ESA Space Environment Monitors Developments

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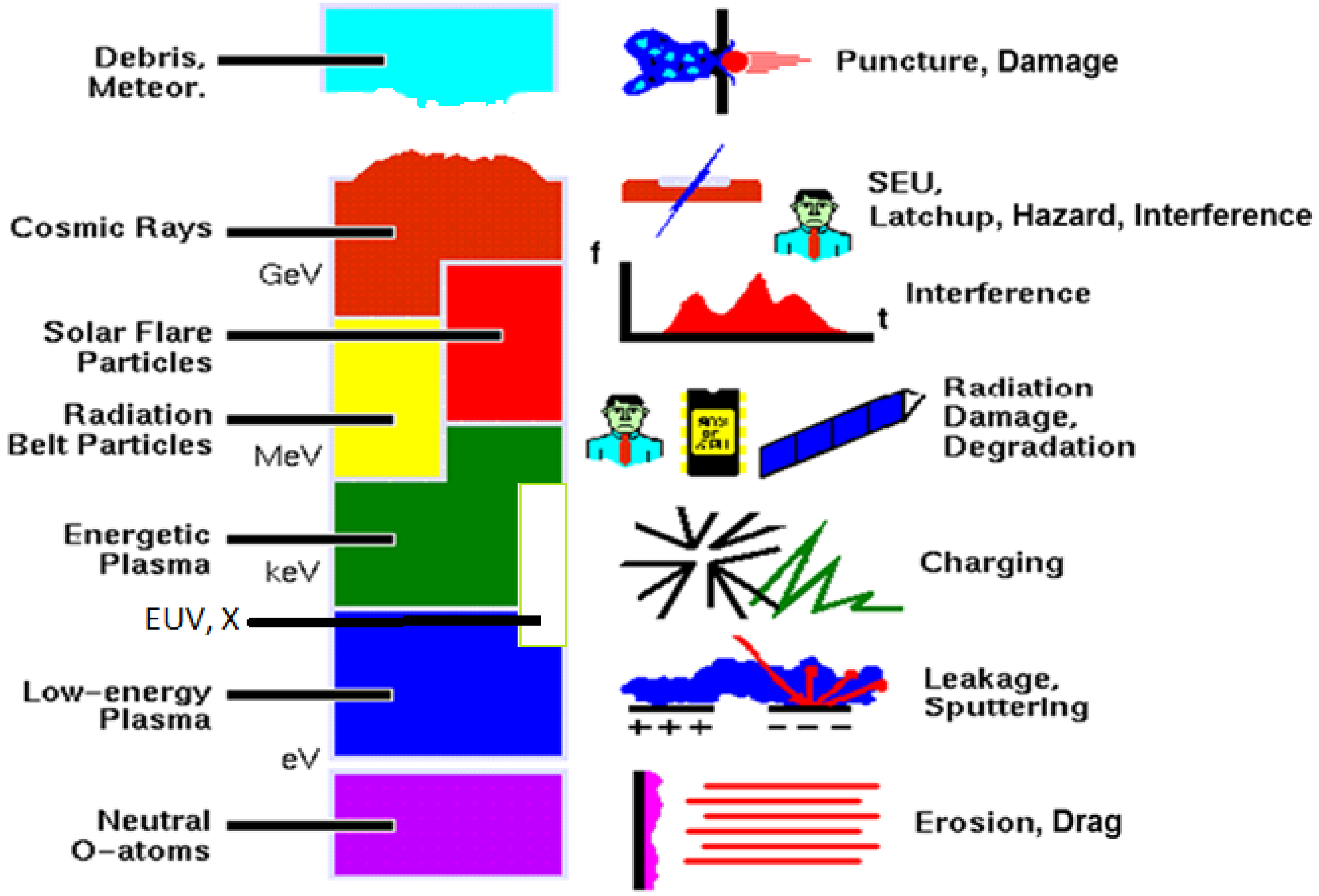
The space environment



Monitors needs and customers

Monitors needs

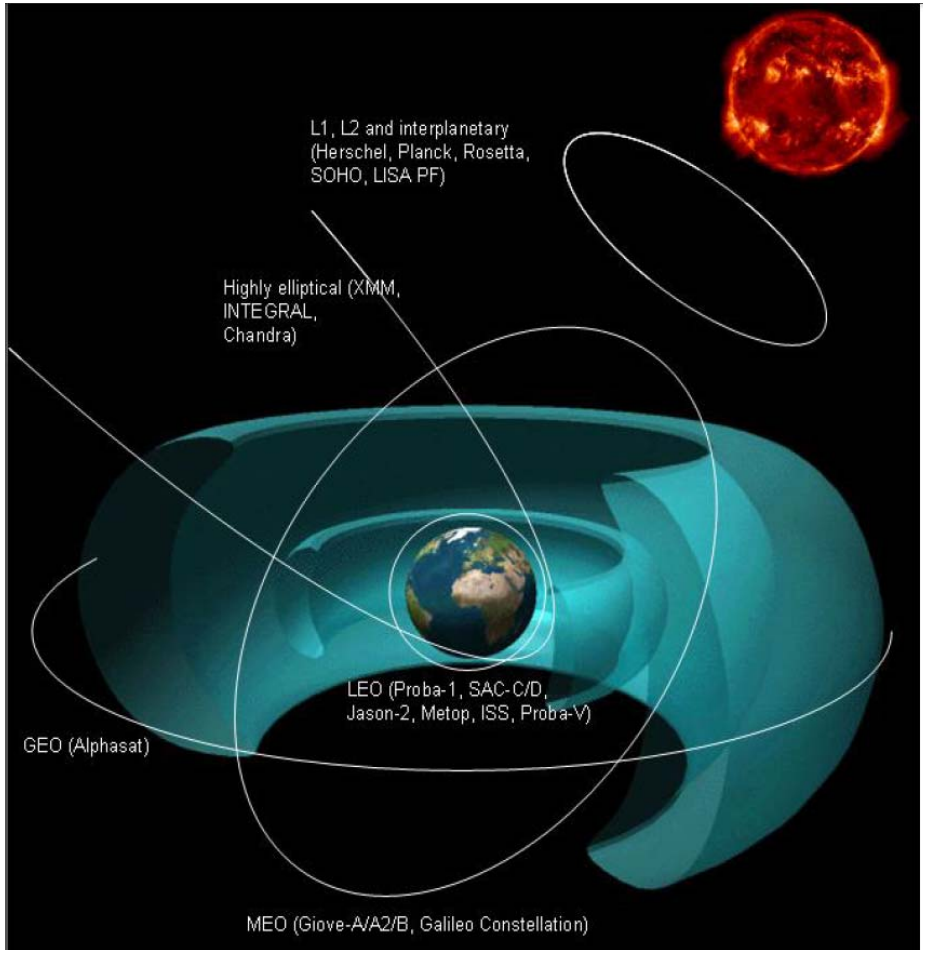
- Support to platform and payloads
- Provision of environment data for services such as:
    - Environment specifications
    - Alerts, warnings, forecast
- *Prototypes and technology demonstrators*

Customers

- Potentially all programmes
- ESA Space environment and effects activities
- SSA/SWE programme
- *R&D programmes*

