DOCUMENT

Euclid Experiment Interface Document - Part A

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APPROVAL

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CHANGE LOG

Reason for change	Issue	Revision	Date
Initial issue for Definition Phase ITT	1	0	16/04/10
Changes following ITT pre-TEB	1	1	23/04/10
Update to take into account request for clarifications from industry and additional inputs mainly on management (following AO and SMP)	1	2	07/06/10
Include comments from the AO review panel	1	3	18/06/10
Include additional inputs from AO review panel	1	4	06/07/10

CHANGE RECORD

Issue 1	**Revision** 4		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Added Q_{opt}	30/06/10	47	4.8.2
Updated VIS and NISP field	30/06/10	52	4.9.1.1.1 and 4.9.1.1.2
Include definition of survey FoV	07/07/10	53	4.9.2
Include content of section 4.17.2	22/06/10	56-57	4.17.2
Added TID, NIEL, SEE information	22/06/10	58- 59	4.17.4
Added micrometeoroids fluence curve	22/06/10	61	4.17.5
Preliminary breakdown of section 6	22/06/10	63	6
Place holder for STOP added	28/06/10	73	8.4.4
Added testing levels	22/06/10	76-78	8.5.4
Added NCTS reference	22/06/10	64	7
Added “via the consortium Lead”	02/07/10	81	9.2.4.1.1
Typo	02/07/10	84	9.2.5.1
Added Payload manager as interface to the consortium with copy to study manager	02/07/10	84	9.2.5.2

Replace PI by instrument provider	02/07/10	86	9.5.2
Typo	22/06/10	85	9.4.1
Updated table 21 with instrument unit names and remove limitation of reduced TMM to thermal interface (now appears in list of deliverable for MDR in section 9.8.6)	28/06/10	89	9.8.1
Preliminary dates for STM and EM	02/07/10	90	9.8.2
Data package updated	28/06/10	91	9.8.6
Update power consumption figures of CCD	22/06/10	94	Appendix A

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1 GENERAL

1.1 Background

The ESA Cosmic Vision Plan objective is to define and implement the future ESA science missions through a competitive process starting from open “Calls for Missions” to the science community and ending by a selection of the missions to be adopted through two down-selection steps. The down-selection decisions involve ESA science advisory structure and require SPC approval. The science return value, the design and technical maturity and the budget are the key mission elements supporting this decision process. For the M-class missions, the selection process is being conducted according to the following schedule:

Assessment Phase in 2008- Aug 2009 (completed)
ESA internal review: Sep – Oct 2009 (completed)
First down-selection of M-class missions to enter the Definition Phase (A/B1): Feb 2010 (Completed)
Second and last down-selection for M1/M2: June 2011
Completion of the Definition Phase (A/B1): by December 2011
Final adoption for the Implementation Phase (B2/C/D/E1): before Feb 2012
Start of the Implementation Phase: by July 2012
Launch: by end 2018

EUCLID is one of the M-class mission candidates selected to enter the Definition Phase (A/B1) which is supposed to last 18 months. The Definition Phase Study (A/B1) is structured in three phases which reflect the decision process. The related work content is tailored to provide the Agency with the relevant timely inputs to make possible the decisions at Science Programme level.

- Phase A1 – Optimization of EUCLID mission;
This Phase shall be completed by October 2010 and include the elaboration of the interface with the experiments. It is foreseen that by the end of this Phase, decision will be made regarding who is providing the science payload instrumentation hardware.

- Phase A2 – Consolidation of EUCLID mission;
This Phase shall be completed by June 2011 and includes the instruments and spacecraft design and performance consolidation, the elaboration of the spacecraft development plan and the consolidation of the space segment industrial cost. At the end of this Phase, the objectives to be achieved are:
To finalize the instruments and spacecraft system design and ensure that the mission objectives can be met. This shall be supported by a detailed modelling of the instrument and spacecraft (mechanical, thermal, AOCS, etc) in order to demonstrate the instruments

and spacecraft compatibility with the science performance requirements and the launcher capability,
To provide programmatic inputs for the instruments and spacecraft development in view of the down-selection process i.e. development plan, compatibility with the implementation schedule, development and schedule risk analyses, space segment cost estimate …

- Phase B1 – Preparation of EUCLID implementation phase.
This Phase will be implemented only if the mission is selected at the end of Phase A. It will be devoted essentially to the preparation of the Implementation Phase (B2/C/D/E1), and shall be completed by December 2011. In particular, a major activity will be the preparation of the bid packages for the subsystem layer procurement for the industrial part and the final consolidation of the instrument system design and subassembly specifications.

1.2 Scope

The purpose of the document is to ensure that:

- The instrument provider design, build, and verify their instruments within the technical constraints imposed by the Euclid spacecraft and compatible with the Euclid mission constraints.
- The Euclid prime contractor designs, builds and verifies the spacecraft such that the instruments can be successfully integrated into the system.
- The spacecraft can be successfully launched and operated to achieve the scientific objectives of the Euclid mission.

The EID consist of two parts; A and B.

The EID-A contains the interface requirements that shall be applied to the design of the instruments and the resources allocated by the spacecraft to the instruments. Part A also defines the Euclid technical and programmatic requirements that all Euclid Instrument Providers have to comply to.

The EID-B of each instrument contains the Instrument Provider response to the technical requirements in part A defining in detail the interface information applicable to the corresponding instrument. Part B will form the sole formal and binding document for all technical and programmatic agreements between the ESA Euclid study team and the Instrument Provider.

The EID A and B will become applicable documents to the Euclid industrial contractors during the definition phase.

In its present limited version, the document provides essentially the main specifications and preliminary resource allocations for the two Euclid instruments:

- The Visible Imager (VIS)
- The Near Infrared Photo-spectrometer (NISP)

It will progressively evolve during the definition phase (and beyond) in order to fulfil eventually its primary goals.
It is also important to emphasize that in such an early phase of the program, the given breakdown of the instruments into units and related resources (mass, power and in particular volume) have been given here as a starting point. Based on trade-off and possible interface evolutions (e.g. with equipment furnished by NASA), a different distribution of the tasks and resources within a given instrument (or between the two instruments, e.g. the data processing unit) can clearly be envisaged.

1.3 Document concept & architecture

The Euclid document tree is schematically presented hereafter:

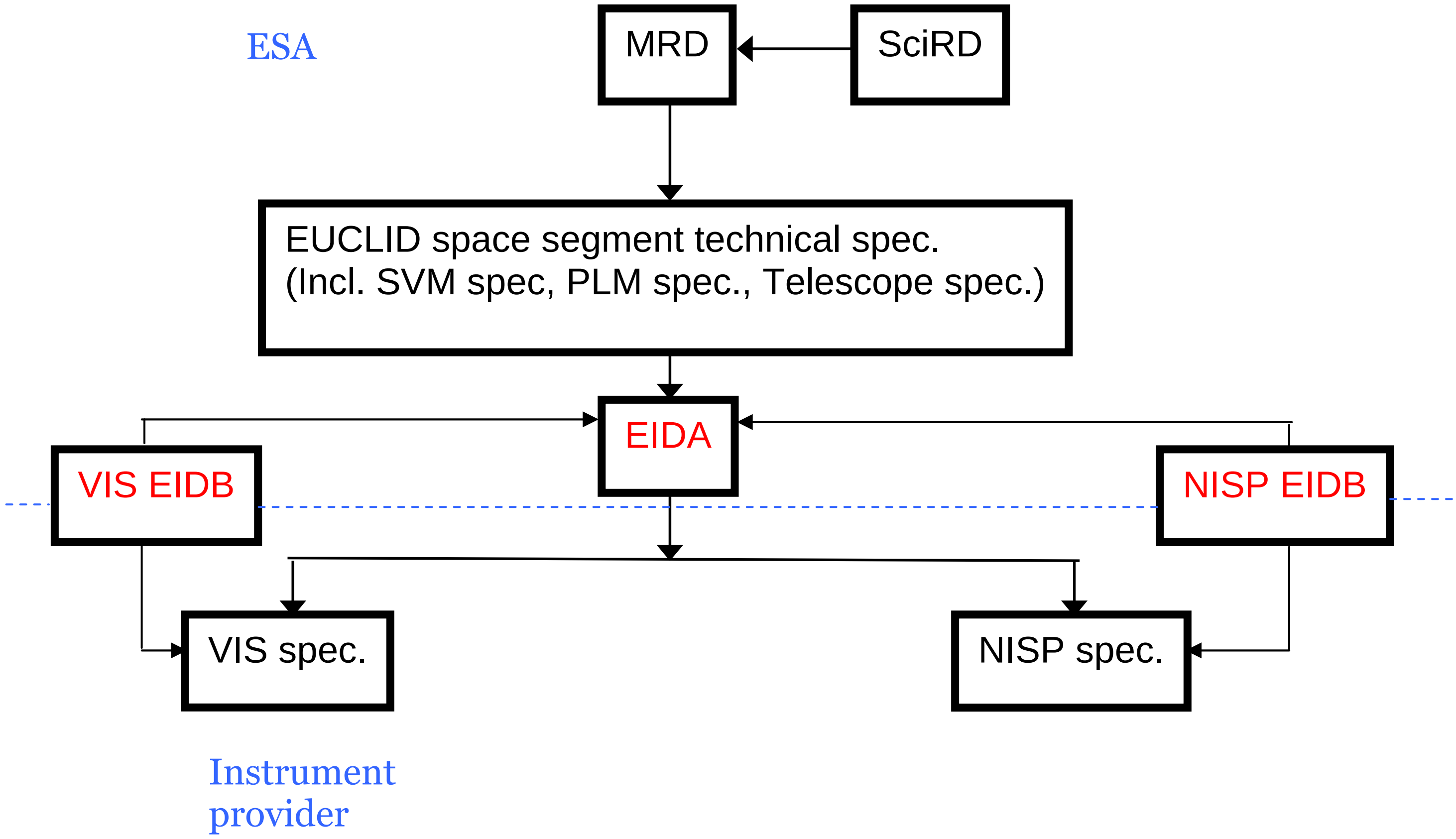

Figure 1 Euclid document tree.

The abbreviations used in the EUCLID document tree (see above Figure) refer to the following documents:

- SRD: Science Requirement Document (existing)
- MRD: Mission Requirement Document (existing)

- S/C Spec: EUCLID Space Segment Specification (to be created during phase A)
- SVM Spec: Service Module Specification and Interface Requirement Document (to be created during phase A)
- PLM Spec: Payload Module Specification and Interface Requirement Document (to be created during phase A)
- TEL Spec: EUCLID Telescope Performance Specification and Interface Requirement Document (to be created during phase A)
- EIDA: Experiment Interface Document Part A (existing in preliminary version)
- VIS EIDB : Visible Imager Experiment Interface Document Part B (to be created after AO)
- NISP EIDB : NISP Experiment Interface Document Part B (to be created after AO)
- VIS Spec : VIS Functional Requirement and Performance Specification (TBC)
- NISP Spec. : NISP Functional Requirement and Performance Specification (TBC)

1.4 Hardware responsibilities

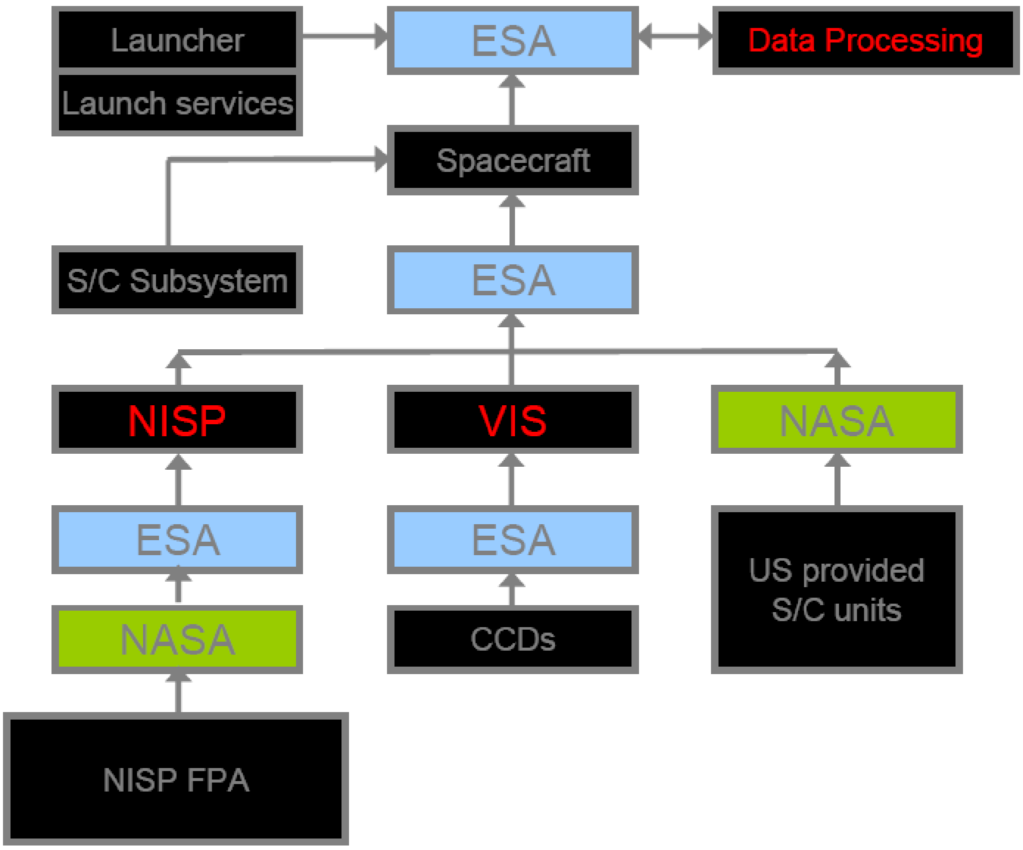

Figure 2 Hardware responsibilities

Figure 2 shows the flow of hardware responsibilities for Euclid. At the bottom of the diagram are shown the so called “ESA Furnished Equipments”:

- For the NISP instrument, the Detector System (NI-DS, see section 3.3.4.5) including the Focal Plane Assembly (NI-FPA), the Focal Plane Control and Data Processing Units (NF-CDPU) and the Focal Plane Power Supply Unit (NF-PSU) will be delivered by NASA to ESA. ESA will then deliver the Detector System to the NISP Instrument provider.
- Similarly ESA will procure the Euclid CCDs (E2V) and delivers them to the VIS instrument provider.

The VIS and NISP instrument provider will then deliver the complete instrument to ESA to be integrated by the prime on the spacecraft.

The Euclid consortium as instruments provider shall assume full responsibility of the development, verification and timely delivery of the instruments including the ESA and NASA furnished equipment.
The Euclid consortium shall carry out the normal system/subsystem engineering and interface engineering tasks for the ESA/NASA provided subsystems as for any other instrument subsystem and unit. The instrument consortium shall participate in all formal subsystem reviews of the ESA/NASA provided subsystems and shall support the related progress meetings as necessary.
ESA will establish the programmatic platform with NASA for their deliveries and will be responsible for the formal programmatic interface to NASA.
ESA will be the unique interface with industry during the next phases. The instrument provider shall support common technical meetings with industry to facilitate a concurrent design process of the spacecraft and the instruments.

1.5 Product Tree

The following figures show the Euclid product trees at different system levels.

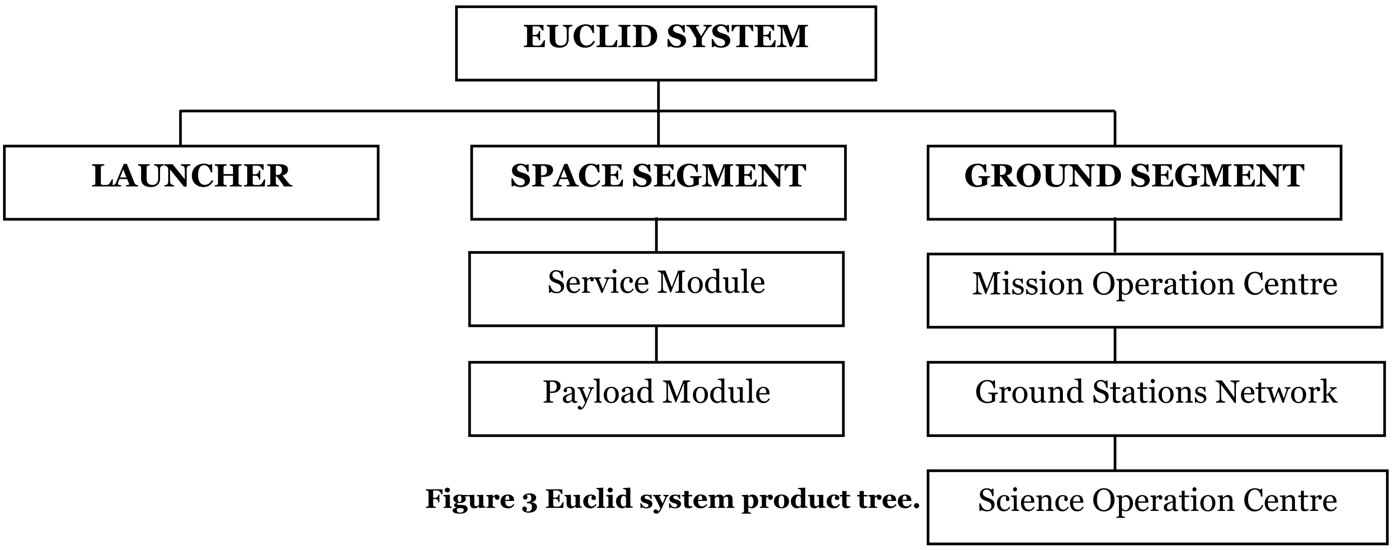

Figure 3 Euclid system product tree.

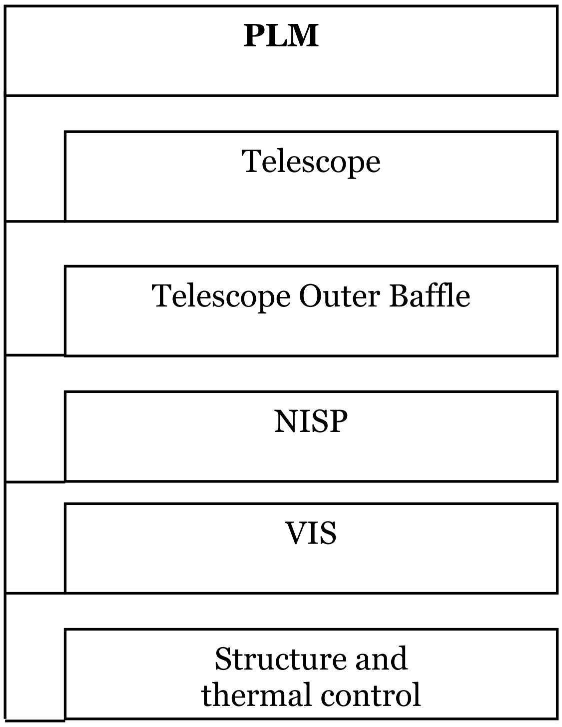

Figure 4 PLM product tree

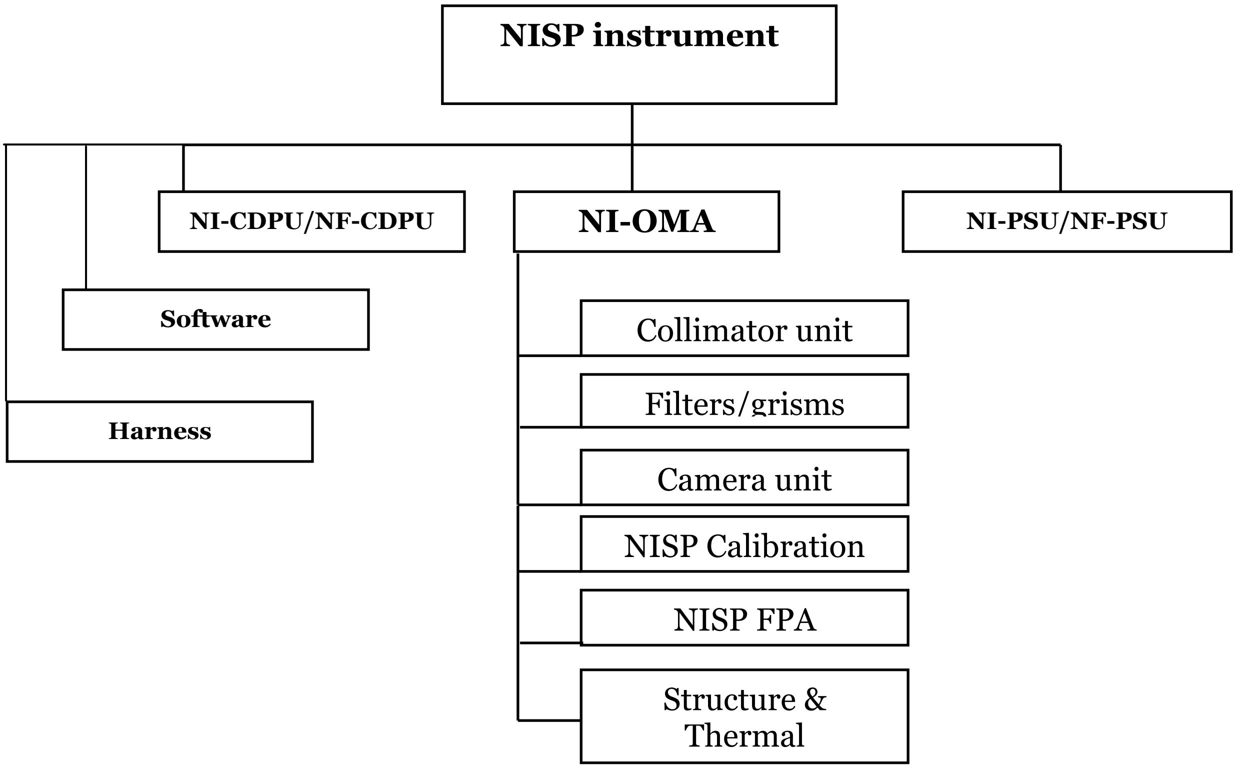

Figure 5 NISP instrument product tree

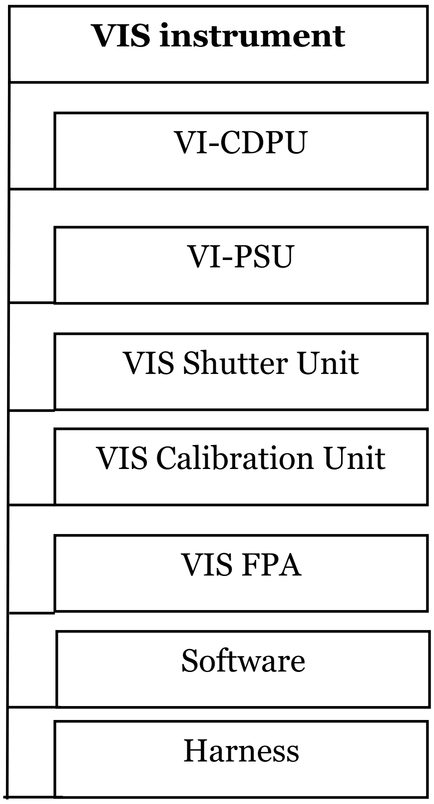

Figure 6 VIS instrument

As mentioned in section 1.2, the breakdown of each instrument into given units is subject to evolution, at this stage, the product tree should be understood more as a functionality tree.

