# Vigil Mission Objectives

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Head of Space Weather Office
13 July 2023

# ESA's Enhanced Space Weather Monitoring System

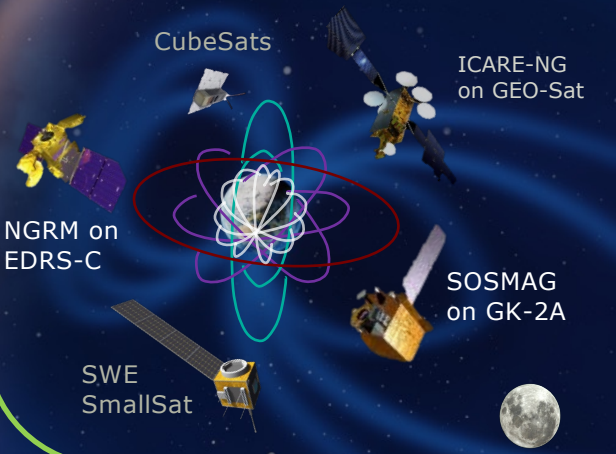
## Sun, solar wind and CME monitoring

L5

L1

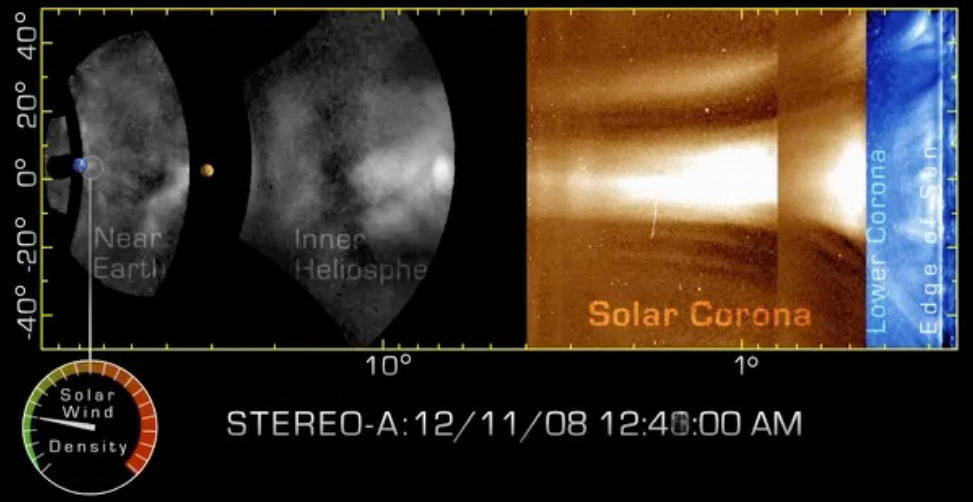
Forecasting & Event detection

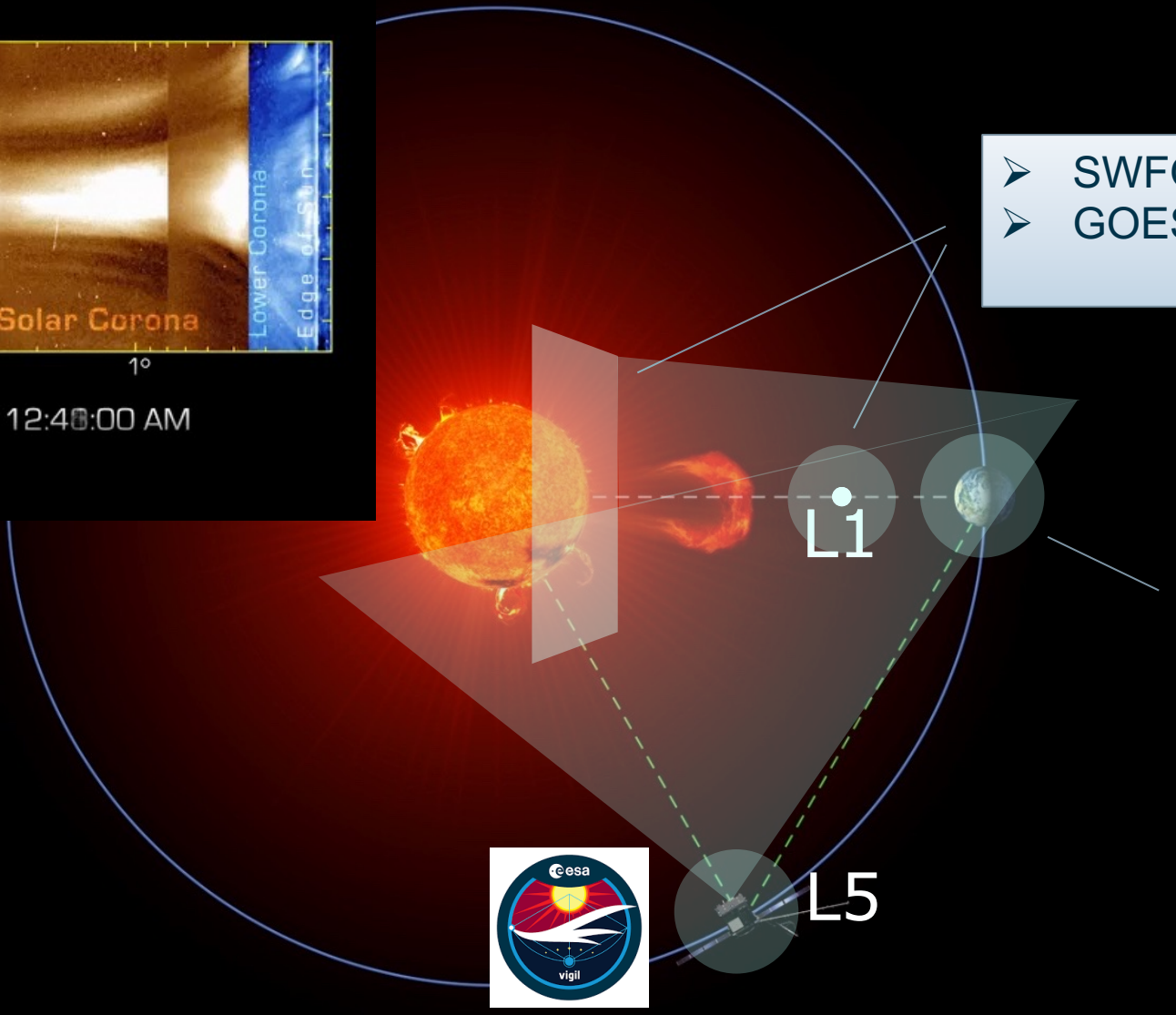
## Impact & state monitoring: D3S




Ground & space sensors

# Space Weather Monitoring Enhancement with Vigil




- SWFO-L1
- GOES-U (CCOR)

- D3S
- collaborative sensors
- ground observatories

# Vigil Mission Objectives

| | Objective | Observations | |
|---|---|---|---|
| A | • Improved assessment of CME motion and density, in the corona and heliosphere, in combination with L1 observations<br>• Observations necessary to improve solar activity onset detection and forecasting | Coronagraphy<br>Heliospheric imaging<br>Magnetography | Nowcasting |
| B | • Measure vector components of the IMF<br>• Determine the characteristics of solar wind features rotating towards Earth | Plasma spectrometry<br>Magnetometry | Forecasting |
| C | • Enable assessment of developing solar activity, through the monitoring of active region development up to 4 or 5 days beyond the East limb | Magnetography | Forecasting |

Vigil Mission Advisory Group: strong recommendation for Vigil to carry an EUV imager for bonus science and support for the mission objectives.

