



Vigil: Pioneering Solar Observation for a Safer Space Environment

Vigil Team

ESTEC

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→ THE EUROPEAN SPACE AGENCY

- *What are the possible impacts of an extreme solar event?*
- Extreme SpW impacts power distribution, aviation, internet, navigation, space based assets.
- Lloyds of London report (2013) estimated cost impact of **\$1-2 Trillion impact after 1-year from only US power grid damage**
- Greater reliance on 'foundation' technologies (Internet, GPS, Comms etc) means increased risk/impact over time.
- Extreme solar event 12-18 hrs from onset to impact – **LATENCY** and **AVAILABILITY** the driving req'ts.
- First ESA mission to SEL5.





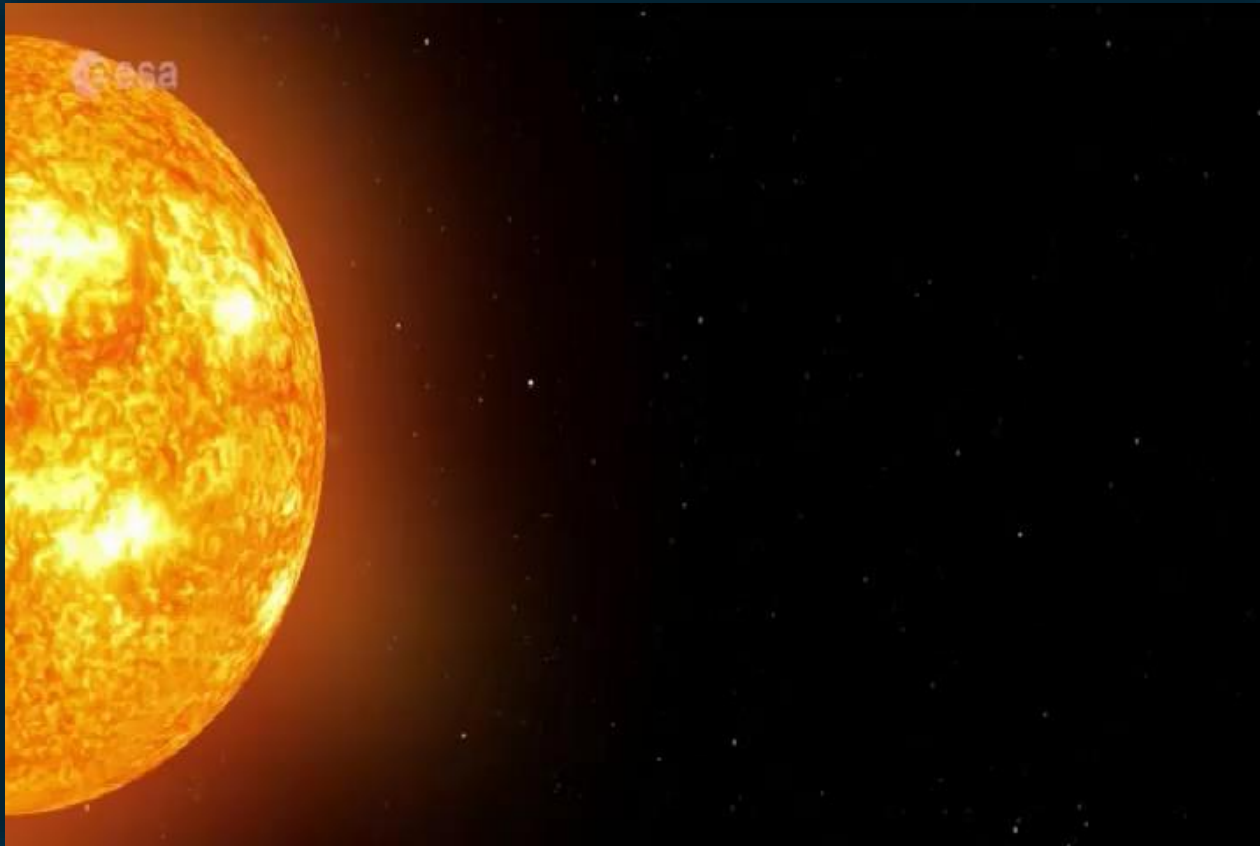
Vigil Mission



- **The Vigil Mission shall ensure a continuous provision of space weather measurements away from Sun-Earth line, to enhance the space weather services to protect critical infrastructure on Earth and in space.**
 - Early warning of emerging hazardous solar weather conditions.
 - Space Weather Forecast up to 4-5 days.
 - More accurate CME time and location impact predictions on Earth.
 - Operational 24/7, including during severe space weather events (e.g. Carrington Events)
 - Low latency data to the Space Weather Network.
 - First ESA mission to SEL5.



