VIGIL: ESA Space Weather Mission To L5

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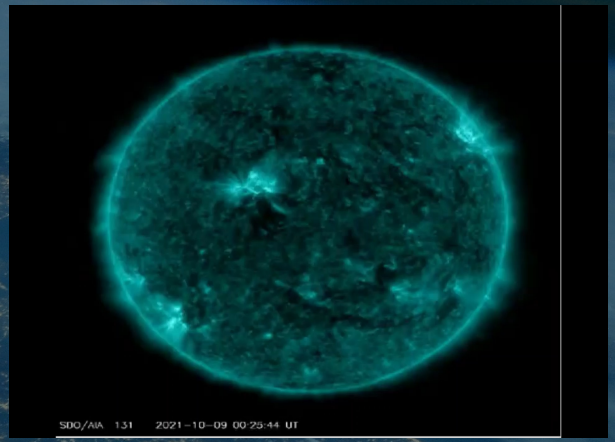
13-07-2023

Mission Objectives

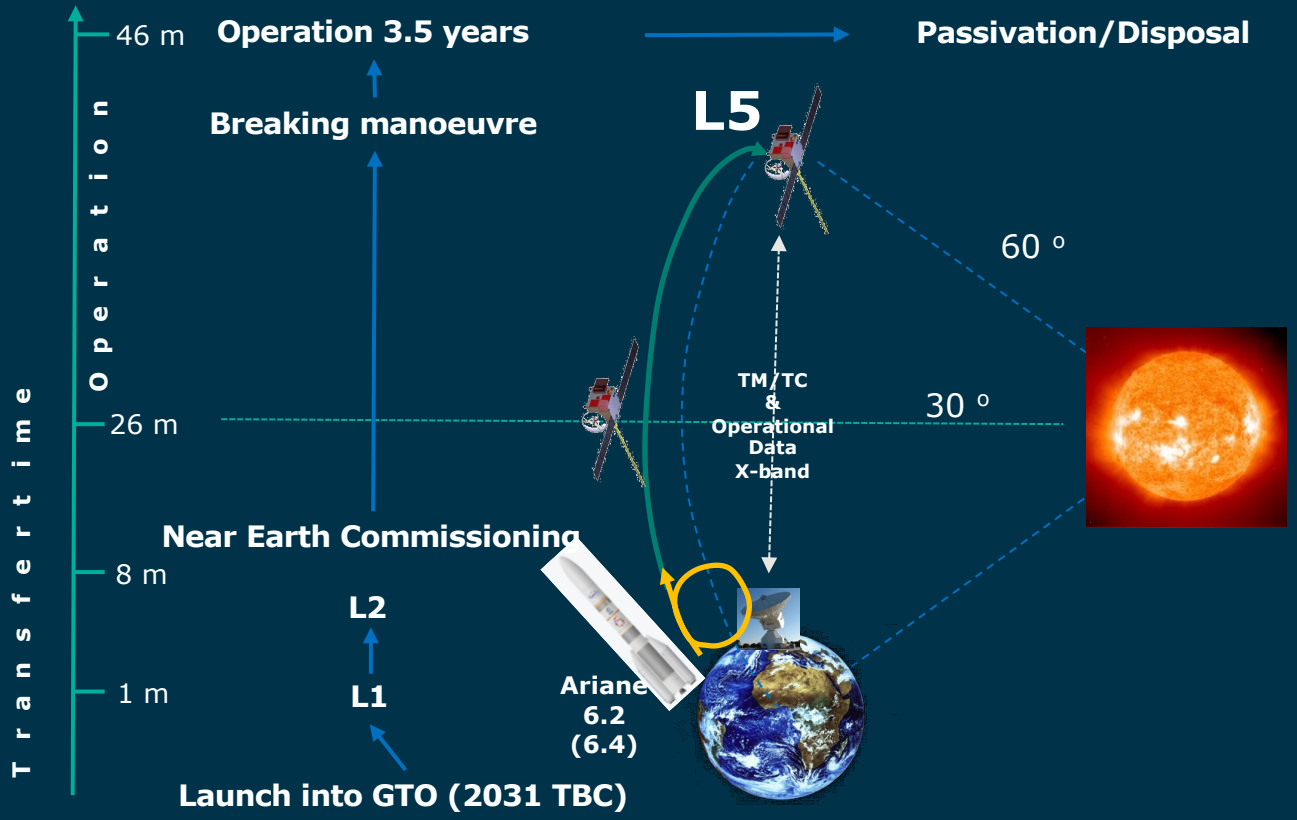
Vigil – An operational mission providing 24/7 Space Weather Now-Casting & Forecasting, utilising experience from previously flown and proven instruments, with innovation in critical areas to gain improved performance=> improved science/modelling

