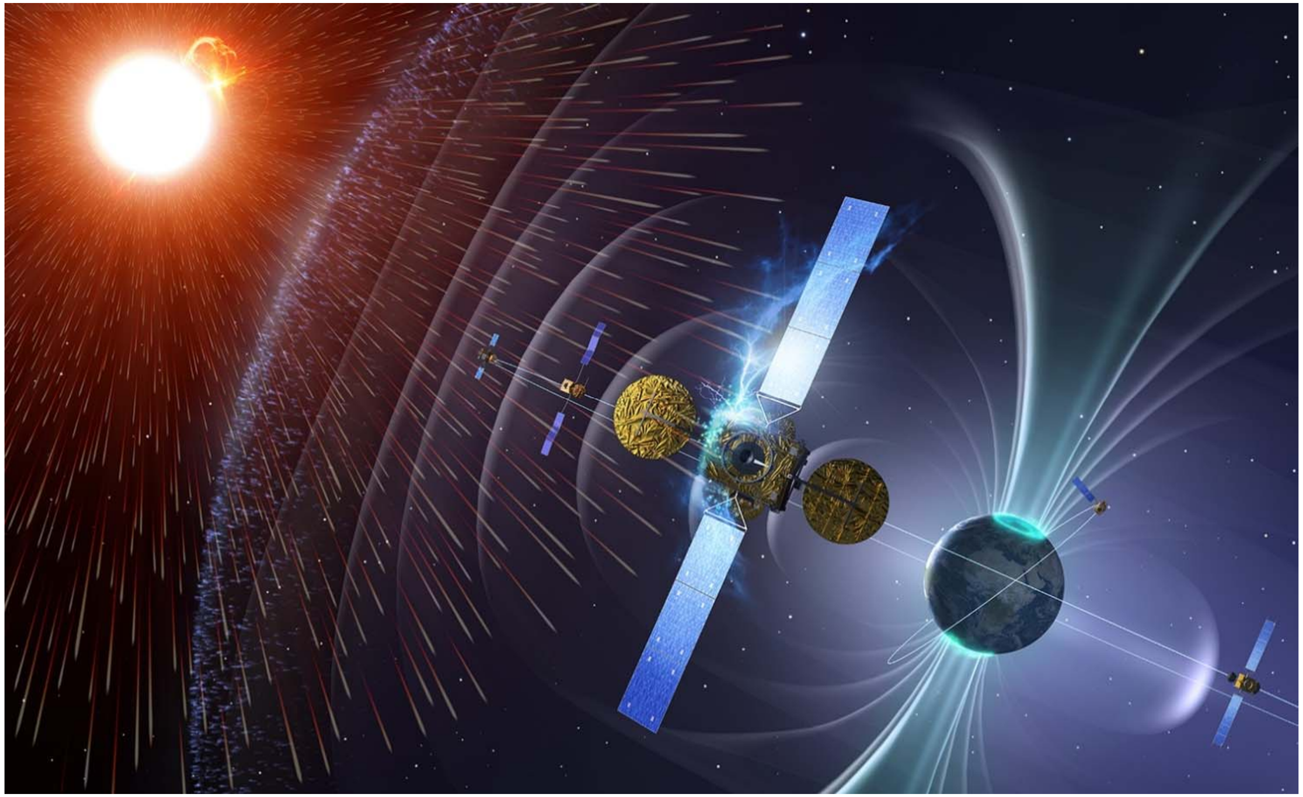
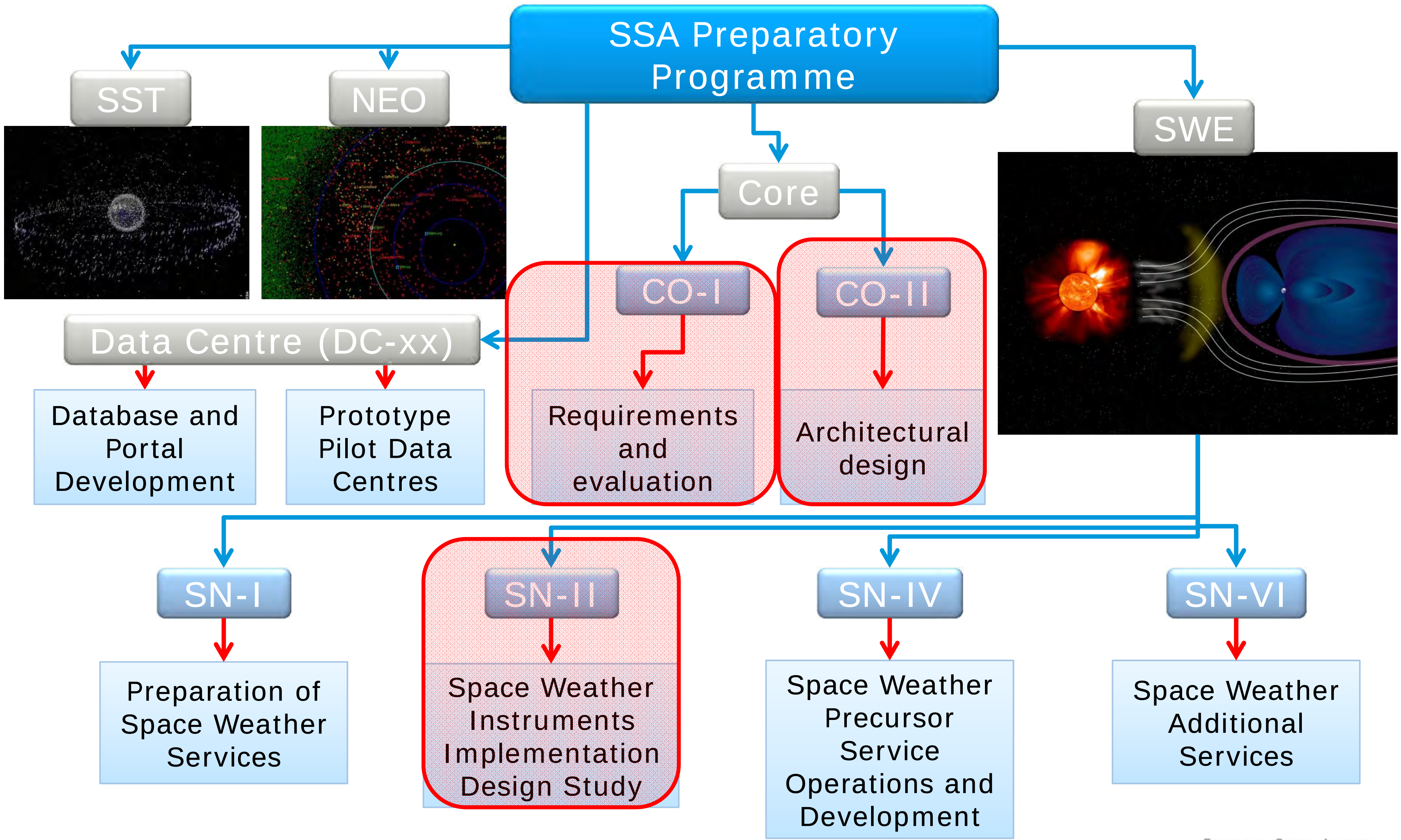
ESA SSA and instrumentation required for space weather activities

