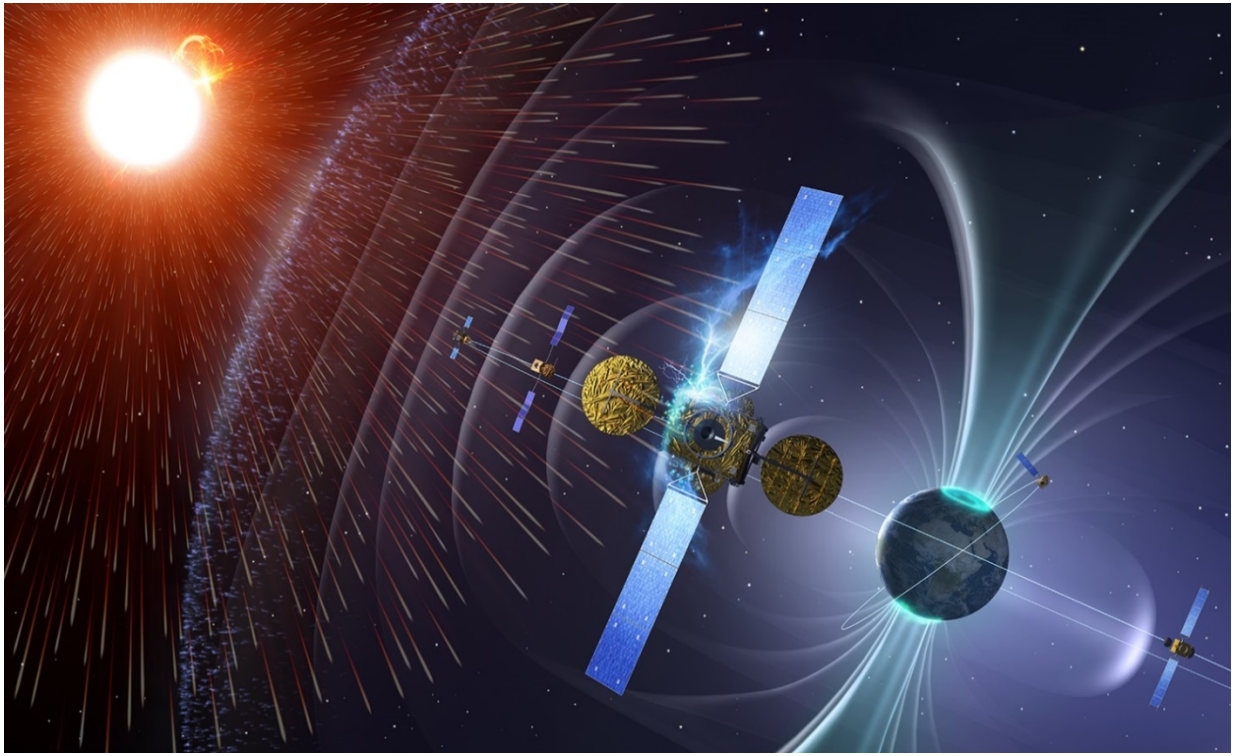
Flight Opportunities and SSA

Piers Jiggens[1], Alain Hilgers[1], Juha-Pekka Luntama[2], Alexi Glover[2], Serge Moulin[3], Petteri Nieminen[1], Eamonn Daly[1]

1 European Space Research and Technology Centre (ESTEC), Noordwijk, NL

2 European Space Operations Centre (ESOC), Darmstadt, Germany

3 European Space Astronomy Centre (ESAC), Madrid, Spain

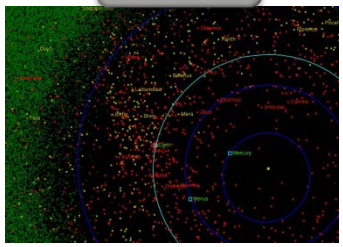


SSA Preparatory Programme Overview (2009-2012)

