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 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 Contractor is responsible for the development, procurement, manufacturing, assembly, integration, test, verification and timely delivery of a fully integrated Payload Module and related items capable of accommodating the delivered Instruments and fulfilling the mission objectives.

3. The Industry Day

Following the Invitation To Tender (ITT) released by the European Space Agency (ESA) in July 2012, Astrium SAS has been selected as Contractor of the Payload Module for the Implementation phase (B2/C/D/E1).

Therefore, Astrium SAS has been authorized to proceed with the competitive procurement process in order to build up the remainder of the PLM industrial team in a time period from Q2 2013 to Q2 2014 for PLM related items. This tendering process will be governed by ESA rules reported in the “Best practices for the selection of subcontractors by Prime Contractors in the frame of ESA’s major procurements” document (available on EMITS, address http://emits.esa.int/ under “Reference Documentation” and “Administrative Documents”).

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

9:30 – Plenary Session - Noordwijk Space Expo Ariane-Room
a) Introduction: objectives & organization of the Euclid PLM Industry Day (ESA)
b) The Euclid mission (ESA)
c) The Euclid System and Space segment (ESA)
d) The Euclid programatics (ESA)
e) The Euclid Space segment procurement approach: PLM First, then Prime (ESA)
f) The GEO return constraints for PLM and then Prime (ESA)
g) Procurement rules (Best practices, ESA and Industry roles) (ESA)
h) ECOS (ESA)

10:15
a) The Euclid PLM overall design (Astrium)
b) The Euclid product tree and constituents (Astrium)
c) The Euclid development logic: Models and objectives & schedule (Astrium)
d) The ITT Process (according to Best Practices) (Astrium)
e) List and dates of the future ITT’s (Astrium)

10:45
a) Presentation of each ITT (description and key-requirements, particular points, model philosophy, schedule)

12:00 Lunch

13:30 Splinter meetings
1. Mechanical ITT’s - Noordwijk Space Expo Ariane-Room
a) External baffle
b) Struts
c) Supports & radiators
d) Internal baffles & shielding & ISM
e) M2 mechanism

2. Support activities – Noordwijk Space Expo Astronaut-Room
a) Project office support
b) Product assurance support
c) Mech/Opt AIT ops
d) Thermal analyses
e) AIT SW & EGSE bench operations

3. Other ITT’s – ESTEC – ESCAPE Dance Room
a) EEE parts
b) MLI
c) Harness
d) Handling & adaptors
e) AC flat mirror, Collimator, Mirrors, dichroic plate

16:15: end of the splinter meetings
16:30: wrap-up with ESA
17:00 departure
Euclid: a mission to map the Dark Universe

The implementation Phase

Payload Module
Industry Day

Noordwijk, 17 April 2013

Giuseppe Racca
Outline of the presentation

1. Euclid Science Objectives
2. Euclid Mission Overview
3. Euclid Product trees
4. The Euclid programmatics
5. The Euclid Space segment procurement approach
6. The GEO return constraints for PLM and then Prime
7. Procurement rules (Best practices, ESA and Industry roles)
• 1st: What Is the Universe Made Of?

• 2nd: What Is the Biological Basis of Consciousness?
• 3rd: Why Do Humans Have So Few Genes?
• 4th: To What Extent Are Genetic Variation and Personal Health Linked?
• 5th: Can the Laws of Physics Be Unified?
Theme 4 question:

How did the Universe originate and what is it made of?

- Investigate the nature and origin of the Dark Energy that is accelerating the expansion of the Universe
The universe is governed by its geometrical properties and by the stuff that it contains (Einstein’s General Relativity, but also classical physics);

Basic physics (Friedman equation) says that if universe is flat, the density of “stuff” in the universe must be $\rho_c$ which is today $\sim 10^{-26}$ kg/m$^3$;

Observations of MBR shows that Universe is indeed flat. Planck showed very well:

But ordinary matter (people, stars, dust, planets, etc.) can only be about 5% of $\rho_c$

Evidence of dark matter (only interacting gravitationally) from galaxy rotation curve can be $< 35\%$ of $\rho_c$

Observations of SN 1a (2011 Nobel Prize) shows that the Universe is expanding in an accelerated fashion. We need a new component (cosmological constant) exerting a negative pressure of a density of about 70% of $\rho_c$
The Cosmology Standard Model: $\Lambda$CDM

Komatsu et al. 2011 (WMAP7+LSS+SNe):

- $H_0 = 68.5 \pm 2.0$ km/s/Mpc
- $\Omega_m = 0.282 \pm 0.016$
- $\Omega_b = 0.048 \pm 0.0028$
- $\Omega_{\Lambda} = 0.723 \pm 0.016$
- $\Omega_r = 0.000086$ (photons + 3 massless neutrinos)
- $0.99 < \Omega_{\text{tot}} < 1.02$ (2 sigma)
The latest news from Planck

Before Planck
- Dark Matter: 22.7%
- Ordinary Matter: 4.5%
- Dark Energy: 72.8%

After Planck
- Dark Matter: 26.8%
- Ordinary Matter: 4.9%
- Dark Energy: 68.3%
Euclid Science Objectives Summary