2 DOCUMENTS

Following the definitions of the ECSS (European Cooperation for Space Standardization), documents relevant to the Euclid mission are classified as Normative and Informative documents. Normative documents are referenced in the text of the EID-A as specific requirements which call up the section in the specified document. Informative documents are listed for information but are not formally requirements documents.

2.1 Normative references

ECSS standards are available for download at http://www.ecss.nl
The latest issue of all the ECSS documents shall apply unless specified otherwise. The applicability of Level 1 ECSS standard (Policy and principles) extends implicitly to the lower standards.

For the definition phase A/B1 of Euclid, special attention shall be paid to the list indicated in the following table.

ECSS number	Actual Title	Issue	Date of publication
ECSS-E-10-03A	Testing	First issue	15 February 2002
ECSS-E-70-41A	Telemetry and telecommand packet utilization	First issue	30 January 2003
ECSS-E-ST-10 C	System engineering general requirements	Third issue	06 March 2009
ECSS-E-ST-10-02C	Verification	Second issue	06 March 2009
ECSS-E-ST-10-04C	Space environment	Second issue	15 November 2008
ECSS-E-ST-10-06C	Technical requirements specification	Third issue	06 March 2009
ECSS-E-ST-10-09C	Reference coordinate system	First issue	31 July 2008
ECSS-E-ST-10-12C	Method for the calculation of radiation received and its effects, and a policy for design margins	First issue	15 November 2008
ECSS-E-ST-20 C	Electrical and electronic	Second issue	31 July 2008
ECSS-E-ST-20-06C	Spacecraft charging	First issue	31 July 2008
ECSS-E-ST-20-07C	Electromagnetic compatibility	First issue	31 July 2008
ECSS-E-ST-31 C	Thermal control general requirements	Second issue	15 November 2008
ECSS-E-ST-32 C Rev.1	Structural general requirements	Revision 1 of Second issue	15 November 2008
ECSS-E-ST-32-01C Rev.1	Fracture control	Revision 1 of Second issue	06 March 2009
ECSS-E-ST-32-03C	Structural finite element models	First issue	31 July 2008
ECSS-E-ST-32-08C	Materials	Second issue	31 July 2008
ECSS-E-ST-32-10C Rev.1	Structural factors of safety for spaceflight hardware	Revision 1 of First issue	06 March 2009
ECSS-E-ST-32-11C	Modal survey assessment	Second issue	31 July 2008
ECSS-E-ST-33-01C	Mechanisms	Second issue	06 March 2009
ECSS-E-ST-40 C	Software	Third issue	06 March 2009
ECSS-E-ST-50-12C	SpaceWire - Links, nodes, routers and networks	Second issue	31 July 2008
ECSS-E-ST-50-13C	Interface and communication protocol for MIL-STD-1553B data bus onboard spacecraft	First issue	15 November 2008

ECSS number	Actual Title	Issue	Date of publication
ECSS-E-ST-50-14C	Spacecraft discrete interfaces	Second issue	31 July 2008
ECSS-E-ST-50-51C	SpaceWire protocol identification	First issue	05 February 2010
ECSS-E-ST-50-52C	SpaceWire - Remote memory access protocol	First issue	05 February 2010
ECSS-E-ST-50-53C	SpaceWire - CCSDS packet transfer protocol	First issue	05 February 2010
ECSS-E-ST-70 C	Ground systems and operations	Second issue	31 July 2008
ECSS-E-ST-70-01C	On-board control procedures	First issue	16 April
ECSS-E-ST-70-11C	Space segment operability	Second issue	31 July 2008
ECSS-E-ST-70-31C	Ground systems and operations - Monitoring and control data definition	Second issue	31 July 2008
ECSS-E-ST-70-32C	Test and operations procedure language	Second issue	31 July 2008
ECSS-M-70A	Integrated logistic support	First issue	19 April 1996
ECSS-M-ST-10 C Rev.1	Project planning and implementation	Third issue revision 1	06 March 2009
ECSS-M-ST-10-01C	Organization and conduct of reviews	Second issue	15 November 2008
ECSS-M-ST-40 C Rev.1	Configuration and information management	Third issue revision 1	06 March 2009
ECSS-M-ST-60C	Cost and schedule management	Third issue	31 July 2008
ECSS-M-ST-80C	Risk management	Third issue	31 July 2008
ECSS-P-001B	Glossary of terms	Second issue	14 July 2004
ECSS-Q-20-07A	Quality assurance for test centres	First issue	31 July 2002
ECSS-Q-70-71A Rev.1	Data for selection of space materials and processes	Revision 1 of First issue	18 June 2004
ECSS-Q-ST-10 C	Product assurance management	First issue	15 November 2008
ECSS-Q-ST-10-04C	Critial-item control	Second issue	31 July 2008
ECSS-Q-ST-10-09C	Nonconformance control system	Third issue	15 November 2008
ECSS-Q-ST-20C	Quality assurance	Third issue	15 November 2008
ECSS-Q-ST-30 C	Dependability	Third issue	06 March 2009
ECSS-Q-ST-30-02C	Failure modes, effects (and criticality) analysis (FMEA/FMECA)	Second issue	06 March 2009
ECSS-Q-ST-30-09C	Availability analysis	Second issue	31 July 2008

ECSS number	Actual Title	Issue	Date of publication
ECSS-Q-ST-30-11C	Derating - EEE components	Third issue	31 July 2008
ECSS-Q-ST-40 C	Safety	Third issue	06 March 2009
ECSS-Q-ST-40-02C	Hazard analysis	Second issue	15 November 2008
ECSS-Q-ST-40-12C	Fault tree analysis - Adoption notice ECSS/IEC 61025	Second issue	31 July 2008
ECSS-Q-ST-70 C	Materials, mechanical parts and processes	Third issue	06 March 2009
ECSS-Q-ST-70-01C	Cleanliness and contamination control	Second issue	15 November 2008
ECSS-Q-ST-80C	Software product assurance	Third issue	06 March 2009
ECSS-S-ST-00C	Description, implementation and general requirements	First issue	31 July 2008

Table 1 List of ECSS standards that shoul be particularly considered during phase A/B1.

The following list corresponds to applicable documents specifically referenced in the present document.

NR1. Euclid mission requirement document, SRE-PA /2010.025
NR2. Margin philosophy for Euclid Definition Study, SRE-PA/2010.028
NR3. ECSS-E-30 Part 1A
NR4. ECSS-E-10-02C
NR5. ECSS M-ST-80C
NR6. ECSS-E-ST-32-10C

2.2 Informative references

IR1. Euclid reference payload concept, SRE-PA/2010.030
IR2. Euclid environmental specifications, JS-22-09
IR3. Soyouz from Guyana Space Center User's manual
IR4. Euclid CCD specification, SRE-PA/2010.051, Issue 0, version 1, 10/06/2010

2.3 Acronyms

ABCL: As Build Configuration List
AO: Announcement of Opportunity
CIDL: Configuration Item Data Lists
CCD: Charge coupled device
EM: Engineering Model
F-CDPU: Focal plane Control and Data Processing Unit

FEM:	Finite Element Model
FM:	Flight Model
FPA:	Focal plane assembly
F-PSU:	Focal plane Power Supply Unit
HK:	House keepings
H2-RG:	HAWAII 2-RG (HgCdTe Astronomy Wide Area Infrared Imager with 2k2 Resolution, Reference pixels and Guide mode).
MLI:	Multi layer insulation
NCR:	Non Conformance Request
NCTS:	Non Conformance Tracking System
PLM:	Payload Module
SCA:	Sensor Chip Assembly
SIDECAR:	System for Image Digitization, Enhancement, Control And Retrieval.
SMM:	Structural Mathematical Model
STM:	Structural and Thermal Model
SVM:	Service module
TC:	Telecommand
TM:	Telemetry

3 SPACECRAFT DESCRIPTION

3.1 Mission objectives

The prime objective of EUCLID is to study the geometry and the nature of the dark Universe (dark matter, dark energy) with unprecedented accuracy. This topic was recognized by the ESA Advisory Structure as the most timely and important one among the M-class mission proposals and was therefore recommended as a top priority.

The mission will investigate the distance-redshift relationship and the evolution of the cosmic structures by measuring shapes and redshifts of distant galaxies out to redshifts ~ 2, or equivalently 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 Weak Lensing measurements consist, through a statistical approach, in observing galaxies distortion caused by gravitational light deflection from unknown and invisible foreground mass concentrations and moreover modified by the expansion of the Universe (cosmic distance ratios). One measures angles between galaxies, dimensionless ellipticities (apparent shapes of the galaxies) and redshifts. Tomographic methods are then applied to map the Dark Matter (in three dimensions) and to build the power spectrum of the shape correlation between galaxies as a function of the angular scales. The analysis of this power spectrum, as a function of the redshift of the lensed galaxies, makes it possible to determine the properties of the Dark Energy that the EUCLID mission is looking for.

The Baryon Acoustic Oscillations are a series of wiggles in the matter power spectrum. They are small amplitude modulations in the distribution of matter, left by sound waves in the primordial plasma-photon fluid and imprinted at the epoch when matter and radiation decoupled. Assuming that the distribution of galaxies reflects the distribution of all matter, the length scale of these oscillations, amplified by the expansion, can be measured from the spatial correlation of galaxies (power spectrum). As a standard ruler, the BAO will provide EUCLID with accurate measurements of the Hubble parameter and the angular diameter distance, putting additional constraints on the Dark Energy.

3.2 System description

The Euclid spacecraft consist of two main modules:

- the Euclid payload module (EPLM) which includes the telescope, the instruments, the baffling system

- the Euclid service module (ESVM) which comprise all the conventional spacecraft subsystems, the sun shield and the solar arrays.

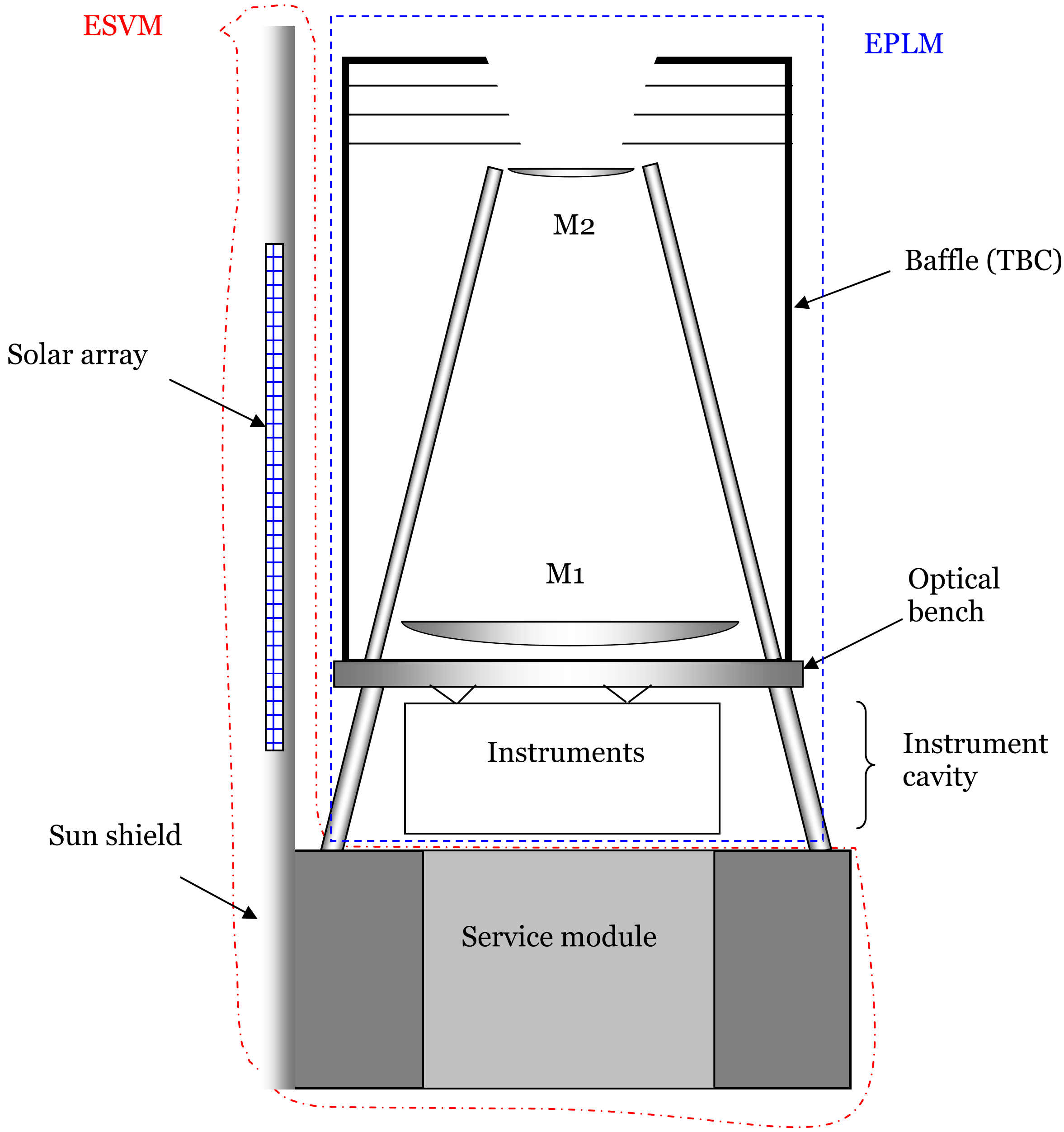

Figure 7 Euclid system schematics

The mission baseline is for Euclid to be launched by a SOYOUZ ST 2-1B from French Guyana Space Center [IR2] before end of 2018.

The Euclid spacecraft will be placed into an orbit around L2. The Euclid nominal in-orbit operation phase that includes commissioning and scientific operation is 5 years.

3.3 Euclid payload module

The Euclid payload module consists in:

- the telescope assembly (TA) including the mirrors, the dichroic - and the support structure,
- the payload module structure and thermal control subsystem that supports the instruments and telescope assembly via e.g. an optical bench (TBC) and that includes the instruments radiators,
- the VIS instrument,
- the NISP instrument,
- the outer telescope baffle.

3.3.1 Telescope Assembly

The telescope is a 3 mirror Korsch configuration with an off axis field [IR1]. The basic parameters of the telescope are:

- Aperture stop at primary mirror, with 1200 mm entrance pupil diameter.
- FOV: 0.79 x 0.83 deg^2 (TBC)
- Effective focal length: 24500.0 mm (TBC).
- Elliptical primary and tertiary, hyperbolic secondary.

The telescope is common to both instruments of the payload complement.

Mirror	*Curvature radius (mm)*	*Conic constant*	*Distance to next surface along optical axis (mm)*	*Clear aperture diameter (mm)*	*Aperture y-decenter (mm)*
Primary	4601.34600	-0.978360	1756.007	1200	
Secondary	1384.21400	-2.203028	1756.007	328.9	25.0
Hole	Primary vertex		600	253.6 (*)	113.3
Fold	Flat		400.9149	112.6x91.2 (**)	
Pick up	Flat		1255.273	120x135 (**)	
Tertiary	1975.31999	-0.576721	3228.22	235.5	225.03

Table 2. EUCLID telescope prescription. (*) The clear aperture corresponds to the central hole in the primary required to let the light through without vignetting. (**) Sides of rectangular aperture in x and y axes.

3.3.2 Outer Telescope Baffle

TBD

3.3.3 VIS instrument

The VISible imager instrument (VIS) is presently consisting of the following units (TBC):

- a Focal Plane Assembly (FPA)
- an Instrument control and data processing unit (VI-CDPU)
- an Instrument power supply unit (VI-PSU)
- a calibration unit
- a shutter unit

3.3.3.1 VIS FPA

The VIS FPA consists in:

- CCD detectors (as specified in Appendix A) and harnesses
- Readout electronic modules
- Readout electronic modules power supply units and harnesses
- CCD plane support
- Readout electronic and power supply units mechanical structure
- Thermal hardware

The light from the Euclid telescope is focused on the FPA CCD detectors which are mounted on the CCD support plane.
The readout electronic modules control the CCD and perform the conversion from the CCD signal to digital signals.
The Readout electronic modules power supply units provide dedicated voltages to the readout electronic modules.
The thermal hardware provides thermal control of the FPA as well as connection to dedicated radiator(s) (not part of the instrument).
The readout electronic modules and dedicated power supplies are hold together by a mechanical structure.
The overall FPA is attached to the payload optical bench by TBD.

3.3.3.2 VIS Instrument Control and Data Processing Unit (VI-CDPU)

The VI-CDPU performs the following task:

- Performs the overall control of the instrument based on the TC received from the SVM
- Controls the shutter

- Controls the readout electronic modules
- Controls the calibration unit
- Buffer the data coming from the readout electronic modules, perform lossless compression and transfer the data to the SVM for storage and TM.
- Acquire overall VIS HK and transmit them to the SVM for TM.

The software and harnesses to the different units are part of the VI-CDPU.

3.3.3.3 VIS Power Supply Unit (VI-PSU)

The VIS power supply unit delivers adapted voltages (from TBD primary voltage) to:

- the VIS FPA
- the VI-CDPU
- the VIS calibration unit
- the VIS shutter unit

The harnesses to the different units are part of the power supply unit.

3.3.3.4 VIS Calibration Unit (VI-CU)

The calibration unit is placed at a TBD location and provide uniform illumination on the VIS FPA.

3.3.3.5 VIS Shutter Unit (VI-SU)

The shutter unit is placed at a TBD location and consists of the mechanical shutter itself, the motors and related electronics. The shutter shall completely prevent the light from the telescope to reach the VIS FPA.

