ESA ESTEC
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands

VIGIL

NIO REQUIREMENTS DOCUMENT

Prepared by	Vigil Team
Organisation	EOP-PJ
Document Type	Requirement Document / Specification (System, Subsystem, Unit, Equipment level)
Reference	VGL-RS-ESA-NIO-0053
Issue/Revision	1.0
Date of Issue	24/04/2023
Status	Draft

APPROVAL

Title	NIO Requirements Document		
Issue Number	1	Revision Number	0
Author	Vigil Team	Date	24/04/2023
Approved By	G. Mandorlo	Date of Approval	

CHANGE LOG

NIO Requirements Document	Issue Nr	Revision Number	Date
Draft version	1	0	

CHANGE RECORD

Issue Number	1	Revision Number	0	
Reason for change		Date	Pages	Paragraph(s)
Fist issue				

DISTRIBUTION

Name/Organisational Unit
National Aeronautics and Space Administration (NASA), United States
Airbus Defence and Space Ltd (ADS-UK), United Kingdom

Table of Content

1. INTRODUCTION

The Vigil NIO Requirements Document defines the verification requirements that are applicable to the NASA Instrument Opportunity to be accommodated on the Vigil Spacecraft. This document is complementary of the NIO Interface Requirement Document.
The term “instrument” has to be considered as the suite containing all the instrument units (sensors, electronic boxes, DPUs, CDPUs, interconnecting harness, ...). The instrument provider shall then appropriately flow down the requirement to the relevant units.

2. DOCUMENTATION

2.1. Applicable Documents

The applicable documents are to be considered as an integral part of this document. The Applicable Documents are identified as [VGL-AD-##].

Ref	Title
[VGL-AD-04]	VGL-RS-ESA-PAS-0003, Product Assurance & Safety Requirements Document (PARD), issue 2.0
[VGL-AD-06]	VGL-RS-ESA-SC-0019, Tailoring and Verification Items for ECSS Engineering Standards, issue 1.0
[VGL-AD-10]	VGL-LI-ESA-SYS-0013, Terms, Definitions, Conventions and Abbreviations, issue 1.0
[VGL-AD-17]	VGL-RS-ESA-SC-0008, Mission Environmental Specifications, issue 1.0
[VGL-RD-48]	VGL-LI-ESA-INS-0017, Vigil Instrument Deliverable Documents List, issue 1.0

In addition, the following documents shall be considered as applicable:

Ref	Title
[ADS-01]	Payload General Design and Interface Requirements Tailoring, LGL5-SC-ADSS-SP-1000941696, issue 4
[ADS-02]	Payload Requirements Document, LGL5-SC-ADSS-SP-1000882707, issue 7 draft
[ADS-03]	Spacecraft and Subsystem Reference Coordinate Frame, LGL5-SC-ADSS-TN-1000494493, issue 5

Ref	Title
[ADS-04]	Finite Element Model Requirement Specification, LGL5-SC-ADSS-SP-1000628580, issue 3
[ASD-05]	Instrument Mechanical Environmental Loads, LGL5-SC-ADSS-TN-1000533186, issue 6
[ADS-06]	Instrument Thermal Environment Document, LGL5-SC-ADSS-TN-1000704775, issue 3
[ADS-07]	Cleanliness Requirement Document (CRS), LGL5-SC-ADSS-SP-1000503731, issue 4
[ADS-08]	Payload Harness Requirement Specification, LGL5-SC-ADSS-SP-1000950357, issue 1
[ADS-09]	SpaceWire Protocol Specification, LGL5-SC-ADSS-SP-1000871277, issue 3
[ADS-10]	MICD specifications & CAD data exchange requirements, ADS.E.1050, issue 4
[ADS-11]	ADS.E.1158, Interface Thermal and Geometrical Model Spec, issue 2
[ADS-12]	Airbus Packet Utilization Standard Interface Requirements Document Volume A, SPS_MSC-SP-1000191225, issue 4
[ADS-13]	Astrobus Packet Utilization Standard Interface Requirements Document Volume B1 – Platform Configuration Tables, ASTN-SP-ADSF-1000843521, issue 3
[ADS-14]	Packet Utilization Standard IRD Volume B2, ADSS-SP-1000997258, issue 1

Note 1: The documents prepared by Airbus Defence and Space (ref [ADS-##]) defining the interfaces on at spacecraft level will be replaced by the latest versions after the kick-off of the Phase B2 of the development of the Vigil spacecraft.

2.2. Reference Documents

Ref	Title
[VGL-AD-05]	VGL-RS-ESA-SC-0004, Space Segment Requirements Document (SSRD)
[VGL-RD-02]	VGL TN ESA SYS 0015, Mission Architecture And Operations Concept, issue 1.0 draft
[VGL-AD-08]	VGL-IRD-ESA-NIO-0037, NIO Interface Requirements Document (IRD)

2.3. Standard Documents

The normative documents include design, manufacturing, quality and verification standards that provide normative requirements to the execution of the work. The Normative Documents include the ECSS standards (2020 release) as well as standards established by other bodies (e.g. CCSDS, ESCC, ISO, MilBus, etc.).

In case of conflict between any of the Vigil Applicable Document and the Normative Documents the conflict shall be brought to the attention of the Agency for resolution.

- To download ECSS Standards, Handbooks, Technical Memoranda and the list of all ECSS DRDs refer to the internet address:

  www.ecss.nl

- To download CCSDS documents, refer to the internet address:

  www.ccsds.org

- To download documents in the area of EEE components specifications refer to the European Space Components Information Exchange System (ESCIES):

  https://escies.org

The tailoring of the product assurance and engineering normative documents is presented in [VGL-AD-04] and [VGL-AD-06] respectively.

3. DEFINITIONS AND CONVENTIONS

The following definition of terms are used in this document.

- Spacecraft (S/C): The Vigil Spacecraft includes Platform (PF) and instruments
- Platform (PF): The Platform comprises all units, equipment, assemblies, flight software and miscellaneous hardware that constitute the Spacecraft without the instruments
- Instrument OR instrument suite: Terms used indifferently to indicate the totality of units (including interconnecting elements such as harness bundles) which constitute a single Payload instrument.
- Instrument unit: A single instrument hardware or software product that does not contain interconnected elements. An interconnecting element, such as a harness bundle, is a separate unit from the elements it interconnects.
- Cadence: Time between the start of two consecutive observational acquisitions/measurements.
- Instrument Latency: Time between the start of an observational acquisition/measurement and completion of the transmission of the data to the platform.
- Survive: To be able to withstand the indicated conditions without any permanent degradation. Unless otherwise specified, the instrument can be assumed to be off.

More definitions, acronyms and assumptions are defined in [VGL-AD-10].

3.1. Requirement Definition

All requirements in this document are uniquely identified as follows: VGL-NIO-nnnn.
Where “nnnn” represents the requirement number. Requirement number is unique within a group and are initially spaced in order to allow for later flexibility.
Additionally, notes attached to requirements provide clarification to aid in the interpretation of the requirement; this additional information is not to be explicitly verified.

4. MISSION OVERVIEW

4.1. Mission Objectives

The Vigil Mission shall position a spacecraft at the 5th Sun-Earth Lagrangian point (SEL5) with the objective to perform continuous observations of the Sun and the space between the Earth and the Sun to provide measurement data for space weather nowcasting and forecasting and for event-based warnings and alerts when solar events take place. The observations from SEL5 will enable more accurate space weather impact predictions and early warnings of potentially hazardous solar weather conditions emerging.

The field of view from SEL5 allows monitoring of the onset of Coronal Mass Ejections (CMEs) with a coronagraph from a different angle than coronagraphy from the Sun-Earth line. Vigil mission will also be able to monitor the entire space between Sun and Earth with a heliospheric imager allowing mid-course tracking of solar wind features including CMEs as they travel towards Earth. Magnetograph observations from SEL5 will provide fresh solar magnetic field data for numerical solar wind models used in CME propagation estimation and enable more precise predictions of the CME arrival times on Earth. Magnetograph data is also expected to improve the solar flare and CME onset forecasting accuracy.

In-situ measurements in SEL5 will allow monitoring of high-speed solar wind streams several days in advance before they rotate towards the Earth.

Vigil mission will demonstrate the benefits from space weather observations away from the Sun-Earth line for operational applications. The mission is required to carry out observations at all times including severe space weather events and to provide data about the current space weather conditions to the users continuously and with low latency.

4.2. Payload Suite Overview

The spacecraft will carry 6 instruments with 3 optical instruments dedicated to remote sensing of the Sun and the interplanetary space between the Sun and the Earth, and 2 instruments locally (in-situ) measuring the changes of the interplanetary magnetic field and the particular environment at the L5 position. The 6th instrument is the NASA instrument of Opportunity (NIO), that will be provided by NASA.

Instrument	Utilisation
Heliospheric Imager	Monitor the evolution and propagation of CMEs and solar wind features travelling away from the Sun
Compact Coronagraph	Detect and monitor the evolution of CMEs propagating away from the Sun through the corona
Photospheric Magnetic Field Imager	Monitor evolving magnetic complexity: input into solar wind modelling and activity forecast
Plasma Analyser	Solar wind monitoring, detection and characterisation of high-speed solar wind streams
Magnetometer	Monitor the IMF magnetic-field properties and dynamics

4.3. Mission Architecture

The Mission aims at providing operational space weather data in a timely manner on a 24/7 basis. In case of Space Weather events, the System is to remain operational in order to ensure a timely warning to the final end users. The System engages with the protection of critical assets on Earth and in space (Internet, power grids, spacecraft navigation and telecommunication based services, spacecrafts in Earth orbit and in interplanetary space and human spaceflight e.g. future outposts on Moon). Most direct users of the instrument data are considered likely to be space weather monitoring services such as that already in operation at the UK Met Office and in future a similar service provided by the ESA Space Weather office which includes the provision of event based alarms, now-cast and forecast parameters together with a data archiving facility. Due to its criticality, the System is designed to be robust against any planned or unplanned unavailability.

