Uvsq-Sat NG

17 March 2024

Mustapha MEFTAH [F4IXO]

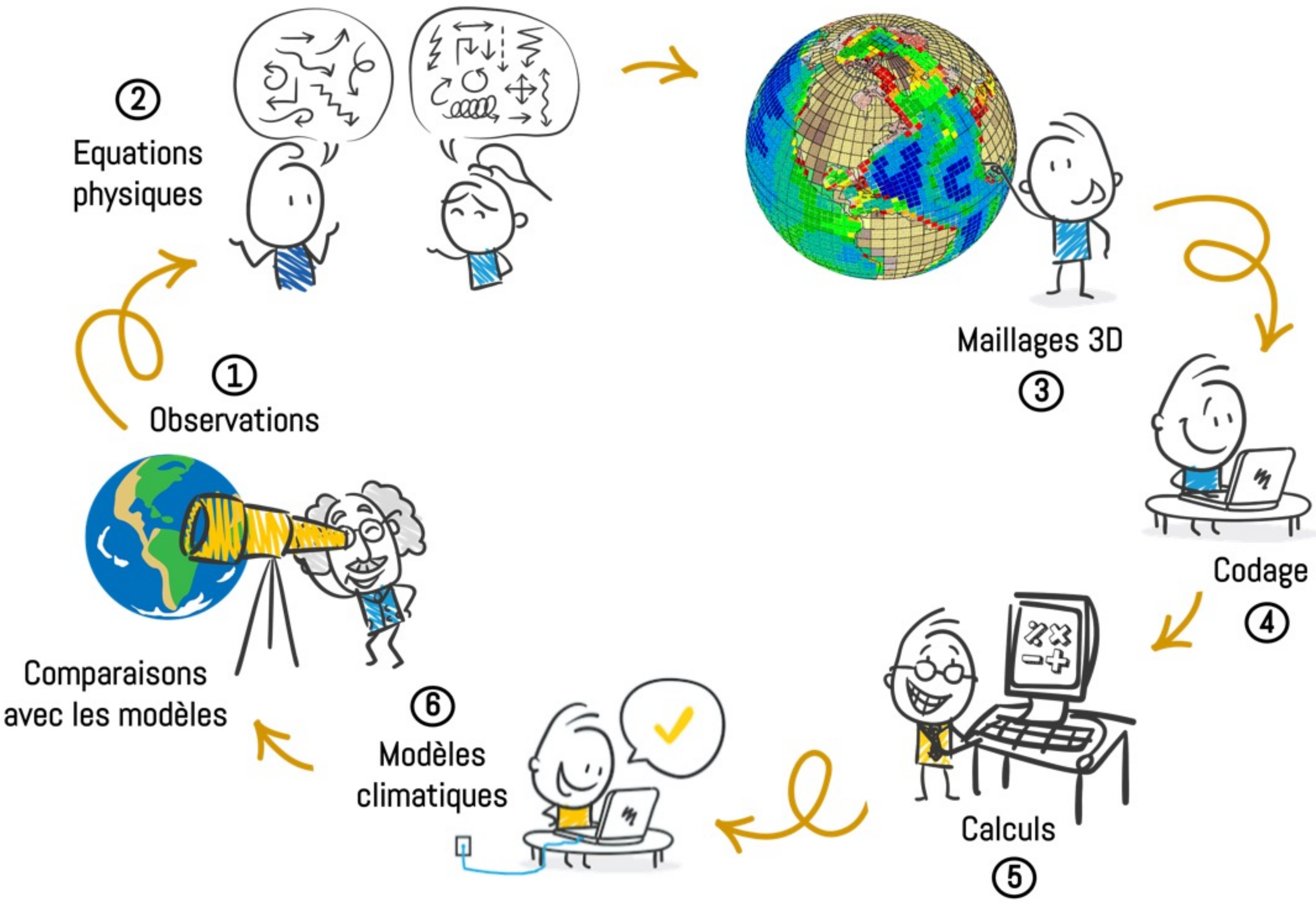
General objectives of the mission

- **(1) Science** : **Earth observation, Climate physics, GHGs, ERB, Solar physics, …**

- **(2) Education & outreach** : Satellite, Payload development, Software development, Training material.
  - Enable students to move towards Nanosat via start-ups in creation
  - Foster the emergence and development of start-ups in the Nanosat field
  - Make the space field more accessible to technicians
  - Create new vocations
  - Thinking about tomorrow's jobs
  - Promote the ‘Space Academy of Île-de-France’

- **(3) Technology demonstration** : Satellite, Payload, Spectrometer, Telescope
  - Instruments miniaturization for Earth observations and solar physics
  - Instruments validation & satellites constellation validation for Earth observations
  - Validation of new low mass, low power and compact design instruments that incorporate artificial intelligence on future space flights
  - Facilitate collaboration with industrial partners

Observations and models



L'espace et le NewSpace au service du climat, *Meftah M., 2023.*

Education

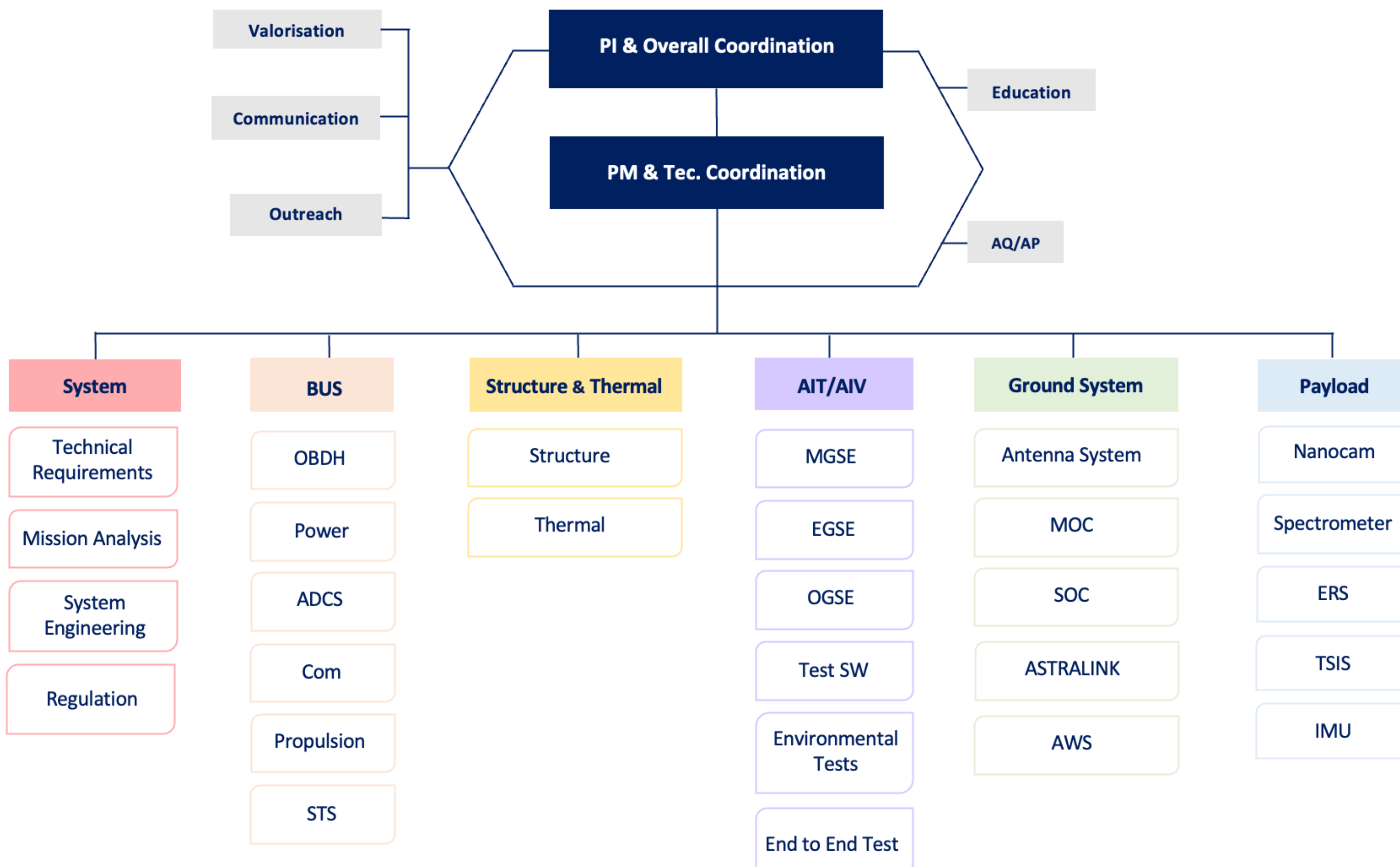
- Formations (master, licence, …)
- Développement de satellites, de charges utiles scientifiques, et de logiciels
- Plus de 60 étudiants impliqués dans ce programme
- Trois thèses soutenues …
- 4 thèses en cours …

2023

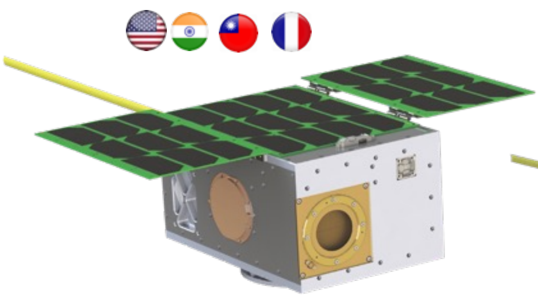
2022

2021

Organization

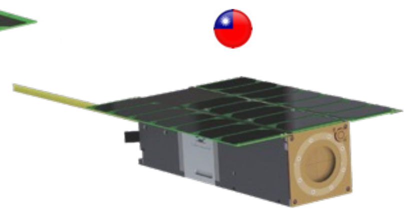


International consortium



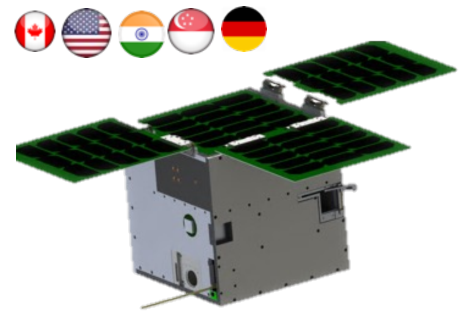
Inspire-Sat 1

Launched on Feb. 2022



Inspire-Sat 2

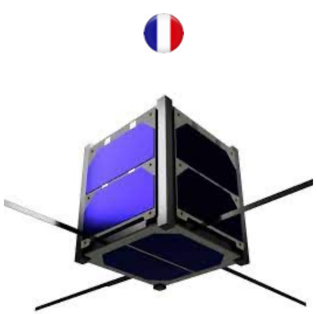
Launched on Jan. 2021



Inspire-Sat 3

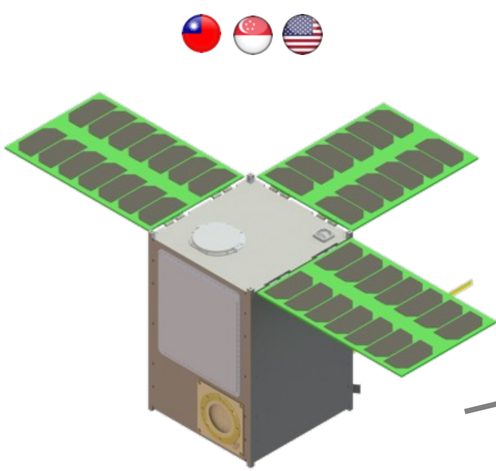
Inspire-Sat 4

Launched on Jul. 2023

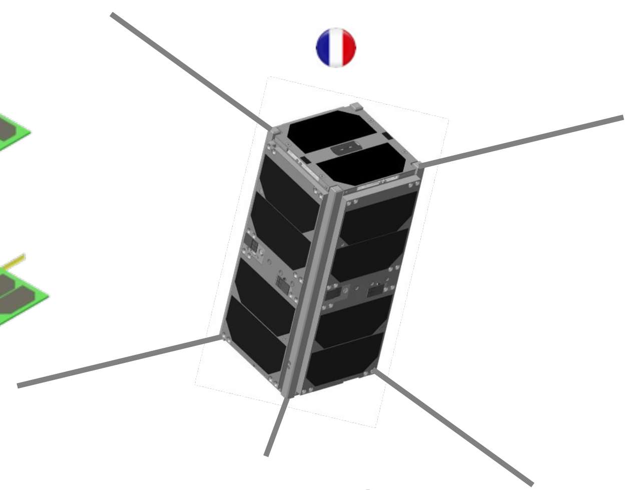


Inspire-Sat 5

Launched on Jan. 2021

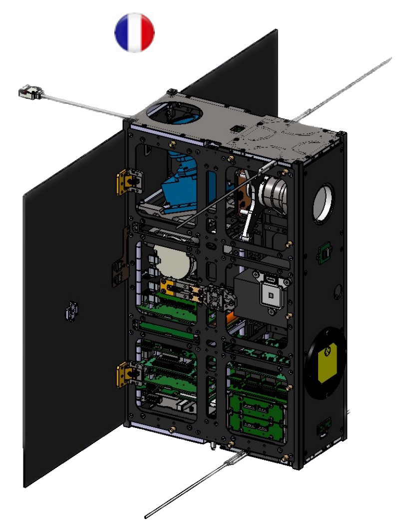


Inspire-Sat 6



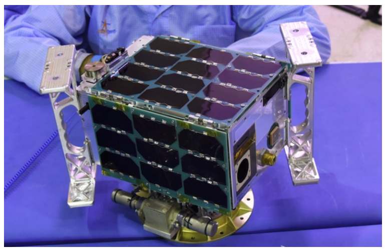
Inspire-Sat 7

Launched on Apr. 2023



Inspire-Sat X

International consortium

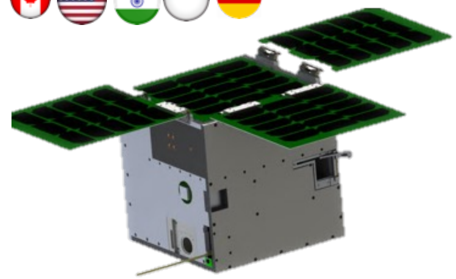


Inspire-Sat 1

Launched on Feb. 2022

Inspire-Sat 2

Launched on Jan. 2021



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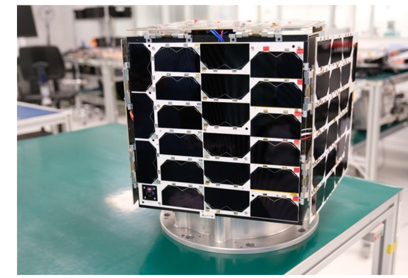
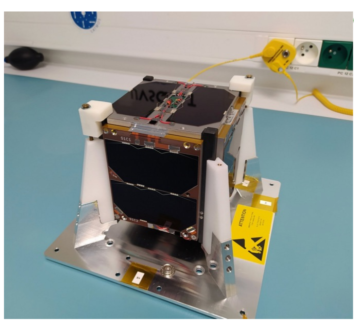