A system which;

- Is able to operate nominally during severe SWE events
  - With high system **reliability & availability**
- Provides **low latency** data to users enabling;
  - Event-based warnings and alerts
  - “Now-Casting” Providing at least 12 hrs warning of fast moving, earth bound CME’s
  - “Forecasting” - tracking, and in the longer-term prediction, of Solar activity onset

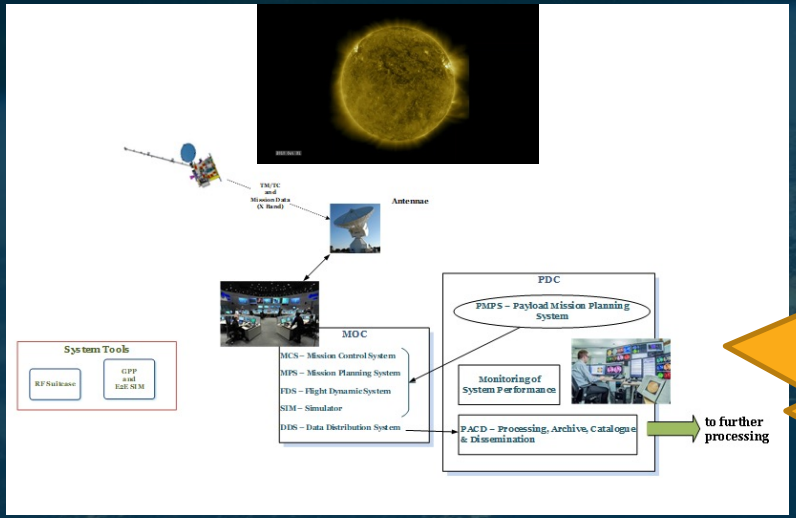


Mission architecture



- 3-revolutions transfer considered as baseline (2-revolutions option)
- 8/7 operation after Near Earth Commissioning
- 24/7 operation using ESTRACK after 30 degree trailing point is passed
- If transfer takes 45 months nominal operation will only be 3.5 to 4 years
- Disposal not mandatory but considered w/o extra margin

Ground Segment



PDC processes data to L1.

- Further processing in many Space Weather Centres around Europe and the world (UK Met Office, NOAA SWPC etc.)

Data Priority Concept

- Each core instrument has two distinct data streams – Priority-1 and Priority-2;
- Priority-1 = Data utilized to provide the service. Subject to full latency and availability requirements
- Priority-2 = ‘Spare’ data bandwidth that can be used for higher cadence science data.

Vigil Platform and Support Developments

- Largely based on standard Airbus platform avionics used in LEO/GEO missions however, design adaptations needed for deep space missions/robustness against severe space weather events. Standard platform equipments and elements include;
  - On-Board Computer (OBC)
  - On-board Software (OBSW)
  - Remote Interface Unit (RIU)
  - Star Trackers
  - Reaction wheels
  - Power Distribution and Conditioning Unit (PCDU)
  - X-Band COMMS system
  - Propulsion subsystem, including main engine
  - **PUS-C**/CCSDS underlying TM/TC protocol;
  - File-based operations. Using CCSDS File Delivery Protocol (CFDP) allows autonomous retransmission of lost packets.