Piers Jiggens, Alain Hilgers (ESTEC/TEC)
Juha-Pekka Luntama, Alexi Glover (ESOC/HSO)

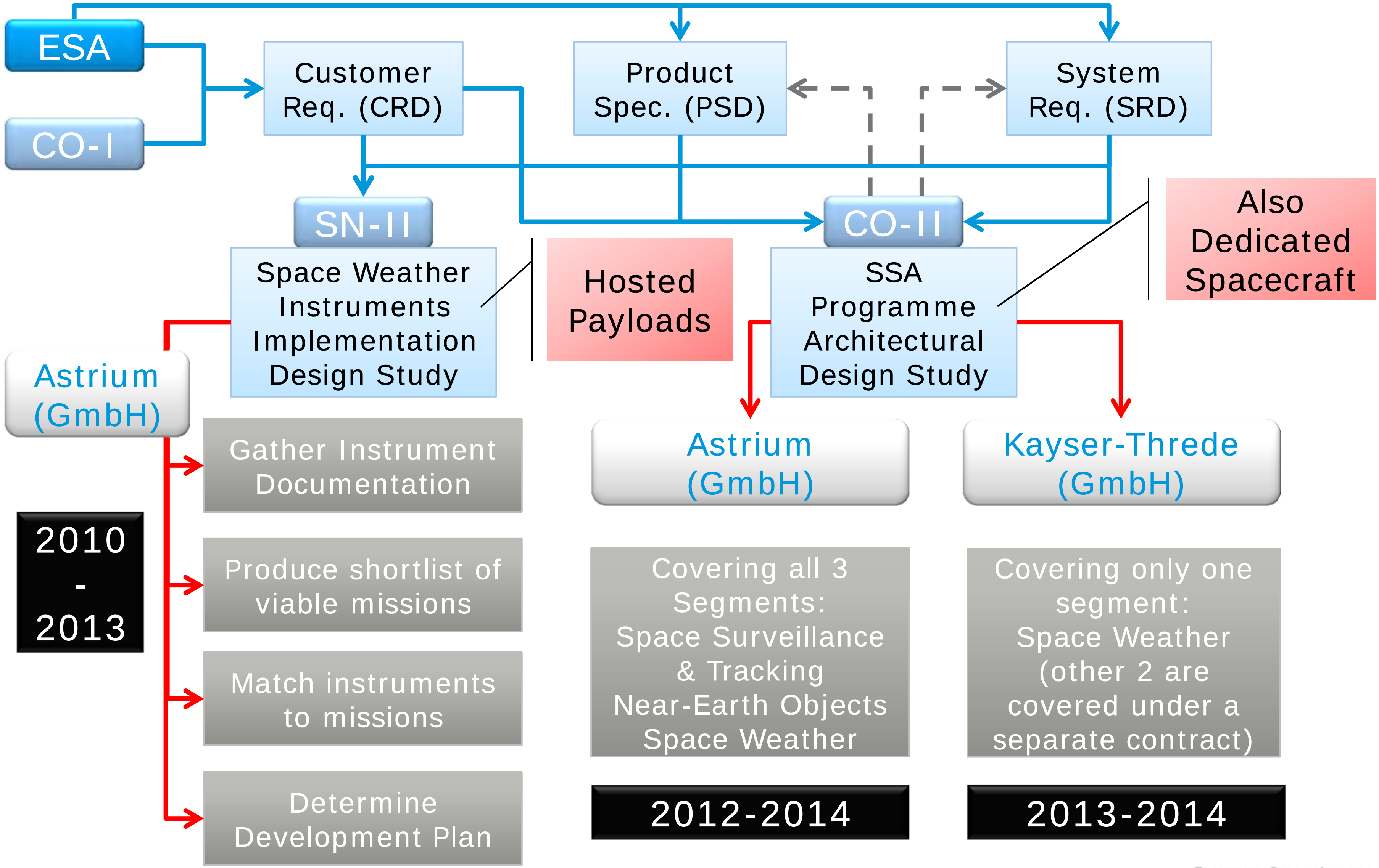


European Space Agency

SSA Preparatory Programme Overview (2009-2012)