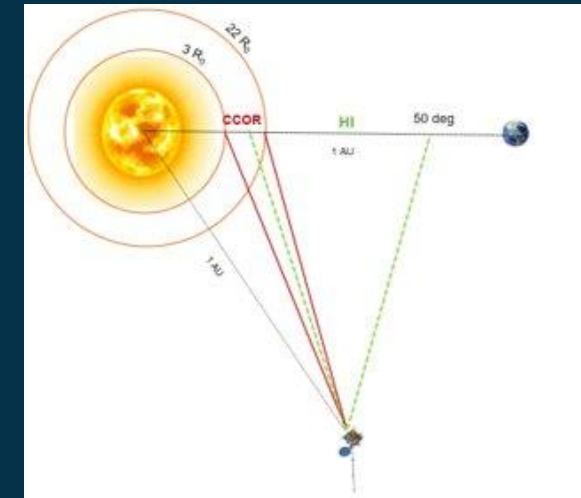
- **L5 – 1: To provide improved assessment of CME motion and density, in the corona and heliosphere**
- **L5 – 2: To provide observations necessary to improve solar activity onset detection**



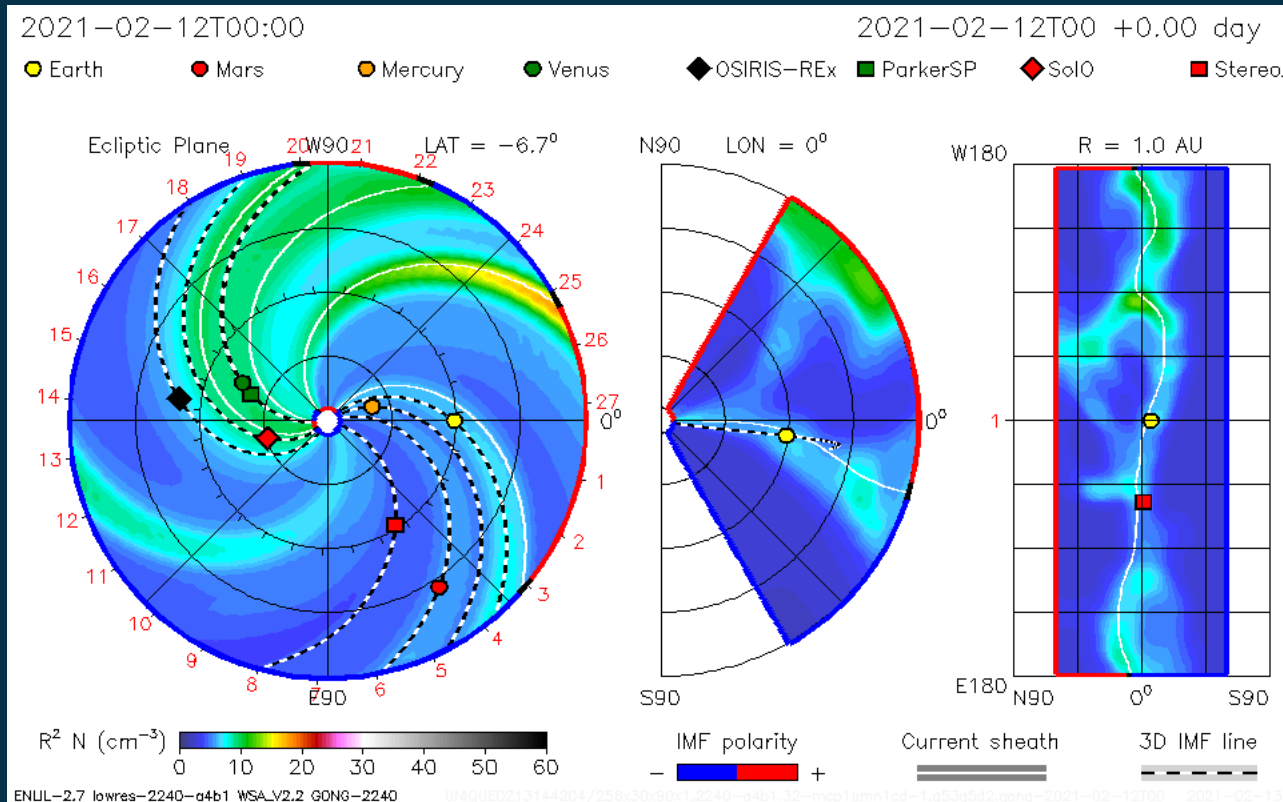
Space Weather Nowcasting

Estimating the current or near-term **Coronal Mass Ejection** Earth arrival time and location using real-time data and predictive analytics.

Coronal Mass Ejection (CME): a significant release of plasma and accompanying magnetic field from the Sun's corona