ESA Space Weather Activities

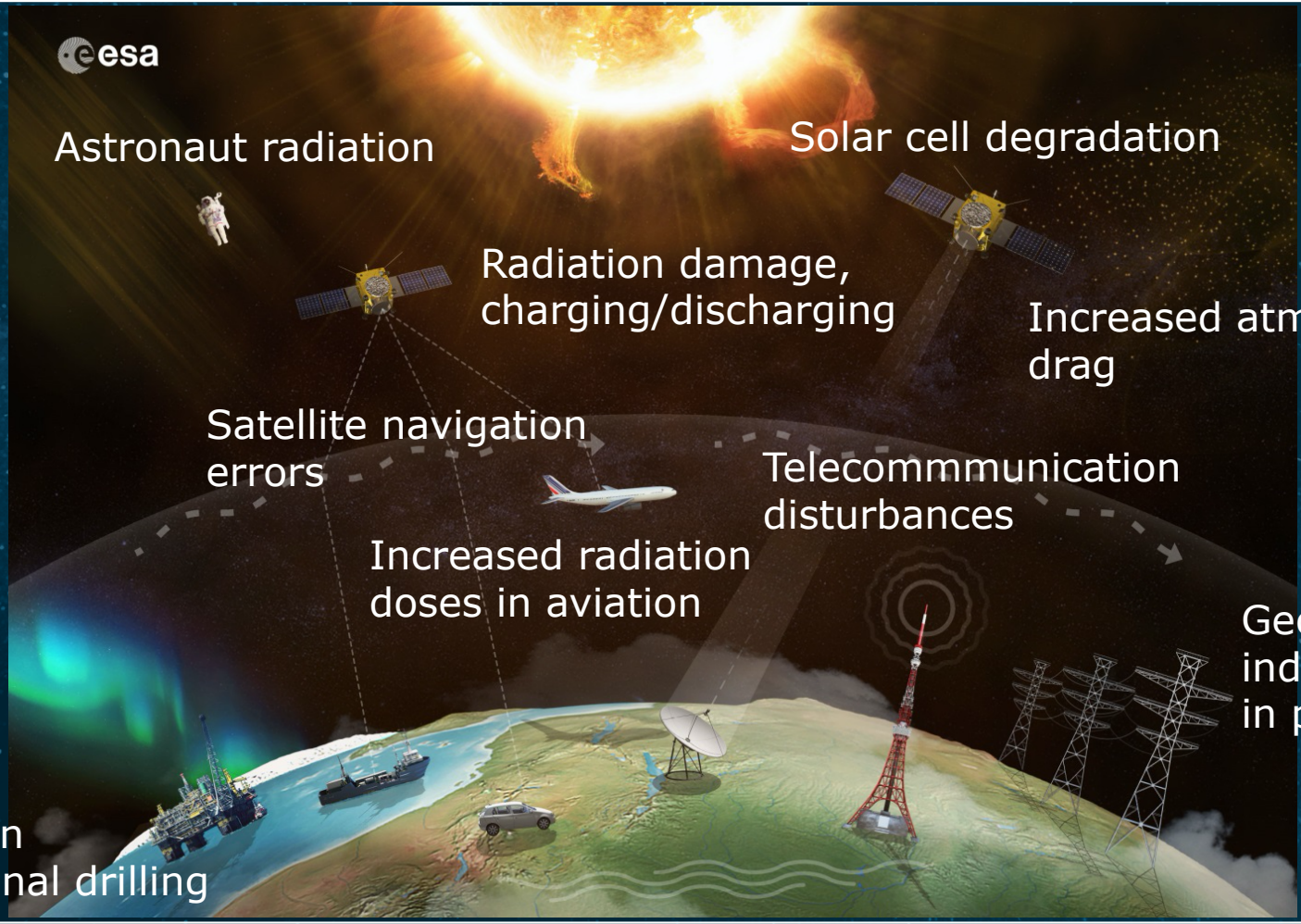
Juha-Pekka Luntama

SpaceTech Alumni Symposium

23.07.2021


esa
Space Safety Programme
Protection of our planet, humanity,
and assets in space and on Earth from dangers originating in Space

