TECHNICAL SPECIFICATIONS DOCUMENT FOR THE PROCUREMENT OF PUBLIC INNOVATION CONTRACTING, IN THE MODALITY OF PUBLIC PROCUREMENT OF INNOVATIVE TECHNOLOGY, FOR THE DESIGN AND PROVISION OF THE OPTICAL SUBSYSTEM OF THE PHOTSAT SATELLITE

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1. Purpose of the contract

The present contract's purpose is the provision of satellite components and services according to the needs identified by the Institut d'Estudis Espacials de Catalunya (IEEC) to carry out the PhotSat mission, an astrophysics satellite dedicated to the observation and study of the space that will integrate an astronomy payload designed and developed by the IEEC.

The provisions and services to be supplied are as follows:

- Design, implementation, testing and validation of the optical subsystem of the PhotSat satellite and its interfaces with the rest of the astronomy payload and the platform systems and modules, following the requirements described by the IEEC in this document and its applicable ones through an iterative design process.
- Support in the integration, verification, and functional validation of the PhotSat astronomy payload process (AIT/AIV of the payload).
- Technical support during the satellite AIV/AIT campaign.

This contract is part of the PhotSat mission, a project co-financed by the Recovery, Transformation and Resilience Mechanism - NextGeneration of the European Union and by the Generalitat de Catalunya. This mission is led and managed by the IEEC with the collaboration of various academic groups and research centers such as the UB (University of Barcelona), the UPC (Polytechnic University of Catalonia), the UAB (Autonomous University of Barcelona), and the ICE-CSIC (Institute of Space Sciences).

2. Technical Specifications and Statement of Work

The services to be performed are defined based on the set of applicable technical specifications for the mission detailed in clause 6 of this document ("Technical Requirements and Specifications") and the overall work expected to be performed by the successful bidder described in clause 7 ("Deadlines, phases, and monitoring of the provision of services").

3. Applicable and Reference Documents

Applicable documents are considered to be part of this document, to the extent specified in this document.

AD	Title/Author	Document Reference	Version	Date
AD-01	PhotSat Optics Requirements Document	PHOTSAT-IEEC-RDD-OPT-044	1.2	2024/02/05

RD	Title/Author	Document Reference	Version	Date
RD-01	CubeSat Design Specification 14	CP-CDS-R14.1		
RD-02	CubeSat Standards Handbook			
RD-03	ECSS Quality assurance	ECSS-Q-ST-20C		

4. Acronyms

AIT	Assembly, Integration and Test
AIV	Assembly, Integration and Verification
CDR	Critical Design Review
CVCM	Collected Volatile Condensable Materials
ECSS	European Coordination for Space Standardization
EGSE	Electrical Ground Support Equipment
EOL	End Of Life
EPS	Electronic Power System
FEE	Front End Electronics
FM	Flight Model
ICD	Interface Control Document
ICU	Instrument Control Unit
IEEC	Institut d'Estudis Espacials de Catalunya
KO	Kick-Off
LEO	Low Earth Orbit
OBC	On Board Computer
OGSE	Optical Ground Support Equipment
PDR	Preliminary Design Review
PM	Project Manager
QM	Qualification Model
SoW	Statement of Work
SSO	Sun-Synchronous Orbit
SW	Software
TCS	Thermal Control System
TML	Total Mass Lost
TRL	Technological Readiness Level
TRP	Temperature Reference Point
TRR	Test Readiness Review
UV	Ultraviolet range
VIS	Visible range
WVR	Water Vapor Regained

5. Introduction

This document defines the services to be executed to comply with the needs of the IEEC in relation to the PhotSat mission regarding the procurement of the PhotSat optical subsystem.

5.1. Background

The PhotSat mission consists of the first space mission entirely led by the IEEC, dedicated to the field of astrophysics through the development of a satellite capable of performing photometry of the brightest stars.

PhotSat mission is an IEEC's space project with the objective to develop a small satellite with two space telescopes, to give response to the IEEC scientific interest in having their own system to observe astronomical phenomena that cannot be properly characterized from ground. Another purpose of this project consists of developing the academic and industrial infrastructure of the space sector in order to be capable to carry out future end-to-end missions and projects using smallsat technology in-house in short development time (<3 years).

Performing astronomy from ground-based observatories is limited by the filtering and distortion of electromagnetic radiation (scintillation or twinkling) due to the atmosphere and by the day-night cycle that limits the amount of time that can be devoted to each object. By avoiding the Earth's atmosphere, space observatories open the possibility of reaching much higher precision in photometry or observing in wavelength regions blocked by the atmosphere.

PhotSat will be a multi-purpose space observatory capable of performing high precision photometry in the Visible (VIS) and Ultraviolet (UV) ranges through two independent telescopes. The observatory will be used for a variety of science cases and will provide supporting data to numerous on-going international programmes including: photometric characterization of sources observed by the JWST, cover the bright end of the LSST survey, combine space-based high quality multiband photometry with ground based observations, among others. More specifically, these kinds of observations will be relevant to the field of: exoplanets, stellar physics, bright transient events (supernova, kilonova and more), variability, solar system objects. Given the development of the NewSpace sector, we also aim at developing a pipeline of expertise to be able to develop scientific experiments with these new platforms.

The satellite of the PhotSat mission will consist of a 12U CubeSat satellite (being 1U, a unit defined according to the CubeSat standard) with an astronomy payload developed at IEEC, that will orbit in a Sun-synchronous Low Earth Orbit at a minimum of 500 km. The main technical objective of the mission is to scan and perform photometric monitoring of the entire available sky, in various photometric bands (VIS and UV), with a cadence of 2 days and with a photometric precision of 1% at the visual magnitude (VIS narrow band) of 12 or brighter. The satellite is expected to be fully operational by the year 2026 and with a lifetime duration of at least 2 years.

The PhotSat satellite's astronomy payload will be composed of various systems and modules. One of them is the optical subsystem, consisting of the structure and a set of lenses and filters, one for each of the two telescopes which will allow both of them to observe and perform high precision photometry in the mentioned bands. Through this contract, the successful bidder will have to provide this optical subsystem, complying with

the technical specifications defined in clause 6 and following the work statement defined in clause 7 of the present document.

5.2. Scope

This document is part of the documentation package delivered for the tender of the service contract for the design and provision of the PhotSat optical subsystem. It contains the technical specifications and the statement of work applicable for the contracting of the mentioned service. This includes:

- Design, implementation, testing and validation of the optical subsystem of the PhotSat satellite and its interfaces with the rest of the astronomy payload and the platform systems and modules, following the requirements described by the IEEC in this document and its applicable ones through an iterative design process.
- Support in the integration, verification, and functional validation of the PhotSat astronomy payload process (AIT/AIV of the payload).
- Technical support during the satellite AIV/AIT campaign.

Clause 6 of this document contains, in the first instance, the description of the PhotSat astronomy payload, its technical objectives and functioning for a better understanding of its operation. Secondly, the technical requirements and specifications for the supply of the PhotSat optical subsystem and its integration into the astronomy payload are described. These specifications will be used by the bidders during the tendering phase to define a proposal to design, develop and manufacture the optical subsystem and how they will support their integration in the PhotSat payload, which will be submitted to the IEEC.

Clauses 7 and 8 contain the statement of work and conditions for the performance of the service proposed for the delivery of the PhotSat optical subsystem. It includes a definition of the phases associated with the project development, the main milestones foreseen within these phases, the deliverables required at each milestone and the proposed reviews to monitor and control the evolution of the project.

5.2.1. Design and manufacturing service

The design and manufacturing service include all those engineering activities related to the achievement of the services entrusted to the successful bidder. Through this service, the successful bidder shall guarantee that all other services may run satisfactorily and in line with the IEEC's needs. This service includes the following tasks:

- Analysis of requirements and needs of the PhotSat astronomy payload.
- Design and development of the PhotSat optical subsystem following the requirements described by the IEEC through an iterative design process.

- Management of purchases, stock and availability of necessary test infrastructure.
- Verification, integration and qualification of the product.
- Logistics to deliver the final product to the IEEC facilities.
- Production of associated documentation, detailed in clause 8 of the present document.

5.2.2. Integration, testing and validation support service

The support service for the integration of an astronomy payload designed and developed by IEEC on board PhotSat satellite and for its functional validation include the following activities:

- Support in the integration, verification, and qualification of the payload process (AIT/AIV of the astronomy payload and the PhotSat satellite) and the payload functional validation before launch.
- The successful bidder must provide technical support during the Payload AIV/AIT campaign as well as Platform AIV/AIT campaign in the only case where the optics fail to comply with a given requirement not validated in previous campaigns. IEEC expects the successful bidder to address the issue even if it means repairing or replacing optics components in order to comply with requirements.
- Coordination with IEEC during all phases of the mission.