For the reasons above, the System is composed of reliable segments and encompasses;

- The Space Segment (one spacecraft), in charge of acquiring the data with an instrument set which fulfils the objectives as specified in this document, handling the data on-board efficiently and transmitting to the Ground Segment in a timely manner to satisfy latency requirements. The spacecraft is designed to observe nominally under a severe space weather conditions and therefore it shows a very high reliability and autonomy.
- Ground Segment (mission operation function, data processing function) which provides the ability to monitor and control the spacecraft during all mission phases as well as receiving, archiving and distributing data products to the users on request. The Mission Operation Centre (MOC) contains elements to support the control, planning, flight dynamics and acquisition and storage of raw mission data for further processing and archiving. It is assumed that the MOC will be tightly coupled with the a Payload Data

Centre which would be primarily responsible for the further processing of the incoming data for archiving and dissemination as well as overall mission planning for the spacecraft and instrument suite. The ground segment comprises all the elements and functionalities aiming to timely react to any source of out-of- service

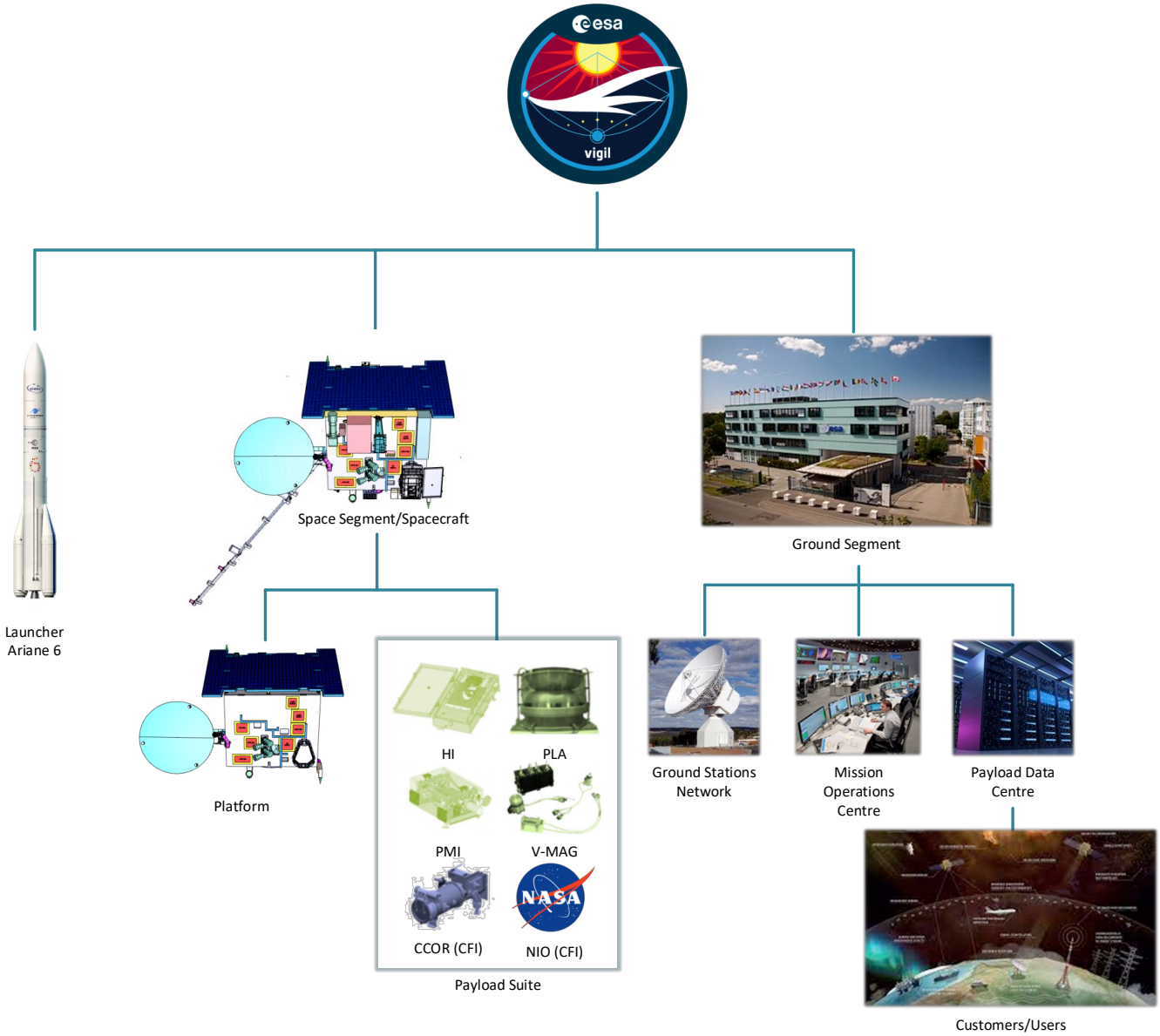

Figure 1: Vigil Mission Architecture

The Mission will be launched from Kourou using an Ariane 6 launcher. After having completed the LEOP, commissioning and calibration of the spacecraft, the spacecraft continues cruising toward the Lagrange point L5. The duration of this phase will be minimised taking into consideration mission return, technical and funding limitations. After the successful completion

of any essential platform in-space commissioning, it would be possible to already begin routine operation of the spacecraft while en route to the L5 Lagrange point. Although this phase would not be covered by formal requirements, it would be possible to provide data for a variety of uses, including; calibration of the instruments, comparison with other data sources (existing instruments in space for example) and input to ground processing facilities to enable early testing and validation of those facilities. Later in the cruise phase (at approximately 30 degrees Spacecraft-Sun-Earth angle), the Mission enters in the routine phase and the instrument data can already be used to improve CME tracking and space weather forecasting.
During the routine phase, the instruments are able to provide two priorities of measurement data; Priority 1 data is covered by the cadence, latency and availability requirements of this document and is the baseline needed to meet the primary objectives of the mission. However, for instruments that can, for example, operate at a much higher cadence than the minimum required there is the opportunity to store Priority 2 data, this additional data can be stored in the spacecraft mass memory for later download to ground. The combination or Priority 1 and 2 data will enable mission planning to maximise the utilisation of the downlink throughout the mission.
Once the cruise is completed, the spacecraft is inserted in an orbit around L5 and the Mission can continue to operate nominally and provide the needed service to the users.

4.4. Mission Phases

The baseline mission timeline and the required phases set, from Pre-Launch phase to routine operation, for the Vigil mission are shown in Figure 2. The figure is a schematic drawing and does not show the specifics such as transfer trajectories and different Ground Stations necessary for the required coverage.

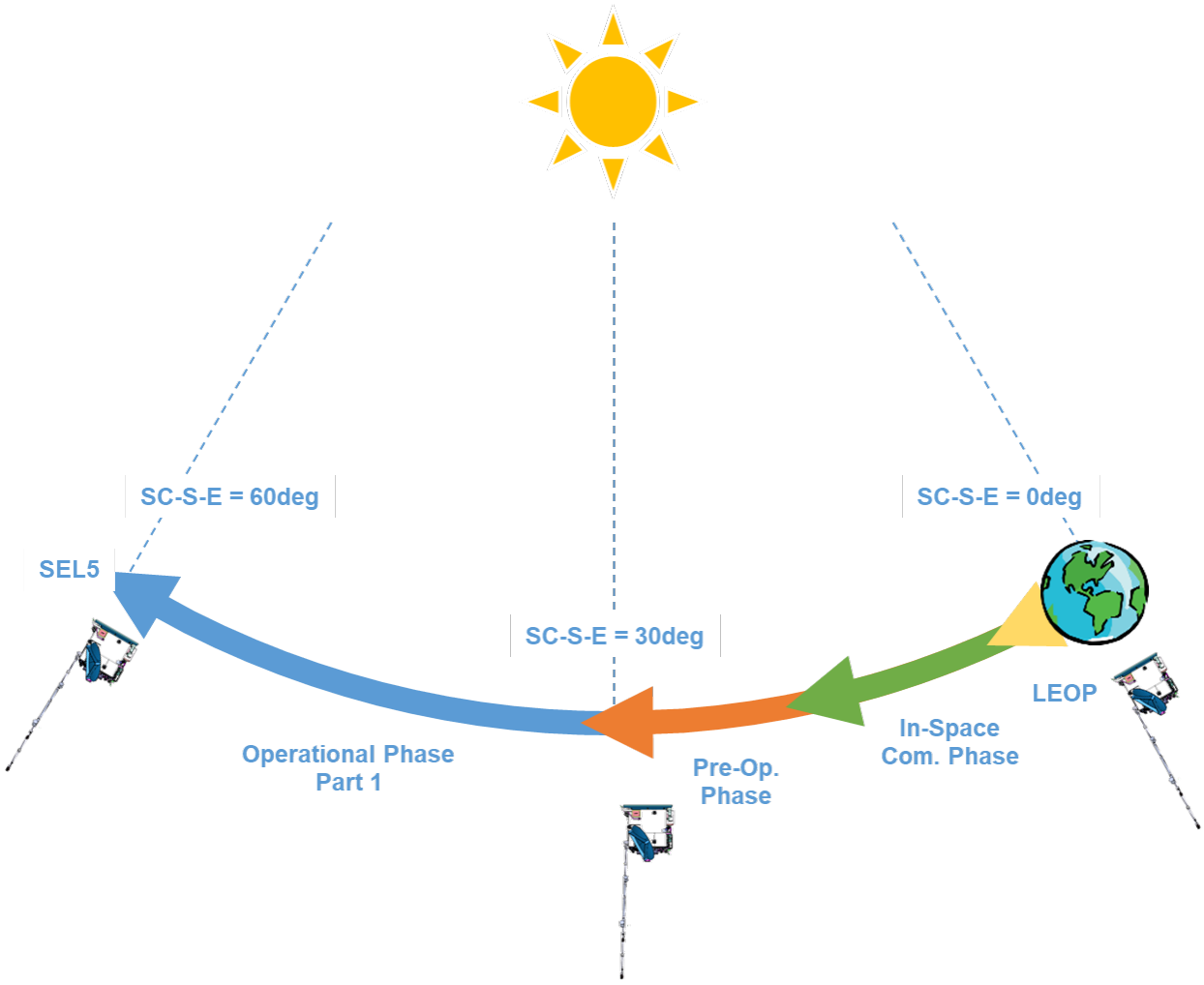

Figure 2: Outline of the mission timeline

The duration of each phase depends on the selected strategy to reach SEL5; currently two approached are considered: via GTO (baseline) by direct injection.

