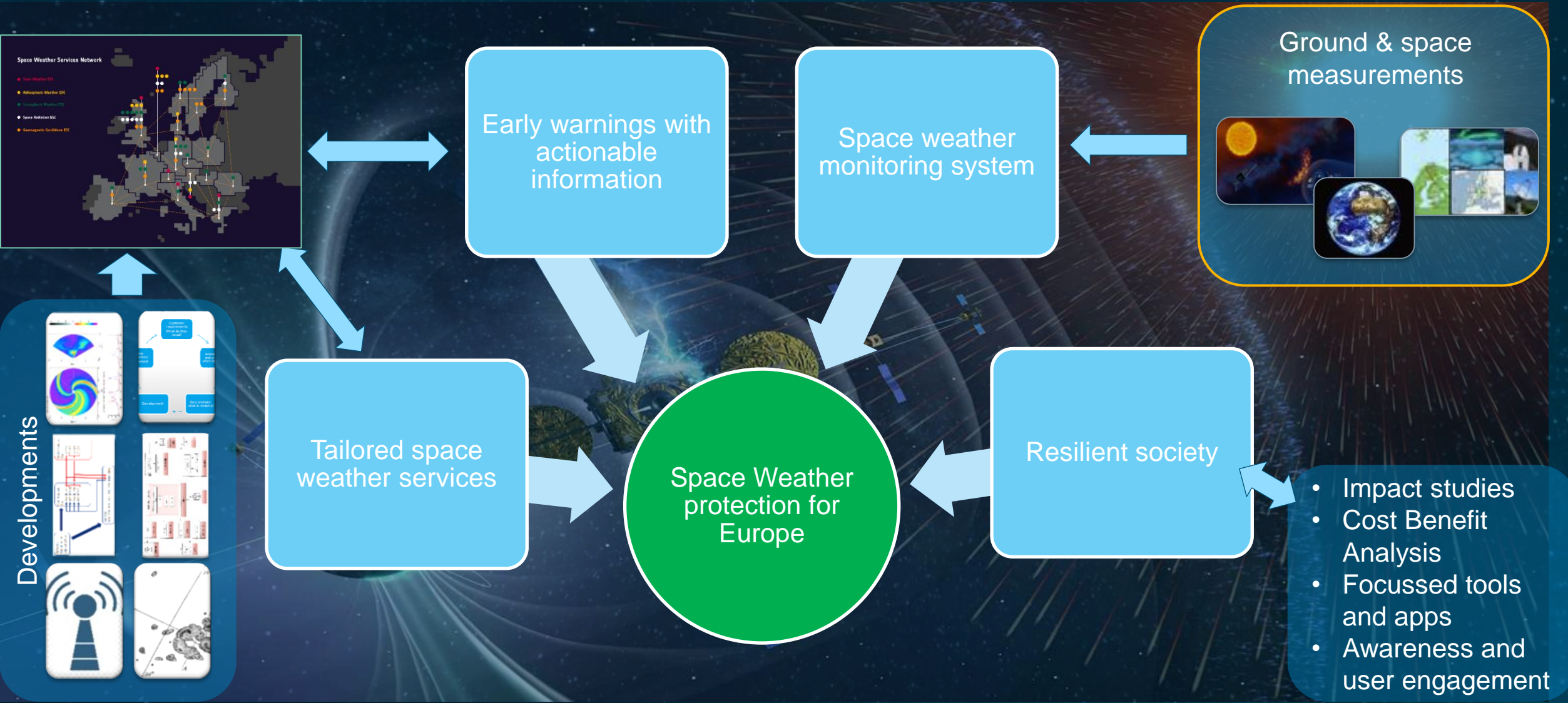


ESA's Distributed Space weather Sensor System (D3S) – Missions and Data

Melanie Heil,
Space Weather Space Segment Coordinator,
ESA/ESOC

Living Planet Symposium, 2025, Vienna

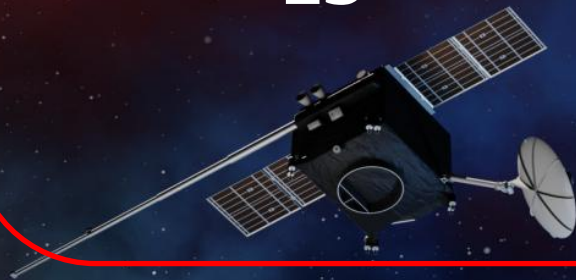
24/06/2025



ESA's Enhanced Space Weather Monitoring System

Missions to solar wind

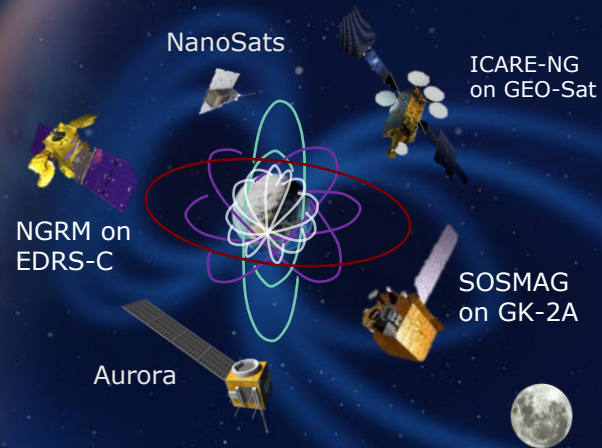
L5



Forecasting
&
Event
detection

L1

Impact & state monitoring



Ground based
measurements

+
D3S:

- Hosted Payloads
- Small missions

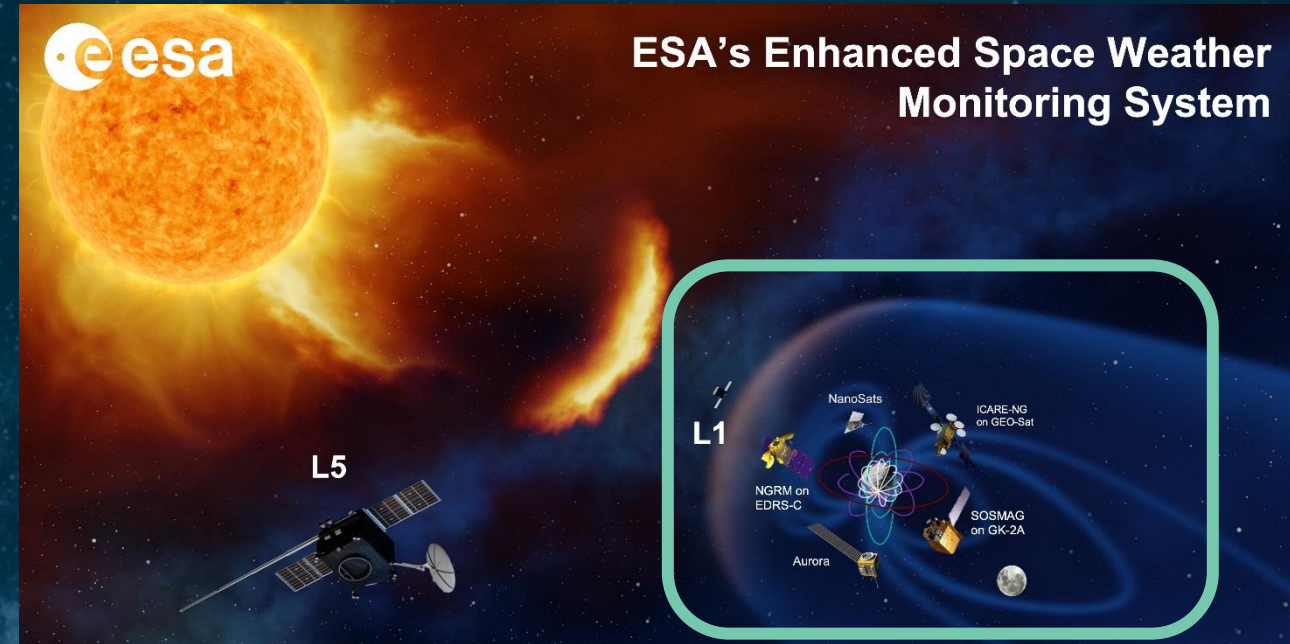
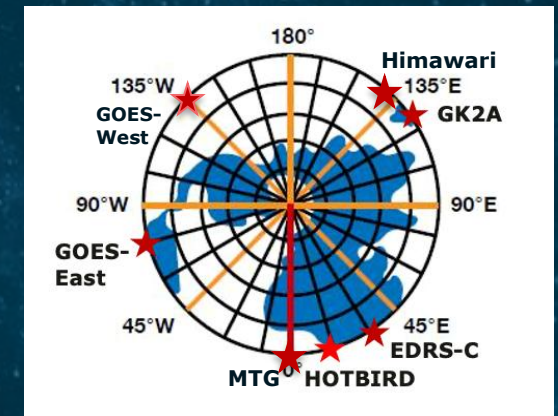
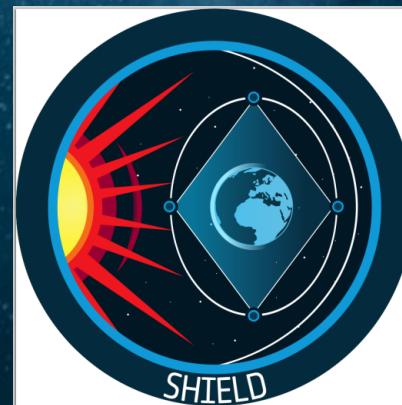
Distributed Space weather Sensor System (D3S)

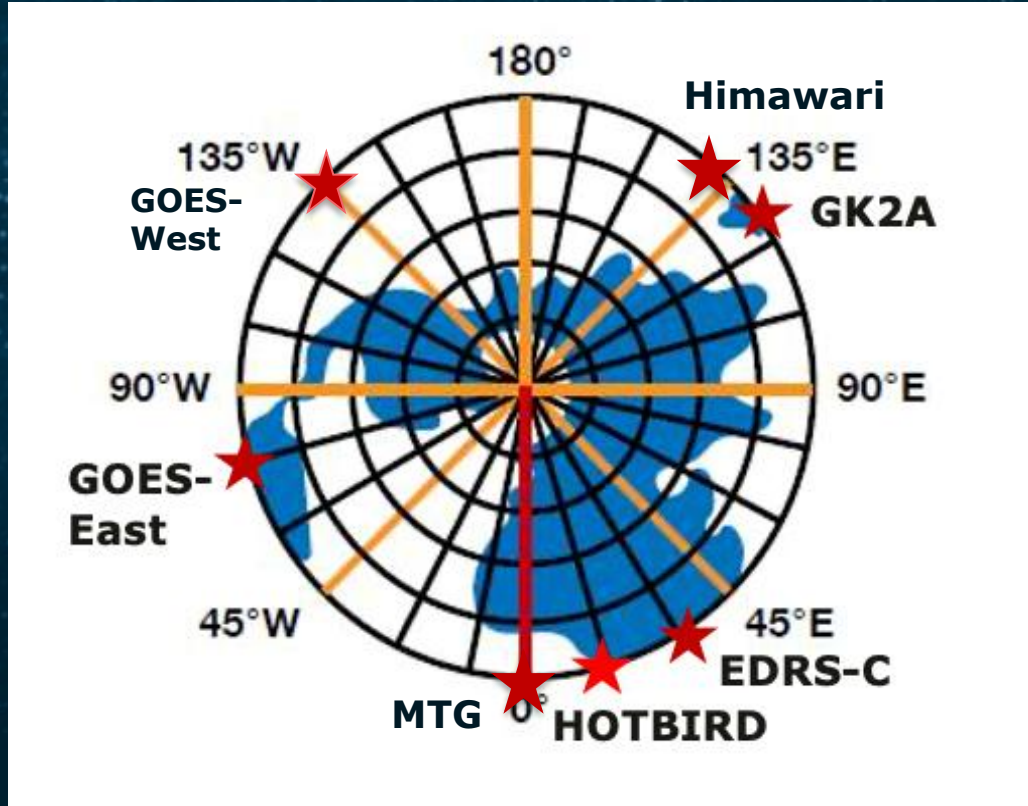
Objective

- Monitoring of the "Earth space" environment
- Near-real time data for operational applications
- Cost effective implementation through small missions and data buy from commercial actors

Missions Overview:

- Aurora
- Nanosat constellations
- SWORD
- SHIELD
- Hosted Payloads
- ERSA, Lunar Pathfinder