3.3.4 NISP instrument

The Near Infrared photo-spectrometer instrument NISP is presently consisting of the following units (TBC):

- the NISP Instrument Opto-Mechanical Assembly (NI-OMA)
- the NISP Instrument Control and Data Processing Unit (NI-CDPU)
- the NISP Focal plane Control and Data Processing Unit (NF-CDPU)
- the NISP Instrument Power Supply Unit (NI-PSU)
- the NISP Focal plane Power Supply Unit (NF-PSU)

3.3.4.1 NISP Instrument Opto-Mechanical Assembly (NI-OMA)

The NISP instrument opto-mechanical assembly consists of the following sub-units:

- the collimator unit
- the filter and grism wheels
- the camera opto-mechanical unit
- any folding optical element,
- the NISP calibration unit
- the NISP focal plane assembly
- the NISP support structure that support the different NISP optical units, filter wheels and focal plane assembly, as well as covers/baffling and dedicated thermal hardware (MLI, heaters, thermal sensors...)

3.3.4.1.1 The NISP instrument filter and grism wheels (NI-FW and NI-GW)

The NISP filter wheel shall accommodate all the filters needed to operate NISP in imaging mode and in spectroscopic mode. It consists of the wheel itself, the filters, the motors and associated electronics.
The NISP grism wheel shall accommodate 4 grisms (TBC) and a TBD filter/lens to operate NISP respectively in spectroscopic and imaging mode. It consists of the wheel itself, the grisms, filter/lens, the motors and associated electronics.

3.3.4.1.2 The NISP instrument calibration unit (NI-CU)

The NISP calibration unit provides:

- uniform illumination on the NISP FPA detectors.
- TBD point sources with known spectra on the NISP FPA.

3.3.4.1.3 NISP instrument FPA (NI-FPA)

The NISP FPA is integrated into the NISP instrument opto-mechanical assembly. It presently consists of the following elements:

- HAWAII 2-RG detectors (as specified in Appendix B) + flexis
- SIDECAR ASIC (as specified in Appendix B) +flexis
- Mechanical structure.
- Harnesses
- Thermal hardware.

Note 1: the need of a dedicated H2-RG/SIDECAR power supply shall be investigated.
Note 2: one sidecar per asic is considered at this stage (32 output mode) to decrease readout time while optimizing noise. Additional trade-off shall be carried out.

3.3.4.2 NISP Instrument Control and Data Processing Unit (NI-CDPU)

The NI-CDPU performs the following task:

- Performs the overall control of the instrument based on the received TC from the SVM
- Controls the filter wheel and grism wheel.
- Buffer the data coming from the FPA, perform lossless compression and transfer the data to the SVM for storage and TM.
- Acquire overall NISP HK and transmit them to the SVM for TM.

The software and harnesses to the different units are part of the NI-CDPU.

3.3.4.3 NISP Focal Plane Control and Data Processing Unit and Power Supply Unit (NF-CDPU and NF-PSU)

The NF-CDPU/PSU performs the following task:

- Controls the NISP Detector System
- Performs noise reduction and cosmic ray rejection
- Delivers adapted voltages to the FPA

The software and harnesses to the different units are part of the NF-CDPU and the NF-PSU

Note 1: lossless compression could potentially be included also in the NF-CDPU (TBC). Dedicated trade-off shall be carried out.

3.3.4.4 NISP Power supply unit (NI-PSU)

The NISP power supply unit delivers adapted voltages (from TBD primary voltage) to:

- the NI-CDPU
- the NI-CU
- the NI-FW
- the NI-GW

The harnesses to the different units are part of the power supply unit.

3.3.4.5 NISP Detector system (NI-DS)

Based on the sub-systems defined in the previous sections, the NI-DS system consists in:

- NI-FPA (defined in section 3.3.4.1.3)
- NF-CDPU (defined in section 3.3.4.3)
- NF-PSU (defined in section 3.3.4.3)

3.3.5 Instrument accommodation

The exact accommodation of the instruments is presently not known however for thermal reasons the following items (TBC) shall be located in the instrument cavity as defined on Figure 7:

- VI-FPA
- VI-CU
- VI-SU
- NI-OMA

The different units will be attached to PLM structure e.g. via an optical bench as defined in Figure 7.

The VI-CDPU, VI-PSU, NF-CDPU, NF-PSU, NI-CDPU and NI-PSU units shall be located in the SVM (TBC).

3.3.6 Instrument Resources and budget control

From the initial instrument design up to launch, the spacecraft resources allocated to the instruments will be controlled according to strict rules in order to show adequate margins, commensurate with the programme milestones.
Such margins will ensure that technical, schedule and financial risks are limited in the interest of all participants of the Euclid programme. The main resources submitted to margin control are: Mass Power, Data Rate, thermal and electrical interfaces. A margin philosophy shall be applied [NR2], with a contingency depletion scheme under control of the Euclid study team.

Mass [kg]	Power [W]	Science data Rate to mass memory unit [Gbit/day]
215 (TBC)	491 (TBC)	680 (TBC)

Table 3 Overall instrument resources allocations

The above table outlines the overall instrument resources on Euclid for mass, power and data rate.

3.4 Euclid service module

There are 8 major subsystems that constitute the Euclid service Module:

- Attitude and Orbit Control (AOCS): the AOCS provides the hardware and associated onboard software to acquire, control and measure the attitude of the satellite during all mission phases and modes according to the system requirements.
- Data Handling (Command and Data Management, CDMS): The Command and Data management Subsystem collects all telemetry data from the satellite. These data

include the scientific data, the science instrument housekeeping (HK) and the spacecraft housekeeping data. The data will be conditioned, digitised and encoded for transmission to ground via the TT&C subsystem. The CDMS will also process the up-link command signals received by the TT&C subsystem and decode, validate and distribute the commands to the users for execution.

- Communications (Tracking, Telemetry and Command): The Telemetry, Tracking and Command (TT&C) subsystems manage the reception and transmission of radio frequency signals for science and housekeeping data telemetry, telecommand and tracking. It is able to operate in both ways (up-link and down-link) during all mission phases when there is ground station contact
- Electrical Power (PCDU, Batteries and Solar array): the Power Control Subsystem conditions, controls and distributes the electrical power generated by the solar array to all payload instruments and spacecraft subsystems/units.
- Structure: the structure subsystems of the SVM supports the SVM units, carries the PLM, and provide interface to the launcher.
- Thermal Control: the thermal control subsystem (TCS) maintains the required SVM and PLM thermal environment for proper operations of equipment, taking into account the different environmental conditions.
- Propulsion: the propulsion subsystem comprises the propellant storage tanks, pipes, necessary valves and pressure transducers and the thrusters. The thrusters are commanded by the AOCS.
- Harness: The SVM harness provides all electrical connections between all electrical equipment in the service module. It includes harnesses for power supplies, signals and synchronisation. It includes also harnesses for connections with the PLM, the umbilical and test connectors.

3.5 Euclid thermal control System

The EUCLID thermal control system is based in the following major subsystems:

- A sunshield (equipped with solar cells, thus providing the solar generator for the satellite, protects the payload module from any incident sun light).
- A thermal (and optical TBC) baffle surrounding the payload module, preventing the direct view of the sun shield as well as from direct view of the cold background of the deep space.
- The SVM thermal control subsystem (TCS) which:
    - maintains the thermal environment required for all SVM units and instrument related units located in the SVM for proper operations of equipment.
    - perform the thermal control of the instrument cavity as well as the telescope assembly, optical bench.

- Provides dedicated thermal interfaces (cold finger, hot element…) to the instruments to allow passive heat dissipation and cooling via radiators (part of the TCS).

The Euclid ESVM will be thermally decoupled from the Euclid EPLM.

3.6 Euclid control and data handling architecture

The Euclid control and data management system (located in the SVM) will perform the following functionalities:

- the primary processing and I/O unit for all SVM subsystems
- the central communication node between the S/C and the Ground Station with the following major tasks:
  - distribution or execution of commands received from ground. In the particular case of the instruments, the data management system will distribute the commands to the dedicated instrument control and processing units.
  - collection, storage, and transmission the SVM and instrument telemetry.
- It will provide the reference signals for Reference Time generation and synchronization with the local timers of the other processors.
-

The following interfaces to the instruments are foreseen as provided by the data management system:

- Dedicated SpaceWire links used to support direct data transfer from instruments to the Mass Memory Unit.
- Communications via
  - MIL STD 1553 bus
  - Discrete I/O & Serial I/O link

The Mass Memory Unit will be sized to store up to 3 days of science in case ground communication is temporarily unavailable.

The basic preliminary avionics architecture (subject to evolution based on trade-off analysis) in relation to the instruments interface is shown in the following diagram.

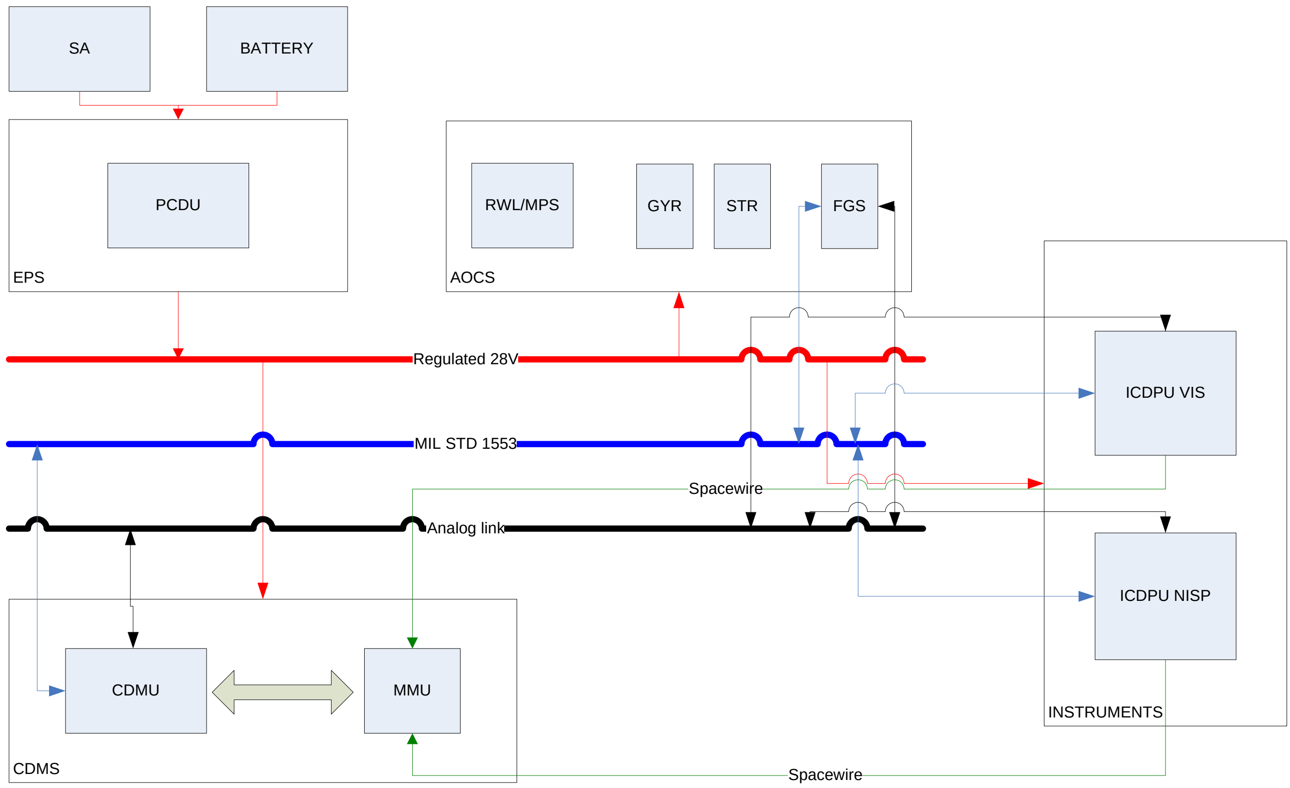

Figure 8 Euclid control and data handling architecture: instruments I/F with S/C avionics.

3.7 Euclid AOCS architecture

The AOCS functional architecture is based on the following set of functions

- Attitude sensor processing
- Attitude estimation
- Attitude guidance
- Control laws implementation
- Actuator command processing
- Thrust management for orbit correction manoeuvres
- TT&C Antenna repointing command
- AOCS FDIR Management and I/F with System FDIR

The Hardware architecture is based on the following set of sensors & actuators:

- Autonomous Star Tracker
- Gyroscopes
- Coarse Rate sensors
- Sun sensors
- Fine Guidance Sensor
- Reaction Wheels/Cold Gas (main actuator selection still TBD)

- Monopropellant thrusters

It is of special importance to notice that even if the FGS detectors have to be integrated in the VIS FPA (TBC), they will be directly managed by the Command and Data management subsystem; similarly the FGS control and processing will be performed by the SVM AOCS subsystem.

3.8 Operating modes

The following minimum operating modes are defined for the Euclid Spacecraft:

- Launch mode identifies the S/C state until separation from the launcher
- Sun Acquisition Mode is first reached after separation, permits the initial rate damping and the Sun acquisition
- Science Mode is the normal mode of operation during science observations and commissioning providing:
    - Fine pointing for image acquisition;
    - Dithering at spacecraft level as required by observation
- Coarse Pointing Mode where fast slew manoeuvres from the current spacecraft attitude to the new one to start the new scientific observations are performed
- Orbital Control Mode: the mode is entered to perform orbital control manoeuvres.
- Survival Mode is reached in case of major/critical problem. Sun tracking is performed by limiting the SAA in order to provide enough power generation to keep critical sub-system alive and for heaters to maintain the temperatures within the qualification range of each equipment in PLM and SVM.
- Communications Mode where communication is performed as well as scientific observations.

4 INSTRUMENT INTERFACES

4.1 Identification and labelling

4.1.1 Project code

TBD

4.1.2 Unit identification code

TBD

4.1.3 Connector identification code

TBD

4.2 General design requirements

4.2.1 Standard metric system

Drawings, specifications and engineering data shall use the International System (SI) Metric
Standard, with the exceptions allowed in NR3 – Table E-3 and 5 . The key and derived units shall be specified in:

- Dimensions in Millimetres [mm]
- Angles in degrees
- Temperatures in degrees Celsius
- Power / Heat in Watts [W]
- Energy in Joules [J]
- Mass in Kilogram [kg]
- Magnetic Field in Tesla [T]
- Time in seconds [s]
- Electric Current in Ampere [A]
- Amount of substances in moles
- Luminous Intensity in candelas

4.2.2 Lifetime requirements

1. design lifetime requirements shall be applied (if not specified differently elsewhere in the documentation for mechanical, thermal and electrical design) with respect to environmental influences and use conditions,

2. Where the design margin is required for demonstration of resistance to failure modes, a factor of two times (TBC) the nominal lifetime shall be included as a minimum.
3. In the frame of the instrument design the following lifetime requirements shall be made applicable to all parties involved in the instruments:
- the overall instrument lifetime shall be compatible with the nominal mission duration of 5 years in space.

4.2.3 Maintainability

TBD

4.2.4 Fault tolerance

TBD

4.3 Co-ordinate system

4.3.1 S/C reference coordinate systems

4.3.1.1 Euclid physical reference frame

The Spacecraft Co-ordinate Systems are axis reference frames physically attached to the respective spacecraft.
All reference frames shall be right-handed orthogonal triads.
The Euclid Physical Reference frame shall be as defined in Table 4.

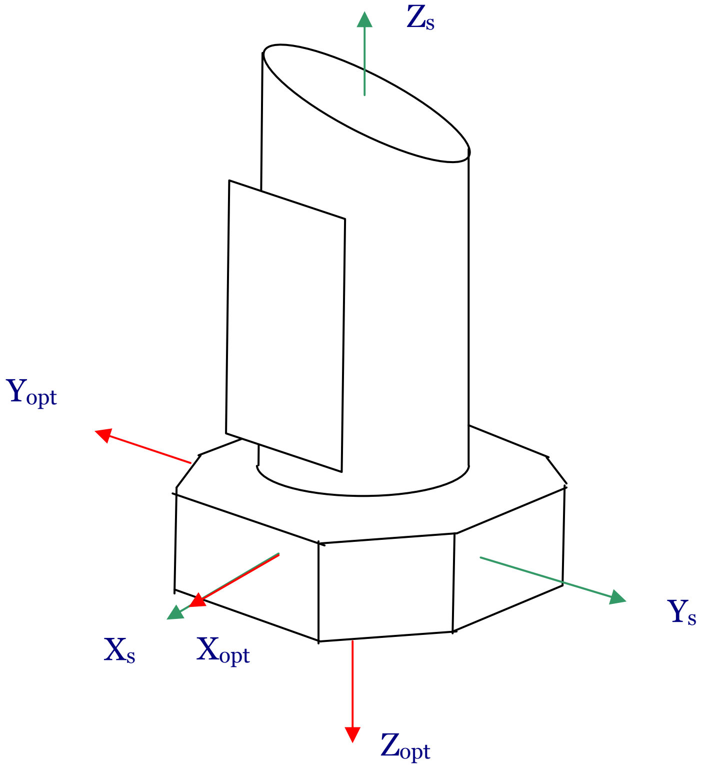

Figure 9 Schematic representation of the Euclid physical reference frame (and optical)

Item	Definition
Origin	in the geometrical centre of the launcher interface,
$+X_s$	in the launcher interface plane, directed to a physical mark on the interface ring, defining the average Sun direction,
$+Y_s$	complete the right-handed orthogonal frame (Xs,Ys,Zs),
$+ Z_s$	coinciding with the direction perpendicular to the launcher interface plane, oriented towards the top of the spacecraft.

Table 4 Euclid physical reference frame.

4.3.1.2 Euclid Optical Reference Frame

The Euclid optical reference frame shall be as defined in Table 5.

Item	Definition
Origin	At the M1 Vertex
$+X_{opt}$	Parallel to +Xs pointing toward the sun
$+Y_{opt}$	Parallel to +Ys (complete the right-handed orthogonal frame X_{opt}, Y_{opt},

	Z_{opt})
+ Z_{opt}	Parallel to +Zs, opposite direction.

Table 5 Euclid optical reference frame.

The normal to an optical surface (direction corresponding to the light) at its centre (x_o, y_o,z_o) in the optical reference frame will be given by a triplet (α,β,γ) where:

- α defines the rotation angle around the Xopt axis, leading to a new reference frame (X_{opt}',Y_{opt}',Z_{opt}').
- β defines the rotation angle around the Yopt' axis, leading to a new reference frame (X_{opt}'',Y_{opt}'',Z_{opt}'').
- γ defines the rotation angle around the Yopt' axis, leading to a new reference frame (X_{opt}''',Y_{opt}''',Z_{opt}''').

The direction is defined by the axis Z_{opt}''' at the location (x_o,y_o,z_o).

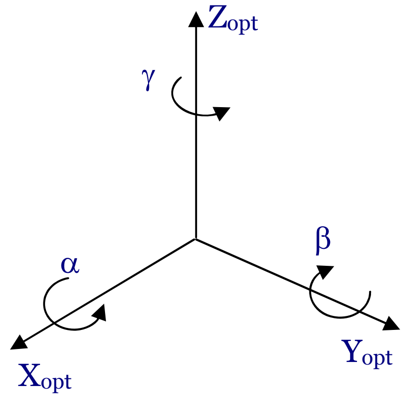

Figure 10 Surface orientation angles definition.

4.3.1.3 Unit co-ordinate System

Unit reference Frame (URF) [Xu, Yu, Zu]

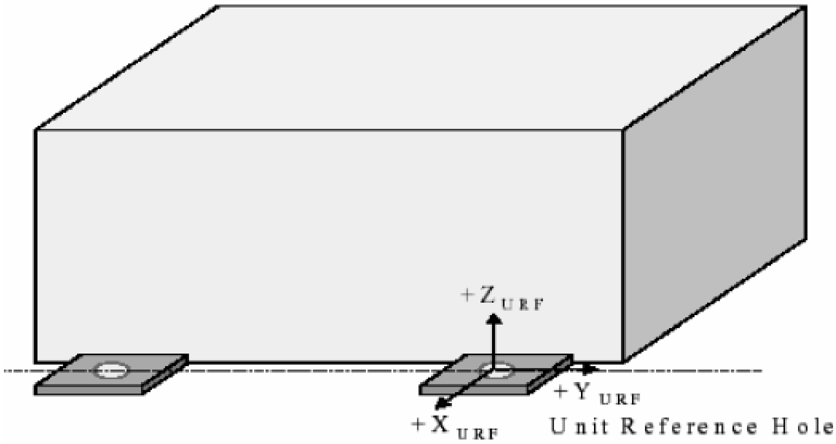

Figure 11 Unit Reference Frame (URF)

4. In order to provide a local reference system for describing the unit physical properties each instrument unit shall have a right-handed ☐artesian coordinate system see Figure 11.

