EUCLID
Mission Assessment Study

Executive Summary

ESA Contract. No. 5856/08/F/VS
September 2009

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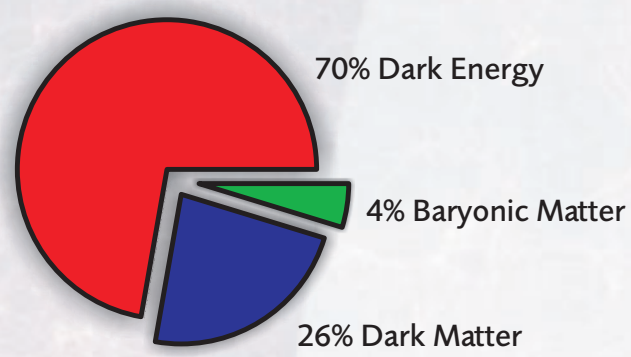
EUCLID – Mapping the Dark Universe

EUCLID is a mission to study geometry and nature of the dark universe. It is a medium-class mission candidate within ESA's Cosmic Vision 2015–2025 Plan for launch around 2017. EUCLID has been derived by ESA from DUNE and SPACE, two complementary Cosmic Vision proposals addressing questions on the origin and the constitution of the Universe.



The observational methods applied by EUCLID are shape and redshift measurements of galaxies and clusters of galaxies. To this end EUCLID is equipped with 3 scientific instruments:

- Visible Imager (VIS)
- Near-Infrared Photometer (NIP)
- Near-Infrared Spectrograph (NIS)

The EUCLID Mission Assessment Study is the industrial part of the EUCLID assessment phase. The study has been performed by Astrium from September 2008 to September 2009 and is intended for space segment definition and programmatic evaluation. The prime responsibility is with Astrium GmbH (Friedrichshafen, Germany) with support from Astrium SAS (Toulouse, France) and Astrium Ltd (Stevenage, UK).

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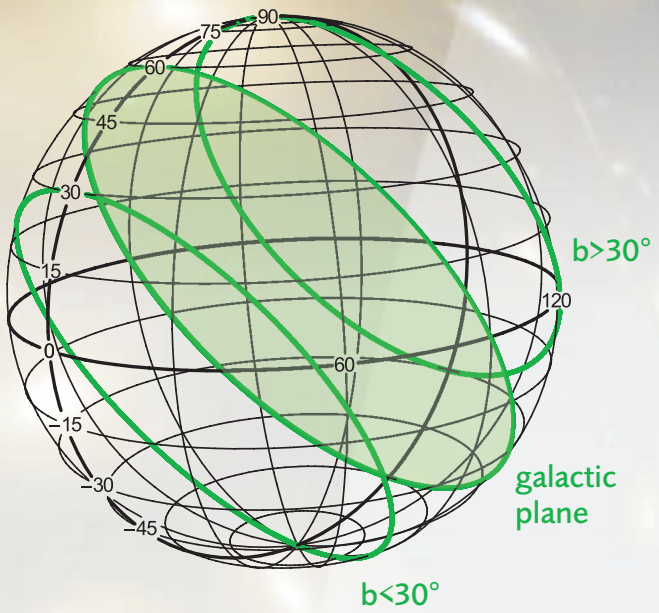
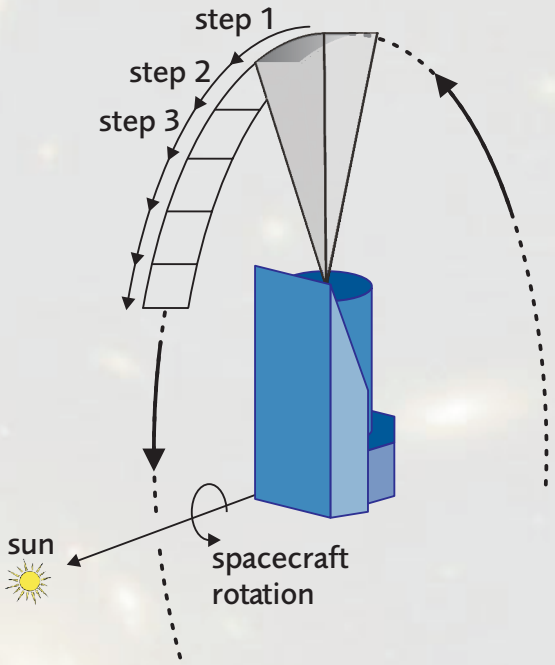
EUCLID Mission

EUCLID shall observe 20.000 deg^2 of the extragalactic sky at galactic latitudes |b|>30 deg. The sky is sampled in step & stare mode with instantaneous fields of about 0.5 deg^2. Nominally a strip of about 20 deg in latitude is scanned per day (corresponding to about 1 deg in longitude).