4.4.1. Pre-Launch

The Pre-Launch phase starts from the integration of the spacecraft on the Launcher to the start of power provision from spacecraft internal battery.

The Pre-Launch phase will include, at least:

- final check-out of the spacecraft in the Pre-Launch mode,
- dress rehearsal tests between the spacecraft and the launch site,
- verification of the count-down and Go/No-Go procedures.

The System is expected to interface with the pre-launch facilities for testing activities purpose.

4.4.2. Launch and Early Orbit Phase (LEOP)

The LEOP begins at the start of the launch countdown procedure and is considered completed when a nominal attitude is established and all equipment needed for the first Apogee Raising Manoeuvre (ARM) are available and verified.

LEOP includes at least the following events:

- spacecraft initialization after separation
- acquisition phase by Ground Station(s)
- propulsion venting
- attitude rate reduction and first attitude acquisition,
- deployments (if applicable) and power generation,
- spacecraft configuration for flight
- transition to 3-axis stabilized pointing mode (nominal mission attitude)

LEOP does not include the Apogee Raising Manoeuvres (ARMs).

4.4.3. Transfer Phase

The Transfer phase begins at the first burn for escaping the Earth orbit and ends once the Spacecraft reaches L5 orbit. The Transfer Phase duration and activities vary significantly depending on the launch scenario. However, the maximum transfer time that the System will support is expected to be 1380 days. The spacecraft needs to carry sufficient propellant to achieve the transfer duration and manoeuvres inaccuracies. The spacecraft can experience some eclipses during manoeuvres and transfer.

4.4.4. Apogee Raising Sequence

After completion of the LEOP, the ARS - Apogee Raising Sequence is performed which consists of a number of Apogee Raising Manoeuvres (ARMs) to progressively raise the apogee with the final manoeuvre to escape from Earth orbit.

The Apogee Raising Sequence (ARS) is expected to have a maximum duration of 14 days without margin for contingency. The ARS duration includes some flexibility for trajectory optimization and lunar perturbation avoidance. Manoeuvres can take place in eclipse.

4.4.5. In-Space Commissioning Phase (ISCP)

The In-Space Commissioning Phase (ISCP) can be split in two sub-phases: spacecraft commissioning and instruments calibration.

The spacecraft commissioning includes the activation of the (remaining) Spacecraft units not activated during LEOP. Key activities during this phase are:

- Platform functional verification (Power system, Thermal system, Data Handling system, ADCS);

- Platform end-to-end verification within flight environment (TT&C links);
- Payload and Data handling functional verification;
- Mission Operations Segment and Ground Segment command and data chain verification (spacecraft commandability, TT&C and Data download passes scheduling and execution, data acquisition and L0 generation, links budget verification).

The phase is completed when:

- The spacecraft and instrument subsystems are functionally verified and stabilized.
- The payload is ready to start its Calibration and validation phase.
- The Ground Segment is ready to support spacecraft Cal/Val operations.

The objectives of the instrument calibration and validation activities are:

- calibrate all instruments;
- tune all L1 processing parameters;
- verify all L1 processing functions;
- verification and preliminary validation of all L1 products;
- provide a preliminary quality assessment of all other L2 products, including synergy products.

4.4.6. Pre-Operational Phase (Pre-OP)

Between the end of the In-Space Orbit Commissioning and the start of the Operational Phase, all instruments of the Payload suite can be put into function for collecting data in advance to their nominal use.

This phase is not considered as operational, since it cannot be guaranteed that all mission performances could be met. For instance, with respect to availability, observations would have to be periodically interrupted to allow the data link of the data after re-pointing of the Spacecraft main antenna.

4.4.7. Operational Phase (OP)

The Operational Phase can be divided in two sub-phases:

- Part 1: starting when the Spacecraft has reached a 30 degrees separation from Earth with respect to the Sun (SC-S-E angle ≥ 30deg) until reaching SEL5.
- Part 2: starting from the final injection in the operational orbit around SEL5 (SC-S-E angle = 60deg) until the end of the mission.

During both parts of the Operational Phase the Spacecraft and the Payload Suite shall operate at their nominal performance.

4.4.8. Disposal Phase

At the end of the mission, the Spacecraft should release the SEL5 orbit by performing a disposal manoeuvre such that the resulting orbital evolution does also not lead to interference

with known operational satellites orbiting around the Earth in the foreseeable future as recommended by [ECSS-U-AS-10C rev 1].

Before End of Life the Spacecraft should be passivated to reduce the chance of an accidental explosion that could generate space debris.

5. DESIGN REQUIREMENTS

5.1. General Requirements

VGL-NIO-0010

The instruments' performances specified in the respective sections shall be met under the following assumptions, unless otherwise specified:

a) after in-space commissioning and calibration;
b) end of the nominal operational lifetime conditions;
c) with a confidence level of 95%;
d) during a 1-in-100-years Space Weather Event.

VGL-NIO-0020

The instrument team shall use in all drawings, specifications and engineering data in the International System of Unit (SI), extended to the officially accepted Non-SI units.

Note 1: See Non-SI units mentioned in the SI - Wikipedia

VGL-NIO-0030

The instrument shall be design taking into account the orbital parameters as in Table 1 and Table 2.

Note: the instrument shall be operational once the spacecraft reaches 30 deg separation angle.

Table 1: Mission parameters during transfer

Orbital Parameter		Variation during transfer: 30 degrees Earth separation to L5 (3 revolution baseline)
Earth Range	Minimum (at 30 deg. separation)	75 Mkm
	Maximum	154 Mkm
Sun Range	Minimum	148 Mkm
	Maximum	162 Mkm
Declination relative to the ecliptic		±0.5 degrees
Z_{SC} axis rotation (yaw)		±0.9 degrees

Table 2: Mission parameters at L5

Orbital Parameter		Variation in orbit around L5
Earth Range	Minimum	146 Mkm
	Maximum	154 Mkm
Sun Range	Minimum	146 Mkm
	Maximum	154 Mkm
Sun-SC-Earth angle		60 ± 0.3 degrees
Earth-Sun-EC angle		60 ± 0.5 degrees
Declination relative to the ecliptic		± 0.5 degrees
Z_{SC} axis rotation (yaw)		± 0.3 degrees

VGL-NIO-0040

The instrument shall meet the performance requirements throughout the mission lifetime of 7.5 years in space.

Note: this requirement includes the commissioning, calibration and routine operations

VGL-NIO-0050

In case a space weather event is known to take place, the instruments shall support postponement of planned maintenance for a period of up to 7 days.

Note: calibration is considered as planned maintenance.

6. ASSEMBLY, INTEGRATION AND TEST

6.1. Instrument Testing

VGL-NIO-0060

The instrument shall be designed to include protective measures like purging or covers that can be installed at any time along AIT phases at instrument and spacecraft level.

VGL-NIO-0070

Verification procedures that ensure repeatability and reproducibility shall be used at all levels of integration.

VGL-NIO-0080

All nominal, redundant and cross strapped functions in an instrument, shall be demonstrated as part of the Full Functional Test (FFT).

6.2. Ground Support Equipment Requirements

VGL-NIO-0090

Instrument GSE shall be compliant with safety requirements.

VGL-NIO-0100

Instrument GSE and the associated handling procedures shall ensure that no flight hardware is submitted to environments exceeding the flight acceptance levels.

VGL-NIO-0110

The instrument EGSE shall provide the needed real time, data storage and post-processing performance in order to support the testing of all the operational modes.

7. VERIFICATION REQUIREMENTS

This chapter addresses the following aspects of the instrument verification: definitions, concept, analyses, acceptance and qualification test programmes, models and test philosophy, responsibilities.

7.1. Documentation

VGL-NIO-0120

The instrument team shall provide an AIV/AIT Plan presenting and justifying the overall verification approach and model philosophy selected to demonstrate the instrument performance and compatibility with Vigil mission. Before implementation, the approach shall be approved by ESA.

VGL-NIO-0130

The instrument team shall provide for each test defined in the instrument Assembly, Integration and Test Plan, a test specification describing, as a minimum, the relevant test configuration, test setup, test levels & tolerances, test facility, test goals, success criteria.

VGL-NIO-0140

The instrument team shall provide a step-by-step procedure for each test defined in the instrument Assembly, Integration and Test Plan.