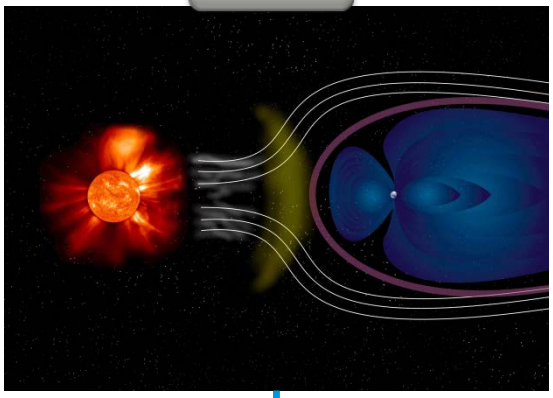
SSA Preparatory Programme

SST

NEO



SWE



Core

CO-I

Requirements and evaluation

CO-II

Architectural design

Data Centre (DC-xx)

Database and Portal Development

Prototype Pilot Data Centres

SN-I

Preparation of Space Weather Services

SN-II

Space Weather Instruments Implementation Design Study

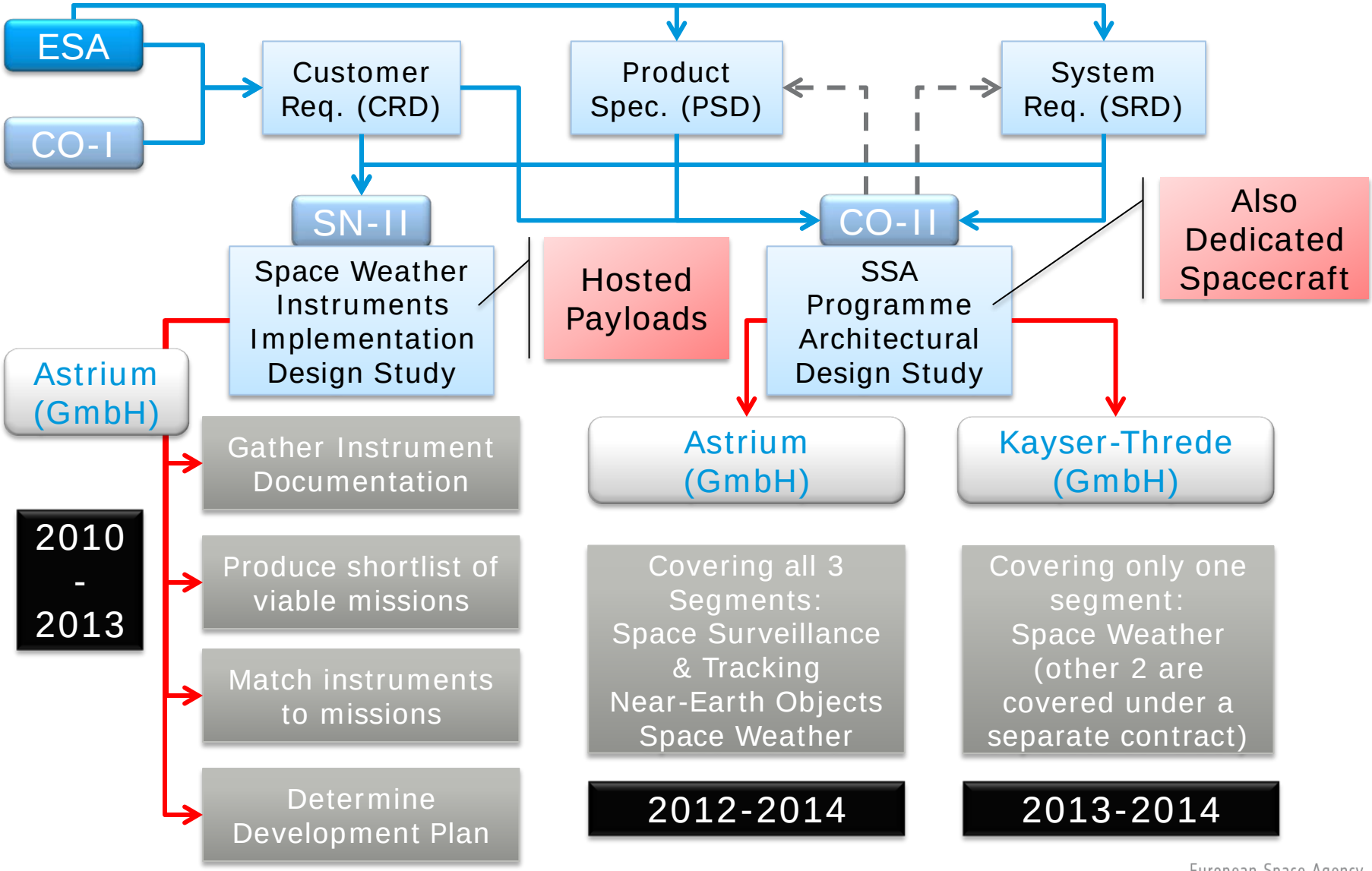
SN-IV

Space Weather Precursor Service Operations and Development

SN-VI

Space Weather Additional Services

SSA Preparatory Programme
Focus on Space-based Assets



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

Astrium (GmbH)
Project Manager:
Norbert Pailer

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

Margins

Planned launch date

Instrument type

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

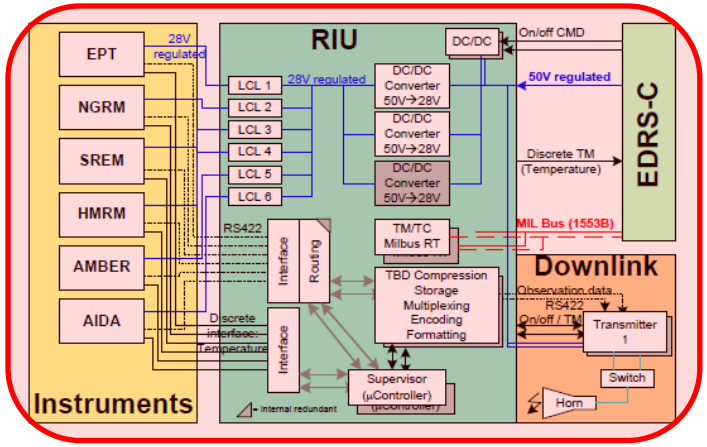
Orbit Information

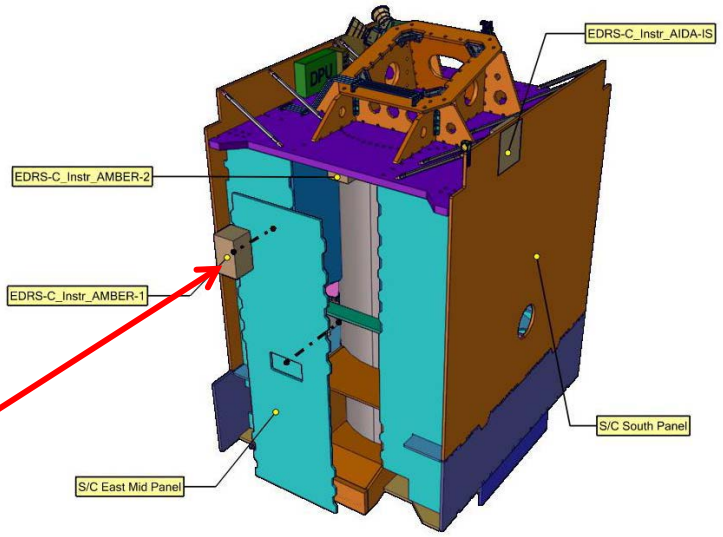
Instrument suitability

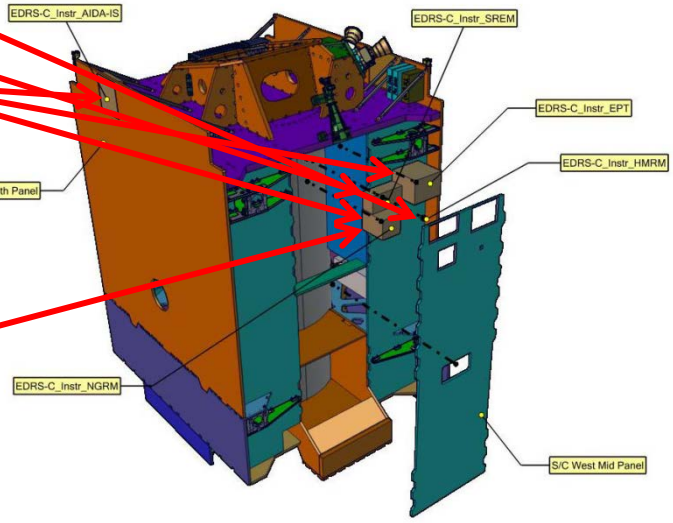