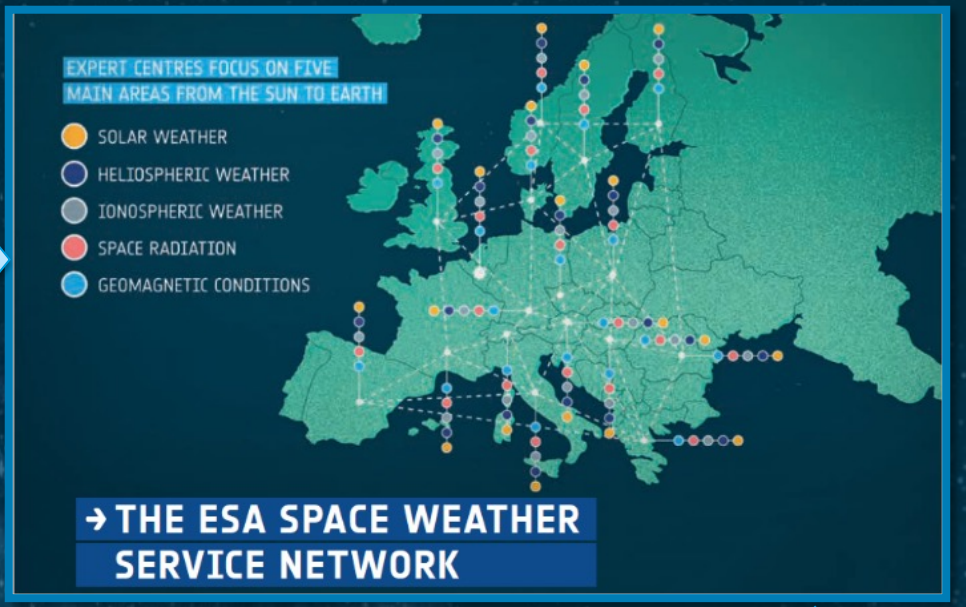
# Vigil Priority 1 Data in ESA Space Weather System

Layer 1: Data acquisition → Layer 2: Data Processing → Layer 3: Services

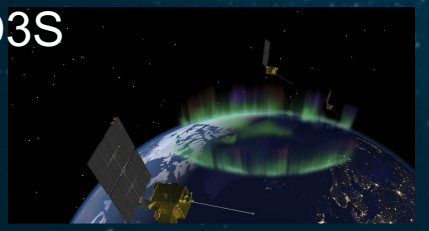
ESTRACK

MOC

Space Weather Payload Data Centre

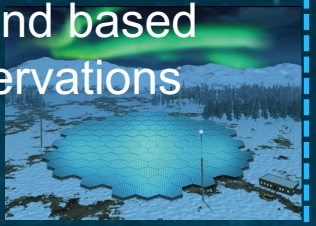



D3S



Collaborating missions

Ground based observations



# VIGIL Payload Suite Overview

C. Bramanti

VIGIL Payload Manager

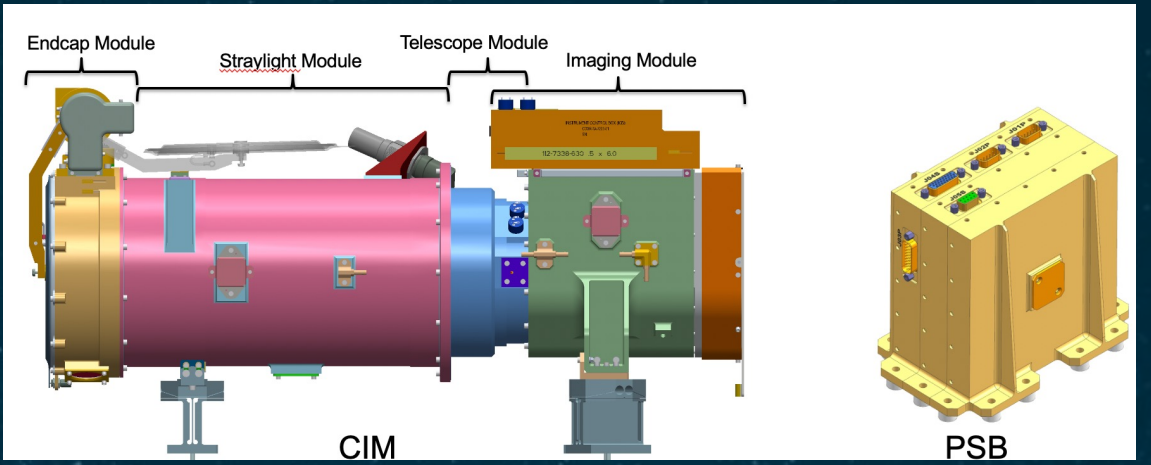
# VIGIL PAYLOAD SUITE OVERVIEW I

| | Instrument | Observation | Utilisation |
|---|---|---|---|
| **Remote Sensing Instruments** | 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 | |
| | Photospheric Magnetic field Imager (PMI) | Vector magnetic field mapping of the solar photosphere | Evolving magnetic filed around the sun: input into solar wind modelling and activity forecast |
| **In-situ instruments** | 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 | |