into the heliosphere. CMEs are often associated with solar flares and other forms of solar activity.



- **L5 – 4: To determine the speed, density and temperature in solar wind features (e.g. SIRs) rotating towards Earth from an in-situ perspective**
- **L5 – 5: To provide observations necessary to improve solar activity onset detection**



Space Weather Forecasting

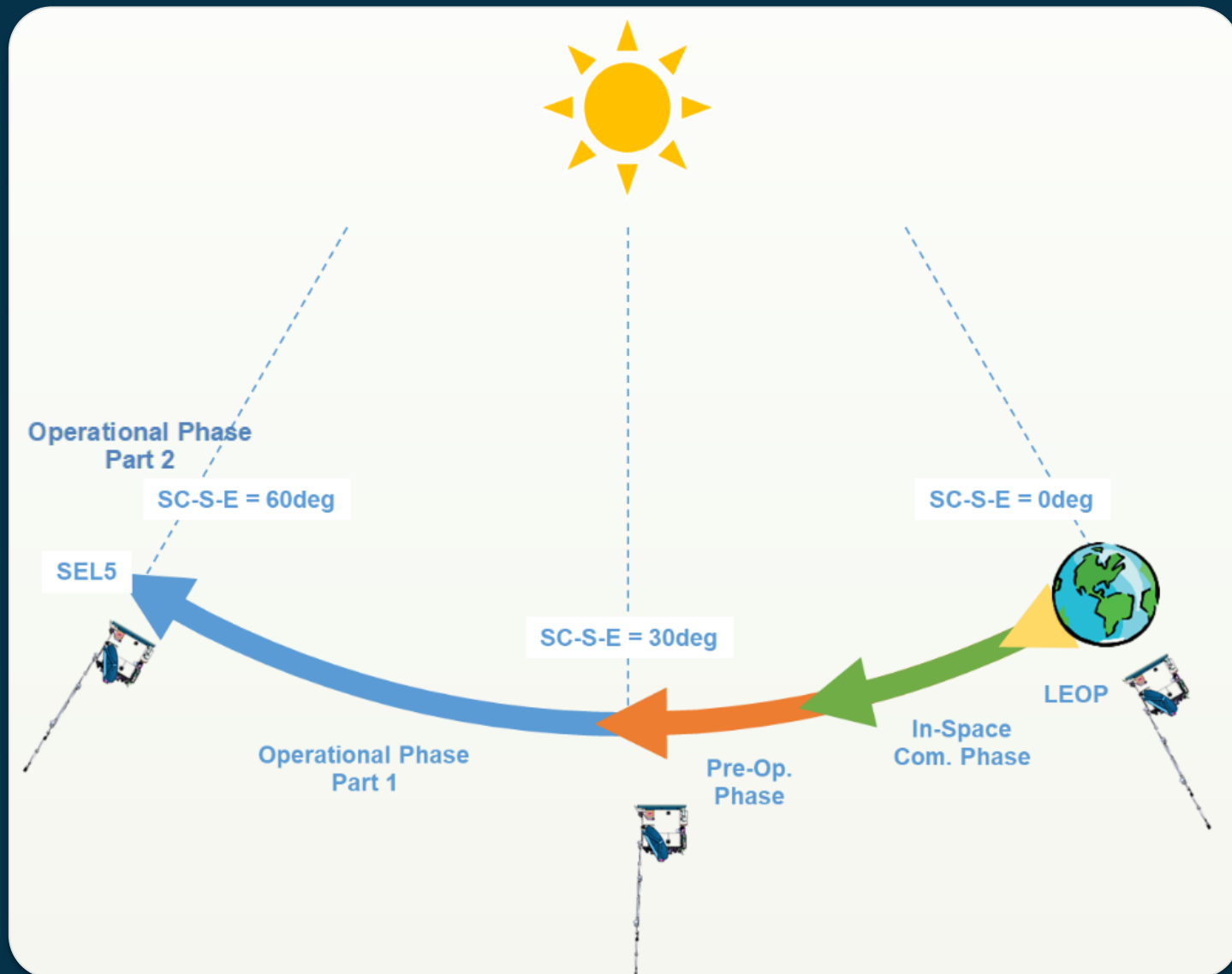
Prediction of high-speed solar wind streams and Co-rotating Interaction Regions several days in advance before they rotate towards the Earth.