Space weather impacts on infrastructure



SWE IMPACT ESTIMATE IN 2016 CBA

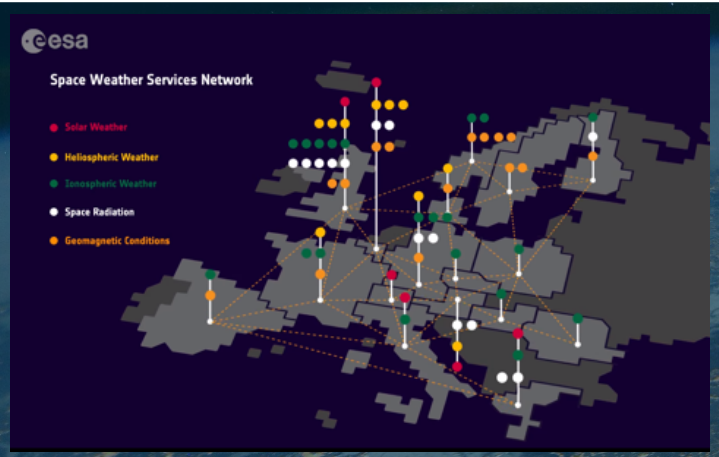
Cost/Benefit	'Do nothing scenario'	'Do ESA scenario'	Value added of ESA services
User domain benefits			
Satellite operations	- €293 M	- €267 M	€26 M
Launch operations (lower bound**)	- €0.3 M	- €0.1 M	€0.2 M
Resource exploitation	- €327 M	- €135 M	€192 M
Power grids operations	- €5,771 M	- €4,546 M	€1,225 M
Aviation	- €3,312 M	- €3,066 M	€246 M
Logistic/Road transport (lower bound**)	- €3,432 M	- €2,888 M	€544 M
Investment benefits GDP impact***	None	€904 M	€904M
Total benefits	**- €13,135 M**	**- € 9,998 M**	**- € 3,137 M**
ESA SWE Programme Costs (CAPEX + OPEX)	**None**	**- €502 M**	**- €502 M**
TOTAL	**- €13,135 M**	**- €10,500 M**	**€ 2,635 M**

Benefit to Cost ratio for SWE is 6.25

COST OF EXTREME EVENT IN 2016 CBA

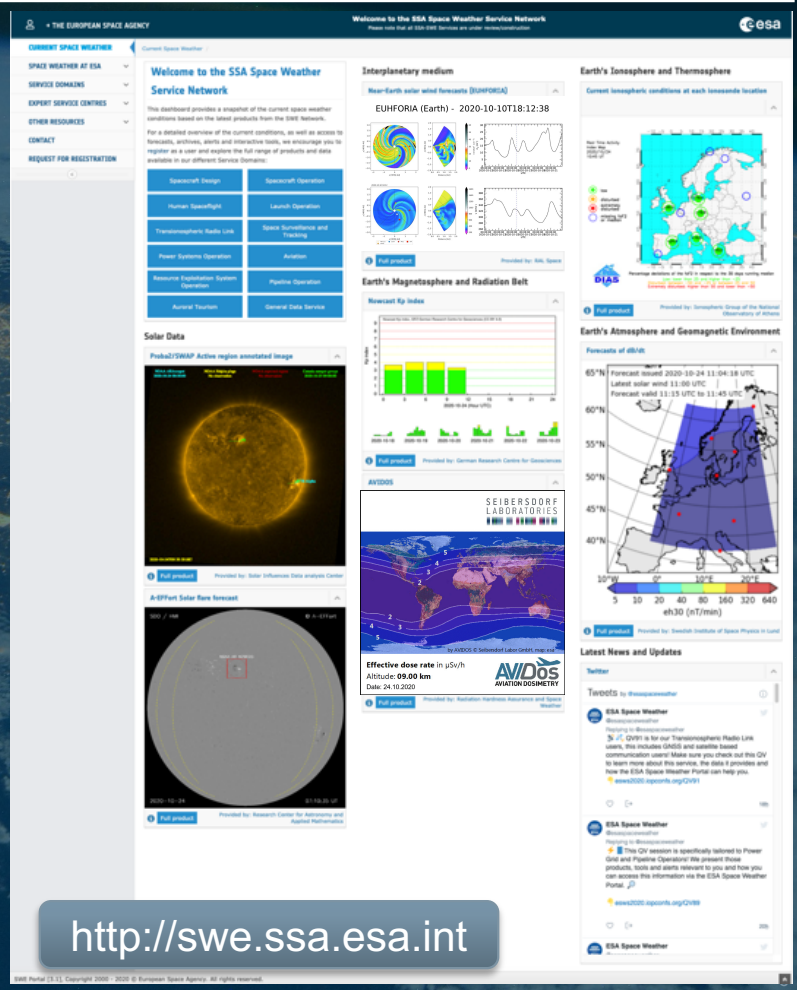
Domain	2016 (year 1)	2024 (year 9)	2032 (year 17)
Spacecraft design and operations	- €912.9 M	- €1,123.2 M	- €1,389.4 M
Launch operations	- €0.008 M	- €0.037 M	- €0.051 M
Aviation	- €6,635.6 M	- €11,139.8 M	- €18,701.5 M
Resource exploitation	- €197.5 M	- €234.9 M	- €279.5 M
Power system operators	- €5,630.5 M	- €6,364 M	- €7,195.2 M
Road & Transportation	- €1,595.4 M	- €1,783 M	- €1,992.8 M
TOTAL	**- €14,971.9 M**	**- €20,644.9 M**	**- €29,558.4 M**

ESA SPACE WEATHER SYSTEM TODAY



Spacecraft Design	Spacecraft Operation
Human Spaceflight	Launch Operation
Transionospheric Radio Link	Space Surveillance and Tracking
Power Systems Operation	Aviation
Resource Exploitation System Operation	Pipeline Operation
Auroral Tourism	General Data Service

- 29 pre-operational services based on >200 products
- European Service Network of >50 Expert Groups
- > 1600 registered users
- > 1.9M hits on service portal monthly
- D3S Hosted payload missions
- Groundbased sensor system enhancements
- Coordinated Communication Protocol