VGL-NIO-0150

The instrument team shall provide a test report containing the objectives, a description of test setup, a result summary vis a vis test predictions and the as-run procedure for each test defined in the instrument Assembly, Integration and Test Plan. Finally, this report shall also express the instrument team's view on the level of success of the test and the way forward.

7.2. Verification Approach

The main instrument verification objectives are as follows:

- to qualify the design
- to ensure that the instrument is free from workmanship defects and acceptable for use in its spacecraft environment
- to verify that the instrument is able to fulfil mission requirements (under NASA responsibility).

VGL-NIO-0160

The instrument team shall seek agreement with ESA before the start of any instrument level test campaign.

VGL-NIO-0170

The instrument team shall apply one or more of the verification methods defined below to meet the above instrument verification objectives.

Note: verification by test is the preferred method.

7.3. Testing

7.3.1. General Test Approach

VGL-NIO-0180

The instrument team shall define a model philosophy for the instrument to be agreed by the VIGIL Project.

VGL-NIO-0190

The instrument team shall ensure that the instrument Flight Model is exposed to acceptance-level tests only, unless the instrument team selects a PFM model philosophy approach. In that case the PFM model shall be subject to tests at qualification levels but with flight acceptance duration.

7.3.2. Test Sequences and Programmes

VGL-NIO-0200

The instrument team shall specify the instrument functional testing to ensure that nominal performance or stress conditions are covered. No specific environmental test sequence is required, but the test programme should be arranged in a way to best disclose problems and failures associated with the characteristics of the hardware and the mission objectives. It is recommended that the vibration/acoustic test precede the thermal vacuum test unless there is an overriding reason to reverse that sequence.

VGL-NIO-0210

The instrument team shall incorporate the following tests as part of the acceptance programme. The actual tests shall be agreed on a case by case basis between ESA and the instrument team.

- instrument performance (optical, magnetic, alignment, etc.)
- Visual Inspection
- Dimensions Verification
- Physical Properties
- Electrical characterisation (in-rush, power consumption, discrete signals)
- Functional Test
- Sine Vibration test
- Random Vibration test
- Shock test
- Acoustic Noise test

- Thermal Vacuum/ Thermal Balance test
- Bonding test
- Isolation test
- Grounding test and conductivity test of space exposed surfaces
- EMC Conducted Emission / Susceptibility test(*)
- EMC Radiated Emission / Susceptibility test
- Magnetic Cleanliness test (DC + AC)
- Purging Rate Verification test

(*) = Susceptibility test may be omitted if conductive emission test is conform to EQM test. To be agreed with ESA.

VGL-NIO-0220

The instrument team shall ensure that modified / repaired / refurbished units (e.g. disassembled from the S/C after the system environmental testing and refurbished / repaired and then supposed to be re-integrated) undergo a set of test to verify the integrity and quality of the modified repaired / refurbished units.

Note: as a guideline the following tests to be agreed by ESA and the instrument team are recommended:

- *Electrical characterisation (in-rush, power consumption, discrete signals)*
- *Functional Test*
- *Random Vibration – 1 axis*
- *Thermal Vacuum (2 cycles)*
- *Grounding / Bonding / Isolation*
- *EMC Conducted Emission / Susceptibility (*)*
- *Magnetic Cleanliness test (DC + AC)*
- *Visual Inspection*

(*) = Susceptibility test may be omitted if conductive emission test is conform to EQM test, To be agreed with ESA.

7.4. Test Requirements at instrument level

7.4.1. Full Performance Test

VGL-NIO-0230

The instrument team shall include all tests performed during the instrument-level FM AIV-program, in the Assembly, Integration and Verification Plan.

VGL-NIO-0240

The instrument team shall define and perform an instrument Full Functional and Performance Test (FFPT), demonstrating that the hardware and software meet their performance requirements within allowed tolerances.

Note: The instrument team is in charge of structuring or decomposing this test as adequate for the instrument.

VGL-NIO-0250

The instrument team shall demonstrate and document that the FFPT, is carried out in the representative environmental conditions and fulfil at least the following:

- FFPT be completed within a working day.
- Verification of the proper operations of all nominal and redundant circuitry.
- instrument performances are meeting the instrument performance requirements in all operational modes.
- When provided with appropriate stimuli, instrument performances are according
- to expectations and outputs are within allowed limits.

7.4.2. Reduced Functional Tests

VGL-NIO-0260

The instrument team shall establish a Reduced Functional Test (RFT)

VGL-NIO-0270

The instrument team shall ensure that, as a minimum, the RFTs:

- focus on verification of instrument overall integrity and functionality
- be completed within, one hour.

Note: RFT are normally a subset of the FFT and can be designed for the instrument-level AIV-flow as quick as necessary and sufficient diagnostic tool after any major testing activity. RFT should test both the nominal and redundant branches. The RFT may also be used in cases where FFT is unwarranted or impracticable.

7.5. Instrument verification with the Spacecraft interface simulator

VGL-NIO-0280

The instrument team shall perform the verification of the EFM and PFM instruments with the Spacecraft Interface Simulator prior the delivery as follows (and it is a pre-requisite to the delivery):

- switch on and off
- FFT, RFT (in ad-hoc basis after agreement with ESA-ADS)
- Verification of the PUS services according to the test Plan.
- MIB database verification

7.6. Hardware Inspections

VGL-NIO-0290

The instrument team shall ensure that the HW inspection, performed at the beginning and end of acceptance and qualification testing include as a minimum:

- Completeness of hardware

- Identification of hardware
- Connectors
- Grounding Points
- Attachment Surfaces
- Thermal Surfaces (any visible changes)
- Inspection of transport conditions
- Inspection for damage
- Inspection of Interfaces
- Visual inspection for contamination assessment
- Completeness of documentation

VGL-NIO-0300

The instrument team shall measure the mass, the CoG and the Momentum of Inertia of each unit.

7.7. Final Acceptance

The acceptance process will demonstrate that the instrument has been fully verified in terms of:

- scientific performances (including calibration and characterization)
- behaviour versus environmental conditions (including EMC)
- all functional interfaces
- all interfaces between the Instrument and the platform

The ESA VIGIL Project will provide specific guidelines and procedures detailing the objectives, the responsibilities, the process, the procedures, the deliverables related to the instrument final acceptance.

NOTE: NASA is responsible to assure the performance of the instrument

7.8. System Level AIT

7.8.1. Model Philosophy

The presently foreseen spacecraft model philosophy consisting of:

- S/C EM: Spacecraft Electrical Functional Model
- S/C PFM: Proto Flight Model.

7.8.2. Instrument Model and Test Philosophy

VGL-NIO-0310

The instrument team shall follow the following model philosophy:

- EM: Engineering Model,
- STM: Structural Thermal Model
- QM: Qualification Model (not needed if PFM approach is considered)

- (P)FM: (Proto) Flight Model.

Note: The Qualification Model can be used as temporary substitution of other deliverable models.

VGL-NIO-0320

The instrument team shall propose, justify and seek agreement with the ESA Vigil Project the instrument model philosophy and the associated qualification and acceptance programme.

VGL-NIO-0330

The instrument team shall ensure that the instrument EM units have the following minimum build standard:

- electronics flight standard except for parts quality,
- non flight standard parts have to be of same technology, same manufacturer as FM parts,
- mechanisms flight representative for electrical actuators,
- structure flight representative for mounting and shape,
- electrically and functionally representative as needed for conducted EMC tests susceptibility + ESD (TBC),
- software flight standard as needed for all command/ control/ data interactions with the spacecraft,
- flight representative harness
- delivered with flight-compatible connector savers
- it shall include handles for units heavier than 10kg and hoisting interfaces for units above 20kg.The EM is a deliverable for testing on the spacecraft EM.

Note: in order to save cost, the EM hardware contents may be reduced by reducing redundancy.

VGL-NIO-0340

The Structural-Thermal Model shall be fully representative of the end product for the following aspects:
- dimensions and shape
- alignment cubes with flight representative mounting & locations (if applicable)
- mass, CoG, MoI and eigenfrequencies for modes below 140Hz
- mounting interface with the S/C
- MLI blankets studs and grounding points
- thermal inertia, dissipation, thermo-optical surface properties, radiative & conductive coupling with the S/C
- thermal hardware (heaters thermistors, straps, cold fingers, radiators,…)
- it shall include handles for units heavier than 10kg and hoisting interfaces for units above 20kg
- the STM shall be designed to sustain the mechanical and thermal qualification environments
- the STM shall be designed so that it can be used, as is or after refurbishment, as flight dummy instead of the instrument flight model.

Note: The STM is a deliverable for testing on the S/C STM.

The following three requirements are applicable to the verification of the STM:

VGL-NIO-0350

The instrument shall demonstrate by review of design, analysis, test or a combination of all these methods, the representativeness of the STM with respect to dimensions, shape, alignment cubes, mass, CoG, natural frequencies below 140Hz (if any), mounting interface with the spacecraft, thermal inertia, dissipation, thermo-optical surface properties, radiative & conductive coupling with the S/C and thermal hardware.

VGL-NIO-0360

The instrument shall demonstrate that the STM is designed to sustain the mechanical and thermal qualification environments applicable to the flight unit, and it is safe to be used for environmental testing on the spacecraft.

VGL-NIO-0370

In some cases, and depending on the complexity of the STM design, ESA can request a verification of the workmanship by test. For this purpose the Instrument Team shall deliver for IPDR a detailed description of the STM design and intended verification. This will be used by ESA to determine in agreement with the prime contractor if a workmanship verification by test is deemed mandatory.

VGL-NIO-0380

The instrument team shall ensure that the instrument QM units have a full flight design and flight standard.