Mission Priority	Mission	Institution	Orbit	Inclination	Orbit Altitude	Instruments	Pointing Dir.	Power Margin	Mass Margin	Launch Year / Design Life	Plasma Analyzer & Langmuir Probe (Low Energy Particles)	Medium + High Energy Particle Detectors	Dust Detectors	Surface Charging Detectors	GNSS Receivers	Magnetometers	Imagers: Sun Oriented Imagers	Imagers: Earth Oriented Imagers	Imagers 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	2013/15	x										
102	MOS-B	Eumetsat	SSO	98.7	817	relay system, space environment	Earth	60	84	2013/15	o										
103	Jason-CS	Eumetsat		66	1300	radar altimeter package	Earth	tbd	tbd	2017	o	x	o	o	x		-	o	-	o	-
104	CSG 1	ASI	SSO	97.8	620	x-band SAR	+/-34deg off	<35	20	2015/7	o	x	o	o	x		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		o	-	-	o	o
106	Merlin	DLR	SSO	polar	500-650	Methan LIDAR (Light Detecting	Earth	low	low	2016/3	x	x	o	o	x		-	-	-	o	o
107	Meteor-MP N3	Roscosmos	SSO	98.77	832	Russian "Metop" version	Earth	tbd	tbd	2016/5	x	x	x	o	x		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		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