<table>
<thead>
<tr>
<th>Issue</th>
<th>Euclid’s Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is Dark Energy</td>
<td><strong>Measure the Dark Energy equation of state parameters</strong> $w_p$ and $w_a$ to a precision of 2% and 10%, respectively, using both expansion history and structure growth.</td>
</tr>
<tr>
<td>Beyond Einstein’s Gravity</td>
<td><strong>Distinguish General Relativity from modified-gravity theories</strong>, by measuring the galaxy clustering growth factor exponent $\gamma$ with a precision of 2%.</td>
</tr>
<tr>
<td>The nature of dark matter</td>
<td><strong>Test the Cold Dark Matter paradigm</strong> for structure formation, and measure the sum of the neutrino masses to a precision better than 0.04eV when combined with Planck.</td>
</tr>
<tr>
<td>The seeds of cosmic structure</td>
<td><strong>Improve by a factor of 20 the determination of the initial condition parameters</strong> compared to Planck alone. $n$ (spectral index), $\sigma_8$ (power spectrum amplitude), $f_{NL}$ (non-gaussianity)</td>
</tr>
</tbody>
</table>
Concept and Requirements

- Optimize the mission for **galaxy clustering** and **weak lensing** two complementary dark energy probes
- Minimum survey area of 15,000 deg$^2$ (40% of all) → 6 year nominal mission

**Weak Lensing**: → **VIS imager + NIR photometer**
- Shapes and shear of galaxies with a density of >30 galaxies/arcmin$^2$.
- Very high image quality, high stability
- Minimum Systematics $\sigma_{\text{sys}} < 10^{-7}$
- Redshift accuracy $dz/z \sim 0.04$, down to $z \sim 2$

**Galaxy clustering**: → **NIR slitless spectrometer**
- Redshifts for >3500 galaxies/deg$^2$
- Redshift range $0.7 < z < 2.05$
- Redshift accuracy $dz/z < 0.001$ in same volume as WL
- ….Line Flux limit $< 3 \times 10^{-16}$ erg cm$^{-2}$s$^{-1}$
1. Primordial acoustic peaks are imprinted in the distribution of matter when light and matter decoupled (CMB);
2. Provides an independent length scale of the universe expansion (Hubble parameter);
3. Structure follows the expansion of the Universe caused by Gravity
The intervening dark matter “lenses” the light from distant galaxies.
1. The weak distortion is simply a (very small) change in ellipticity of a galaxy.

**Dark Matter**

**WL reveals the geometry using the dark matter:**
- Measure shapes of galaxies over a large volume
- Obtain the shear power spectrum for a given redshift bin
- Determine the changes of the power spectrum as a function of redshift
- Determine also the growth factor $\gamma$
Outline of the presentation

1. Euclid Science Objectives
2. Euclid Mission Overview
3. Euclid Product trees
4. The Euclid programmatic
5. The Euclid Space segment procurement approach
6. The GEO return constraints for PLM and then Prime
7. Procurement rules (Best practices, ESA and Industry roles)
Euclid mission overview (1/8)

- Euclid is fundamentally a telescope taking pictures and spectra of galaxies for a large part of the extragalactic sky. Quality of images requires a high pointing stability and extreme telescope quality.
- Euclid is launched from Kourou with Soyuz and injected directly to a trajectory leading it to an orbit revolving around L2. The propulsion system is used to make small corrections.
- Once in L2, the spacecraft performs rotations in steps and taking pictures at every step to have a complete coverage of the sky. The spacecraft rotates fundamentally on a plane perpendicular to the sun direction.
- As the earth revolve around the sun, the rotation plan of Euclid rotates and allow...
Quick view of the spacecraft

- Spacecraft is designed to shadow the telescope assembly, PLM, from the sun and maintain it at low temperature.
- The sunshield is set of large panels creating the required shadow, and upon which the solar array is mounted.
- A structure on the bottom of the spacecraft, the SVM, host the compartments where all the electronics and the propulsion system are hosted.
- Protruding outside the SVM are the antennas and the thrusters for navigation, station keeping and attitude control.
- Euclid is equipped with chemical propulsion for high force manoeuvres, and cold gas propulsion.
The Euclid payload module consists of:

- Optical configuration: 3-mirrors anastigmatic Korsch
- Field of view: $0.763 \times 0.709 \text{ deg}^2$, 0.45deg off-axis
- Free aperture: 1.2 m$^2$
- WFS (or directly VIS CCD) and M2 mechanism for calibration
- Optical quality: WFE $\leq 70\text{nm rms}$ (NISP channel)
- Common bench for telescope and instruments, interface to SVM
- Silicon Carbide SiC-100 technologies
- Dichroic at the exit pupil transmit IR light to NISP and reflects visible light to VIS
- A visible imager (VIS)
- A near-IR instrument (NISP)
1. The spacecraft design is decomposed into subsystems. Each subsystem is designed and procured by a subcontractor selected by the Prime contractor following the established procurement rules. The ITT proposed the following:

- **PLM subcontractor**
  - Design/Verification
  - AIT
  - Procurement
    - Mirrors
    - Structure
    - Mechanism
    - Thermal HW
    - Harness

- **Reaction Control subcontractor**
  - Design
  - Procurement
    - Chemical Propulsion Elements
    - Cold Gas Propulsion Elements

- **Structure & Thermal subcontractor**
  - Design and Verification
  - Procurement
    - Structure
    - Sun-Shield

- **Avionics subcontractor**
  - Design and Verification
  - Procurement
    - On-Board Computer
    - Mass Memory
    - Transponders X/K
    - Antennas
    - Antenna Pointing

- **AOCS subcontractor**
  - Design and Verification
  - Procurement
    - Gyros
    - AST
    - Reaction Wheel
    - Fine Guidance Sensor
    - Sun Sensors

- **ISVV subcontractor**
- **Software subcontractor**
  - Design and Verification

