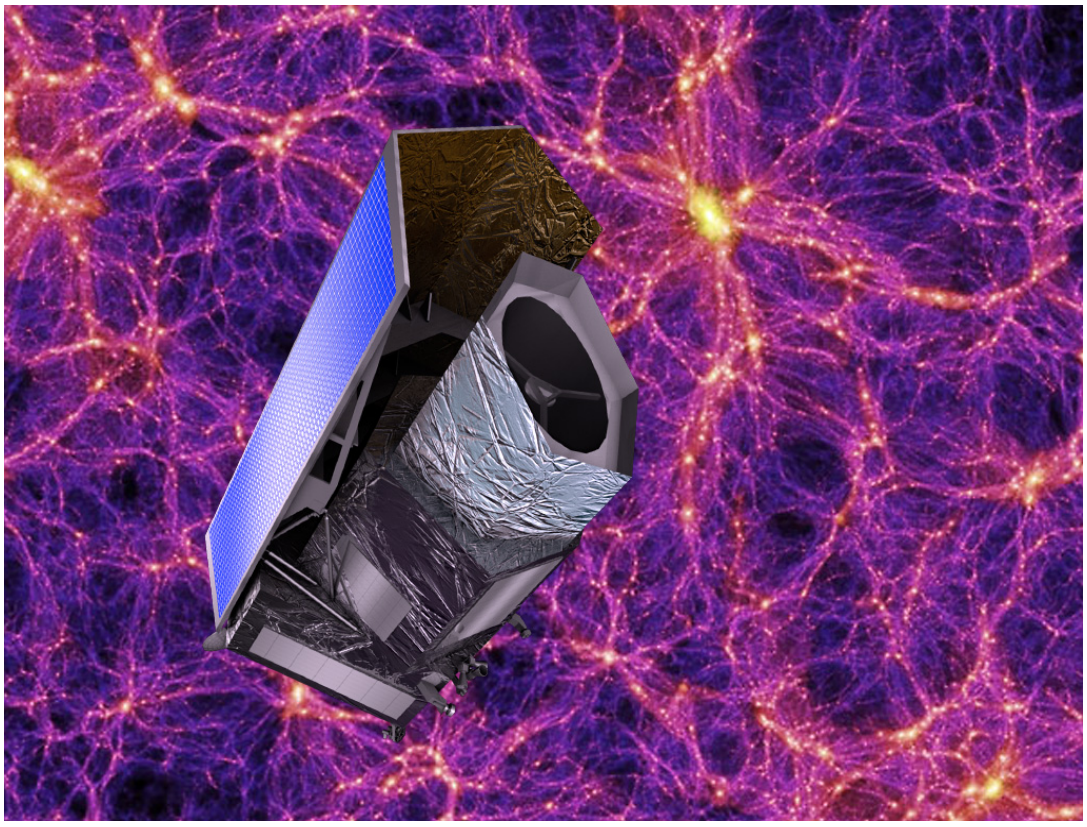
Euclid Spacecraft Industry Day



Organised by ESA and Thales Alenia Space

15 January 2014

European Space Research and Technology Centre (ESTEC)
Newton Conference Centre
Keplerlaan 1
2200 AG Noordwijk

European Space Agency
Agence spatiale européenne

Euclid Spacecraft Industry Day

15 January 2014

European Space Research and Technology Centre (ESTEC)

Keplerlaan 1

2200 AG Noordwijk

(The Netherlands)

Foreword

1. The Euclid Mission

Euclid is an optical/near-infrared survey mission designed to understand the origin of the accelerating expansion of the Universe. It will use cosmological probes to investigate the nature of dark energy, dark matter and gravity by tracking their observational signatures on the geometry of the Universe and on the cosmic history of structure formation.

The mission will investigate the distance-redshift relationship and the evolution of the cosmic structures by measuring shapes and redshifts of distant galaxies by looking back on 10 billion years of cosmic history. It combines several techniques of investigation, also called cosmological probes, in a very large survey over the full extragalactic sky. Among these cosmological probes, two of them play a major role in the Euclid mission concept and the instrumental approach: the Weak Gravitational Lensing (WL) and Galaxy Clustering (GC) including the Baryon Acoustic Oscillations (BAO).

The Euclid spacecraft consists of two main modules:

- The PLM which consists of the PLM structure, the telescope assembly, the optical elements (including the dichroic), the support structure, the Instruments (VIS and NISP), the thermal hardware and the re-focus system.
- the Euclid Service Module (SVM) which comprises all the conventional spacecraft subsystems, the instruments warm electronics units, the sunshield and the solar array.

The target orbit is a large-amplitude libration orbit around the night-side Lagrange point of the Sun-Earth system. The launch service shall be provided by the Soyuz 2-1b with a Fregat upper stage from Kourou.

2. Responsibility

The Euclid mission has been approved by ESA and delegated bodies for a planned launch in 2020 in the frame of the Cosmic Vision 2015-2025 plan.
ESA has the overall responsibility for the Euclid mission design and implementation including the procurement of the launch service.
The established Euclid Consortium is responsible for the development and delivery of the Instruments (VIS and NISP).
The industrial Prime Contractor is responsible for the development, procurement, manufacturing, assembly, integration, test, verification and timely delivery of a fully integrated spacecraft capable of accommodating the Payload Module and fulfilling the mission objectives.
The PLM (Sub) Contractor is responsible for the development, procurement, manufacturing, assembly, integration, test, verification and timely delivery to the Prime Contractor of a fully integrated Payload Module and related items capable of accommodating the delivered Instruments and fulfilling the mission objectives.

3. The Industry Day

Further to the Invitation To Tender (ITT) released by the European Space Agency (ESA) in December 2012, Thales Alenia Space Italy (TAS-I) has been appointed as Prime Contractor of the Euclid space segment for the Implementation phase (B2/C/D/E1).

Therefore TAS-I has been authorized to proceed with the competitive procurement process in order to complete the build-up of the spacecraft industrial team for spacecraft related items. This tendering process will be governed by ESA rules which are reported in the "Best practices for the selection of subcontractors by Prime Contractors in the frame of ESA's major procurements". This document can be downloaded from EMITS (http://emits.sso.esa.int/ under "Reference Documentation" and "Administrative Documents").

In advance to the announcement on EMITS of the ITTs, the objective of this Industry Day is to present to the European industry the overall Euclid mission, the associated business opportunities, the bidding process and schedule for the build-up of the Euclid spacecraft industrial team.

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Agenda

9 :15 – Plenary Session - ESTEC Newton room

a) Introduction : objectives & organization of the Euclid Industry Day (ESA)
b) The Euclid mission (ESA)
c) The Euclid System and Space segment (ESA)
d) The Euclid programmatics (ESA)
e) The Euclid Space segment procurement approach (ESA)
f) The GEO return constraints Prime (ESA)
g) ECOS (ESA)

10 :15

a) The Euclid overall design (TAS-I)
b) The Euclid development logic : Models, objectives & schedule (TAS-I)
c) The Euclid Service Module product tree and constituents (TAS-I)
d) The ITT Process (according to Best Practices) (TAS-I)
e) List and dates of the future ITTs (TAS-I)

10 :45

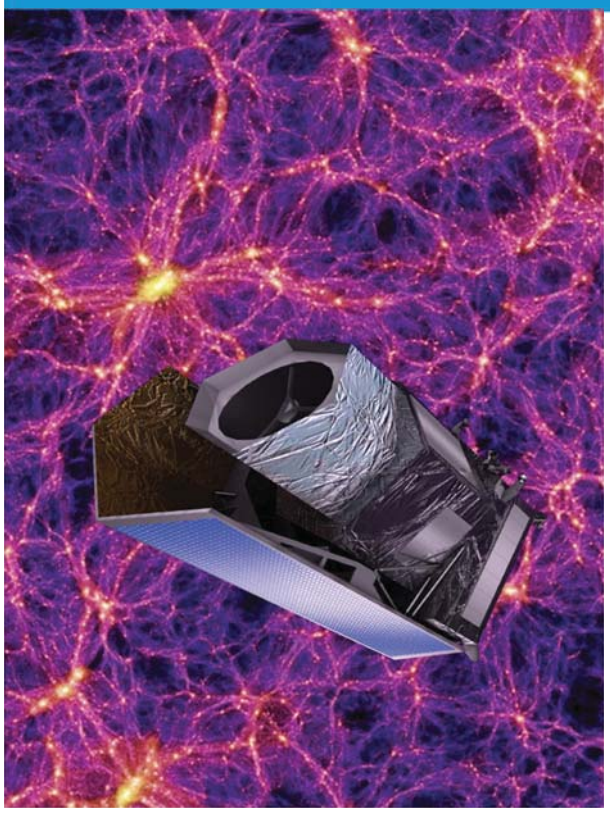
a) Presentation of each ITT (description and key-requirements)

12 :15 Buffet

13 :00 Splinter meetings

1. Mechanical, Propulsion and Thermal ITTs - room Ba 024
2. Avionics, RF and Electrical ITTs – room Ba 030
3. GSE, and Facilities ITTs – room Df 121
4. Software and System Support Activities ITTs - room Ba 031

17 :00: end of the splinter meetings
17 :00: wrap-up (TAS-I and ESA only)
17 :15 departure



Euclid Spacecraft Industry Day

ESTEC, 15/01/2014

European Space Agency

Introduction

ESA and Thales Alenia Space welcome the participants to the Euclid Industry Day.

- 211 participants
- 111 companies
- 21 countries

Introduction

- Euclid is a science mission of ESA in the field of cosmology
- Objective of the Euclid mission is to investigate the nature of dark energy, dark matter and gravity
- The target orbit is a large-amplitude libration orbit around the night-side Lagrange point of the Sun-Earth system.
- The launch service shall be provided by the Soyuz 2-1b with a Fregat upper stage from Kourou.
- Launch planned in 2020
- TAS-I appointed as Prime Contractor
- Astrium SAS appointed as PLM Contractor

Introduction

Objectives of the Industry Day

- To present the Euclid mission
- To inform about the associated business opportunities
- To introduce the bidding process and schedule of the ITTs

Introduction

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Introduction

Splinter Meetings

- Four splinter meetings are foreseen
- Splinter meetings are face-to-face meetings (10 minutes each)
- Splinter meeting arrangements are provided (lists at the foyer)
- Confirmation is required by the participants by signing the paper at the foyer
- Late booking can be accommodated subject to availability (waiting list)

Euclid Mission Overview

Spacecraft Industry Day

Giuseppe D. Racca

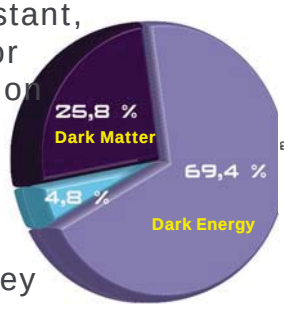
Noordwijk, ESA/ESTEC

15 January 2014

The Euclid Mission in a nutshell

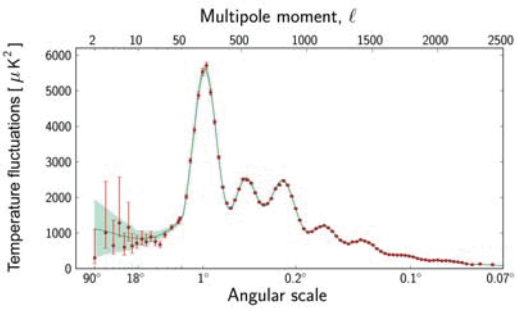
Cosmology beyond the Planck mission:

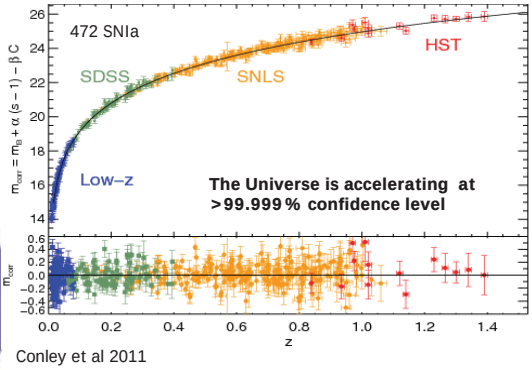
- The universe is governed by its geometrical properties and by the stuff that it contains;
- The universe is geometrically flat;
- The universe is expanding at an accelerated rate;
- The universe is today dominated by Dark Energy
- Dark matter
- What is DE?
  - Einstein Cosmological constant,
  - Dynamical quintessence, or
  - A manifestation of gravity on cosmological scale
- Euclid will probe all this, how?
- Searches the signatures of the dark energy and matter
- Largest extra-galactic sky survey



The Planck collaboration.

Ade et al 2013





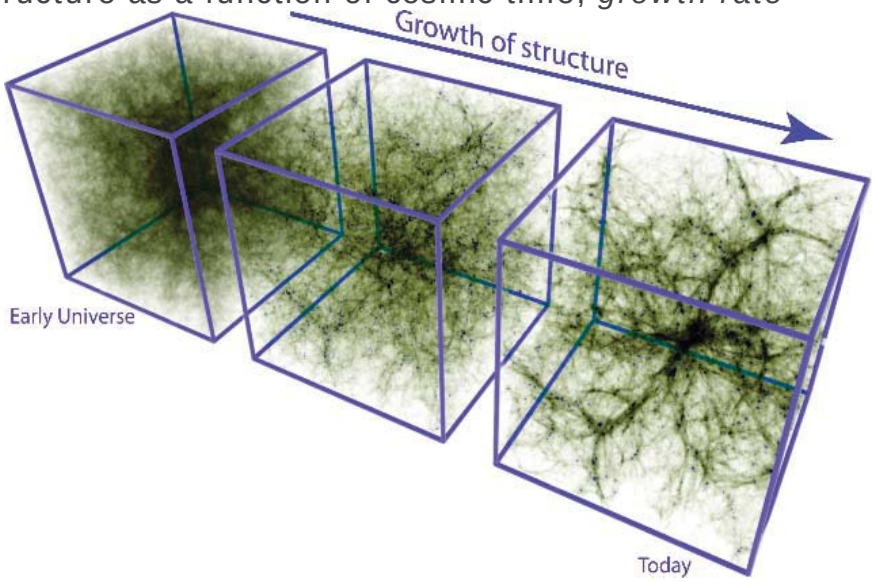
Conley et al 2011

Signatures of the Dark Universe

The dark matter and energy can be studied by looking at:

1. **The geometry of the universe**
    a. Measure of position of galaxies as a function of redshift
2. **Growth of density perturbations**
    a. Evolution of structure as a function of cosmic time, *growth rate*

- Structure follows the expansion of the Universe
- Gravity causes structure to evolve



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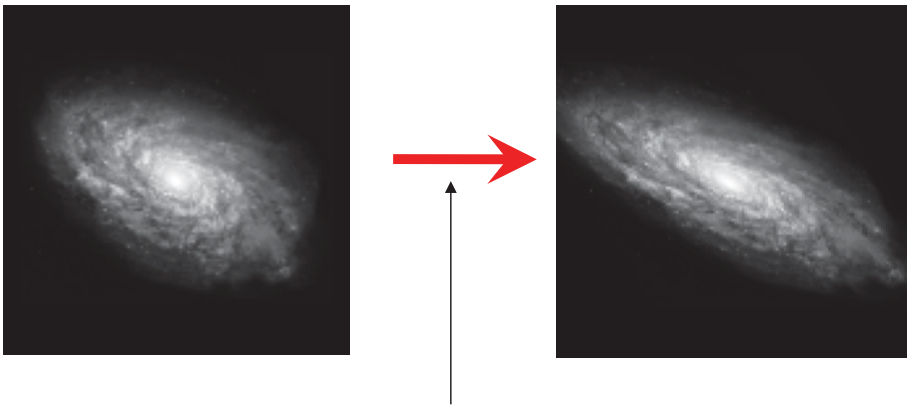
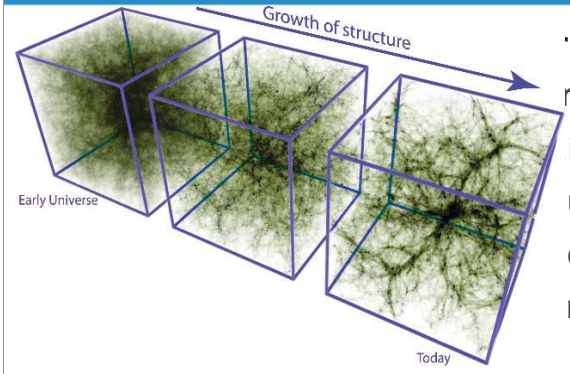
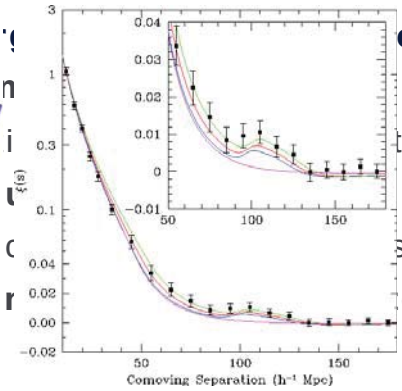
    a. Evolution of structure as a function of cosmic time, *growth rate*
3. **Galaxy image distortion caused by dark matter bending light**

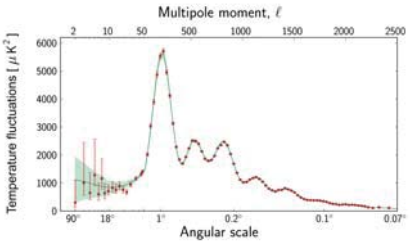


Dark Matter

Signatures of the Dark Universe







Euclid techniques, the *cosmological probes:*

1. **Galaxy Clustering**
    a. **Baryon Acoustic Oscillations (power spectrum large #)**
    b. **z-space distortions**

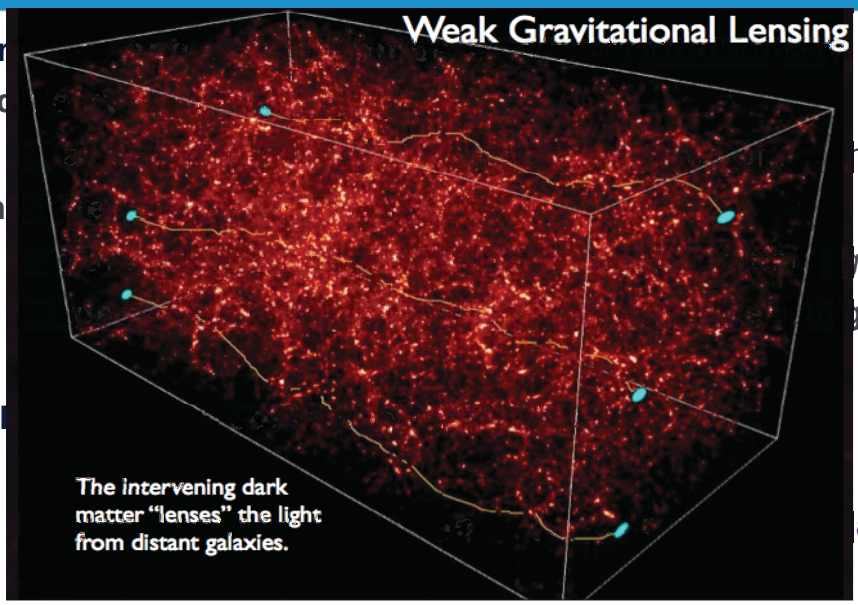
Signatures of the Dark Universe

The dark

1. **The geo**
    a.
2. **Growth**
    a.
3. **Galaxy**

Euclid tec

1. **Galaxy**
    a.
    b.
2. **Weak Gravitational Lensing (Dark matter) ellipticity distortion**



Signatures of the Dark Universe

Largest Galaxies Survey:

a. 15,000 deg^2 ~ 37% of sky at z= 0 to 2 (10 BY back)

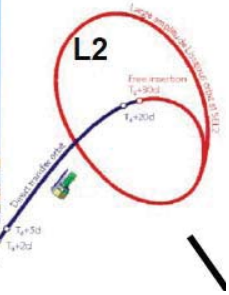
b. 1.5 B galaxies at m_{AB} 24.5

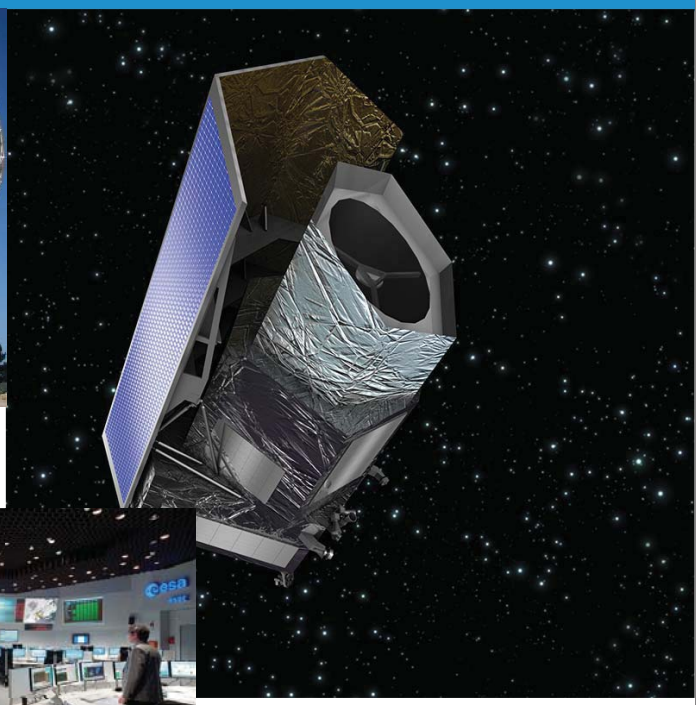
c. 40 deg^2 ~ 0.1% of sky => 4 M galaxies at m_{AB} 26.5, z>>2

Mission Overview

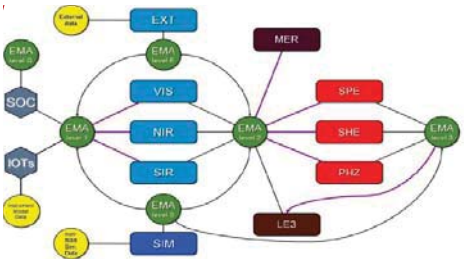
Soyuz@Kourou

Q2 2020





SGS: 2010-2028



Content

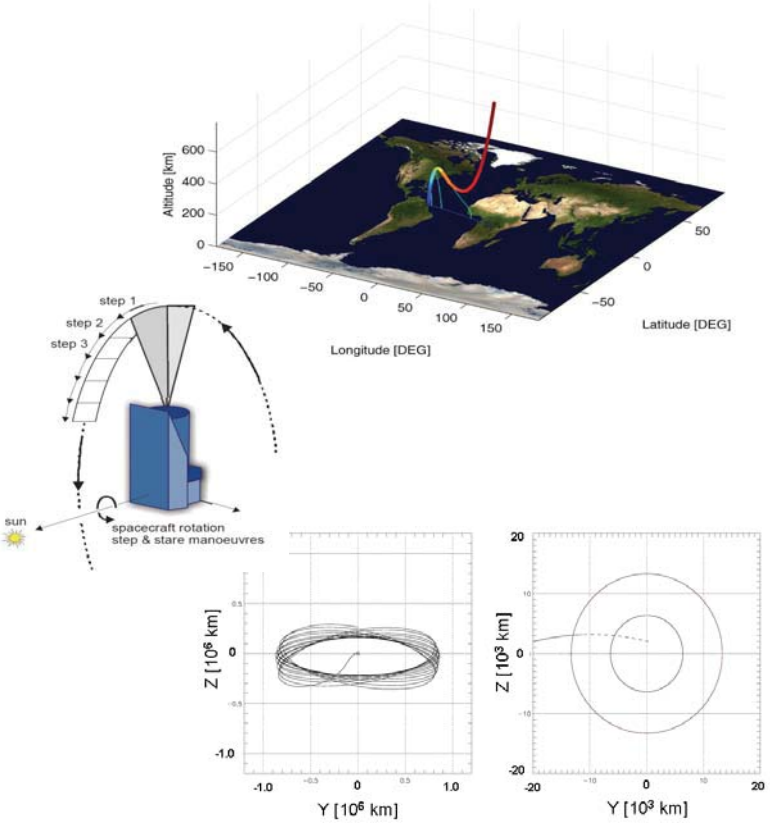
1. The Mission
2. The Launcher
3. The Ground Segment
4. The Spacecraft
5. The Instruments
6. The Schedule
7. Euclid Procurement Approach

Mission requirements

1. The Euclid system shall perform a wide survey of at least 15,000 deg^2 of the extragalactic sky - goal 20,000 deg^2;
2. The Euclid system shall perform a deep survey of at least 40 deg^2;
3. The Euclid system shall perform Visible Imaging in the wavelength range 550-900 nm over the survey area;
4. The Euclid system shall perform Near Infrared Photometric Imaging in the wavelength range 920-2000 nm over the survey area;
5. The Euclid system shall perform Near Infrared Slitless Spectroscopy in the wavelength range 1100-2000 nm over the survey area;
6. Nominal lifetime: 6 years (after commissioning), 7 years sizing;
7. SEL2 orbit;
8. Launched with a SOYUZ ST 2-1B from the Guiana Space Centre;
9. Minimum of 4 hours of ground communication per day, K-band;
10. 850 Gb compressed data per day.