**A NASA Announcement of Opportunity (NIO), an EUV imager, will become the 6th instrument on VIGIL mission**

# CCOR- Compact Coronograph

| Coronal White Light Imaging | Observational Requirement |
|---|---|
| Field of View (FOV) | 3 – 22 $R_{Sun}$ |
| Dynamic Range | 16 bit depth images<br>2 x $10^{-9}$ to 4 x $10^{-11}$ $B_0$<br>$B_0$: 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 |



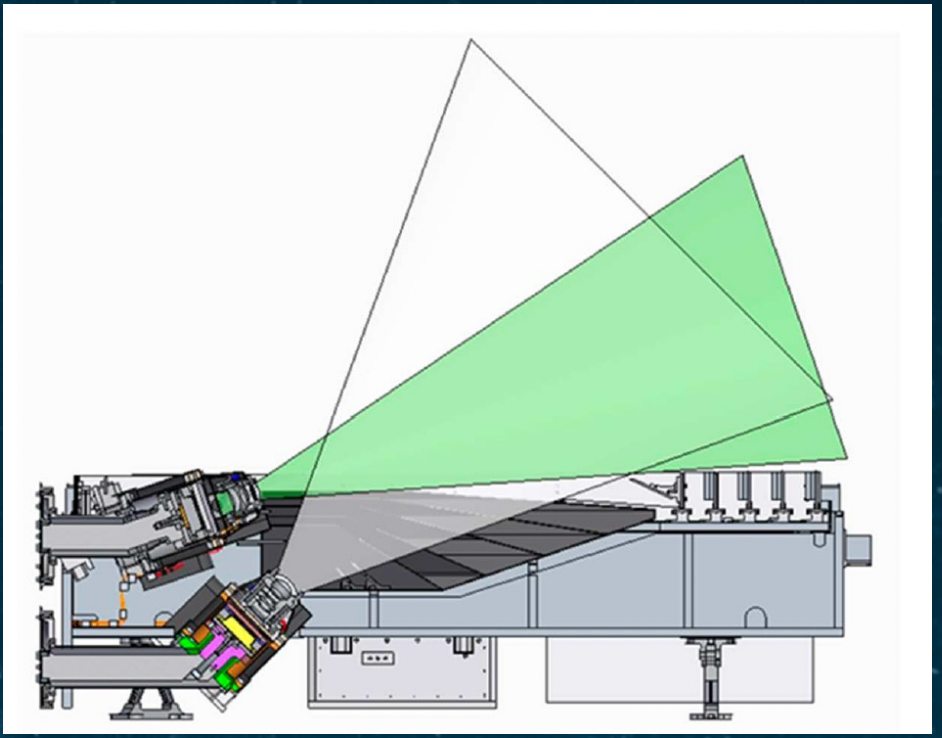

Heritage from CCOR **SWFO-1** and CCOR **GOES-U**

The Compact Coronagraph (CCOR) is the key instrument for detection of the onsets of the Coronal Mass Ejections (CMEs).

Onset of a CME can be seen in the coronagraph image as transient increase in the light scattering from the plasma cloud of the CME. Coronagraph is the most definitive method to detect CME onsets and provide the associated warnings.