- **Power subcontractor**
  - Design and Verification
  - Procurement
    - PCDU
    - Battery
    - Harness
    - PVAs

- **System AIT Contractor**
  - STM AIT
  - AVM AIT
  - FM AIT
  - Procurement
    - GSE
    - Simulators
1. Mission Operation Centre (MOC)
   a. at ESOC (Darmstadt, Germany)

2. Science Operation Centre (SOC)
   a. at ESAC (Villafranca, Spain)

3. Science Data Centres (SDC’s)
   a. 9 Location in Member States
      Final product ~ 30 Petabytes (incl. ext. obs.)

4. Ground Stations:
   a. Cebreros and Malargue antennas
   b. Daily science communication:
      ~ 850 Gbits in K band (26 GHz)
   a. Command and control in X band
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2. Euclid Mission Overview

3. Euclid Product trees

4. The Euclid programmatic

5. The Euclid Space segment procurement approach

6. The GEO return constraints for PLM and then Prime

7. Procurement rules (Best practices, ESA and Industry roles)
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### Euclid Industrial Schedule

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**SVM**
- KO Implement. Phase: Jul 13
- Subsystems Selection: Jul 14
- Equipment Selection: Aug 14
- Equipment Manufacturing: Mar 18
- Equipment Delivery: Feb 16

**PLM**
- KO Implement. Phase: Dec 3
- Equipment Selection: Mar 14
- Equipment Manufacturing: Mar 16
- FM Assembly: Mar 17
- QR: Jul 18
- SVT: Jun 18
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Euclid Procurement approach

- 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), to be released in July 2012 and placed during the fourth quarter 2012;
  - second a procurement action covering the Euclid Spacecraft and Prime contractor activities, including the Service Module (SVM), to be released during the fourth quarter 2012.
  - This second procurement will eventually subsume the PLM contract, by contract novation;
  - The plan is present a Contract Proposal to June IPC for the full Prime Contract (incl. SVM and subsumed PLM)
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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 =>

<table>
<thead>
<tr>
<th>Member State</th>
<th>Geo-return requirements for Euclid</th>
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<tbody>
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<td>Austria</td>
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<tr>
<td><strong>Total</strong></td>
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1. Best Practice “For the Selection of Subcontractors by Prime Contractors in the frame of ESA's Major Procurements” as approved by the IPC (ESA/IPC(2012)65,rev.2) during its 273th meeting held on 27-28 Sep 2012;

2. Industrial Procurement Plan (IPP) is approved by ESA and made public;

3. ESA reviews the ITT/RFQ's documentation prepared by the Contractor [], to ensure its "impartiality" in term of guaranteeing [] a fair competition;

4. ESA approves the ITT/RFQ’s and authorise the Contractor to issue ITT/RFQ’s;

5. If the Contractor is also a sub-contractor tenderer, the Contractor is involved in the evaluation, but the Chairperson of the TEB is an ESA’s staff and no proceedings of the TEB may take place in the absence of the Chairperson;

6. The TEB report is submitted for decision to a Joint Procurement Board (JPB) composed by the ESA and Contractor’s PM’s, CO’s, PC’s and experts;

7. For competitive tenders, the JPB submit the decision to a Senior Procurement Board (SPB) chaired by ESA head of science projects department;

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

ESA UNCLASSIFIED – For Official Use
ECOS - Building the PT/WBS with Support Functions
## ECOS - The Payment Plan Data Entry

### Payment Plan

<table>
<thead>
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<th>Date</th>
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**Expenditures vs Payment**

- **Current Total:** 1,948,000
- **Reference Total:** 1,565,500
- **NC:** 0

### Security

- **Rates and Overheads:** Exposed
- **Password:**

**Exposed Rates and Overheads will be visible to those who open the Tender Answer.**

The password to load and open the Tender Answer must be alphanumeric set of 6-20 characters.

**Tender Number:** ECOS Administrator

**File Name:** C:\Users\Kev\Documents\ECOS5\BDD\TEN
ECOS - A global view over the price

PLEASE SEND YOUR TENDER NOT LATER THAN 15TH FEBRUARY

Expenditures vs Payments

Granularity

Price Type | Price (EUR) | Geographical Req. Country
--- | --- | ---
Total incl. Escalation and Co-Funding | 1,948,000 | 1,948,000
Firm Fixed price | 473,000 | 473,000

ESC: 20%
Max: 80%
<table>
<thead>
<tr>
<th>Advanced features</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Price rounding</td>
<td>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</td>
</tr>
<tr>
<td>Time shifting</td>
<td>To recalculate instantly expenses profiles and escalation in FFP for the block of activities concerned (totality of the scope or only a WBS branch)</td>
</tr>
<tr>
<td>Fully supported yearly variable rates</td>
<td>To automatically calculate yearly amounts when variable yearly rates apply to some resources categories, overheads or profit rates. <strong>Recalculations in case of time shifting are instantaneous</strong></td>
</tr>
<tr>
<td>User WP numbering</td>
<td>The User can define his own WP numbering system and visualize WP list summaries and produce all WP-related reports sorted by User numbers</td>
</tr>
<tr>
<td>Product Libraries</td>
<td>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. Enables 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</td>
</tr>
<tr>
<td>Travel Libraries</td>
<td>All elementary records of price per trip/daily subsistence at your finger tip. Excel Imports (from finance department for instance) allowed</td>
</tr>
<tr>
<td>Import/Export dates</td>
<td>Allow Import/Export to/from any planning tool (Excel based)</td>
</tr>
<tr>
<td>Import/Export data</td>
<td>Allows Import/Export to/from any ERP system (CSV based)</td>
</tr>
<tr>
<td>Colour settings</td>
<td>The User can define his set of colours for various modes (Maintenance/Data Entry/Tender). Useful and agreeable</td>
</tr>
</tbody>
</table>
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:
Euclid Payload Module

