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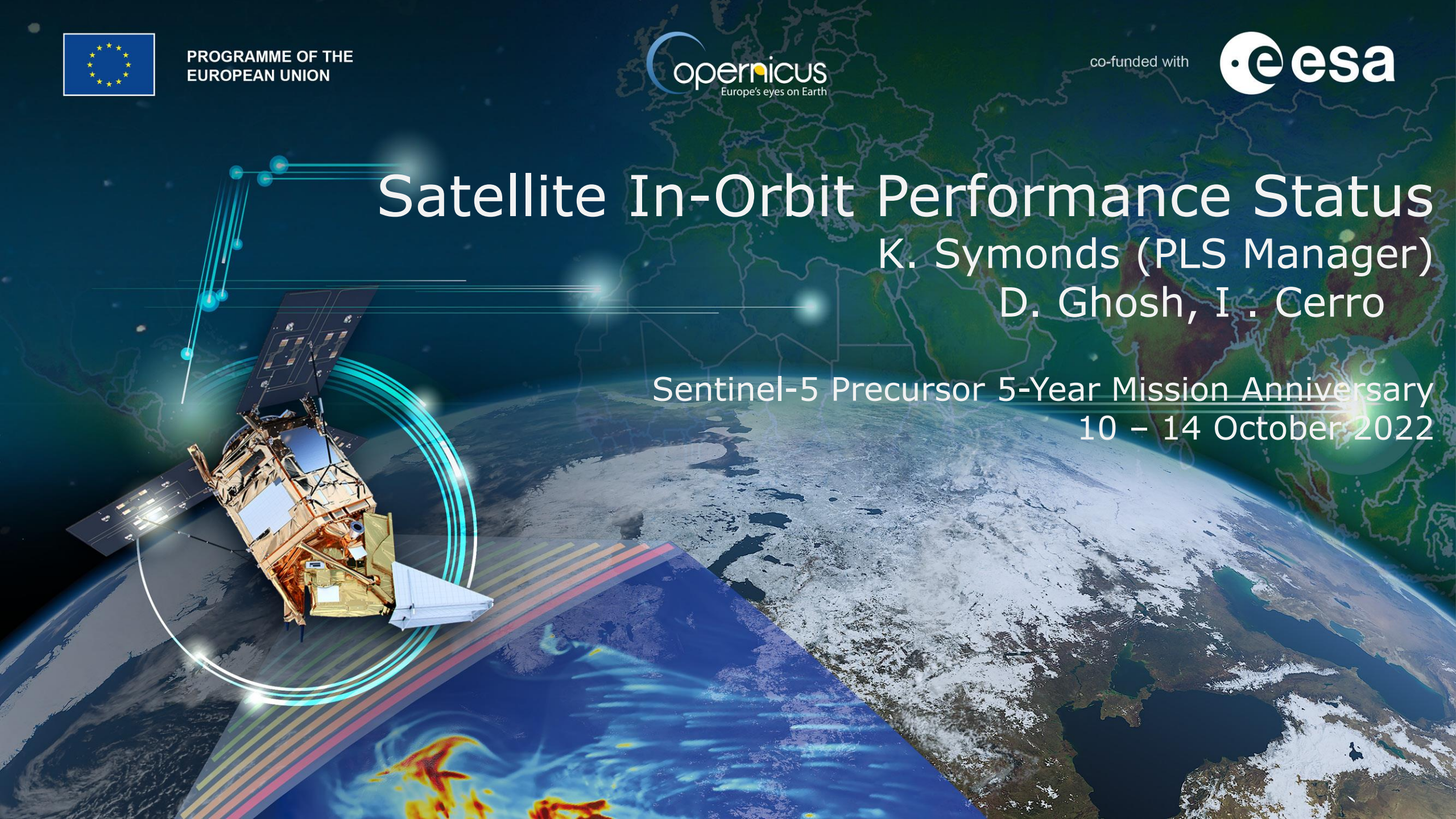
Satellite In-Orbit Performance Status

K. Symonds (PLS Manager)
D. Ghosh, I . Cerro

Sentinel-5 Precursor 5-Year Mission Anniversary
10 – 14 October 2022



- This POST LAUNCH SUPPORT presentation covers:

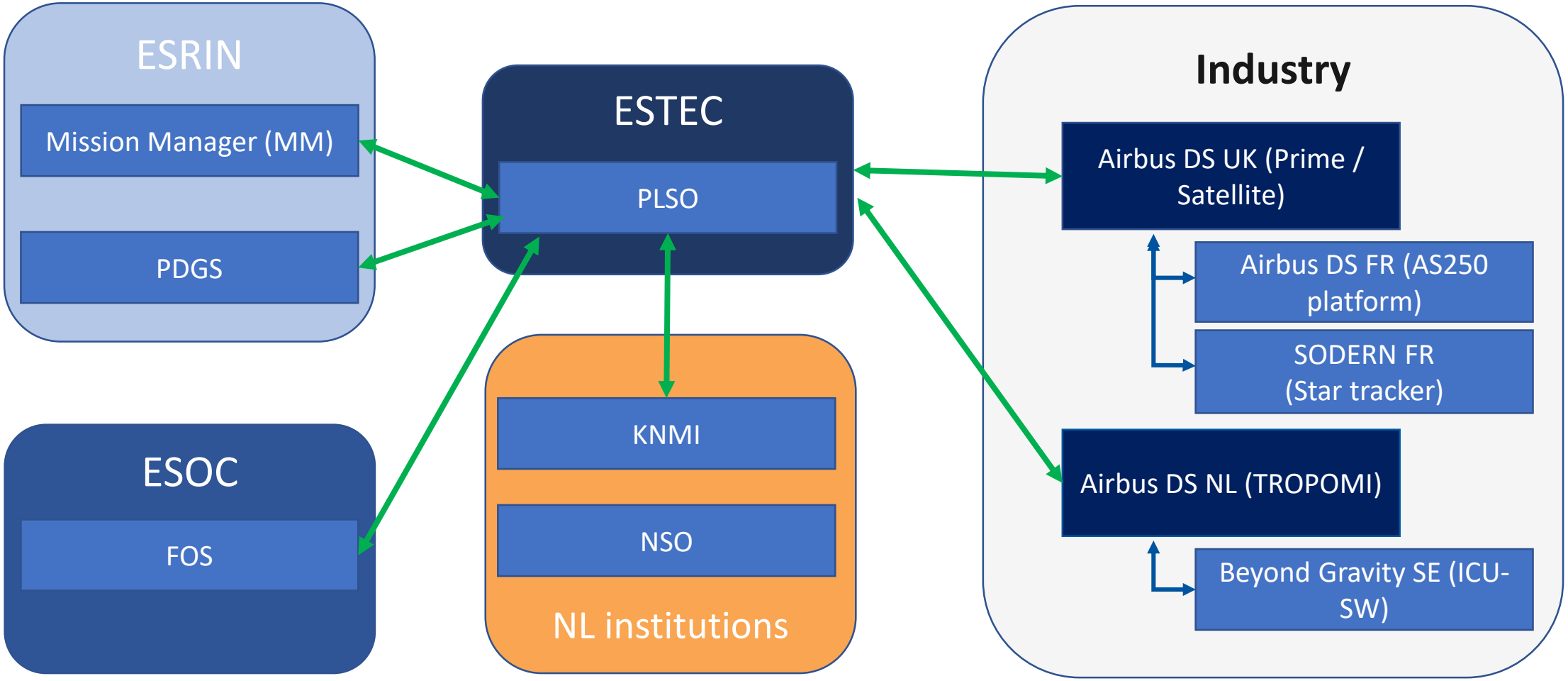
  - **PLS Introduction**
    - PLS Overview and Interfaces

  - **Satellite Performance Aspects**
    - Satellite Long-Term Functional Performance (LTPA & SIOP)
    - Satellite Overall Health Status
    - Life Limited Items & Consumables
    - Satellite Anomalies
    - Satellite Performance Optimisation Studies
    - Satellite Availability & Reliability