Inspire-Sat 4

Launched on Jul. 2023



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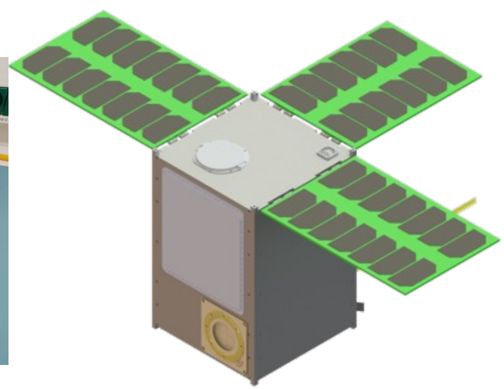
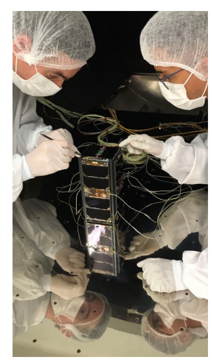


Inspire-Sat 6



Inspire-Sat 7

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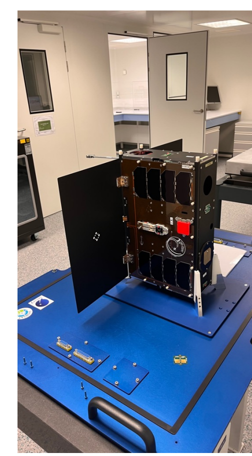


Inspire-Sat X

Partnership Consortium in the project

Partnership Consortium in the Île-de-France Region

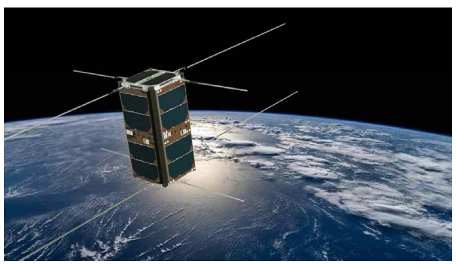
Satellites constellation

UVSQ-SAT (Inspire-Sat 5)

Studies + Manufacture | Tests | Exploitation | End of Life | Data exploitation

1 | 2 | 3 | 4

2018 | **24/01/2021** | 13/03/2021 | 24/01/2024 ?

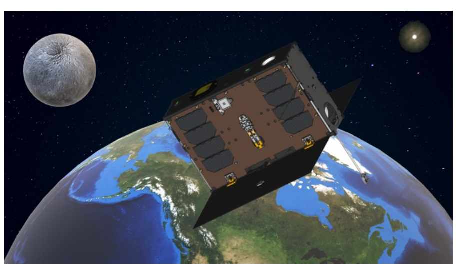


Inspire-Sat 7

Studies + Manufacture | Tests | Exploitation | End of Life | Data exploitation

1 | 2 | 3 | 4

2020 | **15/04/2023** | 15/05/2023 | 15/04/2026 ?



UVSQ-SAT NG (Inspire-Sat X)

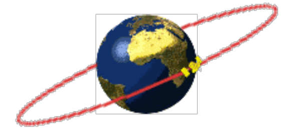
Studies + Manufacture | Tests | Exploitation | End of Life | Data exploitation

1 | 2 | 4

2021 | **13/03/2025**

Phases 0/A, B, C, D | **Phase E** | **Phase F**

Satellites constellation



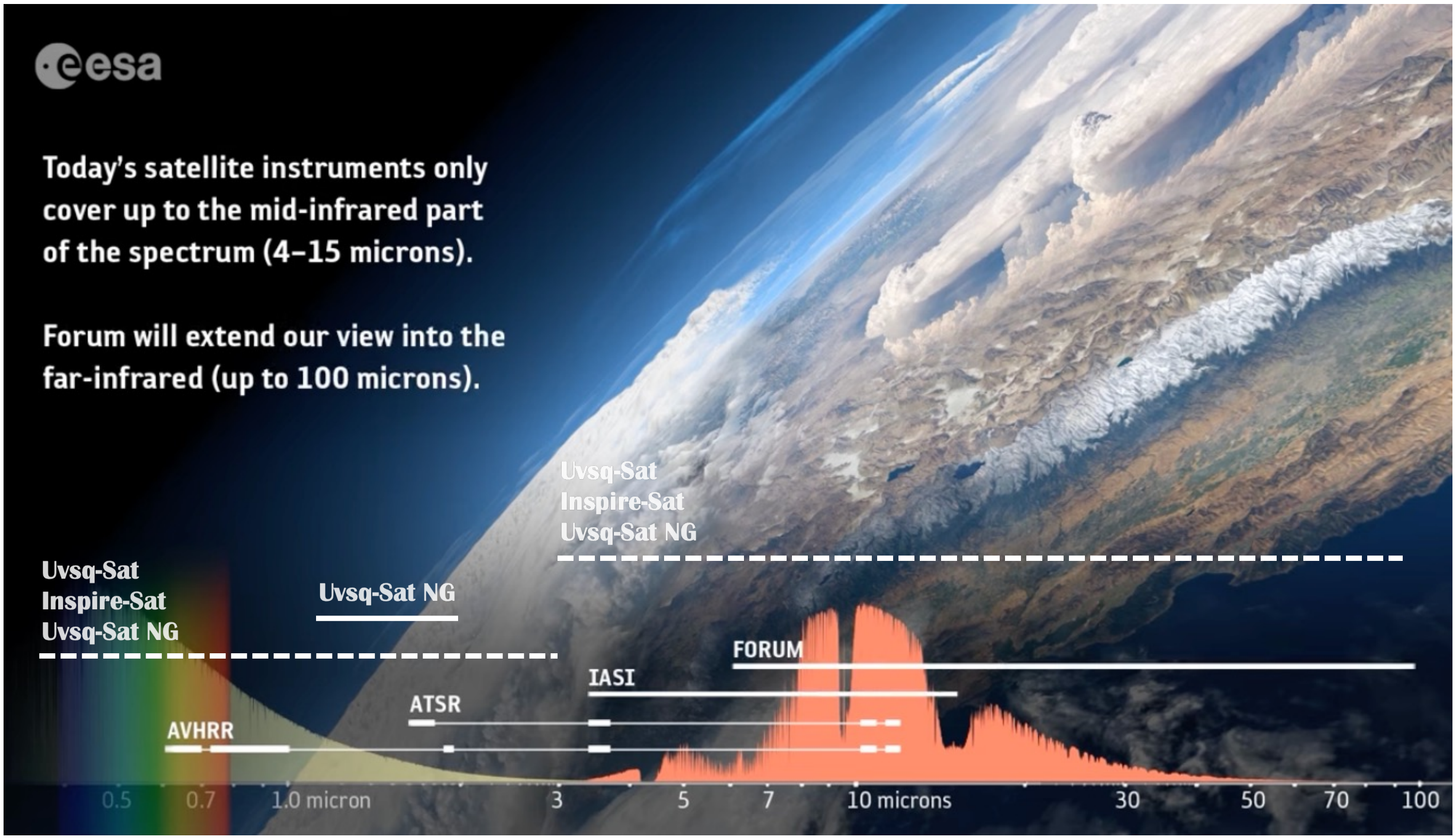
❑ Requirements

Requirements for Uvsq-Sat—Launched on 24 January 2021 from Cape Canaveral, Florida, USA				
ECV	Absolute accuracy	Stability per year	Spatial resolution	Temporal resolution (global map)
OSR	$\pm 10.00\,Wm^{-2}$	$\pm 5.00\,Wm^{-2}$	2500 km per element	30 days with one CubeSat
OLR	$\pm 10.00\,Wm^{-2}$	$\pm 1.00\,Wm^{-2}$	2500 km per element	30 days with one CubeSat
Requirements for Inspire-Sat 7—Launched on 15 April 2023 from Vandenberg, California, USA				
ECV	Absolute accuracy	Stability per year	Spatial resolution	Temporal resolution (global map)
OSR	$\pm 5.00\,Wm^{-2}$	$\pm 1.00\,Wm^{-2}$	2500 km per element	10 days with two CubeSats
OLR	$\pm 5.00\,Wm^{-2}$	$\pm 1.00\,Wm^{-2}$	2500 km per element	10 days with two CubeSats
Requirements for Uvsq-Sat NG—Launch Date in 2025 or in 2026				
ECV	Absolute accuracy	Stability per year	Spatial resolution	Temporal resolution (global map)
OSR	$\pm 3.00\,Wm^{-2}$	$\pm 1.00\,Wm^{-2}$	2500 km per element	5 days with three CubeSats
OLR	$\pm 3.00\,Wm^{-2}$	$\pm 1.00\,Wm^{-2}$	2500 km per element	5 days with three CubeSats
CO_2	± 4.0 ppm	± 1.0 ppm	2–10 km per pixel	> 30 days
CH_4	± 25.0 ppb	± 10.0 ppb	2–10 km per pixel	> 30 days
Requirements for a Hypothetical Satellite Constellation Named Terra-F—Horizon 2035				
ECV	Absolute accuracy	Stability per decade	Spatial resolution	Revisit time
TSI	$\pm 0.54\,Wm^{-2}$	$\pm 0.14\,Wm^{-2}$	–	24 h
OSR	$\pm 1.00\,Wm^{-2}$	$\pm 0.10\,Wm^{-2}$	10–100 km per pixel	3 h
OLR	$\pm 1.00\,Wm^{-2}$	$\pm 0.10\,Wm^{-2}$	10–100 km per pixel	3 h
EEI	$\pm 1.00\,Wm^{-2}$	$\pm 0.10\,Wm^{-2}$	–	24 h
CO_2	± 1.0 ppm	± 1.5 ppm	1–5 km per pixel	3 h
CH_4	± 10.0 ppb	± 7.0 ppb	1–5 km per pixel	3 h

- Mapping of sources and sinks of carbon dioxide (CO_2) on a global scale.
- Global information on atmospheric Methane concentration (CH_4 column density).

Satellites constellation

Synergy with other space-based missions



Uvsq-Sat NG

Uvsq-Sat NG aims:

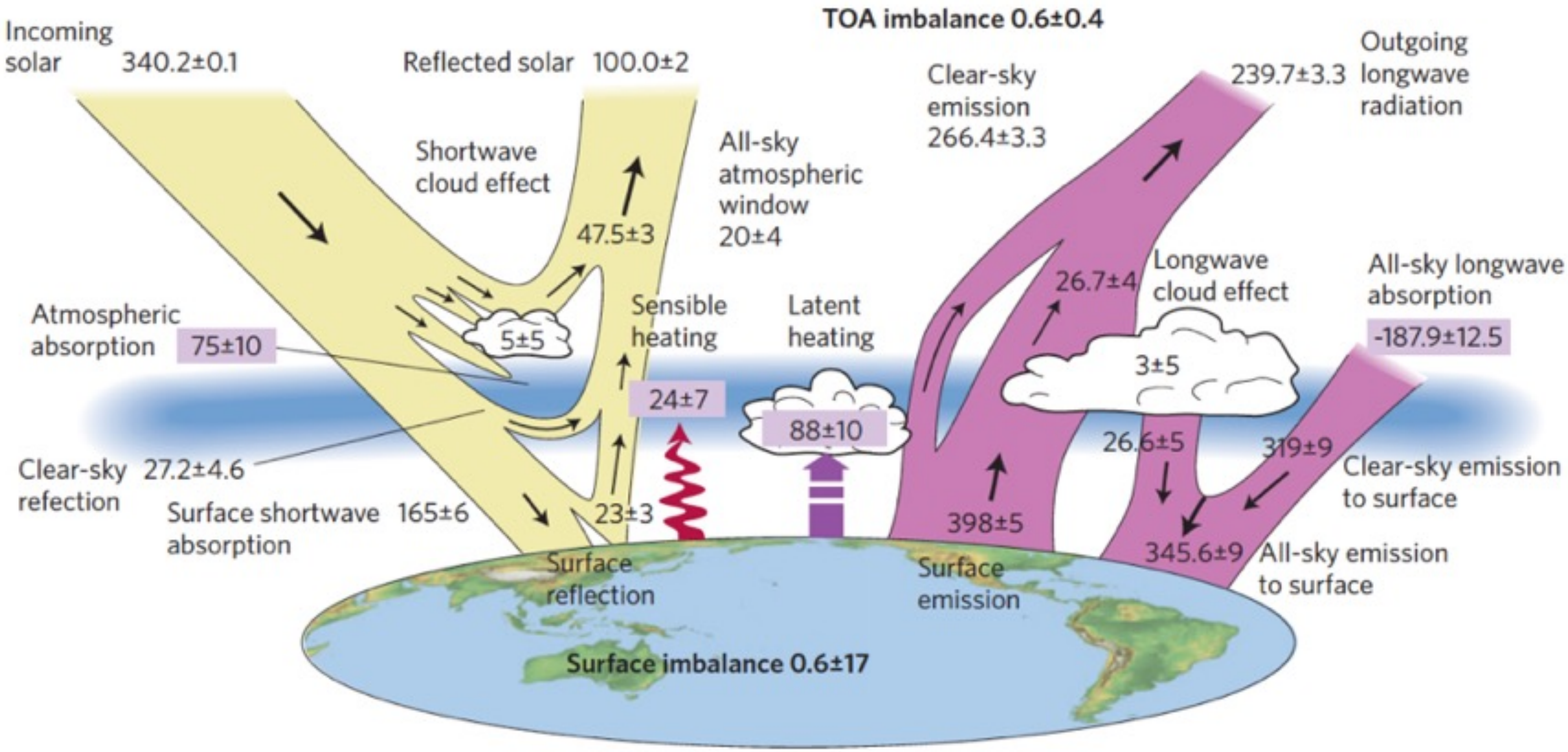
- To continue the **Earth Radiation Budget** (**ERB**) research initiated by Uvsq-Sat and Inspire-Sat satellites. It intends to achieve broadband ERB measurements using advanced yet simple technologies.
- To monitor **atmospheric gas concentrations** (**CO_2** and **CH_4**) on a global scale and explore their correlation with Earth's Outgoing Longwave Radiation (**OLR**).

