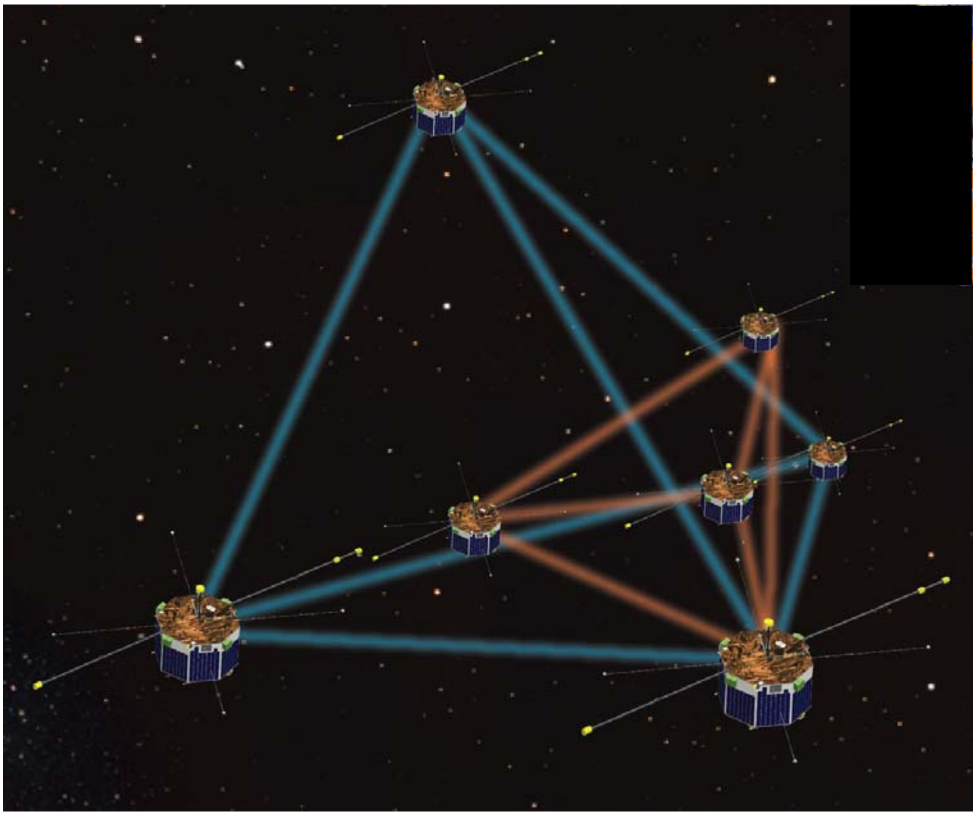
The Cross-Scale Mission:
Executive Summary Report



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1. OVERVIEW OF THE OVERALL STUDY AND THE BASELINE MISSION DESIGN

Cross-Scale is a mission that both builds on the advances from previous spacecraft missions like Cluster and also pushes the frontiers of knowledge in terms of magnetospheric dynamics, energy processes and couplings across different spatial and temporal scales. This is done by *simultaneously* measuring a minimum of two plasma scales (electron and ion scales in year 1 and then ion and fluid scales afterwards) with 7 spacecraft in two nested tetrahedral constellations (with a common apex),over a 5 year period. This document provides a concise summary of the findings from the ESA contract awarded to the Astrium Ltd study team, for the "System Design of the Cross-Scale Mission".

The early phases of the study involved a thorough analysis of the Science, Mission and Programmatic Requirements. This was necessary in order to evaluate the driving requirements for the mission architecture trade-off. A matrix of 72 potential mission architecture combinations/trade-offs resulted for the mission design including various injection and transfer orbit options, and spacecraft design/accommodation designs.

The final baseline mission design/architecture utilises Soyuz-Fregat 2-1B, to launch into an optimal direct injection orbit. The 2 week apogee raising phase is followed by a 4.4month perigee raising phase, which uses lunar resonances to save propellant mass. A composite spacecraft is used for the transfer, based on a redesigned Lisa Pathfinder propulsion module, and a simple dispenser/carrier structure on which to mount the science spacecraft.

The launch date cannot precede Oct 6th 2017, due to unacceptably large transfer eclipses close to the Autumn Equinox. Use of Lunar resonances are necessary for the perigee raising phase of the transfer and achieve a 20% system mass margin with the current baseline mission architecture. Once the desired orbit is achieved, the science spacecraft are deployed over a 7 day period (1 day each).

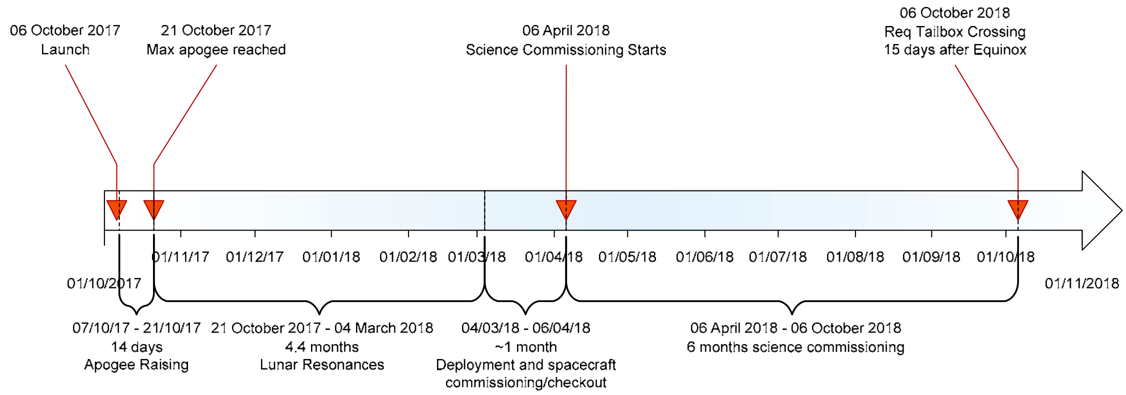


Figure 1-1: Launch, Transfer and Commissioning profile for a required 2018 tailbox crossing

This selected baseline is a pragmatic compromise between cost, mass, accommodation and risk. This allows implementation of a propulsion module with significant heritage, and simple, independently deployed science spacecraft.

