OIP Sensor Systems

NOMAD

PFM User Manual

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			Section 3.7.5	Added this section
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			Section 3.3.1	Corrected memory sizes
			Section 3.5.1	Reported as-measured MLI mass
			Section 4.1.2	Added survival mode to table 10
			Sectoin 5.1	Added restrictions 9 and 10
			Section 5.2.5	Added new section: Instructions for TGO thermal vacuum test
			Section 5.3.3	Added restriction on mirror mechanism operation
			Section 5.5.1	Replaced "flash memory" by "memory"
			Section 8.4.2	Removed the use of goggles
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			Section 5.2.5	Updated references to other sections.
				Added remark on too low temperature at start of functional test
			Section 6.1.9	New section
			Section 6.1.10	New section
			Section 6.1.11	New section
			Section 6.1.12	New section

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1 INTRODUCTION

1.1 SCOPE

This document is the user manual for NOMAD.
It is set up according to the requirements in RD-01, requirement TGO-MTG-ALL-0990, document 24.

1.2 APPLICABILITY

The present document is created for the following model:

Project :	ExoMars
Instrument :	NOMAD Instrument
Model :	PFM

1.3 ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AD	Applicable Document
AIV	Assembly, Integration and Verification
ARR	Assembly Readiness Review
AOTF	Acousto-Optical Tunable Filter
CCD	Charge Coupled Device
CDR	Critical Design Review
COC	Certificate Of Conformity
Co-Is	Co-investigators
CSL	Centre Spatial de Liège
DCL	Declared Component List
DML	Declared Material List
DMPL	Declared Mechanical Parts List
DPL	Declared Processes List
DR	Design Review
EDL (EDM)	Entry, Descent and Landing (Demonstrator Module)
EEE	Electrical, Electronic and Electromechanical
EGSE	Electrical Ground Support Equipment
E-ICD	Experiment - Interface Control Document
EMTGO	ExoMars Trace Gas Orbiter
ENG	Engineering
ESA	European Space Agency
ESOC	European Space Operations Centre

FAR	Final Acceptance Review
FEP	Front End Processor
FM	Flight Model
FS	Flight Spare
FMECA	Failure Mode and Criticality Analysis
GSE	Ground Support Equipment
ICD	Interface Control Document
IAA-CSIC	Instituto de Astrofisica de Andalucia – Consejo Superior de Investigaciones Científicas
IASB-BIRA	Institut d'Aéronomie Spatiale de Belgique (IASB) – Belgisch Instituut voor Ruimte-Aëronomie (BIRA)
IDR/UPM	Universitario "Ignacio Da Riva"/ Universidad Politecnica de Madrid
IR	Infrared
IRB	Internal Review Board
KIP	Key Inspection Point
LNO	Limb Nadir Occultation IR channel of NOMAD
MAPPS	Mapping and Planning Payload Science
MOC	Mission Operations Centre
MIP	Mandatory Inspection Point
MOI	Mars Orbit Insertion
MRB	Material Review Board
MRR	Manufacturing Readiness Review
MTP	Medium Term Plan
NC	Non-Conformance
NCR	Non-Conformance Report
NOMAD	Nadir and Occultation for Mars Discovery
NRB	Non-Conformance Review Board
OIP	Optronic Instruments and Products
OU	Open University
PA	Product Assurance
PAD	Part Approval Document
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PFM	Proto-Flight Model
PI	Principle Investigator
PJM	Project Manager
P/L	Payload
PMP	Parts, Materials and Processes
PO	Purchase Order
PP	Planetary Protection
PTR	Post Test Review
QA	Quality Assurance
QC	Quality Control
QM	Qualification Model
QR	Qualification Review
RD	Reference Document
RFA	Request For Approval
RFD	Request For Deviation
RFW	Request For Waiver

RH	Relative Humidity
SAP/SMP	Science Activity Plan/ Science Master Plan
S/C	Spacecraft
SCC	Stress Corrosion Crack
SEL	Single Event Latch-Up
SEU	Single Event Upset
SO	Solar Occultation IR channel of NOMAD
SOC	Science Operations Centre
SOIR	Solar Occultation in the Infra-Red
SOW	Statement Of Work
SPF	Single Point Failure
STM	Structural and Thermal Model
STP	Short Term Plan
SVT	System Validation Test
SW	Software
SWT	Science Working Team
TAS	Thales Alenia Space
TBC	To Be Confirmed
TBD	To Be Determined
TM/TC	Telemetry/Telecommand
TRB	Test Review Board
TRR	Test Readiness Review
UVIS	Ultraviolet-Visible Spectrometer (channel of NOMAD)
VCD	Verification Control Document
VEX	Venus Express
w.r.t.	With Respect To
WBS	Work Breakdown Structure
WCA	Worst Case Analysis

1.4 REFERENCES

1.4.1 Applicable Document (AD)

N°	TITLE	REFERENCE
AD-01	ExoMars. Nadir and Occultation for MArs Discovery Experiment Interface Control Document (NOMAD E-ICD)	EXM-PL-ICD-ESA-00025 Iss 3, Rev 0

1.4.2 Reference Document (RD)

N°	TITLE	REFERENCE
RD-01	ExoMars Trace Gas Orbiter, Experiment Interface Requirements Document (E-IRD)	EXM-PL-IRD-ESA-00003 issue 3-0
RD-02	NOMAD Software Architecture and Design Report	EXM-NO-REP-IAA-00002-iss3rev1
RD-03	*deleted*	
RD-04	NOMAD Pointing Budget	EXM-NO-TNO-OIP-00006-iss5rev0
RD-05	*deleted*	
RD-06	Hazard analysis	EXM-NO-ANA-OIP-00001-iss2rev1
RD-07	*deleted*	
RD-08	MOC to TGO PI IDD	EXM-GS-IRD-ESC-00004- 1.0
RD-09	*deleted*	
RD-10	Test on Hoisting Tool 1	EXM-NO-REP-AER-00012-iss0rev0
RD-11	NOMAD Thermal and Geometrical Model	EXM-NO-MDL-IDR-00001-iss2rev2
RD-12	SINBAD PFM Software Release Document	EXM-NO-REP-IAA-00007-iss2rev1

2 NOMAD GENERAL DESCRIPTION

2.1 SCIENTIFIC OBJECTIVES

NOMAD (Nadir and Occultation for MArs Discovery) is an instrument that will conduct a spectroscopic survey of Mars' atmosphere in the UV, visible and IR domains covering the 0.2-0.65 and 2.2-4.3 µm spectral ranges.

It is composed of 3 channels: a solar occultation only channel (SO) operating in the infrared wavelength domain, a second infrared channel capable of doing nadir, but also solar occultation and limb observations (LNO), and an ultraviolet/visible channel (UVIS) that can work in all observation modes.

NOMAD offers an integrated instrument combination of a flight-proven concept (SO is a copy of SOIR on Venus Express), and innovations based on existing and proven instrumentation (LNO is based on SOIR/VEX and UVIS has heritage from the ExoMars Humboldt lander), that will provide mapping and vertical profile information at high spatio-temporal resolution.

2.2 NOMAD OVERVIEW AND FUNCTIONAL DIAGRAM

NOMAD consists of the following sub-systems:

- 3 channels, which generate scientific data:
  - SO channel
  - LNO channel
  - UVIS channel
- SINBAD: the central processor unit, which manages all electrical power and data connections between the spacecraft and the 3 channels.
- Mechanical structure:
  - SO base plate, on which are mounted:
    - SINBAD on the under side
    - SO and LNO electronic boxes on the under side
    - SO channel and UVIS channel on the upper side
    - External connector panel in the side wall
    - General Radiator
    - Side walls, which make the connection between the SO base plate and the LNO base plate
  - LNO base plate, on which are mounted:
    - LNO channel
    - Cover for the LNO channel
- Thermal control system:
  - General radiator: maintains operational temperature range for the complete instrument.
  - Temperature sensors
  - Heaters
  - Multi layer insulation (MLI)

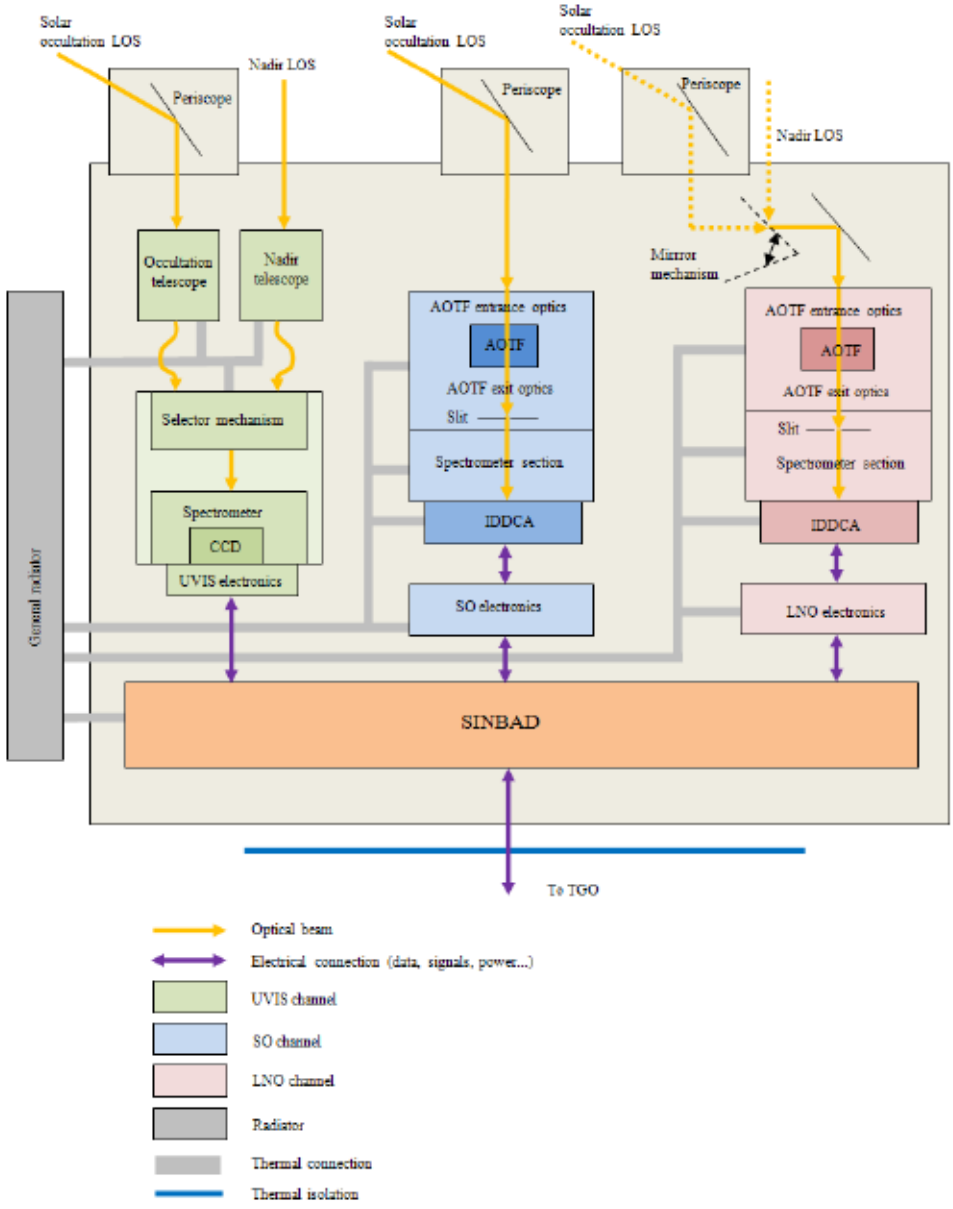


Figure 2-1: NOMAD functional block diagram

NOMAD produces scientific data on the Martian atmosphere in three ways:

1. Nadir observations (LNO and UVIS): analysis of the spectral properties of incoming radiation, mainly due to reflection of solar radiation on the surface of Mars and scattering in its atmosphere.
2. Solar occultation observation (LNO, SO and UVIS): analysis of the spectral properties of the sunlight, as it passes through the Martian atmosphere when the spacecraft enters into or emerges from eclipse. Comparison with measured exo-atmospheric solar spectra allows determination of the composition of the atmosphere.
3. Limb observations (LNO and UVIS): analysis of the spectral properties of incoming radiation, mainly due to scattering in the Martian atmosphere.

3 NOMAD PFM CONFIGURATION

3.1 PHYSICAL INTERFACE

The physical interfaces of NOMAD are adequately described in AD-01, chapter 8.2. As illustration, a reduced resolution version is reproduced

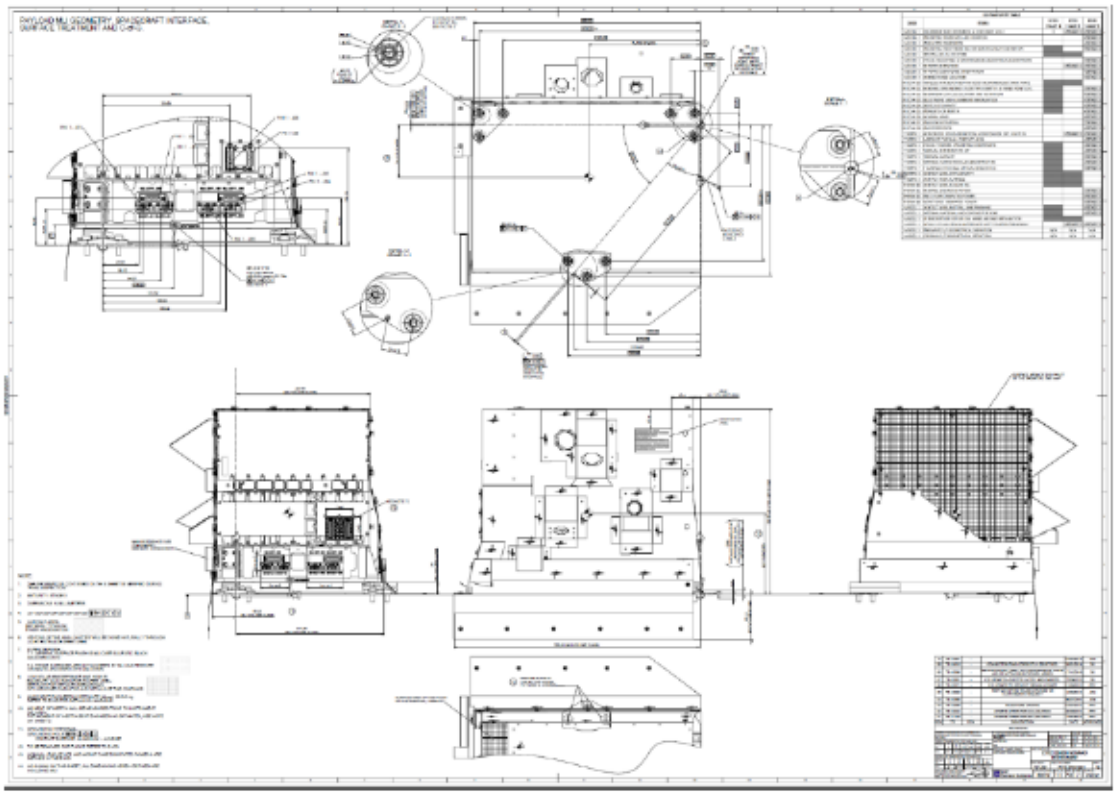


Figure 3-1: NOMAD mechanical ICD drawing (reduced resolution)

3.2 ELECTRICAL INTERFACE

These are the guidelines for the electrical integration of NOMAD. The interface with the Spacecraft is implemented through the external connections. The instructions to connect NOMAD correctly are described.

The NOMAD electrical interface connectors will be protected by connector savers, keeping track of the number of times that they have been plugged and unplugged. The savers will be used for ground testing only.

Table 1: NOMAD external connectors

NOMAD external connectors				
Connector Code	Connector function	Number of pins	pins/sockets (*)	TYPE
NOM-EXT-J01	*SpW (Nom)*	*9*	*sockets*	*microD*
NOM-EXT-J02	*SpW (Red)*	*9*	*sockets*	*microD*

NOM-EXT-J03	*1553 ChA+chB)*	*9*	*sockets*	*microD*
NOM-EXT-J04	*1553 Address*	*9*	*pin*	*microD*
NOM-EXT-J05	*Power + HPC + status (Nom)*	*15*	*pins*	*SD*
NOM-EXT-J06	*Power + HPC + status (Red)*	*15*	*pins*	*SD*
NOM-EXT-J07	*Test Connector*	*9*	*sockets*	*microD*
NOM-EXT-J08	*Survival heater + thermistors (Nom)*	*15*	*pins*	*SD*
NOM-EXT-J09	*Survival heater + thermistors (Red)*	*15*	*pins*	*SD*

Table 2: NOMAD pin allocations

Pin allocation		**Instrument:**	**NOMAD**	
		Connector:	**NM-EXT-J01**	
Pin	**Function**	**Signal type**	**Line type / g**	**Harness**
1	Din+ NOM	BUS/SPW	AWG26	TW/SH1(1,6)-2w to S/C CASE
2	Sin+ NOM	BUS/SPW	AWG26	TW/SH2(2,7)-2w to S/C CASE
3	Inner shield (Secondary GND)	GRND/GND	AWG26	
4	Sout- NOM	BUS/SPW	AWG26	TW/SH3(4,8)-2w to CASE
5	Dout- NOM	BUS/SPW	AWG26	TW/SH4(5,9)-2w to CASE
6	Din- NOM	BUS/SPW	AWG26	
7	Sin- NOM	BUS/SPW	AWG26	
8	Sout+ NOM	BUS/SPW	AWG26	
9	Dout+ NOM	BUS/SPW	AWG26	

overall shield SH(1-9)-9w to NOMAD structure

Pin allocation		**Instrument:**	**NOMAD**	
		Connector:	**NM-EXT-J02**	
Pin	**Function**	**Signal type**	**Line type / g**	**Harness**
1	Din+ RED	BUS/SPW	AWG26	TW/SH1(1,6)-2w to S/C CASE
2	Sin+ RED	BUS/SPW	AWG26	TW/SH2(2,7)-2w to S/C CASE
3	Inner shield (Secondary GND)	GRND/GND	AWG26	
4	Sout- RED	BUS/SPW	AWG26	TW/SH3(4,8)-2w to CASE
5	Dout- RED	BUS/SPW	AWG26	TW/SH4(5,9)-2w to CASE
6	Din- RED	BUS/SPW	AWG26	
7	Sin- RED	BUS/SPW	AWG26	
8	Sout+ RED	BUS/SPW	AWG26	
9	Dout+ RED	BUS/SPW	AWG26	

overall shield SH(1-9)-9w to NOMAD

structure

Pin allocation		Instrument:	NOMAD	
		Connector:	NM-EXT-J03	
Pin	Function	Signal type	Line type / g	Harness
1	Stub 1 channel A	BUS/1553	AWG26	TW/SH1(1,6)-2w to NOMAD structure
3	Common Mode Jumper		AWG26	
5	Stub 2 channel B	BUS/1553	AWG26	
6	Stub 1 RTN	BUS/1553	AWG26	TW/SH2(5,9)-2w to NOMAD structure
9	Stub 2 RTN	BUS/1553	AWG26	

Pin allocation		Instrument:	NOMAD	
		Connector:	NM-EXT-J04	
Pin	Function	Signal type	Line type / g	Harness
1	RT ADRR_4 MSB	/1553	AWG26	
2	RT ADRR_3	/1553	AWG26	
3	RT ADRR_2	/1553	AWG26	
4	RT ADRR_1	/1553	AWG26	
5	RT ADRR_0 LSB	/1553	AWG26	
6	GND	GRND/GND	AWG26	
7	RT ADRR PARITY	/1553	AWG26	
8	GND	GRND/GND	AWG26	
9	GND	GRND/GND	AWG26	

overall shield SH(1-9)-9w to NOMAD structure

Pin allocation		Instrument:	NOMAD	
		Connector:	NM-EXT-J05	
Pin	Function	Signal type	Line type / g	Harness
1	28 V NOM	PWR	AWG20	TW/SH1(1,2,9,10)-4w to NOMAD structure
2	RTN 28 V NOM	PWR	AWG20	
3	EMC separation pin	GND		
4	HPC NOMAD OFF NOM	HPC	AWG26	TW/SH2(4,12)-2w to NOMAD structure
5	EMC separation pin	GND		

6	HPC NOMAD ON NOM	HPC	AWG26	TW/SH3(6,13)-2w to NOMAD structure
7	EMC separation pin	GND		
8	Status NOMAD ON/OFF NOM	BSM	AWG26	TW/SH4(8,15)-2w to NOMAD structure
9	28 V NOM	PWR	AWG20	
10	RTN 28 V NOM	PWR	AWG20	
11	EMC separation pin	GND		
12	RTN HPC NOMAD OFF NOM	HPC	AWG26	
13	RTN HPC NOMAD ON NOM	HPC	AWG26	
14	EMC separation pin	GND		
15	RTN Status NOMAD ON/OFF NOM	BSM	AWG26	

overall shield SH(1-15)-15w to NOMAD structure

Pin allocation		**Instrument:**	**NOMAD**	
		Connector:	**NM-EXT-J06**	
Pin	**Function**	**Signal type**	**Line type / g**	**Harness**
1	28 V RED	PWR	AWG20	TW/SH1(1,2,9,10)-4w to NOMAD structure
2	RTN 28 V RED	PWR	AWG20	
3	EMC separation pin	GND		
4	HPC NOMAD OFF RED	HPC	AWG26	TW/SH2(4,12)-2w to NOMAD structure
5	EMC separation pin	GND		
6	HPC NOMAD ON RED	HPC	AWG26	TW/SH3(6,13)-2w to NOMAD structure
7	EMC separation pin	GND		
8	Status NOMAD ON/OFF RED	BSM	AWG26	TW/SH4(8,15)-2w to NOMAD structure
9	28 V RED	PWR	AWG20	
10	RTN 28 V RED	PWR	AWG20	
11	EMC separation pin	GND		
12	RTN HPC NOMAD OFF RED	HPC	AWG26	
13	RTN HPC NOMAD ON RED	HPC	AWG26	
14	EMC separation pin	GND		
15	RTN Status NOMAD ON/OFF RED	BSM	AWG26	

overall shield SH(1-15)-15w to NOMAD structure

Pin allocation		**Instrument:**	**NOMAD**	
		Connector:	**NM-EXT-J08**	
Pin	**Function**	**Signal type**	**Line type / g**	**Harness**
1	V HTR NOM	PWR	AWG20	TW(1,2,9,10)-4w
2	RTN V HTR NOM	PWR	AWG20	

5	Shield			connected to NOMAD structure
6	ANC3 NOM	BSM	AWG26	SH1/TW(6,13)-2w to NOMAD structure
7	ANC2 NOM	BSM	AWG26	SH2/TW(7,14)-2w to NOMAD structure
8	ANC1 NOM	BSM	AWG26	SH3/TW(8,15)-2w to NOMAD structure
9	V HTR NOM	PWR	AWG20	
10	RTN V HTR NOM	PWR	AWG20	
12	Shield			connected to NOMAD structure
13	RTN ANC3 NOM	TSW	AWG26	
14	RTN ANC2 NOM	TSW	AWG26	
15	RTN ANC1 NOM	TSW	AWG26	

Pin allocation		**Instrument:**	**NOMAD**	
		Connector:	**NM-EXT-J09**	
Pin	**Function**	**Signal type**	**Line type / g**	**Harness**
1	V HTR RED	PWR	AWG20	TW(1,2,9,10)-4w
2	RTN V HTR RED	PWR	AWG20	
5	Shield			connected to NOMAD structure
6	ANC3 RED	TSW	AWG26	SH1/TW(6,13)-2w to NOMAD structure
7	ANC2 RED	TSW	AWG26	SH2/TW(7,14)-2w to NOMAD structure
8	ANC1 RED	TSW	AWG26	SH3/TW(8,15)-2w to NOMAD structure
9	V HTR RED	PWR	AWG20	
10	RTN V HTR RED	PWR	AWG20	
12	Shield			connected to NOMAD structure
13	RTN ANC3 RED	TSW	AWG26	
14	RTN ANC2 RED	TSW	AWG26	
15	RTN ANC1 RED	TSW	AWG26	

It should be noted that there is also a test connector available, NM-EXT-J07. This connector is only used for de-bugging and tests by the NOMAD team. It has no function after integration to TGO. It is covered by a cap during flight.

A drawing with the electrical interface is shown in Figure 3-2:

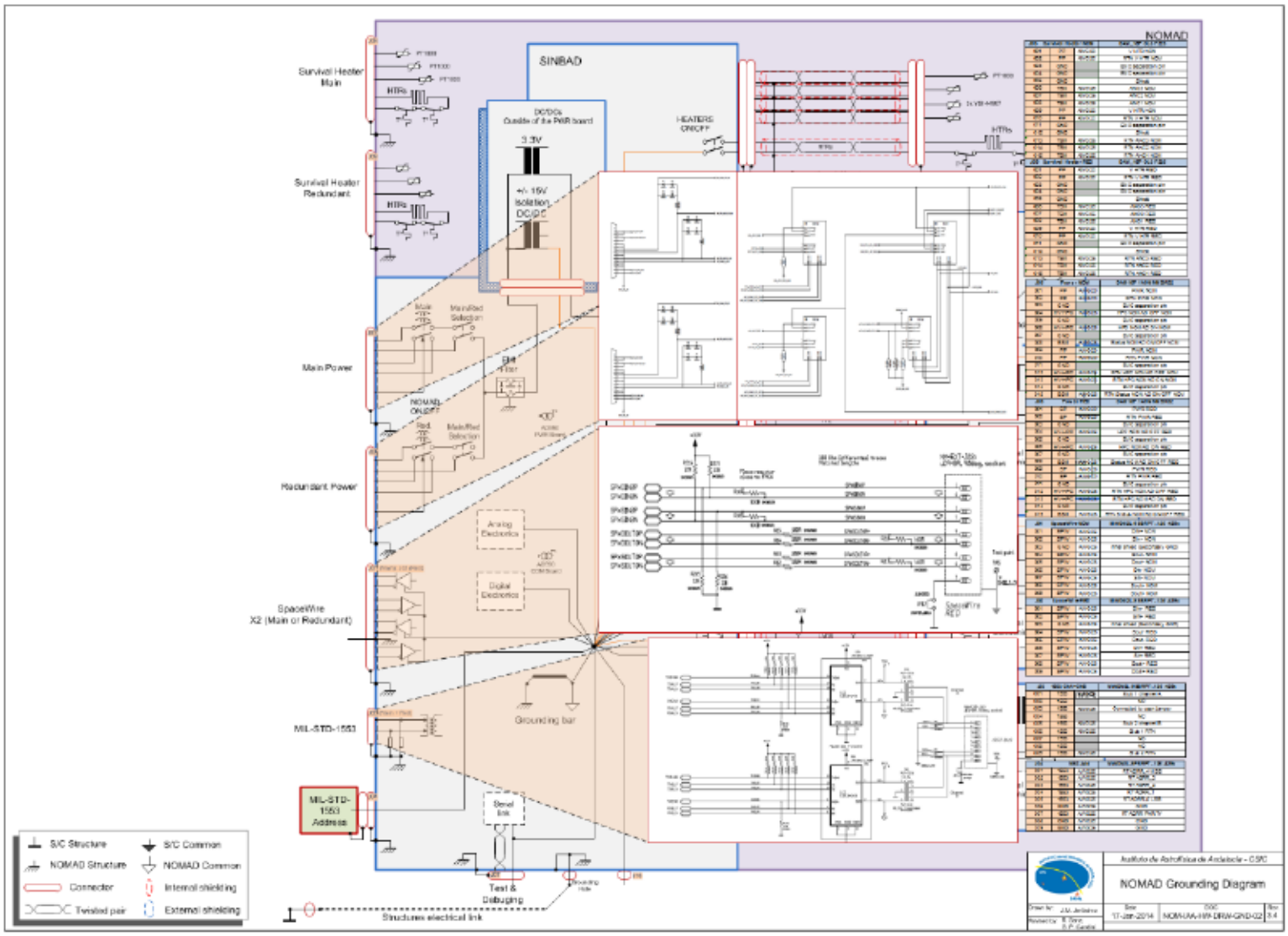


Figure 3-2: Electrical interface drawing

Savers must be installed on the external connectors. One complete set of connector-savers will be provided for PFM.

- NM-EXT-J01 to saver labelled J01-S (male side)
- NM-EXT-J02 to saver labelled J02-S (male side)
- NM-EXT-J03 to saver labelled J03-S (male side)
- NM-EXT-J05 to saver labelled J05-S (female side)
- NM-EXT-J06 to saver labelled J06-S (female side)
- NM-EXT-J08 to saver labelled J08-S (female side)
- NM-EXT-J09 to saver labelled J09-S (female side)

3.2.1 Power

NOMAD operates nominally with input voltage of 22V-36V for electronic units and 20V-36V for survival heaters.

- NM-EXT-J05 to cable connector SubD15 female with label: POWER MAIN.
- NM-EXT-J06 to cable connector SubD15 female with label: POWER RED.
- NM-EXT-J08 to cable connector SubD15 female with label: SURVIVAL HEATERS MAIN.
- NM-EXT-J09 to cable connector SubD15 female with label: SURVIVAL HEATERS RED.

3.2.2 Communications

- NM-EXT-J01 to cable connector microD9 male with label: SPW MAIN.
- NM-EXT-J02 to cable connector microD9 male with label: SPW RED.
- NM-EXT-J03 to cable connector microD9 male with label: 1553 BUS.

The 1553 address connector (NM-EXT-J04) is used as a connector to change the RT number (Remote Terminal). NOMAD has been assigned address "01000" and parity "1".The actual NOMAD RT address is programmed in this external connector.
This external connector (NM-EXT-P04) **must be covered in flight configuration**.

3.3 SOFTWARE ARCHITECTURE

This section describes the architecture used to design SFS and its relation with hardware components.
Figure 3 shows the architecture layers.

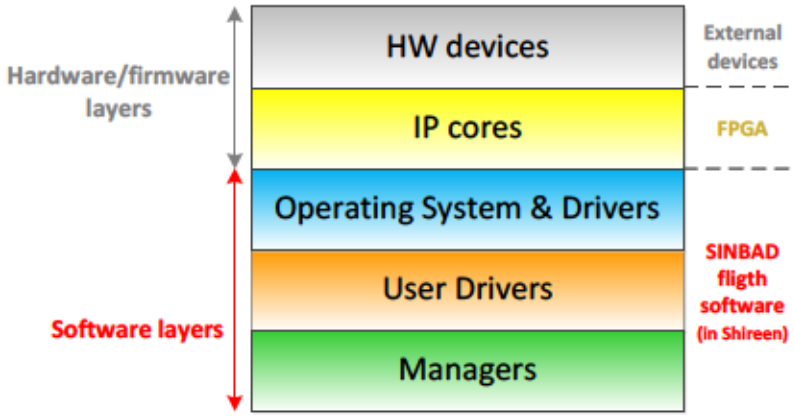


Figure 3-3: Scheme of hardware and software layers

The first layer groups hardware devices. The second layer contains the IP cores implemented in FPGA, which are used to manage hardware devices.

Operating System layer contains the operating system (OS) and the OS drivers (low level drivers). These drivers implement the logic to communicate the operating system and the IP cores, providing and API to be used by User Driver layer.

User Drivers layer is composed of modules which build wrappers for OS drivers. These blocks are used by the *Managers layer*.

Managers layer contains the software modules in charge of implementing the SFS high level logic. These modules handle devices that store hardware configuration and use the functions implemented in the user drivers.

For further details, see RD-02, section Software architecture.

3.3.1 On-board memory maps

SINBAD has two memories, an EPROM of 5MBit which stores data that will not be modified and a magneto resistive RAM of 5x8 MiB used to store data that would be updated. The “magneto resistive” technology allows maintaining the data after power off (permanent storage).

SINBAD memory map is shown in Figure 3-4 below.

For further details, see RD-02, section Memory Management.

The SFS version programed in PFM EEPROM memory is 2.0.0. For further details see RD-12.

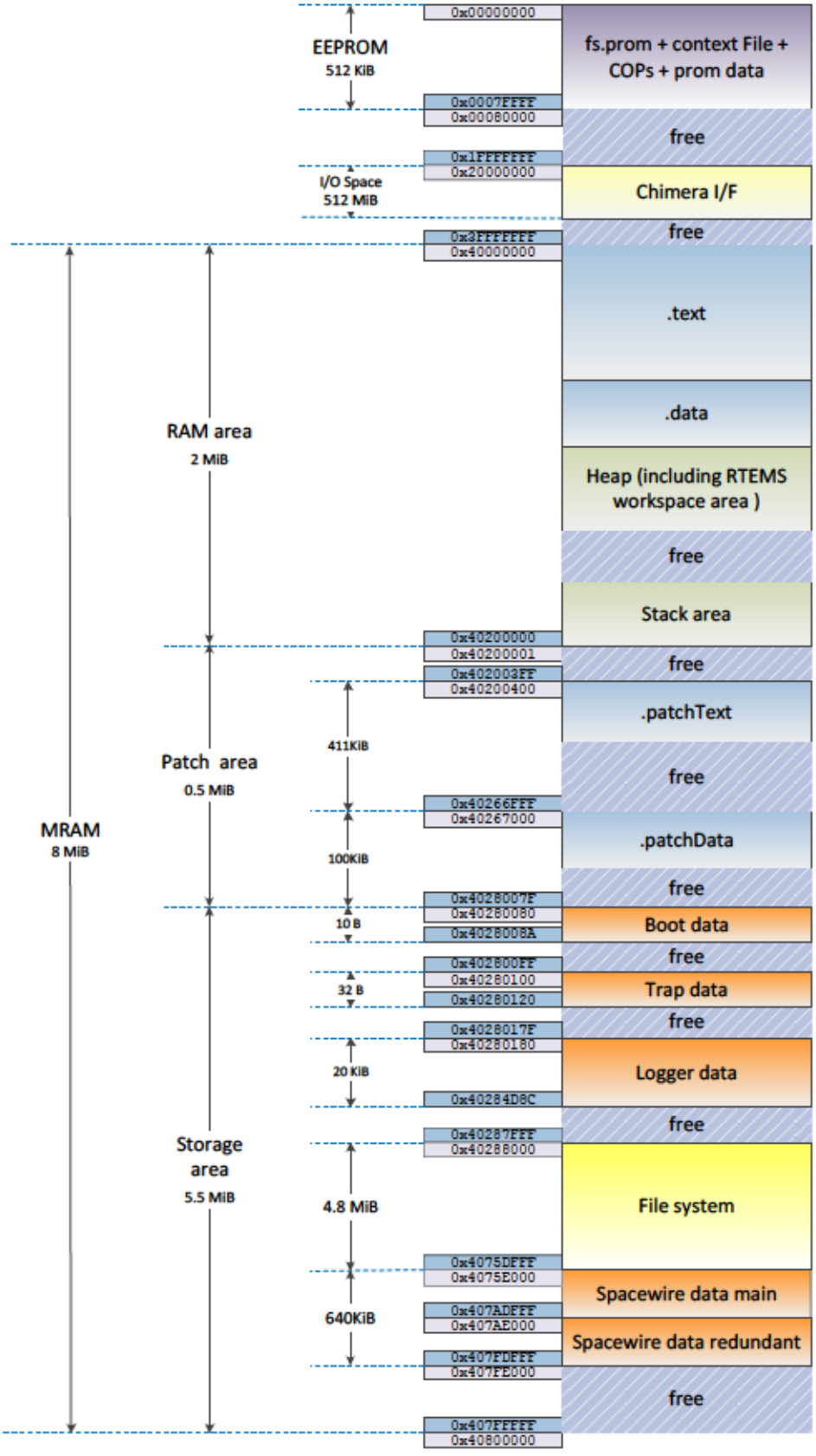


Figure 3-4: SINBAD memory map

3.4 DATA HANDLING

A TC is a command that the spacecraft sends to SINBAD. TMs are data packets sent from SINBAD to the spacecraft (and further down to the ground station on Ground).
All TCs are sent to SINBAD over the 1553 bus. All TMs are sent to the spacecraft over 1553 bus, except Science data TMs, System log TMs and File manager download file report TMs, which use the spacewire interface. Maximum size of TCs to NOMAD is 64 B.
In NOMAD each TC contains all necessary information to perform a complete activity.
Spacecraft sends TCs to SINBAD using MTL, which is stored in the SMU.
Table 3 shows the TC and TM list for communication between spacecraft and SINBAD.

Table 3: TC and TM list for communication between spacecraft and SINBAD

Activity	TC		TM			
			1553 link		SpW link	
	Code	TC Name	Code	TM Name	Code	TM Name
Housekeeping						
			10	Event		
			11	NOMAD HK 1		
			12	NOMAD HK 2		
			13	NOMAD HK 3		
			23	SO HK		
			26	LNO HK		
			29*	UVIS HK		
Science Data						
	20	Start operation				
					22	SO Science
					25	LNO Science
					27	UVIS Applied parameters
					28	UVIS Science
					29	UVIS HK
Memory management						

	30	Patch memory				
	31	Dump memory	**32**	Dump memory report		
	33	Check memory	**34**	Check memory report		
	35	File manager operation	**36**	File manager operation report	**37**	File manager download file report
Mode change						
	40	Safe Mode				
Power						
	50	Ready to power off				
System log						
					60	System log
General						
	70	Custom command				

Format of TCs/TMs in Table 3 is defined by NOMAD, so it has not relation with the PUS format.

For further details, see RD-02, section Software interfaces description.

3.5 BUDGETS

3.5.1 Mass Budget

Table 4: Mass budget

	Mass as-measured
NOMAD PFM (without MLI)	25.93 kg
MLI	0.602 kg
Total	26.53 kg

3.5.2 Mass properties

Table 5: Mass properties

NOMAD Mass Properties			
Centre of Gravity (**NOMAD reference frame / E-IRD instrument unit coordinate frame**)			
CoGx (mm)	171 / 171	+/-	3 mm
CoGy (mm)	112 / 189	+/-	3 mm
CoGz (mm)	239 / 235	+/-	3 mm
Inertial Matrix (m²kg) (with regards to the CoG of NOMAD)			
Ixx	0.79	+/-	10%
Iyy	0.80	+/-	10%
Izz	0.56	+/-	10%

3.5.3 Power and energy budget

Table 6: Power consumption

Input voltage	Operational power (W) (including operational heaters)* As measured on PFM		Operational power (W) (without operational heaters)* As measured on PFM		Non-operational power (W) (survival heater power in cold survival case)		
	Average	Peak	Average	Peak	Average over 1 orbit	Average over 1 eclipse	Peak
22V	35.9	48.7	35.9	48.7	15.7	15.7	15.7
28V	35.9	48.7	35.9	48.7	16.9	25.5	25.5
36V	35.9	48.7	35.9	48.7	13.8	42.2	42.2

* No operational heaters use is foreseen during nominal operations, as the temperature will stay above their switch on limit. They will only work in special cases, for example when only SINBAD is on and channels are off for a long time.

Table 7: Power for subassemblies

Component	Result (as measured on PFM)
SINBAD	11.42 W
SO (while pre-cooling)	32.48W
SO (science operation)	26.32W
LNO (while pre-cooling)	32.48W
LNO (science operation)	26.32W
UVIS	4.76W
Operational heaters	15.12W

3.5.4 Thermal limits

The thermal limits of NOMAD are shown in Table 8 below.

The listed temperatures are NOMAD structural temperatures. During thermal tests, this shall be monitored by thermistor ANC2_NOM in the survival heater chain (via connector NOM-EXT-J08).

Table 8: Thermal limits

NOMAD temperature limits (°C) (sensor ANC2_NOM)						
	Operating		Non Operating		Start up	
	MIN	MAX	MIN	MAX	MIN	MAX
Qualification temperature range	-20°C	38°C	-40°C	50°C	-20°C	38°C
Acceptance temperature range	-15°C	33°C	-35°C	45°C	-15°C	33°C
Design temperature range	-10°C	28°C	-30°C	40°C	-10°C	28°C
Ground storage and transport			-30°C	40°C		

3.5.5 Data rates / data volumes

The estimated data volume produced by NOMAD of Science and HK per nominal case is shown in Table 9

Table 9: NOMAD Science and HK data volume, per orbit and per nominal day (12 orbits)

NOMAD Data Volume			
Science in Spacewire		HK in 1553	
One orbit	One day	One orbit	One day
210.8 Mbit	2525 Mbit	0.56 Mbit	6.64 Mbit

For further details, see section 8.6.3 of AD-01.
The data volume depends on the parameters of each specific observation.

3.5.6 Pointing budget

The pointing budget of NOMAD is described in RD-04.

3.5.7 Alignment budget

The alignment budget of NOMAD is described in RD-04.

There is one contributor in this alignment budget that is of importance during the integration of NOMAD.
The reproducibility of mounting/dismounting NOMAD to/from the spacecraft deck shall be no more than 100 µrad in plane and 50 µrad out of plane.
This shall be assured via mechanical tolerances on the alignment pins.

4 NOMAD OPERATIONAL MODES

4.1 OVERVIEW

4.1.1 Operational modes

During flight NOMAD is always in one of three modes: two operational modes (safe mode and observing mode) and one non-operational mode (power off mode)

The three modes are:

- **Safe Mode**. This is the default mode at NOMAD power on. SO, LNO and UVIS are powered off. In this mode SINBAD can perform patch operations and actions defined with Custom command.
- **Observing Mode**. In this mode SO, LNO, UVIS can be switched ON/OFF following the observing sequence. The power consumption depends on the specific operational configuration (see below).
- **Power Off:** This is not a mode from the software point of view. It is only a state where SINBAD electronics don't have power.

Possible transitions between operational modes are shown in Figure 4-1.

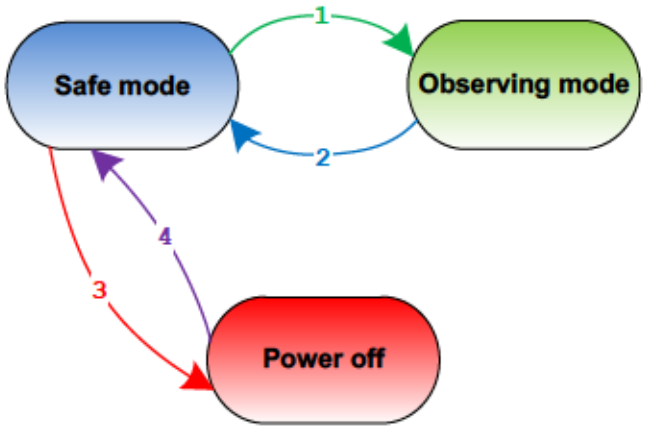


Figure 4-1: Transitions between NOMAD operational modes

During power off mode NOMAD is inactive (no power present in the central processing unit SINBAD and the channels SO, LNO and UVIS). Provided that the survival power lines are enabled by the S/C, survival heaters can be switched on during this mode. Switching on/off of the survival heaters is controlled by thermostats inside NOMAD.

During active operational modes (safe mode and observing mode) SINBAD controls the channels and an operational heater chain. It is suggested to keep SINBAD (and hence NOMAD) on permanently during the science phase of the mission, but switching it on/off as a function of science activity is possible (will result in a higher number of HPCs needed).

Operational heaters can be activated at all times during safe mode and during observing mode when UVIS is active. Operational heaters are not allowed during SO or LNO functioning.

4.1.2 Operational configurations

Definition of "operational configuration":

An operational configuration is defined if one of the following conditions occurs when NOMAD is in Observing Mode:

- *Change in demand on S/C resources (power...)*
- *Specific S/C operational status (pointing)*
- *Functionally distinct operation of instrument*

During Observing Mode NOMAD can be in a number of configurations, with single channels or combinations of channels switched on, depending on the type of observation to be performed.

- The LNO channel can be 'ON or OFF', and draws more power when the detector is in pre-cooling (for ~10 mins at the beginning of an observation). Once the detector reaches its operational temperature, closed-loop cooling is activated and the power use decreases slightly. The mirror mechanism is commanded by SINBAD to place an entrance flip mirror in or out of the optical path, allowing nadir or occultation viewing. This is a one-command movement that requires no power to maintain position. There is no difference between nadir and occultation viewing with LNO, except for the frequency of data sent to the PDHU. LNO will primarily be used for nadir viewing, however.

- The SO channel can be 'ON or OFF' and draws more power when the detector is in pre-cooling (for ~10 mins at the beginning of an observation). Once the detector reaches its operational temperature, closed-loop cooling is activated and the power use decreases slightly. SO will only be used for occultation viewing.

- UVIS is 'ON or OFF' but here the selector mechanism requires power to hold the input fibre at the spectrometer aperture. So the motor is ON during an observation and OFF when UVIS is not observing. There is no difference between nadir and occultation viewing with UVIS, except for the frequency of data sent to the PDHU.

Table 10 Showing power usage for the various NOMAD operational configurations

NOMAD operational configuration	Power Usage (W)	Data rate (Mbit/s)	Functional Use
SINBAD only	11.4	0.077 kbits/s (only 1553)	Startup
SINBAD + Operational heaters	26.5	0.077 kbits/s (only 1553)	Operational heating
SINBAD + UVIS	16.2	51.4 kbits/s	Night side observations, UVIS calibration
SINBAD + UVIS + Operational heaters	31.3	51.4 kbits/s	Night side observations, UVIS calibration with heating
SINBAD +SO	43.9 or less	0.384 kbits/s (during precooling) and 94.4 kbits/s (during observation)	Solar occultation without UVIS, or calibration of SO
SINBAD +SO+UVIS	48.6 or less	0.384 kbits/s (during precooling) and 145.8 kbits/s	Solar occultation in IR and UVIS, or calibration of both SO and UVIS
SINBAD +LNO	43.9 or less	0.384 kbits/s (during precooling) and 6.3 kbits/s	Nadir or limb observation with only the IR channel, or calibration of LNO
SINBAD+LNO+ UVIS	48.6 or less	0.384 kbits/s (during precooling) and 9.73 kbits/s	Nadir or limb observation in IR and UVIS, or calibration of both LNO and UVIS
Survival mode, SINBAD OFF	15.7W at 22V 25.5W at 28V 42.2W at 36V	0 kbits/s	Survival

(*) Approximately every 1 to 10 min (depending on SINBAD activity) a 4 kbytes max system log will be sent

	ECLIPSE				SUNRISE					DAYSIDE										SUNSET	ECLIPSE			
	CASE 1 (Standard) SO/LNO/SO												Average Power:	35.9	W			Peak Power:	48.7	W				
Time (minutes)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
SINBAD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SO			S	S	X													S	S	X				
LNO						S	S	X	X	X	X	X	X	X	X	X	X							
UVIS					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Heater																								
Power (W)	11.4	11.4	43.9	43.9	42.5	48.7	48.7	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	48.7	48.7	42.5	11.4	11.4	11.4	11.4

SINBAD	11.42	W			
SO pre-cooling	32.48	W	SO operation	26.3	W
LNO pre-cooling	32.48	W	LNO operation	26.3	W
UVIS	4.76	W			
Heater	15.12	W			
	Average:	35.87	W		
	Peak:	48.66	W		

Figure 4-2: Typical orbit with 2 solar occultation observations and one nadir observation, using IR and UVIS channels both times

4.2 TRANSITIONS

4.2.1 OFF mode to safe mode

The transition from off-mode to safe mode is performed by:

1. Sending the HPC command level “NOMAD ON”,
2. Verifying the NOMAD BSM status “NOMAD ON”,
3. Applying the nominal voltage from 22v to 36V between the pins 1 and 2 to the connector NM-EXT-J05 or NM-EXT-J06.

After power-ON, the instrument goes into safe mode, i.e. a standby mode where it waits to receive telecommands (TC).

4.2.2 Safe mode to OFF mode

There are three possible power-OFF sequences in NOMAD:

- *Nominal power-off*: SMU sends `TC(50)"Ready to power off"`, afterwards it sends an HV-HPC OFF to NOMAD, and finally it sends a command to switch off the LCL on TGO side.
- *Emergency power-off*: SMU sends an HV-HPC OFF to NOMAD, and it also sends a command to switch off the LCL on TGO side.
- *Self-power-off:* In case of needs (high contingency) SINBAD is capable to switch off its own power supply.

4.2.3 Safe mode to observing mode

While in safe mode different types of telecommand can be accepted by NOMAD. They can be system management related (patching on board software, patching on board tables, interrogating on board operating system, …) or scientific (starting an observation).