→ Uvsq-Sat NG carries multiple payloads, including Earth Radiative Sensors (ERSs) for tracking solar and terrestrial radiation, a Near-Infrared (NIR) Spectrometer for assessing greenhouse gases (GHGs) concentrations, and a high-definition camera (NanoCam) for Earth imaging. The NanoCam helps with geolocating observed scenes and provides an opportunity to estimate the **vertical temperature profile of the atmosphere** by observing the Earth's limb.

→ We will also endeavor to capture images of the aurora between 60 and 80 geomagnetic latitude both above North and South oval. Nadir pointing or close Nadir pointing is convenient but limb geometry could also be very interesting. The goal is to conduct a study on **auroral structures**, with a specific emphasis on the less commonly observed sub-auroral features.

Uvsq-Sat NG

❑ Importance of the key components of the Earth energy budget



Earth Energy Imbalance = Incoming solar –
[Reflected solar (OSR) + Outgoing longwave radiation (OLR)]

Uvsq-Sat NG

❑ Importance of the key components of the Earth energy budget

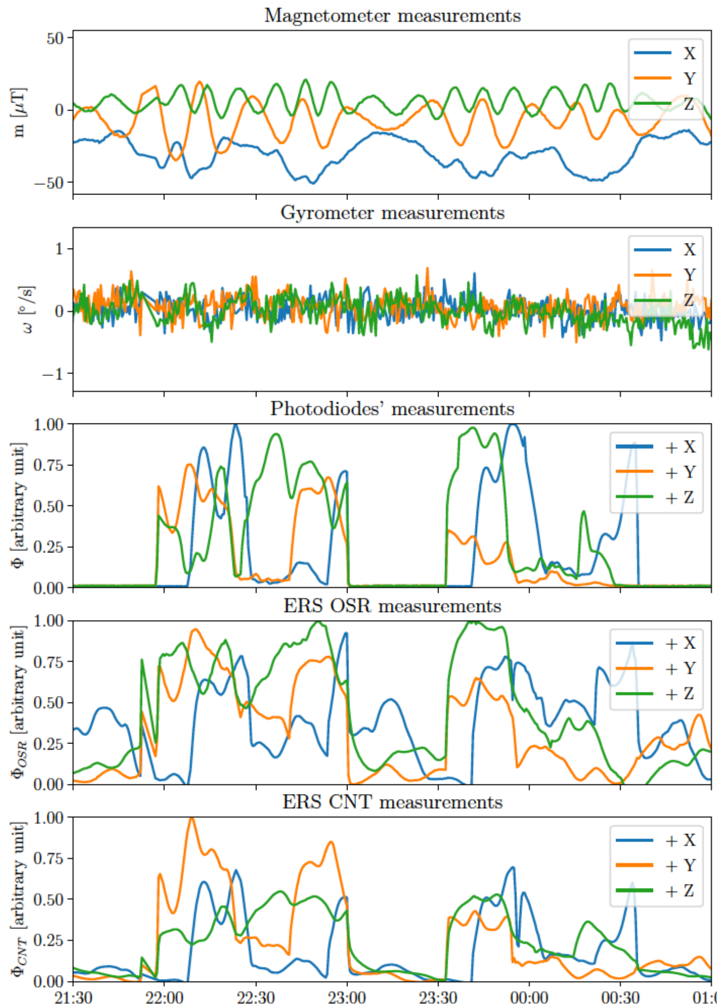
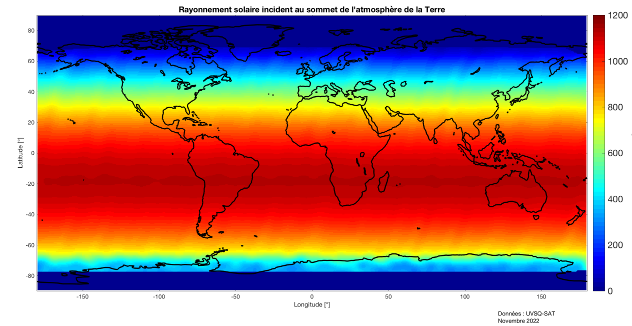
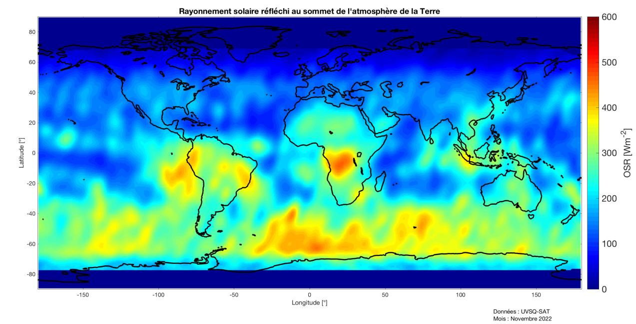


Figure 2. Time series of the measurements for two orbits on 26 March 2021 from the three-axis magnetometer, the three-axis gyrometer, the photodiodes, and the ERS sensors.

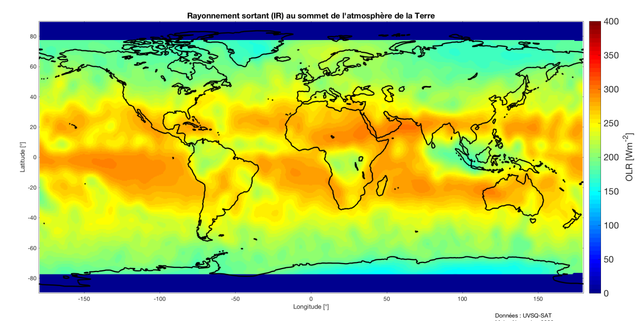
ISR



OSR

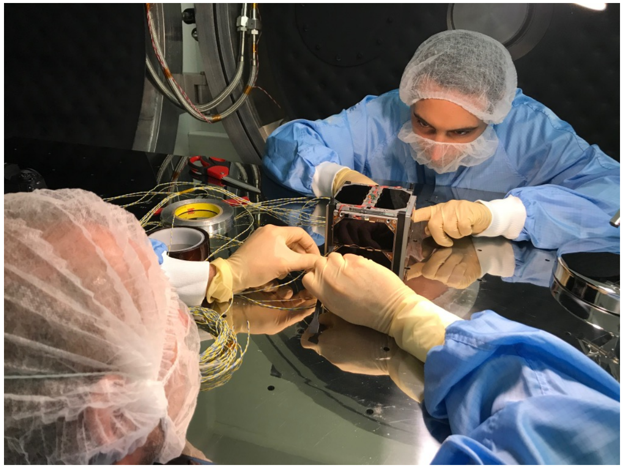


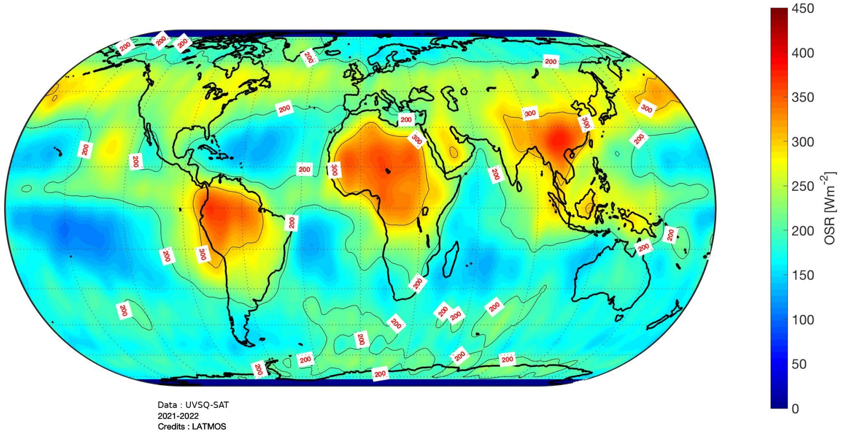
OLR

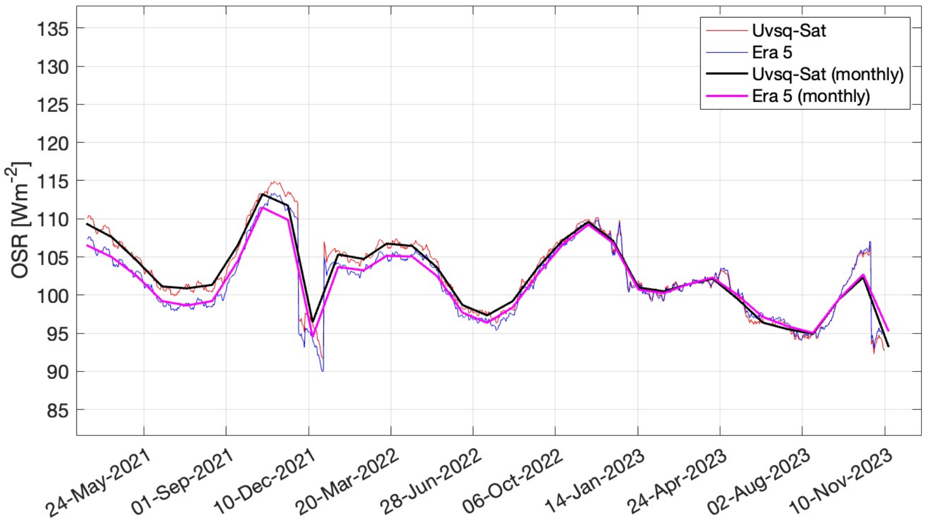


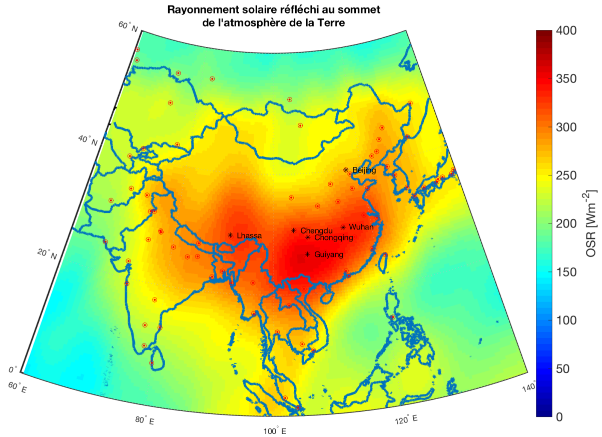
Uvsq-Sat NG

❑ Importance of the key components of the Earth energy budget



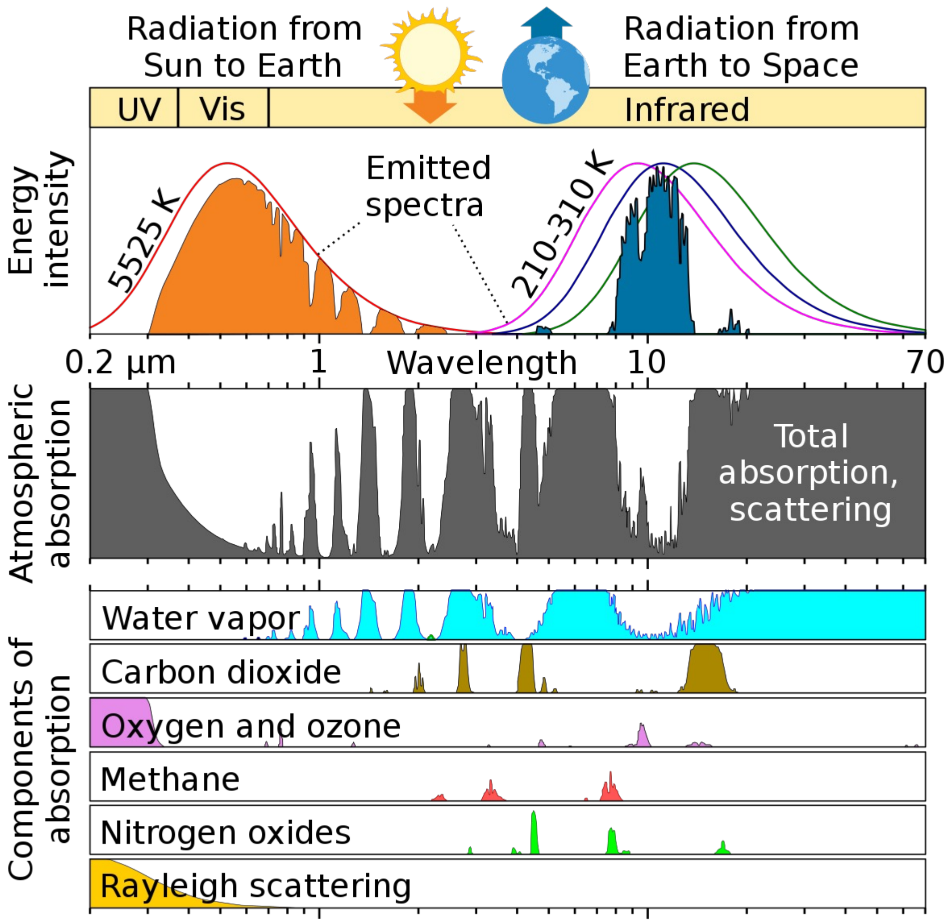






Uvsq-Sat NG

❑ Importance of GHG and role in Earth enegy budget



- CO_2: 1433, 1573, 1603, 1883, 1958 & 2000 nm
- CH_4: 1645 and 1667 nm
- O_2: 1270 nm
- H_2O: Several large absorption bands

- At ~1.6 µm, the entire CO_2 column is measured. Whereas at ~15µm, it’s sensitive to the temperature of the stratosphere.

- The ~8 µm band is sensitive to silicates (deserts).