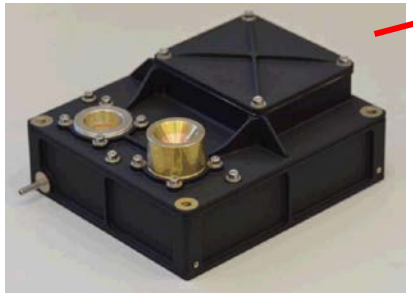
1. Shortlist Missions: ~~CSG -1 & -2~~, Metop-C, Galileo FOC, Alphasat-2, EDRS-C, Eurostar, Jason-CS, ~~Lisa PF~~, Euclid (10 -> 7)
2. Back-up missions: MetOp-SG, ~~MOS-A & B~~, ~~Meteor-MP N3~~, ~~Fengyun-3 (FY-3)~~, ~~COSMIC-2~~, ~~Merlin~~, ~~Heinrich Hertz~~, ~~GK-2A~~, ~~FY-4~~, DSCOVR (11 -> 2)
3. Instruments were matched for 9 Missions
4. Proposal made to EDRS-C including: AMBER (plasma instrument), EPT, ~~NGRM~~, SREM, HMRM (radiation monitors), AIDA ~~(micrometeoroids)~~
5. Remote Interface Unit baseline Requirements







Next-Generation Radiation Monitor (NGRM)



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

1. Review
   - Sys
   - Proc
   - Mea
   - Data Processing and Modelling Tools
2. Investigatio
   - Between orbits and measurements
   - Bet
   - Bet
3. Architecture Model (ESA-AE)
4. Physical Arc
   - In-space infrastructure
   - Gro
   - Dat
5. Security, Resources and Costs
   - Developments
   - Manufacturing
   - Launch and Operations