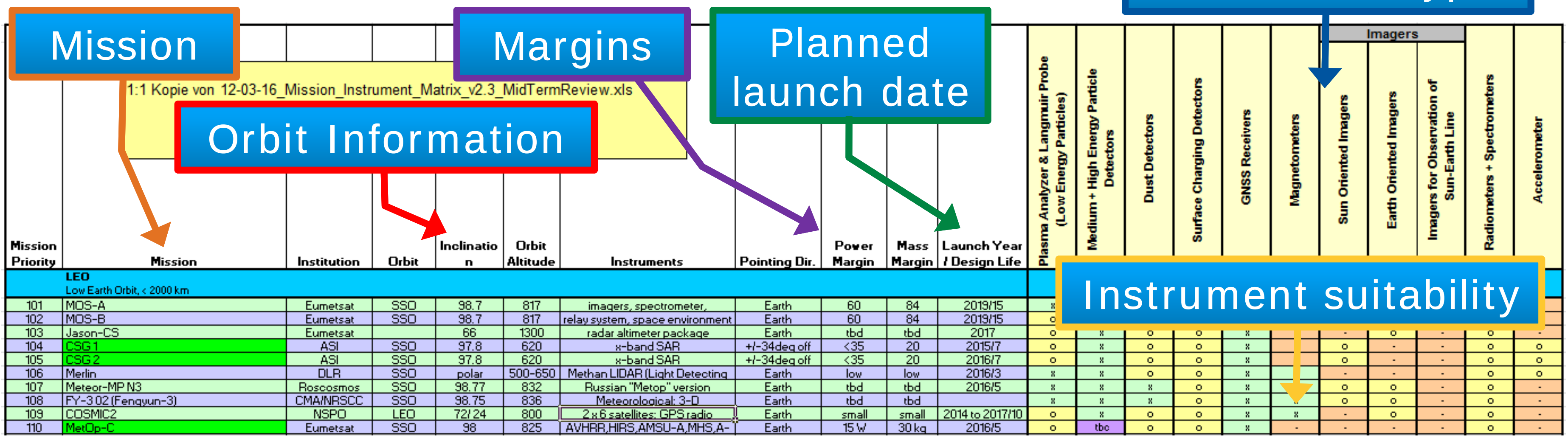
SSA Preparatory Programme Architecture studies



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

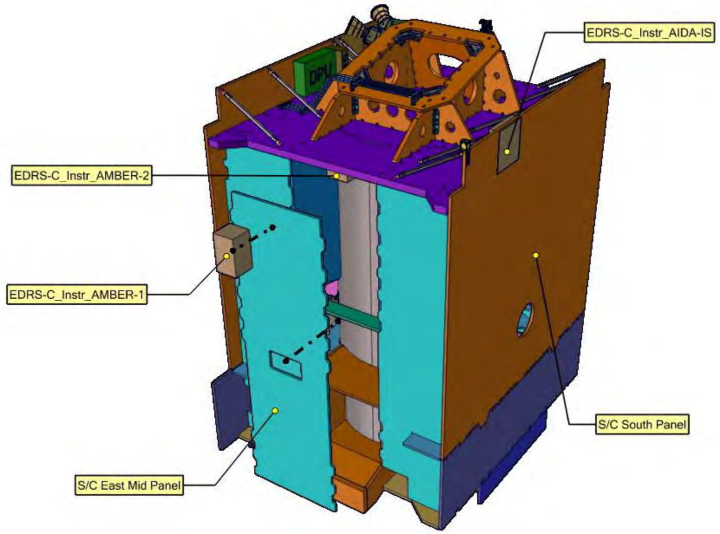
Astrium (GmbH)
Project Manager:
Norbert Pailer