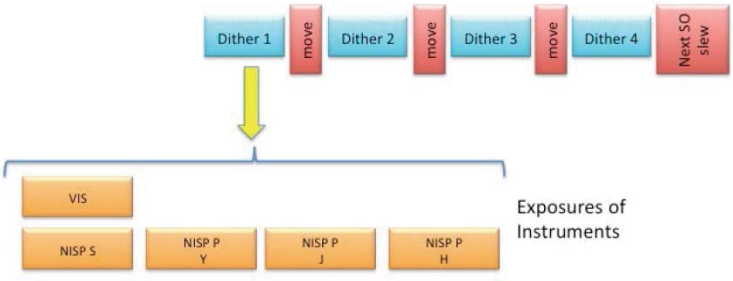
Mission design

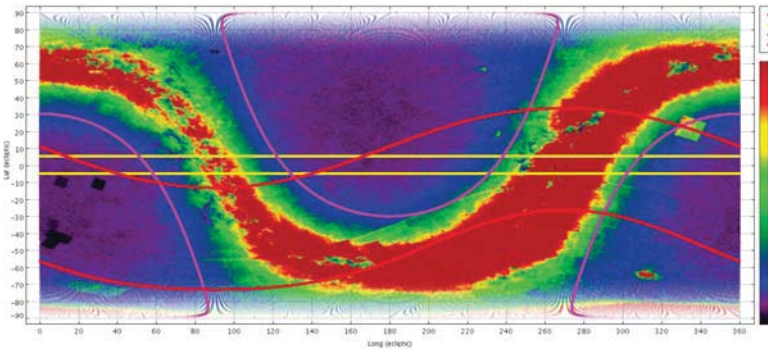
- Soyuz 2.1B + Fregat ascent trajectory for a direct SEL2 transfer without intermediate parking orbit;
- Y-Z plane of the co-rotating frame;
- Earth's penumbra at SEL2, inner circle is the earth's shape;
- maximum distance from the anti-Sun direction of ~ 33º;
- step-and-stare scanning of the sky, the line of sight is kept perpendicular to the Sun direction.



Survey Design

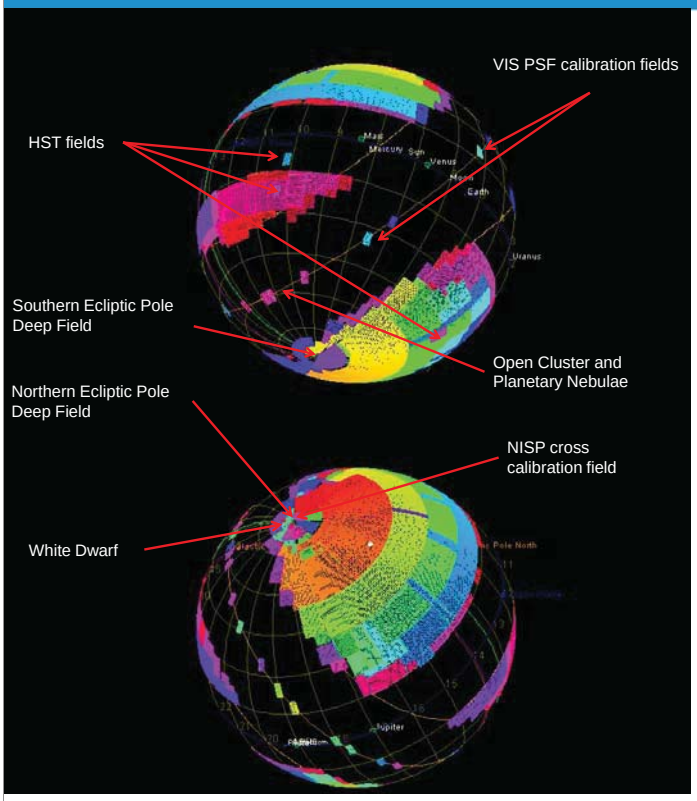
- Instruments observation sequence of one field =>
- |b|>30º
- Minimise SAA variations;
- Minimise zodiacal light => high ecliptic latitude;
- Low galactic extinction;
- Specific pointed calibration (high star density);
- Deep survey observation;

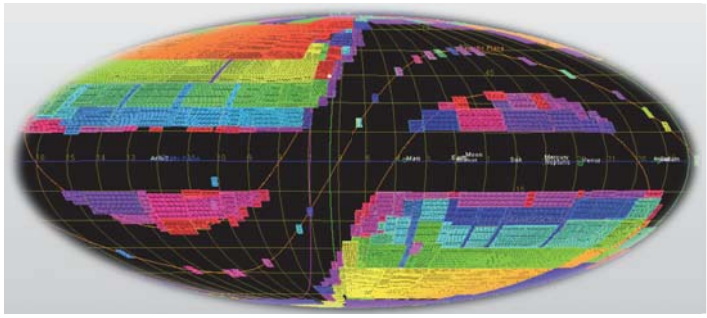




Sky map of stellar densities projected in ecliptic coordinates. regions with galactic latitude |b|>30º, ecliptic latitude |ß| > 5º. Equatorial +10 < δ < -50º, presently best suited for ground based access by southern telescopes

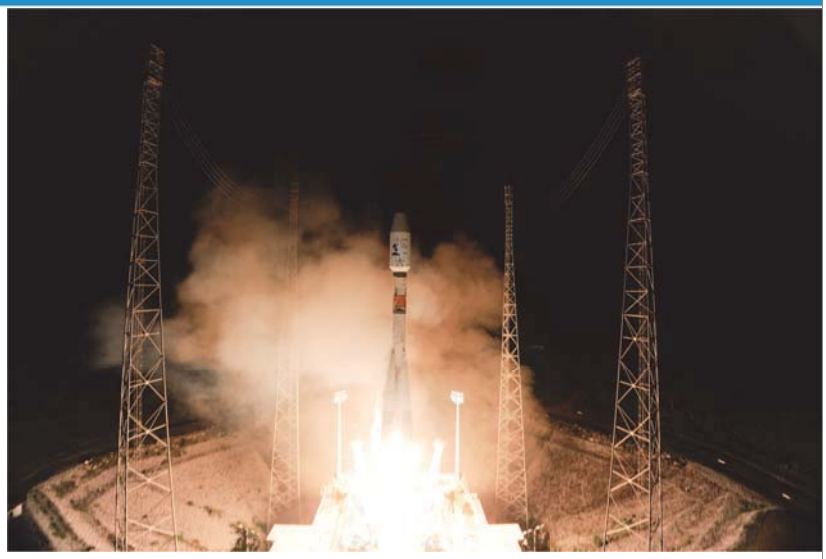
Survey plan: 6 years





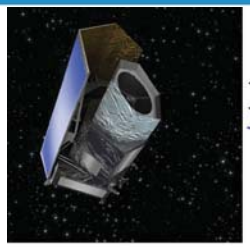
Launch

- Euclid spacecraft will be launched from the Guiana Space Centre, Kourou, on board a Soyuz ST 2.1-B;
- The direct ascent launch: no SEL2 orbit insertion manoeuvre;
- First correction manoeuvre ≤ first 48 hours;
- Two more correction manoeuvres to enter the libration orbit around SEL2;
- Orbit around SEL2 is maintained by regular station-keeping manoeuvres every 30 days;
- Arianespace under contract to support Phase B2/C -> CDR



Gaia on Soyuz VS06, from Europe's Spaceport, French Guiana, on 19 December 2013.

Ground Segment – MOC + SOC functions



Mission Operations Centre

- Design, implementation, validation and operation of the MOC elements of the ground segment
- Support to Project in all development phases
- Operations of the space segment (spacecraft and instruments) during LEOP, Commissioning and Routine Phase

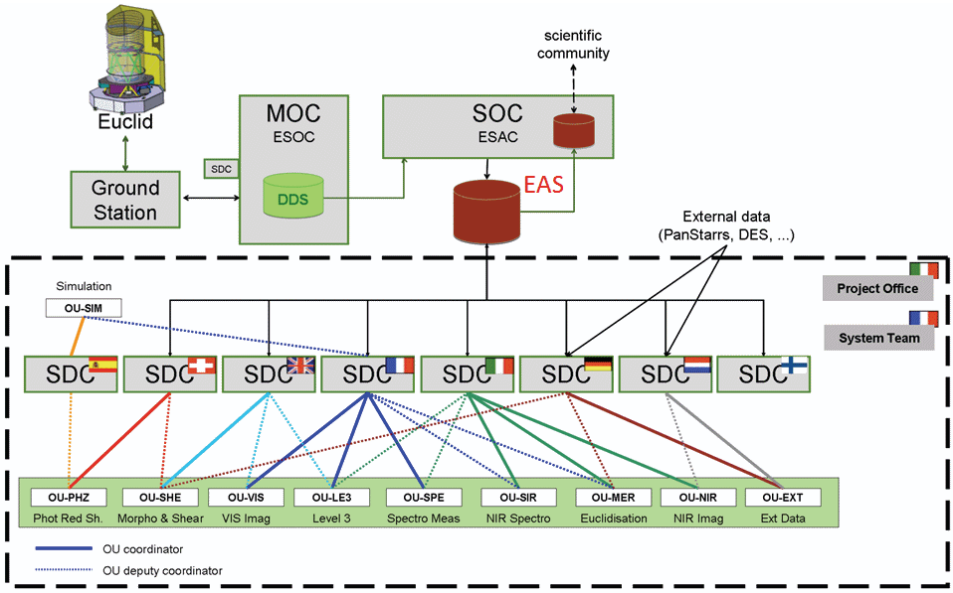
Science Operations Centre

- Interface between the Mission Operations Centre and the other elements of the SGS, providing all necessary mission data to the SDCs.
- Interface to the Scientific Community for the final validated science products once released through the archive system developed at ESAC.
- Overall design and engineering of the SGS, working closely with the System Team.
- It manages the execution and monitoring of the Sky Survey.

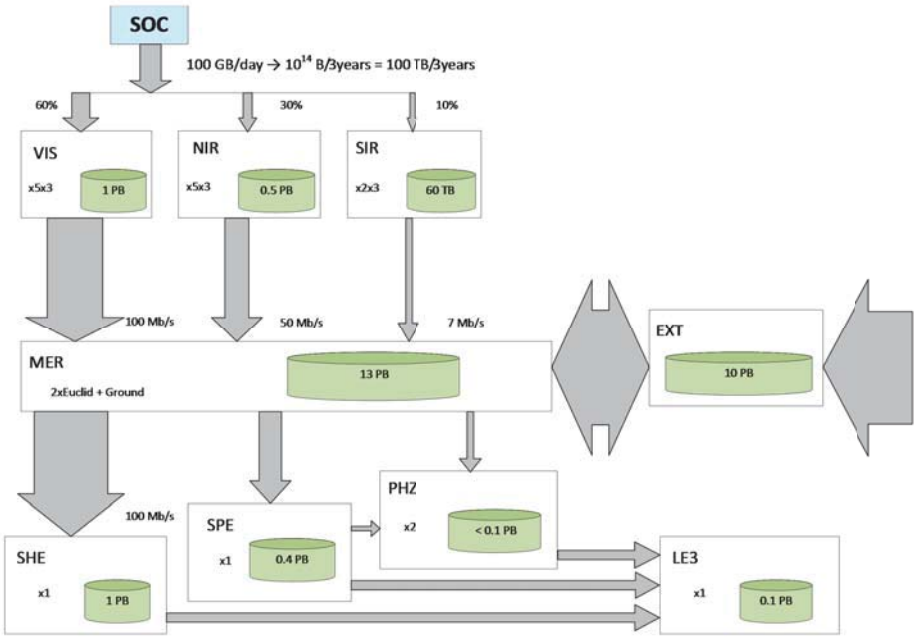
Ground Segment – EC functions

EC-SGS functions

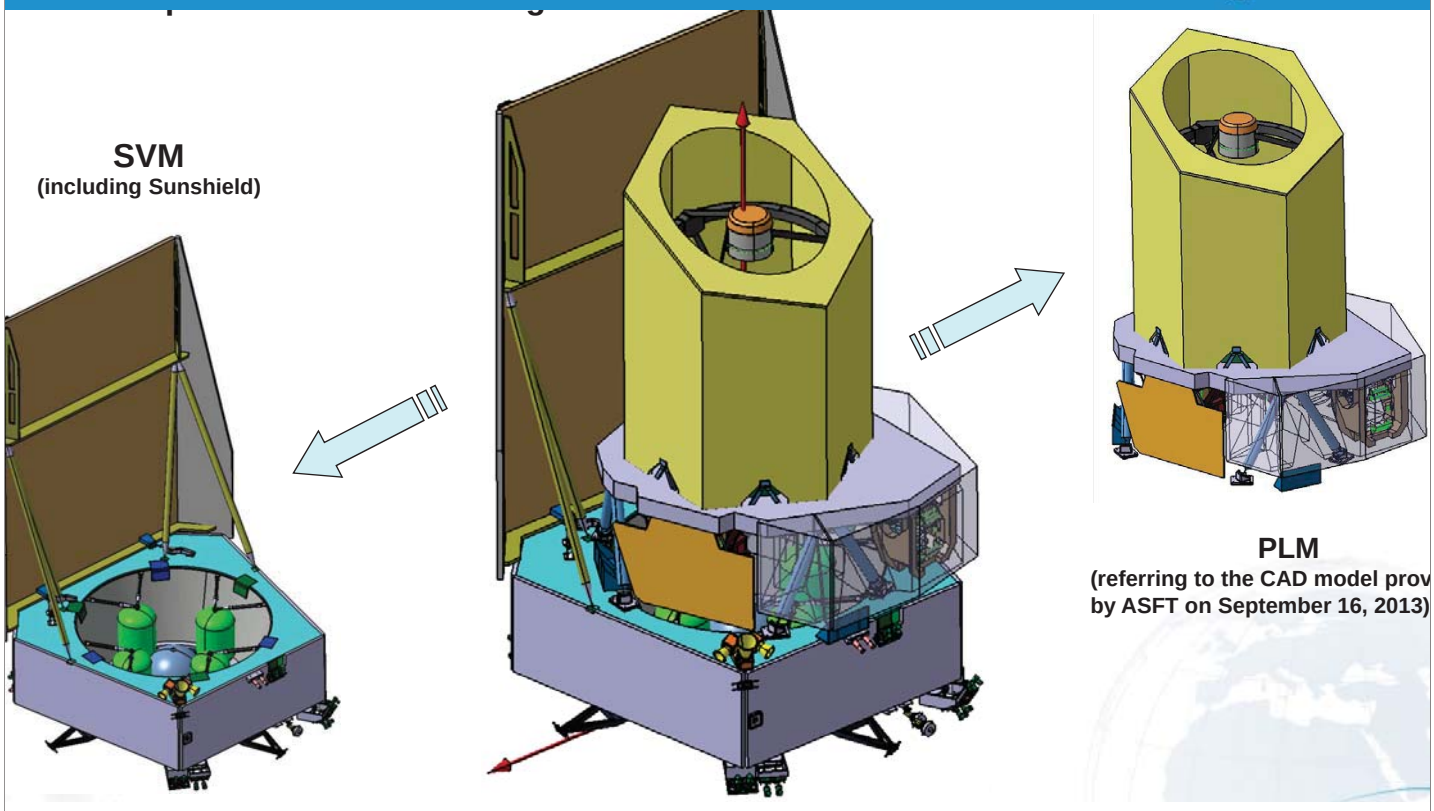
- The Instrument Operation Teams (IOTs), responsible for the maintenance of the instruments production of weekly instrument reports.
- The Science Data Centres (SDCs), host the IOC's, take Level 1 and produce Level 2. Science Processing to obtain Level3. Reprocess external data: Level S.



Science Data Flow

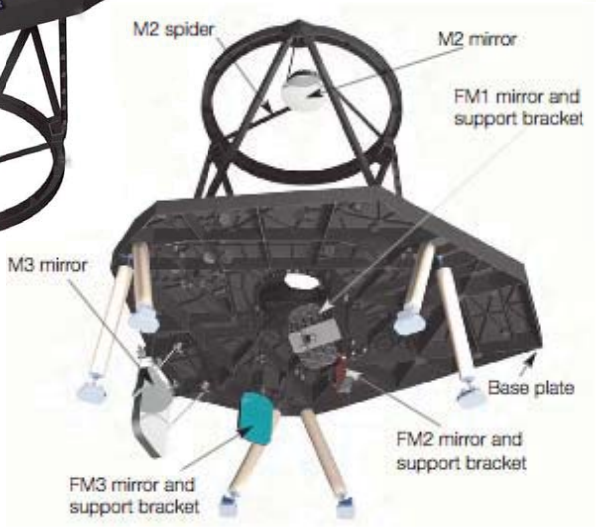


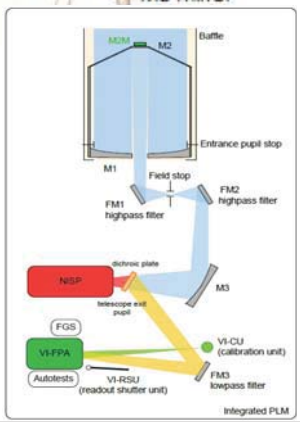
Euclid – Spacecraft Configuration



Euclid – Payload Module

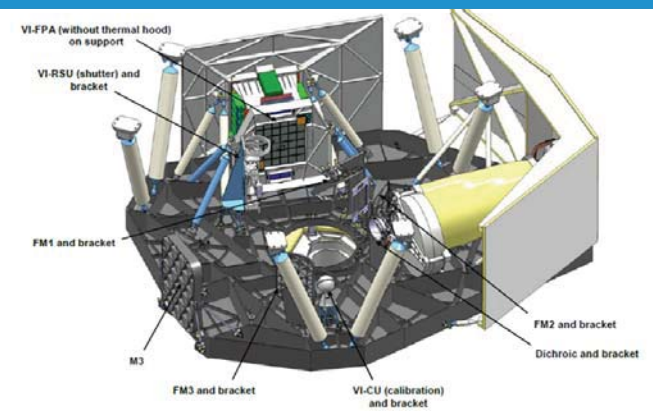
Astrium-Optical.mp4

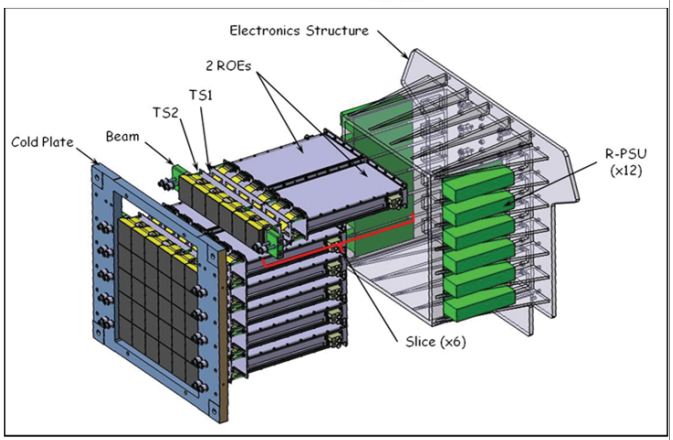




VIS

- Focal plane instrument, no optics;
- limiting magnitude: m_{AB}=24.5 extended sources at 10σ
- spectral range Δλ: 550–920nm
- focal plane: 6×6 CCDs (e2v, 12×12μm² pixels, 4096×4096 pixels)
- plate scale: 0.1arcsec/pix
- field of view: FoV=0.787×0.709 deg²
- focal length: f=24.5 m
- Datarate: ≤ 520 Gbits/day





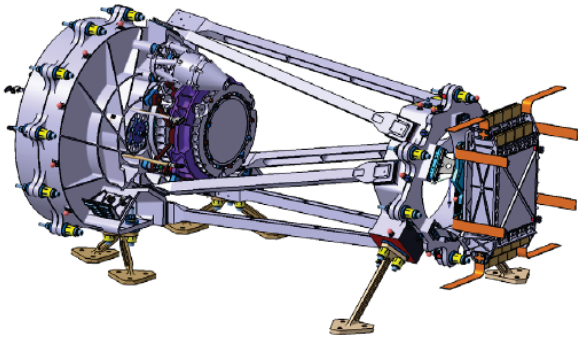
NISP

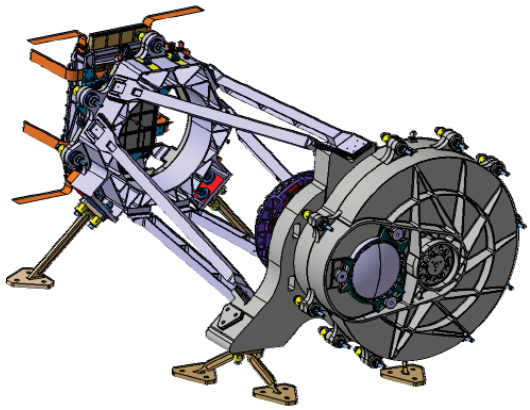
Photometry

- limiting magnitude: m_{AB}=24.5
- redshift resolution: $\sigma z/(1+z) \leq 3\%–5\%$
- spectral range $\Delta\lambda$: 920–1146nm (Y), 1146–1372nm (J), 1372–2000nm (H)

Spectroscopy

- limiting magnitude: m_{AB}=19.5
- redshift resolution: $\sigma z/(1+z) \leq 0.1\%$
- spectral range $\Delta\lambda$: 1000–2000nm
- spectroscopic resolution: $\Delta\lambda/\lambda$=500
- focal plane: 4×4 H2RG, 2048×2048 pixels, 2.3μm cut-off)
- plate scale: 0.3 arcsec/pix
- field of view: FoV=0.763×0.722deg^2
- focal length: f~6.1 m