  - **Conclusions**

Post Launch Support Introduction

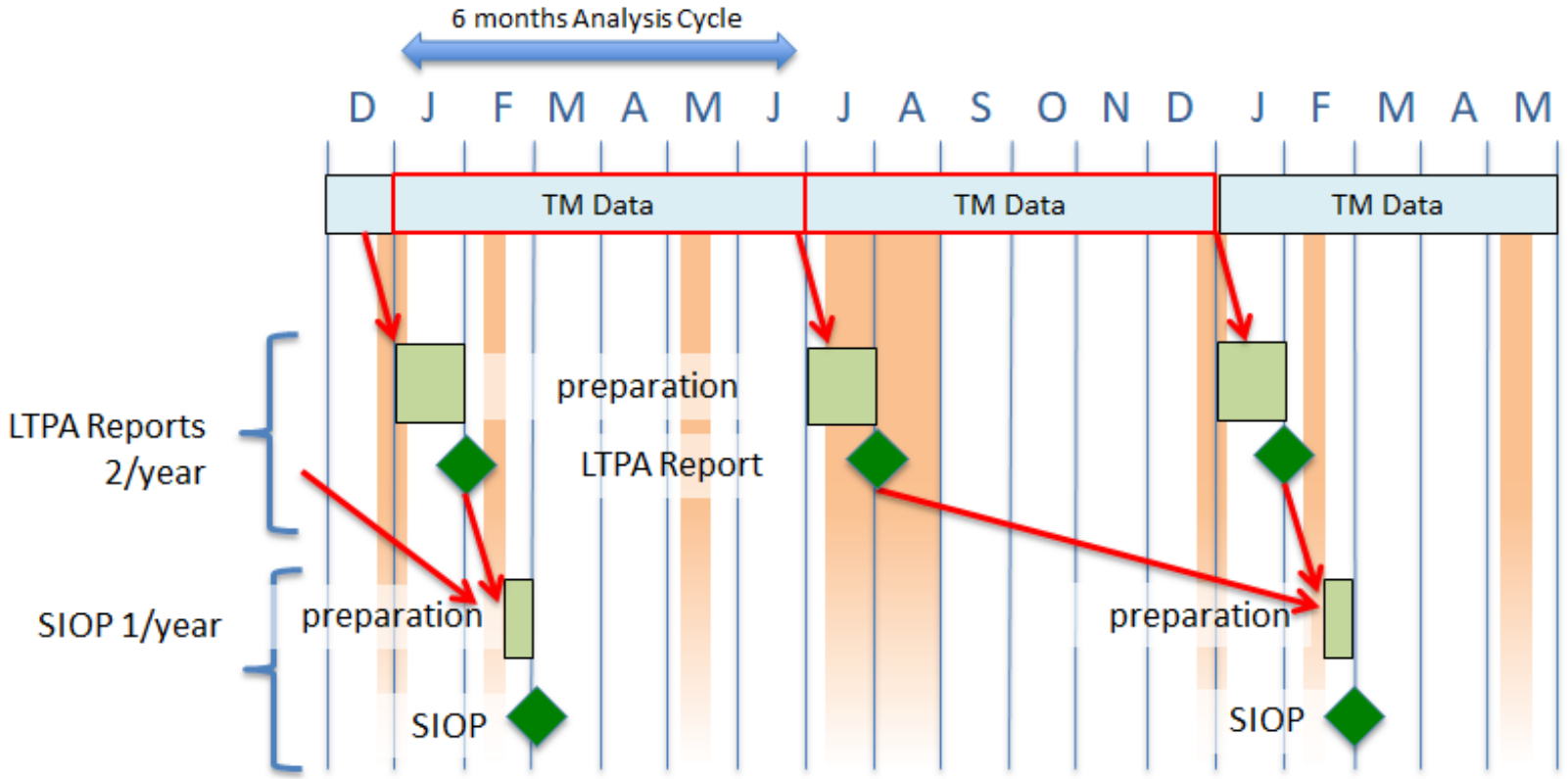
Support Overview & Interfaces



Satellite Performance Aspects

Long-Term Functional Performance

Periodic Reporting Cycle & Performance Tracking



Next SIOP#9 in March 2023

LTPA Performance Reports:

Delivered bi-annually at the end of January and July.

- All reports received on time since beginning of the contract.

SIOP Technical Meetings

~ March/April each year (from 2023)