# Heliospheric Imager (HI)

| Heliosperic Imager | Observational Requirement |
|---|---|
| Field of View (FOV) | 4-50 Deg |
| Dynamic Range | Brightness range from $1 \times 10^{-10}$ 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 |

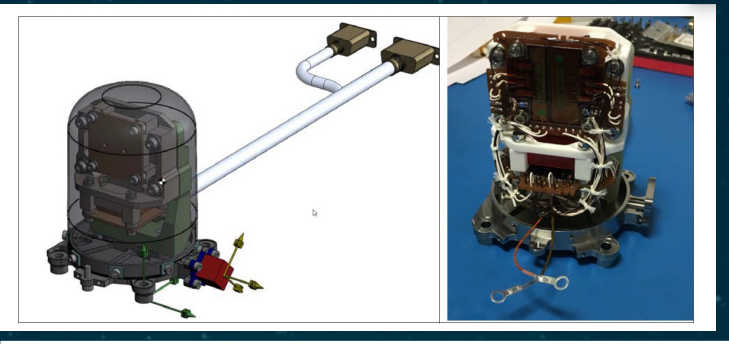


Heritage from **STEREO HI**

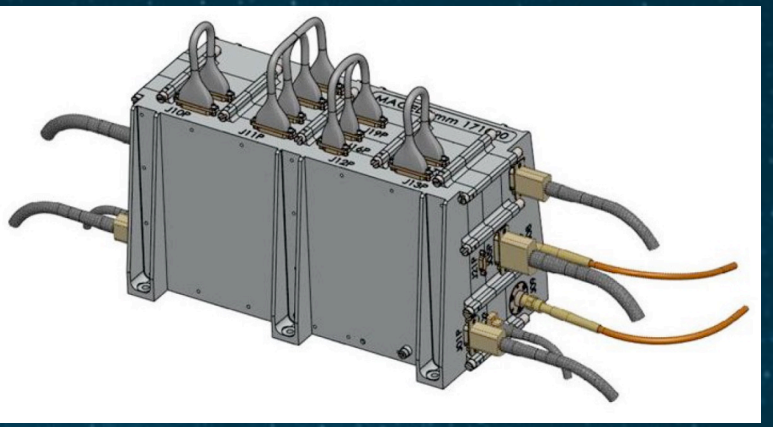
The Heliospheric Imager will provide wide-angle, white-light images of the region of space between the Sun and the Earth (i.e., the heliosphere). These images will enable tracking of Earth-directed CMEs over their propagation path once they have left the field-of-view of the coronagraph instrument.

# Magnetometer (MAG)

| 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:<br>± 1 nT |
| Cadence | 1 min |
| Latency | 60 min |