The sky is nominally observed along great circles in planes perpendicular to the Sun-spacecraft axis (SAA=0). The advantage is optimum thermal stability. The drawback of temporal inefficiency is solved by observing also during the dead times around the Equinoxes. The required spacecraft tilt away from the sun results in solar aspect angles SAA> 0.

EUCLID shall be launched from Kourou by a Soyuz ST 2-1B launch vehicle and shall operate at a large amplitude free-insertion orbit at the second Lagrange point of the Sun-Earth system (SEL2). A direct transfer is targeted.

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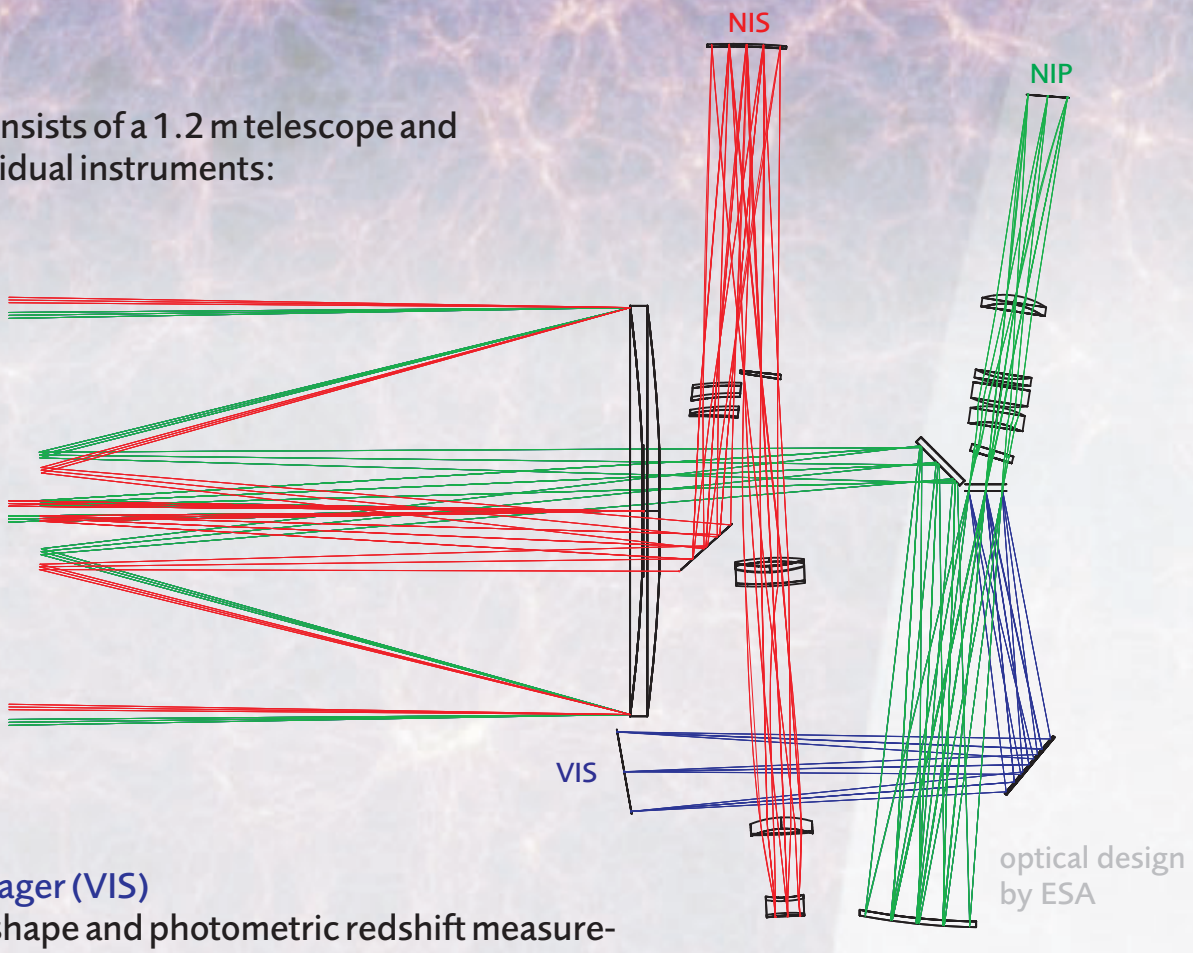
EUCLID Instruments