Solar Wind: A stream of energised, charged particles, primarily electrons and protons, flowing outward from the Sun, through the solar system.

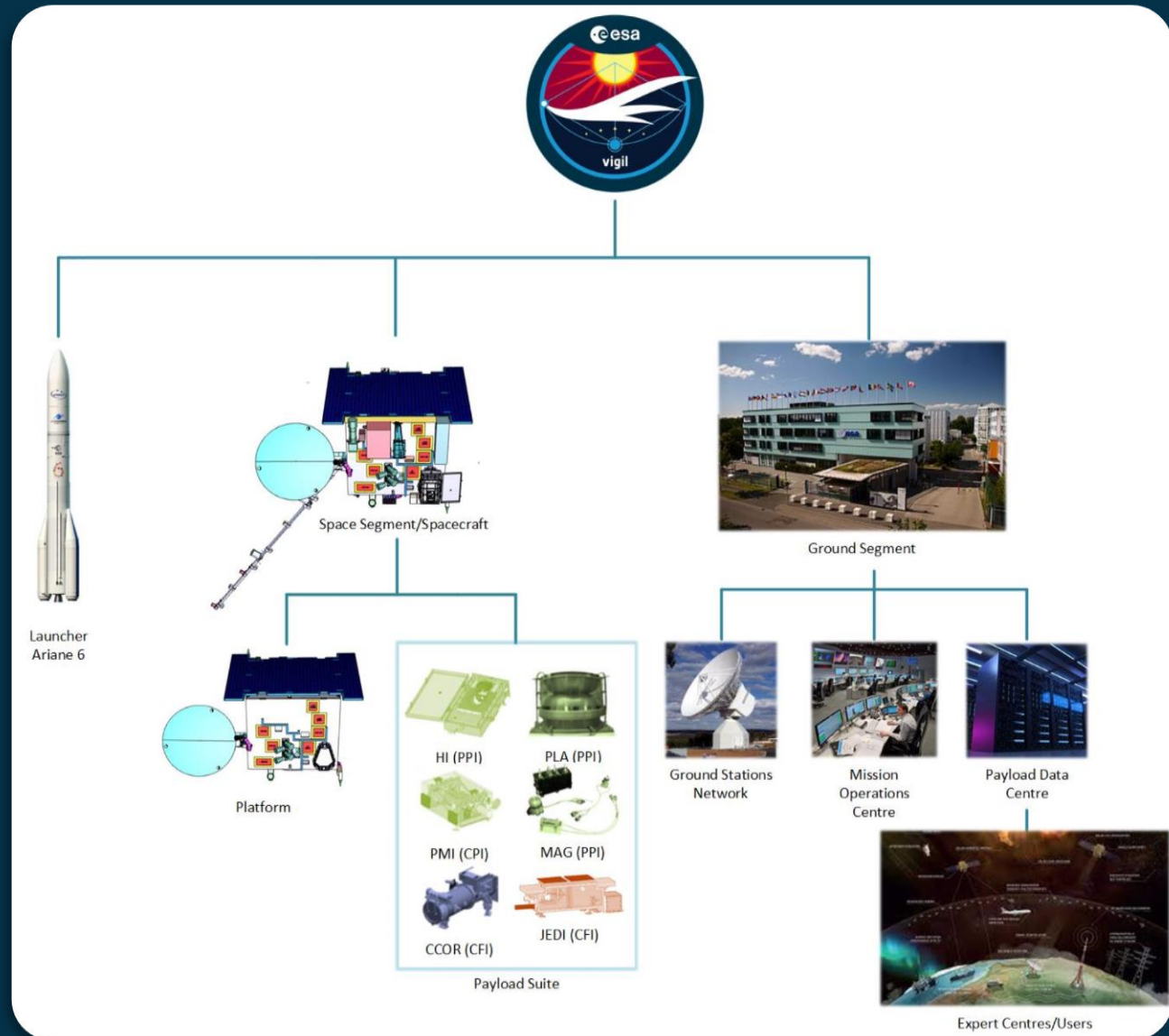
Co-rotating Interaction Regions (CIR): a compression region ahead of a coronal hole high-speed stream (CH HSS). They form due to the interaction of slower, ambient solar wind ahead of the higher-speed stream



