMS.

2.3.10 H/K and Events triggering OBCPs

No H/K neither Events are used to trigger OBCPs. We use only 2 OBCPs: Power ON and Power OFF and these are simply called by TML.

2.4 Budgets

2.4.1 Mass

The mass of the instrument can be retrieved from the single unit masses as reported in the PFM ADP, and listed below:

	Measured Mass (g)
PEM-M	2900.5
PEM-H	1270.0
Optics Module	19460.0
External Baffles	162.0
Lateral MLI	603.0
ME box	5460.0
TOTAL VIRTIS	**29855.5**
Inter Unit Harness	1822.8

The overall mass is compliant with the anticipated value of 29.957 Kg.

2.4.2 Operating Power

In the following two tables are given the power consumption of each subsystem under different operating conditions and different operative modes (table 2.9A). The sources for these values are the electrical tests performed on PFM units and the S/C TBTV tests. The overall power consumption of the experiment, in different modes, is reported then in table 2.9B

#	Modes	Average	Long Peak
A	ME Safe	6.1	9.8
B	ME Idle	6.4 / 6.7	6.4 / 6.7
C	ME Science M+H	8.4 / 10.4	10.4
D	ME Science M	7.9 / 10.0	10.0
E	ME Science H	7.8 / 9.9	9.9
F	ME Test	8.3 / 10.4	10.4
G	H_Idle	6.2	6.2
H	H_Cover		6.5
I	H_Annealing	9.2	9.2
L	H_Science (includes calibration)	7.2 / 7.4	7.2 / 7.4
M	H_Cooler Cool Down	14.3 / 16.5	14.3 / 16.5
N	H_Cooler Steady State	8.6 / 11.7	8.6 / 11.7
O	H_Cooler Open Loop (Max speed)	20.3	20.3
P	H_Cooler Stand-By	2.5	2.5
Q	M_Idle	10.4	10.4
R	M_Cover		11.0
S	M_Science	14.0	14.0
T	M_Calibration	17.0	17.0

U	M_Test	10.4	10.4
V	M_Annealing	13.0	13.0
Z	M_Cooler Cool Down	16.0 / 18.5	16.0 / 18.5
Y	M_Cooler Steady State	9.1 / 14.8	9.1 / 14.8
X	M_Cooler Open Loop (Max Speed)	19.9	19.9
W	M_Cooler Stand-By	2.5	2.5
	Emergency Cover Actuator (each)	15.0	15.0

Table 2.9A VIRTIS Subsystems power consumption.

	VIRTIS Power Consumption Main Power Bus Vs. Operating modes	**Average (BOL) [W]**	**Long Peak [W]**	**Short Peak [W]**
1	Science M/H (C+L+N+S+Y)	47.3 / 58.3	49.3 / 58.3	
2	Science M (D+S+Y)	31.0 / 38.8	33.1 / 38.8	
3	Calibration M (D+T+Y)	34.0 / 41.8	36.1 / 41.8	
4	Science H (E+L+N)	23.6 / 29.0	25.7 / 29.0	
5	Calibration H	23.6 / 29.0	25.7 / 29.0	
6	Upload	9.8	9.8	
7	Download	9.8	9.8	
8	Stand-by (B+G+N+Q+Y)	40.7 / 49.8	40.7	
9	Cover actuation (B+G+H+N+Q+R+Y)		47.2 / 60.8 (1)	
10	Cool-down (M and H)	36.7 / 41.7	36.7 / 41.7	
11	Detectors Annealing (B+I+U)	28.6 / 28.9	28.6 / 28.9	
12	Emergency Cover actuation	15.0	15.0	
13	ME Safe Mode	6.1	9.8	
	Maximum	**58.3**	**60.8**	

Table 2.9B VIRTIS overall power consumption.

2.4.3 Data Rates (H/K and Science)

VIRTIS shall dump data and H/K on the DMS through two channels the 16 bit Serial Digital Telemetry (SDT), slow line, and the High Speed Link (HRD).
The SDT I/F is used for the following functions :

- to transfer in serial form the housekeeping data. Data rate for H/K transmission shall not exceed the 3 Kbit/s (see attachment 2, chapter 2.8.2, table 3)

- to transfer a limited volume of science data in case of failure of HSDC I/F (degraded mode). Average data rate in degraded mode (H/K plus science data) will not exceed 30 Kbit/s.

VIRTIS shall use the HRD channel to download science data directly on the SSMM. Only in case of HRD line failure, the data shall be transferred using the 16bit serial TM line.

The average data rate on the HRD is highly dependent on the selected scientific mode (selected by e.g. pixel binning, repetition time, etc), on the data compression factor, whose exact value depends on the typical scene content, and on the number of channels used (either only –M, only –H or both). The details on the operative modes and the full list of the instrument data rates in the various operative modes are given in attachment 2 (chapter 2.8.2, table 3). The maximum expected data rate shall not exceed the 400 Kbit/s over 5 sec periods.

2.4.4 Non-Ops Heaters.

For non-operational heaters we mean heaters to be powered and controlled directly by the S/C.
VIRTIS shall use two types of non-operational heaters: “Decontamination” and “CCD Storage” heaters.

- Two decontamination heaters are located on the passive radiators belonging to VIRTIS-M and VIRTIS-H, and shall be used to remove ice by raising the temperature from the 130K (operative temperature) to 250K. This operation shall be performed with the instrument in off condition.
- The two CCD Storage heaters are both used during the hibernation period to maintain the CCD at its minimum acceptable temperature of 150K.

The power consumption of the non operational heaters is given in table 2.10.
<u>It must be strongly stressed that the two lines for the decontamination heater are formally the main and the redundant line, but nonetheless they must both active at the same time, to achieve the required temperatures.</u>

	Heater Function	Average (BOL) [W]	Long Peak [W]	Short Peak [W]
1	Decontamination Heater_1	40	40	40
2	Decontamination Heater_2	40	40	40
3	CCD_Storage_1	0.5	0.5	0.5
4	CCD_Storage_2	0.5	0.5	0.5

Table 2.10 Heater main bus consumption.

2.4.5 S/C Powered Thermistors

Temperature monitoring on VIRTIS is for information and safety purposes only. The data can be used to infer background radiance values and to signify when temperatures exceed pre-defined limits. There is no relationship between the temperature data collected from the sensors listed in table 2.11 and the operational control of compensation heaters. The spacecraft is, however, permitted to place sensors about the instrument and agreed upon locations to help it maintain the Temperature Reference Points.

Unit	#	S/C powered Thermistors	Experiment Powered Thermistors	Temperature Range	Location
OM	4	Rosemount 118MF	_	100 ÷340	Optics, FPA's
OM	2	-	Lakeshore Diode XDT-570-50 (TBC)	60 ÷150	IRFPA (M/H)
OM	11	-	Rosemount PRT 118MK /118MM	100 ÷350	VIS FPA, Optics, Cold Box, Baseplate
OM	2	-	2N2222	60 ÷100	Coolers cold tip
ME	3	-	AD590	303 ÷398	DPU, PS

Table 2.11 Temperature Sensors

2.4.6 OBDH Channels

VIRTIS communicates with the OBDH via 5 independent and redundant channels: Telecommand, Telemetry (split in High Speed Telemetry and 16bit serial digital telemetry), Monitor and Timing. The details on the interfaces are given in section 2.2.3.

3 Operating Modes Description

3.1 Introduction

VIRTIS is an highly complex instrument, in fact inside a common structure (the Optics Module) it contains two scientifically complementary but operationally independent instruments: VIRTIS-H and VIRTIS-M. The difficult task of the ME on board software has been thus to manage two separate instruments with different timing and data processing requirements working most of the time in parallel. The Main Electronic Software shall allow full independent operations of VIRTIS-M and VIRTIS-H.

In producing this User Manual we have been trying to summarise the main characteristics of the instrument operations. However, to describe fully the operations of the instrument a large number of documents is required. Thus it has been considered most useful to have these documents being integral part of this User Manual as attachment rather than duplicating information. The following documents have been attached and can be found at the end of the document:

VIR-GAL-UR-040, Issue 5, May 2001	VIRTIS SW User Requirements
VIR-GAL-IC-0048, Issue 6, June 2001	VIRTIS OBDH SW ICD
VIR-GAL-IC-028, Issue 7, July 2001	VIRTIS SW Internal ICD
VIR-DLR-MA-006, Issue2 (draft2) February 2002	VIRTIS On-Board S/W User Manual

The last paragraph of this chapter 3 is devoted to the description of how to build a typical observation session.

3.2 Modes Definition

VIRTIS Modes are defined in compliance with requirements expressed in Sect. 2.8.4.3 of AD1. i.e. distinct modes are to be defined where at least one of the following applies:

- Different resource usage (e.g. power, data rate, SSMM demand);
- Specific requirements put on the S/C (e.g. pointing);
- Different operative phase for the instrument.

However, regarding Data Rate a distinction must be made for VIRTIS which uses the IEEE1355 Interface (High Speed Link) to the Mass Memory, with respect to those instrument having data transfer on the Slow channel (RTU). VIRTIS is in fact Data Volume Limited rather than Data Rate Limited. All science data do not use the standard RTU (except in the Degraded operative mode, see later) and thus do not interfere with the other instruments using the standard slow data interface. From this point of view VIRTIS operation can be considered fairly independent from the Data Rate issue.

As required in Sect. 2.8.3.2.3 of AD1, the H/K TMs provide a specific parameter “VIRTIS Mode Id” that unambiguously identifies the instrument mode of operation. This parameter is contained in the “default” H/K report with the format given in table 3.1. The parameter has three field one for each subsystem of the instrument ME, VIRTIS-M and VIRTIS-H.

<table>
<tr><th colspan="4">ME Operative Mode</th><th colspan="6">V-H Operative Mode</th><th colspan="6">V-M Operative Mode</th></tr>
<tr><td>b_0</td><td>B_1</td><td>b_2</td><td>b_3</td><td>b_4</td><td>b_5</td><td>b_6</td><td>b_7</td><td>B_8</td><td>b_9</td><td>b_{10}</td><td>b_{11}</td><td>b_{12}</td><td>b_{13}</td><td>b_{14}</td><td>b_{15}</td></tr>
<tr><td colspan="4">1 ME_Off
2 ME_Safe
3 ME_Development
4 ME_Idle
5 ME_Science
6 ME_Test</td><td colspan="6">1 H_Off
2 H_Cool_Down
3 H_Idle
4 H_Annealing
5 H_PEM_On
6 H_Test
7 H_Calibration
8 H_Nominal_Simulation

SCIENCE MODES

9 H_Science_Maximum_Data_Rate
10 H_Science_Nominal_Data_Rate
11 H_Science_Minimum_Data_Rate
13 H_Science_Backup
14 H_User_Defined
19: H_Degraded (**)

63 H_ME_Test (*)</td><td colspan="6">1 M_Off
2 M_Cool_Down
3 M_Idle
4 M_Annealing
5 M_PEM_On
6 M_Test
7 M_Calibration

SCIENCE MODES

8 M_Science_High_Spectral_1
9 M_Science_High_Spectral_2
10 M_Science_High_Spectral_3
11 M_Science_High_Spatial_1
12 M_Science_High_Spatial_2
13 M_Science_High_Spatial_3
14 M_Science_Nominal_1
15 M_Science_Nominal_2
16 M_Science_Nominal_3
17 M_Science_Nominal_Compressed
18 M_Science_Reduced_Slit
19 M_User_Defined
20: M_Degraded (**)

63 M_ME_Test (*)</td></tr>
</table>

(*) H_ME_Test and M_ME_Test, which physically correspond to have PEM off but IFE on, are used in ME_Test mode.
(**) Degraded modes are used when HS link is not available. Science data are sent on RTU Link

Table 3.1 VIRTIS MODE Identification. The HK parameter VIRTIS Mode is such that the bit 0-3 represent ME mode, bits 4-9 VIRTIS-H mode and bits 10-15 VIRTIS-M Mode.

A VIRTIS Mode is a unique combination of these 3 fields. However, several VIRTIS Modes have common properties and hence are classified as belonging to the same Mode Group. This is a naming convention to address without ambiguity general statements which are valid in different modes (e.g., “all Science modes” means “all modes of the Science Mode Group”). The Modes Groups are listed below:

- Off
- Safe
- Idle
- Cool-down
- Annealing
- Calibration
- Science
- Test
- Development (used only by S/W developers and not described further)

A visualisation of the transitions between modes groups is given in figure 3.1 representing the general VIRTIS state diagram. In figure 3.2 the mode group transitions for M and H are reported (M and H mode groups are equivalent).

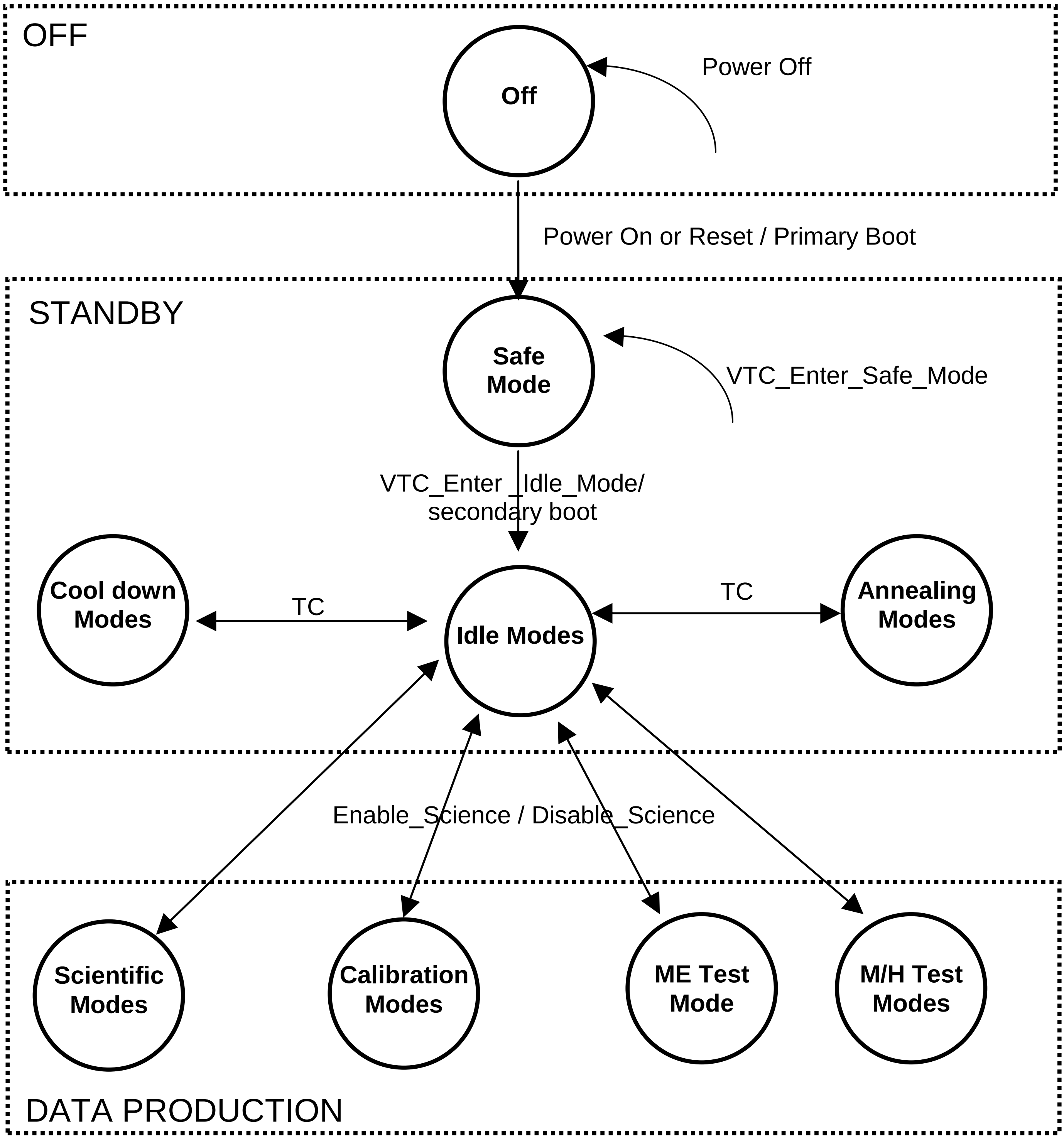


Figure 3.1 VIRTIS Mode Transitions

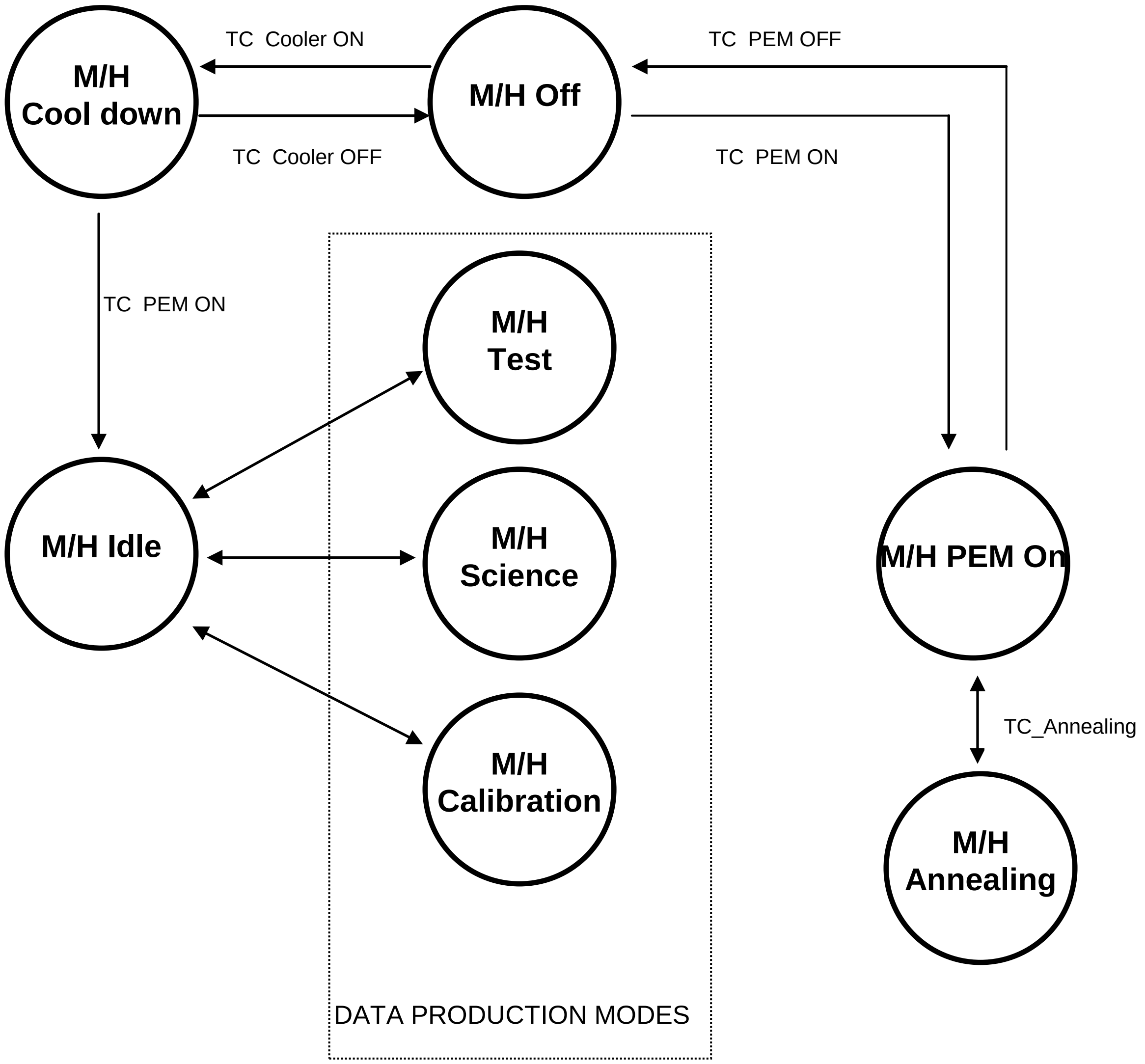


Figure 3.2 Mode transitions for VIRTIS-M and VIRTIS-H

The VIRTIS S/W has been designed to provide the maximum of flexibility and to ensure independence in the usage of the two optical heads (VIRTIS-M and VIRTIS-H), it follows that almost all of the VIRTIS-M operative modes can be used in combination with almost all VIRTIS-H operative modes and vice versa. However, still few constraints based mainly on hardware limitations exists (here V-X and V-Y represent VIRTIS-H and VIRTIS-M indifferently):

- If V-X mode is Annealing, V-Y mode can only be Off.
- If V-X mode is Calibration, V-Y mode can only be Off or Idle.
- Additionally, If ME mode is Off or Safe, then both PEMs are Off.

All the other modes can be freely combined. Table 3.2 lists all the possible ME modes. On the contrary, a similar simple list cannot be produced at channel level. In fact, thanks to the great flexibility of the software, a very large number of univocally determined scientific modes for each channel can be defined simply changing the selection of the channel operation parameters (pixel binning, data compression type, etc.). We thus performed a scientifically meaningful selection of the parameters values and thus defined a reduced number of modes. These operative modes are listed in tables 3.3, 3.4. It must be stressed that this list represent only a subset of all the possible modes, identified by ID # in the first column. Same ID is stored on board and when the VIRTIS software receives a selection of the operational parameters fitting its stored information attaches the relative ID number to it.
However, this does not prevent at all the usage of any other possible selection of the operational parameters; simply, the built mode shall not be recognised by the on board software as a known mode and the “User Defined mode” shall be entered. A detailed discussion of the scientific modes and their construction is given in chapter 3.5.1 (for –M) and 3.5.4 (for –H).