The following telecommands can be sent to NOMAD (see RD-08 for detailed description):

- TC(20) : NOMAD_START_OPERATION 1553 subaddress : 09

- TC(30) : NOMAD_PATCH_MEMORY 1553 subaddress : 10
- TC(31) : NOMAD_DUMP_MEMORY 1553 subaddress : 11
- TC(33) : NOMAD_CHECK_MEMORY 1553 subaddress : 13
- TC(35) : NOMAD_FILE_MANAGER_OPERATIONS 1553 subaddress : 15
- TC(40) : NOMAD_SAFE_MODE 1553 subaddress : 19
- TC(50) : NOMAD_READY_TO_POWER_OFF 1553 subaddress : 20
- TC(70) : CUSTOM_COMMAND (for operational heater and flip mirror commands) 1553 subaddress : 21

Before starting an observation a telecommand needs to be issued to the S/C PDHU to open a data file for storage of NOMAD data (received by the S/C through NOMADs SpaceWire connection). At the end of an observation, a telecommand needs to be issued to close this file.

- OPEN_FILE (opens a file and gives it a name and a time out for closure)
- CLOSE_FILE (closes a file with a given name)

NOMAD is a timeline directed instrument. Correct insertion of telecommands in the on-board S/C timeline is vital.

Upon reception of the NOMAD_START_OPERATIONS telecommand (TC(20)) NOMAD goes into observing mode. SINBAD will turn on the relevant channels at the correct time. Different types of observations (configurations) can be performed with combinations of the three NOMAD channels: looking at the sun (occultation of the sun by Mars), looking at the limb of Mars, and looking at the surface of Mars beneath TGO (nadir). The NOMAD_START_OPERATIONS telecommand contains all parameters needed to set up any of these observations.

Calibrations are also performed from NOMAD's observing mode. During these calibration observations additionally dark sky pointing, solar pointing or solar raster scanning can be required.

Both SO and LNO require pre-cooling of ~10 minutes at the beginning of an observation. For calibration observations this can occur while the spacecraft slews to the required attitude. UVIS will be turned on when science measurement can start. NOMAD will manage the switch on/off of channels, the precooling and measuring periods internally, based on the contents of the NOMAD_START_OPERATIONS telecommand.

Table 11: Observing modes information

	Typical duration (science obs)*	Number per orbit	Conditions
Solar occultation	5 min	2	Sunset and sunrise. Solar LOS pointed at centre of the Sun
Nadir	40 min	1	Bright side of mars Nadir LOS (-y) oriented

			towards the planet
Limb	10 min	<1	Mars bright limb Solar LOS pointed at Mars limb

*The IR channels need 10 mins of pre-cooling before each new observation

4.2.4 Observing mode to safe mode

After ending an observation (in observing mode) the instrument returns to safe mode automatically.
The instrument can be forced back from observing to safe mode by sending a TC(40) “go to safe mode”.

5 NOMAD OPERATIONS

5.1 OPERATIONAL CONSTRAINTS

1. Pointing NOMAD's general radiator towards the sun should be avoided, especially during the science phase.

2. SO and LNO channels cannot be switched ON together (due to limited power resources). SO and LNO can each work together with UVIS.

3. SINBAD needs to be switched ON before any channel can be switched ON.

4. SINBAD controls the LNO mirror mechanism to select between nadir and solar viewing angles. The UVIS selector mechanism controls whether the input from the solar or nadir telescope passes to the spectrometer. Neither of these needs to be monitored by flight control engineers, nor the spacecraft.

5. NOMAD monitors the quantity of ON/OFF and operating hours of the SO/LNO coolers – flight operations need not monitor these values. The number of actuations of the UVIS mechanism and the LNO nadir/occultation mechanism, and their status, will also be monitored by the NOMAD team.

6. NOMAD contains operational heaters. They are controlled internally by the instrument. No S/C control or monitoring is needed.

7. NOMAD contains survival heaters (nominal and redundant chain). Survival heaters will only be enabled while NOMAD is in its power OFF mode (e.g. during cruise phase). Survival heaters are controlled passively by means of thermostats inside NOMAD. Survival heater power is applied directly from the S/C to NOMAD's heater chains.

8. NOMAD needs 1 second to complete its power off sequence. So in the instrument time line, at least 1 second shall always be implemented between the TC(50) NOMAD ready to power off command and the HV-HPC NOMAD off command.

9. At the first occasion to command the NOMAD instrument, the flip mirror has to be placed to nadir position. This has to be done by means of the procedure NO-FCP-031 described in section 9.12. This can only be done after agreement by a PI representative.

10. It is not recommended to switch on SO or LNO channel during UVIS full frame calibration mode.

5.2 GROUND OPERATIONS

5.2.1 Packing and unpacking instructions

5.2.1.1 Container description

NOMAD is transported and stored in a double container.

The container is not temperature controlled, so its internal temperature depends on the environmental temperature during transport or storage.
Humidity is controlled by means of silica gel inside the inner container.
Pressure inside the container is controlled by means of pressure valves (selectable range) guaranteeing compliance with ExoMars requirements.

The transport container is equipped with an RD298 ShockLog Legacy device from Lamerholm-Fleming, monitoring the environmental history of the container (shocks, temperature, pressure, humidity).

The interface of the inner box with the outer box consists of a damping system. This damping system has eigen-frequency values that avoid potential dynamic coupling with the instrument's fundamental frequencies.

The mounting of the instrument inside the container can be done only in one way. A label on the baseplate of the inner container indicates at which side of the container the front side of the instrument has to be placed.

The instrument will be fixed in the inner box of the container through the 3 mounting feet (the same that are used for mounting the instrument on the S/C) and by means of 9 M8 bolts (3 bolts in each foot).

A special tool is delivered with the MGSE for screwing and unscrewing the bolts of the instrument from the baseplate of the transport container. The special tool will stay with the container at all times.

The container is, both on the outside and the inside, easily cleanable (flat surfaces) and not sensitive to cleaning agents (IP65).

The container has to be picked up by a crane (4 hoisting points at the corners of the outer box of the container, clearly marked) or by fork lift (lift up from below).

Additional retractable rings are foreseen for tie-down during transportation. The container has also 4 handles for manual manipulation and to lift the outer lid of the container.

The outer box of the container has permanent labels containing all necessary identification information.

The container will have a label ("this side up") indicating the top side of the box. During storage and transportation the box must always be kept in the upright position.

The inner box of the container will have a label indicating the Reference Axis System of the instrument.

5.2.1.2 Container opening procedure

1. Place the container on a stable surface (use fork lift or crane)
2. Unlock the 4 attachments at the side of the container
3. Lift manually (or with a crane) the lid of the outer box of the container
4. Unlock the attachments of the inner box of the container
5. Lift the lid of the inner box very carefully by hand, handle with gloves.
6. Switch OFF the Shock Controller
7. Install the instrument hoisting system (see below)
8. Unscrew the 9 bolts that fix the instrument to the bottom of the inner box with the tool present in the container (screws and washers are non-flight hardware)
9. Put the washers and bolts in the empty bag attached at the outside of the inner box.
10. Lift the instrument slowly and carefully with the crane
11. Place the instrument on a stable surface
12. Uninstall the instrument hoisting system (see below)
13. Close the inner box and the outer box
14. Store the container in a clean room

5.2.1.3 Container closing procedure

1. Place the bottom plate of the container without lids on a stable surface
2. Place the instrument on a stable surface, handle with gloves.
3. Install the instrument hoisting system (see below)
4. Lift the instrument slowly and carefully with the crane, move the instrument with the crane until a position is reached right above the bottom plate of the container. Take care that the front side of the instrument is in the correct position with respect to the front side of the container (see indication “front” on container).
5. Place the instrument on the container base plate while aligning the 3 mounting feet of the instrument with the 9 fixation points of the container
6. Put 9 screws and their washers in the mounting feet and screw by hand torque only
7. Uninstall the instrument hoisting system (see below)
8. Torque the 9 screws (20 Nm)
9. Switch on the Shock Controller
10. Place the lid of the inner container very carefully by hand
11. Lock the attachments of the inner container
12. Place manually (or with a crane) the lid of the outer container
13. Lock the 4 attachments at the side of the container
14. Take away the container (use fork lift or crane)

Figure 5-1: NOMAD container – closed (container of hoisting tool is on top)

Figure 5-2: NOMAD container – outer lid removed

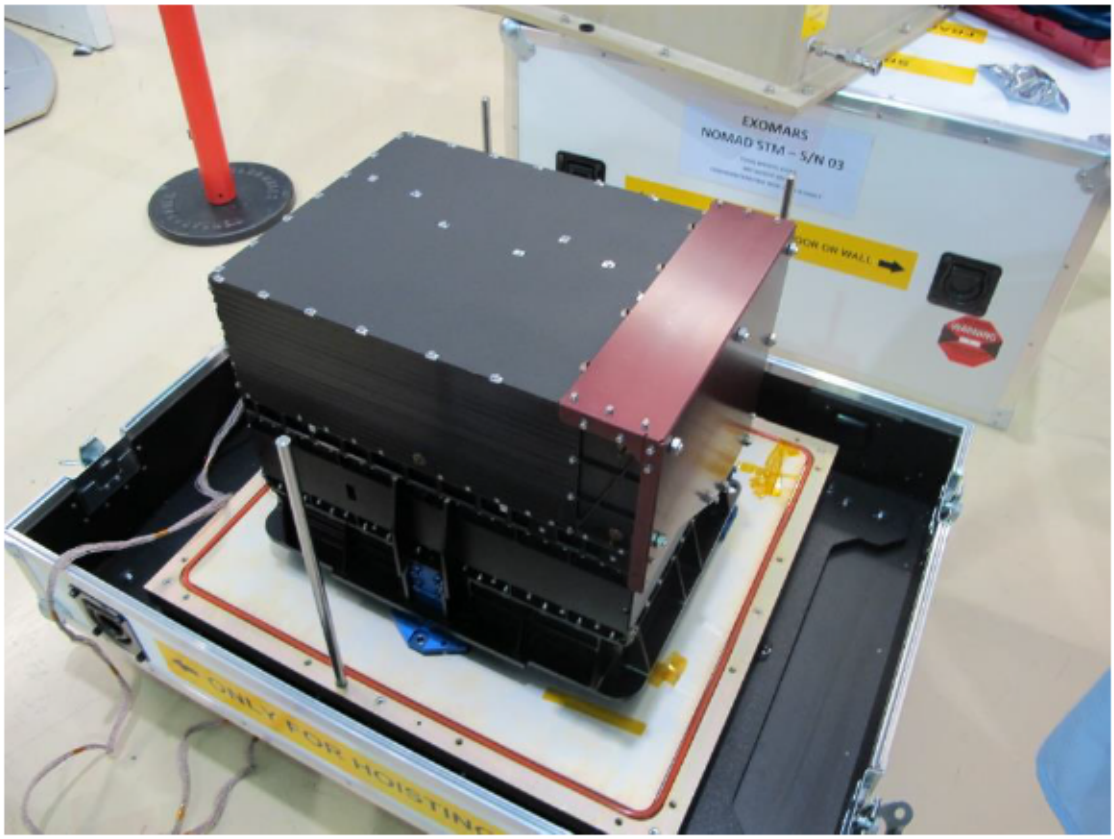


Figure 5-3: NOMAD container – inner lid removed

5.2.2 NOMAD hoisting instructions

5.2.2.1 Description

The mass of the NOMAD instrument is well above 20 kg and hence cannot be lifted manually. The hoisting system is designed to lift the NOMAD instrument safely. It can be used in any configuration of the instrument flight hardware. It can only be used for mounting the instrument on or for dismounting the instrument from the S/C when the EDM is not mounted on the S/C.

Since there is only one way to install the instrument in its container (indicated with "front") and there is only one way to install the hoisting system to the instrument, care has to be taken to place the hoisting system in the right position before proceeding to unpack the instrument.

The hoisting system has a solid top frame with four attachment points. Attachment point cables are fixed in each of these. The four cables are brought together at a ring in which the hook of the crane system can be fitted to lift up NOMAD and its hoisting system. The top frame is red anodised.

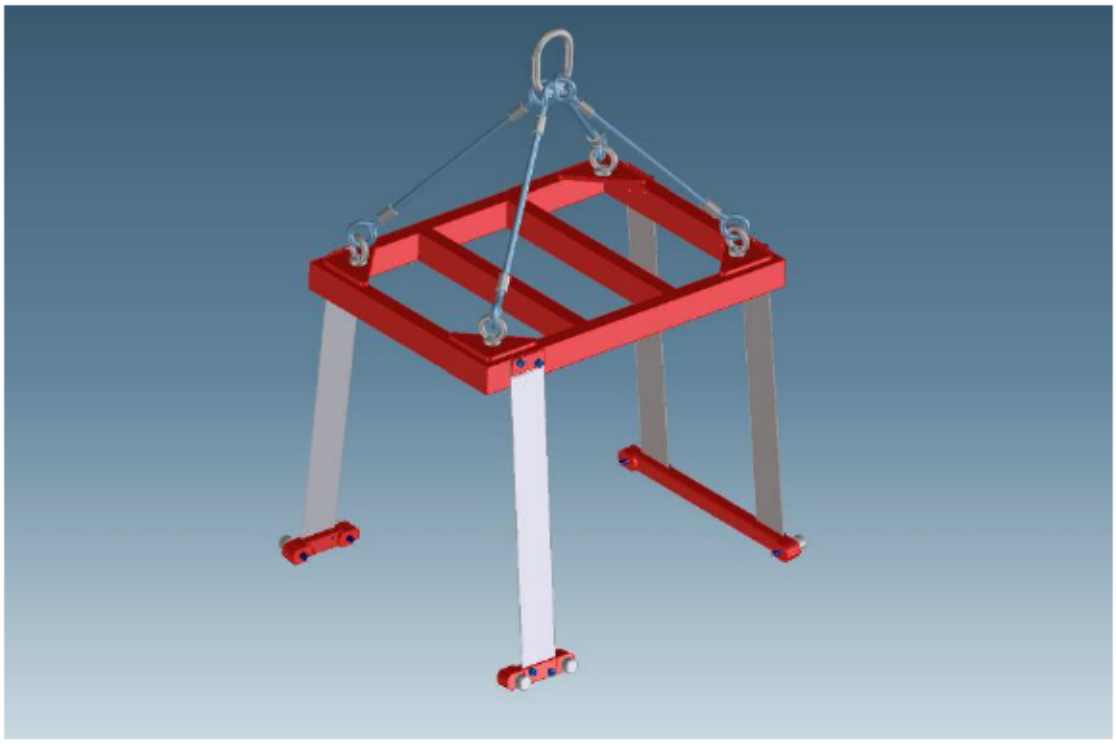


Figure 5-4: Hoisting tool

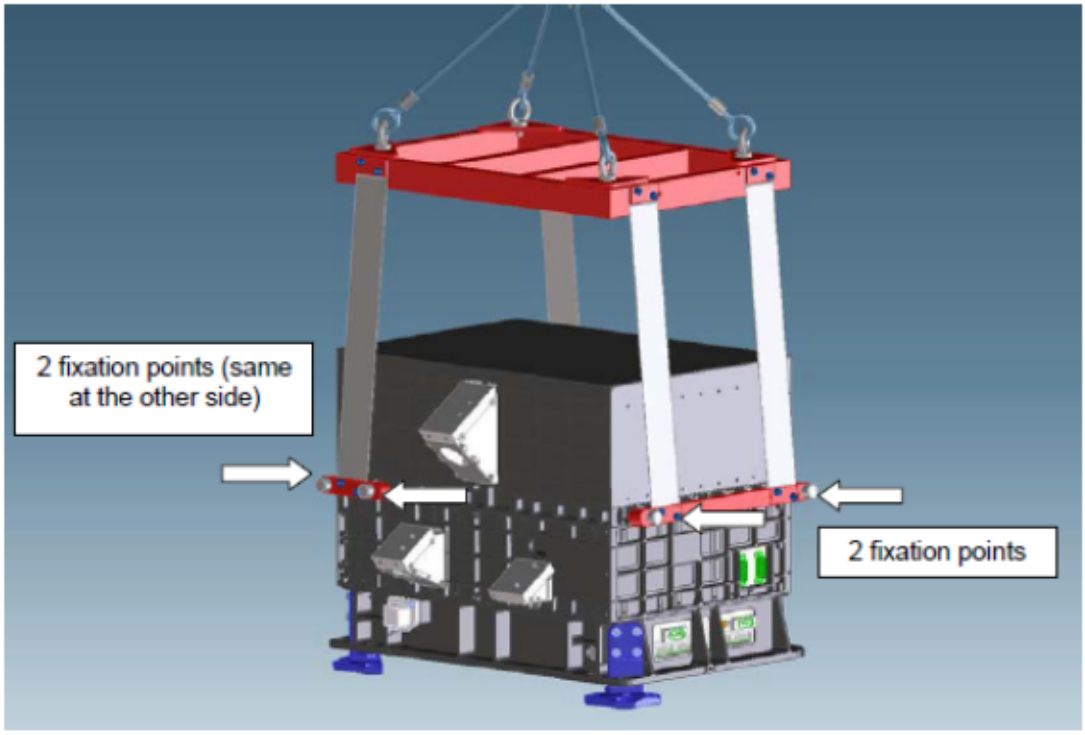


Figure 5-5: NOMAD attached to hoisting tool

Further, the hoisting system has three independent bottom fixation bars that are connected to the top frame through flexible blades. The fixation bars are red anodised. The fixation bars are used for connecting the hoisting system at the +Y, -Y and -Z-side of the instrument.

The fixation bars are each connected by 2 captive M6 screws to the LNO baseplate at its +Y, -Y and -Z-side. Threaded holes are foreseen LNO baseplate. The 6 fixation screws are locked with special clips.

Inside the hoisting system soft protections are foreseen in order not to damage the instrument while handling it.

Mating/demating between the hoisting system and NOMAD has to be done with special tools delivered together with the hoisting system. The captive screws can be torqued using the hexagonal socket with a dedicated torquer or by hand using the levers pressed inside the head of the captive screw.

The hoisting system is easily cleanable (flat surfaces) and not sensitive to cleaning agents (IP65 standard).

The hoisting system is designed and tested to hold 300 kg, i.e. approximately 10 times the weight of the instrument (see RD-10).

5.2.2.2 Installing and uninstalling of hoisting tool

The hoisting device with its associated tools and cables are delivered in a dedicated container.

Installing and uninstalling the hoisting system should always be done with extreme care and taking into account all applicable cleanliness rules.

It is assumed that before installing the hoisting system, the instrument is located in a stable situation, e.g. mounted on the S/C, mounted in its container (lids removed), standing on a table, …

When moving the instrument from one place to another the following procedure has to be followed:

1. Attach the hoisting system with its 4 cables to a crane (check secure locking of crane hook)
2. Approach the hoisting system with the crane until it is located above the instrument (take care that the front of the hoisting system sits at the front side of the instrument)
3. Lower the hoisting system while holding apart the two bottom frames (push outwards the flexible links)
4. Manoeuver the hoisting system until the three fixation bars are at the height of the fixation points of the instrument.
5. Screw the 6 captive screws of the hoisting system in the 6 corresponding threaded holes on the instrument. Use the appropriate tools (delivered with hoisting system),
6. Lock the six captive screws (Torque: 750cNm + 10%)
7. Unscrew the 9 bolts that fix the instrument to its underground (if fixed)
8. Lift the instrument slowly and carefully with the crane

9. Move the instrument to a new stable location
10. Screw the 9 bolts to fix the instrument to its new underground (if fixed)
11. Unlock the six captive screws
12. Unscrew the 6 captive screws of the hoisting system from the 6 threaded holes on the instrument. Use the appropriate tools (delivered with hoisting system).
13. Lift slowly the hoisting system while pushing apart the two bottom frames (push outwards the flexible links)
14. Detach the hoisting system from the crane

5.2.3 Temporary hardware

5.2.3.1 Overview

When NOMAD is delivered, it will contain some items which have to be removed before flight. The list of these so-called "red-tag items" is shown below (Table 12).

In general, it is preferred that these items are removed as late as possible. Their presence can reduce the time needed for recovery in case of problems.

Table 12: NOMAD red-tag items

Item	Function	Earliest allowable removal	Temporary removal allowed?	Advisable removal
Reference cube (master/SO)	Alignment of NOMAD to S/C	After successful integration of NOMAD	NO	Just before shipment of TGO to launch site
Reference cube (LNO)	Co-alignment internal to NOMAD	After successful integration of NOMAD	NO	Just before shipment of TGO to launch site
Cover SO periscope	Cleanliness protection		Yes, for optical or environmental tests	As late as possible (at launch site)
Cover LNO periscope	Cleanliness protection		Yes, for optical or environmental tests	As late as possible (at launch site)
Cover LNO nadir	Cleanliness protection		Yes, for optical or environmental tests	As late as possible (at launch site)
Cover UVIS periscope	Cleanliness protection		Yes, for optical or environmental tests	As late as possible (at launch site)
Cover UVIS nadir	Cleanliness protection		Yes, for optical or environmental tests	As late as possible (at launch site)
Cover general radiator	Cleanliness protection	Before any thermal test at S/C level	Yes, for environmental tests	As late as possible (at launch site)
Connector savers and caps	Protect external Physical protection	During integration of NOMAD	Yes, but to be avoided and to be logged	During integration of NOMAD

5.2.3.2 Reference cube SO

The Reference cube SO is installed on the SO baseplate using 2 captive M4 screws.
The screws are easily accessible (straight access).
Torque of the M4 screws is 3.0 Nm.
Once removed, cube with captive screws should be stored properly (double-bag + box). After removal, a flat MLI patch will be added.
Handling should be done by operators wearing gloves and mouthmask.

It is proposed that the removal of the SO reference cube is performed by the NOMAD team, preferably shortly before the shipment of TGO to the launch site.

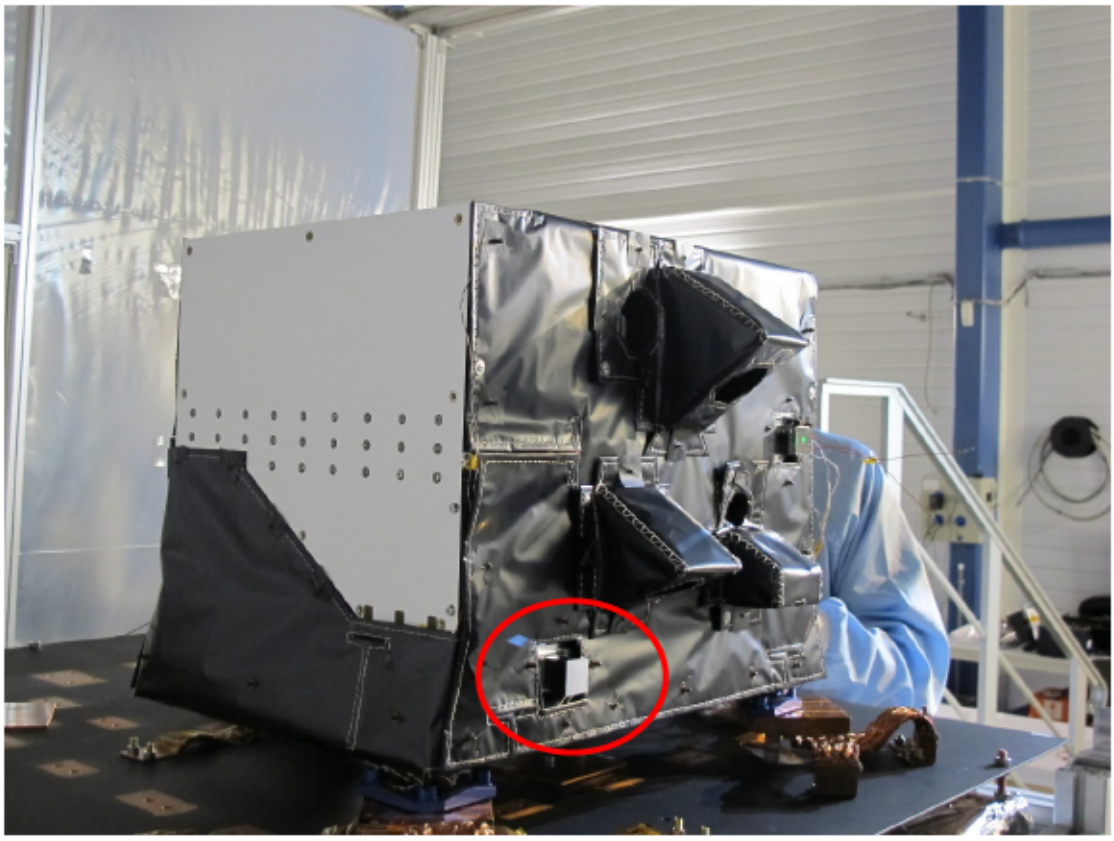


Figure 5-6: Reference cube SO (no MLI cap present)

5.2.3.3 Reference cube LNO

The Reference cube LNO is installed on the LNO baseplate using 2 captive M4 screws.
The screws are easily accessible (straight access).
Torque of the M4 screws is 3.0 Nm.
Once removed, cube with captive screws should be stored properly (double-bag + box). After removal, a flat MLI patch will be added.
Handling should be done by operators wearing gloves and mouthmask.

It is proposed that the removal of the LNO reference cube is performed by the NOMAD team, preferably shortly before the shipment of TGO to the launch site.

Remark: This cube only serves NOMAD's purpose. It has no function for alignment of NOMAD with TGO

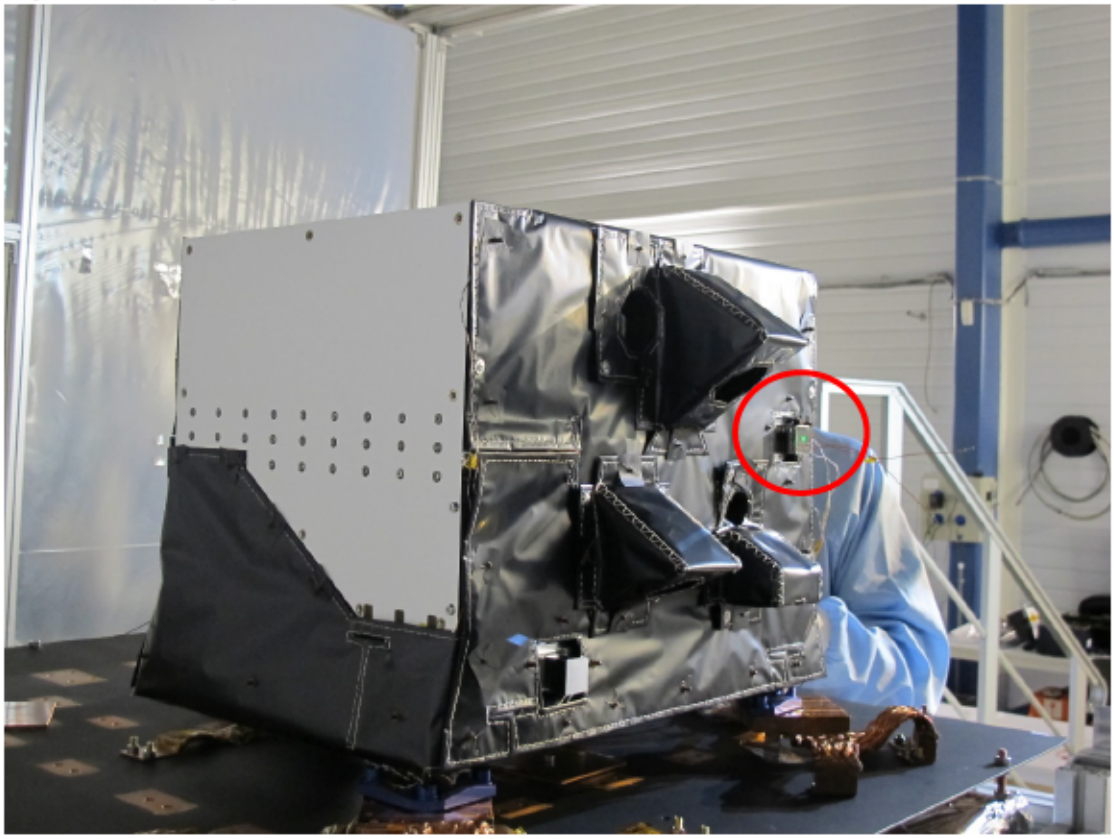


Figure 5-7: Reference cube LNO

5.2.3.4 Covers optical apertures

Five covers for the optical apertures are foreseen:

- Cover SO periscope
- Cover LNO periscope
- Cover LNO nadir
- Cover UVIS periscope
- Cover UVIS nadir

These covers are self-adhesive and can be easily removed without tools, by simply pulling the tag.
Re-applying the cover is also possible.

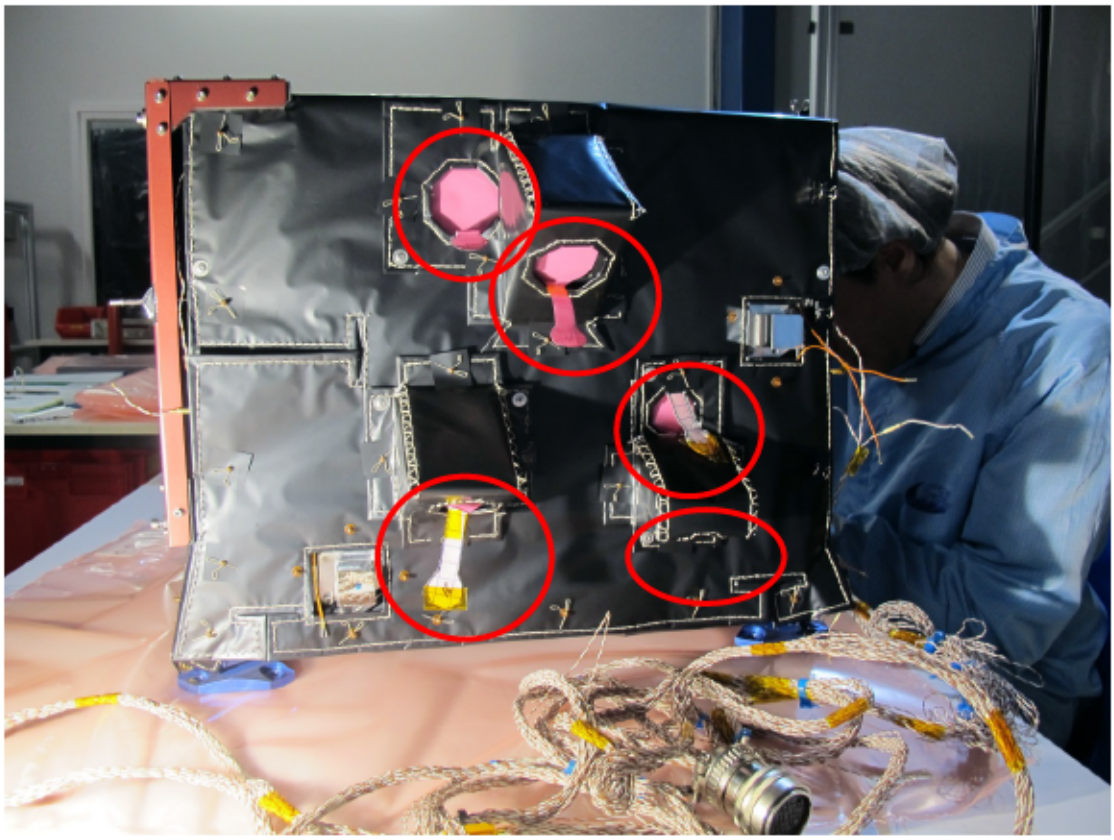


Figure 5-8: Cover for the optical apertures (note UVIS periscope cover is not visible at this angle)

5.2.3.5 Cover general radiator

When the NOMAD PFM is delivered, its radiator cover will be attached.

There are 8 attachment points for the radiator cover. 2 of these may be used to accommodate guiding pins – in this case the other 6 are used for bolting the cover to the PFM.

The dismounting procedure is as follows:

1. Loosen the 6 or 8 screws until they disengage from NOMAD. They are captive, so they don't need to be removed completely
2. Slide the radiator cover horizontally, away from the NOMAD. Take care not to make contact between the cover and the radiator (top and side)
3. Remove the 2 guiding pins

Once removed, cover with captive screws should be bagged in a clean bag.

It is possible to hoist NOMAD with the cover in place.

Should the radiator cover need to be re-attached, it shall be cleaned with an IPA wetted cleaning tissue and inspected prior to installation.
The procedure to re-install the radiator cover is as follows:

1. Install 2 guiding pins in 2 attachment points (see locations in Figure 5-10)
2. Remove the 2 corresponding captive screws from the cover.
3. Slide cover over the guiding pins towards NOMAD
4. Fix the 6 remaining captive screws. The torque to be applied is 1Nm.
5. Do not remove the guiding pins.

The radiator cover and the guiding pins shall be removed for the duration of any environmental test (thermal, structural, …)

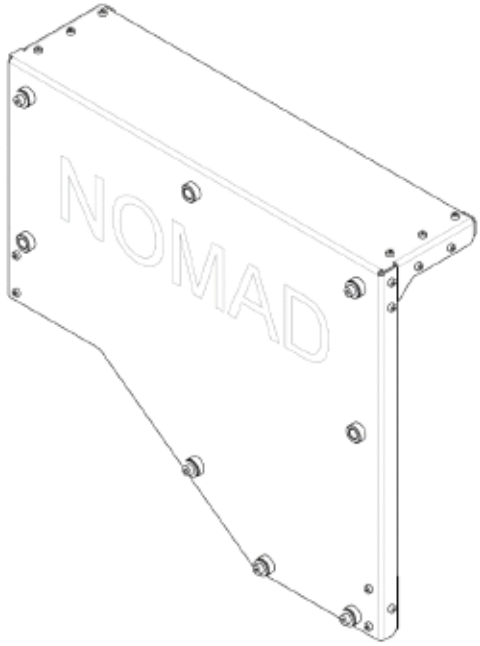


Figure 5-9: Radiator Cover

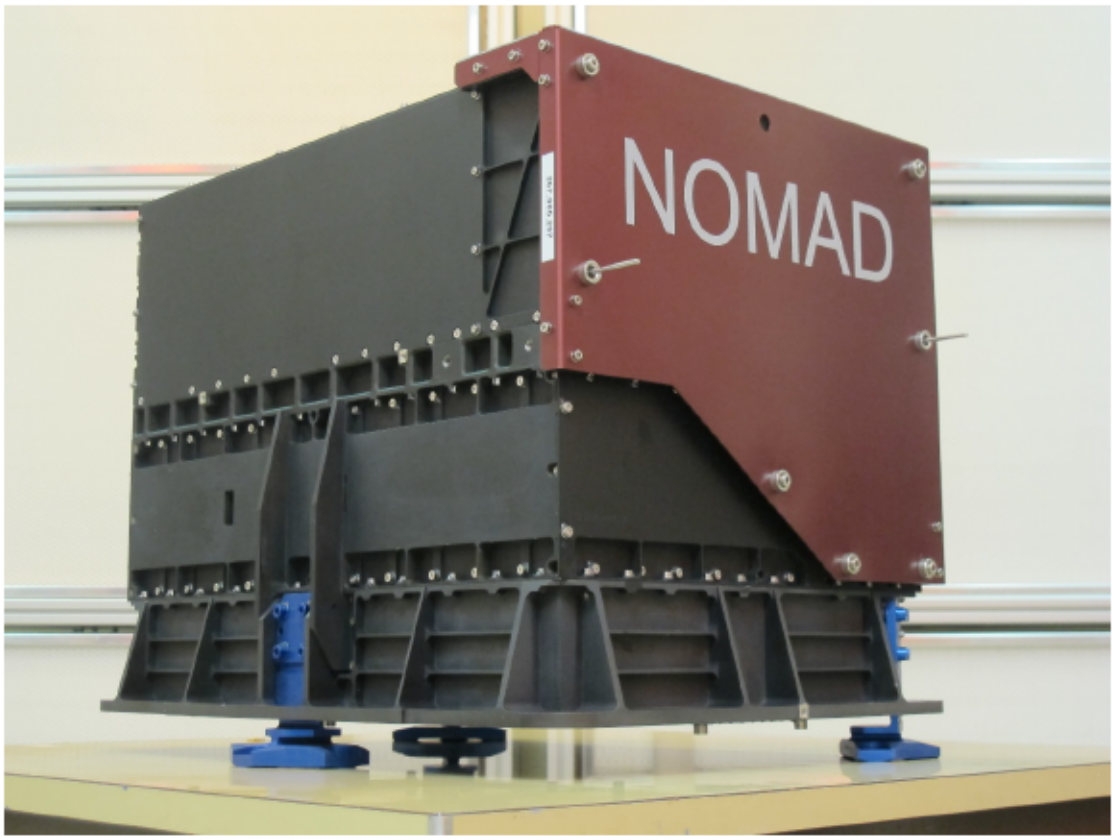


Figure 5-10: Radiator Cover – note the positions of guiding pins

Figure 5-11: Close Up of alignment pin for the radiator Cover

5.2.3.6 Connector savers

Connector savers are installed on all external connectors and will be used during on ground testing. Each functional connector has a dedicated connector saver.

Once NOMAD is integrated the connector savers need to be demated. Demate to be logged in the external connector mate/demate log, which is supplied with the instrument.

Connector savers need to be removed during environmental S/C testing.

Should the connector savers need to be re-attached, the torque to be applied is 33 cNm.

5.2.4 NOMAD integration procedure

Step 1: Preparation (NOMAD)

- Perform functional test before integration
- Verify that LNO mirror mechanism is in launch position
- Attach hoisting tool

Step 2: Hoisting (TAS)

- Hoist NOMAD PFM up for a few centimetre.
- Insert the interface bolts into the interface feet, through the holes in the MLI. (NOMAD is fixed to the S/C using the 9 M8 titanium bolts. These I/F S/C bolts are supplied by TAS. TAS has selected M8x26 bolts, type LN 29950-08-26-B)
- Hoist the NOMAD PFM to its location on the S/C.

Step 3: Positioning (TAS)

- Lower the PFM onto the alignment pins in the deck.
- Engage the interface bolts by a few turns, to ensure they do not fall out.
- To ensure reproducibility when re-mounting, NOMAD will use the 2 pins provided in the S/C deck, which will fit in a hole and slot in the NOMAD interface feet (see Figure 5-13 - the hole and slot are indicated by the red circles).

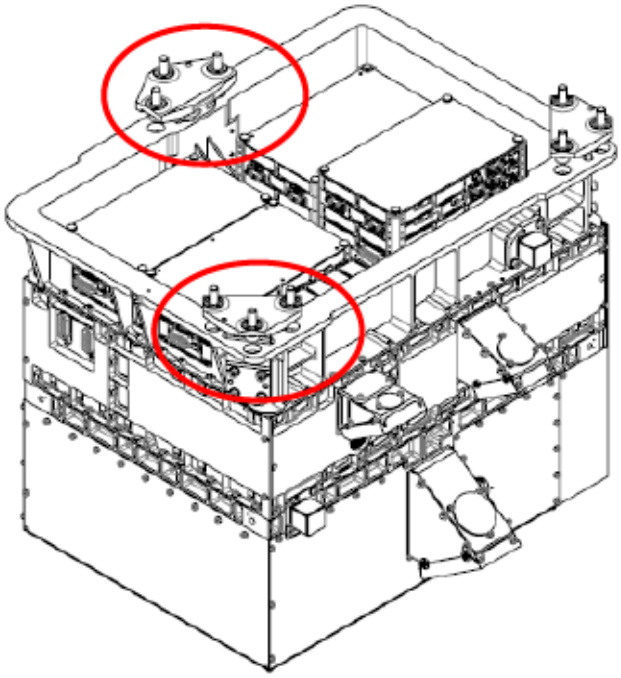


Figure 5-12: I/F feet

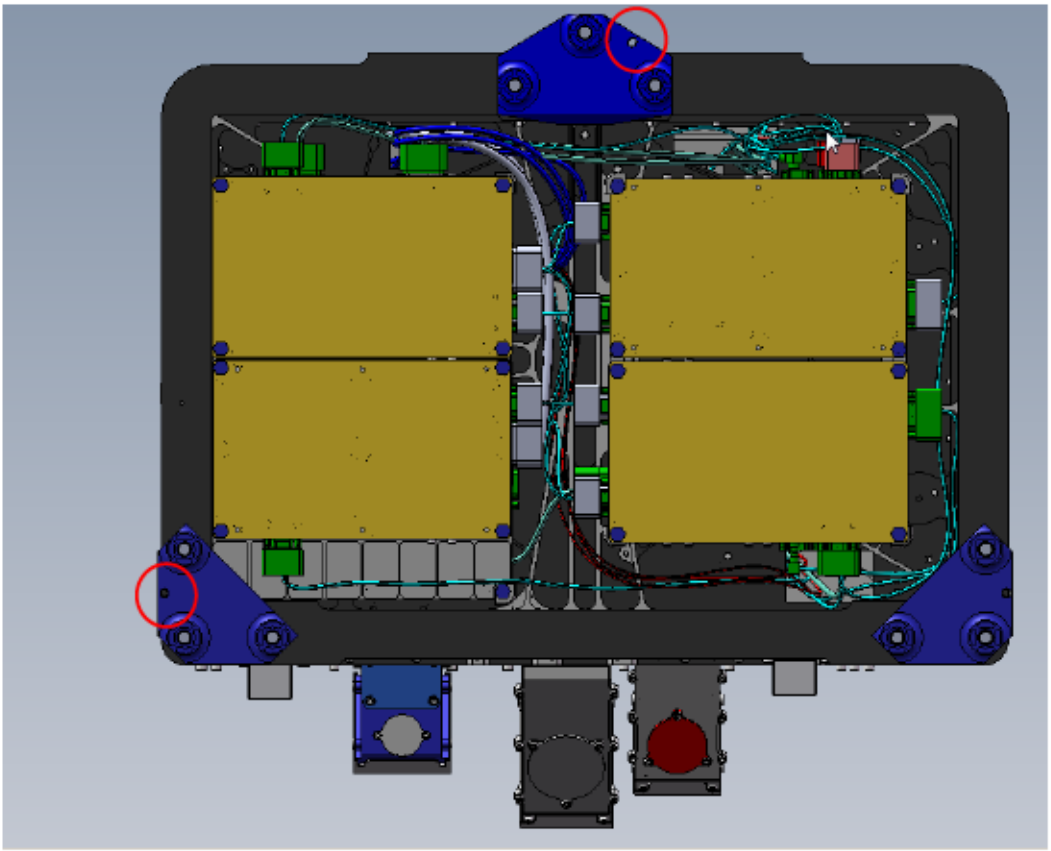


Figure 5-13: Principle for mounting reproducibility (bottom view)

Step 4: Bolting (TAS)

- Torque the interface bolts in the order shown in Figure 5-14.
  First torque all screws to 5Nm, then 10Nm and at the final torque, as determined by TAS-F (20.4 Nm).
- Remove hoisting tool

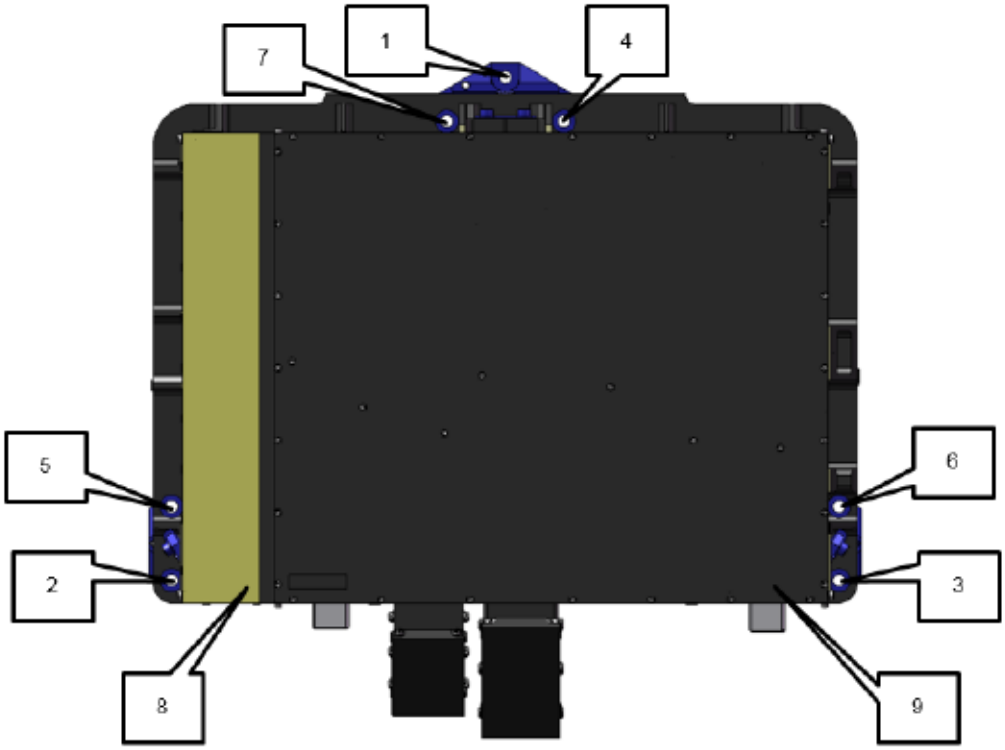


Figure 5-14: Torqueing sequence (top view)

All bolts can be reached from the top with a long tool, except bolts 8 and 9. A special tool is available at TAS-F to reach these.

Slots and flaps are foreseen in the MLI to reach the interface bolts with the tools.

Step 5: Grounding straps (TAS)

- Attach grounding straps to deck.
- Measure resistance

Step 6: MLI skirt

- Fix the three MLI skirts to PFM (NOMAD)
- Fix the three MLI skirts to TGO (TAS)

Step 7: Harnesses (TAS)

- Attach S/C cables to NOMAD.

The recommended torque is 33 cNm.
The screw locks available on NOMAD are made from brass for the sub-D connectors
The screw locks available on NOMAD are made from stainless steel for the micro-D connectors

Step 8: Harness MLI cap (TAS)

- Attach the "harness MLI cap" to the NOMAD PFM, using the 10 common standoffs, fixed to NOMAD.

5.2.5 Instructions for TGO thermal vacuum test

5.2.5.1 Monitoring

For TGO thermal vacuum test, with NOMAD PFM integrated, there are two test temperature sensors identified, to be placed near the NOMAD PFM TRP for monitoring during the test. Their location proposed by TAS in document EXM-OM-TIC-AF-1870 is accepted.

However, as these are on a relatively isolated part of the structure, they do not react quickly in the case of any thermal-control failure within NOMAD or the nearby TGO structure. So, for maintaining a safe temperature of NOMAD, the best method is to have the TGO survival line FDIR active and monitoring two PT1000s survival sensors by the SMU.

The sensors to be monitored (and their corresponding node numbers in the NOMAD thermal model) throughout the TGO TVAC test to ensure the survival of the NOMAD PFM are:

- TRP sensors (external interface foot) (monitored by Test GSE & operator):
  - D026 &D027 / Node 221030
- ANC sensors (internal LNO channel) (monitored by autonomous TGO FDIR):
  - ANC2_NOM & ANC2_RED / Node 521009

However, the startup temperature needs to be checked by the test operator prior to switch on of NOMAD PFM (either for a functional test or for the operation sequence to reach high temperature dwell). For this check, the following sensors are to be used prior to NOMAD PFM switch on:

- ANC sensors (internal LNO channel):
  - ANC2_NOM & ANC2_RED / Node 521009

These sensors must both indicate a temperature within the range of -20°C to +38°C (plus further modification by sensor/SMU acquisition accuracy by party responsible for the test), before NOMAD can be switched on. These limits are as in the Table 14, below, for the operating qualification temperature range.

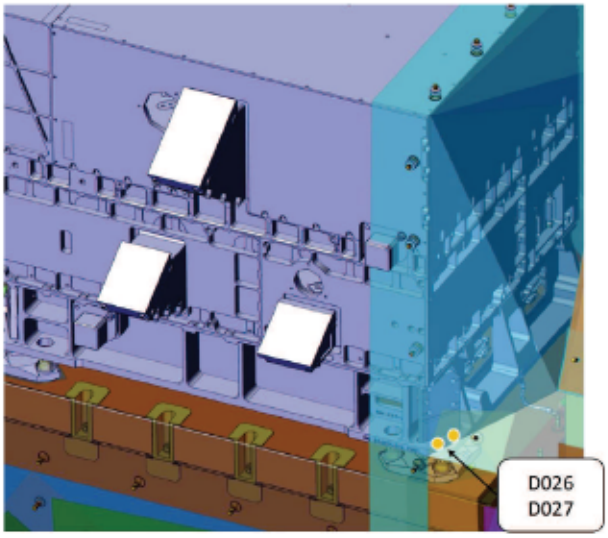


Figure 5-15: Location of TRP sensors (extract from EXM-OM-TIC-AF-1870)

The following tables indicate the acceptable temperature limits for these sensors.