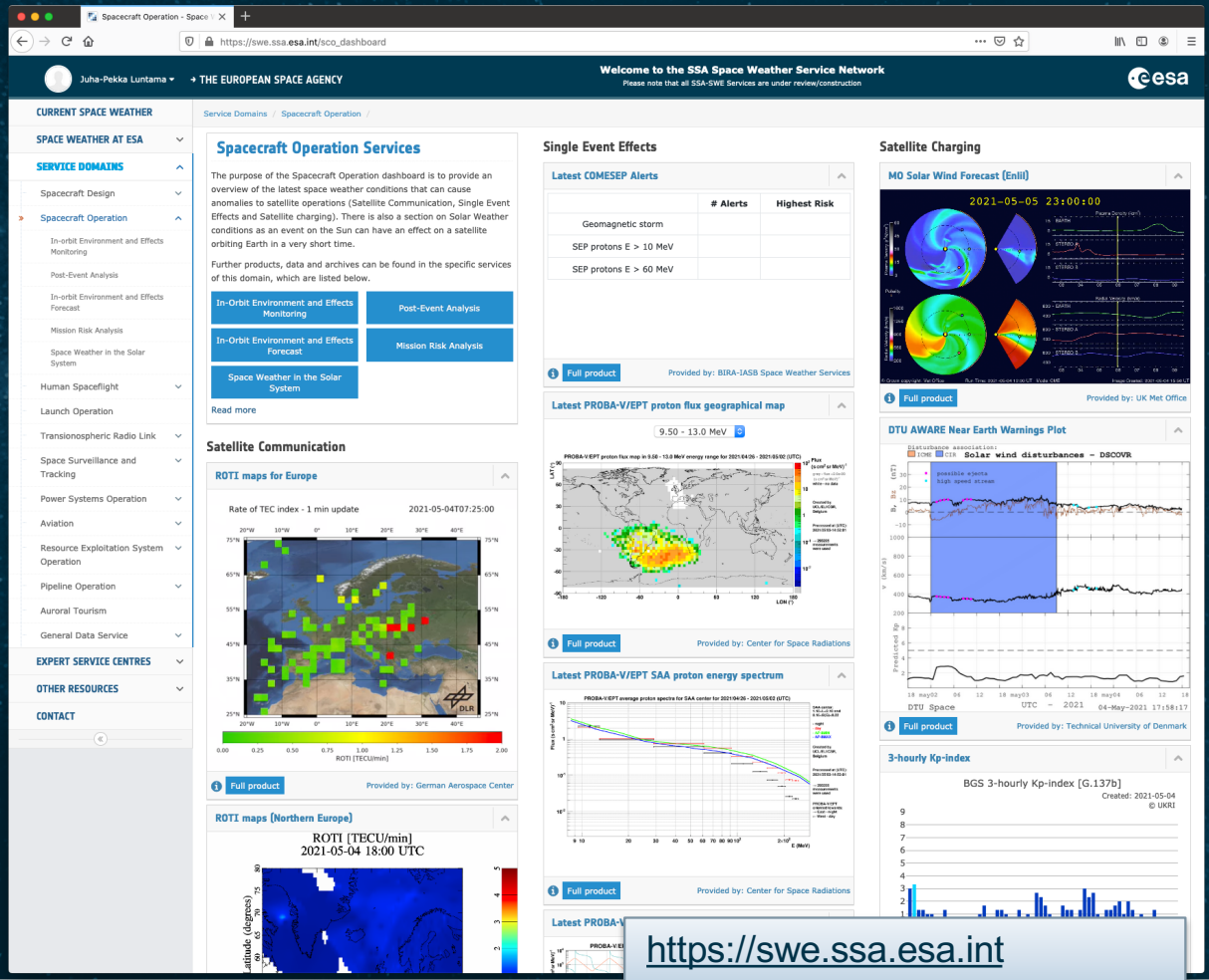
SERVICES FOR SPACECRAFT OPERATORS

Solar activity forecast

SEP alerting

Satellite charging

Ionospheric disturbances



https://swe.ssa.esa.int

In-orbit radiation environment

Space weather in solar system

Post-even analysis

Mission risk analysis

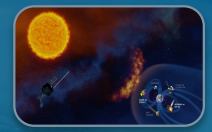
S2P SPACE WEATHER SYSTEM OBJECTIVES

Space Weather Service Network

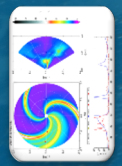
Early warnings with actionable information