Support to ESA platforms and payloads

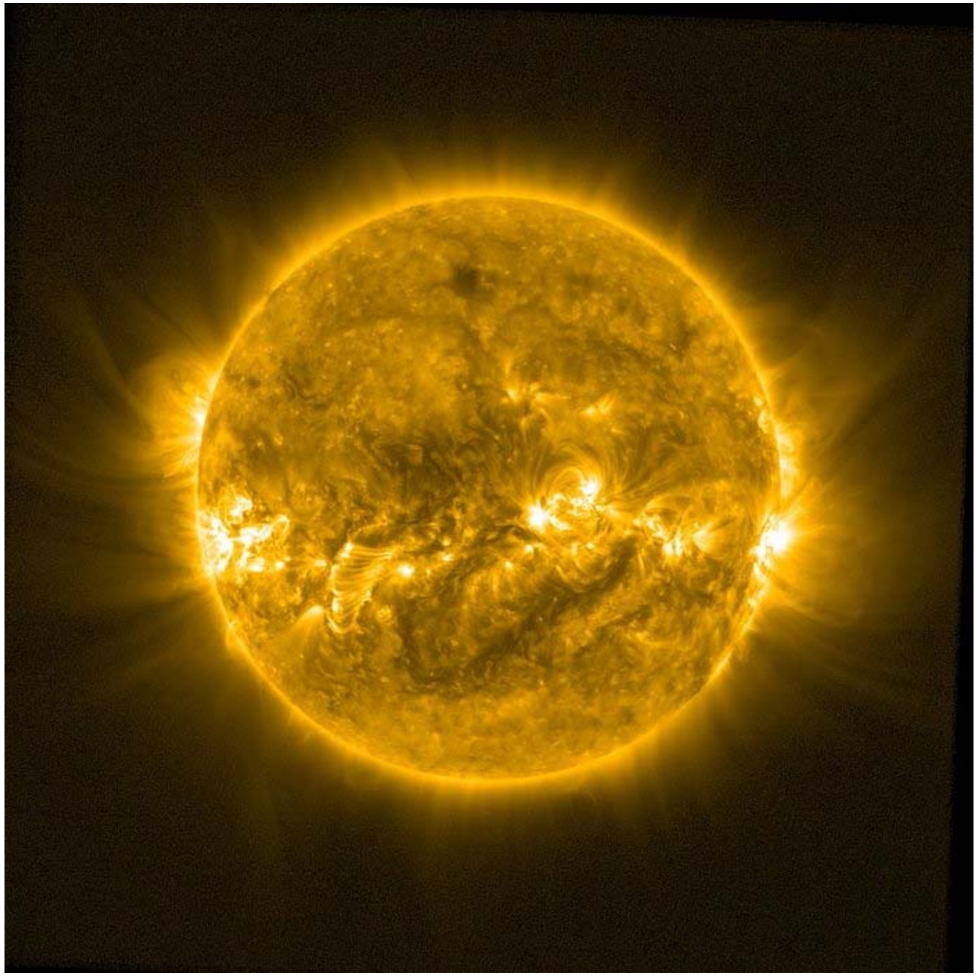
- Flown
  - Meteosat-2 / SEM-1
  - Meteosat-3 / SEM-2
  - XMM/EPIC-RM
  - SMART-1/EPDP
  - PROBA-1/SREM
  - Integral/SREM
  - Rosetta /SREM
  - Hershel/SREM
  - Planck/SREM
  - GIOVE-B/SREM
  - GIOVE-A/Cedex, Merlin
  - Alphasat, rad monitor (MFS)
  - Galileo FOC/EMU
  - Swarm/Various
- Future:
  - MTG/NGRM
  - MSG/???
  - JUICE



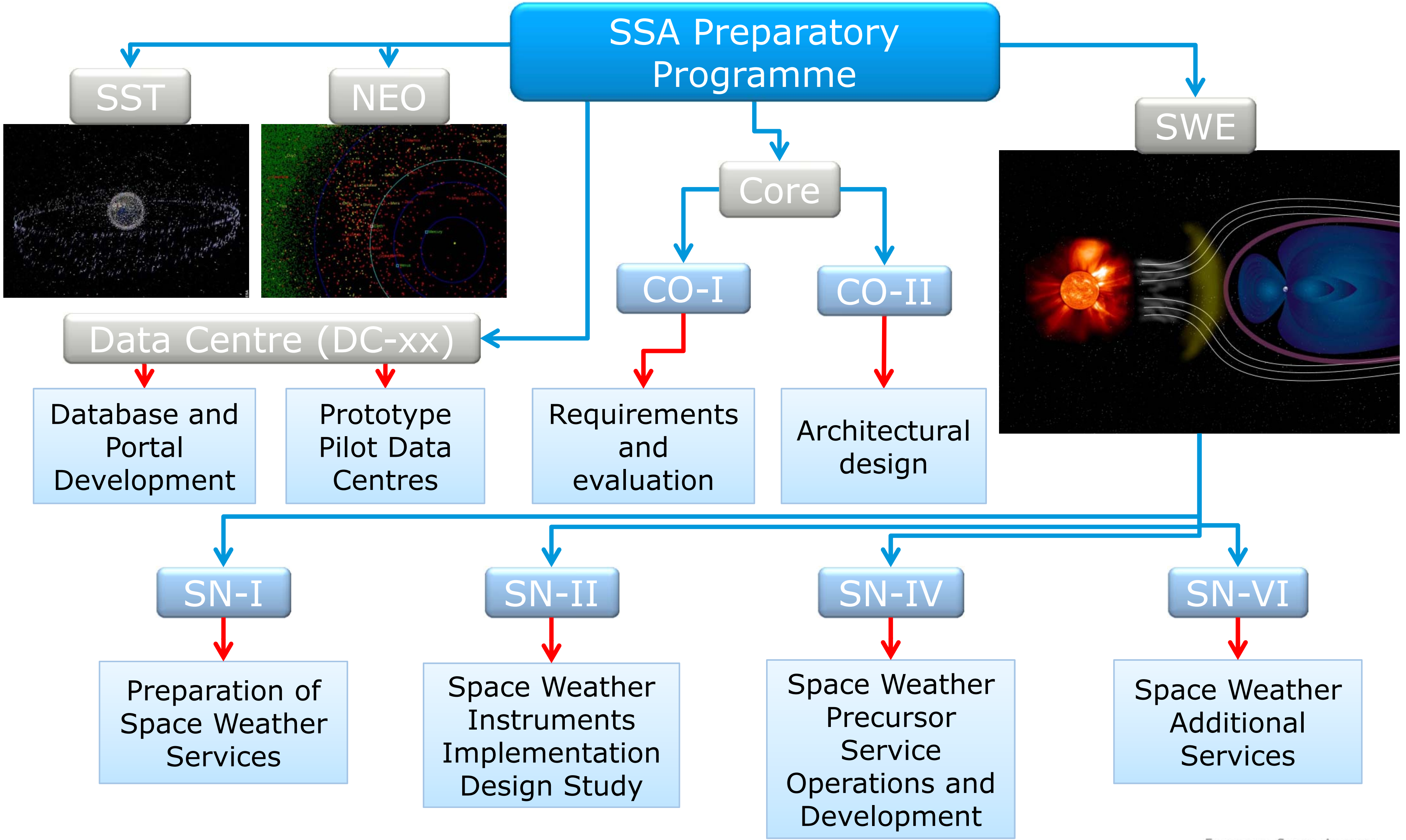
Provision of environment data for services

- Flown
  - Metop-A, B
  - PROBA-2/Solar observation payload and Plasma payload
  - PROBA-V /EPT

- Future
  - Metop-C/SEM
  - EDRS/NGRM
  - Kompsat 2A/SOSMAG
  - Proba-3/??
  - ??/??