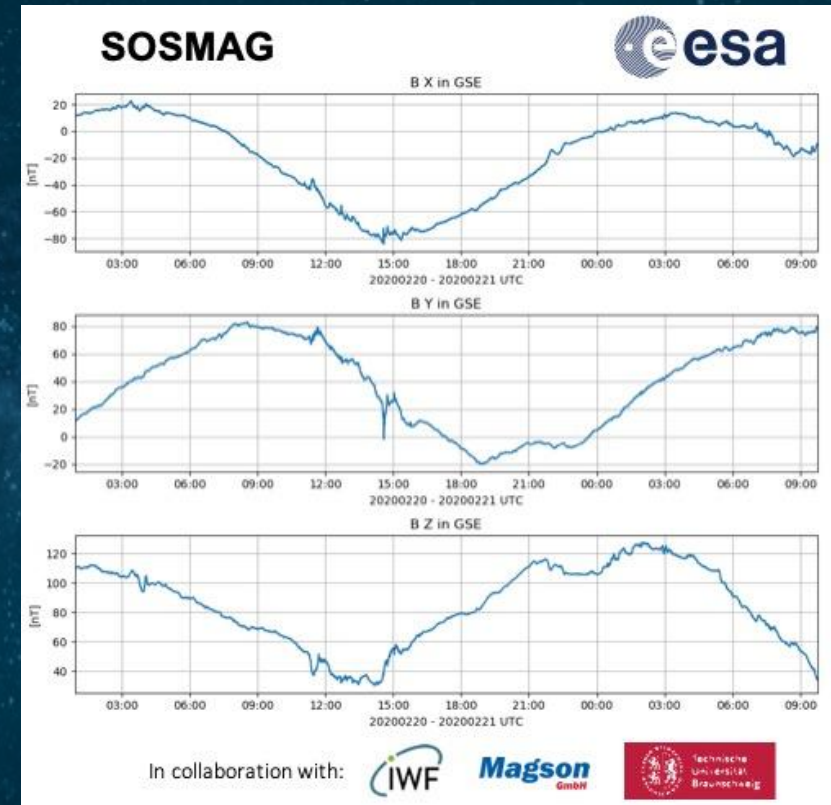


Continuation through SOSMAG-II on GK5 in planning!

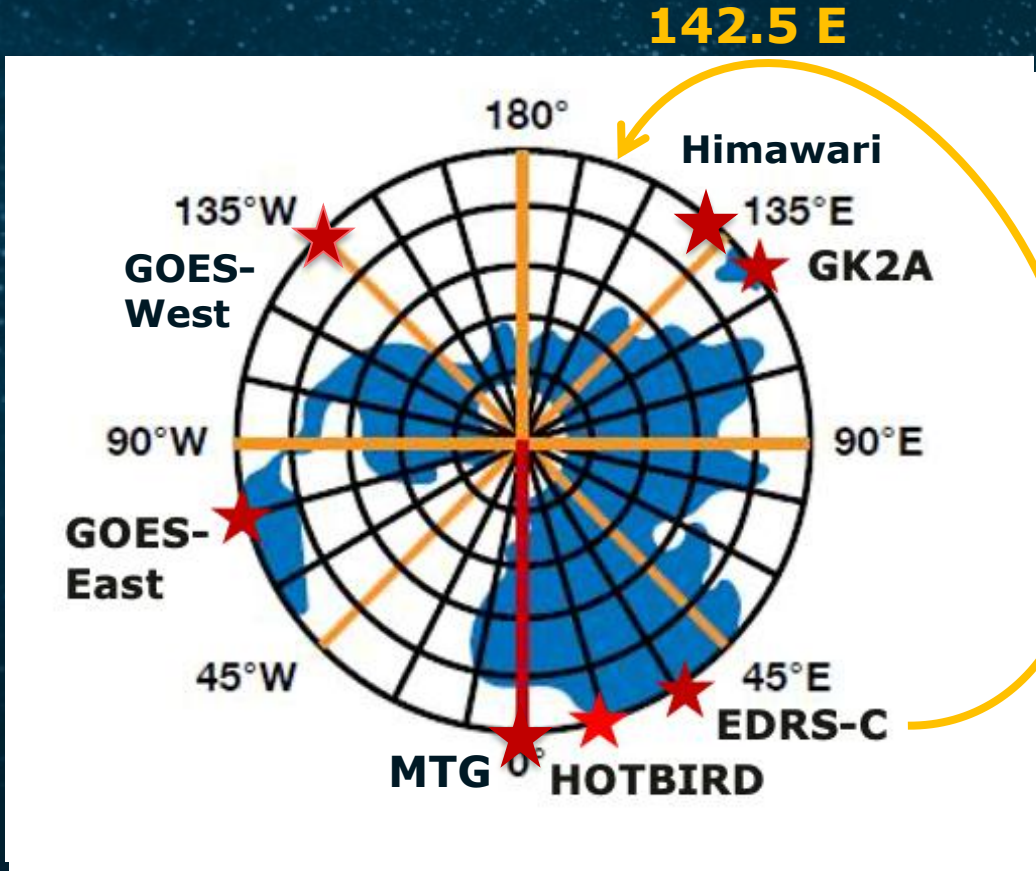
SOSMAG on GK2A:

- Launched end 2018
- near-real time magnetic field measurement in GEO

<https://swe.ssa.esa.int/sosmag>



Active hosted payload missions

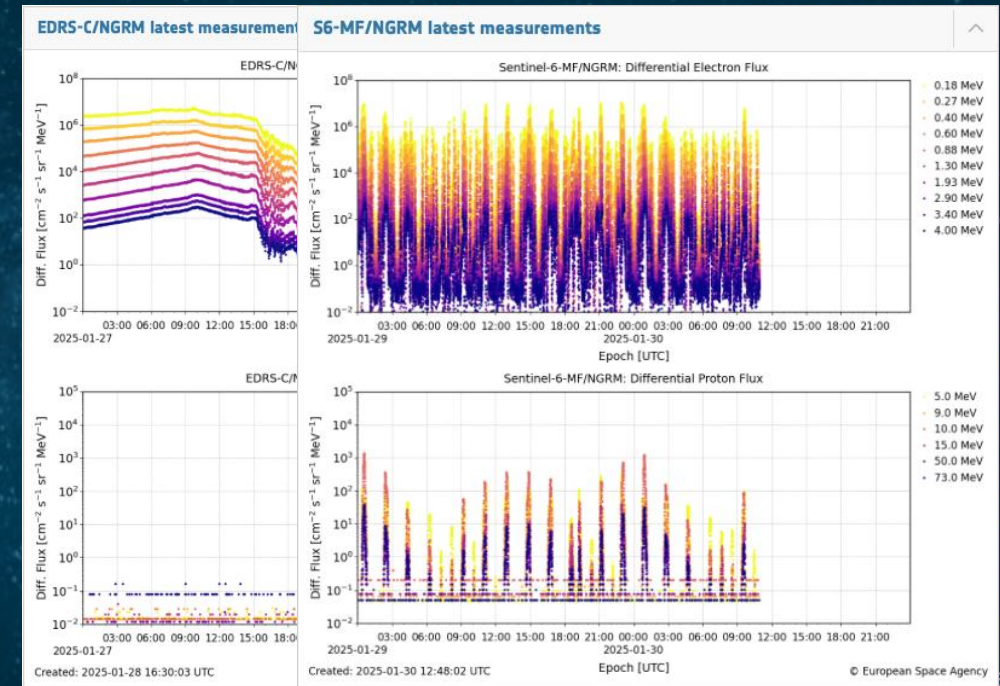


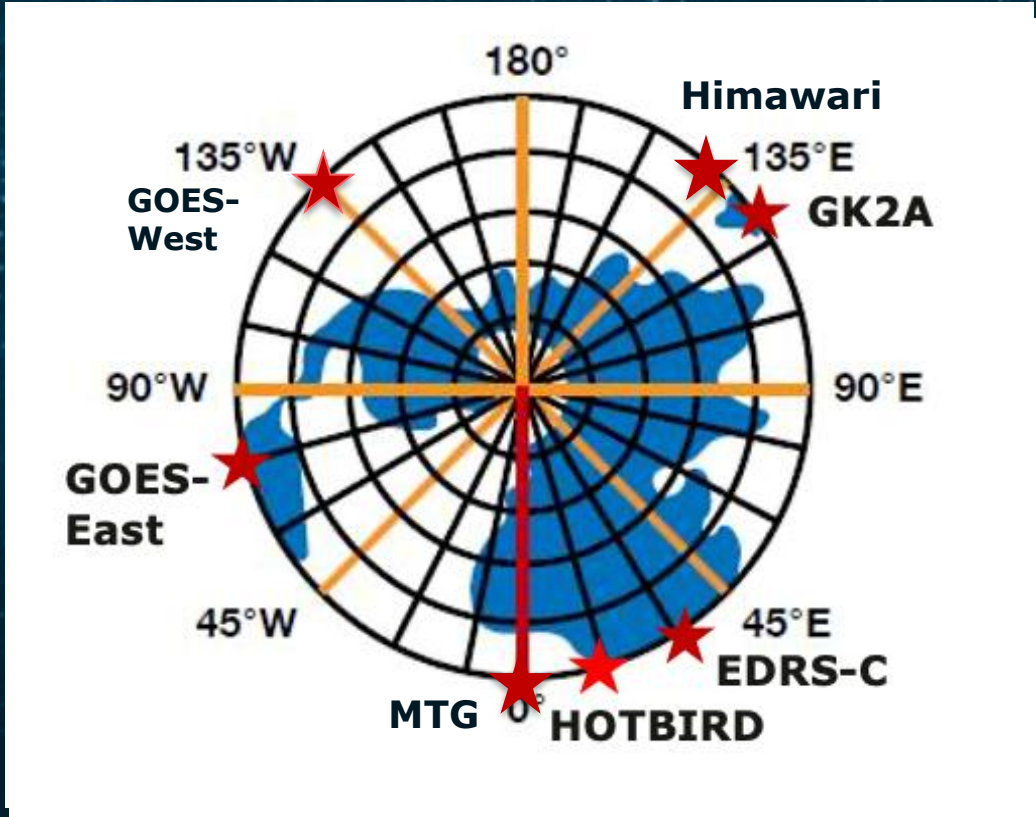
MTG-I1 data to be released this summer!

NGRM on EDRS-C:

- Launched mid 2019
- Near-real time energetic particle flux measurements (electrons: 0.15-3 MeV, protons: 4-200 MeV) in GEO
- Also, on-board Sentinel-6-A (and -B)!

<https://swe.ssa.esa.int/ngrm>

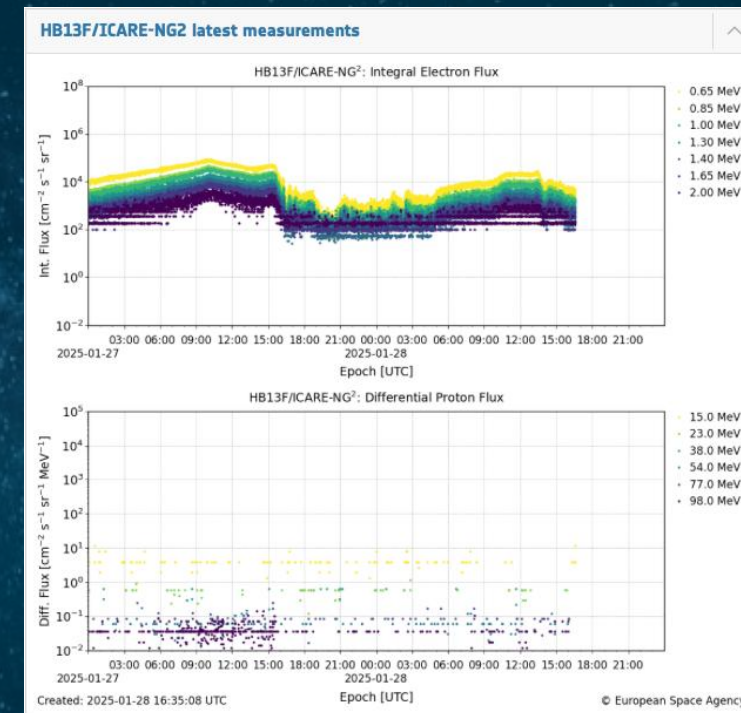




ICARE-NG on HOTBIRDs:

- Launched fall 2022
- Near-real time energetic particle flux measurements (electrons: 0.5-2.5 MeV, protons: 10-200 MeV)

<https://swe.ssa.esa.int/icare-ng>



Space Weather – D3S – Hosted Payloads

- Several hosted payload missions ongoing and additional in implementation
- Many HP missions in intern. collaboration coming up: radiation monitors on all Meteorological missions (6xMTG, 6xMetop-SG)
- Level 1 data provided through space weather portal <https://swe.ssa.esa.int/esa-space-weather-data>
- Future plans:
 - Continued cooperation with KMA on GEO space weather suite: SOSMAG-II to fly on GK5 in 2029/30
 - High energy particle instrument for NOAA L1 mission
 - Potential collaboration on Korean L4 mission and
 - In-orbit demonstrations of new instruments on commercial (LEO) missions