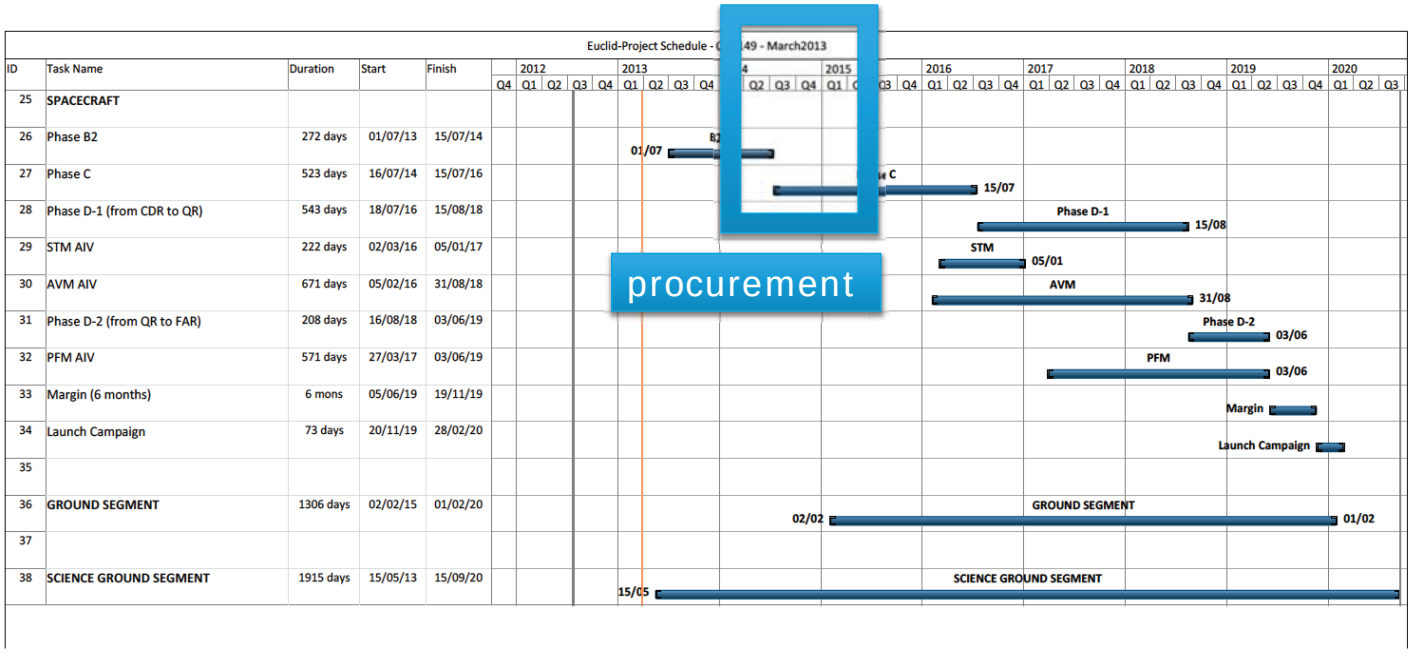




Euclid-Project Schedule - QRC149 - March2013

ID	Task Name	Duration	Start	Finish
1	EUCLID PROJECT PHASE B2/C/D/E1			
2				
3	MISSION MAJOR MILESTONES			
4	Implementation Phase Kick-Off	1 day	01/07/13	01/07/13
5	Mission Requirements Review (MRR)	1 day	03/02/14	03/02/14
6	Mission Preliminary Design Review (MPDR)	1 day	04/05/15	04/05/15
7	Mission Critical Design Review (MCDR)	1 day	08/05/17	08/05/17
8	Mission Flight Acceptance Review (MFAR)	1 day	08/08/19	08/08/19
9	Launch	1 day	01/03/20	01/03/20
10	Mission Commiss. Results Review (MCRR)	1 day	15/05/20	15/05/20
11				
12	PAYLOAD			
13	VIS	908 days	03/02/14	26/07/17
14	VIS CCDs	841 days	05/02/13	26/04/16
15	NISP	930 days	22/01/14	15/08/17
16	NIR Detectors (Eval. Phase)	346 days	23/07/12	18/11/13
17	NIR Detectors (Production Phase)	630 days	01/10/13	29/02/16
18	PLM			
19	Phase B2	307 days	23/01/13	27/03/14
20	Phase C/D	1100 days	28/03/14	14/06/18
21	STM AIV	290 days	26/01/16	06/03/17
22	AVM AIV	523 days	29/03/16	29/03/18
23	FM AIV	482 days	10/08/16	14/06/18
24				

Spacecraft & GS planning



Euclid Procurement approach (1/2)

- Euclid procurement approved by IPC ESA/IPC(2012)1, add.41 in Paris, 27 June 2012
- Euclid industrial work is to be procured in two steps:
  - first, a procurement action covering the Payload Module (PLM), released in July 2012 and placed in December 2012; ✔
  - second a procurement action covering the Euclid Spacecraft and Prime contractor activities, including the Service Module (SVM), released in December 2012; ✔
  - A Contract Proposal was presented to June 2013 IPC for the full Prime Contract (incl. SVM and subsumed PLM)✔
- All activities to be subcontracted will be procured following the ESA Code of Best Practices (ESA/ IPC(2012)65,rev.2);

Euclid Procurement approach (2/2)

- In principle, two steps:
  - firstly the Prime Contractor will select the subsystems responsible, including allocations for the units belonging to it;
  - secondly the selected subsystem contractors will issue ITT for the units procurements.
- The procurement plan is regularly reviewed and adapted in order to achieve the GR return requirements;
- In doing so, preferential clause, limitations, restricted competition or direct negotiation may be used;
- Items may be grouped or, further broken down, to better suit the project needs and/or help achieving GR;
- For stringent technical and programmatic reasons, the competition may be enlarged to non-Member States.

Geo-Return Requirements

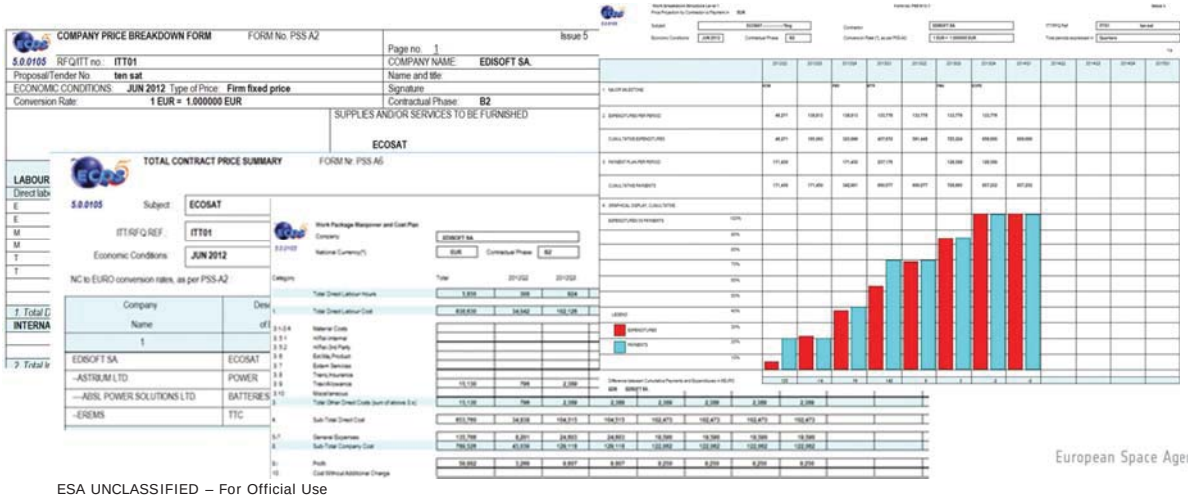
1. Payload Module contract only: (D, F, I, UK) 60%, all others 40%;
2. For the entire Euclid Industrial contract, i.e. PLM+SVM =>

Member State	Geo-return requirements for Euclid
Austria	2.6
Belgium	3.2
Czech Rep.	1.2
Denmark	2.1
Finland	1.7
Greece	2.2
Ireland	1.5
Luxembourg	0.2
Netherlands	5.5
Norway	2.9
Poland	2.6
Portugal	1.5
Romania	1.2
Spain	10.0
Sweden	3.1
Switzerland	3.5
Sub-total	**45.0**
France	
Germany	
Italy	
U.Kingdom	
Sub-total	**55.0**
Total	**100.0**

ECOS – The ESA Costing Software

ECOS benefits

1. ECOS 5 unanimously welcomed by the ESA bidders' Community
2. Allows **error-free** Price aggregation
3. Faster than Excel-based spread sheets once configured
4. All PSS-A forms printed in one batch.



ECOS - The Rate File

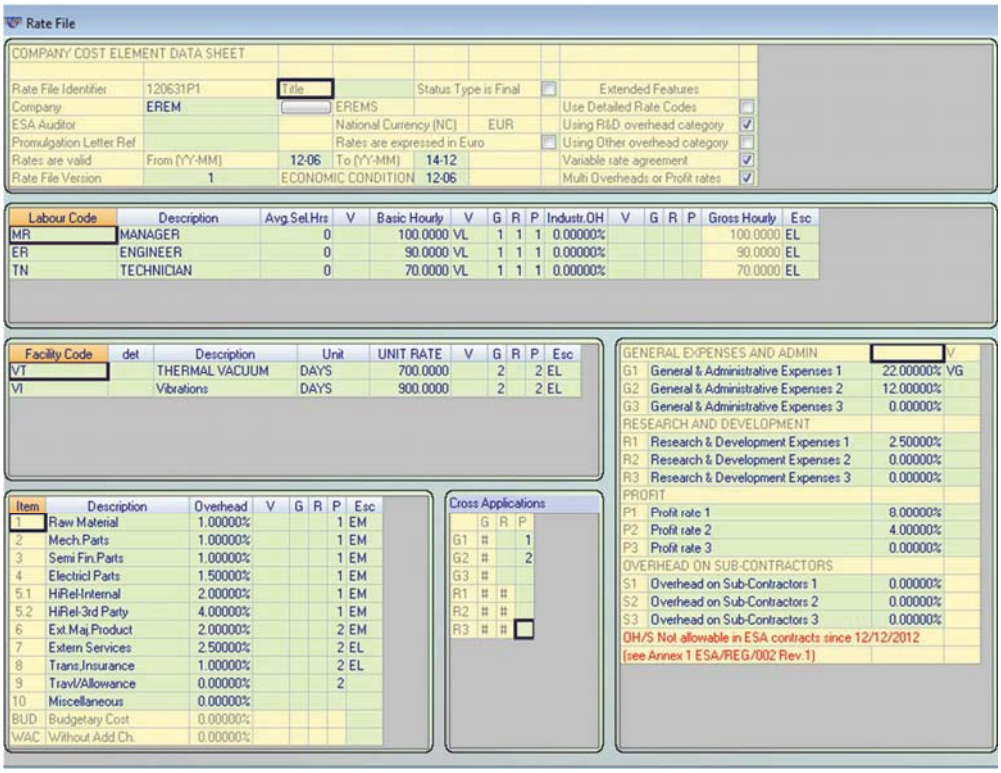
Rate file noticeable features

Escalation tables

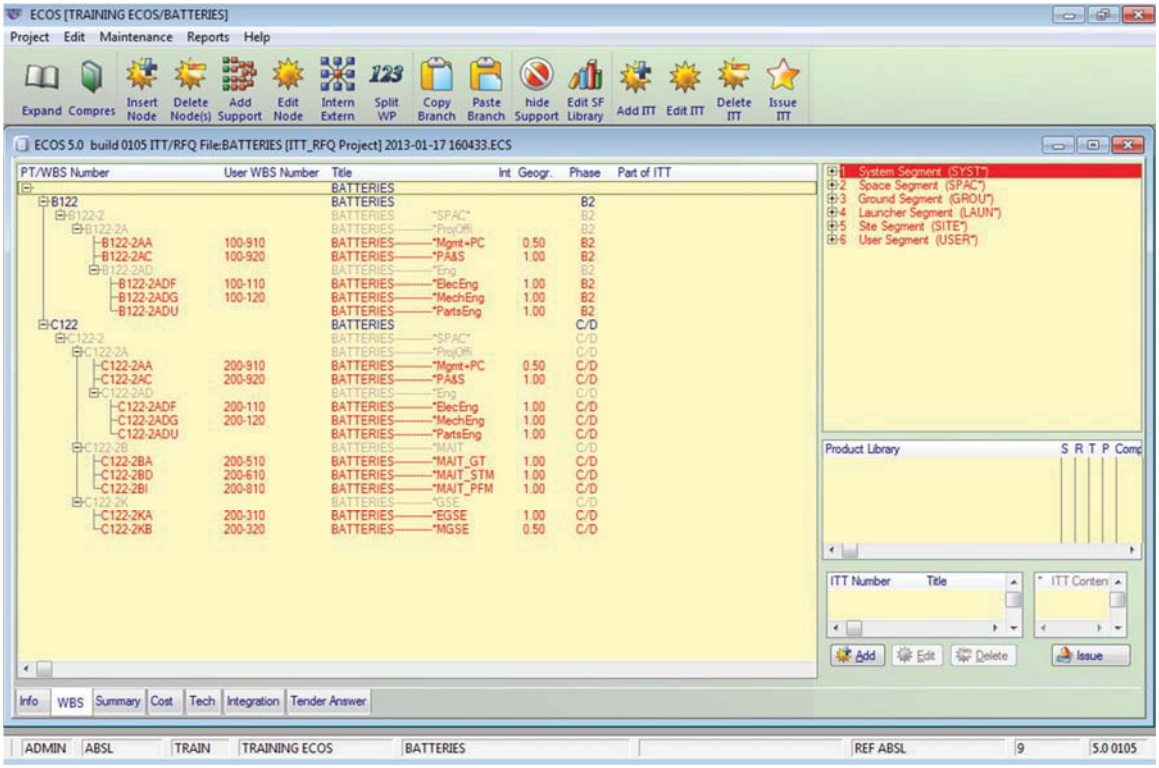
Variable rate agreement

Multiple rates

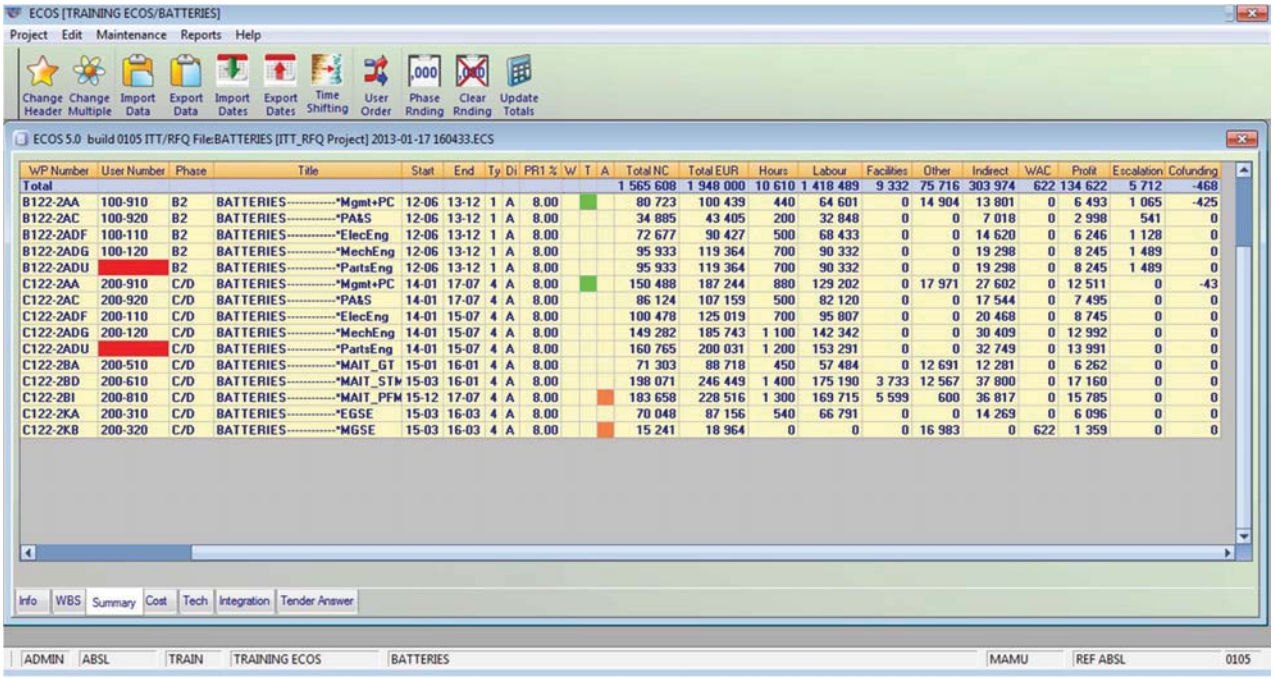
Average sellable hours/year



ECOS - Building the PT / WBS with Support Functions

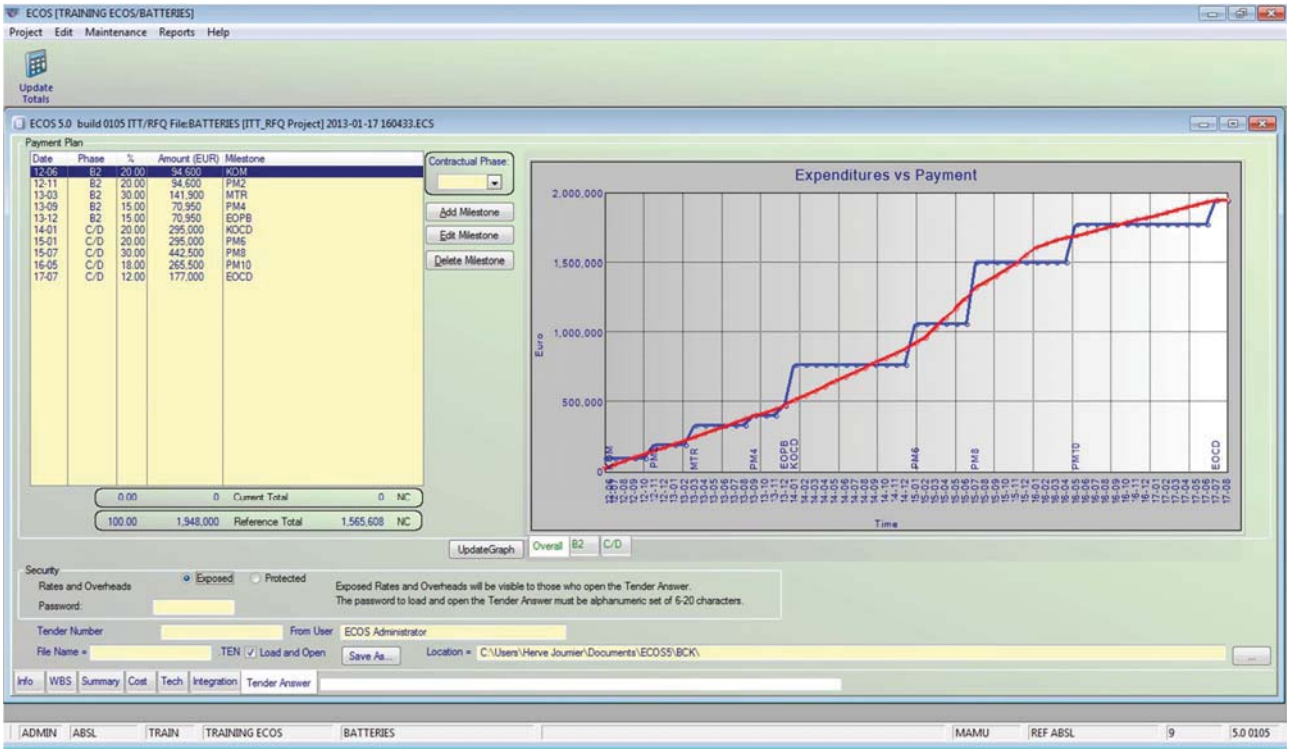


ECOS - The Price Data Entry Summary



European Space Agency

ECOS - The Payment Plan Data Entry



ECOS - A global view over the price

European Space Agency

ECOS - Advanced features

Advanced features	Comments
Price rounding	To give an elegant final touch to the price by presenting rounded numbers per phase. Rounding can easily be cancelled if and when price has to be reworked before generating/submitting the tender
Time shifting	To recalculate instantly expenses profiles and escalation in FFP for the block of activities concerned (totality of the scope or only a WBS branch
Fully supported yearly variable rates	To automatically calculate yearly amounts when variable yearly rates apply to some resources categories, overheads or profit rates. **Recalculations in case of time shifting are instantaneous**
User WP numbering	The User can define his own WP numbering system and visualize WP list summaries and produce all WP-related reports sorted by User numbers
Product Libraries	To record and later reuse by simple drag'n drop, blocks of WBS including resources for any type of product. Highly recommended for Equipment suppliers. Also suitable for standard sets of Project Office activities. Allows to transfer all data entries from one file to another in case of data recovery or any kind of contingency action. For instance: transferring all data entries entered in own created project file into an ITT file received from the Upper-tier contractor at a late stage
Travel Libraries	All elementary records of price per trip/daily subsistence at your finger tip. Excel Imports (from finance department for instance) allowed
Import/Export dates	Allow Import/Export to/from any planning tool (Excel based)
Import/Export data	Allows Import/Export to/from any ERP system (CSV based)
Colour settings	The User can define his set of colours for various mode (Maintenance/Data Entry/Tender). Useful and agreeable

ECOS - How to get and install ECOS

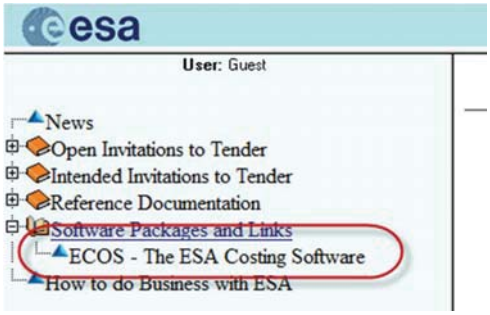
1. **Contact the ECOS Help Desk:**

Tel: +31.(0)71.565.6500

Email: ecoshelp@esa.int

2. **Follow the instructions of the email that you will receive**

3. **Self-Training available from download on EMITS :**



INDUSTRY DAY of the Euclid Spacecraft – contents (1/2)

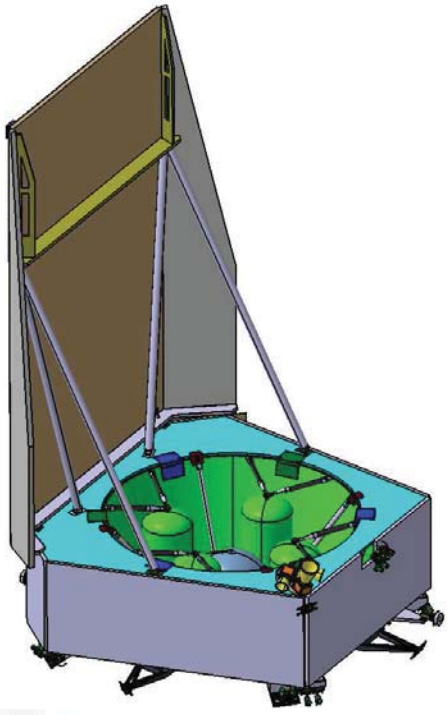
- **General Presentation**
  - The Euclid overall design
    - Spacecraft Configuration
    - Mission Design
    - Design Drivers
    - Launcher
    - SVM Physical Configuration Overview
    - Spacecraft Functional Architecture
  - The Euclid development logic
    - Models
    - Verification philosophy
    - Schedule
  - The Euclid Service Module product tree and constituents
  - The ITT Process (according to Best Practices)
  - List and dates of the future ITTs

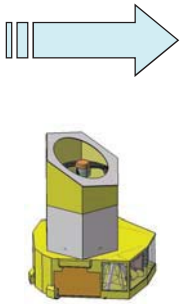
INDUSTRY DAY of the Euclid Spacecraft – contents (2/2)