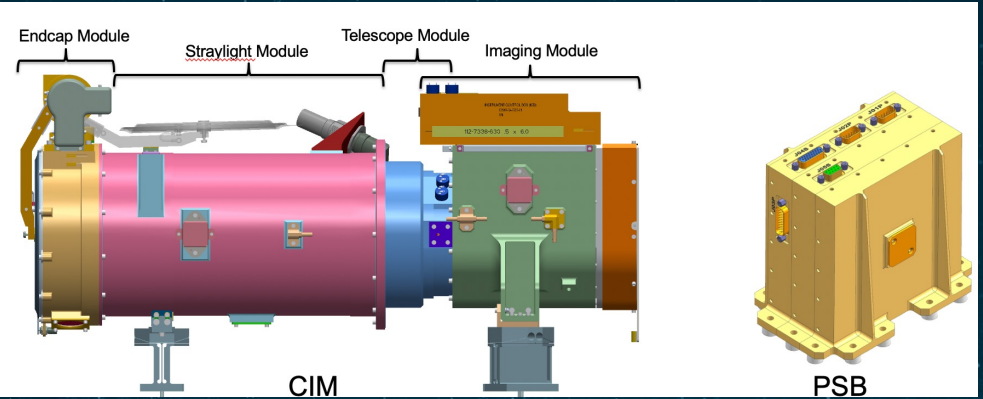
VIGIL INSTRUMENT SUITE Overview

Instrument	Observation	Utilisation
Photospheric Magnetic field Imager (PMI)	Vector magnetic field mapping of the solar photosphere	Evolving magnetic complexity: input into solar wind modelling and activity forecast
Compact Coronagraph (CCOR)	Solar coronagraphy	Evolution and propagation of CMEs- Overlapping observation close to the SUN from 4 deg between CCOR and HI
Heliospheric Imager (HI)	Heliospheric imagery	
Plasma Analyser (PLA)	Solar wind particle densities, temperatures and velocity	Solar wind monitoring, detection and characterisation of high-speed solar wind streams
Magnetometer (MAG)	Interplanetary Magnetic Field vector-magnetic field	

NIO EUVI is foreseen as the 6th instrument on VIGIL – Data used for science objectives and 'enhancement'

CCOR- Compact Coronograph

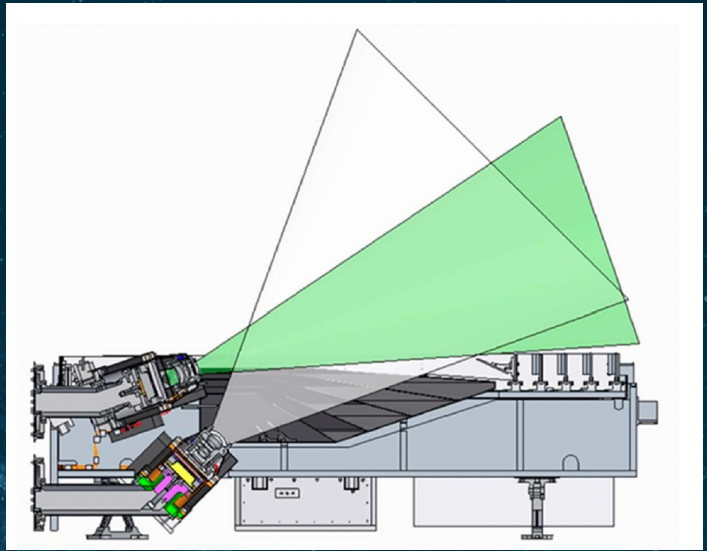
Coronal White Light Imaging	Observational Requirement
Field of View (FOV)	3 – 22 R_{Sun}
Dynamic Range	16 bit depth images 2 x 10^{-9} to 4 x 10^{-11} B_0 B_0: Solar brightness
Accuracy	Detection of CMEs corresponding to ~2 x 10^{-13} of solar brightness with SNR > 4 dB at 22 solar radii.
Angular resolution	2 arcmin
Cadence	15 min
Latency	30 min



Heritage from CCOR **SWFO-1** and CCOR **GOES-U**

Heliospheric Imager

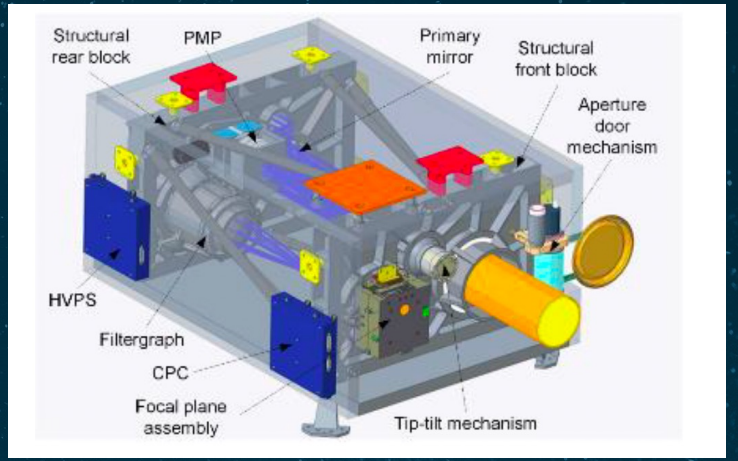
Heliosperic Imager	Observational Requirement
Field of View (FOV)	4-50 Deg
Dynamic Range	Brightness range from 1×10^{-10} to $1 \times 10^{-13} \cdot B_0$ B_0: Solar brightness
Accuracy	Photometric absolute accuracy better than 5% of the measured signal
Spatial resolution	4 arcmin (inner heliosphere)
Sensitivity	Sufficient to measure CME intensities that are 100 times weaker than a CME corresponding to $3 \times 10^{-15} \cdot B_0$.
Cadence	60 min
Latency	120 min