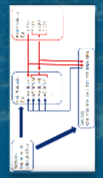
Space weather monitoring system

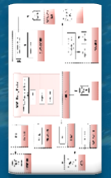
Ground & space

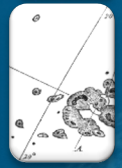


S2P Developments









Tailored space weather services

Space Weather protection for Europe

Resilient society

- User engagement
- Impact studies
- CBAs
- Focussed tools and apps
- Awareness

ENHANCED SPACE WEATHER MONITORING

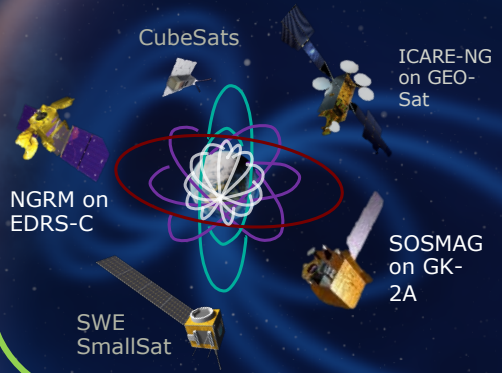
Missions to solar wind

L5

L1

Forecasting
&
Event
detection

Impact & State Monitoring



Ground based measurements

+

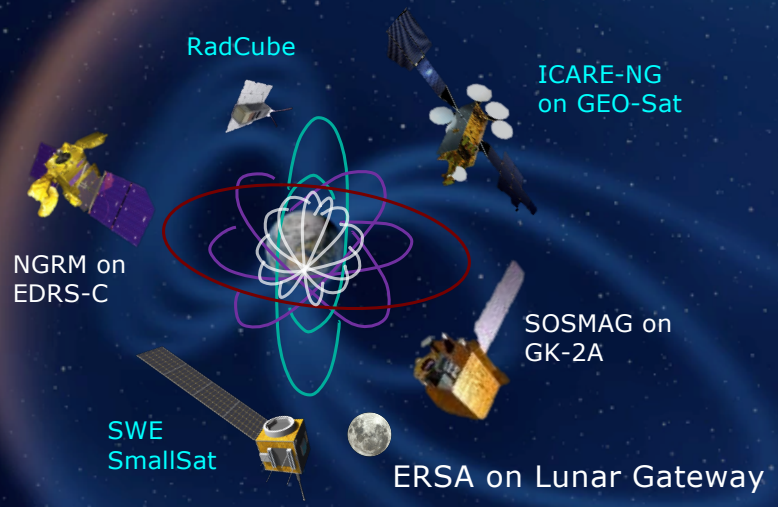
D3S:

- Hosted Payloads
- SmallSat mission

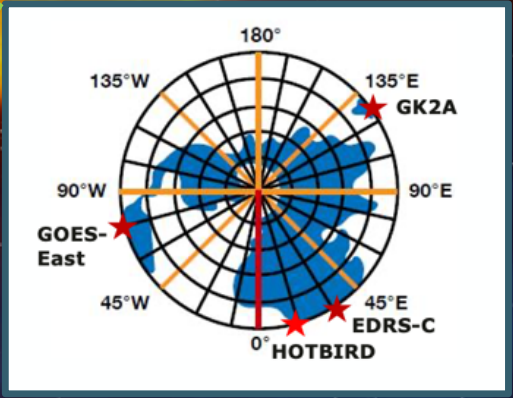
DISTRIBUTED SPACE WEATHER MONITORING SYSTEM (D3S)

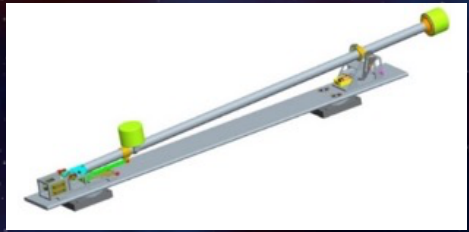
Monitoring of SWE impact near Earth:

- Magnetic field, neutral/charged particle, plasma and micro-particle environment measurements, auroral imaging, …:
  - ➢ Hosted Payloads
  - ➢ Dedicated Small/CubeSats
  - ➢ LEO/MEO/HEO/GEO
  - ➢ Ground based observations



HOSTED PAYLOAD ACHIEVEMENTS

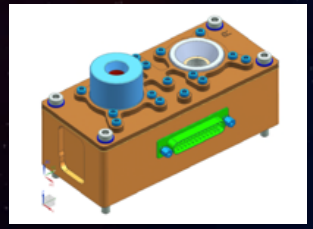




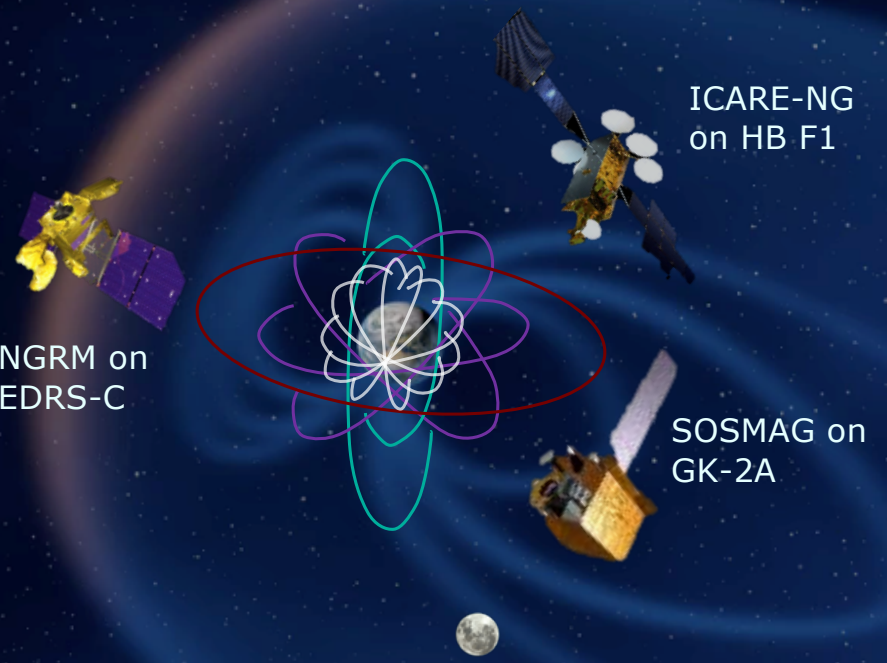
SOSMAG
GK2A 2018

ICARE-NG
HOTBIRD™ F1
2022 + ERSA on Lunar Gateway 2023

NGRM
EDRS-C 2019
(as RMU on MTG, Metop-SG, Sentinel-6,...)