- **Presentation of each ITT**
  - SVM Flight products
    - AOCS , FGS
    - CDMS , TT&C
    - SVM STRUCTURE & THERMAL CONTROL
    - SUN SHIELD & SOLAR ARRAY
    - PROPULSION
    - BATTERY , HARNESS , PCDU
    - ASW
  - SVM Ground Support Equipment
    - EGSE
    - MGSE
  - System support activities
  - CPPA
  - ISVV
  - Test facilities

Euclid Spacecraft Configuration

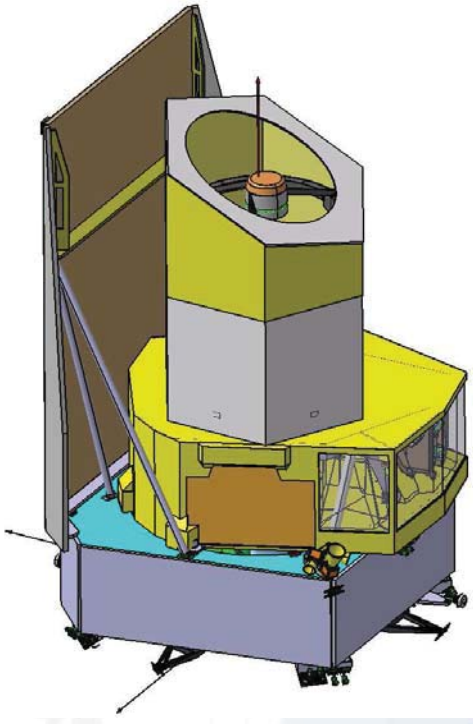
SVM (including Sunshield)





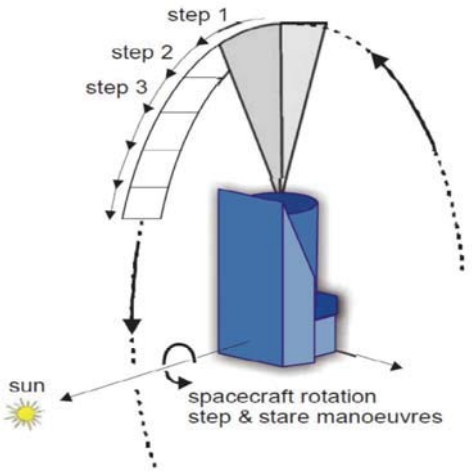
PLM (developped independently)

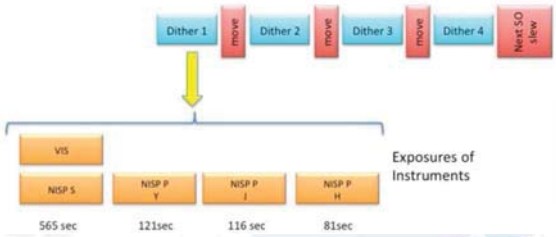
EUCLID Spacecraft



Mission design

- Nominal lifetime: 6 years (after 3 months commissioning), 7 years sizing for consumables
- Orbit at Sun-Earth L2
- Launched with Soyuz ST 2-1B from French Guiana, direct transfer
- 4 hours of ground communication per day
- K-band science telemetry link, 850 Gb compressed data per day
- Step-and-stare scan of the sky with Telescope line of sight nearly perpendicular to the Sun direction
  - Each 0.5 deg² field observed for 4500s
  - Four dithered exposures of VIS
  - Four dithered exposures of NISP-S in 2 different bands each with 2 different dispersion orientations
  - Four dithered exposures of NISP-P in 3 different bands





Design Drivers

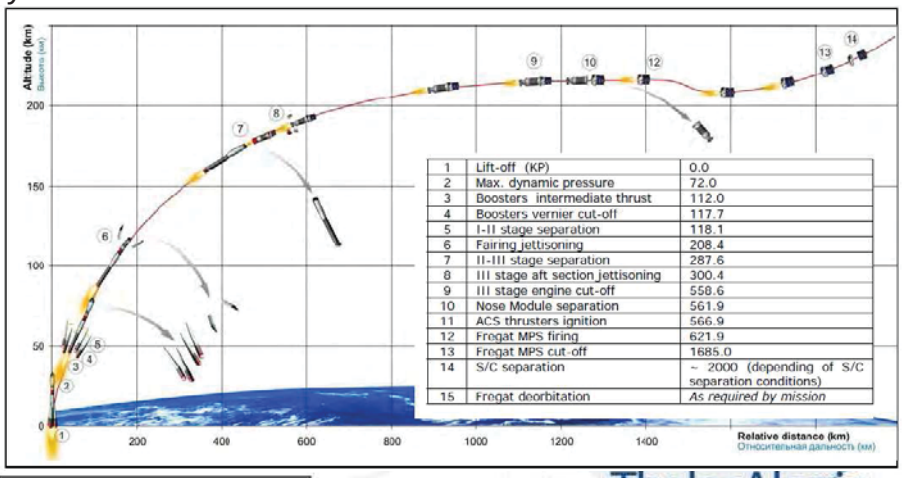
- Survey speed: nearly half the sky (15 000 deg²) covered in 6 years
  - Large Telescope Field of View (0.5 deg²)
  - Optimised survey strategy with minimal dead times (fast slews, fast settling)
  - large data rates
- Survey depth and signal to noise ratio
  - Mission at L2
  - permanently shaded telescope
  - low detector (on PLM) temperatures
- Size reconstruction and stability of the Point Spread Function
  - high Telescope image quality
  - high pointing stability
  - high thermoelastic stability

} co-location of the AOCS sensor (FGS) with the science sensor (VIS)

Launcher

- Launch from the Guiana Space Centre, Kourou, on board a Soyuz ST 2.1-B; 1st quarter 2020
- Direct ascent launch: no L2 orbit insertion manoeuvre;
  - First correction manoeuvre ≤ first 48 hours;
  - Two more correction manoeuvres to enter the libration orbit around L2;
  - Orbit around L2 is maintained by regular station-keeping manoeuvres every 30 days

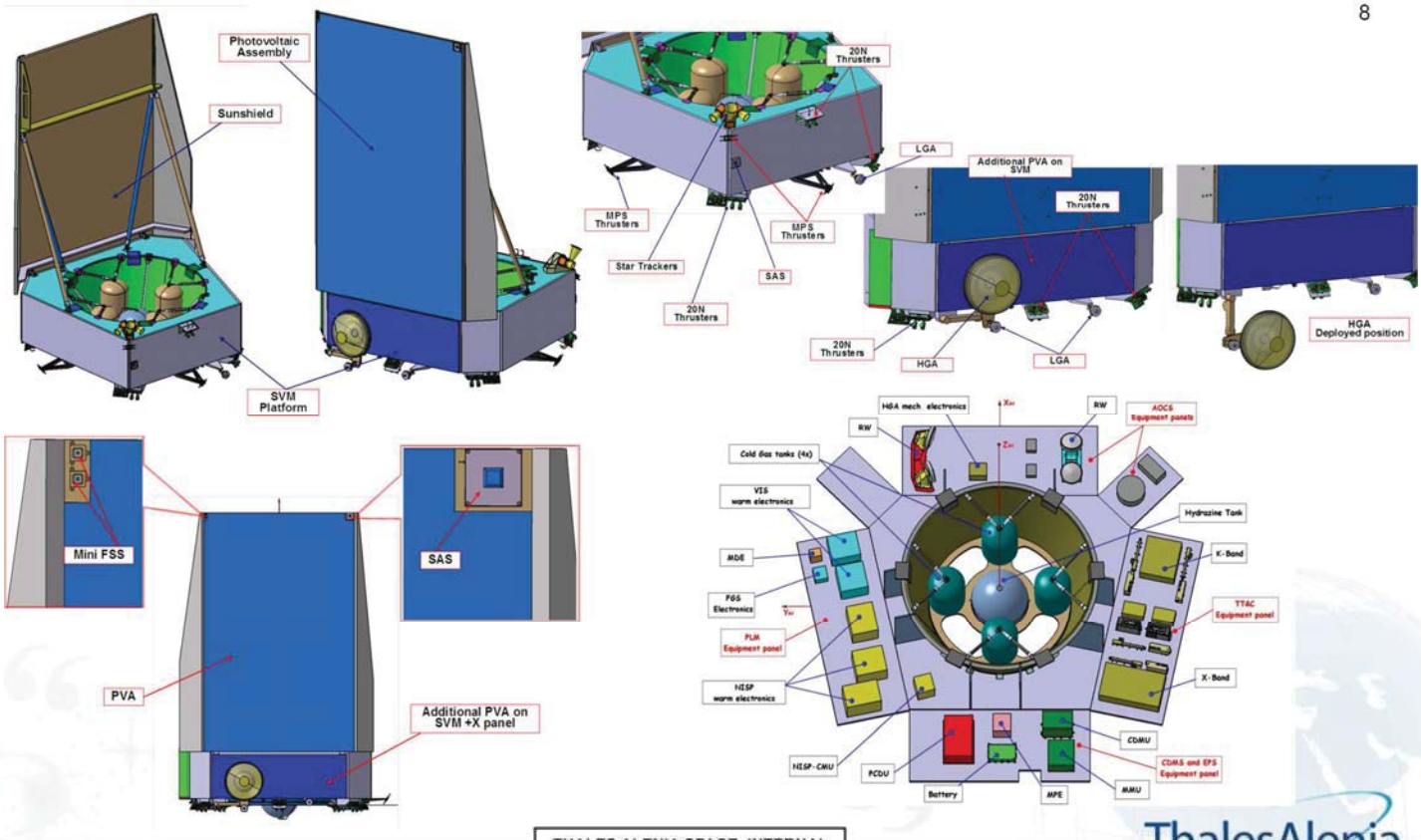
- 2160 kg launch mass
- adapter included



1	Lift-off (KP)	0.0
2	Max. dynamic pressure	72.0
3	Boosters intermediate thrust	112.0
4	Boosters vernier cut-off	117.7
5	I-II stage separation	118.1
6	Fairing jettisoning	208.4
7	II-III stage separation	287.6
8	III stage aft section jettisoning	300.4
9	III stage engine cut-off	558.6
10	Nose Module separation	561.9
11	ACS thrusters ignition	566.9
12	Fregat MPS firing	621.9
13	Fregat MPS cut-off	1685.0
14	S/C separation	~ 2000 (depending of S/C separation conditions)
15	Fregat deorbitation	*As required by mission*

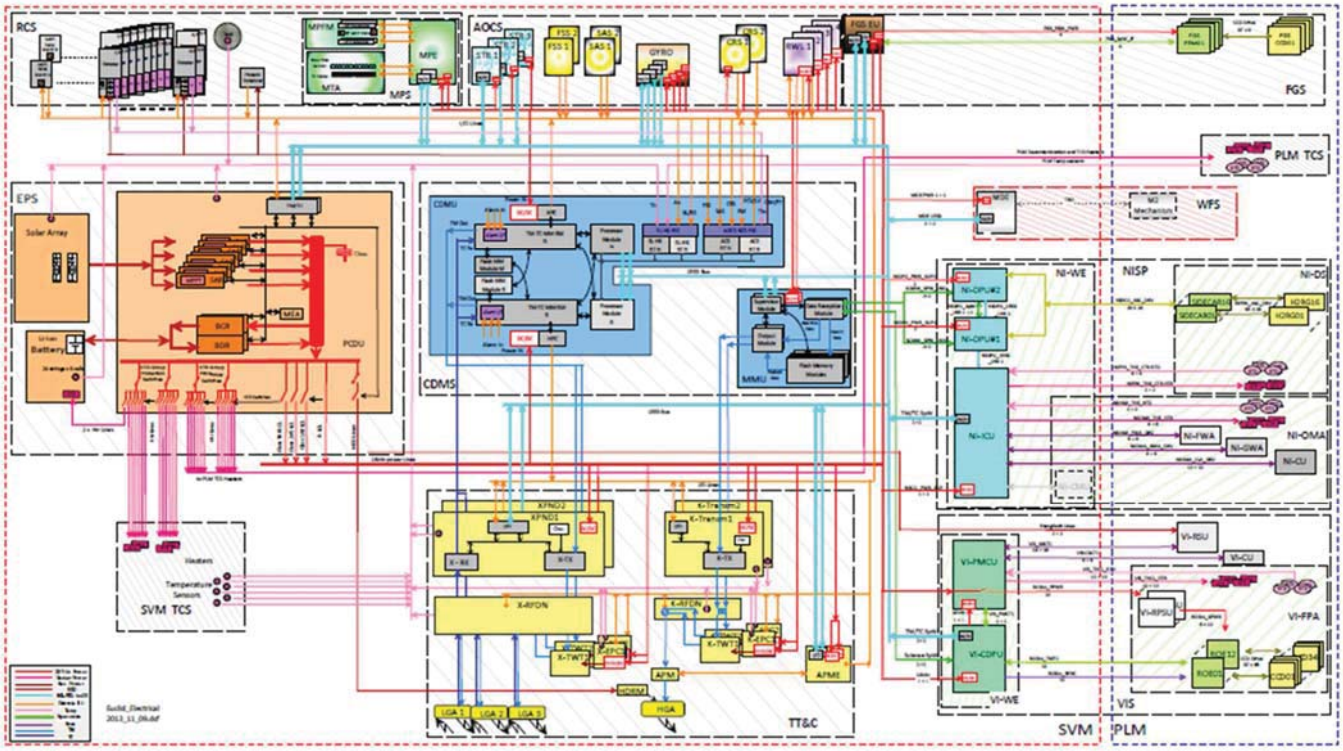
THALES ALENIA SPACE INTERNAL

SVM Physical Configuration



THALES ALENIA SPACE INTERNAL

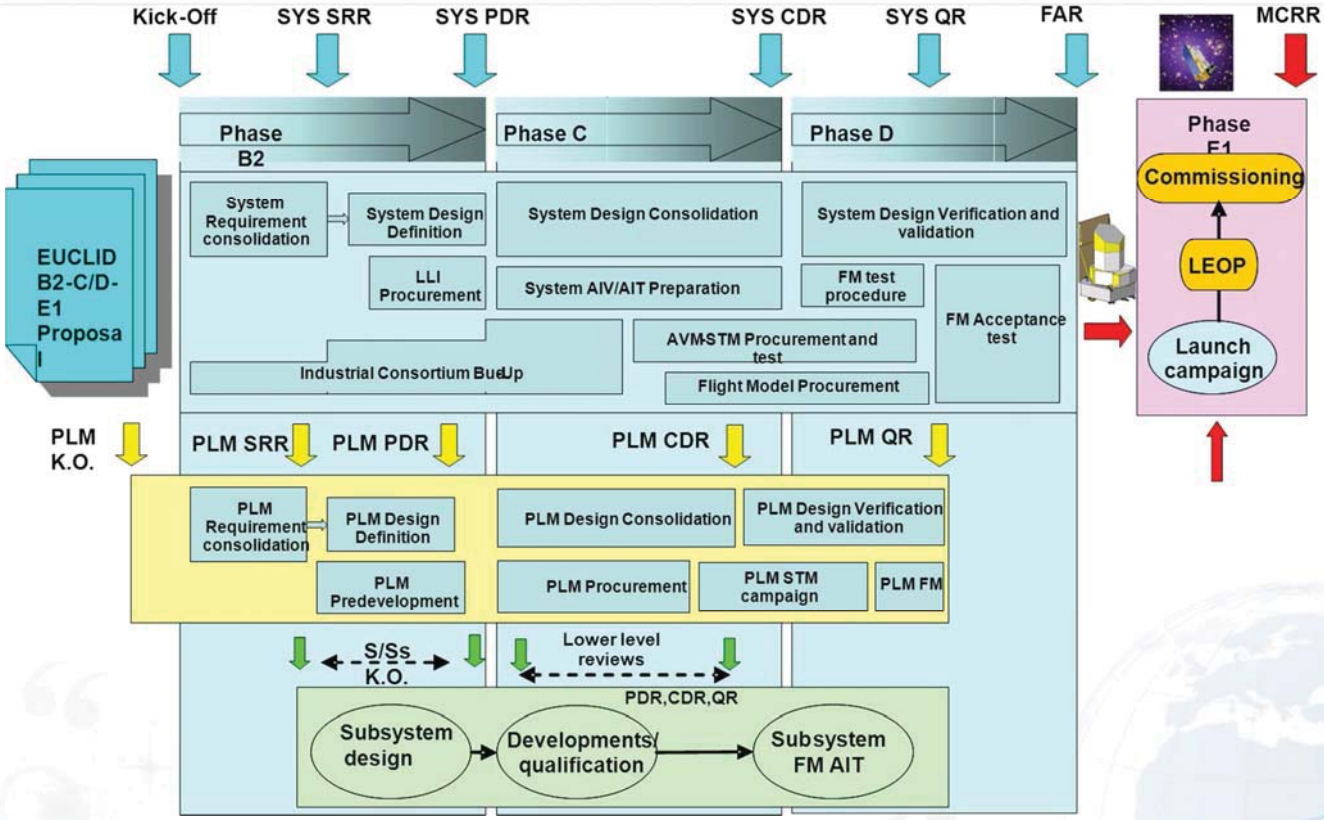
Spacecraft Functional Architecture



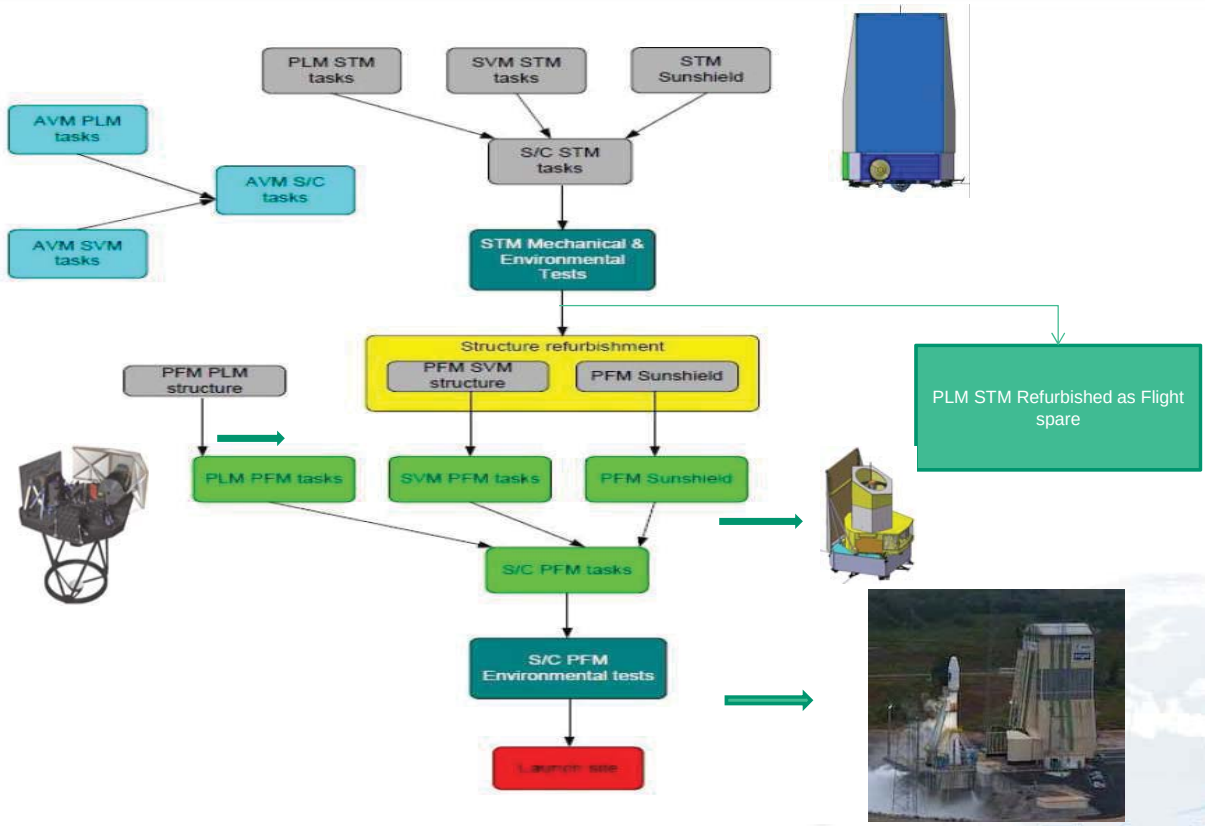
The Euclid development logic / Models

- The baseline Spacecraft model philosophy is a 3-model approach consisting of:
  - Structural and Thermal Model (STM), built at flight standard, for structure and thermal qualification. The STM will include the SVM and the PLM STMs and will be equipped with equipment dummies/STMs
  - Avionic Model (AVM), built from units engineering models (EM) or engineering qualification models (EQM), constituted of the SVM and PLM AVM, for early verification of the functional, software, electrical interfaces and the Flight Operational aspects as well the SRD.
  - Proto Flight Model (PFM), used to complete the qualification, submitted to a full proto-flight programme and launch preparation and suitable for launch and flight operations.