**Two identical sensors MAGOBS and MAGIBS**

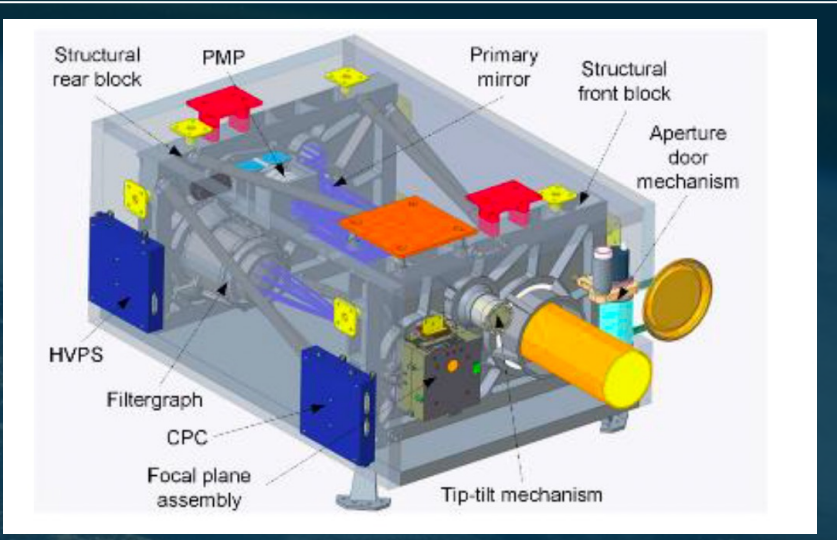


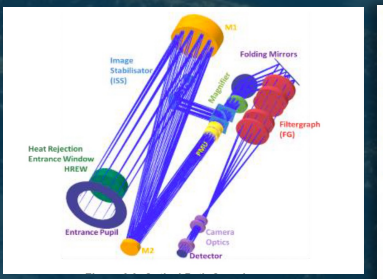
**MAGELB**

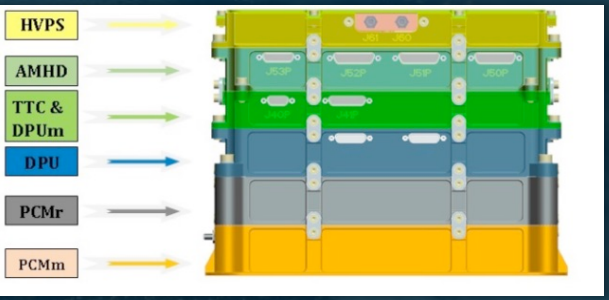
- The MAG shall measure the 3 components of the Interplanetary Magnetic Field (IMF) vector (0.1 - 200nT, +/-1nT)
- MAG is an extensive re-use of JUICE J-MAG (Dual-sensors Fluxgate magnetometer)

# Photospheric Magnetic Field Imager (PMI) - MPS

| Photospheric 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 | 2.5 arcsec |
| Dynamic Range | ±4 kG |
| Cadence | 60 min |
| Latency | 120 min |



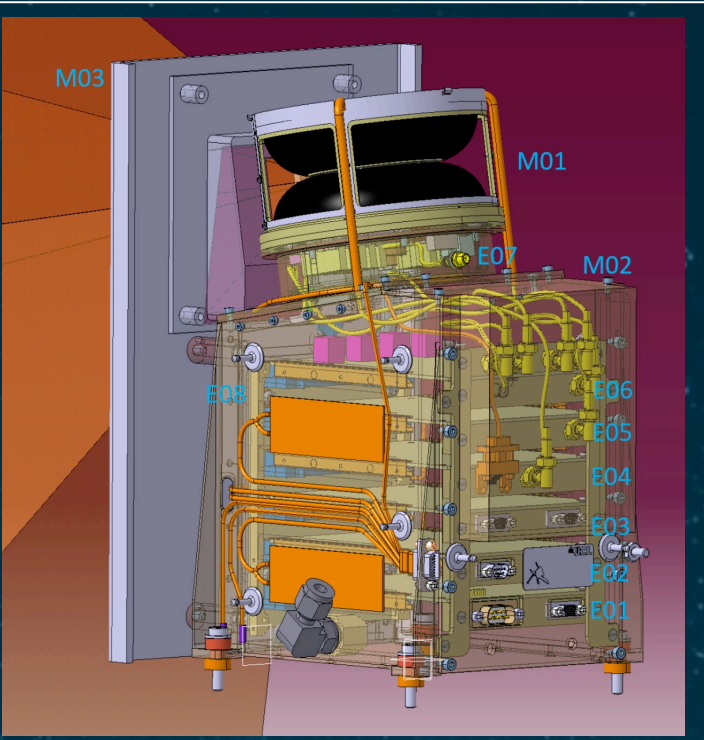



PMI is an heritage instrument from SOLO and will provide:

- the complete photospheric vector magnetic field information (field strength, azimuth, inclination)
- crucial physical parameters (e.g. distribution of vertical horizontal magnetic fields, distribution of inclination angles, twist, writhe, helicity, current density, share angles, photospheric magnetic excess energy etc.)

# Plasma Analyser (PLA) – MSSL

| 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* |
| Angular resolution | 5 degrees x 5 degrees |
| Dynamic Range | Velocity: 200 - 2500 km $s^{-1}$<br>Density: 0.2-150 $cm^{-3}$<br>Temperature: 40,000 - 1,000,000 K |
| Accuracy | 5% for bulk density<br>20% for temperature |
| Cadence | 1 min |
| Latency | 60 min |




Heritage from EAS **SOLO**

The Plasma Analyser (PLA) shall provide measurements which allow to derive the solar wind, by measuring the characteristics of the ions with selected energy :

- bulk Velocity in a range of 200 - 2500 Km/sec
- plasma bulk Density in a range of 0.2 - 150 $cm^{-3}$
- bulk Temperature in a dynamic range of 40,000 - 1,000,000 K can be derived.

# 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**

# THANK YOU

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