Instrument	Hosting flight	Orbit (altitude in km / longitude in °)	Launch Date	Mission Lifetime
SOSMAG	GK-2A	GEO (128° East)	2018	10 years
NGRM	EDRS-C	GEO (31° East)	2019	10 years
NGRM	Sentinel-6-A	LEO (1336 km, 66° incl)	2020	7 years
ICARE-NG	HB 13F	GEO (13° East)	2022	10 years
ICARE-NG	HB 13G	GEO (13° East)	2022	10 years
NGRM	MTG-I1	GEO (0°)	2022	8.5 years
NGRM	MTG-S1	GEO (0°)	2025 (planned)	8.5 years
NGRM	MOS A1	LEO (~830 km, SSO)	2025 (planned)	7 years
NGRM	MOS B1	LEO (~830 km, SSO)	2026 (planned)	7 years
NGRM	MTG-I2	GEO (0°)	2026 (planned)	8.5 years
NGRM	Sentinel-6-B	LEO (1336 km, 66° incl)	2026 (planned)	7 years
MiniRMU	Lunar Pathfinder	Lunar (elliptical)	2026 (planned)	8 years
ERSA	Lunar Gateway	Lunar (NRHO)	2027 (planned)	5+ years
SOSMAG-II, next ICARE-NG, NGRMs...	GK5, MTGs, MOSs, and TBDs	GEO, LEO, and TBDs	2026+	

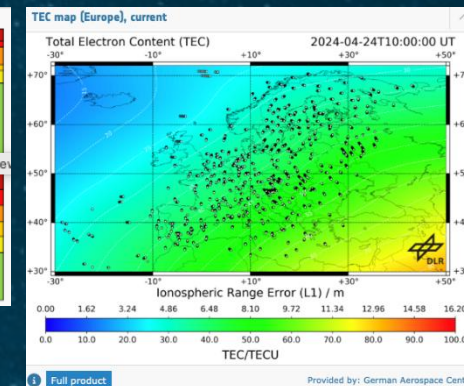
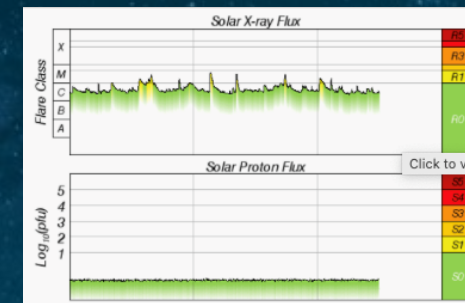
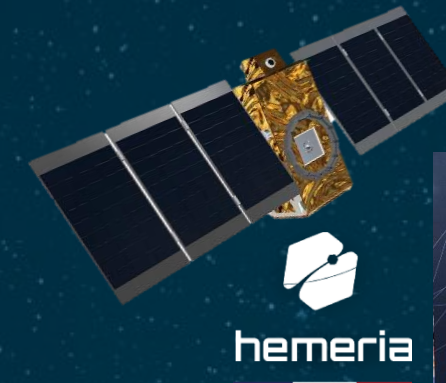
D3S: Space Weather Nanosatellites

- **Objective:**
 - **Cost effective implementation of D3S LEO measurement requirements (see SWE PSD)**
 - **To demonstrate the capability of very small platforms to provide data with sufficient reliability, availability and low latency for use in operational applications**
 - **To assess potential business case of a commercial constellation with ESA/EC as (anchor) customer**
- **Two Nanosatellite missions were funded in 2022/23**



Space Weather – D3S – 1st Nanosat - SWING

- Consortium:
 - Prime: Hemeria (FR)
 - sub-cos: Eidel (NO), Isaware (FI), Syntony (FR), Planetek (IT)
- Addressing the needs of ionospheric space weather services
- Mission design:
 - LEO SSO (~550 km), local time TBD, 3 years lifetime, high reliability & availability (90%), low latency (<60 minutes)
- Instruments:
 - Radiation monitor - DREAM,
 - Langmuir probe - mNLP,
 - GNSS radio occultation - Aquila,
 - X-ray flux monitor – XFM-NS



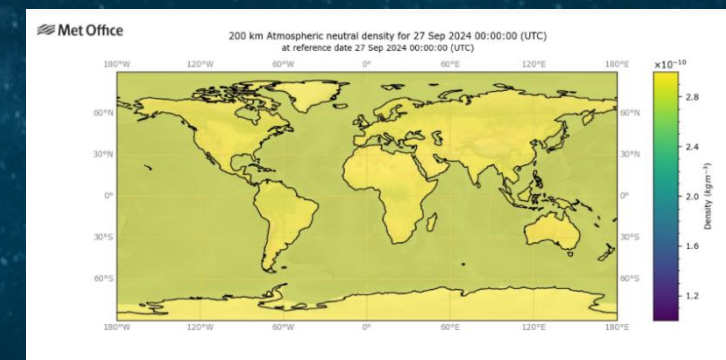
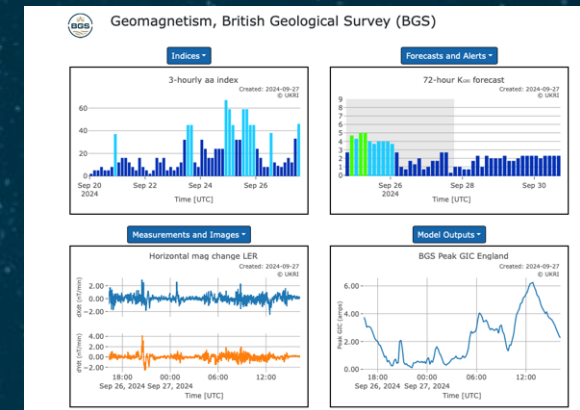
Service to become available early 2027 through Space Weather Portal