VGL-NIO-0390

If a FM philosophy is applied, the instrument team shall build at least a Qualification Model (QM) fully representative of the instrument Flight Model.
The QM shall be used by the instrument team for instrument development and qualification.

Note: QM is not a deliverable item

VGL-NIO-0400

The instrument team shall propose a spares philosophy (parts and boards for all units), to be agreed with the Vigil Project.

Note: a repair time not longer than 60 calendar days from the occurrence of the failure shall be assured.

8. PRODUCT ASSURANCE

The requirements in [VGL-AD-06] apply.

9. MANAGEMENT REQUIREMENTS

This chapter defines the agreements and requirements between ESA and the instrument team related to project management, organizations, programmatic and deliverable aspects.

9.1. Organization and Responsibilities

The management of the VIGIL mission will be under the responsibility of the ESA Vigil Project Manager located at ESTEC, Noordwijk, The Netherlands. The ESA Vigil Project Manager will have full responsibility for all aspects of the development, launch and initial operations of the mission. The ESA Vigil Project Manager will be directly supported in the execution of the programme by the engineering, administrative and project control staff of the ESA Vigil Project located at ESTEC.
The Vigil instruments are managed by the Vigil Payload Manager and their team of engineers under the overall responsibility of the ESA Vigil Project Manager.
The Vigil Payload Manager and their team of engineers will deal with the day to day instrument activities and follow up on a regular basis the progress to ensure that they meet the Vigil programme objectives. The Payload Manager and their team of engineers will have in particular the following responsibilities:

- Support the instrument team in solving technical and programmatic issues.
- Accommodation of the payload into the spacecraft in line with the technical and programmatic requirements.
- Assess and disposition engineering change requests (ECRs).
- Oversee acceptance tests of the instrument deliverable items as part of the delivery procedure to the Industrial consortium.
- Supervise and coordinate with the instrument team the support and inputs required for the spacecraft system test activities, the launch campaign and the operations in flight.
- Coordinate with the instrument team and the industrial Prime Contractor all deliverables needed by either the instrument team or the Prime Contractor in relation to the accommodation of the instruments in the spacecraft.

The ESA Vigil Project will fulfil its function until the completion of the spacecraft in-flight commissioning phase.
An ESA Vigil Mission Operations Manager will be responsible for the conduct of the mission operations from the end of the commissioning phase until the end of the mission.

9.2. Instrument Management Requirements

VGL-NIO-0410

The instrument Manager shall ensure that the complete instrument is developed and implemented within the mission and schedule constraints of the approved Vigil Programme.

VGL-NIO-0420

The instrument Manager shall be responsible for the overall instrument management and for his/her team organisation.

VGL-NIO-0430

The instrument team shall be fully responsible for the instrument programme and delivery of instrument models to ESA.

VGL-NIO-0440

The instrument team shall include, as a minimum, personnel responsible for the following tasks:

- Project Management
- Project Control
- Schedule Control
- Documentation and Configuration Control
- System Engineering
- Assembly Integration Test and Verification
- Product Assurance
- Export control

VGL-NIO-0450

The instrument team shall provide the necessary training, if necessary, for the correct use of his/ her deliverable HW, SW and GSE to ESA and to the Prime Contractor relevant staff.

VGL-NIO-0460

The instrument team during the relevant instrument system level activities, shall be integrated with the ESA Vigil Project team and work under its technical management.

VGL-NIO-0470

The instrument team shall make available the necessary resources to support the technical Working Groups, chaired by ESA/Spacecraft industrial Prime.

VGL-NIO-0480

The instrument team shall ensure compliance with all export control / ITAR / EAR regulations in a timely manner and keep ESA and the Industrial Prime Contractor duly informed at any time.

VGL-NIO-0490

The instrument team shall request and maintain all agreements and licenses required falling under the Export Control laws and regulations. As necessary, they shall manage updates and amendments to the export licences, so they are complete at the time of Instrument Delivery Review Board (I-DRB) for the items / units / equipment to which export control applies and/or at the time of delivery of the components to the recipient.

VGL-NIO-0500

The instrument team shall ensure that approved export licences are updated to reflect all foreign consignees and launch authorities in the Vigil industrial team.

VGL-NIO-0510

The instrument team shall ensure that the approved licences and amendments:

- as a minimum, allow transfer of the components to the recipient
- at a minimum be valid up to two years after the nominal launch late.

VGL-NIO-0520

For items governed by the International Traffic in Arms Regulations (ITAR) as well as the Arms Export Control Act, the instrument team shall maintain accurate records and shall be able to provide those records on demand for a period of five years from the date of export or license expiration

VGL-NIO-0530

The instrument team shall maintain:

- a database of all export control licences
- export license files
- records related to exemptions and their use

VGL-NIO-0540

The instrument team shall report to the ESA Vigil Project any surveillance requirements arising from ITAR / EAR regulations.

VGL-NIO-0550

The instrument team shall bear any costs associated with such surveillance requirements.

VGL-NIO-0560

The instrument team shall produce, implement and maintain under configuration control a Management Plan covering the proposed investigation for the entire duration of the mission and shall include as a minimum the following:

- the contribution of each institution and the responsibilities of each participant including HW & SW deliverables and related dates
- a complete instrument team directory and organigrams containing the names of all Partners and their roles and responsibilities
- the qualifications and experience of the instrument team members
- a Product Tree (PT) to identify and break down the instrument into its components, both hardware software and GSE and identify the related responsibilities
- a Work Breakdown Structure (WBS), based on the PT, with its Work Packages which shall define and describe the scope of the work including the instrument development models and support functions necessary to produce all the HW, SW, GSE, documentation and the operations activities
- a Risk Management Plan

VGL-NIO-0570

The instrument team shall develop, as part of the Management Plan, a Risk register. For each identified major risk, the following information are expected to be specified:

- The name of the custodian for control of the risk
- An explanatory description
- Reasons for its criticality
- Importance of their consequences (classification and severity)
- Magnitudes of consequences (e.g. schedule and/or cost impacts)
- Probability of their occurrence
- The preferred solution, with reasons and possible secondary risks
- Alternative solutions and contingencies
- Current status
- The Top 10 risks status shall be updated and reported as part of the Progress Report

VGL-NIO-0580

The instrument team shall provide the inputs for the definition and implementation of the operations planning, and data handling and archiving concepts.

VGL-NIO-0590

The instrument team shall support the definition of the instrument interfaces to the spacecraft in coordination with the ESA Vigil Project and the Industrial Prime contractor.

VGL-NIO-0600

The instrument team shall participate in the technical working groups and the control boards as requested by the ESA Vigil Project.

9.3. Project Phasing, Planning and Schedule Requirements

For the implementation phase, the main spacecraft milestones and key events are as follows:

Event	Date*	Planning
S/S (Preliminary) Authorisation To Proceed	May-23	T0
S/S System Requirements Review (S-SRR)*	Jul-23	T0 + 2 calendar months
S/S Preliminary Design Rev. (S-PDR)*	Jan-25	T0 + 20 calendar months
S/S Critical Design Rev. (S-CDR)*	Jul-26	T0 + 38 calendar months
S/S Qualification and Acceptance Rev. (S-QAR)*	Apr-29	T0 + 70 calendar months
Launch	Nov-29	L=T0 + 76 calendar months
In-Space Commissioning Rev. (ISCR)	Jun-30	L + 8 calendar months

** The dates assume a start of the activities in May 2023 and will have to be revised after the contract Space Segment signature.*

VGL-NIO-0610

The instrument team shall establish and maintain under configuration control an instrument Schedule in Microsoft Project format covering in detail all the instrument programme activities identified in the Work Breakdown Structure.

VGL-NIO-0620

The instrument team shall include in the instrument Schedule as a minimum the following programme activity:

- HW, SW and GSE delivery dates
- Design, development, integration, testing and calibration of each instrument model, and, where applicable, also of breadboards and/or of development models / subsystems
- Qualification activities
- Long lead items procurement
- all export control / ITAR/ EAR related approval aspects
- Activities on the critical path
- Main instrument milestones (including, for example TRRs, PTRs)
- Main instrument reviews
- Main spacecraft milestones
- System schedule Margin

VGL-NIO-0630

The instrument team shall identify for each activity / task included in the instrument schedule their interdependencies, durations, constraints, slack.

VGL-NIO-0640

The instrument team shall notify the ESA Vigil Project of any change to the instrument Baseline Master Schedule that affect agreed instrument milestones within 5 working days

VGL-NIO-0650

The instrument team shall seek approval with the ESA Vigil Project about (changes to) the instrument Baseline Master Schedule to ensure that it is in line with the spacecraft schedule.

VGL-NIO-0660

The instrument team shall identify additional milestones as required and shall agree them with the ESA Vigil Project

9.4. Progress Control and Reporting Requirements

VGL-NIO-0670

The instrument team shall submit 5 working days after the end of the month an instrument Monthly Progress Report (as defined in VGL-LI-ESA-INS-0017).

VGL-NIO-0680

The instrument team shall provide to the ESA Vigil Project a monthly schedule report as part of the Monthly Progress Report.

9.5. Document Deliverables for definition Phase

VGL-NIO-0690

The instrument team shall deliver the documents as per [VGL-LI-ESA-INS-0017]

9.6. Meetings, Teleconferences and Reviews Requirements

VGL-NIO-0700

The instrument team shall organize progress Technical Interface Meeting (TIM) & Progress Meetings (PM), at least every 4 weeks among the relevant members of the ESA Vigil Project, the instrument team and the Prime Contractor Team(s).

Note1: These meetings can also be done through videoconferencing when agreed with the ESA Vigil Project.