Product name and Code

Physical Requirements on the Measurement

Spatial Requirements

Temporal Requirements on the Measurement

Required Accuracy

Justification, Comment and Related Services

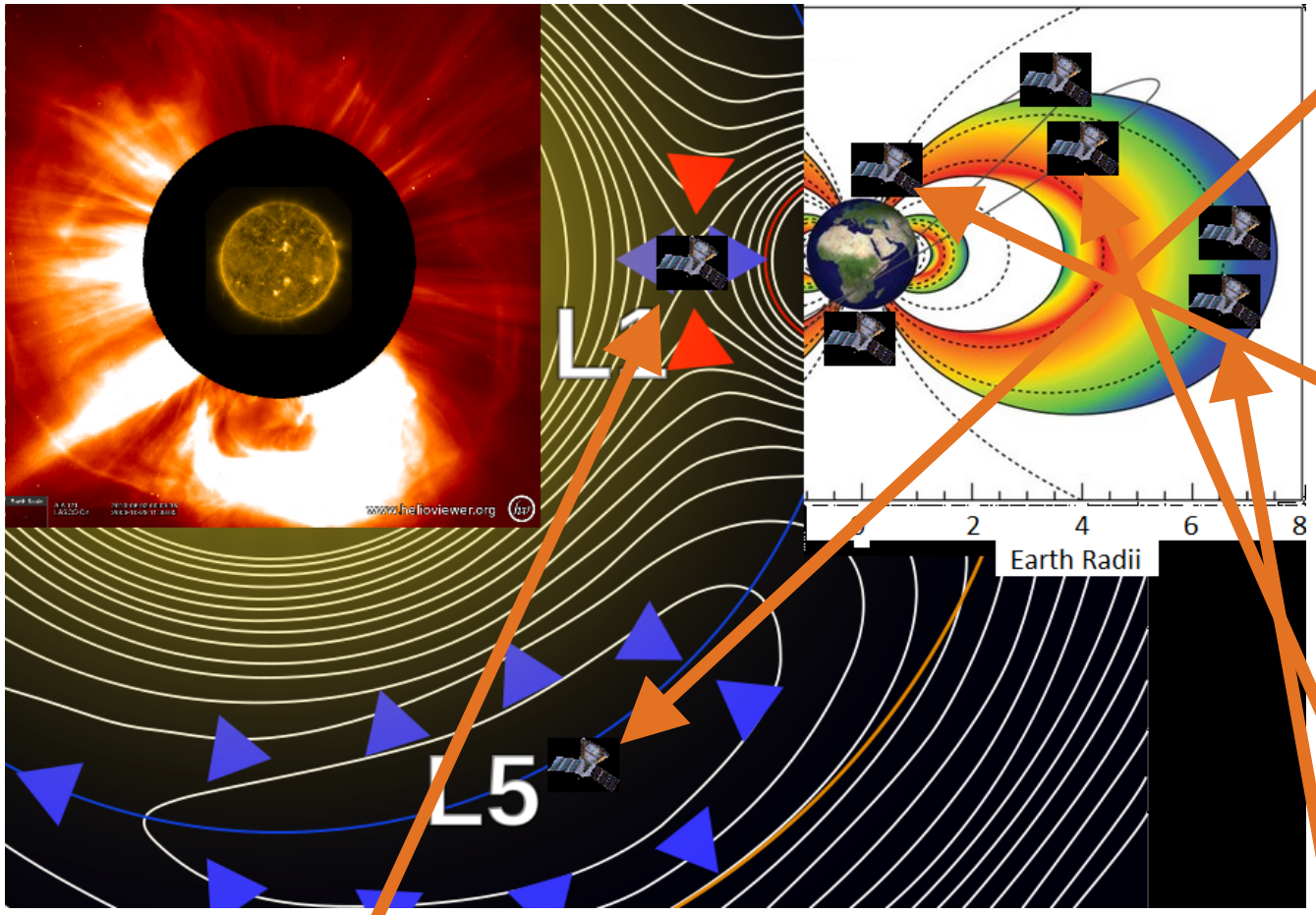
Example entry in the PSD

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