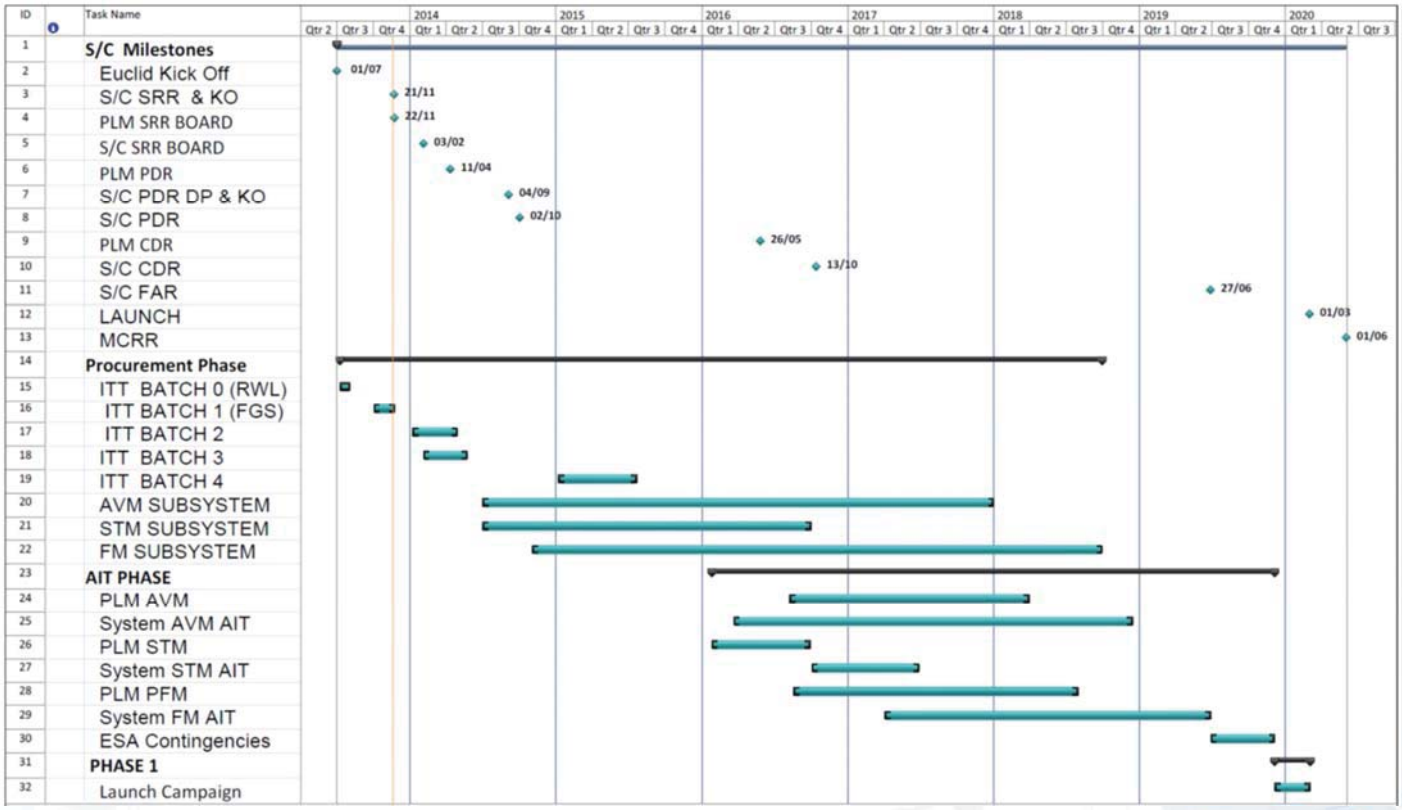
Euclid development logic



Verification philosophy – Overall



Euclid Development Schedule



The Euclid Service Module product tree and constituents

2				SVM
2	**1**			**Structure and Thermal Control**
2	1	1		Structure
2	1	1	1	Thrust Cone
2	1	1	2	Platforms
2	1	1	3	Panels, struts, brackets
2	1	1	4	Structure Miscellanea
2	1	1	5	LVA (CFI)
2	1	1	6	AVM Structure
2	1	2		SVM Thermal Control
2	1	2	1	Heaters
2	1	2	2	Doubler
2	1	2	3	Temperature sensors
2	1	2	4	OSR
2	1	2	5	MLI
2	1	2	6	Black Paint
2	1	2	7	Filler
2	1	2	8	Miscellanea
2	**2**			**Propulsion**
2	2	1		Micropropulsion
2	2	1	1	Micropropulsion Thruster
2	2	1	2	Micropropulsion Tank
2	2	1	3	FVV
2	2	1	4	Filters
2	2	1	5	Pressure Regulator
2	2	1	6	Pressure Transducer
2	2	1	7	Latch valve
2	2	1	8	Piping and Miscellanea
2	2	2		Monopropellant Propulsion
2	2	2	1	20N Thruster
2	2	2	2	Propellant Tank
2	2	2	3	FDV
2	2	2	4	FVV
2	2	2	5	Pressure Transducer
2	2	2	6	Filter
2	2	2	7	Latch valve
2	2	2	8	Piping and Miscellanea

2	**3**			**CDMS**
2	3	1		CDMU + HDSW
2	3	2		MMU
2	4			Software
2	**4**	**1**		**CDMS ASW**
2	**4**	**2**		**ISVV**
2	**5**			**TT&C**
2	5	1		X-Band transponder
2	5	2		X-Band RFDN
2	5	3		X-Band TWTA
2	5	4		X-Band LGA
2	5	5		K-Band modulator
2	5	6		K-Band RFDN
2	5	7		K-Band TWTA
2	5	8		K-Band HGA Assembly
2	5	8	1	K-Band HGA
2	5	8	2	HGA APM
2	**6**			**AOCS**
2	6	1		AOCS SW
2	6	2		Reaction Wheel
2	6	3		SAS
2	6	4		FSS
2	6	5		Gyroscope Assembly
2	6	6		CRS
2	6	7		Accelerometer Assembly
2	6	8		STR
2	**6**	**9**		**FGS**
2	6	10		AOCS SCOE
2	**7**			**Sunshield & Solar Array**
2	7	1		Sunshield Structure
2	7	2		Sunshield Thermal Control
2	7	3		PVA
2	8			Electrical Power
2	**8**	**1**		**Battery**
2	**8**	**2**		**PCDU**
2	9			System Harness
2	**9**	**1**		**SVM Harness**

3				GSE
3	1			EGSE
3	1	1		System EGSE
3	**1**	**1**	**1**	**CCS**
3	**1**	**1**	**2**	**Power SCOE**
3	**1**	**1**	**3**	**CDMU and TM/TC SCOE**
3	**1**	**1**	**4**	**TT&C SCOE**
3	**1**	**1**	**5**	**RF Suitcase**
3	1	1	6	PLM SCOE
3	2			MGSE
3	**2**	**1**		**System & SVM MGSE**
3	2	1	1	Integration Stands
3	2	1	2	Adapters
3	2	1	3	Hoisting/Lifting Devices
3	2	1	4	Access Platforms
3	2	1	5	Shipping Containers
3	2	1	6	Other MGSE
3	**2**	**2**		**Mechanical & Thermal Dummies**

Bold red:
Products procured by ITT packages issued at Prime level

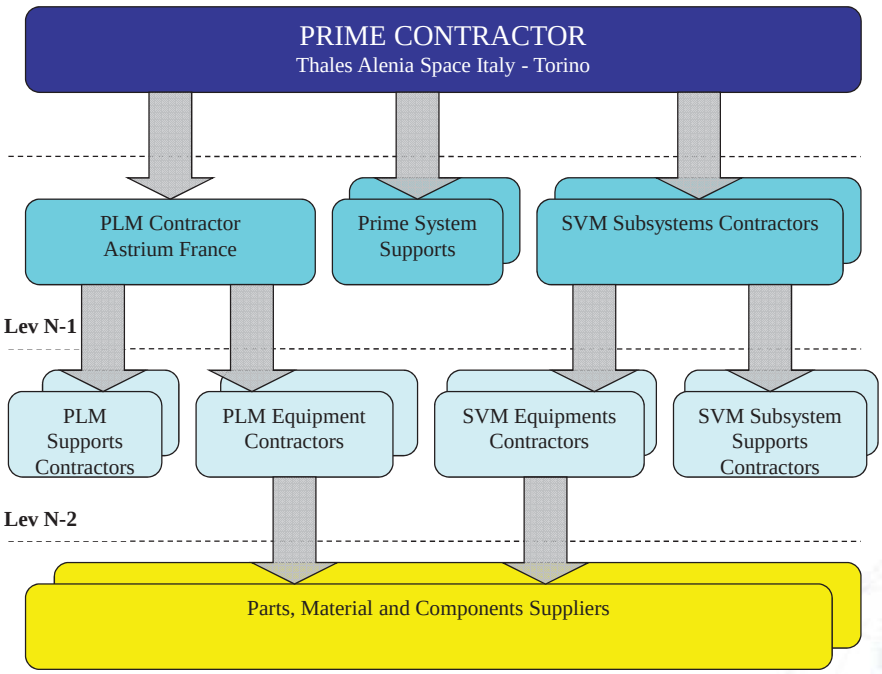
Other PRIME ITT outside Product Tree:

- **CPPA**
- **Test Facility**
- **System Support Tasks**

The ITT process according to Best Practices

- EUCLID Project Industrial Organization
- Procurement Approach
- Geographical Return Targets
- Overview of Selection process steps and duration
- Overview of ITT pack composition
- Evaluation Criteria
- Procurement Needs

EUCLID Project Industrial Organization (1/2)



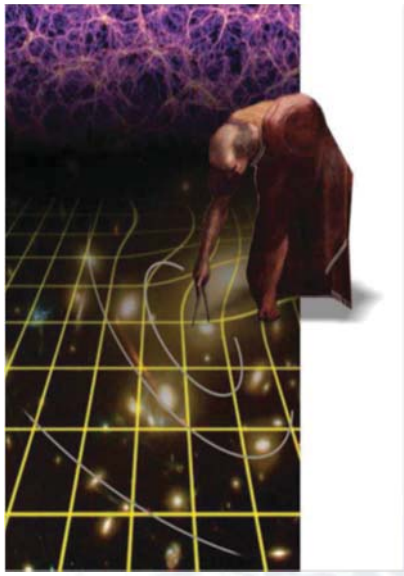
EUCLID Project Industrial Organization (2/2)

- **Prime Contractor TAS-I**
  - Responsible for overall programme management, coordination and control of the main Subcontractors (Level 1), system architecture, detailed design, analysis and specification of all SVM subsystems and Sunshield elements
- **PLM Contractor Astrium SAS**
  - Responsible for PLM architecture, detailed design, analysis and specification of all PLM equipment
- **Subsystem Contractors**
  - responsible of deploying the subsystem specifications to the Suppliers of the equipment/elements, of their procurement and of ensuring the full qualification and acceptance of the subsystems delivered to the Prime
- **Equipment Contractors**
  - in charge of manufacturing the equipment/elements and to deliver fully qualified products to the Subsystem Contractors

Procurement Approach (1/3)

- The **Industrial Organization build-up** is starting in the frame of Phase B and it will be completed in Phase C/D.
- The **Subcontractors' Selection Process** will be performed in accordance with the Project's requirements that are based on the

  ESA Code Of Best Practices
- The Offers will be evaluated by a board (TEB) composed by the Issuing company, TAS-I and ESA.
- In the event that the Issuing Company or one of its affiliates submits a bid, the TEB responsibility will be taken by TAS-I Prime or ESA.



Procurement Approach (2/3)

- The principal procurement method is the Open Competition, that will be managed by releasing Invitations To Tender (ITTs) on EMITS.
- The **Invitations To Tender** are addressed to companies and organizations residing in all ESA Member and Associated States.
- TAS-I is responsible for procuring:
  - SVM Flight Subsystems, Equipment's and Software
  - Supports for the System Activities,
  - Ground Support Equipment's (GSE) for on ground tests and verifications
- The Subsystem Contractors will be responsible for procuring:
  - Flight Equipments
  - Ground Support Equipment's (GSE) for on ground tests and verifications
  - Materials, parts, components

Procurement Approach (3/3)

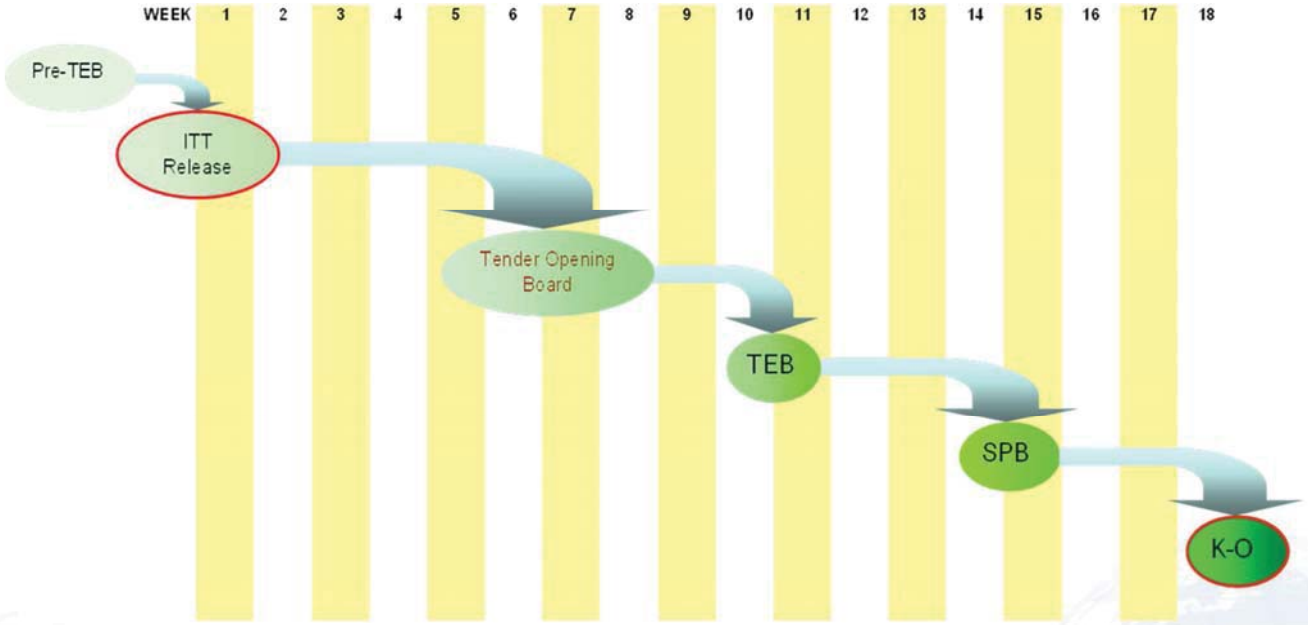
- For the S/S level ITTs, the Cover letter will contain also a set of constraints chosen among these main elements, aimed to maximise open competition, participation of non-LSI and achievement of georeturn targets :
  - Subsystem core team : a maximum size of core team in % of the S/S value may be specified (core team defined as the sum of all the proposed MAKE plus all the preselected BUY)
  - Lower level competition: outside the S/S core team share, the open competition will be the standard approach for the Equipment procurement, however some specific activities (e.g unit X, WP Y) may be specifically requested to be procured in restricted competition
  - Geo return: dedicated S/S geo return target, exclusions, restriction, DN, may be set depending on return evolution.

Note that the above elements can be used individually or in combination.

Geographical Return Targets

Country	Geo-return requirements for Euclid [%]
Germany + France + Italy + United Kingdom	< 55.0
Austria	2.6
Belgium	3.2
Czech Rep.	1.2
Denmark	2.1
Finland	1.7
Greece	2.2
Ireland	1.5
Luxembourg	0.3
Netherlands	4.5
Norway	2.9
Poland	3.8
Portugal	1.5
Romania	1.2
Spain	10.0
Sweden	3.1
Switzerland	3.5
Total	100.0

Overview of Selection process steps and duration



- **Proposal Preparation: 6 weeks**

Overview of ITT pack composition

- The ITT package available on EMITS will be composed by:
  - **Cover Letter**
  - **Special Conditions Of Tender**
  - **Draft Contract**
  - **Statement Of Work**
- Dedicated e-links will be provided in the Cover Letter for the Technical Requirement Specification and for the Normative References (Applicable Documents).

Evaluation Criteria

1. Background and experience of the company, key personnel, adequacy of proposed facilities
2. Understanding of objectives, discussion of problem and risk areas, proposed design solutions, performance and trade-offs. Compliance to the requirements
3. Quality and suitability of proposed programme of work, adequacy of engineering and verification approach including risk mitigation
4. Adequacy of management, costing and planning
5. Compliance with tender conditions and acceptance of contract conditions.

Note: criteria weighting factors will be made available in the SCOT.

TAS-I ITTs issuing dates

	ITT SUBJECT	ITT release reference date
BATCH 1		
	FGS	Nov-2013
BATCH 2		
	CDMS	Feb-2014
	SVM STRUCTURE & THC	Feb-2014
	AOCS	Feb-2014
	SSH & S.A.	March-2014
	TT&C	January-2014
	CPPA	Apr-2014
BATCH 3		
	MGSE	Apr-2014
	Mech. Therm. Dummies	Apr-2014
	ASW	March-2014
	PROPULSION	May-2014
	BATTERY	June-2014
	HARNESS	Apr-2014
	PCDU	May-2014
	CCS EGSE	May-2014
	POWER SCOE	May-2014
	CDMU and TMTC SCOE	June-2014
	TT&c SCOE	Apr-2014
	SYSTEM SUPPORTS	Sept-2014
BATCH 4		
	RF SUITCASE	January-2016
	ISVV	March-2015
	TEST FACILITIES	Apr-2015

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Euclid Industry Day 15-January-2014

THALES ALENIA SPACE INTERNAL

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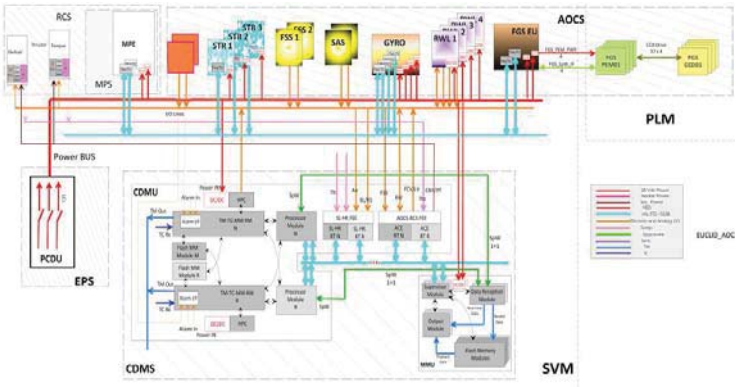
Presentation of each ITT

AOCS

- The Euclid AOCS provides:
  - measurement of satellite attitude
  - control of satellite attitude via suitable actuators
  - management and control of the propulsion subsystem
  - FDIR to guarantee mission safety
  - communication with spacecraft CDMS, including command handling and TM generation



Abstract

Main deliverables

Item	STM	EM	FM	FS
Star Tracker	3	1	3	1
Fine Sun Sensor	2	1	2	1
Coarse Rate Sensor	2	1	2	1
Sun Acquisition Sensor	2	1	2	1
Gyroscope Assembly	1	1	1	1
Reaction Wheel	4	1	4	1
Accelerometer assembly	2	1	2	1
AOCS SW (v0, v1, v2)				
AOCS SCOE (2x)				

AOCS key features and main tasks

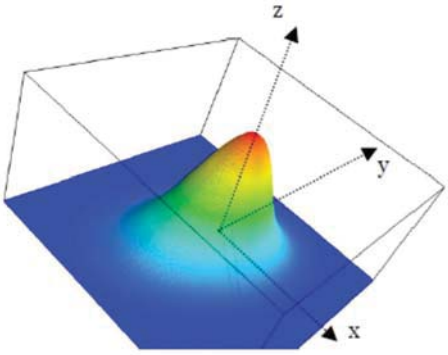
- **Key Features**
  - Very stringent pointing requirement (RPE and APE)
  - Use of a CFI dedicated sensor for high precision attitude measurement: Fine Guidance Sensor
  - High agility to perform frequent manoeuvres
  - Use of 2 propulsion subsystems not under AOCS procurement
    - Hydrazine RCS for orbit/SK/safe attitude manoeuvres
    - Cold gas MPS for low noise / precise attitude control in science mode
  - Science Mode with two stellar sensor (STR and FGS) plus gyro and two actuators (RWL and Cold Gas)
  - Sun sensor and coarse rate sensor dedicated to FDIR
  - AOCS SW on main CDMU
- **Main Tasks**
  - Responsible for the design, procurement, verification and validation of the complete subsystem, HW+SW
  - Core Team definition and procurement of needed products and services according to Best Practices
  - Subsystem AIT before delivery to TAS-I and Support at TAS-I for System AIT

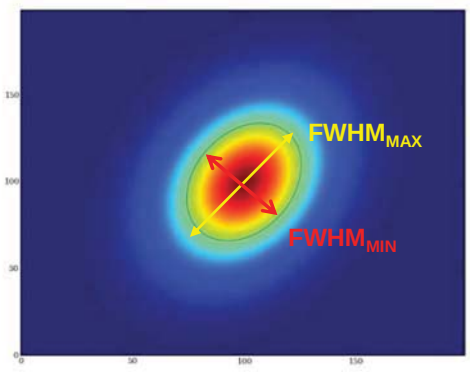
Key Milestones

MLS	Date
Kick Off	July 14
SRR	Sept 14
PDR	April 15
CDR	June 16
E(Q)M	Sept 16
QR	Aug 16
(P)FM	Oct 17

AOCS budgets and required performance

- **Performance in science mode:**
  - Absolute Pointing Error (APE) < 2.5 arcsec, 68% CL (X and Y axis) and <7.5 arcsec, 68% CL (Z axis)
  - Relative Pointing Error (RPE) over 700s (VIS, NISP Spectro) shall be better than:
    - 25 milli-arcseconds (X and Y axes) at 68% Confidence Level (CL)
    - 500 milli-arcseconds (Z axis) at 68% Confidence Level (CL)
  - Point Spread Function (PSF) Ellipticity < 21%
    - Constraint on the difference between the Full Width Half Maximum (FWHM) along the two principal axes of the PSF spatial distribution
- **Mass**: ≤45 kg
- **Power**:
  - ≤84 W in Science Mode, (weighted average between observation, slew, and dither phases)
  - ≤38 W in low order modes
  - ≤124 W when reaction wheels are active in nominal conditions





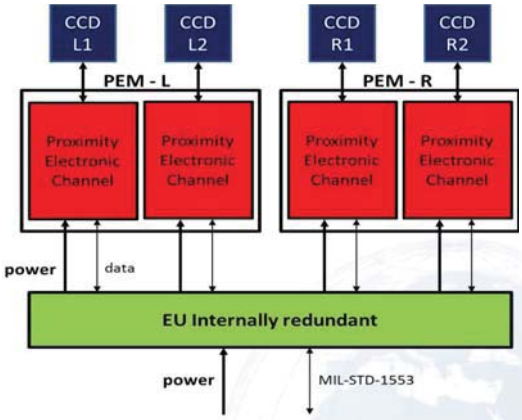
Fine Guidance Sensor

Abstract

FGS Purpose and composition

- The FGS is a star sensor aimed at providing the AOCS with the high accuracy attitude measurement required to meet the demanding pointing performance during science observation.
- The FGS is composed of
  - Focal Plane Assembly (detectors and detectors support structure) and the Proximity Electronics, installed on the Euclid Payload Module (PLM)
  - Electronic Unit mounted on the Euclid Service Module (SVM)
  - Embedded SW
- The contract includes the development of a FGS EGSE for ground testing, verification, and validation

- FGS ITT on emits since 29/11/2013: AO30175
- ITT closing date: 7/2/2014 13:00 CET



FGS features and milestones

FGS key features

- The FGS focal planes are placed in close proximity to the VIS instrument focal plane at ~ 150 K
  - the proximity electronics are also in close proximity and share the same radiator
  - FGS uses the telescope optical path in the VIS channel (focal length = 24.5 m)
- key requirements on thermal dissipation towards the cold PLM and structural stability (use of SiC).
- EMC compatibility between FGS and VIS
- Integration of a star catalogue to provide Inertial attitude

Main Tasks

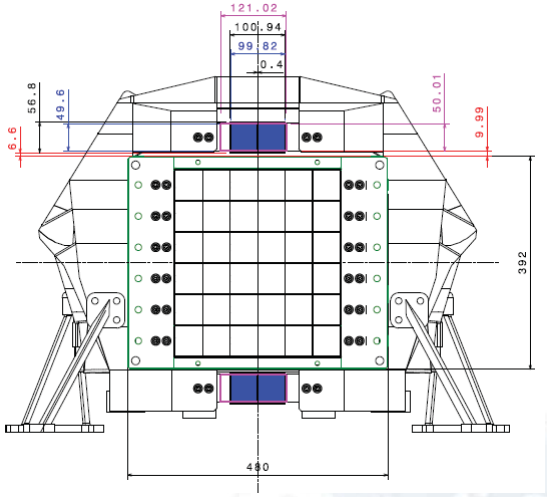
- Responsible for the design, procurement, verification and validation of the equipment, HW and SW
- Core Team definition and procurement of needed products and services.
  - Key aspects is the procurement of detectors
- Subsystem AIT before delivery
- Support to TAS-I and PLM for System AIT

Key Milestones

MLS	Date	Quantity
Kick Off	03/14	
SRR	06/14	
PDR	02/15	
CDR	02/16	
E(Q)M	06/16	1EU+1PEM +1FP
QR	08/16	
(P)FM	04/17	1EU+2PEM +2FP
Spare	06/17	see SoW