Table 13: Thermal limits TRP sensors

NOMAD temperature limits (°C) TRP sensors						
	Operating		Non Operating		Start up	
	MIN	MAX	MIN	MAX	MIN	MAX
Qualification temperature range	-30°C	50°C	-50°C	50°C	-30°C	50°C
Acceptance temperature range	-25°C	45°C	-45°C	45°C	-25°C	45°C
Design temperature range	-20°C	40°C	-40°C	40°C	-20°C	40°C

For the setting of TGO TVAC test red and yellow warning flags relating to the TRP, it is expected that these levels will be set according to a common philosophy taken for all instruments and other TGO units.

Table 14: Thermal limits ANC2 sensors

NOMAD temperature limits (°C) sensor ANC2_NOM & ANC2_RED						
	Operating		Non Operating		Start up	
	MIN	MAX	MIN	MAX	MIN	MAX
Qualification temperature range	-20°C	38°C	-40°C	50°C	-20°C	38°C
Acceptance temperature range	-15°C	33°C	-35°C	45°C	-15°C	33°C
Design temperature range	-10°C	28°C	-30°C	40°C	-10°C	28°C

5.2.5.2 Functional tests

5.2.5.2.1 Cold survival

At the cold survival dwell, a functional test shall be executed according to section 6.1.10.

Before starting this test, the ANC2 sensors shall be verified, as in section 5.2.5.1:

- Temperature limit for safe switch on: -20°C to 38°C
- Target cold temperature for starting the functional test at cold survival dwell is: -18°C

Note: should the ANC2 sensor indicate a too low temperature, the test in section 6.1.10.1 shall be modified: the waiting time in step 13 shall then be increased. Continue waiting, until the operational heaters have raised the temperature to above -20°C.

It is not expected that NOMAD PFM will reach a steady-state temperature before the functional check is performed. This is because in non-operational (survival) mode, the equilibrium temperature reached by the ANC2-monitored LNO channel will be below the safe switch-on limit of -20ºC. Therefore, switching the NOMAD PFM on once equilibrium has been reached would be a more complicated approach needing staged switch-on to safely warm the PFM back up to a level where a functional check can be performed.

This target cold temperature is based on the safe switch-on limit and may need to be modified by the test responsible depending on the predicted test boundary conditions for cold dwell.

5.2.5.2.2 Hot Operational

At the hot operational dwell, a functional test shall be executed according to section 6.1.10.

Before starting this test, the ANC2 sensors shall be verified, as in section 5.2.5.1:

- Temperature limit for safe switch on: -20°C to 38°C
- Target hot temperature for starting functional test at hot operational dwell: 30°C

In order to simulate a nominal operation average power dissipation (so that the transition from cold to hot dwell is as quick and representative as possible), the NOMAD PFM shall be operated such that the science orbit is accurately replicated. This can be achieved by continuously repeating the procedure in section 6.1.11.

5.3 FLIGHT OPERATIONS

5.3.1 EMTGO Mission Operations

The ExoMars 2016 mission operations will be performed from the ESA European Space Operations Centre (ESOC) in Darmstadt, Germany from Launch to End of Mission. These operations are described in RD-08 – the Ground Segment IRD document.

TGO-FOP-ALL-0010, -0030, -0050 concerning mission operations – NOMAD states compliance.

TGO-FOP-ALL-0080 concerning solar conjunction operations – NOMAD states compliance.

TGO-FOP-ALL-0090 NOMAD will issue instrument operations reports after each non-science in-flight phase

TGO-FOP-ALL-0100 NOMAD operations will be governed by the rules and guidelines established by the SWT.

TGO-FOP-ALL-0110 NOMAD will document any instrument pointing constraints in the NOMAD Flight User Manual

The instrument user manual will provide input for the ESOC Flight operations plan (TGO-FOP-ALL-0420), which the NOMAD team will review (TGO-FOP-ALL-0430). If a command sequence needs to be changed in flight, a FOP change request will be raised as per TGO-FOP-ALL-0440. Changes to the configuration controlled spacecraft database after Ground Segment Readiness Review will be requested as per TGO-FOP-ALL-0450.

The EMTGO mission phases and their duration are:

Launch window	7-27/01/2016
Near Earth Commissioning	L+8d for 1 month
Cruise Phase	Approx. 250 days
Mars orbit insertion	19/10/2016
Aerobraking into 400km circular orbit	Approx. 377 days
On-orbit commissioning	Approx. 2 weeks
Science Operations	1 Martian Year
Relay Phase	2018 rover arrival
End of Mission	31/12/2022

Table 15: EMTGO mission phases and timing

5.3.2 AIV and Pre-Launch activities

The NOMAD team with support spacecraft interface tests as per TGO-FOP-ALL-0350, providing test procedure inputs and evaluating test results as per TGO-FOP-ALL-0360. This will validate MOC interface to the spacecraft and to NOMAD itself, testing typical mission scenarios.

The NOMAD team will be involved in the development of nominal and mission critical sequences that involve payload functions to be tested during SVTs and simulation campaigns (TGO-FOP-ALL-0370).

The NOMAD team will support EDDS interfaces as required (TGO-FOP-ALL-0390). Post-launch sequences necessary for payload health checks and in-flight calibration will be developed, tested and approved prior to launch.

The NOMAD team will support End-to-End testing of the MOC/SOC mission planning (TGO-FOP-ALL-0400) and a simulations campaign (TGO-FOP-ALL-0410).

5.3.3 Near Earth Commissioning (spacecraft composite check-out phase)

This Commissioning Phase is dedicated mainly to activation and checkout of each of NOMAD's channels and its central computer. This involves, amongst other activities, the checkout of the interfaces with the S/C subsystems, interference measurements between NOMAD and the S/C subsystems, instrument calibration, and verification that the overall system performance meets the requirements. A list of check-out tests to be performed is found in sections 5.4.1and 6.2.2.

Critical operations, e.g. power-up sequences, during commissioning will initially be performed only in ground coverage periods where real-time control and monitoring of the S/C is possible. Depending on the position of the EDM with respect to the NOMAD radiator, the check-outs before EDM release will not be fully representative since the instrument will not be at its optimal measuring temperature.

NOMAD is compliant with TGO-FOP-ALL-0130,-0140,-0150,-0160, and -0170.

NOMAD team members will be available on-site to support commissioning as requested by the MOC. The NOMAD EGSE will be installed at the MOC during this commissioning.

At the first occasion to command the NOMAD instrument, the flip mirror has to be placed to nadir position. This has to be done by means of the procedure NO-FCP-031 described in section 9.12. This can only be done after agreement by a PI representative.

5.3.4 Cruise Phase, EDM release, Mars Orbit Insertion & Aerobraking

During the Cruise Phase, NOMAD will be OFF, except for survival heaters – powered directly by EMTGO. Check-outs should be performed at least twice during cruise (compliant with TGO-FOP-ALL-0180).
Once the Entry, Descent and Landing Demonstrator Module (EDM) has been detached and performed its mission, EMTGO will be inserted into Mars orbit. Without the EDM, NOMAD will finally be at its optimal measuring temperature, and ideally a new checkout and calibration session will be performed before aerobraking, so that any issues raised during this session can be analysed during the ~377 days of aerobraking in search of solutions/software patches etc.

The Flight Operations Plan therefore includes performing all flight calibration tests after MOI and before aerobraking.
The list is:

- Line of Sight mismatch calibration,
- Spectral calibration,
- Straylight calibration,
- Dark sky calibration.

These must be performed for SO/UVIS and LNO/UVIS. They are described in section 5.4.2 and the detailed procedures are given in section 6.2.

5.3.5 Science Phase

The science operations phase starts after aerobraking has finished and EMTGO has reached a 400 km altitude circular orbit. Science operations will last at least one Martian Year, before EMTGO passes into relay mode for the arrival of the 2018 ExoMars mission. In the science phase various science objectives will be pursued, according to the Science Master Plan (SMP) established by the NOMAD Science Team and managed by the NOMAD Project Scientist. This will give complete guidelines for the science operations and the selection of observation strategies. It will obviously allow for flexibility to organise joint observations with other EMTGO instruments to optimise scientific synergies, and to adapt the plan in light of new discoveries. Science operations planning is based on the operations planning used for SOIR for the Venus Express mission, but can be adapted as necessary. Should further science operations be possible after the relay phase has finished, the same operations plan will be valid. These operations are compliant with TGO-FOP-ALL-0200 and -0220.

The science activity plan (SAP) describes high-level mission planning. It takes into account different observation conditions, specific needs to fulfil the mission goals, as well as individual requests from the experiments and limitations imposed by the environment at Mars and spacecraft resources. The SAP will be developed in compliance with the flight rules and takes into account available resources.

This is worked out between the SOC and the Principal Investigators, with some details being discussed at Science Working Team (SWT) meetings. The SAP provides the highest-level planning document for the Midterm Plans, including what science cases are intended to be run in which orbits.

5.3.6 Science operations planning concept

For SOIR on Venus Express the operational planning was performed at 3 levels. This is compliant with RD-08, more specifically TGO-FOP-ALL-0290.

Long Term Planning (LTP): translating the Payload Mission Scenario into an operational Payload Mission Planning. Typically one long term plan (LTP) is defined for each major P/L operations phase of the mission. For NOMAD therefore, the entire 1 Martian Year of projected Science Operations could be considered as 1 LTP. This level of planning would be finalised around 6 to 12 months in advance of the actual operations of each phase. Inputs required from the mission operations centre to the NOMAD operations team are general orbit parameters – approximate duration of eclipse, duration of possible nadir dayside observations, the timing of solar occultations as well as the start and finish altitude.

Medium Term Planning (MTP): dividing the Payload Mission Planning into shorter periods and optimizing it for each period, resulting in high level run procedures (RP). The high level RPs are translated into high level timelines allowing allocation of resources and identification of eventual conflicts in instrument operations. These high level timelines are not uploaded. Inputs required from the mission operations centre are more detailed observation parameters – power constraints on which instruments can be on when, more accurate eclipse duration, dayside duration and timing of solar occultations as well as the start and finish altitude, latitudinal, longitudinal and local solar time information on coverage of observations, possible special pointing calibration slots (frequency and duration).

Short Term Planning (STP): dividing the medium term plan into observation blocks, resulting in low level run procedures. These low-level RPs are translated into mission timelines that freeze S/C resources. Short term planning files specify instrument operations to the level needed for actual instrument commanding. These instrument command files are then provided to the MOC team for uplink to the spacecraft for timely execution. At this level, the distribution of nadir and occultation measurements is decided (as well as possible night side measurements, if power and telemetry constraints allow), and the choice of species that will be observed in each orbit is made. Calibration sessions are inserted into the timelines when needed.

MTPs will be split into STPs according to Martian Season and the evolution of the EMTGO orbit around Mars (beta angle, eclipse season etc.). In general, inputs for the generation of the complete plan for each mission phase (Long Term Plan - LTP) will be required to be submitted several months before the start of the phase. The planning process will then continue at a more detailed level, subdividing each phase in planning periods (MTP, later STP), for each of which a separate deadline for submission of final inputs concerning the details on the operations to be conducted in the period will be given. In any case, due to the characteristics of the mission and the off-line approach of the operations concept, the finalization of the detailed mission plan for each planning period (STP) will always be several days before the start of the observation period.

NOMAD science operations are timeline controlled. A typical one orbit timeline is given in Figure 5-16 (assuming SINBAD is permanently on and in safe mode with no HPC to be sent). Figure 5-16 also assumes a 2hr orbital period, which is not

accurate, but a good approximation. Each block represents 5 minutes of day or night side of the orbit, and SO or LNO operations, as shown by the legend.

The timeline (sending of telecommands to NOMAD) is constructed around events. Typical events for NOMAD are: end of solar occultation (e.g. beginning or end egress), start of solar occultation (beginning or end of ingress), start of nadir (day or night). S/C manoeuvers have to be correlated to these events as well.
The timings of eclipse, occultation and day side are assumed as inputs to the MTP from the MOC or SOC. Over short time periods there will not be much variation, and the timeline will remain more or less the same. However, over the course of weeks, the orbit beta angle changes and the length of eclipse and dayside change, so several different timelines will be needed.

At STP level, the decision is taken on which species will be targetted in the IR channel observations. This can vary at sunrise, sunset and nadir. UVIS always takes a spectrum that covers the full wavelength range.

	ECLIPSE				SUNRISE							DAYSIDE								SUNSET	ECLIPSE			
	CASE 1 (Standard) SO/LNO/SO												Average Power:		35.9	W		Peak Power:		48.7	W			
Time (minutes)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
SINBAD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SO			S	S	X													S	S	X				
LNO						S	S	X	X	X	X	X	X	X	X	X	X							
UVIS					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Heater																								
Power (W)	11.4	11.4	43.9	43.9	42.5	48.7	48.7	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	48.7	48.7	42.5	11.4	11.4	11.4	11.4

SINBAD	11.42	W		
SO pre-cooling	32.48	W	SO operation	26.3 W
LNO pre-cooling	32.48	W	LNO operation	26.3 W
UVIS	4.76	W		
Heater	15.11	W		
Average:	35.87	W		
Peak:	48.66	W		

Figure 5-16: Typical orbit with 2 solar occultation observations and one nadir observation, using IR and UVIS channels both times.

Detailed command sequences and timelines are given in chapter 6.

5.4 IN-FLIGHT CALIBRATION AND CHECKOUT PROCEDURES

NOMAD requires periodic health checks and calibration. For simplicity we use '*checkout*' to refer to TGO offered instrument health check sessions and '*calibration*' to refer to more detailed instrument checks.

This is reflected in the procedures and command sequences also.

5.4.1 Checkouts

NOMAD proposes the following checkouts:

- 1 time during near-Earth commissioning;
- 2 times during cruise phase;
- 1 time between EDM separation and science phase;
- During science phase each time the instrument has been inactive for one month.

A checkout consists of two parts: a first part where the SO and UVIS channel are active together, and a second part where the LNO and the UVIS channel are active together. SO and LNO cannot be operated simultaneously. One checkout for NOMAD lasts approximately 35 minutes. No specific S/C pointing is required, as a checkout is similar to a dark sky calibration session, with actuation of the UVIS selector mechanism and the LNO flip mirror in addition.

Details on the checkout procedure, including telecommands, are given in chapter 6.

5.4.2 Calibration sessions

Calibration sessions with NOMAD are needed regularly throughout the science phase of the mission.

A calibration session is either dedicated to the SO and UVIS channels, or to the LNO and the UVIS channels.

NOMAD strongly advises a calibration session after the EDM has been released and prior to aerobraking starting. This will be the first time NOMAD is in real operating conditions, and will allow time to analyse the results during the aerobraking passes. At the least a dark sky calibration should be performed. If time, power, guidance allow, any other calibration session will give valuable data.

NOMAD also requires a full calibration session (one of each of the observations described in this section) if NOMAD has, for any reason, been inactive for a month during the science phase. Otherwise, calibration sessions will be planned within the science phase, as part of normal operations. Some require specific pointing and will be planned with the MOC.

The following calibrations are required:

1. LoS mismatch calibration (see also 6.2.3 and 6.2.4)
2. Spectral calibration and UVIS selector mechanism calibration calibration (see also 6.2.5 and 6.2.7)
3. Stray light calibration calibration (see also 6.2.3)
4. Dark sky calibration calibration (see also 6.2.6)

5.4.2.1 LoS mismatch calibration

The misalignment between the NOMAD solar LoS (Line-Of-Sight) and the pointing axis of the S/C has to be checked in flight. NOMAD highly recommends checking the ACS solar LoS mismatch at the same time. The mismatch angles (theta and phi) that result from these calibration sessions could (optionally) be taken into account by the S/C (as offsets) for future Sun pointing.

Insertion in the mission timeline

This calibration session can be performed at any time the spacecraft can be pointed at the Sun, outside the Martian atmosphere.

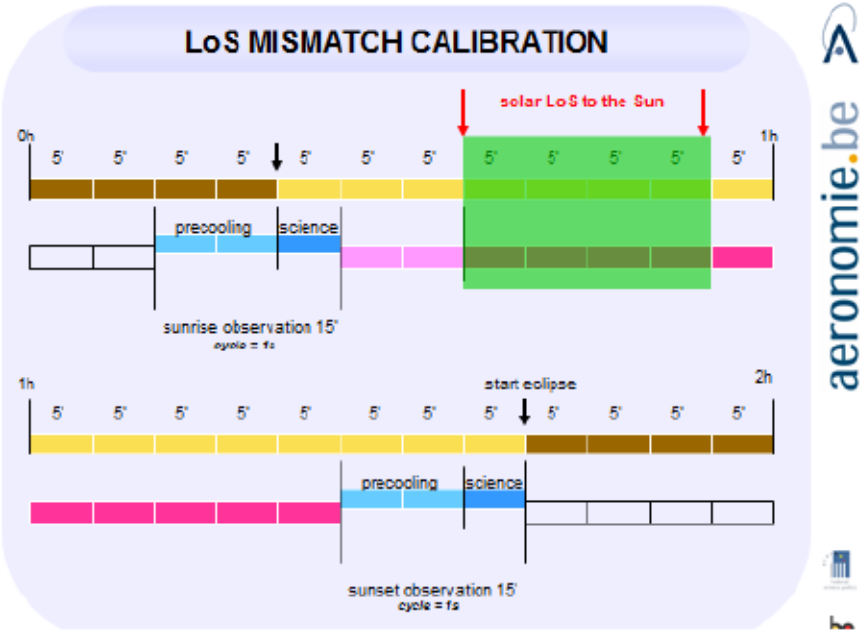


Figure 5-17: LoS mismatch calibration – example of insertion in mission timeline (during typical orbit in science phase). Green zone = anytime during dayside

This calibration session has to be repeated every 2 to 3 months during the science phase. It is acceptable to plan this during periods of high beta angle when solar occultations will not be observed, and TGO is in a more constant thermal environment. This will allow knowledge of long term changes but must then be coupled with line scan LOS mismatch measurements at other beta angles to characterise a situation more similar to real solar occultation measurements. These shorter calibrations are described in RD2 and can replace a normal science occultation measurement (7 min).

This calibration session can be part of a check out, and could be combined with spectral calibration, selector mechanism check and a straylight measurement.

5.4.2.2 Spectral calibration and UVIS selector mechanism calibration

For the SO and LNO channels, a spectral calibration is performed by stepping the AOTF frequency through the spectral domain. In parallel the UVIS channel records spectra using the solar entrance optics and parameters, whilst stepping the selector mechanism from its rest position (dark) to the occultation hard stop (16 steps) to characterise fibre-slit alignment. Ideally the UVIS selector mechanism calibration will perform 3 cycles of the 16 steps. Each integration takes 1s, so the 48s cycle fits within the SO/LNO spectral calibration timing.

Insertion in the mission timeline

This calibration session can be performed at any time the spacecraft can be pointed at Sun outside the atmosphere (see orange zone in figure below).

A particularly interesting moment to accommodate this calibration session is immediately before a sunset or immediately after a sunrise (see green zones in figure below).

It may be a possibility to put this calibration in the waiting time at the end of a sunrise. This time is planned to have a symmetric guidance profile – and balances out the 'tranquilisation time' foreseen after the slew to inertial solar pointing before a solar occultation measurement. The pointing remains inertial during the waiting time, and the Sun is therefore still in the solar line of sight. This would be the ideal moment to obtain spectra outside the Martian atmosphere, provided there is sufficient time above 250km (2 minutes is a minimum).

This calibration session has to be repeated every month during the science phase.

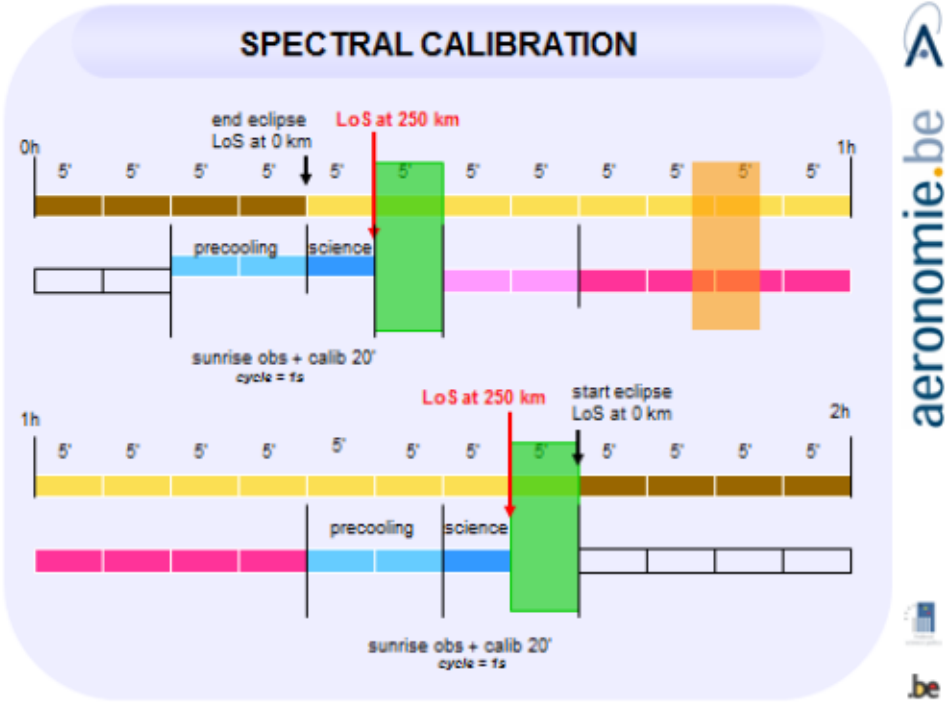


Figure 5-18: Spectral calibration – examples of insertion in mission timeline (during typical orbit in science phase). Orange zone = anytime during dayside, green zone = adjacent to sunrise and/or sunset

5.4.2.3 Stray light calibration

Stray light calibration sessions serve to check the instrument's immunity to stray light generated inside the instrument by the Sun or solar reflection on the S/C.

Insertion in the mission timeline

This calibration session can be performed at any time the spacecraft can be pointed at the Sun, outside the Martian atmosphere.

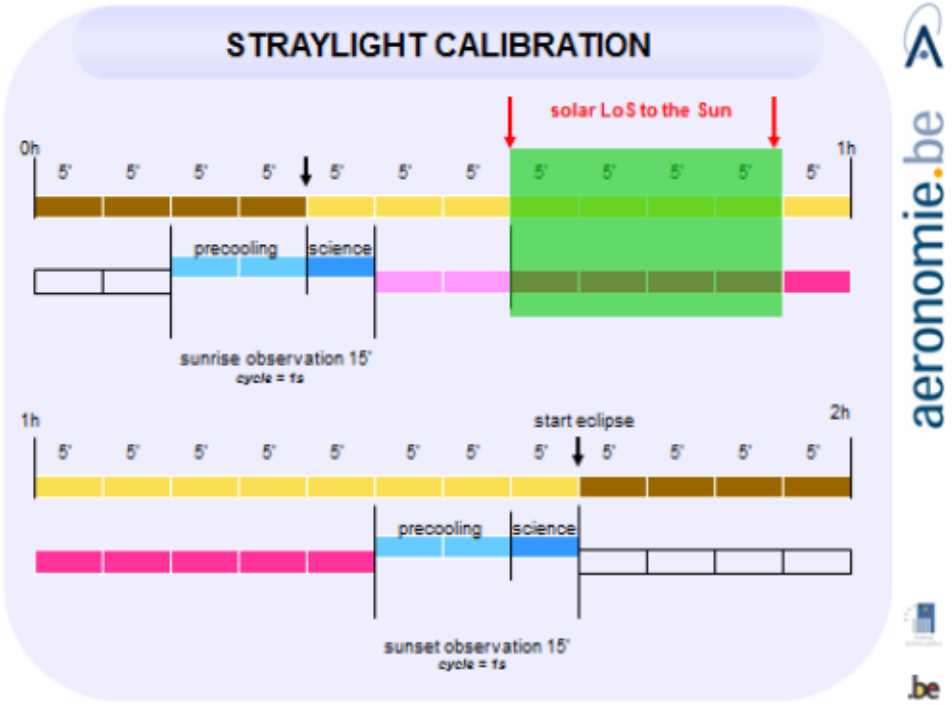


Figure 5-19: Stray light calibration – example of insertion in mission timeline (during typical orbit in science phase). Green zone = anytime during dayside

This calibration session has to be done 2 or 3 times during the mission.

This calibration session can be partly combined with spectral calibration, selector mechanism stepping (UVIS) and LoS mismatch.

5.4.2.4 Dark sky calibration

During dark sky calibration sessions, dark current and (thermal) background measurements are performed for different integration times of the detectors. These measurements are used to calibrate the spectra on the ground.

Insertion in the mission timeline

This calibration session can be performed at any time the spacecraft can be pointed to dark sky (see orange zones in the figure below).

It may be possible to perform dark sky measurements during 'waiting time' after a sunset measurement (on the dark side of Mars). In this particular case it might be acceptable to stay inertially pointed towards the Sun while doing the dark sky calibration, since the planet obscures the Sun. Doing a dark sky calibration immediately after a sunset observation would necessitate performing the dark sky measurement with the same channel as the one used for the sunset observation just in front (taking advantage of the fact that or the SO or the LNO detector is already cooled).

Due to data rate limitations in SINBAD (UVIS performs a full frame measurement) it is not possible to have SO and UVIS or LNO and UVIS switched on together during this type of calibrations. Therefore during a dark sky calibration UVIS will be always calibrated after SO or after LNO.

This calibration session has to be repeated every 2 to 3 months during science phase.

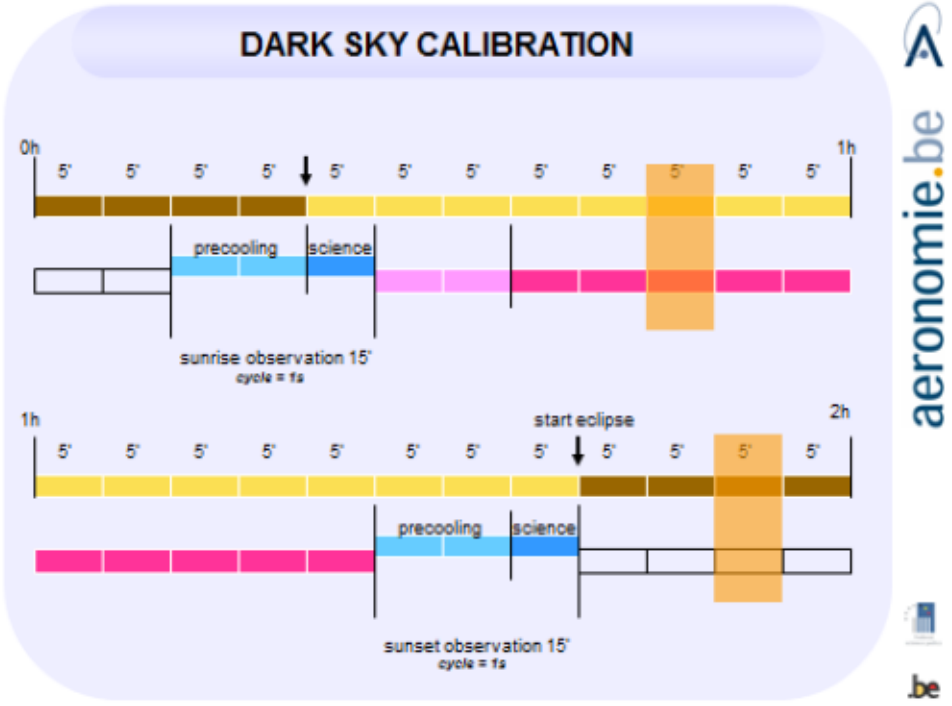


Figure 5-20: Dark sky calibration – examples of insertion in mission timeline (during typical orbit in science phase). Orange zone = anytime dark sky can be pointed

5.4.2.5 General remarks

- In principle calibration of SO is always in parallel with calibration of UVIS (SO/UVIS) except in dark sky calibrations where UVIS calibration comes after SO calibration;
- In principle calibration of LNO is always in parallel with calibration of UVIS (LNO/UVIS)) except in dark sky calibrations where UVIS calibration comes after LNO calibration;
- No dedicated calibration campaigns are foreseen for UVIS;
- SO and LNO cannot be switched on together (by design). Therefore SO/UVIS and LNO/UVIS must be calibrated sequentially, but not necessarily in the same calibration session;
- For LNO calibration the flip mirror is entered in the incoming light beam (solar occultation mode of LNO). For calibration of LNO it is not necessary to point the nadir LoS at the Sun;
- At no time during calibration sessions should the nadir LoS be used;

Each measurement with SO or LNO has to take into account the precooling time for the detectors (typically 10 minutes). During precooling no requirements are imposed on pointing. Detailed in flight procedures, including telecommands, data rate and power consumption are given in Chapter 6

5.5 FAILURE DETECTION AND RECOVERY STRATEGY

There is no strategy implemented to recover data packets transmitted between S/C and NOMAD. Packets that are detected (checksum control) as erroneous will be discarded and the action will be cancelled.

NOMAD has the possibility to turn itself OFF upon detection of a contingency situation.

NOMAD has a telecommand NOMAD_READY_TO_POWER_OFF. This telecommand can be inserted in command sequence (at least 1 second) prior to performing the HPC NOMAD_OFF in order to provoke an orderly shutdown of the instrument.

NOMAD will survive any sudden (non-announced) power shutdown by the S/C.

NOMAD has 4 Contingency Recovery Procedures:

1. redundant switch ON of NOMAD,
2. redundant switch OFF of NOMAD,
3. selection of redundant TC/TM branch,
4. emergency activation of pinpuller in flip mirror mechanism

See details below.

5.5.1 Non-optimal operations

RD-02 describes how NOMAD's onboard computer (SINBAD) checks telecommands received from the spacecraft, detects errors and rejects non-conformant commands. To perform these tasks NOMAD implements its own packet protocol.

The system log sent down over the Spacewire link with the science data (described in RD-02) contains a list of errors generated, with their time stamp, along with other useful data and memory reports requested to check the onboard flight software status. It is understood that ESOC cannot monitor science telemetry for instrument health (TGO-FOP-ALL-0310). Information to allow processing of non-science data will be provided (as per TGO-FOP-ALL-0320)

Software maintenance is also described in RD-02, including a tally of the number of TCs required to patch the memory. In a nominal case, NOMAD requires 9-12 TCs per orbit (112 to 150 per Martian day). This is one to open the file, one to command the observation and one to close the file PER observation (occultation, nadir, occultation). The minimum number of TCs per 12 orbits is therefore 48. Patches fit in the 64 bytes TC size limit imposed by the spacecraft. However, many patches are necessary to update the complete memory; approximately 4227 TCs to modify all observation parameters, and 1409 to update fully the flight software. Despite this NOMAD will comply with the limit of 3000 TCs per operational cycle (max duration 5 days) for the full complement of instruments (we assume 600 for NOMAD).

Onboard software maintenance is compliant with TGO-FOP-ALL-0230, -0240, -0250, -0260, -270 and -0280. Command requests will be handled in compliance with TGO-FOP-ALL-0300.

5.5.2 FDIR

FDIR is implemented in the SINBAD onboard S/W as described in the FDIR analysis *EXM-NO-ANA-SEN-00001-2.0-NOMAD FDIR analysis.*

6 OPERATIONAL PROCEDURES

This chapter contains details on all procedures described in chapter 5.

6.1 ON-GROUND PERFORMANCE VERIFICATION PROCEDURES

6.1.1 Introduction

In order to verify the correct performance of the instrument, e.g. during environmental testing a number of performance verification tests can be executed.

6.1.2 Full solar performance test

Instrument	NOMAD
Title	Full solar performance test
Objective	Verification of NOMAD's functional performance in solar occultation mode
Description	After switch on of SINBAD, the SO and UVIS channel will be switched on and operated. SINBAD will be switched off again
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	17 minutes 30 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.0678	0 (*)
	00.01.35	00.15.20	NO-FCP-014	Perform one observation with SO+UVIS	12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (5')
	00.16.55	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.0678 → 0	0 (*)
	00.17.30			End of sequence	0	0	0

6.1.3 Full nadir performance test

Instrument	NOMAD
Title	Full nadir performance test
Objective	Verification of NOMAD's functional performance in nadir observation mode
Description	After switch on of SINBAD, the LNO and UVIS channel will be switched on and operated. SINBAD will be switched off again. Before starting LNO operation the flip mirror has to be placed in default position
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 3.6576 kbits/s max during precooling phase (UVIS ON during precooling) and 9.8016 kbits/s during science phase
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	53 minutes 30 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.0678	0 (*)
	00.01.35	00.01.00	NO-FCP-031	Flip mirror to default position	12	0.0678	0 (*)
	00.02.35	00.50.20	NO-FCP-015	Perform one observation with LNO+UVIS	12 → 47.9 → 46.9 →12	0.0678	3.6576 (10') 9.8016 (40')
	00.52.55	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.0678 → 0	0 (*)
	00.53.30			End of sequence	0	0	0

6.1.4 Limited performance test SO

Instrument	NOMAD
Title	Limited performance test SO
Objective	Verification of NOMAD SO channel functional performance
Description	After switch on of SINBAD, the SO channel will be switched on and operated (for a limited time). SINBAD will be switched off again
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0523 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 1.936 kbits/s max during precooling phase and 94.1 kbits/s during science phase
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	17 minutes 30 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.0523	0 (*)
	00.01.35	00.15.20	NO-FCP-011	Perform one observation with SO	12 → 43.4 → 42.4 →12	0.0523	1.936 (10') 94.1 (5')
	00.16.55	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.0523 → 0	0 (*)
	00.17.30			End of sequence	0	0	0

6.1.5 Limited performance test LNO

Instrument	NOMAD
Title	Limited performance test LNO
Objective	Verification of NOMAD LNO channel functional performance
Description	After switch on of SINBAD, the LNO channel will be switched on and operated (for a limited time). SINBAD will be switched off again. Before starting LNO operation the flip mirror has to be placed in default position
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0523 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 0.1291 kbits/s max during precooling phase and 6.28 kbits/s during science phase
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	18 minutes 30 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.0523	0 (*)
	00.01.35	00.01.00	NO-FCP-031	Flip mirror to default position	12	0.0523	0 (*)
	00.02.35	00.15.20	NO-FCP-012	Perform one observation with LNO	12 → 43.4 → 42.4 → 12	0.0523	0.1291 (10") 6.28 (5')
	00.17.55	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.0523 → 0	0 (*)
	00.18.30			End of sequence	0	0	0

6.1.6 Limited performance test UVIS

Instrument	NOMAD
Title	Limited performance test UVIS
Objective	Verification of NOMAD UVIS channel functional performance
Description	After switch on of SINBAD, the UVIS channel will be switched on and operated (for a limited time). SINBAD will be switched off again
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0544 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 52.928 kbits/s max
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	7 minutes 30 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.0544	0 (*)
	00.01.35	00.05.20	NO-FCP-013	Perform one observation with UVIS	12 → 16.9 → 12	0.0544	52.928
	00.06.55	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.0544 → 0	0 (*)
	00.07.30			End of sequence	0	0	0

6.1.7 Performance test SINBAD

Instrument	NOMAD
Title	Performance test SINBAD
Objective	Verification of NOMAD SINBAD functional performance
Description	Verification is performed in 2 blocks. **BLOCK 1.** SINBAD is switched on (nominal branch), one single memory byte is patched and SINBAD is switched off again. **BLOCK 2.** SINBAD is switched on (redundant branch), a complex memory pattern is patched and SINBAD is switched off again. **BLOCK 3.** SINBAD is switched on (nominal branch), a series of file system operations is executed and SINBAD is switched off again. **BLOCK 4.** SINBAD is switched on (redundant branch), operational heaters are switched on and off and SINBAD is switched off again
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.039 kbits/s max Telemetry rate from NOMAD to S/C (SpW): only system logs
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	32 minutes 40 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00			START BLOCK 1	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.039	0 (*)
	00.01.35	00.01.20	NO-FCP-021	Single byte patch sequence	12	0.039	0 (*)
	00.01.55	00.00.35	NO-FCP-002	switch off of NOMAD	12 → 0	0.039 → 0	0 (*)
	00.02.30			Wait time	0	0	0
	00.05.00			START BLOCK 2	0	0	0
	00.05.00	00.01.35	NO-FCP-101	Redundant switch on of NOMAD	0 → 12	0 → 0.039	0 (*)
	00.06.35	00.04.00	NO-FCP-022	Complex patch sequence	12	0.039	0 (*)
	00.10.35	00.00.35	NO-FCP-002	switch off of NOMAD	12 → 0	0.039 → 0	0 (*)
	00.11.10			Wait time	0	0	0
	00.12.00			START BLOCK 3	0	0	0
	00.12.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.039	0 (*)
	00.13.35	00.05.30	NO-FCP-023	File system operations	12	0.039	0 (*)
	00.19.05	00.00.35	NO-FCP-002	switch off of NOMAD	12 → 0	0.039 → 0	0 (*)
	00.19.40			Wait time	0	0	0
	00.20.00			START BLOCK 4	0	0	0
	00.20.00	00.01.35	NO-FCP-101	Redundant switch on of NOMAD	0 → 12	0 → 0.039	0 (*)
	00.21.35	00.10.30	NO-CRP-551	Switching of operational heaters	24	0.039	0 (*)
	00.32.05	00.00.35	NO-FCP-002	switch off of NOMAD	12 → 0	0.039 → 0	0 (*)
	00.32.40			End of sequence	0	0	0

6.1.8 GO-NO-GO test

Instrument	NOMAD
Title	Go-no-go test of SINBAD
Objective	Quick verification of NOMAD SINBAD functional performance
Description	SINBAD is switched on (nominal branch) and switched off again (nominal branch). In between no actions are taken. SINBAD is in safe mode and will send housekeeping and telemetry data.
Instrument configuration	NOMAD integrated on S/C or S/C simulation bench No stimuli
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.039 kbits/s max Telemetry rate from NOMAD to S/C (SpW): only system logs
Environmental constraints	N/A
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	5 minutes 35 seconds

Sequence	Overall delta time	Procedure duration	Procedure Code	Procedure Name	Power (W)	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence	0	0	0
	00.00.00	00.01.35	NO-FCP-001	Nominal switch on of NOMAD	0 → 12	0 → 0.039	0 (*)
	00.01.35			Wait time	12	0.039	0 (*)
	00.05.00	00.00.35	NO-FCP-002	Nominal switch off of NOMAD	12 → 0	0.039 → 0	0 (*)
	00.05.35			End of sequence	0	0	0

6.1.9 Specific verification procedures for X-check at TAS-F

6.1.9.1 Generic sequence

The following generic verification sequence is proposed:

STEP	ACTION	FLIGHT CONTROL PROCEDURE (as per NOMAD User Manual)	DESCRIPTION
	Execute the yellow highlighted cells only when NOMAD has been powered off previously following the emergency power off procedure (without using the TC(50) "Ready to Power Off") instead of the nominal power off procedure		
1	Open PDHU file	TAS responsibility	opens PDHU file
2	WAIT 00:00:02		wait 2 seconds
3	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
4	WAIT 00:05:00		waits 5 minutes
5	TC(50) - READY TO POWER OFF (see 6.1.9.2.5 and/or 6.1.9.4.5)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
6	WAIT 00:00:30		waits 30 seconds
7	NOMAD OFF NOMINAL		high power command switches NOMAD off via nominal power line
8	WAIT 00:00:02	TAS responsibility	waits 2 seconds
9	Close PDHU file		closes the PDHU file
10	Open PDHU file	TAS responsibility	opens PDHU file
11	WAIT 00:00:02		wait 2 seconds
12	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
13	WAIT 00:00:30		waits 30 seconds
14	TC(20) – SO+UVIS (see 6.1.9.2.1 and/or 6.1.9.4.1)	NO-FCP-014	executes an observation with the SO and UVIS channel

15	WAIT 00:16:00		waits 16 minutes
16	TC(70) – FMM TO SOLAR (see 6.1.9.2.2 and/or 6.1.9.4.2)	NO-FCP-031B	puts flip mirror mechanism in solar position
17	WAIT 00:01:00		waits 1 minute
18	TC(20) – LNO+UVIS (see 6.1.9.2.3 and/or 6.1.9.4.3)	NO-FCP-015	executes an observation with the LNO and UVIS channel
19	WAIT 00:16:00		waits 16 minutes
20	TC(70) – FMM TO LAUNCH (see 6.1.9.2.4 and/or 6.1.9.4.4)	NO-FCP-031C	puts flip mirror mechanism in launch position
21	WAIT 00:01:00		waits 1 minute
22	TC(50) - READY TO POWER OFF (see 6.1.9.2.5 and/or 6.1.9.4.5)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
23	WAIT 00:00:30		waits 30 seconds
24	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
25	WAIT 00:00:02	TAS responsibility	waits 2 seconds
26	Close PDHU file		closes the PDHU file

(*) in NO-FCP-002 procedure also the redundant power line is switched off by HPC "NOMAD OFF REDUNDANT". This is not necessary in this procedure, as the instrument has been switched on by the nominal power line in NO-FCP-001.

The total duration (run time) of the sequence is approximately 35 minutes.

This verification sequence can be run once or several times (depending on available time).

For functional checking the NOMAD team typically runs this sequence twice, but with different parameter values in the two runs for the TC(20)-commands (see below)

For X-check tests in TAS-F the following is proposed:

- Run the sequence twice with different TC20-parameters in each run (i.e. perform typical NOMAD functional check). Leave 5 to 10 minutes between 2 runs. Telecommands for run 1 are described below in 6.1.9.2, Telecommands for run 2 are described below in 6.1.9.4.

6.1.9.2 Telecommand parameters first run

Note: the following TC strings are the "useful" contents of the TC. These strings have to be preceeded by the 1553 header (CW RT Address, CW Direction, CW RT SubAddress, CW Word Count) (TAS responsibility).

6.1.9.2.1 SO + UVIS

The TC(20) for the observation SO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 8A

This telecommand contains the following parameters:

			start operation SO+UVIS	
			NO-FCP-014	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	10	00 0A
SO_START_SCIENCE_1	2 bytes	NMTC2002	640	02 80
SO_START_SCIENCE_2	2 bytes	NMTC2003	810	03 2A
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	30	1E
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	30	1E
SO_DURATION_TIME	2 bytes	NMTC2006	900	03 84
SO_COP_GENERAL	1 byte	NMTC2007	102	66
SO_COP_PRECOOLING	1 byte	NMTC2008	1	01
SO_COP_SCIENCE_1	2 bytes	NMTC2009	3279	0C CF
SO_COP_SCIENCE_2	2 bytes	NMTC2010	3279	0C CF
LNO_START_TIME	2 bytes	NMTC2011	0	00 00
LNO_START_SCIENCE_1	2 bytes	NMTC2012	0	00 00
LNO_START_SCIENCE_2	2 bytes	NMTC2013	0	00 00
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	0	00
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	0	00
LNO_DURATION_TIME	2 bytes	NMTC2016	0	00 00
LNO_COP_GENERAL	1 byte	NMTC2017	0	00
LNO_COP_PRECOOLING	1 byte	NMTC2018	0	00
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	0	00 00
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	0	00 00
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	32	00 20
CHECKSUM	2 bytes			04 8A

6.1.9.2.2 Flip mirror to solar position

The TC(70) to put the flip mirror in solar position (NO-FCP-032) in hexadecimal format is:

0x 46 00 00 0b 0b 0c 02 ee 02 01 5A

This telecommand contains the following parameters:

			flip mirror to solar position NO-FCP-031B	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0B
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5A

6.1.9.2.3 LNO + UVIS

The TC(20) for the observation LNO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 b4 01 0c ee 0c ee 02 62 01 2c 01 60 05 57

This telecommand contains the following parameters:

			start operation LNO+UVIS	
			NO-FCP-015	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	0	00 00
SO_START_SCIENCE_1	2 bytes	NMTC2002	0	00 00
SO_START_SCIENCE_2	2 bytes	NMTC2003	0	00 00
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	0	00
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	0	00
SO_DURATION_TIME	2 bytes	NMTC2006	0	00 00
SO_COP_GENERAL	1 byte	NMTC2007	0	00
SO_COP_PRECOOLING	1 byte	NMTC2008	0	00
SO_COP_SCIENCE_1	2 bytes	NMTC2009	0	00 00
SO_COP_SCIENCE_2	2 bytes	NMTC2010	0	00 00
LNO_START_TIME	2 bytes	NMTC2011	10	00 0A
LNO_START_SCIENCE_1	2 bytes	NMTC2012	640	02 80
LNO_START_SCIENCE_2	2 bytes	NMTC2013	810	03 2A
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	30	1E
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	30	1E
LNO_DURATION_TIME	2 bytes	NMTC2016	900	03 84
LNO_COP_GENERAL	1 byte	NMTC2017	180	B4
LNO_COP_PRECOOLING	1 byte	NMTC2018	1	01
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	3310	0C EE
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	3310	0C EE
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	352	01 60
CHECKSUM	2 bytes			05 57

6.1.9.2.4 Flip mirror to launch position

The TC(70) to put the flip mirror in launch position (NO-FCP-033) in hexadecimal format is:

0x 46 00 00 0b 0c 0c 02 ee 02 01 5B

This telecommand contains the following parameters:

			flip mirror to launch position	
			NO-FCP-031C	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0C
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5B

6.1.9.2.5 Ready to power NOMAD off

The TC(50) to warn NOMAD that switching off is imminent in hexadecimal format is:

0x 32 00 00 06 00 38

This telecommand contains the following parameters:

			ready to power off	
			NO-FCP-002	
			DEC	HEX
TYPE	1 byte		50	32
LENGTH	3 bytes		6	00 00 06
CHECKSUM	2 bytes			00 38

6.1.9.3 Summary telecommand list first run

The list of telecommands (real values) during the first run of the sequence is then:

STEP	TELECOMMAND
	Yellow highlighted lines only when previous power off was not nominal
1	Open PDHU file
2	WAIT 00:00:02
3	NOMAD ON NOMINAL
4	WAIT 00:05:00
5	TC(50) - READY TO POWER OFF 0x 32 00 00 06 00 38
6	WAIT 00:00:30
7	NOMAD OFF NOMINAL
8	WAIT 00:00:02
9	Close PDHU file
10	Open PDHU file
11	WAIT 00:00:02
12	NOMAD ON NOMINAL
13	WAIT 00:00:30
14	TC(20) – SO+UVIS 0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 8A
15	WAIT 00:16:00
16	TC(70) – FMM TO SOLAR 0x 46 00 00 0b 0b 0c 02 ee 02 01 5A
17	WAIT 00:01:00
18	TC(20) – LNO+UVIS 0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 b4 01 0c ee 0c ee 02 62 01 2c 01 60 05 57
19	WAIT 00:16:00
20	TC(70) – FMM TO LAUNCH 0x 46 00 00 0b 0c 0c 02 ee 02 01 5B
21	WAIT 00:01:00
22	TC(50) - READY TO POWER OFF 0x 32 00 00 06 00 38
23	WAIT 00:00:30
24	NOMAD OFF NOMINAL

25	WAIT 00:00:02
26	Close PDHU file

6.1.9.4 Telecommand parameters second run

Note: the following TC strings are the "useful" contents of the TC. These strings have to be preceeded by the 1553 header (CW RT Address, CW Direction, CW RT SubAddress, CW Word Count) (TAS responsibility).