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

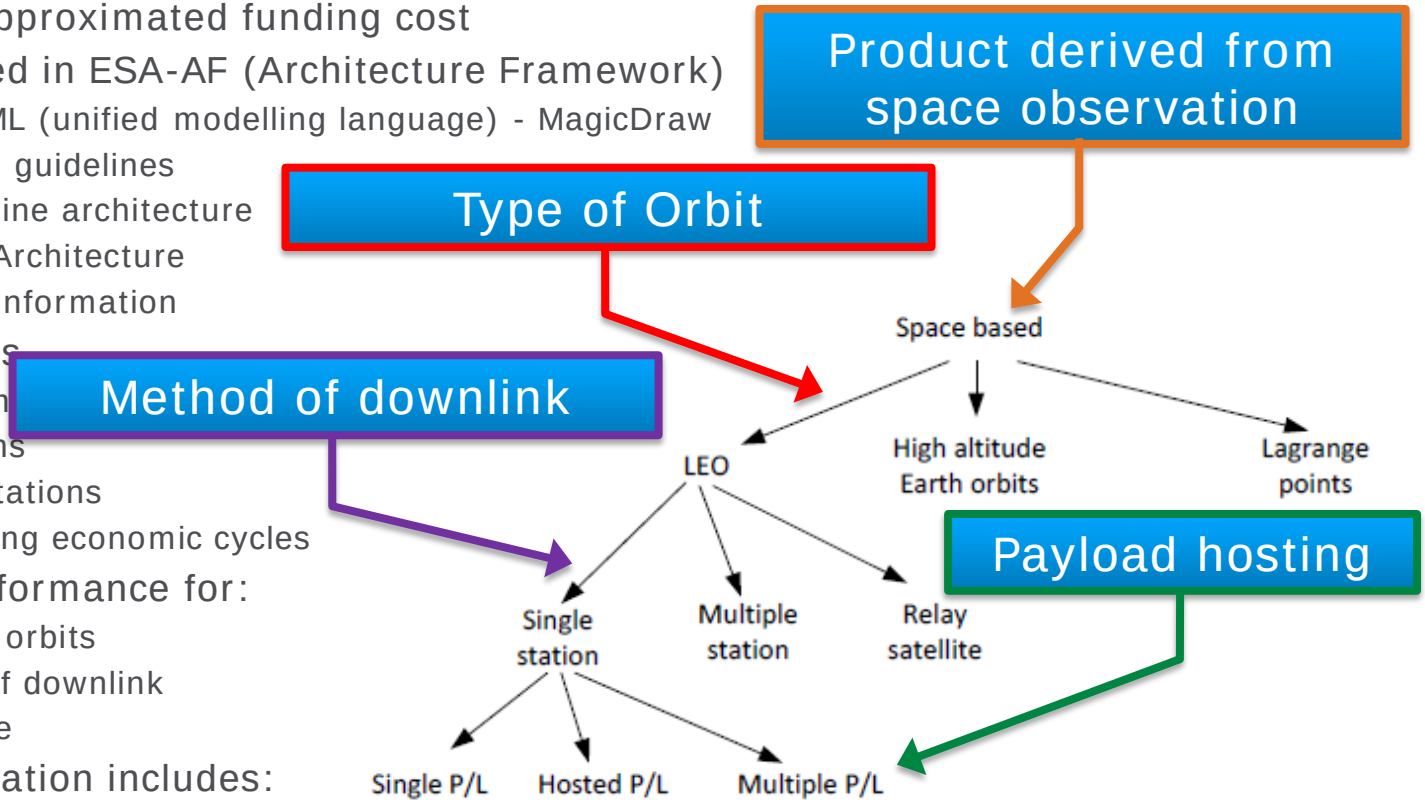
One spacecraft in orbit about Lagrange 1 point (L1)

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

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

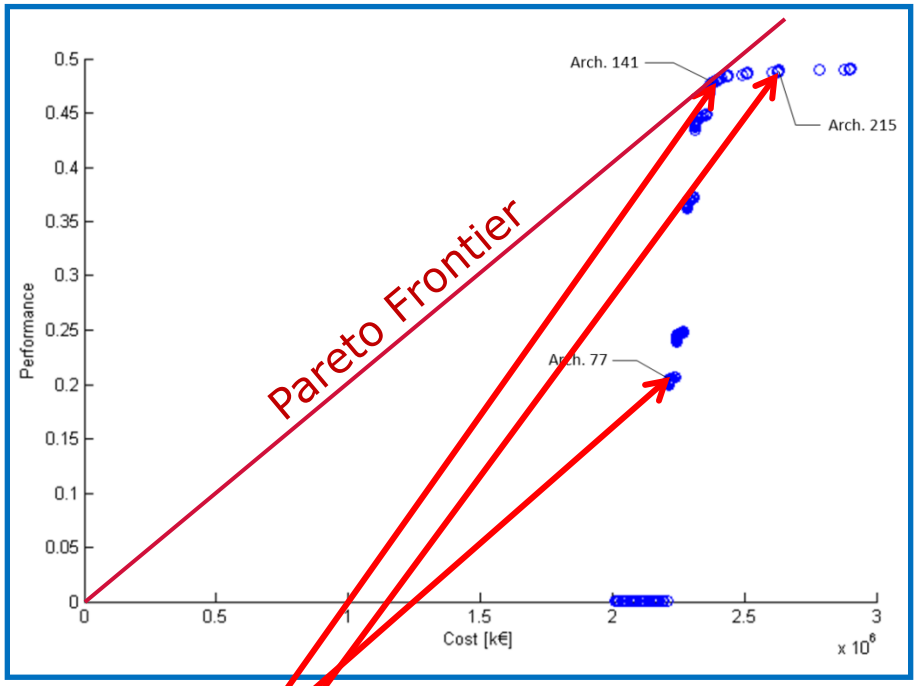
Kayser-Threde (GmbH)
Project Manager: Hilda Kinter