In order to provide **localisation and synchronisation**, the electron scale spacecraft are required to also use an inter-satellite link (ISL), where S-band RF equipment is used. Localisation from the ground is carried out for the ion scale spacecraft, though synchronisation is less demanding than ISL and is perfomed by all spacecraft. The ISL is one of the very few technologies that requires development.

The baseline **Ground Segment Design** requires two ESA 15m ground stations. A combination of Maspalomas and Kourou is an optimum configuration for maximum data downlink. To further maximise data downlink, variable data downlink is assumed, along with dual frequency simultaneous downlink. Particular constellation level constraints such as spacecraft switchover and ranging are included. In summary the constellation is able to downlink almost **34%** of its average nominal data, which is substantially greater than the 20% requirement.

In summary, the study has shown that the science goals are achieveable with the selected baseline mission design, which is feasible from a mass, cost, accommodation and programmatic perspective.

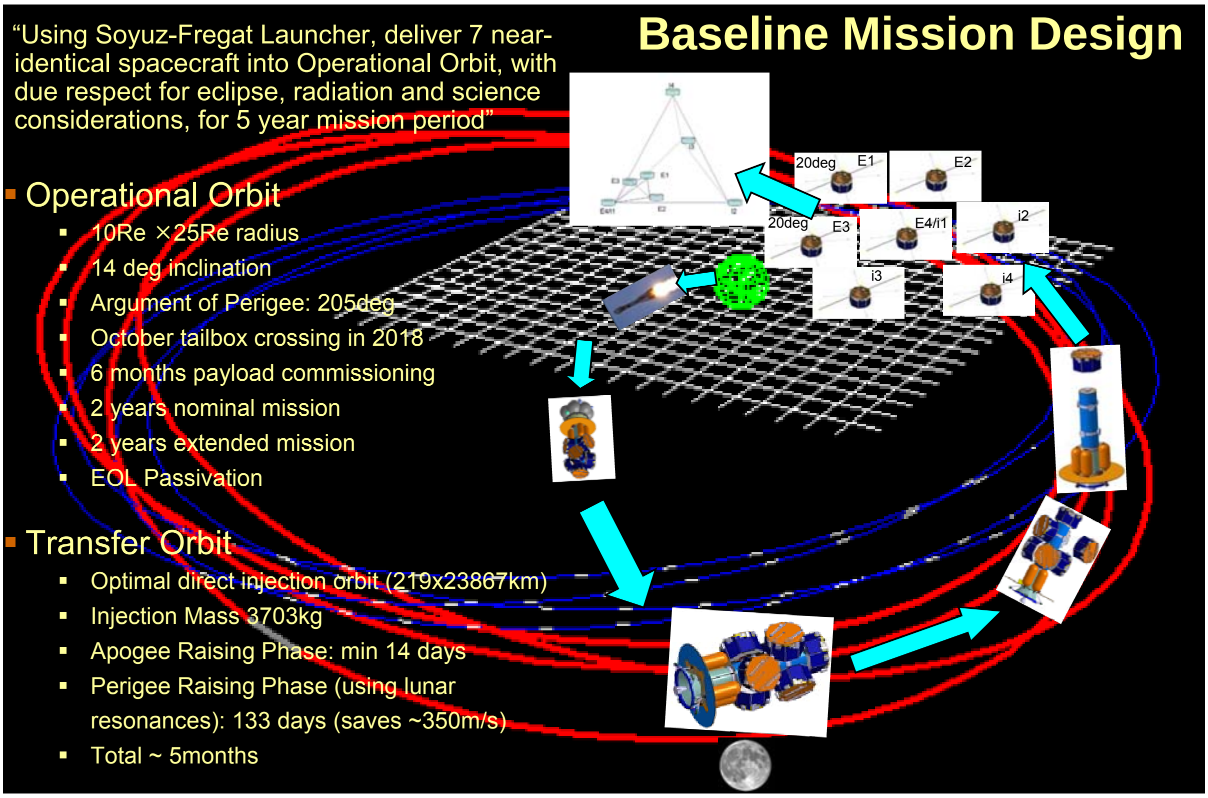


Figure 1-2: The baseline Cross-Scale mission design

Baseline Concept Summary Update	
Number of ESA Spacecraft	-7
Constellation Pointing	-Inertially Fixed: 5 spacecraft are pointed at 5° from the ecliptic north pole, remaining 2 are pointed at 20° from the ecliptic north pole (separated by 40° from each other)
Payloads	-5 different payload configurations (E1&E2, E3, E4/I1&I3, I2, and I4). A dedicated payload module is baselined to simplify AIV to spacecraft
Transfer to operational orbit	-Launch by Soyuz-Fregat 2-1B from Kourou, after Oct 6th 2017 -Injection orbit: 3703 kg (nc. 90kg 1666-SF Adapter) into 219 km × 23867 km -Transfer to operational orbit using minimum 2 week apogee raising phase followed by 4.4 months for perigee raising phase using lunar resonances -Transfer DeltaV requirement (nc. 5% margin): 1418m/s
Mission and Propulsion Architecture	-Chemical Bipropellant System (LISA PF PRM Heritage) -Transfer to operational orbit by modified PRM + Carrier Structure composite (LISA PRM Heritage)
Operational orbit	-Perigee altitude: 9 RE (10Re radius) -Apogee altitude: 24 RE (25Re radius) -Inclination: 14° -Argument of Perigee: 205° for October tailbox crossing in 2018 -Orbit Period: ~103 hours
Ground Segment	-Two full time 15m ground stations at Kourou & Maspalomas
Key Environments	-Eclipses: Transfer (must be <2.5 hrs), on-orbit solar (3.3hrs), lunar (TBD) -Radiation Dose: 100krad behind 1.5 mm Al shielding (LISA PF Req <60krad) -Charging: Not expected to be above -300V in tail eclipse (ref. GeoTAIL)
Operational lifetime	-1 year for transfer, deployment, spacecraft and payload commissioning -2 years science operational phase -2 years extended science operation
Localisation & Synchronisation	-Dedicated ISL required for E-Scale localisation. Ion-Scale only synchronises
Spacecraft Reliability	~95.5% (Individual spacecraft reliability estimate after 5 years, from SSC)
Constellation Reliability	~70% (Overall constellation reliability estimate after 5 years, from SSC)

Table 1-1: Summary of the baseline Cross-Scale mission architecture from the Detailed Design Phase

2. PAYLOAD COMPLEMENT

The instruments foreseen on Cross-Scale will be used to characterise both electro-magnetic fields and charged particles. The payload equipment on the seven spacecraft has taken into account the minimum instrumentation that is required to be compliant with the science requirements.