PLM Industrial Day
Noordwijk Space Expo
May, 17th, 2013
Contents

- The Euclid PLM
  - Overall design
  - The PLM product tree and constituents
  - The Euclid development logic: Models and objectives & schedule

- The build-up of the PLM industrial team
  - the ITT Process (according to Best Practices)
  - List and dates of the future ITT’s

- Presentation of each ITT
  - Scope, key-requirements, particular points, model philosophy, schedule
Image Quality Performance

- **VIS Performances**

- **NISP Performances**

- The Criteria of Image Quality are linked to the Point Spread Function and its stability.
PLM Euclid main requirements

- A stable large Euclid telescope
  - Korsch on axis 1,2 m optical configuration

- Sharp and demanding astronomy image quality
  - Shape and stability of the Spread Function (VIS)
  - Encircled Energy (NISP)

- It is a cold telescope that includes
  - 2 instruments VIS et NISP at cryogenic temperature (150 K et 95 K)
  - AOCS sensors for pointing
  - One dichroic to split the VIS et NISP channels
  - Efficient thermal design to achieve few mK stability

- The Spacecraft is
  - Located at Lagragian L2 point for a 6 year life time
  - Launch on Soyuz

- The program requires mature technology : TRL > 5
PLM overview
Functional architecture & constituents

Telescope Assembly

- PLM
  - Thermal control
  - M1+M2
  - FM1 & FM2 folding mirrors
  - M3
  - Dichroic
  - Mechanism

- VIS optical path
- NISP optical path
- FGS optical path
- Science data
- FGS data
- Control signals

- FM3 folding mirror
- Shutter
  (VI-RSU)
- Filter & grism wheels
  (NI-FWA & NI-GWA)
- Optics (NI-OA)
- Detection system
  (NI-DS)
- Calibration
  (NI-CU)

- Detector plane
  (VI-FPA-DP)
- Electronics
  (VI-FPA-ES)
- Calibration
  (VI-CU)

- Proximity electronics

- SVM
  - MDE
  - WPU
  - VI-CDPU
  - VI-PMCU
  - NI-DCU
  - NI-DPU
  - NI-ICU
  - NI-CMU

- VPU
- VI-FPA-DP

- NISP
  (PLM units)
  - SVM
  - NISP
  (SVM units)

- SVM resources

- VI-PMCU
- VI-PMCU

- VI-CU
  (calibration unit)
- FM3
  (lowpass filter)
- VPU
  (readout shutter unit)
- VI-FPA
  (telescope exit pupil)

- VI-CU
- Autotests
- VPU
- VI-FPA
  (readout shutter unit)

All the space you need
A silicon-carbide telescope

- A single homogeneous and isotropic material for mirrors and stable structures
  - Idem Astrium cameras
  - Idem Gaia

- Advantages
  - Outstanding thermo-elastic behaviour
  - Excellent stiffness
  - Process qualified for cold environment
  - Immune to radiations
  - No moisture release

  - Euclid will be the 10th Korsch telescope designed and aligned by Astrium
A cold telescope

- A cold and passive thermal control

- Advantages
  - Invisible for NISP wavelengths
  - NISP detectors at~ 89 K OK
  - Simplified instrument thermal control
  - 100% margin of radiative areas possible
  - Outstanding thermal regulation ~10 mK
  - Better reliability,
  - Low dissipation
PLM Structural & Thermal Model

- **Objectives**
  - Qualification of the PLM structure
  - The STM PLM is then integrated inside the STM Spacecraft
  - It shall withstand Spacecraft Mechanical & Thermal test sequence
  - It will be used for mechanical & Thermal model correlation & validation
  - It will be used to retrieve mechanical loads at instrument interfaces and PLM equipment interfaces
  - Most structural and thermal equipment used as spare FM

- **Test sequence**

![Diagram showing the test sequence process involving PLM STM integration, VIBRATIONS & ACOUSTIC TESTS, SATELLITE VIBRATIONS & ACOUSTIC TESTS, SATELLITE THERMAL VACUUM TEST, and delivery to Prime and PLM return to Astrium.](diagram.png)
PLM Avionic Model

- Objectives
  - Verification of electrical design
  - Verification of electrical & software interfaces
  - Verification of the instruments electrical compatibility in integrated environment
  - Verification of the FGS functionality & related electrical interfaces
  - Validation of the test procedures, data base and related test applications
  - Interfaces with the EGSE bench provided by the SC Prime

- Test sequence

```
PLM AVM integration

MDE EQM

Instruments EM units

FGS EM units

PLM EMC & FUNCTIONAL TESTS

VIS FPA / FGS autocompatibility
Conducted Emission & Susceptibility
Functional tests
Database validation

Delivery to Prime
```
PLM Flight Model

- Objectives
  - Submitted to Proto-flight programme
  - Will perform the end to end performance test under vacuum
  - Suitable for launch and flight operations

- Test sequence

  Telescope Assembly FM integration → TELESInsp ANBENT FUNCTIONAL TESTS → PLM FM integration
  
  Optical performances at ambient ±1 g test (WFE)