EUCLID consists of a 1.2 m telescope and three individual instruments:



optical design by ESA

Visible imager (VIS)

- for shape and photometric redshift measurements of galaxies up to mag_{AB}= 24.5
- wavelength regime from 550 –920 nm
- instrument interface is focal plane

Near-infrared photometer (NIP)

- photometric redshift measurements of galaxies up to mag_{AB}=24
- 4 wavelength bands Y (920–1146 nm) J (1146–1372 nm) and Hp (1372–2000 nm)
- instrument interface is the focal pupil (dichroic mirror)

Near-infrared spectrograph (NIS)

- spectroscopic redshift measurements of galaxies up to mag_{AB}=19.5
- spectral resolution of 500
- wavelength regime from 1000 –2000 nm
- instrument interface is the afocal pupil (GRISM)

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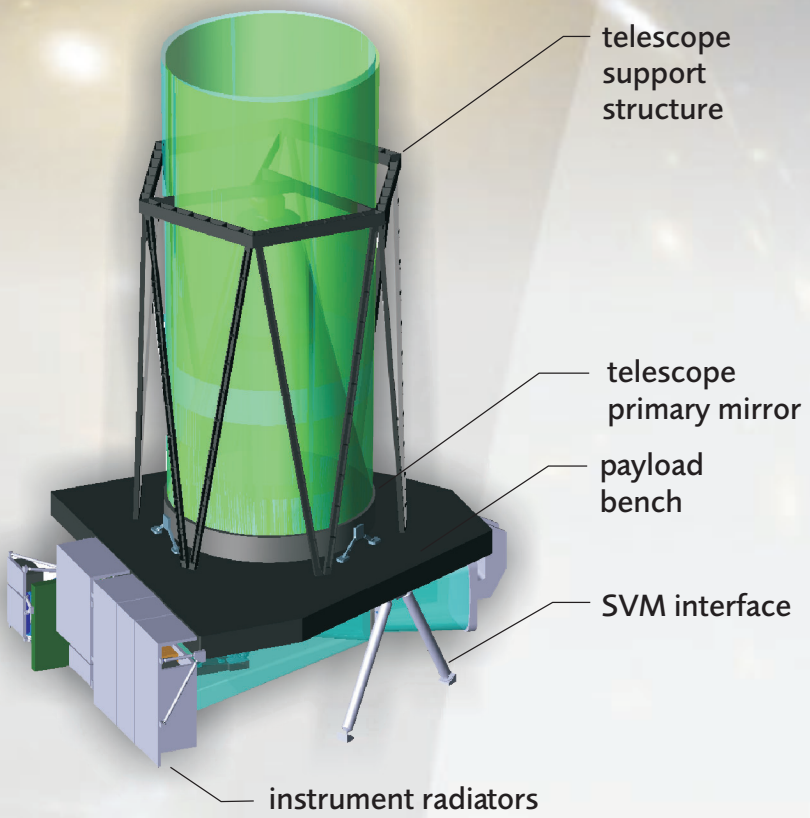
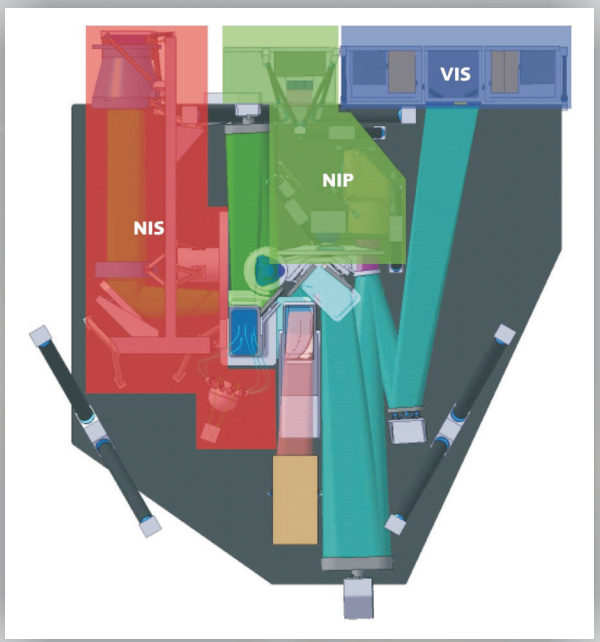
EUCLID Payload

The payload module (PLM) consists of an optical bench supporting all 3 instruments and the mirrors of the telescope. The base plate interfaces the SVM via 3 isostatic bipods. The baseline material for the telescope is silicon carbide (SiC). The telescope and the payload are covered by a thermal baffle. The dimensions of the PLM are 3300 mm in height and 2640 mm times 2420 mm in width. The total mass amounts to 783 kg incl. 20% system margin.