This comprises the electro-magnetic field suite which is common to all spacecraft as well as varying numbers of particle analysers EESA (Electron Electrostatic Analyser), IESA (Ion Electrostatic Analyser), ICA (Ion Composition Analyser) and HEP 2D (High Energy Particle Detector), the corresponding CPP (Central Processing Unit) and ASPOC (Active Spacecraft Potential Control Unit).

The electro-magnetic field suite comprises the MAG (DC Magnetometer) ACB (AC Serach Coil magnetometer), E2D (four 50m wire boom units with probes at tip, to measure electric field), as well as ACDPU (Processing Unit) including the electron density sounder EDEN (Electron Density Sounder).

Table 2-1 shows that the resulting mass and power budgets for the different spacecraft[1] in the constellation are between 15 kg/15W (E3) and 33kg/60W (E1 and E2). The driver for the E1 and E2 payload resources are the four EESA units while on E3 only the electromagnetic field suite is foreseen. A mass and power margin between 10% and 20% dependent on the instrument TRL (i.e. Technology Readiness Level) have been added. The extra mass for the magnetometer booms and the required harness is included in the spacecraft budgets. A simple analysis of the increase of the instrument shielding revealed an additional mass requirement for the constellation of about 21 kg based on a 3 mm thick aluminium layer and 25% coverage of the particle analysers. The instrument power requirements include the nominal power required during science operations as well as the peak power required for specific purposes such as calibration, energy sweeps or data compression. The peak power can become up to 20 W higher than the nominal power and has to be buffered by the on-board battery.

The uncompressed data rate produced during nominal operations has been assessed with the instruments running in 100% duty cycle. In addition, the generated data volume during two orbits of 100 hours duration each has been calculated for the on-board memory sizing. In Table 2-2 the compressed data has been derived from the uncompressed raw data by assuming compression factors of 10 for the EESA, 3 for the electromagnetic field instruments and 1 for the other instruments. The data generation drivers are again the E1 and E2 spacecraft due to the fact that four EESA units running in fast cadence are equipped. From the compressed 3.6 Gbit constellation data rate only about 22% of the science data can be retrieved on ground when assuming the minimum required downlink rate of 800 kbit/s. An assessment of the data downlink strategy based on the quasi continuous sample data downlink has revealed an optimised data storage scheme.

The accommodation of the payload has been traded with respect to the optimisation of the field of view, compliance with the EMC requirements as well as with the mounting requirements and the required coverage. An important aspect has been to design a standardised payload deck (payload module, see Figure 2-1) which is able to cope with the five different instrument compositions and leads to significant simplifications of the AIV and the corresponding cost and schedule optimisation. In the baseline octagonal spacecraft shape, the four flat panel centred E2D units are accommodate at 90° to each other, the magnetometer booms are accommodated on the edges at 22.5° to the E2D, the EESA under 30° to E2D and 37.5° to the booms. Finally, the IESA has been accommodated on an edge position under 22.5° to the E2D. The HEP and ICA are accommodated on abandoned IESA positions while the positions of the ACDPU, the CPP and the ASPOC have to be optimised with respect to other spacecraft components on the payload deck. The final configuration of the five planned instrument compositions can be seen in Figure 2-2, where the instrument fields of view have been indicated by yellow fans.

In general, the EESA has been identified as driver of all resources, data rate and also the instrument accommodation. This is also true for the allowed instrument thermal ranges of 0° to 30°C under nominal operations conditions or -20° to 50°C for non-operating conditions.

[1] i.e. E1, E2, E3, E4/I1, I2, I3, I4, where the suffixes E indicates Electron Scale, and I indicates Ion Scale

	total mass incl. margin [kg]	total power incl. margin [W]	peak power incl. margin [W]
E1 & E2	33.31	59.32	80.35
E3	15.27	14.96	19.60
E4/I1 & I3	28.71	44.48	57.88
I2	31.11	47.72	64.36
I4	31.36	49.52	65.58

Table 2-1: Payload mass and power budgets for each of the seven different spacecraft

	uncompressed data:		compressed data:	
	total data rate [Mbit/s]	data volume for 2 orbits [Gbit]	total data rate [Mbit/s]	data volume for 2 orbits [Gbit]
E1	10.46	7534.66	1.34	963.13
E2	10.46	7534.66	1.34	963.13
E3	1.25	897.41	0.42	299.14
E4/I1	0.63	450.36	0.17	119.15
I2	0.60	433.88	0.16	113.66
I3	0.34	248.07	0.09	67.20
I4	0.44	314.42	0.12	89.32
Sum	**24.19**	**17413.45**	**3.63**	**2614.73**

Table 2-2: Science data rate and data volume with and without compression

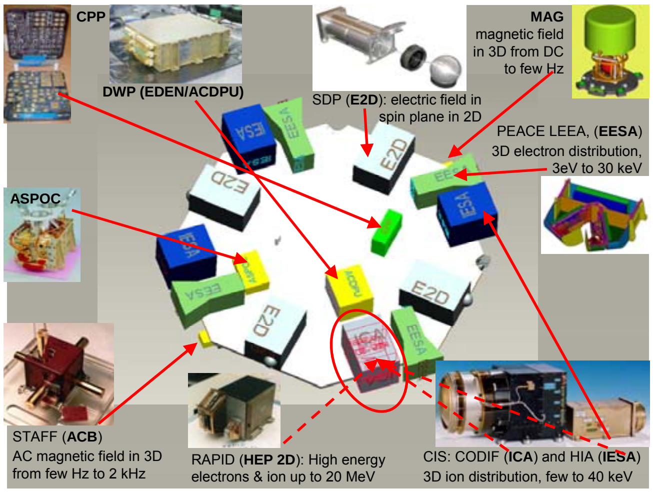


Figure 2-1: Reverse view of payload module (stowed). Note that the HEP/IESA/ICA overlap never actually happens (see below), so no accommodation issues