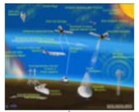


SSA Preparatory Programme Overview (2009-2012)

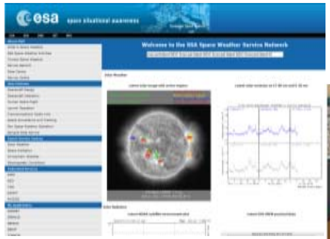


SSA / SWE Precursor service segment

SSA-SWE Users



SSA-SWE Service Portal: swe.ssa.esa.int



SSA Space Weather Coordination Centre

SWE Data Centre
Redu, Belgium

SWE Service Coordination Centre, Space Pole, Belgium

SWE Expert Service Centre
Solar Weather
ROB, Belgium (coord.)
Uni. Graz, Austria

SWE Expert Service Centre
Ionospheric Weather
DLR, Germany (coord.)
NMA, Norway
NOA, Greece

SWE Expert Service Centre
Space Radiation
BIRA, Belgium (coord.)
AIT, Austria
UOA, Greece

SWE Expert Service Centre
Geomagnetic Conditions
TGO, Norway (coord.)

SWE Expert Service Centre
Heliospheric weather

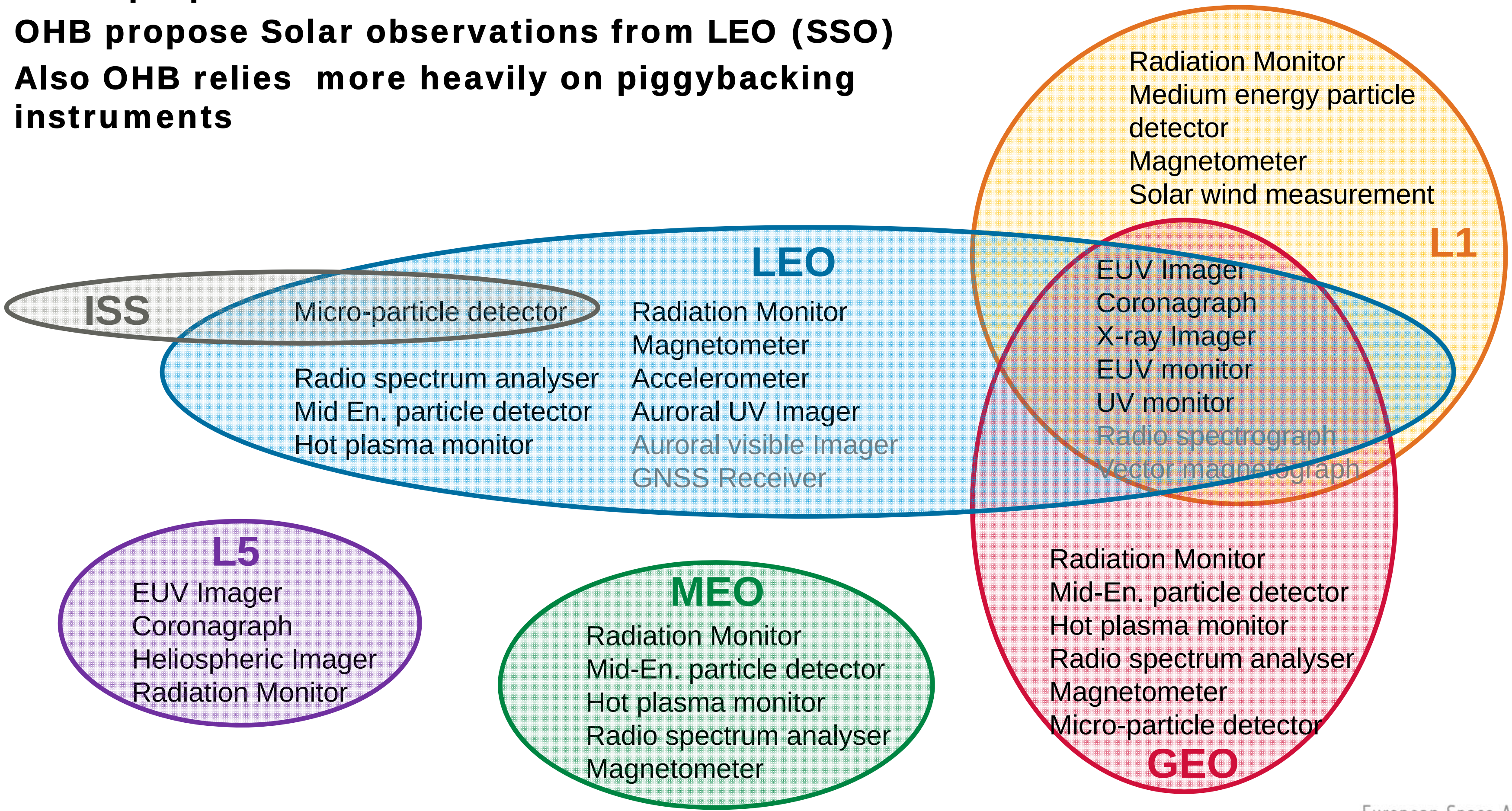
CO-II Architecture studies from AD&S and OHB

Results are similar but:

AD&S proposes Solar observations from L1

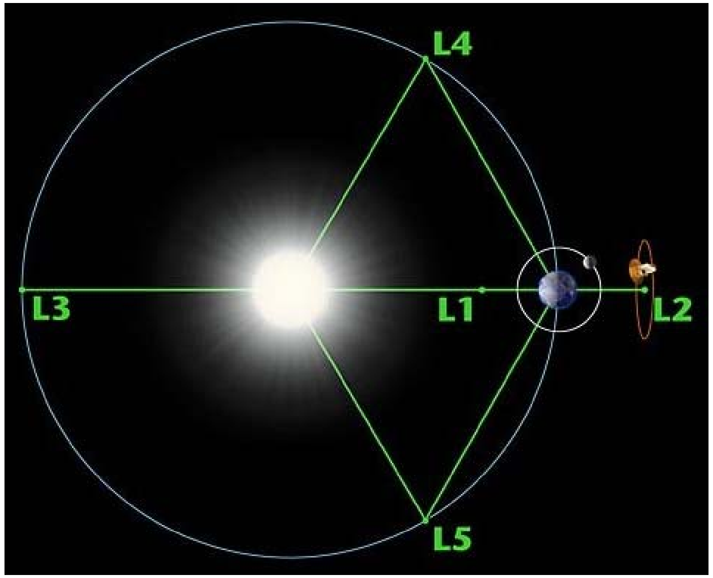
OHB propose Solar observations from LEO (SSO)