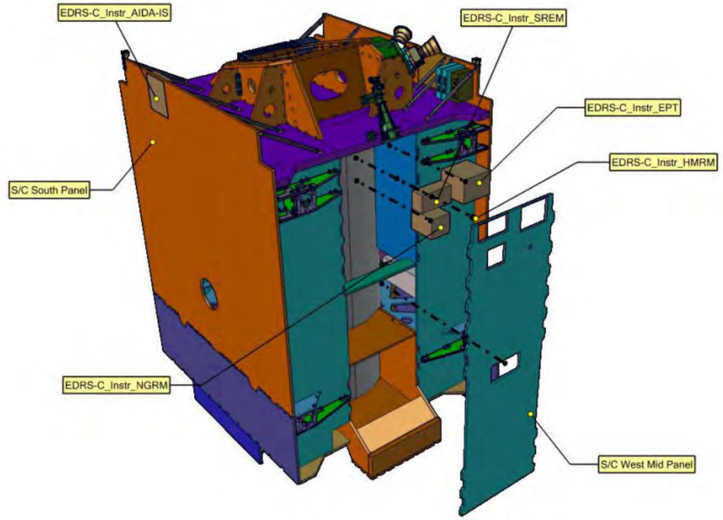
1. Create database of instruments (46 originally included)
2. AO + instrument workshop (ESTEC, November 2010)
3. List of all possible mission opportunities (> 200 initially)
4. Shortlist of representative instruments based on maturity at the time and the amount of data provided (Design Descriptions, 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



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





CO-II: SSA Architecture Study (Astrium, GmbH) - Requirements

1. Review
    - System requirements
    - Product specifications
    - Measurement Techniques
    - Data Processing and Modelling Tools
2. Investigation of connections
    - Between orbits and measurements
    - Between measurements and products
    - Between products and services
3. Architecture Model (ESA-AF)
4. Physical Architecture
    - In-space infrastructure
    - Ground based-sensor network
    - Data processing
5. Security, Resources and Costs
    - Developments
    - Manufacturing
    - Launch and Operations

Example entry in the PSD

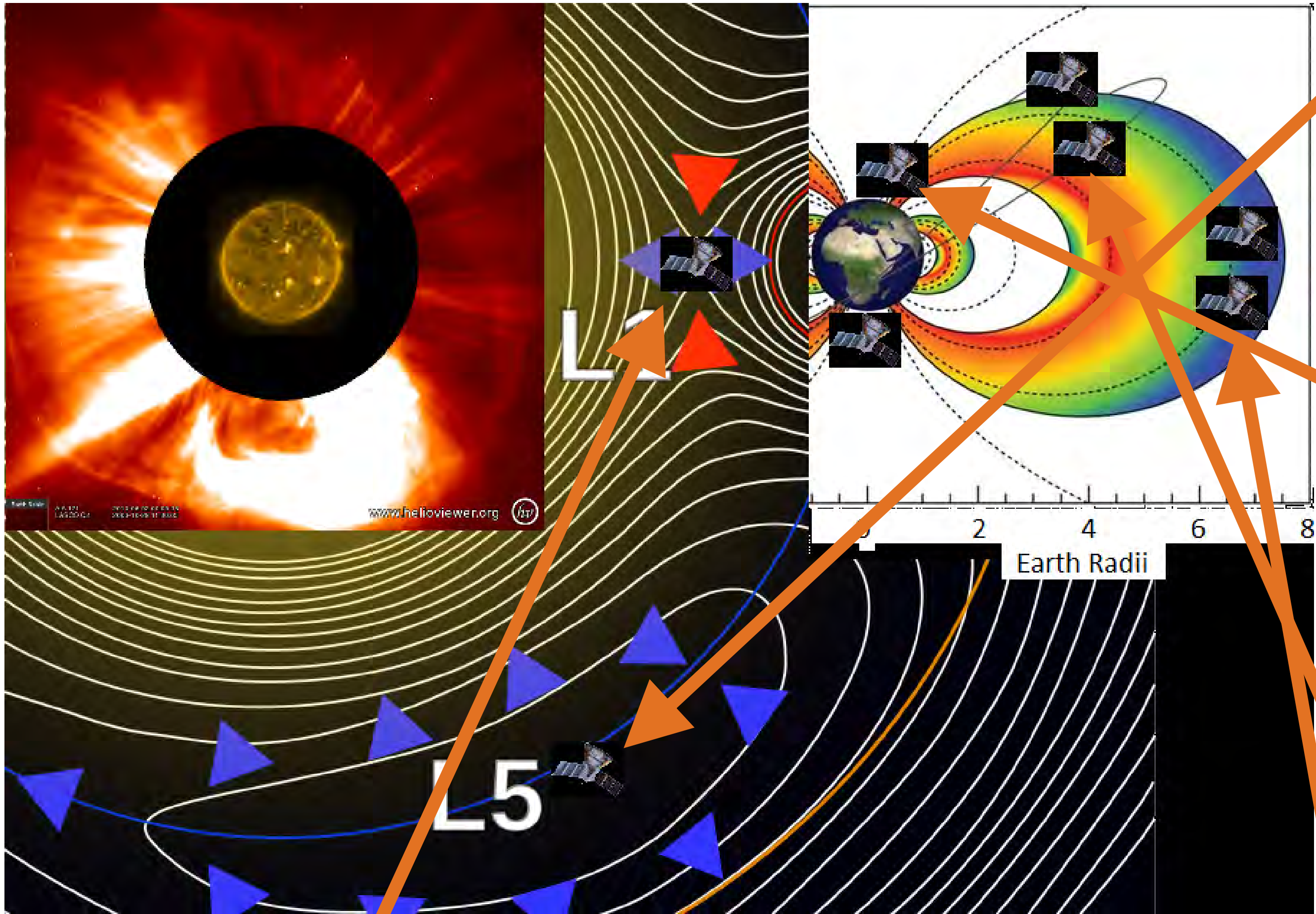
Astrium (GmbH) Project Manager: Axel Wagner