The instruments are realized as individual entities with the defined interfaces to the payload module. Each instrument has its own base plate. The radiators are aligned on the cold side of the spacecraft.

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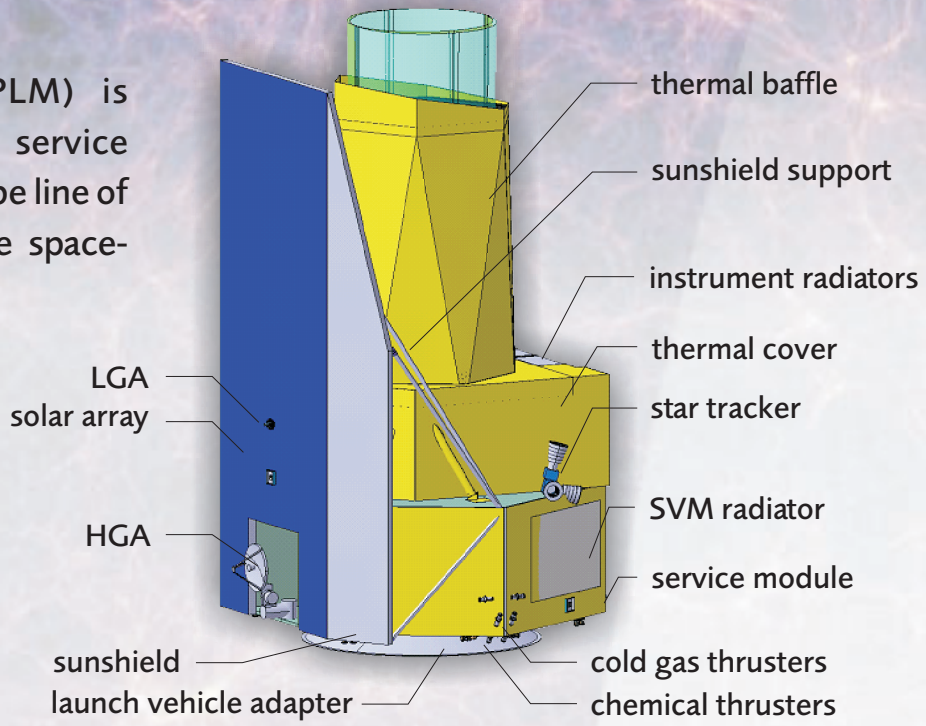
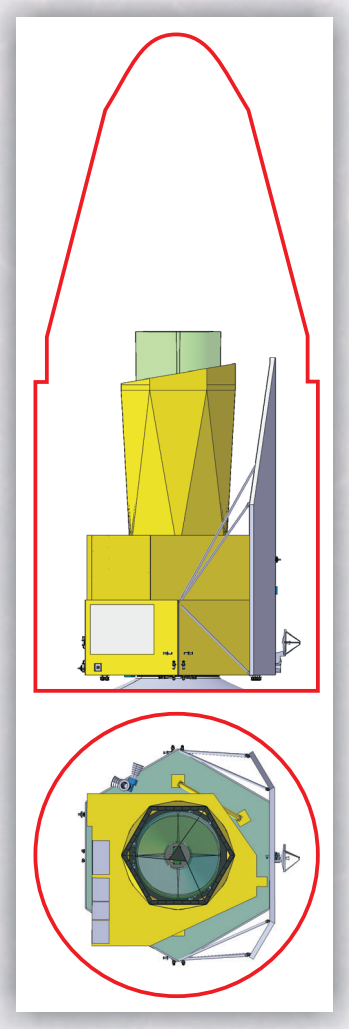
EUCLID Spacecraft

The payload module (PLM) is accommodated atop the service module (SVM). The telescope line of sight is co-aligned with the spacecraft main axis.





Sunshield

- canted design for high stiffness and optimum shading
- directly interfacing the SVM
- 8.9 m^2 solar arrays, mounted onto the sunshield
- size of 4670 mm in height and 2990 mm in width

SVM structure

- hexagonal shape, Al honeycomb with CFRP facets
- central cone (1194mm) interfaces the launch adapter
- size of 3100 mm in diameter and 1100 mm in height

AOCS

- orbit maintenance and attitude control with mono-propellant Hydrazine thrusters (10N and 1N)
- step and dither manoeuvres with cold gas (0.5 mN)
- required pointing performance of 25 mas rms APE is safely achieved by proper design of the AOCS.