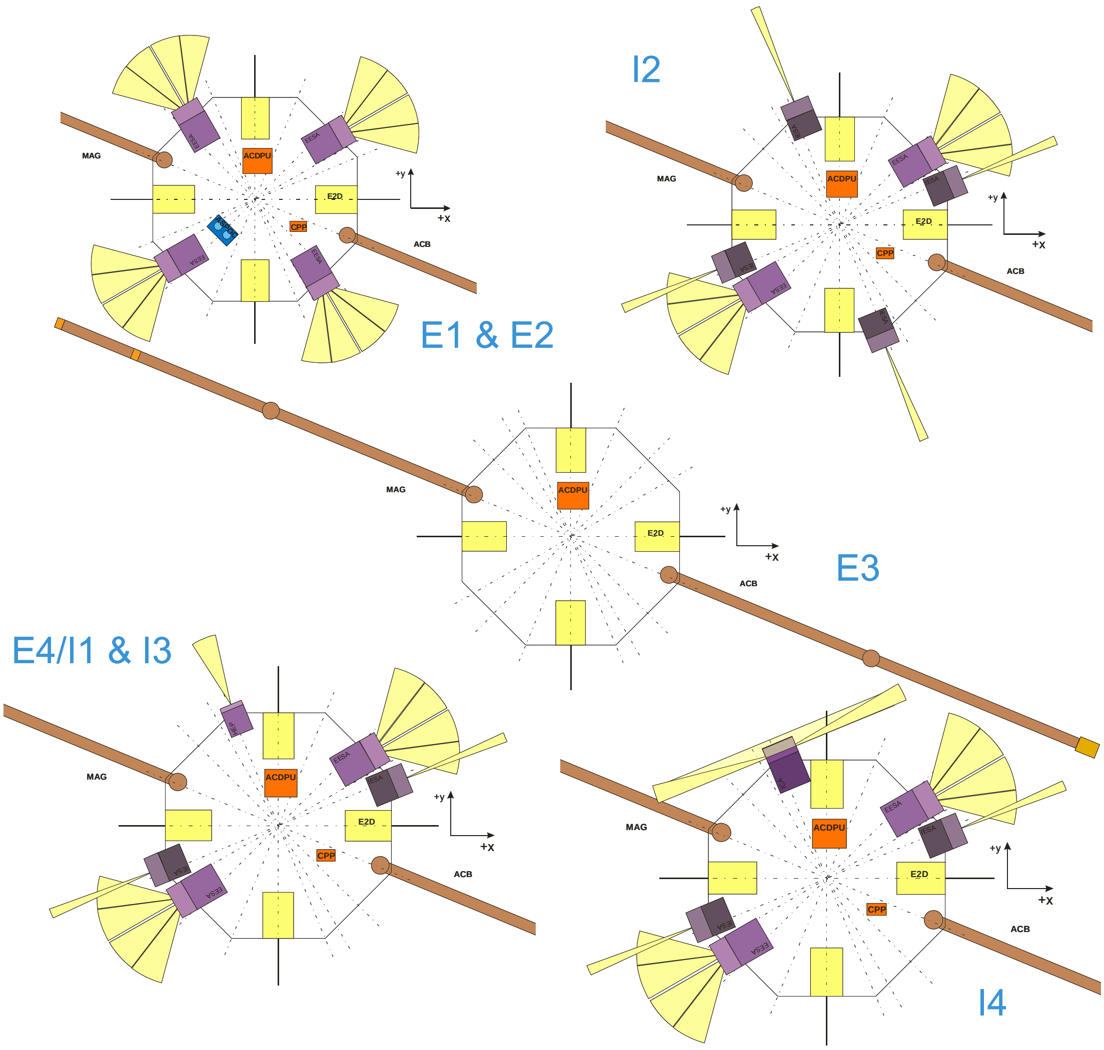


Figure 2-2: Instrument accommodation for the 7-spacecraft constellation

3. SCIENCE SPACECRAFT

Each of the 7 near-identical science spacecraft, provide the main “platform” functions, and a separate payload module for the payloads. The main platform features are:

The structure design consists of a top deck – the payload module – a bottom deck, and four vertical walls that connect the two decks. The eight panels are mounted at the edge of the top and bottom decks and carry some loads in order to stiffen the structure. Four explosive bolts separate the spacecraft from the carrier. The dedicated payload module enables payload-platform AIV simplification.

The data handling system (DHS) is based on the Data handling System for Sweden’s Prisma satellite with a stronge heritage from ESA’s SMART-1 Moon probe. The mass memory uses flash technology: with 4GB modules from 3D plus (the largest flash devices available).The on-board software has a strong heritage from the ESA’s SMART-1 mission and Sweden’s Prisma.

Communications: The main downlink antenna has a toroidal gain pattern for which the gain in the spin plane is +2.2 dBi and about -2 dBi at ±30° from the spin plane. This antenna is mounted on a 70 cm long boom extending along the spin axis from the top deck. A hemispherical pattern antenna is located on each of the top and bottom deck. One of these antennas is connected to the back-up transponder, and the other is connected to the inter-satellite-link system. By using a transponder with 10 Watts RF ouput power a downlink data rate of about 700 kbps can be achieved at apogee if the spacecraft spin axis is near the ecliptic north pole. If pointed 20º away from the north pole the date rate at apogee that can be supported is about 200 kbps.

Attitude determination and control. The 15 rpm spin rate drives the star tracker design. Presently only the DTU Advanced Stellar Compass seems suitable. Sun sensors provide spin phase data for radial thruster firings and instruments. Passive nutation dampers provide a clean spin before boom deployement. Radial 1-N thrusters are located at the edge of top and bottom deck for maximum lever arm. Two redundant thrusters provide delta-v along the spin-axis, i.e. for out-of-plane manoeuvres. The spacecraft spin up to ≈5 rpm after separation (perpendicular to the orbital plane). Spacecraft then fire thrusters to take up position in the constellation. The spin axis is adjusted to the correct attitude for science operations. The booms are then deployed, and the spin increased to 15 rpm. The wire boom deployment to 50 m is a major consumer of propellant; contributing 3.7 kg out of the total propellant mass.