One option for the URF system is defined as follows:
• the origin is located in the centre of the reference hole on the interface plane. (The reference hole can be freely selected as best suited for the instrument)
• the mounting plane is the plane of the unit that is to be attached to the spacecraft and it shall contain the Xu and Yu axis.
• the +Zu axis is normal to the mounting plane in the direction from the mounting plane to the unit.
• the Yu axis should pass through the centre of at least one other mounting hole in addition to the one located at the origin.
2. The definition of the unit co-ordinate system shall be contained in the unit configuration drawings.

4.4 Instrument location and alignment

4.4.1 Instrument location

TBD

4.4.2 Instrument alignment

TBD

4.5 External configuration Drawings

For each instrument unit, a configuration drawing is required to establish the mechanical interfaces with the spacecraft structure, harnesses and thermal hardware.

These drawings shall contain the following information:
• Dimensions and associated tolerances (at ambient temperatures), including feet, internal connectors and their dedicated clearance
• Focus position w.r.t. instrument coordinate system (dimensions and tolerances at operational temperatures)
• Identification of a reference hole
• Mounting hole pattern dimensions and hole patterns
• Dimensions of mounting feet and contact area (base-plate and mounting feet)
• Spot-faced area for seating of the mounting screw washers (if and where applicable)
• Dimensions and location of dowel pins (where applicable)
• Mass and associated tolerances (precise if estimated, calculated or weighted)
• Location, naming, type and function of all connectors
• Connector key shape orientation, the identification of connector contact "1", showing connector in front view and the connector center line
• Information about connector fixation
• Identification of bonding studs
• Identification of non-flight items
• Location of unit and connector identification labels
• Details of instrument provided mounting hardware, thermal/electrical isolation
• Location and routing of any harness interconnecting modules of a "stacked" box configuration
• Identification of free areas for harness fixation
• Calculated Centre of Gravity location in instrument unit co-ordinate system and Moments of Inertia and its co-ordinate system if different from instrument unit coordinate system
• Location of transport/storage purging connections (if applicable)
• Material of housing and surface finish
• Flatness and roughness of contact area
• Base plate material and surface treatment
• Surface coating (IR Emissivity and Solar absorptance if external location)
• Specific heat (J/Kg/K) (calculated or measured)
• Design and location of handling points

2. Drawings shall clearly specify the unit they represent and the responsible design authority; they shall be subject to a properly controlled numbering and revision updating system. Each revision of a drawing shall be accompanied by a list detailing all changes that I incorporated since the previous revision on the drawing itself.

3. 2D Drawings shall be submitted to the Euclid study team as computer readable and editable files, preferably in a vectorial file format (.hgl, .drw or .cgm (compatible MS word) , or pdf avoid definition loss) together with one hard copy of each file.

4. The Metric Standard (SI-SYSTEM INTERNATIONAL) shall be used for design and manufacturing of all instruments. For components and equipment, the dimensions shall be given in millimetres and the angles in degrees.

4.6 Size and mass

4.6.1 Mass tolerances

TBD

4.6.2 Centre of gravity Location and tolerances

TBD

4.6.3 Moments of Inertia and tolerances

TBD

4.6.4 Overall instrument mass allocation

The mass margins to be applied are:

- > 5 % for "Off-The-Shelf" items (ECSS Category: A / B, see NR4)
- > 10 % for "Off-The-Shelf" items requiring minor modifications (ECSS Category: C, see NR4)
- > 20 % for new designed / developed items, or items requiring major modifications or re-design (ECSS Category: D, see NR4).

The total mass allocated for the Euclid instruments is given in Table 3. The detailed breakdown is given hereafter.
As mentioned in section 1.2, the present unit breakdown and related resources shall be subject to trade-off analysis and shall therefore only considered as a starting point. For the ICDPU units, redundancy has been considered for the mass estimate.

The VIS imager (all units) shall have a maximum total mass of 107 kg (TBC) with a preliminary breakdown as indicated in Table 6.

Unit	Mass (kg)
VI-FPA	66 (TBC)

VI-CDPU	18 (TBC)
VI-PSU	14 (TBC)
VI-CU	1 (TBC)
VI-SU	8 (TBC)

Table 6 VIS instrument preliminary mass breakdown (including 20 % margin).

The NISP imager (all units) shall have a maximum mass of 108 kg (TBC) with the following preliminary breakdown as indicated in Table 7.

Unit	Mass (kg)
NI-FPA	10(TBC)
NI-CDPU+ NI-PSU+ NF-CDPU+NF-PSU	30 (TBC)
NI-OMA (without NI- FPA)	68 (TBC)

Table 7 NISP instrument preliminary mass breakdown (including 20% margin).

The following table shows the corresponding mass breakdown with respect to SVM and PLM mounted equipements.

SVM mounted Unit	Mass (kg)
VI-CDPU+ VI-PSU	32 (TBC)
NI-CDPU+ NI-PSU+ NF-CDPU+NF-PSU	30 (TBC)
Total	62 (TBC)

Table 8 SVM mounted VIS and NISP units masss breakdown.

PLM mounted Unit	Mass (kg)
VI-FPA	66 (TBC)
VI-CU	1 (TBC)
VI-SU	8 (TBC)
NI-FPA	10 (TBC)
NI-OMA (without NI-FPA)	68 (TBC)
Total	153 (TBC)

Table 9 PLM mounted VIS and NISP units mass break down.

4.6.5 Geometrical models

For each unit (as defined in sections 3.3.3 and 3.3.4), the instrument provider shall maintain a GeometricalModel (CATIA files including mass properties and, specifically mechanical interfaces) to be delivered to the Agency upon request.

4.6.6 FEM models

For the following units:

- NISP instrument opto-mechanical assembly (NI-OMA)
- VI-FPA

he instrument provider shall maintain a FEM model (NASTRAN files) to be delivered to the Agency upon request.

4.7 Mechanical interfaces

4.7.1 EPLM

The centre of the VIS FPA front surface shall be located at the position (in the optical reference frame):
(-740.34930 mm,-1116.35679 mm,600.0000 mm) with the normal of the surface (toward the FPA) defined by the triplet (-90,-89.913,90)

The centre of the front surface of the first optical element of the NISP instrument shall be located (in the optical reference frame):
(405.44247 mm,78.96293 mm,600.0000 mm) with the normal to the surface (toward the surface) defined by the triplet (-90,0,90).

4.7.2 ESVM

For instrument units located in the ESVM. TBD

4.7.3 Payload generated disturbances

The instrument providers shall define the instrument generated disturbances (ie internal mechanisms, etc). First level estimates shall include the moving mass and the movement frequencies and characteristics.

4.7.4 Overall instrument volume allocation

As mentioned in section 1.2, the present unit breakdown and related resources shall be subject to trade-off analysis and shall therefore only considered as a starting point/overall envelop.

4.7.4.1 VIS

The VI-FPA shall have a maximum volume of 500 x 500 x 500 mm x mm x mm (TBC).
The VII-CDPU shall have a maximum volume of 270 x 270 x 270 mm x mm x mm (TBC).
The VI-PSU unit shall have a maximum volume of 300 x 300 x 300 mm x mm x mm (TBC).

The VI-CU shall have a maximum volume of TBD.
The VI-SU shall have a maximum volume of TBD.

4.7.4.2 NISP

The NI-CDPU and NF-CDPU shall each have a maximum volume of 270 x 270 x 150 mm x mm x mm (TBC).
The NI-PSU and NF-PSU units shall each have a maximum volume of 270 x 150 x 180 mm x mm x mm (TBC).
The NI-OMA shall have a maximum volume of 1100 x 550 x 650 mm x mm x mm (TBC, the last given dimension is along the Zs axis as defined in Figure 9).

4.8 Thermal interfaces

4.8.1 Thermal control definitions and responsibilities

4.8.1.1 Thermal control definitions

This section provides a list of terms used in the context of thermal control. It excludes the ground phases (test, transport, storage).

1. The definition of the interface temperatures and associated margins shall be according to the following definitions:

Mission
The word "mission" covers the launch and flight phases.

Spacecraft Thermal Control sub-System (TCS)
The Spacecraft TCS includes all the means, hardware (heaters, thermostats, temperature sensors...) and software, to control the spacecraft heat flows and temperatures.

Unit
The word "unit" refers to a payload instruments under the responsibility of the IP.

Unit Reference Point (URP)
The URP is a physical point located on the unit close to the mechanical interface to the spacecraft. Its temperature provides a simplified representation of the unit thermal behaviour. Its temperature is controlled by the TCS.

Cold Finger Interface Temperature (T_{CF})
Temperature of the cold finger structure used to define the conductive heat exchange to the spacecraft.

Hot Element Interface Temperature (T_{HE})
Temperature of the hot element interface used to define the conductive heat exchange to the spacecraft.

Radiative Sink Temperature (T_R)
This is a virtual black body radiation temperature used to define the equivalent radiative thermal load on a unit.

Unit Temperatures
All unit temperatures recalled in this section shall be defined at the URP and given for the following conditions:
• at switch-on
• when operating
• when non-operating
They are the design temperatures specified for the ground and mission phases.
(TCS) Design Temperature Range
This is the maximum range of temperature experienced in flight by a unit throughout the mission and during ground phases. In absence of specification, the ground range is assumed to coincide with the flight range.

(TCS) Calculated Temperature Range
This is the unit temperature range obtained by analysis excluding prediction uncertainties.

(TCS) Predicted Temperature Range
This is the temperature range obtained by adding the prediction uncertainties to the calculated temperature range.

Switch-on Temperature
This is the lowest temperature at which a unit can safely be switched-on throughout the mission and during ground phases. In absence of specification, the ground range is assumed to coincide with the flight range.

(TCS) Acceptance Temperature Range
It is an extension of the design temperature range by the acceptance margin at both ends. Partial deviation from the performance requirements may be accepted within unit qualification margins provided they do not affect the interfaces with the spacecraft and they are reversible when the unit is brought back within its acceptance test temperature range.

(TCS) Acceptance Test Temperature Range
All flight units shall be tested prior to delivery to the spacecraft at this extreme temperature range.
It is an extension of the acceptance range by the test uncertainties.

(TCS) Qualification Temperature Range
It is an extension of the acceptance temperature range by the qualification margin at both ends.

(TCS) Qualification Test Temperature Range
This is the extreme test temperature range at which a unit shall be tested to qualify its design. It is an extension of the qualification range by the test uncertainties.

(TCS) Internal Design Temperature Range
This is the extreme temperature for which unit components or parts are selected.
The URP temperatures and margin logic are TBD.

4.8.1.2 Spacecraft thermal control system responsibilities

The spacecraft will:

- design the spacecraft TCS
- maintain the URP within their allowable range at any time of the mission (design limits) and during ground operations.
- Monitor the URP
- Define, procure and install the necessary thermal control H/W (heaters, thermostats, temperature sensors…) and control S/W that is necessary to provide the relevant interfaces
- Demonstrate the performance of the TCS by analysis and test incl. uncertainties

4.8.1.3 Instrument responsibilities

1. Define and describe the unit internal thermal design with particular attention to:
• the thermal control principles,
• the baffle (if required), the cold finger (for FPAs) and the hot elements of the unit,
• the thermal interfaces to the spacecraft.
2. Define the URP location.
3. Define the URP temperature and the temperature requirements of critical internal parts.
4. Maintain the internal parts within their allowed temperature limits during:
• the mission i.e. launch and flight,
• ground phases,
• unit level acceptance and qualification tests.
5. Provide an Interface Geometric Mathematical Model (IGMM) and an Interface Thermal Mathematical Model (ITMM) for coupled thermal analysis with the spacecraft as specified in TBD section Thermal Mathematical Models.
6. Procure the necessary instrument thermal H/W such as heaters, etc. to maintain the payload unit within the specified temperature limits.
7. Provide the figures on the heat dissipated by the unit and report the interface heat flux in allrelevant environments.

8. Demonstrate the performance of the unit internal thermal design by analysis and test including uncertainties.

4.8.2 Thermal interface definition

The instrument providers shall use the following definitions in defining the instrument units interface with the spacecraft.

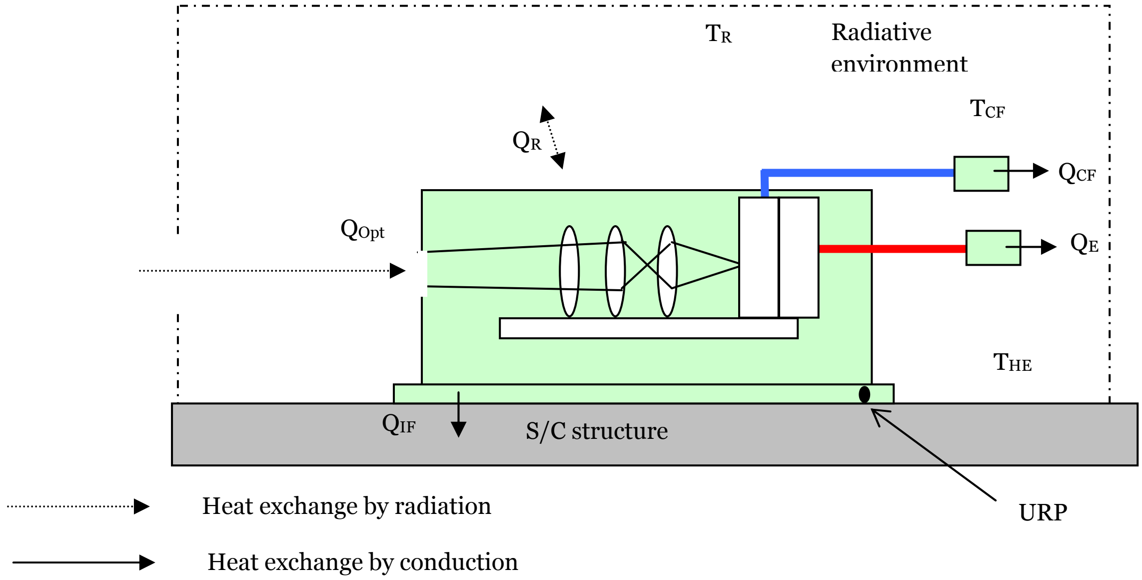

Figure 12 Temperature and heat load definition for units mounted in the PLM.

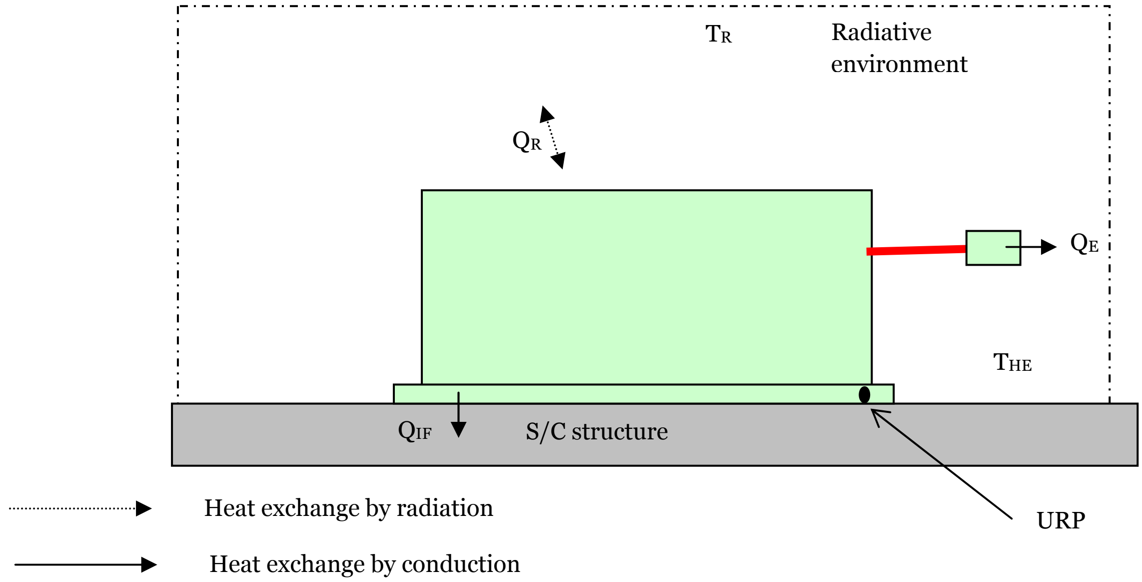

Figure 13 Temperature and heat load definition for units mounted in the SVM.

The above mentioned thermal interfaces can be summarized as follows:

- Conductive interface temperature: T_{URP}.
- Net conductive Heat flux: Q_{IF}
- Radiative Interface Temperature: T_R
- Cold finger Interface Temperature: T_{CF}
- Net conductive Heat flux: Q_{CF}
- Hot element Interface Temperature: T_{HE}
- Net conductive Heat flux: Q_{HE}
- Net radiative heat flux along the optical beam (from spider, baffle, telescope..): Q_{OPT}

4.8.3 Thermal interfaces - margins

The parameter inaccuracies to be taken into account during Phase A/B1 are shown in Table 10.

Parameter	Inaccuracy
MLI conductance	± 50 %
External radiative connections	± 20 %
Internal radiative connections	± 10 %
Linear connections	± 50 %
External heat loads	± 20 %
Internal heat loads	
- large values	± 20 %
- small values	± 40 %

Table 10 Thermal parameter inaccuracies to be taken into account in Euclid phase A/B1.

4.8.4 Thermal interfaces on the EPLM

4.8.4.1 Concept

The preliminary thermal concept is schematically shown on Figure 14. The optical bench as well as the payload cavity envelop will be at a temperature of 150 K (emissivity of 0.05 TBC corresponding to MLI), ie T_R=150K, T_{URP} for VIS and NISP units is 150 K (TBC).

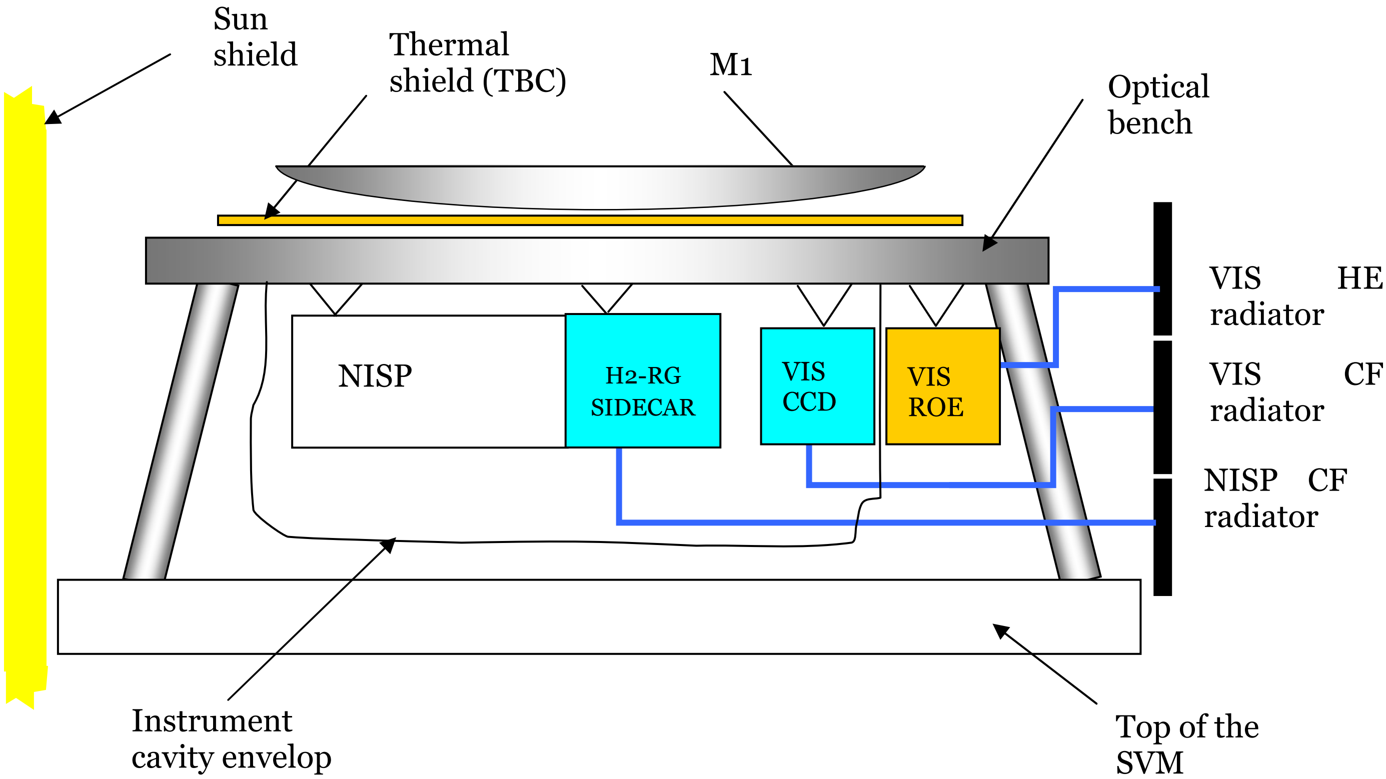

Figure 14 Euclid instrument thermal concept.