- **Mission Life: 7.5 years**
 - The spacecraft will embark consumables for a 5 years extension.
- **Transfer to SEL5**
 - Injection in GTO and transfer to SEL5 using of the SEL1/SEL2 connection and the weak stability boundary effects near SEL2.
 - Duration: ≈3 years
 - *Can be reduced to 1 year if direction injection becomes feasible (i.e. solo launch).*
- **Operational Phase (OP)**
 - To maximise the benefit of the mission, Vigil can enter in operation state as soon as the Spacecraft has reached a 30 degrees separation from Earth wrt the Sun.
- **End of Life and Disposal Phase**
 - The Satellite will release the SEL5 orbit by performing a disposal manoeuvre after passivation.



- **With respect to the Vigil Mission Architecture the Space Segment consists of:**
 - A single spacecraft orbiting around the Sun-Earth Lagrangian point 5 (SEL5).
- **Platform featuring:**
 - Fixed Solar Array.
 - Bi-propellant propulsion system.
 - Deployable and steerable High Gain Antenna.
 - Extension boom for the EMC sensitive instruments.
- **Payload Suite consisting of:**
 - 3 remote sensing instruments.
 - 2 in-situ instruments.
 - 1 hosted instrument from NASA as instrument of opportunity.
- **Launcher: Ariane 6.2 dual launch configuration**
 - The Spacecraft will be compatible with Ariane 6.4 and Falcon 9 too.





VIGIL INSTRUMENT SUITE Overview



Instrument	Instrument Prime	Observation	Utilisation
Photospheric Magnetic field Imager (PMI)	MPS/IAA	Vector magnetic field mapping of the solar photosphere	Evolving magnetic complexity: input into solar wind modelling and activity forecast
Compact Coronagraph (CCOR)	NOAA/NRL	Solar coronagraphy	Evolution and propagation of CMEs- Overlapping observation close to the SUN from 4 deg between CCOR and HI
Heliospheric Imager (HI)	Leonardo SpA	Heliospheric imagery	
Plasma Analyser (PLA)	MSSL	Solar wind particle densities, temperatures and velocity	Solar wind monitoring, detection and characterisation of high-speed solar wind streams
Magnetometer (MAG)	IPL/IWF	Interplanetary Magnetic Field vector-magnetic field	
JEDI	NASA/SWRI	Extreme Ultraviolet Images	Complementary to existing instruments for the forecasting service