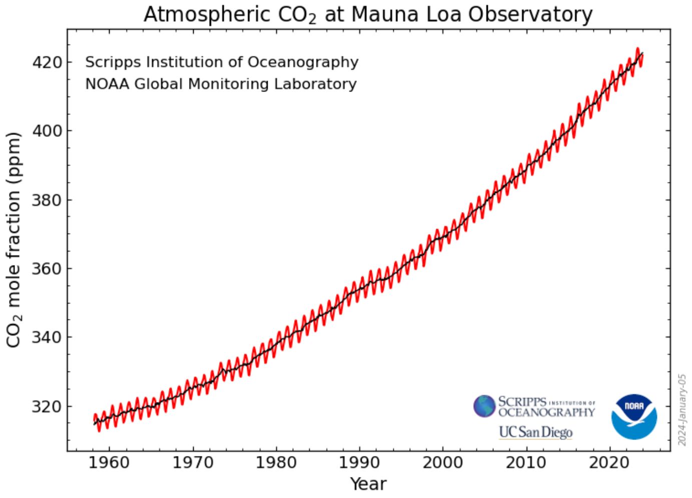
- The ~10µm band is sensitive first to the surface temperature and then to emissivity.

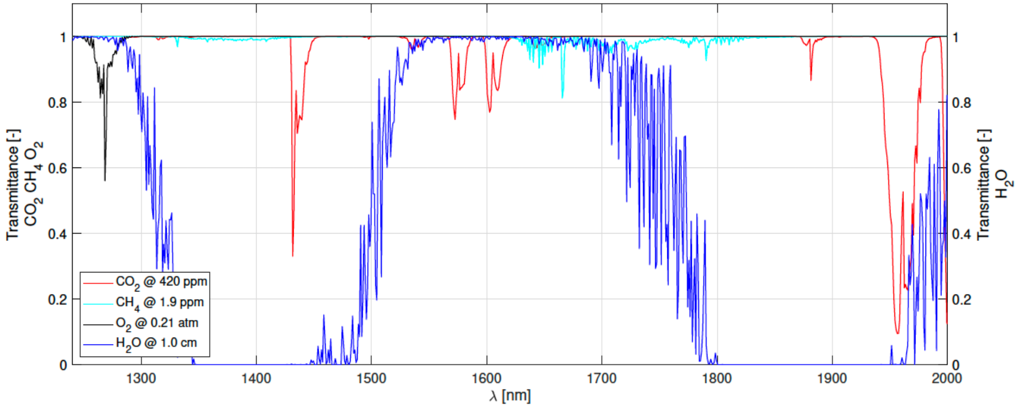
- At ~19.2 µm, it's sensitive to the presence and characteristics of high cirrus clouds.

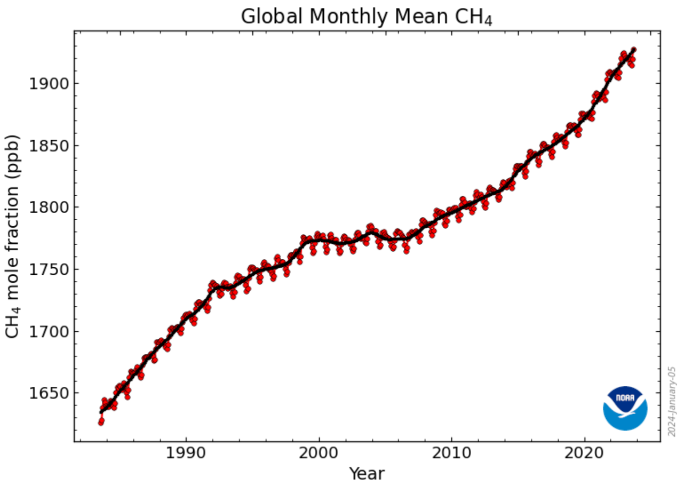
- At ~40 µm, it depends on stratospheric water vapor.

Uvsq-Sat NG

❑ Importance of GHG and role in Earth enegy budget







Predictions of CO_2 and CH_4 evolution rely on:

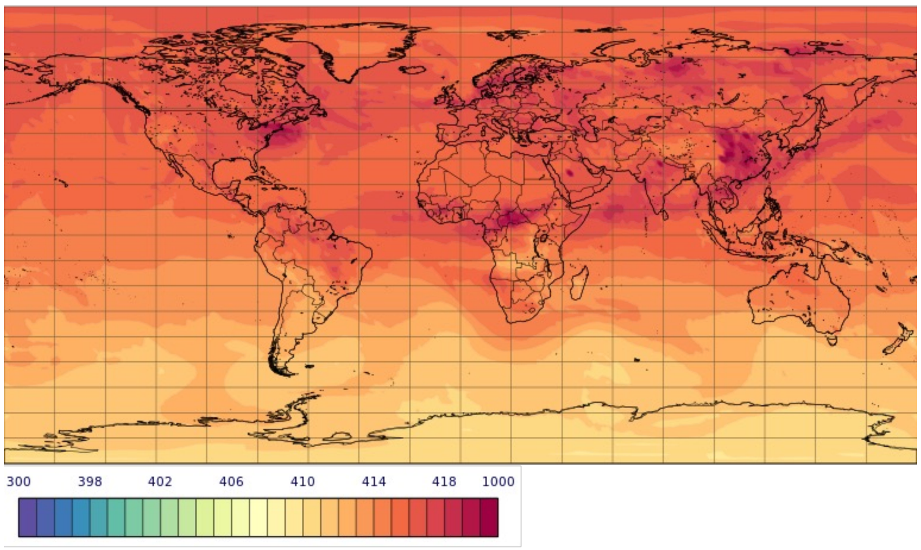
- In situ measurements
- National inventories and declaration
- Modelling of natural processes (emission/absorption) and exchange processes

Advantage of space systems:

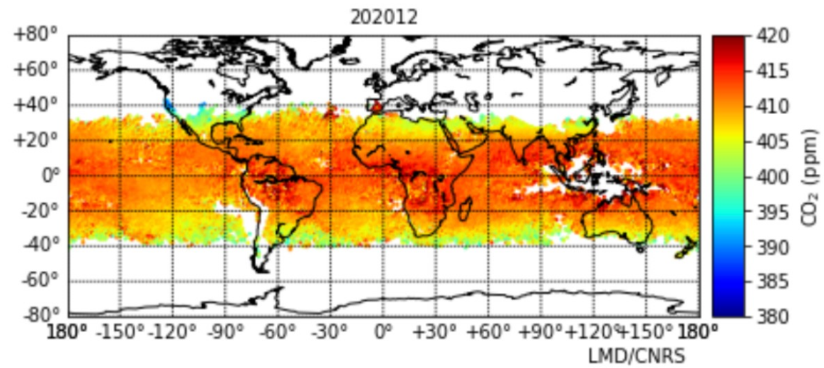
- Global coverage
- Unique sensor

Uvsq-Sat NG

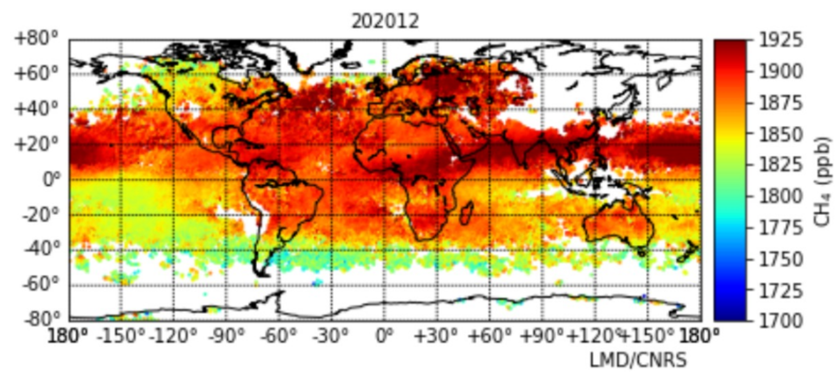
❑ Importance of GHG and role in Earth enegy budget



Total column of carbon dioxide [ppmv] for Thursday 28 November 2019. (Credit: Copernicus Atmosphere Monitoring Service, ECMWF)

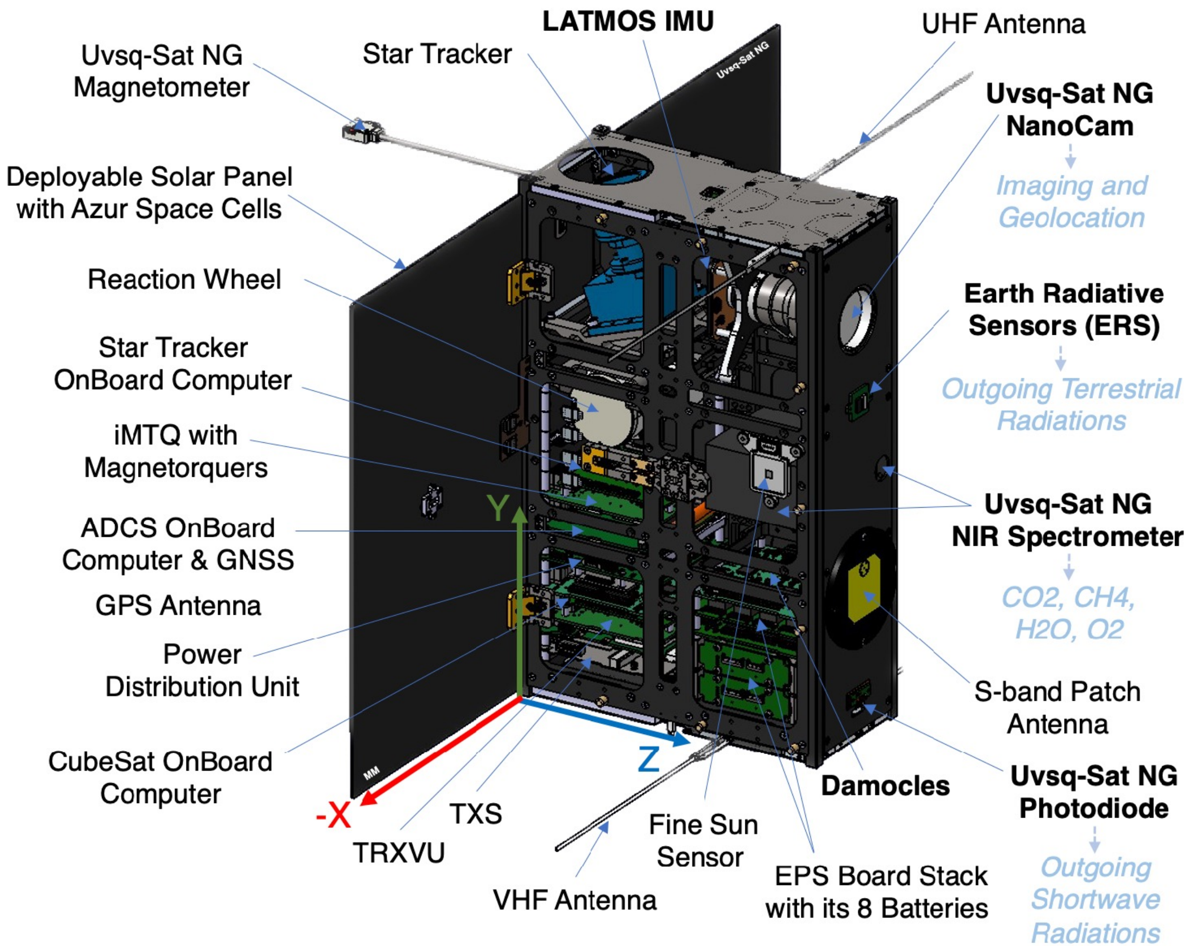


Carte de Colonne de CO_2 (IASI/Metop-B) mois de décembre 2020



Carte de Colonne de CH_4 (IASI/Metop-B) mois de décembre 2020

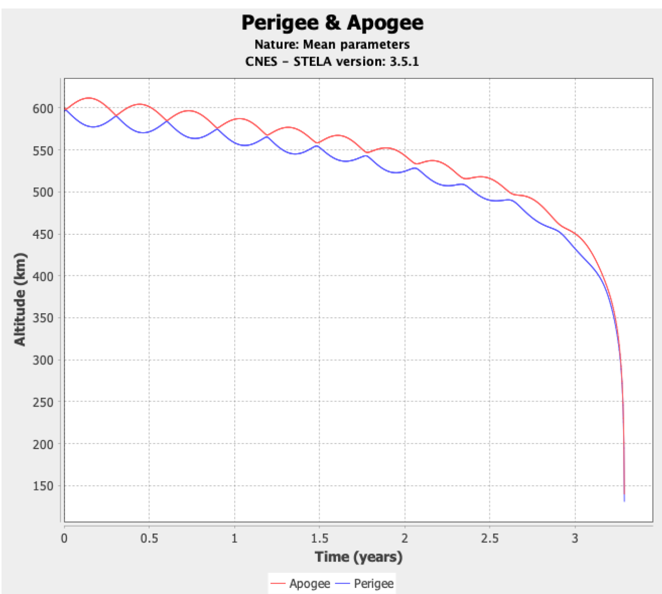
Uvsq-Sat NG

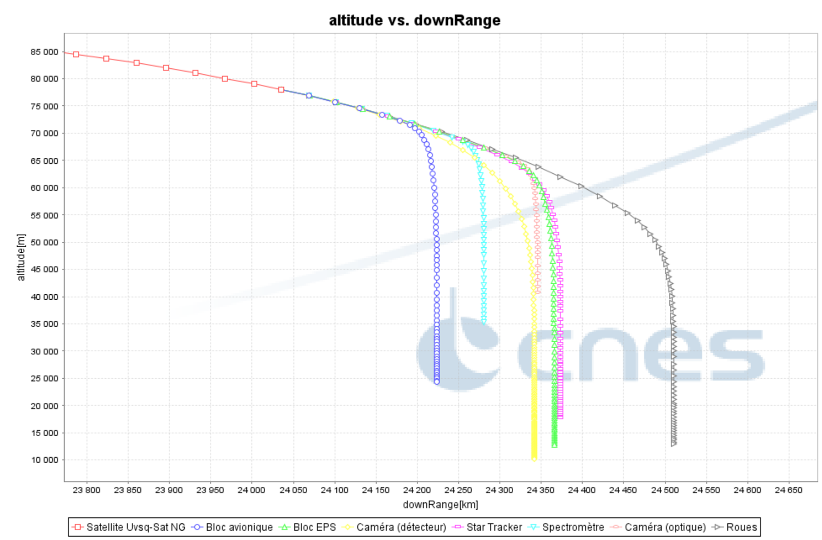


Uvsq-Sat NG, a new satellite to envision the space of tomorrow. An In-Orbit Demonstrator to prepare the SmallSats constellations of the future.