The propulsion system provides impulse for both orbit changes and attitude manoeuvres. The 1-N thrusters use SSC’s non-toxic HPGP monopropellant with I_{sp}=227 s. Two tanks capable of holding 15 litres of HPGP are placed on vertical panels on each side of the spin axis and operate in the blow-down mode.

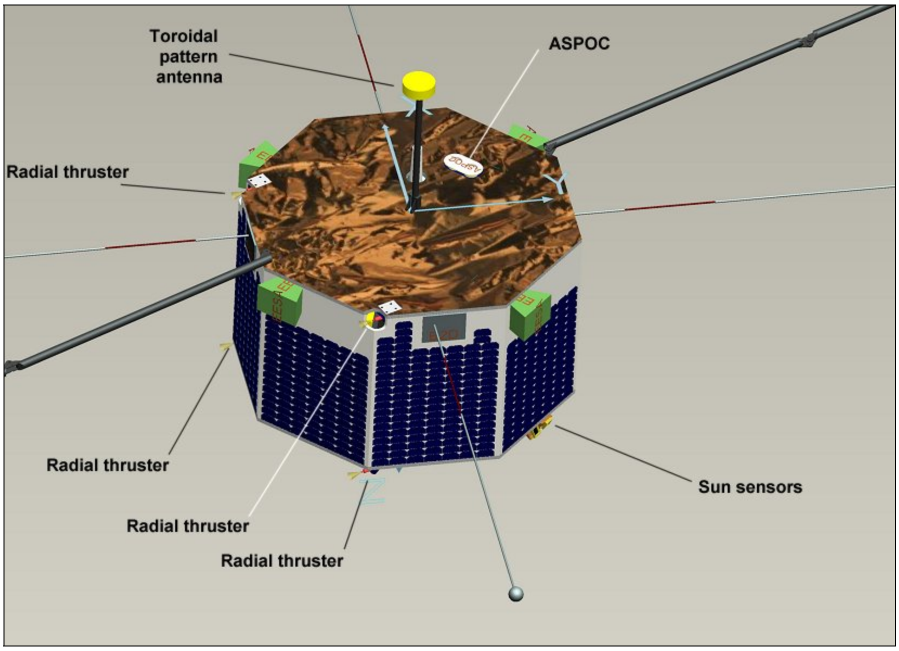
The electrical power system design is driven by the spacecraft dimensions that limit the amount of available solar array power, and by the long (≤ 3.3 hours) but few (≈500) eclipses that determine the battery sizing. The transponder is the highest power consumer (68 W) followed by the payload (≤59 W). The eight solar panels feed ≤ 237 Watts to a 28V bus system. All spacecraft are equipped with a 7.1 kg battery. The long orbital period and therefore very few eclipses enable a high depth-of-discharge, ≈75%, while maintaining reliability.

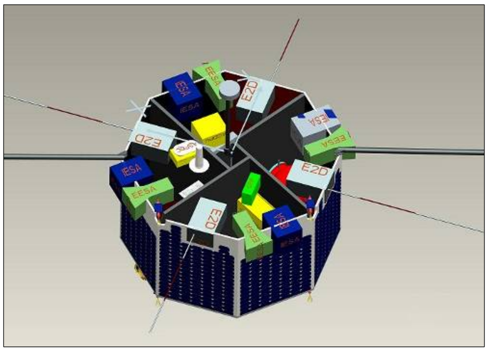
The thermal control system is driven by the requirements to keep the spacecraft sufficiently warm during the long eclipses and during the transfer phase when the spacecraft are in shadow. To avoiding losing too much heat through the solar panels during the transfer phase the panels are covered by multi-layer insulation on their back sides. During other mission phases the excess needs to be radiated. This takes place via a radiator on the bottom deck. This radiator is blocked by the carrier during the transfer phase reducing the need for power from the composite to maintain spacecraft temperature.

Electromagnetic Compatibility. Electrostatic cleanliness is achieved by using conducting MLI, paint and solar cell cover glass, whereas the DC magnetic requirement is satisfied with a stiff boom length of 2.9 metres.

Spacecraft E1 is driving the spacecraft design for all seven spacecraft, due to the payload mass/power requirements, 20º tilt angle, high scientific data volume and ”Identicality” of platforms goal.

The **total launch mass** of all spacecraft is **1208 kg.**





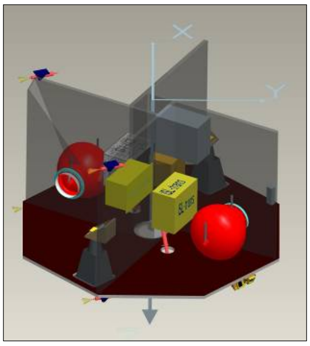


Figure 3-1: The configuration of the science spacecraft and their internal arrangement.

Item	Characteristics
Dimensions	Diameter 1.59 m, Height 0.98 m, octagonal prism
Mass properties	Platform dry 132.7 or 134.7 kg, spacecraft dry 161.4-168 kg, MoI ≤ 3000 kgm^2
Propulsion	HPGP propellant I_{sp} = 227 s, Propellant: attitude:control = 4.2 kg , Δv ≤ 7.8 kg
Data handling	LEON FT processor, SpaceWire, CAN, 1553B, 128 GB flash memory
Communications	S-band, EIRP ≤ 11.5 dBW, data rate ≥ 200 kbps, Reed-Solomon + Viterbi coding
Power system	222W min available power (E1 at EOL), GaAs-28% cells, DoD ≤ 75%, 28 V bus.
Attitude control	Spin at 15 rpm, Advanced Stellar Compass, micro sun sensors, nutation dampers

Table 3-1: Cross Scale spacecraft at a glance.