1.3.13 MR-006-M: High Energy >10MeV Protons in Earth Magnetosphere and Radiation Belt – Measurement

PRODUCT	High Energy >10MeV Protons in Earth Magnetosphere and Radiation Belt – Measurement
Product Code	MR-006-M
Input Data required	
Data to be provided and associated units	proton flux in m^-2.s^-1.sr^-1.MeV^-1
Dynamic Range	10^8 per channel (min. 0.00001 > 200 MeV; max. 10^9 @ 10 MeV)
Physical Range	Threshold of 5 channels, goal of 8+ channels, logarithmically spaced in energy ranging from 10 MeV to 400 MeV. Goal of 2 PI steradians with PI pitch angle coverage with resolution of 10 degree half-angle cones. Threshold of single cone of minimum 20 deg half-angle.
Spatial range	400 km - 60,000 km altitude, long: 0 - 360, lat: -90, 90
Spatial resolution	2 observation points on polar LEO, 2 observation points on MEO and 2 observation points on GEO.
Time Range	current date
Time resolution	10 s
Timeliness/Latency	The data shall be available with a maximum delay of 5 min. This requirements can be downgraded subject to Customer approval to 100 min.
Accuracy	0,2
Other Specific	
Related CRD Requirement	SWE-CRD-SCD-1512 SWE-CRD-LAU-1629 SWE-CRD-GEN-1713
Justification of the requirements	A factor in a wide range of dose, NIEL and single-event related effects. Protons in the range 1-10 MeV affects solar cells.
Comment	Also required outside the radiation belts, e.g. above polar cap, at GEO; Source of radiation also include Solar Energetic Particles and Galactic Cosmic Rays; For the ions (other than proton) the source is mainly SEP and GCR. Particles in the south atlantic anomaly are included in the requirements. Sensors should remain in two separate hemispheres (i.e. the phasing should roughly be 180 degrees). for MEO, Galileo altitudes are adequate (threshold), a greater range of altitudes is desirable (goal).
Related Services	2-1, 3-1, 4-1

CO-II: SSA Architecture Study (Astrium, GmbH) – Proposed Orbits

esa



One spacecraft at L5

Optical Imagers and Charged Particle Instruments

Two identical spacecraft for polar Low earth orbit (LEO) [inclination ~ 89°]

Wide-field Auroral UV imager, Magnetometer, GPS/GNSS Receiver, Accelerometer, Particle and Plasma Instruments and Radio Spectrum Analyser.

Two identical spacecraft in Medium-height orbit (MEO) [inclination ~ 50-60°]

Radio Spectrum Analyser, Magnetometer, Particle and Plasma Instruments

Two identical spacecraft in Geosynchronous orbit (GEO)

Radio Spectrum Analyser, Magnetometer, Charged Particle and Plasma Instruments

Proposed:

8 dedicated SSA/SWE Spacecraft

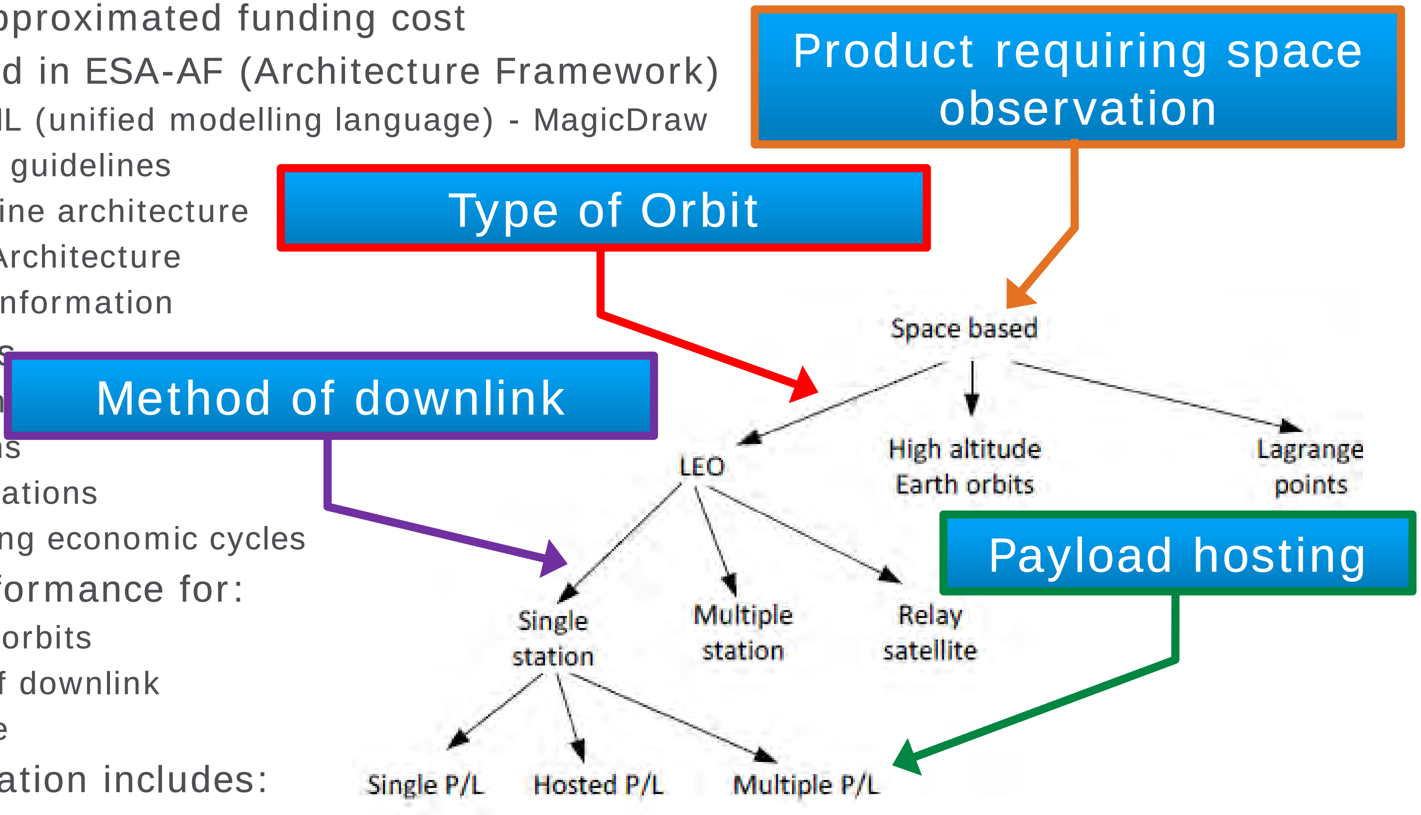
One spacecraft in orbit about Lagrange 1 point (L1)

Optical Imagers, Optical Flux Meters, Radio Telescope, Magnetometer, Charged Particle Instruments and Solar Plasma Analyser

CO-II: SSA Architecture Study (Kayser Threde, GmbH) - Approach

Kayser-Threde (GmbH)
Project Manager:
Hilda Kinter

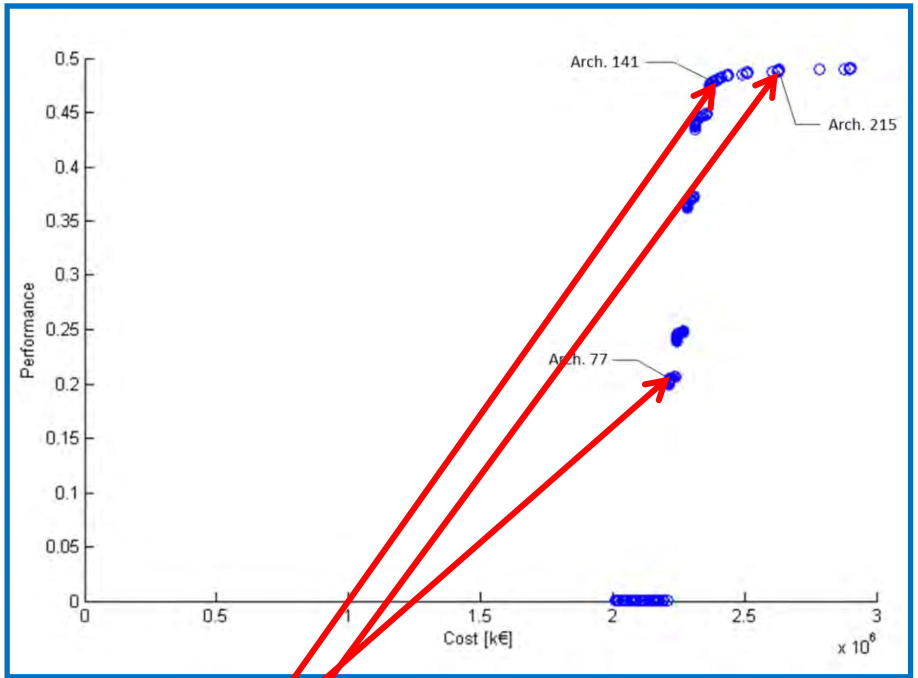
1. Database of Assets to fulfil SRD/PSD Requirements
    - Space-based sensors (function, mass, volume, data rate)
    - Ground-based sensors
    - Processing and archive facilities
2. Versions of assets were derived from existing assets to estimate the evolution of the assets for a approximated funding cost
3. Assets are included in ESA-AF (Architecture Framework)
    - Visual UML (unified modelling language) - MagicDraw
    - Modelling guidelines
    - Full baseline architecture
    - Physical Architecture
    - Flows of information
4. Estimation of costs
    - Developm
    - Operations
    - ground stations
    - Considering economic cycles
5. Calculation of performance for:
    - Range of orbits
    - Method of downlink
    - Orbit type
6. Architecture derivation includes:
    - Hosted payloads
    - Data relay