Mode	Id	HK Data Rate [kbits/s]	Power [w]
ME_Off	1	0	0
ME_Safe	2	0.075	5
ME_Development	3	0.075	9.5
ME_Science	4	0.075	7.3
ME_Idle	5	0.075	5
ME_Test	6	0.075	10.5

TABLE 3.2 Main Electronics (ME) Operative Modes

Mode #	V-M Mode	Cooler	PEM	M_ACQ_MODE	VIS slice	IR slice	Spatial x Spectral Binning	Science Data Compression Type	External Repetition Time [s]	Science Data Rate (kbps)
1	M_Off	OFF	OFF	don't care	don't care	don't care	don't care	don't care	don't care	0
2	M_Cool_Down	Closed / Open Loop	ON/OFF	don't care	don't care	don't care	don't care	don't care	don't care	0
3	M_Idle	Closed / Open Loop	ON	don't care	don't care	don't care	don't care	don't care	don't care	0
4	M_Annealing	OFF	ON	don't care	don't care	don't care	don't care	don't care	don't care	0
5	M_PEM_On	OFF	ON	don't care	don't care	don't care	don't care	don't care	don't care	0
6	M_Test (1)	ON any state (2)	ON	any	(4)	(4)	(4)	any	any	708 MAX (6)
7	M_Calibration	Closed / Open Loop	ON	All_Pixels	256x432	256x432	1x1	no compression	don't care	165 (3)
8	M_Science_High_Spectral_1	Closed / Open Loop	ON	high spectral	64x432	64x432	4x1	lossless	T#1 = 5s	88
9	M_Science_High_Spectral_2	Closed / Open Loop	ON	high spectral	64x432	64x432	4x1	lossless	T#2 = 20s	22
10	M_Science_High_Spectral_3	Closed / Open Loop	ON	high spectral	64x432	64x432	4x1	lossless	T#3 = 60s	7.4
11	M_Science_High_Spatial_1	Closed / Open Loop	ON	high spatial	256x144	256x144	1x3	lossless	T#1 = 5s	118
12	M_Science_High_Spatial_2	Closed / Open Loop	ON	high spatial	256x144	256x144	1x3	lossless	T#2 = 20s	29.5
13	M_Science_High_Spatial_3	Closed / Open Loop	ON	high spatial	256x144	256x144	1x3	lossless	T#3 = 60s	9.8
14	M_Science_Nominal_1	Closed / Open Loop	ON	nominal	64x144	64x144	4x3	lossless	T#1 = 5s	29.5
		ON any state (2)		VIS_Only	64x288	No	4x1			
				IR_Only/Alter_IR	No	64x288	4x1			
15	M_Science_Nominal_2	Closed / Open Loop	ON	nominal	64x144	64x144	4x3	lossless	T#2 = 20s	7.4
		ON any state (2)		VIS_Only	64x288	No	4x1			
				IR_Only/Alter_IR	No	64x288	4x1			
16	M_Science_Nominal_3	Closed / Open Loop	ON	Nominal	64x144	64x144	4x3	lossless	T#3 = 60s	2.5
		ON any state (2)		VIS_Only	64x288	No	4x1			
				IR_Only/Alter_IR	No	64x288	4x1			
17	M_Science_Nom_Compress	Closed / Open Loop	ON	Nominal	64x144	64x144	4x3	M_WAVELET F1	5	7.4
18	M_Science_Reduced_Slit	Closed / Open Loop	ON	Reduced	64x144	64x144	1x3	Lossless	5	29.5
19	M_User_Defined (1)	ON any state (2)	ON	any	(4)	(4)	(4)	Any	any	663 MAX
20	M_Degraded	Closed / Open Loop	ON	nominal	64x144	64x144	4x3	M_WAVELET_F3	T#3 = 60s	0.29
63	M_ME_Test (5)	OFF	OFF	don't care	don't care	don't care	don't care	don't care	don't care	663 MAX

TABLE 3.3 V-M Operative Modes

(1) M_Test and M_User_Defined modes allow the user to select any combination of the operative parameters.
(2) Cooler states are: Closed Loop, Open Loop and Stand By.
(3) The Calibration is an automatic sequence that lasts 775s (2134s if RTU operation is selected). The data rate applies to this time span.
(4) Values according to the M_ACQ_MODE selection.
(5) Onle ME is powered on; PEM is off; Simulated data from M/IFE are generated.
(6) Max data rate is obtained by (256x432) x 2 (VIS and IR detectors) x 15 (15 bit integers) / 5 (repetition time) = 663 kbps

Mode #	V-H Mode	Cooler Mode	PEM	Data Production Mode	Max Science Data Rate (kbps)	Max HK data Rate (kbps)
1	H_Off	OFF	OFF	Don't care	0	0
2	H_Cool_Down	Closed / Open Loop	ON/OFF	Don't care	0	0
3	H_Idle	Closed / Open Loop	ON	Don't care	0	0
4	H_Annealing	OFF	ON	Don't care	0	0
5	H_PEM_On	OFF	ON	Don't care	0	0
6	H_Test	ON any state (4)	ON	H_Image_Slice (1)	270	0.6
7	H_Calibration	Closed / Open Loop	ON	7 H_Image_Slice + 2 H_Spectrum	45 (5)	0.28
8	H_Nominal_Simulation	Closed / Open Loop	ON	H_Spectra_Slice (3) + H_Spectrum (2)	3.4	0.06
9	H_Science_Max_Data_Rate	Closed / Open Loop	ON	H_Spectra_Slice + H_Spectrum	84	3
10	H_Science_Nom_Data_Rate	Closed / Open Loop	ON	H_Spectra_Slice + H_Spectrum	27	1.2
11	H_Science_Min_Data_Rate	Closed / Open Loop	ON	H_Spectra_Slice + H_Spectrum	3.4	0.06
13	H_Science_Backup	Closed / Open Loop	ON	H_Image_Slice	270	0.6
14	H_User_Defined	ON any state (4)	ON	Any	270	3
19	H_Degraded	Closed / Open Loop	ON	H_Spectra_Slice + H_Spectrum	0.9	0.02
63	H_ME_TEST	OFF	OFF	H_Image_Slice	270	3

TABLE 3.4 V-H Operative Modes

NOTE

(1) **H_Image_Slice** : IR full frame adjusted in pixel size to a 432x256 pixels
(2) **H_Spectrum**: Composition of the 8 orders spread over the H-IR detector. The PEM-H uses the pixel map to extract 3456 pixels containing the spectral information from the full detector window of 432x256
(3) **H_Spectra_Slice**: Collection of 64 H_Spectrum, consequently acquired.
(4) Cooler states are: Closed Loop, Open Loop and Stand By.
(5) Calibration data volume is fixed. The data volume is 124kbit over a 274s period (448s if RTU link is used)

3.3 Safe Mode

During normal operations this condition is reached after power-on; all the modules are powered-off except for ME, which shall perform the Primary Boot (run of the PROM S/W) thus initialising all the ME hardware (set watch-dogs, set S/C interface, etc.).
All commands relative to the management of the memory areas are possible exclusively from the Safe Mode (TC_Load_Memory, TC_Dump_Memory, TC_Check_Memory, VTC_Get_EEPROM_Status) as only the PROM S/W contains the routines to operate on memory areas.

This mode can be reached also

1. After reset from failure (event of category V and VI)
2. With an explicit VTC_Enter_Safe_Mode telecommand.

3.4 Idle Modes

Upon reception of the TC_Enter_Idle_Mode, the ME shall perform the Secondary Boot and will be able to accept commands for the PEMs and for the other internal subsystems This mode group contains several Idle conditions as reported in table 3.5.

Mode	ME	PEM-M	PEM-H	Cooler-M	Cooler-H
Idle 1 (ME_Idle, H_Off, M_Off)	On	Off	Off	Off	Off
Idle 6(ME_Idle, H_PEM_On, M_Off)	On	Off	On	Off	Off
Idle 3(ME_Idle, H_Off, M_PEM_On)	On	On	Off	Off	Off
Idle 7(ME_Idle, H_PEM_On, M_PEM_On)	On	On	On	Off	Off
Idle 4(ME_Idle, H_Idle, M_Off)	On	Off	On	Off	On
Idle 2(ME_Idle, H_Off, M_Idle)	On	On	Off	On	Off
Idle 5(ME_Idle, H_Idle, M_Idle)	On	On	On	On	On

Table 3.5 Idle Modes Group description.

The Idle mode is the Stand-by mode of the instrument. Any sequence of TCs intended to bring VIRTIS in a stand-by condition must end in one of the above listed Idle Modes (see also chapter 3.3 for a graphical description).
When the ME is in Idle and one of the two PEMs or both are also in Idle we are ready to start the setting of the instrument to prepare it for the science acquisition.

3.5 Science Modes

Before starting the description of the scientific modes we need to define some nomenclature of the terms used in this framework:

H_Spectrum
A H_Spectrum is a composition of the 8 orders imaged on the H-IR detector, the H_Spectrum is extracted from the two-dimensional detector by using a spectral map

stored in memory of the lighted pixels. The result is a spectrum based on 8 spectral orders of 432 elements and a width of 5 pixel for each order. The 5 pixels are reduced to 1 pixel by averaging. The H_Spectrum is thus composed of 3456 pixels.

H_Spectra_Slice
A H_Spectra_Slice is 2-dimensional data array stored in the ME, and composed by 64 subsequent acquisitions of a H_Spectrum and consequently has a total dimension of 3456 x 64 elements. The H_Spectra_Slice is successively decomposed in sub-slices (compression units) of 144x64 pixels. A H_Spectra_Slice is thus decomposed in 24 sub-slices. The H_Spectra_Slice is a mathematical artifice adopted to built a data correlation inside the H_Spectra_Slice and improve the performances of the compression algorithm.

H_Image_Slice
A H_Image_Slice is a H-IR full frame, adjusted to the common (with M-IR) dimension of 432x256. It is an instantaneous reading from the PEM-H without application of the Pixel Map.

Slice
A Slice is a 2-dimensional array of elements with a spectral (X) and spatial (Y) dimension. Is the instantaneous acquisition of M-VIS and M-IR detectors. A slice is window adjusted, reducing the M-VIS from a full acquired window of 438x256 elements and the M-IR window of 438x270 elements to a common sized slice of 432x256. Successively, the selected binning factor (resampling over X and Y) is applied thus providing

No binning	432x256	= 12 subslices
3x4	144X64	= 1 subslices
3x1	144x256	= 4 subslices
1x4	432x64	= 3 subslices

Sub-slice
A Sub-slice is a portion of a Slice or of a H_Image_Slice and has a dimension of 144x64 elements. The sub-slice is the compression unit.

3.5.1 VIRTIS-M Science Modes

Before enabling the scientific acquisition, VIRTIS-M must be configured in a scientific operative mode. This is achieved by means of 5 different TCs. Not all of them have to be necessarily uploaded each time a new Scientific Mode needs to be implemented, but all of them contain several parameters used for the scientific mode configuration:

3.5.1.1 MTC_Change_Data_Production_Param.

This TC uses a single parameter (M_DATA_PRODUCT_PARAM or in short M_DPT) which select the acquisition type:

1. **M_Data_Science**. Value=0 Normal selection for scientific acquisition.
2. **M_Data_Calibration**. Value=1 Start of a calibration sequence.

3. **M_Data_Test**. Value=2 Enter the test mode of the M channel.

This last test mode is specifically important in case of ME malfunction to command directly the PEM-M (through the TC MTC_Command_Word) without any filter from the ME.

3.5.1.2 MTC_Change_Operational_Parameter

This TC is used to select the ME data processing (spatial/spectral binning, data compression algorithm, frame summing, etc) and the repetition rate. The parameters of this TC define the value of the input for the algorithm for the calculation of the expected data rate.

Parameter	Function
M_ERT Default =0	External Repetition Time. Represents the interval between two subsequent slices delivered to the S/C. It can assume only 4 values: 0 = 5 sec 1 = 20 sec 2 = 60 sec 3 = 300 sec
M_SS Default=1	Number of slices to be summed (SS = Slice Summing).within one M_ERT. M_SS, M_IR_EXPO, M_IR_DELAY, M_CCD_EXPO and M_CCD_DELAY define the M_IRT (Internal Repetition Time) . M_SS and M_SU_NUM_IRT_ANGLE define the spatial resolution along the scan direction (perpendicular to the slit direction). Summing it is used to improve SNR by taking multiple acquisition on the same location (in this case scan mirror shall not be moved during one full M_ERT), or to reduce the spatial resolution along the scan direction (scan mirror is positioned to the new point every M_IRT).
M_ACQ_MODE Default = 0	Define the spatial/spectral binning performed by the ME on the single slice. We can select 8 modes: 0 = **M_ACQ_MODE_NOMINAL_3x4_FULL_WIN** 1 = **M_ACQ_MODE_VIS_ONLY_1x4** 2 = **M_ACQ_MODE_IR_ONLY_1x4** 3 = **M_ACQ_MODE_HIGH_SPECTRAL_1x4_FULL_WIN** 4 = **M_ACQ_MODE_HIGH_SPATIAL_3x1_FULL_WIN** 5 = **M_ACQ_MODE_ALL_PIX_FULL_WIN** 6 = **M_ACQ_MODE_REDUCED_SLIT_3x1** 7 = **M_ACQ_MODE_ALTER_IR_ONLY_1x4**
M_COMP_MODE Default = 1	Defines the on-line compression mode for the sub-slice (144x64). **0 = M_NO_COMPRESSION:** no compression is done **1 = M_LOSSLESS_COMPRESSION:** Minimum compression factor is 2. **2 = M_WAVELET_F1_COMPRESSION:** Compression factor is 8. **3 = M_WAVELET_F2_COMPRESSION:** Compression factor is 10.67. **4 = M_WAVELET_F3_COMPRESSION:** Compression factor is 16.

Table 3.6 Parameters of the MTC_Change_Operative_Param.

The 8 different values of the M_ACQ_MODE parameter shall correspond to the following window selections:

M_ACQ_MODE	PIXELS		BINNING		
	Spectral	**Spatial**	**Spectral**	**Spatial**	**Detectors**
NOMINAL_3X4_FULL_WIN	144	64	3	4	VIS + IR
VIS_ONLY_1X4	288	64	1	4	VIS
IR_ONLY1X4	288	64	1	4	IR
HIGH_SPECTRAL1X4_FULL_WIN	432	64	1	4	VIS+IR
HIGH_SPATIAL_3X1_FULL_WIN	144	256	3	1	VIS+IR
ALL_PIX_FULL_WIN	432	256	1	1	VIS+IR
REDUCED_SLIT_3X1	144	64	3	1	VIS+IR
ALTER_IR_ONLY_1X4	288	64	1	4	IR

Table 3.7 M_ACQ_MODE window definition

For the IR and VIS only modes the user has the freedom to define the spectral region, in fact only 288 spectral pixels are used out of 432 available. This is true also for the Reduced Slit acquisition mode in which on 64 spatial pixels (high resolution) shall be transferred. Selection is performed by means of M_IR(VIS)_WIN_X(Y)_1(2) described below.

3.5.1.3 MTC_Change_Functional_Parameter

With this TC we define the settings and values of parameters needed for the configuration of the PEM-M. Note that not all the parameters of this TC are listed as not all of them contribute to the selection of the science mode.

Parameter	Function
M_IR_WIN_X1 M_IR_WIN_X2 M_IR_WIN_Y1 M_IR_WIN_Y2	Co-ordinates for window adjustment of the IR detector data. The PEM-M transfer to ME always the full 438x270 pixels window, which needs to be reduced to the window defined by M_ACQ_MODE.
M_IR_DELAY M_IR_EXPO	M_IR_DELAY represents an IR integration delay time to synchronise VIS and IR acquisitions. M_IR_EXPO is the IR exposition (integration) time.
M_CCD_WIN_X1 M_CCD_WIN_X2 M_CCD_WIN_Y1 M_CCD_WIN_Y2	Co-ordinates for window adjustment of the IR detector data. The PEM-M transfer to ME always the full VIS 876x512 pixels window, which needs to be reduced to the window defined by M_ACQ_MODE. **Note**: the M-PEM CCD channel is commanded internally by a window of 876x512 elements, but the PEM send a data set of 438x256 pixel to the ME which means the M-PEM performs a element binning of 2x2 (i.e. 4 detector elements are binned to 1 pixel).
M_CCD_DELAY M_CCD_EXPO	M_CCD_DELAY represents a CCD integration delay time to synchronise VIS and IR acquisitions. M_CCD_EXPO is the CCD exposition (integration) time.
M_SU_MODE M_SU_ANGLE_FIRST M_SU_ANGLE_LAST M_SU_ANGLE_STEP_SIZE M_SU_NUM_IRT_ANGLE	These parameter are those required for the control of the Mirror Scan Unit (SU). **If M_SU_MODE = Off (2)**, the SU is <u>not</u> switched-on and <u>no</u> PEM commanding for SU control is done by the software independently from the -M mode. **If M_SU_MODE = Point (0)**, the SU is switched-on and the mirror is moved to the point given by parameter M_SU_ANGLE_FIRST and kept fixed until the Disable Science command. **If M_SU_MODE = Scan (1)** the SU is switched-on and the mirror is scanned from M_SU_ANGLE_FIRST to M_SU_ANGLE_LAST with steps given by M_SU_ANGLE_STEP_SIZE. Stepping is performed every M_SU_NUM_IRT_ANGLE internal repetition times (IRT)
M_D_BCK_RATE	This parameter defines the frequency of dark acquisitions in terms of M_ERT, i.e. if M_D_BCK_RATE = 10, then one dark acquisition is performed every 10 M_ERTs. The dark

	acquisition shall never be summed (regardless of the M_SS value) and shall use the full M_ERT

Table 3.8 Parameters of the MTC_Change_Functional_Param (only those relative to the Scientific Mode selection).

3.5.1.4 MTC_Change_Alternate_Parameter

This TC is used only in the IR_Only_Mode (only the IR detector is used) and allows to define a subset of the functional parameters, namely the coordinates (M_IR_WIN_X1, M_IR_WIN_X2, M_IR_WIN_Y1, M_IR_WIN_Y2) the M_IR_DELAY and M_IR_EXPO.

3.5.1.5 MTC_Change_Calibration_Parameter

This TC is used only whenever M_DPT is set equal to "M_Data_Calibration". The parameters in this case define the integration times and the delay times for the CCD and IR detectors in each of the 7 phases of the calibration sequence, as well as the voltages and stabilisation times of the calibration lamps. See below for a description of the Calibration Mode.

Upon reception of a TC_Enable_Science , the ME shall transfer to the relevant PEM the table containing the parameters, defined above and required to set up the observation. A dump of the uploaded table is also issued to ground.
At this point the specific parameters selection define the operative mode and the PEM-M shall start the scientific acquisition and remain in this state until the ME receives the TC_Disable_Science from the Mission Time Line of the S/C.

3.5.2 VIRTIS-M Data Rate

We must distinguish between :

1. The scientific data rate (described in the first part of this chapter) which depends on the selected operative mode (binning, windowing, compression).
2. and the effective data rate from VIRTIS to the S/C which takes into account the fact that only 512 words packets are allowed and that in each packet the first 12 words are constituted by: a packet header (3 words), a data field header (5 words) and a specific data description header (4 words). This means that the ME shall format in each packet 500 scientific data words. As the number of words for each acquisition frame are in general not a multiple number of 500 the packets shall have a different length according to their total data size.

The calculation of the scientific data rate takes into account the window size, the compression factor and the repetition time, according to the following formula:

Average Data rate = $Det * 16 * \frac{Nspatial * Nspectral}{C * M\_ERT}$ [bps]

Where

- *Det* is either 1 if only one detector mode is used and 2 if both CCD and IR detectors are in use.
- *C* is the compression factor relative to the selected compression algorithm, given in table 3.6 .
- *M_ERT* is the selected repetition time
- *Nspatial* and *Nspectral* are the number of pixels in spatial and spectral directions, reported in table 3.7

The calculated value ranges from 0.06 kbps for a single detector reading with a repetition time of 300s and a maximum compression factor, to 707.79 kbps for an IR+VIS full window with minimum repetition time and no compression.

3.5.3 VIRTIS-M Science Data Format

SCIENCE data generated by the VIRTIS-M VIS and VIRTIS-M IR are stream of 16bit words, each corresponding to one pixel. Detector data are acquired on a spectral basis (spectrum by spectrum). In figure 3.4 is reported a sketch of the detectors and their alignment with respect to the slit and spectrum direction. The axes are aligned to the axes of the spacecraft.

The VIS CCD detector is a frame transfer detector of 1024x1024 CCD elements, thus only 512x1024 pixels are usable as image area. Moreover, each detector element have a physical size which is the half of the IR detector pixel, thus summation of 2x2 pixels shall be performed by the PEM to match spatial resolution of the IR channel. This action is performed directly by the PEM and is transparent to the final user.
The ME receives from the CCD 438 spectral and 256 spatial pixels and from the M-IR in full window mode receives 438 spectral and 270 spatial pixels. For compatibility with an integer binning value these format are further reduced to a common 432x256 by the ME.

For M-IR the ME can command the PEM to produce a reduced window (438 spectral and 90 spatial pixels) to be used in the *M_reduced_slit* mode. In this case 90 pixels in the central area of the slit are selected.

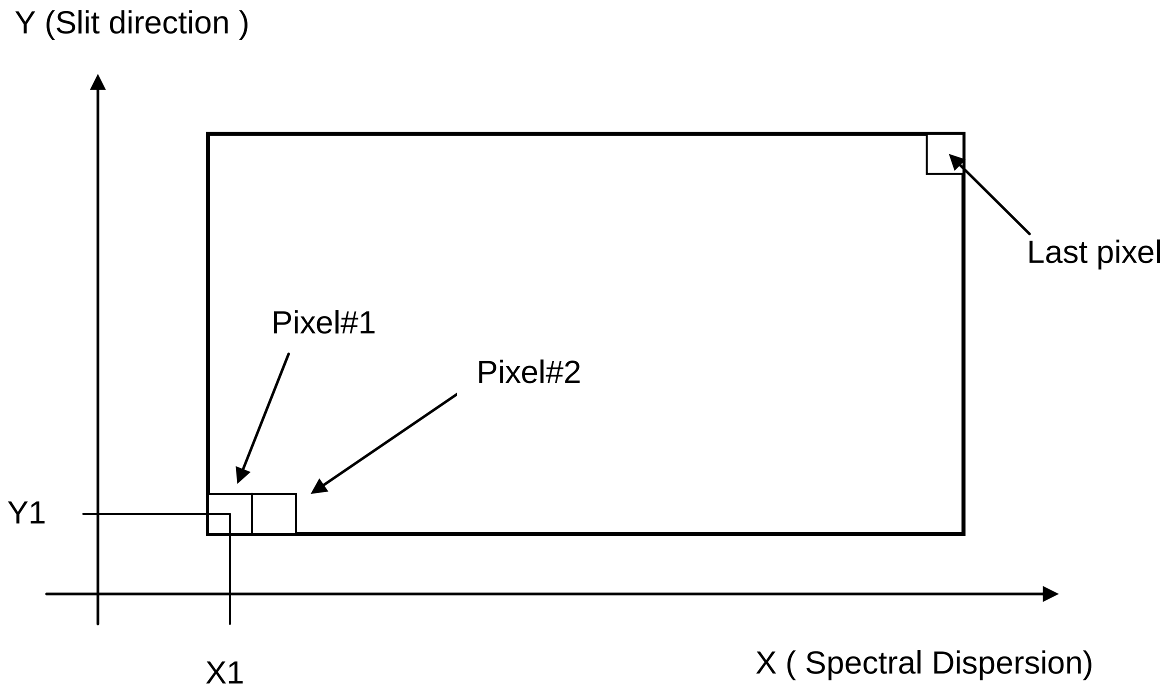


Figure 3.4 Data Organisation on the CCD and IR detectors of VIRTIS-M

3.5.4 VIRTIS-H Science Modes

As for VIRTIS-M we need to define the configuration of the H channel and the data processing to be applied by the ME. This is achieved by means of 4 TCs:

HTC_Change_Data_Production_Param. This TC uses a single parameter (H_DATA_PRODUCT_PARAM or in short H_DPT) which select the acquisition type and the data structure sent by the PEM-H to the ME after each single acquisition:

1. H_Nominal_Observation. The Pixel map is used to select region of the IR detector to be downloaded to ME.
2. H_Calibration. Start of a calibration sequence.
3. H_Nominal_Simulation. Data structure is as for H_Data_Nominal_Observation but the data content is simulated by the FPGA.
4. H_Science_Backup. Full window reading of the IR detector (270x438 pixels)
5. H_Spectral_Calibration_Simulation. An H_Image_Slice (same size as H_Science_Backup but only simulated data) is delivered to the ME
6. H_Test. Enter the test mode of the H channel, in which we can command directly the PEM-H (through the TC HTC_Command_Word) without any filter from the ME.

HTC_Change_Oper_Param. This TC is used to select the ME data processing of the data acquired (data compression algorithm, frame summing) from the detectors and the integration time and read-out frequency. The parameters of this TC define the value of the input for the algorithm for the calculation of the expected data rate.