6. Technical requirement specifications

The requirements and technical specifications that the optical subsystem must comply with are described in Annex I of this document.

7. Deadlines, phases and monitoring of the provision of services

7.1. Maximum deadline for performance and partial deadlines

The development of the services must be in accordance with the technical requirements described in clause 6 of this document. ***Figure 1*** shows, without a time scale, the relationship between the Milestones and Phases applicable to the performance of the contract.

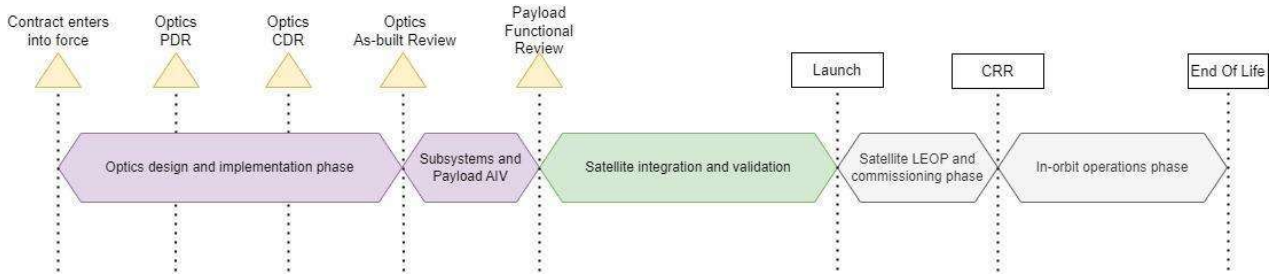


Figure 1 *Relationship between Milestones and Phases (with no time scale)*

Table 1 sets out the partial deadlines related to the milestones defined below according to the following timeline, T0 being the date on which the contract is signed:

Milestone	Name	Deadline
1	Preliminary Design Review (PDR)	T0 + 1 month
2	Critical Design Review (CDR)	Milestone 1 + 1 month & 15 days
3	Optics As-built Review	Milestone 2 + 2 months
4	Payload Functional Review	Milestone 3 + 2 months

Table 1 *List of contractual milestones and contract deadlines.*

7.2. Phases and monitoring of the provision of services

The contract will be monitored through milestones and follow-up meetings at different intervals according to the applicable phase attended by the person responsible for the contract on the part of the awarded company and the specialized staff of the IEEC, either the person responsible for the contract or the person designated by them. The milestones will be considered achieved when the successful bidder delivers the associated deliverables and the corresponding reference and applicable documentation, the two parties accept the minutes of the meeting and agree that there are no open review item discrepancies.

Both the IEEC and the successful bidder may request the convening of any additional technical meetings that may be necessary for the correct performance of the contract.

In each of the meetings, the successful bidder will deliver the minutes of the meeting and the additional applicable documentation:

- Milestones: deliverables and associated reference documentation.
- Follow-up meetings: progress report.

The successful bidder will monitor the actions that may arise from the meetings throughout the duration of the contract.

7.2.1. KO phase

The project begins with a kick-off meeting (KO). The kick-off meeting will:

- Confirm and formalize the start of the project and initiate the next phase.
- Ensure that both parties have a clear understanding of the contract terms and conditions related to project execution.
- Discuss and resolve any issues or concerns that have arisen since the bidding phase.
- Set specific deadlines to resolve any pending issues related to project documentation.
- Ensure agreement on the content and format of the deliverables.

7.2.2. Design and implementation phase

The design and implementation phase starts automatically with the start of the contract and ends with the Optics As-built Review.

During this phase, the successful bidder, based on the proposed technical requirements defined in clause 6, is responsible for the design, development, manufacturing, validation and testing of the optical subsystem. Given that the astronomy payload in which the optics will be integrated is designed and implemented by the IEEC, this phase requires close coordination between the technical teams of the successful bidder and the IEEC.

A team of engineers from the IEEC will collaborate with the successful bidder regarding the design and implementation of mechanical interfaces with the platform structure and the payload detectors.

After the CDR, the manufacturing of the flight models will start. In parallel, the successful bidder shall coordinate the preparation of the AIV/AIT documentation and activities of the optics with IEEC engineers in those tests where the detector is required.

After the acceptance of the Optics As-built Review milestone, the successful bidder will coordinate the tasks associated with the integration, assembly and the validation of the payload together with the IEEC engineering team.

7.2.2.1. Monitoring

Monitoring during this phase will be done as follows:

- Follow-up meetings, where the successful bidder will deliver a Progress Report according to the method described in clause 8 of this document, with the frequency of 1 meeting weekly. The bidder may propose additional meetings of a technical nature.
- Holding of the following milestones:
  - PDR: Preliminary Design Review
  - CDR: Critical Design Review
  - Optics As-built Review

The technical documentation required and method of holding each milestone is detailed in clause 8 of this document.

In order to proceed to the next contractual milestone, the design phase must be successfully completed in accordance with the technical guidelines of the IEEC.

7.2.3. Subsystems and Payload AIV

Between Milestone 3 (Optics As-built Review) and 4 (Payload Functional Review), the successful bidder will coordinate the activities relating to:

- Coordinate the shipping of the Optics and their OGSEs from successful bidder facilities and the detectors and their EGSEs from IEEC facilities to the testing facilities.
- Reception and integration of all the elements for the payload AIV/AIT campaign.
- Execution of the Functional and Performance validation of the Optics together with the detectors and with the involvement of IEEC engineering team.

7.2.3.1. Validation tests

The successful bidder must pass at least the following qualification tests (QT), to be further specified during the development phase together with IEEC engineers:

- Functional Test (at sea level and vacuum pressures)
- Performance Test (at sea level and vacuum pressures)

- Interfaces Test (with the siderostat mechanism, the detector and the satellite structure)

7.2.3.2. Monitoring

The follow-up meetings will be on a weekly basis from this phase until the contract's termination.

The technical documentation required and method of holding each milestone is detailed in clause 8 of this document.

In order to proceed to the next contractual milestone, the review phase of the optical subsystem and the functional review of the payload must be successfully completed in accordance with the technical guidelines of the IEEC.

7.2.4. Support during the Payload and Satellite AIV/AIT and Commissioning phases

Once the astronomy payload is assembled and validated, it will be sent directly to the platform provider facilities for its integration into the satellite platform. From there, the successful bidder will provide the support in the procedures of the AIV/AIT (Assembly, Integration, Verification and Testing) of the astronomy payload with the satellite platform (executed by the platform provider), specifically in those tests and verifications where the optics are involved, with the help from the IEEC Engineering team.

The successful bidder must provide technical support during the platform AIV/AIT campaign in the only case where the Optics fail to comply with a given requirement not validated in previous campaigns. IEEC expects the successful bidder to address the issue even if it means repairing or replacing Optics components in order to comply with requirements.

8. Conditions for the performance of the service

8.1. Deliverables

The successful bidder, in the periodic follow-up meetings, will deliver a Progress Report. The report will detail the content listed below once a month, throughout the duration of the contract.

- Activities carried out since the last progress report.
- Incidents, anomalies and actions.
- Planned activities until the next follow-up meeting.
- Follow-up of open actions.
- Forecast of achievement of future Milestones.

Table 2 shows the deliverables associated with each of the contractual milestones. In the event that a previously delivered document is subject to review or amendment, it must be delivered at the current contractual milestone.

Document	PDR	CDR	Optics As-built Review	Optics AIV/AIT Review
System Concept and Design Iterations (Trade-off)	X	X		
Straylight analysis	X	X	X	
System and Subsystems Requirements and Specifications	X	X		
Technical Budgets Analysis	X	X		
Requirements Compliance Matrix	X	X	X	
Detailed Design Description Document (CAD + ZEMAX)	X	X	X	
Optics AIV Plan and Procedures		X	X	X
ICD of the optical subsystem within the astronomy payload	X	X	X	
Verification Control Reports	X	X	X	X

Table 2 *List of deliverables for each of the contractual Milestone*

8.2. Communication and disclosure

Any communications associated with the publication of results or technical achievements derived from the fulfillment of the various milestones stipulated in the contract must be coordinated and approved by IEEC.

Once the contract has been awarded, IEEC and the successful bidder will agree on a communication plan for each phase.

The successful bidder will not be able to make public any audiovisual material (image, video, etc.) generated in relation to the PhotSat mission until it is explicitly authorized to do so by the IEEC. In the case of material owned by IEEC, the IEEC will establish the conditions for dissemination by the successful bidder and third parties, where applicable.