Both instruments will have 2 (TBC) radiators with the given interfaces:

- Cold Fingers used for:
- * VIS: CCD detectors (TBC)
- * NISP: H2-RG + SIDECAR (TBC)
- Thermal straps (TBC) used forHot Elements:
- VIS: readout electronic modules of the FPA (TBC)
- NISP: TBC (corresponding radiator not represented on Figure 14).

For power dissipated by mechanisms (mainly transient), a TBD interface is foreseen.
The VIS FPA front electronic module (located behind the CCD but operated warm) will not be within the instrument cavity envelop.

4.8.5 Thermal interfaces on the ESVM

TBD

4.8.6 Thermal interface requirements

1. The Instrument interface heat flow provided in Table 11 defines the maximum allowable heat load from the instrument interfaces.

Instrument unit	Max allowable heat load					
	Q_{HE} (W)	Q_{CF} (W)	Q_R(W)	$Q_{I/F}$ (W)	Total	Note
VI- FPA	143 (TBC)	4.8 (TBC)	TBD	TBD	TBD	Sub-unit analysis is required to define Q_R and $Q_{I/F}$
VI-SU	TBD	-	TBD	TBD	TBD	
VI-CU	TBD	TBD	TBD	TBD	TBD	
VI-CDPU	TBD	-	TBD	TBD	TBD	
VI-PSU	TBD	-	TBD	TBD	TBD	
NI-FPA	2.9 (TBC)	0.12 (TBC)	TBD	TBD	TBD	Sub-unit analysis is required to define Q_R and $Q_{I/F}$
NI-OMA	TBD	-	TBD	TBD	TBD	
NI-CDPU	TBD	-	TBD	TBD	TBD	
NI-PSU	TBD		TBD	TBD	TBD	
NI-CDPU	TBD	-	TBD	TBD	TBD	
NF-PSU	TBD		TBD	TBD	TBD	

Table 11 Instrument maximum allowable thermal load to Spacecraft (TBC)

Note 1: the maximum heat load for the VIS FPA on CF has been made with the following assumption:
- 36 CCDs
- 112 mW per CCD
- 20 %margin

Note 2: the maximum heat load for the VIS FPA on HE has been made with the following assumption:
- 12 Readout electronic modules
- 12 dedicated power supply unit
- 20 % margin

Note 3: the maximum heat load for the NISP-FPA H2-RG has been made with the following assumption:
- 6 mW per H2-RG, 16 H2-RG
- 20 % margin

Note 4: the maximum heat load for the NISP-FPA SIDECAR has been made with the following assumption:

- 150 mW per SIDECAR, 16 SIDECAR
- 20 % margin

Note 5: No power dissipation associated to thermal control has been considered yet.
Note 6: Transient heat load associated to mechanisms will be included later on after trade-off and dedicated analysis.

2. The instrument interface design temperature range shall be as presented in Table 12.

Unit	T_{HE}, T_{URP} (K)					T_{CF}	T_R	
	Min non op	Min op	Max op	Max non op	start	Max Op	Max	Min
VI-FPA	240,150 TBC	240,150 TBC	240,150 TBC	240,150 TBC	120,150 TBC	140 TBC	150 TBC	150 TBC
VI-SU	TBD,150 TBC	TBD,150 TBC	TBD,150 TBC	TBD,150 TBC	TBD,150 TBC	-	150 TBC	150 TBC
VI-CU								
VI-PSU	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	-	293 K TBC	293 K TBC
NI-FPA	120,150 TBC	120,150 K TBC	120,150 K TBC	120,150 K TBC	120,150 K TBC	90 K TBC	150 TBC	150 TBC
NI-CDPU	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC		293 TBC	293 TBC
NI-PSU	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC		293 TBC	293 TBC
NF-CDPU	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC		293 TBC	293 TBC
NF-PSU	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC	TBD,293 TBC		293 TBC	293 TBC
NI-OMA (excluding NI-FPA)	120,150 TBC	120,150 TBC	120,150 TBC	120,150 TBC	120,150 TBC	-	150 TBC	150 TBC

Table 12 Thermal interface temperatures.

3. Q_{opt} for NI-OMA and VIS-FPA are TBD.

4.8.7 Temperature stability

TBD

4.8.8 Temperature monitoring

The temperature monitoring request expressed by instrument will be satisfied. In addition the thermal control system will have a certain number of sensors for temperature control and temperature monitoring used to guarantee that the temperature is in the required range. These temperature information will be available in the TM.

4.8.9 Thermal models

For each unit (as defined in sections 3.3.3 and 3.3.4), the instrument provider shall maintain a Thermal and Geometrical Mathematical Model (ESATAN/TMS files with related description) to be delivered to the Agency upon request.

4.9 Optical interfaces

4.9.1 Euclid telescope interface

The Euclid telescope in its present version is described in section 3.3.1. It has to be noted that the dichroic is considered as part of the telescope.

4.9.1.1 Optical interface requirements

4.9.1.1.1 VIS

The following optical interface requirements will be fulfilled by the telescope at the VIS Focal plane array:

- Un-vignetted telescope field of view: 0.590 deg x 0.786 deg (TBC)
- Central obstruction (surfacique): 8.4 % (TBC)
- System f/D: 20.4167 (TBC)
- Transmission: TBD %

4.9.1.1.2 NISP

The following optical interface requirements will be fulfilled by the telescope at the exit pupil:

- Un-vignetted field of view: 0.586 x 0.832 deg x deg (TBC)
- Central obstruction (surfacique): 8.4 % (TBC)
- System f/D: 20.4167 (TBC)
- Pupil size: 96.6 mm (to be oversized for pupil wander TBC)
- Transmission: TBD %

4.9.1.2 Telescope optical parameters

Defined in Table 2.

4.9.2 Survey field of view

The Survey field of view is defined as the maximum field size common to both VIS and NISP instrument: Geom_x ▪ Geom_y0.586 x 0.786 (TBC), where Geom_y corresponds to the direction of slew of the spacecraft from one field to another.

4.9.3 Straylight

The straylight level for VIS and NISP will be limited to 20 % of the zodiacal background in the corresponding wavelength ranges.

The contrast ratio of ghost images to image source in theVIS field of view will be less or equal to 10-4 (TBC).

4.9.4 Thermal background

The telescope primary and secondary mirrors will be at a maximum temperature of 240 K (TBC). The emissivities of the different optical elements are TBD.

4.9.5 Optical model

For the following units:
- NISP instrument opto-mechanical assembly (NIOMA)
- VIS assembly

The instrument provider shall maintain an optical model (ZEMAX/Code V) to be delivered to the Agency upon request.

4.10 Power

The power margins to be applied are:

- > 5 % for "Off-The-Shelf" items (ECSS Category: A / B, see NR4)
- > 10 % for "Off-The-Shelf" items requiring minor modifications (ECSS Category: C, see NR4)
- > 20 % for new designed / developed items, or items requiring major modifications or re-design (ECSS Category: D, see NR4).

4.10.1 Thermal dissipation in the Euclid payload module

See section 4.8.6.

4.10.2 Thermal dissipation in the Euclid service module

The VIS instrument shall dissipate a maximum of 99 Watts (TBC) in the ESVM.

The NISP instrument shall dissipate a maximum of 171 Watts (TBC) in the ESVM.

4.10.3 Power supply- Load on main bus

The VIS imager shall use a maximum power of 292.8 Watts (TBC):
- 147.8 Watt (TBC) for the FPA
- 73 Watt (TBC) for ICDPU
- 36 Watt (TBC) for PSU
- 36 Watt (TBC) for mechanisms and calibration unit.
- TBD watt for thermal control

The NISP imager shall use a maximum power of 198 Watt (TBC) :
- 136 Watt (TBC) for ICDPU+FCDPU
- 35 Watt (TBC) for PSU's
- 3.0 Watt (TBC) for the FPA
- 24 Watt (TBC) for mechanisms and calibration unit.
- TBD Watt for thermal control

4.11 Connectors, harness, grounding, bonding

TBD

4.12 Data handling

The following interfaces are foreseen (TBC) as provided by the Euclid data management system:
- Dedicated SpaceWire links used to support direct data transfer from instruments to the Mass Memory Unit.
- Communications via
  - MIL STD 1553 bus
  - Discrete I/O & Serial I/O link

The Mass Memory Unit will be sized to store up to 3 days of science in case ground communication is temporarily unavailable
The overall satellite operations in flight are organized into satellite modes. Each mode is defined by a set of subsystems and instruments modes and configuration. Correspondence between the defined modes and the various phases of the mission is still TBD.

4.12.1 Telemetry

The data of the instruments will be categorized in science data and instrument housekeeping data.
The instruments will have to:

- provide HK data to the Euclid data management system on board computer for monitoring and packetization whenever they are switched on.
- interface directly with the mass memory unit of the Euclid data management system for storage of packetized science data.

4.12.2 Telecommand

The telecommand interface between the instruments and the Euclid control and data management system is still TBD.
The Commands can be received from different sources (TBC) where the source is indicated in the TC header:

- Ground
- Mission Timeline
- On Board Control Procedures
- FDIR procedures

The total telecommand rate will be shared between spacecraft and instruments commanding. The maximum telecommand rate will be TBD kbits/s. The maximum command rate to the instruments will be TBD kbits/s.

4.13 Attitude and orbit control/pointing

4.13.1 Definition

- Attitude Measurement Error (AME): AME is the instantaneous angular separation between the actual LoS direction and the estimated LoS direction. This is referred to as 'a posteriori knowledge'.
- Absolute Pointing Error (APE): is the angular separation between the desired LoS direction, and the instantaneous actual LoS direction.
- Relative Pointing Error (RPE): is the angular separation between the instantaneous LoS direction and the short time average LoS direction during some time interval. This is also known as the pointing stability

4.13.2 Pointing requirements

The following pointing requirements need to be meet during the different phases of the mission:

	X (arcsec)	Y (arcsec)	Z (arcsec)
APE	TBD	TBD	TBD
RPE (integration time)	TBD	TBD	TBD
AME	TBD	TBD	TBD

Table 13 Pointing requirements summary table.

4.13.3 AOCS Modes

TBC

4.13.4 AOCS calibration

4.13.4.1 Star Tracker

TBD

4.13.4.2 Fine Guidance Sensor

TBD

4.13.5 Attitude constraints

The EUCLID S/C will be compatible with SAA up to TBD deg in order to complete the sky survey in the required period of time. The design of the S/C will be compatible with all range of SAA in order to guarantee the functionality and required performance for both SVM and PLM.

4.14 On-board hardware/software and autonomy functions

TBD

4.15 EMC

TBD

4.16 Instrument handling

TBD

4.17 Environment requirements

4.17.1 Pressure

TBD

4.17.2 Mechanical environment

Instruments shall be designed to withstand the mechanical environment during all phases of AIV/AIT, qualification and acceptance testing and that produced at launch.

4.17.2.1 Stiffness requirement

The instruments and their components shall have a first global resonance above the following values:

Units with a mass ≤ 50kg: f < 140Hz
Units with a mass > 50kg: f > 60Hz

All experiments units with mechanisms locked during launch shall show a first resonance frequency higher than 2Hz (TBC) in unlocked configuration.

4.17.2.2 Design limit loads

For the purpose of global dimensioning of P/L units and of their interfaces, the strength requirements are defined below. These are Design Loads which are to be applied simultaneously and are applicable to the centre of gravity. These loads can apply in any direction. The design shall also consider loads resulting from local dynamic amplifications that can occur during sine or random vibration excitations.

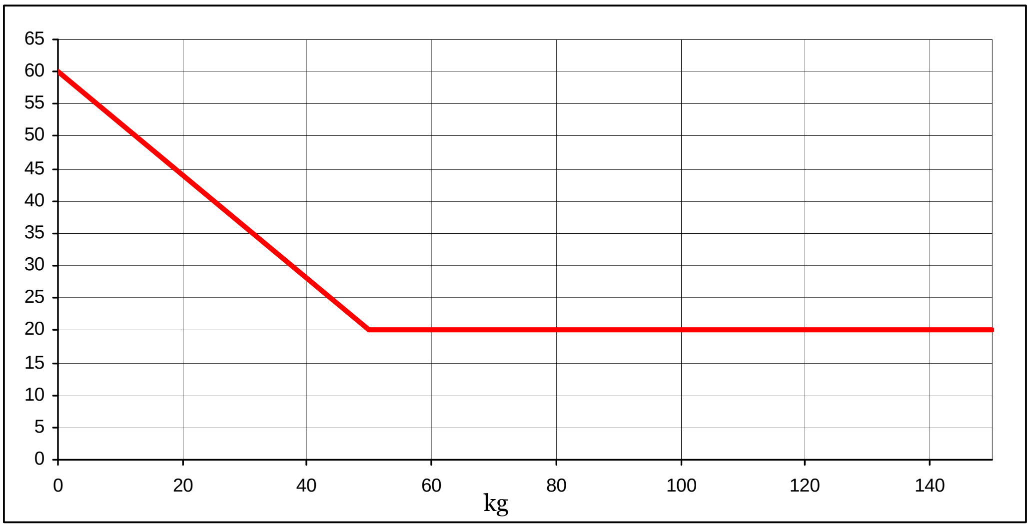

Table 14 Design loads

4.17.2.3 Margin of safety

The design shall have positive margin of safety which is defined by the following formula:

$$MOS = \frac{(allowable\ load)}{(applied\ load) \times FOS} - 1$$

with:

allowable load: allowable load under specified functional conditions (e.g. yield, buckling, ultimate)

applied load: computed or measured load under defined load condition (design loads)

FOS: Factor of safety applicable to the specified functional conditions including the specified load conditions (e.g. yield, ultimate, buckling)

Safety factors are specified in the NR6 section 4.3.2.

4.17.3 Thermal environment

TBD

4.17.4 Radiation environment

The expected radiation environment at L2 is described in details in IR2.

4.17.4.1 Total ionizing dose

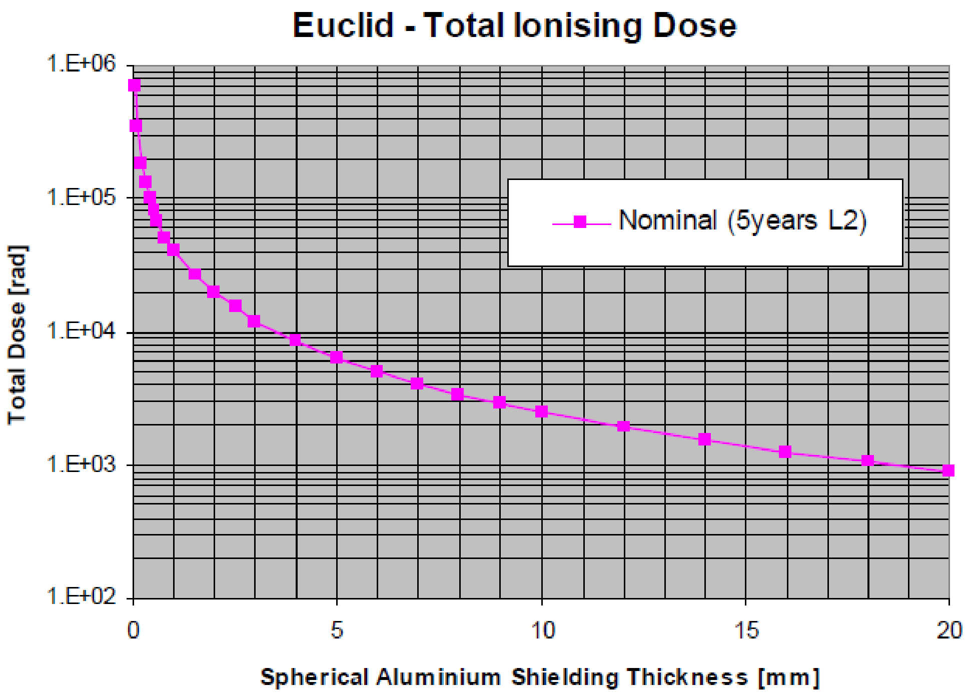

Figure 15 Dose in Si as a function of spherical Al shielding as calculated by SHIELDOSE (IR2) .

4.17.4.2 Non ionizing Energy Loss

Aluminium shielding thickness [mm]	Non ionising energy loss and equivalent proton fluence			
	Energy loss [MeV/g(Si)]	Eq 10MeV Proton fluence [#/cm2]	Eq 60MeV Proton fluence [#/cm2]	Eq 200MeV Proton fluence [#/cm2]
0.05	1.30E+10	1.89E+12	3.76E+12	5.42E+12
0.1	5.85E+09	8.48E+11	1.69E+12	2.44E+12
0.2	2.99E+09	4.34E+11	8.66E+11	1.25E+12
0.3	2.15E+09	3.11E+11	6.21E+11	8.94E+11
0.4	1.66E+09	2.41E+11	4.82E+11	6.94E+11
0.5	1.33E+09	1.92E+11	3.84E+11	5.53E+11
0.6	1.11E+09	1.61E+11	3.22E+11	4.64E+11
0.8	8.22E+08	1.19E+11	2.38E+11	3.43E+11
1	6.69E+08	9.70E+10	1.94E+11	2.79E+11
1.5	4.24E+08	6.15E+10	1.23E+11	1.77E+11
2	3.25E+08	4.71E+10	9.39E+10	1.35E+11
2.5	2.46E+08	3.56E+10	7.10E+10	1.02E+11
3	2.04E+08	2.95E+10	5.90E+10	8.49E+10
4	1.45E+08	2.10E+10	4.20E+10	6.05E+10
5	1.10E+08	1.59E+10	3.18E+10	4.58E+10
6	8.92E+07	1.29E+10	2.58E+10	3.72E+10
7	7.45E+07	1.08E+10	2.15E+10	3.10E+10
8	6.18E+07	8.96E+09	1.79E+10	2.58E+10
9	5.40E+07	7.83E+09	1.56E+10	2.25E+10
10	4.74E+07	6.87E+09	1.37E+10	1.97E+10
12	3.70E+07	5.37E+09	1.07E+10	1.54E+10
14	3.07E+07	4.45E+09	8.89E+09	1.28E+10
16	2.52E+07	3.65E+09	7.28E+09	1.05E+10
18	2.18E+07	3.16E+09	6.30E+09	9.08E+09
20	1.84E+07	2.67E+09	5.33E+09	7.67E+09

Figure 16 Non-Ionizing Energy Loss and equivalent proton fluences as a function of shielding thickness for the Euclid nominal mission (IR2).

4.17.4.3 Single Event Effects

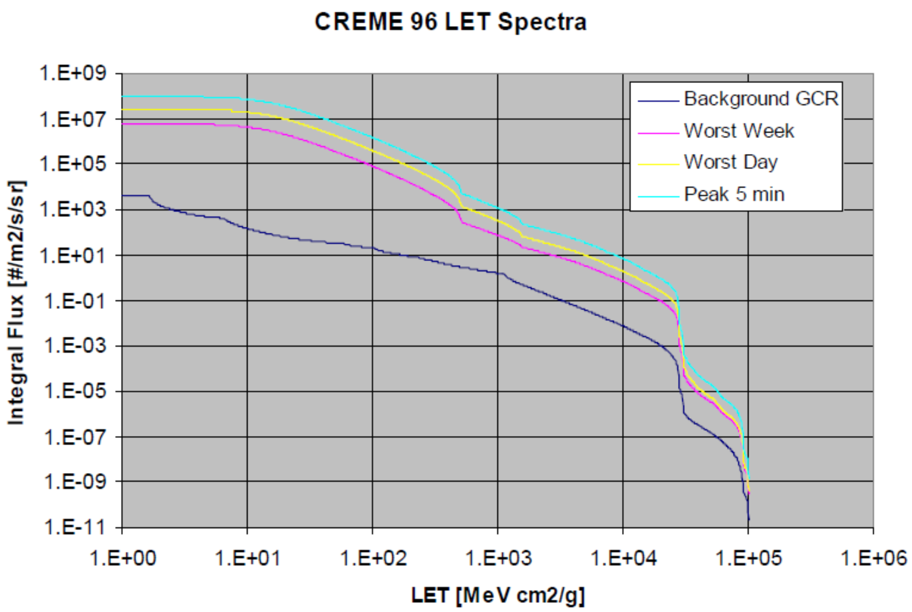

Figure 17 CREME96 Galactic Cosmic Ray LET Spectra for three levels of activity, nominal (quiet), worst week , and peak 5 minute (worst case) for a component shielded by 1 g/cm² (IR2).