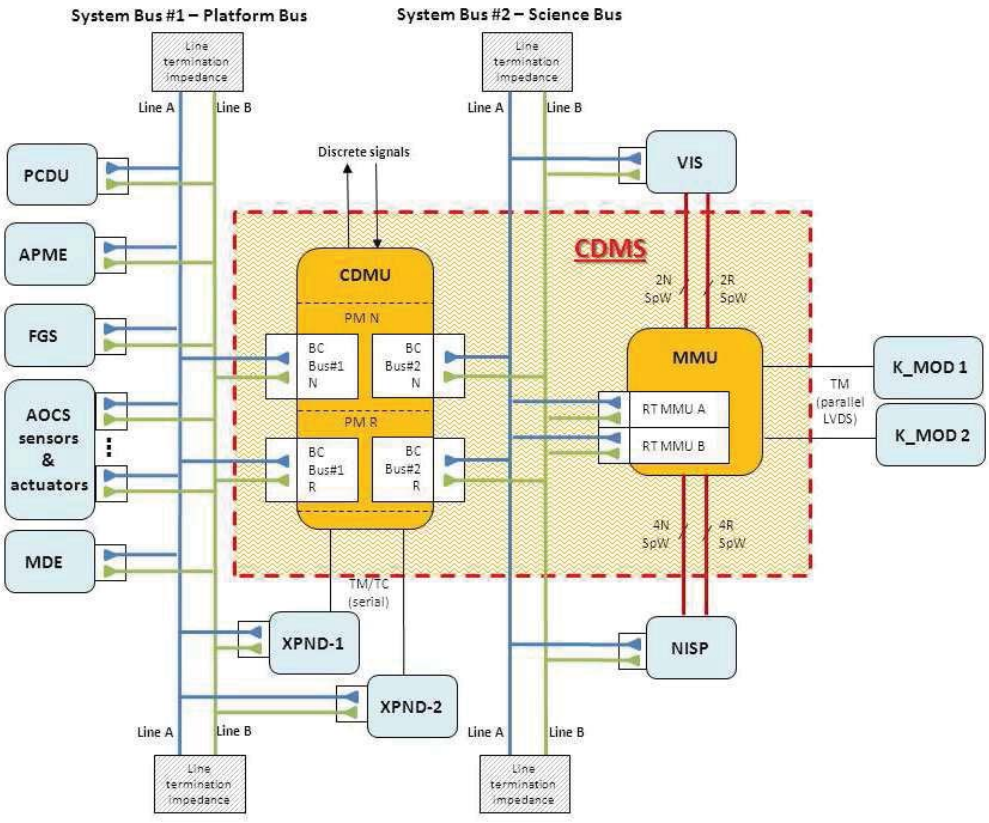
FGS required performance

- To meet image quality requirements, the FGS provides very accurate absolute and relative attitude measurement with frequency 0.5 Hz ≤ f ≤ 2Hz
- FGS provides:
  - relative attitude measurement with accuracy better than 30 mas (99.7% confidence level) cross optical axis and 2.1'' (99.7% C.L.) around optical axis, over 4500s.
  - absolute attitude measurement with accuracy better than 0.6'' (99.7% C.L.) cross optical axis and 5'' (99.7% C.L.) around optical axis, to meet APE requirements.
- The FGS has 2 main operative modes:
  - Relative Tracking Mode (RTM) in which targets to be tracked are selected without external information from full frame images.
  - Absolute Tracking Mode (ATM) in which targets are selected using a star catalogue provided as CFI by TAS-I.
- Mass: ≤ 6 kg
- Power: ≤ 14.5 W



CDMS (Command and Data Management S/S)

Abstract



- Collect and store on-board HK and science data;
- Perform on-board data conditioning, processing, formatting, encoding and transmission to ground
- Perform command acquisition, decoding, validation, execution or distribution

CDMS

Key Features

- It consists of two main units: the Command and Data Management Unit (CDMU) and the Mass Memory Unit (MMU).
- The CDMU embeds Boot-init SW and Hardware Dependent SW (HDSW) needed to drive the HW of CDMU.
- The CDMU provides computational capabilities for the Application Software which manages and controls all subsystems including the AOCS.
- The CDMU maintains and distribute the on-board time to all on-board users.
- The MMU collects, stores and downloads satellite HK and scientific data by the MMU SW consisting of: HDSW, Operating System and Application Layer SW (**including the CFDP protocol**)

Main Tasks

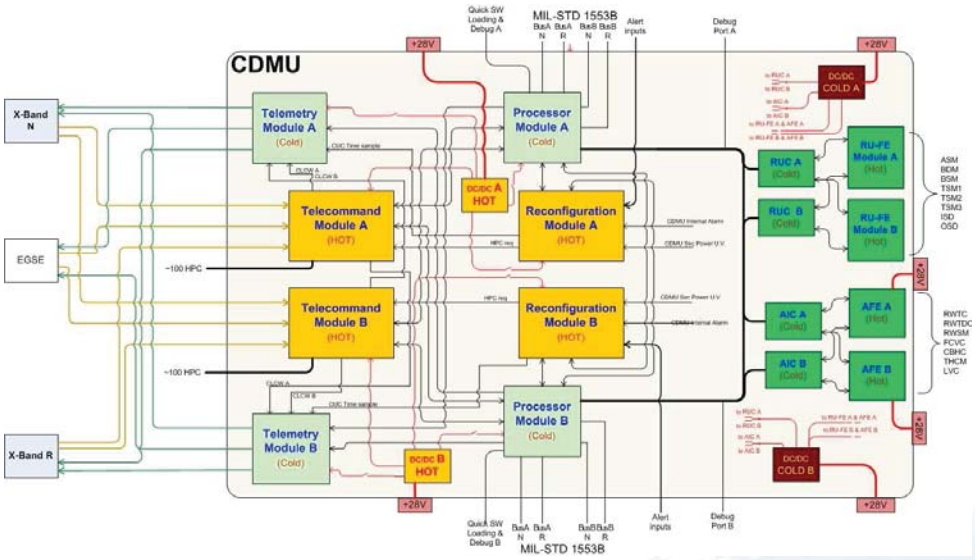
- Design, development and manufacturing/procurement of all the CDMS components (CDMU, MMU, CDMU HDSW and MMU SW)
- Selection of the Equipment's according to Best Practices
- Integration of MMU HDSW, Operating System and Application Layer on the MMU unit.
- Verification, validation and qualification of each CDMS component and of the integrated CDMS subsystem.
- Support at TAS-I for System AIT

Key Milestones

MLS	Date	Quantity
Kick Off	June ‘14	
SRR	Sept ’14	
PDR	Feb ‘15	
CDR	June ‘16	
QR	July ‘16	
FUMO	Aug ‘15	#2 CDMU
STM	March ‘16	#1 CDMU #1 MMU
E(Q)M	May ‘16	#1 CDMU #1 MMU
(P)FM	Nov ‘17	#1 CDMU #1 MMU

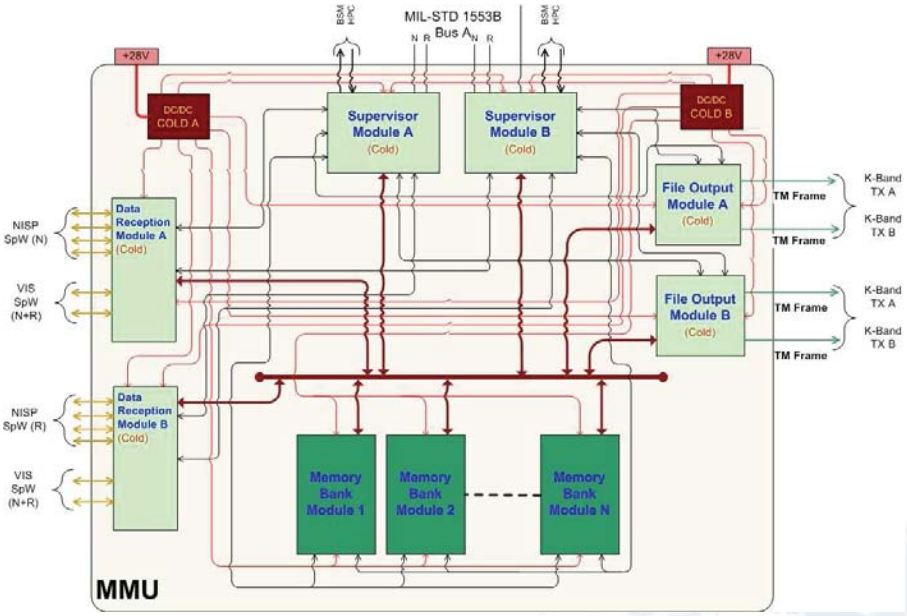
CDMU Performances

- Processor Module
  - > 40MIPS
  - > 5MFLOPS
  - > 2*4Mbyte EEPROM
  - > 64 Kbyte PROM
  - > 16 Mbyte RAM
  - Two Dual redundant MIL-STD-1553B
- Reconfiguration Module
  - FDIR
  - CUC time generation (Stability better than $1*10E^{-6}$)
  - SGM > 1 Mbyte
  - Mass Memory > 12 Gbit
- TC & TM Modules
- Remote Unit I/F
- AOCS & RCS I/F
- Mass target = 18 kg max
- Power dissipation = 33 watts max
- Width: 500 W x250 D x 280 H mm (including mounting feet)



MMU Performances

- Memory Bank Module
  - 4 Tbit
  - A spare Bank is installed, to provide SPFT
  - > 15 Mbps storing
  - > 90 Mbps reading
- Supervisor Module
  - Host MMU Application SW
  - Implement an HW “Supervisior Failure Detection and Isolation”
  - I/F CDMU via 1553B
- Data Reception Module
  - 6 SpW, each 160Mbps, w/buffering capabilities
- File Output Module
  - Redundant I/F to K-Band Transponder, 8 data lines + CLK, physical LVDS
- Mass target = 15 kg max
- Power dissipation = 59 watts max
- Width: 300 W x250 D x 300 H mm (including mounting feet)

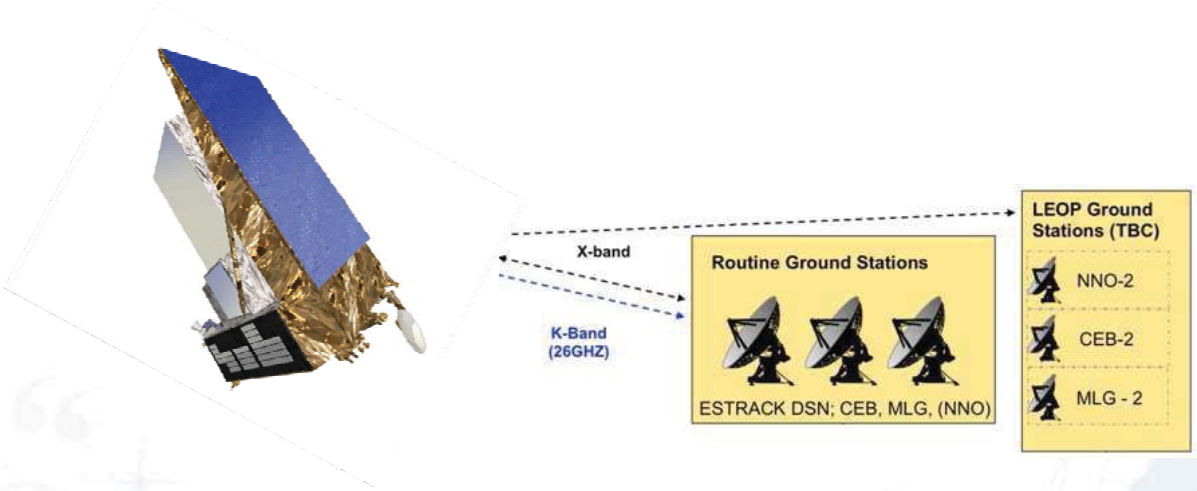


CDMS Model Philosophy

- Models to be delivered:
  - Structural and Thermal Model (STM) for both CDMU and MMU
  - Two CDMU FuMo (no redundancy required) in support to SW integration and test
  - Engineering Qualification Model (EQM or EM) for both CDMU and MMU
  - Flight Model (FM or PFM) for both CDMU and MMU
  - Repairing kit for the CDMU and MMU flight hardware
  - a SW model representative of the CDMU (CDMU Emulator) including CDMU HW model, Interface models and processor model (TSIM) to be integrated into the System SW Verification Facility
  - a SW model representative of the functional behavior of the MMU
- CDMS subsystem E(Q)M shall implement the same redundancies as the (P)FM.
  - The model philosophy of the single units (EM + PFM or EQM + FM) shall be defined by CDMS Contractor taking into account the design maturity

TT&C shall support the communication link with Earth

- LEOP via X-Band link
- Spacecraft Commandability and Observability via X-Band link during daily contact of 4 hours
- Download of scientific data (850 Gbit/day) via K-Band during daily contact of 4 hours.



Key Features

- X-Band section for TC, HK TM and ranging
  - 2 Transponders
  - 2 Power Amplifiers
  - RFDN (switches, WG, coaxial and miscellanea)
  - 3 LGA's (one of them on HGA support structure)
- K-Band section for science + HK TM
  - 2 Modulators with coding capability
  - 2 TWTA's
  - RFDN (switches, WG, coaxial and miscellanea)
  - steerable HGA

Key Milestones

MLS	Date	Quantity
Kick Off	June '14	
PDR	April '15	
CDR	April '16	
E(Q)M	August '16	Whole S/S
QR	July '16	
(P)FM	October '17	Whole S/S
Spare	October '17	Kit

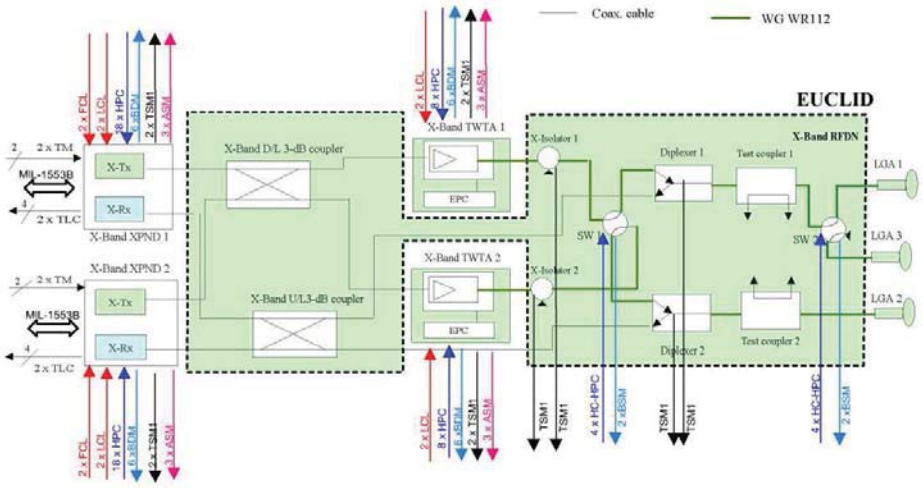
Main Tasks

- Detailed TT&C S/S Design
- Selection of the X-Band and K Band Equipment's according to Best Practices
- Procurement & integration on the Structural panel of the equipment
- End to End S/S AIT and Verification on both AVM and FM

X-Band Performances

- TC rate = 4 kb/s, TM rate = 2 kb/s and RNG for each attitude
  - Through LGA-1 and LGA-2 cross-coupled in uplink
- TC rate = 16 kb/s (to support CFDP NAK transmission), TM rate = 26 kb/s and RNG during nominal operations
  - Through LGA-3, mounted on HGA support platform

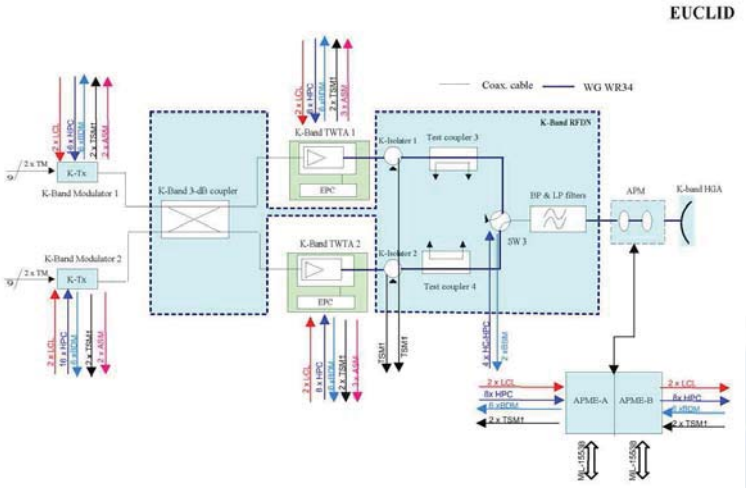
- S/S Mass target = 22.5 kg max
- Power dissipation:
  - 33 W in Launch Mode,
  - 101 W in Sun Asq. Mode
  - 260 W in Nom. Telec. Mode
  - 57 W in Stand By Mode
  - 115 W in Survival Mode
  - 60 W in Re-Pointing Mode
- Dimensions : except antennas and external WGs (WR112), all equipment shall be integrated on a single panel (2260 x 801 mm) together with the K- Band Equipment



K-Band Performances

- TM rate = ~73.85 Mb/s, nominal rate
  - To download HK + science TM generated in 1 day and stored in MMU
- TM rate = ~ 36.93 Mb/s low rate
  - To be used in adverse weather conditions
- Link supported by 2 DoF mechanically steerable HGA (approx 60 cm diameter)

- S/S Mass target = 36 kg max
- Power dissipation:
  - 33 W in Launch Mode,
  - 90 W in Sun Acq. Mode
  - 217 W in Nom. Telec. Mode
  - 52 W in Stand By Mode
  - 104 W in Survival Mode
  - 55 W in Re-Pointing Mode
- Dimensions : except antennas, APM and external WGs (WR34), all equipment shall be integrated on a single panel (2260 x 801 mm) together with the X-Band Equipment



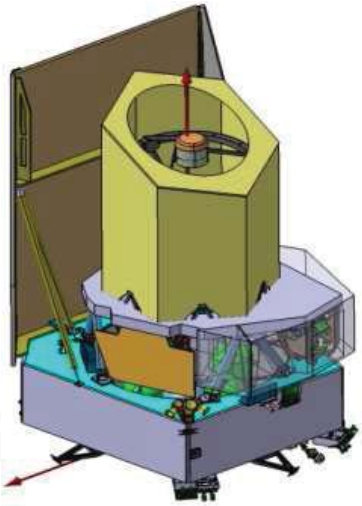
TT&C Model Philosophy

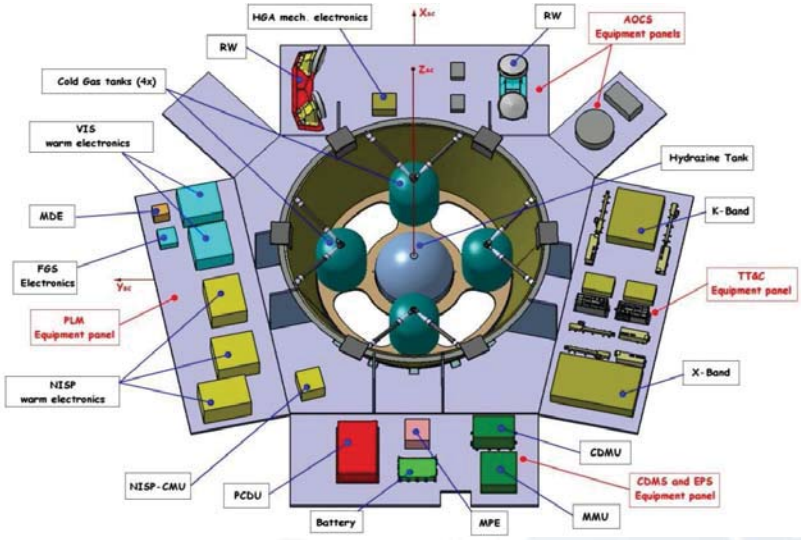
- Models to be delivered:
  - Structural and Thermal Model (STM)
  - Engineering Qualification Model (EQM or EM)
  - Flight Model (FM or PFM)
  - Repair kit for the TT&C flight hardware or Flight Spare to be proposed by the Contractor and agreed with the Prime
  - a SW simulation model for each unit interfacing with MIL-1553B i.e. Transponder and APME
- TT&C subsystem EQM shall implement the same redundancies as the FM/PFM
  - The model philosophy of the single units shall be defined by TT&C Contractor taking into account the design maturity

Structure and Thermal Control

Abstract

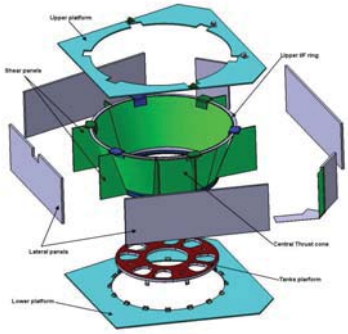
The structure and thermal control shall provide the adequate resources to support the mechanical and thermal environments

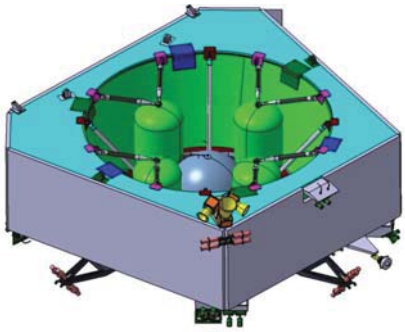




Structure and Thermal Control

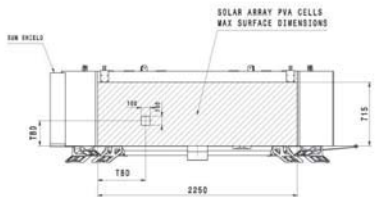
- **Key Features – Structure:**
  - It consists of a central thrust structure (Cone + 2 rings) connected to 6 lateral panels (hosting units and equipment) by means of eight shear panels
  - It shall:
    - Provide support, to Payload Module, Sunshield & Solar Array Subsystem, Hydrazine and Cold Gas Tanks, Equipment and Units installed on SVM
    - Transfer properly launch loads
    - Provide handling and lifting points to allow transportation of fully equipped S/C
    - Assure high thermo-structural dimensional stability
    - Concur to meet stiffness and strength requirements in accordance to S/C specification (1st mode above 15 Hz lateral & 35 Hz Longitudinal)
    - Not exceed mass target of 204 kg

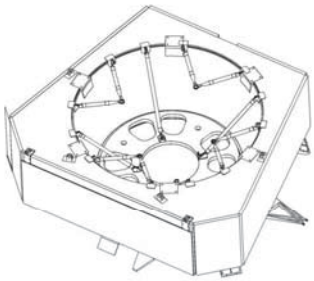


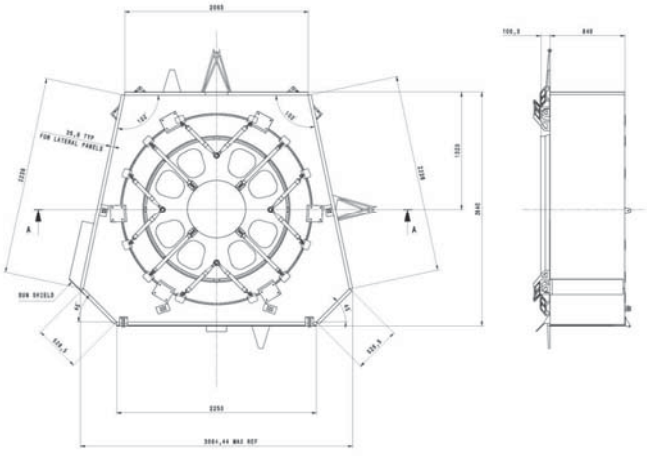


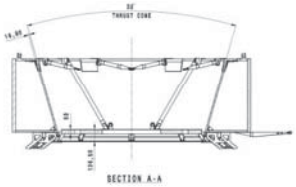
Structure and Thermal Control

Structure - Main Dimensions:









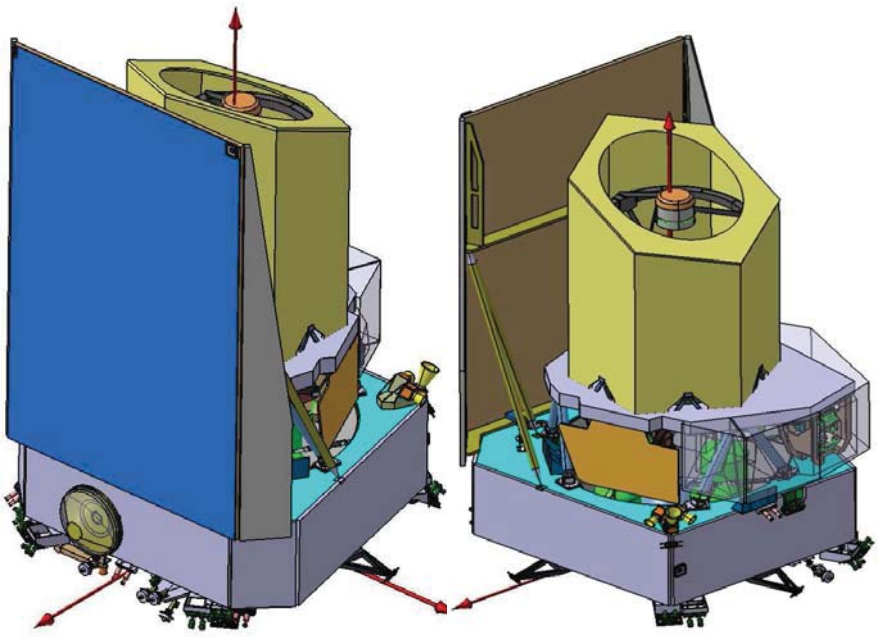
Key Features – Thermal Control :

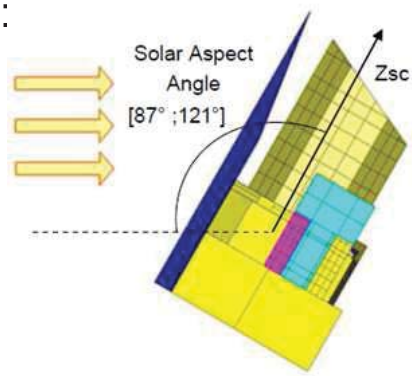
- It includes all the means, hardware and software, to monitor and control temperatures, heat flows and gradients, like thermal insulation blankets, radiator panels and heaters
- It shall:
  - Provide the required thermal environment to all equipment and units along the mission lifetime
  - Maintain the PLM-SVM conductive I/F at the requested temperature (19 +/- 2 ℃), during the operative phases.
  - Provide High efficiency MLI blankets to reduce radiative heat transfer to PLM radiators from SVM top floor, central cone top surface, Solar Shield (SSH) back side area
  - Reduce to the requested value the radiative Field of View to the VIS radiators
  - Maintain the radiative flux toward the NISP Radiator < 25 mW
  - Provide a SVM stable thermal environment during the operative phases (11000 seconds)
  - Provide S/S Thermal Analysis for Thermal Control design sizing and verification
  - Prepare Overall System TMM for Thermal analysis at System level
  - Support System (Prime) during Thermal tests (TB/TV at STM level TB/TV at PFM level)
- Mass: ≤ 30 kg
- Power:

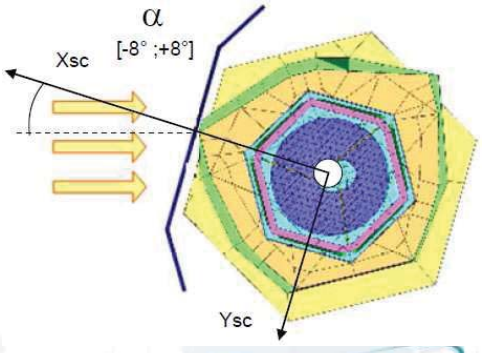
Description	Thermal Control Subsystem operational modes					
	PLOM	LM	LPM	NSM	NSTM	SM
TCS heater power budget [W]	30	60	60	322* 220**	209* 105**	444

- At BOL with SAA= 0°
- At EOL with SAA=-33°

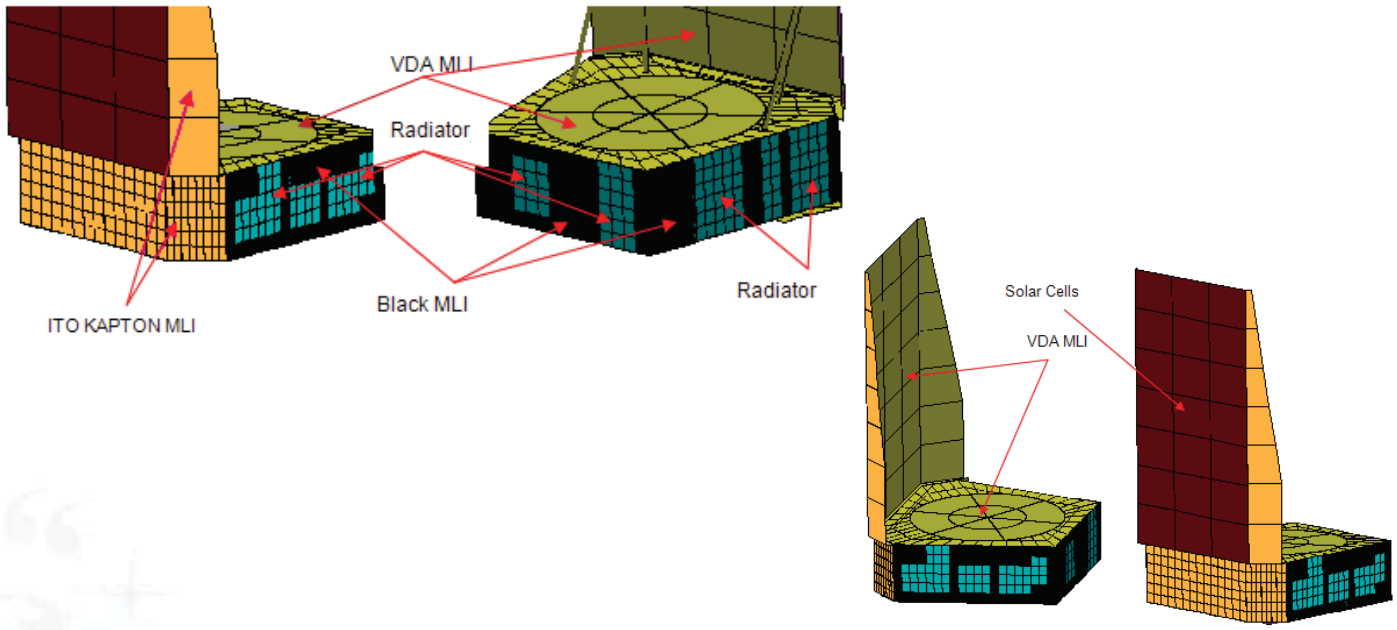
Thermal Control – External Configuration:







Thermal Control – External Configuration (2):



Structure and Thermal Control

Main Tasks

- Design, development and manufacturing/procurement of all structure and thermal control subsystem components
- Selection of materials and components according to Best Practices
- Subsystem structural analyses
- Subsystem thermal analyses
- System thermal analyses
- Provide high efficiency MLI blankets
- Provide MLI blankets for SVM and SSH
- Prepare PFM from STM refurbishment
- Subsystem AIT before delivery to TAS-I
- Support at TAS-I for System AIT (including mechanical and thermal TB/TV tests)

Models to be Delivered

- Structural and Thermal Model (STM)
- Flight Model (PFM) by STM refurbishment
- Avionic Model (AVM) 3D representative of SVM but built with commercial materials

Key Milestones

MLS	Date	Quantity
Kick Off	July ’14	
PDR	March ‘15	
CDR	April ’16	
QR	Nov. ‘16	
AVM	May ‘16	1
STM	March ’16	1
PFM	Sep. ‘17	1(STM refurb.)
Spare	Sep. ‘17	KIT

Structure and Thermal Control

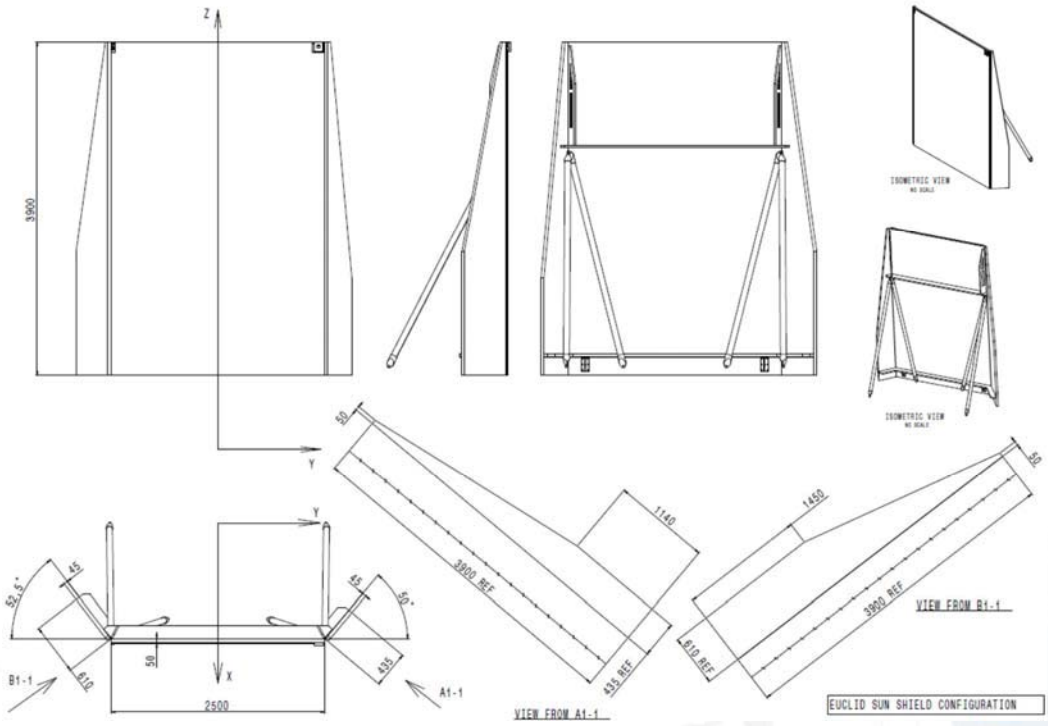
Models To be delivered:

- Structure
  - Structural and Thermal Model (STM)
  - Flight Model (PFM) using STM refurbished
  - Avionic Model (AVM) 3D representative of SVM with respect to electronic unit and Harness Layout
- Thermal hardware
  - STM and FM

Sunshield & Solar Array

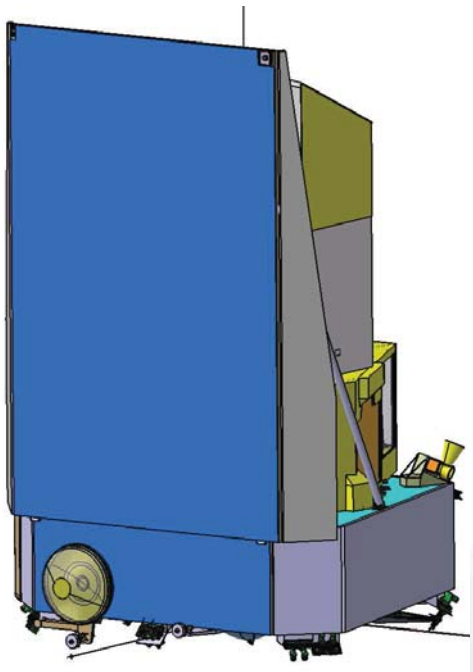
- It comprises the Sunshield structure, the thermal blankets and the PVA.
- It performs the following functions:
  - Protect the whole PLM from direct sun illumination and guarantee a stable thermal environment to both telescope and optical bench
  - Avoid straylight effects on the P/L telescope
  - Provide solar cells (PVA) for electrical power supply
  - Provide mechanical interfaces such as to preserve the Payload Module from mechanical and thermal disturbances (mechanical interfaces limited to SVM upper platform)
- Main mechanical requirements
  - Meet stiffness and strength requirements in accordance to S/C specification (1st mode above 22 Hz)
  - Not exceed mass target of 114 kg (Structure and PVA) and 11 kg (Thermal hardware)

Main Dimensions:



Description and key requirements – Solar Array:

- Power requirement : 1970 W at V>33 V
  - @ worst case SAA: 33° around Y, 10° around Z; 34.2° total
  - @ worst case solar flux: 1293 W/m²
  - @ EoL, with 1 string failed
- Area available for PVA
  - Large panel of 9.7m² integrated on SSH structure
  - additional (growth capability) area of 1.6m² on SVM panel
- The SVM mounted panel described above is today considered as a growth capability and is included in the mass target



Main Tasks

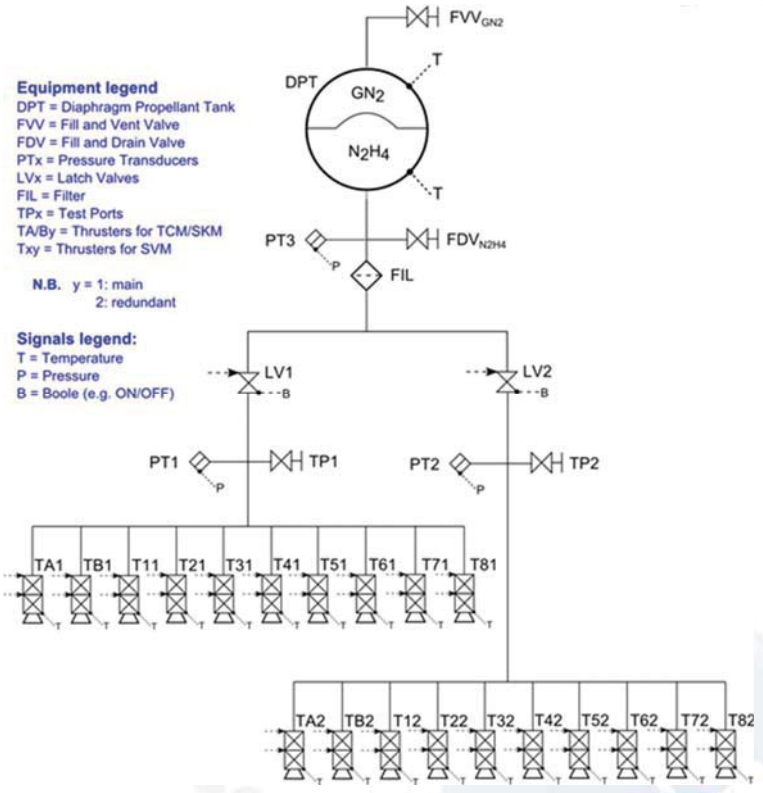
- Core Team definition and procurement of needed products and services
- Subsystem Design and Analysis
- Selection of the Equipment's according to Best Practices
- Subsystem AIT before delivery to TAS-I
- Sunshield structure refurbishment STM → PFM
- Support at TAS-I for System AIT

Key Milestones

MLS	Date	Quantity
Kick Off	July '14	
PDR	Feb '15	
CDR	Apr '16	
QR	Jan '17	
STM	Aug '16	1
(P)FM	Set '17	1
Spare	Set '17	kit

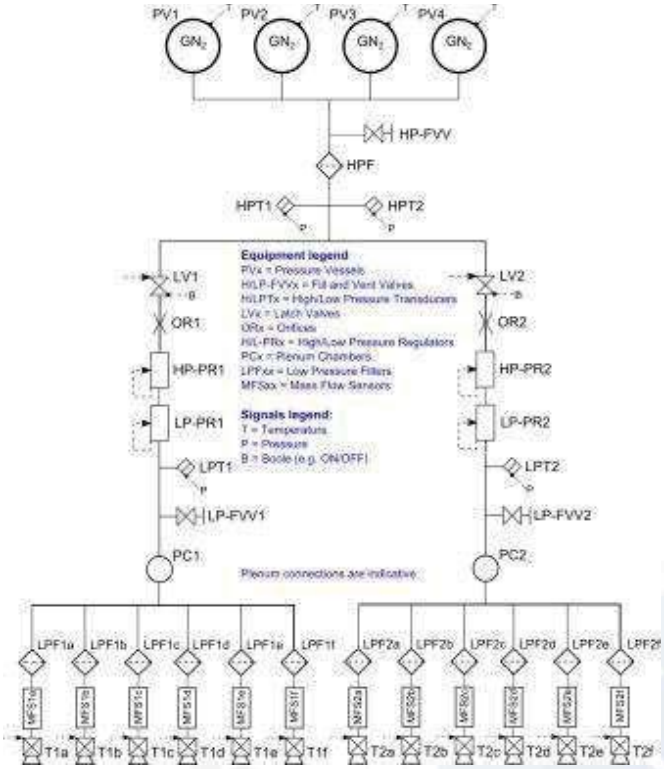
Abstract

- **The EUCLID propulsion subsystem is constituted of two systems devoted to different manoeuvering purposes :**
  - Monopropellant RCS
  - Cold Gas Micropropulsion (MPS)
- **Monopropellant RCS**
  - used for providing the DV required for the transfer correction manoeuvres (TCM) bringing the spacecraft to L2, and the periodic station keeping manoeuvres (SKM) for bounding the spacecraft trajectory around L2.
  - In addition, the RCS provides the torques necessary for stabilising the spacecraft attitude after separation from the launcher, for managing the safe mode, and for offloading the angular momentum accumulated by the reaction wheels.



Cold Gas Micropropulsion (MPS)

- devoted to provide finely controlled torques during the science pointing sessions when exceptional attitude stability is required.



Key Features

- Maximum reuse of existing and qualified HW
- Layout architecture defined to minimise AIT effort and MPS functional validation tasks
- Specific for the MPS
  - Fine thruster resolution
  - Extended lifetime
  - Wide thrust range (1μN to 1000μN)
  - Low noise
- Dry mass ≤ 104 kg

Main Tasks

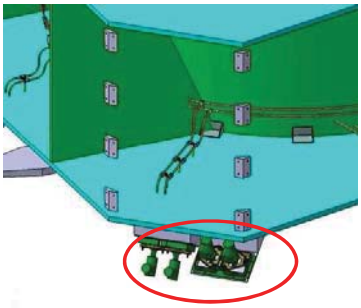
- Perform the Propulsion System Design & Development for both the RCS and the MPS
- Perform the Components EQSR
- Perform the components procurement
- Perform the propulsion sub-assemblies integration on the SVM structure and test it
- Perform the final Propulsion system (RCS and MPS) integration and test on the SVM structure at TASI premises
- Support system level design activities
- Support system level testing activities

Key Milestones

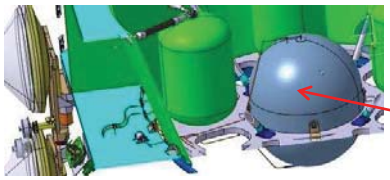
MLS	Date	Quantity
Kick Off	Sept ‘14	
PDR	Mar ‘15	
CDR	Sept ‘16	
QR	June ‘17	
STM	March ‘16	S/S Units
FM	Nov ‘17	S/S Integrated
Spare kit	Nov ‘17	

RCS characteristics

- RCS (Monopropellant)
  - Propellant: anhydrous hydrazine
  - Thrust BOL: 20N
  - Operating mode: blow-down
  - Thruster type: right angle
  - Propellant mass: 121,5 Kg
  - RCS Power ≤ 255 W (it is assumed simultaneous actuation of 7 thrusters as a worst case)



RCSThrusters

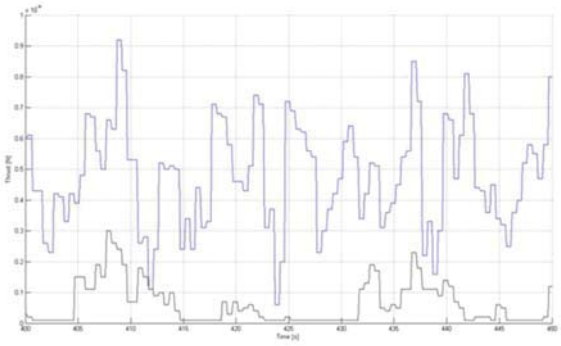


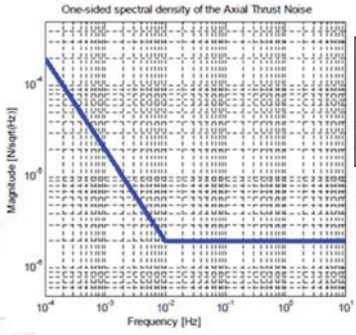
RCS hydrazine Tank

MPS characteristics

- MPS (Micropropulsion)
  - Min Thrust: 1 µN
  - Min Isp (@min thrust): 45s
  - Thrust resolution ≤ 1 µN.
  - Thrust range: 1 µN to 1000µN
  - Thrust Response Time: 0.3 sec (1 to 500 µN, 63% commanded value)
  - Continuous Ops: 60000hr
  - Thrusters activations: 3.78*10^8
  - Closed loop control
  - MPS Power ≤ 50 W

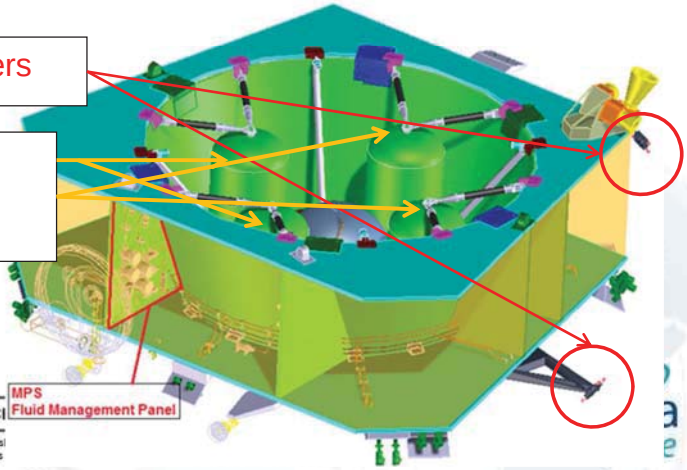
Typical Thrust profiles (lower thrust range)





MPS Thrusters

MPS tanks
65 kg of N2



Propulsion Model Philosophy

- Models to be delivered:
  - Structural and Thermal Model (STM)
  - Flight Model (FM or PFM)
  - Micropropulsion Assembly development model
    - composed by Microthruster(s), mass sensor, driving electronics, pressure gauge, pressure regulator and piping at least
    - not used at system level, but needed to verify the performances at S/S level to validate its design

PCDU

Abstract

Provides power conditioning/ regulation and power distribution to SVM and P/L

- Handling up to 2kW
- 28V Regulated bus
- MPPT (tbc)
- TM/TC I/F via 1553 RT and direct lines
- Distribution:
  - 60 LCL
  - 6 NED drivers
  - 130 Heater line drivers

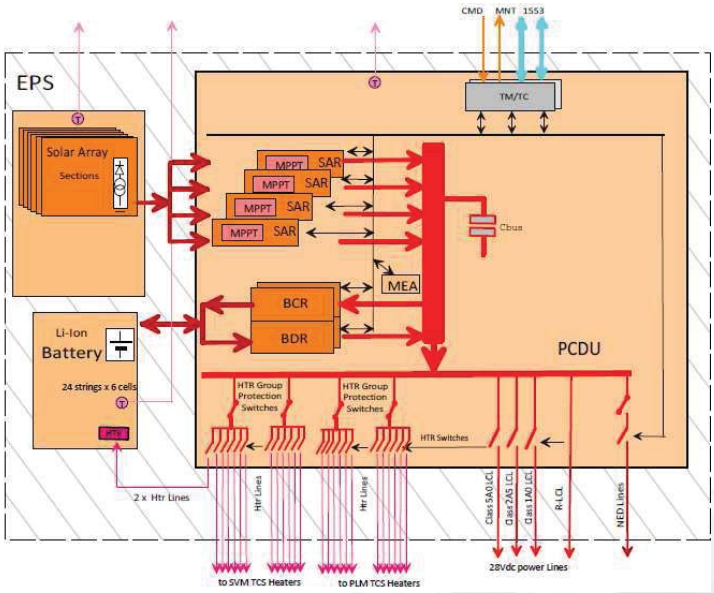
Very high stability (short term) required on power delivered to some heater line drivers