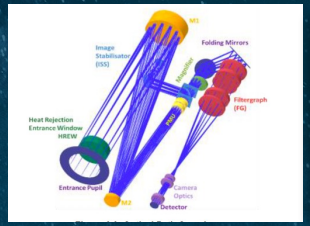


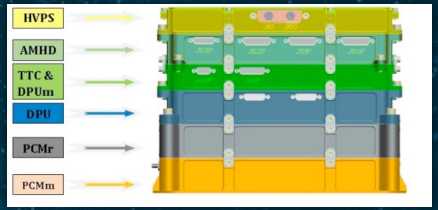
Heritage from **EUCLID/STEREO HI**

Photospheric Magnetic field Imager

Photosperic Magnetic Field Imager	Observational Requirement
Magnetic field direction	Derive magnetic field direction.
Spatial Range	Full disk plus margin to allow for absolute pointing error
Accuracy	10G
Spatial resolution	Vector: 2.5 arcsec
Dynamic Range	±4 kG
Cadence	60 min
Latency	120 min





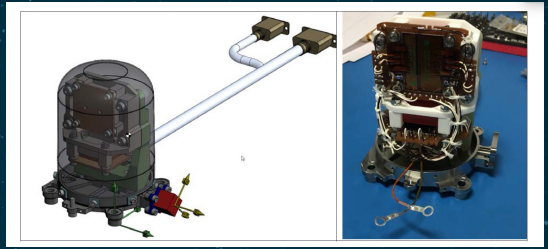


Heritage from PHI **SOLO**

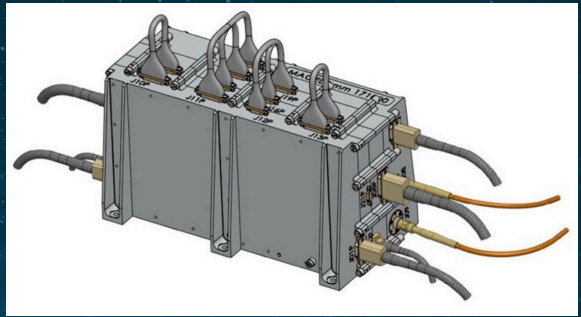
Magnetometer

Magnetomer	Observational Requirement
Phisical Range	Vector with 3 components
Dynamic Range	0.1 – 200 nT for every component, along positive and negative axis
Accuracy	Absolute: ± 1 nT
Cadence	1 min
Latency	60 min