MiniRMU
Lunar Pathfinder 2023



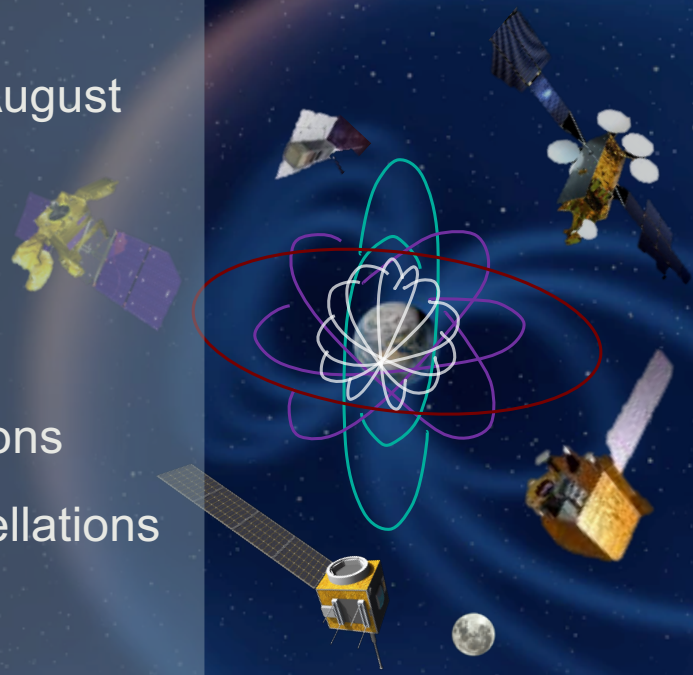
HOSTED PAYLOADS – NEXT STEPS

S2P P1

- Hosted payload radiation monitor in LEO
- Development of miniaturised radiation/magnetic field instrument package
  - ➢ Base on RadCube IOD to be launched in August

S2P P2

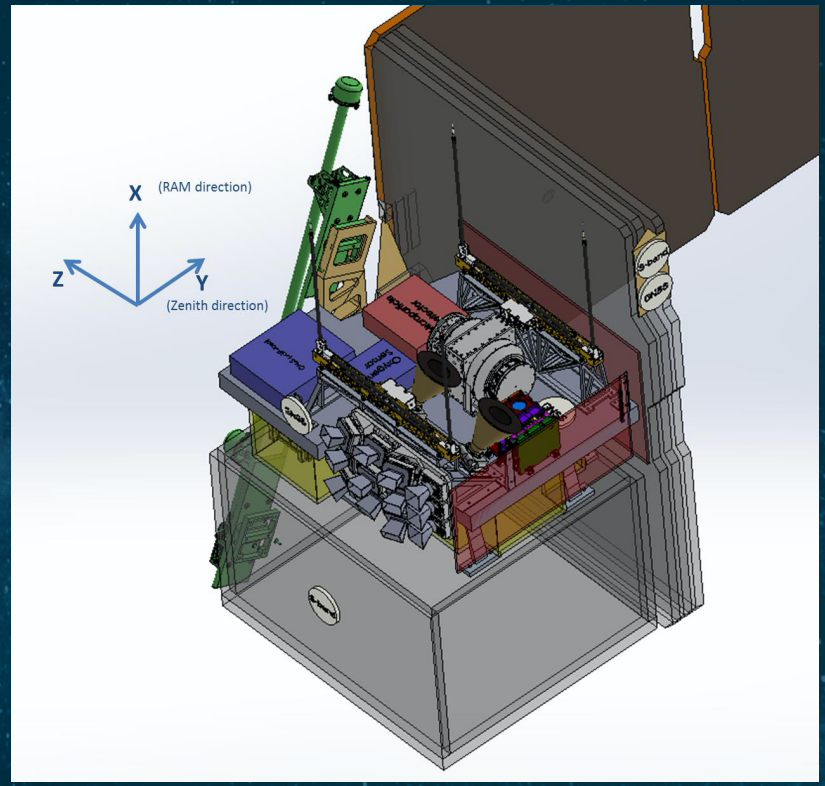
- Magnetometer in GEO at European Longitudes
- In-situ package for MEO s/c
- Radiation monitors on s/c in undersampled regions
- Environment monitoring package in large constellations
- Continuous radiation monitoring in Lunar orbit
- …



D3S SMALLSAT MISSION STUDY

SWE SmallSat Phase A/B:

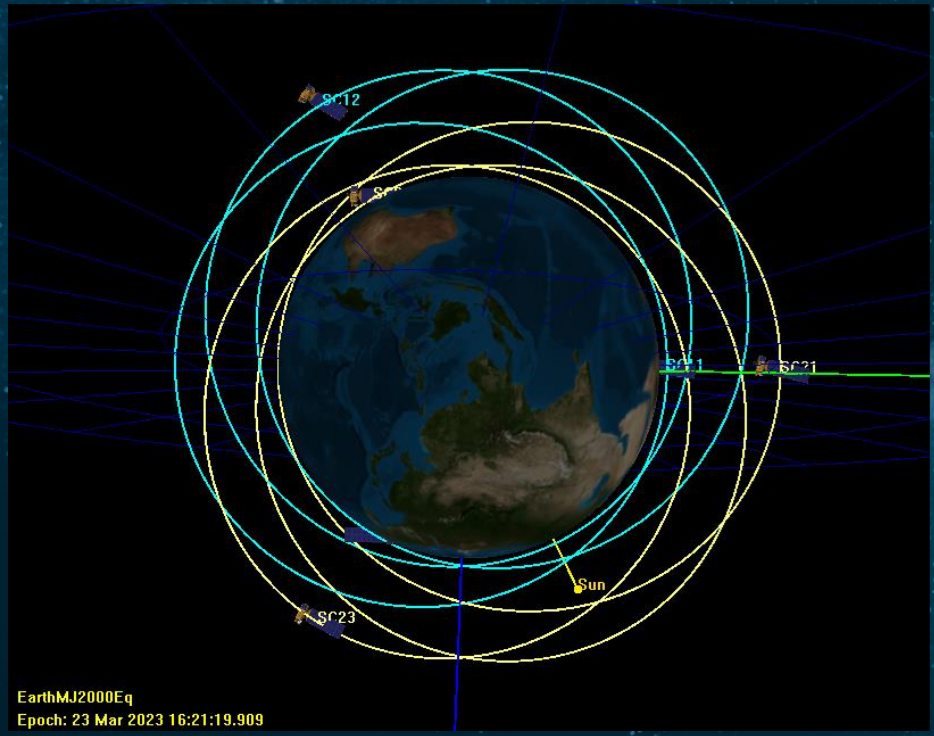
- Continuous auroral oval monitoring and multi-point in-situ measurements of Earth's magnetosphere, ionosphere and thermosphere
- Payload candidates:
  - **WFAI (optical & FUV)**
  - Magnetometer
  - Radiation Monitor
  - Multi-Needle Langmuir Probe
  - Plasma Analyser
  - Oxygen Sensor
  - GNSS receiver
  - Microparticle Detector

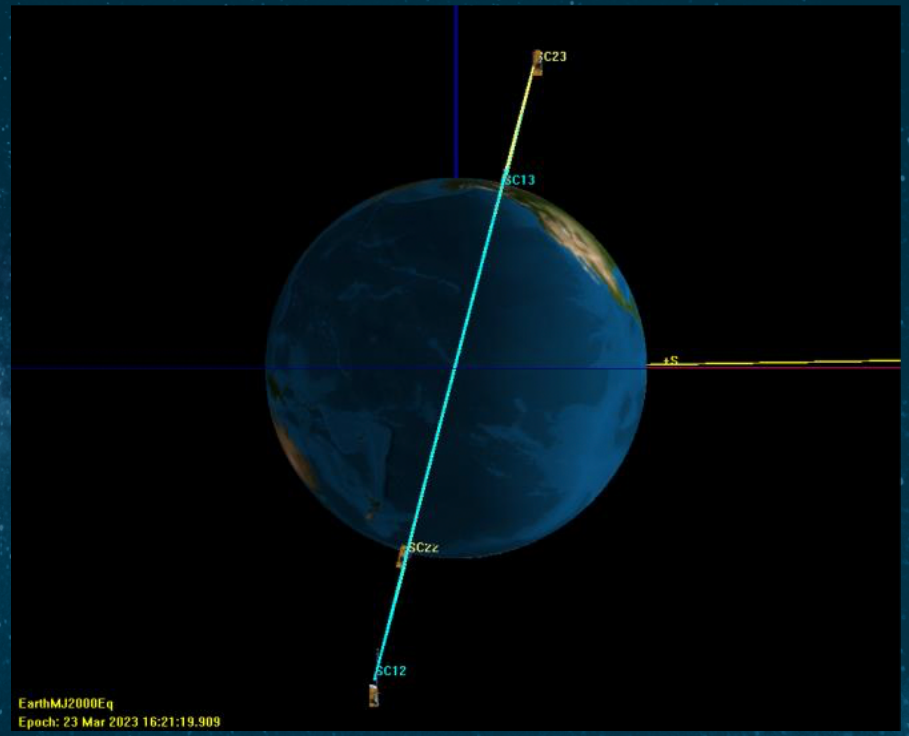


D3S SMALLSAT MISSION STUDY

SmallSat Phase A/B:

- Constellation of 3-6 small satellites in elliptical LEO SSO (350/300 km – 1500/2500/4000 km, TBC)