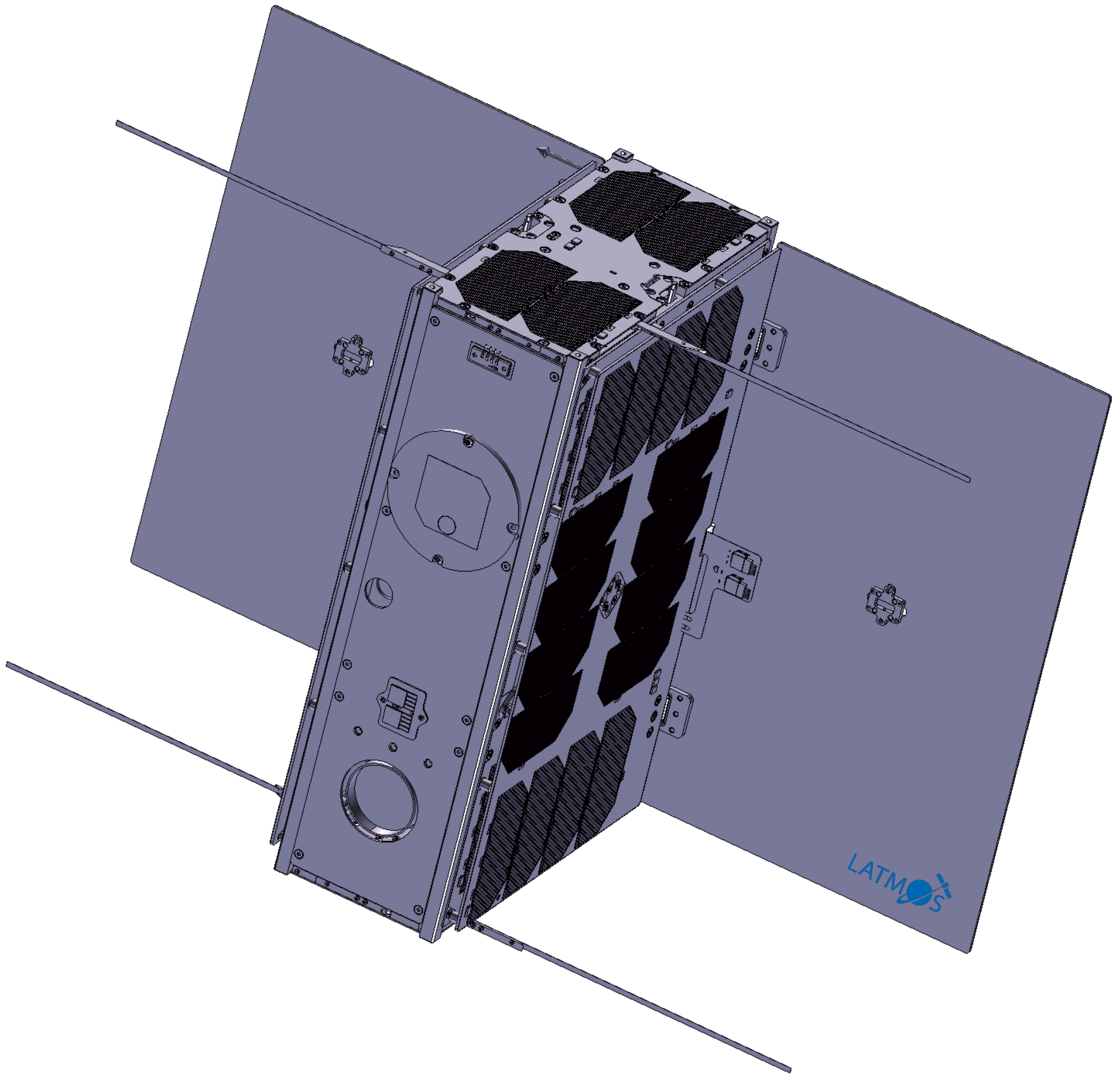
Uvsq-Sat NG

Properties	Value	Comments
Orbit	Sun-Synchronous Orbit (SSO)	Maximum altitude of 600 km, LTAN of 06:30
Design life time	Minimum of 2 years in LEO	3 years desired
Launch date	Between Q2 2025 and Q1 2026	Launch vehicle: Falcon 9, Vega-C or Zéphyr
Launch adapter	QuadPack or EXOpod deployer	Payload mass up to 12 kg
CubeSat type	6U XL	Easy-to-assemble modular design
Launch mass	10.0 kg [1]	Maximum with margins
Dimensions	10.0 cm × 36.6 cm × 22.6 cm	Stowed along X, Y, and Z axes
	111.3 cm × 36.6 cm × 38.8 cm	Unstowed including all deployable elements



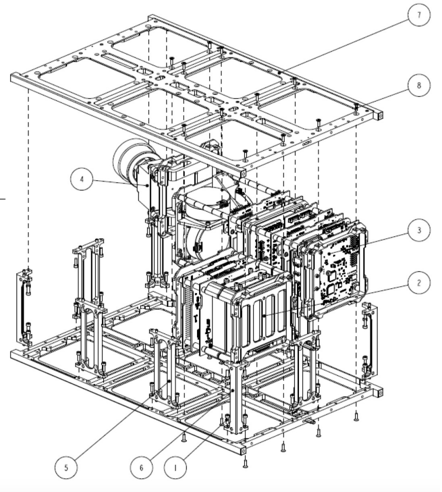
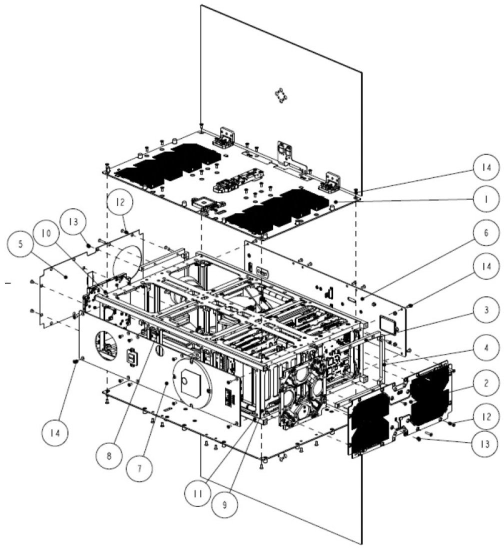
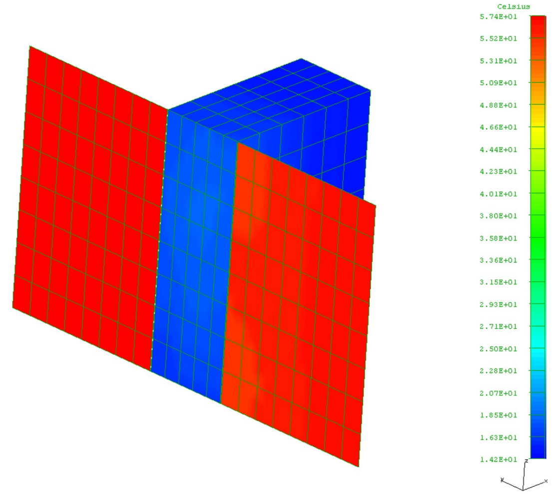


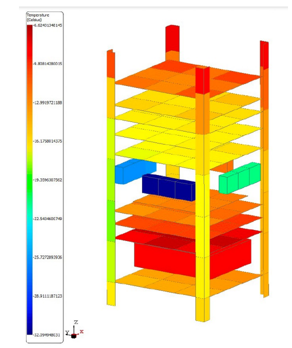
Uvsq-Sat NG

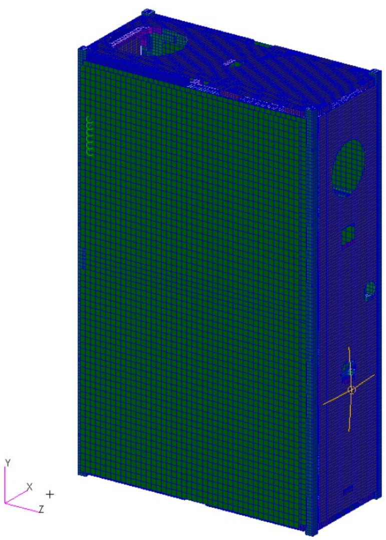
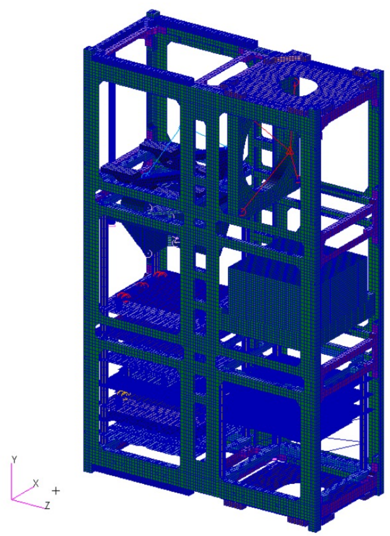
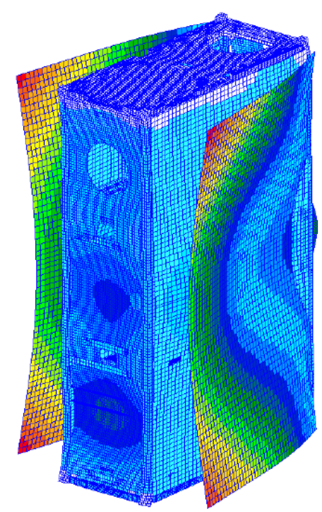
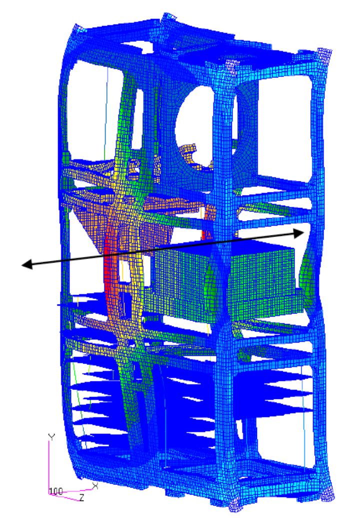


Uvsq-Sat NG

❑ (1) Analysis



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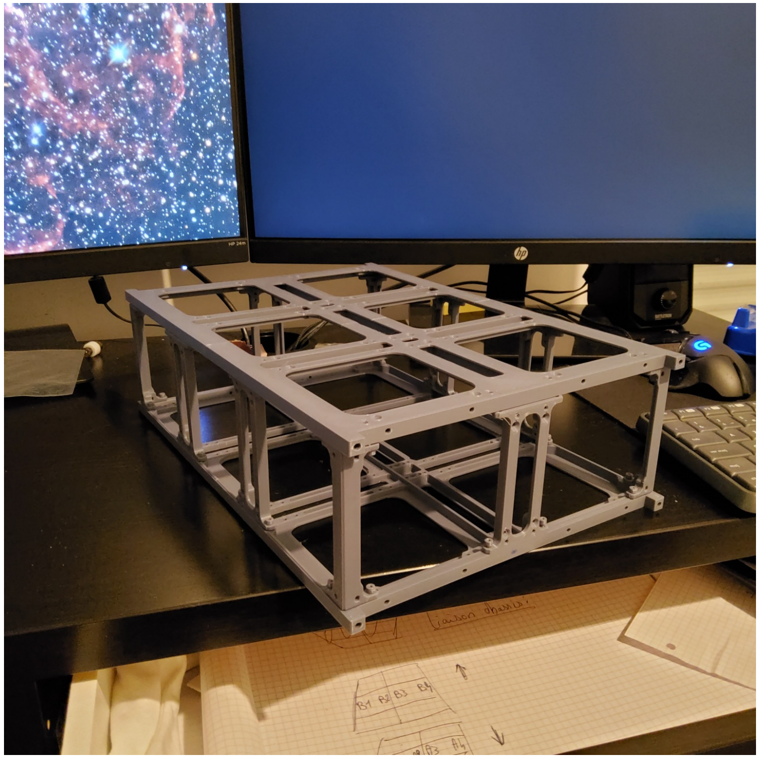