Full Heritage from JMAG **JUICE**



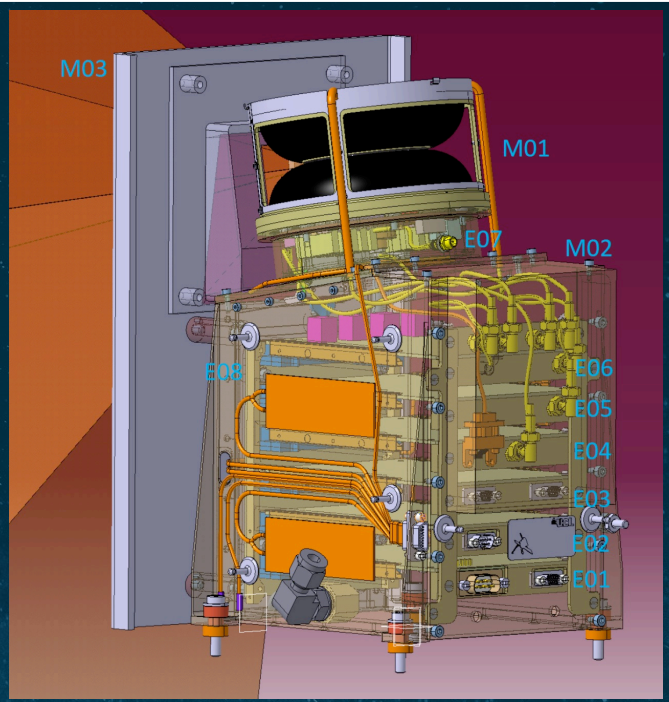
Two identical sensors MAGOBS and MAGIBS



MAGELB

Plasma Analyser

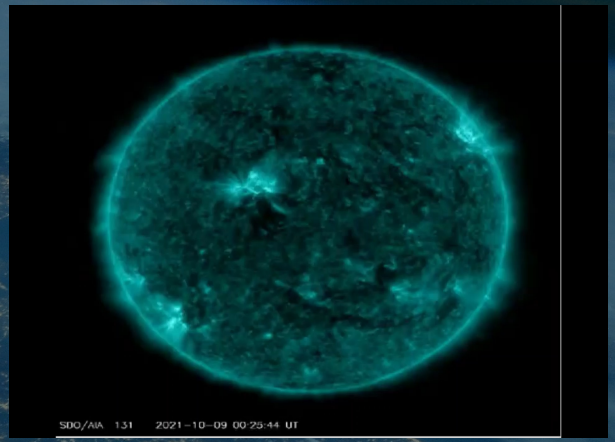
Plasma Analyser	Observational Requirement
Field of View (FOV)	*±22.5° (azimuthal FoV, in ecliptic plane) x 45° (elevation direction) with the centre of the FoV pointing towards the sun with an offset of 10 degrees*
Dynamic Range	Velocity: 200 - 2500 km s^{-1} Density: 0.2-150 cm^{-3} Temperature: 40,000 - 1,000,000 K
Accuracy	Absolute: (TBC) 5% for bulk density 5% for temperature Relative: (TBC) 5% for velocity
Cadence	1 min
Latency	60 min



Heritage from EAS **SOLO**

Key Satellite Design Drivers

- Data downlink => Relatively high BW for deep space mission. Allocation for NIO: 20kb/s averaged rate (P1) and 33kb/s averaged rate (P2).
  - Spacewire link can run at Mb/s rate, therefore data can be transmitted to OBC at ‘fast’ rate, for downlink at ‘lower’ rate;
  - Finite storage in OBC => Vigil Mission planning to size/authorise requests for greater BW in ‘burst/higher cadence mode’;
  - P2 data will be downlinked without latency requirements.
  - All data rates dependant on 24/7 link. G/S outages or lower G/S performance will reduce the *daily* data volumes.
- Contamination aspects => FM Optical instruments/PLA require strict satellite cleanliness requirements. In-orbit decontamination modes to be declared by bidders to check impact on Vigil mission availability. Also applicable to mass dummy
- Magnetic cleanliness => Possible impact on material selection



NDA

A NDA is needed by AIRBUS UK (VIGIL Spacecraft Prime) in order to be able to share the VIGIL Airbus Applicable and Reference documents with the NIO potential bidders.

NASA will distribute the NDA to the potential bidders to be filled.

Airbus Defence and Space, a company duly organised and existing under the laws of _____, with a share capital of _____, registered in _____, under number _____, having its registered office located at _____, acting through its Business Line [Insert one BL as appropriate],
Represented by [Name], acting in his/her capacity as [Title],
Hereinafter referred to as "**Airbus Defence and Space**",

and

_____, a company duly organised and existing under the laws of _____, with a share capital of _____, registered in _____, under number _____, having its registered office located at _____,
Represented by [Name], acting in his/her capacity as [Title],
Hereinafter referred to as the "**XXX**",

and

Vigil Satellite Key Personnel

- Vigil Project Manager: Giuseppe Mandorlo (ESTEC)
- Vigil Payload Manager: Cristina Bramanti (ESTEC)
- Vigil System Performance, SW and Operations Manager: Mark Dean (ESTEC)
  - Vigil System Performance Engineer: Adriano Lupi (ESTEC)

- Vigil Satellite Engineering Manager: Massimo Palomba (ESTEC)
- Vigil PA Manager: Vanina Ficaja (ESTEC)
- Vigil Mission Scientist: Juha-Pekka Luntama (Space Weather Office, ESOC)

ESA Vigil Project Point-of-Contact(s) => Cristina Bramanti, Jussi Luntama, Giuseppe Mandorlo

Satellite Schedule

- NIO Delivery Dates
  - EM => Q3 2026
  - FM => Q4 2027

Note: Dates to be finalised and agreed between stakeholders – some limited flexibility possible (Satellite tendering ongoing);

THANK YOU

https://www.esa.int/Space_Safety/ESA_Vigil_overview

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