- 8 SIOP Meetings held since beginning of the contract
- Last SIOP#8 in May 2022

PLS Performance Reporting is nominal

Satellite Overall Health Status
Platform summary

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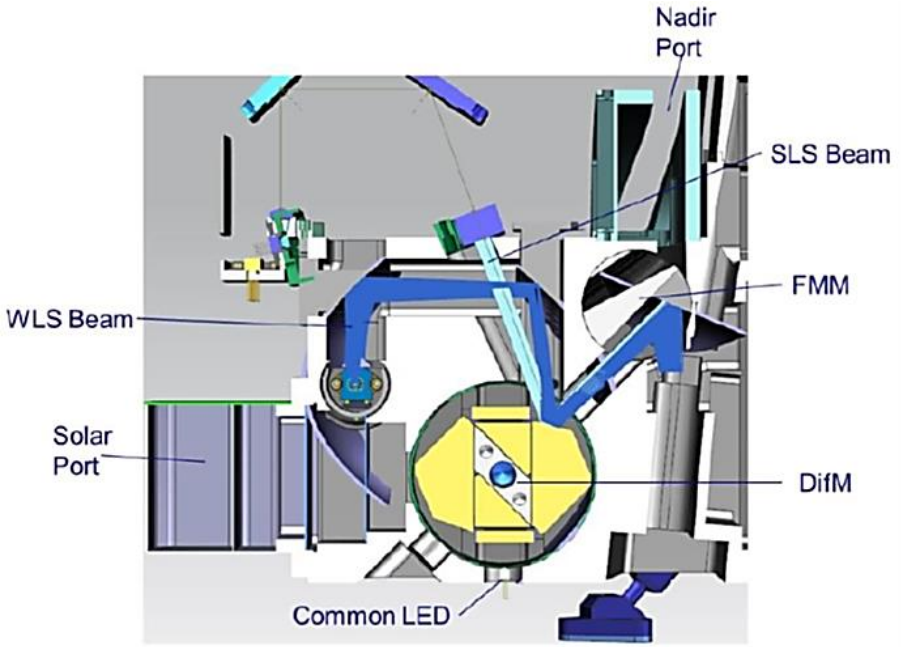
Component	Status	Unit Config
Spacecraft / AOCS mode	**Nominal**	SAT_NOM / CAP
Data Handling (OBC / RIU)	**Nominal**	
S-Band TX (SBS)	**Nominal**	
X-Band TX (XBS)	**Nominal**	
Payload Data Handing (PDHU)	**Nominal**	
AOCS	**Nominal**	
Power (EPS)	**Nominal**	
Thermal (TCS)	**Nominal**	
Propulsion (RCS)	**Nominal**	

Summary of TROPOMI components

Component	Status	Remarks
White Light Source (WLS) - Halogen light bulb	**Nominal**	Some degradation observed/ trending (as expected)
Folding Mirror Mechanism (FMM) - Stepper motor w/ 2 positions	**Nominal**	
Diffusor Mechanism (DIFM) - Stepper motor w/ 2 positions	**Nominal**	
ICU EEPROM	**Nominal**	ICU-B EEPROM refresh needed by Nov. 2023
Overall Status	**Nominal**	TROPOMI instrument thermally stable, seasonal variations visible on some parameters.



Life Limited Items & Consumables

Subsystems Summary (04/2022)

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S5P	Value	Prediction	Design Limits
RCS Propellant Remaining	71.718 kg	2032	Deorbiting Allocation: 37.03kg
XBS TWT Amplifier	20,134	2037	100,000 TWT ON/OFF cycles
XBS Cathode	6	2306	500 Cathode ON/OFF cycles
XBS Waveguide Switch	2	infinite	1,000 Waveguide switches
S-Band Transponder	**17,538**	**2036**	76,000 TX OFF/ON cycles
TROPOMI White Light Source	28.21 hrs	2028	60 hours WLS ON Time
TROPOMI Folding Mirror Mechanism	**18,857**	**2026**	30,000 FMM cycles*
TROPOMI DIFM Cycles	11,163	2032	30,000 DIFM cycles
TROPOMI DIFM Oscillation Cycles	11,996	infinite	81,000 oscillation cycles (equivalent to 45 hours)

All LLI & consumables projections go **beyond the end of satellite nominal design lifetime (Oct 2024)**

***TROPOMI FMM lifetime prediction being re-assessed based on in-flight environment**

Note: Design Lifetime 7 years

Launch: Oct 2017

Satellite Anomalies Status

- **44 anomalies** since launch: 24 during LEOP/IOC and **20** in 4.5 years of Routine Phase operations
- Only **1 major anomaly** during routine phase (in 2019): STX-A switch-on failed (one-off transient event)
- 1 **ad-hoc anomaly review board (ARB) held in 2022** → All other anomalies handled at Status-ARB level (no urgency/no criticality involved).
- Only **1 minor anomaly currently open** (PDHU memory related, similar to previous issue)

Date	S/S	Unit	Description	Root Cause	Contingency
Sep-19	SBS	STX	STX-A switch-on failed	Unknown	On-board FDIR triggered switchover to STX-B, no recurrence
Jun-19	PDHT	PDHT	PDHU Reports Memory Uncorrectable Errors	Unknown	No further recurrence following unit self-test
Aug-18	AOCS	GPS	GPS restart triggered by watchdog	Unknown	Use as is (known issue with MOSAIC GPS receivers)
Jul-18	AOCS	STR	STR Minor Error - Loss of tracking	SW problem	STR SW patch
Apr-18	DHS	PM	[Commissioning]: PM-A corrected errors counter continuous increase	HW error caused by SEU	Scrubber not working as expected on affected memory area. SW Patch in PM-RAM applied

Satellite Performance Optimisation Studies

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Title	Status	Summary
New Collision Avoidance Manoeuvre (CAM) & Payload FDIR strategy	**Completed**	Shorten Mission Unavailability in case of CAMs. Improve automatization of payload recovery actions in case of FDIR. Implemented on-board in 2020.
TROPOMI performance improvements	**Ongoing***	Various studies to understand equipment behaviour / degradation and its impact on products: CCD gain variation, UVIS spectrometer 'scratch', UV spectral bleaching/ageing, WLS source power reduction, UVN pixel saturation, diffusor & FMM degradation
S-Band Transponder predicted lifetime / switching reduction	**Completed**	New predicted maximum number of cycles (76,000 instead of 38,000) extending end of life prediction to 2026.