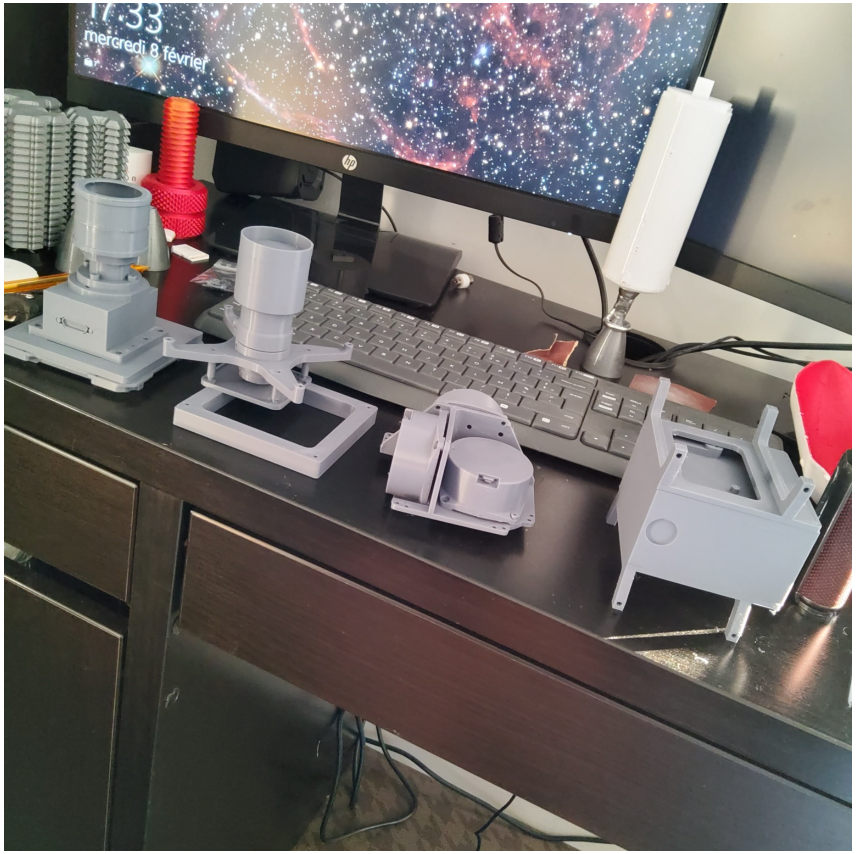

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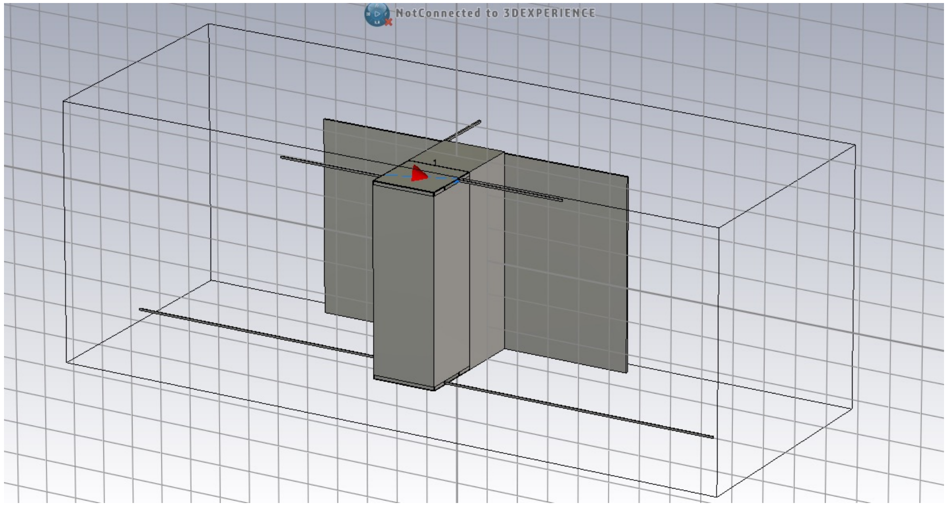
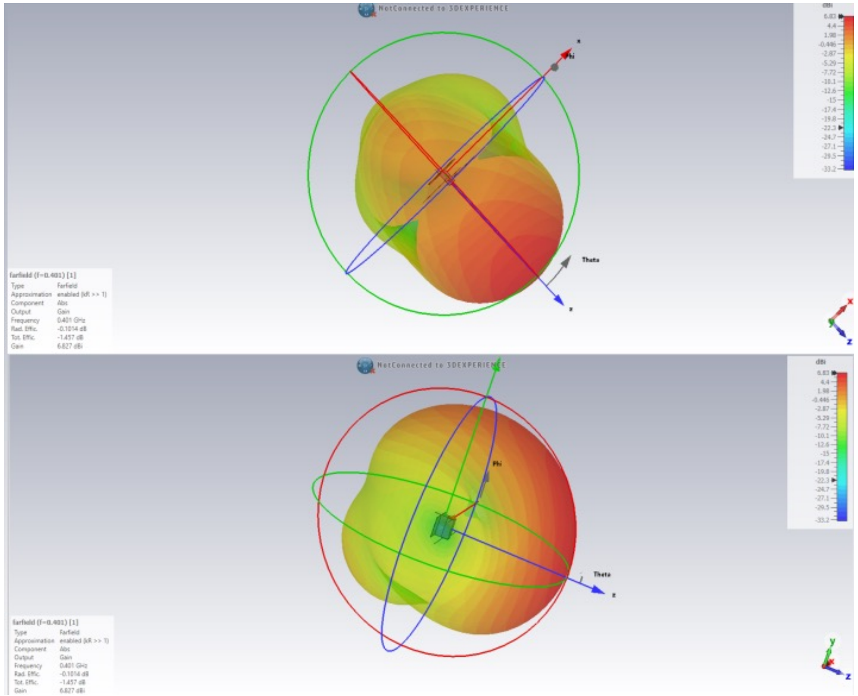
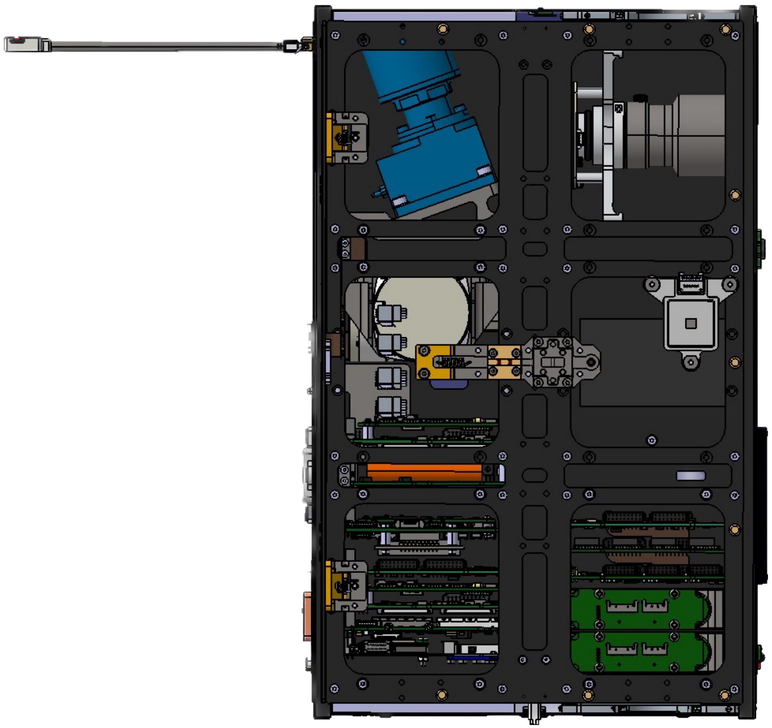
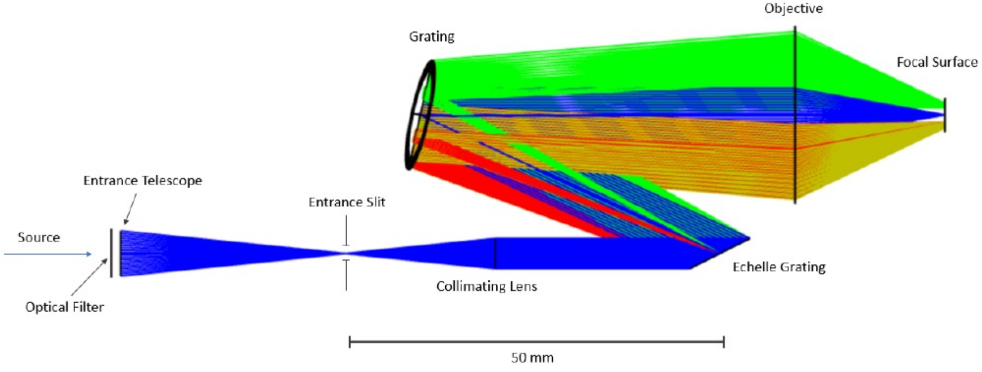
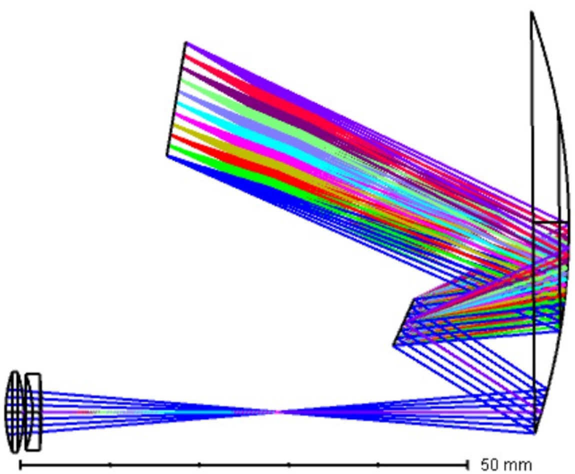


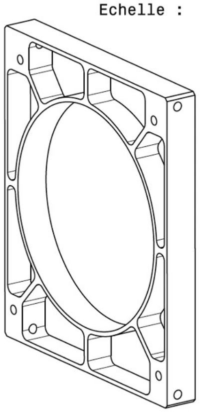


Uvsq-Sat NG

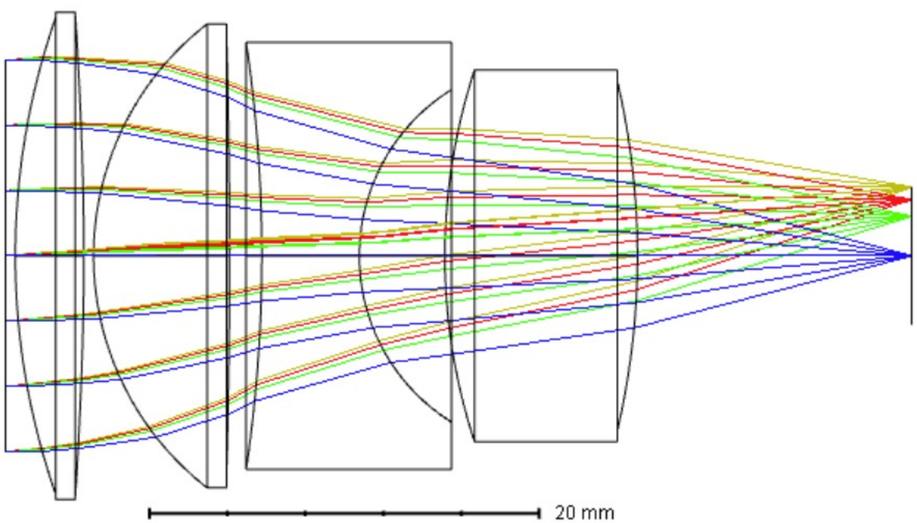


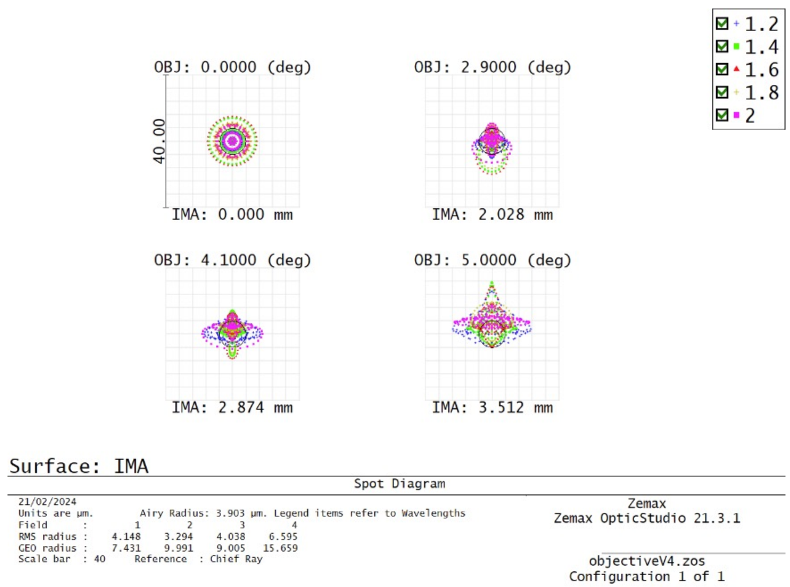

Objective
Grating
Focal Surface
Entrance Telescope
Entrance Slit
Source
Echelle Grating
Collimating Lens
Optical Filter
50 mm


50 mm

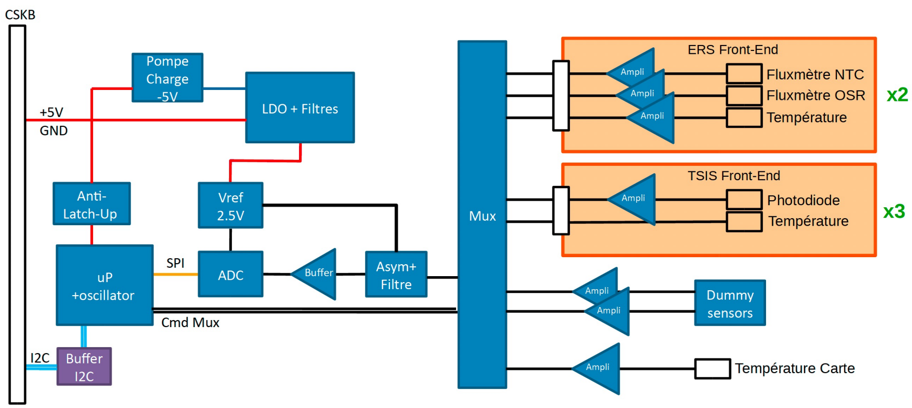

Vue isométrique
Echelle : 1:1

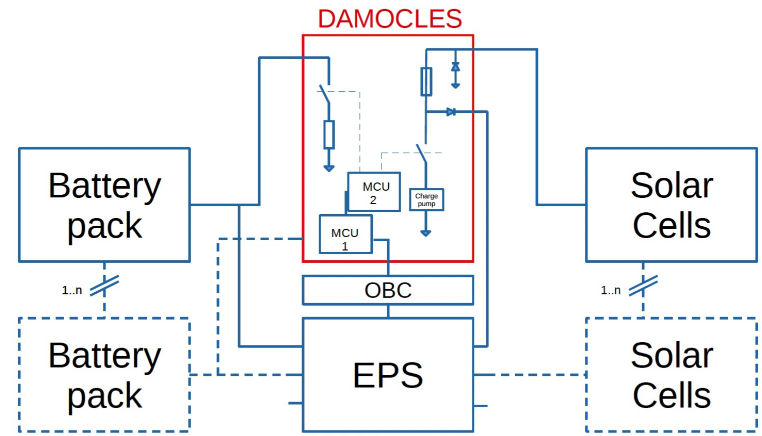
Uvsq-Sat NG

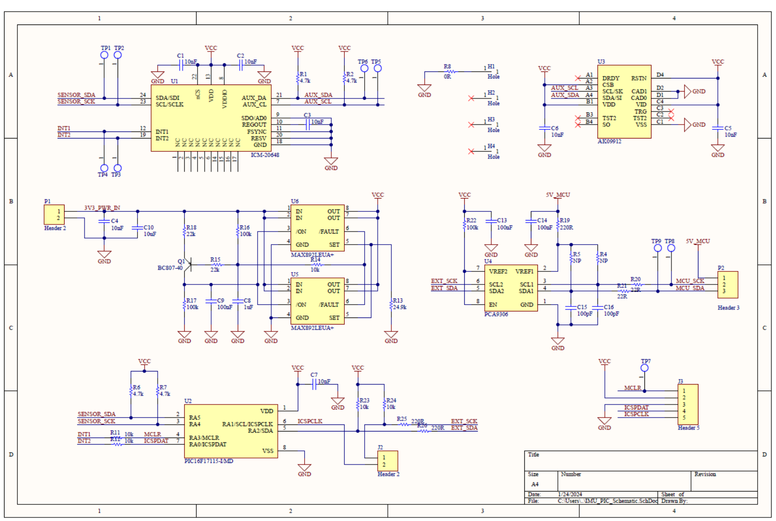

20 mm

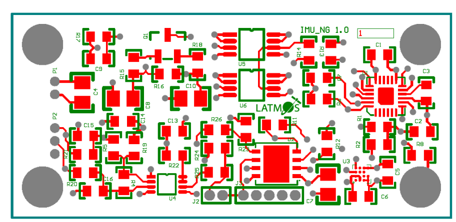

1.2
1.4
1.6
1.8
2
OBJ: 0.0000 (deg)
40.00
IMA: 0.000 mm
OBJ: 2.9000 (deg)
IMA: 2.028 mm
OBJ: 4.1000 (deg)
IMA: 2.874 mm
OBJ: 5.0000 (deg)
IMA: 3.512 mm
Surface: IMA
Spot Diagram
21/02/2024
Units are µm. Airy Radius: 3.903 µm. Legend items refer to Wavelengths
Field : 1 2 3 4
RMS radius : 4.148 3.294 4.038 6.595
GEO radius : 7.431 9.991 9.005 15.659
Scale bar : 40 Reference : Chief Ray
Zemax
Zemax OpticStudio 21.3.1
objectiveV4.zos
Configuration 1 of 1