4.17.4.4 Shielding

It is up to the instrument provider to insure proper shielding of the sensitive equipment. The S/C may provide additional shielding (TBC).

4.17.4.4.1 Shielding VI-FPA

A dedicated extra shielding of TBD mm (Al. equivalent) will be provided by the S/C .

It is up to the hardware instrument provider to specify the amount of shielding required (thickness, distribution...) .

4.17.4.4.2 Shielding NI-FPA

A dedicated extra shielding of TBD mm (Al. equivalent) will be provided by the S/C .

It is up to the hardware instrument provider to specify the amount of shielding required (thickness, distribution...) .

4.17.4.4.3 Allocation

The total amount of extra shielding will be limited to TBD kg.

4.17.5 Micrometeorite environment

The expected micrometeorite environment is described in details in IR2.

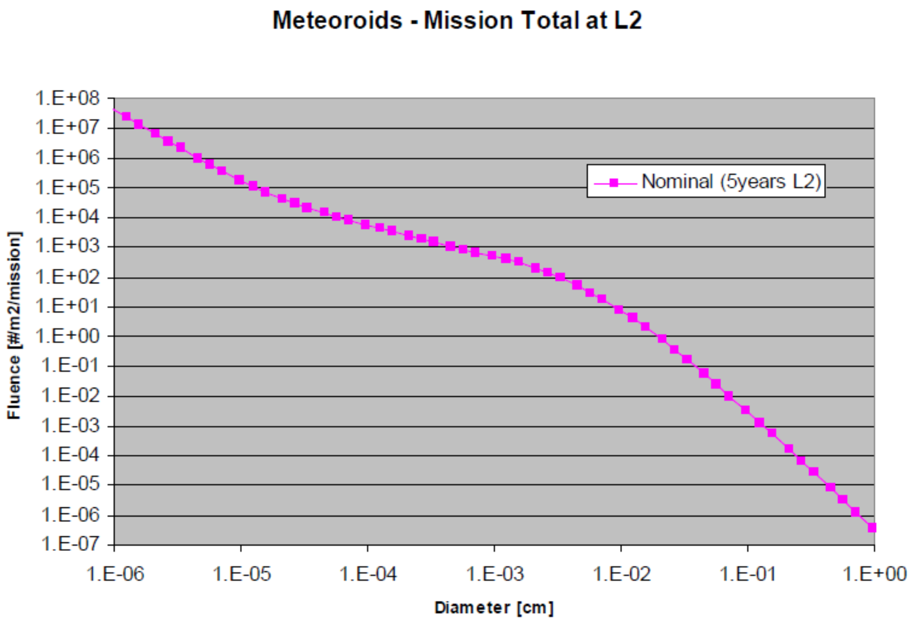

Figure 18 Cumulative number of impacts, N, to a randomly oriented plate for a range of minimum particle sizes. The results are for interplanetary at 1 AU. The meteorid fluxes were obtained by the model from Gruen et al. IR2.

5 GROUND SUPPORT EQUIPMENT

TBD

6 INTEGRATION, TESTING AND OPERATIONS

This chapter covers all instrument related activities after the acceptance of the instruments by ESA and hand-over to the industrial contractor.

6.1 AIV sequence overview

TBD

6.2 Integration

TBD

6.3 Euclid testing

TBD

7 PRODUCT ASSURANCE

At this stage of the program, ECSS-Q standards (see Table 1) shall be generally applied. During the course of phase A/B1, the standards will be specifically customized to the Euclid needs.

The instrument provider shall use the ESA web based tracking system, NCTS, as the sole system to register and track the NCR's raised across the full consortium.

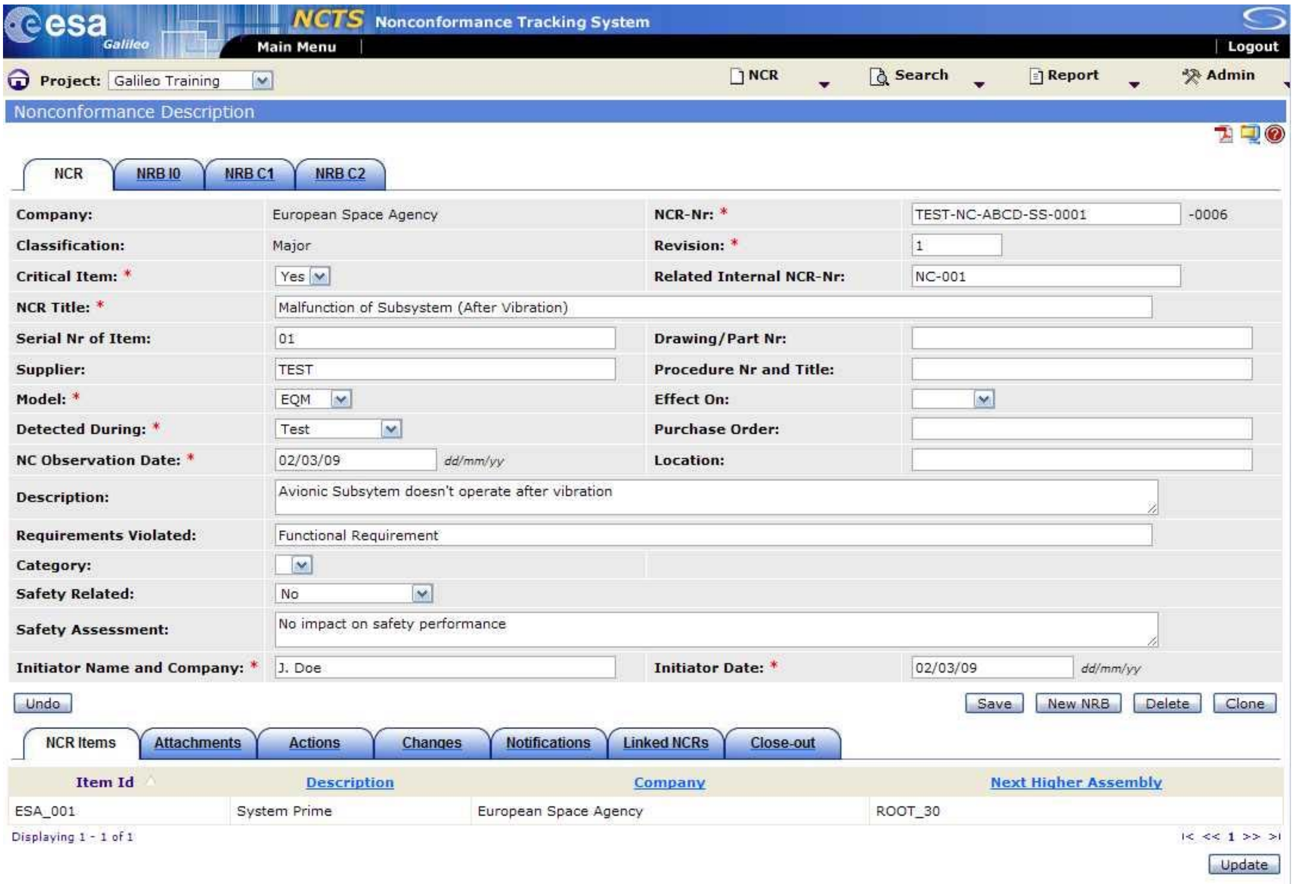

Figure 19 Screenshot of the NCTS system.

8 DEVELOPMENT AND QUALIFICATION

8.1 Foreword

The Instrument Provider shall, in a systematic manner, verify the instrument design and build against each requirement specified in the EID-A and B.
This section establishes the verification requirements for the qualification and flight certification of the instrument units giving specific test levels and durations and describing acceptance test and analytical methods for implementing the requirements.
The Instrument Provider shall include in the Design Development and Verification Plan the tests and analyses that collectively demonstrate that hardware and software complies with the requirements.
The Plan shall show the overall approach to accomplish the instrument qualification and acceptance programme. The interaction of the test and analysis activity shall be described.

8.2 Definitions

The following definitions are to be used:

Design Qualification Verification: Tests and analyses intended to demonstrate that the item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch and orbital operations. The purpose is to uncover deficiencies in design and method of manufacture and is not intended to exceed design safety margins or to introduce unrealistic modes of failure.

Acceptance Verification: Tests intended to demonstrate that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies, and normally to provide the basis for delivery of an item under terms of a contract or agreement.

Proto-flight Verification: The protoflight concept replaces the classical approach of design qualification and flight acceptance on dedicated models by a combination of qualification and acceptance on the flight hardware. A proto flight item is designated in advance to serve both as qualification and flight model and has to be designed for such purpose.
The protoflight model is subject to tests at qualification levels but with flight acceptance duration.

Functional Tests: The operation of a unit in accordance with defined operational procedures to determine that performance is within the specified requirements.

Performance Verification: Determination by test, analysis, or a combination of the two that the complete instrument or instrument unit can operate as intended in a particular mission: this includes proof that the design of the complete instrument or instrument unit has been qualified and that the particular item has been accepted as compliant to the design and ready for flight operations.

Thermal Balance Test: A test conducted to verify the adequacy of the Thermal Model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal Vacuum Test: A test to demonstrate the validity of the design in meeting functional goals: it also demonstrates the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test can also uncover latent defects in design, parts and workmanship.

Static Loads: The maximum combination (longitudinal and lateral) of static loads which acts on an instrument during the various segments of the flight profile. It consists of steady state accelerations (e.g. due to engine constant thrust or lateral wind loads) and quasi-static loads which are structure borne loads generated by the launch vehicle in the low frequency (less than 100 Hz) range (e.g. engine cut-off loads or wind gusts).

Shock Tests: A test conducted to verify the design under the environment induced by shocks produced by the launcher during events such as stage and satellite separation and by the S/C during events such as pyro firings.

Modal Survey Test: A series of mechanical investigations to determine the natural frequencies and associated modes of a structure.

Sinus Vibration Test: A test to demonstrate that the instrument can withstand the mechanical environment of the low frequency (less than 100 Hz) sinusoidal and transient vibrations. This test can also be used to demonstrate compatibility with the static loads.

Acoustics/Random Vibration: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile: it manifests itself throughout the instrument in the form of directly transmitted acoustic excitation and as structure-borne random vibration excitation.

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Interference (EMI): Electromagnetic energy which interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

Electromagnetic Susceptibility: Undesired response by a component, instrument or system to conducted or radiated electromagnetic emissions.

8.3 MODEL PHILOSOPHY

8.3.1 Spacecraft Models

It is the Instrument Provider's responsibility to qualify his instrument according to the requirements defined in this EID.

The Instrument Provider shall define an appropriate instrument development and verification program (DDV) and the instrument models involved. In order to optimize the flow of activities the Instrument Provider should take the S/C level test philosophy into consideration when preparing the test plan on instrument level.

In addition, the Instrument Provider shall provide instrument models defined in chapter 8.3.2 to support the spacecraft system verification program. The spacecraft system program consists of the Structural Thermal Model (STM) program and the Engineering Model (EM) program, which are performed in parallel, followed by the Flight Model (FM) program. The spacecraft level activities of each program are preceded by parallel PLM and SVM integration activities. A summary of the spacecraft system test program is given in Table 15.

The early development, bread boarding and testing of critical technologies and designs must be undertaken by the Instrument Provider already during the definition study in order to safeguard the timely delivery of the instruments.
The identification of the critical technologies and designs and the associated early development activities plus identified back-ups in case of failure, must be defined in the DDV Plan.

	Spacecraft System		
	STM	EM	EM
<u>Electrical</u>			
Electrical Performance		F	F
Software Validation		F	F
EMC/ESD		Q	A
<u>Mechanical</u>			
Static Load Test			
Since Vibration Test	Q		P
Acoustic Test	Q		P
Shock Test	Q		A
Mechanisms/Deployment	Q		A
Test	C		
Modal Survey			
<u>Structural Integrity</u>			
	Q		A
Leakage	C		A
Mass Properties and Balance	C		C
Alignment			
<u>Thermal</u>			
	Q		
Thermal Balance			P
Thermal Vacuum			

Legend:
Q: Qualification
A: Acceptance
P: Protoflight
F: Functional
C: Characterisation Test and Measurements

Table 15 System Model Tests and Measurements (TBC)

8.3.2 Deliverable Instrument Models

8.3.2.1 Structural Thermal Models

The STM system test objectives are:

- Qualification of primary structure by test
- Verification of mechanisms function in system environment
- Verification of structural mathematical model
- Qualification of thermal design by test
- Verification of thermal mathematical model.

The instrument STM units therefore have to have the following build standard:

- Structure flight standard
- Mechanisms flight standard
- Pyrotechnics flight standard (including electrical interfaces)
- Thermal control hardware flight standard
- Internal units flight representative for mass, stiffness, mounting, shape and internal power dissipation
- Harness flight representative for mass, shape.

8.3.2.2 Engineering Model

The EM system test objectives are:

- Verification of all electrical and software interfaces
- Verification of subsystem and instrument performance within system environment
- Qualification of on-board software
- Verification of system performance
- Verification of operational procedures
- Verification of electro-magnetic compatibility by emission, susceptibility and ESD tests.

The instrument EM units therefore have to have the following built standard:

- Electronics flight standard except for parts. Commercial parts have to be of same technology, same supplier as FM parts
- Mechanisms flight representative for electrical actuators
- Structure flight representative for mounting and shape
- Software flight standard
- Harness flight representative.

In order to save cost the EM hardware contents may be reduced by reducing redundancy:

- Cold redundant units may be deleted if no automatic switch-over function is involved

- Multiple redundancy of hot redundant units or modules may be reduced by electrical dummies (to e.g. dual redundancy) if EM objectives for interference and crosstalk tests are not compromised.

8.3.2.3 Flight Model

The FM system test objectives are:
- Completion of qualification programme
- Acceptance of spacecraft system by functional and environmental tests

The FM units therefore have to have the following built standard:
- Full flight standard verified by formal functional and environmental acceptance tests.

8.3.2.4 Flight Spares

The FS objectives are:
- Replacement of failed or damaged equipment at integration and launch site.

The FS units have to have the following build standard:
- Full flight standard verified by formal acceptance tests.

In order to save cost the FS units
- may be derived from refurbished qualification units if full flight worthiness can be demonstrated
- may be reduced to repair kits for repair at manufacturer's site if pre-determined turnaround time is ensured. This approach has to be agreed with the project office on a case by case basis.

8.4 ANALYSES

8.4.1 Structural Mathematical Models and Analyses

8.4.1.1 General

The mechanical performances of the instrument shall be calculated by means of Structural Mathematical Models (SMMs).
The Instrument Provider shall use models for his own design and shall also provide model(s) to the Agency for use during spacecraft design and test results predictions. The Instrument Provider shall update the models according to instrument and system test results.
The required delivery dates of the instruments SMMs are listed in section 9.8.1.
The detailed requirements for each model / analysis are listed in the following chapters.

8.4.1.2 Detailed Stress Analysis

This shall include at least:
1) A description of the configuration analysed with reference to interface controlled drawings
2) A description of the mathematical finite element model and/or of the assumptions taken to verify the structure
3) A description of all possible loading cases and an identification of the design driving load cases or load combinations
4) Detailed description of the most loaded elements listed with relevant stresses, and the loading cases that generated them
5) A list of the materials and structural components with characteristics data sheets (including long-life effects under space environment)
6) A set of tables showing, for each structural element, the maximum value on each type of stress or combination of them with the allowable value, and the load case that determines it, together with its margin of safety.

8.4.1.3 Dynamic Model

The structural mathematical model of the instrument shall be detailed enough to predict the dynamic loads to size the structure elements, and the interface loads in particular, with sufficient accuracy.
This means that it shall be able to reproduce the low frequency modes with an upper limit to the frequency range to be defined on a case-by-case basis.
The model shall fulfil the requirements of the Design Verification Requirements, when compared to test results.
A finite element model shall be accompanied by a clear description of the model itself and of the assumption made in the model, particularly concerning the boundary conditions at the spacecraft interfaces. For mechanisms, two or more models (stowed, deployed; general position), may be required.
All mathematical models shall be maintained in current configuration.
The mathematical models to be delivered to ESA shall be compiled in accordance with the Requirement Specification for Structural FEM Models doc. EUC-RQ-TBD.

8.4.1.4 Dynamic Analysis

This shall include at least:
1) A description of the configuration analysed with reference to interface controlled drawings
2) A description of the mathematical finite element model and/or of the assumptions/reductions introduced in the analysis
3) A description of the checks performed on the model to verify its quality (e.g. rigid body modes, residual forces)

4) A list of eigen-frequencies with relevant mode type and associated modal effective masses
5) Plots and listings of eigen-vectors.
6) Where necessary (large exposed areas, e.g. optical bench), to perform:
   - frequency analysis and response
   - acoustic response analysis.

8.4.1.5 Mechanisms Functional Analysis

Each mechanism shall be analysed functionally and the following information shall be at least supplied:
1) A detailed description of the mechanisms, with particular reference to its discrete components (bearings, actuators, switches) and to its operational/safety features
2) A detailed description of the operating modes with reference to ground and orbital activations
3) A definition of operating loads in various configurations with a clear definition of analysis assumptions. In particular, the functional analysis shall include the effects of the worst environmental conditions that could produce distortions or changes in clearance between movable parts (e.g. thermal gradient through bearings)
4) A Failure Modes, Effects and Criticality Analysis (FMECA) defining the failure modes and the functional margins of safety against each of the
5) A performance description of the control system that the mechanisms form a part of.

8.4.2 Thermal Mathematical Models and Analysis

8.4.2.1 Thermal Mathematical Models

The thermal performances of the instrument shall be calculated by means of Thermal Mathematical Models (TMMs).
The Instrument Provider shall use models for his own design and shall also provide model(s) to the Agency for use during spacecraft design and test results predictions.
The TMM(s) to be delivered to the Agency should in general be a condensed version of the overall instrument TMM, however the degree of detail (i.e. number of nodes, conductors etc.) shall be at least sufficient to show that all interface requirements are met.
The models shall allow to perform steady state and transient analyses and shall be updated as the experiment design evolves.
For the model to be delivered to Agency the Instrument Provider shall provide as a minimum:

a) Description of the model
b) Identification of the instrument configuration considered with reference to the I/F Control Drawings.
c) Description of the thermal surfaces (materials, surface finishes, thermal optical properties) and thermal capacities.

d) Assumptions/simplifications made w.r.t. the instrument configuration.

The Instrument Provider shall update the models according to instrument and system test results.

The required delivery dates of the instruments TMMs are listed in chapter 9.8.

8.4.2.2 Thermal Analyses

The Instrument Provider shall perform steady state and transient analyses to cover any applicable combination of instrument mode and spacecraft mode as specified in section 3.8.

The analyses shall identify a set of design cases which shall then be used as reference for instrument design and verification.

The analyses shall include at least :

a) Description of the configuration analysed
b) Description of the considered boundary conditions (e.g environmental and I/F with the spacecraft)
c) Description of the considered load cases (e.g. internal power dissipation, heat fluxes input)
d) The uncertainty policy applied in the thermal analysis
e) The temperature distribution on the internal instrument nodes
f) The temperature distribution at the interface node with the spacecraft
g) The nodes temperature evolution (in the transient analyses)
h) The heat exchange between the instrument main surfaces and the spacecraft.

The Instrument Provider shall agree with the Agency the uncertainty policy to be applied for the thermal analysis. In the absence of any uncertainty analysis an initial uncertainty margin of 10 C shall be retained.

8.4.2.3 Thermal Analysis Software

The Instrument Provider is encouraged to use ESATAN thermal analyser for the TMM which will be delivered to the Agency.

In case this is not possible the Instrument Provider shall generate a TMM Specification which shall allow ESA or the S/C Prime to build an ESATAN TMM representative of the instrument.

The thermal analysis software delivered to the Agency shall be formally updated (either by delivery of the new code or by update of the TMM spec).

8.4.3 Optical Mathematical Model and Analysis

TBD

8.4.4 Structural, Thermal, Optical and Performance Analysis (STOP)

TBD

8.5 TESTING

8.5.1 General Test Requirements

8.5.1.1 Test Procedures and Reports

For each test defined in the DDV plan (e.g. EMC, vibration, electrical, thermal, etc.), the Instrument Provider shall provide a detailed procedure.
The Instrument Provider shall provide a final report for each test.