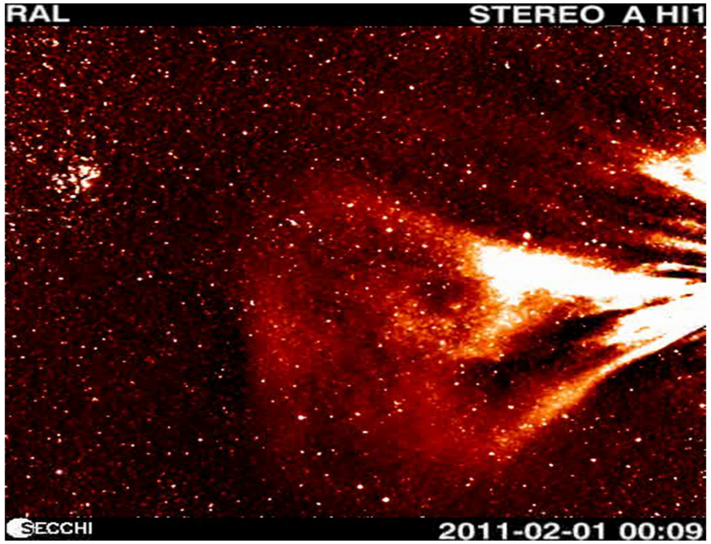
Also OHB relies more heavily on piggybacking instruments

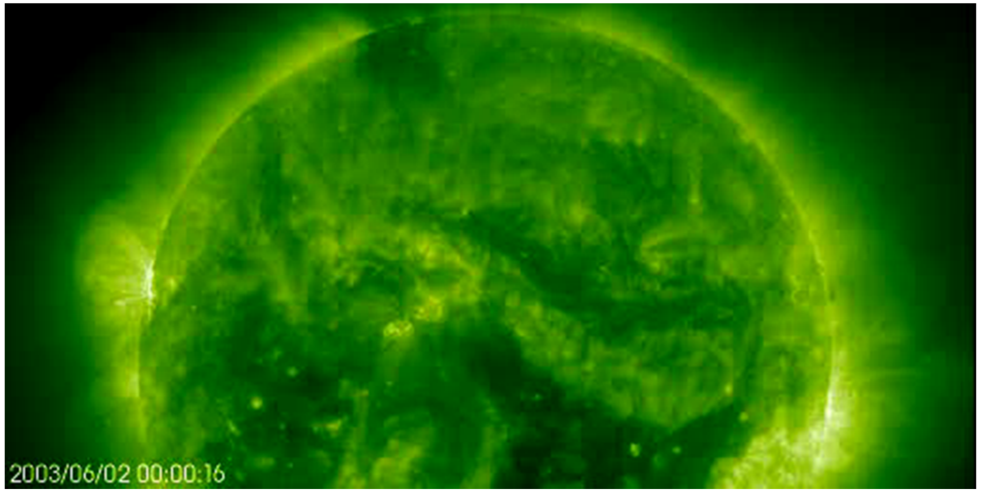


Concepts for enhanced Space Weather monitoring

1. In-situ L1 observations are critical for consolidating the ICME warnings and making geoeffective predictions
2. EUV imaging of the solar disc from L5 point gives an opportunity for early detection of potentially hazardous active regions
3. In-situ observations of solar energetic particles and fields at L5 gives ahead information about central meridian CMEs which can be geoeffective
4. Solar EUV and solar magnetic field imaging at L4 could give better information on well-connected solar particle events (SPEs) important for spacecraft, launchers and human spaceflight







SN-II: Space Weather Instrument Implementation Design Study - Inputs

esa

Astrium (GmbH)
Project Manager:
Norbert Pailer

1. Create database of instruments (46 originally included)
2. AO + instrument workshop (ESTEC, November 2010)
3. List of all possible mission opportunities (> 200 initially)
4. Shortlist of representative instruments based on maturity at the time and the amount of data provided (Design Descriptions, ICDs) including:
   - Radiation Monitors: NGRM, HMRM, EPT, SREM; Plasma instruments: SW-ChaPS, AMBER, AMBER_GEO, M-NLP
   - Micrometeoroids: AIDA-IS, SODA; Surface Potential: SPD; Magnetometer: MRMAG; Auroral Imager: WFAI; Solar X-rays: XFM
5. Shortlist of feasible hosted payload opportunities

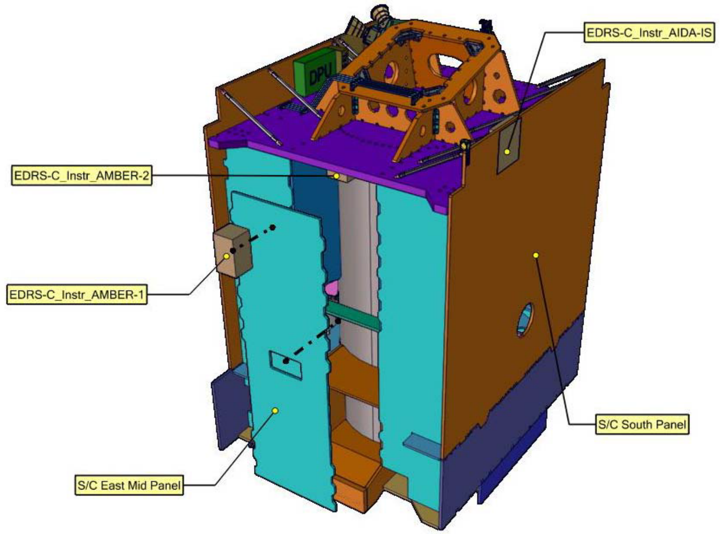
Mission | Orbit Information | Margins | Planned launch date | Instrument type | Instrument suitability

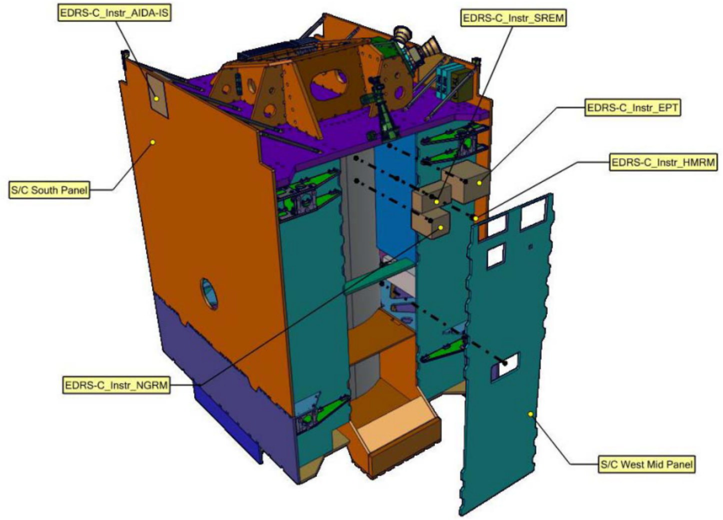
1:1 Kopie von 12-03-16_Mission_Instrument_Matrix_v2.3_MidTermReview.xls