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

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).

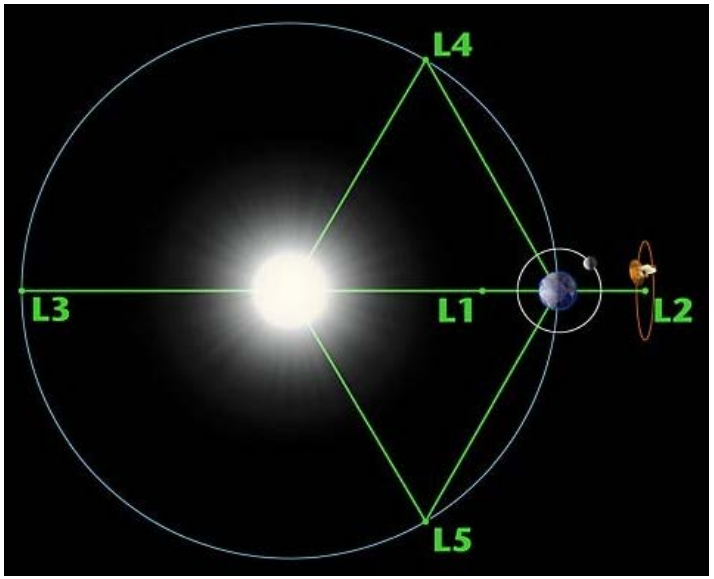


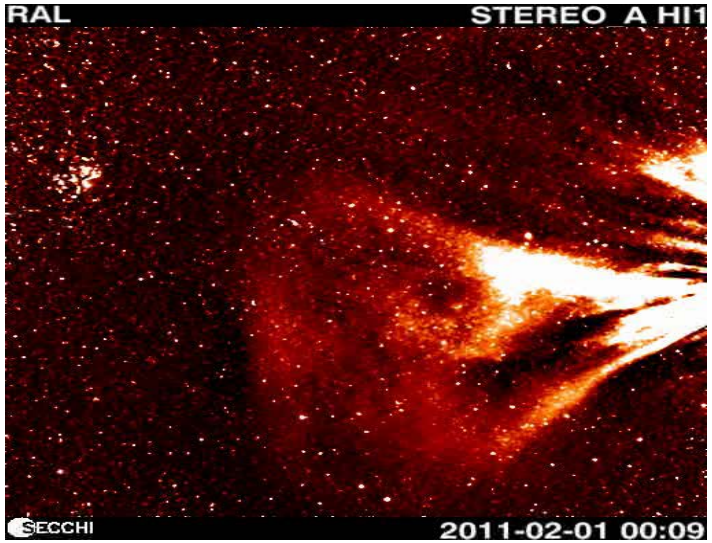
	Number of Instruments / Number of Platforms		
Architecture	LEO-MEO	GEO	L1-L2-L5
77	13 / 1	4 / 1	5 / 2
141	15 / 4	3/ 1	5 / 2
215	16 / 4	2/ 1	5 / 2