  PLM EMC & FUNCTIONAL TESTS → PLM SINE & ACOUSTIC TESTS → PLM THERMAL VACUUM TEST → Delivery to Prime

  PLM mechanical proto-qualification
  PLM control validation
  Optical tests in Thermal Vacuum
  Correlation of thermal model
  Correlation of thermal model
  Flight temperatures prediction
  End-to-end system performance
PLM Phase B2, CD schedule
Industrial team build-up

- Geo return constraints applicable to the PLM contract:
  - Geo return: non-Big4 countries (F, G, UK et I) ≥ 40%

- During proposal phase a large « sourcing » effort:
  - 119 RFP/RFIs submitted towards the European industry
  - All subcontractor proposals have been analysed and submitted in our proposal to ESA
  - Consolidation of requirements, schedule and cost

- Now in phase B2, selection of the industrial team:
  - Via competitive Best Practices processes
  - In the course of phase B2 and early phase CD
## SubContracted Items

<table>
<thead>
<tr>
<th>Nature of activity</th>
<th>Items to be Subcontracted</th>
<th>ITT release</th>
<th>Price Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Office support</td>
<td>Schedule, Documentation &amp; Configuration control</td>
<td>Dec 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>Product Assurance support</td>
<td>Assurance Quality &amp; RAMS</td>
<td>Dec 2013</td>
<td>200-500 K€</td>
</tr>
<tr>
<td>Engineering support</td>
<td>Thermal analyses &amp; engineering support during TVAC test</td>
<td>Dec 2013</td>
<td>200-500 K€</td>
</tr>
<tr>
<td>AIT support</td>
<td>AIT SW &amp; EGSE bench operations</td>
<td>Oct 2015</td>
<td>200-500 K€</td>
</tr>
<tr>
<td></td>
<td>Mechanical / Optical AIT operations</td>
<td>1 T 2014</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>Optical equipment</td>
<td>Mirrors polishing &amp; coating</td>
<td>June 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td></td>
<td>Dichroic plate</td>
<td>April 2013</td>
<td>200-500 K€</td>
</tr>
<tr>
<td>Mechanical equipt</td>
<td>External baffle</td>
<td>Sept 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>Mechanism with electronics</td>
<td>M2 Mechanism subsystem</td>
<td>June 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>Non ceramic Mechanical structures</td>
<td>Struts</td>
<td>Sept 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td></td>
<td>Supports &amp; radiators</td>
<td>Oct 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td></td>
<td>Internal baffles &amp; shielding &amp; Isostatic Mounts</td>
<td>Nov 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>Thermal hardware</td>
<td>MLI &amp; SLJ, &amp; conductive straps</td>
<td>Mars 2014</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td></td>
<td>EEE parts</td>
<td>Dec 2013</td>
<td>200-500 K€</td>
</tr>
<tr>
<td>Electrical product</td>
<td>PLM Harness</td>
<td>Mars 2014</td>
<td>200-500 K€</td>
</tr>
<tr>
<td>MGSE</td>
<td>Handling &amp; adaptators</td>
<td>April 2014</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td>OGSE</td>
<td>AC flat mirror</td>
<td>May 2013</td>
<td>&gt;500 K€</td>
</tr>
<tr>
<td></td>
<td>Collimator</td>
<td>May 2013</td>
<td>&gt;500 K€</td>
</tr>
</tbody>
</table>
ITT Process

- Open competition for all the ITT’s following ESA Best practices, which ensure impartiality in the overall selection process.

  - At least 2 weeks before ITT emission, an Intended ITT (summary description of the ITT, indicative budget) is issued in EMITS.
  - The data package is issued on EMITS.
  - It consists mainly in a cover letter, a draft contract, the SCOT, the requirement specification, the SOW, the PA requirements, the GDIR. The evaluation criteria, the weighting factors and the closing date for the receipts of tenders are given.
  - The tendering period will be at least 30 working days for procurements > 300 k€, otherwise 20 working days
  - During the tendering period, any question shall be asked to Astrium, ESA copy (not later than 10d before the closing date). Answers will be quick (< 3d) and given via EMITS. All the tenderers know the question and the answer.
ITT Process

- At the end of the tendering phase, a Tender Opening Board takes place which checks the completeness of the proposals.
- The proposals are distributed to the participants of the Tender Evaluation Board (ESA + Astrium). They remain confidential.
- Evaluation period: 2 to 3 weeks.
- In the event that Astrium or one of its affiliates submits a bid, the TEB is under the responsibility of ESA
ITT Process

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

Weighting factors are allocated to each criteria and published for ITT. An overall weighted mark is calculated.
ITT Process

- TEB prepares a report with a recommendation. It remains confidential.
- It is transmitted to the Joint Procurement Board, which takes into account the price and the geo-return constraints and makes a recommendation to the Senior Procurement Board (ESA and Astrium directors).
- The JPB/SPB process can take about 1 month.
- SPB makes the final decision.
- Negotiation can start with the selected bidder. Questions on the proposal are sent to the bidder. After analysis of the answers, a negotiation meeting takes place at Astrium premises.
- Where negotiations are unsuccessful, the SPB is reconvened.
This afternoon, It resumes at 13:30

- **Mechanical ITT’s - Noordwijk Space Expo Ariane-Room**
  - External baffle
  - Struts
  - Supports & radiators
  - Internal baffles & shielding & ISM
  - M2 mechanism

- **Support activities ITT’s – Noordwijk Space Expo Astronaut-Room**
  - Project office support
  - Product assurance support
  - Mech/Opt AIT ops
  - Thermal analyses
  - AIT SW & EGSE bench operations