Parameter	Function
H_INT_SCIENCE_NUM1 & H_INT_SCIENCE_NUM2	Two words (NUM1 = LSW and NUM2=MSW) used to define the integration time. The integration time t in sec is given by t= (1024* NUM2+NUM1)*512x10^{-6}
H_SUM	Determine if we perform on-board frame averaging (0=no sum; 1=sum)
H_N_FRAME **(see note)**	If H_SUM=0 the parameter represent the ME frame transfer frequency. e.g. if H_N_FRAME is 3, all frames are read by the PEM-H but only one every 3 is delivered to the ME If H_SUM=1 Don't care
H_N_SUM_FRAME **(see note)**	If H_SUM=0 Don't care If H_SUM=1 the parameter represent the number of frames to be averaged. In this case all the frames are read and delivered to the ME, but they are averaged before compression.
H_DARK_RATE	The number of frames between two consecutive dark acquisitions.
H_COMP_MODE	The selected compression mode

NB. The H detector is used in free run mode, in other words the PEM-H reads continuously the detector; however not all the frames are sent to the ME. The data transfer to ME is defined by the operational parameters H_N_FRAME, H_SUM and H_N_SUM_FRAME. If no averaging is performed a frame is sent to the ME every H_N_FRAME acquisitions. If H_SUM is 1 (summing), H_N_SUM_FRAME are averaged and the averages frame is sent to the SSMM. This approach has been selected as it should ensure a good temperature stabilisation (for an example see appendix E.1 of AD10)

Table 3.9 Parameters of the HTC_Change_Operational_Param

There are limitations in the parameters selectable values. For instance:

- IF (H_INT_SCIENCE. Equal or less than. 700ms) AND (H_Data_Production_Mode=0) then H_SUM=0 and H_N_FRAME. equal or greater than. 2)
- IF (H_DATA_PRODUCTION_MODE=0 or 3) than H_DARK_RATE=2^{K} with K=0,1,2…

3.5.5 VIRTIS-H Data Rate

As for VIRTIS-M the specific selection of the operative parameters shall determine the average data rate for each mode. The data rate for H can be calculated as follows:

Average Data rate = $16 * \frac{Npixels * Ndark}{C * H\_IRT * N\_Frame}$ [bps]

where

- *Npixels* = 432x8 (Nominal_Observation); 432x256 (H_Science_Backup) see chapter 3.5.6
- *Ndark = H_Dark_Rate + 1*
- *C* is the compression factor relative to the selected compression algorithm:
    - H_NO_COMPRESSION C=1
    - H_LOSSLESS COMPRESSION C=2
    - H_WAVELET_F1_COMPRESSION C=8
    - H_WAVELET_F2_COMPRESSION C=10
    - H_WAVELET_F3_COMPRESSION C=16
- *H_IRT* = $(H\_INT\_Science + Science\_readout + HK\_readout + Idle\_time)$
- *Science_readout* =0.18458 s in nominal mode
  =1.1934 s in backup mode
- *HK_readout* = 2.304 ms
- *Idle_Time* = 79.872 ms#
- *N_Frame* = *H_Dark_Rate*H_N_SUM_FRAME + 1* *if H_SUM=1*
  *H_Dark_Rate*H_N_FRAME + 1* *if H_SUM=0*

The above formulas allows to define three different data rate ranges:
Minimum: < 3.4 Kbps
Nominal: 3.5 through 27 Kbps
Maximum: 28 through 87 Kbps

3.5.6 VIRTIS-H Science Data Format

VIRTIS-H uses the same IR detector as VIRTIS-M however, due to the different design of the two channels the detector is used rather differently.
VIRTIS-H is a high resolution spectrometer and does not perform imaging (for a complete description of VIRTIS-H optical head see chapter 1.2). The H-IR detector is used to acquire spectra spread over its surface, thus only a portion of the pixels contains useful scientific data, see figure 3.5. The 8 spectral orders are spread over the entire surface matrix. In each spectral order the spectrum covers 432x5 pixels (where 5 pixels represent the image of the slit size when imaged on the detector).
Thus overall only 15% of the 438x270 pixels matrix surface is used. To reduce the overall data rate and volume, H uses the so called Pixel Map which gives the exact location of the spectra over the H-IR detector. The ME calculates the location of the pixels to be downloaded and passes it to PEM-H which then download them accordingly. The downloaded data are the H_SPECTRUM, a set of 432x8x5. As H has no spatial resolution the 5 pixels are averaged together, thus the final end-product in the H_Nominal acquisition mode is a 3456 (or 432x8) pixels spectrum representing the full spectral range of the instrument from 1.88 through 5.03 micron.

However, the PEM-H can also be commanded to download the full frame to ME in the *Calibration* and *Science Backup* modes. In this case the full 432x256 pixels are sent to ME.

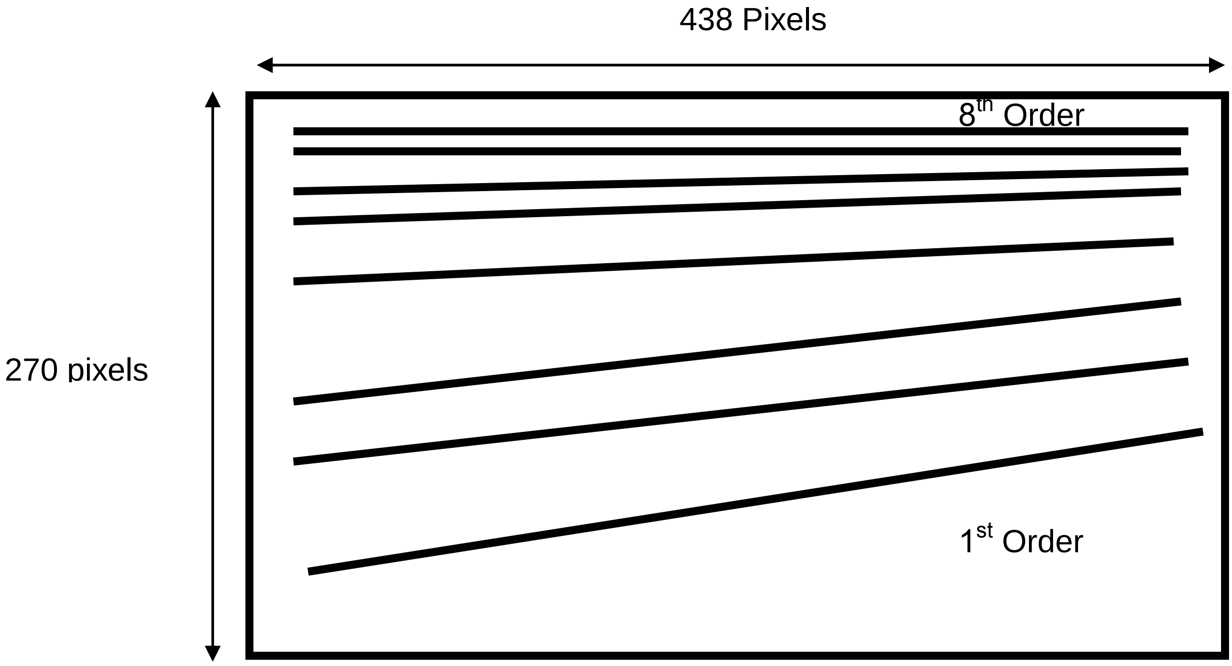


Figure 3.5 Spectral orders distributed over the IR FPA area. Only 15% of the matrix contains scientific data.

3.6 Test Modes

We can test independently the ME or the M or H channels, however the behaviour of the instrument in the two cases is profoundly different.
When ME test is selected we can test the DPU, PS, and the interfaces to M and H (M-IFE and H-IFE); in fact in ME_Test mode the two PEMs are switched off. In this case the default H/K will show for M and H the mode M_ME_Test and H_ME_Test.
On the contrary entering the test modes for M and H allows to command directly the PEMs (by means of telecommand MTC_PEM_Command_Word and HTC_PEM_Command_Word) without interference from the ME; thus we can test directly the two channels. In this case the default H/K will show for M and H the mode M_Test and H_Test.

3.6.1 ME Test Mode

VTC_Enter_Test_Mode is needed to enter the ME_Test_Mode. It is used for testing the main parts of the ME (DPU, M/H-IFE, PS). Only simulated Science data are produced.

ME test mode means:
- entering the test mode can only be done in ME_IDLE mode.

- only the DHSU power converter and the H-IFE and M-IFE are switched-ON.
- the –M and –H converters are OFF.
- after VTC_Enter_Test_Mode(ME) and after TC_Enable_Science, the M-IFE and/or H-IFE produces periodically pseudo random test pattern
- the test pattern are compared (completely word by word) on-line by software, if there is an error in the pattern, an event is issued to the S/C, so IFE/DPU hardware problems can be detected
- the pattern are processed (as defined by the –M/-H data processing parameter), packed in TM packets (as for science data coming from the PEMs) and are sent to the S/C via HS link or SDT interface
- the data volume to be generated by the M-IFE or/and H-IFE and the repetition rate for each channel are selected by the parameter in VTC_Enter_Test_Mode

3.6.1.1 Entering a ME test mode with max. data volume and high repetition rate

- Preconditions: ME IDLE mode; H-PEM Off, M-PEM Off, HSLink Active
- MTC_Change_Operat_Param_RAM(ALL_PIX_FULL_WIN, NO_COMP)
- HTC_Change_Operat_Param_RAM(NO_COMPRESSION)
- VTC_Enter_Test_Mode
    - Unit_ID = 1 (ME)
    - M Repetition rate = 5sec
    - Number of M-VIS words = 112153 (438x256 science words + 25 H/K words)
    - Number of M_IR words = 118280 (438x270 science words + 20 H/K words)
    - H Repetition Rate = 5 s
    - Number of H_IR words = 118296 (438x270 science words + 36 H/K words)
- Default HK will show ME =**ME_Test**, H = **Off**, M = **Off**
- TC_Enable_M_Science_SSMM ; start of M-IFE pattern generation
- Default HK will show ME =**ME_Science**, H = **Off**, M = **M_ME_TEST**
- TC_Enable_H_Science_SSMM ; start of H-IFE pattern generation
- Default HK will show ME =**ME_Science**, H = **H_ME_TEST**, M = **M_ME_TEST**
- Each 5 seconds 684 (3 x 228) Science TM packets and 3 PEM-HK TM packets are produced.
- TC_Disable_M_science_SSMM ; stop of M-IFE pattern generation
- TC_Disable_H_science_SSMM ; stop of H-IFE pattern generation

In this particular case science data are produced with an average rate of about 1.1 Mbit/s. In ME test mode data rate and volume to be simulated from the IFEs is defined only by the VTC_Enter_Test_Mode (not by –M or –H specific parameter, e.g. the M_ERT)

3.6.2 M Test Mode

The M_Test mode can be entered by selecting M_DPT= 2 (M_Data_Test) in the TC_Change_Data_Product telecommand. The M channel shall enter the M_Test Mode (mode number 6 in table 3.1) when an MTC_Enable_Science_HSLink telecommand is sent.
Moreover, when in M_Test mode the PEM can be commanded directly by means of the MTC_PEM_Command_Word without any control by the ME. Thus such a mode is

extremely useful if we need to overcome the ME controls or if we need to check some specific behaviour of the M channel.

During M_Test the M-cooler could be in any state.
The M science telemetry data format can be anyone as the science data are downloaded from M in the same way as a normal science mode (full frame for Vis and IR).

3.6.3 H Test Mode

The description given above for the M_Test mode is essentially valid also for the H_Test mode. However there is a limitation in the H science telemetry data format. In fact, as the Pixel Map is not used, the full IR frame is transferred to the ME and thus H shall always produce an H_Image_Slice.

3.7 Annealing Mode

Both IR detectors, for M and H, can be annealed however the specific procedure adopted is different for the two channels.

3.7.1 M_Annealing

The MTC_Annealing command is used to start or stop annealing of the M-IR detector. The M cooler must be off while the PEM-M must be powered on before commanding the annealing.

If annealing is started, the following procedure is performed:

1. the M-PEM is commanded by M_IR_DETECTOR_OFF
2. the M-PEM is commanded by M_IR_ANNEALING_ON
3. the M-Mode is changed to M_ANNEALING
4. the M_IR_TEMP PEM-HK are monitored every 10seconds and the M_IR_TEMP is checked against the M_ANNEAL_LIMITS (given by the ACTUAL functional parameter). If the M_IR_TEMP is 5K over M_ANNEAL_LIMITS the PEM is commanded by M_IR_ANNEALING_OFF and the annealing sequence is stopped.
5. Otherwise the PEM-M shall perform autonomous temperature control regulating the heater power to achieve the M_ANNEAL_LIMITS temperature.
6. The ME shall remain in the annealing mode until one of the following cases is verified
    - a MTC_Annealing(Stop) command is received
    - a time-out (given by M_ANNEAL_TIME_OUT in ACTUAL functional parameter) is reached.
7. The PEM is then commanded by M_IR_ANNEALING_OFF and the M-Mode M_ANNEALING is left.

Before issuing the MTC_Annealing command we must specify in the MTC_Change_Functional_Parameters, the temperature set point (parameter M_ANNEAL_LIMITS) and the maximum time for the annealing heater to be powered (M_ANNEAL_TIME_OUT).

3.7.1.1 M_Annealing sequence example

Starting from the condition (ME=idle, M=On, H=Off), to activate the annealing of M we shall issue the following commands:

- MTC_Change_Func_Param_RAM all default parameter values except:
    - M_ANNEAL_LIMITS = required temperature set-point (max 38C)
    - M_ANNEAL_TIME_OUT = required time out (max 255 minutes)
- MTC_ANNEALING with parameter = 1 (START)

The instrument shall go in the condition (ME=idle, M=Annealing, H=Off),

- Wait for the required time
- MTC_ANNEALING with parameter = 2 (STOP)
- The instrument shall return to the condition (ME=idle, M=On, H=Off).

3.7.2 H Annealing

For H the sequence is rather similar to the H, however there is an essential change as the heater control is performed by the ME and not by the PEM-H.

The HTC_Annealing command is used to start or stop annealing of the H-IR detector. The H cooler must be off while the PEM-H must be powered on before commanding the annealing.

If annealing is started, the following procedure is performed:

1. the H-detector is commanded OFF
2. the H-Mode is changed to H_ANNEALING
3. The detector temperature is checked every H_ANNEAL_CHECK_PERIOD seconds, if the Detector temperature is lower than H_ANNEAL_TEMP (the temperature to be reached during annealing), the annealing heater is powered.
4. The ME shall remain in the annealing mode until one of the following cases is verified
    - a HTC_Annealing(Stop) command is received
    - a time-out (given by H_ANNEAL_TIME in ACTUAL functional parameter) is reached.
5. The M-Mode M_ANNEALING is then left.

Before issuing the HTC_Annealing command we must specify in the HTC_Change_Functional_Parameters, the temperature set point (parameter H_ANNEAL_TEMP), the maximum time for the annealing heater to be powered (M_ANNEAL_TIME) and the detector temperature monitor interval H_ANNEAL_CHECK_PERIOD.

3.7.2.1 H_Annealing sequence example

Starting from the condition (ME=idle, M=Off, H=On), to activate the annealing of H we shall issue the following commands:

- HTC_Change_Func_Param_RAM all default parameter values except:
    - H_ANNEAL_CHECK_PERIOD = required monitor interval (max 255 s)
    - H_ANNEAL_TEMP = required temperature set-point (max 80C)
    - M_ANNEAL_TIME = required time out (max 255 minutes)
- HTC_ANNEALING with parameter = 1 (START)

The instrument shall go in the condition (ME=idle, M=Off, H= Annealing),

- Wait for the required time
- HTC_ANNEALING with parameter = 2 (STOP)
- The instrument shall return to the condition (ME=idle, M=Off, H= Annealing).

3.8 Cool-Down Modes

M and H Coolers can be operated together or separately. Moreover, for each cooler we can power either only the CCE (Cooler Control Electronics) or the CCE plus the Motor itself. The following conditions apply:

Mode	CCE	Motor
Off	OFF	OFF
Stand-by	ON	OFF
Closed Loop	ON	ON
Open Loop	ON	ON

The Stand-by mode is used to check the CCE electronics, no actual cooling is performed as the motor is powered off.
The Closed Loop mode is the selection when working in nominal conditions. In this case the parameter passed to the ME is the temperature set point. Every 10 sec the ME shall check the cold tip temperature of the cooler against the set point temperature to verify reaching of steady state conditions.
The Open Loop mode is used in case of failure of the Closed Loop mode. In this case the parameter passed to the ME is the motor rotation speed. While in Closed Loop the speed of the motor is varied according to the temperature conditions reached, in Open Loop the motor speed is kept constant throughout the operation sequence.

When Closed Loop or Open Loop modes are selected, the VIRTIS SW shall control the mode progress as follows :

1. At each H/K acquisition, the VIRTIS SW shall check the H/K of the coolers which are On

2. If a cooler is in Close Loop and the measured temperature matches the commanded one within 1.5°C, the “Cool_Down_End_Success” Normal Progress Event (service 5,subtype 1) shall be reported to the S/C and the cooler is said to be in Steady State.

3. If after a predefined time of 2 hours the target temperature (i.e. the commanded temperature for Closed Loop cool-down or the 80K temperature for Open Loop cool-down) has not been reached (within 1.5°C), the “Cool_Down_End_Failure” Warning Event Report (service 5, subtype 2) shall be reported to the S/C.

4. When the cooler Steady State is reached, the VIRTIS SW shall monitor the measured temperature to verify that it is equal (within 1.5°C) to the target temperature (i.e. the commanded temperature for Closed Loop cool-down or the 80K temperature for Open Loop cool-down); if this check fails, the “Cooler Steady State failure” Warning Event Report (service 5, subtype 2) shall be reported to the S/C.

When the Cooler operations are started the corresponding channel mode shall be reported “Cool-Down” in the Default H/K.
Moreover, if a PEM is powered on when the respective Cooler has not yet reached the operative temperature, the instrument mode shall remain “Cool-Down”. On the contrary, if the Steady State condition has been reached the powering of the PEM shall cause the instrument to perform a transition to the “Idle” mode.
This is summarised in the next table:

PEM (M or H)	**Cooler (M or H)**	**Resulting (M or H) Mode**
Off	Off	Off
Off	Cool Down	Cool Down
Off	Steady State	Cool Down
On	Cool Down	Cool Down
On	Steady State	Idle
On	Off	On

4 Experiment Operations

4.1 Operational Constraints

In this chapter we list the operational constraints (for both on ground and in-flight activities) and instrument usage tips arisen during testing/operation of the instrument. Also some disposition from closed NCR have been added

4.1.1 Thermal limitation on ME usage.

According to the latest TV qualification test performed on the ME PFM (refer to VIR-KAY-RP-079), the FM can be operated at 50°C TV environmental conditions in nominal power mode with both VIRTIS M and H modules running simultaneously. The ME FM can be operated at 60°C TV conditions only in the so-called 70% power mode, i.e. either VIRTIS-M or VIRTIS-H is running.

In reduced power mode, to minimise the thermal stress to the ME PS, VIRTIS-H should be operated only with the Main DHSU (main power) and VIRTIS-M should only be operated with the Redundant DHSU (redundant power). The rationale for this lies in the fact that VIRTIS-H DC/DC transformer is farther away from the H-CCE and viceversa for the M DC/DC, thus we can avoid hot spots.

However, we must also take into considerations that the overall VIRTIS qualification was performed in Officine Galileo with VIRTIS-M and VIRTIS-H PFM and with the ME QM. This has caused several failures summarised in the NCRs; RO-VIR-NCR-43/45/48/49/54. The disposition for these NCR is the following:
VIRTIS has been qualified only up to 45°C, for both Full Power and Reduced Power conditions; thus the maximum operational temperature for VIRTIS shall be considered 35°C. At any rate being all these NCRs caused by PS malfunctions the first paragraph statement should apply and operations should not be affected by these NCRs.

4.1.2 High Speed Link Disconnection

Due to a bug in the IEEE1355 chip, when the link is disconnected by SSMM we have to go through a full VIRTIS reset operation. That is:

- VIRTIS is sent to Safe Mode (TC_Enter_Safe_Mode command)
- Secondary boot is performed (TC_Enter_Idle_Mode command)
- The HSL is started again (TC_Reset_And_Start_HSLink)

4.1.3 Incorrect House Keeping reading (NCR RO-VIR-NCR-0038)

As specified in the mentioned Non Conformance Report, the reading of the H/K value of the M_Grating_Temperature parameter in the MTM_PEM_IR_HK_Report (3,25) telemetry is wrong due to a malfunction of the relevant thermistors inside the Optics Module. The value must not be considered valid.

4.1.4 No event report of successful Primary Boot

Upon power-on VIRTIS shall perform the download of the PROM S/W to RAM, and shall initialise the ME (Primary Boot). At the end of the primary boot the ME shall be in Safe_Mode. However, no event report has been anticipated to signal the end of execution of this command. Moreover, no H/K is sent until completion of the synchronisation to the S/C SCET, by means of TC_Accept_Time_Update. If not synchronised within 60s the instrument shall start with a SCET of 0x8000000000.

4.1.5 Event RUNS Unsynchronised

This event is issued only when a accept_time_update is issued after 60s. Is sent as an answer to an improper time update. ruivedere

4.1.6 Offset in PS/DPU temperature readings (RO-VIR-NCR-0049).

For unknown reasons, on the Redundant Power line, when the H cryocooler is powered on an offset in the temperatures reading of the PS and DPU temperatures is added. See table

	PS Temp (°C)	DPU Temp(°C)
H Cryocooler OFF	T=T0	T=T1
H Cryocooler ON	T=T0+4	T=T1+3

4.1.7 Software versions

The EEPROM Software has been updated throughout the life of the instrument to cope with malfunctions (NCRs) and new requirements arisen during the instrument usage. On the contrary the PROM S/W version has been fixed very early in the program and we were able to keep the same version.

Throughout all the calibrations, before instrument delivery to ESTEC, the following S/W versions have been used:

- PROM version V2.0-1
- EEPROM version V3.4
- EGSE software version V6.2

The EQM S/C hosts the EQM instrument which carries the following S/W versions

- PROM version V1.1-1
- EEPROM versions: V3.6 (address 0x20078000) and V3.5.4 (address 0x20000000) on both Main and Redundant

The PFM S/C hosts the PFM instruments which had the following versions

November 2001 – May 2002

- PROM version V2.0-1

- EEPROM versions: V3.5.4 (address 0x20000000) on both Main and Redundant

This has been used throughout the TB/TV tests on the S/C.

June 2002 – August 2002
- PROM version V2.0-1
- EEPROM versions: V3.5.4 (address 0x20000000) and V3.6 (address 0x20078000) on both Main and Redundant

This has been used during SFT and SVT1

August 2002 - Launch
- PROM version V2.0-1
- EEPROM versions: V3.6.1 (address 0x20000000) and V3.6 (address 0x20078000) on both Main and Redundant

Used during SVT2, and also during the new launch campaign.