9. ANNEX I

9.1. Technical requirement and specifications

The technical requirements and specifications described in this clause are extracted from the requirement definition documents [AD-01].

9.1.1. Purpose and scope

The purpose of this clause is to define the technical requirements and objectives for the design, development and manufacture of the PhotSat optical subsystem and its integration in the astronomy payload.

9.1.2. Requirements Format Definition

Each requirement and goal will be defined in a table containing all the relevant information to identify, track, understand and verify a given requirement/goal. The following section defines the format of this table and its parameters.

ID	R-SUBS-TYPE-PRI-VER-XXY
Title	
Description	
Priority	
Verification	
Parents	
Justification	

9.1.2.1. ID (Identification code)

The requirement/goal identification code. With its cell painted in gray if it is a Requirement and painted in blue if it is a Goal. It follows a *R-SUBS-TYPE-PRI-VER-XXY* format where:

SUBS refers to the subsystem which shall comply with the requirement:

code	definition
SM	Siderostat Mechanism
VIS	Visible Optics
UV	Ultraviolet Optics
VISUV	Visible and Ultraviolet Optics
DET	Detector and its electronics
ICU	Instrument Control Unit
TCS	Thermal Control System

TYPE refers to the type of requirement, and shall be one of the following options:

code	definition
SCI	Scientific requirement
FUN	Functional Requirement
PER	Performance Requirement
ENV	Environmental Requirement
IF	Interface Requirement
QA	Quality Assurance Requirement
LG	Logistics Requirement
DEV	Development Requirements

PRI refers to the priority of the requirement, and shall be one of the following options:

code	definition
L	Low priority
M	Medium priority
H	High priority

VER refers to the verification method used to validate the compliance of the requirement, and shall be one or a combination of the following options:

code	definition
R	Verification by Review of Design
I	Verification by Visual Inspection
A	Verification by Analysis
T	Verification by Test

XXY is the number of the requirement/goal of a given *SUBS* and *TYPE:*

code	definition
XX	2-digit number starting with 01
Y	0 if it is a requirement. 5 if it is a goal.

Example: R-PFM-SCI-H-R-010

9.1.2.2. Title

A human readable name for the requirement/goal.

9.1.2.3. Description

Detailed description of the requirement/goal.

9.1.2.4. Priority

Priority of the requirement/goal. It shall be one of the following options and match the ID of the requirement/goal:

Priority	ID *PRI* code	Meaning
Low Priority	L	Modifying the nature of the requirement does not directly impact Scientific mission nor other requirements
Medium Priority	M	Modifying the nature of the requirement implies a trade off with other requirements
High Priority	H	Modifying the nature of the requirement is not possible as it directly impacts the Scientific mission or other critical requirements

9.1.2.5. Verification Method

Verification method to validate the correct implementation of the requirement/goal. It shall be one or a combination of the following options and match the ID code of the requirement/goal:

Verification Method	ID *VER* code
Review of the design	R
Inspection	I
Analysis	A
Test	T

9.1.2.6. Parents

Parent requirements ID codes of the requirement/goal, separated with commas.

Example: R-TOP-SCI-H-R-010, R-TOP-SCI-H-R-020, …

9.1.2.7. Justification (optional)

Optional field. Description of the reasons and the context that justifies the requirement's existence.

9.1.2.8. Examples

ID	R-VIS-QA-H-R-030
Title	VIS Optics TRL
Description	The TRL of the VIS Optics components shall be 7 or higher.
Priority	High
Verification	Review of the Design
Parents	R-TOP-QA-H-R-30
Justification	

ID	R-VIS-QA-H-R-030
Title	VIS Optics TRL Goal
Description	The TRL of the VIS Optics components should be 9 and have flight heritage.
Priority	High
Verification	Review of the Design
Parents	R-TOP-QA-H-R-35
Justification	

9.1.3. Satellite system overview

This section explains the general view of the mission, with special attention to the PhotSat satellite astronomy payload and its structure and technical objectives.

The PhotSat satellite consists of a 12 units CubeSat (12U according to the CubeSat standard - cubesat.org), shown in ***Figure 2***. To maximize power and thermal stability it will orbit the Earth at an altitude of approximately and no less than 500 km in a Sun synchronous Dawn-Dusk orbit (SSO), keeping its solar panels always perpendicular to the Sun. With agile development, the satellite is expected to be launched by the end of 2025.

PhotSat is a satellite mission aimed at monitoring the full accessible sky every two days extracting photometry of the brightest stars while detecting and warning of possible transient phenomena. With two small cameras (telescopes) and with a mirror rotating mechanism, the PhotSat satellite will be able to observe stars within the range of VIS and UV wavelength, while detecting and warning of possible variable sources. The sky is covered by keeping the satellite in a rigid pointing with respect to the sky during each orbit, and using the rotating mechanism, a siderostat mirror, at the entrance of the telescope to scan a great circle strip. At the following orbit, the plane of rotation of the siderostat is changed by reorienting the satellite and the process is repeated until the full sky is covered.