6.1.9.4.1 SO+UVIS

The TC(20) for the observation SO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 9b 01 0c a4 0c a4 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 69

This telecommand contains the following parameters:

			start operation SO+UVIS	
			NO-FCP-014	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	10	00 0A
SO_START_SCIENCE_1	2 bytes	NMTC2002	640	02 80
SO_START_SCIENCE_2	2 bytes	NMTC2003	810	03 2A
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	30	1E
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	30	1E
SO_DURATION_TIME	2 bytes	NMTC2006	900	03 84
SO_COP_GENERAL	1 byte	NMTC2007	155	9B
SO_COP_PRECOOLING	1 byte	NMTC2008	1	01
SO_COP_SCIENCE_1	2 bytes	NMTC2009	3236	0C A4
SO_COP_SCIENCE_2	2 bytes	NMTC2010	3236	0C A4
LNO_START_TIME	2 bytes	NMTC2011	0	00 00
LNO_START_SCIENCE_1	2 bytes	NMTC2012	0	00 00
LNO_START_SCIENCE_2	2 bytes	NMTC2013	0	00 00
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	0	00
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	0	00
LNO_DURATION_TIME	2 bytes	NMTC2016	0	00 00
LNO_COP_GENERAL	1 byte	NMTC2017	0	00
LNO_COP_PRECOOLING	1 byte	NMTC2018	0	00
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	0	00 00
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	0	00 00
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	32	00 20
CHECKSUM	2 bytes			04 69

6.1.9.4.2 Flip mirror to solar position

The TC(70) to put the flip mirror in solar position (NO-FCP-032) in hexadecimal format is:

0x 46 00 00 0b 0b 0c 02 ee 02 01 5A

This telecommand contains the following parameters:

			flip mirror to solar position	
			NO-FCP-031B	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0B
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5A

6.1.9.4.3 LNO + UVIS

The TC(20) for the observation LNO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 1e 01 0d 99 0d 99 02 62 01 2c 01 60 04 19

This telecommand contains the following parameters:

			start operation LNO+UVIS	
			NO-FCP-015	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	0	00 00
SO_START_SCIENCE_1	2 bytes	NMTC2002	0	00 00
SO_START_SCIENCE_2	2 bytes	NMTC2003	0	00 00
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	0	00
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	0	00
SO_DURATION_TIME	2 bytes	NMTC2006	0	00 00
SO_COP_GENERAL	1 byte	NMTC2007	0	00
SO_COP_PRECOOLING	1 byte	NMTC2008	0	00
SO_COP_SCIENCE_1	2 bytes	NMTC2009	0	00 00
SO_COP_SCIENCE_2	2 bytes	NMTC2010	0	00 00
LNO_START_TIME	2 bytes	NMTC2011	10	00 0A
LNO_START_SCIENCE_1	2 bytes	NMTC2012	640	02 80
LNO_START_SCIENCE_2	2 bytes	NMTC2013	810	03 2A
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	30	1E
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	30	1E
LNO_DURATION_TIME	2 bytes	NMTC2016	900	03 84
LNO_COP_GENERAL	1 byte	NMTC2017	30	1E
LNO_COP_PRECOOLING	1 byte	NMTC2018	1	01
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	3481	0D 99
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	3481	0D 99
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	352	01 60
CHECKSUM	2 bytes			04 19

6.1.9.4.4 Flip mirror to launch position

The TC(70) to put the flip mirror in launch position (NO-FCP-033) in hexadecimal format is:

0x 46 00 00 0b 0c 0c 02 ee 02 01 5B

This telecommand contains the following parameters:

			flip mirror to launch position	
			NO-FCP-031C	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0C
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5B

6.1.9.4.5 Ready to power NOMAD off

The TC(50) to warn NOMAD that switching off is imminent in hexadecimal format is:

0x 32 00 00 06 00 38

This telecommand contains the following parameters:

			ready to power off	
			NO-FCP-002	
			DEC	HEX
TYPE	1 byte		50	32
LENGTH	3 bytes		6	00 00 06
CHECKSUM	2 bytes			00 38

6.1.9.5 Summary telecommand list second run

The list of telecommands (real values) during the second run of the sequence is then:

STEP	TELECOMMAND
	Yellow highlighted lines only when previous power off was not nominal
1	Open PDHU file
2	WAIT 00:00:02
3	NOMAD ON NOMINAL
4	WAIT 00:05:00
5	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
6	WAIT 00:00:30
7	NOMAD OFF NOMINAL
8	WAIT 00:00:02
9	Close PDHU file
10	Open PDHU file
11	WAIT 00:00:02
12	NOMAD ON NOMINAL
13	WAIT 00:00:30
14	TC(20) – SO+UVIS **0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 9b 01 0c a4 0c a4 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 69**
15	WAIT 00:16:00
16	TC(70) – FMM TO SOLAR **0x 46 00 00 0b 0b 0c 02 ee 02 01 5A**
17	WAIT 00:01:00
18	TC(20) – LNO+UVIS **0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 1e 01 0d 99 0d 99 02 62 01 2c 01 60 04 19**
19	WAIT 00:16:00
20	TC(70) – FMM TO LAUNCH **0x 46 00 00 0b 0c 0c 02 ee 02 01 5B**
21	WAIT 00:01:00
22	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
23	WAIT 00:00:30
24	NOMAD OFF NOMINAL

25	WAIT 00:00:02
26	Close PDHU file

6.1.10 Specific verification procedures for TVC functional test at TAS-F

The purpose of this procedure is to execute a "short" functional check during thermal cycle testing

6.1.10.1 Generic sequence

The following generic verification sequence is proposed:

STEP	ACTION	FLIGHT CONTROL PROCEDURE (as per NOMAD User Manual)	DESCRIPTION
	Execute the yellow highlighted cells only when NOMAD has been powered off previously following the emergency power off procedure (without using the TC(50) "Ready to Power Off") instead of the nominal power off procedure		
1	Open PDHU file	TAS responsibility	opens PDHU file
2	WAIT 00:00:02		wait 2 seconds
3	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
4	WAIT 00:05:00		waits 5 minutes
5	TC(50) - READY TO POWER OFF (see 6.1.10.2.5)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
6	WAIT 00:00:30		waits 30 seconds
7	NOMAD OFF NOMINAL		high power command switches NOMAD off via nominal power line
8	WAIT 00:00:02	TAS responsibility	waits 2 seconds
9	Close PDHU file		closes the PDHU file
10	Open PDHU file	TAS responsibility	opens PDHU file
11	WAIT 00:00:02		wait 2 seconds
12	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
13	WAIT 00:00:30		waits 30 seconds
14	TC(20) – SO+UVIS (see 6.1.10.2.1)	NO-FCP-014	executes an observation with the SO and UVIS

			channel
15	WAIT 00:16:00		waits 16 minutes
16	TC(70) – FMM TO SOLAR (see 6.1.10.2.2)	NO-FCP-031B	puts flip mirror mechanism in solar position
17	WAIT 00:01:00		waits 1 minute
18	TC(20) – LNO+UVIS (see 6.1.10.2.3)	NO-FCP-015	executes an observation with the LNO and UVIS channel
19	WAIT 00:16:00		waits 16 minutes
20	TC(70) – FMM TO LAUNCH (see 6.1.10.2.4)	NO-FCP-031C	puts flip mirror mechanism in launch position
21	WAIT 00:01:00		waits 1 minute
22	TC(50) - READY TO POWER OFF (see 6.1.10.2.5)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
23	WAIT 00:00:30		waits 30 seconds
24	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
25	WAIT 00:00:02	TAS responsibility	waits 2 seconds
26	Close PDHU file		closes the PDHU file

(*) in NO-FCP-002 procedure also the redundant power line is switched off by HPC "NOMAD OFF REDUNDANT". This is not necessary in this procedure, as the instrument has been switched on by the nominal power line in NO-FCP-001.

The total duration (run time) of the sequence is approximately 35 minutes.

6.1.10.2 Telecommand parameters

Note: the following TC strings are the "useful" contents of the TC. These strings have to be preceeded by the 1553 header (CW RT Address, CW Direction, CW RT SubAddress, CW Word Count) (TAS responsibility).

6.1.10.2.1 SO + UVIS

The TC(20) for the observation SO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 8A

This telecommand contains the following parameters:

			start operation SO+UVIS	
			NO-FCP-014	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	10	00 0A
SO_START_SCIENCE_1	2 bytes	NMTC2002	640	02 80
SO_START_SCIENCE_2	2 bytes	NMTC2003	810	03 2A
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	30	1E
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	30	1E
SO_DURATION_TIME	2 bytes	NMTC2006	900	03 84
SO_COP_GENERAL	1 byte	NMTC2007	102	66
SO_COP_PRECOOLING	1 byte	NMTC2008	1	01
SO_COP_SCIENCE_1	2 bytes	NMTC2009	3279	0C CF
SO_COP_SCIENCE_2	2 bytes	NMTC2010	3279	0C CF
LNO_START_TIME	2 bytes	NMTC2011	0	00 00
LNO_START_SCIENCE_1	2 bytes	NMTC2012	0	00 00
LNO_START_SCIENCE_2	2 bytes	NMTC2013	0	00 00
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	0	00
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	0	00
LNO_DURATION_TIME	2 bytes	NMTC2016	0	00 00
LNO_COP_GENERAL	1 byte	NMTC2017	0	00
LNO_COP_PRECOOLING	1 byte	NMTC2018	0	00
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	0	00 00
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	0	00 00
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	32	00 20
CHECKSUM	2 bytes			04 8A

6.1.10.2.2 Flip mirror to solar position

The TC(70) to put the flip mirror in solar position (NO-FCP-032) in hexadecimal format is:

0x 46 00 00 0b 0b 0c 02 ee 02 01 5A

This telecommand contains the following parameters:

			flip mirror to solar position	
			NO-FCP-031B	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0B
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5A

6.1.10.2.3 LNO + UVIS

The TC(20) for the observation LNO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 b4 01 0c ee 0c ee 02 62 01 2c 01 60 05 57

This telecommand contains the following parameters:

			start operation LNO+UVIS	
			NO-FCP-015	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	0	00 00
SO_START_SCIENCE_1	2 bytes	NMTC2002	0	00 00
SO_START_SCIENCE_2	2 bytes	NMTC2003	0	00 00
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	0	00
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	0	00
SO_DURATION_TIME	2 bytes	NMTC2006	0	00 00
SO_COP_GENERAL	1 byte	NMTC2007	0	00
SO_COP_PRECOOLING	1 byte	NMTC2008	0	00
SO_COP_SCIENCE_1	2 bytes	NMTC2009	0	00 00
SO_COP_SCIENCE_2	2 bytes	NMTC2010	0	00 00
LNO_START_TIME	2 bytes	NMTC2011	10	00 0A
LNO_START_SCIENCE_1	2 bytes	NMTC2012	640	02 80
LNO_START_SCIENCE_2	2 bytes	NMTC2013	810	03 2A
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	30	1E
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	30	1E
LNO_DURATION_TIME	2 bytes	NMTC2016	900	03 84
LNO_COP_GENERAL	1 byte	NMTC2017	180	B4
LNO_COP_PRECOOLING	1 byte	NMTC2018	1	01
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	3310	0C EE
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	3310	0C EE
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	300	01 2C
UVIS_COP_ROW	2 bytes	NMTC2023	352	01 60
CHECKSUM	2 bytes			05 57

6.1.10.2.4 Flip mirror to launch position

The TC(70) to put the flip mirror in launch position (NO-FCP-033) in hexadecimal format is:

0x 46 00 00 0b 0c 0c 02 ee 02 01 5B

This telecommand contains the following parameters:

			flip mirror to launch position NO-FCP-031C	
			DEC	HEX
TYPE	1 byte		70	46
LENGTH	3 bytes		11	00 00 0B
OPERATION_CODE	1 byte	NMTC7001	11	0C
STEPPER_SPEED	1 byte	NMTC7002	12	0C
MAX_STEP_NUMBER	2 bytes	NMTC7003	750	02 EE
(1 bit) LS_NADIR_NOMINAL_ENABLING	1 byte	NMTC7004	0	02
(1 bit) LS_NADIR_OVERSHOOT_ENABLING		NMTC7005	0	
(1 bit) LS_SOLAR_NOMINAL_ENABLING		NMTC7006	1	
(1 bit) LS_SOLAR_OVERSHOOT_ENABLING		NMTC7007	0	
CHECKSUM	2 bytes			01 5B

6.1.10.2.5 Ready to power NOMAD off

The TC(50) to warn NOMAD that switching off is imminent in hexadecimal format is:

0x 32 00 00 06 00 38

This telecommand contains the following parameters:

			ready to power off NO-FCP-002	
			DEC	HEX
TYPE	1 byte		50	32
LENGTH	3 bytes		6	00 00 06
CHECKSUM	2 bytes			00 38

6.1.10.3 Summary telecommand list

The list of telecommands (real values) during the first run of the sequence is then:

STEP	TELECOMMAND
	Yellow highlighted lines only when previous power off was not nominal
1	Open PDHU file
2	WAIT 00:00:02
3	NOMAD ON NOMINAL
4	WAIT 00:05:00
5	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
6	WAIT 00:00:30
7	NOMAD OFF NOMINAL
8	WAIT 00:00:02
9	Close PDHU file
10	Open PDHU file
11	WAIT 00:00:02
12	NOMAD ON NOMINAL
13	WAIT 00:00:30
14	TC(20) – SO+UVIS **0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 8A**
15	WAIT 00:16:00
16	TC(70) – FMM TO SOLAR **0x 46 00 00 0b 0b 0c 02 ee 02 01 5A**
17	WAIT 00:01:00
18	TC(20) – LNO+UVIS **0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 b4 01 0c ee 0c ee 02 62 01 2c 01 60 05 57**
19	WAIT 00:16:00
20	TC(70) – FMM TO LAUNCH **0x 46 00 00 0b 0c 0c 02 ee 02 01 5B**
21	WAIT 00:01:00
22	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
23	WAIT 00:00:30

24	NOMAD OFF NOMINAL
25	WAIT 00:00:02
26	Close PDHU file

6.1.11 Specific procedure for TVC –science orbit simulation at TAS-F

6.1.11.1 Generic sequence

The following generic verification sequence is proposed, it consists of the consecutive execution of the two "single" runs (green resp blue cells), spaced apart by a period of 40 minutes where NOMAD is placed in safe mode (orange cells).

STEP	ACTION	FLIGHT CONTROL PROCEDURE (as per NOMAD User Manual)	DESCRIPTION
	Execute the yellow highlighted cells only when NOMAD has been powered off previously following the emergency power off procedure (without using the TC(50) "Ready to Power Off") instead of the nominal power off procedure		
1	Open PDHU file	TAS responsibility	opens PDHU file
2	WAIT 00:00:02		wait 2 seconds
3	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
4	WAIT 00:05:00		waits 5 minutes
5	TC(50) - READY TO POWER OFF	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
6	WAIT 00:00:30		waits 30 seconds
7	NOMAD OFF NOMINAL		high power command switches NOMAD off via nominal power line
8	WAIT 00:00:02	TAS responsibility	waits 2 seconds
9	Close PDHU file		closes the PDHU file
10	Open PDHU file	TAS responsibility	opens PDHU file
11	WAIT 00:00:02		wait 2 seconds
12	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
13	WAIT 00:00:30		waits 30 seconds
14	TC(20) – SO+UVIS	NO-FCP-014	executes an observation with the SO and UVIS channel

15	WAIT 00:16:00		waits 16 minutes
16	TC(70) – FMM TO SOLAR	NO-FCP-031B	puts flip mirror mechanism in solar position
17	WAIT 00:01:00		waits 1 minute
18	TC(20) – LNO+UVIS	NO-FCP-015	executes an observation with the LNO and UVIS channel
19	WAIT 00:16:00		waits 16 minutes
20	TC(70) – FMM TO LAUNCH	NO-FCP-031C	puts flip mirror mechanism in launch position
21	WAIT 00:01:00		waits 1 minute
22	TC(50) - READY TO POWER OFF	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
23	WAIT 00:00:30		waits 30 seconds
24	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
25	WAIT 00:00:02	TAS responsibility	waits 2 seconds
26	Close PDHU file		closes the PDHU file
27	WAIT 00:00:30		waits 30 seconds
28	Open PDHU file	TAS responsibility	opens PDHU file
29	WAIT 00:00:02		wait 2 seconds
30	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
31	WAIT 00:40:00		waits 40 minutes
32	TC(50) - READY TO POWER OFF	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
33	WAIT 00:00:30		waits 30 seconds
34	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
35	WAIT 00:00:02	TAS responsibility	waits 2 seconds
36	Close PDHU file		closes the PDHU file

37	WAIT 00:00:30		waits 30 seconds
38	Open PDHU file	TAS responsibility	opens PDHU file
39	WAIT 00:00:02		wait 2 seconds
40	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
41	WAIT 00:00:30		waits 30 seconds
42	TC(20) – SO+UVIS	NO-FCP-014	executes an observation with the SO and UVIS channel
43	WAIT 00:16:00		waits 16 minutes
44	TC(70) – FMM TO SOLAR	NO-FCP-031B	puts flip mirror mechanism in solar position
45	WAIT 00:01:00		waits 1 minute
46	TC(20) – LNO+UVIS	NO-FCP-015	executes an observation with the LNO and UVIS channel
47	WAIT 00:16:00		waits 16 minutes
48	TC(70) – FMM TO LAUNCH	NO-FCP-031C	puts flip mirror mechanism in launch position
49	WAIT 00:01:00		waits 1 minute
50	TC(50) - READY TO POWER OFF	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
51	WAIT 00:00:30		waits 30 seconds
52	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
53	WAIT 00:00:02	TAS responsibility	waits 2 seconds
54	Close PDHU file		closes the PDHU file

(*) in NO-FCP-002 procedure also the redundant power line is switched off by HPC "NOMAD OFF REDUNDANT". This is not necessary in this procedure, as the instrument has been switched on by the nominal power line in NO-FCP-001.

The total duration (run time) of the sequence is approximately 112 minutes.

6.1.11.2 Summary telecommand list

The list of telecommands (real values) during a science orbit simulation is:

STEP	TELECOMMAND
	Yellow highlighted lines only when previous power off was not nominal
1	Open PDHU file
2	WAIT 00:00:02
3	NOMAD ON NOMINAL
4	WAIT 00:05:00
5	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
6	WAIT 00:00:30
7	NOMAD OFF NOMINAL
8	WAIT 00:00:02
9	Close PDHU file
10	Open PDHU file
11	WAIT 00:00:02
12	NOMAD ON NOMINAL
13	WAIT 00:00:30
14	TC(20) – SO+UVIS **0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 8A**
15	WAIT 00:16:00
16	TC(70) – FMM TO SOLAR **0x 46 00 00 0b 0b 0c 02 ee 02 01 5A**
17	WAIT 00:01:00
18	TC(20) – LNO+UVIS **0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 b4 01 0c ee 0c ee 02 62 01 2c 01 60 05 57**
19	WAIT 00:16:00
20	TC(70) – FMM TO LAUNCH **0x 46 00 00 0b 0c 0c 02 ee 02 01 5B**
21	WAIT 00:01:00
22	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
23	WAIT 00:00:30

24	NOMAD OFF NOMINAL
25	WAIT 00:00:02
26	Close PDHU file
27	WAIT 00:00:30
28	Open PDHU file
29	WAIT 00:00:02
30	NOMAD ON NOMINAL
31	WAIT 00:40:00
32	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
33	WAIT 00:00:30
34	NOMAD OFF NOMINAL
35	WAIT 00:00:02
36	Close PDHU file
37	WAIT 00:00:30
38	Open PDHU file
39	WAIT 00:00:02
40	NOMAD ON NOMINAL
41	WAIT 00:00:30
42	TC(20) – SO+UVIS **0x 14 00 00 2C 00 0a 02 80 03 2a 1e 1e 03 84 9b 01 0c a4 0c a4 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 01 2c 00 20 04 69**
43	WAIT 00:16:00
44	TC(70) – FMM TO SOLAR **0x 46 00 00 0b 0b 0c 02 ee 02 01 5A**
45	WAIT 00:01:00
46	TC(20) – LNO+UVIS **0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 03 84 1e 01 0d 99 0d 99 02 62 01 2c 01 60 04 19**
47	WAIT 00:16:00
48	TC(70) – FMM TO LAUNCH **0x 46 00 00 0b 0c 0c 02 ee 02 01 5B**

49	WAIT 00:01:00
50	TC(50) - READY TO POWER OFF 0x 32 00 00 06 00 38
51	WAIT 00:00:30
52	NOMAD OFF NOMINAL
53	WAIT 00:00:02
54	Close PDHU file

6.1.12 Specific verification procedures for EMC-test at TAS-F

6.1.12.1 Generic sequence

The following generic verification sequence is proposed:

STEP	ACTION	FLIGHT CONTROL PROCEDURE (as per NOMAD User Manual)	DESCRIPTION
	Execute the yellow highlighted cells only when NOMAD has been powered off previously following the emergency power off procedure (without using the TC(50) "Ready to Power Off") instead of the nominal power off procedure		
1	Open PDHU file	TAS responsibility	opens PDHU file
2	WAIT 00:00:02		wait 2 seconds
3	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
4	WAIT 00:05:00		waits 5 minutes
5	TC(50) - READY TO POWER OFF (see 6.1.12.2.3)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
6	WAIT 00:00:30		waits 30 seconds
7	NOMAD OFF NOMINAL		high power command switches NOMAD off via nominal power line
8	WAIT 00:00:02	TAS responsibility	waits 2 seconds
9	Close PDHU file		closes the PDHU file
10	Open PDHU file	TAS responsibility	opens PDHU file
11	WAIT 00:00:02		wait 2 seconds
12	NOMAD ON NOMINAL	NO-FCP-001	high power command switches NOMAD on via nominal power line
13	WAIT 00:00:30		waits 30 seconds
14	TC(20) – SO+UVIS (see 6.1.12.2.1)	NO-FCP-014	executes an observation with the SO and UVIS channel

15	WAIT 00:36:00		waits 36 minutes
16	TC(20) – LNO+UVIS (see 6.1.12.2.2)	NO-FCP-015	executes an observation with the LNO and UVIS channel
17	WAIT 00:36:00		waits 36 minutes
18	TC(50) - READY TO POWER OFF (see 6.1.12.2.3)	NO-FCP-002 (*)	inform SINBAD that switch off is imminent
19	WAIT 00:00:30		waits 30 seconds
20	NOMAD OFF NOMINAL (NOMAD OFF REDUNDANT)		high power command switches NOMAD off via nominal power line
21	WAIT 00:00:02	TAS responsibility	waits 2 seconds
22	Close PDHU file		closes the PDHU file

(*) in NO-FCP-002 procedure also the redundant power line is switched off by HPC "NOMAD OFF REDUNDANT". This is not necessary in this procedure, as the instrument has been switched on by the nominal power line in NO-FCP-001.

The total duration (run time) of the sequence is approximately 73 minutes.

For upcoming EMC tests in TAS-F the following is proposed:

- run the sequence once with the TC20-parameters given in 6.1.12.2.
- NOMAD is in full operation, with highest power consumption, and maximum radiated emission in the period after TC20 (step 14 and step 16). Representative EMC measurement are therefore best conducted during the 36 minutes wait times of step 15 and step 17 (preferably from minute 6 to minute 35).

6.1.12.2 Telecommand parameters EMC run

Note: the following TC strings are the "useful" contents of the TC. These strings have to be preceeded by the 1553 header (CW RT Address, CW Direction, CW RT SubAddress, CW Word Count) (TAS responsibility).

6.1.12.2.1 SO + UVIS

The TC(20) for the observation SO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2c 00 0a 02 80 03 2a 1e 1e 08 34 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 05 dc 00 20 04 f3

This telecommand contains the following parameters:

			start operation SO+UVIS	
			NO-FCP-014	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	10	00 0A
SO_START_SCIENCE_1	2 bytes	NMTC2002	640	02 80
SO_START_SCIENCE_2	2 bytes	NMTC2003	810	03 2A
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	30	1E
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	30	1E
SO_DURATION_TIME	2 bytes	NMTC2006	2100	08 34
SO_COP_GENERAL	1 byte	NMTC2007	102	66
SO_COP_PRECOOLING	1 byte	NMTC2008	1	01
SO_COP_SCIENCE_1	2 bytes	NMTC2009	3279	0C CF
SO_COP_SCIENCE_2	2 bytes	NMTC2010	3279	0C CF
LNO_START_TIME	2 bytes	NMTC2011	0	00 00
LNO_START_SCIENCE_1	2 bytes	NMTC2012	0	00 00
LNO_START_SCIENCE_2	2 bytes	NMTC2013	0	00 00
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	0	00
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	0	00
LNO_DURATION_TIME	2 bytes	NMTC2016	0	00 00
LNO_COP_GENERAL	1 byte	NMTC2017	0	00
LNO_COP_PRECOOLING	1 byte	NMTC2018	0	00
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	0	00 00
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	0	00 00
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	1500	05 DC
UVIS_COP_ROW	2 bytes	NMTC2023	32	00 20
CHECKSUM	2 bytes			04 F3

6.1.12.2.2 LNO + UVIS

The TC(20) for the observation LNO+UVIS (NO-FCP-014) in hexadecimal format is:

0x 14 00 00 2C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 08 34 b4 01 0c ee 0c ee 02 62 05 dc 01 60 05 c0

This telecommand contains the following parameters:

			start operation LNO+UVIS	
			NO-FCP-015	
			DEC	HEX
TYPE	1 byte		20	14
LENGTH	3 bytes		44	00 00 2C
SO_START_TIME	2 bytes	NMTC2001	0	00 00
SO_START_SCIENCE_1	2 bytes	NMTC2002	0	00 00
SO_START_SCIENCE_2	2 bytes	NMTC2003	0	00 00
SO_DURATION_REFERENCE_1	1 byte	NMTC2004	0	00
SO_DURATION_REFERENCE_2	1 byte	NMTC2005	0	00
SO_DURATION_TIME	2 bytes	NMTC2006	0	00 00
SO_COP_GENERAL	1 byte	NMTC2007	0	00
SO_COP_PRECOOLING	1 byte	NMTC2008	0	00
SO_COP_SCIENCE_1	2 bytes	NMTC2009	0	00 00
SO_COP_SCIENCE_2	2 bytes	NMTC2010	0	00 00
LNO_START_TIME	2 bytes	NMTC2011	10	00 0A
LNO_START_SCIENCE_1	2 bytes	NMTC2012	640	02 80
LNO_START_SCIENCE_2	2 bytes	NMTC2013	810	03 2A
LNO_DURATION_REFERENCE_1	1 byte	NMTC2014	30	1E
LNO_DURATION_REFERENCE_2	1 byte	NMTC2015	30	1E
LNO_DURATION_TIME	2 bytes	NMTC2016	2100	08 34
LNO_COP_GENERAL	1 byte	NMTC2017	180	B4
LNO_COP_PRECOOLING	1 byte	NMTC2018	1	01
LNO_COP_SCIENCE_1	2 bytes	NMTC2019	3310	0C EE
LNO_COP_SCIENCE_2	2 bytes	NMTC2020	3310	0C EE
UVIS_START_TIME	2 bytes	NMTC2021	610	02 62
UVIS_DURATION_TIME	2 bytes	NMTC2022	1500	05 DC
UVIS_COP_ROW	2 bytes	NMTC2023	352	01 60
CHECKSUM	2 bytes			05 C0

6.1.12.2.3 Ready to power NOMAD off

The TC(50) to warn NOMAD that switching off is imminent in hexadecimal format is:

0x 32 00 00 06 00 38

This telecommand contains the following parameters:

			ready to power off	
			NO-FCP-002	
			DEC	HEX
TYPE	1 byte		50	32
LENGTH	3 bytes		6	00 00 06
CHECKSUM	2 bytes			00 38

6.1.12.3 Summary telecommand list

The list of telecommands (real values) during the EMC sequence is then:

STEP	TELECOMMAND
	Yellow highlighted lines only when previous power off was not nominal
1	Open PDHU file
2	WAIT 00:00:02
3	NOMAD ON NOMINAL
4	WAIT 00:05:00
5	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
6	WAIT 00:00:30
7	NOMAD OFF NOMINAL
8	WAIT 00:00:02
9	Close PDHU file
10	Open PDHU file
11	WAIT 00:00:02
12	NOMAD ON NOMINAL
13	WAIT 00:00:30
14	TC(20) – SO+UVIS **0x 14 00 00 2c 00 0a 02 80 03 2a 1e 1e 08 34 66 01 0c cf 0c cf 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 62 05 dc 00 20 04 f3**
15	WAIT 00:36:00
16	TC(20) – LNO+UVIS **0x 14 00 00 2c 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0a 02 80 03 2a 1e 1e 08 34 b4 01 0c ee 0c ee 02 62 05 dc 01 60 05 c0**
17	WAIT 00:36:00
18	TC(50) - READY TO POWER OFF **0x 32 00 00 06 00 38**
19	WAIT 00:00:30
20	NOMAD OFF NOMINAL
21	WAIT 00:00:02
22	Close PDHU file

6.2 IN-FLIGHT OPERATIONAL PROCEDURES

As explained in §5.4, calibration sessions with NOMAD must be performed regularly throughout the complete mission. In-flight calibration during science operations should be performed upon request by NOMAD, replacing science measurements if needed to comply with the spacecraft GNC constraints. Specific pointing (such as dark sky) can be coordinated with ACS.

Table 16 gives a summary of the calibration parameters. The session durations in this table are for maximum cases and including precooling of 10'00" and slew/tranquilisations of 02'00"/position.

Table 16: Calibration and checkouts sessions summary

Session	Total duration / TCs	Timing	Pointing	Contents	Channel
Spectral calibration	max 17'35" (1) 2 HPC 6 TCs	every 1 month	inertial Sun 1 point outside atm (> 250 km) APE/RPE as in science	AOTF frequency scan UVIS selector mechanism stepping max measurement time in one point = 05'00" tranquilization needed after slew (total = 02'00")	SO/UVIS or LNO/UVIS
LoS mismatch calibration	max 33'35" (2) 2 HPC 6 TCs	every 2-3 months	inertial grid around Sun max 10 points 5 to 30 arcmin/step outside atm (> 250 km) APE/RPE as in science	grid scan max measurement time in one point = 00'15" tranquilization needed after slew (total = 02'00")	SO/UVIS or LNO/UVIS
Simplified LoS mismatch calibration	max 20'35" (2) 2 HPC 6 TCs	every 1 month	Line scans over solar disk max 3 points/lines outside atm (> 250 km) ***APE/RPE as in science***	line scan max measurement time in one line = 01'00" tranquilization needed after slew (total = 02'00")	SO/UVIS or LNO/UVIS

Stray light calibration	max 33'35" (3) 2 HPC 6 TCs	2 to 3 times during mission	inertial line of points starting from the solar center max 10 points 10 to 60 arcmin/step outside atm (> 250 km) APE/RPE as in science	line scan max measurement time in one point = 00'15" tranquilization needed after slew (total = 02'00")	SO/UVIS or LNO/UVIS
Dark sky calibration	max 25'00"" (4) 2 HPC 6 TCs	every 2-3 months	dark sky 1 point outside Mars (> 400 km) outside Sun (> 5°) APE/RPE N/A	Integration time scan max measurement time in one point = 05'00" no tranquilization needed after slew	SO/UVIS or LNO/UVIS
Checkout	Max 35'35" (5) 2 HPC 6 TCs	(6)	default: no specific pointing APE/RPE as in science	health check	SO/UVIS followed immediately by LNO/UVIS

(1) 10'00" precooling + 05'00"' measurement + 2 x slew/tranquilisation (02'00"/slew)

(2) 10'00" precooling + 10 x measurement points (00'15"/points) + 11 x slew/tranquilisation (02'00"/slew)

(3) 10'00" precooling + 10 x measurement points (00'15"/points) + 11 x slew/tranquilisation (02'00"/slew)

(4) 10'00" precooling SO or LNO + 05'00 SO or LNO measurement + 08'00" UVIS measurement + 2 x slew (02'00"/slew)

(5) 10'00" precooling + 05'00"' measurement + 2 x slew (02'00"/slew)

(6) NEC (1x), Cruise (2x), between EDM separation ad science phase (1x), during science phase after inactivity of 1 month

6.2.1 Typical science orbit

Instrument	NOMAD
Title	NOMAD typical science orbit
Objective	Perform a typical science orbit with NOMAD
Description	This sequence consists of 2 blocks. Each block contains two observations. BLOCK 1. (a) solar occultation measurement with SO and UVIS and (b) dayside nadir observation with LNO + UVIS. These observations are referenced to the SOLAR EGRESS event (stopped such that block 2 can be executed in time) BLOCK 2. (a) solar occultation measurement with SO and UVIS and (b) night side limb observation with UVIS. These observations are referenced to the SOLAR INGRESS event. Remark: the length of the procedures is only indicative. The real length of each observation (procedure) will depend on the timing of the events and will differ from orbit to orbit.
Instrument configuration	In flight It is possible that SINBAD remains switched on all the time. In this case the NO-FCP-001 and NO-FCP-002 need to be withdrawn from this sequence.
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase Pointing requests: see below
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success	Telemetry analysed by PI

criteria	
Output	All telemetry files
Duration	1 hour 38 minutes 35 seconds (depends on actual orbital events)

Sequence	**Overall delta time**	**Block delta time**	**Procedure Code**	**Procedure Name**	**Orbital events and pointing requests**	**Power**	**1553 rate (kbits/s)**	**SpW rate (kbits/s)**
	00.00.00			Start of sequence		0	0	0
	00.00.00			START BLOCK 1		0	0	0
	00.00.00	-00.11.35	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	-00.10.00	NO-FCP-014	Perform one observation with SO+UVIS		12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (5')
	00.06.35	-00.05.00			S/C POINTING Start slew to Sun inertial pointing (assumption slew of 2')			
	00.08.35	-00.03.00			S/C POINTING S/C is pointed to the Sun and stable (at least 3' before event)			
	00.11.35	**00.00.00**			**EVENT** **SOLAR EGRESS**			
	00.16.55	+00.05.20		Procedure NO-FCP-014 end	Insert wait time	12	0.039	0 (*)
	00.18.40	+00.07.05			S/C POINTING Start slew to nadir orientation (assumption slew of 2')			
	00.18.40	+00.07.05	NO-FCP-031	Flip mirror to default position		12 → 18 →12	0.039	0 (*)

	00.19.40	+00.08.05	NO-FCP-015	Perform one observation with LNO+UVIS		12 → 47.9 → 46.9 →12	0.0678	3.6576 (10') 9.8016 (40')
	00.20.40	+00.09.05			S/C POINTING S/C is pointed to nadir and stable			
	01.10.00			Procedure NO-FCP-015 end	Insert wait time	12	0.0678	0 (*)
	01.12.00			START BLOCK 2		12	0.0678	0 (*)
	01.12.00	-00.10.00	NO-FCP-014	Perform one observation with SO+UVIS		12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (5')
	01.17.00	-00.05.00			S/C POINTING Start slew to Sun inertial pointing (assumption slew of 2')			
	01.19.00	-00.03.00			S/C POINTING S/C is pointed to the Sun and stable (at least 3' before event)			
	01.22.00	00.00.00			EVENT SOLAR INGRESS			
	01.27.20	+00.05.20		Procedure NO-FCP-014 end	Insert wait time	12	0.039	0 (*)
	01.29.00	+00.07.00			S/C POINTING Start slew to limb orientation (assumption slew of 2')			
	1.31.00	+00.09.00		NO-FCP-013	Perform one observation with UVIS	12 → 16.9 → 12	0.0544	52.928
	1.36.20	+00.14.20		Procedure NO-FCP-013 end	Insert wait time	12	0.0544	0 (*)
	1.38.00	+00.16.00			S/C POINTING			

					Start slew to limb orientation (assumption slew of 2')			
	01.38.00	+00.16.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.0544 → 0	0 (*)
	1.38.35	+00.16.35		End of sequence		0	0	0

6.2.2 Checkouts

Instrument	NOMAD
Title	NOMAD check out
Objective	Perform a health check of NOMAD
Description	This sequence consists of 2 blocks. **BLOCK 1**. Activation of SINBAD and observation with SO + UVIS **BLOCK 2**. Activation of SINBAD and observation with LNO + UVIS. Note that in this case LNO+UVIS has the same data rate as SO+UVIS because data are sent each second (LNO in solar occultation mode). Flip mirror in contingency position (solar line of sight)
Instrument configuration	In flight
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase Pointing requests: the check out can be performed with or without S/C pointing. Pointing could be requested with solar ports or with nadir ports to the Sun or to Earth (see below)
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	35 minutes 35 seconds

A checkout consists of two parts: a first part where the SO and UVIS channel are active together, and a second part where the LNO and the UVIS channel are active together. One checkout for NOMAD lasts approximately 35 minutes. No specific S/C pointing is required during checkouts.

A checkout procedure includes following verifications:

- Actuation of the UVIS selector mechanism (check power draw)
- Actuation of the LNO flip mirror mechanism (check housekeeping for position feedback)
- Switch on of each channel, verification of the entire electronics chain from detector read out to spacecraft communication. This follows the same procedure as a science observation and reads out all the detectors in a nominal way. For the IR channels this means precooling the detectors before read out.
- Activation of the SO and LNO channel AOTF and RF drivers (check power draw and possible temperature increase)
- Both UVIS and IR FPGAs are also foreseen with a "test-card" function. This, upon receipt of a TC with a flag to activate the test-card, sends back a simulated spectrum with all the housekeeping. It is possible to use this option during a checkout.
- Read-out of full set of housekeeping data (temperature, voltages, status messages)

Sequence	Overall delta time	Block delta time	Procedure Code	Procedure Name	Orbital events and pointing requests	Power	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence		0	0	0
	00.00.00			START BLOCK 1		0	0	0
	00.00.00	00.00.00	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	+00.01.35	NO-FCP-014	Perform one observation with SO+UVIS		12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (5')
	00.06.35	+00.06.35			S/C POINTING Start slew to Sun inertial pointing (assumption slew of 2')			

	00.08.35	+00.08.35			S/C POINTING S/C is pointed to the Sun and stable			
	00.16.55	+00.16.55		Procedure NO-FCP-014 end	Insert wait time	12	0.039	0 (*)
	00.17.00			START BLOCK 2		12	0.039	0 (*)
	00.17.00	00.00.00	NO-FCP-031	Flip mirror to contingency (solar) position	S/C remains pointed to the Sun	12	0.039	0 (*)
	00.18.00	+00.01.00	NO-FCP-015	Perform one observation with LNO+UVIS	Observation with reduced length and 1 second polling rate (equal to NO-FCP-014)	12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (5')
	00.33.20	+00.16.20		Procedure NO-FCP-015 end	Insert wait time	12	0.039	0 (*)
	00.35.00	+00.18.00			S/C POINTING Start slew to nadir orientation (assumption slew of 2')			
	00.35.00	+00.18.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.039 → 0	0 (*)
	00.35.35			End of sequence		0	0	0

6.2.3 Line-Of-Sight Mismatch Calibration and straylight calibration

Instrument	NOMAD
Title	NOMAD Line of Sight mismatch or straylight calibration
Objective	Exactly the same sequence of procedures is used to perform an in-flight Line of Sight calibration or a straylight calibration of NOMAD. Only the pointing pattern adopted by the S/C is different.
Description	Activation of SINBAD and observation with SO + UVIS (NO-FCP-014) or with LNO + UVIS (NO-FCP-015). In the second case the flip mirror has to be in redundant position (solar line of sight). Duration of the observation is tuned by means of TC parameters The sequence below gives the example of LNO + UVIS
Instrument configuration	In flight
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase Pointing requests: solar ports are pointed to 9 points on a specific grid (LoS mismatch) or on a line (straylight)
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	33 minutes 35 seconds

LOS mismatch calibration

Goal

The misalignment between the NOMAD solar LoS and the pointing axis of the S/C has to be checked in flight. The mismatch angles (theta and phi) that result from these calibration sessions could (optionally) be taken into account by the S/C (as offsets) for future Sun pointing. The nadir LoS mismatch is not calibrated, as mis-alignment there will not result in NOMAD FoVs being off the planet's surface.

Channels

The mismatch angles will be measured for the LoS of all three channels. One calibration session can be dedicated to SO/UVIS or to LNO/UVIS. UVIS reads out only 1 row of the detector in this calibration, as per normal science operations.

Procedure + timing

The pointing axis of the S/C has to be directed towards a series of points in the sky, located on a grid. Inertial pointing is requested at each point, without rotation around the line of sight.

Typically between 5 and 10 grid points are requested per calibration session.

The grid step is between 5 and 30 arcmin (to be decided on a case by case basis).

In each position a measurement of 00'15" is performed.

A slew + tranquilisation time of the S/C to go from one point to the next has to be taken into account. It is assumed here to be 02'00" (a very pessimistic assumption).

Time between start of first measurement and end of last measurement (depending on slew/tranquilisation time) = 20'30"

S/C away from nominal attitude (depending on slew/tranquilisation time) = 24'30"

Total duration (including precooling, initial and final slew) = 33'35". Note that precooling does not require solar pointing.

At the beginning of the mission this calibration session has to be done with a coarse grid (e.g. grid step = 15 arcmin). Later it can be done with a finer grid (e.g. grid step = 5 arcmin).

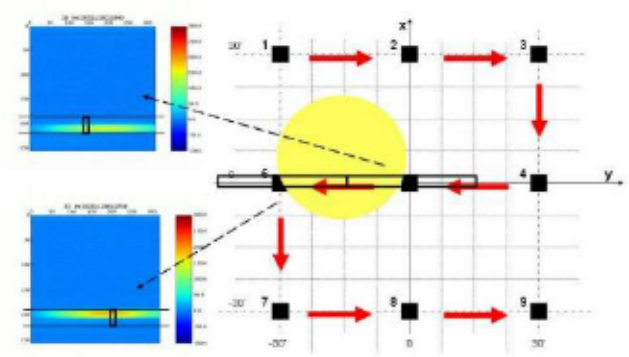


Figure 6-1: Example of coarse LoS mismatch calibration scan (SOIR-VEX)

Pointing requirements

The instrument LoS has to be pointed towards the consecutive grid points in inertial mode.

The grid points will be situated in the vicinity of the centre of the Sun.

The pointing axis towards each grid point is not allowed to cross the atmosphere, i.e. tangent point of LoS > 250 km above planet surface.

Absolute pointing (APE), pointing stability (RPE) and measurement error (AME) requirements at each point are identical to the requirements during science observations (see AD-01), except that rotation about the LoS can be tolerated.

Straylight calibration

Goal

Stray light calibration sessions serve to check the instrument's immunity to stray light generated inside the instrument by the Sun or solar reflection on the S/C.

Channels

Stray light calibration will be performed for all three channels. One calibration session can be dedicated to SO/UVIS or to LNO/UVIS. This will characterise all but the first mirror in the LNO channel and the UVIS nadir channel entrance optics and fibre. It is not possible to calibrate these without pointing the nadir viewing direction at the Sun – which is impossible for TGO.

Procedure + timing

The pointing axis of the S/C has to be directed towards a series of points in the sky, located on a line.

Typically between 5 and 10 grid points are requested per calibration session.

The step between two points can be from 10 to 60 arcmin (to be decided on a case by case basis).

In each position a measurement is done of 00'15".

A slew + tranquilisation time of the S/C to go from one point to the next has to be taken into account. It is assumed here to be 02'00".

Time between start of first measurement and end of last measurement (depending on slew/tranquilisation time) = 20'30"

S/C away from nominal attitude (depending on slew/tranquilisation time) = 24'30"

Total duration (including precooling, initial and final slew) = 33'35"

Figure below gives an example of a stray light calibration with 7 points performed for SOIR-VEX.

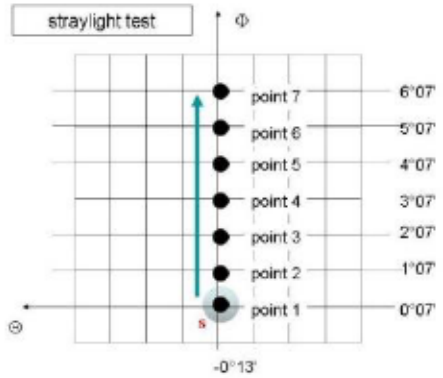


Figure 6-2: Example of stray light scan (SOIR-VEX)

Pointing requirements

The instrument LoS has to be pointed towards the consecutive points in inertial mode.

The first point will be the centre of the Sun. The next points will be gradually away from the centre of the Sun.

The pointing axis towards each grid point is not allowed to cross the atmosphere, i.e. tangent point of LoS > 250 km above planet surface.

Absolute pointing (APE), pointing stability (RPE) and measurement error (AME) requirements during this calibration session are identical to the requirements during science observations (see E-ICD).

Sequence	Overall delta time	Block delta time	Procedure Code	Procedure Name	Orbital events and pointing requests	Power	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence		0	0	0
	00.00.00	-00.12.35	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	-00.11.00	NO-FCP-031	Flip mirror to redundancy (solar) position		12	0.039	0 (*)
	00.02.35	-00.10.00	NO-FCP-015	Perform one observation with LNO+UVIS	Observation with reduced length	12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (20')
	00.09.00	-00.03.00			S/C POINTING Start slew to Sun inertial point 1 (assumption slew of 2')			
	00.12.00	**00.00.00**			**EVENT** **POINT 1**			
	00.14.15	+00.02.15			S/C POINTING Start slew to Sun inertial point 2 (assumption slew of 2')			
	00.16.30	+00.04.30			S/C POINTING Start slew to Sun inertial point 3 (assumption slew of 2')			
	00.18.45	+00.06.45			S/C POINTING Start slew to Sun inertial point 4 (assumption slew of 2')			
	00.21.00	+00.09.00			S/C POINTING Start slew to Sun inertial			

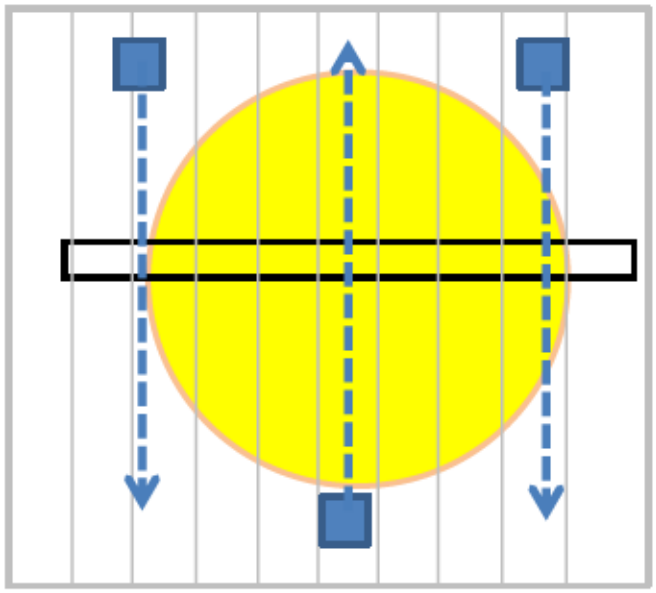
					point 5 (assumption slew of 2')			
	00.23.15	+00.11.15			S/C POINTING Start slew to Sun inertial point 6 (assumption slew of 2')			
	00.25.30	+00.13.30			S/C POINTING Start slew to Sun inertial point 7 (assumption slew of 2')			
	00.27.45	+00.15.45			S/C POINTING Start slew to Sun inertial point 8 (assumption slew of 2')			
	00.30.00	+00.18.00			S/C POINTING Start slew to Sun inertial point 9 (assumption slew of 2')			
	00.32.15	+00.20.15		Procedure NO-FCP-015 end	Insert wait time	12	0.039	0 (*)
	00.33.00	+00.21.00			S/C POINTING Start slew to default (assumption slew of 2')			
	00.33.00	+00.21.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.039 → 0	0 (*)
	00.33.35	+00.21.35		End of sequence		0	0	0

6.2.4 Simplified Line-Of-Sight Mismatch Calibration

Instrument	NOMAD
Title	NOMAD simplified Line of Sight mismatch calibration
Objective	Perform a shorter Los Mismatch calibration session than the full LoS mismatch calibration. This simplified calibration could possible be fit in more easily and hence more frequently during science operations.
Description	Activation of SINBAD and observation with SO + UVIS (NO-FCP-014) or with LNO + UVIS (NO-FCP-015). In the second case the flip mirror has to be in redundant position (solar line of sight). Duration of the observation is tuned by means of TC parameters The sequence below gives the example of SO + UVIS
Instrument configuration	In flight
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase Pointing requests: S/C is pointed to 3 points, from which the S/C scans linearly over the solar disk. These three lines are chosen e.g. left, center and right on the Sun.
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	20 minutes 35 seconds

Since the full LoS mismatch measurement takes quite a long time, it is possible to perform a shorter (simplified) calibration measurement more frequently to complement the full measurements. This shorter measurement would consist of three line scans – nominally 'left', 'centre' and 'right' on the sun (total spacing 15'-20'). This can be performed with a spacecraft slew rate of 20 arcseconds per second, using short integration times (~20ms). In this way it would take about a minute to go from the 'top' of the sun to the 'bottom'. NOMAD's SO channel would download 24 lines per second, but each line would show a snapshot position (not affected by the slew). No rotation about line of sight is permitted.

Figure 6-3: Simplified LoS mismatch calibration



The total time is 20'35", but only 7 minutes require solar pointing (if the tranquilisation time of 2' is still needed prior to a line scan, less if this time can be reduced). This should fit in a normal solar occultation slot, though would prevent other solar pointing instruments from performing normal science measurements.

This measurement requires high accuracy knowledge on the spacecraft position and slew rate. The LoS is not allowed to cross the atmosphere, i.e. tangent point of LoS > 250 km above planet surface.