4.2 Ground Operation Plan

The ground test plan along with the specific procedures is given in the PFM System Level Test Specifications and Procedures (RO-VIR-TS-002 issue 1)

In the present document we need to point out that VIRTIS is **not intended for use under ambient conditions in its full configuration.** In fact, VIRTIS is an infrared spectrometer which needs to be cold to operate properly. Typical operating temperatures are in the region of 130K. Moreover, the scan mirror in VIRTIS-M has a sophisticated blocking mechanisms which frees it only below 200K.
This means that full operation can be performed only with the instrument under vacuum and at low environmental temperatures (less than 200K). Usage in air will damage the cryocoolers the IR detectors and the VIRTIS-M Scan Mirror. This means that the testing activities at S/C level shall be split:

1. Tests performed in clean room but at ambient pressure/temperature conditions. This include Bench Test, I&T, IST and partially the SFT which shall be limited to all the operations that do not require usage of Cryocoolers and IR detectors. In practice all test performed at Alenia - Torino premises fall in this category. Full functionality of the instrument cannot be tested; nonetheless, all the S/C interface can be operated and exercised.
2. Test carried out inside the TV chamber (Thermal Vacuum and Thermal Balance tests). Under proper environmental conditions also performance measurements can be executed. We propose to run the internal calibration procedure as well as a test routine for the Scan Mirror Unit.

4.3 Flight Operation Plan TO BE REVISED ACCORDING TO THE NEW LAUNCH.

The Rosetta mission is characterised by different mission phases identified and described in some details in AD1 volume VI and in AD3. In what follows we have summarised the scientific objectives in each phase, giving an indication of the activities to be carried out and of the operative modes, of the data volume produced and of the expected power consumption. We took into consideration the latest information from ESOC contained in AD4 through AD7 regarding the first mission phases (commissioning, cruise, planets swing-bys and asteroids fly-bys), while for the comet phases a revision shall be performed later on.

The instrument power dissipation, see chapter 2.3, by the Main Electronics Module is such that full operation (both channels M and H working at the same time) of the instrument cannot be guaranteed for heliocentric distances below 1.4 AU. Thus it has been agreed to reduce the power dissipation of the Main Electronic Module by a 30% allowing only single channel acquisition. It has been also agreed with the ROSETTA Project Office that in case of over-temperature conditions shall be VIRTIS responsibility to take actions to prevent damages to the S/C and to the instrument.

A word of caution must be added regarding the description (activities, data volume and data rates) of the phases after the Commissioning and Cruise, as a thorough reanalysis of them is being carried out by the team.

4.3.1 Commissioning Plan

The commissioning phase activities related to instruments usage shall be devoted to the Functional Tests (including internal calibration), to the Interference Tests (susceptibility of VIRTIS to external electrical noise and vice-versa) and to the co-alignment of VIRTIS with the other remote sensing instruments (ALICE, MIRO, OSIRIS and NAVCAM). In the present ESOC plan (see AD 4) 5 full days are allocated for Functional Test, 5 days for Interference Test and 2.5 weeks for the instruments co-alignment.

Critical operations are conducted during ground station passes (about 7 hours duration) with an immediate feedback to ground; less critical activities can be carried out outside these periods uploading a sequence of TC to be executed autonomously by the DMS (using Mission Time Line).

The overall data volume of the commissioning activity is given by summing the VIRTIS functional tests, plus calibration sequence plus the VIRTIS co-alignment procedures (described in the following). The overall result is **699.5 Mbit plus about 250 Mbit for functional tests (TBC).**

We must again point out that for proper usage of the instrument the environmental temperature must be below 200K. This condition must be verified during ground operations (see chapter 3.4) as well as during in flight operations, and particularly for the commissioning phase when for the first time the instrument shall be powered.

4.3.1.1 Functional tests

During the VIRTIS Functional Tests campaign we shall exercise all the instrument functions, all the mechanisms and we shall check the instrument performances variation as a function of various internal conditions (change in calibration lamps voltages, change of IR detector temperatures) to demonstrate that after launch all the instrument functions have not been degraded. We shall have to:

❖ Verify all Services. All services must be checked, however, the following distinction is valid:

- Service 9 Time Management
- Service 17 Connection Tests

Are executed during the POWER-ON OBCP. No need to be repeated.

- Service 255 Common Payload Private TCs

One TC belonging to this service is executed, and hence verified, at POWER-ON (TC_Reset_And_Start_HSLink). The rest needs to be checked.

- Service 1 TC Acknowledge
- Service 3 H/K Reporting
- Service 5 Event Reporting
- Service 20 Science Reporting
- Service 192 Common Private TCs
- Service 193 VIRTIS-M Private TCs
- Service 194 VIRTIS-H Private TCs

These service shall be verified when performing Science Acquisition and Calibration, moreover they have been extensively tested on ground (IST and S/C TV) so there is no need to re-test them here.

- Service 6 Memory Manag. + Service (192,13) GET_EEPROM_STATUS

This service must be verified explicitly in this procedure as it is a PROM S/W only activity and also is an essential capability of the instrument for S/W Patch upload.

The above considerations are summarised in the procedure VIR-CVP-001: Services Verification.

❖ Exercise Acquisition modes. We need to test acquisition in several M and H modes plus check the instrument/SSMM behaviour under limiting conditions.

- Maximum Data Rate: full detectors (M-VIS + M-IR + H), minimum repetition time, no compression, no scan.

- Maximum Data Processing: M+H max binning modes, minimum repetition time, lossy compression, scan on.

- Nominal M+H mode with default parameters

- Nominal M Science with default parameters

- Nominal H Science with Default Parameters

❖ VIRTIS-M/H additional Modes Test. It is required to test several additional operative modes. A procedure is listed in the commissioning phase plan but the detailed procedure description and the parameter values are still TBD.

❖ Scan Unit Test. While covers and cryocoolers shall be tested in the framework of the internal calibration, the scan unit must be tested independently. Commanded angle Vs measured angle, operation with various starting/ending points and various step sizes, etc.

❖ VIRTIS-H Pixel Map. As part of the VIRTIS-H testing we require to upload a new pixel map (the list of coefficient used to calculate the coordinates of those pixels to be analysed by the ME) and a bad pixel map.

❖ Cryocooler temperature calibration . We shall select three temperatures in Closed Loop mode (70-80-90K) and 3 cooler motor speeds (1500,2200,2800 rpm) for each detector and monitor the detector and cold finger temperatures

❖ Science Data Transfer via RTU. Check IST for a template of mode implementation

❖ M Internal Calibration. This shall be carried out under various conditions of lamp current. For M every internal calibration cycle takes about 30min. The values shall be

	Minimum (mA)	Nominal (mA)	Maximum (mA)
IR Lamp	94	100	109
VIS Lamp	240	250	254

❖ H Internal Calibration. Also in this case we shall perform several calibration run with different values of the parameters. At present we are not able to define the details of this procedure but it shall be very similar to the one for M. It is listed in the commissioning phase plan and a template is reported in the detailed procedure description but the parameter value are still TBD.

❖ MAIN / REDUNDANT power channel. All the above procedures are performed on the MAIN Power Channel. A limited number of tests shall be performed on the redundant channel:
  - In-Flight Calibration with nominal parameters.
  - Science data transfer via HSL
    - Maximum Data Rate
    - Maximum Data Processing

- Science Data transfer via RTU
- Cryocooler temperature calibration

4.3.1.2 Interference Tests

The interference Test detailed modalities shall be agreed with SOC.

However, as a preliminary input we anticipate to induce disturbances on other instruments due to:

1. Mechanical vibrations >> Cryocooler on MIDAS
2. EMC due to intensive operations >> max data rate/ max data processing.

In principle we could be also subjected to EMC noise from other instruments to check this VIRTIS shall be placed in nominal acquisition mode while other instruments perform their “noisy” activities.

4.3.1.3 Internal Calibration Sequence

The VIRTIS-M calibration procedure is divided in 7 phases which are summarised in table 4.1. In each phase 5 repetition are performed. The data volume for the –M calibration shall then be given by: [(432x256) x 2 detectors (IR and CCD)] x 7 phases x 5 acquisitions x 16bit. The real Data volume must take into account also the packetisation for delivery to the S/C, thus producing a total of **128 Mbit (16 Mbytes).**

Calibration for –H (see table 4.2) consists of a spectral calibration with full detector reading and use of three different lamps. The calibration is partitioned in 4 phases each devoted to the use of a single lamp. For each lamp 7 H_Image_slice and 2 H_Spectrum shall be produced, giving a total data volume of **13.2 Mbit (1.65 Mbytes)**.

Phase #	Cover	Shutter	Lamp IR/VIS	Int. Time IR/VIS (s)	Mode	Duration (s)
0	Close	Open	OFF/OFF	0.0 / 0.0	Read-Out Noise	151
1	Close	Open	OFF/OFF	0.5 / 1.0	Background VIS+IR	120
2	Close	Close	OFF/OFF	0.5 / 1.0	Dark VIS+IR	60
3	Close	Open	ON/OFF	0.5 / 20.0	IR acquisition +VIS	180
4	Close	Open	OFF/ON	0.1 / 1.0	VIS Acquisition + IR	84
5	Close	Close	OFF/OFF	0.5 / 1.0	Dark VIS+IR	60
6	Close	Open	OFF/OFF	0.5 / 1.0	Background VIS+IR	120

Table 4.1 VIRTIS-M calibration phases sequence. **Total duration 775 sec on HSLink; 2134 on RTU.**

Phase #	Cover	Shutter	Slit Lamp	Telescope Lamp	Radiometric Lamp	Mode
1	Closed	Open	OFF	OFF	OFF	Slit Calibration - Background
	Closed	Closed	OFF	OFF	OFF	Slit Calibration – Dark
	Closed	Open	ON	OFF	OFF	Slit Calibration – Lamp On
2	Closed	Closed	OFF	OFF	OFF	Telescope Calibration – Dark
	Closed	Open	OFF	ON	OFF	Telescope Calibration – Lamp ON
3	Closed	Closed	OFF	OFF	OFF	Radiometric Calibration (Image) - Dark
	Closed	Open	OFF	OFF	ON	Radiometric Calibration (Image) – Lamp ON
4	Closed	Closed	OFF	OFF	OFF	Radiometric Calibration (Spectrum) - Dark
	Closed	Open	OFF	OFF	ON	Radiometric Calibration (Spectrum) – Lamp ON

Table 4.2 VIRTIS-H calibration phases sequence. **Total Time 274s on the HSLink; 448 on RTU**

Additionally, we shall also perform measurements of external dark opening the cover. For VIRTIS-M one 64x64 image acquisition in nominal mode requires 18.9 Mbit uncompressed (including one dark every ten slices). For VIRTIS-H the image mode correspond to 64 spectra (plus one dark every ten spectra) each of 55kbit. This make about 3.5 Mbit uncompressed. After the data compression with a compression factor of 2 (conservative) produces a data volume of 11.2 Mbit. Taking into account 10 repetitions of this cycle we get an overall data volume of **112.1Mbit**.
Thus, the presently envisaged full calibration plan is given in table 4.3
A full calibration sequence lasts up to 3 hours depending on the environmental conditions.

OPERATION	TIME (*) Minutes	DATA VOLUME Mbit	AVERAGE POWER Watts	COMMENTS
Power ON	-	-	9.8	
Instrument Settings	5	0.1	9.8	Only housekeeping
Instrument Checkout	5	0.1	49.2	Only housekeeping
Cool Down M+H	130	0.1	57.9	Only housekeeping
Calibration M+H	5	28.2	65.8	
Cover open	1	0.1	65.8	Only housekeeping
(M+H) Science	30	112.1	65.8	10 x (Dark + Space)
Cover close	1	0.1	65.8	Only housekeeping
Instrument Checkout	5	0.1	49.2	Only housekeeping
Power OFF	-	-	-	
TOTALS	180	140.5		

(*) Timing is still an approximation. Proper timing shall be measured on the PFM.

Table 4.3 Full calibration plan

4.3.1.4 VIRTIS-M / Spacecraft alignment

Based upon the orbital position and the solar angles, a standard star is chosen and the spacecraft positioned within its APE to view the star. Therefore, we shall need to perform a scan of about 0.6 degrees (twice the APE) around the –M boresight in order to find the reference star; if we work in the high spatial resolution mode each step shall be of 0.250 mrad and thus 64 steps shall be needed and hence 64 slices. Translating this in data volume we get (64+6)x256x144x2x16 = 83 Mbit.
However, as we expect to image regions with multiple stars in the full FOV of the instrument we shall take several full FOV images of selected sky regions to co-align also with the other remote sensing instrument and to define our geometric distortions if any. A single slice is composed of 256x144 pixels for each detector, and a full FOV is made of 256 slices. We must then add a dark acquisition every 10 science acquisitions (on average) for both detectors. Thus, each full acquisition shall be composed of (256+25)x256x144x2x16=330 Mbit. We shall multiply by three this data volume as at least three different acquisitions shall be needed. We shall then produce 990 Mbit

When compressed by a factor of 2 the overall VIRTIS-M alignment procedure shall produce **537 Mbit.**

4.3.1.5 VIRTIS-H / Spacecraft alignment.

VIRTIS stability shall be such that the two channels shall be aligned within ½ -M high resolution pixel (125 μrad), and will remain aligned after launch vibrations. However, as the in flight co-alignment procedure is autonomously performed we cannot use the previous knowledge on the star location to have the S/C drifting (with an error in pointing proportional to RPE) to the real star position. Thus, we shall need a S/C scan over a square of 0.6 x 0.6 degrees (twice the APE) in steps of one -H FOV (0.450 mrad). This translate in 576 -H slices, in the **-H Only Science Mode** (approx. 55kbit each slice). The total data volume shall be **22.0 Mbits**.

4.3.1.6 VIRTIS / Other remote sensing instruments co-alignment

As before the launch the imaging experiments will be co-aligned with an accuracy of 7’ (2.1 mrad or 4 -H pixels) for instrument mounted on the same panel (VIRTIS Vs OSIRIS) or 11’ (3.3 mrad or 8 -H pixels) for instruments on different panels (VIRTIS Vs NAV, ALICE, MIRO), and as the combined VIRTIS IFOVs are the smallest of all the above instruments, when aligning VIRTIS Vs S/C with a known star, the same star will fall inside the FOV of the other instruments; thus, VIRTIS -H and -M will be simultaneously co-aligned with the other imaging instruments.

4.3.2 Observations

The observations performed till now are described in the Observation Reports.

4.3.3 Comet Escort Phases

The Comet Escort Phases are described in VIRTIS Observations Requests Comet Escort Phases Input to WG2-3 (VIR-IAS-TN-023).

4.4 Failure Detection and Recovery Strategy

VIRTIS fault tolerance design has been oriented towards the maximum simplicity of redundancy design taking advantage of the fact that being a two channels instrument, any failure along one channel chain still allows for the operation of the other channel. From this point of view VIRTIS does not contains any single point failure. However, being both channels necessary for the fulfilment of the scientific objectives, the reliability concept of each channel has been optimised by means of fail open mechanisms (shutters and covers). Thus, cold redundancy has been implemented only inside the ME in the boards PS and DPU which have identical replicas, which can be powered by means of the redundancy power line whenever a failure event is issued.
From an operational point of view VIRTIS shall be capable of autonomous failure detection. To monitor the instrument status VIRTIS shall provide to ground and to DMS unambiguous operational information contained in:

1. TC verification reports (Acceptance and/or Execution).
2. H/K data reporting.
3. TM Events reporting. A service used to provide information on failures, anomalies and normal progress of sequences.

The DMS shall control VIRTIS behaviour by means of the TM Events Reports, and during the power on OBCP also using the Default H/K parameter information.
Events are classified according to their subtype:

Sub Type 1 Normal Progress Event Report
Sub Type 2 Warning Anomalous Event Report
Sub Type 3 Ground Action Anomalous Event Report
Sub Type 4 On-Board Action Anomalous Event Report

A full list of VIRTIS TM event is given in table 6.1. The events can be generated anytime during operations, but for the sake of the autonomous on-board activities we can split them in three parts:

- anomalies detected during Primary Boot
- anomalies detected during Secondary Boot
- anomalies during normal operations

VIRTIS is fully autonomous from the S/C in terms of emergency recovery from any type of S/W and H/W failure. If a major malfunction is found, the ME issue a subtype 3 or 4 event and perform a full instrument reset:

1. Power off all subsystems (PEMs, cryocoolers, etc.)

2. Perform a Primary Boot: upload of primary level software
3. Enter the Safe Mode of the instrument.

This is the safest condition for VIRTIS. If the failure is detected during Power On OBCP procedure, the OBCP itself shall be aborted and VIRTIS powered off, if the failure is detected during normal operations, VIRTIS in Safe Mode shall guarantee that no additional damage is done to the instrument itself, prior to the on-ground analysis.

5 Operational Procedures and Telecommand Sequences

5.1 Ground Test Sequences

The ground test plan along with the specific procedures is given in the PFM System Level Test Specifications and Procedures (RO-VIR-TS-002 issue 1) which is also item2 of the PFM ADP Support Documentation.

5.2 On-Board Control Procedures (OBCPs)

At present for VIRTIS have been defined 2 OBCPs:

- PL_OBCP_5_VR.1 VIRTIS power on
- PL_OBCP_5_VR.2 VIRTIS power off

The latest available update of the VIRTIS OBCP document (RO-DSS-RS-1024) is annexed as attachment 3.

However, the development of the flight S/W has pointed out the necessity of several TM event report with on-board actions required. This means that one or more OBCPs shall be needed to handle instrument anomalies.

In the following description of the procedures, we shall assume that the power on OBCP shall place VIRTIS in Idle_Mode (stand-by conditions) without HSLink connection. Same applies for the Power off OBCP, which starts with the instrument in Idle_Mode (stand-by) with no connection to SSMM.

5.3 Flight Operations Sequences

Tables 5.1a, 5.1b and 5.1c lists all the presently defined command sequences. The listed sequences are those present in AD11 (the Flight Operation Plan issued by ESOC on the basis of the experimenters input). Each sequence is a timeline describing the commands (and their parameters if any) to be issued to VIRTIS to achieve a given instrument configuration.

The sequences listed here cover and define all the main instrument configurations, however additional sequences shall be defined in the future in relation to the needs that shall arise.

According to AD12 (issued by RSOC responsible of the flight operation of ROSETTA after the commissioning phase) the experiment must be described in the file EDF (Experiment Description File). As a consequence all the sequences listed here in tabular format must be replicated in the VIRTIS.EDF file in ITL (Instrument Time Line) format.
Usage of edf and itl files is described at length in AD12 and shall not be repeated here.

In Table 5.1a are listed those sequences which are not under VIRTIS responsibility and shall not be described here. These sequences are, for instance, those performed through OBCPs (power on and power off or SSMM link initialisation), or those performed with VIRTIS in off conditions (heaters configuration). The OBCPs however, contains VIRTIS telecommands which have been defined and agreed upon among VIRTIS, ASTRIUM and ESOC. Additionally, provision have been made by ESOC to have additional sequences performing the same operations of the OBCPs in case of OBCPs failure or unavailability.

Table 5.1b list the sequences required to define every VIRTIS configuration and are directly under VIRTIS responsibility. These sequences are also described in the EDF file.

Table 5.1c finally lists all other sequences which have been specifically designed for the first part of the commissioning phase (Functional Tests) and this are listed as ACVFxxxx. However, this shall not prevent to use them on later occasions.

The duration of each sequence is still approximate, although it has been used as baseline for the definition of the commissioning phase activities. A more definite assessment of the correct duration for each sequences shall be provided after the commissioning phase.

Command Sequences	**Sequence Title**	**Duration (hh:mm:ss)**
AVRF001A	VIRTIS ON OBCP Main power (A) line	00:15:00
AVRF001B	VIRTIS ON OBCP Redundant power (B) line	00:15:00
AVRF003A	Start Link to SSMM OBCP	00:15:00
AVRF006A	VIRTIS Power OFF OBCP	00:15:00
AVRF007A	VIRTIS Manual Power ON Main Power Line	00:15:00
AVRF007B	VIRTIS Manual Power ON Redundant Power Line	00:15:00
AVRF008A	VIRTIS Manual Power OFF	00:15:00
AVRF015A	Start Manual SSMM Link	
AVRF016A	Stop Writing to SSMM Link	
AVRF018A	Start VIRTIS decontamination	
AVRF018B	Stop VIRTIS decontamination	

Table 5.1a List of sequences under S/C responsibility

Command Sequences	Sequence Title	Duration (hh:mm:ss)
AVRF002A	M Initialisation Coolers in Closed Loop	02:00:00
AVRF002B	H Initialisation Coolers in Closed Loop	02:00:00
AVRF002C	M+H Initialisation Coolers in Closed Loop	02:00:00
AVRF004A	M channel power OFF	
AVRF004B	H channel power OFF	
AVRF004C	M/H Channels power OFF	
AVRF004D	ME Transition from Idle Mode to Safe Mode	
AVRF005A	M Internal Calibration	00:21:00
AVRF009A	Stop Science Acquisition on SSMM M Only	00:01:00
AVRF009B	Stop Science Acquisition on SSMM H Only	00:01:00
AVRF009C	Stop Science Acquisition on SSMM M+H	00:01:00
AVRF010A	Start M Nominal Science Acquisition	00:01:00
AVRF011A	Coolers Performance Test	05:46:00
AVRF012A	H Internal Calibration	00:15:00
AVRF013A	Transition from Safe Mode to Idle Mode	00:02:00
AVRF014A	VIRTIS Memory Management >>> TBW	
AVRF017A	Cooler in Open Loop M Only	
AVRF017B	Cooler in Open Loop H Only	
AVRF017C	Cooler in Open Loop M+H	
AVRF019A	Start H Nominal Science Acquisition on SSMM	
AVRF020A	Start H Back-up Science Acquisition on SSMM	

Table 5.1b List of general VIRTIS Sequences

Command Sequences	Sequence Title	Duration (hh:mm:ss)
ACVF202A	Scan Unit Test	00:15:30
ACVF203A	Maximum Data Rate Acquisition	00:03:00
ACVF204A	Maximum Data Processing Acquisition	00:03:00
ACVF205A	H Pixel Map	00:01:00
ACVF206A	M/H Modes Test	00:26:00
ACVF207A	Services Verification	00:04:30
ACVF208A	RTU Test Acquisition	00:02:30
ACVF209A	Stop Science Acquisition on RTU	00:01:00

Table 5.1c List of commissioning phase Sequences

5.4 Flight Control Plan

In the next chapters we provide the anticipated plans for the various mission phases. At the present moment, only the commissioning phase has a well defined plan as described in the AD11. The plan for the subsequent activities shall be defined at a later phase with RSOC.
The duration of each command sequence is the one assigned by ESOC in the FOP and does not reflect the real duration of each sequence.

5.4.1 Commissioning Phase (CVP) **To be revised for the new launch conditions.**

The commissioning phase has been described in chapter 3.5.1. Tables 5.2a through 5.2e reports the CVP Plan split in operative days.