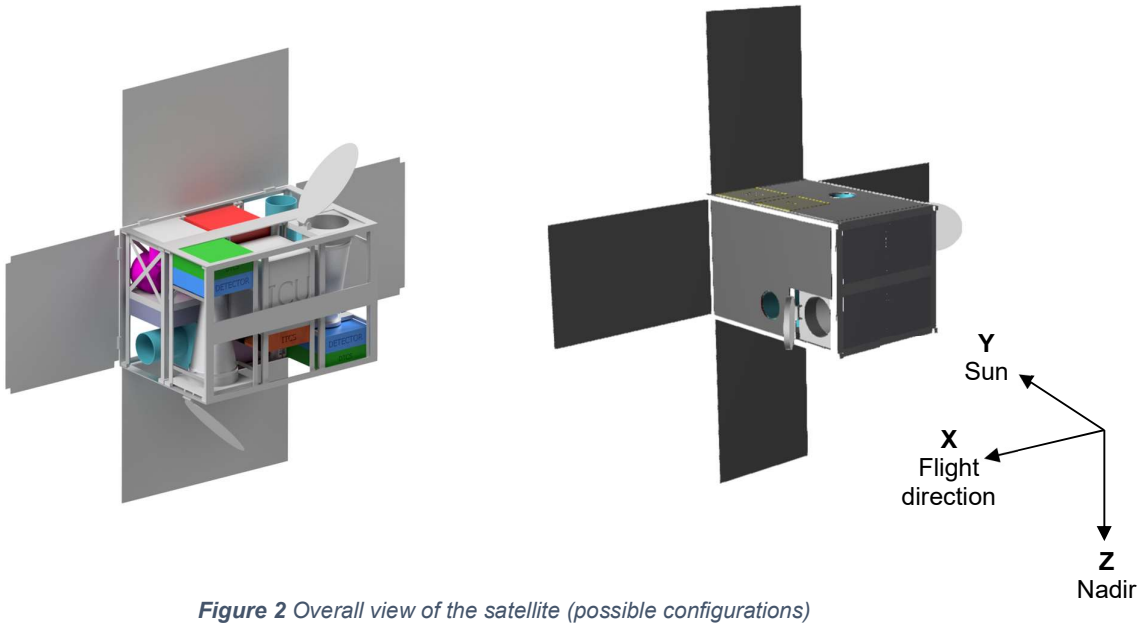


Figure 2 *Overall view of the satellite (possible configurations)*

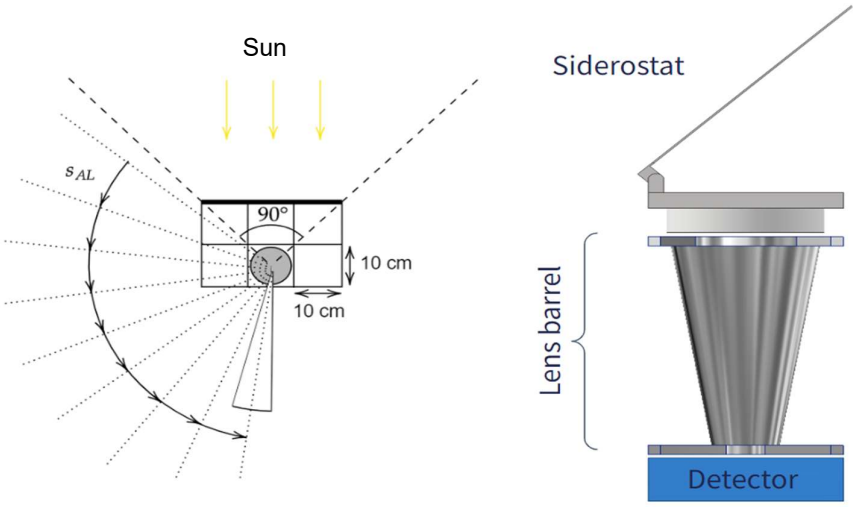
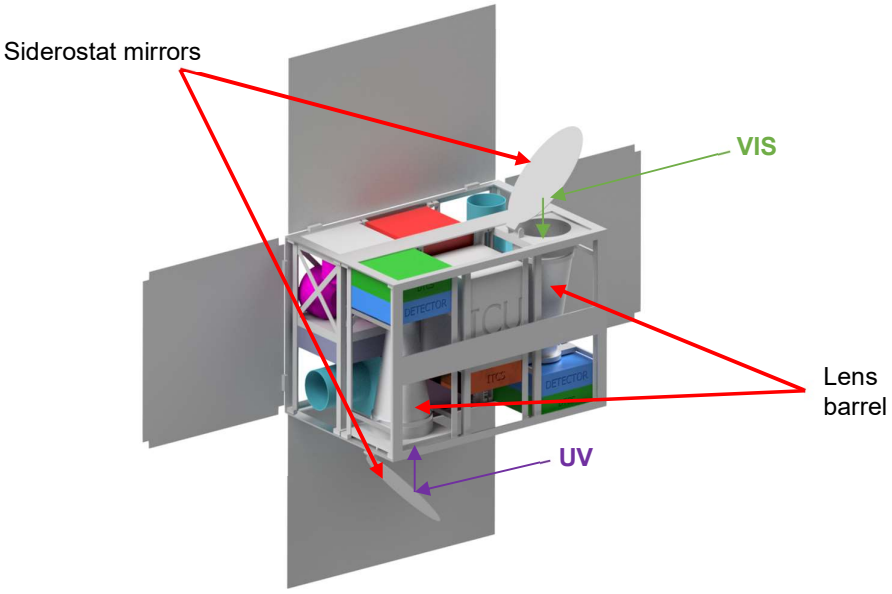


Figure 3 *Rotation diagram of the siderostat (left) and the concept of the optical subsystems (right) for each telescope*



The satellite is equipped with two small apertures but with a large field of view each (6 or 8 deg in diameter). The telescopes (or channels) are almost identical devices except for their wavelength sensitivity: a visual channel (500 to 700 nm, divided in two bands for better spectral resolution), and an ultraviolet channel (200-300 nm, single band to enhance signal and simplify optics). The two channels consist of specifically designed lenses (one for VIS and one for UV) coupled space proven off-the-shelf detector technology (CMOS, 2k x 2k 5-micron pixels or larger - GSENSE 2020BSI).

Each siderostat and telescope are shielded against direct solar light by the solar panels themselves, which also block access to the sky at about 60 deg from the direction of the Sun (Sun avoidance angle), as shown in ***Figure 3***.

The central science case used to set the mission requirements consists of obtaining images of the full available sky every two days, reaching a photometric precision of about 1% in the VIS channel (VIS narrow band) at magnitude 12 mag, which encompasses more than 2 million sources. As it will obtain and download to ground full images, objects (stars but also transient phenomena) up to 16 mag shall also be detectable at a photometric precision of about 20% at the faint limit. For the UV channel, the magnitude limit is less certain as this is an unexplored domain (scientifically and with respect to the technology performance), but we expect to reach good photometric precision at about 9 mag (1% level), and a detection limit at 13 mag.

A block diagram of the PhotSat satellite can be seen in ***Figure 5***, with a clear distinction between payload and platform subsystems. While the payload will move the siderostats and extract scientific data from the optical system, the platform will be in charge of powering the satellite, controlling its orientation, establishing communications with the ground segment and managing all data between subsystems, including the astronomy payload.

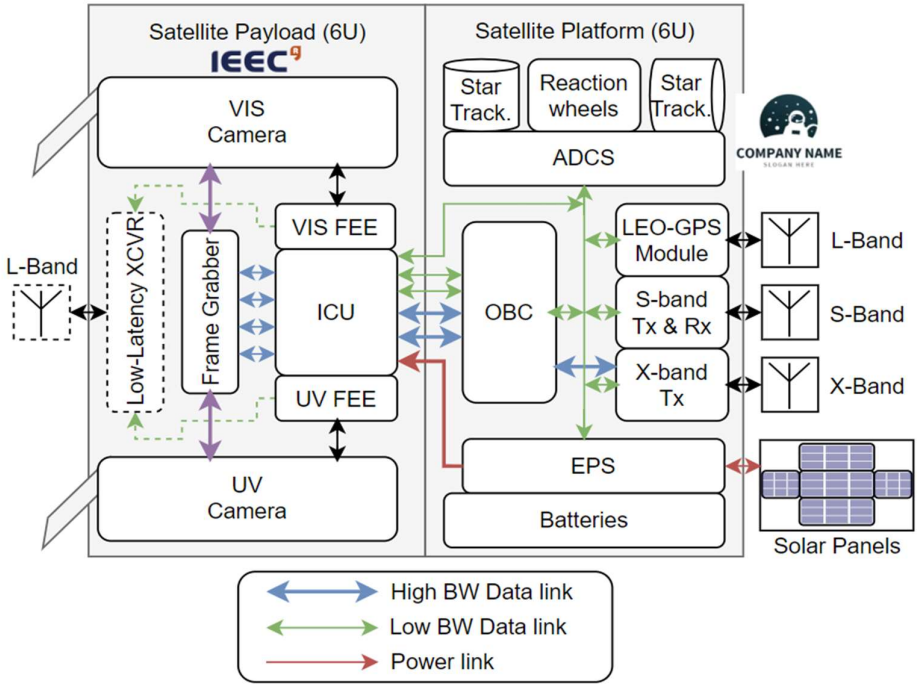


Figure 5 *PhotSat astronomy payload and platform main subsystems concept*

The figure below shows a general view of the astronomy payload with special attention to the separation between the different main subsystems.

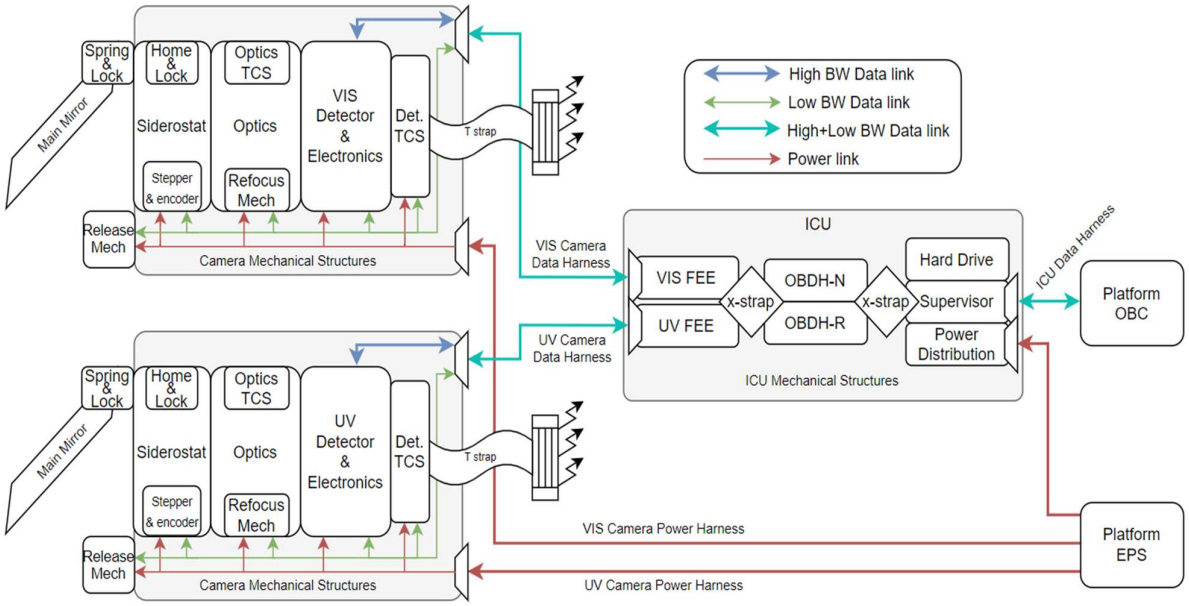


Figure 6 *PhotSat astronomy payload main subsystems concept*

9.1.4. VIS Optics Requirements

Lists of the flowed-down requirements that apply to the Optics subsystem in the visible (VIS) spectrum.

9.1.4.1. Functional Requirements

Specify what the Optics must do, and how it shall interact with the astronomy payload and the platform.