Mission Priority	Mission	Institution	Orbit	Inclination	Orbit Altitude	Instruments	Pointing Dir.	Power Margin	Mass Margin	Launch Year / Design Life	Plasma Analyzer & Langmuir Probe (Low Energy Particles)	Medium + High Energy Particle Detectors	Dust Detectors	Surface Charging Detectors	GNSS Receivers	Magnetometers	Imagers: Sun Oriented Imagers	Imagers: Earth Oriented Imagers	Imagers: Imagers for Observation of Sun-Earth Line	Radiometers + Spectrometers	Accelerometer
	LEO Low Earth Orbit, < 2000 km																				
101	MOS-A	Eumetsat	SSO	98.7	817	imagers, spectrometer,	Earth	60	84	2019/15	x	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
102	MOS-B	Eumetsat	SSO	98.7	817	relay system, space environment	Earth	60	84	2019/15	o	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
103	Jason-CS	Eumetsat		66	1300	radar altimeter package	Earth	tbd	tbd	2017	o	x	o	o	x	[illegible]	-	o	-	o	-
104	CSG 1	ASI	SSO	97.8	620	x-band SAR	+/-34deg off	<35	20	2015/7	o	x	o	o	x	[illegible]	o	-	-	o	o
105	CSG 2	ASI	SSO	97.8	620	x-band SAR	+/-34deg off	<35	20	2016/7	o	x	o	o	x	[illegible]	o	-	-	o	o
106	Merlin	DLR	SSO	polar	500-650	Methan LIDAR (Light Detecting	Earth	low	low	2016/3	x	x	o	o	x	[illegible]	-	-	-	o	o
107	Meteor-MP N3	Roscosmos	SSO	98.77	832	Russian "Metop" version	Earth	tbd	tbd	2016/5	x	x	x	o	x	[illegible]	o	o	-	o	-
108	FY-3 02 (Fengyun-3)	CMA/NRSCC	SSO	98.75	836	Meteorological: 3-D	Earth	tbd	tbd		x	x	x	o	x	[illegible]	o	o	-	o	-
109	COSMIC2	NSPO	LEO	72/ 24	800	2 x 6 satellites: GPS radio	Earth	small	small	2014 to 2017/10	o	x	o	o	x	x	-	o	-	o	-
110	MetOp-C	Eumetsat	SSO	98	825	AVHRR,HIRS,AMSU-A,MHS,A-	Earth	15 W	30 kg	2016/5	o	tbc	o	o	x	-	-	-	-	o	-

SN-II: Space Weather Instrument Implementation Design Study - Outputs

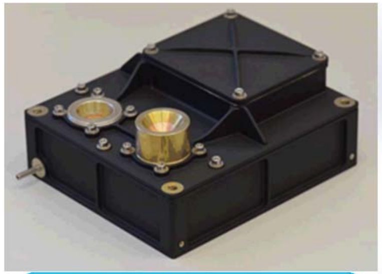
1. Shortlist Missions: ~~CSG -1 & -2~~, Metop-C, Galileo FOC, Alphasat-2, EDRS-C, Eurostar, Jason-CS, ~~Lisa PF~~, Euclid (10 -> 7)
2. Back-up missions: MOS-A & B, ~~Meteor-MP N3, Fengyun-3 (FY-3), COSMIC-2, Merlin, Heinrich Hertz, GK-2A, FY-4, DSCOVR~~ (11 -> 2)
3. Instruments were matched for 9 Missions
   a. MetOp-C: AIDA-IS, EPT, HMRM, M-NLP, NGRM, SPD
   b. EuroStar: 3x XFM, SREM, EPT, NGRM, HMRM, AIDA-IS, AMBER_GEO
   c. Alphasat: 3x XFM, SREM, EPT, NGRM, HMRM, AIDA-IS, AMBER_GEO
   d. EDRS-C: same as above -> only NGRM selected by programme.
   e. Euclid: HMRM, NGRM, XFM
   f. MetOp-SG A: AMBER, SODA, MRMAG /MetOp-SG B: AMBER, SODA, MRMAG, WFAI
   g. Galileo-FOC: (NGRM (modified) + HMRM = eNGRM
   h. Jason-CS: HMRM, Amber
4. Remote Interface Unit baseline Requirements



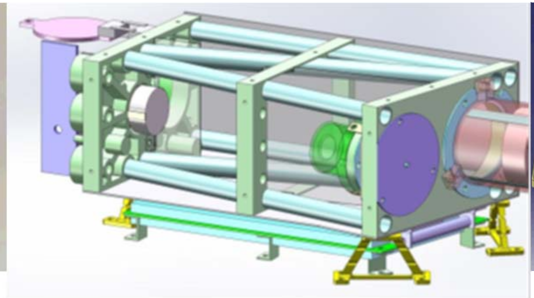


Instrument Technology Development Activities

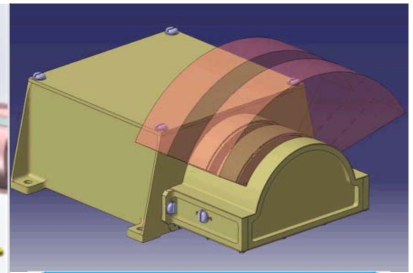
- On-going activities:
- Generic:
  - NGRM (Radiation Monitor)
  - HMRM (Radiation Monitor [TRP])
  - 3DEES (e^- Spectrometer)
  - AIDA (Advanced Impact Detector Array)
  - HOPE-M (Plasma Monitor)
- Specific for SSA:
  - Space SOSMAG (Magnetometer)
  - ESIO (EUV Solar Imager)
  - MAGIC (Magnetometer)
  - M-NLP (Multi-Needle Langmuir Probe)
  - APPOLLON (Oxygen flux monitor)



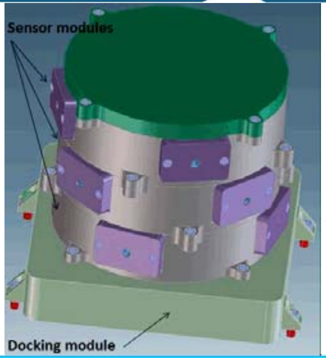
Next Generation Radiation Monitor (NGRM) [RUAG, Ch]



EUV Solar Imager for Operations (ESIO) [CSL, Be]

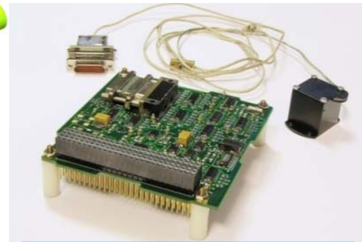


HOt Plasma Environment Monitor (HOPE-M) [UCL, UK]

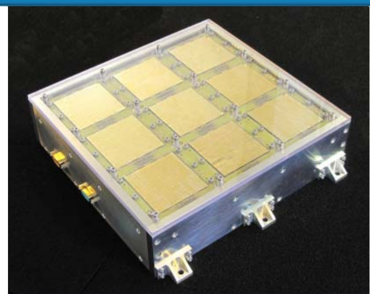


3d Energetic Electron Spectrometer (3DEES) **[UCL, Be]**

Service-Oriented Spacecraft Magnetometer (SOSMAG) [Magson, D]