Step	**Start Time**	**Activity**	**Sequence Used**
10	00:00:00	Power On OBCP MAIN Channel	AVRF001A
20	00:15:00	VIRTIS stop link to SSMM OBCP	AVRF016A
30	00:30:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
40	00:45:00	Services Verification	ACVF207A
50	01:15:00	Transition from Safe Mode to Idle Mode	AVRF013A
60	01:30:00	Start Link to SSMM OBCP(*)	AVRF003A
70	01:45:00	Instrument M+H Initialisation	AVRF002C
80	03:45:00	Scan Unit Test	ACVF202A
90	04:00:00	M Internal Calibration (nominal parameters)	AVRF005A
100	04:30:00	M Internal Calibration (Parameter Set #1)	AVRF005A
110	05:00:00	M Internal Calibration (Parameter Set #2)	AVRF005A
120	05:30:00	H Internal Calibration (nominal parameters)	AVRF012A
130	06:00:00	H Internal Calibration (Parameter Set #1)	AVRF012A
140	06:30:00	H Internal Calibration (Parameter Set #2)	AVRF012A
150	07:00:00	VIRTIS stop link to SSMM OBCP	AVRF016A
160	07:15:00	M/H Channels power OFF	AVRF004C
170	07:30:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
180	07:45:00	Power Off OBCP	AVRF006A
	08:00:00	END DAY 1	

Table 5.2a Description of the Post-LEOP Commissioning Plan. DAY1 Instrument Functional Test Main Power Channel

Step	Start Time	Activity	Procedure Name
10	00:00:00	Power On OBCP MAIN Channel	AVRF001A
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Start M Science Acquisition	AVRF010A
40	02:30:00	Start H Nominal Science Acquisition	AVRF019A
50	02:45:00	Stop M+H Science Acquisition on SSMM	AVRF009C
60	03:00:00	Start M Science Acquisition	AVRF010A
70	03:15:00	Start H Back-Up Science Acquisition	AVRF020A
80	03:30:00	Stop M+H Science Acquisition on SSMM	AVRF009C
90	03:45:00	Maximum Data Rate Acquisition	ACVF203A
100	04:15:00	Stop M+H Science Acquisition on SSMM	AVRF009C
110	04:30:00	Maximum Data Processing Acquisition	ACVF204A
120	05:00:00	Stop M+H Science Acquisition on SSMM	AVRF009C
130	05:15:00	RTU Test acquisition	ACVF208A
140	05:45:00	Stop M+H Science Acquisition on RTU	ACVF209A
150	06:00:00	Uplink Pixel Map	ACVF205A
160	06:15:00	M/H Modes Test	ACVF206A
170	06:45:00	VIRTIS stop link to SSMM OBCP	AVRF016A
180	07:00:00	M/H Channels power OFF	AVRF004C
190	07:15:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
200	07:30:00	Power Off OBCP	AVRF006A
	07:45:00	END DAY 2	

Table 5.2b Description of the Post-LEOP Commissioning Plan. DAY2 Instrument Functional Test Main Power Channel

Step	Start Time	Activity	Procedure Name
10	00:00:00	Power On OBCP MAIN Channel	AVRF001A
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Cooler Performance Test	AVRF011A
40	06:15:00	VIRTIS stop link to SSMM OBCP	AVRF016A
50	06:30:00	M/H Channels Power OFF	AVRF004C
60	06:45:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
70	07:00:00	Power Off OBCP	AVRF006A
	07:15:00	END DAY 3	

Table 5.2c Description of the Post-LEOP Commissioning Plan. DAY3 Instrument Functional Test Main Power Channel

Step	Start Time	Activity	Procedure Name
10	00:00:00	Power On OBCP Redundant Channel	AVRF001B
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Maximum Data Rate Acquisition	ACVF203A
40	02:45:00	Stop M+H Science Acquisition on SSMM	AVRF009C
50	03:00:00	Maximum Data Processing Acquisition	ACVF204A
60	03:30:00	Stop M+H Science Acquisition on SSMM	AVRF009C
70	03:45:00	RTU Test acquisition	ACVF208A
80	04:15:00	Stop M+H Science Acquisition on RTU	ACVF209A
90	04:30:00	M Internal Calibration (nominal parameters)	AVRF005A
100	05:00:00	H Internal Calibration (nominal parameters)	AVRF012A
110	05:30:00	VIRTIS stop link to SSMM OBCP	AVRF016A
120	05:45:00	M/H Channels Power OFF	AVRF004C
130	06:00:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
140	06:15:00	Power Off OBCP	AVRF006B
	06:30:00	END DAY 4	

Table 5.2d Description of the Post-LEOP Commissioning Plan. DAY4 Instrument Functional Test Redundant Power Channel

Step	Start Time	Activity	Procedure Name
10	00:00:00	Power On OBCP MAIN Channel	AVRF001B
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Cooler Performance Test	AVRF011A
40	06:15:00	VIRTIS stop link to SSMM OBCP	AVRF016A
50	06:30:00	M/H Channels Power OFF	AVRF004C
60	06:45:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
70	07:00:00	Power Off OBCP	AVRF006B
	07:15:00	END DAY 5	

Table 5.2e Description of the Post-LEOP Commissioning Plan. DAY5 Instrument Functional Test Redundant Power Channel

5.4.2 Cruise Phases (CR1 through CR6)

The maintenance procedure we have envisaged for VIRTIS requires that during each cruise phase a full check out of the experiment is performed. The schedule is to have a maintenance check every 6 months, approximately, provided it does not interfere with the hibernation periods.
The plan, described in table 5.3, consists of a subset of the procedures performed during the commissioning phase on both main and redundant channel.

Step	**Start Time**	**Activity**	**Procedure Name**
10	00:00:00	Power On OBCP MAIN Channel	AVRF001A
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Start M Science Acquisition	AVRF010A
40	02:30:00	Start H Nominal Science Acquisition	AVRF019A
50	03:00:00	Stop M+H Science Acquisition on SSMM	AVRF009C
60	03:15:00	Cooler Performance Test	AVRF011A
70	07:15:00	M Internal Calibration (nominal parameters)	AVRF005A
80	07:45:00	H Internal Calibration (nominal parameters)	AVRF012A
90	08:15:00	VIRTIS stop link to SSMM OBCP	AVRF016A
100	08:30:00	M/H Channels Power OFF	AVRF004C
110	08:45:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
120	09:00:00	Power Off OBCP	AVRF006A
	09:15:00	END DAY 1	
10	00:00:00	Power On OBCP REDUNDANT Channel	AVRF001B
20	00:15:00	Instrument M+H Initialisation	AVRF002C
30	02:15:00	Start M Science Acquisition	AVRF010A
40	02:30:00	Start H Nominal Science Acquisition	AVRF019A
50	03:00:00	Stop M+H Science Acquisition on SSMM	AVRF009C
60	03:15:00	Cooler Performance Test	AVRF011A
70	07:15:00	M Internal Calibration (nominal parameters)	AVRF005A
80	07:45:00	H Internal Calibration (nominal parameters)	AVRF012A
90	08:15:00	VIRTIS stop link to SSMM OBCP	AVRF016A
100	08:30:00	M/H Channels Power OFF	AVRF004C
110	08:45:00	ME Transition from Idle Mode to Safe Mode	AVRF004D
120	09:00:00	Power Off OBCP	AVRF006A
	09:15:00	END DAY 2	

Table 5.3 Plan for Cruise Phases

5.5 VIRTIS Command Sequences Description

5.5.1 AVRF002A: M Initialisation Closed Loop

PRECONDITIONS: ME in Idle mode, PEM-M and cryocoolers-M off, HRD active
OBJECTIVES: Power on M Cryocoolers in Closed Loop and PEM-M
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Idle
H = Don't care

DATA RATE
H/K TM Data Rate 0.151 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00212 =2048 default value (Tset_point 2048 ≡ 80K)

Time	OPERATION	TC	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Cooler	ZVR00125 PVRG00212	VVRG00212	Cooler On Closed Loop
02:00:00	MTC PEM ON	ZVR00120		PEM M power on
02:00:30				Procedure Ends

5.5.2 AVRF002B: H Initialisation Closed Loop

PRECONDITIONS: ME in Idle mode, PEM and cryocooler off, HRD active
OBJECTIVES: Power on H Cryocooler in Closed Loop and PEM-H
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Don't care
H = Idle

DATA RATE
H/K TM Data Rate 0.1 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00214 = 2048 default value (Tset_point ≡ 80K)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC Cooler	ZVR00136 PVRG00214	 VVRG00214	H Cooler On Closed Loop
02:00:00	HTC PEM ON	ZVR00131		PEM H power on
02:00:30				Procedure Ends

5.5.3 AVRF002C: M+H Initialisation Closed Loop

PRECONDITIONS: ME in Idle mode, PEMs and cryocoolers off, HRD active
OBJECTIVES: Power on Cryocoolers in Closed Loop and PEMs
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Idle
H = Idle

DATA RATE
H/K TM Data Rate 0.25 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00210 = 2048 default value (Tset_point ≡ 80K)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	VTC Cooler	ZVR00113 PVRG00210	VVRG00210	Both Cooler On Closed Loop
02:00:00	VTC PEM_ON	ZVR00110		Both PEMs power on
02:00:30				Procedure Ends

5.5.4 AVRF004A: M channel Power OFF

PRECONDITIONS: Instrument in IDLE mode
ME = Idle
M = Idle, Cooldown, On
H = Off
M Cover either Close/Open
M Cooler all modes
SSMM Link not active
OBJECTIVES: Power off M Cryocooler and PEM-M, close M cover.
STATUS AT END: ME in Idle

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Cover	ZVR00124		Closes M cover
00:02:00	M PEM SWITCH OFF	ZVR00121		PEM M power OFF
00:02:10	M Cooler OFF	ZVR00127		M Cooler OFF
00:02:30				Procedure Ends

5.5.5 AVRF004B: H channel power off

PRECONDITIONS: Instrument in IDLE mode
ME = Idle
M = Off
H = Idle, Cooldown, On
H Cover either Close/Open
H Cooler all modes
SSMM Link not active
OBJECTIVES: Power off H Cryocooler and PEM-H, close H cover
STATUS AT END: Me in Idle Mode

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC Cover	ZVR00135		Closes H cover
00:02:00	H PEM SWITCH OFF	ZVR00132		PEM H power OFF
00:02:10	H Cooler OFF	ZVR00138		H Cooler OFF
00:02:30				Procedure Ends

5.5.6 AVRF004C: M/H channels power off

PRECONDITIONS: Instrument in IDLE mode
ME = Idle
M = Idle, Cooldown, On
H = Idle, Cooldown, On
Covers either Close/Open
SSMM Link not active

OBJECTIVES: Power off Cryocoolers and PEMs, close covers
STATUS AT END: Me in Idle

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Cover	ZVR00124		Closes M cover
00:02:00	HTC Cover	ZVR00135		Closes H cover
00:04:00	PEMs SWITCH OFF	ZVR00111		power OFF M/H PEMs
00:04:10	Coolers OFF	ZVR00115		Power OFF M/H Coolers
00:04:30				Procedure Ends

5.5.7 AVRF004D: Transition from Idle Mode to Safe Mode (Only ME)

PRECONDITIONS: Instrument in IDLE mode (Only ME, PEM-H and PEM-M are off)
ME = Idle
M = Off
H = Off

OBJECTIVES: ME to safe mode
STATUS AT END: Me in Safe

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	Stop time update to VIRTIS	ZDMX0224		Stop time to VIRTIS 51
00:00:10	VTC_Enter_Safe_Mode	ZVR00037		
00:00:30	Send time to VIRTIS	ZDMX0213 FDMX0013	 3600	 Update every hour
00:01:00				Procedure Ends

5.5.8 AVRF005A: M Internal Calibration

PRECONDITIONS:	VIRTIS in IDLE mode,HRD active		
		ME	= Idle
		M	= Idle
		H	= Don't Care
OBJECTIVES:	Perform M Internal calibration		
STATUS AT END:	VIRTIS in Idle Mode, HRD Active		

DATA RATE

H/K TM Data Rate	0.151 Kbit/s
Science TM Data Rate	< 169 kbit/s
Science Data Volume	128 Mbit

Formal Parameters

VVRG0055	=	M_IR_Delay1	98	(default value)
VVRG0056	=	M_IR_Delay2	98	(default value)
VVRG0057	=	M_IR_Delay3	98	(default value)
VVRG0058	=	M_IR_Delay4	3	(default value)
VVRG0059	=	M_IR_Delay5	98	(default value)
VVRG0060	=	M_IR_Delay6	98	(default value)
VVRG0061	=	M_IR_EXPO1	5	(default value)
VVRG0062	=	M_IR_EXPO2	5	(default value)
VVRG0063	=	M_IR_EXPO3	5	(default value)
VVRG0064	=	M_IR_EXPO4	1	(default value)
VVRG0065	=	M_IR_EXPO5	5	(default value)
VVRG0066	=	M_IR_EXPO6	5	(default value)
VVRG0067	=	M_IR_L_Stab	600	(default value)
VVRG0068	=	M_IR_L_Curr	6	(default value)
VVRG0069	=	M_CCD_Delay1	1	(default value)
VVRG0070	=	M_CCD_Delay2	1	(default value)
VVRG0071	=	M_CCD_Delay3	1	(default value)
VVRG0072	=	M_CCD_Delay4	1	(default value)
VVRG0073	=	M_CCD_Delay5	1	(default value)
VVRG0074	=	M_CCD_Delay6	1	(default value)
VVRG0075	=	M_CCD_EXPO1	10	(default value)
VVRG0076	=	M_CCD_EXPO2	10	(default value)
VVRG0077	=	M_CCD_EXPO3	200	(default value)
VVRG0078	=	M_CCD_EXPO4	10	(default value)
VVRG0079	=	M_CCD_EXPO5	10	(default value)
VVRG0080	=	M_CCD_EXPO6	10	(default value)
VVRG0081	=	M_CCD_L_Stab	600	(default value)
VVRG0082	=	M_CCD_L_Curr	2	(default value)

Time	OPERATION	TC/ TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Default Configuration	ZVR00061		
00:00:01	Change Data Prod RAM	ZVR00143		Set M Calibration MODE
00:00:02	Change Operat Param RAM	ZVR00016		
		PVRG0051	0	Repetition rate 5s
		PVRG0052	1	Slice summing NO
		PVRG0053	5	Acquisition mode full window
		PVRG0054	0	Compression NONE
00:00:03	Change Calib Param RAM	ZVR00018		
		PVRG0055	VVRG0055	
		PVRG0056	VVRG0056	
		PVRG0057	VVRG0057	
		PVRG0058	VVRG0058	
		PVRG0059	VVRG0059	
		PVRG0060	VVRG0060	
		PVRG0061	VVRG0061	
		PVRG0062	VVRG0062	
		PVRG0063	VVRG0063	
		PVRG0064	VVRG0064	
		PVRG0065	VVRG0065	
		PVRG0066	VVRG0066	
		PVRG0067	VVRG0067	
		PVRG0068	VVRG0068	
		PVRG0069	VVRG0069	
		PVRG0070	VVRG0070	
		PVRG0071	VVRG0071	
		PVRG0072	VVRG0072	
		PVRG0073	VVRG0073	
		PVRG0074	VVRG0074	
		PVRG0075	VVRG0075	
		PVRG0076	VVRG0076	
		PVRG0077	VVRG0077	
		PVRG0078	VVRG0078	
		PVRG0079	VVRG0079	
		PVRG0080	VVRG0080	
		PVRG0081	VVRG0081	
		PVRG0082	VVRG0082	
00:00:04	Enable M Science on SSMM	ZVR00104		Enable science V-M
00:20:00	Disable M Science on SSMM	ZVR00106		Disable science V-M
00:20:30				Procedure Ends

5.5.9 AVRF009A: Stop Science Acquisition on SSMM M Only

PRECONDITIONS: VIRTIS in science mode (M only, H Don't Care)
OBJECTIVES: Disable M Acquisition
STATUS AT END: VIRTIS in Idle (M Only, H Don't Care)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	TC_Disable_Science	ZVR00106		Disable science V-M
00:00:10				Procedure Ends

5.5.10 AVRF009B: Stop Science Acquisition on SSMM H Only

PRECONDITIONS: VIRTIS in science mode (H only, M Don't Care)
OBJECTIVES: Disable Acquisition
STATUS AT END: VIRTIS in Idle (H Only, M Don't Care)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	TC_Disable_Science	ZVR00107		Disable science V-H
00:00:10				Procedure Ends

5.5.11 AVRF009C: Stop Science Acquisition on SSMM M+H

PRECONDITIONS: VIRTIS in science mode (M and H)
OBJECTIVES: Disable Acquisition
STATUS AT END: VIRTIS in Idle

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	TC_Disable_Science	ZVR00106		Disable science V-M
00:00:01	TC_Disable_Science	ZVR00107		Disable science V-H
00:00:10				Procedure Ends

5.5.12 AVRF010A: Start M Nominal Science Acquisition

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Start acquisition, Only M in Science Mode
STATUS AT END: VIRTIS in Science Mode (M Only)
DATA RATE Depends on the parameter selection
Science between 0.03 and 730 Kbit/s
H/K between 0.13 and 0.328 Kbit/s

Formal Parameters

VVRG0051	=	M_ERT	0	(default value)
VVRG0052	=	M_SS	1	(default value)
VVRG0053	=	M_ACQ_MODE	0	(default value)
VVRG0054	=	M_COMP	1	(default value)
VVRG0022	=	M_IR_WIN_X1	1	(default value)
VVRG0023	=	M_IR_WIN_X2	432	(default value)
VVRG0024	=	M_IR_WIN_Y1	7	(default value)
VVRG0025	=	M_IR_WIN_Y2	262	(default value)
VVRG0026	=	M_IR_VDETCOM	2430	(default value)
VVRG0027	=	M_IR_VDETADJ	2213	(default value)
VVRG0028	=	M_IR_DELAY	1	(default value)
VVRG0029	=	M_IR_EXPO	10	(default value)
VVRG0030	=	M_CCD_WIN_X1	5	(default value)
VVRG0031	=	M_CCD_WIN_X2	436	(default value)
VVRG0032	=	M_CCD_WIN_Y1	0	(default value)
VVRG0033	=	M_CCD_WIN_Y2	255	(default value)
VVRG0034	=	M_CCD_DELAY	1	(default value)
VVRG0035	=	M_CCD_EXPO	10	(default value)
VVRG0036	=	M_SU	1	(default value)
VVRG0037	=	M_ALPHA_FIRST	2687	(default value)
VVRG0038	=	M_ALPHA_LAST	62847	(default value)
VVRG0039	=	M_DELTA_ALPHA	235	(default value)
VVRG0040	=	M_N_ALPHA_IRT	1	(default value)
VVRG0041	=	M_DBCK_RATE	20	(default value)
VVRG0042	=	M_SHUTT_CURR	6	(default value)
VVRG0043	=	M_SHUTT_STAB	50	(default value)
VVRG0044	=	M_ANN_LIMITS	63	(default value)
VVRG0045	=	M_ANN_T_OUT	360	(default value)
VVRG0046	=	M_ECA_ACT	30	(default value)
VVRG0047	=	M_OPN_COV_STPS_1	81	(default value)
VVRG0048	=	M_IR_DET_OFF	0	(default value)
VVRG0049	=	M_CLOSE_COV_STPS	81	(default value)
VVRG0050	=	M_INIT_COV_STPS	16	(default value)
VVRG0220	=	M_IR_WIN_X1_Alt	1	(default value)
VVRG0221	=	M_IR_WIN_X2_Alt	432	(default value)

VVRG0222 = M_IR_WIN_Y1_Alt 7 (default value)
VVRG0223 = M_IR_WIN_Y1_Alt 262 (default value)
VVRG0224 = M_IR_DELAY 1 (default value)
VVRG0225 = M_IR_EXPO 10 (default value)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC_Default Conf	ZVR00061		
00:00:01	Change M Data Prod RAM	ZVR00142		M science mode
00:00:02	Change M Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 VVRG0051 VVRG0052 VVRG0053 VVRG0054	
00:00:03	Change M Func Par RAM	ZVR00014 PVRG0022 PVRG0023 PVRG0024 PVRG0025 PVRG0026 PVRG0027 PVRG0028 PVRG0029 PVRG0030 PVRG0031 PVRG0032 PVRG0033 PVRG0034 PVRG0035 PVRG0036 PVRG0037 PVRG0038 PVRG0039 PVRG0040 PVRG0041 PVRG0042 PVRG0043 PVRG0044 PVRG0045 PVRG0046 PVRG0047 PVRG0048 PVRG0049 PVRG0050	 VVRG0022 VVRG0023 VVRG0024 VVRG0025 VVRG0026 VVRG0027 VVRG0028 VVRG0029 VVRG0030 VVRG0031 VVRG0032 VVRG0033 VVRG0034 VVRG0035 VVRG0036 VVRG0037 VVRG0038 VVRG0039 VVRG0040 VVRG0041 VVRG0042 VVRG0043 VVRG0044 VVRG0045 VVRG0046 VVRG0047 VVRG0048 VVRG0049 VVRG0050	
00:00:04	MTC Change Alternate Param	ZVR00020 PVRG0220 PVRG0221 PVRG0222 PVRG0223 PVRG0224 PVRG0225	 VVRG0220 VVRG0221 VVRG0222 VVRG0223 VVRG0224 VVRG0225	
00:00:05	TC_Enable_Science M	ZVR00104		Enable science V-M
00:00:10				Procedure Ends

5.5.13 AVRF011A: Coolers Performance Test

PRECONDITIONS: VIRTIS in IDLE mode (ME, M and H), HRD active, coolers at 80K.