Sequence	Overall delta time	Block delta time	Procedure Code	Procedure Name	Orbital events and pointing requests	Power	1553 rate (kbits/s)	SpW rate (kbits/s)

	00.00.00			Start of sequence		0	0	0
	00.00.00	-00.12.40	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	-00.11.05	NO-FCP-032	Flip mirror to redundancy position		12	0.039	0 (*)
	00.02.35	-00.10.05	NO-FCP-014	Perform one observation with SO+UVIS	Observation with reduced length	12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (8')
	00.09.00	-00.03.00			S/C POINTING Start slew to Sun inertial point 1 (assumption slew of 2')			
	00.12.00	**00.00.00**			**EVENT** **START LINE SCAN 1**			
	00.13.00	+00.01.00			S/C POINTING Start slew to Sun inertial point 2 (assumption slew of 2')			
	00.15.00	+00.03.00			START LINE SCAN 2			
	00.16.00	+00.04.00			S/C POINTING Start slew to Sun inertial point 4 (assumption slew of 2')			
	00.18.00	+00.06.00			START LINE SCAN 3			
	00.19.00	+00.07.00		Procedure NO-FCP-014 end	Insert wait time	12	0.039	0 (*)
	00.20.00	+00.08.00			S/C POINTING Start slew to default (assumption slew of 2')			
	00.20.00	+00.08.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.039→ 0	0 (*)
	00.20.35	+00.08.35		End of sequence		0	0	0

6.2.5 Spectral calibration

Instrument	NOMAD
Title	NOMAD spectral calibration
Objective	Perform a spectral calibration of (a set of) NOMAD channel(s).
Description	A spectral calibration can be performed for one channel (NO-FCP-011 for SO, NO-FCP-012 for LNO, NO-FCP-013 for UVIS) or for combinations of channels (NO-FCP-014 for SO + UVIS, NO-FCP-015 for LNO + UVIS). Length of the procedure can be tuned by TC parameters. When LNO is calibrated the flip mirror has to be put in redundancy position. The UVIS calibration includes a UVIS selector mechanism calibration The sequence below is given for a calibration of SO + UVIS
Instrument configuration	In flight
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0678 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 54.864 kbits/s max during precooling phase (UVIS ON during precooling) and 147.024 kbits/s during science phase Pointing requests: inertial pointing to the Sun is required with the solar ports or with the nadir ports (see below)
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	17 minutes 35 seconds

Goal

For the SO and LNO channels, a spectral calibration is performed by stepping the AOTF frequency through the spectral domain. In parallel the UVIS channel records spectra using the solar entrance optics and parameters. UVIS only requires one spectrum for this, and could therefore simultaneously perform the selector mechanism calibration.

Channels

The spectral calibration will be performed for all three channels. One calibration session can be dedicated to SO/UVIS or to LNO/UVIS. The nadir looking LNO channel shares the optical bench with the LNO limb channel so the calibration is valid for nadir also. The same is true for UVIS. No calibration of the nadir viewing path is necessary.

Procedure + timing

The solar LoS of each of the three NOMAD channels has to be pointed towards the Sun outside the atmosphere.

The S/C remains in this inertial position for 02'00" to 05'00" during which the calibration measurement is performed. Precooling of 10'00" is necessary before the measurement. Slewing of the S/C to the inertial position can be done during the precooling.

Time between start of first measurement and end of last measurement (depending on slew/tranquilisation time) = 05'00"

S/C away from nominal attitude (depending on slew/tranquilisation time) = 09'00"

Total duration (including precooling, initial and final slew) = 17'35"

Pointing requirements

The instrument LoS has to be pointed towards the Sun in inertial mode.

The instrument LoS must not cross the atmosphere, i.e. tangent point of LoS > 250 km above planet surface.

Absolute pointing (APE), pointing stability (RPE) and measurement error (AME) requirements during this calibration session are identical to the requirements during science observations (see E-ICD).

Sequence	Overall delta time	Block delta time	Procedure Code	Procedure Name	Orbital events and pointing requests	Power	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence		**0**	0	0

	00.00.00	-00.08.40	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	-00.07.05	NO-FCP-014	Perform one observation with SO+UVIS		12 → 47.9 → 46.9 → 12	0.0678	54.864 (10') 147.024 (6')
	00.06.00	-00.02.00			S/C POINTING Start slew to inertial point (assumption slew of 2')			
	00.08.00	+00.00.00			**EVENT** **S/C is pointed and stable**			
	00.16.15	+00.08.15		Procedure NO-FCP-014 end	Insert wait time	12	0.039	0 (*)
	00.17.00	+00.09.00			S/C POINTING Start slew to default position (assumption slew of 2')			
	00.17.00	+00.09.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.039→ 0	0 (*)
	00.17.35	+00.09.35		End of sequence		0	0	0

6.2.6 Dark Sky Calibration

Instrument	NOMAD
Title	NOMAD dark sky calibration
Objective	Perform a dark sky calibration of (a set of) NOMAD channel(s).
Description	A dark sky calibration can be performed only channel by channel. One dark sky calibration will always contain a suite of SO and UVIS calibration (NO-FCP-011 for SO followed by NO-CRP-513 for UVIS), or LNO and UVIS calibration (NO-FCP-012 for LNO followed by NO-CRP-513 for UVIS). Length of the procedure can be tuned by TC parameters. For LNO calibration the flip mirror has to be put in redundancy position. The sequence below is given for a calibration of SO followed by UVIS
Instrument configuration	In flight
S/C requirements	Telemetry rate from NOMAD to S/C (1553): 0.0544 kbits/s max Telemetry rate from NOMAD to S/C (SpW): 252.704 kbits/s max Pointing requests: inertial pointing to a point in dark sky (>5° away from Sun, > 400 km away from Martian surface) is required (see below)
Environmental constraints	Thermal integrity constraints of S/C and P/L checked
Success criteria	Telemetry analysed by PI
Output	All telemetry files
Duration	23 minutes 35 seconds

Sequence	Overall delta time	Block delta time	Procedure Code	Procedure Name	Orbital events and pointing requests	Power	1553 rate (kbits/s)	SpW rate (kbits/s)
	00.00.00			Start of sequence		0	0	0
	00.00.00	-00.08.40	NO-FCP-001	Nominal switch on of NOMAD		0 → 12	0 → 0.039	0 (*)
	00.01.35	-00.07.05	NO-FCP-011	Perform one observation with SO		12 → 43.4 → 42.4 →12	0.0523	1.936 (10') 94.1 (6')
	00.06.00	-00.02.00			S/C POINTING Start slew to inertial point (assumption slew of 2')			
	00.08.00	+00.00.00			**EVENT** **S/C is pointed and stable**			
	00.16.15	+00.08.15		Procedure NO-FCP-011 end	Insert wait time	12	0.039	0 (*)
	00.17.00	+00.09.00	NO-FCP-013	Perform one full frame observation with UVIS	S/C POINTING S/C is pointed and stable	12 → 16.9 →12	0.0544	252.704
	00.22.20	+00.14.20		Procedure NO-FCP-013 end	Insert wait time	12	0.039	0 (*)
	00.23.00	+00.15.00			S/C POINTING Start slew to default position (assumption slew of 2')			
	00.23.00	+00.15.00	NO-FCP-002	Nominal switch off of NOMAD		12 → 0	0.039→ 0	0 (*)
	00.23.35	+00.15.35		End of sequence		0	0	0

6.2.7 Selector mechanism calibration

Goal

The UVIS selector mechanism is driven to a hard stop at each observation position (occultation telescope or nadir telescope). This calibration checks the alignment between the fibre and the slit at the occultation hard stop position.

Channels

Only UVIS has a selector mechanism.

Procedure + timing

The stepper motor can be stepped up to the hard stop, taking a spectrum each time (~1s). The profile of intensity at each step position is then examined on ground. Power is as per normal operation, with one selector 'cycle' consisting of 16 spectra. These spectra are only 1 row of the detector, as for normal science operations. At least 3 cycles should be performed to ensure accurate characterization (i.e. 48 spectra). This measurement can be performed simultaneously with the SO or LNO spectral calibration, as UVIS only requires one spectrum, not multiple ones.

Pointing requirements

The instrument LoS has to be pointed towards the Sun in inertial mode.

The instrument LoS must not cross the atmosphere, i.e. tangent point of LoS > 250 km above planet surface.

Absolute pointing (APE), pointing stability (RPE) and measurement error (AME) requirements during this calibration session are identical to the requirements during science observations (see E-ICD).

7 DATA OPERATIONS HANDBOOK

7.1 TELECOMMANDS (VIA 1553)

Table 17 gives an overview of the NOMAD telecommands, Table 18shows the packet structure of the telecommands

Table 17: 1553 bus telecommand packets and parameters

code	name	1553 subaddress	function	sub-function	timing	structure						telemetry generated blue = 1553 red = SpaceWire
						type	packet size	data			checksum	
						1 byte	3 bytes	data code	data length	data name	2 bytes	
NMTC2000	TC(20)	9	start operation	N/A	async	20	44	NMTC2001	2 bytes	SO_START_TIME	CC	TM(22), TM(23), TM(25), TM(26), TM(27), TM(28) TM(29) (every 30 s via 1553) TM(29) (every 1 s via SpW for solar occ) TM(29) (every 15 sec via SpW for nadir)
								NMTC2002	2 bytes	SO_START_SCIENCE_1		
								NMTC2003	2 bytes	SO_START_SCIENCE_2		
								NMTC2004	1 byte	SO_DURATION_REFERENCE_1		
								NMTC2005	1 byte	SO_DURATION_REFERENCE_2		
								NMTC2006	2 bytes	SO_DURATION_TIME		
								NMTC2007	1 byte	SO_COP_GENERAL		
								NMTC2008	1 byte	SO_COP_PRECOOLING		
								NMTC2009	2 bytes	SO_COP_SCIENCE_1		
								NMTC2010	2 bytes	SO_COP_SCIENCE_2		
								NMTC2011	2 bytes	LNO_START_TIME		
								NMTC2012	2 bytes	LNO_START_SCIENCE_1		
								NMTC2013	2 bytes	LNO_START_SCIENCE_2		
								NMTC2014	1 byte	LNO_DURATION_REFERENCE_1		
								NMTC2015	1 byte	LNO_DURATION_REFERENCE_2		

								NMTC2016	2 bytes	LNO_DURATION_TIME		
								NMTC2017	1 byte	LNO_COP_GENERAL		
								NMTC2018	1 byte	LNO_COP_PRECOOLING		
								NMTC2019	2 bytes	LNO_COP_SCIENCE_1		
								NMTC2020	2 bytes	LNO_COP_SCIENCE_2		
								NMTC2021	2 bytes	UVIS_START_TIME		
								NMTC2022	2 bytes	UVIS_DURATION_TIME		
								NMTC2023	2 bytes	UVIS_COP_ROW		
NMTC3000	TC(30)	10	patch memory	N/A	async	30	min = 13 max = 64	NMTC3001	1 byte	PATCH_COUNT = c = 1 … 9	CC	none
								NMTC3002	4 bytes	PATCH_ADDRESS_A1		
								NMTC3003	1 byte	PATCH_SIZE_S1 = N1 = 1 … 52		
								NMTC3004	N1 bytes	PATCH_DATA_D1		
								…	…	…		
								NMTC30xx	4 bytes	PATCH_ADDRESS_Ac		
								NMTC30xx	1 byte	PATCH_SIZE_Sc = Nc = 1 … 52		
								NMTC30xx	Nc bytes	PATCH_DATA_Dc		
NMTC3100	TC(31)	11	dump memory	N/A	async	31	11	NMTC3101	4 bytes	DUMP_ADDRESS	CC	TM(32)
								NMTC3102	1 byte	DUMP_SIZE = N = 1 … 53		
NMTC3300	TC(33)	13	check memory	N/A	async	33	min = 13 max = 49	NMTC3301	1 byte	CHECK_COUNT = c = 1 … 7	CC	TM(34)
								NMTC3302	4 bytes	CHECK_ADDRESS_A1		
								NMTC3303	2 bytes	CHECK_SIZE_C1 = N1 = 1 … 1023		
								…	…	…		
								NMTC33xx	4 bytes	CHECK_ADDRESS_Ac		
								NMTC33xx	2 bytes	CHECK_SIZE_Sc = Nc = 1 … 1023		
NMTC3500	TC(35)	15	file manager	append to file	async	35	min = 10	NMTC3501	1 byte	OPERATION_CODE = 10	CC	TM(36) if SEND_REPORT

			operation				max = 64	NMTC3502	1 byte	FILE_ID		= 1
								NMTC3503	1 byte	(1 bit) SEND_REPORT		
								NMTC3504		(7 bits) BYTE_SIZE = N = 1 ... 55		
								NMTC3505	N bytes	PATCH_BYTES		
				update file	async	35	min = 14 max = 64	NMTC3501	1 byte	OPERATION_CODE = 11	CC	TM(36) if SEND_REPORT = 1
								NMTC3506	1 byte	FILE_ID		
								NMTC3507	4 bytes	RELATIVE_OFFSET		
								NMTC3508	1 byte	(1 bit) SEND_REPORT		
								NMTC3509		(7 bits) BYTE_SIZE = N = 1 ... 51		
								NMTC3510	N bytes	PATCH_BYTES		
				update column file	async	35	min = 18 max = 64	NMTC3501	1 byte	OPERATION_CODE = 12	CC	TM(36)
								NMTC3511	1 byte	FILE_ID		
								NMTC3512	2 bytes	ROW_BYTE_SIZE		
								NMTC3513	2 bytes	START_ROW		
								NMTC3514	2 bytes	END_ROW		
								NMTC3515	2 bytes	START_COLUMN		
								NMTC3516	1 byte	BYTE_SIZE = N = 1 ... 47		
								NMTC3517	N bytes	PATCH_BYTES		
				copy entire file	async	35	9	NMTC3501	1 byte	OPERATION_CODE = 13	CC	TM(36)
								NMTC3518	1 byte	FILE_ID_SOURCE		
								NMTC3519	1 byte	FILE_ID_DESTINATION		
				copy partial file	async	35	21	NMTC3501	1 byte	OPERATION_CODE = 14	CC	TM(36)
								NMTC3520	1 byte	FILE_ID_SOURCE		
								NMTC3521	4 bytes	SOURCE_RELATIVE_OFFSET		
								NMTC3522	4 bytes	SOURCE_BYTE_SIZE		
								NMTC3523	1 byte	FILE_ID_DESTINATION		

								NMTC3524	4 bytes	DESTINATION_RELATIVE_OFFSET		
				fill file with memory area	async	35	17	NMTC3501	1 byte	OPERATION_CODE = 15	CC	TM(36)
								NMTC3525	1 byte	FILE_ID		
								NMTC3526	1 byte	COMPRESSION_ALGORITHM (d)		
								NMTC3527	4 bytes	SOURCE_ADDRESS		
								NMTC3528	4 bytes	SOURCE_BYTE_SIZE		
				create empty file	async	35	43	NMTC3501	1 byte	OPERATION_CODE = 20	CC	TM(36)
								NMTC3529	4 bytes	MAX_BYTE_SIZE		
								NMTC3530	32 bytes	FILE_NAME		
				delete last file	async	35	7	NMTC3501	1 byte	OPERATION_CODE = 21	CC	TM(36)
				erase file content	async	35	8	NMTC3501	1 byte	OPERATION_CODE = 22	CC	TM(36)
								NMTC3531	1 byte	FILE_ID		
				reset file system	async	35	7	NMTC3501	1 byte	OPERATION_CODE = 30	CC	TM(36)
				decompress file	async	35	17	NMTC3501	1 byte	OPERATION_CODE = 31	CC	TM(36)
								NMTC3532	1 byte	FILE_ID_SOURCE		
								NMTC3533	1 byte	FILE_ID_DESTINATION		
								NMTC3534	4 bytes	DESTINATION_RELATIVE_OFFSET		
								NMTC3535	4 bytes	UNCOMPRESSED_SIZE		
				download compressed file	async	35	8	NMTC3501	1 byte	OPERATION_CODE = 40	CC	TM(36), TM(37)
								NMTC3536	1 byte	FILE_ID		
				print file status	async	35	8	NMTC3501	1 byte	OPERATION_CODE = 41	CC	TM(36)
								NMTC3537	1 byte	FILE_ID		
				print full status	async	35	7	NMTC3501	1 byte	OPERATION_CODE = 42	CC	TM(36)
				print file system status	async	35	7	NMTC3501	1 byte	OPERATION_CODE = 43	CC	TM(36)
NMTC4000	TC(40)	19	safe mode	N/A	async	40	6	N/A	N/A	N/A	CC	TM(10)

NMTC5000	TC(50)	20	ready to power off	N/A	async	50	6	N/A	N/A	N/A	CC	TM(10)
NMTC7000	TC(70) (c)	21	custom command	enable forced powering of ops heaters	async	70	7	NMTC7001	1 byte	OPERATION_CODE = 1	CC	TM(10) (except in EIM)
				disable forced powering of ops heaters	async	70	7	NMTC7001	1 byte	OPERATION_CODE = 2	CC	TM(10) (except in EIM)
				flip mirror to nadir position	async	70	11	NMTC7001	1 byte	OPERATION_CODE = 10	CC	TM(10)
								NMTC7002	1 byte	STEPPER_SPEED		
								NMTC7003	2 bytes	MAX_STEP_NUMBER		
								NMTC7004	1 byte (b)	(1 bit) LS_NADIR_NOMINAL_ENABLING (a)		
								NMTC7005		(1 bit) LS_NADIR_OVERSHOOT_ENABLING (a)		
								NMTC7006		(1 bit) LS_SOLAR_NOMINAL_ENABLING (a)		
								NMTC7007		(1 bit) LS_SOLAR_OVERSHOOT_ENABLING (a)		
				flip mirror to solar position	async	70	11	NMTC7001	1 byte	OPERATION_CODE = 11	CC	TM(10)
								NMTC7002	1 byte	STEPPER_SPEED		
								NMTC7003	2 bytes	MAX_STEP_NUMBER		
								NMTC7004	1 byte (b)	(1 bit) LS_NADIR_NOMINAL_ENABLING (a)		
								NMTC7005		(1 bit) LS_NADIR_OVERSHOOT_ENABLING (a)		
								NMTC7006		(1 bit) LS_SOLAR_NOMINAL_ENABLING (a)		
								NMTC7007		(1 bit) LS_SOLAR_OVERSHOOT_ENABLING (a)		
				flip mirror to launch position	async	70	11	NMTC7001	1 byte	OPERATION_CODE = 12	CC	TM(10)
								NMTC7002	1 byte	STEPPER_SPEED		
								NMTC7003	2 bytes	MAX_STEP_NUMBER		
								NMTC7004	1 byte (b)	(1 bit) LS_NADIR_NOMINAL_ENABLING (a)		

								NMTC7005		(1 bit) LS_NADIR_OVERSHOOT_ENABLING (a)		
								NMTC7006		(1 bit) LS_SOLAR_NOMINAL_ENABLING (a)		
								NMTC7007		(1 bit) LS_SOLAR_OVERSHOOT_ENABLING (a)		
				arm pin puller (step 1)	async	70	7	NMTC7001	1 byte	OPERATION_CODE = 20	CC	"arm pin puller" and "fire pin puller" to be seen as 1 command (in 2 steps) TM(10) (event = "pinpuller fired" if arm+fire successful, event = "pinpuller disarmed" if arm not followed by fire within 30 s)
				fire pin puller (step 2)	async	70	7	NMTC7001	1 byte	OPERATION_CODE = 21	CC	arm pin puller and "fire pin puller" to be seen as 1 command (in 2 steps) TM(10) (event = "pinpuller fired" if arm+fire successful, event = "pinpuller disarmed" if arm not followed by fire within 30 s)

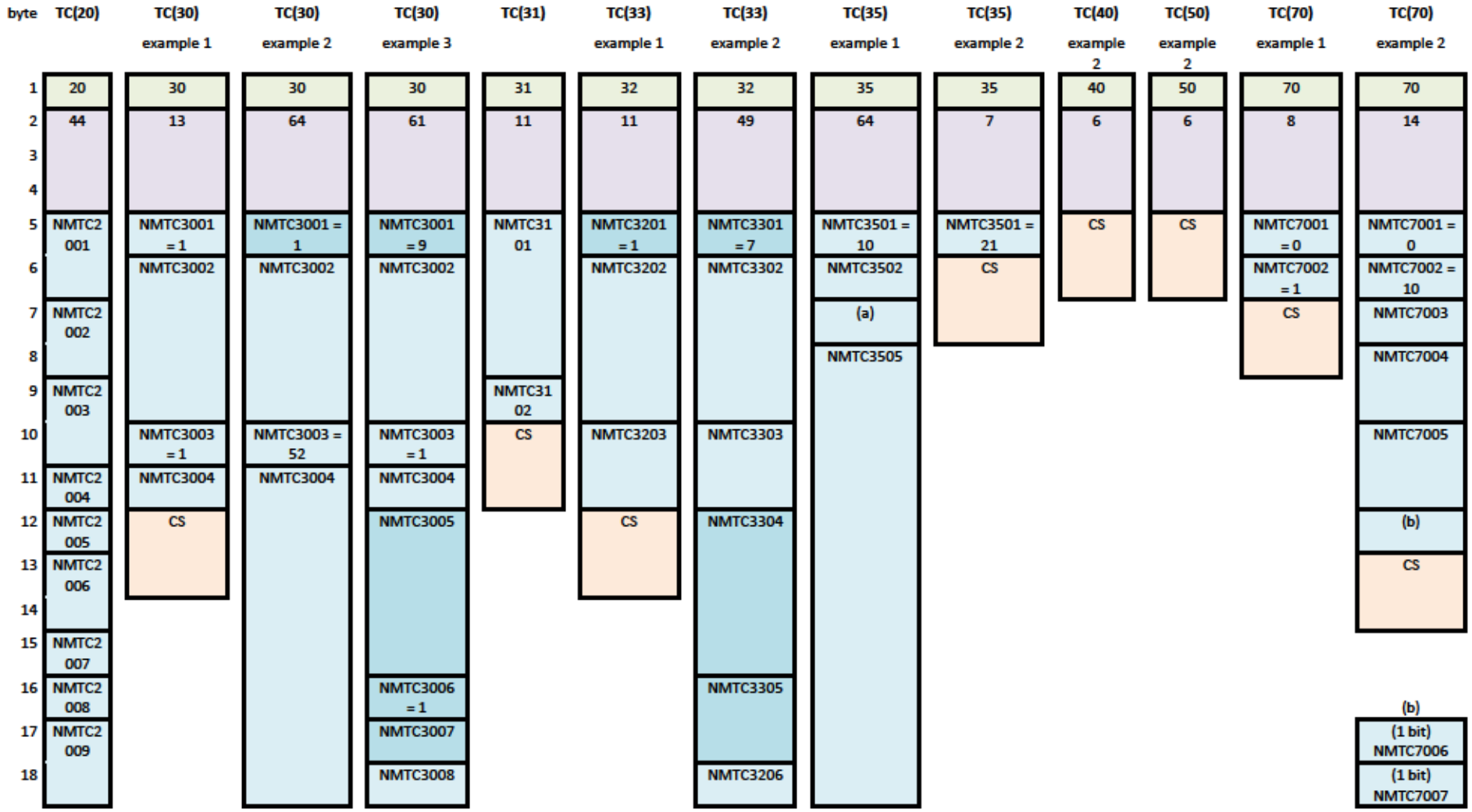
(a) "0" to enable the limit switch (LS), "1" to disable the limit switch (LS)

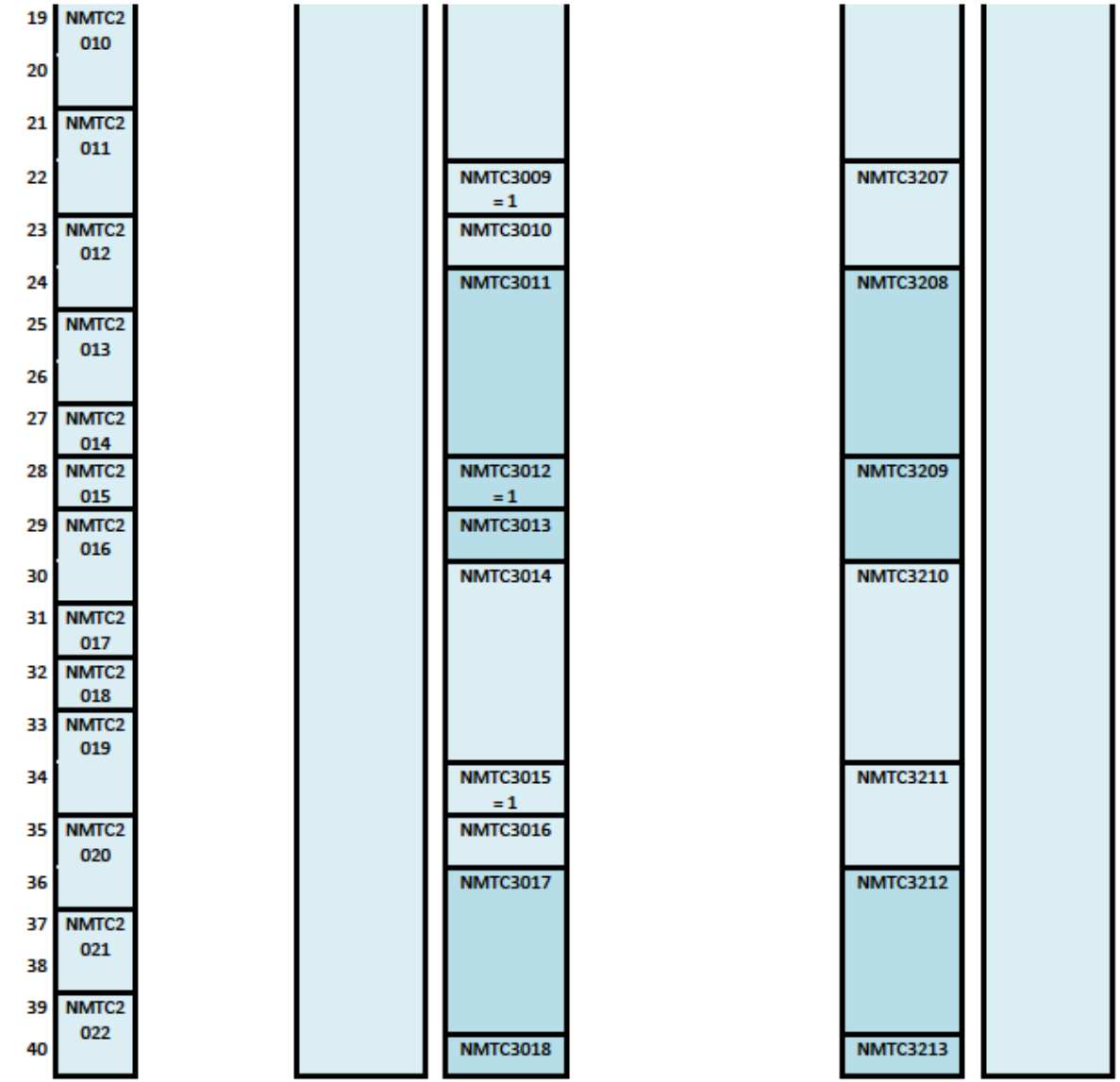
(b) this bytes contains 4 spare bits (at MSB side) and 4 significant bits (at LSB side)

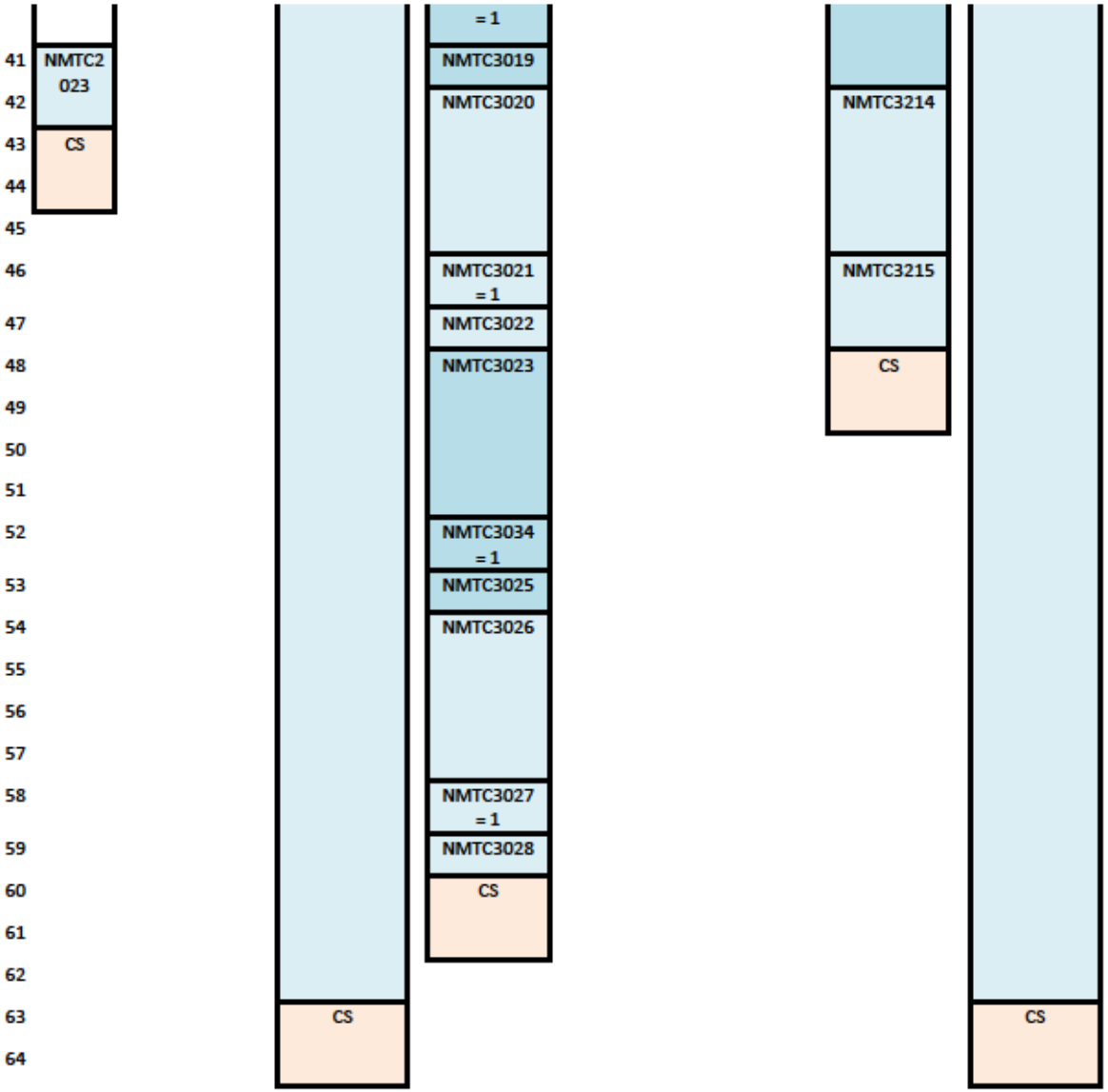
(c) additional TC(70) exist with OPERATION_CODE = 100, 101 and 102 for laboratory tests (direct commanding of SO channel). These are not implemented in deliverable models

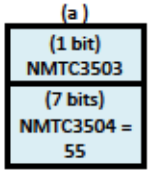
(d) possible values for COMPRESSION_ALGORYTHM: 0x12 (no compression), 0x56 (MKPROM compression), 0xF9 (ZLIB compression)

Table 18:1553 bus telecommand packet structure








(a)
(1 bit)
NMTC3503
(7 bits)
NMTC3504 =
55

7.2 TELEMETRY DATA (VIA 1553)

Table 19 gives an overview of the NOMAD 1553 bus telemetry data, Table 20 shows the packet structure of the 1553 bus telemetry.

Table 19: 1553 bus telemetry data packets and parameters.

code	name	1553 subaddress	function	timing	structure								generated after telecommand + repetition rate
					type	packet size	timestamp	TM count	data			checksum	
					1 byte	3 bytes	8 bytes	2 bytes	code	data length	name	2 bytes	
NMHK1000	TM(10)	22	event	async (30") (b)	10	21	NMHK1001	NMHK1002	NMHK1010	1 byte	EVENT_CODE	CC	TC(40), TC(50), TC(70) + at event
									see table 1	4 bytes	EVENT PARAMETER		
NMHK1100	TM(11)	5	NOMAD HK 1	sync (30")	11	53	NMHK1101	NMHK1102	see table 2	32 bytes	SINBAD_SENSORS	CC	continuously
									see table 3	1 byte	ADC_1_SENSOR_SUPERVISOR		
									see table 4	1 byte	ADC_2_SENSOR_SUPERVISOR		
									see table 5	1 byte	HEATER_SUPERVISOR		
									see table 6	1 byte	NOMAD_POWER_STATUS		
									see table 7	1 byte	NOMAD_FLIP_MIRROR_STATUS		
NMHK1200	TM(12)	6	NOMAD HK 2	sync (30")	12	39	NMHK1201	NMHK1202	see table 8	1 byte	OPERATIONAL_MODE	CC	continuously
									see table 9	11 bytes	CONTINGENCIES		
									see table 10	11 bytes	EVENTS		
NMHK1300	TM(13)	7	NOMAD HK 3	sync (30")	13	54	NMHK1301	NMHK1302	see table 11	4 bytes	1553 _BUS	CC	continuously
									see table 12	4 bytes	SPACE_WIRE		
									see table 13	1 byte	MAIN_CHANNEL		
									see table 14	14 bytes	STATISTICS_MAIN		

									see table 15	1 byte	REDUNDANT_CHANNEL		
									see table 16	14 bytes	STATISTICS_REDUNDANT		
NMHK2300	TM(23)	2	SO HK	sync (30") (a)	23	50	NMHK2301	NMHK2302	see table 17	34 bytes	SO_HOUSEKEEPING	CC	TC(20) - continuously
NMHK2600	TM(26)	3	LNO HK	sync (30") (a)	26	50	NMHK2601	NMHK2602	see table 18	34 bytes	LNO_HOUSEKEEPING	CC	TC(20) - continuously
NMHK2900	TM(29)	4	UVIS HK	sync (30") (a)	29	58	NMHK2901	NMHK2902	see table 19	42 bytes	UVIS_HOUSEKEEPING	CC	TC(20) - continuously
NMHK3200	TM(32)	12	dump memory report	async (30") (b)	32	min = 12 max = 64			NMHK3201	4 bytes	DUMP_ADDRESS	CC	TC(31) - once
									NMHK3202	1 byte	DUMP_SIZE = N = 1 ... 53		
									NMHK3203	N bytes	DUMP_DATA		
NMHK3400	TM(34)	14	check memory report	async (30") (b)	34	min = 15 max = 63			NMHK3401	1 byte	CHECK_COUNT (1...7)	CC	TC(33) - once
									NMHK3402	4 bytes	CHECK_ADDRESS_A1		
									NMHK3403	2 bytes	CHECK_SIZE_S1		
									NMHK3404	2 bytes	CHECK_DATA_D1		
									...	...	...		
									NMHK34xx	4 bytes	CHECK_ADDRESS_Ac (c = 1 ... 7)		
									NMHK34xx	2 bytes	CHECK_SIZE_Sc (c = 1 ... 7)		
									NMHK34xx	2 bytes	CHECK_DATA_Dc (c = 1 ... 7)		
NMHK3600	TM(36)	16	file manager operation report (see table 27)	async (30") (b)	36	22			NMHK3601	1 byte	OPERATION_CODE	CC	TC(35) - once
									NMHK3602	4 bytes	OPERATION_SEQUENCE_COUNT		
									NMHK3603	4 bytes	RESULT_CODE (see table 23)		

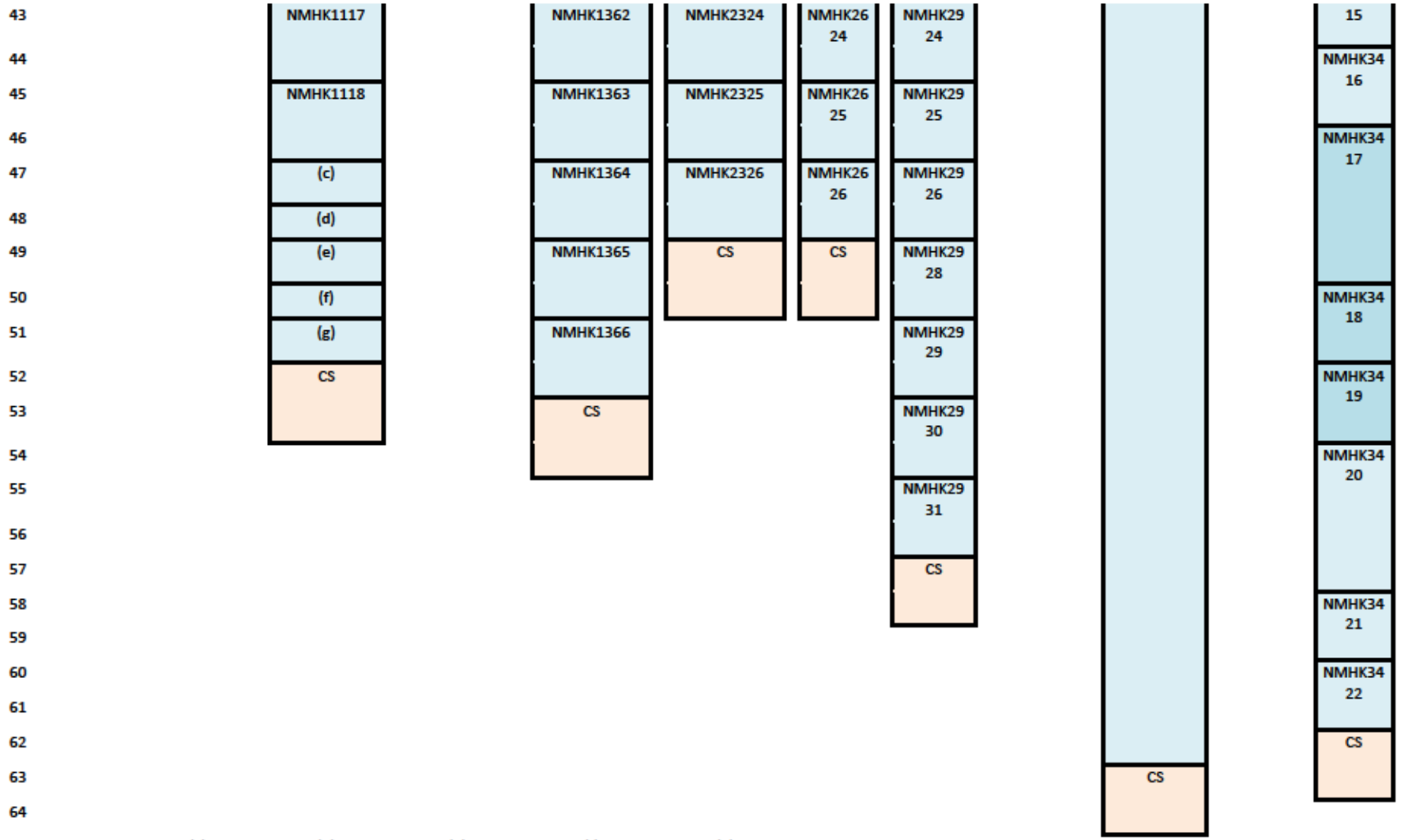
NMHK3604	1 byte	FILE_ID	
NMHK3605	4 bytes	BYTE_SIZE	
NMHK3606	2 bytes	CHECKSUM	

(a) if channel is switched on

(b) created asynchronously - transmitted at 30 sec clock tick

Table 20: 1553 bus telemetry packet structure

byte	TM(10)	TM(11)	TM(12)	TM(13)	TM(23)	TM(26)	TM(29)	TM(32) example 1	TM(32) example 2	TM(34) example 1	TM(34) example 2	TM(36)
1	10	11	12	13	23	26	29	32	34	36	36	36
2	21	53	39	54	50	50	58	12	64	14	63	18
3												
4												
5	NMHK1001	NMHK1101	NMHK1201	NMHK1301	NMHK2301	NMHK2601	NMHK2901	NMHK3201	NMHK3201	NMHK3401	NMHK3401	NMHK3601
6										NMHK3402	NMHK3402	NMHK3602
7												
8												
9								NMHK3202 = 1	NMHK3202 = 53			
10								NMHK3203	NMHK3203	NMHK3403	NMHK3403	NMHK3603
11								CS				
12										NMHK3404	NMHK3404	
13	NMHK1002	NMHK1102	NMHK1202	NMHK1302	NMHK2302	NMHK2602	NMHSK2902					
14										CS	NMHK3405	NMHK3604
15	NMHK1003	NMHK1103	NMHK1210	NMHK1310	NMHK2310	NMHK2610	NMHK2910					NMHK3605
16	NMHK1004		NMHK1220									
17		NMHK1104			NMHK2311	NMHK2611	NMHK2911				NMHK3406	
18			NMHK1221									
19		NMHK1105		NMHK1320	NMHK2312	NMHK2612	NMHK2912					NMHK3606



NMHK1121	NMHK1131	NMHK1161	NMHK1141	NMHK1151
(1 bit) NMHK1122	(1 bit) NMHK1132			
(1 bit) NMHK1123	(1 bit) NMHK1133		(1 bit) NMHK1142	
(1 bit) NMHK1124	(1 bit) NMHK1134		(1 bit) NMHK1143	
(1 bit) NMHK1125	(1 bit) NMHK1135	(1 bit) NMHK1162	(1 bit) NMHK1144	(1 bit) NMHK1152
(1 bit) NMHK1126	(1 bit) NMHK1136	(1 bit) NMHK1163	(1 bit) NMHK1145	(1 bit) NMHK1153
(1 bit) NMHK1127	(1 bit) NMHK1137	(1 bit) NMHK1164	(1 bit) NMHK1146	(1 bit) NMHK1154
(1 bit) NMHK1128	(1 bit) NMHK1138	(1 bit) NMHK1165	(1 bit) NMHK1147	(1 bit) NMHK1155

Table 21: Event parameters

Sub function (event type)	EVENT_CODE		EVENT_BYTE_1			EVENT_BYTE_2			EVENT_BYTE_3			EVENT_BYTE_4		
	code	value	code	length	name	code	length	name	code	length	name	code	length	name
INFORMATION														
NOMAD in safe mode	NMHK1010	1												
NOMAD in observing mode		2												
boot loader run count		3	NMHK1090	4 bytes	RUN_COUNT									
system log TM(60) generated		4												
flip mirror to default position (nadir)		5	NMHK1011	1 byte	(4 bits) spare	NMHK1013	1 byte	(4 bits) spare	NMHK1015	2 bytes	STEPS_COUNTER			

			NMHK1012		(4 bits) LS_STATUS (c) (table 20)	NMHK1014		(4 bits) LS_ENABLING (d) (table 21)							
flip mirror to contingency position (solar)		6	NMHK1016	1 byte	(4 bits) spare	NMHK1018	1 byte	(4 bits) spare	NMHK1020	2 bytes	STEPS_COUNTER				
			NMHK1017		(4 bits) LS_STATUS (c) (table 20)	NMHK1019		(4 bits) LS_ENABLING (d) (table 21)							
flip mirror to launch position		7	NMHK1021	1 byte	(4 bits) spare	NMHK1023	1 byte	(4 bits) spare	NMHK1025	2 bytes	STEPS_COUNTER				
			NMHK1022		(4 bits) LS_STATUS (c) (table 20)	NMHK1024		(4 bits) LS_ENABLING (d) (table 21)							
pinpuller fired		8													
end of measurement cycle		9													
force heater operation		10	NMHK1026	3 bytes	spare							NMHK1027	1 byte	(7 bits) spare	
												NMHK1028		(1 bit) force_heater_status (1 = force enabled, 0 = force disabled)	
ERRORS															
SpW error: error sending data	NMHK1010	100													
SpW error: main channel error		101													
SpW error: redundant channel error		102													
TC rejected: error in bytesize		110	NMHK1092	1 byte	spare	NMHK1093	3 bytes	WRONG_TC_SIZE							
TC rejected: error in checksum		111	NMHK1094	2 bytes	spare				NMHK1095	2 bytes	WRONG_CHECKSUM_TYPE				

TC rejected: unknown TC	112	NMHK1096	3 bytes	spare						NMHK1097	1 byte	WRONG_TC_TYPE	
TC rejected: error in parameters	113	NMHK1032	3 bytes	spare						NMHK1033	1 byte	TC_CODE	
TC not allowed in safe mode	114	NMHK1034	3 bytes	spare						NMHK1035	1 byte	TC_CODE	
TC not allowed in observing mode	115	NMHK1036	3 bytes	spare						NMHK1037	1 byte	TC_CODE	
flip mirror: max number of steps taken	120	NMHK1056	1 byte	(4 bits) spare	NMHK1058	1 byte	(4 bits) spare	NMHK1060	2 bytes	STEPS_COUNTER			
		NMHK1057		(4 bits) LS_STATUS (c) (table 20)	NMHK1059		(4 bits) LS_ENABLING (d) (table 21)						
flip mirror: already in commanded position	121	NMHK1041	1 byte	(4 bits) spare	NMHK1043	1 byte	(4 bits) spare	NMHK1045	2 bytes	STEPS_COUNTER			
		NMHK1042		(4 bits) LS_STATUS (c) (table 20)	NMHK1044		(4 bits) LS_ENABLING (d) (table 21)						
flip mirror: to default position - error limit switch (e)	122	NMHK1046	1 byte	(4 bits) spare	NMHK1048	1 byte	(4 bits) spare	NMHK1050	2 bytes	STEPS_COUNTER			
		NMHK1047		(4 bits) LS_STATUS (c) (table 20)	NMHK1049		(4 bits) LS_ENABLING (d) (table 21)						
flip mirror: to contingency position - error limit switch (f)	123	NMHK1051	1 byte	(4 bits) spare	NMHK1053	1 byte	(4 bits) spare	NMHK1055	2 bytes	STEPS_COUNTER			
		NMHK1052		(4 bits) LS_STATUS (c) (table 20)	NMHK1054		(4 bits) LS_ENABLING (d) (table 21)						
pin puller disarmed - no firing command received	124												

system reboot by watchdog	130	NMHK1099	3 bytes	spare					NMHK1061	1 byte	WATCHDOG_ERROR (1=trap error, 2=RTEMS fatal error, 3=Leon error, 4=1553 error)
sensor out of range	131	NMHK1070	3 bytes	spare					NMHK1071	1 byte	SENSOR_INDEX (see table 26)
contingency detected	132	NMHK1080	3 bytes	spare					NMHK1081	1 byte	CONTINGENCY_CODE (see table 22)
file system error	140	NMHK1083	1 byte	(7 bits) spare	NMHK1085	1 byte	FILE_ID	NMHK1086	2 bytes	CURRENT_CHECKSUM		
		NMHK1084		(1 bit) IS_FILE_SYSTEM (0 = is a file, 1= is file system)								

(c) "0" if limit switch (LS) is pressed, "1" if limit switch (LS) is not pressed
(d) "0" if limit switch (LS) is enabled "1" if limit switch (LS) is disabled

(e) when "LS nadir nominal switch enabled but not pressed" OR "LS nadir nominal switch disabled while LS nadir overshoot enabled switch and not pressed"
(f) when "LS solar nominal switch enabled but not pressed" OR "LS solar nominal switch disabled while LS solar overshoot enabled switch and not pressed"

Table 22: NOMAD housekeeping parameters – "SINBAD sensors"