ID	R-VIS-FUN-H-RA-010
Title	VIS Optics operative location
Description	The PhotSat Optics shall operate inside a CubeSat Satellite (standard CubeSat cubesat.org), in a Heliosynchronous Dawn-Dusk LEO orbit (with an eccentricity lower than 0.0025, no lower than 500 km altitude and the inclination required for the orbital plane to precede e.g. 97.7º) and observe the sky with the siderostat mechanism attached at one end and the GSENSE 2020BSI detector at the other.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-020
Title	VIS Optics spectral range
Description	The PhotSat VIS Optics shall be able to observe the stars with one camera tailored for the visible spectrum: from 500 nm to 700 nm.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-025
Title	VIS Optics spectral range Goal
Description	The PhotSat VIS Optics should be able to observe the stars with one camera tailored for the visible spectrum: from 370 nm to 840 nm.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-030
Title	VIS Optics optical filters
Description	The PhotSat VIS Optics shall use 2 filters to separate the optics bandwidth in 2 areas over the detector, using 2 filters side by side (each filter covering half of the total detector's area) on the detector's window (tapped cover glass).
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-035
Title	VIS Optics optical filters Goal
Description	The PhotSat VIS Optics should use 2 filters to separate the optics bandwidth in 2 areas over the detector, using 2 filters using a chessboard-like pattern (4 quadrants) on the detector's window (tapped cover glass).
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-040
Title	VIS Optics optical filters range
Description	The PhotSat VIS Optics shall use 2 filters to separate the optics bandwidth in 2 areas over the detector: Filter A: 500-700 nm passband (wide) Filter B: 600-700 nm passband (narrow)
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-FUN-H-RAT-045
Title	VIS Optics optical filters range Goal
Description	The PhotSat VIS Optics should use 2 filters to separate the optics bandwidth in 2 areas over the detector: Filter A: 380-840 nm passband (wide) Filter B: 600-840 nm passband (narrow)
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	

ID	R-VIS-PER-H-RAI-050
Title	VIS Optics filters pixel alignment
Description	The boundary of the two filters of the VIS Optics shall be aligned with the pixel columns/rows of the detector to 6 arcmin.
Priority	High
Verification	Review of the Design, Analysis, Inspection
Parents	
Justification	

ID	R-VIS-PER-H-RAI-060
Title	VIS Optics filters area
Description	The number of pixels illuminated by each filter of the VIS Optics shall be the same (50% ± 4 pixels columns/rows).
Priority	High
Verification	Review of the Design, Analysis, Inspection
Parents	
Justification	

ID	R-VIS-FUN-H-RA-070
Title	VIS Optics thermal control systems
Description	The PhotSat Optics shall be designed for maximum thermal uncoupling with the rest of the satellite, but if needed, heat generation shall be performed with electrical heaters (provided by payload's ICU), while heat extraction shall use passive elements such platform structural anchoring points, heat pipes or thermal straps and radiators placed in the anti-Sun face of the satellite.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	The satellite shall have a thermal control system to function, especially for the detectors, optical system and the ICU.

ID	R-VIS-FUN-H-RIAT-080
Title	VIS Optics straylight
Description	The straylight contamination component shall contribute to the detected light with a percentage lower than 10^{-5}.
Priority	High
Verification	Review of the design, Inspection, Analysis, Test
Parents	
Justification	The Earth, the Moon and the Solar system planets and potentially also the Sun will be around the satellite pouring light into the optical system.

9.1.4.2. Performance Requirements

Specify how well a subsystem must perform in order to meet the mission objectives.

ID	R-VIS-PER-H-RA-010
Title	VIS Optics diffraction encircled energy (>80%)
Description	The PhotSat VIS Optics shall concentrate photons (with a polychromatic diffraction encircled energy of >80%) over an area of the detector of 13 µm.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	13 µm corresponds to the pixel size x2, sampling of 2 pixel per resolution element.

ID	R-VIS-PER-H-RAT-015
Title	VIS Optics diffraction encircled energy (>80%) Goal
Description	The PhotSat VIS Optics should concentrate photons (with a polychromatic diffraction encircled energy of >80%) over an area of the detector of 6.5 µm.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	6.5 µm corresponds to the pixel size.

ID	R-VIS-PER-H-RAT-020
Title	VIS Optics Effective Image Quality
Description	The PhotSat VIS Optics shall be optimized for a flat focal plane and provide an effective image quality over the detector of at least: From field center up to 80% FoV < 13 µm Above 80% FoV < 20 µm
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	The fields written are from the optical axis, so the real FoV is double the number.

ID	R-VIS-PER-H-RAT-025
Title	VIS Optics Effective Image Quality Goal
Description	The PhotSat VIS Optics should be optimized for a flat focal plane and provide an effective image quality over the detector of at least: From field center up to 90% FoV < 6.5 µm Above 90% FoV < 18 µm
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	The fields written are from the optical axis, so the real FoV is double the number.

ID	R-VIS-PER-H-RAT-030
Title	VIS Optics transmittance
Description	The PhotSat VIS Optics shall allow a total transmittance (from the aperture until the detector) higher than 70% at any operational wavelength.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-PER-H-RAT-035
Title	VIS Optics transmittance Goal
Description	The PhotSat VIS Optics should allow a total transmittance (from the aperture until the detector) higher than 80% at any operational wavelength.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-PER-H-RAT-040
Title	VIS Optics Telecentricity
Description	The PhotSat VIS Optics shall be telecentric at full Field of View to ≤2º (degrees).
Priority	Medium
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VIS-PER-H-RAT-050
Title	VIS Optics distortion
Description	The PhotSat VIS Optics shall have radial f-Tan(θ) ≤2% through the full FoV.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

The requirements and goals related to:

- Field of View
- Relative aperture
- Operative lifetime
- Performance vs Temperature

Both the visible (VIS) and ultraviolet (UV) optical subsystems must comply with the specifications with the same parameters, either both meeting the requirements or both meeting the goal.

These requirements are specified in section *9.1.6. VIS and UV Optics common requirements*.

9.1.4.3. Environmental Requirements

Specify the environmental conditions that a subsystem must be able to withstand, on ground, during launch and in space.

ID	R-VIS-ENV-H-RI-010
Title	VIS Optics Satellite Standards
Description	PhotSat VIS Optics shall follow the CubeSat standard [RD-01] and the tailored ECSS standards for CubeSats [RD-03] and be able to complete its mission with the Open Cosmos 12U CubeSat and the astronomy payload developed at IEEC.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	CubeSat standards are suitable for a fast mission like PhotSat and reduce design, development and manufacturing of the satellite as well as its launch costs.

ID	R-VIS-ENV-H-RI-020
Title	VIS Optics volume allocation
Description	The VIS Optics subsystem's total volume (excluding mechanical interfaces) shall be less than 9cm x 9cm x 135cm and fit inside a 1.35U (CubeSat 1U = 10cm x 10cm x 10cm).
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	This goes from the first surface, which includes the diaphragm (or aperture of the siderostat), to the focal plane, which is the detector. The detector itself (the box plus its electronics) is not included.

ID	R-VIS-ENV-H-RT-030
Title	VIS Optics mass allocation
Description	The VIS Optics subsystem total dry mass shall be less than 1.8 kg.
Priority	High
Verification	Review of the Design, Test
Parents	
Justification	CubeSat 1U max mass = 1,333 kg // 1.35U = 1,799 kg (margins not taken into account).

ID	R-VIS-ENV-H-RA-040
Title	VIS Optics launch environment
Description	The PhotSat VIS Optics, its structures and subsystems shall be able to withstand the vibrational, acoustic and shock environment of the launch.
Priority	High
Verification	Review of the design, Analysis
Parents	
Justification	Launch vehicle is still not chosen, but probably will be a Falcon 9 from SpaceX. It is not defined as "test" because IEEC will test its launch resilience in a shaker.

ID	R-VIS-ENV-M-A-050
Title	VIS Optics radiation environment
Description	The PhotSat VIS Optics shall survive and operate in the radiation environment present in a polar LEO orbit, for the duration of the mission (up to 10 krad).
Priority	Medium
Verification	Analysis
Parents	
Justification	

ID	R-VIS-ENV-M-A-060
Title	VIS Optics Atomic O environment
Description	VIS Optics elements exposed to the exterior of the satellite (the first lens) shall incorporate in their design mitigation techniques to reduce the impact of the atomic oxygen erosion in LEO orbit and ensure its optimal operations for the duration of the mission or provide enough evidence that no optical degradation will occur.
Priority	Medium
Verification	Analysis
Parents	
Justification	Atomic Oxygen will "rain" from every direction (as the satellite rotates to scan all the maximum circles) and affect the external surfaces of the satellite, except from the Sun and anti-Sun faces, which are almost orthogonal to trajectory. Seems like glass is not that affected, so the main mirror should be OK, but the coatings in some parts might not.