- **Other ITT’s – ESTEC – ESCAPE Dance Room**
  - EEE parts
  - MLI
  - Harness
  - Handling & adaptors
  - AC flat mirror, Collimator, Mirrors, dichroic plate
Euclid Payload Module
Mechanical ITT’s

17/04/2013
External baffle

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500 k€
  - Foreseen ITT issue date: Sept 2013

- **Description and key requirements**
  - Mechanical, Optical and thermal functions
  - $h \approx 2.6$ m within $\varnothing 1.9$ m
  - 60 Kg max, QSL 30g + acoustic, 1st mode above 90 Hz, $[60 \text{ K} - 323 \text{ K}]$
External baffle

- **Particular points**
  - Iso-static mounts; thermal strap efficiency and characterisation, qualification; paint (qualification); contamination

- **Model philosophy**
  - 1 PFM + 1FM + spares (ISMs; thermal straps)

- **Schedule requirements**
  - PDR: 08/14
  - CDR: 02/15
  - PFM DRB: 03/16
  - FM DRB: 09/16
Struts

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500 k€
  - Foreseen ITT issue date: Sept 2013

- **Description and key requirements**
  - Mechanical and thermal decoupling
  - GFRP tube with foam inside, end-fitting acting as a flexural blade and a bracket on each side.
  - QSL and I/F forces/displacements from system analysis

6 identical struts of about 1 m (forming 3 bipods) acting as a pseudo iso-static mount.

High axial stiffness (typ. $8 \times 10^7$ N/m) and low angular and radial stiffness ($< 10^3$ Nm/rd)
Struts

- Description and key requirements (cont’d)
  - GFRP tube length about 300 mm
  - Ti end-fittings and bracket
  - $f_p > 90$ Hz

- Particular points
  - GFRP tube / end-fitting thermo-elastic behaviour (cold env.), overall thermal conductance stringent requirement and performance characterisation, manufacturing skill and mastering / quality / control

- Model philosophy
  - 1 PFM + 1FM + 1 Flight Spare kit

- Schedule requirements
  - PDR: 08/14; CDR: 04/15; PFM DRB: 12/15; FM: 05/16
Supports and Radiators

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500 k€
  - Foreseen ITT issue date: Oct 2013

- **Description and key requirements**
  - Thermal function only
  - VIS radiator:
    - Rectangular Aluminium Alloy plate, evolving thickness, attached to the equipment through several bolts in its centre, about 1m²
  - NISP radiator:
    - Assembly of Aluminium Alloy plates,
    - Evolving thickness, supported by struts,
    - About 1,8 m²
Supports and Radiators

- **Particular points**
  - Thermal decoupling struts, stiffness, paint (qualification), acoustic

- **Model philosophy**
  - 1 PFM + 1FM + spares for mounts

- **Schedule requirements**
  - PDR: 07/14
  - CDR: 04/15
  - PFM DRB: 12/15
  - FM DRB: 05/16
Internal baffles and ISM

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500 k€
  - Foreseen ITT issue date: Nov 2013

- **Description and key requirements**
  - Optical function only
  - Aluminium design seems adequate
  - QSL 50g & acoustic
  - [60 K – 333 K]
  - fp > 100 Hz

- **Diagram:**
  - Black paint
  - Iso-static mounts
  - Support structure
  - h ≈ 0.6m within Ø 0.3 m
  - h ≈ 0.36m with Ø 0.32 m
Internal baffles and ISM

- **Particular points**
  - iso-static mounts; stiffness; paint (qualification)

- **Model philosophy**
  - 1 PFM + 1FM + spares (ISMs)

- **Schedule requirements**
  - PDR: 07/14
  - CDR: 04/15
  - PFM DRB: 12/15
  - FM DRB: 06/16
M2M Mechanism

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500€
  - Foreseen ITT issue date: June 2013

- **Description and key requirements**
  - Three axis of freedom refocusing mechanism
  - Supporting M2 mirror (mass 3Kg)
  - Two boxes architecture: mechanism part (M2MM) and drive electronic part (MDE)
  - M2MM [110 K – 125 K]
  - MDE [273 K – 313 K]
  - Mass: M2MM<3,5Kg, MDE<2,5Kg
M2M Mechanism

- **Particular points**
  - Performances :
    - Z axis: translation +/-275 µm, accuracy +/-2 µm
    - X and Y axis: rotation +/- 2 mrad, accuracy +/- 30µrad
  - Operation at low temperature, limited thermal conduction through harness

- **Model philosophy**
  - PLM need: MDE EM, M2MM EQM, M2M (M2MM+MDE+Harness) FM
  - Development models: depend on heritage

- **Schedule requirements**
  - EM/EQM DRB: 12/15
  - FM DRB: 05/16
PLM Industrial day
Splinter 2 : Support Activities ITTs
Contents

- Support activities
  - Project office support
  - Project assurance support
  - Thermal analyses
  - AIT software & EGSE bench operations
  - Opto-mechanical AIT support
Project office support

- Abstract
  - Title: Project office support
  - Tender type: Open Competition with preferential clause.
  - Price Range: > 500 K€
  - Foreseen ITT issue date: Dec 2013

- Scope & key requirements
  - Endorse responsibility during PLM phase CD of
    - Documentation management
    - Technical data, configuration management
    - Schedule control
Project office support

- Schedule requirements
  - Kick-off: April 2014
  - Activities will be performed during phase CD until PLM DRB end July 2018