Summary masses, including margins

Item	e1	e2	e3	e4/i1	i2	i3	i4
Platform dry w/o ISL	130,7	130,7	130,7	130,7	130,7	130,7	130,7
ISL	4,0	4,0	4,0	4,0	2,0	2,0	2,0
Plattform dry	134,7	134,7	134,7	134,7	132,7	132,7	132,7
Instruments	33,3	33,3	15,3	28,7	31,1	28,7	31,4
S/C dry	168,0	168,0	149,9	163,4	163,8	161,4	164,0
Attitude control propellant	4,2	4,2	4,2	4,2	4,2	4,2	4,2
Delta-v propellant	7,8	7,8	7,0	4,3	4,3	4,6	4,6
Total S/C	**179,9**	**179,9**	**161,1**	**171,8**	**172,2**	**170,1**	**172,8**

Table 3-2: Summary Mass Budgets all for spacecraft

4. COMPOSITE DESIGN INCLUDING PROPULSION MODULE

The 7 science spacecraft will be transferred to the operational orbit by way of a propulsion module comprising of a relatively simple cylindrical carrier structure (which provides interface for the science spacecraft) mounted on top of a substantially modified LISA Pathfinder Propulsion Module (LISA PF PRM). The 7 spacecraft attached to carrier, are in a configuration with 6 attached around the sides (i.e. 3 around bottom, 3 around middle), and 1 horizontal on top. This allows a 20% system mass margin and a comfortable accommodation margin within the Soyuz-Fregat launcher.

As the LISA PF PRM is close to flight qualification, this design builds strongly on flight heritage for structure, thermal and propulsion design. Composite control philosophy also builds on LISA PF (i.e. control and communications by the science spacecraft on the top of the dispenser, a 'master spacecraft'), However, as the composite is 3-axis stabilised and the science spacecraft are spin-stabilised, it is assumed that the spacecraft will *not* be able to provide the AOCS sensors for adequate transfer control. This will therefore require an extra set of attitude control sensors on the PRM to maintain stability during both the transfer and deployment phases of the mission. Such AOCS sensor hardware is not required on a standard LISA PRM, as the spacecraft (3-axis) is able to provide full control during transfer.

The baseline composite system level design is to point the Main Engine (composite long axis) at sun during cruise phase and utilise the solar array and its backing structure as an occulting structure to maintain a stable thermal environment for the spacecraft and PRM tanks in transfer. The composite array is required to provide up to 1401W (at End-Of-Life, EOL) of power for the entire composite, as the spacecraft and most of the PRM will be in shade, and therefore cold. Power is also provided by the composite battery, in eclipse or burn modes.

Due to this requirement for a large power system, the Cross-Scale composite power system is the main significant deviation from the standard LISA PRM design, as a large ($6.6m^2$) fixed solar array, and a heavy battery (>40kg), and PCDU (~20kg) are required to provide the power supply for the entire composite in transfer.

The main advantages of the baseline composite, are that the PRM-redesign is cost-effective, the GNC is straightforward and the thermal environment is stable. In addition, the tapered PRM cylinder reduces line loads to the adapter, allowing implementation of an off-the-shelf adapter, the 1666-SF.

In summary the baseline composite design is the following:

- A sun-pointing configuration during cruise phase, with the **main engine (composite long axis) sun-pointing.**
- A **modified LISA-PRM cylinder with tapered dimensions** (and increased stiffening) for the Cross-Scale PRM.
- A dedicated power system, including a **large solar array forming an annulus around the base of the PRM tank support structure**. The solar array and its backing structure as an occulting structure to maintain a stable thermal environment for the spacecraft and PRM tanks in transfer. Power is also provided by the **composite battery**, in eclipse or burn modes.
- **Intelligence and control** for the composite in transfer, **provided by the top science spacecraft**.

The **total launch mass** of the composite is **3691.5 kg** which allows an extra mass capacity of 11.5kg <u>in addition to</u> the 20% system dry mass margin.

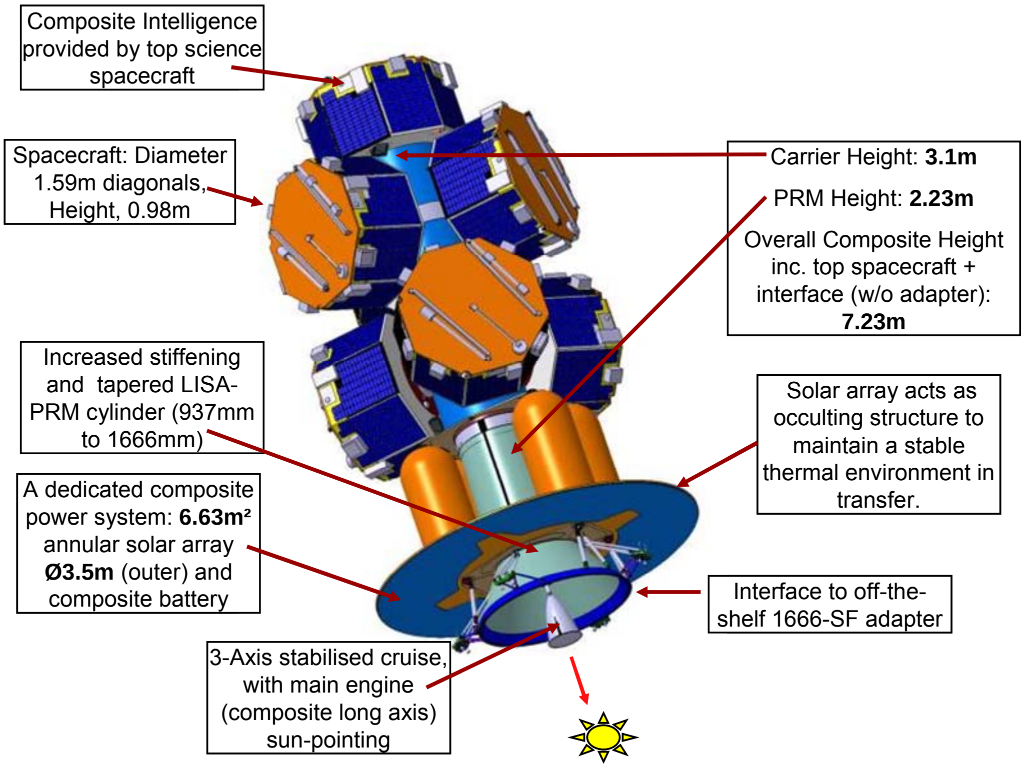


Figure 4-1: Final baseline for the Cross-Scale composite (LAE sun-pointing except in burns)