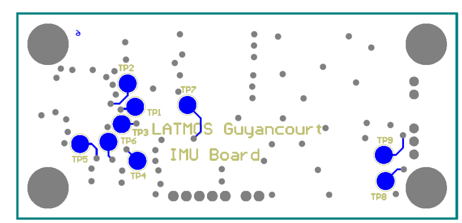
Uvsq-Sat NG


CSKB
Pompe Charge -5V
LDO + Filtres
+5V
GND
Anti-Latch-Up
Vref 2.5V
uP +oscillator
SPI
ADC
Buffer
Asym+ Filtre
Mux
Cmd Mux
I2C
Buffer I2C
ERS Front-End
Ampli
Fluxmètre NTC
Fluxmètre OSR
Température
x2
TSIS Front-End
Photodiode
Température
x3
Dummy sensors
Température Carte


DAMOCLES
Battery pack
MCU 2
Charge pump
MCU 1
OBC
EPS
Solar Cells
1..n
Battery pack
Solar Cells

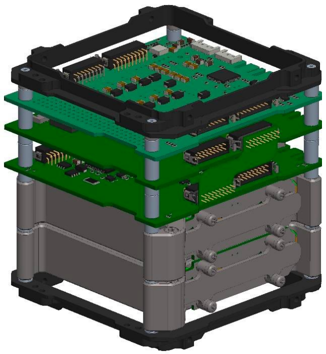


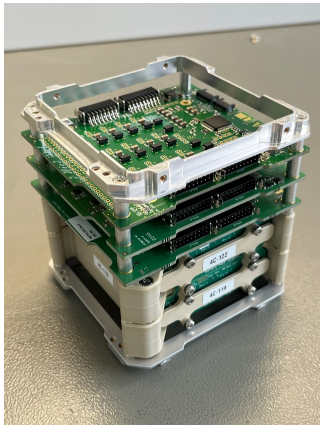

IMU_NG 1.0
LATMOS

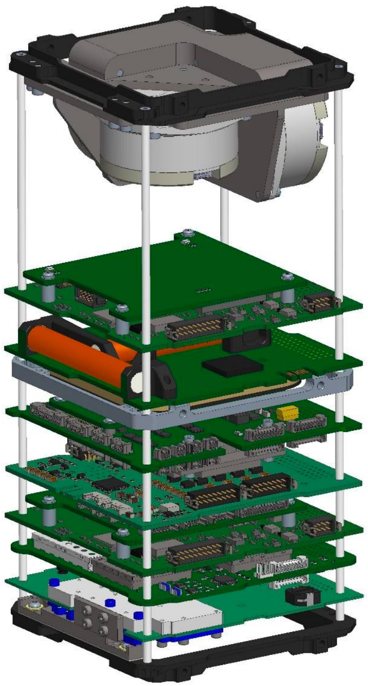

LATMOS Guyancourt
IMU Board

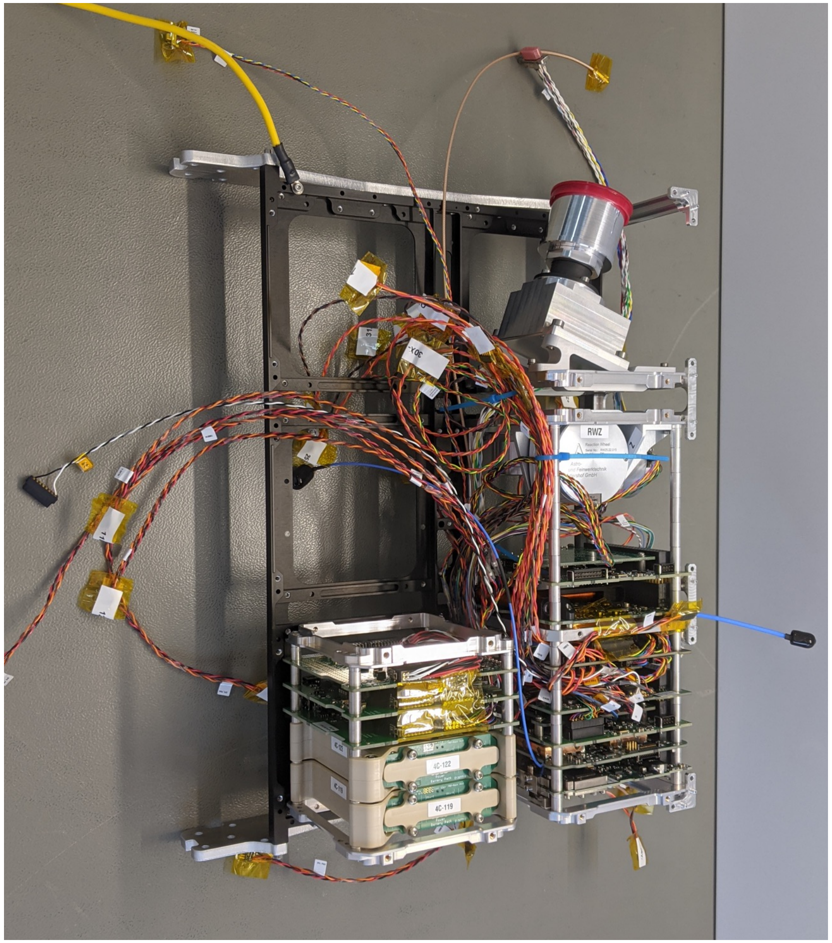
Uvsq-Sat NG

❑ <u>(2) Manufacture</u>

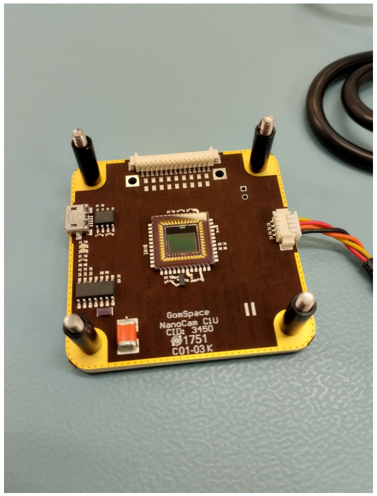


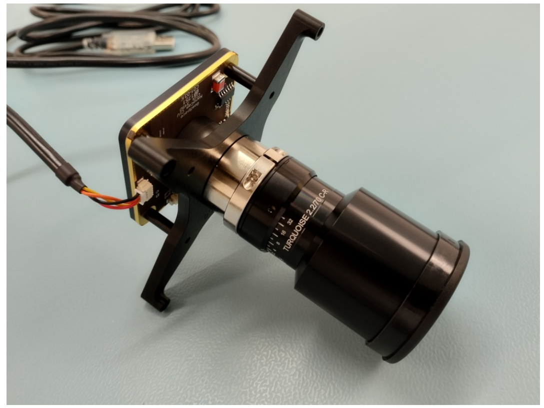


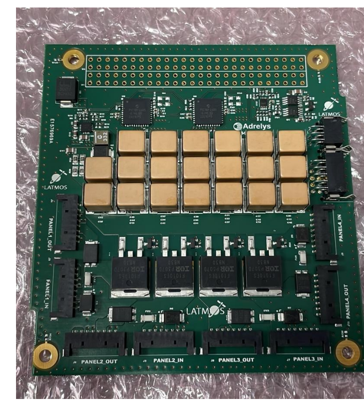


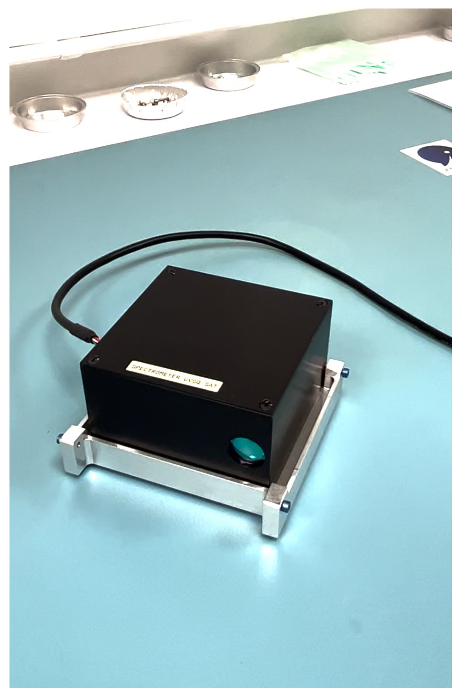


Uvsq-Sat NG

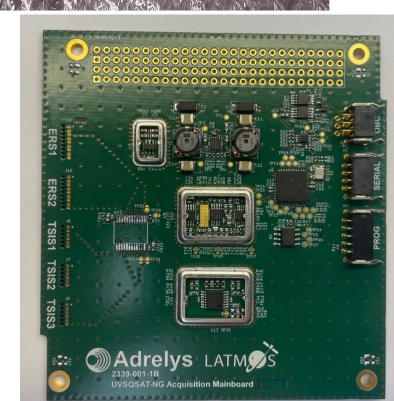

GomSpace
NanoCam C1U



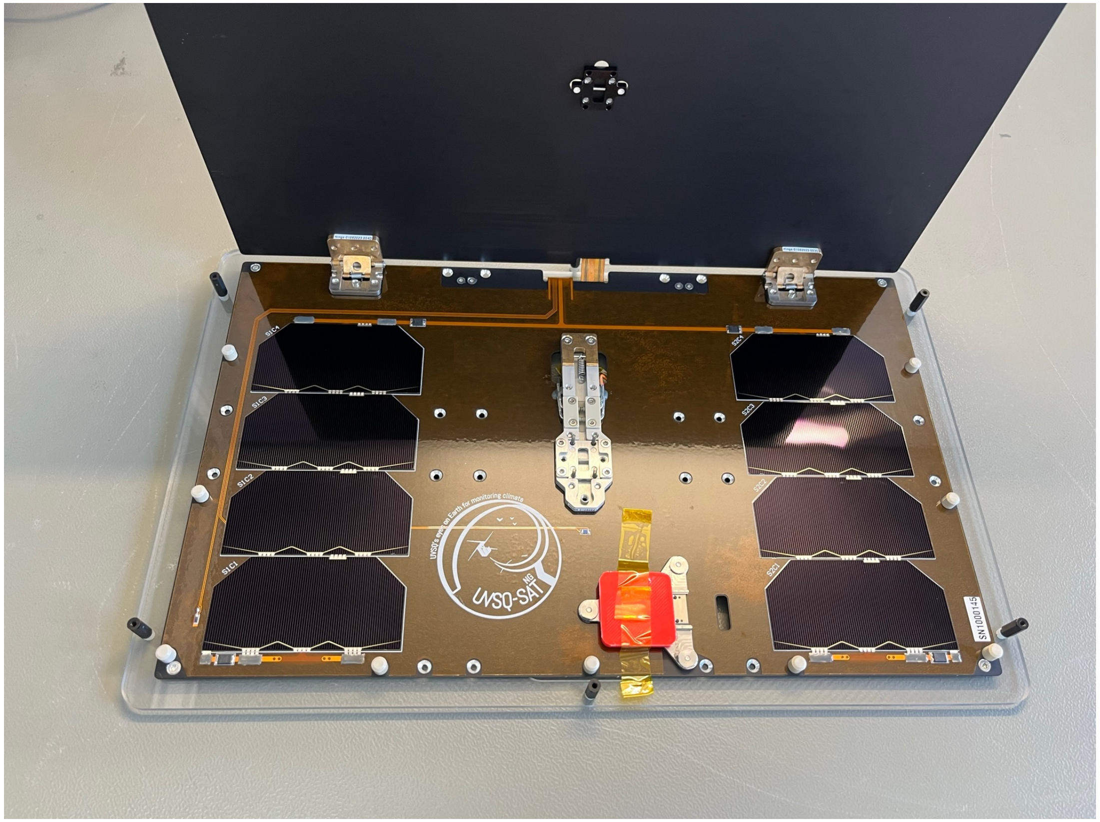