OBJECTIVES: Change set point temperatures and cooler speed to calibrate Cold Tip Temperature and IR detectors Temperatures readings. While in Closed loop perform also M/H internal calibration

STATUS AT END: VIRTIS in IDLE mode, HRD active

DATA RATE Science TM Data Rate 13 Kbit/s (spread over 6 hours duration)
Science Data Volume 282.4 Mbit
H/K TM Data Rate 0.25 Kbit/s

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC_Close_Cover	ZVR00135		
Start First Closed Loop Cycle				
00:02:00	MTC PEM OFF	ZVR00121		
00:02:01	HTC PEM OFF	ZVR00132		
00:02:30	MCT Cooler Closed Loop	ZVR00125 PVRG0212	 1024	 M Cooler set at T=70K
00:02:31	HCT Cooler Closed Loop	ZVR00136 PVRG0214	 1024	 H Cooler set at T=70K
00:02:40	MTC PEM ON	ZVR00120		
00:02:41	HTC PEM ON	ZVR00131		
01:00:00	MTC Default Config	ZVR00061		
01:00:01	HTC Default Config	ZVR00042		
01:00:02	MTC Change Data Prod RAM	ZVR00143		M Calibration MODE
01:00:03	Change M Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 0 1 5 0	 Repetition rate Slice Summing All pixel Full window Compression
01:00:04	HTC Change Data Prod RAM	ZVR00149		H Calibration MODE
01:00:05	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 1 10 10 0	 H_int_Science_num1 (3s) H_int_Science_num2 H_Sum H_N_Frame H_N_Sum_Frame H_Dark_Rate H_Comp
01:00:06	HTC Change Func Param RAM	ZVR00045 PVRG0093 PVRG0094 PVRG0095 PVRG0096 PVRG0097 PVRG0098 PVRG0099 PVRG0100 PVRG0101	 882 2 12 0 787 4 193 120 120	 H_INT_SPECT_T_NUM1 H_INT_SPECT_T_NUM2 H_INT_SPECT_S_NUM1 H_INT_SPECT_S_NUM2 H_INT_RAD_NUM1 H_INT_RAD_NUM2 H_V_BIAS H_I_LAMP_SPECT_T H_I_LAMP_SPECT_S

		PVRG0102 PVRG0103 PVRG0104 PVRG0114 PVRG0115 PVRG0116	120 120 63 3 7 0	H_I_LAMP_RADIO H_I_Shutter H_STAB_LAMP_TIME H_XWIN H_YWIN H_Test_Init
01:00:07	TC_Enable_Science	ZVR00104		Enable science V-M
01:21:00	TC_Disable_Science	ZVR00106		Disable science V-M
01:21:10	TC_Enable_Science	ZVR00105		Enable science V-H
01:32:00	TC_Disable_Science	ZVR00107		Disable science V-H
Start Second Closed Loop Cycle				
01:32:10	MTC PEM OFF	ZVR00121		
01:32:11	HTC PEM OFF	ZVR00132		
01:32:30	MCT_Cooler Closed Loop	ZVR00125 PVRG0212	3072	M Cooler set at T=90K
01:32:31	HCT_Cooler Closed Loop	ZVR00136 PVRG0214	3072	H Cooler set at T=90K
01:33:00	MTC PEM ON	ZVR00120		
01:33:01	HTC PEM ON	ZVR00131		
02:30:00	TC_Enable_Science	ZVR00104		Enable science V-M
02:50:00	TC_Disable_Science	ZVR00106		Disable science V-M
02:50:30	TC_Enable_Science (20,10)	ZVR00105		Enable science V-H
03:00:00	TC_Disable_Science	ZVR00107		Disable science V-H
Start First Open Loop Cycle				
03:00:30	MTC PEM OFF	ZVR00121		
03:00:31	HTC PEM OFF	ZVR00132		
03:00:40	MCT_Cooler Open Loop	ZVR00126 PVRG0213	1500	M Cooler speed
03:00:41	HCT_Cooler Open Loop	ZVR00137 PVRG0215	1500	H Cooler speed
03:00:50	MTC PEM ON	ZVR00120		
03:00:51	HTC PEM ON	ZVR00131		
Start Second Open Loop Cycle				
04:00:00	MTC PEM OFF	ZVR00121		
04:00:01	HTC PEM OFF	ZVR00132		
04:00:20	MCT Cooler Open Loop	ZVR00126 PVRG0213	2200	M Cooler speed
04:00:21	HCT Cooler Open Loop	ZVR00137 PVRG0215	2200	H Cooler speed
04:00:30	MTC PEM ON	ZVR00120		
04:00:31	HTC PEM ON	ZVR00131		
Start Third Open Loop Cycle				
05:00:00	MTC PEM OFF	ZVR00121		
05:00:01	HTC PEM OFF	ZVR00132		
05:00:11	MCT Cooler Open Loop	ZVR00126 PVRG0213	2800	M Cooler speed
05:00:12	HCT Cooler Open Loop	ZVR00137 PVRG0215	2800	H Cooler speed
05:00:30	MTC PEM ON	ZVR00120		
05:00:31	HTC PEM ON	ZVR00131		
Return to Closed Loop Cycle 80K				
06:00:00	MTC PEM OFF	ZVR00121		
06:00:01	HTC PEM OFF	ZVR00132		
06:00:10	MCT Cooler Closed Loop	ZVR00125 PVRG0212	2048	M Cooler set at T=80K

06:00:11	HCT Cooler Closed Loop	ZVR00136 PVRG0214	2048	H Cooler set at T=80K
06:00:21	MTC PEM ON	ZVR00120		
06:00:22	HTC PEM ON	ZVR00131		
07:00:00				**Procedure Ends**

5.5.14 AVRF012A: H Internal Calibration

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Perform H Internal calibration
STATUS AT END: VIRTIS in Science Mode (H Only)
DATA RATE

H/K TM Data Rate	0.1 Kbit/s
Science TM Data Rate	< 45.6 kbit/s
Science Data Volume	13.2 Mbit

Formal Parameters

VVRG0093	=	H_Int_Spect_T_Num1	882	(default value)
VVRG0094	=	H_Int_Spect_T_Num2	2	(default value)
VVRG0095	=	H_Int_Spect_S_Num1	12	(default value)
VVRG0096	=	H_Int_Spect_S_Num2	0	(default value)
VVRG0097	=	H_Int_Rad_Num1	787	(default value)
VVRG0098	=	H_Int_Rad_Num2	4	(default value)
VVRG0099	=	H_V_Bias	193	(default value)
VVRG0100	=	H_I_Lamp_Spect_T	120	(default value)
VVRG0101	=	H_I_Lamp_Spect_S	120	(default value)
VVRG0102	=	H_I_Lamp_Radio	120	(default value)
VVRG0103	=	H_I_Shutter	120	(default value)
VVRG0104	=	H_Stab_Lamp_Time	63	(default value)
VVRG0105	=	H_Stab_Det_Time	10	(default value)
VVRG0106	=	H_Shutter_Time	10	(default value)
VVRG0107	=	H_Open_Cover_Step_160		(default value)
VVRG0108	=	H_Spare	0	(default value)
VVRG0109	=	H_Close_Cover_Step	60	(default value)
VVRG0110	=	H_Init_Cover_Step	16	(default value)
VVRG0203	=	H_ECA_ACT	30	(default value)
VVRG0111	=	H_ Ann_Check_Period	10	(default value)
VVRG0112	=	H_ Ann_Temp	333	(default value)
VVRG0113	=	H_ Ann_Time	30	(default value)
VVRG0114	=	H_ Xwin	3	(default value)
VVRG0115	=	H_ Ywin	7	(default value)
VVRG0116	=	H_ Test_Init	0	(default value)

VVRG0117	=	H_Int_Science_Num1	929	(default value)
VVRG0118	=	H_Int_Science_Num2	1	(default value)
VVRG0119	=	H_Spare	0	(default value)
VVRG0120	=	H_Sum	0	(default value)
VVRG0121	=	H_N_Frame	1	(default value)
VVRG0122	=	H_N_Sum_Frame	10	(default value)
VVRG0123	=	H_Dark_Rate	10	(default value)
VVRG0124	=	H_Comp	0	(default value)

Time	OPERATION	TC/ TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	H Cover Close	ZVR00135		
00:02:00	HTC Default Configuration	ZVR00042		
00:02:01	Change Data Prod RAM	ZVR00149		Set H Calibration MODE
00:02:02	Change Operat Param RAM	ZVR00047		
		PVRG0117	VVRG0117	default
		PVRG0118	VVRG0118	default
		PVRG0119	VVRG0119	
		PVRG0120	VVRG0120	default
		PVRG0121	VVRG0121	default
		PVRG0122	VVRG0122	default
		PVRG0123	VVRG0123	default
		PVRG0124	VVRG0124	no compression
00:02:03	Change Funct Param RAM	ZVR00045		
		PVRG0093	VVRG0093	
		PVRG0094	VVRG0094	
		PVRG0095	VVRG0095	
		PVRG0096	VVRG0096	
		PVRG0097	VVRG0097	
		PVRG0098	VVRG0098	
		PVRG0099	VVRG0099	
		PVRG0100	VVRG0100	
		PVRG0101	VVRG0101	
		PVRG0102	VVRG0102	
		PVRG0103	VVRG0103	
		PVRG0104	VVRG0104	
		PVRG0105	VVRG0105	
		PVRG0106	VVRG0106	
		PVRG0107	VVRG0107	
		PVRG0108	VVRG0108	
		PVRG0109	VVRG0109	
		PVRG0110	VVRG0110	
		PVRG0203	PVRG0203	
		PVRG0111	VVRG0111	
		PVRG0112	VVRG0112	
		PVRG0113	VVRG0113	
		PVRG0114	VVRG0114	
		PVRG0115	VVRG0115	
		PVRG0116	VVRG0116	
00:02:04	Enable H Science on SSMM	ZVR00105		Enable science V-H
00:14:00	Disable H Science on SSMM	ZVR00107		Disable science V-H
00:15:00				Procedure Ends

5.5.15 AVRF013A: Transition from Safe Mode to Idle Mode

PRECONDITIONS: VIRTIS in Safe Mode
OBJECTIVES: VIRTIS in Idle Mode HSLink still not active
STATUS AT END: VIRTIS in Idle Mode, PEMs Off.

HSLink must be activated with a subsequent call to the relevant OBCP, or call the VR-FCP-015 procedure (see AD11) for manual activation (not under VIRTIS responsibility)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	VTC_EnterIdle	ZVR00000 PVRG0000	20000000 hex	Start address of S/W 3.6.1 version
00:01:00				Procedure Ends

5.5.16 AVRF017A: M Initialisation Open Loop

PRECONDITIONS: ME in Idle mode, PEM-M and cryocoolers-M off, HRD active
OBJECTIVES: Power on M Cryocoolers in Open Loop and PEM
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Idle
H = Don't Care

DATA RATE
H/K TM Data Rate 0.151 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00213 = 2800 default value (actual speed in rpm)

Time	OPERATION	TC	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Cooler	ZVR00126 PVRG00213	VVRG00213	M Cooler On Open Loop
02:00:00	MTC PEM ON	ZVR00120		PEM M power on
02:00:30				Procedure Ends

5.5.17 AVRF017B: H Initialisation Open Loop

PRECONDITIONS: ME in Idle mode, PEM and cryocooler off, HRD active
OBJECTIVES: Power on H Cryocooler in Open Loop and PEM
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Don't Care
H = Idle

DATA RATE
H/K TM Data Rate 0.1 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00215 = 2800 default value (speed in rpm)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC Cooler	ZVR00137 PVRG00215	 VVRG00215	H Cooler On Open Loop
02:00:00	HTC PEM ON	ZVR00131		PEM H power on
02:00:30				Procedure Ends

5.5.18 AVRF017C: M+H Initialisation Open Loop

PRECONDITIONS: ME in Idle mode, PEMs and cryocoolers off, HRD active
OBJECTIVES: Power on Cryocoolers in Open Loop and PEMs
STATUS AT END: VIRTIS in Idle Mode
ME = Idle
M = Idle
H = Idle

DATA RATE
H/K TM Data Rate 0.25 Kbit/s
Science TM Data Rate 0.0

Formal Parameters
VVRG00211 = 2800 default value (speed in rpm)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	VTC Cooler	ZVR00114 PVRG00211	VVRG00211	Both Coolers On Open Loop
02:00:00	VTC PEM_ON	ZVR00110		Both PEMs power on
02:00:30				Procedure Ends

5.5.19 AVRF019A: Start H-Nominal Science Acquisition

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Start acquisition, H in Nominal Observation Mode
STATUS AT END: VIRTIS in Science Mode (H Only)
DATA RATE Depends on the parameter selection
Science between 3.5 and 354 Kbit/s
H/K between 0.1 and 1.17 Kbit/s

Formal Parameters

VVRG0093	=	H_Int_Spect_T_Num1	882	(default value)
VVRG0094	=	H_Int_Spect_T_Num2	2	(default value)
VVRG0095	=	H_Int_Spect_S_Num1	12	(default value)
VVRG0096	=	H_Int_Spect_S_Num2	0	(default value)
VVRG0097	=	H_Int_Rad_Num1	787	(default value)
VVRG0098	=	H_Int_Rad_Num2	4	(default value)
VVRG0099	=	H_V_Bias	193	(default value)
VVRG0100	=	H_I_Lamp_Spect_T	120	(default value)
VVRG0101	=	H_I_Lamp_Spect_S	120	(default value)
VVRG0102	=	H_I_Lamp_Radio	120	(default value)
VVRG0103	=	H_I_Shutter	120	(default value)
VVRG0104	=	H_Stab_Lamp_Time	63	(default value)
VVRG0105	=	H_Stab_Det_Time	10	(default value)
VVRG0106	=	H_Shutter_Time	10	(default value)
VVRG0107	=	H_Open_Cover_Step_160		(default value)
VVRG0108	=	H_Spare	0	(default value)
VVRG0109	=	H_Close_Cover_Step	60	(default value)
VVRG0110	=	H_Init_Cover_Step	16	(default value)
VVRG0203	=	H_ECA_ACT	30	(default value)
VVRG0111	=	H_ Ann_Check_Period	10	(default value)
VVRG0112	=	H_ Ann_Temp	333	(default value)
VVRG0113	=	H_ Ann_Time	30	(default value)
VVRG0114	=	H_ Xwin	3	(default value)
VVRG0115	=	H_ Ywin	7	(default value)
VVRG0116	=	H_ Test_Init	0	(default value)
VVRG0117	=	H_Int_Science_Num1	929	(default value)
VVRG0118	=	H_Int_Science_Num2	1	(default value)
VVRG0119	=	H_Spare	0	(default value)
VVRG0120	=	H_Sum	0	(default value)
VVRG0121	=	H_N_Frame	1	(default value)
VVRG0122	=	H_N_Sum_Frame	10	(default value)
VVRG0123	=	H_Dark_Rate	10	(default value)
VVRG0124	=	H_Comp	1	(default value)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	H_Cover_Open	ZVR00134		
00:02:00	HTC_Default Conf	ZVR00042		
00:02:01	HTC Change Data Prod RAM	ZVR00148		H Nominal Observation
00:02:02	HTC Change Func Param RAM	ZVR00045 PVRG0093 PVRG0094 PVRG0095 PVRG0096 PVRG0097 PVRG0098 PVRG0099 PVRG0100 PVRG0101 PVRG0102 PVRG0103 PVRG0104 PVRG0105 PVRG0106 PVRG0107 PVRG0108 PVRG0109 PVRG0110 PVRG0203 PVRG0111 PVRG0112 PVRG0113 PVRG0114 PVRG0115 PVRG0116	 VVRG0093 VVRG0094 VVRG0095 VVRG0096 VVRG0097 VVRG0098 VVRG0099 VVRG0100 VVRG0101 VVRG0102 VVRG0103 VVRG0104 VVRG0105 VVRG0106 VVRG0107 VVRG0108 VVRG0109 VVRG0110 VVRG0203 VVRG0111 VVRG0112 VVRG0113 VVRG0114 VVRG0115 VVRG0116	
00:02:03	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 VVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 VVRG0117 VVRG0118 VVRG0119 VVRG0120 VVRG0121 VVRG0122 VVRG0123 VVRG0124	
00:02:04	TC_Enable_Science H	ZVR00105		Enable science V-H
00:02:10				Procedure Ends

5.5.20 AVRF020A: Start H Science Backup Science Acquisition

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Start acquisition, H in Science Backup Mode
STATUS AT END: VIRTIS in Science Mode (H Only)
DATA RATE Depends on the parameter selection
Science < 354 Kbit/s
H/K < 0.25 Kbit/s

Formal Parameters

VVRG0093	=	H_Int_Spect_T_Num1	882	(default value)
VVRG0094	=	H_Int_Spect_T_Num2	2	(default value)
VVRG0095	=	H_Int_Spect_S_Num1	12	(default value)
VVRG0096	=	H_Int_Spect_S_Num2	0	(default value)
VVRG0097	=	H_Int_Rad_Num1	787	(default value)
VVRG0098	=	H_Int_Rad_Num2	4	(default value)
VVRG0099	=	H_V_Bias	193	(default value)
VVRG0100	=	H_I_Lamp_Spect_T	120	(default value)
VVRG0101	=	H_I_Lamp_Spect_S	120	(default value)
VVRG0102	=	H_I_Lamp_Radio	120	(default value)
VVRG0103	=	H_I_Shutter	120	(default value)
VVRG0104	=	H_Stab_Lamp_Time	63	(default value)
VVRG0105	=	H_Stab_Det_Time	10	(default value)
VVRG0106	=	H_Shutter_Time	10	(default value)
VVRG0107	=	H_Open_Cover_Step_160		(default value)
VVRG0108	=	H_Spare	0	(default value)
VVRG0109	=	H_Close_Cover_Step	60	(default value)
VVRG0110	=	H_Init_Cover_Step	16	(default value)
VVRG0203	=	H_ECA_ACT	30	(default value)
VVRG0111	=	H_ Ann_Check_Period	10	(default value)
VVRG0112	=	H_ Ann_Temp	333	(default value)
VVRG0113	=	H_ Ann_Time	30	(default value)
VVRG0114	=	H_ Xwin	3	(default value)
VVRG0115	=	H_ Ywin	7	(default value)
VVRG0116	=	H_ Test_Init	0	(default value)
VVRG0117	=	H_Int_Science_Num1	929	(default value)
VVRG0118	=	H_Int_Science_Num2	1	(default value)
VVRG0119	=	H_Spare	0	(default value)
VVRG0120	=	H_Sum	0	(default value)
VVRG0121	=	H_N_Frame	1	(default value)
VVRG0122	=	H_N_Sum_Frame	10	(default value)
VVRG0123	=	H_Dark_Rate	10	(default value)
VVRG0124	=	H_Comp	1	(default value)

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC_Default Conf	ZVR00042		
00:00:01	H_Cover_Open	ZVR00134		
00:02:00	HTC Change Data Prod RAM	ZVR00152		H Science Backup
00:02:02	HTC Change Func Param RAM	ZVR00045 PVRG0093 PVRG0094 PVRG0095 PVRG0096 PVRG0097 PVRG0098 PVRG0099 PVRG0100 PVRG0101 PVRG0102 PVRG0103 PVRG0104 PVRG0105 PVRG0106 PVRG0107 PVRG0108 PVRG0109 PVRG0110 PVRG0203 PVRG0111 PVRG0112 PVRG0113 PVRG0114 PVRG0115 PVRG0116	 VVRG0093 VVRG0094 VVRG0095 VVRG0096 VVRG0097 VVRG0098 VVRG0099 VVRG0100 VVRG0101 VVRG0102 VVRG0103 VVRG0104 VVRG0105 VVRG0106 VVRG0107 VVRG0108 VVRG0109 VVRG0110 VVRG0203 VVRG0111 VVRG0112 VVRG0113 VVRG0114 VVRG0115 VVRG0116	
00:02:03	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 VVRG0117 VVRG0118 VVRG0119 VVRG0120 VVRG0121 VVRG0122 VVRG0123 VVRG0124	
00:02:04	TC_Enable_Science H	ZVR00105		Enable science V-H
00:02:10				Procedure Ends

5.5.21 ACVF202A: Scan Unit Test

PRECONDITIONS: VIRTIS in IDLE mode, HRD active, M cryocooler steady state
Telescope temperature must be < -70C

OBJECTIVES: Check release of scan unit mirror, perform image acquisition at three different mirror locations.

STATUS AT END: VIRTIS in IDLE mode, HRD active, M cryocooler steady state

DATA RATE H/K TM Data Rate 0.33 kbit/s
Science TM Data Rate 30 Kbit/s
Data Volume 27 Mbit

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	MTC Default Config	ZVR00061		
00:00:01	MTC Change Data Prod RAM	ZVR00142		M science mode
00:00:02	MTC Change Oper Par RAM	ZVR00016		
		PVRG0051	0	Repetition rate 5s
		PVRG0052	1	No Slice Summing
		PVRG0053	0	3x4 full window
		PVRG0054	1	lossless compression
00:00:03	MTC_Change_Func_Par_RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2213	Default value
		PVRG0028	1	Default value
		PVRG0029	10	Default value
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	Default value
		PVRG0036	0	M_SU (point)
		PVRG0037	32904	M_ALPHA FIRST (boresight)
		PVRG0038	62847	M_ALPHA LAST
		PVRG0039	235	M_DELTA_ALPHA
		PVRG0040	1	M_N_ALPHA_IRT
		PVRG0041	20	Default value
		PVRG0042	6	Default value
		PVRG0043	50	Default value
		PVRG0044	63	Default value
		PVRG0045	360	Default value
		PVRG0046	30	Default value
		PVRG0047	81	Default value
		PVRG0048	0	Default value
		PVRG0049	81	Default value
		PVRG0050	16	Default value

00:00:04	TC_Enable_Science (20,10)	ZVR00104		Enable science V-M
00:05:00	TC_Disable_Science	ZVR00106		Disable science V-M
00:05:15	MTC_Change_Func_Par_RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2213	Default value
		PVRG0028	1	Default value
		PVRG0029	10	Default value
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	Default value
		PVRG0036	0	M_SU (point)
		PVRG0037	23665	M_ALPHA FIRST
		PVRG0038	62847	M_ALPHA LAST
		PVRG0039	235	M_DELTA_ALPHA
		PVRG0040	1	M_N_ALPHA_IRT
		PVRG0041	20	Default value
		PVRG0042	6	Default value
		PVRG0043	50	Default value
		PVRG0044	63	Default value
		PVRG0045	360	Default value
		PVRG0046	30	Default value
		PVRG0047	81	Default value
		PVRG0048	0	Default value
		PVRG0049	81	Default value
		PVRG0050	16	Default value
00:05:16	TC_Enable_Science	ZVR00104		Enable science V-M
00:10:00	TC_Disable_Science	ZVR00106		Disable science V-M
00:10:15	MTC_Change_Func_Par_RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2213	Default value
		PVRG0028	1	Default value
		PVRG0029	10	Default value
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	Default value
		PVRG0036	0	M_SU (point)
		PVRG0037	41869	M_ALPHA FIRST
		PVRG0038	62847	M_ALPHA LAST
		PVRG0039	235	M_DELTA_ALPHA
		PVRG0040	1	M_N_ALPHA_IRT
		PVRG0041	20	Default value
		PVRG0042	6	Default value
		PVRG0043	50	Default value

		PVRG0044 PVRG0045 PVRG0046 PVRG0047 PVRG0048 PVRG0049 PVRG0050	63 360 30 81 0 81 16	Default value Default value Default value Default value Default value Default value Default value
00:10:16	TC_Enable_Science	ZVR00104		Enable science V-M
00:14:30	TC_Disable_Science	ZVR00106		Disable science V-M
00:15:00				Procedure Ends

5.5.22 ACVF203A: Maximum Data Rate Acquisition

PRECONDITIONS: VIRTIS in IDLE mode, HRD active

OBJECTIVES: Perform acquisition in maximum data rate mode
M: Repetition Rate 5s, Full Frame, No compression
H: Integration time 1s, no compression, no frame skipping (H_N_Frame=1)

STATUS AT END: VIRTIS in Science mode (M and H)

DATA RATE H/K TM Data Rate 1.18 Kbit/s
Science TM Data Rate (M) 730 + (H) 74.6 = 804.6 Kbit/s
Data Volume : depends on duration. For 60s we get 48 Mbit

Time	OPERATION	TC/TM	TC / TM PARAMETER S	COMMENTS/REMARKS
00:00:00	HTC_Cover_Open	ZVR00134		
00:02:00	MTC Default Configuration	ZVR00061		
00:02:01	HTC Default Configuration	ZVR00042		
00:02:02	MTC Change Data Prod RAM	ZVR00142		M Science Mode
00:02:03	MTC Change Oper Par RAM	ZVR00016		
		PVRG0051	0	Repetition rate 5s
		PVRG0052	1	Slice Summing
		PVRG0053	5	All pixels full window
		PVRG0054	0	No compression
00:02:04	MTC Change Func Par RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2213	Default value
		PVRG0028	1	Default value
		PVRG0029	10	Default value
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	Default value
		PVRG0036	2	M_SU (OFF)
		PVRG0037	32904	Default value
		PVRG0038	62847	Default value
		PVRG0039	235	Default value
		PVRG0040	1	Default value
		PVRG0041	20	Default value
		PVRG0042	6	Default value
		PVRG0043	50	Default value
		PVRG0044	63	Default value
		PVRG0045	360	Default value
		PVRG0046	30	Default value
		PVRG0047	81	Default value
		PVRG0048	0	Default value

		PVRG0049 PVRG0050	81 16	Default value Default value
00:02:05	HTC Change Data Prod RAM	ZVR00148		H Data Nominal Observation
00:02:06	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 781 0 0 0 1 1 16 0	 H_int_Science_num1 (0.4s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate H_Comp
00:02:10	TC_Enable_Science	ZVR00104		Enable science V-M
00:02:20	TC_Enable_Science	ZVR00105		Enable science V-H
00:02:30				Procedure Ends

5.5.23 ACVF204A: Maximum Data Processing

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Perform acquisition in maximum data processing mode
M: Repetition Rate 60s, 3x4, 10 frame summing, wavelet compression, image mode
H: 10 frames summing, wavelet compression
STATUS AT END: VIRTIS in Science mode (M and H)