MAGnetometer from Imperial College (MAGIC) [ICL, UK]



Advanced Impact Detector Array (AIDA) [etamax, D]

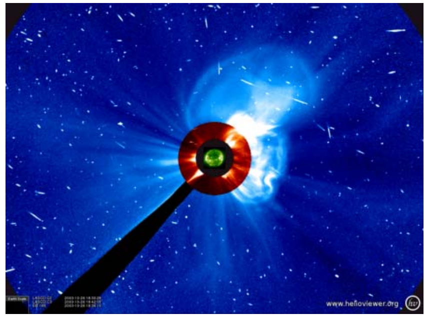
Multi-Needle Langmuir Probe (M-NLP) [Eidel, No]

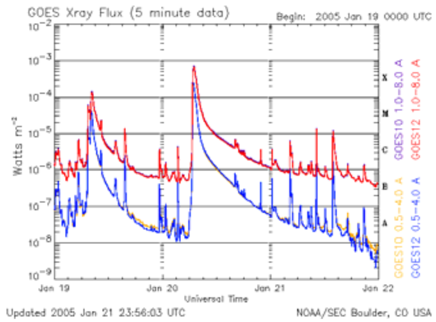
Highly Miniaturised Radiation Monitor (HMRM) [RAL, UK]

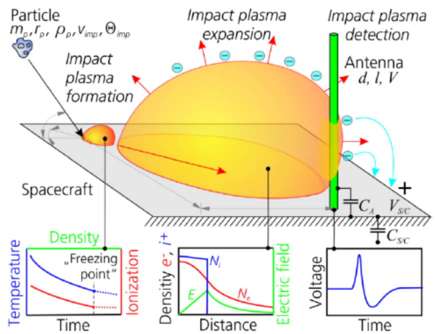
Instrument Technology Development Activities - continued

- Just starting:
  - SCOPE (Compact Wide Angle Coronagraph)

- Future – Not approved yet:
  - Impact plasma based particle detector
  - Antenna noise spectroscopy
  - ESD monitor
  - Remote Interfacing Unit (RIU)
  - Airborne radiation detector
  - Wide-field space-based auroral camera
  - X-ray flux monitor
  - Passive electron emitter
  - Integrated radiation - magnetic sensors

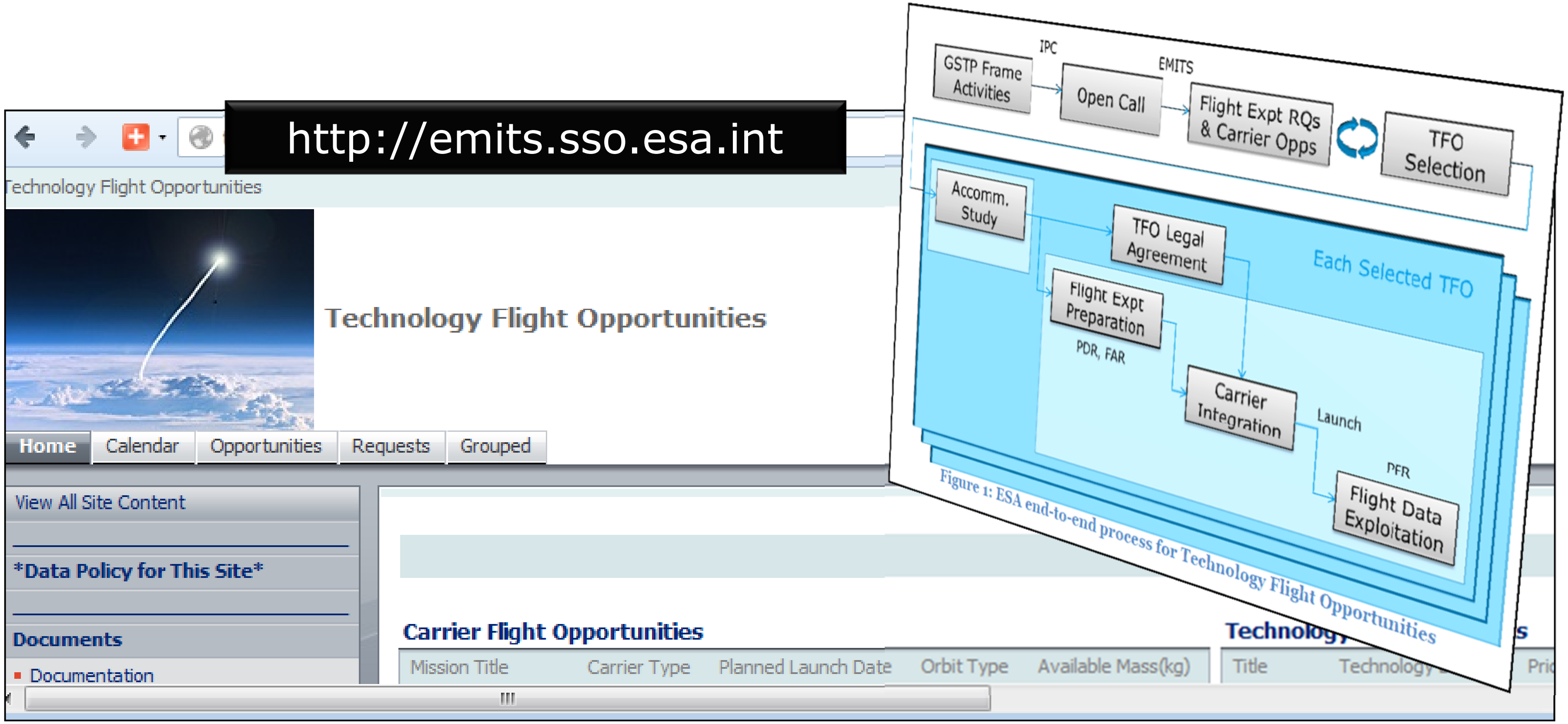






Technology programmes

- See EMITS

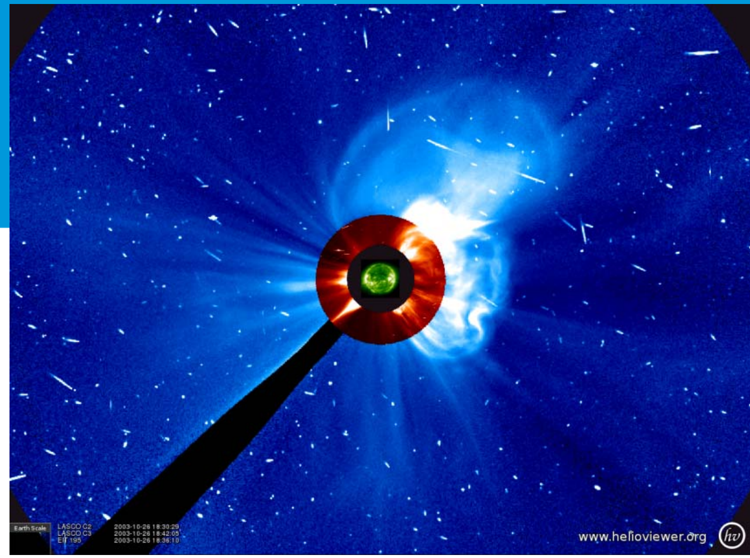


Summary

- Various activities for developping space environment monitors
- SSA programme offers opportunities for:
    - Instruments,
    - data services,
    - flight opportunities
- Other area should be explored:
    - ESD flight monitor
    - EP diagnostic package
    - Other…