Communication

- 850 Gbit/day science data volume (4h/day link time)
- steerable K-band HGA (30 cm diameter), actuated during spacecraft manoeuvres

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EUCLID System Performance

The mission duty cycle of 77% is driven by the integration time per frame of the VIS instrument.

Instrument	SNR Requ irement	Band	FWHM / arcs ec	Integration Time per Frame /s	
VIS	10	R+I+Z 550–920 nm	0.40	568	568
NIP	5	Y 920–1146 nm	0.29	160	466
		J 1146–1372 nm	0.30	209	
		Hp 1372–2000 nm	0.30	97	
VIS	5	1000 nm	0.99	531	531
		2000 nm	1.00	446	

A total ellipticity of 10.6% is estimated for the EUCLID instrument. This is within the requirement of 20% maximum.

Ellipticity contributor	Ellipticity / %
Optical distortion	2.0
Wavefront error (60 nm RMS)	7.6
Inhomogeneous detector MTF	5.0
Line of sight stability	0.0
Effect of FWHM increase mechanism	5.0
Total (RSS)	10.6

For the worst case of a 45 deg spacecraft step (around the Equinoxes), the ellipticity variation introduced by thermal variations over 3 strips amounts to 0.017% (30 mK thermal stability). This is within the requirement of 0.02%.

Thermal ellipticity varation (RMS)	Variation / %
SAA = 30 deg	0.011
SAA = 45 deg	0.017

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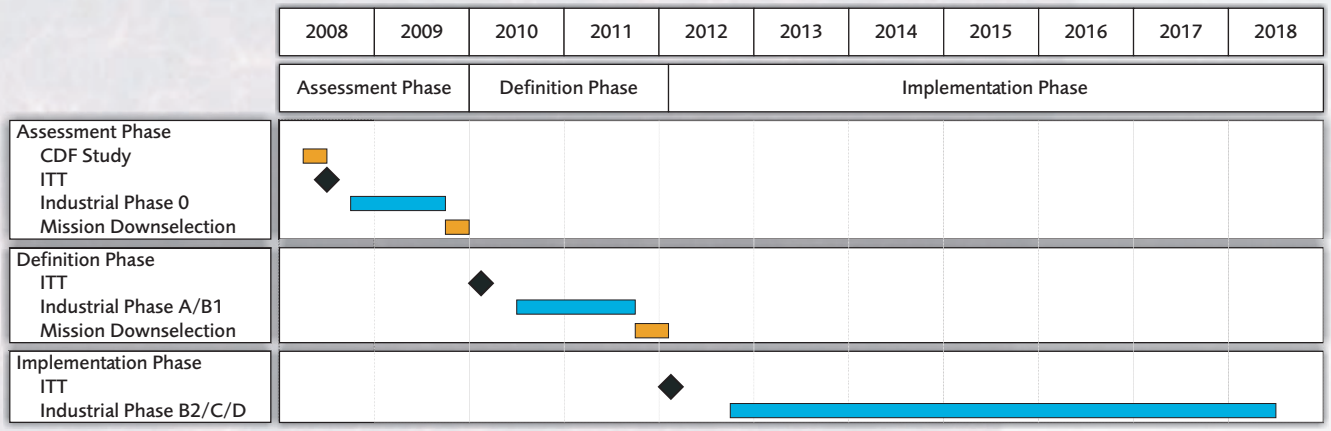
EUCLID Programmatics

The EUCLID mission schedule is determined by the Cosmic Vision planning. The current activity, industrial Phase 0, is part of the Assessment Phase. After the down selection an industrial Phase A/B1 of 15 months is planned within the Definition Phase. The Implementation Phase, industrial Phase B2/C/D, shall start after mission selection in spring 2012.



The overall complexity and the programmatic constraints imply some potential risks:

- **Interfaces**: Technical instrument interfaces as well as administrative interfaces between the industrial prime contractor and the instrument consortia.
- **Schedule and long-lead items**: The telescope primary mirror polishing and the focal plane development (detectors, proximity electronics, interface module) drive the schedule.
- **Payload AIT**: The final performance can only be verified at spacecraft level. The instruments have to be fully qualified before integration into the PLM.

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Summary & Conclusions

Within the EUCLID Mission Assessment Study the EUCLID mission has been basically defined and the major mission concepts have been established.

The mission feasibility has been shown in terms of mission concept, spacecraft concept, payload concept and instrument concept. The key mission requirements can be fulfilled.

The EUCLID mission is compatible with the Cosmic Vision M-class mission constraints in terms of planning, technology readiness and costing. The potential risks are manageable. No show stoppers have been identified.

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