DATA RATE H/K TM Data Rate 1.0 Kbit/s
Science TM Data Rate (M) 0.063 + (H) 4.3 = 4.363 Kbit/s
Data Volume : depends on duration. ½ hour yields 5.6 Mbit

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC_Cover_Open	ZVR00134		
00:02:00	MTC Default Configuration	ZVR00061		
00:02:01	HTC Default Configuration	ZVR00042		
00:02:02	MTC Change Data Prod RAM	ZVR00142		M Science Mode
00:02:03	MTC Change Oper Par RAM	ZVR00016		
		PVRG0051	2	Repetition rate 60s
		PVRG0052	10	10 Slice Summing
		PVRG0053	0	3x4 full window
		PVRG0054	2	Wavelet compression
00:02:04	MTC Change Func Par RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2113	Default value
		PVRG0028	30	M_IR_DELAY
		PVRG0029	1	M_IR_EXPO
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	M_CCD_EXPO
		PVRG0036	1	M_SU (Image)
		PVRG0037	2687	M_ALPHA FIRST
		PVRG0038	62847	M_ALPHA LAST
		PVRG0039	235	M_DELTA_ALPHA
		PVRG0040	1	M_N_ALPHA_IRT
		PVRG0041	2	M_DBCK_RATE
		PVRG0042	6	Default value
		PVRG0043	50	Default value
		PVRG0044	63	Default value
		PVRG0045	360	Default value
		PVRG0046	30	Default value
		PVRG0047	81	Default value
		PVRG0048	0	Default value
		PVRG0049	81	Default value

		PVRG0050	16	Default value
00:02:05	HTC Change Data Prod RAM	ZVR00148		H Data Nominal Observation
00:02:06	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 1 1 10 16 1	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = YES H_N_Frame H_N_Sum_Frame H_Dark_Rate H_Comp
00:02:07	MTC Enable Science	ZVR00104		Enable science V-M
00:02:30	HTC Enable Science	ZVR00105		Enable science V-H
00:03:00				Procedure Ends

5.5.24 ACVF205A: H Pixel Map

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Upload a new pixel map, perform an internal check.
STATUS AT END: VIRTIS in IDLE mode, HRD active

Time	OPERATION	TC/TM	TC / TM PARAMETER	COMMENTS/REMARKS
00:00:00	HTCDefault Config	ZVR00042		
00:00:01	HTC Change Pix Map	ZVR00053		
		PVRG0179	4219AE3B	Parameters are all default
		PVRG0180	3DFA6C44	In <hex> format
		PVRG0181	38C453C2	
		PVRG0182	42B62E9F	
		PVRG0183	3DC93DA1	
		PVRG0184	3875C7FB	
		PVRG0185	42FC59B2	
		PVRG0186	3DAAFFB4	
		PVRG0187	3812FFA4	
		PVRG0188	4317C58A	
		PVRG0189	3D8EB0EC	
		PVRG0190	37A1E2FF	
		PVRG0191	432AFA9B	
		PVRG0192	3D60E08A	
		PVRG0193	3781C55B	
		PVRG0194	4338FE9A	
		PVRG0195	3D3856D3	
		PVRG0196	3740460B	
		PVRG0197	4343617A	
		PVRG0198	3D2777DE	
		PVRG0199	35FF7CCA	
		PVRG0200	434B7628	
		PVRG0201	3D10680A	
		PVRG0202	B2528E04	
00:00:02	HTC Load Pixel map	ZVR0055		Load Pixel Map to PEM-H
00:00:32	HTC Check Pixel Map	ZVR0056		
00:01:00				Procedure Ends

5.5.25 ACVF206A : M/H Modes Test

PRECONDITIONS: VIRTIS in Idle Mode, HRD active
OBJECTIVES: To Test all M and H Scientific Modes
STATUS AT END: VIRTIS in IDLE mode, HRD active
DATA RATE

Mode Selected	**Data Rate (Kbit/s)**	**Duration (sec)**	**Data Volume (Mbit/Mbytes)**
M Nominal Acquisition	30.4	60	1.8/0.23
M High Spectral Acquisition	91.2	60	5.5/0.7
M High Spatial Acquisition	122	60	7.3/0.91
M Nominal Compressed	7.6	60	0.46/0.06
M Reduced Slit	30.4	60	1.8/0.23
H Nominal Acquisition	23.3	120	2.8/0.35
H Minimum Data Rate	2.84	360	1.0/0.13
H Maximum Data Rate	43.1	120	5.2/0.65
H Backup No Compression	166	60	10/1.25
H Backup Lossless Compr.	89.7	60	5.4/0.675
H Backup Wavelet Compr.	32.8	60	2/0.25
	AVERAGE 39.3		**TOTAL 42.8/5.35**

Time	**OPERATION**	**TC/TM**	**TC / TM PARAMETERS**	**COMMENTS/REMARKS**
00:00:00	HTC_Cover_Open	ZVR00134		
00:02:00	HTCDefault Config	ZVR00042		
00:02:01	MTCDefault Config	ZVR00061		
M Nominal Acquisition				
00:02:02	MTC Change Data Prod RAM	ZVR00142		M Science Mode
00:02:03	MTC Change Func Par RAM	ZVR00014		
		PVRG0022	1	Default value
		PVRG0023	432	Default value
		PVRG0024	7	Default value
		PVRG0025	262	Default value
		PVRG0026	2430	Default value
		PVRG0027	2213	Default value
		PVRG0028	1	Default value
		PVRG0029	10	M_IR_EXPO
		PVRG0030	5	Default value
		PVRG0031	436	Default value
		PVRG0032	0	Default value
		PVRG0033	255	Default value
		PVRG0034	1	Default value
		PVRG0035	10	M_CCD_EXPO
		PVRG0036	1	M_SU (Image)
		PVRG0037	2687	Default value
		PVRG0038	62847	Default value
		PVRG0039	235	Default value
		PVRG0040	1	Default value
		PVRG0041	2	Default value
		PVRG0042	6	Default value
		PVRG0043	50	Default value

		PVRG0044 PVRG0045 PVRG0046 PVRG0047 PVRG0048 PVRG0049 PVRG0050	63 360 30 81 0 81 16	Default value Default value Default value Default value Default value Default value Default value
00:02:04	MTC Enable Science	ZVR00104		Enable science V-M
00:03:00	MTC_Disable_Science	ZVR00106		
M High Spectral Acquisition				
00:03:30	MTC Change Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 0 1 3 1	 Repetition rate 5s Slice Summing 1x4 full window Lossless compression
00:03:31	MTC Enable Science	ZVR00104		Enable science V-M
00:04:30	MTC_Disable_Science	ZVR00106		
M High Spatial Acquisition				
00:05:00	MTC Change Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 0 1 4 1	 Repetition rate 5s Slice Summing 3x1 full window Lossless compression
00:05:01	MTC Enable Science	ZVR00104		Enable science V-M
00:06:00	MTC_Disable_Science	ZVR00106		
M Nominal Compressed Acquisition				
00:06:30	MTC Change Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 0 1 0 2	 Repetition rate 5s Slice Summing 3x4 full window Wavelet compression
00:06:31	MTC Enable Science	ZVR00104		Enable science V-M
00:07:30	MTC_Disable_Science	ZVR00106		
M Reduced Slit Acquisition				
00:08:00	MTC Change Oper Par RAM	ZVR00016 PVRG0051 PVRG0052 PVRG0053 PVRG0054	 0 1 6 1	 Repetition rate 5s Slice Summing 3x1 reduced slit lossless compression
00:08:01	MTC Change Func Par RAM	ZVR00014 PVRG0022 PVRG0023 PVRG0024 PVRG0025 PVRG0026 PVRG0027 PVRG0028 PVRG0029 PVRG0030 PVRG0031 PVRG0032 PVRG0033 PVRG0034 PVRG0035 PVRG0036 PVRG0037	 1 432 7 70 2430 2213 1 10 5 436 0 63 1 10 1 32904	 Default Value Default Value Default Value M_IR_Win_Y2 Default Value Default Value Default Value M_IR_EXPO Default Value Default Value Default Value M_CCD_Win Default Value M_CCD_EXPO M_SU (Image) Default Value

		PVRG0038 PVRG0039 PVRG0040 PVRG0041 PVRG0042 PVRG0043 PVRG0044 PVRG0045 PVRG0046 PVRG0047 PVRG0048 PVRG0049 PVRG0050	62847 235 1 2 6 50 63 360 30 81 0 81 16	Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value Default Value
00:08:02	MTC Enable Science	ZVR00104		Enable science V-M
00:09:00	MTC_Disable_Science	ZVR00106		
H Nominal Acquisition (Default)				
00:09:30	HTC Change Data Prod RAM	ZVR00148		H Data Nominal Observation
00:09:31	HTC Enable Science	ZVR00105		Enable science V-H
00:11:30	HTC Disable Science	ZVR00107		Disable science V-H
H Minimum Data Rate Acquisition				
00:12:00	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 3 10 10 2	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate Wavelet F1
00:12:01	HTC Enable Science	ZVR00105		Enable science V-H
00:18:00	HTC Disable Science	ZVR00107		Disable science V-H
H Maximum Data Rate Acquisition				
00:18:30	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 1 10 10 0	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate No Compression
00:18:31	HTC Enable Science	ZVR00105		Enable science V-H
00:20:30	HTC Disable Science	ZVR00107		Disable science V-H
H Science Backup Acquisition – No Compression				
00:21:00	HTC Change Data Prod RAM	ZVR00152		H Science Backup
00:21:01	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 5 10 10 0	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate No Compression
00:21:02	HTC Enable Science	ZVR00105		Enable science V-H
00:22:00	HTC Disable Science	ZVR00107		Disable science V-H

H Science Backup Acquisition – Lossless Compression				
00:22:31	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 5 10 10 1	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate Lossless Compression
00:22:32	HTC Enable Science	ZVR00105		Enable science V-H
00:23:30	HTC Disable Science	ZVR00107		Disable science V-H
H Science Backup Acquisition – Wavelet Compression				
00:24:00	HTC Change Oper Param RAM	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 5 10 10 2	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum = NO H_N_Frame H_N_Sum_Frame H_Dark_Rate Wavelet Compression
00:24:01	HTC Enable Science	ZVR00105		Enable science V-H
00:25:00	HTC Disable Science	ZVR00107		Disable science V-H
00:25:30				Procedure Ends

5.5.26 ACVF207A: Services Verification

PRECONDITIONS: VIRTIS is in Safe Mode, HRD not active, PEMs off
OBJECTIVES: Test of services 6 and 255
STATUS AT END: VIRTIS is in Safe Mode, HRD not active, PEMs off

To perform memory operations we need to be in Safe mode (only PROM S/W can manage service 6). This Command Sequence shall be called after the AVRF004D (Transition from Idle to Safe Mode) and the Command Sequence AVRF013A (Transition from Safe to Idle Mode) shall be called at the end.

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	TC Reset TM Output Buffer	ZVR00057		Delete any TM data present in the output buffer
00:00:01	VTC Get EEPROM Status	ZVR00038		Check Status of the EEPROM, and currently used EEPROM code
	Verify packet reception	YVR00013		EID Report 47502
00:00:10	TC Dump Memory ID140	ZVR14005 PVRG6060 PVRG6064 PVRG6065 PVRG6066	 140 1 0x20000000 20	Dump 1 word Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14006 NVRA0611 NVRA0612 NVRA0613 NVRA0614	 140 1 0x20000000 20	Reads the requested word Mem_ID Number of Blocks Start Address Block Length
00:00:20	TC Check Memory ID140	ZVR14009 PVRG6060 PVRG6064 PVRG6065 PVRG6066	 140 1 0x20000000 20	Check 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Check Report ID140	YVR14010 NVRA0611 NVRA0612 NVRA0613 NVRA0614	 140 1 0x20000000 20	Check content of memory Mem_ID Number of Blocks Start Address Block Length
00:00:30	TC Dump Memory ID141	ZVR14105 PVRG6061 PVRG6064 PVRG6065 PVRG6066	 141 1 0x010000 1	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14106 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615 NVRA0616 NVRA0617	 141 1 0x010000 1 TBD TBD TBD	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:00:40	TC Load Memory ID141	ZVR14102		Loads 1 word in DM RAM

		PVRG6061 PVRG6064 PVRG6065 PVRG6066 PVRG6067 PVRG6068 PVRG6069	141 1 0x 010000 1 ABAB ABAB ABAB	Mem_ID (DM RAM) Number of Blocks Start_Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:00:50	TC Dump Memory ID141	ZVR14105 PVRG6061 PVRG6064 PVRG6065 PVRG6066	 141 1 0x010000 1	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14106 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615 NVRA0616 NVRA0617	 141 1 0x010000 1 ABAB ABAB ABAB	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:01:00	TC Check Memory ID141	ZVR14109 PVRG6061 PVRG6064 PVRG6065 PVRG6066	 141 1 0x010000 1	Check 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Check Report ID141	YVR14110 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0620 NVRA0621	 141 1 0x010000 1 0000 TBD	Check content of memory Mem_ID Number of Blocks Start Address Block Length Checksum Spare Checksum Word
00:01:10	TC Dump Memory ID142	ZVR14205 PVRG6062 PVRG6064 PVRG6065 PVRG6066	 142 1 0x0000000 1	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14206 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615 NVRA0616 NVRA0617	 142 1 0x0000000 1 TBD TBD TBD	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:01:20	TC Load Memory ID142	ZVR14202 PVRG6062 PVRG6064 PVRG6065 PVRG6066 PVRG6067 PVRG6068 PVRG6069	 142 1 0x 00000000 1 AB CDEF 1234	Loads 1 word in DM RAM Mem_ID (DM RAM) Number of Blocks Start_Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:01:21	TC Dump Memory ID142	ZVR14205 PVRG6062 PVRG6064 PVRG6065	 142 1 0x0000000	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address

		PVRG6066	1	Block Length
	TM Memory Dump Report	YVR14206 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615 NVRA0616 NVRA0617	 142 1 0x0000000 1 00AB CDEF 1234	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15 Data Block bits 16-31 Data Block bits 32-47
00:01:30	TC Check Memory ID142	ZVR14209 PVRG6062 PVRG6064 PVRG6065 PVRG6066	 142 1 0x0000000 1	Check 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Check Report ID142	YVR14210 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0620 NVRA0621	 142 1 0x00000000 1 0000 TBD	Check content of memory Mem_ID Number of Blocks Start Address Block Length Checksum Spare Checksum Word
00:01:40	TC Dump Memory ID143	ZVR14305 PVRG6063 PVRG6064 PVRG6065 PVRG6066	 143 1 0x30000000 1	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14306 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615	 143 1 0x30000000 1 TBD	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15
00:01:50	TC Load Memory ID143	ZVR14302 PVRG6063 PVRG6064 PVRG6065 PVRG6066 PVRG6067	 143 1 0x 30000000 1 ABAB	Loads 1 word in DM RAM Mem_ID (DM RAM) Number of Blocks Start_Address Block Length Data Block bits 0-15
00:01:51	TC Dump Memory ID143	ZVR14305 PVRG6063 PVRG6064 PVRG6065 PVRG6066	 143 1 0x30000000 1	Dump 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Dump Report	YVR14306 NVRA0611 NVRA0612 NVRA0613 NVRA0614 NVRA0615	 143 1 0x30000000 1 ABAB	Reads the requested word Mem_ID Number of Blocks Start Address Block Length Data Block bits 0-15
00:02:00	TC Check Memory ID143	ZVR14309 PVRG6063 PVRG6064 PVRG6065 PVRG6066	 143 1 0x30000000 1	Check 1 word in DM RAM Mem_ID (EEPROM) Number of Blocks Start_Address Block Length
	TM Memory Check Report ID143	YVR14310 NVRA0611 NVRA0612	 143 1	Check content of memory Mem_ID Number of Blocks

		NVRA0613 NVRA0614 NVRA0620 NVRA0621	0x30000000 1 0000 TBD	Start Address Block Length Checksum Spare Checksum Word
00:04:30				Procedure Ends

5.5.27 ACVF208: RTU Test Acquisition

PRECONDITIONS: VIRTIS in IDLE mode, HRD active
OBJECTIVES: Upload nominal acquisition parameters, set acquisition via RTU, start acquisition
STATUS AT END: VIRTIS is in IDLE mode, HRD active

DATA RATE H/K TM Data Rate 0.144 (M) + 0.101 (H) +0.03 (ME) = 0.275 kbit/s
Science TM Data Rate 2.53 (M) + 1.23 (H) = 3.76Kbit/s
Data Volume depends on duration

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	HTC Open Cover	ZVR00134		
00:02:00	HTCDefault Config	ZVR00042		
00:02:01	MTCDefault Config	ZVR00061		
00:02:02	MTC Change Data Prod RAM	ZVR00142		M science mode
00:02:03	MTC Change Oper Par RAM	ZVR00016		
		PVRG0051	2	Repetition rate 60s
		PVRG0052	1	No Slice Summing
		PVRG0053	0	3x4 full window
		PVRG0054	1	lossless compression
00:02:04	MTC Change Func Par RAM	ZVR00014		
		PVRG0022		Default value
		PVRG0023		Default value
		PVRG0024		Default value
		PVRG0025	70	M_IR_Win_Y2
		PVRG0026		Default value
		PVRG0027		Default value
		PVRG0028		Default value
		PVRG0029	10	M_IR_EXPO
		PVRG0030		Default value
		PVRG0031		Default value
		PVRG0032		Default value
		PVRG0033	63	M_CCD_Win
		PVRG0034		Default value
		PVRG0035	10	M_CCD_EXPO
		PVRG0036	0	M_SU (Point)
		PVRG0037		Default value
		PVRG0038		Default value
		PVRG0039		Default value
		PVRG0040		Default value
		PVRG0041		Default value
		PVRG0042		Default value
		PVRG0043		Default value
		PVRG0044		Default value
		PVRG0045		Default value
		PVRG0046		Default value
		PVRG0047		Default value
		PVRG0048		Default value
		PVRG0049		Default value
		PVRG0050		Default value
00:02:05	HTC_Change_Data_Prod_RAM	ZVR00148		H Nominal Observation

00:02:06	HTC_Change_Oper_Param_RAM (194,15)	ZVR00047 PVRG0117 PVRG0118 PVRG0119 PVRG0120 PVRG0121 PVRG0122 PVRG0123 PVRG0124	 929 1 0 0 18 1 15 1	 H_int_Science_num1 (1s) H_int_Science_num2 H_Spare H_Sum H_N_Frame H_N_Sum_Frame H_Dark_Rate Lossless
00:02:07	TC_Enable_Science RTU(20,1)	ZVR00100		Enable science V-M
00:02:30	TC_Enable_Science RTU(20,1)	ZVR00101		Enable science V-H
00:03:00				Procedure Ends

5.5.28 ACVF209: Stop Science Acquisition on RTU

PRECONDITIONS: VIRTIS in Science mode through RTU
OBJECTIVES: Stop acquisition via RTU, leave VIRTIS in Idle Mode
STATUS AT END : VIRTIS in Idle Mode
DATA RATE H/K TM Data Rate 0.25 kbit/s
Science TM Data Rate 0.0Kbit/s

Time	OPERATION	TC/TM	TC / TM PARAMETERS	COMMENTS/REMARKS
00:00:00	TC Disable Science RTU	ZVR00102		Disable science V-M
00:00:30	TC Disable Science RTU	ZVR00103		Disable science V-H
00:01:00				Procedure Ends

5.6 Contingency Recovery Procedures

As explained in chapter 4.4 VIRTIS ME S/W is capable of detecting internal failures and act accordingly. However, if a failure is detected during scientific operations, the instrument shall reset itself and the scientific session from that moment until a subsequent reset of the instrument is lost.
To minimise scientific data loss, the team has proposed a recovery procedure in case a malfunction was to be detected during scientific operations. The Recovery OBCP was supposed to do the following:

1. DMS detect a subtype 4 event. This trigger the issue of a “start VIRTIS Recovery OBCP” command
2. DMS is commanded to interrupt VIRTIS TimeLine
3. VIRTIS is power cycled (power off main power line, power on redundant power line)
4. Upload SCET time update
5. Issue VTC_Enter_Idle_Mode
6. Restart HSLink connection to SSMM
7. Start cool-down both channels (wait for temperature steady state to be reached)
8. Power On both PEMs
9. Restore VIRTIS TimeLine
10. Return

An OBCP based on the above activities has been proposed as an ECR (Engineering Change Request) RO-VIR-ER-058, which has been rejected by ESOC with the following comment:

> *The OBCP is not operationally acceptable since it would put the instrument in a state which might be different from what has gone through the mission planning done at RMOC. This is deemed to be unnecessary and complex.*

6 Data Operations Handbook

6.1 Telecommand Function Definitions

See the EID-B section 2.8.3.2.2 given in attachment 2.

6.2 Telecommand Parameters Definitions

See the EID-B section 2.8.3.2.2 and appendixes B,C given in attachment 2.

6.3 Telemetry Packet Definitions

See the EID-B section 2.8.3.2.1 given in attachment 2 and the database printouts.

6.4 Telemetry Parameters Definitions

See the EID-B section 2.8.3.2.1 and appendixes B,C given in attachment 2 and the database printouts.

6.5 Event Packet Definitions

See the EID-B section 2.8.3.2.1 given in attachment 2 and the database printouts

6.6 Anomaly Report Definition

See the EID-B section 2.8.3.2.1 given in attachment 2 and the database printouts
A full list of the presently defined events reports is given in table 6.1. It contains not only the anomalous conditions but also the normal progress event of subtype 1.