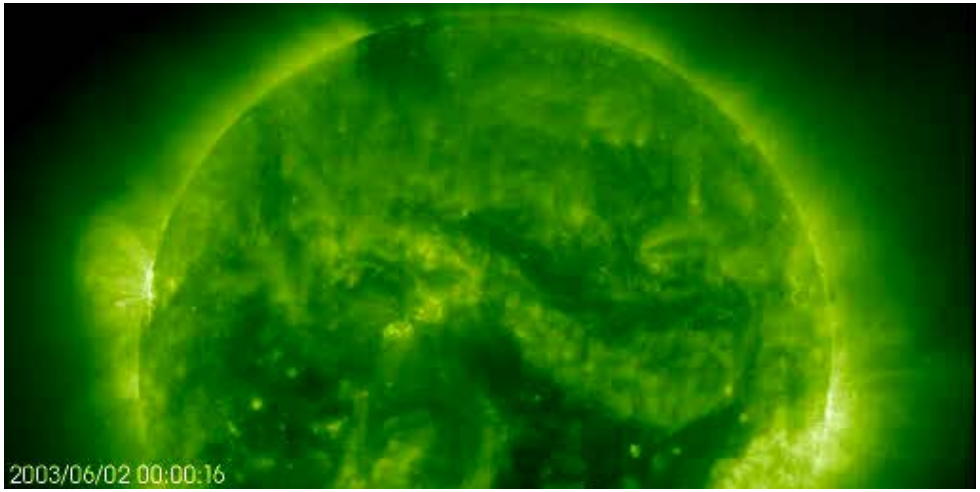
Study to be completed in July 2014

Concepts for enhanced Space Weather monitoring

1. In-situ L1 observations are critical for consolidating the CME 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, e.g. for GICs
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

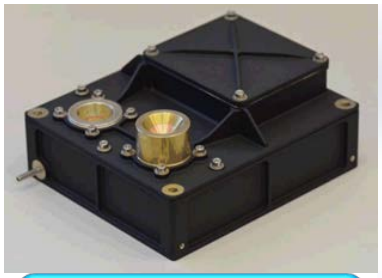




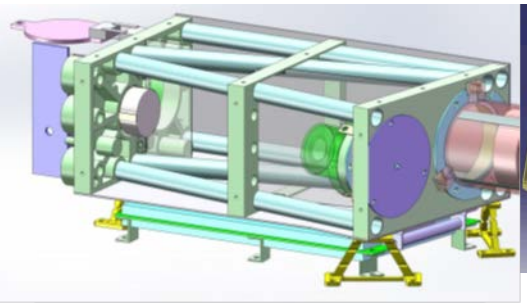


GSTP Instrument Technology Development Activities (in Support of SSA)

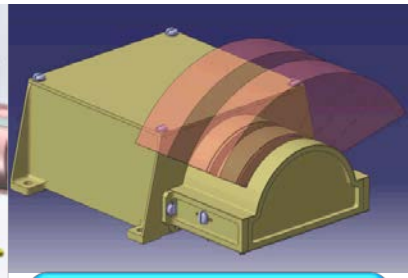
1. On-going activities:
   - NGRM (Radiation Monitor)
   - ESIO (EUV Solar Imager)
   - HOPE-M (Plasma Monitor)
   - 3D-EES (e^- Spectrometer)
   - SOSMAG (Magnetometer)
   - MAGIC (Magnetometer)
   - AIDA (Advanced Impact Detector Array)
   - M-NLP (Multi-Needle Langmuir Probe)
   - HMRM (Radiation 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…



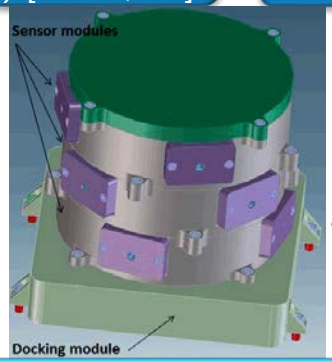
Next Generation Radiation Monitor (NGRM) [RUAG, Ch]



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



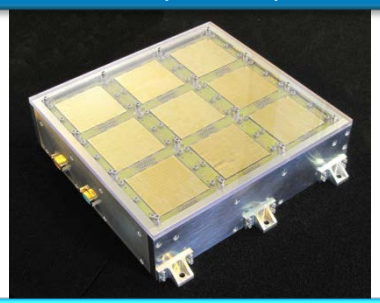
HOt Plasma Environment Monitor (HOPE-M) [UCL, UK]



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

Non-SSA flight opportunities

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