ID	R-VIS-ENV-H-A-070
Title	VIS Optics Outgassing environment
Description	VIS Optics elements shall have a TML < 1% with a CVCM of < 0.1% and a WVR < 1% or better.
Priority	High
Verification	Analysis
Parents	
Justification	Especially sensible near the detector.

ID	R-VIS-ENV-H-A-080
Title	VIS Optics Vacuum environment
Description	VIS Optics shall be able to nominally operate under a pressure of 10^{-8} mbar for the duration of the mission and provide purge holes to evacuate trapped air inside complicated geometries and assemblies. VIS Optics shall also withstand (not operate) sea level pressure during development, manufacturing, between tests and in storage.
Priority	High
Verification	Analysis
Parents	
Justification	Vacuum testing will be done at IEEC.

ID	R-VIS-ENV-H-R-090
Title	VIS Optics Charging environment
Description	All metallic VIS Optics elements shall be electrically connected to the satellite structure and share a "chassis" connection with the EPS.
Priority	High
Verification	Review of the design
Parents	
Justification	grounding tests will be done at IEEC.

For the thermal environment, both the visible (VIS) and ultraviolet (UV) optical subsystems shall be able to nominally operate under the same thermal conditions present inside a CubeSat, either both meeting the requirements or both meeting the goal.

This requirement is specified in section *9.1.6. VIS and UV Optics common requirements*.

9.1.4.4. Interface Requirements

Specify how a subsystem must interact with other subsystems, both electrically and physically.

ID	R-VIS-IF-H-RA-010
Title	VIS Optics Thermal Interfaces
Description	PhotSat VIS Optics shall use the payload and platform subsystems tailored thermal interfaces (via mechanical structure or sticking heaters from ICU) to maintain its nominal and survival temperature ranges.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	

ID	R-VIS-IF-H-RI-020
Title	VIS Optics Platform Mechanical Interfaces
Description	PhotSat VIS Optics shall provide a mechanical interface to anchor it to the Open Cosmos 12U CubeSat internal structure, which is composed of lateral rails with equidistant holes in which to anchor subsystems via M2.5 screws (similar to a server rack structure).
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-IF-H-RI-030
Title	VIS Optics Siderostat Mechanical Interface
Description	PhotSat VIS Optics shall provide an internal mechanical interface to connect to the siderostat, maintaining performance after launch and minimizing straylight impact throughout the mission.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-IF-H-RI-040
Title	VIS Optics Detector Mechanical Interface
Description	PhotSat VIS Optics shall provide an internal mechanical interface to connect to the detector, maintaining performance (optical quality) after launch and in vacuum.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

9.1.4.5. Quality Assurance and Reliability Requirements

Specify the Quality Assurance and Reliability considerations that must be taken into account when designing and operating the Optics.

ID	R-VIS-QA-H-R-010
Title	VIS Optics ECSS Standards
Description	VIS Optics development shall conform with the ECSS standards that are applicable to CubeSats, if there are no budget or time constraints (in which case a justification report shall be issued).
Priority	High
Verification	Review of the Design
Parents	
Justification	By default, ECSS standards shall be applied, but there might be some cases in which other standards (automotive, medical, etc) can be used.

ID	R-VIS-QA-H-R-020
Title	VIS Optics Margin Philosophy
Description	VIS Optics development shall take into account a 20% margin for the engineering budgets (volume, mass, power, pointing, timings, etc) during early phases and until CDR. From CDR, 10% margins.
Priority	Medium
Verification	Review of the Design
Parents	
Justification	

ID	R-VIS-QA-H-RI-030
Title	VIS Optics Manufacturing, Assembly and Verification Plan
Description	The VIS Optics supplier shall provide and document the planning of the manufacturing, assembly and integration stages in the manufacturing plan or flow chart for the VIS Optics subsystem, including the sequence of operations, inspections, tests and verifications, with the reference to the procedures by which the various activities are performed and the required cleanliness levels and temperature and humidity requirements of the facilities.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-QA-H-RI-040
Title	VIS Optics Assembly and Verification Procedures
Description	The VIS Optics supplier shall provide an Assembly Procedure and a Functional Test Procedure so a third party can integrate the Siderostat, the Optics and the Detector inside the 12U CubeSat Structure from Open Cosmos and validate its nominal operations.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-QA-H-R-050
Title	VIS Optics Plans and Developments Reviewing Methods
Description	The manufacturing, verification and commissioning plans shall be reviewed and discussed with Payload engineers during the development phase to simplify and accelerate the tests and verifications of the Payload.
Priority	High
Verification	Review of the Design
Parents	
Justification	

ID	R-VIS-QA-H-R-060
Title	VIS Optics Non-Conformance Procedure
Description	The VIS Optical supplier should implement a non-conformance control procedure
Priority	High
Verification	Review of the Design
Parents	
Justification	

9.1.4.6. Logistics Requirements

Specify the logistics considerations that must be taken into account when manufacturing, assembling, testing and operating the Optics.

ID	R-VIS-LG-H-RI-010
Title	VIS Optics Development Shipping
Description	The VIS Optics supplier shall be responsible, in cost and risk, for the transport of the complete VIS Optics subsystem and its different elements during the development phase.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-LG-H-RI-020
Title	VIS Optics Package
Description	PhotSat VIS Optics shall be properly packaged by the provider after the Functional Test campaign at the end of the development phase with a container that ensures a safe transportation and a clean storage environment for the optics.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

9.1.4.7. Development and Verifications Requirements

Specify the considerations that must be taken into account when developing and verifying the Optics.

ID	R-VIS-DEV-H-RI-010
Title	VIS Optics Functional Test Activities
Description	The VIS Optical supplier shall be responsible for performing the functional verification under nominal conditions of the complete VIS Optical subsystem with the support of the IEEC Engineering team.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	While the supplier will test the functionality, IEEC will test the performance under different environmental factors.

ID	R-VIS-DEV-H-RI-020
Title	VIS Optics Mechanical EM
Description	The VIS Optics supplier shall provide a physical Engineering Model (EM) and its CAD, of the subsystem's mechanical structure, representative of the Flight Model thermo-mechanical behavior, no later than T0+4months (T0 being the date on which the contract is signed), to ease the mechanical integration between the optics and the Siderostat, Detectors and Open Cosmos 12U CubeSat structure.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-VIS-DEV-H-R-030
Title	VIS Optics Validation and Commissioning
Description	The VIS Optics supplier shall provide support to IEEC engineers during AIV/AIT campaigns and until Commissioning of the astronomy payload in LEO, in case there are problems or issues with the optics or non-conformance results.
Priority	High
Verification	Review of the Design
Parents	
Justification	

9.1.5. UV Optics Requirements

Lists of the flowed-down requirements that apply to the Optics subsystem in the ultraviolet (UV) spectrum.

9.1.5.1. Functional Requirements

Specify what the Optics must do, and how it shall interact with the astronomy payload and the platform.

ID	R-UV-FUN-H-RA-010
Title	UV Optics operative location
Description	The PhotSat Optics shall operate inside a CubeSat Satellite (standard CubeSat cubesat.org), in a Heliosynchronous Dawn-Dusk LEO orbit (with an eccentricity lower than 0.0025, no lower than 500 km altitude and the inclination required for the orbital plane to precede e.g. 97.7º) and observe the sky with the siderostat mechanism at one end and the GSENSE 2020BSI detector at the other.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	

ID	R-UV-FUN-H-RAT-020
Title	UV Optics spectral range
Description	The PhotSat UV Optics shall be able to observe the stars with one camera tailored for the ultraviolet spectrum: from 250 nm to 300 nm.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-UV-FUN-H-RAT-025
Title	UV Optics spectral range Goal
Description	The PhotSat UV Optics should be able to observe the stars with one camera tailored for the ultraviolet spectrum: from 200 nm to 365 nm.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-UV-FUN-H-RAT-030
Title	UV Optics optical filters
Description	The PhotSat UV Optics shall use one single passband filter of the full nominal spectral range of the UV Optics, placed on the detector's window (tapped cover glass).
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-UV-FUN-H-RA-040
Title	UV Optics thermal control systems
Description	The PhotSat Optics shall be designed for maximum thermal uncoupling with the rest of the satellite, but if needed, heat generation shall be performed with electrical heaters (provided by payload's ICU), while heat extraction shall use passive elements such platform structural anchoring points, heat pipes or thermal straps and radiators placed in the anti-Sun face of the satellite.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	The satellite shall have a thermal control system to function, especially for the detectors, optical system and the ICU.