6.7 Context File Definition

No context files are used by VIRTIS

6.8 Data and Dump File Definitions

See the EID-B section 2.8.3.2.1 given in attachment 2 and the database printouts

EID	Event Report Name	Sub-type
	GENERAL EVENTS (47501 ... 47550)	
47501	EVENT_SECONDARY_BOOT_COMPLETE	1
47502	EVENT_EEPROM_STAT	1
47503	EVENT_WRONG_EVENT_CAT	2
47504	EVENT_SW_53_COMPR_BUFFER_OVERFLOW	2
47505	EVENT_SW_53_COMPR_SIZE_WRONG	2
47506	EVENT_SW_53_COMPR_IBR_WRONG	2
47507	EVENT_SW_53_COMPR_UNKNOWN_ERROR	2
47508	EVENT_SW_CALL_NOT_ACTIVE_TASK	2
47509	EVENT_ENTER_SAFE_MODE_COMMANDED	2
47510	EVENT_ENTER_IDLE_MODE_COMMANDED	2
47511	EVENT_SW_53_COMPR_FACTOR_LESS_THAN_1	2
47512..47521	FREE	
47522	EVENT_SW_212_NO_TC_PACKET_BLOCK_FREE	2
47523	EVENT_SW_212_FIFO_OVERFLOW	2
47524..47525	FREE	
47526	EVENT_SW_26_LINK_NOT_ESTABLISHED	2
47527	EVENT_SW_237_HRD_TM_TRANSFER_TIME_OUT	2
47528	EVENT_SW_26_WRONG_HRD_PACKET_SIZE	2
47529	FREE	
47530	EVENT_SW_23_TM_APID_WRONG	internal
47531	EVENT_SW_233_HK_SID_WRONG	4
47532	EVENT_SW_614_RAM_RD_ADDRESS_WRONG	4
47533	EVENT_SW_614_RAM_RD_BLOCK_SIZE_WRONG	4
47534	EVENT_SW_614_RAM_RD_WR_MODE_WRONG	4
47535	EVENT_SW_612_EEPROM_NO_BOOT_DATA_FOUND	4
47536	EVENT_SW_6_WATCH_MODE_WRONG	4
47537	EVENT_SW_6_TIMER_WRONG	4
47538	EVENT_SW_6_TIMER_MODE_WRONG	4
47539	EVENT_SW_25_SCET_TIMER_MODE_WRONG	4
47540	EVENT_SW_24_SDT_BUFFER_COMPLETE	Internal
47541	EVENT_SW_24_SDT_BLOCK_STATUS_WRONG	4
47542	EVENT_SW_24_SDT_BUFFER_FULL	2
47543	EVENT_SW_24_NO_SDT_BLOCK_IN_BUFFER	4
47544	EVENT_SW_613_EEPROM_SWITCH_VAL_WRONG	4
47545	EVENT_SW_613_EEPROM_RD_WR_MODE_WRONG	4
47546	EVENT_SW_613_EEPROM_NOT_ENOUGH_SPACE	4
47547	EVENT_SW_613_EEPROM_ADDRESS_WRONG	4
47548	EVENT_SW_613_EEPROM_BLOCK_SIZE_IS_ZERO	4
47549	EVENT_SW_3_4_VIR_DATA_CHANNEL_WRONG	internal
47550	EVENT_SW_0_CRC_BLOCK_SIZE_IS_ZERO	4

EID	Event Report Name	Sub-type
	ME Unit Hardware related Events/Errors (47601 ... 47700)	
47601	EVENT_ME_MLC_FIFO_FULL	4
47602	EVENT_ME_SCET_WRONG	4 (in safe mode) 2 (in other modes)
47603	EVENT_ME_PS_DAT_ID_WRONG	4
47604	EVENT_ME_DPU_DM1_WRITE_WRONG	4
47605	EVENT_ME_EEPROM_WRITE_WRONG	4
47606	EVENT_SW_612_EEPROM_START_SEG_WRONG	4
47607	EVENT_SW_612_BOOT_END_SEG_FAILED	4
47608	EVENT_SW_612_BOOT_SEG_CRC_WRONG	4
47609	EVENT_ME_DPU_DM2_WRITE_WRONG	4
47610	EVENT_ME_PS_NO_RESPONSE	4
47611	EVENT_ME_PS_ADC_DATA_WRONG	4
47612	EVENT_ME_SEU_DETECTED	2
47613..47628	FREE	
47629	EVENT_ME_PS_UNKNOWN_ERROR_CODE	2
47630	EVENT_SC_TC_CONFIRMATION_FAILED	2
47631	EVENT_SCET_RUNS_UNSYNCHRONIZED	2
47632..47647	FREE	
47648	EVENT_ME_HK_DPU_VOLTAGE_OUT_OF_RANGE	2
47649	EVENT_ME_HK_PS_TEMP_OUT_OF_RANGE	2
47650	EVENT_ME_HK_DPU_TEMP_OUT_OF_RANGE	2
47651	FREE	
47652	EVENT_IFE_INVALID_PORT_ADDRESS	2
47653	EVENT_ME_HRD_PARITY_WRONG	2
47654	EVENT_ME_HRD_DISCONNECT	2
47655	EVENT_SC_HS_LINK_COMMANDED_TWICE	4
47656..47657	FREE	
47658	EVENT_ME_PS_CMD_VIR_MONITOR_FAIL	4
47659	EVENT_ME_PS_CMD_VIR_UNDERVOLTAGE	4
47660	EVENT_ME_PS_CMD_VIR_OVERVOLTAGE	4
47661	EVENT_ME_PS_CMD_EXECUTE_ERROR	4
47662	EVENT_ME_PS_CMD_UNKNOWN	4
47663	EVENT_ME_PS_CMD_SHADOW_WRONG	4
47664	EVENT_ME_PS_POW_STAT_WRONG	4
47665	EVENT_ME_PS_ADC_NOT_ON	4
47666	EVENT_ME_EEPROM_NO_EXE_FOUND	Internal
47667	EVENT_ME_DPU_BBC_WRITE_WRONG	4
47668	EVENT_ME_DPU_REG_WRITE_WRONG	4
47669	EVENT_ME_WATCHDOG_DISABLED	4
47670	EVENT_ME_TIMER_3_NOT_READABLE	4
47671	EVENT_ME_SCET_TIMER_NOT_RUNNING	4 (in PROM) 2 (internal EEPROM)

47672	EVENT_ME_EEPROM_NO_EXE_VERSION_FOUND	internal
47673	EVENT_ME_EEPROM_NO_EXE_FOUND	internal
47674	EVENT_ME_EEPROM_WRITE_ERROR	4
47675	EVENT_ME_EEPROM_NOT_WRITEABLE	4
47676..47679	FREE	
47680	EVENT_NO_VTC_CONFIRM_AFTER_CRITICAL_TC	2
47681	EVENT_ME_EEPROM_CURRENT_PARAMETER_UPDATE_WRONG	4
47682	EVENT_SC_TC_UPLOAD_MEM_ID_WRONG	4
47683	EVENT_SC_TC_UPLOAD_FORMAT_WRONG	4
47684	EVENT_SC_TC_UPLOAD_SIZE_WRONG	4
47685	EVENT_SC_TC_UPLOAD_ADDRESS_WRONG	4
47686	EVENT_SC_TC_DUMP_FORMAT_WRONG	4
47687	EVENT_SC_TC_CHECK_FORMAT_WRONG	4
47688	EVENT_ME_MLC_FIFO_EMPTY	internal
47689	EVENT_SC_TC_WRONG_SAFE_MODE_TC	2
47690	EVENT_ME_SDT_FIFO_HALF_FULL	Internal
47691	EVENT_ME_SDT_FIFO_FULL	4
47692	EVENT_ME_PS_EEPROM_NOT_OFF	4
47693	EVENT_ME_PS_EEPROM_NOT_ON	4
47694	EVENT_ME_PS_STAT_WRONG	4
47695	EVENT_ME_DPU_NO_BBC_STATUS_AVAILABLE	4
47696	EVENT_ME_DPU_REG_ISR_WRONG	4
47697	EVENT_ME_DPU_REG_TRS_WRONG	4
47698	EVENT_ME_DPU_INIT_ERROR	4
47699	EVENT_ME_DPU_PM_WRITE_WRONG	4
47700	EVENT_ME_DISP_DRV_STAT_WRONG_LOW	4
	VIRTIS-M control software events (47701 ... 47740	
47701	EVENT_M_DUMP_DATA_PRODUCTION_PARAMETER	1
47702	EVENT_M_DUMP_FUNCTIONAL_PARAMETER	1
47703	EVENT_M_DUMP_OPERATIONAL_PARAMETER	1
47704	EVENT_M_DUMP_ALTERNATE_PARAMETER	1
47705	EVENT_M_DUMP_CALIBRATION_PARAMETER	1
47706	EVENT_M_COOL_DOWN_END_SUCCESS	1
47707	EVENT_ME_SU_ANGLE_STEP_SIZE_NOT_INT_OF_ANGLE_RANGE	2
47708	EVENT_ME_SU_FIRST_ANGLE_GREATER_LAST_ANGLE	2
47709..47734	FREE	
47735	EVENT_SW_342_MODE_USER_DEFINED_STARTED	2
47736	FREE	
47737	EVENT_SW_31_M_PEM_CMD_FIFO_OVERFLOW	2
47738	EVENT_M_VIS_DATA_SLICE_LOST	2
47739	EVENT_M_IR_DATA_SLICE_LOST	2
47740	EVENT_SW_34_M_MODE_UNVALID	2

EID	Event Report Name	Sub-type
	VIRTIS-M terminator hardware events (47741 ... 47800)	
47741	EVENT_M_COOLER_STEADY_NOT_REACHED	2
47742	EVENT_M_COOLER_CMD_OFF_DURING_OPERATION	2
47743	EVENT_M_COOLER_CMD_OPEN_LOOP	2
47744	EVENT_M_COOLER_CMD_DURING_STEADY_STATE	2
47745	EVENT_M_COOLER_CMD_DURING_COOL_DOWN	2
47746	EVENT_M_ECA_ALREADY_MOVED	2
47747	EVENT_M_ECA_NOT_MOVED	2
47748	EVENT_M_IR_DETECTOR_NOT_OFF	2
47749	EVENT_M_ANNEAL_NOT_POSSIBLE	2
47750	EVENT_M_ANNEAL_STOPPED_AFTER_EXCEED_TEMP	2
47751	EVENT_M_ANNEAL_STOPPED_AFTER_TIME_OUT	2
47752	EVENT_M_COVER_CTRL_IN_M_MODE_X	2
47753	EVENT_M_COVER_ALREADY_CLOSED	2
47754	EVENT_M_COVER_ALREADY_OPEN	2
47755	EVENT_M_COVER_OPEN	2
47756	EVENT_M_COVER_NOT_OPEN	2
47757	EVENT_M_COVER_CLOSED	2
47758	EVENT_M_COVER_NOT_CLOSED	2
47759	EVENT_M_SCIENCE_DATA_GENERATION_STOPPED	2
47760	EVENT_M_MODE_USER_DEFINED_STARTED	2
47761	EVENT_M_IR_DATA_OUTSIDE_OF_RANGE	2
47762	EVENT_M_VIS_DATA_OUTSIDE_OF_RANGE	2
47763	EVENT_M_IR_LESS_DATA_THAN_EXPECTED	2
47764	EVENT_M_IR_DATA_ACQ_TIME_OUT	2
47765	EVENT_M_VIS_DATA_ACQ_TIME_OUT	2
47766	EVENT_M_COOL_STEADY_STATE_FAILURE	2
47767	EVENT_M_CALIBR_SEQ_PHASE_FINALIZED	1
47768	EVENT_M_SU_HK_WRONG	2
47769	EVENT_M_SHUTTER_NOT_OPEN	2
47770	EVENT_M_MODE_WRONG	2
47771	EVENT_M_IR_ADC_LATCH_UP	2
47772	EVENT_M_IR_CMD_TIME_ERROR	2
47773	EVENT_M_IR_CMD_WORD_ERROR	2
47774	EVENT_M_VIS_ADC_LATCH_UP	2
47775	EVENT_M_VIS_CMD_TIME_ERROR	2
47776	EVENT_M_VIS_CMD_WORD_ERROR	2
47777	EVENT_M_COOL_DOWN_END_FAILURE	2
47778	EVENT_M_CCD_WIN_SIZE_NOT_NOMINAL	2
47779	EVENT_M_VIS_IFE_FIFO_CLK_NUMBER_WRONG	2
47780	EVENT_M_IR_IFE_FIFO_CLK_NUMBER_WRONG	2
47781	EVENT_M_VIS_IFE_FIFO_EMPTY_FIFO_READ	2

47782	EVENT_M_IR_IFE_FIFO_EMPTY_FIFO_READ	2
47783	EVENT_M_VIS_IFE_FIFO_RD_ORDER_WRONG	2
47784	EVENT_M_IR_IFE_FIFO_RD_ORDER_WRONG	2
47785	EVENT_M_VIS_LESS_DATA_THAN_EXPECTED	2
47786	EVENT_M_IR_DATA_SIZE_TOO_LARGE	2
47787	EVENT_M_PEM_IR_CONNECTION_WRONG	2
47788	EVENT_M_VIS_IFE_FIFO_NOT_EMPTY	2
47789	EVENT_M_IR_IFE_FIFO_NOT_EMPTY	2
47790	EVENT_M_VIS_DATA_SIZE_TOO_LARGE	2
47791	EVENT_M_IR_WIN_SIZE_NOT_NOMINAL	2
47792	EVENT_M_IFE_ACCESS_WRONG	2
47793	EVENT_M_PEM_VIS_CONNECTION_WRONG	2
47794	EVENT_M_IFE_COMMAND_WRONG	2
47795	EVENT_M_VIS_IFE_TEST_PATTERN_WRONG	2
47796	EVENT_M_IR_IFE_TEST_PATTERN_WRONG	2
47797	EVENT_M_VIS_IFE_FIFO_FULL	2
47798	EVENT_M_IR_IFE_FIFO_FULL	2
47799	EVENT_M_VIS_IFE_FIFO_EMPTY	2
47800	EVENT_M_IR_IFE_FIFO_EMPTY	2
	VIRTIS-H control software events (47901 ... 47930)	
47901	EVENT_H_DUMP_DATA_PRODUCTION_PARAMETER	1
47902	EVENT_H_DUMP_FUNCTIONAL_PARAMETERS	1
47903	EVENT_H_DUMP_OPERATIONAL_PARAMETERS	1
47904	EVENT_H_DUMP_PIXEL_MAP_PARAMETERS	1
47905	EVENT_H_ANNEALING_FLAG	1
47906	EVENT_COOL_DOWN_END_SUCCESS	1
47907	EVENT_H_PIX_MAP_NOT_UPLOADED	2
47908	EVENT_H_PIX_MAP_NR_OF_BITS_WRONG	2
47909	EVENT_H_PIX_MAP_WRONG	2
47910	EVENT_H_PIX_MAP_CHECK_SUCCESS	1
47911..47926	FREE	
47927	EVENT_SW_41_H_PEM_CMD_FIFO_OVERFLOW	2
47928	EVENT_H_DATA_SLICE_LOST	2
47929	FREE	
47930	EVENT_SW_44_H_MODE_UNVALID	2
	VIRTIS-H terminator hardware events (47931 ... 47980)	
47931	EVENT_H_ADC_LATCH_UP	2
47932	EVENT_H_HKMS_SHUTTER_STAT_WRONG	2
47933	EVENT_H_COVER_INIT_HES1_FAILED	2
47934	EVENT_H_COVER_NOT_OPEN_NOT_CLOSED	2
47935	EVENT_H_COVER_CLOSING_FAILED	2
47936	EVENT_H_ANNEAL_NOT_STARTED_HK_WRONG	2
47937	EVENT_H_ANNEAL_PEM_LIMIT_DETECT	2
47938	EVENT_H_PEM_HK_WRONG_DURING_ANNEAL	2
47939	EVENT_H_PEM_HK_OUT_OF_RANGE_AFTER_RESET	2
47940	EVENT_H_COVER_CTRL_IN_MODE_X	2

47941	EVENT_H_MODE_USER_DEFINED_STARTED	2
47942	EVENT_H_WIN_SIZE_NOT_NOMINAL	2
47943	EVENT_H_COOLER_STEADY_NOT_REACHED	2
47944	EVENT_H_COOLER_CMD_OFF_DURING_OPERATION	2
47945	EVENT_H_COOLER_CMD_OPEN_LOOP	2
47946	EVENT_H_COOLER_CMD_DURING_STEADY_STATE	2
47947	EVENT_H_COOLER_CMD_DURING_COOL_DOWN	2
47948	EVENT_H_ECA_ALREADY_MOVED	2
47949	EVENT_H_ECA_NOT_MOVED	2
47950	EVENT_H_DETECTOR_NOT_OFF	2
47951	EVENT_H_ANNEAL_NOT_POSSIBLE	2
47952	EVENT_H_ANNEAL_STOPPED_AFTER_EXCEED_TEMP	2
47953	EVENT_H_ANNEAL_STOPPED_AFTER_TIME_OUT	2
47954	EVENT_H_COOL_DOWN_END_FAILURE	2
47955	EVENT_H_COVER_ALREADY_CLOSED	2
47956	EVENT_H_ COVER_ALREADY_OPEN	2
47957	EVENT_H_ COVER_OPEN	2
47958	EVENT_H_ COVER_NOT_OPEN	2
47959	EVENT_H_ COVER_CLOSED	2
47960	EVENT_H_ COVER_NOT_CLOSED	2
47961	EVENT_H_SCIENCE_DATA_GENERATION_STOPPED	2
47962	EVENT_H_DATA_OUTSIDE_RANGE	2
47963	EVENT_H_LESS_DATA_THAN_EXPECTED	2
47964	EVENT_H_DATA_ACQ_TIME_OUT	2
47965	EVENT_H_COOL_STEADY_STATE_FAILURE	2
47966	EVENT_H_CALIBR_SEQ_FINALISED	2
47967	EVENT_H_MODE_NOT_EXPECTED	2
47968	EVENT_H_IFE_FIFO_CLK_NUMBER_WRONG	2
47969	EVENT_H_IFE_FIFO_EMPTY_FIFO_READ	2
47970	EVENT_H_IFE_FIFO_RD_ORDER_WRONG	2
47971	EVENT_H_ECA_28V_SWITCH_CMD_WRONG	2
47972	EVENT_H_IFE_COMMAND_WRONG	2
47973	EVENT_H_IFE_FIFO_NOT_EMPTY	2
47974	EVENT_H_DATA_TO_LARGE	2
47975	EVENT_H_CCE_28V_SWITCH_CMD_WRONG	2
47976	EVENT_H_IFE_ACCESS_WRONG	2
47977	EVENT_H_PEM_CONNECTION_WRONG	2
47978	EVENT_H_IFE_TEST_PATTERN_WRONG	2
47979	EVENT_H_IFE_FIFO_FULL	4
47980	EVENT_H_IFE_FIFO_EMPTY	2
47981	EVENT_H_PEM_SHUTTER_OPEN_HK_WRONG	2
47982	EVENT_H_ PEM_SHUTTER_CLOSE_HK_WRONG	2
47983	EVENT_H_SHUTTER_CTRL_TIME_EXCEEDED	2
47984	EVENT_H_CMD_WORD_ERROR	2
47985	EVENT_H_SHUTTER_NOT_OPEN	2
47986	EVENT_H_PEM_HK_OUT_OF_RANGE_IN_CALIBR	2

47987	EVENT_H_ PEM_HK_OUT_OF_RANGE_IN_SCIENCE	2
47988	EVENT_H_CALIBR_SEQ_PHASE_FINALISED	1

TABLE 6.1 List of VIRTIS issued instrument Events.

6.9 On ground Monitoring of H/K and Events

The CCS is required to monitor VIRTIS behaviour using all three different modes of reporting available to the experiments during on ground and in flight activities; namely:

- TC verification reports (Acceptance and/or Execution). The S/C controls that the previous TC has been accepted and is executed. This feature is avalable only for a limited number of TCs. Lack of response from the experiment is either due to malfunction or bad TC structure (wrong parameter values, invalid mode transition, etc.)
- H/K data reporting. Health state of VIRTIS is monitored by means of H/K TMs; a list of parameters which are to be monitored is given in the following of this document.
- TM Events reporting. A service used to provide information on failures, anomalies and normal progress of sequences.

For a complete list of TC and TM, and for more details the reader is referred to attachment 2.

6.9.1 TC verification reports

If an Acceptance Report is required by TC, the user generates it, indicating either success or failure of the checks performed prior to execute the TC, including verification of check of packet correctness (header, checksum, etc.) and consistency of the TC with the actual VIRTIS mode. The acknowledge is generated within 4 sec of receipt of the TC.

The TM acknowledge packet always includes both the TC Packet ID and the SEQUENCE CONTROL fields as identifier of the TC packet being acknowledged

The TC Acceptance is applicable to all TCs, while the Execution Success is applicable only to:

1. Disable_Science_HSLink (TC20,11)
2. Disable_Science_RTU_Link (TC20,2)
3. MTC_Cover (TC193,3)
4. HTC_Cover (TC194,3)
5. MTC_ECA (TC193,4)
6. HTC_ECA (TC194,4)

While the Execution failure is applicable only to:

1. MTC_Cover (TC193,3)
2. HTC_Cover (TC194,3)
3. MTC_ECA (TC193,4)
4. HTC_ECA (TC194,4)

6.9.2 H/K Reporting

This service is used to transmit H/K data required both for monitoring the operational aspects of the instrument and for interpreting science data. The ME collects H/K data from the powered modules and generates HK Report TM packets at the rates and conditions given in table 2.9 (see section 2.3.4.4)

It is evident from the table that H/K with SID 2 and 3 cannot be received when performing test in air as the coolers and ECA (Emergency Cover Actuator) shall not be operated. Monitoring of this H/K must then be disabled on CCS.

We must also point out that during scientific acquisition TM with SID 4,5,6 are sent not only with each science data (as separate H/K packets) but also every 10s.

<u>The S/C DMS shall not perform any check on the H/K values</u>

6.9.3 Events Reporting

This service provides for the reporting to ground or DMS of unambiguous operational significative information such as:

- failures and/or anomalies detected on-board
- autonomous on-board actions
- normal progress of payload operation/activities

Event reports:

- identifies uniquely the event, its occurrence time and related data
- are generated only once per event occurrence and are concise
- includes the nature/severity of the event
- are self standing (i.e. not require data from other packets or TC history to be interpreted)

Events are classified according to their subtype:

Sub Type 1 Normal Progress Event Report
Sub Type 2 Warning Anomalous Event Report
Sub Type 3 Ground Action Anomalous Event Report
Sub Type 4 On-Board Action Anomalous Event Report

The following table 6.2 shows the different Event Report types as defined for the VIRTIS instrument according to attachment 3. This list shall be updated according to the last Flight S/W version.

<u>The DMS/CCS is requested to monitor **all** the subtype 3,4 to point out anomalies in the instrument behaviour</u>

7 Attachments

7.1 Attachment 1 - Mechanical Interface Control Drawings

7.2 Attachment 2 - VIRTIS OBDH ICD (RO-EST-RS-3015/EID-B, SECTION 2.8 and VIR-GAL-IC-0048 issue 6 18/6/2001)

7.3 Attachment 3 – VIRTIS On-Board Software User Manual (VIR-DLR-MA-006, issue 2 draft 2 19/2/2002)

7.4 Attachment 4 - VIRTIS OBCP URD

7.5 Attachment 5 – VIRTIS SW User Requirements (VIR-GAL-UR-040, issue 5, July 2001)

7.6 Attachment 6 – VIRTIS SW Internal Interface Control Document (VIR-GAL-IC-028, issue 7, July 2001)

ATTACHMENT 1

VIRTIS Modules Mechanical ICDs And Assembly Drawings

ASSEMBLY DRAWINGS

1. OPTICS MODULE Assembly Drawing	AD 28030C17958A	Issue 1	5 sheets
2. ME Assembly Drawing	VIR-KAY-DR-100	Issue 3	2 sheets
3. PEM-M Assembly Drawing	AD 12030C17959B	Issue 0	1 sheet
4. PEM-H Assembly Drawing	521.2-0002 -A		1 sheet

INTERFACE CONTROL DRAWINGS

5. OPTICS MODULE ICD	DF 28079C17958A	Issue 3	3 sheets
6. VIRTIS ME ICD	VIR-KAY-DR-001	Issue 4	1 sheets
7. VIRTIS PEM-M ICD	DF 12079C17959B	Issue 0	1 sheet
8. PEM-H Assembly Drawing	521.2-0001-C		1 sheet

********** **********

ATTACHMENT 2

VIRTIS OBDH ICD

(VIR-GAL-IC-0048 Issue 7, 20/03/2003)

********** Chapter 2.8 of RO-EST-RS-3015/EID-B **********

ATTACHMENT 3

VIRTIS On Board SoftWare User Manual for S/W version 3.6 and 3.54

(VIR-DLR-MA-006 Issue 2 rev2, 10/09/2002)

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ATTACHMENT 4

VIRTIS Experiment OBCP User Requirements Document

(RO-DSS-RS-1024, Issue 1D, 13/09/2002)

ATTACHMENT 5

VIRTIS Software User Requirements Document

(VIR-GAL-UR-040, Issue 6, 27/08/2002)

ATTACHMENT 6

VIRTIS Software Internal Interface Control Document

(VIR-GAL-IC-028, Issue 8, 27/08/2002)