Baseline Concept Summary			
S/C modules	**PRM/Carrier**	**Electron/Fluid-Scale**	**Ion-Scale**
Number of S/C	1	4 (1 shared)	4 (1 shared)
Stabilization	3 axis	15rpm	15rpm
Dimensions	1666-SF Adapter: 0.457m high PRM: 2.225m high Carrier: 3.1m high, 0.94m wide	Diameter across diagonals 1.59m (1.47m across flats), Height, 0.982m	Diameter across diagonals 1.59m (1.47m across flats), Height, 0.982m
DeltaV requirements (inc. EOL manoeuvre & 5% margin)	1418m/s (no EOL)	114m/s (inc. move to fluid scale after year 1)	42m/s
Design lifetime	Up to 6 months	5 years	5 years
Platform dry mass (excl. P/L)	465kg (PRM)/161kg (Carrier)	134.7kg	132.7kg
Model P/L mass / power	N/A	Min 15.3kg/15W (e3) Max 33.3kg/59W (e1&2)	Min 28.7kg/44W (E4/i1,i3) Max 31.4kg/50W(i4)
Total mass (incl. propellant and subsystem margins)	**2001kg** (1375kg Propellant)	Min 161.1kg (e3) Max 179.9kg (e1, e2)	Min 170.1kg (i3) Max 172.8kg (i4)
		Total Mass of all 7 ESA s/c: **1208kg** (Av mass: ~173kg)	
Max Power Required inc. 20% margin	116W (not inc. s/c) 1264W (inc. s/c)	210.8W sunlight (e1) 162.7W eclipse (e1)	
Maximum Power produced (inc. margins)	1401W at EOL	221.6W EOL (21° worst case cosine angle, E1)	
Telemetry band	S-Band	S-Band	S-Band
Data Downlink capability	N/A	710kbps at apogee (nominal off-pointing)	
Composite Total Mass	**3691.5kg** (inc. 20% system margin and 90kg launch adaptor)		
Composite Max Power required in transfer (injection orbit)	**1264W Sunlight; 1026W Eclipse** (both inc. 20% system dry mass margin, 45 min initial eclipse, + 30minute burn outage)		

Table 4-1: Summary explaining the mission and spacecraft architecture for the Detailed Design

5. PROGRAMMATIC ASPECTS

The study has carried out a rigorous investigation of all programmatic aspects required for Cross-Scale, including schedule and procurement/ESA ITT constraints, manufacturing issues, risk management, and technology development. In addition a detailed costing analysis has been carried out, in order to validate the mission affordability within the constraints of the Cosmic Vision M-Class mission envelope. Developing 7 very similar but non-identical, electromagnetically-clean science spacecraft is a challenge in order to meet the target 2017 launch date for Cross-Scale, which is, after all, only 8 years away. This demands an extremely intensive **schedule** (see Figure 5-1) from start of Phase C to launch, a period of only 5 years.

The overall science spacecraft **AIV strategy** is to completely decouple the qualification of the design and the production of the flight spacecraft. Time-consuming re-work is eliminated and the schedule risk is reduced. A fully equipped spacecraft, the EQM, is used to perform all qualification testing before embarking on the AIV of the seven flight model spacecraft, which are only subjected to acceptance tests. This is called the **"EQM+7"** approach. The EQM spacecraft consists of a fully representative structure and EQM models of platform and instruments and its dedicated payload module can be adapted to different instrument suites. A dedicated payload module prior to platform integration, is baselined, to lower integration complexity for payload-platform.

The total number of instruments to be embarked, adds up to more than 100 for the seven spacecraft constellation. More than 10 units of MAG, EESA and IESA, and up to 28 units of E2D have to be procured. Although this is very challenging, the relevant institutes can build on experience in developing multiple payloads in significant numbers, from the Cluster I and II missions.

The Transfer Module AIV philosophy consists of a Structure Model **STM** followed by a Protoflight Model **PFM**. At the end of the testing phase, an entire composite stack test with some or all the spacecraft is required to structurally confirm the launch configuration, and electrically check out the release systems and interfaces.

Production and testing of the flight model spacecraft (see Figure 5-2). In order to ensure uniformity in the assembly work, any particular item should be assembled and integrated on all seven spacecraft by the same person(s). After the assembly and integration phase, functional testing of the flight spacecraft is performed with three spacecraft simultaneously. The subsequent environmental acceptance tests can be performed in parallel with one spacecraft at each of the test facility's three major laboratories (EMC, thermal and mechanical test). At each of these labs, one EGSE and one test team is deployed. A significant challenge to the Cross-Scale test schedule is verification of the high electromagnetic cleanliness requirements of the Cross-Scale spacecraft on such a large number of spacecraft. In particular, this covers the ability to compensate the external magnetic field by large Helmholtz coils to enable high sensitivity magnetic calibration. Currently the only facility in Europe that is equipped to conduct EMC tests at the level required for Cross-Scale is IABG (Munich).

Table 5-1 summarizes the **Development Activities** that should be undertaken in order to assure a sufficient level of maturity of the Cross Scale related technology. It is assumed, that before entering into phase B (Feb. 2012), the Technology Readiness Level will be at an adequate level, i.e. ≥ 5.

Identified Pre-development	Initial TRL	Assessment Description
ISL Transceiver	5	ISL system due to fly on PRISMA but requires modification for Cross-Scale
Mass Memory	4 or greater	An existing technology (Flash Memory): Flown already in US, but not Europe. Note that Astrium is currently developing Flash Memory-based mass memories
Toroidal Pattern Antenna	3/4	TRL can raise very quickly due to the simplicity related to this technology. No breakthrough is needed to build an antenna with the required performance
Star Tracker	7	Technology available and already flown. Possible delta-qualification required due to spin requirements.
Carrier/PRM Structure	4	Tapered shape of PRM never flown so far. Carrier also never flown before. Detailed feasibility analysis to be carried out
PRM Composite Solar Array	4	New Fixed solar array is required. Equipment envisaged to be space qualified

Table 5-1: Summary of the main overall Development Activities that should be undertaken in order to assure a sufficient level of maturity of the Cross Scale related technology