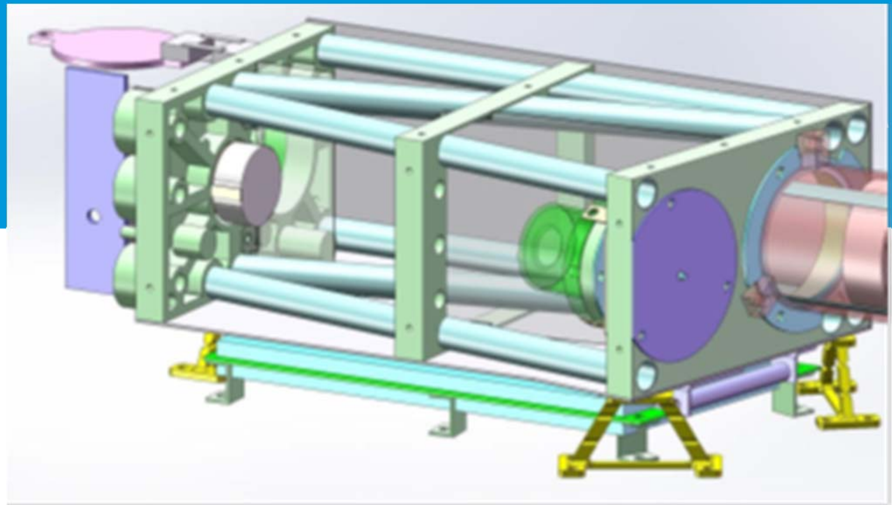
BACKUP SLIDES

Solar Coronagraph for OPErations (SCOPE)



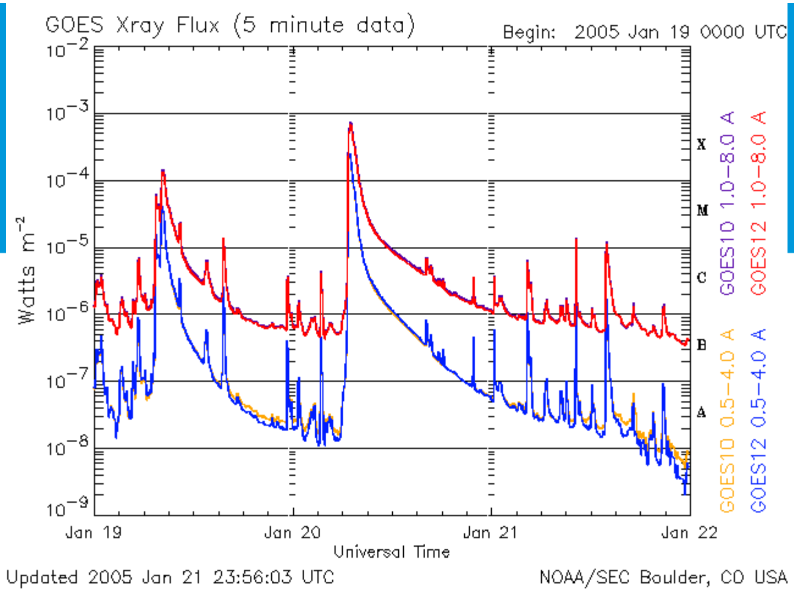
- ITT closed in March 2013
- To be able to track CMEs to from 1.5-3 to 20-25 Solar Radii and determine velocity for Space Weather use
- Shall operate in all space weather conditions
- Reduction of resources compared to science-class instrument and use of only one imager channel
- Mass: <12 kg
- Power consumption: ~10 W
- Volume: tbd
- Phase A-B to last until end of 2016
- Phase C-D should be conducted from 2017-2019

EUV Solar Imager for Operations (ESIO)



- Being developed by Centre Spatial Liège (Be) and Royal Observatory of Belgium (Be)
- Mass: 6 kg
- Power consumption: ~10 W
- Volume: 5.75 litres
- EUV images (17.5 or 19.5 nm)
- EUV flux (10 – 20 nm & 121.6 nm (Lyman-alpha))
- Phase B due to complete by the end of 2015
- Phase C/D should be 2017-2019 (33 months)

Solar X-ray Flux Monitor



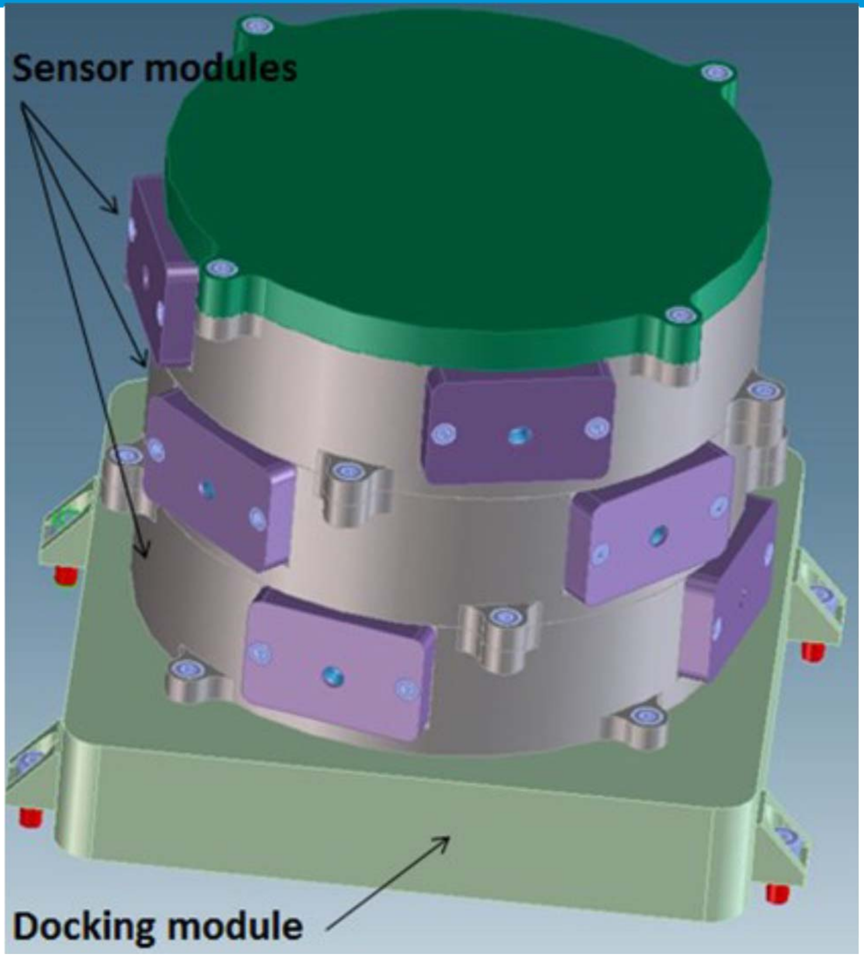
1. Planned activity
   a. not yet formally supported)
2. Compact X-ray flux monitor to cover 0.05 – 0.8 nm (similar to GOES wavelengths) for detection of Solar Flares
3. Mass: < 0.5 kg
4. Volume: < 1 litre
5. Power consumption: tbd
6. Planned duration: ~3.5 years (2016-2019)
7. Additional study to produce imaging unit with baseline flare angular position determination of:
   a. 7 arc-min for M1
   b. 0.7 arc-min for X1 and
   c. 0.07 arc-min for X10 class flares

3DEES – phase A/B

Aim:
Multi-directional high precision measurements. This gives fluxes as a function of energy and pitch angle. To act as a reference for simpler monitors and to provide inputs to radiation belt physical modelling.