Note2: The main objective of these meeting will be to ensure that the interfaces, the design integrity of the instrument and its elements, its compatibility with the spacecraft system and resources and the instrument programmatic are proceeding in a manner which does not jeopardize the overall programme. Detailed technical problems occurring on either side of the interface will be flagged during these TIM meetings and corrective actions, including their schedule impact, will be agreed and implemented.

VGL-NIO-0710

The instrument team shall call for and organise, if considered necessary, ad-hoc meetings or telecons to address specific critical / urgent subjects among the relevant members of the ESA Vigil Project, the instrument team and the Prime Contractor Team.

VGL-NIO-0720

The instrument team shall support with relevant members of his/her team ad-hoc meetings / telecons to address specific critical / urgent when requested by the ESA Vigil Project or the Prime.

VGL-NIO-0730

The instrument team shall take the minutes of the progress meetings, of the monthly telecons and of the ad-hoc meetings / telecons.

Note: minutes of the meetings will be finalised and agreed by the end of meetings / telecons.

VGL-NIO-0740

The instrument team shall agree with the ESA Vigil Project and make available the necessary level of resources to support the reviews at instrument, ground segment and mission level on a case by case basis.

The following is an indicative list of presently foreseen reviews at instrument, ground segment and mission level:

a. **instrument Level**
   i. instrument Requirements Review, IRR
   ii. instrument Preliminary Design Review, IPDR
   iii. instrument Critical Design Review, ICDR
   iv. instrument Qualification Review, IQR
   v. instrument FM Delivery Review Board, IDRB
   vi. Other Reviews as required (e.g. Test Readiness Reviews (TRR), Post-Test Review (PTR), etc)

Note 1 : The IDRB is a hardware related review and will be conducted prior to the delivery of the FM to the Prime in view of the system FM test campaign. The objectives of the review is:

- *Assess the instrument FM programme*
- *Accept the models of the spacecraft system level AIV*
- *Freeze the on-board software ensuring that the updates to the S/W required after previous system level tests are completed and successfully integrated in the FM.*

The sole basis for the assessment is the End Item Data Package. This review will issue the "consent to ship" but shall not be regarded as final acceptance for flight.

b. Ground Segment Level
   i. Ground Segment Requirements Review
   ii. Ground Segment Design Review
   iii. Ground Segment Implementation Review
   iv. Ground Segment Readiness Review
   v. Operations readiness review

c. Spacecraft Level

- Preliminary Requirements Review, SRR
- Preliminary Design Review, PDR
- Critical Design Review, CDR
- Qualification Review, QR
- Flight Acceptance Review, FAR
- In-Orbit Commissioning Review, IOCR
- Other Reviews as required

The instrument reviews will take place according to the following planning, with all instrument reviews kicked-off by the specified dates:

- April 2025 instrument Preliminary Design Review (IPDR) (TBC)
- April 2026 instrument Critical Design Review (ICDR) (TBC)
- December 2027 instrument FM Delivery Review Board (I-DRB)

The ESA Vigil Project will organise and conduct the instrument Level reviews. ESA will define the objectives, the success criteria, the content of the acceptance data package, the organisation, the review process and the schedule of the instrument level review in specific procedures, which will be distributed to the relevant parties at least 2 months before the relevant review kick-off

The following presents the typical objective of the ESA Reviews.

Preliminary Design Review
The main objectives are:

1. Confirm the compliance of the baseline design of the instruments, its predicted performance and compatibility with the overall mission requirements
2. Verify the compliance of interface with the spacecraft;
3. Verify that the operational concept is defined and is compliant with the S/C and mission phases requirements (i.e. commissioning, interplanetary cruise and nominal science mission phases).
4. Confirm the suitability of the breadboard and /or development test results available to date (TRL status, BB etc…) in support of the baseline definition;
5. Confirm the suitability of the proposed model philosophy as well as the instrument integration and verification/calibration approach including the facilities and the relevant GSE's (at instrument and S/C level);
6. Confirm the suitability of the instrument schedule and verify the credibility of milestones and delivery dates to the Spacecraft;
7. Confirm that the PA&S programme of work is compliant with the applicable requirements;
8. Verify the completeness of the risk management plan, that all technical and programmatic risks have been identified, and that adequate mitigation actions are in place

Critical Design Review
The main objectives are:

1. Confirm compliance of the detailed design of the instrument and its predicted performance with the overall mission requirements;
2. Verify the compliance of interface with the spacecraft,
3. Verify the completeness of the preliminary Operations, User Manual and Data-Bases with the system, MOC/SOC and mission phases requirements (i.e. commissioning, interplanetary cruise and nominal science mission phases)
4. Review the available unit test results (e.g. breadboard, development model, engineering model or other engineering activities) in support of the detailed design baseline;
5. To confirm the completeness and consistency of the instrument procurement schedule with the project needs;
6. To confirm the completeness and suitability of the proposed verification program (including calibration) through review of the AIT/AIV plans, and verification matrix (CTVCD);
7. Confirm suitability and availability of proposed tools, test facilities and equipment's, jigs.
8. Confirm that the PA&S programme of work is compliant with the applicable requirements (XX), including Cleanliness and Contamination Control;

9. Verify the completeness of the risk identification, and the adequacy of the mitigation actions put in place;
10. Confirm the absence of showstoppers against the start of manufacturing of the qualification and (proto)flight instrument models

Delivery Review Board

The main objectives of the Delivery Review Board are the following:

1. Confirm that all deliverable products are available in accordance with the approved deliverable items list and deliverable documents list (e.g. User Manual, test report(s));
2. Confirm that the verification process has demonstrated that the deliverable items are ready for subsequent operational use;
3. Verify the "as built" product and its constituent components against the applicable technical interface requirements, including relevant change proposals and reconciliation of changes;
4. Evaluate the status of the test programme/test flow & test reports:
    a) Evaluate the verification status of requirements, VCD
    b) Qualification/Acceptance test successfully run
    c) verify that the verification record is complete (e.g. logbook) at this and all lower levels in the customer supplier chain;
5. Evaluate inspection results including cleanliness status.
    a) a) Verify witness samples
    b) b) MIP/KIP reports
6. Establish acceptability of residual safety hazards, and availability of the dangerous goods declaration,
7. To confirm that the non-compliances were adequately justified and processed;
8. To check the NCR status and verify that open NCRs can be accepted with no impact on FM activities;
9. Verify that the end Data Package is complete;
10. Verify the acceptability of all waivers and deviations as relevant to the FM;
11. Review all interface and critical items, including constraints that may affect higher level AIT;
12. Evaluate Historical Records, Mate/demate log, Limited Life Item Records, Open Work Records, Temporary Installation Records, Red Flag Items, and other sections of the EIDP for content and completeness.
13. Evaluate Operational constraints, Operating and Maintenance Manuals Review the hardware status and procedure(s) for packaging, handling shipping, and storage (the transportation containers have to be adequate and have the proper monitoring equipment to provide confirmation of proper transportation (shock/humidity);
14. Perform visual inspection of the instrument FM and related GSE;
15. Authorise the shipment

VGL-NIO-0750

The instrument team shall provide, for each instrument Level review a specific set the documents, the Review Data Package, as defined in 0.

VGL-NIO-0760

The instrument team shall provide the relevant review data package 2 weeks before the review kick-off date to be agreed with the ESA Vigil Project.

9.7. Configuration Management Requirements

The objectives of Configuration Management are to establish:

- a configuration identification baseline system which defines through approved specifications, interface documents and associated data the requirements for the instrument,
- a configuration control system which controls all the changes to the identified configuration of the instrument,
- a configuration accounting system which documents all changes to the baseline configurations, maintains an accurate record of configuration change incorporation, and ensures conformity between the end item As Built Configuration (ABCL) and its appropriate design and qualification identification (CIDL including waivers).

VGL-NIO-0770

The instrument team shall establish a configuration control management system which shall ensure that all hardware, software, GSE and documentation are fully and unambiguously identified and their changes traceable at any time throughout the life cycle of the instrument.

VGL-NIO-0780

The instrument team shall ensure that configuration changes to his / her documents are introduced, only after consultation with the ESA Vigil Project, if such change impact on technical interface or programmatic agreement between them.

VGL-NIO-0790

The instrument team shall allow the ESA Vigil Project to conduct a configuration audit, if requested, at any time in the life cycle of the instrument in order to obtain the up-to-date status of the instrument configuration.

VGL-NIO-0800

The instrument team shall establish, for each model delivered to the ESA Vigil Project, an instrument configuration baseline with respect to requirements, design and verification documents.

VGL-NIO-0810

The instrument team shall present the instrument configuration baseline at each instrument Level review, identifying any change introduced since the previous review.
Note: instrument configuration baselines may also be reviewed, if requested by the ESA Vigil Project, other intermediate stages of the instrument life cycle.

VGL-NIO-0820

The instrument team shall explicitly identify in the “Compliance, Traceability and Verification Matrix to the Requirements Baseline” those requirements that he/she does not intend to comply with, if any.

VGL-NIO-0830

The instrument team shall inform the ESA Vigil Project of any change of in his / her instrument configuration baseline impacting science performance, engineering interface requirements, allocated resources, schedule agreed milestones, verification and calibration requirements and plans, within 2 weeks from the change.

VGL-NIO-0840

The instrument team shall identify and document, for each non-flight model delivered to the ESA Vigil Project, the differences, if any, with respect to the (as designed) FM instrument configuration baseline.

VGL-NIO-0850

The instrument team shall propose changes by means of an Engineering Change Request (ECR).

Note: the ECR may be initiated at any time by either the instrument team or ESA in writing.