8.5.1.2 Test Matrix

In addition to the DDV Plan, the Instrument Provider shall prepare a Test Matrix that summarises all the tests that will be performed on each instrument unit.
The purpose of the matrix is to provide a ready reference to the contents of the test programme in order to prevent the deletion of a portion thereof without an alternate means of accomplishing the objectives; it has the additional purpose of ensuring that all flight hardware has seen environmental exposures that are sufficient to demonstrate acceptable workmanship.
In addition, the matrix shall provide traceability of the qualification heritage of hardware.
All flight hardware, spares (and prototypes when appropriate), shall be included in the matrix.

8.5.1.3 Test Sequences

No specific environmental test sequence is required, but the test programme should be arranged in a way to best disclose problems and failures associated with the characteristics of the hardware and the mission objectives.
It is strongly recommended that the vibroacoustic test precede the thermal vacuum test unless there is an overriding reason to reverse that sequence.

8.5.1.4 Test Level Tolerances

To be defined in the definition phase

8.5.2 Electrical Functional Test Requirements

8.5.2.1 Full Performance Test

1. The Full Performance Test (FPT) shall be a detailed demonstration that the hardware and software meet their performance requirements within allowed tolerances.
2. The test shall demonstrate operations of all redundant circuitry.
3. It shall also demonstrate satisfactory performance in all operational modes.
4. The initial FPT shall serve as a baseline against which the results of all later FPTs can be readily compared.

5. The test shall also demonstrate that, when provided with appropriate stimuli, performance is satisfactory and outputs are within allowed limits.

8.5.2.2 Limited Performance Tests

1. The Limited Performance Tests (LPT) shall be a subset of the FPT.
2. The LPT shall be performed before, during and after environmental tests, as appropriate, in order to demonstrate that functional capability has not been degraded by the environmental tests.
3. The limited tests may also be used in cases where comprehensive performance testing is unwarranted or impracticable.

4. Specific items on which it is intended that Limited Performance Tests will be performed shall be listed in the Verification Plan.
5. The Limited Performance Tests shall demonstrate that the performance of selected hardware and software functions is within allowed limits.

8.5.3 EMC Test Requirements

To be defined in the definition phase

8.5.3.1 General Set-up Requirements

TBD

8.5.3.2 EMC Test Categories

TBD

8.5.3.3 Bonding, Isolation and Grounding/Conductivity Tests

TBD

8.5.3.4 Conducted Emission Test

TBD

8.5.3.5 Conducted Susceptibility Tests

TBD

8.5.3.6 Radiated Emission

TBD

8.5.3.7 Radiated Susceptibility

TBD

8.5.3.8 Electrostatic Discharge Tests (ESD Test)

TBD

8.5.4 Structural Tests Requirements

To be defined during the definition study

8.5.4.1 Sine Vibration Test Levels

Sinusoidal acceptance & qualification test levels for equipment with mass ≤ 50 kg:

Frequency	Acceptance Level	Qualification Level
(5 - 21) Hz	9 mm (0 - peak)	11 mm (0 - peak)
(21 - 60) Hz	16 g (0 - peak)	20 g (0 - peak)
(60 - 100) Hz	4.8 g (0 - peak)	6 g (0 - peak)
Sweep rate:	TBD Oct/min	TBD Oct/min

Table 16 Sinusoidal acceptance & qualification tests levels for equipment with mass ≤ 50 kg

Sinusoidal acceptance & qualification test levels for equipment with mass > 50 kg:

Frequency	Acceptance Level	Qualification Level
(5 - 15) Hz	9 mm (0 - peak)	11 mm (0 - peak)
(15 - 50) Hz	8 g (0 - peak)	10 g (0 - peak)
(50 - 80) Hz	4.8 g (0 - peak)	6 g (0 - peak)
(80 - 100) Hz	2.8g (0 - peak)	3.5g (0 - peak)
Sweep rate:	TBD Oct/min	TBD Oct/min

Table 17 Sinusoidal acceptance & qualification tests levels for equipment with mass ≥ 50 kg

8.5.4.2 Random Vibration Test Levels

Random vibration qualification test levels for equipment with mass ≤ 50 kg:

Location	Duration	Levels	
Equipment located on "external panel [a] or with unknown location	Vertical [b] 2,5 min/axis	(20 - 100) Hz	+3 dB/octave
		(100 - 300) Hz	PSD(M) [c] = 0,12 g^2/Hz × (M + 20 kg)/(M + 1 kg)
		(300 - 2 000) Hz	-5 dB/octave
	Lateral [b] 2,5 min/axis	(20 - 100) Hz	+3 dB/octave
		(100 - 300) Hz	PSD(M) [c] = 0,05 g^2/Hz × (M + 20 kg)/(M + 1 kg)
		(300 - 2 000) Hz	-5 dB/octave
Equipment not located on "external" panel [a]	All axes 2,5 min/axis	(20 - 100) Hz	+3 dB/octave
		(100 - 300) Hz	PSD(M) [c] = 0,05 g^2/Hz × (M + 20 kg)/(M + 1 kg)
		(300 - 2 000) Hz	-5 dB/octave

a Panel directly excited by payload acoustic environment.

b Equipment vertical axis = perpendicular to fixation plane.
Equipment lateral axis = parallel to fixation plane.

c M = equipment mass in kg, PSD = Power Spectral Density in g^2/Hz.

Table 18 Random vibration qualification test levels for equipment with mass ≤ 50 kg

Random vibration qualification test levels for equipment with mass > 50 kg:

Frequency	Level	Remark
(20 - 110) Hz	+3 dB/octave	11,12 g r.m.s.
(110 - 700) Hz	0,09 g^2/Hz	
(700 - 2 000) Hz	3 dB/octave	
Duration: all axes - 2,5 min/axis.		

Table 19 Random vibration qualification test levels for equipment with mass > 50 kg

Random vibration acceptance test levels:

Mass	Frequency	Level	Remark
$M \le 50$ kg	(20 – 80) Hz	+ 3 dB/octave	6,06 g_{rms}
	(80 – 350) Hz	0,04 g^2/Hz	
	(350 – 2 000) Hz	-3 dB/octave	
$M > 50$ kg	(20 – 80) Hz	+ 3 dB/octave	
	(80 – 350) Hz	PSD(M) = $[0{,}05\times(M+50)/(M+1)] / (1{,}5)^2]$	
	(350 – 2 000) Hz	-3 dB/octave	
Where:	PSD is in g^2/Hz, M is in kg.		
Duration:	all axis, 2 minutes per axis.		

Table 20 Random vibration acceptance test levels

8.5.4.3 Acoustic Test Levels

As per Soyouz User's Manual.

8.5.4.4 Shock vibration loads

TBD.

8.5.5 Mechanism Test Requirements

To be defined during the definition phase

8.5.6 Thermal Tests Requirements

To be defined during the definition phase.

9 MANAGEMENT, PROGRAMME, SCHEDULE

9.1 General

In line with the Cosmic Visions M-class missions, the Euclid schedule is as follows:

- Start of Definition Phase with two parallel industrial contracts: July 2010
- Release of updated AO documents for implementation phase: March 2011.
- Submission of final proposal for the implementation phase: May 2011
- Down-selection for CV M1/M2 missions: June 2011
- Completion of the Definition Phase (A/B1): December 2011
- Final adoption for the Implementation Phase (B2/C/D/E1): Feb 2012
- Start of the Implementation Phase: July 2012
- Delivery of Instrument Structural Thermal Model: July 2013 (TBC)
- Delivery of Instrument Engineering Model: July 2014 (TBC)
- Delivery of Instrument Flight Model: July 2016 (TBC)
- Launch (L): end 2018
- L+: launch and early operations phase (LEOP)
- L+ a few days: start Satellite Commissioning and Payload Performance Verification Phases
- L+ t≤6 months: start of nominal in-orbit science operation Phase
- L+5 years: end of nominal in-orbit operation Phase.

Therefore, the next milestones for the Euclid study is the down selection for phase B1 in June 2011, ending the phase A. At industrial level, this Phase includes the spacecraft design and performance consolidation, the elaboration of the spacecraft development plan and the consolidation of the space segment industrial cost. These should be supported by parallel definition activities at instrument level, to fully benefit from the concurrent design of the spacecraft and to safeguard the overall project schedule.

Given the time constraints associated with this phase and the complexity of the interface related to the EFE (ESA furnished equipments[1]), it is essential for the instrument provider to adhere to the requirements established in this chapter:

- the management structure of the instrument team, to ensure that en efficient organisational structure is established which will perform the tasks associated with phase A/B1 (and later if applicable) .
- project control processes to ensure that the work to be performed is adequately scoped and scheduled, and that appropriate management principles are implemented

[1] CCD for the VIS instrument and also potential NASA contributions.

- reviews and reporting to provide an assessment of the completion status of the instruments and early identification of potential risks which may impact the performance of the instruments, the spacecraft interfaces and resources, and the schedule of deliverables
- the definition of the deliverables
- the Euclid study baseline schedule to synchronize due dates of deliverables

The ESA technical and programmatic requirements will be updated in the course of the definition study to reflect the full complement of requirements for the implementation phase. At the end of the Definition Phase A, the Consortium shall update his full response to the AO. This update shall reflect the progress and findings from the definition phase and answer to the updated ESA requirements. This update will also form part of the basis on which the final down-select will take place.

9.2 Project Management

9.2.1 Use of Uniform Approach

All generated information shall be made in the English language.

The current applicable International System of Units shall be used.

The Instrument provider shall provide a directory of the acronyms and abbreviations to be used by the whole project as one coordinated system.

The Instrument provider shall establish, maintain and distribute a Project Directory and send this and its revisions to the ESA Project Office. The Instrument provider shall highlight within the Project Directory the names of all key personnel of the whole OBS. The Project Directory shall be available as an electronic database.

9.2.2 ESA responsibilities and overall organization

ESA is responsible for the overall implementation of the mission.

The interface between the Industrial Contractor (2 contractors during phase A/B1) and the EUCLID Consortium is under ESA responsibility.

ESA will establish the programmatic platform with NASA for their deliveries and will be responsible for the formal programmatic interface to NASA.

During the phase A/B1, the ESA Euclid study team is organized as follows:
- the Euclid study manager responsible for the overall study
- the Euclid study payload manager addressing all payload related issues
- the Euclid system engineer addressing all spacecraft related issues

- the Euclid Project scientist

with support of field experts.

9.2.3 Industrial contractors responsibilities

After the phase A/B1, an Industrial Contractor will be responsible for the development, procurement, manufacturing, assembly, integration, test, verification and timely delivery of a fully integrated spacecraft capable of accommodating the defined payload elements, fulfilling the mission requirements and achieving the mission objectives. In particular, the Contractor is responsible for the provision of the EUCLID telescope. The VIS imager, the NISP instrument and the satellite subsystems to be provided by the Consortium or an International Partner will be considered by this Contractor as Customer Furnished Equipment.

9.2.4 Instrument provider responsibilities

The **Euclid consortium as** instruments provider shall assume full responsibility of the development, verification and timely delivery of the instruments including the ESA and NASA furnished equipment.

The **Euclid** consortium shall carry out the normal system/subsystem engineering and interface engineering tasks for the ESA/NASA provided subsystems as for any other **instrument** subsystem and unit. The instrument consortium shall participate in all formal subsystem reviews **of the ESA/NASA provided subsystems** and shall support the related progress meetings as necessary.

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The EUCLID Consortium Lead (CL) shall be responsible for ensuring that the complete instrument programme is implemented and executed within the constraint of the EUCLID programme.

9.2.4.1 Management

9.2.4.1.1 Project management organisation

The instrument provider shall establish a centralised Project Office coordinating all the activities of the instrument consortium. The Project Office shall be headed by the EUCLID Consortium Instrument Project Manager. The Project Office shall be responsible for the overall project management of the instrument and will include key personnel responsible for the following tasks across the instrument consortium:

- Project Management
- Project Control
- Schedule Control

- Documentation and Configuration Control
- System Engineering
- Assembly Integration Test and Verification
- Product Assurance

The Project Office shall independent of any funding arrangements, be in a position to ensure the overall technical and programmatic consistency of the complete instrument
The Project Office is responsible for the overall technical and programmatic coordination of the Instrument and the regular reporting to the ESA Project Office via the office consortium Lead.
Furthermore the Project Office shall maintain the overall Cost at Completion of the instrument, monitoring the evolution of cost and ensuring that the necessary contingencies are in place throughout the consortium participants.
Subsystems or major activities contributed by participating consortium members shall be under the responsibility of a Local Project Manager, who independently of any funding arrangement, shall report to the Consortium Instrument PM to ensure overall technical and programmatic consistency of the complete instrument. In particular, the Local PM shall provide adequate information to the Consortium Instrument PM for him to assess the overall technical design and development of the instrument. The Local PM shall be supported by a local Project Office

9.2.4.2 Instrument provider team organization

An Instrument Team shall be established to provide an effective and efficient managerial scheme and to ensure that all aspects of the instrument programme are covered by the appropriate expertise.
The instrument provider shall establish a detailed organisation chart, identifying all the responsibilities involved and the associated links and reporting lines, with defined named responsibilities clearly showing that all aspects of the instrument are efficiently covered by the appropriate expertise. Key personnel, including technical instrument managers, shall be identified within the management scheme together with a short description of their tasks and functions and their time allocation to the project. Key personnel are defined as persons who because of their positions and individual qualifications perform an essential function required to achieve the objectives and requirements of the instrument development. CVs shall be provided for all the proposed key personnel. The appointment of key personnel and changes thereto shall always be agreed together with the Agency.

9.2.4.2.1 Management plan

The instrument provider shall establish an overall Management Plan compliant with the management requirements defined in this EID-A. The instrument provider shall submit evidence to the Agency of concurrence by its participants to this Management Plan. The instrument provider's project management and project control organisation shall implement the approved Management Plan and maintain the Management Plan up to date throughout the project. In particular, the instrument provider shall describe in its Management Plan the relation between the instrument team and its own host organisation. The instrument provider's Plans for the implementation of project control, schedule management, risk management as well as logistics and inventory control may form a part of the Management Plan or be presented as separate documents.

9.2.4.2.2 Management of risks

The instrument provider shall identify a function in its project organisation responsible for the identification and management of risk. The instrument provider shall identify and register risks with:

- The name of the custodian for control of the risk
- The related Work Package
- An explanatory description
- Reasons for their criticality
- Importance of their consequences (classification and severity)
- Magnitudes of consequences (e.g. schedule and/or cost impacts)
- Probability of their occurrence
- The preferred solution, with reasons
- Alternative solutions and contingencies
- Current status

The instrument provider shall analyse risks and evaluate alternative solutions and ensure awareness at all levels and elements of the project. The instrument provider shall monitor risks, put into action contingency plans and report the status of risks as part of the Progress Report to ESA. Where there is a possibility that risks may have a compounding effect, the instrument provider shall implement control mechanisms to minimise their impact and highlight these in the Progress Reports.

The instrument provider shall maintain a Top 10 Risk register to be included in the Progress Report.

The instrument provider shall propose, for agreement by the Agency and in line with NR5, a risk management plan.

9.2.4.3 Documentation

The instrument provider shall establish an index of all deliverable documents (Document Delivery List) as required in the AO. All Controlled Documents (identified in a Configuration Item Data List for a Configuration Item) shall be included in the Document Delivery Lists. The instrument provider shall agree any additions, deletions or revisions to the Document Delivery List with the Agency.

The instrument provider shall maintain the Document Delivery List up to date under configuration control and shall report the status within the progress report to the Agency.

The instrument provider shall establish a common repository where the instrument baseline documentation is maintained. The instrument consortium participants and the Agency shall be given access to this common repository.
All Controlled Documents shall be subject to the Configuration Management requirements.
Updates to Controlled Documents shall be recorded by means of a Document Change Notice, issued to all recipients.
The instrument provider shall protect and distribute documents according to the level of confidentiality of information they contain.

9.2.5 Communication with ESA

9.2.5.1 Formal Communication

All formal communication and agreements concerning technical and programmatic aspects shall be made between the Consortium Lead and the ESA Study Manager. No other party shall have formal authority, without written delegation.

9.2.5.2 Communication at working level

On a working level, for all technical aspects of the instruments, the ESA Payload Manager or his delegated shall represent the focal point for all communications between the instrument provider and ESA
All communication between the instrument provider and the spacecraft Industrial Contractors shall be conducted via the ESA Euclid Payload Manager with copy to the ESA study manager.

9.2.6 Financing

The instrument provider is at all time responsible for the instrument funding.
The instrument provider shall at all times ensure that appropriate funding arrangement is in place. A funding margin shall be provided, not only to provide for the development evolution, but also to finance interface changes resulting from parallel development of the spacecraft and the ground segment.
In the case of interface problems, changes to be introduced shall attempt to minimise the overall financial impact to the programme. Each side shall bear the consequences of the change and there shall be no exchange of funds.
The instrument provider shall not assume any funding from ESA, for any part of his programme, other than the agreed EFEs.
The instrument provider shall maintain, through its Project Office, an overview of the financial situation across the instrument consortium and shall monitor the depletion of the contingency. This overview shall include the contingency status and an update of the cost estimate at completion (EaC) and be reported to ESA twice a year in a dedicated report.

9.3 Project control

9.3.1 Project control objectives

In order to manage the overall Euclid study, the instrument provider will implement project control systems and procedures focusing on the definition, maintenance and reporting of schedule, and configuration information.
The objective of this section is to clearly specify the management information required from the Instrument provider. Due to the importance of the instruments in the programme, it is essential that the instrument provider supports this scheme with relevant schedule and configuration information. In case the instrument provider feels that the spirit of the requirement could be met by a more appropriate approach, he should propose alternatives which will be reviewed by ESA.

9.3.2 Project breakdown structures (phase A/B1)

In order to clearly identify the instrument, the scope of the work and the responsibilities involved, the following structures shall be created by the Instrument provider:
- the Product Tree (PT) to break down the instrument into its components, both hardware an software
- the Work Breakdown Structure (WBS) to define the scope of the work and the responsibilities.

<u>Product Tree:</u>
A Product Tree shall be developed by the instrument provider, depicting a product oriented breakdown of the instrument into successive levels of detail. The Product Tree shall be submitted to ESA.

<u>Work Breakdown Structure:</u>
A Work Breakdown Structure shall be developed by the instrument provider, based on its agreed Product Tree and extending the applicable elements to include appropriate support functions necessary to complete the phase A/B1.
For each Work Package, the instrument provider shall complete a Work Package Description (WPD). The instrument provider shall ensure all the responsibilities assigned to manage or to perform all the Work Packages are identified in the instrument team organisation chart (see section 9.2.4.2). The WBS shall be submitted to ESA.

9.4 Schedule control

9.4.1 Baseline master schedule

The industrial study schedule has the following milestones:

- Kick-off on 1st July 2010

- Mission Definition Review in October 2010
- Preliminary Requirement Review in June 2011
- Baseline Design Consolidation Review in January 2012

The instrument provider shall establish and submit to ESA, a baseline master schedule covering all the instrument programme activity identified in the Work Breakdown structure. All the instrument required inputs and milestones associated with the industrial study (section 9.7.1) shall be included.

9.4.2 Schedule monitoring

The instrument provider shall continuously record progress achieved and maintain forecasts.
The instrument provider shall consolidate the progress and forecasts of all groups contributing to the instrument and compare schedule performance with respect to the overall baseline master schedule.
Where deviations to the baseline have occurred or are predicted, the instrument provider shall develop corrective actions, and report these directly to ESA.

9.4.3 Schedule reporting

In order to track the progress, the instrument provider shall provide to ESA on a monthly basis a quick look report showing the status of the different activity as defined in the Work Breakdown Structure.

9.5 Configuration management

9.5.1 Objectives

The objectives of Configuration Management are to establish:
- a configuration identification baseline system which defines through approved specifications, interface documents and associated data the requirements for the instrument
- a configuration control system which controls all the changes to the identified configuration of the instrument

9.5.2 Responsibilities

The instrument provider shall be responsible for managing the configuration of his/her instrument and the lower level products of which it consists. For this purpose, he shall set up the necessary organisation and means for satisfying the objectives and requirements of configuration management.
The instrument provider shall also impose configuration management requirements on contractors and suppliers (if applicable) as appropriate for the items being provided to the instrument. For this purpose, the instrument provider shall ensure compatibility between

his/her own configuration management and the one implemented by all other participants to his/her instrument programme.
The instrument provider shall be responsible for the implementation and operation of a Configuration Control Board (CCB) at his/her level.

9.5.3 Configuration identification

The configuration baseline shall be established with respect to requirements, design and verification.
At this stage, the baseline list of documents shall be defined by the instrument provider but shall contain at least

- EID-B
- Instrument Functional Requirement and Performance specifications document
- Subassembly/unit specifications and ICD's
- Project plans
- TBD

9.6 Configuration control

9.6.1 Instrument internal configuration control

TBD for later phases.