								Sensors ADC readout (decimal format, ADC counts, expected values)	
code	parameter name	transfer function	size (bits)	description	Raw Value Range	Calculated Value Range	Calculated Units	Nominal or channel OFF (approx. value)	Channel ON (approx. Value)
NMHK1103	DC_DC_MODULE_TEMPERATURE	real_val (°C) = 0.1362*code - 273.2	16	temperature of DC/DC module	1638 to 2739	-50.10 to 99.85	deg C		
NMHK1104	POWER_BOARD_TEMPERATURE	real_val (°C) = 0.1362*code - 273.2	16	temperature of POW board	1638 to 2739	-50.10 to 99.85	deg C		
NMHK1105	LNO_DETECTOR_TEMPERATURE	real_val (°C) = -0.0721*code + 99.702	16	temperature of LNO cold section	0 to 3747	99.70 to -170.46	deg C		
NMHK1106	LNO_TEMPERATURE	real_val (°C) = -4.7346538E-09*code*code*code + 3.1940866E-05*code*code - 0.093183624*code + 121.48852	16	temperature of LNO	362 to 4095	91.72 to -49.61	deg C		
NMHK1107	UVIS_TEMPERATURE	real_val (°C) = -4.7346538E-09*code*code*code + 3.1940866E-05*code*code - 0.093183624*code + 121.48852	16	temperature of UVIS	362 to 4095	91.72 to -49.61	deg C		
NMHK1108	SO_TEMPERATURE	real_val (°C) = -4.7346538E-09*code*code*code + 3.1940866E-05*code*code - 0.093183624*code + 121.48852	16	temperature of SO	362 to 4095	91.72 to -49.61	deg C		
NMHK1109	ADC_1_REFERENCE_VOLTAGE_0_V	real_val (V) = code*(5/4095)	16	reference voltage 0 V for ADC1	0 to 10	0 to 0.013	V	1	
NMHK1110	ADC_1_REFERENCE_VOLTAGE_3_3_V	real_val (V) = code*(5/4095)	16	reference voltage 3.38 V for ADC1	2702 to 2826	3.3 to 3.45	V		2776
NMHK1111	SO_VOLTAGE	real_val (V) = 0.0105*code - 0.116	16	voltage for SO	11 to 3059	0 to 32	V	12	2856
NMHK1112	LNO_VOLTAGE	real_val (V) = 0.0107*code - 0.1282	16	voltage for LNO	12 to 3003	0 to 32	V	12	2820
NMHK1113	UVIS_VOLTAGE	real_val (V) = 0.0106*code - 0.117	16	voltage for UVIS	11 to 3030	0 to 32	V	12	2832
NMHK1114	SO_CURRENT	real_val (A) = 0.0003*code - 0.0413	16	current of SO	139 to 3000	0 to 0.859	A	139	2400-3000
NMHK1115	LNO_CURRENT	real_val (A) = 0.0003*code - 0.0511	16	current of LNO	173 to 3013	0 to 0.85	A	173	2400-3000

NMHK1116	UVIS_CURRENT	real_val (A) = 4E-05*code - 0.0111	16	current of UVIS	310 to 4095	0 to 0.153	A	310	3300-4095
NMHK1117	HEATER_CURRENT	real_val (A) = 0.0001*code - 0.0147	16	current op operational heaters	106 to 4095	0 to 0.4	A	106	approx. 3000
NMHK1118	ADC_2_REFERENCE_VOLTAGE_3_3_V	real_val (V) = code*(5/4095)	16	reference voltage 3.38 V for ADC2	2702 to 2826	3.3 to 3.45	V		2782

Table 23: NOMAD housekeeping parameters – "ADC 1 sensor supervisor"

code		parameter name	transfer function	size (bits)	description
NMHK1120	NMHK1121	SPARE	N/A	2	spare
	NMHK1122	DC_DC_MODULE_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of DC/DC module temperature (0=off, 1=on)
	NMHK1123	POWER_BOARD_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of POW board temperature (0=off, 1=on)
	NMHL1124	LNO_DETECTOR_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of LNO cold section temperature (0=off, 1=on)
	NMHK1125	SO_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of SO temperature (0=off, 1=on)
	NMHK1126	LNO_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of LNO temperature (0=off, 1=on)
	NMHK1127	UVIS_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of status of UVIS temperature (0=off, 1=on)

Table 24: NOMAD housekeeping parameters – "ADC 2 sensor supervisor"

code		parameter name	transfer function	size (bits)	description
NMHK1130	NMHK1131	SPARE	N/A	1	spare
	NMHK1132	SO_VOLTAGE_SUPERVISOR	N/A	1	supervisor of status of SO voltage (0=off, 1=on)
	NMHK1133	LNO_VOLTAGE_SUPERVISOR	N/A	1	supervisor of status of LNO voltage (0=off, 1=on)
	NMHK1134	UVIS_VOLTAGE_SUPERVISOR	N/A	1	supervisor of status of UVIS voltage (0=off, 1=on)
	NMHK1135	SO_CURRENT_SUPERVISOR	N/A	1	supervisor of status of SO current (0=off, 1=on)
	NMHK1136	LNO_CURRENT_SUPERVISOR	N/A	1	supervisor of status of LNO current (0=off, 1=on)

	NMHK1137	UVIS_CURRENT_SUPERVISOR	N/A	1	supervisor of status of UVIS current (0=off, 1=on)
	NMHK1138	HEATER_CURRENT_SUPERVISOR	N/A	1	supervisor of status of heater current (0=off, 1=on)

Table 25: NOMAD housekeeping parameters – "heater supervisor"

code		parameter name	transfer function	size (bits)	description
NMHK1160	NMHK1161	SPARE	N/A	4	spare
	NMHK1162	HEATER_CONTROL_SUPERVISOR	N/A	1	supervisor of heater control (0=off, 1=on)
	NMHK1163	HEATER_SO_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of SO heater temperature (0=off, 1=on)
	NMHK1164	HEATER_LNO_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of LNO heater temperature (0=off, 1=on)
	NMHK1165	HEATER_UVIS_TEMPERATURE_SUPERVISOR	N/A	1	supervisor of UVIS heater temperature (0=off, 1=on)

Table 26:– NOMAD housekeeping parameters – "NOMAD power status"

code		parameter name	transfer function	size (bits)	description
NMHK1140	NMHK1141	SPARE	N/A	2	spare
	NMHK1142	OPERATIONAL_HEATER_POWER_STATUS	N/A	1	heater power status (0=off, 1=on)
	NMHK1143	SO_POWER_STATUS	N/A	1	SO power status (0=off, 1=on)
	NMHK1144	LNO_POWER_STATUS	N/A	1	LNO power status (0=off, 1=on)
	NMHK1145	UVIS_POWER_STATUS	N/A	1	UVIS power status (0=off, 1=on)
	NMHK1146	SINBAD_POWER_LINE_REDUNDANT_STATUS	N/A	1	SINBAD power line redundant status (0=off, 1=on)
	NMHK1147	SINBAD_POWER_LINE_MAIN_STATUS	N/A	1	SINBAD power line main status (0=off, 1=on)

Table 27: NOMAD housekeeping parameters – "NOMAD flip mirror status"

code		parameter name	transfer function	size (bits)	description
NMHK1150	NMHK1151	SPARE	N/A	4	spare
	NMHK1152	STEPPER_LIMIT_SWITCH_NADIR_NOMINAL_STATUS	N/A	1	limit switch nadir nominal status (0=pressed, 1=not pressed)
	NMHK1153	STEPPER_LIMIT_SWITCH_NADIR_OVERSHOOT_STATUS	N/A	1	limit switch nadir overshoot status (0=pressed, 1=not pressed)
	NMHK1154	STEPPER_LIMIT_SWITCH_SOLAR_NOMINAL_STATUS	N/A	1	limit switch solar nominal status (0=pressed, 1=not pressed)
	NMHK1155	STEPPER_LIMIT_SWITCH_SOLAR_OVERSHOOT_STATUS	N/A	1	limit switch solar overshoot status (0=pressed, 1=not pressed)

Table 28: NOMAD housekeeping parameters – "Operational mode"

code	parameter name	transfer function	size (bits)	description
NMHK1210	CURRENT_OPERATIONAL_MODE	N/A	8	operational mode (87=safe mode, 165=science mode)

Table 29: NOMAD housekeeping parameters– "Contingencies"

code	parameter name	transfer function	size (bits)	description
NMHK1220	CONTINGENCY_COUNT	N/A	16	contingency count
NMHK1221	LAST_CONTINGENCY_SECONDS	Sinbad_seconds	32	last contingency seconds
NMHK1222	LAST_CONTINGENCY_MICRO_SECONDS	Sinbad_micro_seconds	32	last contingency microseconds
NMHK1223	LAST_CONTINGENCY_CODE	N/A	8	last contingency code (255=no value, other value = contigency code)

Table 30: NOMAD housekeeping parameters – "Events"

code	parameter name	transfer function	size (bits)	description
NMHK1230	EVENT_COUNT	N/A	16	event count
NMHK1231	LAST_EVENT_SECONDS	Sinbad_seconds	32	last event seconds
NMHK1232	LAST_EVENT_MICRO_SECONDS	Sinbad_micro_seconds	32	last event microseconds
NMHK1233	LAST_EVENT_CODE	N/A	8	last event code

Table 31: NOMAD housekeeping parameters – "1553 BUS"

code	parameter name	transfer function	size (bits)	description
NMHK1310	BUS_1553_SENT_BYTE	N/A	32	bytes sent over 1553 bus

Table 32: NOMAD housekeeping parameters – "Space_Wire"

code	parameter name	transfer function	size (bits)	description
NMHK1320	SPACE_WIRE_SENT_BYTE	N/A	32	bytes sent over SpaceWire

Table 33: NOMAD housekeeping parameters – "SPACE_WIRE_MAIN_CHANNEL"

code	parameter name	transfer function	size (bits)	description
NMHK1330	SPW_STATUS_MAIN	N/A	8	possible values: error_reset (0), error_wait (1), ready (2), started (3), connecting (4), running (5), uninitialized (14)

Table 34: NOMAD housekeeping parameters – "SPACE_WIRE_STATISTICS_MAIN"

code	parameter name	transfer function	size (bits)	description
NMHK1340	TX_LINK_ERROR_MAIN	N/A	16	transmission link error main channel
NMHK1341	PARITY_ERROR_MAIN	N/A	16	parity error main channel
NMHK1342	ESCAPE_ERROR_MAIN	N/A	16	escape error main channel
NMHK1343	CREDIT_ERROR_MAIN	N/A	16	credit error main channel
NMHK1344	PACKET_DISCARDED_COUNT_MAIN	N/A	16	Number of discared packets due to AMBA errors in spw main channel
NMHK1345	DISCONNECT_ERROR_MAIN	N/A	16	disconnect error main channel
NMHK1346	PACKET_SENT_COUNT_MAIN	N/A	16	number of packets sent on main channel

Table 35: NOMAD housekeeping parameters – "SPACE_WIRE_REDUNDANT_CHANNEL"

code	parameter name	transfer function	size (bits)	description
NMHK1350	SPW_STATUS_REDUNDANT	N/A	8	possible values: error_reset (0), error_wait (1), ready (2), started (3), connecting (4), running (5), uninitialized (14)

Table 36: NOMAD housekeeping parameters – "SPACE_WIRE_STATISTICS_REDUNDANT"

code	parameter name	transfer function	size (bits)	description
NMHK1360	TX_LINK_ERROR_REDUNDANT	N/A	16	transmission link error redundant channel
NMHK1361	PARITY_ERROR_REDUNDANT	N/A	16	parity error redundant channel
NMHK1362	ESCAPE_ERROR_REDUNDANT	N/A	16	escape error redundant channel
NMHK1363	CREDIT_ERROR_REDUNDANT	N/A	16	credit error redundant channel
NMHK1364	PACKET_DISCARDED_COUNT_REDUNDANT	N/A	16	Number of discared packets due to AMBA errors in spw redundant channel
NMHK1365	DISCONNECT_ERROR_REDUNDANT	N/A	16	disconnect error redundant channel
NMHK1366	PACKET_SENT_COUNT_REDUNDANT	N/A	16	number of packets sent on redundant channel

Table 37: SO channel housekeeping parameters

code	parameter name	transfer function (a)	size (bits)	description	Raw Value Range	Calculated Value Range	Calculated Units
NMHK2310	POSITIVE_12_V_MEASURED_ON_SO_CCC	real_val (V) =code*(3/8192)*(47+12)/12	16	+12 V measured on CCC board of SO	-8192 to 8191	-14.75 to 14.75	V
NMHK2311	NEGATIVE_12_V_MEASURED_ON_SO_CCC	real_val (V) =code*(3/8192)*(47+12)/12	16	-12 V measured on CCC board of SO	-8192 to 8191	-14.75 to 14.75	V
NMHK2312	POSITIVE_8_5_V_MEASURED_ON_SO_HSK	real_val (V) = code*(3/8192)*(33.2+10)/10	16	+8.5 V measured on HSK board of SO	-8192 to 8191	-12.96 to 12.96	V
NMHK2313	NEGATIVE_8_5_V_MEASURED_ON_SO_HSK	real_val (V) = code*(3/8192)*(33.2+10)/10	16	-8.5 V measured on HSK board of SO	-8192 to 8191	-12.96 to 12.96	V
NMHK2314	POSITIVE_3_3_V_MEASURED_ON_SO_CCC	real_val (V) = code*(3/8192)*(2.5+10)/10	16	+3.3 V measured on CCC board of SO	-8192 to 8191	-3.75 to 3.75	V
NMHK2315	POITIVE_2_5_V_MEASURED_ON_SO_CCC	real_val (V) = code*(3/8192)	16	+2.5 V measured on CCC board of SO	-8192 to 8191	-3 to 3	V
NMHK2316	POSITIVE_5_V_MEASURED_ON_SO_HSK	real_val (V) = code*(3/8192)*(10+10)/10	16	+5 V measured on HSK board of SO	-8192 to 8191	-6 to 6	V

NMHK2317	NEGATIVE_5_V_MEASURED_ON_SO_HSK	real_val (V) = code*(3/8192)*(10+10)/10	16	-5 V measured on HSK board of SO	-8192 to 8191	-6 to 6	V
NMHK2318	FPA_1_FULL_SCALE_TEMPERATURE_SO	x=code*(3/8192)*(10/29.1) real_val (°K) =- 460,66*x*x*x*x + 1053,2*x*x*x - 813,45*x*x - 227,36*x + 539,7	16	SO focal plane array full scale temperture	0 to 8191	74.46 to 539.7	deg K
NMHK2319	FPA_2_ZOOMED_TEMPERATURE_SO	real_val (V) = code*(3/8192)	16	SO focal plane array zoomed temperature	-8192 to 8191	-3 to 3	V
NMHK2320	SENSOR_1_TEMPERATURE_SO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 1 near SO AOTF housing	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2321	SENSOR_2_TEMPERATURE_SO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 2 near SO grating structure	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2322	SENSOR_3_TEMPERATURE_SO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 3 near SO detector structure	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2323	AOTF_TEMPERATURE_SO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature inside SO AOTF box	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2324	RF_AMPLITUDE_SO	real_val (V) = code*(3/8192)	16	RF amplitude of SO AOTF driver	-8192 to 8191	-3 to 3	V
NMHK2325	GROUND_MEASURED_ON_SO_HSK	real_val (V) = code*(3/8192)	16	ground potential measured on SO HSK board	-8192 to 8191	-3 to 3	V
NMHK2326	MOTOR_POWER_DAC_CODE_SO	real_val = code	16	SO cooler motor power DAC control	-8192 to 8191	0 to 8191	ADU

(a) the raw value should be treated as a 14-bit signed value (padded with 2 leading zeroes).
(b) In the infrared channels (SO and LNO) we use a 14-bit ADC. We are treating the 16-bit value as a 14-bit signed value (if you ignore the 2 most significant bits). Before conversion, please apply following rule: if (code =< 8191) then (code = code) else (code = code - 16384)

Table 38: LNO channel housekeeping parameters

code	parameter name	transfer function (a)	size (bits)	description	Raw Value Range	Calculated Value Range	Calculated Units
NMHK2610	POSITIVE_12_V_MEASURED_ON_LNO_CCC	real_val (V) =code*(3/8192)*(47+12)/12	16	+12 V measured on CCC board of LNO	-8192 to 8191	-14.75 to 14.75	V
NMHK2611	NEGATIVE_12_V_MEASURED_ON_LNO_CCC	real_val (V) =code*(3/8192)*(47+12)/12	16	-12 V measured on CCC board of LNO	-8192 to 8191	-14.75 to 14.75	V
NMHK2612	POSITIVE_8_5_V_MEASURED_ON_LNO_HSK	real_val (V) = code*(3/8192)*(33.2+10)/10	16	+8.5 V measured on HSK board of LNO	-8192 to 8191	-12.96 to 12.96	V
NMHK2613	NEGATIVE_8_5_V_MEASURED_ON_LNO_HSK	real_val (V) = code*(3/8192)*(33.2+10)/10	16	-8.5 V measured on HSK board of LNO	-8192 to 8191	-12.96 to 12.96	V

NMHK2614	POSITIVE_3_3_V_MEASURED_ON_LNO_CCC	real_val (V) = code*(3/8192)*(2.5+10)/10	16	+3.3 V measured on CCC board of LNO	-8192 to 8191	-3.75 to 3.75	V
NMHK2615	POSITIVE_2_5_V_MEASURED_ON_LNO_CCC	real_val (V) = code*(3/8192)	16	+2.5 V measured on CCC board of LNO	-8192 to 8191	-3 to 3	V
NMHK2616	POSITIVE_5_V_MEASURED_ON_LNO_HSK	real_val (V) = code*(3/8192)*(10+10)/10	16	+5 V measured on HSK board of LNO	-8192 to 8191	-6 to 6	V
NMHK2617	NEGATIVE_5_V_MEASURED_ON_LNO_HSK	real_val (V) = code*(3/8192)*(10+10)/10	16	-5 V measured on HSK board of LNO	-8192 to 8191	-6 to 6	V
NMHK2618	FPA_1_FULL_SCALE_TEMPERATURE_LNO	x=code*(3/8192)*(10/29.1) real_val (°K) =- 460,66*x*x*x*x + 1053,2*x*x*x - 813,45*x*x - 227,36*x + 539,7	16	LNO focal plane array full scale temperture	0 to 8191	74.46 to 539.7	deg K
NMHK2619	FPA_2_ZOOMED_TEMPERATURE_LNO	real_val (V) = code*(3/8192)	16	LNO focal plane array zoomed temperature	-8192 to 8191	-3 to 3	V
NMHK2620	SENSOR_1_TEMPERATURE_LNO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 1 near LNO AOTF housing	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2621	SENSOR_2_TEMPERATURE_LNO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 2 near LNO grating structure	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2622	SENSOR_3_TEMPERATURE_LNO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature sensor 3 near LNO detector structure	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2623	AOTF_TEMPERATURE_LNO	real_val (°C) = (code*(3*1000/8192)+3/11)/51	16	temperature inside LNO AOTF box	-8192 to 8191	-58.83 to 58.82	deg C
NMHK2624	RF_AMPLITUDE_LNO	real_val (V) = code*(3/8192)	16	RF amplitude of LNO AOTF driver	-8192 to 8191	-3 to 3	V
NMHK2625	GROUND_MEASURED_ON_LNO_HSK	real_val (V) = code*(3/8192)	16	ground potential measured on LNO HSK board	-8192 to 8191	-3 to 3	V
NMHK2626	MOTOR_POWER_DAC_CODE_LNO	real_val = code	16	LNO cooler motor power DAC control	0 to 8191	0 to 8191	ADU

(a) the raw value should be treated as a 14-bit signed value (padded with 2 leading zeroes).
(b) In the infrared channels (SO and LNO) we use a 14-bit ADC. We are treating the 16-bit value as a 14-bit signed value (if you ignore the 2 most significant bits). Before conversion, please apply following rule: if (code =< 8191) then (code = code) else (code = code - 16384)

Table 39: UVIS channel housekeeping parameters

code TM(29) - 1553	code TM(28)	code TM(29) - SpW	parameter name	transfer function	size (bits)	description	Raw Value Range	Calculated Value Range	Example Raw Value (code) on FM	Example Calculated Value on FM	Calculated Units
NMHK2910	NMTM2810	NMTM2910	POSITIVE_10_V_RAIL_VOLTAGE	real_val (V) = code * (3980/4096) / 20000 *	16	10V_POS	1500 to 1833	9 to 11	1677	9.777	V

				(100+20)							
NMHK2911	NMTM 2811	NMTM291 1	NEGATIVE_10_V_RAIL_V OLTAGE	real_val (V) = -code* (3980/4096) / 20000 * 100	16	10V_NEG	1800 to 2200	minus 9 to minus 11	2037	-9.897	V
NMHK2912	NMTM 2812	NMTM291 2	POSITIVE_5_V_RAIL_VOL TAGE	real_val (V) = code* (3980/4096) / 20000 * (20+30.1)	16	5V_POS	1600 to 2400	4 to 6	2012	4.897	V
NMHK2913	NMTM 2813	NMTM291 3	NEGATIVE_5_V_RAIL_VO LTAGE	real_val (V) = -code * (3980/4096) / 20000 * 50	16	5V_NEG	1600 to 2400	minus 4 to minus 6	2033	-4.939	V
NMHK2914	NMTM 2814	NMTM291 4	POSITIVE_12_V_RAIL_CU RRENT	real_val (mA) = code* (3980/4096) * 0.2	16	(+12V rail current)	0 to 500	0 to 100	194	37.7	mA
NMHK2915	NMTM 2815	NMTM291 5	NEGATIVE_12_V_RAIL_C URRENT	real_val (mA) = code* (3980/4096) * 0.2	16	(-12V rail current)	0 to 500	0 to 100	131	25.458	mA
NMHK2916	NMTM 2816	NMTM291 6	POSITIVE_5_V_RAIL_CUR RENT	real_val (mA) = code* (3980/4096) * 0.2	16	(+5V rail current)	0 to 250	0 to 50	157	30.511	mA
NMHK2917	NMTM 2817	NMTM291 7	NEGATIVE_5_V_RAIL_CU RRENT	real_val (mA) = code* (3980/4096) * 0.002	16	(-5V rail current)	0 to 5000	0 to 10	88	0.171	mA
NMHK2918	NMTM 2818	NMTM291 8	CCD_IMAGE_CLOCK_HIG H	real_val (V) = code* (3980/4096) / 20000 * (20 +80)	16	CCD image clock HI	1600 to 3000	8 to 15	2429	11.801	V
NMHK2919	NMTM 2819	NMTM291 9	CCD_IMAGE_CLOCK_LO W	real_val (V) = code* (3980/4096) /1000	16	CCD image clock LO	0 to 3000	0 to 3	611	0.594	V
NMHK2920	NMTM 2820	NMTM292 0	CCD_READOUT_REGISTE R_HIGH	real_val (V) = code* (3980/4096) / 20000 * (20 +80)	16	CCD readout register HI	1600 to 3000	8 to 15	2216	10.766	V
NMHK2921	NMTM 2821	NMTM292 1	CCD_READOUT_REGISTE R_LOW	real_val (V) = code* (3980/4096) /1000	16	CCD readout register LO	0 to 3000	0 to 3	606	0.589	V
NMHK2922	NMTM 2822	NMTM292 2	SUBSTRATE_VOLTAGE_VS S	real_val (V) = code* (3980/4096)/ 2490 * (6.8+2.49)	16	Substrate Voltage (VSS)	2087 to 2870	8 to 11	2447	8.871	V
NMHK2923	NMTM 2823	NMTM292 3	OUTPUT_GATE_VOLTAGE _VOG	real_val (V) = code* (3980/4096) /1000	16	Output gate voltage (VOG)	1000 to 5000	1 to 5	3042	2.956	V
NMHK2924	NMTM 2824	NMTM292 4	OUTPUT_DRAIN_VOLTAG E_VOD	real_val (V) = code * (3980/4096) / 20000 * (249+20)	16	Output drain voltage (VOD)	2007 to 2379	27 to 32	2230	29.144	V
NMHK2925	NMTM 2825	NMTM292 5	RESET_TRANSISTOR_DRAI N_VOLTAGE_VRD	real_val (V) = code* (3980/4096) / 20000 * (20+150)	16	Reset transistor drain voltage (VRD)	1764 to 2236	15 to 19	1980	16.353	V
NMHK2926	NMTM 2826	NMTM292 6	DIODE_DRAIN_VOLTAGE _VDD	real_val (V) = code* (3980/4096) / 20000 * (20+226)	16	Diode drain voltage (VDD)	1788 to 2033	22 to 25	2005	23.963	V
NMHK2927	NMTM 2827	NMTM292 7	TEMPERATURE_1	real_val (°C) = code* (3980/4096) /2.49 - 273.27	16	Temp 1 (Proximity Board)	530 to 930	minus 60 to + 100	797	37.62	deg C
NMHK2928	NMTM	NMTM292	TEMPERATURE_2	real_val (°C) = code*	16	Temp 2 (CCD)	530 to	minus 60 to +	777	29.816	deg C

	2828	8		(3980/4096) /2.49 - 273.27			930	100			
NMHK2929	NMTM 2829	NMTM292 9	TEMPERATURE_3	real_val (°C) = code* (3980/4096) /2.49 - 273.27	16	Temp 3 (Detector Board)	530 to 930	minus 60 to + 100	775	29.035	deg C
NMHK2930	NMTM 2830	NMTM293 0	MOTOR_CURRENT_A	real_val (mA) = code* (3980/4096)* 0.2	16	Motor current	0 to 600	0 to 120	20, 268, 506	3.887, 52.08, 98.334	mA

Table 40: LIMIT SWITCH STATUS BITS

bit	function
7 (MSB)	spare
6	spare
5	spare
4	spare
3	status NADIR_NOMINAL switch
2	status NADIR_OVERSHOOT switch
1	status SOLAR_NOMINAL switch
0 (LSB)	status SOLAR_OVERSHOOT switch

Table 41: LIMIT SWITCH ENABLING BITS

bit	function
7 (MSB)	spare
6	spare
5	spare
4	spare
3	enabled/disabled NADIR_NOMINAL switch
2	enabled/disabled NADIR_OVERSHOOT switch
1	enabled/disabled SOLAR_NOMINAL switch

0 (LSB)	enabled/disabled SOLAR_OVERSHOOT switch

Table 42: CONTINGENCY LIST

contingency code	description
Sensor contingencies	
0	SINBAD DC/DC module temperature sensor above range
1	SINBAD POW board temperature sensor above range
2	heater on - current sensor above range
3	heater on - current sensor below range
4	heater off - control enabled - current sensor above range
5	SO channel temperature sensor above range
6	SO channel temperature sensor below range
7	SO channel voltage sensor above range
8	SO channel voltage sensor below range
9	SO channel on - current sensor above range
10	SO channel on - current sensor below range
11	SO channel off - current sensor above range
12	LNO detector temperature sensor above range
13	LNO detector temperature sensor below range
14	LNO channel temperature sensor above range
15	LNO channel temperature sensor below range
16	LNO channel voltage sensor above range
17	LNO channel voltage sensor below range

18	LNO channel on - current sensor above range
19	LNO channel on - current sensor below range
20	LNO channel off - current sensor above range
21	UVIS channel temperature sensor above range
22	UVIS channel temperature sensor below range
23	UVIS channel voltage sensor above range
24	UVIS channel voltage sensor below range
25	UVIS channel on - current sensor above range (contigency code not used)
26	UVIS channel on - current sensor below range
27	UVIS channel off - current sensor above range
Channel contingencies	
28	SO channel no data
29	LNO channel no data
30	UVIS channel no data
31	LNO flip mirror error going to default position
32	LNO flip mirror error going to contingency position position
33	LNO flip mirror does not stop movement
255	No contigency

Table 43: RESULT CODE

Result Code	name	description
0	Operation OK	Operation sucessfully applied
-40	File corrupted	Source/destination file has wrong size or name
-41	File checksum error	Error in the source/destination file checksum
-42	Offset out of range	Offset in file or data bytes size to update file are out of range (greater than the file size or maximum size)
-43	File name already exists	The name of the new file already exists
-44	Cannot add more files in file system	The file system has raised the maximum number of file, 255.
-45	No room in file system	The file system has not free space to store more files
-46	Cannot delete a default file	It is not allowed to delete the first 19 files
-47	Error in file compression	Error in file compression
-48	Error in file decompression	Error in file decompression
-49	Error getting data from EEPROM	Error getting data from EEPROM
-50	File system corruption	Some files or the file system are corrupted (corruption implies wrong size, name or checksum)

Table 44: SENSOR INDEX

sensor index	sensor name
0	DC DC temperature sensor
1	Power board temperature sensor
2	LNO detector temperature sensor
3	LNO channel temperature sensor
4	UVIS channel temperature sensor

5	SO channel temperature sensor
6	ADC 1 voltage reference 0 V
7	ADC 1 voltage reference 3.3 V
8	SO channel voltage sensor
9	LNO channel voltage sensor
10	UVIS channel voltage sensor
11	SO channel current sensor
12	LNO channel current sensor
13	UVIS channel current sensor
14	Heater current sensor
15	ADC 2 voltage reference 3.3 V

Table 45: FILE MANAGER OPERATIONS REPORT

Op. Code	File op. name	Result code		File ID	Byte Size	Checksum
		Code	Meaning			
10	Append to file	0	Operation OK	file ID	file updated byte size	file updated checksum
		-40	File corrupted	file ID	file byte size	file checksum
		-41	File checksum error	file ID	file byte size	file checksum
		-42	Offset out of range	file ID	file byte size	file checksum
11	Update file	0	Operation OK	file ID	file updated byte size	file updated checksum
		-40	File corrupted	file ID	file byte size	file checksum
		-41	File checksum error	file ID	file byte size	file checksum

		-42	Offset out of range	file ID	file byte size	file checksum
12	Update column file	0	Operation OK	file ID	file updated byte size	file updated checksum
		-40	File corrupted	file ID	file byte size	file checksum
		-41	File checksum error	file ID	file byte size	file checksum
		-42	Offset out of range	file ID	file byte size	file checksum
13	Copy entire file	0	Operation OK	destination file ID	destination file byte size	destination file checksum
		-40	File corrupted	source/destination file ID	source/destination file byte size	source/destination file checksum
		-41	File checksum error	source/destination file ID	source/destination file byte size	source/destination file checksum
		-42	Offset out of range	destination file ID	destination file byte size	destination file checksum
14	Copy partial file	0	Operation OK	destination file ID	destination file byte size	destination file checksum
		-40	File corrupted	source/destination file ID	source/destination file byte size	source/destination file checksum
		-41	File checksum error	source/destination file ID	source/destination file byte size	source/destination file checksum
		-42	Offset out of range	source/destination file ID	source/destination file byte size	source/destination file checksum
15	Fill file with memory area	0	Operation OK	destination file ID	destination file byte size	destination file checksum
		-40	File corrupted	destination file ID	destination file byte size	destination file checksum
		-41	File checksum error	destination file ID	destination file byte size	destination file checksum
		-42	Offset out of range	destination file ID	destination file byte size	destination file checksum
		-48	Error in file decompression	destination file ID	0	0
20	Create empty file	0	Operation OK	new file ID	0	0
		-43	File name already exists	file ID of the file with this name	file size of the file with this name	checksum of the file with this name
		-44	Cannot add more files in file system	file system max file count	0	file system checksum
		-45	No room in file system	file system file count	0	file system checksum
21	Delete last file	0	Operation OK	deleted file id	deleted file byte size	deleted file checksum
		-46	Cannot delete a default file	last file ID	last file byte size	last file checksum
22	Erase file content	0	Operation OK	file ID	file byte size	file byte size

30	Reset file system	0	Operation OK	0	file system file count	file system checksum
		-49	Error getting data from EEPROM	file ID of the (last) erroreus file	file system file count	file system checksum
31	Decompress file	0	Operation OK	destination file ID	destination file byte size	destination file checksum
		-40	File corrupted	source/destination file ID	source/destination file byte size	source/destination file checksum
		-41	File checksum error	source/destination file ID	source/destination file byte size	source/destination file checksum
		-42	Offset out of range	destination file ID	destination file byte size	destination file checksum
		-48	Error in file decompression	source file ID	source file byte size	source file checksum
40	Download compressed file	0	Operation OK	source file ID	source file byte size	source file checksum
		-40	File corrupted	source file ID	source file byte size	source file checksum
		-41	File checksum error	source file ID	source file byte size	source file checksum
		-47	Error in file compression	source file ID	source file byte size	source file checksum
41	Print file status	0	Operation OK	file ID	file byte size	file checksum
		-40	File corrupted	file ID	file byte size	file checksum
		-41	File checksum error	file ID	file byte size	file checksum
42	Print full status	0	Operation OK	0 (not applicable)	file system file count	file system checksum
		-50	File system corruption	0 (not applicable)	file system file count	file system checksum
43	Print file system status	0	Operation OK	0 (not applicable)	file system file count	file system checksum
		-50	File system corruption	0 (not applicable)	file system file count	file system checksum

7.3 TELEMETRY DATA (VIA SPACEWIRE)

Table 46 gives an overview of the NOMAD SpaceWire bus telemetry data, Table 47shows the packet structure of the SpaceWire bus telemetry.

Table 46: SpaceWire bus telemetry data packets and parameters

code	name	sub address	function	timing	type	packet size	timestamp	TM count	data			checksum	generated after telecommand + repetition rate
					1 byte	3 bytes	8 bytes	2 bytes	code	length	name	2 bytes	
NMTM2200	TM(22)	N/A	SO science	async	22	min = 242 max = 11762	NMTM2201	NMTM2202	NMTM2203	8 bytes	TC_EXECUTION_TIMESTAMP	CC	TC(20) - continuously
									NMTM2204	1 byte	CHANNEL_ID (1= SO, 2= LNO)		
									NMTM2205	1 byte	FLIP_MIRROR_INFO (0= contingency position(solar), 1= default position(nadir), 255= unknow position)		
									NMTM2206	44 bytes	HSK_TIMESTAMP (8 bytes)		
											HSK_TM_COUNT (2 bytes)		
											LAST_HOUSEKEEPING_DATA (34 bytes)(see table 17)		
									NMTM2207	2 byte	SIZE_OF_TC_COPY (25 ,50, 75, 100, 125 or 150)		
									NMTM2208	4 bytes	SIZE_OF_SCIENCE_DATA = N = 16 or 11536		
									NMTM2209	25 bytes	LAST_TELECOMMAND SUBDOMAIN_1 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_2 (see table 25)		

										25 bytes	LAST_TELECOMMAND SUBDOMAIN_3 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_4 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_5 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_6 (see table 25)		
									NMTM2210	N bytes	SO_SCIENCE_DATA (a)		
NMTM2500	TM(25)	N/A	LNO science	async	25	min = 242 max = 11762	NMTM2501	NMTM2502	NMTM2503	8 bytes	TC_EXECUTION_TIMESTAMP	CC	TC(20) - continuously
									NMTM2504	1 byte	CHANNEL_ID (1= SO, 2= LNO)		
									NMTM2505	1 byte	FLIP_MIRROR_INFO (0= contingency position(solar), 1= default position(nadir), 255= unknow position)		
									NMTM2506	44 bytes	HSK_TIMESTAMP (8 bytes)		
											HSK_TM_COUNT (2 bytes)		
											LAST_HOUSEKEEPING_DATA (34 bytes)(see table 18)		
									NMTM2507	2 byte	SIZE_OF_TC_COPY (25 ,50, 75, 100, 125 or 150)		
									NMTM2508	4 bytes	SIZE_OF_SCIENCE_DATA = N = 16 or 11536		
									NMTM2509	25 bytes	LAST_TELECOMMAND SUBDOMAIN_1 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_2 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_3 (see table 25)		

										25 bytes	LAST_TELECOMMAND SUBDOMAIN_4 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_5 (see table 25)		
										25 bytes	LAST_TELECOMMAND SUBDOMAIN_6 (see table 25)		
									NMTM2510	N bytes	LNO_SCIENCE_DATA (a)		
NMTM2700	TM(27)	N/A	UVIS applied parameters	async	27	48	NMTM2701	NMTM2702	NMTM2703	1 byte	UVIS_RESET_SELECTOR	CC	TC(20) - once
									see table 24	31 bytes	UVIS_COP_ROW_VALUES		
NMTM2800	TM(28)	N/A	UVIS science	async	28	min = 2186 max = 31530	NMTM2801	NMTM2802	see table 24	32 bytes	UVIS_COP_ROW_VALUES	CC	TC(20) - continuously
									see table 19 in sheet "TELEMETRY (1553)"	42 bytes	UVIS_HOUSEKEEPING		
									NMTM2890	N x 2096 bytes	UVIS_SCIENCE_DATA (N=1, ..., 15) (c)(d) (e) (f)		
NMTM2900	TM(29) (b)	N/A	UVIS HK	async	29	58	NMTM2901	NMTM2902	see table 19 in sheet "TELEMETRY (1553)"	42 bytes	UVIS_HOUSEKEEPING	CC	TC(20) - continuously
NMTM3700	TM(37)	N/A	file manager download file report	async	37 (type 1)	55			NMTM3701	1 byte	FILE_ID	CC	TC(35) with OPERATION_CODE = 40 Always at least 2 TM(37) are sent, one of type 1 and one (or more) of type 2 (depending on file size)
									NMTM3702	2 bytes	CHUNK_NUMBER = 0		
									NMTM3703	4 bytes	START_ADDRESS_TEMP_FILE		
									NMTM3704	4 bytes	USED_BYTES_TEMP_FILE		
									NMTM3705	4 bytes	MAX_BYTES_TEMP_FILE		
									NMTM3706	32 bytes	NAME_COMPRESSED_FILE		
									NMTM3707	2	CHECKSUM_TEMP_FILE		

										bytes			
					37 (type 2)	min = 10 max = 1024			NMTM3710	1 byte	FILE_ID	CC	
									NMTM3711	2 bytes	CHUNK_NUMBER = 1 (optional 2, 3, ...)		
									NMTM3712	Nd bytes	FILE_DATA (Nd = 1 ... 1015)		
NMTM6000	TM(60)	N/A	system log	sync (10')	60	max = 4096			NMTM6001	max 4090 bytes	LOG_LIST	CC	continuously Rate depends on occupancy of SINBAD and number of events (between 1' and 10')

(a) described in SO/LNO TM/TC Strategy document (RD02) --> during science phase the size of SO/LNO_SCIENCE DATA is 16bytes+320 pixels*24lines/pixel*1.5 byte/pixel = 11536 bytes. Total size of TM(22)(25) is then 11762 bytes.During the precooling phase the size of SO/LNO_SCIENCE DATA is 16 bytes hence total size of TM(22)(25) packets is 242 bytes.

(b) same data as TM(29) in 1553 channel

(c) described in UVIS TM/TC Strategy document (RD03)

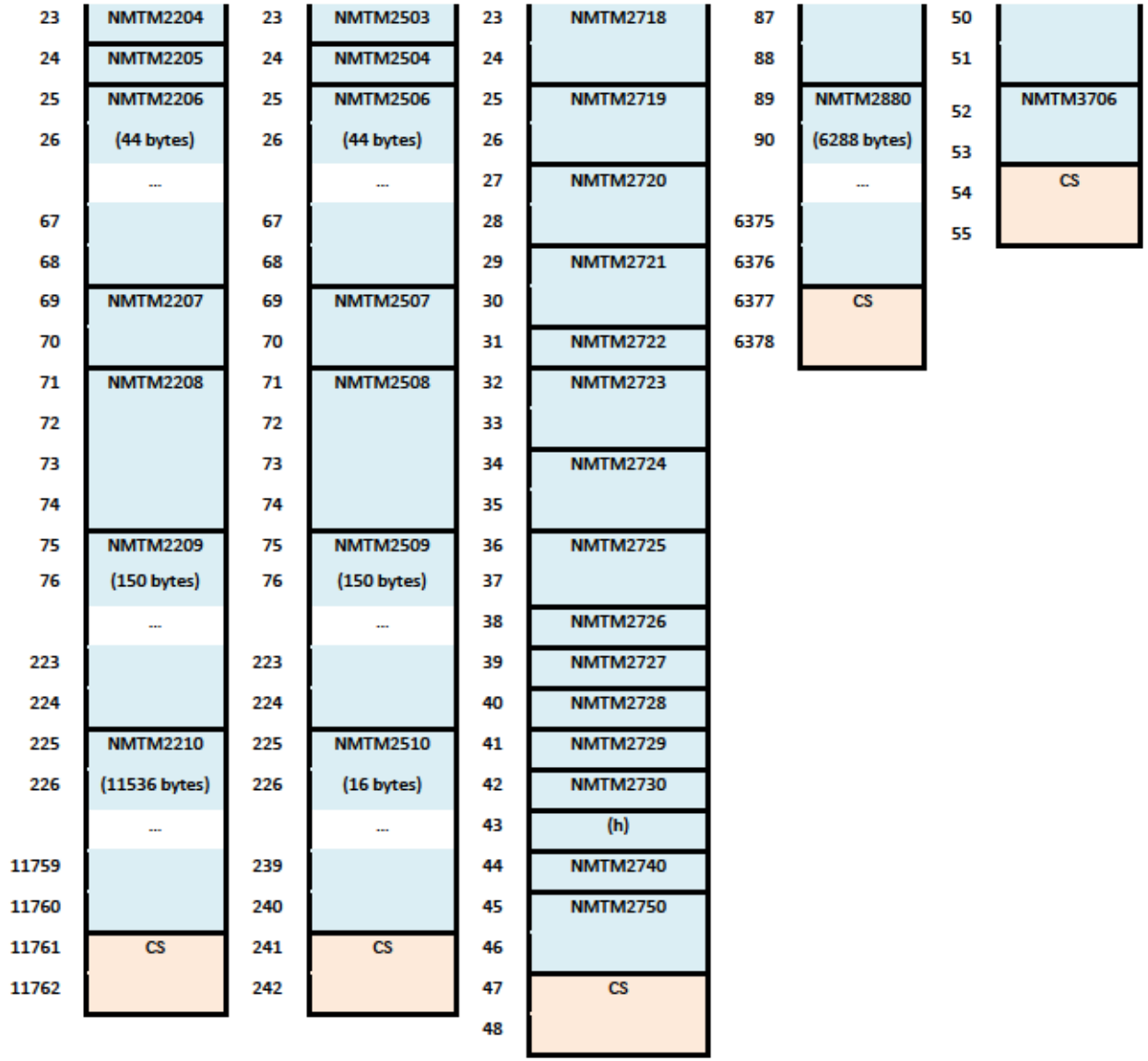
(d) N=1,2,3 for normal science; N=15 for downloading full frames (dark sky calibration, testing, ...)

(e) N = 1.25; TM (28) UVIS SCIENCE packets with length 2710 bytes. It is explained by OU that these are the standard UVIS packets. These are created when "off chip binning" is performed. In that case a data string of 2.5 bytes x 1048 is created. This mode is set by putting bit 7 "On/Off Chip Binning" to 0 in parameter "Flag Register" (see table 24 below) in the UVIS COP rows.

(f) It is also worth pointing out that UVIS can be sending 1 packet (size 6378 bytes = 2096*3+90) of three lines every 1s (or 15s) or 3 packets of one line (2096+90 = 2186 bytes/packet) each 1s (or 15s). Note that first UVIS science packet (and only first packet) of each observation has a size of 4282 bytes (2096*2+90).

Table 47: SpaceWire bus telemetry packet structure

byte	TM(22) example "long"	TM(25) example "short"	TM(27)	TM(28) example N=3	TM(37) type 1	TM(37) type 2	TM(60) example max size of 4096 bytes
1	22	25	27	28	37	37	60
2	11762	242	48	6378	55	1024	4096
3							
4							
5	NMTM2201	NMTM2501	NMTM2701	NMTM2801	NMTM3701	NMTM3710	NMTM6001
6					NMTM3702 = 0	NMTM3711	
7							...
8					NMTM3703	NMTM3712	
9						(1015 bytes)	
10						...	
11							
12					NMTM3704		
13	NMTM2201	NMTM2502	NMTM2702	NMTM2802		CS	
14							
15	NMTM2203	NMTM2502	NMTM2703	NMTM2810			
16			NMTM2711	(42 bytes)	NMTM3705		
17			NMTM2712	...			
18			NMTM2713				
19			NMTM2714				
20			NMTM2715	NMTM2841	NMTM3706		
21			NMTM2716	(32 bytes)	(32 bytes)		
22			NMTM2717	...	...		
1021							
1022							
1023							
1024							
4093							
4094							
4095							CS
4096							



(h)
(1 bit) NNMTM2731
(1 bit) NMTM2732
(1 bit) NMTM2733
(1 bit) NMTM2734
(1 bit) NMTM2735
(1 bit) NMTM2736
(1 bit) NMTM2737
(1 bit) NMTM2738

Table 48: UVIS_COP_ROW_VALUES

code TM(27)	code TM(28)	parameter name	size (bits)		description
NMTM2711	NMTM2841	MODE	8		Functional mode for this set of scans
NMTM2712	NMTM2842	ACQUISITION_MODE	8		CCD readout mode
NMTM2713	NMTM2843	BIAS_AVERAGE	8		Number of 'Bias' scans to average.
NMTM2714	NMTM2844	DARK_AVERAGE	8		Number of 'Dark' scans to average.
NMTM2715	NMTM2845	SCIENCE_AVERAGE	8		Number of 'Science' scans to average.
NMTM2716	NMTM2846	V_START	8		Top Right Corner, Y - Coordinate
NMTM2717	NMTM2847	V_END	8		Bottom Left Corner, Y - Coordinate
NMTM2718	NMTM2848	H_START	16		Top Right Corner, X - Coordinate
NMTM2719	NMTM2849	H_END	16		Bottom Left Corner, X - Coordinate
NMTM2720	NMTM2850	VOD_VALUE	16		Value to apply to VOD DAC
NMTM2721	NMTM2851	VRD_VALUE	16		Value to apply to VRD DAC
NMTM2722	NMTM2852	START_DELAY	8		Delay from start command
NMTM2723	NMTM2853	ACQUISITION_DELAY	16		Delay between two successive acquisitions
NMTM2724	NMTM2854	INTEGRATION_TIME	16		Exposure delay before the CCD readout starts.
NMTM2725	NMTM2855	NUMBER_OF_ACQUISITIONS	16		Number of acquistions to return in current sweep
NMTM2726	NMTM2856	NUMBER_OF_FLUSHES	8		Number of flush operations to carry out
NMTM2727	NMTM2857	DARK_TO_OBSERVATION_STEPS	8		Steps to drive motor from dark to observation mode
NMTM2728	NMTM2858	OBSERVATION_TO_DARK_STEPS	8		Steps to drive motor from observation mode to dark
NMTM2729	NMTM2859	MOTOR_DELAY	8		Sets stepper motor drive frequency
NMTM2730	NMTM2860	MOTOR_START_POSITION	8		Sets the starting pole position for the SO and NADIR motor sequences
NMTM2731	NMTM2861	FLAG_REGISTER	1		bit 0 (Lsb) = LED control

NMTM2732	NMTM2862		1		b1 = Loop Dark
NMTM2733	NMTM2863		1		b2 = Integration time increment
NMTM2734	NMTM2864		1		b3 = sci HK
NMTM2735	NMTM2865		1		b4 = locate Dark
NMTM2736	NMTM2866		1		b5 = LED
NMTM2737	NMTM2867		1		b6 = Motor Hold
NMTM2738	NMTM2868		1		b7 = Set on/off chip binning
NMTM2740	NMTM2870	HORIZONTAL_AND_COMBINED_BINNING_SIZE	8		Horizontal and Combined binning
NMTM2750	NMTM2880	CONTROL_BITS	16		Control bits
	NMTM2885	REVERSE_FLAG_AND_DATA_TYPE_FLAG_REGISTER	8		Reverse flag + Data type flag

Table 49: LAST TELECOMMAND STRUCTURE

code TM(22) i = 1, … , 6	code TM(25) i = 1, … , 6	parameter name	byte nr	size (bits)	description
NMTM2209-i-01	NMTM2509-i-01	spare	0	5	spare
NMTM2209-i-02	NMTM2509-i-02	AOTF power cmd		1	AOTF power command flag
NMTM2209-i-03	NMTM2509-i-03	write cooler parameters		1	write coolers parameter flag
NMTM2209-i-04	NMTM2509-i-04	start accumulation		1	start accumulations flag
NMTM2209-i-05	NMTM2509-i-05	force AOTF enable	1	1	force AOTF enable flag
NMTM2209-i-06	NMTM2509-i-06	hsk enable		1	housekeeping enable flag
NMTM2209-i-07	NMTM2509-i-07	DEGF		1	detector gain flag
NMTM2209-i-08	NMTM2509-i-08	DVAF		1	detector video amplifier flag
NMTM2209-i-09	NMTM2509-i-09	force size AB		1	force size A/B flag

NMTM2209-i-10	NMTM2509-i-10	prog enable		1	programming enable flag
NMTM2209-i-11	NMTM2509-i-11	SBSF		1	spectral background subtraction flag
NMTM2209-i-12	NMTM2509-i-12	detector enable		1	detector enable flag
NMTM2209-i-13	NMTM2509-i-13	NRACC	2	8	number of accumulations
NMTM2209-i-14	NMTM2509-i-14	DWNL	3	8	height of detector window (i.e. number of lines in detector window)
NMTM2209-i-15	NMTM2509-i-15	DWYA	4	8	number of first line in detector window
NMTM2209-i-16	NMTM2509-i-16	BF	5	8	binning factor
NMTM2209-i-17	NMTM2509-i-17	DEIT	6	24	detector integration time
			7		
			8		
NMTM2209-i-18	NMTM2509-i-18	spare	9	5	spare
NMTM2209-i-19	NMTM2509-i-19	DS		1	detector supply flag
NMTM2209-i-20	NMTM2509-i-20	DDS		1	data source flag
NMTM2209-i-21	NMTM2509-i-21	DVS		1	data valid source flag
NMTM2209-i-22	NMTM2509-i-22	spare	10	8	spare
NMTM2209-i-23	NMTM2509-i-23	spare	11	1	spare
NMTM2209-i-24	NMTM2509-i-24	TGA		7	AOTF delay
NMTM2209-i-25	NMTM2509-i-25	AOPS	12	8	AOTF power setting
NMTM2209-i-26	NMTM2509-i-26	AOFS	13	32	AOTF frequency setting
			14		
			15		
			16		
NMTM2209-i-27	NMTM2509-i-27	spare	17	8	spare

NMTM2209-i-28	NMTM2509-i-28	spare	18	4	spare
NMTM2209-i-29	NMTM2509-i-29	PFCM		1	closed loop flag
NMTM2209-i-30	NMTM2509-i-30	CED1		1	cooler enable flag 1
NMTM2209-i-31	NMTM2509-i-31	CED2		1	cooler enable flag 2
NMTM2209-i-32	NMTM2509-i-32	CED3		1	cooler enable flag 3
NMTM2209-i-33	NMTM2509-i-33	spare	19+20	3	spare
NMTM2209-i-34	NMTM2509-i-34	PCP		13	cooler set point (target temperature)
NMTM2209-i-35	NMTM2509-i-35	spare	21	8	spare
NMTM2209-i-36	NMTM2509-i-36	C1	22	4	cooler closed loop coefficient 1
NMTM2209-i-37	NMTM2509-i-37	spare		4	spare
NMTM2209-i-38	NMTM2509-i-38	spare	23	2	spare
NMTM2209-i-39	NMTM2509-i-39	C2		4	cooler closed loop coefficient 2
NMTM2209-i-40	NMTM2509-i-40	spare		2	spare
NMTM2209-i-41	NMTM2509-i-41	spare	24	4	spare
NMTM2209-i-42	NMTM2509-i-42	C3		4	cooler closed loop coefficient 3

8 SPECIAL CONSIDERATIONS

8.1 CLEANLINESS

8.1.1 Monitoring

Cleanliness monitoring is done by means of supplied MOC and PFO witness plates.