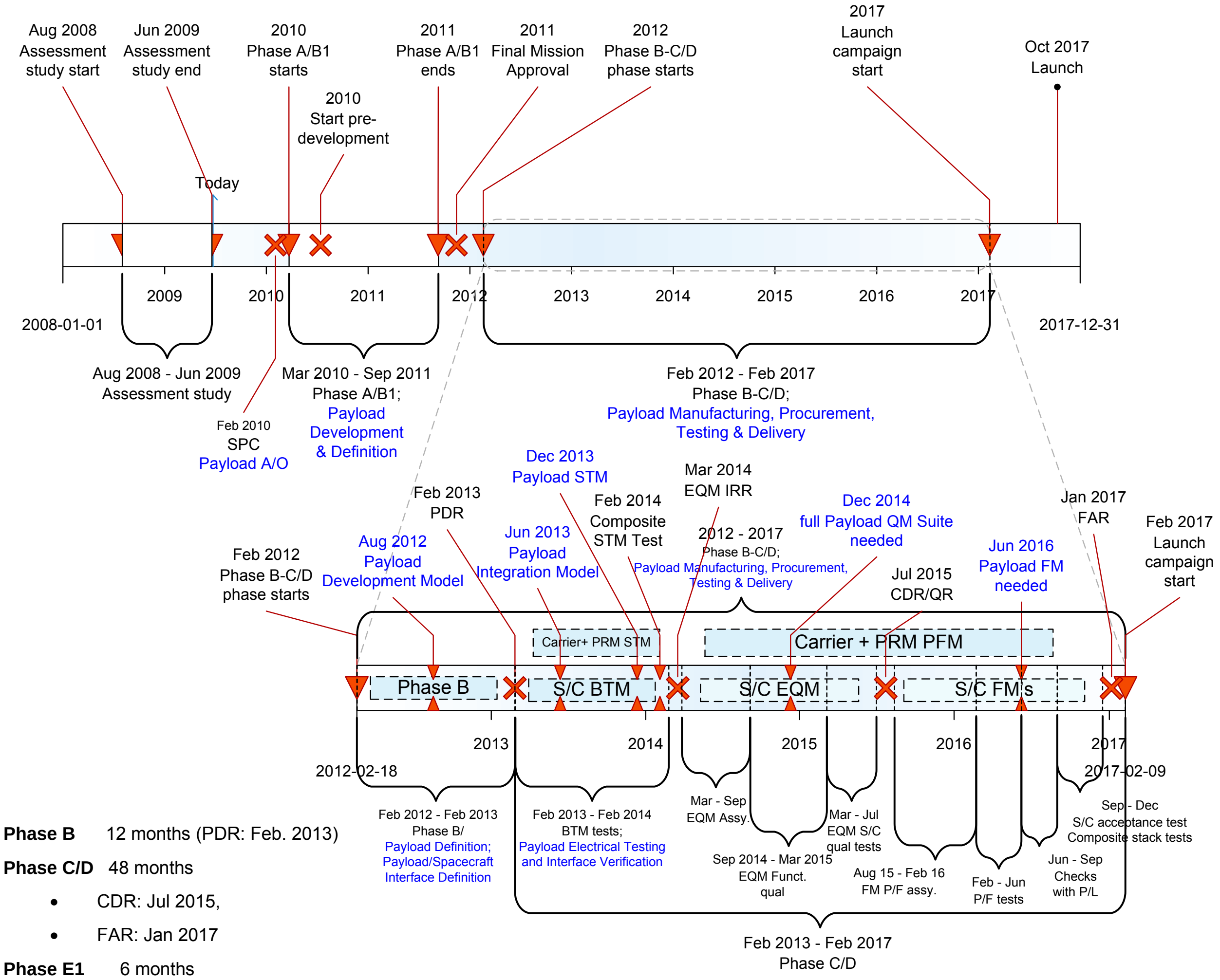


Figure 5-1: Summary of the current programmatics timeline for the ESA Cross-Scale mission up until launch, including particular key detail for the payload and platform testing

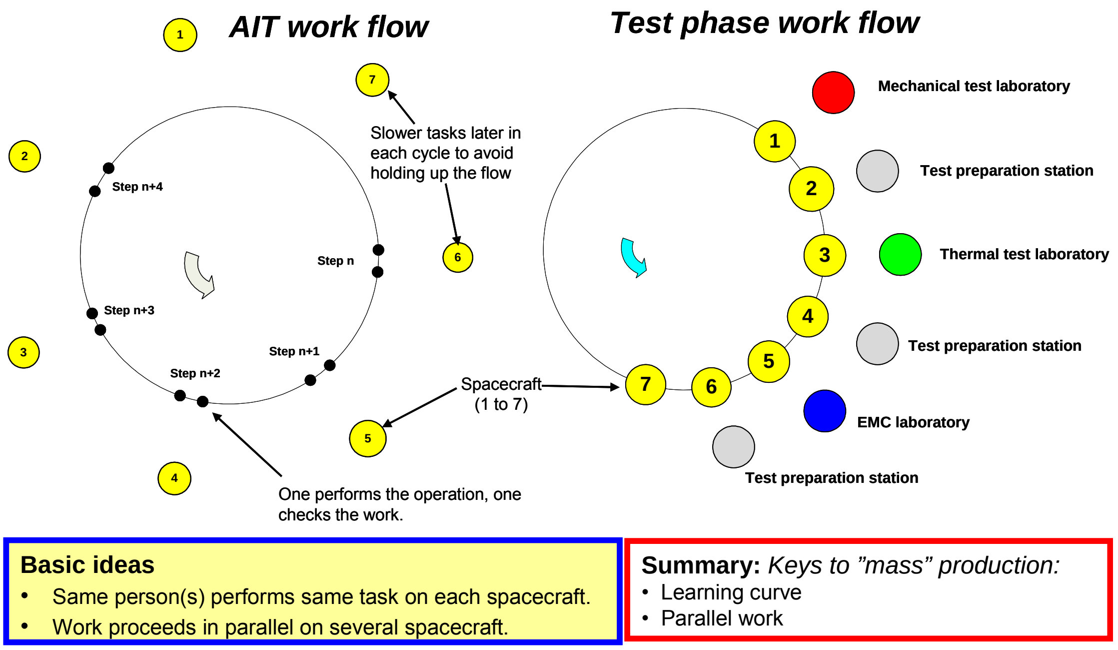


Figure 5-2: Flight spacecraft integration cycles (left) and work flow in environmental test labs (right).