Space Weather – D3S – 2nd Nanosatellite - SAWA



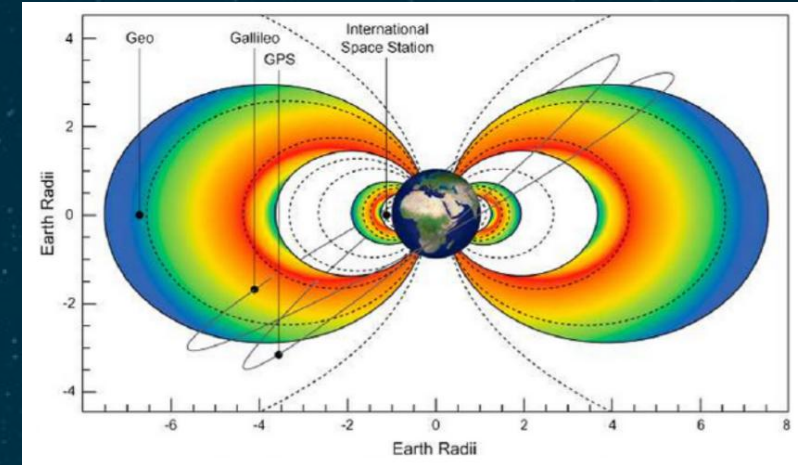
- Phase 0/A1 study contract signed:
 - Prime: Creotech Instruments SA (PL)
 - Subs: CBK PAN (PL), WUST (PL)
- Addressing space weather data complementary to 1st mission, e.g.:
 - LEO magnetic field,
 - Radiowaves – electric field
 - Neutrals density (atomic oxygen)
 - Optional: Medium energy particle fluxes
- LEO SSO (~550 km), local time TBD, 3 years lifetime, high reliability & availability (90%), low latency (<60 minutes)
- Planned schedule: launch end 2028



Objective: Radiation belt monitoring from "GTO":



- Cross-section of inner and outer belt at least **every 5 hours** (constellation of two satellites)
 - Spinning satellite for determination of **pitch angle distribution** allowing extrapolation to all Earth orbits
 - **Latency of <60 minutes**, goal of 5 minutes
- Comprehensive instrument suite covering particles of energies (electrons 1 keV to 8 MeV, protons 0.1 keV to 1 GeV), complemented with Magnetometer, Plasma Analyser, Langmuir Probes
 - Small OTS satellite <200 kg, 3 years lifetime, targeted **launch in 2031** – regular replenishment for operational system
 - ESA CDF completed, parallel pre-Phase A study with industry on going, Phase A ITT planned in September



Continuous monitoring of the Auroral Oval

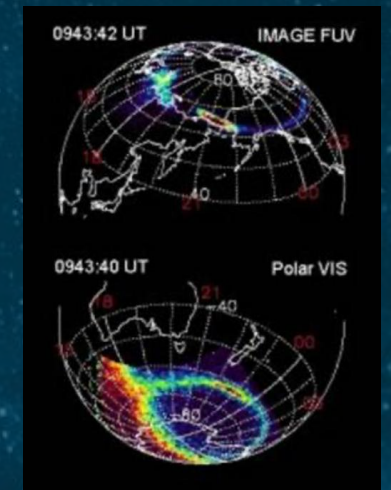
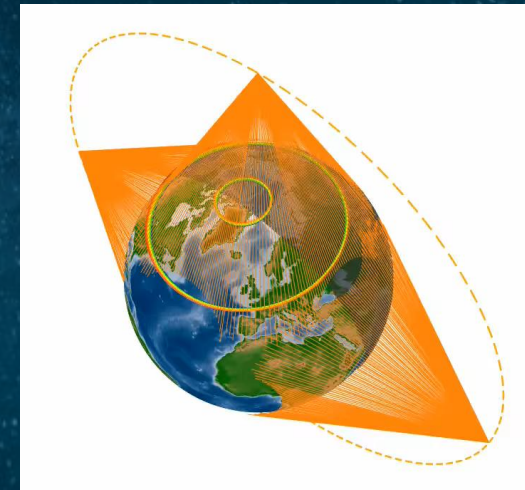
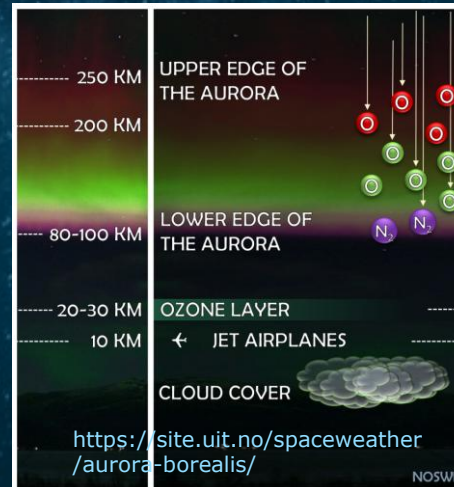
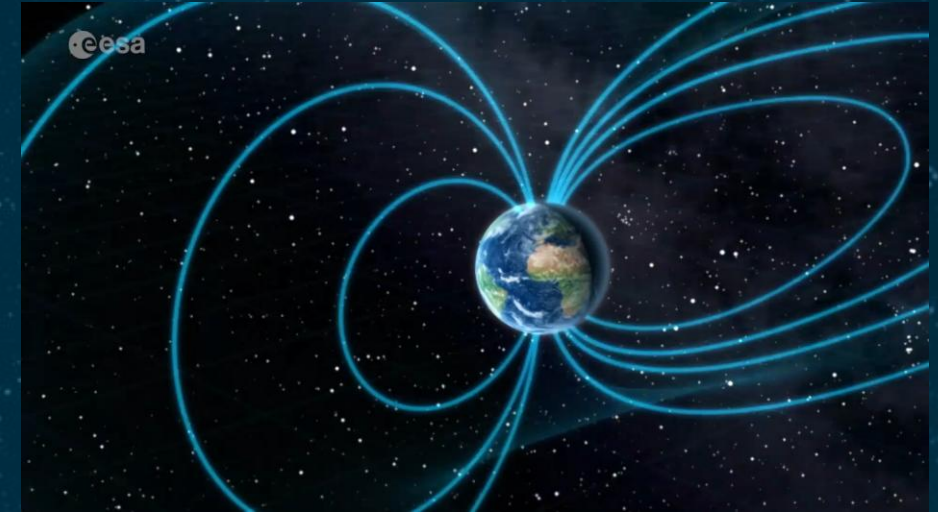
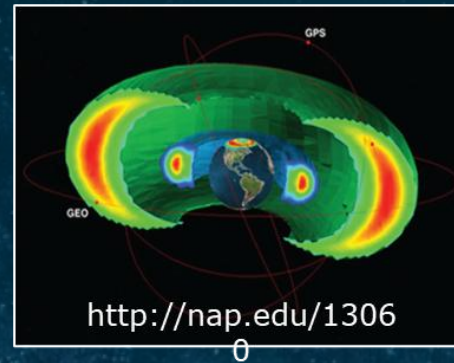
- Small Satellite demonstration mission (Aurora-D) in preparation of constellation (Aurora-C)
- Aurora-C: 4-satellites with 90 degree phasing
- Aurora-D: single satellite launch planned in 2031