VIGIL Platform and Support Developments



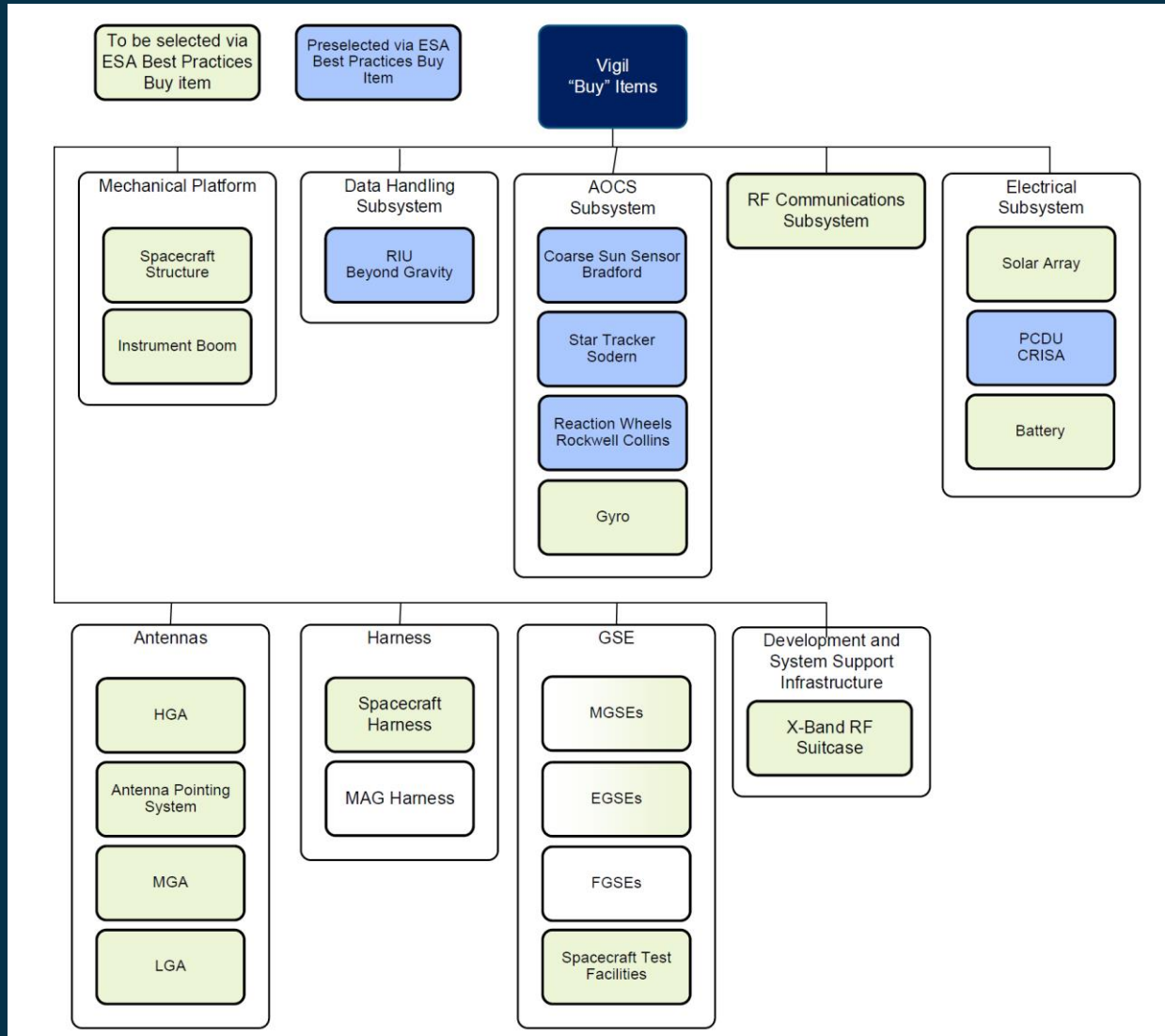
- **Largely based on Astrobus NEO, standard platform avionics equipments;**
 - OBC
 - OBSW
 - RIU
 - Star Trackers
 - Reaction wheels
 - PCDU
- **Vigil Mission-specific/Open items**
 - X-Band COMMS system
 - MAG Boom
 - Solar Array
 - Propulsion subsystem, including main engine
 - File-based operations (CFDP)
- **End-to-end simulator and Ground Prototype Processor (GPP) as well as EGSE opportunities are available;**



- The Prime Contractor shall develop the Vigil Space Segment consisting of a Spacecraft inclusive of the Instruments of the Payload suite, spares, supporting equipment and related documentation in compliance with the Agency requirements.

- **The Vigil Instruments are procured under different schemes with different sharing of responsibility between ESA and the Prime:**