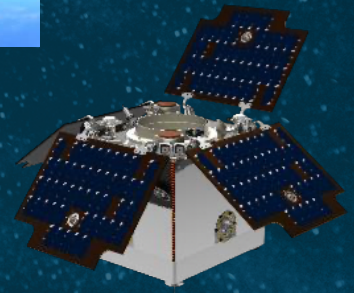
D3S NANOSATELLITE MISSIONS

- First Phase 0/A study in progress

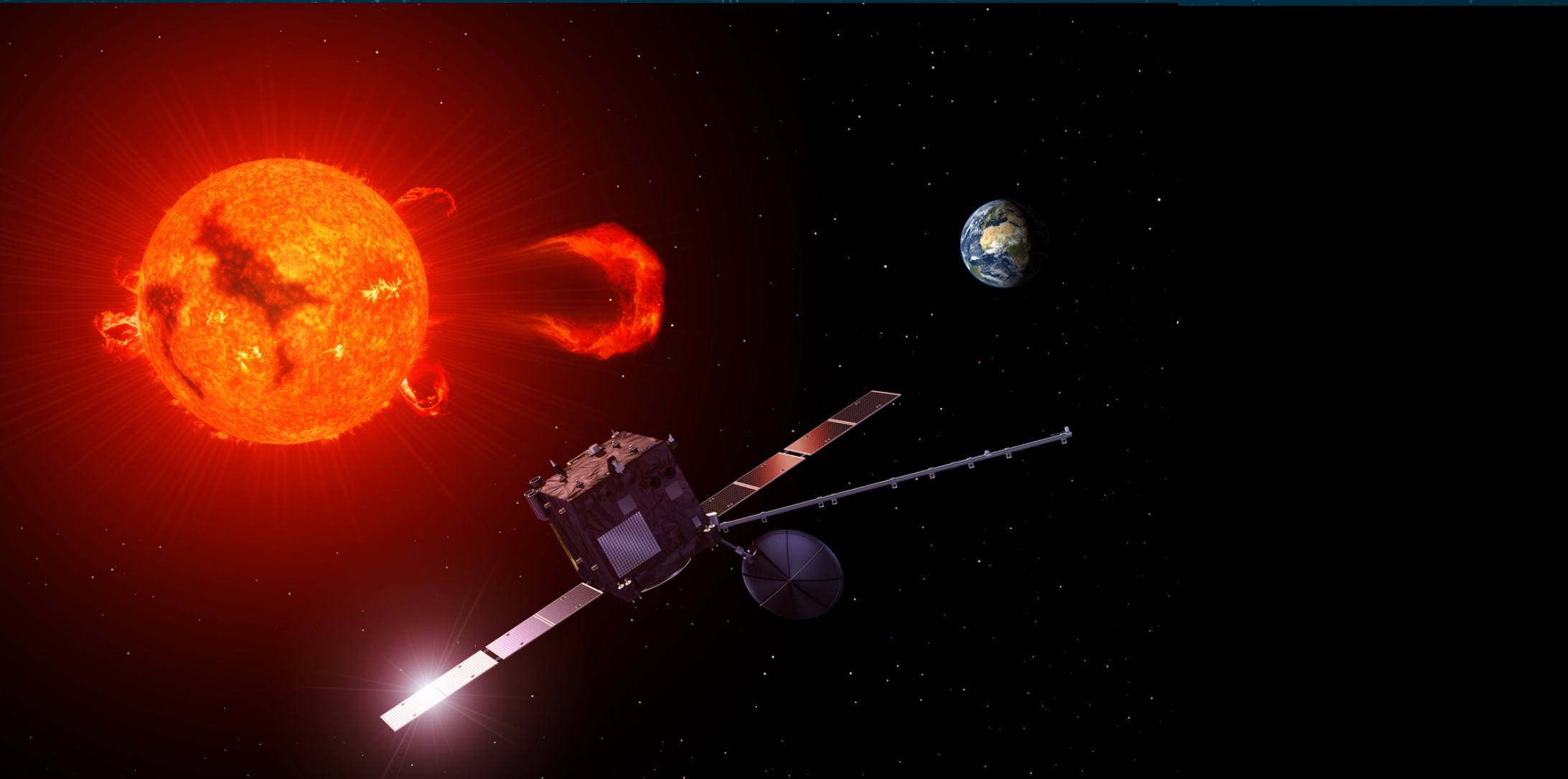
- Objective:
  - ➢ Initial mission concept study to assess the feasability (latency, lifetime, reliability) to use nanosatellites for operational space weather monitoring in near-Earth space.