Mission orbit & satellites

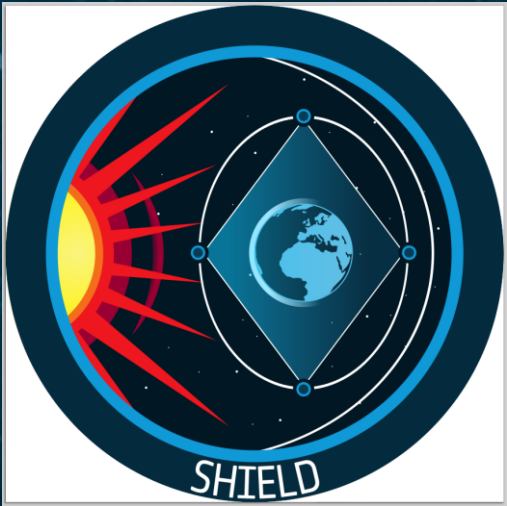
- Medium Earth Orbit @ ~6500 km, circular, drifting
- ~210 kg incl. instrument
- ~350 W nominal operation (TBC)
- S-band communication, ~360 kbps downlink rate

Instruments

- Auroral Optical Spectral Imager (AOSI) - **Intensities of multiple lines (6) between 350-1100nm**
- Aurora far UV Imager (AUI) - **1 (2) spectral bands within Oxygen lines or LBH-L and LBH-S**
- Radiation Monitor and Magnetometer (RadMag) - **Energy distribution proton flux (2-500 MeV) and electron flux (0.3-5 MeV), Heavy ions particle count, 3d- magnetic field vector**
- Full auroral oval image refresh rate ~ 20-30 minutes
- SSD 30km at nadir, 200km at edge



Objective: 2 hours advanced warning time for CME arrival



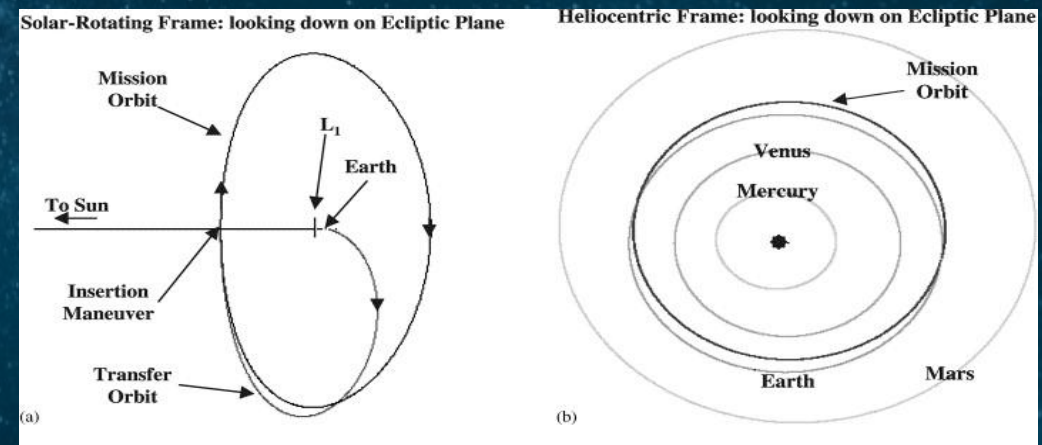
- Shield mission shall provide low latency (5-10 min) in-situ observations of solar wind and interplanetary magnetic field ahead of Earth enabling final Earth impact prediction with a lead time equaling or exceeding 2 hours*
* for CMEs up to 2000km/s
- Shield mission shall provide in-situ solar wind observations for space weather modelling and scientific research
- Shield mission shall measure high energy solar particles allowing detection of Solar Energetic Particle events

Payloads:

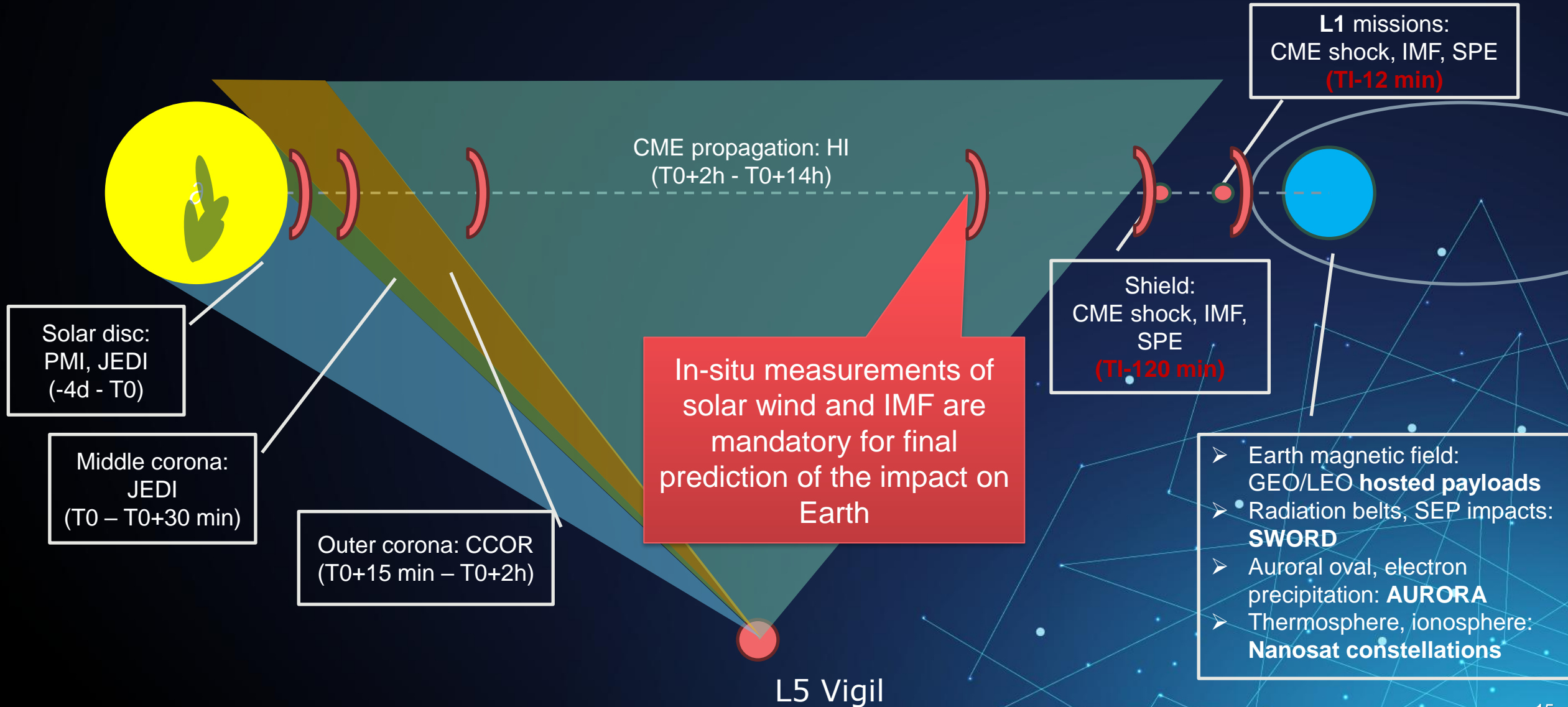
- Plasma Analyser
- Magnetometer
- Radiation Monitor