The NOMAD team will provide MOC and PFO followers.

- MOC plates will be analysed by Centre Spatial de Liège (CSL) in Belgium.
- PFO plates need to be analysed by a standard PFO Photometer type Mark III for example.

Figure 8-1: PFO plate

8.1.2 Cleaning

The outer surfaces of NOMAD are wrapped in MLI, except for the apertures and radiator.
All selected materials can be cleaned by means of IPA, with the exception of the radiator.
The painted radiator (MAP paint SG121FD) is scratch-sensitive. It is not allowed to clean the radiator surface. It is recommended to keep on the radiator cover as much as possible.

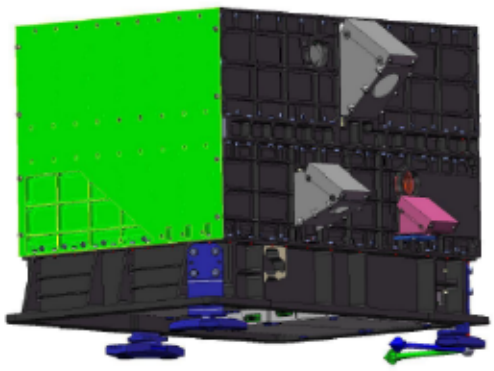


Figure 8-2: General Radiator on NOMAD

The MLI surfaces can be cleaned gently using cleaning swabs wetted with IPA.
All cleaning operations need to be logged in the logbook.

8.2 ESD PRECAUTIONS

Operators should wear conductive ESD wrist straps, connected to a good earth ground when handling the NOMAD PFM.

ESD ground connections should be made using firm fitting electrical connections like metallic crimp connectors, snaps, or banana plugs.

When the instrument is tested and/or powered ON, the grounding should be checked properly as part of the inspection step in the test procedure.

No high voltages are produced in NOMAD.

Relative humidity should be maintained at 40% minimum RH at all times.

8.3 LIMITED LIFE TIME COMPONENTS

The SO and LNO detectors have a limited lifetime.

A budget of 200 hours operation is foreseen between the delivery of NOMAD to the integration facility and launch.

The integrator shall maintain a log of all tasks that include operation of the NOMAD detectors (mainly functional tests), so that it can be verified the budget of 200 hours is not exceeded.

Following operational time is foreseen:

- NOMAD integration and testing: 1000 hours
- Orbiter integration and testing: 200 hours
- Storage: 0 hours
- Checkouts during cruise and aerobraking: 50 hours
- Science mission
    - SO: 4122 hours (1 Martian year, with 2x 10 minutes of cooldown and 2x 5 minutes of observation per orbit)
    - LNO: 8250 hours (1 Martian year, at a working cycle of 50%)

Total:

- SO: 5372 hours
- LNO: 9500 hours.

8.4 SAFETY

8.4.1 General

A detailed hazard analysis is provided in RD-06.

The most critical hazard related to NOMAD is the use of TeO_2 crystals in the SO and LNO channel (hazard report HR-G-05 in RD-06).

In summary, TeO_2 is hazardous in pulverized state.

8.4.2 On-ground safety

Before opening the NOMAD container, it should be inspected for any signs of drops or large shocks.

Take following precautions during the integration of NOMAD in TGO.

1. Never handle NOMAD without gloves and suitable clothing (mouth mask as a minimum).
2. Whenever there is a risk for a shock to NOMAD, cover the optical apertures with the provided not-for-flight covers, to minimise any exposure.
3. Prepare cleaning equipment (vacuum cleaner with fine dust filter) and/or disposal container in case a crystal shatters.

8.4.3 In-flight safety

Not applicable. No safety critical items in flight.

9 ANNEX 1 : COMMAND SEQUENCES

For NOMAD a number of command sequences are defined. Each command sequence (CSEQ) corresponds to one single Flight Control Procedure (FCP) or Contingency Recovery Procedure (CRP).

These FCPs and CRPs will be used throughout the on ground test campaigns and during in-flight operations (commissioning, check out, calibration, science).

A distinction is made between nominal command sequences (CSEQ_NOM) (associated to Flight Control Procedures) and contingency command sequences (CSEQ_RED) (associated to Contingency Recovery Procedures, CRPs).

The following Table 50 gives an overview of NOMAD procedures and associated command sequences. All of them need to be validated during on ground testing.

Table 50: NOMAD command sequences

Procedure	Command sequence	Descriptor
NO-FCP-001	NO_CSEQ_NOM_001A	nominal switch on of NOMAD
NO-FCP-002	NO_CSEQ_NOM_002A	switch off of NOMAD
NO-FCP-011	NO_CSEQ_NOM_011A	perform one observation with SO
NO-FCP-012	NO_CSEQ_NOM_012A	perform one observation with LNO
NO-FCP-013	NO_CSEQ_NOM_013A	perform one standard observation with UVIS
NO-FCP-014	NO_CSEQ_NOM_014A	perform one observation with SO+UVIS
NO-FCP-015	NO_CSEQ_NOM_015A	perform one observation with LNO+UVIS
NO-FCP-021	NO_CSEQ_NOM_021A	single byte patch sequence
NO-FCP-022	NO_CSEQ_NOM_022A	complex patch sequence
NO-FCP-023	NO_CSEQ_NOM_023A	file system operations sequence
NO-FCP-031	NO_CSEQ_NOM_031A	flip mirror to default/contingency/launch position
NO-FCP-101	NO_CSEQ_NOM_101A	redundant switch on of NOMAD
NO-CRP-541	NO_CSEQ_RED_541A	activate and actuate pinpuller
NO-CRP-551	NO_CSEQ_RED_551A	operational heaters switching

These *Command Sequences* or the corresponding *Procedures* have to be validated before flight.

In the *Command Sequences* and the *Procedures* power and telemetry bit rates (both on 1553 and SpaceWire) are given. These are maximum values and can depend on the parameters used in the commands.

The bit rates are calculated based on the standard housekeeping (TM(11), TM(12), TM(13), TM(23), TM(26) and TM(29)) and science data (TM(22), TM(25), TM(27), TM(28), TM(29)) packet production.

Besides these standard packets, certain events (reception of telecommands, switching between modes, patching instructions, file operation instructions, etc.), arriving asynchronously, might cause the production of other telemetry data (TM(10), TM(32), TM(34), TM(36), TM(37)). For these packets no bit rate is given in the tables

(mostly negligible compared to the main housekeeping and science bit rates) but the TM type is indicated, e.g. TM(10).

Finally SINBAD produces on a regular basis a telemetry packet with its system log (TM(60)) It is sent to S/C over SpW with intervals ranging from 1' to 10', depending on SINBAD activity. Its size is approximately 4 kbytes. This is not included in the given bit rates, but indicated by (*), to remind that such a packet will be sent.

In the sequences below 2 columns are foreseen to indicate which parameters need to be checked during the functioning of the instrument:

- column "check S/C" indicates which parameters have to be checked on board by the S/C. This column is empty. No checking of controlling of NOMAD parameters is requested on board by the S/C;
- column "display MOC" indicates which parameters need to be monitored at the MOC. The parameter codes NMHKxxxx correspond to codes given in the data operations handbook. The same codes can be found in the mission database (MIB) by changing the NMHKxxxx to ENONxxxx.

Besides the NOMAD parameters it is expected that a number of S/C parameters are monitored by the MOC to verify the behaviour of NOMAD. These parameters are listed in the Table 51 below (and are given temporary arbitrary names).

Table 51: Monitoring of S/C parameters

Parameter name	Function	Expected value(s)
EXMLCL01	Status of nominal LCL A	LCL A = ENABLED, DISABLED
EXMLCL02	Status of redundant LCL B	LCL B = ENABLED, DISABLED
EXMLCL03	Current of nominal LCL A	LCL A = (value) A
EXMLCL04	Current of redundant LCL B	LCL B = (value) A
EXMBUS01	Status of nominal 1553 branch	1553B A = ENABLED, DISABLED
EXMBUS02	Status of redundant 1553 branch (*)	1553B B = ENABLED, DISABLED
EXMBUS03	Status of nominal SpW branch	SPWB A = ENABLED, DISABLED
EXMBUS04	Status of redundant SpW branch	SPWB B = ENABLED, DISABLED
EXMFIL01	Status of PHDU file for NOMAD	FILE = OPEN, CLOSED

(*) we assume that there exist a nominal and a redundant 1553 branch. If not, EXMBUS02 has to be disregarded in the above table and all following sequences.

9.1 NO-FCP-001

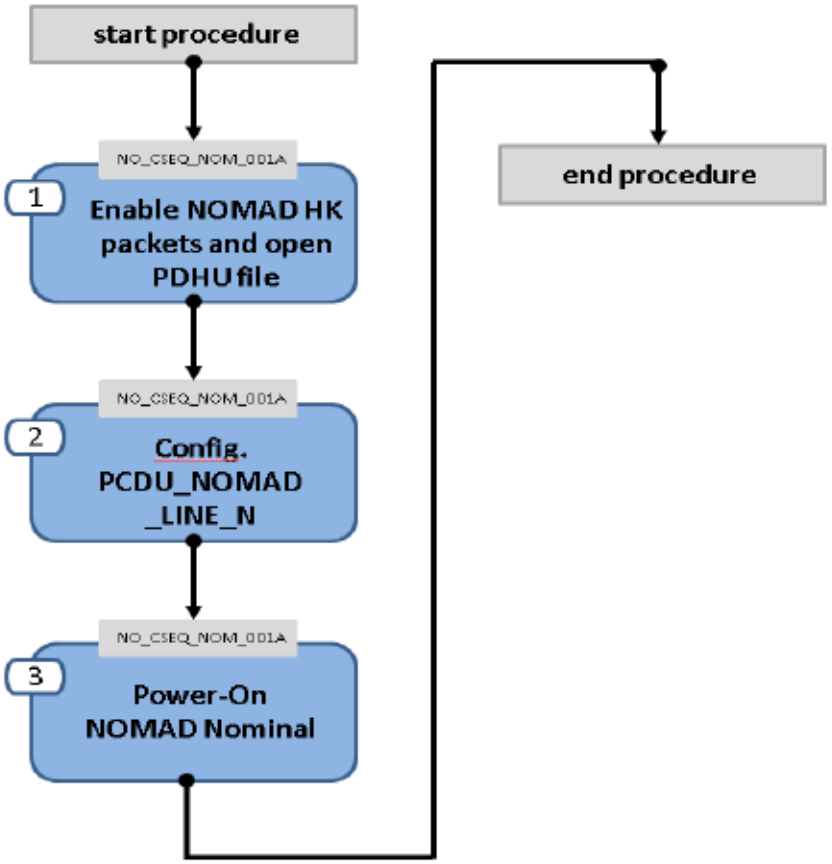
Procedure name	NO-FCP-001
Summary	Switch on the NOMAD instrument via the nominal High Power Command line
Objective	The objective of the NOMAD switch on procedure is to enable the power supply to the instrument (via LCL), to establish the nominal TC and TM links, to put the instrument in its safe mode and to update the instrument time. The power demand = 12 W max (without operational heaters) There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	A waiting period of 10 seconds is mandatory after execution of the last command in this procedure.
S/C configuration	Start of procedure: • PDHU file is opened to catch system logs (TM(60)) and HSK-packets are enabled. For routine operations, the PDHU file name will be supplied by the NOMAD team via the POR mechanism. • S/C selects by default the nominal branches for communication with NOMAD • NOMAD power is off End of procedure: • NOMAD power is on • NOMAD is in safe mode • TC and TM links are established • Time update executed

	• PDHU file remains open
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_001A
Applicable telecommand	n/a
Referenced displays	Data logged on display: • EXMLCL01, EXMLCL03, EXMBUS01, EXMBUS02, EXMBUS03, EXMBUS04, EXMFIL01 • NMHK1010, NMHK1210, NMHK1146, NMHK1147

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
09/03/2015	03	Procedure updated	bristic

Flowchart


start procedure
NO_CSEQ_NOM_001A
1
Enable NOMAD HK packets and open PDHU file
NO_CSEQ_NOM_001A
2
Config. PCDU_NOMAD _LINE_N
NO_CSEQ_NOM_001A
3
Power-On NOMAD Nominal
end procedure

Procedure

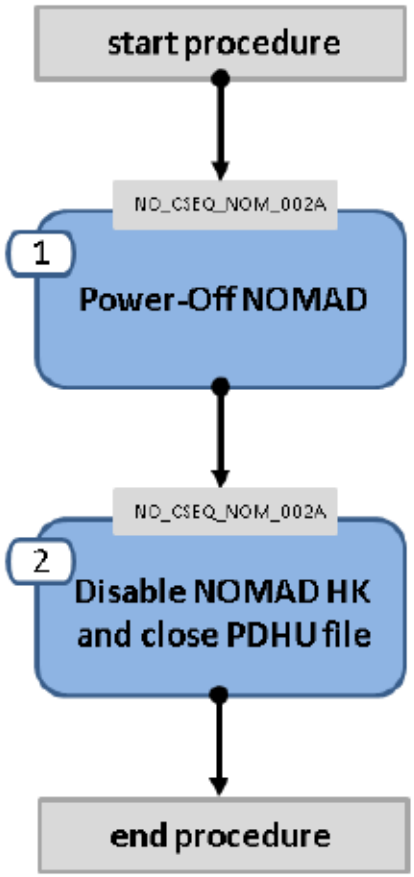
step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-001		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_001A		start of command sequence nominal switch on of NOMAD						
1		enabling of housekeeping packets and opening of PHDU file for NOMAD data	→ 2					
	00.00.00	execute command(s) to enable housekeeping packets and open PDHU file parameter = *file name*				0	0	0
		check file status result in TM : FILE *filename* = OPEN HK status = ENABLED			EXMFIL01	0	0	0
		check 1553B link state result in TM : 1553B A = *ENABLED* result in TM : 1553B B = *DISABLED*			EXMBUS01 EXMBUS02	0	0	0
		check SpW link state result in TM : SPWB A = *ENABLED* result in TM : SPWB B = *DISABLED*			EXMBUS03 EXMBUS04	0	0	0
2		Config. PCDU_NOMAD_LINE_N	→ 3					
	00.00.38	perform LCL A switch on				0	0	0
		check LCL A state result in TM : LCL A STATE = *ENABLED*			EXMLCL01	0	0	0
		check NOMAD current result in TM : LCL A CURRENT = *value*			EXMLCL03	0	0	0
3		Power-On NOMAD Nominal	→ END					
	00.00.50	execute HPC(01) : NOMAD_ON_NOMINAL				12	0.039 + TM(10)	0 (*)
	00.01.02	GPA13295 PM:MDF UNIT STS				12	0.039 + TM(10)	0 (*)

		check NOMAD power on status				12	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = *1 (SAFE MODE)* OPERATIONAL_MODE = *87 (SAFE)* SINBAD_POWER_RED = *OFF* SINBAD_POWER_MAIN = *ON*			NMHK1010 NMHK1210 NMHK1146 NMHK1147	12	0.039	0 (*)
		To collect all TMs a waiting period of 30 seconds is mandatory before executing any new procedure				12	0.039 + TM(10)	0 (*)
NO_CSEQ_NOM_001A		end of command sequence nominal switch on of NOMAD						
NO-FCP-001		end of procedure						

9.2 NO-FCP-002

Procedure name	NO-FCP-002
Summary	Switch off the NOMAD instrument (via the nominal and redundant High Power Command line)
Objective	The objective of the NOMAD switch off procedure is to disable the power supply to the instrument (via LCL) and to disable the nominal TC and TM links. The power demand = 12 W max (without operational heaters) There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	
S/C configuration	Start of procedure: • NOMAD power is on • TC and TM links are established End of procedure: • TC and TM links are disabled • NOMAD power is off
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_002A
Applicable telecommand	n/a
Referenced displays	Data logged on display: • EXMLCL01, EXMLCL02, EXMLCL03, EXMLCL04, EXMBUS01, EXMBUS02, EXMBUS03, EXMBUS04

	• NMHK1010, NMHK1210, NMHK1146, NMHK1147			
Configuration control	Date	Version	Modification	Author
	11/06/2013	01	Creation of the procedure	eneefs
	18/10/2013	01	Modification after CDR	eneefs
	28/01/2014	02	Telecommand contents added	eneefs
	09/03/2015	03	Procedure updated	bristic

Flowchart	

start procedure
ND_CSEQ_NOM_002A
1
Power-Off NOMAD
ND_CSEQ_NOM_002A
2
Disable NOMAD HK and close PDHU file
end procedure

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-002		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_002A		start of command sequence switch off of NOMAD						
1		Power-Off NOMAD	→ 2					
	00.00.00	execute TC(50) : NOMAD_READY_TO_POWER_OFF				12	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = 1 (SAFE MODE) OPERATIONAL_MODE = *87 (SAFE)* SINBAD_POWER_RED = *OFF* SINBAD_POWER_MAIN = *ON*			NMHK1010 NMHK1210 NMHK1146 NMHK1147	12	0.039 + TM(10)	0 (*)
	00.00.10	GPA13295 PM:MDF UNIT STS				12	0.039 + TM(10)	0 (*)
	00.00.12	execute HPC(02) : NOMAD_OFF_NOMINAL				0	0	0
	00.00.13	execute HPC(04) : NOMAD_OFF_REDUNDANT				0	0	0
		check NOMAD power off status						
	00.00.14	perform LCL A switch off (NOM)				0	0	0
	00.00.15	perform LCL B switch off (RED)				0	0	0
		check LCL state result in TM : LCL A/B STATE = *DISABLED*			EXMLCL01 EXMLCL02	0	0	0
		check NOMAD current result in TM : LCL A/B CURRENT = *0*			EXMLCL03 EXMLCL04	0	0	0
2		Disable NOMAD HK and close PDHU file	→ END					
	00.00.27	execute command(s) to disable housekeeping packets and close PDHU file parameter = *file name*				0	0	0

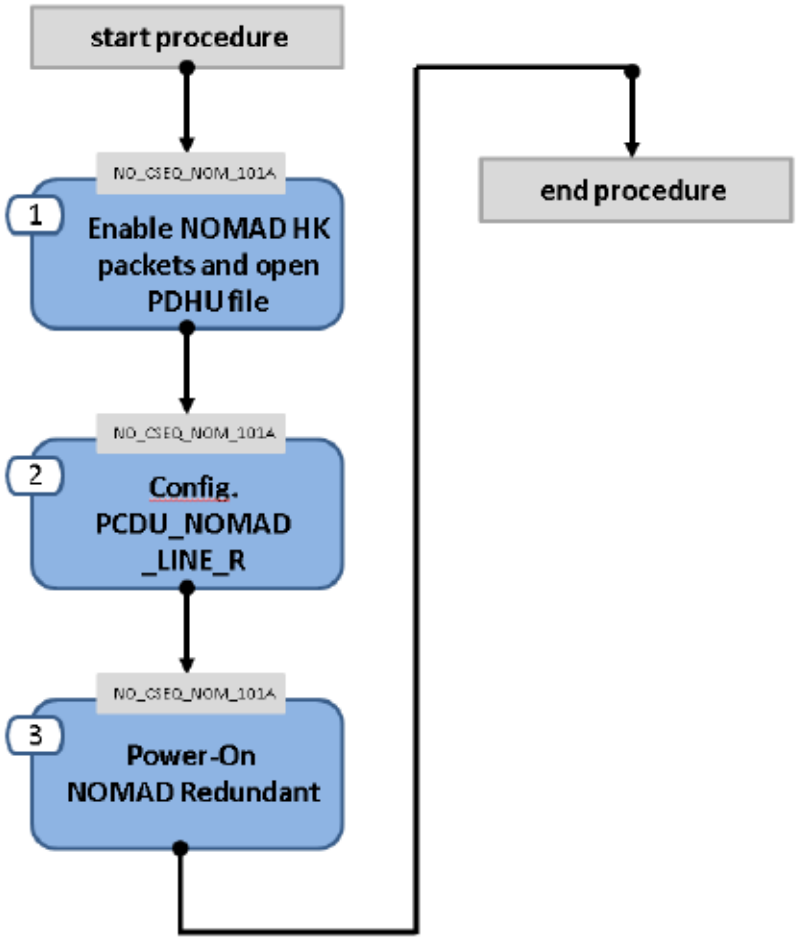
			check file status result in TM : FILE *filename* = CLOSED HK status = DISABLED			EXMFIL01	0	0	0	
			check 1553B link state result in TM : 1553B A = DIS*ABLED* result in TM : 1553B B = *DISABLED*			EXMBUS01 EXMBUS02	0	0	0	
			check SpW link state result in TM : SPWB A = DIS*ABLED* result in TM : SPWB B = *DISABLED*			EXMBUS03 EXMBUS04	0	0	0	
	NO_CSEQ_NOM_002A		end of command sequence switch off of NOMAD							
	NO-FCP-002		end of procedure							

9.3 NO-FCP-101

Procedure name	NO-FCP-101
Summary	Switch on the NOMAD instrument via the redundant High Power Command line
Objective	The objective of the NOMAD switch on procedure is to enable the power supply to the instrument (via LCL), to establish the redundant TC and TM links, to put the instrument in its safe mode and to update the instrument's time. The power demand = 12 W max (without operational heaters) There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 10 min a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	A waiting period of 10 seconds is mandatory after execution of the last command in this procedure.
S/C configuration	Start of procedure: • PDHU file is opened to catch system logs (TM(60)) and HSK-packets are enabled. For routine operations, the PDHU file name will be supplied by the NOMAD team via the POR mechanism. • S/C selects by default the redundant branches for communication with NOMAD • NOMAD power is off End of procedure: • NOMAD power is on • NOMAD is in safe mode • TC and TM links are established • Time update executed

	• PDHU file remains open
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_101A
Applicable telecommand	n/a
Referenced displays	Data logged on display: • EXMLCL02, EXMLCL04, EXMBUS01, EXMBUS02, EXMBUS03, EXMBUS04, EXMFIL01 • NMHK1010, NMHK1210, NMHK1146, NMHK1147
Configuration control	Date / Version / Modification / Author 11/06/2013 / 01 / Creation of the procedure / eneefs 18/10/2013 / 01 / Modification after CDR / eneefs 28/01/2014 / 02 / Telecommand contents added / eneefs 09/03/2015 / 03 / Procedure updated / bristic

Flowchart



Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-101		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_101A		start of command sequence redundant switch on of NOMAD						
1		enabling of housekeeping packets and opening of PHDU file for NOMAD data	→ 2					
	00.00.00	execute command(s) to enable housekeeping packets and open PDHU file parameter = *file name*				0	0	0
		check file status result in TM : FILE *filename* = OPEN HK status = ENABLED			EXMFIL01	0	0	0
		check 1553B link state result in TM : 1553B A = DIS*ABLED* result in TM : 1553B B = EN*ABLED*			EXMBUS01 EXMBUS02	0	0	0
		check SpW link state result in TM : SPWB A = DIS*ABLED* result in TM : SPWB B = EN*ABLED*			EXMBUS03 EXMBUS04	0	0	0
2		Config. PCDU_NOMAD_LINE_R	→ 3					
	00.00.38	perform LCL B switch on				0	0	0
		check LCL state result in TM : LCL B STATE = *ENABLED*			EXMLCL02	0	0	0
		check NOMAD current result in TM : LCL B CURRENT = *value*			EXMLCL04	0	0	0
3		Power-On NOMAD Redundant	→ END					
	00.00.50	execute HPC(03) : NOMAD_ON_REDUNDANT				12	0.039 + TM(10)	0 (*)
	00.01.02	GPA13295 PM:MDF UNIT STS				12	0.039 + TM(10)	0 (*)

			check NOMAD power on status				12	0.039 + TM(10)	0 (*)	
			verify 1553B telemetry : EVENT_CODE = *1 (SAFE MODE)* OPERATIONAL_MODE = *87 (SAFE)* SINBAD_POWER_RED = *OFF* SINBAD_POWER_MAIN = *ON*			NMHK1010 NMHK1210 NMHK1146 NMHK1147	12	0.039	0 (*)	
			To collect all TMs a waiting period of 30 seconds is mandatory before executing any new procedure				12	0.039 + TM(10)	0 (*)	
	NO_CSEQ_NOM_101A		end of command sequence redundant witch on of NOMAD							
	NO-FCP-101		end of procedure							

9.4 NO-FCP-011

The structures of Flight Control Procedures NO-FCP-011, NO-FCP-012, NO-FCP-013, NO-FCP-014 and NO-FCP-015 are identical. Only the contents of the TC(20) inside the procedure are different. The contents of TC(20) define which of the observations will be performed.

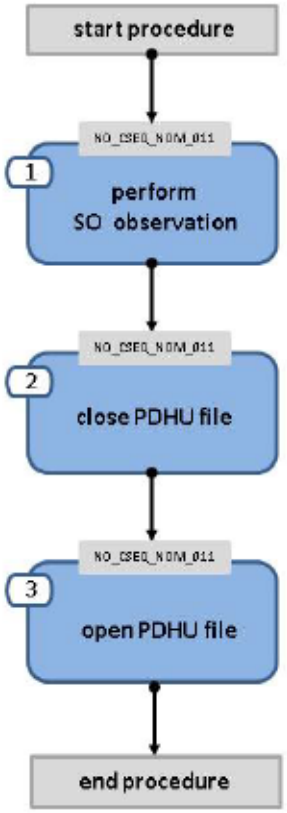
Procedure name	NO-FCP-011
Summary	Perform an SO observation with NOMAD
Objective	Perform an observation with the SO channel only A measurement duration of 15 minutes is assumed (10 min precooling + 5 minutes science observation). Duration can be variable depending on TC parameters. Polling in SO is every second. The power demand = 43.4 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.0523 kbits/s max (1.57 kbits max every 30 seconds) (TM(11), TM(12), TM(13), TM(23)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • the data rate over the SpW = 1.936 kbits/s (during precooling) and 94.1 kbits/s (during observation) (TM(22)) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. SpW telemetry will be stored in a PDHU file that will be opened and closed during this procedure.
Constraints	During this observation a special attitude may be requested from the S/C. See Pointing Request files
S/C configuration	Start of procedure: • NOMAD switched on • NOMAD in safe mode End of procedure: • NOMAD switched on

	• Observation performed → data delivered (science mode) • NOMAD back to safe mode • PDHU file closed with data of observation, new PDHU file opened for next observation
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_011A
Applicable telecommand	NMTC2000/01 (see table 1)
Referenced displays	Data logged on display: • EXMFIL01 • NMHK1010, NMHK1210, NMHK1143, NMHK1111, NMHK1114

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
09/03/2015	03	Procedure updated	bristic

Flowchart



Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-011		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_011A		start of command sequence						

		perform SO observation						
1		start a NOMAD operation	→ 2					
	00.00.00	execute NOMAD command TC(20) START_OPERATION (NMHK2000/01) TC(20) parameters 13-25 are set to 0 (only SO is ON) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = SO_START_TIME parameter 4 = SO_START_SCIENCE_1 parameter 5 = SO_START_SCIENCE_2 parameter 6 = SO_DURATION_REFERENCE_1 parameter 7 = SO_DURATION_REFERENCE_2 parameter 8 = SO_DURATION_TIME parameter 9 = SO_COP_GENERAL parameter 10 = SO_COP_PRECOOLING parameter 11 = SO_COP_SCIENCE_1 parameter 12 = SO_COP_SCIENCE_2 parameter 13 = LNO_START_TIME parameter 14 = LNO_START_SCIENCE_1 parameter 15 = LNO_START_SCIENCE_2 parameter 16 = LNO_DURATION_REFERENCE_1 parameter 17 = LNO_DURATION_REFERENCE_2 parameter 18 = LNO_DURATION_TIME parameter 19 = LNO_COP_GENERAL parameter 20 = LNO_COP_PRECOOLING parameter 21 = LNO_COP_SCIENCE_1 parameter 22 = LNO_COP_SCIENCE_2 parameter 23 = UVIS_START_TIME parameter 24 = UVIS_DURATION_TIME parameter 25 = UVIS_COP_ROW parameter 26 = SIMPLE_PROTOCOL_CHECKSUM				43.4 (10') 42.4 (5')	0.0523 + TM(10)	1.936 (10') 94.1 (5')
		verify 1553B telemetry : EVENT_CODE = *2 (OBSERVING MODE)* OPERATIONAL_MODE = *165 (SCIENCE)* SO_POWER_STATUS = *ON* SO_VOLTAGE = *value* SO_CURRENT = *value*			NMHK1010 NMHK1210 NMHK1143 NMHK1111 NMHK1114	43.4 (10') 42.4 (5')	0.0523	1.936 (10') 94.1 (5')

2		closing of PDHU file for NOMAD data	→ 3						
	00.15.00	execute command to close PDHU file parameter = *filename*				12	0.0523	0 (*)
	00.15.05	check file status result in TM : FILE *filename* = CLOSED			EXMFIL01	12	0.0523	0 (*)
3		opening of PHDU file for NOMAD data	→ END					
	00.15.10	execute command to open PDHU file parameter = *filename*				12	0.0523	0 (*)
	00.15.20	check file status result in TM : FILE *filename* = OPEN			EXMFIL01	12	0.0523	0 (*)
NO_CSEQ_NOM_011A		end of command sequence perform SO observation						
NO-FCP-011		end of procedure						

TM/TC stats

Code	Name	Byte size	Count	Total byte size		Over 1553	Over spw
20	Start operation	44	1	44		44	
10	Event	21	9	189		189	
11	NOMAD HK 1	53	30	1590		1590	
12	NOMAD HK 2	39	30	1170		1170	
13	NOMAD HK 3	54	30	1620		1620	
23	SO HK	50	30	1500		1500	
26	LNO HK	50	0	0		0	
29	UVIS HK	58	0	0		0	0
22	SO Science (only HK)	242	600	145200	3673800		3673800
22	SO Science	11762	300	3528600			
25	LNO Science (only HK)	242	0	0	0		0
25	LNO Science	11762	0	0			

	27	UVIS Applied parameters	48	0	0		0
	28	UVIS Science	6558	0	0		0
	60	System log	max 4096	6	24576		24576
		Total		1036	3704489	6113	3698376

9.5 NO-FCP-012

The structures of Flight Control Procedures NO-FCP-011, NO-FCP-012, NO-FCP-013, NO-FCP-014 and NO-FCP-015 are identical. Only the contents of the TC(20) inside the procedure are different. The contents of TC(20) define which of the observations will be performed.

Procedure name	NO-FCP-012
Summary	Perform a short LNO observation with NOMAD
Objective	Perform a short observation with the LNO channel only A measurement duration of 15 minutes is assumed (10 min precooling + 5 minutes science observation). Duration can be variable depending on TC parameters. Polling in LNO is every 15 seconds. The power demand = 43.4 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.0523 kbits/s max (1.57 kbits max every 30 seconds) (TM(11), TM(12), TM(13), TM(26)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • the data rate over the SpW = 0.1291 kbits/s (during precooling) and 6.28 kbits/s (during observation) (TM(25)) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. SpW telemetry will be stored in a PDHU file that will be opened and closed during this procedure.
Constraints	During this observation a special attitude may be requested from the S/C. See Pointing Request files
S/C configuration	Start of procedure: • NOMAD switched on • NOMAD in safe mode End of procedure: • NOMAD switched on • Observation performed → data delivered (science mode)

	• NOMAD back to safe mode • PDHU file closed with data of observation, new PDHU file opened for next observation
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_012A
Applicable telecommand	NMTC2000/02 (see table 1)
Referenced displays	Data logged on display: • EXMFIL01 • NMHK1010, NMHK1210, NMHK1144, NMHK1112, NMHK1115
Configuration control	Date / Version / Modification / Author 11/06/2013 01 Creation of the procedure eneefs 18/10/2013 01 Modification after CDR eneefs 28/01/2014 02 Telecommand contents added eneefs 10/03/2015 03 Procedure updated bristic

Flowchart	

start procedure
1
perform
LNO observation
2
close PDHU file
3
open PDHU file
end procedure

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-012		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_012A		start of command sequence perform LNO observation						
1		start a NOMAD operation	→ 2					
	00.00.00	execute NOMAD command TC(20) START_OPERATION (NMHK2000/02) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = 0 parameter 4 = 0 parameter 5 = 0 parameter 6 = 0 parameter 7 = 0 parameter 8 = 0 parameter 9 = 0 parameter 10 = 0 parameter 11 = 0 parameter 12 = 0 parameter 13 = LNO_START_TIME parameter 14 = LNO_START_SCIENCE_1 parameter 15 = LNO_START_SCIENCE_2 parameter 16 = LNO_DURATION_REFERENCE_1				43.4 (10') 42.4 (5')	0.0523 +TM(10)	0.1291 (10') 6.28 (5')

		parameter 17 = LNO_DURATION_REFERENCE_2 parameter 18 = LNO_DURATION_TIME parameter 19 = LNO_COP_GENERAL parameter 20 = LNO_COP_PRECOOLING parameter 21 = LNO_COP_SCIENCE_1 parameter 22 = LNO_COP_SCIENCE_2 parameter 23 = 0 parameter 24 = 0 parameter 25 = 0 parameter 26 = SIMPLE_PROTOCOL_CHECKSUM				43.4 (10') 42.4 (5')	0.0523 +TM(10)	0.1291 (10') 6.28 (5')
		verify 1553B telemetry : EVENT_CODE = *2 (OBSERVING MODE)* OPERATIONAL_MODE = *165 (SCIENCE)* LNO_POWER_STATUS = *ON* LNO_VOLTAGE = *value* LNO_CURRENT = *value*			NMHK1010 NMHK1210 NMHK1144 NMHK1112 NMHK1115	43.4 (10') 42.4 (5')	0.0523	0.1291 (10') 6.28 (5')
2		closing of PHDU file for NOMAD data	→ 3					
	00.15.00	execute command to close PDHU file parameter = *file name*				12	0.0523	0 (*)
	00.15.05	check file status result in TM = file name CLOSED			EXMFIL01	12	0.0523	0 (*)
3		opening of PHDU file for NOMAD data	→ END					
	00.15.10	execute command to open PDHU file parameter = *filename*				12	0.0523	0 (*)
	00.15.20	check file status result in TM = *file name* OPEN			EXMFIL01	12	0.0523	0 (*)
NO_CSEQ_NOM_012A		end of command sequence perform LNO observation						
NO-FCP-012		end of procedure						

TM/TC stats

Code	Name	Byte size	Count	Total byte size	Over 1553	Over spw
20	Start operation	44	1	44	44	
10	Event	21	9	189	189	

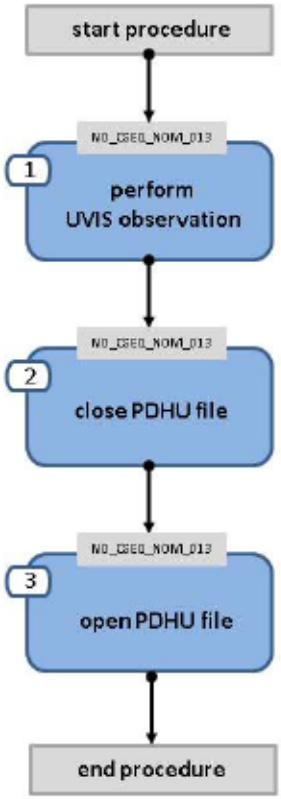
11	NOMAD HK 1	53	30	1590		1590	
12	NOMAD HK 2	39	30	1170		1170	
13	NOMAD HK 3	54	30	1620		1620	
23	SO HK	50	0	0		0	
26	LNO HK	50	30	1500		1500	
29	UVIS HK	58	0	0		0	0
22	SO Science (only HK)	242	0	0	0		0
22	SO Science	11762	0	0			
25	LNO Science (only HK)	242	40	9680	244920		244920
25	LNO Science	11762	20	235240			
27	UVIS Applied parameters	48	0	0			0
28	UVIS Science	6558	0	0			0
60	System log	max 4096	6	24576			24576
	Total		196	275609		6113	269496

9.6 NO-FCP-013

The structures of Flight Control Procedures NO-FCP-011, NO-FCP-012, NO-FCP-013, NO-FCP-014 and NO-FCP-015 are identical. Only the contents of the TC(20) inside the procedure are different. The contents of TC(20) define which of the observations will be performed.

Procedure name	NO-FCP-013
Summary	Perform a short UVIS observation with NOMAD
Objective	Perform a short observation with the UVIS channel only A measurement duration of 5 minutes is assumed. Duration can be variable depending on TC parameters. Polling in UVIS is every second. The power demand = 16.9 W max. Note that UVIS can also be on when the operations heaters are ON. The power consumption is then 32.9 W max. There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.0544 kbits/s max (1.633 kbits max every 30 seconds) (TM(11), TM(12), TM(13), TM(29)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • the data rate over the SpW = 52.928 kbits/s (TM(27), TM(28) 3 packets of 2186 bytes (1 line read out) sent per second, TM(29)). This example is shown in the procedure below. • the data rate over the SpW = 51.488 kbits/s (TM(27), TM(28) 1 packet of 6378 bytes (3 lines read out) sent per second, TM(29)) • the data rate over the SpW = 252.704 kbits/s (TM(27), TM(28) with max 15 lines, total size 31530 bytes, TM(29)). This is a full frame observation with the UVIS channel (full frame is divided in 17 blocks of 31530 bytes) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. SpW telemetry will be stored in a PDHU file that will be opened and closed during this procedure.
Constraints	During an observation a special attitude may be requested from the S/C. See Pointing Request files
S/C configuration	Start of procedure: • NOMAD switched on • NOMAD in safe mode End of procedure: • NOMAD switched on

	• Observation performed → data delivered (science mode) • NOMAD back to safe mode • PDHU file closed with data of observation, new PDHU file opened for next observation
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_013A
Applicable telecommand	NMTC2000/03 (see table 1)
Referenced displays	Data logged on display: • EXMFIL01 • NMHK1010, NMHK1210, NMHK1143, NMHK1113, NMHK1116
Configuration control	Date / Version / Modification / Author 11/06/2013 01 Creation of the procedure eneefs 18/10/2013 01 Modification after CDR eneefs 28/01/2014 02 Telecommand contents added eneefs 10/03/2015 03 Procedure updated bristic

Flowchart	

start procedure
NO_CSEQ_NOM_013
1
perform
UVIS observation
NO_CSEQ_NOM_013
2
close PDHU file
NO_CSEQ_NOM_013
3
open PDHU file
end procedure

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-013		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_013A		start of command sequence perform UVIS observation						
1		start a NOMAD operation	→ 2					
	00.00.10	execute NOMAD command TC(20) START_OPERATION (NMTC2000/03) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = 0 parameter 4 = 0 parameter 5 = 0 parameter 6 = 0 parameter 7 = 0 parameter 8 = 0 parameter 9 = 0 parameter 10 = 0 parameter 11 = 0 parameter 12 = 0 parameter 13 = 0 parameter 14 = 0 parameter 15 = 0 parameter 16 = 0				16.9	0.0544 +TM(10)	52.928

		parameter 17 = 0 parameter 18 = 0 parameter 19 = 0 parameter 20 = 0 parameter 21 = 0 parameter 22 = 0 parameter 23 = UVIS_START_TIME parameter 24 = UVIS_DURATION_TIME parameter 25 = UVIS_COP_ROW parameter 26 = SIMPLE_PROTOCOL_CHECKSUM				16.9	0.0544	52.928
		verify 1553B telemetry : EVENT_CODE = *2 (OBSERVING MODE)* OPERATIONAL_MODE = *165 (SCIENCE)* UVIS_POWER_STATUS = *ON* UVIS_VOLTAGE = *value* UVIS_CURRENT = *value*			NMHK1010 NMHK1210 NMHK1145 NMHK1113 NMHK1116	16.9	0.0544	52.928
2		closing of PHDU file for NOMAD data	→ 3					
	00.05.00	execute command to close PDHU file parameter = *file name*				12	0.0544	0 (*)
	00.05.05	check file status result in TM : FILE filename = CLOSED			EXMFIL01	12	0.0544	0 (*)
3		opening of PHDU file for NOMAD data	→ END					
	00.05.10	execute command to open PDHU file parameter = *file name*				12	0.0544	0 (*)
	00.05.20	check file status result in TM : FILE *filename* = OPEN			EXMFIL01	12	0.0544	0 (*)
NO_CSEQ_NOM_013A		end of command sequence perform UVIS observation						
NO-FCP-013		end of procedure						

TM/TC stats

Code	Name	Byte size	Count	Total byte size	Over 1553	Over spw
20	Start operation	44	1	44	44	
10	Event	21	4	84	84	

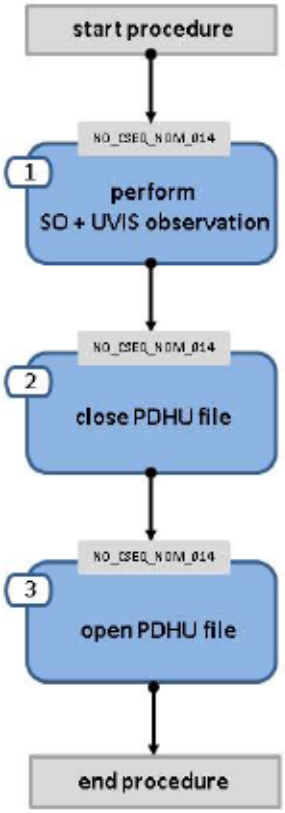
	11	NOMAD HK 1	53	10		530	530	
	12	NOMAD HK 2	39	10		390	390	
	13	NOMAD HK 3	54	10		540	540	
	23	SO HK	50	0		0	0	
	26	LNO HK	50	0		0	0	
	29	UVIS HK	58	30		1740	580	1160
	22	SO Science (only HK)	242	0	0	0		0
	22	SO Science	11762	0	0			
	25	LNO Science (only HK)	242	0	0	0		0
	25	LNO Science	11762	0	0			
	27	UVIS Applied parameters	48	1		48		48
	28	UVIS Science	6558	20		131160		131160
	60	System log	max 4096	1		4096		4096
		Total		87		138632	2168	136464

9.7 NO-FCP-014

The structures of Flight Control Procedures NO-FCP-011, NO-FCP-012, NO-FCP-013, NO-FCP-014 and NO-FCP-015 are identical. Only the contents of the TC(20) inside the procedure are different. The contents of TC(20) define which of the observations will be performed.

Procedure name	NO-FCP-014
Summary	Perform an SO+UVIS observation with NOMAD
Objective	Perform an observation with the SO and UVIS channels together A typical measurement duration of 15 minutes is assumed (10 min precooling + 5 minutes science observation). Duration can be variable depending on TC parameters. Polling in SO and UVIS is every second. The power demand = 47.9 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.0678 kbits/s max (2.032 kbits max every 30 seconds) (TM(11), TM(12), TM(13), TM(23), TM(29)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link There are several possibilities for UVIS during this observations: • the data rate over the SpW = 1.936 kbits/s (during precooling and UVIS off during precooling) and 145.584 kbits/s (during science observation) (TM(22), TM(27), TM(28) (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second), TM(29)) • the data rate over the SpW = 1.936 kbits/s (during precooling and UVIS off during precooling) and 147.024 kbits/s (during science observation) (TM(22), TM(27), TM(28) (3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second), TM(29)). • the data rate over the SpW = 54.864 kbits/s (during precooling and UVIS on during precooling and 3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second) and 147.024 kbits/s (during science observation) (TM(22), TM(27), TM(28) (and 3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second), TM(29)). This example is given in the procedures below. • the data rate over the SpW = 53.424 kbits/s (during precooling and UVIS on during precooling and (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second) and 145.584 kbits/s (during science observation) (TM(22), TM(27), TM(28) (and (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second), TM(29)) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. SpW telemetry will be stored in a PDHU file that will be opened and closed during this procedure.

Constraints	During this observation a special attitude may be requested from the S/C. See Pointing Request files
S/C configuration	Start of procedure: • NOMAD switched on • NOMAD in safe mode End of procedure: • NOMAD switched on • Observation performed → data delivered (science mode) • NOMAD back to safe mode • PDHU file closed with data of observation, new PDHU file opened for next observation
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_014A
Applicable telecommand	NMTC2000/04 (see table 1)
Referenced displays	Data logged on display: • EXMFIL01 • NMHK1010, NMHK1210, NMHK1143, NMHK145, NMHK1111, NMHK1113, NMHK1114, NMHK1116
Configuration control	Date / Version / Modification / Author 11/06/2013 / 01 / Creation of the procedure / eneefs 18/10/2013 / 01 / Modification after CDR / eneefs 28/01/2014 / 02 / Telecommand contents added / eneefs 10/03/2015 / 03 / Procedure updated / bristic

Flowchart	

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-014		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_014A		start of command sequence perform SO+UVIS observation						
1		start a NOMAD operation	→ 2					
	00.00.00	execute NOMAD command TC(20) START_OPERATION (NMTC2000/04) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = SO_START_TIME parameter 4 = SO_START_SCIENCE_1 parameter 5 = SO_START_SCIENCE_2 parameter 6 = SO_DURATION_REFERENCE_1 parameter 7 = SO_DURATION_REFERENCE_2 parameter 8 = SO_DURATION_TIME parameter 9 = SO_COP_GENERAL parameter 10 = SO_COP_PRECOOLING parameter 11 = SO_COP_SCIENCE_1 parameter 12 = SO_COP_SCIENCE_2 parameter 13 = 0 parameter 14 = 0 parameter 15 = 0 parameter 16 = 0				47.9 (10') 46.9 (5')	0.0678 +TM(10)	54.864 (10') 147.024 (5')

		parameter 17 = 0 parameter 18 =0 parameter 19 = 0 parameter 20 = 0 parameter 21 = 0 parameter 22 = 0 parameter 23 = UVIS_START_TIME parameter 24 = UVIS_DURATION_TIME parameter 25 = UVIS_COP_ROW parameter 26 = SIMPLE_PROTOCOL_CHECKSUM				47.9 (10') 46.9 (5')	0.0678 +TM(10)	54.864 (10') 147.024 (5')
		verify 1553B telemetry : EVENT_CODE = *2 (OBSERVING MODE)* OPERATIONAL_MODE = *165 (SCIENCE)* SO_POWER_STATUS = *ON* UVIS_POWER_STATUS = *ON* SO_VOLTAGE = *value* UVIS_VOLTAGE = *value* SO_CURRENT = *value* UVIS_CURRENT = *value*			NMHK1010 NMHK1210 NMHK1143 NMHK1145 NMHK1111 NMHK1113 NMHK1114 NMHK1116	47.9 (10') 46.9 (5')	0.0678	54.864 (10') 147.024 (5')
2		closing of PHDU file for NOMAD data	→ 3					
	00.15.00	execute command to close PDHU file parameter = *file name*				12	0.0678	0 (*)
	00.15.05	check file status result in TM : FILE *filename* = CLOSED			EXMFIL01	12	0.0678	0 (*)
3		opening of PHDU file for NOMAD data	→ END					
	00.15.10	execute command to open PDHU file parameter = *file name*				12	0.0678	0 (*)
	00.15.20	check file status result in TM : FILE *filename* = OPEN			EXMFIL01	12	0.0678	0 (*)
NO_CSEQ_NOM_014A		end of command sequence perform SO+UVIS observation						
NO-FCP-014		end of procedure						

TM/TC stats

Code	Name	Byte size	Count	Total byte size	Over 1553	Over spw
20	Start operation	44	1	44	44	

10	Event	21	17	357		357	
11	NOMAD HK 1	53	30	1590		1590	
12	NOMAD HK 2	39	30	1170		1170	
13	NOMAD HK 3	54	30	1620		1620	
23	SO HK	50	30	1500		1500	
26	LNO HK	50	0	0		0	
29	UVIS HK	58	930	53940		1740	52200
22	SO Science (only HK)	242	600	145200	3673800		3673800
22	SO Science	11762	300	3528600			
25	LNO Science (only HK)	242	0	0	0		0
25	LNO Science	11762	0	0			
27	UVIS Applied parameters	48	1	48			48
28	UVIS Science	6558	900	5902200			5902200
60	System log	max 4096	14	57344			57344
	Total		2883	9693613		8021	9685592

9.8 NO-FCP-015

The structures of Flight Control Procedures NO-FCP-011, NO-FCP-012, NO-FCP-013, NO-FCP-014 and NO-FCP-015 are identical. Only the contents of the TC(20) inside the procedure are different. The contents of TC(20) define which of the observations will be performed.