CO-II: SSA Architecture Study (Kayser Threde, GmbH) – 1st Iteration

esa

1. Using the assets database products were assigned to all measurements but those combinations which failed to fulfil the PSD requirement or had timeliness over twice the baseline were excluded
2. Tradespace exploration was used to assess the ability of all possible architectures to fulfil the requirements and at what cost
3. Three options presented to ESA
4. Architecture 141 was recommended as it has the best performance to cost ratio
5. In Phase 2, Kayser-Threde will refine the selected architecture baseline design providing a description and analysis down to a lower level
6. Assessment of possible architectures close to the baseline (with more details) will be done based also on operability, security, flexibility and development approach (not just fulfilment of SRD/PSD requirements).

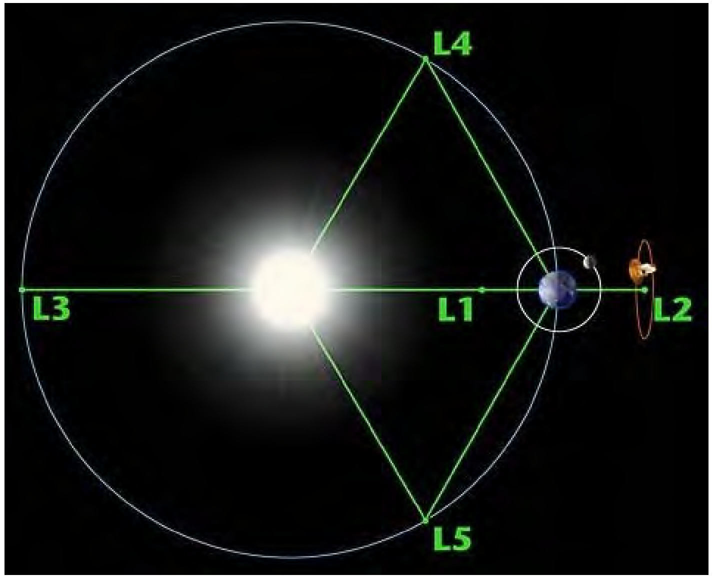


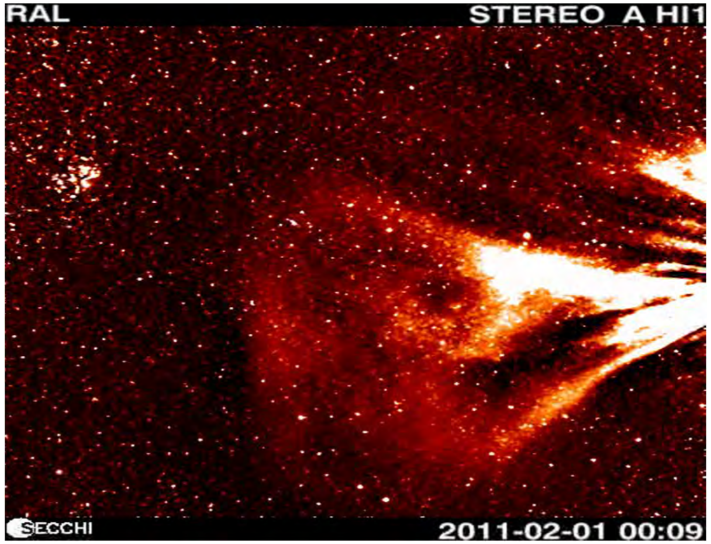
	Number of Instruments / Number of Platforms		
Architecture	LEO-MEO	GEO	L1-L2-L5
77	13 / 1	4 / 1	5 / 2
141	15 / 4	3/ 1	5 / 2
215	16 / 4	2/ 1	5 / 2