*long term trending and performance tracked by KNMI and applied in mission products

Satellite Availability & Reliability

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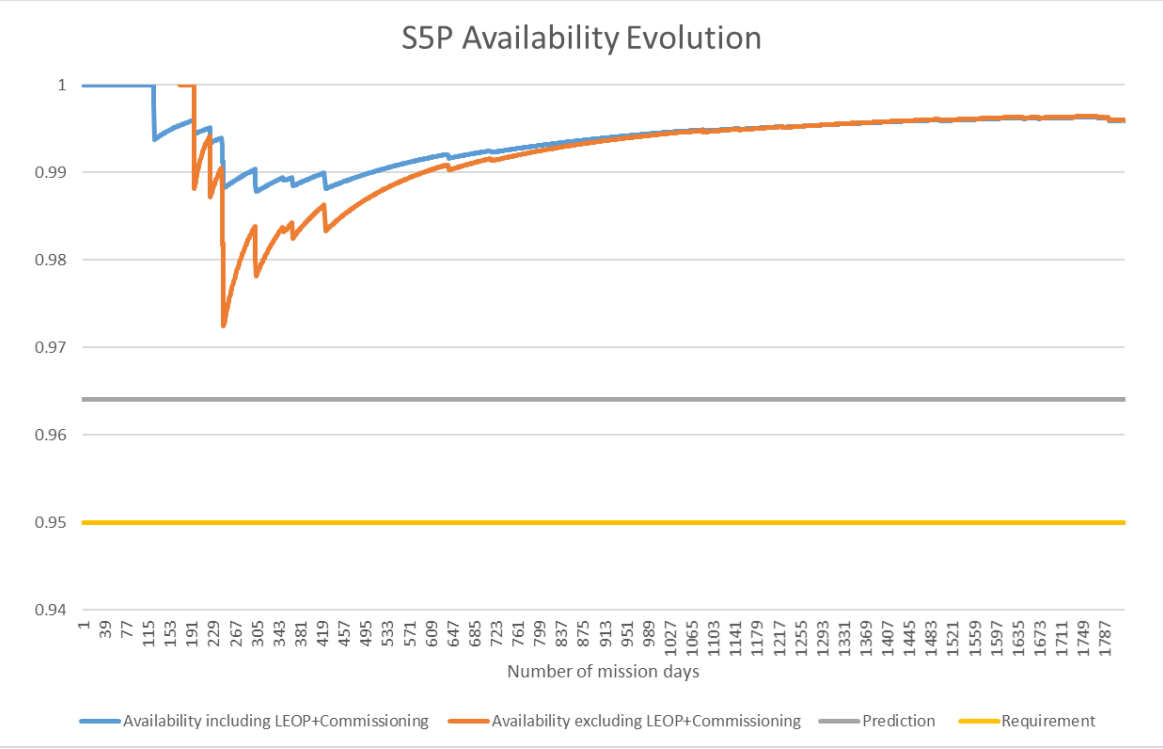
Operational lifetime (Nominal Mission) duration 56979 hrs (6.5 years)

Availability	Required	Measured*	Predicted
S5P	0.95	0.995 ^	0.964



Operational lifetime (Nominal Mission + Commissioning) duration 61362 hrs (7 years)

Reliability	Required	Measured*	Predicted
Platform	0.75	1 ^	0.916
TROPOMI	0.87	1 ^	0.937
S5P	0.65	1 ^	0.858

* Nominal mission not ended.

^ calculated until Oct 2022

PLS Satellite In-orbit Status - Conclusions

Post Launch Support Reporting:

All reporting processes running smoothly

-> PLS Performance Reporting is **nominal**

Satellite Long-Term Functional Performance:

The subjective high-level functional performance assessment looks excellent. No long-term performance degradation or trends have become apparent over 4+ years of routine operation, based on the Industry Performance analyses:

-> Satellite long-term in-orbit performance is **excellent**

Satellite Anomalies Status:

No major anomalies since 2019, only 1 AR currently open for tracking of recurrences.

-> Satellite Anomaly processes & Anomaly Status are **nominal**

Post-Launch Support (PLS) Status is nominal