VGL-NIO-0860

The instrument team (or any raising party) shall complete the ECR with all relevant entries.

Note: the ECR will be addressed to the instrument team, ESA Project Manager, with copy to the relevant payload or instrument managers.

VGL-NIO-0870

The instrument team shall submit for approval to the ESA Vigil Project and justify deviations to the requirements defined in NIO Requirement Document and the applicable documents by means of a Request for Waiver (RFW). And Request for Deviation (RFD)

VGL-NIO-0880

The instrument team shall identify in the RFW/RFD the baseline and specification affected, provide an estimate of the impact on schedule, and logistics.

VGL-NIO-0890

The instrument team shall keep the ECRs and RFDs/RFWs under configuration control.

VGL-NIO-0900

The instrument team (or any other initiating party) shall ensure that following its receipt, the ECR / RFW/ RFD is submitted to the Change Control Board (CCB) of the receiving part which shall process the request and take a decision on the change (ECR / RFW disposition within 4 weeks).
The Change Control Process constitutes of the following:

ECR from instrument team to ESA:

1) Upon receipt of the ECR, ESA will carry out an investigation as to the consequences of the request, and together with an assessment initiate the change to the Prime Contractor, together with status information to the originating instrument team.
2) The Prime Contractor will assess the consequences by a Change Control Board (CCB) and (typically within 1 week) prepare an Engineering Change Proposal (ECP) addressing all aspects of possible implementation including cost and schedule. ESA shall assess the ECP and decide on the disposition of the change (approval / reject) and inform the Originator accordingly.
3) In order to shortcut possible iterations and to ensure an efficient process it is expected that early identification of potential changes and informal exchange is used between the instrument team, ESA and the Prime Contractor to the utmost possible extend.

ECR from Prime/ESA to instrument team:

1) Following receipt/generation of an ECP and initial assessment, ESA shall inform the instrument team about any changes affecting his / her instrument, and similarly the instrument team (respectively the Contractor responsible for instrument procurement) shall return his / her assessment using equivalent bodies (CCB) within 1-2 weeks.
2) Again early exchange of information at working level between the three involved parties (instrument team, ESA and Prime, represented by his / her experiment interface engineers) should be used to anticipate the impact of arising changes.

RFD/RFW

1) Upon receipt of the RFD/RFW, ESA will carry out an investigation as to the consequences of the request. If this impact other parties their assessment will be required.
2) The affected parties will assess the consequences and prepare a report, part of the RFD/RFW assessment file, addressing all aspects of the possible implementation including cost and schedule and give a formal answer through a Change Control Board (CCB). ESA CCB will assess and decide on the disposition of the RFD/RFW and inform the Originator accordingly
3) In order to shortcut possible iterations and to ensure an efficient process it is expected that early identification of potential RFD/RFW and informal exchange is used between the instrument team, ESA and the Prime Contractor to the utmost possible extent

VGL-NIO-0910

The instrument team shall deliver the related DOORS modules as part of the reviews data pack.

9.8. Deliverable Items Requirements

Additionally to the requirements below, the list of expected deliverables is in Appendix 1.

VGL-NIO-0920

The instrument team shall deliver to the ESA Vigil Project and maintain under configuration control as a minimum the documents listed in 0.

VGL-NIO-0930

The instrument team shall deliver, in line with the baselined instrument model philosophy, the following models, by the following deadlines:

- Engineering Model, EM: Date: August 2026 (TBC)
- Structural Thermal Model Date: December 2027
- (Proto) Flight Model, (P)FM: Date: December 2027
- Flight Spares, FS: not applicable, the FS will be delivered to ESA only if needed

The EM units will remain at the Prime Contractor's and/or ESA premises following delivery.

VGL-NIO-0940

All the flight SW items to be installed on the instrument shall be delivered in the following executable formats:

- Executable and Linkable Format (ELF)
- Binary
- Motorola S-Record (SREC)

VGL-NIO-0950

All the flight SW items to be installed on the instrument shall be delivered in source code format, including:

- source code files
- map file
- makefiles
- linker script
- any other scripts needed to build the SW executable.

VGL-NIO-0960

The instrument team shall deliver the instrument SW relevant to the delivered instrument models, including the executable code(s), source, mapping and test files.

VGL-NIO-0970

The instrument team shall provide together with each delivered instrument Model, an End-Item Data Package (EIDP), as defined in documents listed in 0.

Note: the instrument team will propose and agree possible tailoring of the content of the EIDP with the ESA VIGIL Project for the EM instrument models.

VGL-NIO-0980

The instrument team shall be responsible for the packing and shipment of both the various instrument deliverable models and the associated GSE, after their formal acceptance, to the delivery point designated by ESA.

Note: the points of delivery of all items will be determined later in the programme.

VGL-NIO-0990

The instrument team shall be responsible for the shipment back of the instrument models in case of repair.

VGL-NIO-1000

The instrument team shall be responsible for the transportation of all the relevant equipment back to his / her premises at the completion of the launch campaign.

VGL-NIO-1010

The instrument team shall be responsible for any insurance deemed necessary for his / her equipment during shipment or whilst on the premises of the Agency, it's Prime Contractor or on the launch site.

VGL-NIO-1020

The instrument team shall be responsible for the preparation of all Export Control papers (among which EAR, ITAR) necessary for obtaining the licences and for shipment prior to the required shipment date. The Instrument Team is also responsible for returning the ITAR/ EAR ground items to the manufacturer, when applicable.

VGL-NIO-1030

The instrument team shall remain responsible for the repair and maintenance of the instrument hardware, software and GSE after delivery up to the end of mission.

VGL-NIO-1040

The instrument team shall make available the necessary resources to support the verification of updated instrument software at system level.

VGL-NIO-1050

The instrument team shall deliver, together with each instrument model, suitable Mechanical Ground Support Equipment (MGSE) necessary to transport, handle and integrate the instrument on the spacecraft

VGL-NIO-1060

The instrument team shall deliver, together with each instrument model suitable Electrical Ground Support Equipment (EGSE) necessary to stimulate the instrument, to perform quick look analysis and functional test of instrument during system tests at ESA, at the Prime Contractor premises and launch site

Note: interfaces between instrument EGSE connected to spacecraft EGSE will be agreed between the instrument team, ESA and the Prime Contractor.

VGL-NIO-1070

The instrument team shall deliver, together with the MGSE and EGSE, appropriate documentation for its description and correct use, for proof load and for calibration certificates, if applicable.

VGL-NIO-1080

The instrument team shall provide Ground Support Equipment (GSE) with appropriate CE marking.

VGL-NIO-1090

The instrument team shall ensure that the delivered instrument EGSE consists at least of the following items:

- One or more instrument workstations in charge of processing instrument telemetry and to ask for delivery of telecommands.
- One or more equipment to generate electrical stimuli to the experiment (if needed).
- A dedicated Interface Test Equipment to verify the health status of the instrument stand-alone, prior integration to the spacecraft.
- All cabling and ancillary items necessary to properly use and operate the above-mentioned equipment.

Note: the instrument ground support equipment will remain at the spacecraft integration site until launch.

VGL-NIO-1100

The instrument team shall replace or update the HW and/or SW of the EGSE at each instrument model delivery to maintain its compatibility.

VGL-NIO-1110

The instrument team shall be responsible for the maintenance of his/her Ground Support Equipment

VGL-NIO-1120

The instrument team shall deliver, if necessary, any special Ground Support Equipment in support of instrument calibration and verification

9.9. Customer Furnished Items

ADS will deliver the Spacecraft Simulator (SIS) by Date: At least 6 months prior the EM delivery

Appendix 1 Deliverable Item and Service List

This Appendix specifies the deliverable items the Instrument Supplier shall deliver to the Spacecraft Prime within the frame of the Vigil Phase-B2/C/D/E1.

Deliverable documentation is specified in a separate document 0.

Deliverables shall be accompanied by an End Item Data Package (EIDP) reflecting design, development, test and verification, plus a “User and Installation Manual”, in case of H/W and S/W deliverables and where applicable, warranty and maintenance for the final deliveries.

Development models identified in the framework of the development concept either at equipment, instrument or module level, together with all residual flight equipment (e.g. high-rel parts, materials, sub-assemblies, mechanisms, etc.) shall be delivered either to the Agency.

Any software procured or developed shall be delivered to the Agency. All deliverable software shall be fully tested and documented according to the applicable engineering and product assurance requirements. The Instrument supplier shall provide visibility on the development status and testing of software and deliver software packages to the Agency, if requested, during development. If the developed software is embedded in, or relies upon, another software product, then the Instrument Supplier shall offer the Agency the option for a license to use the supporting product, if it is not commonly available. Supporting tools e.g. scripts, test sequences and test results shall be delivered so that the Agency can make meaningful use of the software produced under this contract.

The Instrument Supplier shall maintain a Software Plan in which all the software procured or developed under the contract by him or any subcontractor is listed. All software shall be compatible with the Agency’s standards, unless specifically otherwise agreed by the Agency.

The Instrument Supplier is responsible for the maintenance of all software delivered until the completion of the ISCR – In Space Commissioning Review.

A.1-1 Deliverable Hardware

ID	Item or Service	Delivery Milestone	Location	Description
HW-01	Instrument Proto-Flight Model (PFM)	On-time for the execution of the spacecraft AIT	Stevenage ADS-UK	It is assumed that the instrument follows a PFM approach. However, pending the outcome of the EQSR and the level of re-use, the instrument might be considered as Flight Model (FM). The instrument supplier shall deliver the instrument to the Prime premises, after the successful completion of the verification phase at instrument level. A support for the instrument testing at spacecraft level is expected and will be agreed in the course of the project. Once the spacecraft verification is successfully completed, the instrument can be considered fully accepted.
HW-02	Instrument Engineering Model (EM)	EM DRB: On-time for the execution of FlatSat/EM campaign at spacecraft level	Stevenage ADS-UK	The instrument supplier shall deliver the instrument Model to the Prime premises, after the successful completion of the verification phase at instrument level. A support for the instrument testing at spacecraft level is expected and will be agreed in the course of the project.