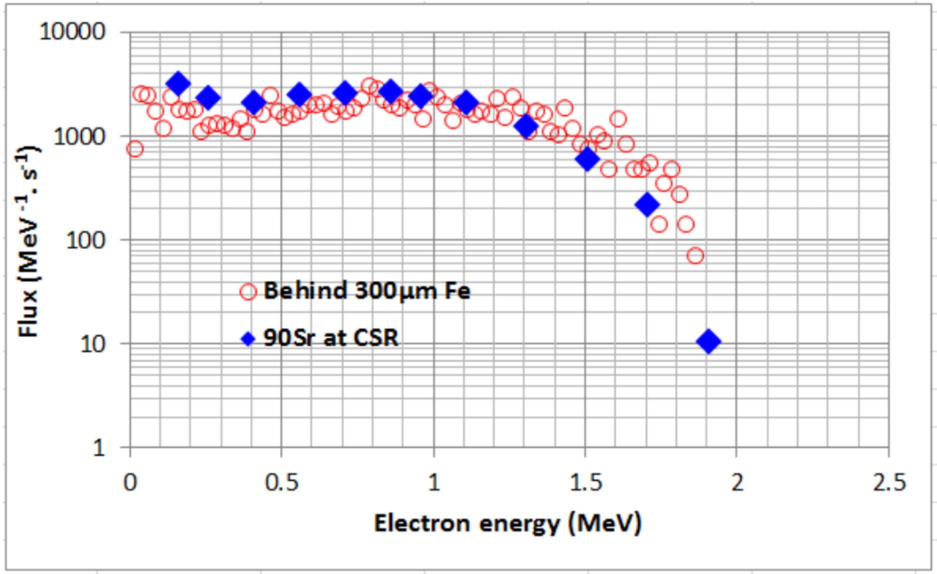
Phase A/B ended with successful PDR

Led by: UCL(B)
Phase A/B complete
ESA IPC approved phase C1/C2/D
Phase C1 funded by Belspo



3DEES – phase A/B

Although the original goal focused on electrons, protons are measured with no extra resources.
Simulation, back-up with laboratory testing showed the performance is good.



Right: Measured spectrum of electrons from a 90Sr source (blue) compared to simulation results of a source behind a 300µm Fe shielding (red)

HOPE-M

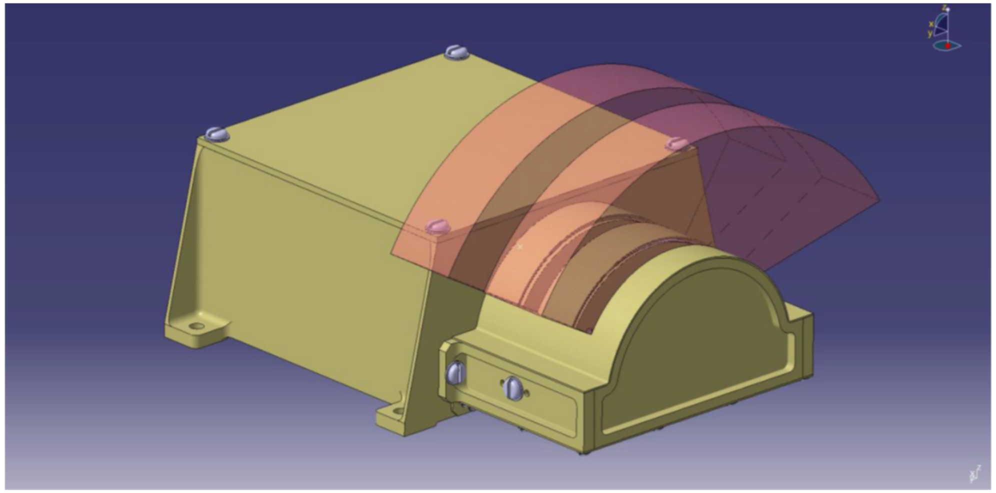
Ambitious goals for a low mass high quality plasma instrument have led to a design based on the 'Bessel Box' concept.

MSSL has led this activity

Breadboard fabrication is complete but full analysis of testing has not yet been completed. (The talk at this meeting may give further information)

30eV to 30keV, 22.5x120deg FOV

Further development of an EM is planned under SSA

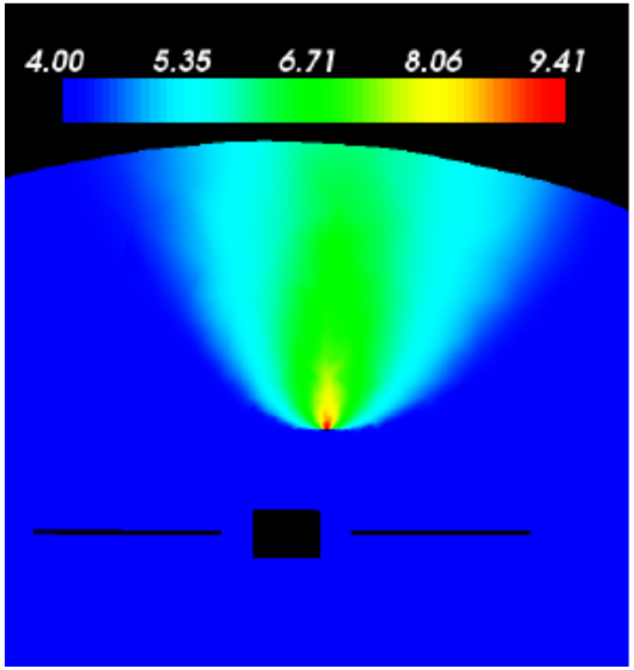


ESD monitor

1. A GSTP candidate activity that has yet to be approved (we may introduce it into another programme)
2. To develop and test a prototype monitor of electrostatic discharge transients on spacecraft and to produce a flight model design. In laboratories, commercial pulse-height analysers and multichannel analysers are commonly used to perform this task and pulse-height analysers on single chips have been developed.

Passive electron emitter

1. GSP study led by ONERA led to the preliminary design of a feasible passive emission system to reduce charging on spacecraft.
2. Simulation at micro- and macro-scopic levels give favourable results



The next phase should be a TRP development of a prototype and we hope to get this adopted