ID	R-UV-FUN-H-IAT-050
Title	UV Optics straylight
Description	The straylight contamination component shall contribute to the detected light with a percentage lower than 10^{-5}.
Priority	High
Verification	Inspection, Analysis, Test
Parents	
Justification	The Earth, the Moon, the planets and the Sun will be around the satellite pouring light into the optical system.

9.1.5.2. Performance Requirements

Specify how well a subsystem must perform in order to meet the mission objectives.

ID	R-UV-PER-H-RA-010
Title	UV Optics diffraction encircled energy (>80%)
Description	The PhotSat UV Optics shall concentrate photons (with a polychromatic diffraction encircled energy of >80%) over an area of the detector of 26 µm.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	26 µm corresponds to the pixel size x4.

ID	R-UV-PER-H-RA-015
Title	UV Optics diffraction encircled energy (>80%) Goal
Description	The PhotSat UV Optics should concentrate photons (with a polychromatic diffraction encircled energy of >80%) over an area of the detector of 13 µm.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	13 µm corresponds to the 2x the pixel size.

ID	R-UV-PER-H-RAT-020
Title	UV Optics Effective Image Quality
Description	The PhotSat UV Optics shall be optimized for a flat focal plane and provide an effective image quality over the detector of at least: From field center up to 80% FoV < 13 µm Above 80% FoV < 20 µm
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	The fields written are from the optical axis, so the real FoV is double the number.

ID	R-UV-PER-H-RAT-025
Title	UV Optics Effective Image Quality Goal
Description	The PhotSat UV Optics should be optimized for a flat focal plane and provide an effective image quality over the detector of at least: From field center up to 90% FoV < 6.5 µm Above 90% FoV < 18 µm
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	The fields written are from the optical axis, so the real FoV is double the number.

ID	R-UV-PER-H-RAT-030
Title	UV Optics transmittance
Description	The PhotSat UV Optics shall allow a total transmittance (from the aperture until the detector) higher than 50% at any operational wavelength.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-UV-PER-H-RAT-035
Title	UV Optics transmittance Goal
Description	The PhotSat UV Optics should allow a total transmittance (from the aperture until the detector) higher than 70% at any operational wavelength.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-UV-PER-M-RA-040
Title	UV Optics Chief Ray Incidence Angle (CRA)
Description	The PhotSat UV Optics shall have CRA through the full Field of View CRA ≤10º (degrees).
Priority	Medium
Verification	Review of the Design, Analysis
Parents	
Justification	

ID	R-UV-PER-H-RA-050
Title	UV Optics Distortion
Description	The PhotSat UV Optics shall have radial f-Tan(θ) ≤5% through the full FoV.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	

The requirements and goals related to:

- Field of View
- Relative aperture
- Operative lifetime
- Performance vs Temperature

Both the visible (VIS) and ultraviolet (UV) optical subsystems must comply with the specifications with the same parameters, either both meeting the requirements or both meeting the goal.

These requirements are specified in section *9.1.6. VIS and UV Optics common requirements*.

9.1.5.3. Environmental Requirements

Specify the environmental conditions that a subsystem must be able to withstand, on ground, during launch and in space.

ID	R-UV-ENV-H-RI-010
Title	UV Optics Satellite Standards
Description	PhotSat UV Optics shall follow the CubeSat standard [RD-01] and the tailored ECSS standards for CubeSats [RD-03] and be able to complete its mission with the Open Cosmos 12U CubeSat and the astronomy payload developed at IEEC.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	CubeSat standards are suitable for a fast mission like PhotSat and reduce design, development and manufacturing of the satellite as well as its launch costs.

ID	R-UV-ENV-H-RI-020
Title	UV Optics volume allocation
Description	The UV Optics subsystem's total volume (excluding mechanical interfaces) shall be less than 9cm x 9cm x 135cm and fit inside a 1.35U (CubeSat 1U = 10cm x 10cm x 10cm).
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	This goes from the first surface, which includes the diaphragm (or aperture of the siderostat), to the focal plane, which is the detector. The detector itself (the box plus its electronics) is not included.

ID	R-UV-ENV-H-RT-030
Title	UV Optics mass allocation
Description	The UV Optics subsystem total dry mass shall be less than 1.8 kg.
Priority	High
Verification	Review of the Design, Test
Parents	
Justification	CubeSat 1U max mass = 1,333 kg // 1.35U = 1,799 kg (margins not taken into account).

ID	R-UV-ENV-H-RA-040
Title	UV Optics launch environment
Description	The PhotSat UV Optics, its structures and subsystems shall be able to withstand the vibrational, acoustic and shock environment of the launch.
Priority	High
Verification	Review of the design, Analysis
Parents	
Justification	Launch vehicle is still not chosen, but probably will be a Falcon 9 from SpaceX. It is not defined as "test" because IEEC will test its launch resilience in a shaker.

ID	R-UV-ENV-M-A-050
Title	UV Optics radiation environment
Description	The PhotSat UV Optics shall survive and operate in the radiation environment present in a polar LEO orbit, for the duration of the mission (up to 10 krad).
Priority	Medium
Verification	Analysis
Parents	
Justification	

ID	R-UV-ENV-M-A-060
Title	UV Optics Atomic O environment
Description	UV Optics elements exposed to the exterior of the satellite (the first lens) shall incorporate in their design mitigation techniques to reduce the impact of the atomic oxygen erosion in LEO orbit and ensure its optimal operations for the duration of the mission or provide enough evidence that no optical degradation will occur.
Priority	Medium
Verification	Analysis
Parents	
Justification	Atomic Oxygen will "rain" from every direction (as the satellite rotates to scan all the maximum circles) and affect the external surfaces of the satellite, except from the Sun and anti-Sun faces, which are almost orthogonal to trajectory. Seems like glass is not that affected, so the main mirror should be OK, but the coatings in some parts might not.

ID	R-UV-ENV-H-A-070
Title	UV Optics Outgassing environment
Description	UV Optics elements shall have a TML < 1% with a CVCM of <0.1% and a WVR < 1% or better
Priority	High
Verification	Analysis
Parents	
Justification	Especially sensible near the detector.

ID	R-UV-ENV-H-A-080
Title	UV Optics Vacuum environment
Description	UV Optics shall be able to nominally operate under a pressure of 10^{-8} mbar for the duration of the mission and provide purge holes to evacuate trapped air inside complicated geometries and assemblies. UV Optics shall also withstand (not operate) sea level pressure during development, manufacturing, between tests and in storage.
Priority	High
Verification	Analysis
Parents	
Justification	Vacuum testing will be done at IEEC.

ID	R-UV-ENV-H-R-090
Title	UV Optics Charging environment
Description	All metallic UV Optics elements shall be electrically connected to the satellite structure and share a "chassis" connection with the EPS.
Priority	High
Verification	Review of the design
Parents	
Justification	Grounding tests will be done at IEEC.

For the thermal environment, both the visible (VIS) and ultraviolet (UV) optical subsystems shall be able to nominally operate under the same thermal conditions present inside a CubeSat, either both meeting the requirements or both meeting the goal.

This requirement is specified in section *9.1.6. VIS and UV Optics common requirements*.

9.1.5.4. Interface Requirements

Specify how a subsystem must interact with other subsystems, both electrically and physically.

ID	R-UV-IF-H-RA-010
Title	UV Optics Thermal Interfaces
Description	PhotSat UV Optics shall use the Payload and Platform subsystems tailored thermal interfaces (via mechanical structure or sticking heaters from ICU) to maintain its nominal and survival temperature ranges.
Priority	High
Verification	Review of the Design, Analysis
Parents	
Justification	

ID	R-UV-IF-H-RI-020
Title	UV Optics Platform Mechanical Interfaces
Description	PhotSat UV Optics shall provide a Mechanical Interface to anchor it to the Open Cosmos 12U internal satellite structure, which is composed of lateral rails with equidistant holes in which to anchor subsystems via M2.5 screws (similar to a server rack structure).
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-IF-H-RI-030
Title	UV Optics Siderostat Mechanical Interface
Description	PhotSat UV Optics shall provide an internal mechanical interface to connect to the Siderostat, maintaining performance after launch and minimizing straylight impact throughout the mission.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-IF-H-RI-040
Title	UV Optics Detector Mechanical Interface
Description	PhotSat UV Optics shall provide an internal mechanical interface to connect to the Detector, maintaining performance (optic alignment) after lunch and in vacuum.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

9.1.5.5. Quality Assurance and Reliability Requirements

Specify the Quality Assurance and Reliability considerations that must be taken into account when designing and operating the Optics.