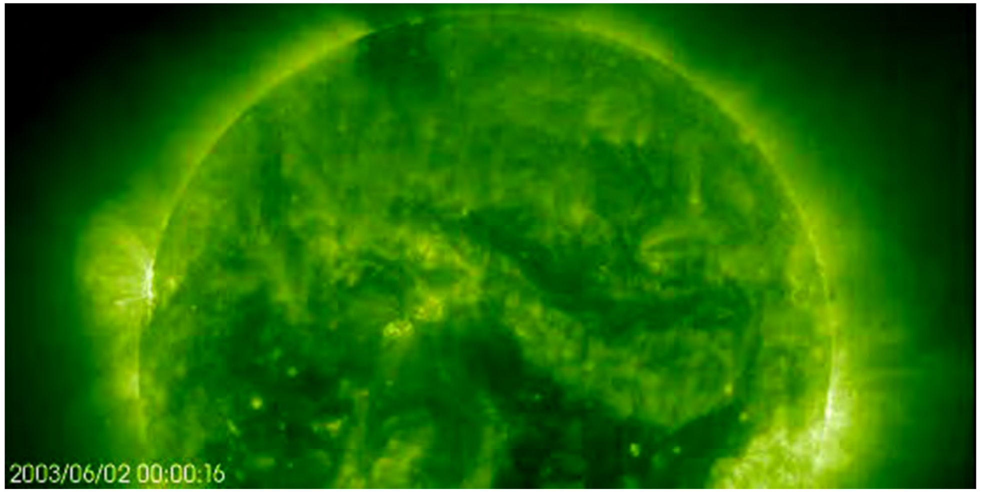
Study to be completed in July 2014

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

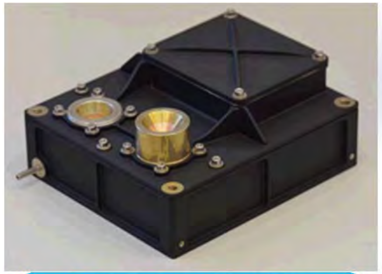




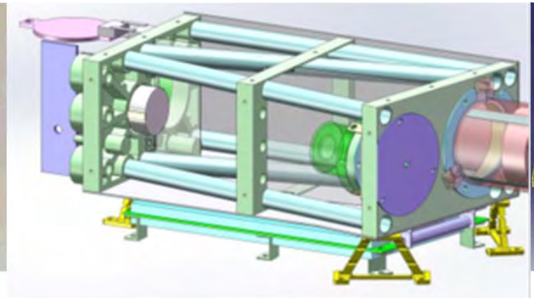


GSTP Instrument Technology Development Activities (in Support of SSA)

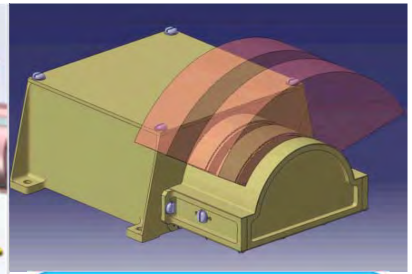
1. On-going activities:
   - NGRM (Radiation Monitor)
   - ESIO (EUV Solar Imager)
   - HOPE-M (Plasma Monitor)
   - 3D-EES (e^- Spectrometer)
   - SOSMAG (Magnetometer)
   - MAGIC (Magnetometer)
   - AIDA (Advanced Impact Detector Array)
   - M-NLP (Multi-Needle Langmuir Probe)
   - HMRM (Radiation Monitor [TRP])
2. Planned activities: Compact Wide Angle Coronagraph, Remote Interfacing Unit (RIU), Airborne radiation detector, Wide-field space-based auroral camera prototype, Solar X-ray Monitor
3. Plus: Fireball monitor for SSA, Combined Radiation Monitor Data Analysis System, Heliospheric modelling techniques and more…



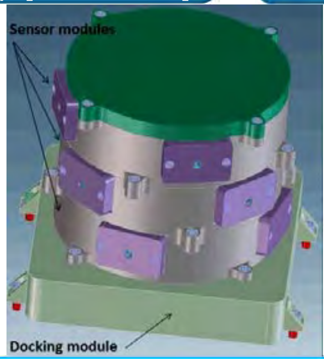
Next Generation Radiation Monitor (NGRM) [RUAG, Ch]



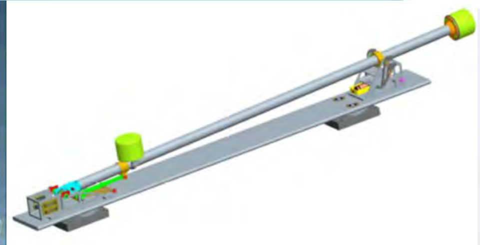
EUV Solar Imager for Operations (ESIO) [CSL, Be]



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

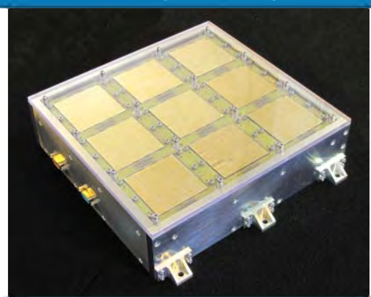


3d Energetic Electron Spectrometer (3d-EES) **[UCL, Be]**



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]

SSA SWE Segment Objectives
Period 2: 2013-2016

1. Networking of available national and European SWE assets (sensors, data centres, service centres, service coordination, user support)
2. Preparing new services & expanding Expert Service Centres (ESCs) network
3. Exploitation of SWE instruments, data and European centres of expertise
4. Utilisation of PROBA-2 mission SWE data
   - SSA-SWE Segment responsible for Mission Management since July 2013
   - Data incorporated into SWE precursor services
5. Implementation of the first SWE hosted payload (HP) missions
   - First opportunities are based on results of SN-II activity in SSA PP
   - First HP flight opportunity: NGRM instrument on-board EDRS-C
   - Continuation of the hosted payload flight opportunity assessments for new missions and new instruments
6. Phase C/D development of selected new SWE instruments including:
   - Magnetometer especially for hosted payload missions
   - Hot plasma instruments
7. Preparation for new SWE missions into the solar wind
   - Replacement of aging L1 missions SOHO and ACE
   - Studies on the combined L1, L5, L4 monitoring system

Technology programmes

Open Call for Technology Flight Demonstrators and Carrier Flight Opportunities

- GSTP 6 Element 3
- Proposals may be submitted at any time during the entire period of GSTP-6 (2013-2018)
- See EMITS **(News)** for details

http://emits.sso.esa.int