ID	Item or Service	Delivery Milestone	Location	Description
HW-03	Instrument Structural Thermal Model (STM)	On-time for the execution of the spacecraft AIT	Stevenage ADS-UK	The instrument supplier shall deliver the instrument Model to the Prime premises, after the successful completion of the verification phase at instrument level. A support for the instrument testing at spacecraft level is expected and will be agreed in the course of the project.
HW-04	Full set of Instrument MLI	Instrument DRB	Stevenage ADS-UK	The instrument supplier shall deliver the full set of MLI to the spacecraft Prime and it will be in charge also of its installation. The spare philosophy for the MLI shall be agreed in the course of the project.
HW-05	Harness	Instrument DRB	Stevenage ADS-UK	The instrument supplier shall deliver the instrument HW comprising the harness interconnecting the different instrument units, when applicable. The harness to the Platform is responsibility of the Spacecraft Prime.
HW-06	Flight Spare Kit	Instrument DRB	ESA/ESTEC	According to the spare philosophy.
HW-07	Full set of Connector Savers & Covers, green and red tags	Instrument DRB	Stevenage ADS-UK	

ID	Item or Service	Delivery Milestone	Location	Description
HW-08	GSE, jigs and tools	Instrument DRB/prior the start of spacecraft AIT	Stevenage ADS-UK	The instrument supplier shall deliver all the elements aimed to support the instrument verification, calibration, data evaluation, SW uploading, storage, transport, lifting and handling at spacecraft level. This applies to all the instrument models foreseen by the development philosophy. Specific elements supporting the launch campaign are included.
HW-09	Cleanliness cover set	Instrument DRB	Stevenage ADS-UK	The instrument supplier shall design, verify and procure any cover sets (hard and soft) which ensure the compliance to the cleanliness requirements.

A.1-2 Deliverable Software

ID	Item or Service	Delivery Milestone	Location	Description
SW-01	Instrument Flight On-Board SW	V0: TBD V1: TBD V3: TBD V4 TBD	Stevenage ADS-UK ESA/ESTEC	The Instrument supplier shall deliver all on-board software. All software and support information shall include as minimum: - Boot-up PROM Image - SGM content - Datapool parameters - RAM and EEPROM/MRAM images in format to be agreed - Operations inputs to spacecraft Data base - Memory map - Complete Source Code and build environment/scripts - Software User Manual and Numerical Requirements Documents - Target Processor Executable Image - Context and Configuration of the SW - Link cross-reference listings (with reference to target environment memory maps) - Compiler options - Run-time library - SRD/SRS, ADD, SUM, HW/SW ICD, TM/TC ICD, System Test Plan and Report - Quality model (metrics). - Version Release notes. In addition to the above items the Instrument supplier shall deliver the set of test cases, procedures and run test results utilized to validated new releases of the on-board software. The software Release Document shall contain the Version number of the released software and spacecraft version information (**????**) (for all contributing elements to the OBSW build), the changes with respect to the previous version (Configuration Control File showing changes down), list of open and closed SPR in the current release, the applicable waivers and deviations to the requirements baseline and applicable standards. The Instrument supplier shall provide additional deliveries of the software upon Agency request whenever this is updated. The software version 3 (V3) shall be fully functional.
SW-02	Instrument EM onboard FPGA code	EM HW delivery	ESA/ESTEC	

ID	Item or Service	Delivery Milestone	Location	Description
SW-03	Instrument PFM onboard FPGA code	PFM HW delivery	ESA/ESTEC	
SW-04	Instrument PFM onboard FPGA code (if Any, after delivery of the flight build)			The number of updates shall be minimised.
SW-05	Inputs for ESOC Spacecraft Simulator	TBD	Stevenage ADS-UK ESA/ESTEC	These are documentation and mathematical model of the equipment that are needed to be modelled in the ESOC simulator. The Contractor shall provide engineering support for clarification necessary to the MOC for building a representative simulation of the spacecraft for operations purposes. The Simulator development might be conducted off-ESA-site by an ESOC frame contractor, and any technical documentation made available to ESA, may be made available to the simulator developer; the software deliveries shall not contain anything that prevents ESA providing the software delivery to the Simulator Development company for their use in developing the Operational Simulator.
SW-06	Instrument Reference Database	V0: Instrument CDR V1: to be agreed with ADS V2: to be agreed with ADS V3: to be agreed with ADS V4: to be agreed with ADS (Flight version)	Stevenage ADS-UK	
SW-07	Instrument Data Sets	As requested	Stevenage ADS-UK	The Instrument supplier shall deliver sets of Instrument Data to support ground segment development. The accuracy/representativity of the data series shall be agreed with ESA and the Prime. The data sets will be derived at specific points during the spacecraft development and testing based on a set of representative nominal and non-nominal mission scenarios, to be agreed with ESA and the Prime.

ID	Item or Service	Delivery Milestone	Location	Description
SW-8	Instrument Traceability and Verification Database (DOORS)	Instrument Reviews	ESA/ESTEC	
SW-9	Level-0/1 Data Sets	Instrument PDR Instrument CDR	Stevenage ADS-UK ESA/ESTEC	Sets of coherent and scientifically meaningful raw/L0/L1 test data sets are required during the development phase for validating the PDC processors.. .

A.1-3 Deliverable Models

ID	Item or Service	Delivery Milestone	Location	Description
MD-01	Instrument Thermal Models	Instrument Reviews As requested	Stevenage ADS-UK	The mathematical models and/or programmes shall be developed and delivered at major reviews and at to-be-agreed milestones. In case of major updates of the models/ programmes (e.g. after model correlation or major design changes) the latest versions of the affected models shall be delivered. A set of reference analysis cases to be used for all formal model deliveries shall be agreed between the Instrument supplier, the Prime and the Agency. The sizing hot and cold cases, as well as a survival case, shall be taken as a minimum when agreeing on the reference analysis cases. Formal deliveries occur at key delivery milestones. Other intermediate deliveries can occur on an ad-hoc basis, for example, between technical experts to aid communication or problem resolution. Thermal analysis tools: The thermal analysis tools to be used by the Instrument supplier shall be agreed between the Instrument supplier and the Prime. Thermal model delivery: for each reference analysis case, the thermal models shall be delivered as a corresponding GMM and TMM pair.
MD-2	Optical Model	Instrument Reviews As requested	Stevenage ADS-UK	The instrument supplier is expected to deliver the model also when needed.

ID	Item or Service	Delivery Milestone	Location	Description
MD-03	Instrument FEM	Instrument Reviews As requested		The contractor shall develop and maintain finite element models of the instrument suitable for the various analyses to be performed: dynamic analyses including sine, vibro-acoustic and micro-vibrations, thermo-elastic analyses for strength and performance assessment, strength analyses for stress and load levels assessment and computation of margins. All different models used for the different type of analyses shall be provided. The mathematical model shall follow the quality criteria as indicated in the relevant ECSS. The model shall be maintained to follow the evolutions in the configuration and mass. It shall also be updated to include all the results from characterization tests (material data, CTE, stiffness) as soon as they are available. The model used for dynamic analyses including sine, vibro-acoustic and micro-vibrations shall allow to represent the dynamic behaviour of the instrument in a frequency range large enough to capture the main responses. This model shall include correlated models as soon as they are available after test campaigns. The model used for thermo-elastic analyses shall be able to compute the distortions and misalignments with the needed accuracy. A special attention shall be paid to the reliable mapping of detailed temperature maps on the mechanical model. The various models shall be consistent with each other and configured and delivered with a dedicated model description document.

ID	Item or Service	Delivery Milestone	Location	Description
MD-04	Instrument CAD	Instrument Reviews As requested		The mathematical models and/or programmes shall be developed and delivered at major reviews and at to-be-agreed milestones. In case of major updates of the models/ programmes (e.g. after model correlation or major design changes) the latest versions of the affected models shall be delivered. The Instrument supplier shall develop and maintain the physical design of the instrument in a CAD [Computer Aided Design] tool based model. The CAD models shall reflect the details in each phase of the design, in support of the necessary analyses in the relevant domains. The CAD models shall be under configuration control to ensure the latest design is available for the different domain analyses. The final CAD models shall reflect the Flight Hardware. The various CAD models shall be consistent with each other and configured and delivered in both Native CAD format and the ISO Standard with a dedicated model description document.

A.1-4 Deliverable Services

ID	Item or Service	Delivery Milestone	Location	Description
SER-01	Support to SVT's and SOVTs preparation and execution.	As needed	ESA/ESOC	
SER-02	Support to Simulations and Rehearsal Campaigns, including campaigns of specific operational phases (pre-launch, count-down, LEOP, IOCR, deployment sequences).	As Needed	Various	
SER-03	Support to the development of the Satellite Simulator.	As Needed	N/A	
SER-04	Support to the Cross-validation Campaign of the Operational Ground Processor by providing test data sets, as well as support in the analysis of discrepancies between GPP and Operational Processor results.	As Needed	N/A	
SER-05	Engineering support to Instrument Commissioning.	As Needed	ESA/ESOC	
SER-06	Support to resolving/fixing In-Flight Anomalies and corresponding Anomaly Review Boards during phase E1.	As Needed	N/A	