ID	R-UV-QA-H-R-010
Title	UV Optics ECSS Standards
Description	UV Optics development shall conform with the ECSS standards that are applicable to CubeSats, if there are no budget or time constraints (in which case a justification report shall be issued)
Priority	High
Verification	Review of the Design
Parents	
Justification	By default, ECSS standards shall be applied, but there might be some cases in which other standards (automotive, medical, etc) can be used. Ref: LINK

ID	R-UV-QA-H-R-020
Title	UV Optics Margin Philosophy
Description	UV Optics development shall take into account a 20% margin for the engineering budgets (volume, mass, power, pointing, timings, etc) during early phases and until CDR. From CDR, 10% margins.
Priority	Medium
Verification	Review of the Design
Parents	
Justification	

ID	R-UV-QA-H-RI-030
Title	UV Optics Manufacturing, Assembly and Verification Plan
Description	The UV Optics supplier shall provide and document the planning of the manufacturing, assembly and integration stages in the manufacturing plan or flow chart for the UV Optics subsystem, including the sequence of operations, inspections, tests and verifications, with the reference to the procedures by which the various activities are performed and the required cleanliness levels and temperature and humidity requirements of the facilities.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-QA-H-RI-040
Title	UV Optics Assembly and Verification Procedures
Description	The UV Optics supplier shall provide an Assembly Procedure and a Functional Test Procedure so a third party can integrate the Siderostat, the Optics and the Detector inside the 12U CubeSat Structure from Open Cosmos and validate its nominal operations.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-QA-H-R-050
Title	UV Optics Plans and Developments Reviewing Methods
Description	The manufacturing, verification and commissioning plans shall be reviewed and discussed with Payload engineers during the development phase to simplify and accelerate the tests and verifications of the Payload.
Priority	High
Verification	Review of the Design
Parents	
Justification	

ID	R-UV-QA-H-R-060
Title	UV Optics Non-Conformance Procedure
Description	The UV Optical supplier should implement a non-conformance control procedure.
Priority	High
Verification	Review of the Design
Parents	
Justification	

9.1.5.6. Logistics Requirements

Specify the logistics considerations that must be taken into account when manufacturing, assembling, testing and operating the Optics.

ID	R-UV-LG-H-RI-010
Title	UV Optics Development Shipping
Description	The UV Optics supplier shall be responsible, in cost and risk, for the transport of the complete UV Optics subsystem and its different elements during the development phase.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-LG-H-RI-020
Title	UV Optics Package
Description	PhotSat UV Optics shall be properly packaged by the provider after the Functional Test campaign at the end of the development phase with a container that ensures a safe transportation and a clean storage environment for the optics.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

9.1.5.7. Development and Verification Requirements

Specify the considerations that must be taken into account when developing and verifying the Optics.

ID	R-UV-DEV-H-RI-010
Title	UV Optics Functional Test Activities
Description	The Platform supplier shall be responsible for performing the functional verification under nominal conditions of the complete UV Optical subsystem with the support of the IEEC Engineering team.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	While the supplier will test the functionality, IEEC will test the performance under different environmental factors.

ID	R-UV-DEV-H-RI-020
Title	UV Optics Mechanical EM
Description	The UV Optics supplier shall provide a physical Engineering Model (EM) and its CAD, of the subsystem's mechanical structure, representative of the Flight Model thermo-mechanical behavior, no later than T0+4months (T0 being the date on which the contract is signed), to ease the mechanical integration between the optics and the siderostat, detectors and Open Cosmos 12U CubeSat structure.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	

ID	R-UV-DEV-H-R-030
Title	UV Optics Validation and Commissioning
Description	The UV Optics supplier shall provide support to IEEC engineers during AIV/AIT campaigns and until Commissioning of the Payload in LEO, in case there are problems or issues with the optics or non-conformance results.
Priority	High
Verification	Review of the Design
Parents	
Justification	

9.1.6. VIS and UV Optics Common Requirements

Lists of the flowed-down requirements that apply for both the visible (VIS) Optics and the ultraviolet (UV) Optics subsystems.

9.1.6.1. Performance Requirements

Specify how well a subsystem must perform in order to meet the mission objectives.

ID	R-VISUV-PER-H-RI-010
Title	VIS Optics and UV Optics relative aperture
Description	The PhotSat VIS Optics and UV Optics shall have a relative aperture of F≤1.8.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	Related to the physical aperture that corresponds to the siderostat aperture.

ID	R-VISUV-PER-H-RI-015
Title	VIS Optics and UV Optics relative aperture Goal
Description	The PhotSat VIS Optics and UV Optics should have a relative aperture of F≤1.7.
Priority	High
Verification	Review of the Design, Inspection
Parents	
Justification	Related to the physical aperture that corresponds to the siderostat aperture.

For the relative aperture, both the visible (VIS) and ultraviolet (UV) optical subsystems must have the same relative aperture, either both meeting the requirements or both meeting the goal.

ID	R-VISUV-PER-H-RAT-020
Title	VIS Optics and UV Optics Field of View
Description	The PhotSat VIS Optics and the UV Optics shall be able to observe the sky with a 6º FoV.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	6º is the minimum "area" to scan all sky in 3 days. 6º = 11.459 arcsec.

ID	R-VISUV-PER-H-RAT-025
Title	VIS Optics and UV Optics Field of View Goal
Description	The PhotSat VIS Optics and the UV Optics should be able to observe the sky with FoV ≥ 8º FoV.
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	8º is the minimum "area" to scan all sky in 2 days.

For the Field of View, both the visible (VIS) and ultraviolet (UV) optical subsystems must have the same Field of View, either both meeting the requirements or both meeting the goal.

ID	R-VISUV-PER-H-R-030
Title	VIS Optics and UV Optics operative lifetime
Description	The VIS Optics and UV Optics subsystems shall remain fully operational and fulfilling the requirements described in this document for the duration of the mission, since commissioning and until EOL (2 years).
Priority	High
Verification	Review of the Design
Parents	
Justification	The PhotSat payload shall provide scientific data during the nominal operations of the satellite for a minimum of 2 years.

ID	R-VISUV-PER-H-R-035
Title	VIS Optics and UV Optics operative lifetime Goal
Description	The VIS Optics and UV Optics subsystems should remain fully operational and fulfill all the requirements described in this document and goals accepted in the contract for the duration of the mission, since commissioning and until the possible extended mission lifetime (3 years).
Priority	High
Verification	Review of the Design
Parents	
Justification	The PhotSat payload should provide scientific data as long as possible, 3 years or more.

ID	R-VISUV-PER-H-RAT-040
Title	VIS Optics and UV Optics Performance vs Temperature
Description	The PhotSat VIS Optics and UV Optics shall maintain performance when operating inside the Operative Thermal Range [5ºC - 35º C] and shall not lose performance after thermal excursions up to its Survival Thermal Range [-40ºC to +85ºC].
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

ID	R-VISUV-PER-H-RAT-045
Title	VIS Optics and UV Optics Performance vs Temperature Goal
Description	The PhotSat VIS Optics and UV Optics should maintain performance when operating inside the Operative Thermal Range [0ºC - 40º C] and should not lose performance after thermal excursions up to its Survival Thermal Range [-50ºC to +100ºC].
Priority	High
Verification	Review of the Design, Analysis, Test
Parents	
Justification	

9.1.6.2. Environmental Requirements

Specify the environmental conditions that a subsystem must be able to withstand, on ground, during launch and in space.

ID	R-VISUV-ENV-H-RAT-010
Title	VIS Optics and UV Optics thermal environment
Description	The PhotSat VIS Optics and UV Optics shall be able to nominally operate under the thermal conditions present inside a CubeSat in a Sun-Synchronous Dawn-Dusk LEO ([+5ºC to +35ºC] at its TRP) as well as be able to survive up to [-40ºC to +85ºC], using platform's structure and heaters to maintain these levels.
Priority	High
Verification	Review of the design, Analysis, Test
Parents	
Justification	As the lenses will be inside the CubeSat, they need to comply with the internal thermal environment. TRP = Thermal Reference Point.

ID	R-VISUV-ENV-H-RAT-015
Title	VIS Optics and UV Optics thermal environment Goal
Description	The PhotSat VIS Optics should be able to nominally operate under the thermal conditions present inside a CubeSat in a Sun-Synchronous Dawn-Dusk LEO ([0ºC to +40ºC] at its TRP) as well as be able to survive up to [-50ºC to +100ºC], using Platform's structure and heaters to maintain these levels.
Priority	High
Verification	Review of the design, Analysis, Test
Parents	
Justification	As the lenses will be inside the CubeSat, they need to comply with the internal thermal environment. TRP = Thermal Reference Point.

Castelldefels, October 2024

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