- 28V +/- 0.05% on some lines

Mass target = 32 kg max

Internal Power dissipation = 54W (excluding power conversion efficiency and serial losses) calculated at the unit inputs

Width: 500 W x350 D x 200 H mm (including mounting feet)



Main Tasks

- Definition and procurement of needed products and services
- Support at TAS-I for System AIT and verification during Power functional and performance verification

Key Milestones

MLS	Date	Quantity
Kick Off	Nov ‘14	
PDR	May ‘15	
CDR	Sep ‘16	
QR	Jun ‘17	
STM	Jan ‘16	1
E(Q)M	Jul ‘16	1
(P)FM	Oct ‘17	1
Spare	Oct ‘17	kit

Functions

- Supplies power to the Spacecraft prior to lift-off and during ascent
- Possible utilization to cover spacecraft power consumption peaks (i.e. Reaction Wheels)
- Used in case of attitude loss

Performances

- Li-ion cells
- Minimum Voltage 25.2V
- 800 Wh
- Max DoD = 70%
- Mass target = 8 kg max
- Width: 330 W x 200 D x 120 H mm (incl. mounting feet)

Main Tasks

- Definition and procurement of needed products and services
- Support at TAS-I for System AIT and verification during Power functional and performance verification

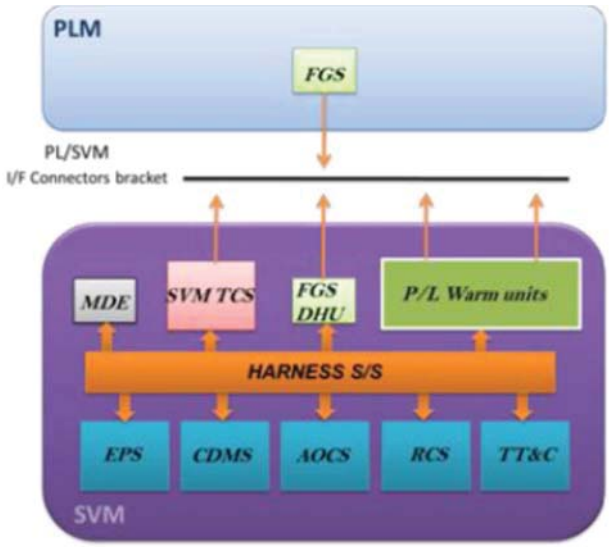
Key Milestones

MLS	Date	Quantity
Kick Off	Nov ‘14	
PDR	Apr ‘15	
CDR	Apr 16	
QR	Jun ‘17	
STM	Mar ‘16	1
E(Q)M	Jun ‘16	1
(P)FM	Apr ‘17	1
Spare	Apr ‘17	1

SVM Harness

Abstract

- Provides connection
  - between SVM units installed on SVM
  - to the PLM units till the PLM/SVM interconnecting Brackets
  - to the FGS located on the PLM
  - to the skin connectors
- It includes:
  - Wires, connectors, Contacts, Back Shells, Grounding Rails, Brackets and installation accessories



SVM Harness

Key Features:

- ~800 FM connectors (around 100 circular type)
- ~4000 FM wires (Several cables connecting SVM and PLM)
- Connecting units located on lateral panels (tiltable and dismountable) and up to SVM/PFM I/F connectors
- Target mass ~ 70 kg

Main Tasks

- Detailed routing definition based on constraints (stay in/out areas, EICD) defined by system configuration
- Manufacturing, installation and verification (on STM, AVM and FM) of needed products
- Selection of suppliers for lower level mechanical parts according to Best Practices.

Key Milestones

MLS	Date	Quantity
Kick Off	Sept ‘14	
PDR	Mar ‘15	
CDR	Jul ‘16	
QR	Apr ‘17	
STM	Mar ‘16	1
E(Q)M	Maj ‘16	1
PFM	Nov ‘17	1
Spare	Apr ‘17	kit

SVM Harness Model Philosophy

Models to be delivered:

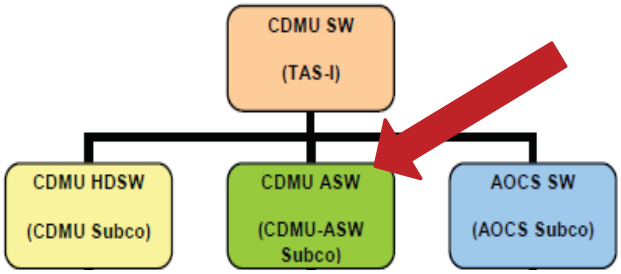
- Structural and Thermal Model (STM)
- Engineering Model (EM) installed on AVM
- Proto Flight Model (PFM) installed on FM
- Repairing kit for flight hardware

ASW

EUCLID Application Software (to be integrated in the CDMU HW) consists of:

- The **Operating System (OS)**
- **Basic Layer** that contains an Implementation of the Packet Utilisation Standard (PUS) services and general standard services and managers for data handling, equipments, FDIR, OBT, on board monitoring facility, Spacecraft Control Language (SCL) interpreter, On Board Control Procedure (OBCP) management, Mission Time Line (MTL) management etc…
- **Application Layer** that contains the user's software applications (System Safeguarding Logic, AOCS Management Framework, MMU Management, Thermal Control, Power Management, TT&C Management and Payload Management).

Abstract



ASW Activities

Main Tasks

- Production of Technical Specification
  - Software Specification
  - Architectural Design
- Implementation of ASW
  - Detail Design, Coding
  - Integration of ASW with the other OBSW components (HDSW and AOCS Application SW)
  - Verification vs TS on SVF
  - Validation vs RB on CDMU FUMO
- Provide OBSW stub to AOCS SW supplier.
- Support to AOCS SW Supplier for integrated OBSW verification.
- Support to TAS-I for integrated OBSW validation and System AIT

Phase	Specification		Design and Coding		Validation		Acceptance
Activities	RB specification	TS specification and Architecture	Design	Coding, Unit and Integration Tests	Validation vs TS	Validation vs RB	Acceptance
Reviews	RB SRR	SRR PDR	DDR		TS TRR CDR	RB TRR QR	AR

- This block of Activities and Reviews will be repeated for each SW version.
- Some of the reviews for certain SW versions, may be replaced by Check-Points, with reduced process formalism.

ASW Versions

MLS	Date	Description
Kick Off	October '14	
V0	April '16	• Operative System and ASW initialization • TM/TC handling and Busses data management versus all the Units on SVM, allowing integration and test on the AVM • PUS Services • Memory management read/ write mode to the EEPROM • Interfaces services needed for the defined AOCS SW V0 • MMU management interface with CFDP protocol • Instruments TM/TC Interface • Thermal control functionality • Power control functionality • TT&C control functionality • Preliminary Mission Timeline (MTL)
V1	Feb '17	The added functionalities are: • Complete System Mission Mode Control Management • FDIR control and autonomous logic for reconfiguration • Complete Instruments support functions and control Management • Final tuning on Thermal Power and TT&C • Complete MTL management • Complete OBCP management
V2	Feb. '18	Full functionality, fixing bugs, complete ASW to support final AOCS SW, allowing AOCS FDIR and redundancy management.

MGSE (1/5)

	MGSE Item	Acronyme	Quantity
INTEGRATION STANDS	Integration Support Stand	ISS	1
	Panels Support / Tilting Stand	PSS	8
	AVM SVM Support Stand	ASS	1
	SVM and S/C Tilting / Rotating Stand	TRS	1
ADAPTERS	Handling Lifting Adapter	HLA	1
	Spacecraft Handling Adapter Ring	SHA	1
	Handling Clamp Band	HCB	1
	Test Clamp Band	TCB	1
	Vibration Test Adapter	VTA	1
	Physical Properties Adapter	PPA	1
	Thermal Test Adapter	TTA	1
HOISTING / LIFTING DEVICES	SVM Multipurpose Panels Handling Device	SPHD	3
	SVM and S/C Vertical Lifting Device	VLD	1
	SVM and S/C Horizontal Lifting Device	HLD	1
ACCESS PLATFORMS	Mobile Access Platform	MAP	1
	Access Platform	AP	1
SHIPPING CONTAINERS	RF Panel Transport Container	RFTC	1
	Spacecraft Transport & Storage Container	S/C TSC	1
	Warm Unit Panel Transport Container	WUTC	1
	AVM SVM Wooden Shipping Container	ASSC	1
OTHER MGSE	SVM & Spacecraft Mass Dummy	SMD	1

Delivery date March 2016

MGSE (2/5)

Integration Support Stand (ISS)

It is the static support of the SVM and S/C structures (SVM + PLM) with “Z” axis in vertical.

Panels Support/Tilting Stand (PSS)

It support the Panels in the deployed configuration to allow unit integration and to tilt the single panel of 90°.

AVM SVM Support Stand (ASS)

It supports the AVM SVM during integration activities with panels fully deployed.

SVM and S/C Tilting/Rotating Stand (TRS)

It will be used to tilt and rotate the SVM and the complete Spacecraft.

Handling Lifting Adapter (HLA)

It is the interface device between:

- the SVM or the S/C (constrained to the SHA interface flange via the HCB/TCB)
- the PLM (constrained to the PHA interface flange via the HCB/TCB)

and the ISS or the TRS.

Spacecraft Handling Adapter Ring (SHA)

It is the device connected to the SVM base or to the S/C base via the HCB/TCB which interfaces to the ISS and to the TRS.

MGSE (3/5)

Handling Clamp Band (HCB) / Test Clamp Band (TCB)

It is a constraining belt reproducing the Launcher Clamp Band foreseen to constrain the SVM and the S/C separation flange to the SHA for the handling , integration and test activities.

Vibration Test Adapter (VTA)

It is the interface flange between the S/C and the vibration system.

Physical Properties Adapter (PPA)

It is the interface flange between the S/C and the Physical Properties test facility.

Thermal Test Adapter (TTA)

It is the interface flange between the S/C and the TB/TV interface chamber.

SVM Multipurpose Panels Handling Device (SPHD)

It should perform all the operations needed to hoist, transfer and prepare the single items.

SVM and S/C Vertical Lifting Device (VLD)

It shall allow the lifting/hoisting operation of the SVM Module and of the S/C with the “Z” axis in vertical position.

SVM and S/C Horizontal Lifting Device (HLD)

It shall allow the lifting/hoisting operation of the SVM Module and of the S/C, through the HLA interface, with the “Z” axis in horizontal position.

MGSE (4/5)

Mobile Access Platform (MAP)

It will be used to allow flexible, easy and stable access to the SVM/PLM and F/H in various configurations during assembly, integration and tests. It could be a commercial item.

Access Platform (AP)

It is a stand placed around the spacecraft or main sub-assembly to allow easy and stable access to the STM and/or PFM when installed on ISS during assembly, integration and tests.

RF Panel Transport Container (RFTC)

It shall provide a proper support and a controlled environment for the transport and storage of the relevant pre-integrated panels.

Spacecraft Transport & Storage Container (S/C TSC)

It shall provide a proper support and a controlled and conditioned environment for the transport and storage of the PLM, SVM and complete S/C.

Warm Unit Panel Transport Container (WUTC)

It shall provide a proper support and a controlled environment for the transport and storage of the Warm Unit Panel.

SVM & Spacecraft Mass dummy (SMD)

It is necessary for the re-certification of the complete set of mechanical MGSE.
It will simulate the geometry and mass (factorized at the foreseen re-certification value) of the SVM and S/C.

MGSE (5/5)

Equipment mass dummies

In addition a set of equipment mechanical and thermal dummies are necessary to simulate units during system STM test campaign. They shall typically be representtaive of mechnical properties (mass, cog, moi, 1st resonance frequency) and thermal properties (dissipation, alfa, epsilon)

EGSE Contents (1/4)

EGSE List and Functions Items description

EGSE	Qty	Delivery date for AVM (TBC)	Delivery date for PFM (TBC)
CCS		**18/01/2016**	**25/10/2016**
CCS	**4**		
CCS Lite	**2**		
POWER SCOE		**22/01/2016**	**28/11/2016**
SAS	**2**		
Launch Power Supply	**2+1**		
Umbilical	**2**		
Bat SIM	**2**		
Battery Conditioning Equipment (BCE)	**2**		
CDMU and TM/TC SCOE		**21/03/2016**	**21/12/2016**
TM_TC FE	**2+1**		
CDMU SCOE	**2**		
Bus Monitors (MIL Bus 1553/SPACEWIRE)	**2**		
CDMU DFE (Per PLM EGSE)	**4**		
TM/TC Amplifier (for Launch Campaign)	**1**		
S/C I/F Simulator (for Launch Campaign)	**1**		
OBSW Loader	**2**		
TT&C SCOE	**2**	**02/02/2016**	**07/12/2016**
PLM EGSE		**06/06/2016**	
PLM SCOE (only Power Functions)	**2**		
Simplified PLM SCOE (VIS)	**1**		
Simplified PLM SCOE (NISP)	**1**		
RF SUITCASE	**1**	**end 2018**	

EGSE (2/4)

CCS EGSE

- The CCS (Central Checkout System) is the central control system of the overall EGSE: it will be used to support electrical, functional, performance and environmental tests during all the duration of the EUCLID project ground activities.
- Compatible with SCOS-2000.

POWER SCOE

- The POWER SCOE shall be able to provide the required electrical power simulating the real Battery, the Solar Array behavior, Main Bus Voltage Monitoring, Launch Power Supply and Battery Charge/discharge

TT&C SCOE

- The tasks of the TT&C SCOE is to communicate with the on-board TT&C (Telemetry, Tracking and Command) Subsystem via the nominal RF-Link (X and K band).

RF SUITCASE

- The purpose of the RF suitcase is to demonstrate in advance of the Euclid launch, the RF compatibility in terms of communication interfaces between the Spacecraft (TT&C subsystem and relevant parts of the avionics) and the selected Ground Station.
- The RF suitcase shall also support the verification of the overall link performance (BER, frame loss probability) including the relevant elements of the on-board subsystem and the ground station.

EGSE (3/4)

CDMU and TM/TC SCOE

- CDMU SCOE

  The CDMU SCOE will be used in every moment during Tests if it is required to exercise the Bus Acquisition and Monitoring capabilities.

  The CDMU SCOE shall be composed of the following main functional blocks:
  - Simulation of the missing Units (Experiments) over 1553 Bus
  - Simulation of the missing Units (Experiments) over Space-wire Bus
  - Simulation of other missing Units (Remote Terminals)
  - 1553 Bus Acquisition and Monitoring
  - Space-wire Bus Acquisition and Monitoring
  - 1553 Bus Controller Module for PCDU direct commanding and monitoring.
- TM/TC DFE

  The TM/TC DFE will be used in all EGSE configurations during all over the EUCLID test campaign, both during AVM, PFM Service Modules, and System activities, including Environmental testing and Launch Campaign.

EGSE (4/4)

Additional EGSE procured as part of other ITT packages

AOCS SCOE [procured with AOCS ITT]

PLM SCOE

EGSE provided to the PLM is foreseen composed by the following items:

- Central Checkout Equipment (CCS) [procured with S/C CCS]
- Power Supply [procured with Power SCOE]
- CDMU DFE [procured with CDMU SCOE]

EGSE provided to the Instruments will be a simplified version of the above items.

ITTs for System support activities

- Foreseen during Phase C/D and requires personnel on site (Turin)
- Typically (a) analytical work in support of system design verification, (b) AIT support
- Already identified activities are
  - Radiation Analysis based on FASTRAD tool to
    - support spacecraft lay-out optimisation
    - Tolerance of selected unit component to the radiation environment
    - Identify criticality vs. SEU tolerance
  - AIT test operators support (thermomechanical / functional)
- Other specific support tasks will be identified during Phase B

Euclid EEE components procurement approach

- Use of CPPA service is offered and recommended to equipment manufacturers
  - in line with standard practices for ESA science projects
  - as a cost saving measure for EEE part procurement due to lower Non-Recurring costs
- CPPA (Co-ordinated Parts Procurement Agent) will be selected by TAS-I and ESA with dedicated ITT
- The objective of the CPPA is to meet quality, cost and schedule requirements of the project via standardization and common procurement of Flight model EEE parts
- ESA, TAS-I and CPPA will organize periodic Parts Review Boards (EUC-PCB) for review and approval of FM EEE parts

CPPA tasks

CPPA will be in charge of the following activities for co-ordinated procured components:

- **Support of experienced Parts Engineer** for components selection/evaluation
- **Euclid Preferred Part List** will be issued by CPPA as baseline for parts selection
- **PAD** preparation and submission for approval to EUC-PCB
- **Testing and RVT plan preparation and follow-up** (with input from final User)
- Management of **Purchase orders** to manufacturers
- **Export licence submission**
- **Pre-cap, DPA, buy-off, incoming inspection**

CPPA schedule control

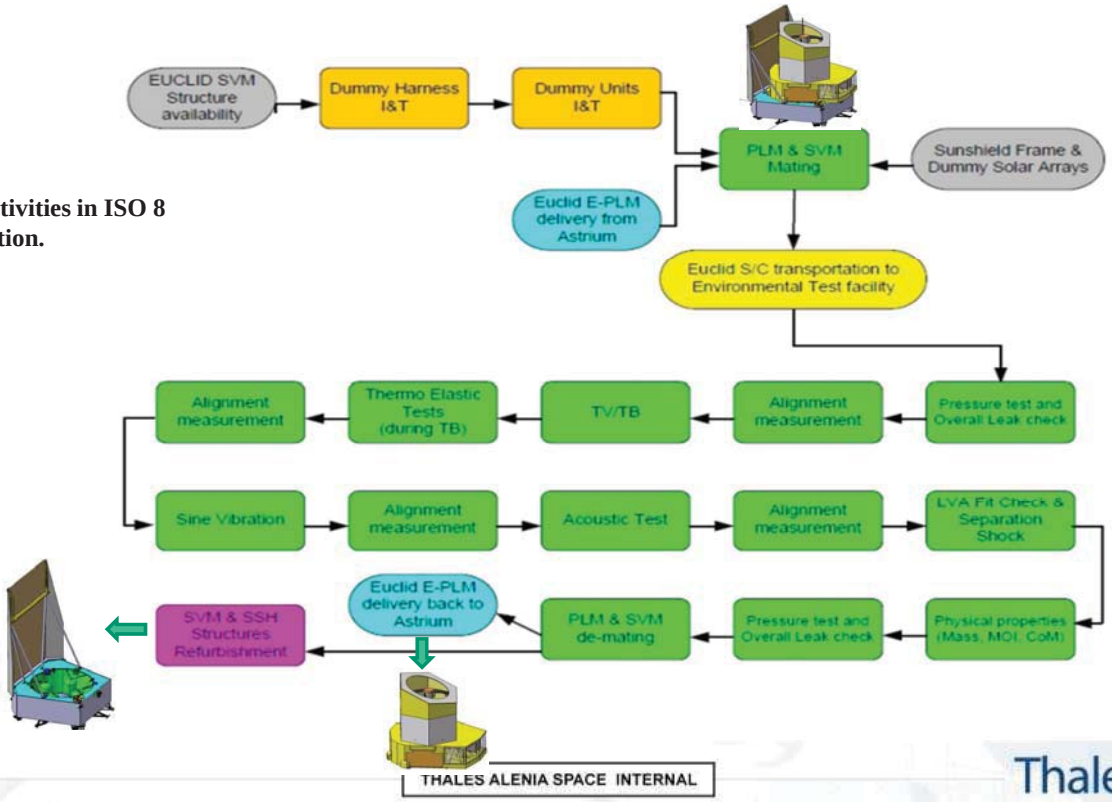
- **Users** will identify reliable **need dates** for parts
- **CPPA** will establish **Cut-off dates** for orders
- **Early cut-off date** will be defined for **LLI and critical items**
- **Advanced procurement** of LLI and critical items can be authorized
- CPPA will **monitor delivery dates** from all manufactures

ISVV

ISVV Main Tasks		
Verification	Requirements	**The following verifications will be performed on requirements:** • **Completeness** • **Correctness** • **Testability**
	Design	**The following verifications will be performed on the software design:** • **Adequacy and conformance to requirements (functional, I/F, performance)** • **Feasibility** • **Maintenance**
	Code	**The following verifications will be performed on software code:** • **Completeness** • **Correctness** • **Consistency** • **Code Metrics Analysis** • **Compliance to Coding Standards**
Validation		**The validation activities will be focused on the following aspects:** • **Identification of unstable components/functionalities** • **Error handling** • **Compliance to Software Requirements** • **Review of black box testing** • **Review of white box testing**

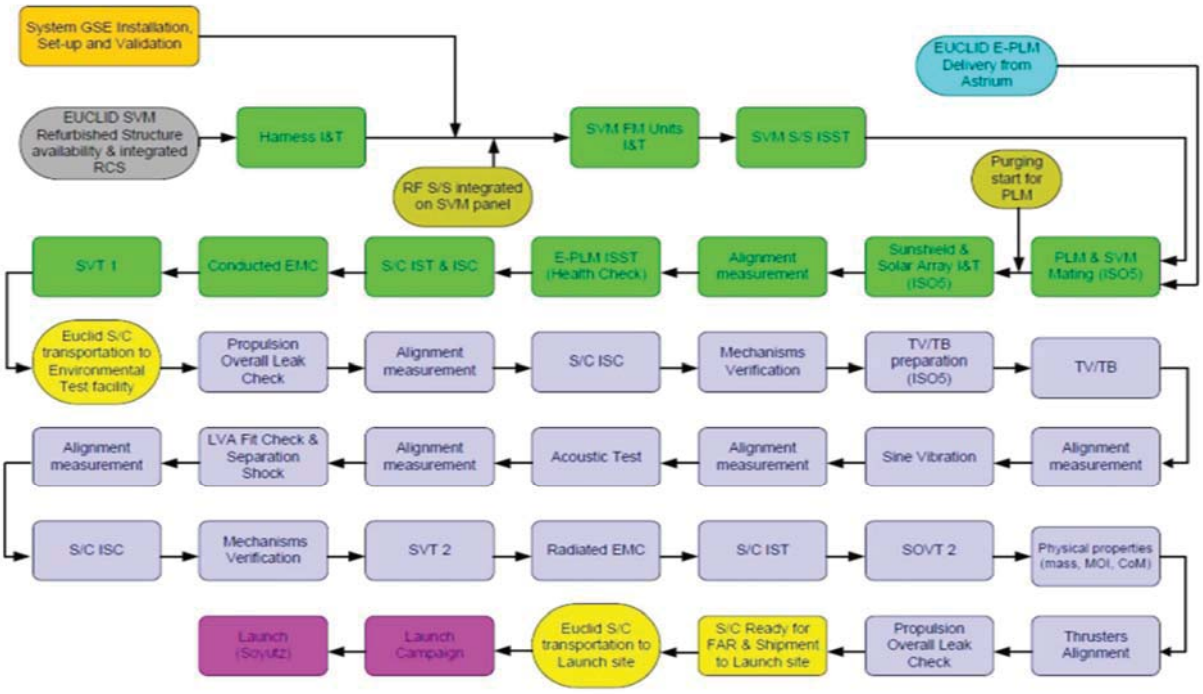
- Critical SW will be submitted to ISVV.
- ISVV activities will be performed by an independent Contractor (not involved in the software development process) under direct control of the Prime,
- Scope of ISVV is to assess both the processes and the resulting products.

STM Environment Test Campaign : 7 months in 2017



All activities in ISO 8 condition.

PFM Environment Test Campaign : 9 months in 2018-2019



All activities at Test Facility in ISO 8 condition except for System TB/TV preparatio where ISO 5 is required.