- Specific points
  - The activities will be performed in Astrium Toulouse premises
  - The Astrium management tools and processes will be used for the execution of the tasks
  - Experience of proposed manpower in ESA space programs
  - Autonomy & ability to integrate the project team
Product Assurance support

Abstract

- Title: Product Assurance support
- Tender type: Open Competition with preferential clause.
- Price Range: 200 - 500 K€
- Foreseen ITT issue date: Dec 2013

Scope & key requirements

- Quality assurance responsibility during PLM procurement
- Focal point for equipment subcontractors for equipment subcontractors
- Phase CD RAMS activities
Product Assurance support

- Schedule requirements
  - Kick-off: April 2014
  - Activities will be performed during phase CD until equipment hardware deliveries until April 2016
  - Extra RAMS support activities beyond April 2016 for PLM DRB & QR July 2018 & FAR 3Q2018.

- Specific points
  - The activities will be performed in Astrium Toulouse premises until equipment hardware deliveries until April 2016.
  - The Astrium management tools and processes will be used for the execution of the tasks
  - Experience of proposed manpower in ESA space programs
  - Autonomy & ability to integrate the project team
Thermal analyses

• Abstract
  • Title: Project office support
  • Tender type: Open Competition with preferential clause.
  • Price Range: 200 - 500 K€
  • Foreseen ITT issue date: Dec 2013

• Scope & key requirements
  • Endorse responsibility during PLM phase CD of
    o Thermal model updates and analyses
    o In situ colocation support during thermal tests
Thermal analyses

- Schedule requirements
  - Kick-off: Dec 2013
  - Activities will be performed during phase CD until PLM DRB

- Specific points
  - Phase B thermal models provided by Astrium
  - Thermal models are ESATAN TMM and THERMICA GMM
  - Phase CD thermal analyses campaigns for CDR, FM test and flight predictions
  - Full time in situ support during PLM FM Tvac test (May 2018) at CSL Liège
AIT software & EGSE bench operations

- Abstract
  - Title: AIT software & EGSE bench operations
  - Tender type: Open Competition with preferential clause.
  - Price Range: 200-500 K€
  - Foreseen ITT issue date: Oct 2015

- Scope & key requirements
  - Endorse responsibility during PLM phase CD of
    - AIT software development
    - EGSE operations activities
AIT software & EGSE bench operations

- Schedule requirements
  - Kick-off: 2016
  - Activities will be performed during phase CD from June 2016 to July 2018

- Specific points
  - The activities will be performed in Astrium Toulouse premises
  - The EGSE is TBD and will be provided by Prime
  - SCOS 2000 (TBC), Matlab, SIS database, MOIS
  - Experience of proposed manpower in ESA space programs
  - Autonomy and ability to integrate the project team
Opto-mechanical AIT support

- **Abstract**
  - Title: Project office support
  - Tender type: Open Competition with preferential clause.
  - Price Range: > 500 K€
  - Foreseen ITT issue date: 1T 2014

- **Scope & key requirements**
  - Endorse responsibility of opto mechanical activities
  - From integrated telescope to completion of PLM integration
  - For both STM and FM models
  - Includes MGSE
Opto-mechanical AIT support

- Schedule requirements
  - Kick-off: 2T 2014
  - Activities will be performed during phase CD until PLM DRB end July 2018

- Specific points
  - Collocation period during AIT preparation phase
    In Astrium premises (Toulouse) from Kick-off to STM MRR
  - Appropriate large optical clean room
  - Experience of company in optical instruments (preferably with SIC)
  - Autonomy and ability to integrate the project team
Euclid Payload Module
Other ITT’s

17/04/2013
Flight mirrors

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500k€
  - Foreseen ITTs issue dates:
    - M1, M2, M3 June 2013
    - FM1, FM2, FM3 Sept 2013
Optics functional chain
## Telescope mirrors description & key requirements

<table>
<thead>
<tr>
<th>Shape</th>
<th>Ø (mm)</th>
<th>MSE (nm rms)</th>
<th>Coating</th>
<th>Front face</th>
<th>Rear face</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Elliptical concave</td>
<td>1250</td>
<td>10</td>
<td>Protected silver</td>
<td><img src="front_face1.png" alt="Image" /></td>
<td><img src="rear_face1.png" alt="Image" /></td>
</tr>
<tr>
<td>M2 Hyperbolic concave</td>
<td>350</td>
<td>10</td>
<td>Protected silver</td>
<td><img src="front_face2.png" alt="Image" /></td>
<td><img src="rear_face2.png" alt="Image" /></td>
</tr>
<tr>
<td>M3 Elliptical concave</td>
<td>540</td>
<td>9 overall area 4 on Ø165</td>
<td>Protected silver</td>
<td><img src="front_face3.png" alt="Image" /></td>
<td><img src="rear_face3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

The diagram shows the reflection properties of the telescope mirrors across different wavelengths (VIS and NISP) with a high reflection rate above 96%. The mirrors are designed to ensure high performance in both visible and near-infrared spectrums.
## Folding mirrors description & key requirements