- Future opportunities:
  - ➢ Commercial nanosatellite systems as a service

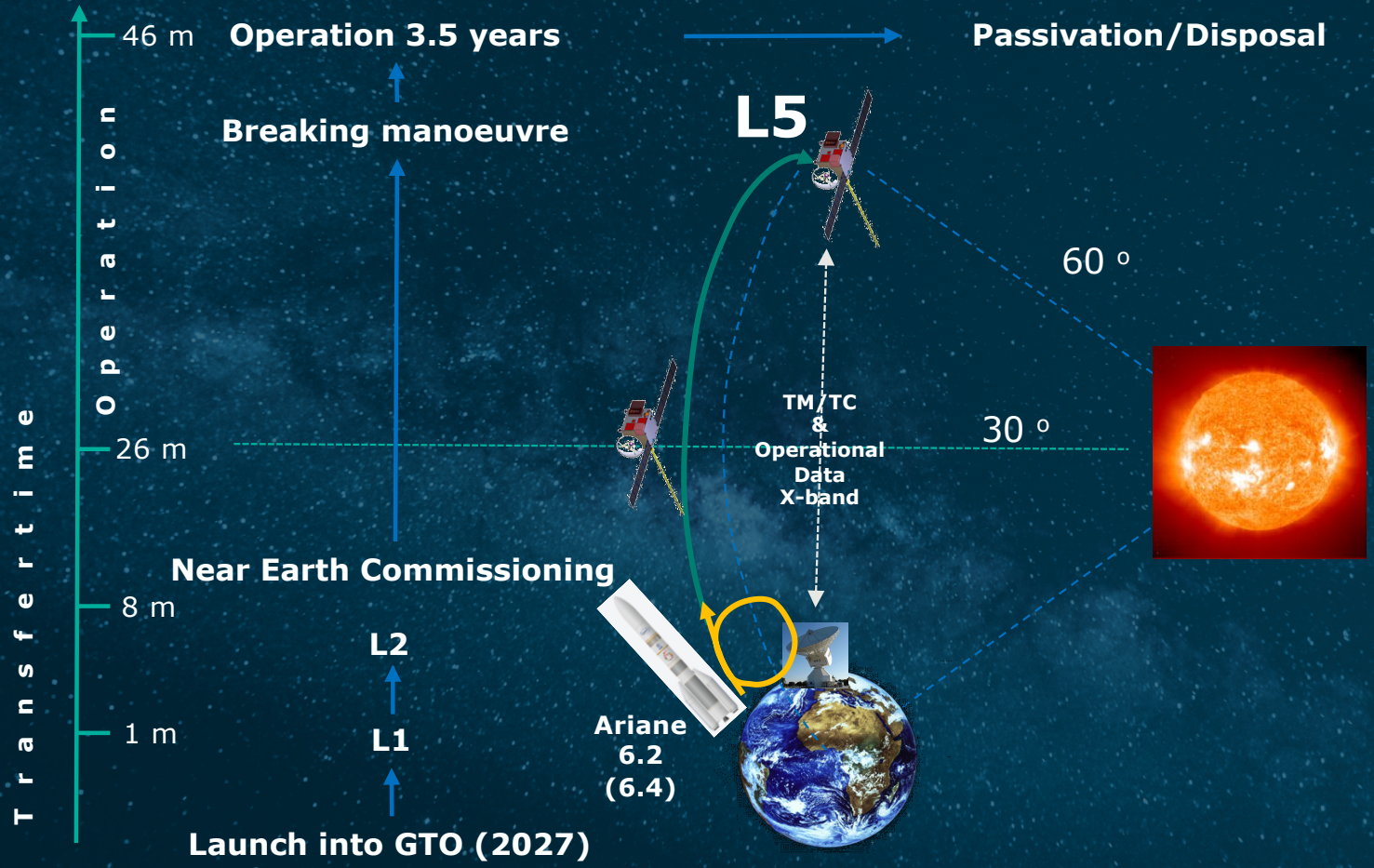
    => Marketing space weather data and products
  - ➢ Nanosatellite/SmallSat based tailored services



LAGRANGE MISSION TO L5

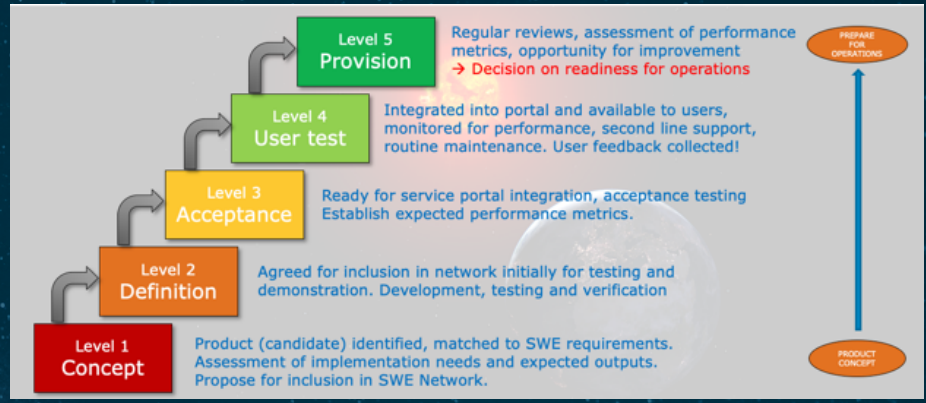


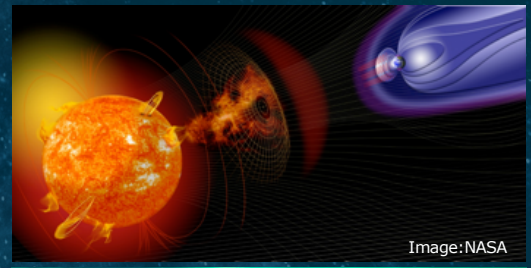
LAGRANGE MISSION SCENARIO



SPACE WEATHER CAPABILITY CHALLENGES

- End user needs:
  - Early warnings and event based alarms
  - Nowcasts and forecasts!!
- New space weather capabilities
  - Driven by evolving user needs
  - End-to-end modelling, accuracy, timeliness
  - Customer tailored service
  - Sustainable monitoring system
- Provision of operational 24/7 services
- New service concepts?





THANK YOU

swe.ssa.esa.int

www.esa.int

@esaspaceweather