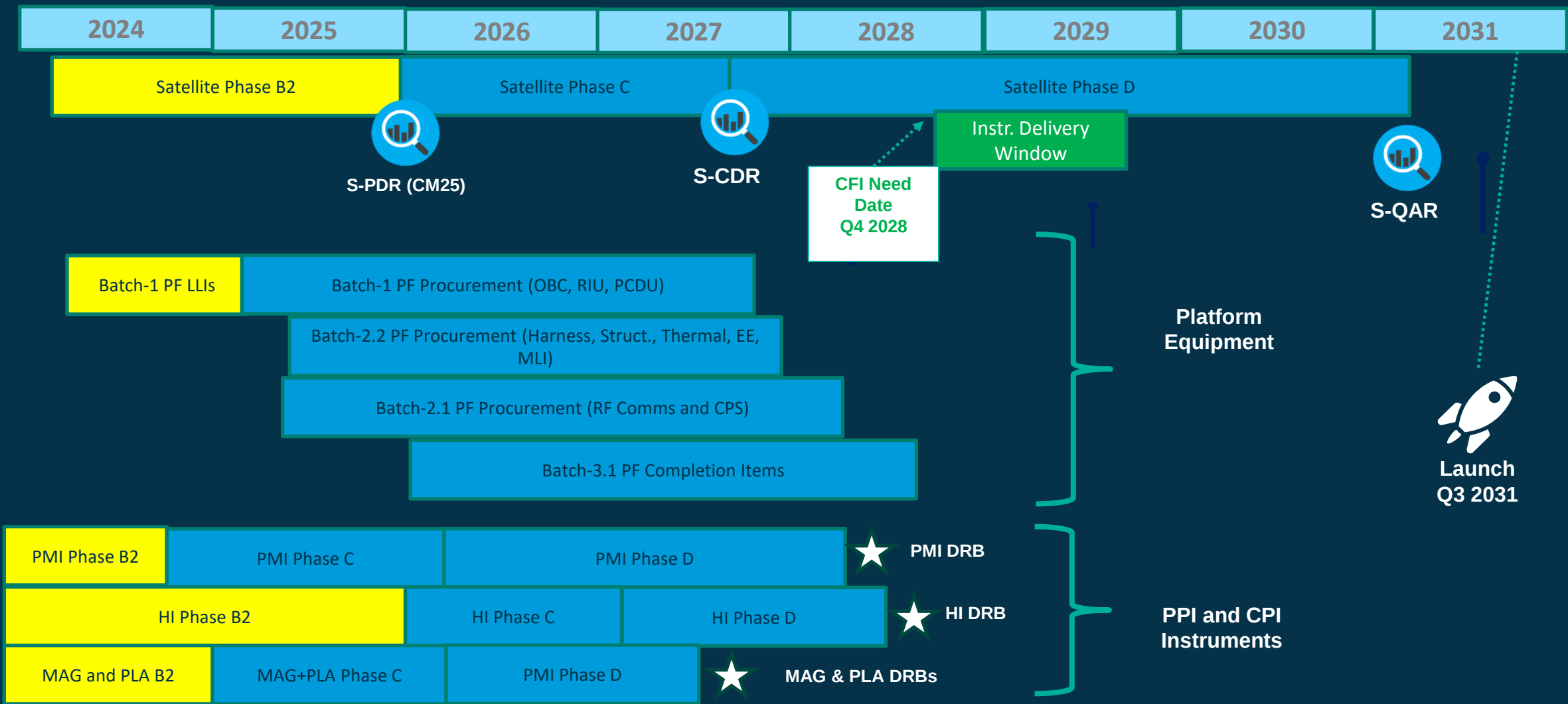
- "Prime Procured Instruments" (PPI): the Heliographic Imager (HI), the Magnetometer (MAG) and the Plasma Analyser (PLA), are those instruments whose procurement is under the responsibility of the Prime Contractor.
- "Customer Procured Instrument" (CPI): Photo-Magnetospheric field Imager (PMI), is procured by the Agency and placed under the technical management of the Prime Contractor for its design, development, verification.
 - *PMI is developed by the Max Planck Institute for Solar System Research (MPS).*
- "Customer Furnished Instruments" (CFI): the Compact Coronagraph (CCOR) and the Joint EUV coronal Diagnostic Investigation (JEDI), are provided by the Agency and delivered to the Prime Contractor for integration and testing.
 - *CCOR is provided by NOAA in the frame of the agreements with ESA regarding to the Cooperation on Space Based Space Weather Observations.*
 - *JEDI is provided by NASA as Instrument of Opportunity to be hosted on the Vigil spacecraft; JEDI scientific mission objectives can complement those of the Vigil mission, but it is not considered essential for its success.*



- Standard avionics already baselined and preselected;
- Several opportunities in other platform elements;
- Opportunities at instrument level can be explored directly with the Vigil Instrument primes;
- Direct contact with ADS Ltd Vigil Team is strongly encouraged;
- Ground segment opportunities being identified => Direct contact with ESA;
- Industry/ESA to jointly close the loop with individual delegations;



Vigil Satellite Schedule





THANK YOU!

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