9.6.2 EID Configuration control

The requirements defined in the EID part A and Bs will be subject to configuration control and shall reflect the up to date agreed configuration baseline between ESA, the industrial contractors and the instrument provider. Changes to these documents shall be handled using the Engineering Change Request (ECR). Deviations from the requirements defined in EID-A and EID-B will be handled using the request for waiver. This system will be applicable after the end of phase A1 (see section 1.1).

9.6.3 Configuration status accounting

The configuration status of all configured documents shall be sent to ESA, as part of the reporting procedure required in section 9.7.4. The instrument provider shall ensure that all members of the instrument consortium are kept up to date on the configuration status accounting.
Configuration Item Data Lists (CIDL) listing all the documents and their applicable issues and revisions which defines the configuration baseline shall be prepared and submitted for each Instrument Review.
The Instrument Provider shall establish and maintain As Build Configuration List (ABCL) listing all the documents and their issues and revisions defining the as build configuration.
Differences between the as designed baseline and the as build configuration list shall be identified for all qualification and flight hardware and software. The validity of all design

verifications, including analyses and tests, shall be assessed for all the differences and modifications from the as designed baseline.

9.7 Reviews and reporting

9.7.1 General

The industrial contractors study reviews for phase A/B1 are:

- Mission Definition Review (**MDR**): successful review at the end of Phase A1 leading to an approved preliminary EUCLID system functional specification, a baseline mission description and an updated experiment interface document (EID A).
- Preliminary Requirement Review (**PRR**): successful review at the end of Phase A2 (June 2011) leading to a EUCLID system concept definition, baseline EUCLID functional specifications and interface requirements, and coherent project plans
- Baseline Design Consolidation Review (**BDCR**): successful review at the end of Phase B1 (December 2011) leading to a consolidated mission design, consolidated plans and including the definition of all sub-systems interfaces.

9.7.2 Instrument reviews

In order to support spacecraft definition activities by Industries and coordinate with progress on Instrument definition activities by the instrument provider, the following Instrument review will be organized:
- Participation of the Instrument provider Team to the Mission Definition Review (**MDR** - October 2010) leading to baseline EUCLID instrument concept description and including a first issue of the experiment interface document (EID B).

- Preliminary Instrument Requirement Review (**PIRR**): successful review at the end of Phase A2 (April 2011) leading to a EUCLID instrument concept definition, baseline EUCLID instrument functional specifications and interface requirements, and coherent instrument project plans

Instrument Design Consolidation Review (**IDCR**): successful review at the end of Phase B1 (October 2011) leading to consolidated instrument designs, consolidated plans and including the definition of all instrument sub-systems specifications and interfaces.

The review plan during the implementation phase foresees the following reviews at Instrument level: Preliminary Design Review, Critical Design Review, Qualification Review, and Acceptance Review. These reviews will be managed by the ESA Project Office. The instrument subassemblies shall follow a similar review plan. These reviews will be managed by the Instrument Project Office and supported by the ESA Project Office.
Ad hoc reviews shall be organised by the Instrument Project Office with support form the ESA Project Office where deemed required. Any party can call for such reviews.

9.7.3 Instrument progress meetings

Regular Instrument Progress Meetings shall be held nominally on the premises of the instrument provider during the phase A/B1.These meetings will be conducted between ESA and the Instrument Team with the objective of ensuring that the interface technical design integrity of the instrument, its compatibility with the spacecraft system, and instrument programmatic are proceeding in a manner which will not jeopardise the overall programme.
The Instrument Team shall be represented by the necessary team to provide the required information.
The meetings shall be held on a 2 months basis (starting in September 2010, TBC). The frequency may be changed on request of ESA.
The instrument provider is encouraged to organise regular teleconferences of the consortium engineering teams, with the participation of the Agency, to ensure a smooth progress of the activities.
Detailed technical problems occurring on either side of the interface shall be flagged during these meetings and corrective actions, including their schedule impact, agreed and implemented.

9.7.4 Reporting

The instrument provider shall submit to ESA, 5 days after the end of the month, a Monthly Progress Report in which the current status of each activity is described and problem areas or potential problem areas are highlighted together with identification of proposed remedial action. A summary of the latest working schedule shall also be included.

9.8 Deliverable items

9.8.1 Mathematical models

The instrument provider shall deliver the mathematical models outlined in sections 4.6.5, 4.6.6, 4.8.9, 4.9.5. These instrument mathematical models shall be updated as the design progresses. They will serve as input to the spacecraft mathematical models. The models shall be kept under strict configuration control by the instrument provider.
The models are formal deliverables at each instrument review and shall be delivered at any time in between upon request from ESA.

More specifically, the following table shall apply:

Mathematical Models		Remarks	Unit
Unit Geometrical Model		CATIA Files including mass properties and, specifically mechanical interfaces	all
Unit Preliminary FEM		NASTRAN files	NI-OMA, VIS FPA, VI-SU

Unit Preliminary Thermal and Geometrical Mathematical Model (GMM/TMM)		ESATAN/TMS files with related description	NI-OMA, VIS FPA, VI-SU
Reduced TMM		ESATAN/TMS files	NI-CDPU, NI-PSU, NF-CDPU, NF-PSU, VI-CU, VI-PSU, VI-CDPU
Optical Model			NI-OMA, VIS Assembly

Table 21 Mathematical model deliverables.

9.8.2 Instrument models

The detailed schedule for EUCLID development will be established during the definition Phase. To secure a 2018 launch date, it is anticipated that:
- the Instrument Structural Thermal (STM) shall be delivered to the Euclid prime contractor before July 2014 (TBC).
- the Instrument Engineering Models (EM) shall be delivered to the Euclid prime contractor before July 2015 (TBC).
- the Instrument Flight Models shall be delivered to the EUCLID prime Contractor before July 2016 (TBC).

The EUCLID program model philosophy will be defined in the definition phase. As deliverable development models the instrument provider shall assume a Structural Thermal Model and an Engineering Model.

9.8.3 Instrument Simulators

The instrument provider shall provide an Instrument Performance Simulator to support the calibration and support the development of the science operation tools.
The instrument provider shall provide an Instrument Functional Simulator to support development and verification of system test scripts and instrument operational procedures.
The detailed build standard of the simulators will be defined during the definition phase.

9.8.4 Instrument GSE

The Instrument Provider is responsible for the shipment of all the instrument deliverable models to the industrial prime contractors integration site.
The Instrument Provider is responsible for the shipment/storage containers.
Any Instrument units with a mass more than 10 Kg (TBC) shall be delivered with appropriate lifting/installation GSE.
The Instrument Provider shall deliver appropriate EGSE to monitor, analyse and support the functional and performance test of the Instrument during system level testing. Full set of EGSE for both the Instrument EM and FM must be delivered, as parallel testing of the Spacecraft EM and FM model can be foreseen.
The detailed build standard for the GSE will be defined in the definition phase.

9.8.5 EFE

The delivery dates of the EFE from the Agency to the instrument provider are TBD.

9.8.6 Review data packages

A data package shall be provided for each of the scheduled instrument reviews detailed above.

MDR:
- first issue of the EID part B (draft in response to the AO).
- Instrument functional requirements and performance specifications document
- Delivery of all the mathematical models as defined in Table 21 (reduced TMM can be limited to thermal interfaces).

PIRR:
- input to updates of the EID-part B
- updated Instrument functional requirements and performance specifications document
- draft issue of unit level specifications and ICD
- Delivery of all the mathematical models as defined in Table 21
- Supporting tech notes and analyses reports demonstrating full compliance of the instrument with the applicable requirements.
- Draft instrument operation al concept document
- Pre-development status report
- Final update of complete AO proposal for the implementation.

IDCR:
- input to updates of the EID- part B
- updated Instrument functional requirements and performance specifications
- formal issue of unit level specifications and ICD
- Supporting tech notes and analyses reports demonstrating full compliance of the instrument with the applicable requirements
- Delivery of all mathematical models as defined in Table 21
- Consolidated instrument operational concept document
- Final project plans.
- Updated financial plan
- Pre-development status report

The exact data package will be confirmed by the Agency after the AO.
The data package for the PDR, CDR, QR and AR will be defined during the definition phase.
The content of the End Item Data Package for all deliverables will be defined during the definition phase.

APPENDIX A EUCLID CCD SPECIFICATIONS

The Euclid CCD specifications are gathered in the following tables (based on IR4).

Euclid main CCD parameters
4096 x4132 pixels (TBC): the active area is separated in two independent areas of 2048 lines by 4096 columns. Compatibility with 203-82 maintained.
12 um square pixels
2 serial registers, 4 ports, equally distributed over the two active areas
Readout mode: 4 ports simultaneously, 200 kpixs per node
3 erms total noise
Back-illuminated, deep depletion (40 um thick TBC), red-enhanced AR coating (typical QE: 0.86 at 550 , 0.86 at 750 and 0.28 at 950 nm)
Minimum MTF at 800 nm (Nyquist): TBC
Dark current: 0.01 e/pix/hour at 153 K typical.
Nominal operating temperature of 150 K (TBC)
Typical full-well of 200 ke-
No anti-blooming
Charge injection: capability to independently inject charges on each active area
Temperature sensor included (TBC)
SiC or CeSiC package with flexi connections (GAIA heritage), 4 sides buttable. Mass of 80 g (TBC)

Table 22 Euclid CCD general specifications

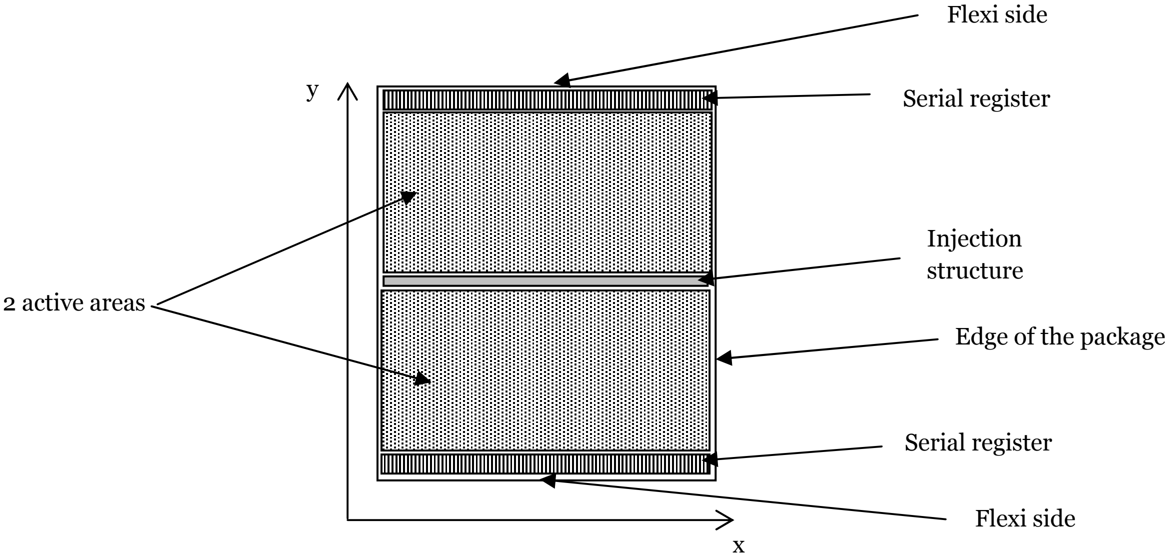

Figure 20 Euclid CCD schematic representation.

Parameters	Value	Unit	Comments
Pixel size	12.0 (x) – 12.0 (y)	µm x µm	See Figure 20 fro definition of x and y
Number of light sensitive useful pixe(half)	4096 (x) – 2066 (y)	Pixels x pixels	The two halves are separated by the charge injection
Image area size (half)	49.152 (x) – 24.792 (y)	mm x mm	
Charge injection width (y direction)	48	µm	
Package dimensions	50.269± 0.025 (x) - 56.798 (y) ± 0.160	mm x mm	
Package height	14± 0.020	mm	
Flatness	20 ptv(TBC)	Um	Maximum distance between two parallel planes containing the sensitive surfaces of the device
Recommended distance between adjacent packages	500	µm	On each side
Flexi length	100 (TBC)	mm	Thermal conductivity <1e-3 W/K (TBC)

Table 23 Euclid CCD mechanical specifications

Parameter	Value	Unit	Comments		
	Min.	Typ.	Max.		
Static power dissipation, 4 ports powered, no dummy o/ps		40	52	mW	During charge collection
Static power dissipation, 4 ports powered, “real” and dummy outputs powered		80	104	mW	During charge collection
Dynamic power dissipation, 4 ports simultaneously @		46	60	mW	Sum of clocking power and

200Kpix/s, no dummy o/ps					static power
Dynamic power dissipation, 4 ports simultaneously @ 200Kpix/s, "real" and dummy outputs powered		86	112		Sum of clocking power and static power

Table 24 Euclid CCD power specifications (asseumes 10 kΩ load resistor for each port)

APPENDIX B EUCLID NISP FOCAL PLANE ASSEMBLY INTERFACE SPECIFICATION:

Introduction

The NISP FPA is an ESA furnished equipment. It consists in:
- H2-RG detectors and harnesses
- SIDECAR asic and harnesses
- Interface electronic
- Front end electronic power supply units and harnesses
- H2-RG support structure
- SIDECARs, and front end electronic power supply units mechanical structure
- Cold cut-off filter (TBC)
- Thermal hardware

The light from the NISP channel is focused on the H2-RG detectors which are mounted on the H2-RG support structure.
The SIDECAR asics control the H2-RG and perform the conversion from the H2-RG signals to digital signals.
The front end electronic power supply provides power supply to the H2-RGs and the SIDECAR asics.
The cold cut-off filter defines the upper cut-off wavelength for the NISP instrument.
The interface electronic provides a link between the SIDECAR asics and the NISP ICDPU.
The thermal hardware provides thermal control of the FPA as well as connection to dedicated radiator(s) (not part of the instrument).
The interface electronic and front end electronic power supply units are hold together by a mechanical structure.

FPA geometry

TBD

Infrared Detector Specifications

Euclid Infrared detectors SCA main parameters
H2RG detector (Teledyne Imaging Sensors)
2048×2048 pixels (2040×2040 active light sensitive pixels)
18 μm square pixels
Readout mode: 32 output ports simultaneously, 50 kpixel/sec per output
<15 electrons rms single CDS (correlated double sample)
2.5 μm cut-off detector with full substrate removal
Quantum efficiency ≥80 % over 0.9 to 2.1 μm
Cross-talk ≤ 2 %
Dark current ≤ 0.05 e- / pixel /s
Nominal operating temperature ~100 K
Pixel operability ≥ 96%
Well capacity ≥ 80,000 e-
Persistence ≤ 0.1 %
Inter-pixel capacitance ≤ 2 % (1% typical)
SiC package (TBC), mass <60 g
2 temperature sensors included.
Each H2RG detector is controlled by one Sidecar ASIC focal plane electronics module

Table 25 Euclid infrared detectors SCA main specifications

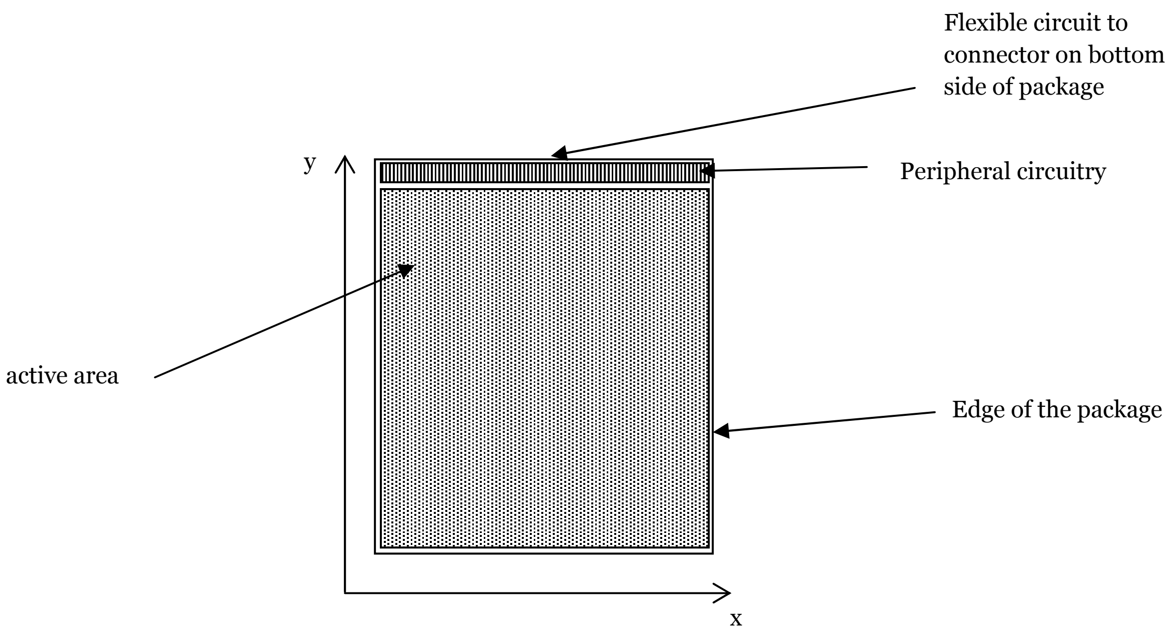

Figure 21 Euclid infrared detector SCA schematic representation.

Parameters	Value	Unit	Comments
Pixel size	18.0 (x) – 18.0 (y)	µm × µm	See Figure 21 for definition of x and y
Number of light sensitive useful pixel	2040 (x) – 2040 (y)	Pixels × pixels	4 rows and columns of reference pixels on each side.
Image area size	36.72 (x) – 36.72 (y)	mm × mm	Only active pixels
Package dimensions (including flexi)	39.3 (x) – 42.4 (y)	mm × mm	Drawings to be supplied by Teledyne. Thickness of package is 10.4 mm (without counting 3 legs, which are about 5 mm tall)
Buttability	4 sides	N/A	3 mm gap between active pixels on 3 sides of the package. 6 mm gap between active pixels on the connector side of the package.
Flatness	< 10	µm	Peak-to-valley
Recommended distance between adjacent packages	200	µm	

Table 26 Euclid infrared detector SCA mechanical specifications

Parameters	Value			Unit	Comments
	Min	**Typ.**	**Max**		
Power consumption	4	6	8	mW	32 outputs mode (unbuffered), 50 kpixels/sec/port

Table 27 Euclid infrared detectors power specifications.

The SIDECAR ASICs will be used to control and digitize the signals from the H2RG SCA.

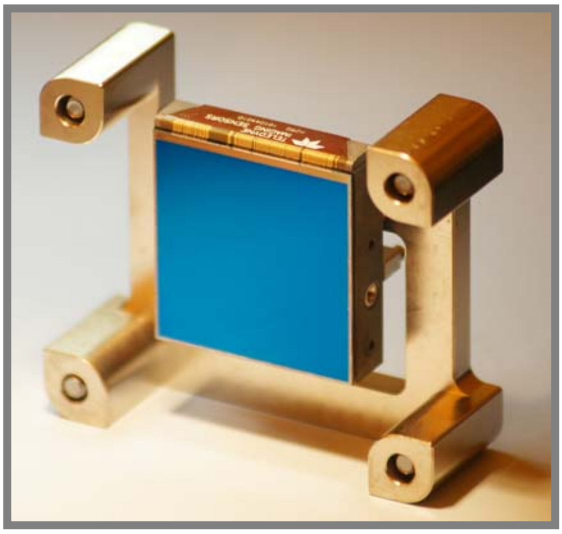

Figure 22 Left: front side view of the H2-RG on a support frame. Right: back side of the H2-RG.

EUCLID sidecar specifications

Euclid SIDECAR ASIC main parameters
The SIDECAR ASIC contains all the necessary electronics to readout the H2RG in all its operating modes and conditions
Operating temperature TBD – can be used at room temperature to 35K. To conserve radiative cooling power of EUCLID, an operating temperature of 150K may be optimal.
Typical power consumption in 36 (32 video channels+4 HK) channels mode, 50 Ksps ≤100 mW (at 100 ksps, 32 ports, power will be <150 mW)
Dimensions of SIDECAR ASIC board 76 mm (TBC) x 38 mm (TBC)
Mass < 150 g
Each H2RG detector is controlled by one SIDECAR ASIC

Table 28 Euclid SIDECAR main specifications

Figure 23 Overall mechanical assembly for the H2-RG, flex and SIDECAR PCB (TBC).