Procedure name	NO-FCP-015
Summary	Perform an LNO+UVIS observation with NOMAD
Objective	Perform an observation with the LNO and UVIS channel togehter A typical measurement duration of 50 minutes is assumed (10 min precooling + 40 minutes science observation). Duration can be variable depending on TC parameters. Polling in LNO and UVIS is every 15 seconds. The power demand = 47.9 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.0678 kbits/s max (2.032 kbits max every 30 seconds) (TM(11), TM(12), TM(13), TM(26), TM(29)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link There are several possibilities for UVIS during this observations: • the data rate over the SpW = 0.1291 kbits/s (during precooling and UVIS off during precooling) and 9.7056 kbits/s (during science observation) (TM(25), TM(27), TM(28) (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second), TM(29)) • • the data rate over the SpW = 0.1291 kbits/s (during precooling and UVIS off during precooling) and 9.8016 kbits/s (during science observation) (TM(25), TM(27), TM(28) (3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second), TM(29)) • • the data rate over the SpW = 3.6576 kbits/s (during precooling and UVIS on during precooling and 3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second) and 9.8016 kbits/s (during science observation) (TM(25), TM(27), TM(28) (and 3 UVIS TM(28) packets of 2186 bytes (1 line read out) sent per second), TM(29)). This example is given in the procedures below. • • the data rate over the SpW = 3.5616 kbits/s (during precooling and UVIS on during precooling and (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second) and 9.7056 kbits/s (during science observation) (TM(25), TM(27), TM(28) (and (1 UVIS TM(28) packet of 6378 bytes (3 lines read out) sent per second), TM(29)) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table.

	SpW telemetry will be stored in a PDHU file that will be opened and closed during this procedure.
Constraints	During this observation a special attitude may be requested from the S/C. See Pointing Request files
S/C configuration	Start of procedure: • NOMAD switched on • NOMAD in safe mode End of procedure: • NOMAD switched on • Observation performed → data delivered (science mode) • NOMAD back to safe mode • PDHU file closed with data of observation, new PDHU file opened for next observation
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_015A
Applicable telecommand	NMTC2000/05 (see table 1)
Referenced displays	Data logged on display: • EXMFIL01 • NMHK1010, NMHK1210, NMHK1144, NMHK145, NMHK1112, NMHK1113, NMHK1115, NMHK1116
Configuration control	Date / Version / Modification / Author 11/06/2013 01 Creation of the procedure eneefs 18/10/2013 01 Modification after CDR eneefs 28/01/2014 02 Telecommand contents added eneefs 10/03/2015 03 Procedure updated bristic

Flowchart	

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-015		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_015A		start of command sequence perform LNO+UVIS observation						
1		start a NOMAD operation	→ 2					
	00.00.00	execute NOMAD command TC(20) START_OPERATION (NMTC2000/05) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = 0 parameter 4 = 0 parameter 5 =0 parameter 6 = 0 parameter 7 = 0 parameter 8 = 0 parameter 9 = 0 parameter 10 = 0 parameter 11 = 0 parameter 12 = 0 parameter 13 = LNO_START_TIME parameter 14 = LNO_START_SCIENCE_1 parameter 15 = LNO_START_SCIENCE_2 parameter 16 = LNO_DURATION_REFERENCE_1				47.9 (10') 46.9 (5')	0.0678 +TM(10)	3.6576 (10') 9.8016 (40')

		parameter 17 = LNO_DURATION_REFERENCE_2 parameter 18 = LNO_DURATION_TIME parameter 19 = LNO_COP_GENERAL parameter 20 = LNO_COP_PRECOOLING parameter 21 = LNO_COP_SCIENCE_1 parameter 22 = LNO_COP_SCIENCE_2 parameter 23 = UVIS_START_TIME parameter 24 = UVIS_DURATION_TIME parameter 25 = UVIS_COP_ROW parameter 26 = SIMPLE_PROTOCOL_CHECKSUM				47.9 (10') 46.9 (5')	0.0678 +TM(10)	3.6576 (10') 9.8016 (40')
		verify 1553B telemetry : EVENT_CODE = *2 (SCIENCE MODE)* OPERATIONAL_MODE = *165 (SCIENCE)* LNO_POWER_STATUS = *ON* UVIS_POWER_STATUS = *ON* LNO_VOLTAGE = *value* UVIS_VOLTAGE = *value* LNO_CURRENT = *value* UVIS_CURRENT = *value*			NMHK1010 NMHK1210 NMHK1144 NMHK1145 NMHK1112 NMHK1113 NMHK1115 NMHK1116	47.9 (10') 46.9 (5')	0.0678	3.6576 (10') 9.8016 (40')
2		closing of PHDU file for NOMAD data	→ 3					
	00.50.00	execute command to close PDHU file parameter = *file name*				12	0.0678	0 (*)
	00.50.05	check file status result in TM : FILE *filename* = CLOSED			EXMFIL01	12	0.0678	0 (*)
3		opening of PHDU file for NOMAD data	→ END					
	00.50.10	execute command to open PDHU file parameter = *file name*				12	0.0678	0 (*)
	00.50.20	check file status result in TM : FILE *filename* = OPEN			EXMFIL01	12	0.0678	0 (*)
NO_CSEQ_NOM_015A		end of command sequence perform LNO+UVIS observation						
NO-FCP-015		end of procedure						

TM/TC stats

Code	Name	Byte size	Count	Total byte size		Over 1553	Over spw
20	Start operation	44	1	44		44	
10	Event	21	28	588		588	
11	NOMAD HK 1	53	100	5300		5300	
12	NOMAD HK 2	39	100	3900		3900	
13	NOMAD HK 3	54	100	5400		5400	
23	SO HK	50	0	0		0	
26	LNO HK	50	7	350		350	
29	UVIS HK	58	300	17400		5800	11600
22	SO Science (only HK)	242	0	0	0		0
22	SO Science	11762	0	0			
25	LNO Science (only HK)	242	40	9680	1891600		1891600
25	LNO Science	11762	160	1881920			
27	UVIS Applied parameters	48	1	48			48
28	UVIS Science	6558	200	1311600			1311600
60	System log	max 4096	25	92774			92774
	Total		1062	3329004		21382	3307622

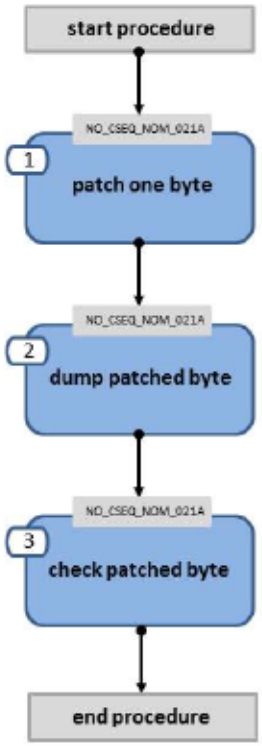
9.9 NO-FCP-021

Procedure name	NO-FCP-021
Summary	Patching of one byte in SINBAD memory
Objective	This procedure performs three actions: patching of one byte in SINBAD memory (code or COP zone), dumping of the patched byte to ground, sending a checksum of the patched byte to ground. In the PATCH_MEMORY command the parameter PATCH_MEMORY_COUNT = 1 The power demand = 12 W max There will be data sent over the 1553B link the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • after reception of a TC(31) a telemetry packet (TM(32)) will be sent (min 12, max 64 bytes) • after reception of a TC(33) a telemetry packet (TM(34)) will be sent (min 15, max 63 bytes) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	
S/C configuration	Start of procedure: • NOMAD in safe mode End of procedure: • one byte in memory patched • dump and check of the patched byte executed
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_021A

Applicable telecommand	NMTC3000/01 (see table 1) NMTC3100/01 (see table 1) NMTC3300/01 (see table 1)
Referenced displays	Data logged on display: • NMHK3201 • NMHK3402

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
10/03/2015	03	Procedure updated	bristic

Flowchart	

start procedure
NO_CSEQ_NOM_021A
1
patch one byte
NO_CSEQ_NOM_021A
2
dump patched byte
NO_CSEQ_NOM_021A
3
check patched byte
end procedure

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-21	start of procedure					W	kbits/s	kbits/s
NO_CSEQ_NOM_021A		start of command sequence patch one byte						
1		perform a memory patch	→ 2					
	00.00.00	execute NOMAD command TC(30) PATCH_MEMORY (NMTC3000/01) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = PATCH_MEMORY_COUNT=1 parameter 4 = PATCH_MEMORY_ADDRESS_1 parameter 5 = PATCH_MEMORY_DATA_SIZE_1=1 parameter 6 = PATCH_MEMORY_DATA_1 parameter 7 = SIMPLE_PROTOCOL_CHECKSUM				12	0.039	0 (*)
2		perform a memory dump	→ 3					
	00.00.10	execute NOMAD command TC(31) DUMP_MEMORY (NMTC3100/01) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=1 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0.039 +TM(32)	0 (*)
		verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3201	12		
3		perform a memory check	→ END					
	00.00.20	execute NOMAD command TC(33) CHECK_MEMORY (NMTC3300/01) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = CHECK_MEMORY_COUNT=1 parameter 4 = CHECK_MEMORY_ADDRESS_1 parameter 5 = CHECK_MEMORY_DATA_SIZE_1=1 parameter 6 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 +TM(34)	0 (*)

	00.01.20	Wait 1 minute to collect all TMs. verify 1553B telemetry : CHECK_ADDRESS_A1 = *value*			NMHK3402	12	0.039	0 (*)
	NO_CSEQ_NOM_021A	end of command sequence patch one byte						
	NO-FCP-021	end of procedure						

9.10 NO-FCP-022

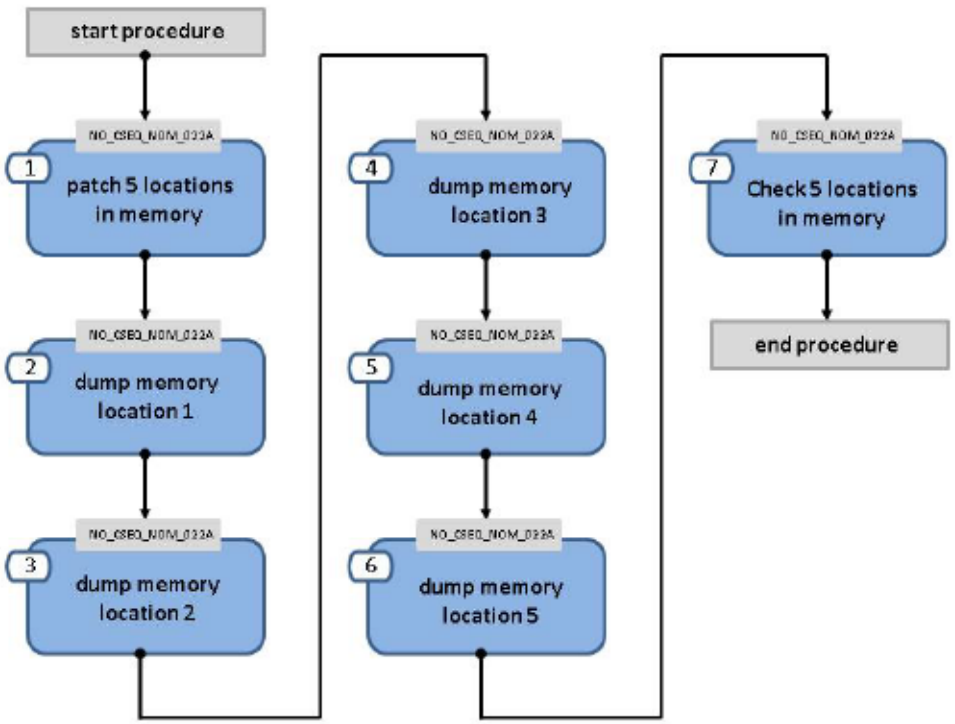
Procedure name	NO-FCP-022
Summary	Patching at 5 locations in SINBAD memory
Objective	This procedure performs the following actions: patching of 5 locations in SINBAD memory (code or COP zone) with different patched lengths, dumping of the patched bytes to ground, sending a checksum of the patched bytes to ground. In the PATCH_MEMORY command the parameter PATCH_MEMORY_COUNT = 5 The power demand = 12 W max There will be data sent over the 1553B link the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • after reception of a TC(31) a telemetry packet (TM(32)) will be sent (min 12, max 64 bytes) • after reception of a TC(33) a telemetry packet (TM(34)) will be sent (min 15, max 63 bytes) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	
S/C configuration	Start of procedure: • NOMAD in safe mode End of procedure: • 5 memory locations are patched • dump and check of the patched bytes executed
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_022A

Applicable telecommand	NMTC3000/02 (see table 1) NMTC3100/02 (see table 1) NMTC3100/03 (see table 1) NMTC3100/04 (see table 1) NMTC3100/05 (see table 1) NMTC3100/06 (see table 1) NMTC3300/02 (see table 1)
Referenced displays	Data logged on display: • NMHK3101 • NMHK3402

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
10/03/2015	03	Procedure updated	bristic

Flowchart


start procedure
1
patch 5 locations in memory
2
dump memory location 1
3
dump memory location 2
4
dump memory location 3
5
dump memory location 4
6
dump memory location 5
7
Check 5 locations in memory
end procedure

Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-22	start of procedure					W	kbits/s	kbits/s
NO_CSEQ_NOM_022A		start of command sequence complex patch						
1		perform a memory patch	→ 2					
	00.00.00	execute NOMAD command TC(30) PATCH_MEMORY (NMTC3000/02) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = PATCH_MEMORY_COUNT=5 parameter 4 = PATCH_MEMORY_ADDRESS_1 parameter 5 = PATCH_MEMORY_DATA_SIZE_1=1 parameter 6 = PATCH_MEMORY_DATA_1 parameter 7 = PATCH_MEMORY_ADDRESS_2 parameter 8 = PATCH_MEMORY_DATA_SIZE_2=3 parameter 9 = PATCH_MEMORY_DATA_2 parameter 10 = PATCH_MEMORY_ADDRESS_3 parameter 11 = PATCH_MEMORY_DATA_SIZE_3=2 parameter 12 = PATCH_MEMORY_DATA_3 parameter 13 = PATCH_MEMORY_ADDRESS_4 parameter 14 = PATCH_MEMORY_DATA_SIZE_4=16 parameter 15 = PATCH_MEMORY_DATA_4 parameter 16 = PATCH_MEMORY_ADDRESS_5 parameter 17 = PATCH_MEMORY_DATA_SIZE_5=10 parameter 18 = PATCH_MEMORY_DATA_5 parameter 19 = SIMPLE_PROTOCOL_CHECKSUM				12	0.039	0 (*)
2		perform a memory dump	→ 3					
	00.00.10	execute NOMAD command TC(31) DUMP_MEMORY (NMTC3100/02) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=1 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 +TM(32)	0 (*)

			verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3101	12	0.039	0 (*)
	3		perform a memory dump	→ 4					
		00.00.20	execute NOMAD command TC(31) DUMP_MEMORY (NMTC3100/03) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=3 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 + TM(32)	0 (*)
			verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3101	12	0.077	0 (*)
	4		perform a memory dump	→ 5					
		00.00.30	execute NOMAD command TC(31) DUMP_MEMORY (NMTC3100/04) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=2 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 + TM(32)	0 (*)
			verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3101	12	0.077	0 (*)
	5		perform a memory dump	→ 6					
		00.00.40	execute NOMAD command TC(31) DUMP_MEMORY(NMTC3100/05) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=16 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 + TM(32)	0 (*)

		verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3101	12	0.039	0 (*)
6		perform a memory dump of memory location 5	→ 7					
	00.00.50	execute NOMAD command TC(31) DUMP_MEMORY (NMTC3100/06) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = DUMP_MEMORY_ADDRESS parameter 4 = DUMP_MEMORY_DATA_SIZE=10 parameter 5 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 +TM(32)	0 (*)
		verify 1553B telemetry : DUMP_ADRESS = *value*			NMHK3101	12	0.039	0 (*)
7		perform a memory check	→ END					
	00.01.00	execute NOMAD command TC(33) CHECK_MEMORY (NMTC3300/02) parameter 1 = SIMPLE_PROTOCOL_TYPE parameter 2 = SIMPLE_PROTOCOL_LENGTH parameter 3 = CHECK_MEMORY_COUNT=5 parameter 4 = CHECK_MEMORY_ADDRESS_1 parameter 5 = CHECK_MEMORY_DATA_SIZE_1=1 parameter 6 = CHECK_MEMORY_ADDRESS_2 parameter 7 = CHECK_MEMORY_DATA_SIZE_2=3 parameter 8 = CHECK_MEMORY_ADDRESS_3 parameter 9 = CHECK_MEMORY_DATA_SIZE_3=2 parameter 10 = CHECK_MEMORY_ADDRESS_4 parameter 11 = CHECK_MEMORY_DATA_SIZE_4=16 parameter 12 = CHECK_MEMORY_ADDRESS_5 parameter 13 = CHECK_MEMORY_DATA_SIZE_5=10 parameter 14 = SIMPLE_PROTOCOL_CHECKSUM				12	0,039 +TM(34)	0 (*)
	00.04.00	Wait 3 min to collect all TMs. verify 1553B telemetry : CHECK_ADRESS_A1 = *value*			NMHK3402			
NO_CSEQ_NOM_022A		end of command sequence complex patch						
NO-FCP-022		end of procedure						

9.11 NO-FCP-023

Procedure name	NO-FCP-023
Summary	Performing a series of operations on the SINBAD file system
Objective	This procedure performs the uploading of a file into SINBAD's file system and its consecutive downloading. The following series of file operations is executed: • erase SINBAD "temp file" using "erase file" command • upload file into "temp file" using two "update file" commands • create new file "test file" using "create file" command • copy contents of "temp file" into "test file" using "copy file" command • erase SINBAD "temp file" using "erase file" command • print file status of 'test file" • download "test file" using "download file" command • delete 'test file" using "erase file" command • print full status The size of the uploaded "test file" is 80 bytes (not compressed). Note that this procedure is not realistic because the test file is uploaded that at the end will be deleted. This is not what we want do in-flight. Also the number of bytes that is being uploaded/patched is unrealistically small i.e. 80 bytes. However this procedure is kept "as is" for now to be in line with the flight operations procedure (FOP) NO-FCP-023 defined by MOC. This procedure shall be adjusted as follows; discussions with MOC are going to be started in the coming weeks/months. The following series of file operations is executed to upload uncompressed COP table (49152 bytes): • erase SINBAD "temp file" using "erase file" command • upload uncompressed COP-file into "temp file" using 964 "update file" commands (worst case, biggest COP table,49152 bytes) • print file status of 'COP file" to have info about the original file in the syslog • erase current "COP file" using "erase file" command • copy contents of "temp file" into "COP file" using "copy entire file" command • erase SINBAD "temp file" using "erase file" command • print file status of 'COP file" to have info about the new/uploaded file in the syslog • download "COP file" using "download file" command (wait 30 sec before executing next bullet) • print full status The following series of file operations is executed to upload compressed COP table (20 KiB): • erase SINBAD "temp file" using "erase file" command • upload compressed COP-file into "temp file" using 402 "update file" commands (worst case, biggest COP table compressed,20 KiB) • print file status of 'COP file" to have info about the original file in the syslog • erase current "COP file" using "erase file" command

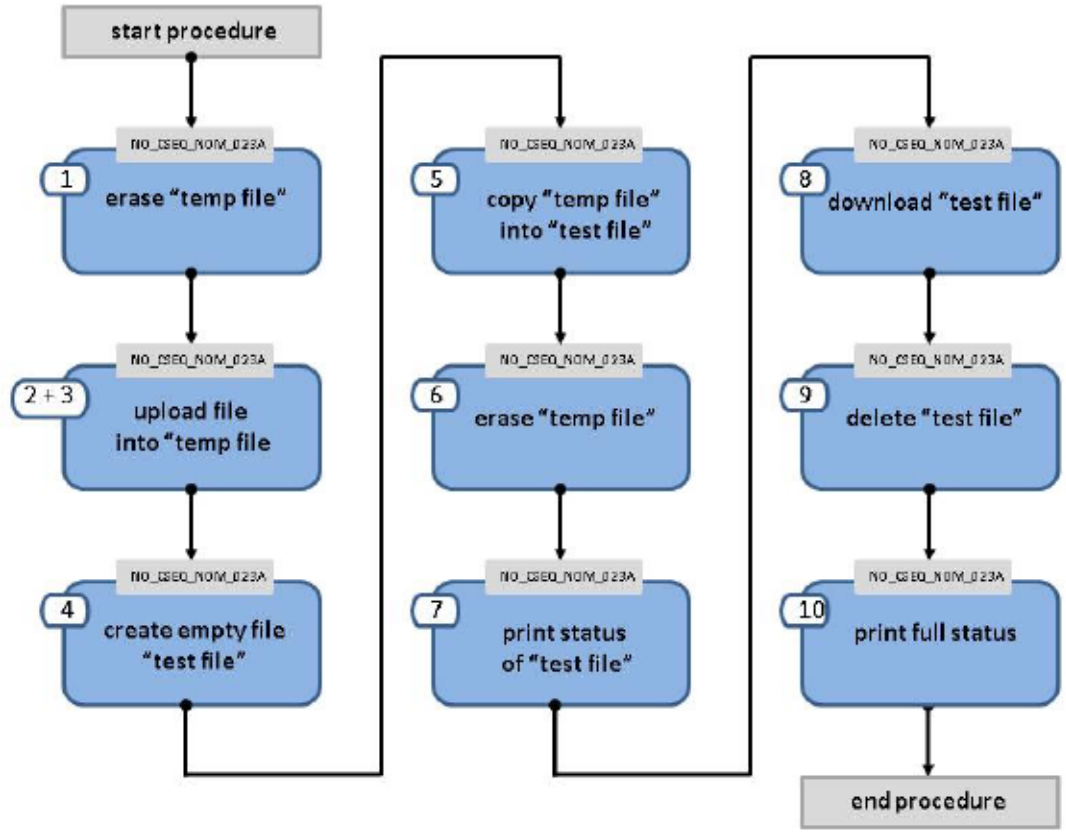
	• decompress "temp file" (destination = COP file) using "decompress file" command • erase SINBAD "temp file" using "erase file" command • print file status of 'COP file" to have info about the new/uploaded file in the syslog • download "COP file" using "download file" command (wait 30 sec before executing next bullet) • print full status The power demand = 12 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • after reception of a TC(35) a telemetry packet with a file manager operation report (TM(36)) will be sent (22 bytes) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • a file manager download file report packet (TM(37)) is used to download the file to ground (max 1024 bytes per TM(37)) • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	
S/C configuration	Start of procedure: • NOMAD in safe mode End of procedure: • File "test file" is uploaded • File "test file" is downloaded • File "test file" is deleted
Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_023A
Applicable telecommand	NMTC3500/01 (see table 1)

	NMTC3500/02 (see table 1) NMTC3500/03 (see table 1) NMTC3500/04 (see table 1) NMTC3500/05 (see table 1) NMTC3500/06 (see table 1) NMTC3500/07 (see table 1) NMTC3500/08 (see table 1) NMTC3500/09 (see table 1) NMTC3500/10 (see table 1)
Referenced displays	Data logged on display: • NMHK3601, NMHK3604

Configuration control

Date	Version	Modification	Author
31/10/2013	01	Creation of the procedure	eneefs
28/01/2014	02	Telecommand contents added	eneefs
10/03/2015	03	Procedure updated	bristic

Flowchart



Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-23	start of procedure					W	kbits/s	kbits/s
NO_CSEQ_NOM_023A		start of command sequence file operations						
1		perform "erase file" command	→ 2					
	00.00.00	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/01) parameter 1 = OPERATION_CODE=22 parameter 2 = FILE_ID=18				12	0.039 +TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *22* FILE_ID = 18			NMHK3601 NMHK3604	12	0.039	0 (*)
2		perform "update file" command	→ 3					
	00.00.10	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/02) parameter 1 = OPERATION_CODE=11 parameter 2 = FILE_ID=18 parameter 3 = RELATIVE_OFFSET=0 parameter 4 = SEND_REPORT=0 parameter 5 = BYTE_SIZE=51 parameter 6 = PATCH_BYTES				12	0.039	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *11* FILE_ID = 18			NMHK3601 NMHK3604	12	0.039	0 (*)

3		perform "update file" command	→ 4					
	00.00.20	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/03) parameter 1 = OPERATION_CODE=11 parameter 2 = FILE_ID=18 parameter 3 = RELATIVE_OFFSET=51 parameter 4 = SEND_REPORT=1 parameter 5 = BYTE_SIZE=29 parameter 6 = PATCH_BYTES				12	0.039 +TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *12* FILE_ID = 18			NMHK3601 NMHK3604	12	0.039	0 (*)
4		perform "create file" command	→ 5					
	00.00.30	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/04) parameter 1 = OPERATION_CODE=20 parameter 2 = BYTE_SIZE=80 parameter 3 = FILE_NAME="test file 0"				12	0.039 +TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *20*			NMHK3601	12	0.039	0 (*)
5		perform "copy file" command	→ 6					
	00.00.40	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/05) parameter 1 = OPERATION_CODE=13 parameter 2 = FILE_ID_SOURCE=18 parameter 3 = FILE_ID_DESTINATION=19				12	0.039 +TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *13* FILE_ID = 18			NMHK3601 NMHK3604	12	0.039	0 (*)

6		perform "erase file" command	→ 7					
	00.00.50	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/06) parameter 1 = OPERATION_CODE=22 parameter 2 = FILE_ID=18				12	0.039 + TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *22* FILE_ID = 18			NMHK3601 NMHK3604	12	0.039	0 (*)
7		perform "print file status" command	→ 8					
	00.01.00	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/07) parameter 1 = OPERATION_CODE=41 parameter 2 = FILE_ID=19				12	0.039 + TM(36)	0 (*)
		verify 1553B telemetry : OPERATION_CODE = *41* FILE_ID = 19			NMHK3601 NMHK3604	12	0.039	0 (*)
8		perform "download file" command	→ 9					
	00.01.10	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/08) parameter 1 = OPERATION_CODE=40 parameter 2 = FILE_ID=19				12	0.039 + TM(36)	2 x TM(37)
		verify 1553B telemetry : OPERATION_CODE = *40* FILE_ID = 19			NMHK3601 NMHK3604	12	0.039	0 (*)

	9		perform "delete test file 0" command	→ 10					
		00.01.20	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/09) parameter 1 = OPERATION_CODE=21				12	0.039 +TM(36)	0 (*)
			verify 1553B telemetry : OPERATION_CODE = *21*			NMHK3601	12	0.039	0 (*)
	10		perform "print full status" command	→ END					
		00.01.30	execute NOMAD command TC(35) FILE_MANAGER_OPERATION (NMTC3500/10) parameter 1 = OPERATION_CODE=42				12	0.039 +TM(36)	0 (*)
		00.05.30	Wait 4 min to collect all TMs. verify 1553B telemetry : OPERATION_CODE = *42*			NMHK3601	12	0.039	0 (*)
	NO_CSEQ_NOM_023A		end of command sequence file operations						
	NO-FCP-023		end of procedure						

9.12 NO-FCP-031

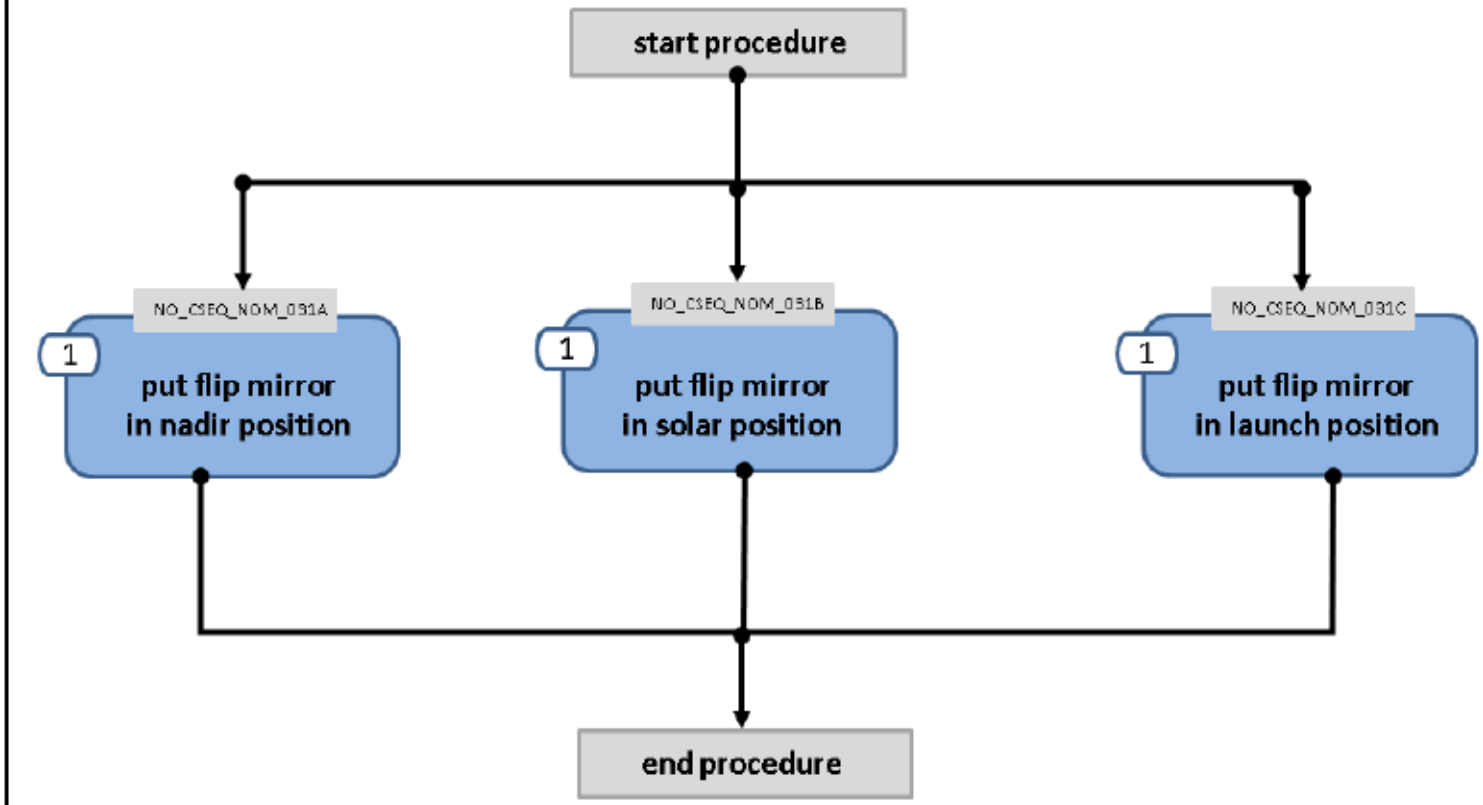
Procedure name	NO-FCP-031
Summary	Put flip mirror mechanism in: • A: default mode (nadir) or • B: contingency mode (solar) or • C: launch
Objective	The objective of the procedure is to put the flip mirror in the LNO channel: • in its default position, i.e. so that the channel can observe in the nadir direction (mirror is placed in the optical path) • or in its contingency position, i.e. so that the channel can observe in the direction of the Sun (mirror is taken out of the optical path) • or in its launch position, i.e. a position between nominal and contingency positions (where the switches are not activated) The power demand = 18 W max There will be data sent over the 1553B link the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	
S/C configuration	Start of procedure: • NOMAD power is on • NOMAD is in safe mode End of procedure: • NOMAD power is on • mirror is in nadir/solar/launch position

Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_NOM_031A or NO_CSEQ_NOM_031B or NO_CSEQ_NOM_031C
Applicable telecommand	NMTC7000/05 (see table 1), nadir NMTC7000/06 (see table 1), solar NMTC7000/07 (see table 1), launch
Referenced displays	Data logged on display: • NMHK1010, NMHK1012, NMHK1014, NMHK1015, NMHK1017, NMHK1019, NMHK1020, NMHK1022, NMHK1024, NMHK1025

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
10/03/2015	03	Procedure updated	bristic

Flowchart



Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-FCP-031		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_NOM_031A/B/C		start of command sequence flip mirror to nadir/solar/launch						
1		bring flip mirror to a position	→ 2					
	00.00.00	execute TC(70) : CUSTOM_COMMAND (NTC7000/05 or 06 or 07) parameter 1 = CODE *= 10 (nadir) or 11 (solar) or 12(launch)* parameter 2 = STEPPER_SPEED = 12 parameter 3 = MAX_STEPS = 1000 parameter 4 = ENABLE LS1=*0* parameter 5 = ENABLE LS2=*0* parameter 6 = ENABLE LS3=*0* parameter 7 = ENABLE LS4=*0*				18	0.039	0 (*)
		waiting period of 60 seconds				18	0,039 +TM(10)	0 (*)
	00.01.00	verify 1553B telemetry : EVENT_CODE = 5 (nadir) or 6 (solar) or 7 (launch) LS_STATUS = *0111(nadir) or 1101 (solar) or1111 (launch)* LS_ENABLING = *0000* STEPS_COUNTER = *value*	→ END		NMHK1010 NMHK1012/17/22 NMHK1014/19/24 NMHK1015/20/25	12	0.039	0 (*)
NO_CSEQ_NOM_031A/B/C		end of command sequence flip mirror to nadir/solar/launch						
NO-FCP-031		end of procedure						

9.13 NO-CRP-541

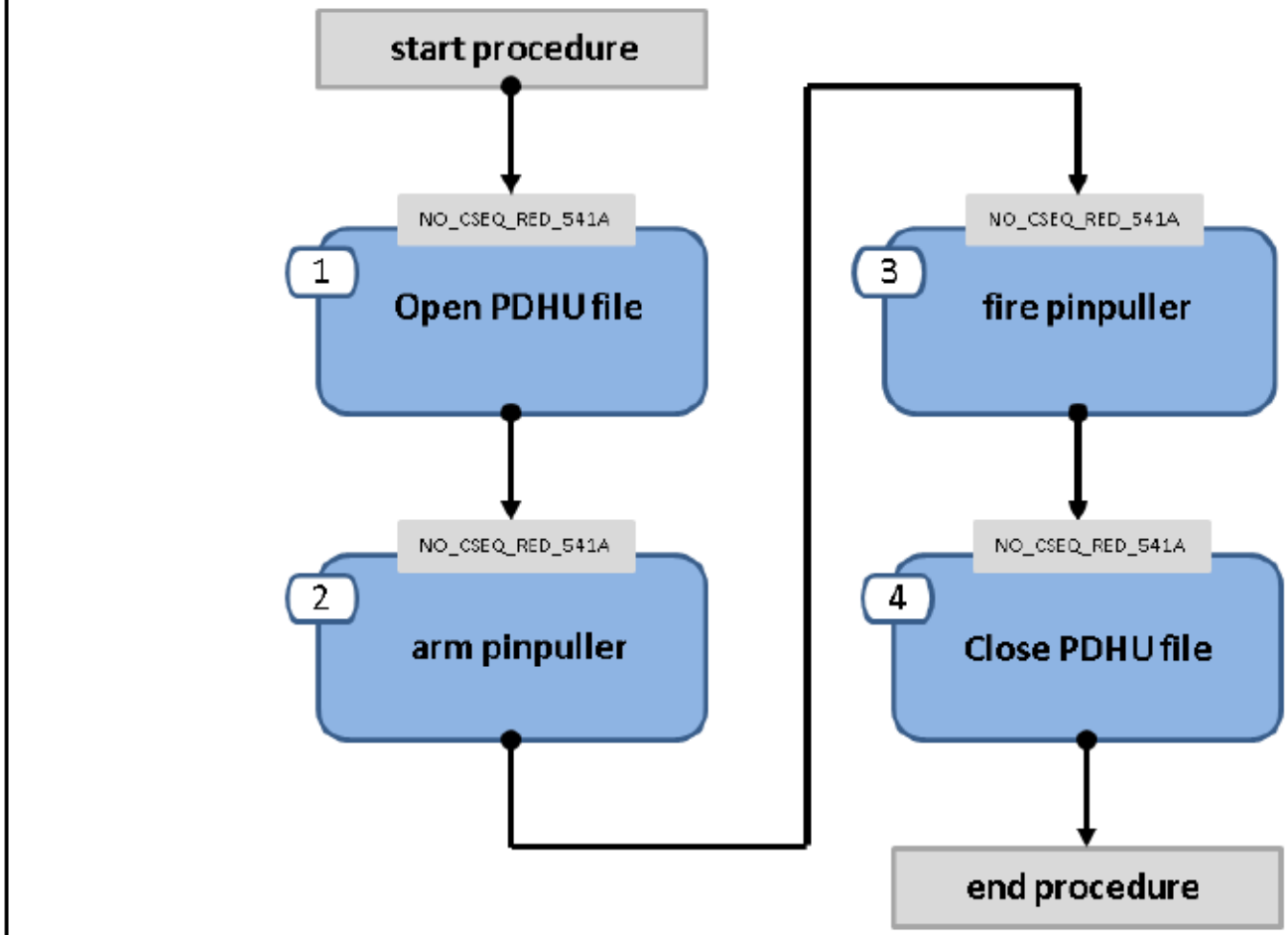
Procedure name	NO-CRP-541
Summary	Arm and fire pinpuller
Objective	The objective of the procedure is to put the flip mirror in the LNO channel permanently in its nominal position, by arming and firing the emergency pinpuller mechanism. Two actions are required: • 'arming' of the pinpuller by a first TC(70) • 'firing' of the pinpuller by a second TC(70) The waiting time between the two TC(70)- commands should be 5 seconds The power demand = 14 W max There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	IMPORTANT: this procedure CAN NOT be executed during ground validation, unless access is available to the flip mirror mechanism. This procedure arms and fires the flip mirror emergency mechanism and puts it in an irreversible state. After this test the pinpuller should be manually re-armed. Procedure can only be executed after written authorization by the PI or its representative.
S/C configuration	Start of procedure: • NOMAD power is on • NOMAD is in safe mode End of procedure: • NOMAD power is on • mirror is PERMANENTLY in nominal position

Reference file(s)	Input command sequence: Output command sequence: NO_CSEQ_RED_541A
Applicable telecommand	NMTC7000/03 (see table 1) NMTC7000/04 (see table 1)
Referenced displays	Data logged on display: • NMHK1010

Configuration control

Date	Version	Modification	Author
11/06/2013	01	Creation of the procedure	eneefs
18/10/2013	01	Modification after CDR	eneefs
28/01/2014	02	Telecommand contents added	eneefs
10/03/2015	03	Procedure updated	bristic

Flowchart


start procedure
NO_CSEQ_RED_541A
1
Open PDHU file
NO_CSEQ_RED_541A
2
arm pinpuller
NO_CSEQ_RED_541A
3
fire pinpuller
NO_CSEQ_RED_541A
4
Close PDHU file
end procedure

Procedure

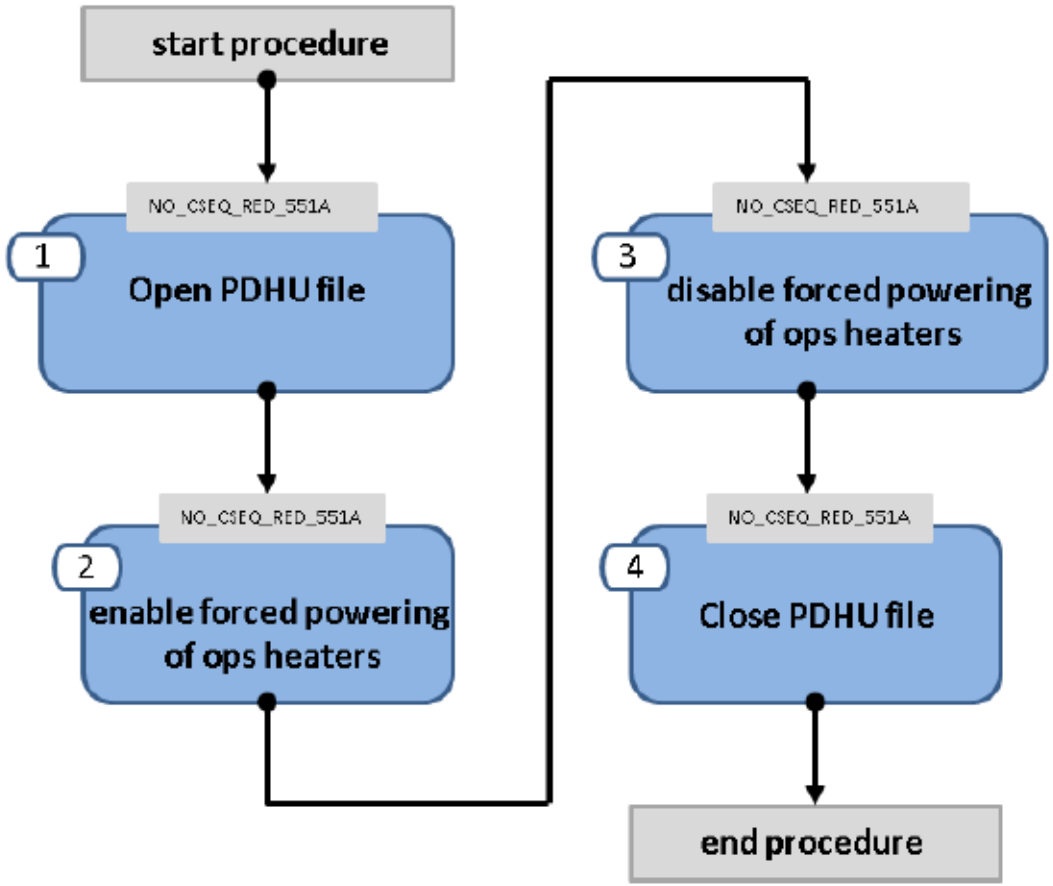
step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate
NO-CRP-0541		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_RED_541A		start of command sequence pinpuller arming/firing						
1		open PDHU file	→ 2					
	00.00.00	EPDZ140N OPEN FILE NOMAD				12	0.039 + TM(10)	0 (*)
2		arm the pinpuller	→ 3					
	00.00.05	execute TC(70) : CUSTOM_COMMAND (NMTC7000/03) parameter 1 = CODE=20				12	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = 8			NMHK1010	12	0.039	0 (*)
		wait 5 seconds				12	0.039	0 (*)
3		fire the pinpuller	→ 4					
	00.00.10	execute TC(70) : CUSTOM_COMMAND (NMTC7000/04) parameter 1 = CODE=21				14	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = 8			NMHK1010	14	0.039	0 (*)
		a waiting period of 60 seconds is mandatory before executing any new procedure						
4		close PDHU file	→ END					
		Wait about 10 minutes to capture syslog over SpW (syslog is sent every 1' to 10' (here worst case is taken = 10 min)						
	00.10.30	EPDZ141N CLOSE FILE NOMAD				12	0.039 + TM(10)	0 (*)
NO_CSEQ_RED_541A		end of command sequence pinpuller arming/firing						
NO-CRP-0541		end of procedure						

9.14 NO-CRP-551

Procedure name	NO-CRP-551
Summary	Switching of operational heaters
Objective	The objective of the procedure is to enable forced powering of the operational heaters for a short period and then disable forced powering again. Two actions are required: • enabling forced powering of the operational heaters by a first TC(70) • disabling forced powering of the operational heaters by a second TC(70) Between the two TC(70) commands a heat up time of 5 minutes will be put. The power demand = 27 W max (operational heater power is 15 W (TBC)) There will be data sent over the 1553B link • the synchronous data rate over the 1553B link = 0.039 kbits/s max (1.17 kbits max every 30 seconds) (TM(11), TM(12), TM(13)) • event messages (TM(10)) will be created asynchronously at the occurrence of certain events There will be data sent over the SpW link • no science data • approximately every 1 to 10 min (depending on SINBAD activity) a system log (TM(60)) will be sent (4 kbytes), this is indicated by (*) in the sequence table. Note that a PDHU file should be open at S/C side to receive these TM(60) packets.
Constraints	IMPORTANT: this procedure can only be executed after written authorization by the PI or its representative.
S/C configuration	Start of procedure: • NOMAD power is on • NOMAD is in safe mode End of procedure: • NOMAD power is on • NOMAD temperature has slightly increased
Reference file(s)	Input command sequence:

	Output command sequence: NO_CSEQ_RED_551A
Applicable telecommand	NMTC7000/01 (see table 1) NMTC7000/02 (see table 1)
Referenced displays	Data logged on display: • NMHK1010 • NMHK1103, NMHK1104, NMHK1106, NMHK1107, NMHK1108, NMHK1117 • NMHK1210
Configuration control	Date / Version / Modification / Author 31/10/2013 / 01 / Creation of the procedure / eneefs 28/01/2014 / 02 / Telecommand contents added / eneefs

Flowchart



Procedure

step	label/time	activity/remark/branch	next step	check S/C	display MOC	power	1553 rate	SpW rate	

NO-CRP-0551		start of procedure				W	kbits/s	kbits/s
NO_CSEQ_RED_551A		start of command sequence operational heater switching						
1		open PDHU file	→ 2					
	00.00.00	EPDZ140N OPEN FILE NOMAD				12	0.039 + TM(10)	0 (*)
2		enable forced powering of ops heater	→ 3					
	00.00.05	execute TC(70) : CUSTOM_COMMAND (NMTC7000/01) parameter 1 = CODE=1				27	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = 1 (SAFE MODE) OPERATIONAL_MODE = 87 (SAFE MODE) HEATER_CURRENT = value DC_DC_MODULE_TEMP = value POW_BOARD_TEMP = value SO_CHANNEL_TEMP = value LNO_CHANNEL_TEMP = value UVIS_CHANNEL_TEMP = value			NMHK1010 NMHK1210 NMHK1117 NMHK1103 NMHK1104 NMHK1108 NMHK1106 NMHK1107	27	0.039	0 (*)
		wait 5 minutes				27	0.039	0 (*)
3		disable forced powering of ops heater	→ 4					
	00.05.05	execute TC(70) : CUSTOM_COMMAND (NMTC7000/02) parameter 1 = CODE=2				27	0.039 + TM(10)	0 (*)
		verify 1553B telemetry : EVENT_CODE = 1 (SAFE MODE) OPERATIONAL_MODE = 87 (SAFE MODE) HEATER_CURRENT = value DC_DC_MODULE_TEMP = value POW_BOARD_TEMP = value SO_CHANNEL_TEMP = value LNO_CHANNEL_TEMP = value UVIS_CHANNEL_TEMP = value			NMHK1010 NMHK1210 NMHK1117 NMHK1103 NMHK1104 NMHK1108 NMHK1106 NMHK1107	27	0.039	0 (*)

			a waiting period of 5 minutes is mandatory before executing any new procedure							
	4		close PDHU file	→ END						
			Wait about 5 minutes to capture syslog over SpW (syslog is sent every 1' to 10')							
		00.10.30	EPDZ141N CLOSE FILE NOMAD				12	0.039 + TM(10)	0 (*)	
	NO_CSEQ_RED_551A		end of command sequence switching operational heaters							
	NO-CRP-0551		end of procedure							