ESA CDF study started June 3rd!
Mission targeted for launch 2031

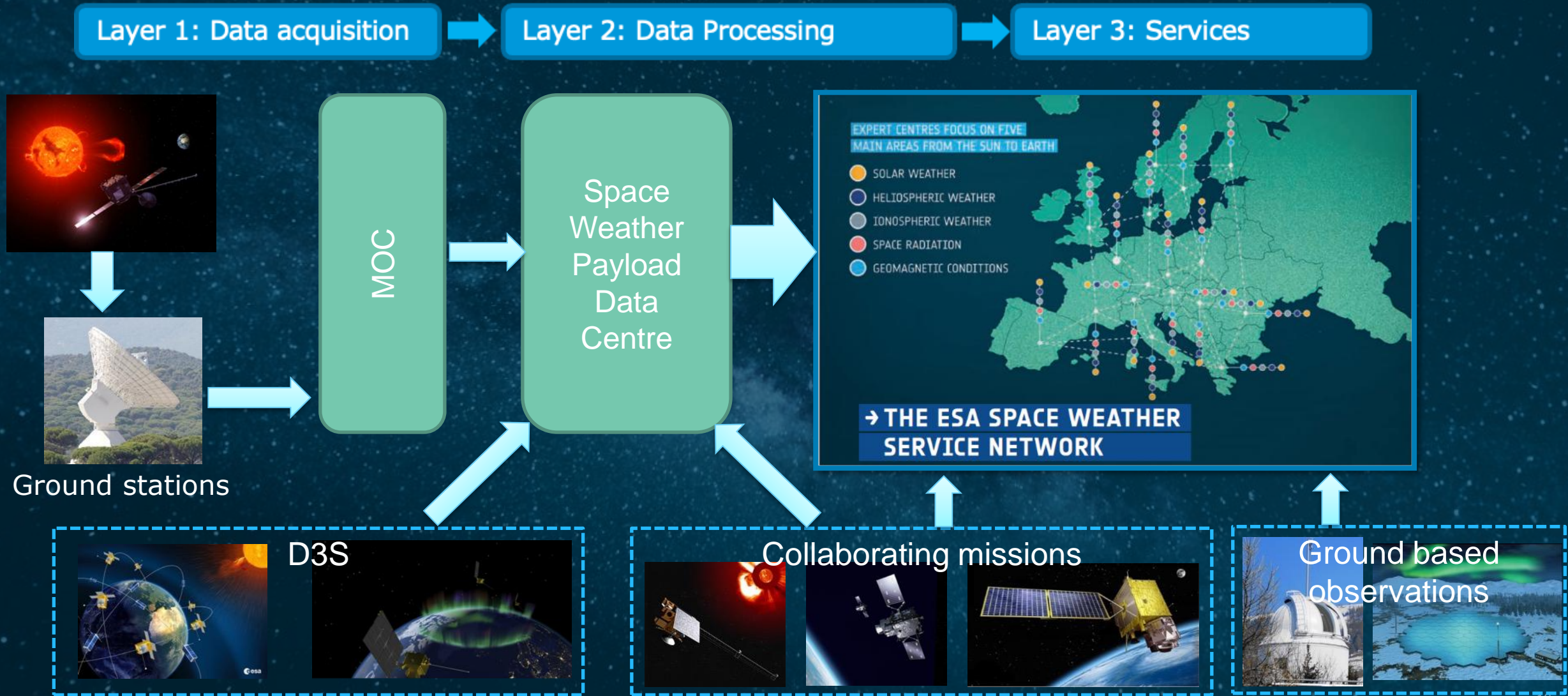
Image: O.C.St. Cyr et al,
[https://doi.org/10.1016/S1364-6826\(00\)00069-9](https://doi.org/10.1016/S1364-6826(00)00069-9)



Goal: End-to-end Space Weather Monitoring



Space Weather services to end users

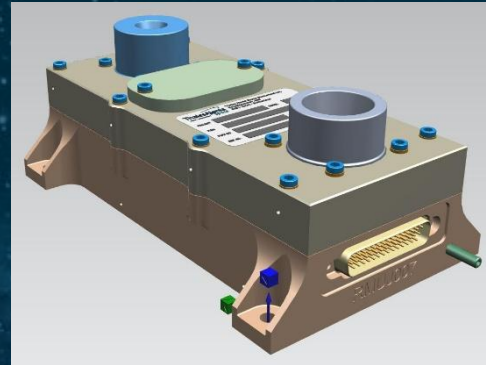


Thank you!



- MiniRMU on Lunar Pathfinder

- Monitoring of high energy electrons and protons (sensors identical to NGRM)
- Planned launch in late 2026



- ERSA on Lunar Gateway

- Comprised of several radiation monitors (NGRM, ICARE-NG, SREM), dosimeters (Hardpix, EADs) and magnetometers (MAGIC)
- Close collaboration with NASA solar physics HERMES payload
- Planned launch NET 2027