<table>
<thead>
<tr>
<th>Shape</th>
<th>Size (mm)</th>
<th>MSE (nm rms)</th>
<th>Coating</th>
<th>Front face</th>
<th>Rear face</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM1 FLAT</td>
<td>378 x 230</td>
<td>9 overall area 4 on Ø70</td>
<td>High pass dielectric</td>
<td><img src="image1" alt="Front face" /></td>
<td><img src="image2" alt="Rear face" /></td>
</tr>
<tr>
<td>FM2 FLAT</td>
<td>350</td>
<td>9 overall area 4 on Ø70</td>
<td>High pass dielectric</td>
<td><img src="image3" alt="Front face" /></td>
<td><img src="image4" alt="Rear face" /></td>
</tr>
<tr>
<td>FM3 FLAT</td>
<td>378 x 230</td>
<td>9 overall area 4 on Ø70</td>
<td>Lowpass metal-dielectric</td>
<td><img src="image5" alt="Front face" /></td>
<td><img src="image6" alt="Rear face" /></td>
</tr>
</tbody>
</table>

**FM1/FM2 highpass coating reflection template**

**FM3 lowpass coating reflection template**

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Confidential Astrium
Mirrors general features

- Particular points
  - Polishing on SiC CVD cladded substrate
  - Coatings
    - Qualification to environments
    - Spectral performance validation at 130K
    - Foldings: calibration of coating stress at 130K

- Model philosophy
  - 1 coated Flight model
  - 1 non coated Flight spare

- Schedules
  - M1: 01/16
  - M2: 02/16
  - M3: 03/16
  - FM1: 02/16
  - FM2: 03/16
  - FM3: 05/16
Dichroic plate

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: 200-500 k€
  - Foreseen ITT issue date: April 2013

- **Description and key requirements**
Dichroic plate

- **Particular Point**
  - Minimization the bending effect of the coated plate in order to fulfill optical performance at cold operational temperature

- **Model philosophy**
  - Development in parallel by 2 companies of one DM
  - Choice mid-2014
  - QM & FM

- **Schedule requirements**
  - DM DRB: 06/14
  - QM DRB: 03/15
  - FM DRB: 02/16
Acflat mirror

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: > 500 k€
  - Foreseen ITT issue date: May 2013

- **Description and key requirements**
  - The ACF Mirror Assembly includes a polished mirror and a supporting cell.
  - Useful optical aperture $\Phi > 1300$ mm
  - WFE over useful optical aperture $< 30$nm rms
Acflat mirror

- **Particular Point**
  - Compatible with cryogenic tests

- **Model philosophy**
  - Single model

- **Schedule requirements**
  - DRB: Nov 2015
Collimator assembly

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: > 500 k€
  - Foreseen ITT issue date: May 2013

- **Description and key requirements**
  - The collimator assembly includes 3 sub assemblies:
    - Polished and coated mirrors
    - Supporting structure
    - Focal plane assembly equipped with motorized system for fibre displacements
  - Useful optical aperture \( \Phi > 1250 \text{ mm} \).
  - WFE at FOV centre <25 nm rms.
Collimator assembly

- **Particular Point**
  - Compatible with cryogenic tests.
  - Low emissivity required during cryogenic tests (heat exchange <5.5W with Euclid PLM baffle).
  - Performances to be held with ±0.5° tilt of its optical axis and cryogenic test conditions.

- **Model philosophy**
  - Single model

- **Schedule requirements**
  - DRB: August 2016
Handling & Adaptors

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: > 500 k€
  - Foreseen ITT issue date: April 2014

- **Description**
  - PLM +/- 1g trolley
  - Adaptators (vibrations & vacuum)
  - AVM support
  - AC flat mechanism & structure
  - Covers for contamination

- **Schedule requirements**
  - DRB: 12/15
Handling & Adaptors

+/- 1g trolley

AC flat mechanism & structure

Handling device
MLIs / SLIs

- **Abstract**
  - Tender type: ITT (open competition with preferential clause)
  - Price range: > 500 k€
  - Foreseen ITT issue date: March 2014

- **Model philosophy**
  - STM & FM

- **Schedule requirements**
  - PDR: 11/14
  - CDR: 02/15
  - STM DRB: 08/15
  - FM DRB: 03/16
Description and key requirements

- Geometry/coverage:
  - Essentially external housing
  - Total surface: 42 m² assessed

- Application of MLI design standards for optical instruments

- High insulation required from SVM and PLM
EEE Thermal hardware parts

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: < 200 k€
  - Foreseen ITT issue date: Dec 2013

- **Description and key requirement**
  - Single layer kapton foil at flight standard
    - Wires according
    - Geometry according PLM thermal architect definition
    - Single layer only for cold temperature
  - NTC thermistors 15 kOhm for VI-FPA-ES thermal zone (above 230K)
  - PTC type PT1000 thermistors for all others parts
EEE Thermal hardware parts

- **Model philosophy**
  - STM & FM

- **Schedule requirements**
  - STM DRB: 12/15
  - FM DRB: 05/16
Harness

- **Abstract**
  - Tender type: ITT (open competition with preferential clauses)
  - Price range: > 500 k€
  - Foreseen ITT issue date: > 03/14

- **Description and key requirements**
  - ~2000 wires for different type of signals: video (LVDS, Spacewire), power, sensors and motors signals
  - Large temperature gradient between Euclid instrument warm electronics (293K) and cold focal planes (127K)
  - Specification to limit heat transfer (6W): cryogenic materials to be used (stainless steel, phosphor-bronze etc.)
  - Non-cryogenic harness also part of ITT
Harness

- **Particular points**
  - Several bundles for Visible (VIS), Infra-Red (NISP), thermal control and mechanisms
  - Harness design to be proposed to limit heat transfer and meet electrical requirements

- **Model philosophy**
  - STM, EM & FM

- **Schedule requirements**
  - STM DRB: 12/15
  - EM DRB: 05/15
  - FM DRB: 05/16