Adrelys
LATMOS




LATMOS
PIT
www.ovsq.uvsq.fr/pit

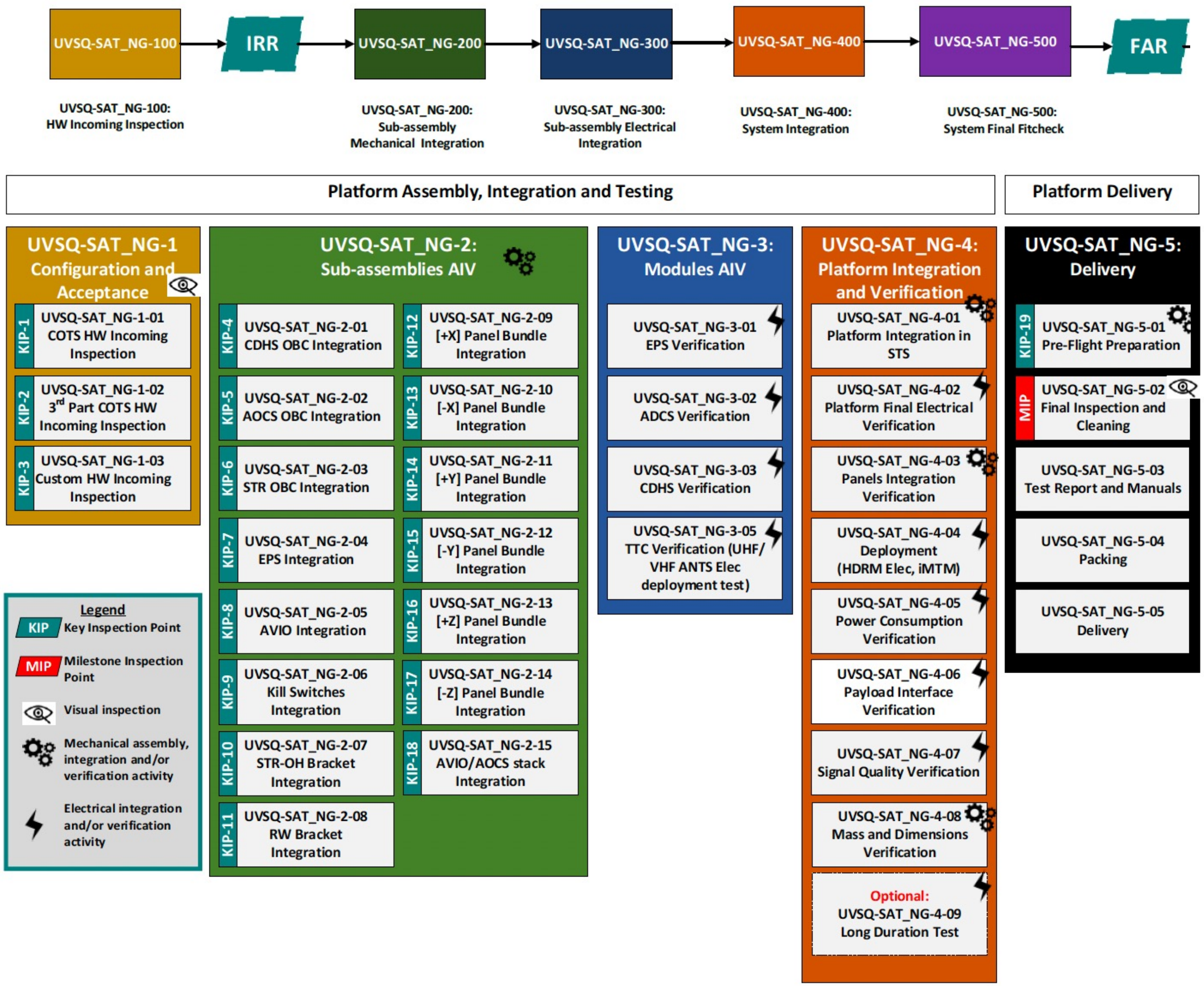

ERS1
ERS2
TSIS1
TSIS2
TSIS3
USB
SERIAL
PROG
Adrelys
LATMOS
2339-001-1B
UVSQSAT-NG Acquisition Mainboard

Uvsq-Sat NG



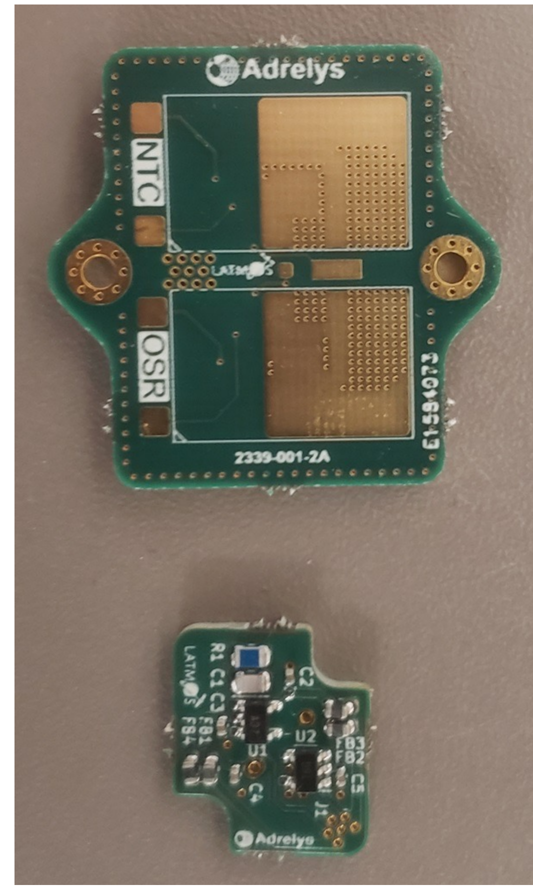
Uvsq-Sat NG

❑ (3) AIT

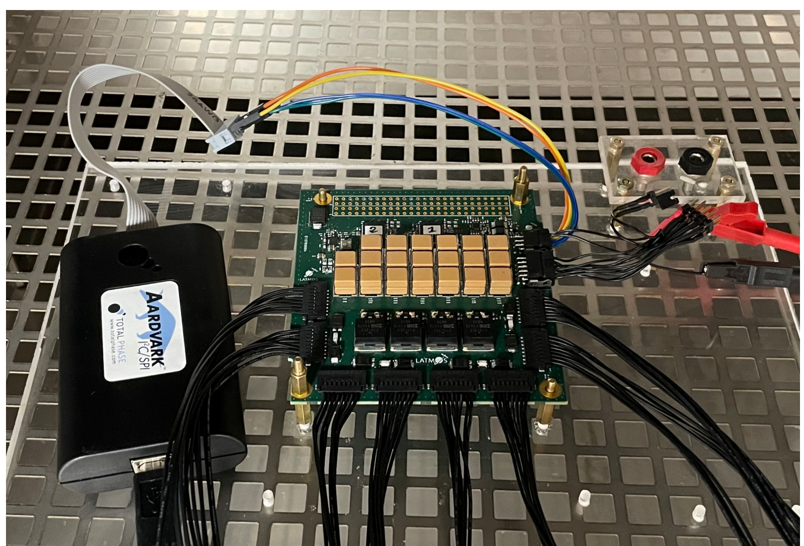


Uvsq-Sat NG

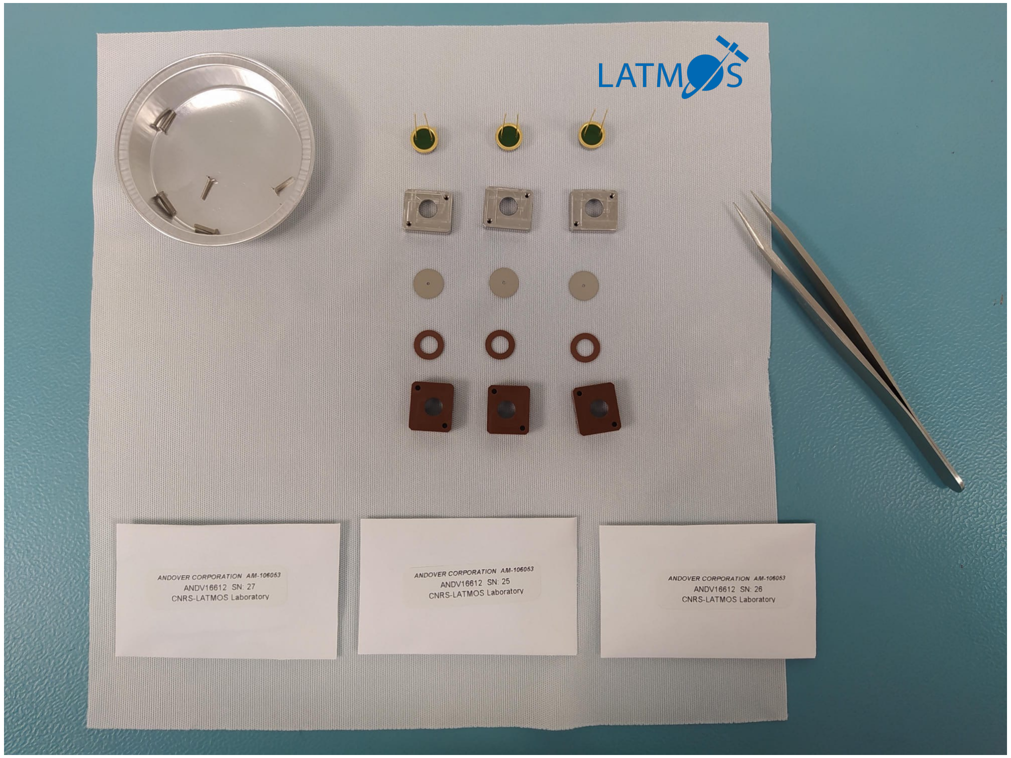

Adrelys
LATMOS
PANEL2_OUT
PANEL2_IN
PANEL3_OUT
PANEL3_IN

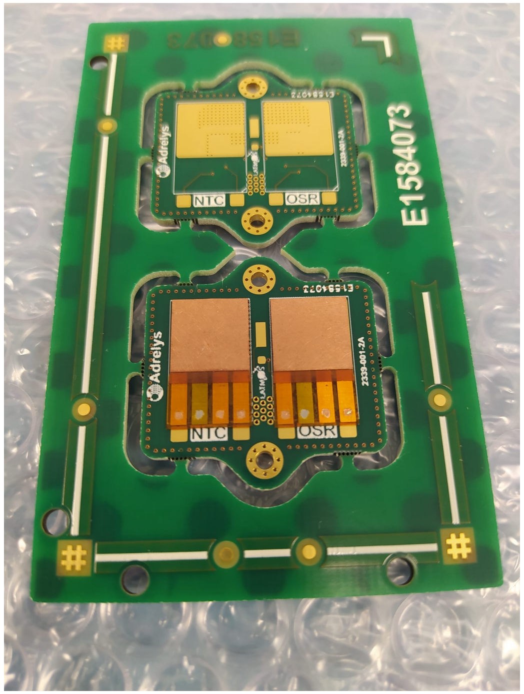

Adrelys
NTC
OSR
2339-001-2A

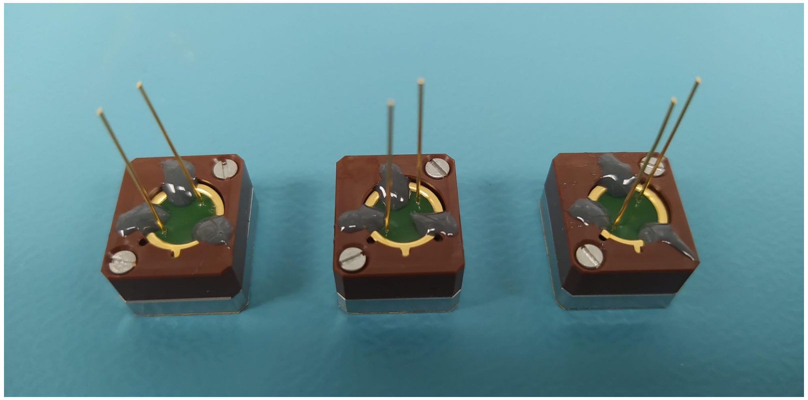

Adrelys
LATMOS
2339-001-2A
UVSQSAT-NG Acquisition Mainboard
E1585618


AARDVARK
TOTAL PHASE

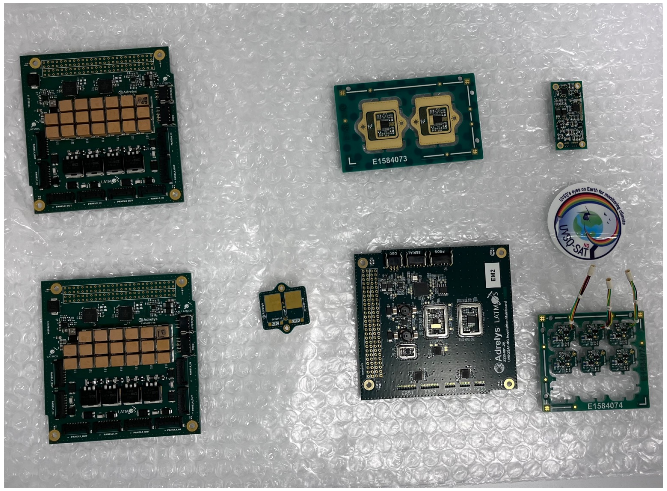
Uvsq-Sat NG

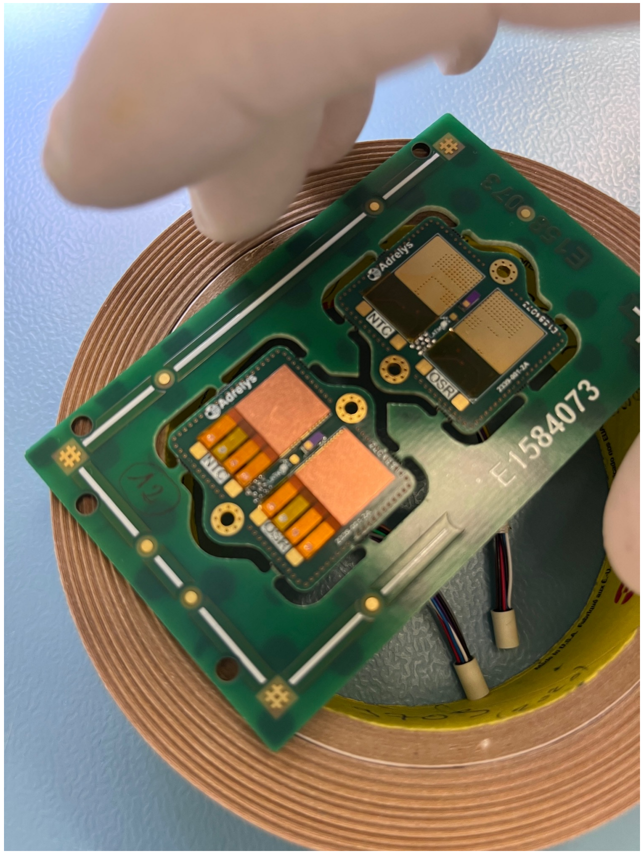

LATMOS
ANDOVER CORPORATION AM-106053
ANDV16612 SN: 27
CNRS-LATMOS Laboratory
ANDOVER CORPORATION AM-106053
ANDV16612 SN: 25
CNRS-LATMOS Laboratory
ANDOVER CORPORATION AM-106053
ANDV16612 SN: 26
CNRS-LATMOS Laboratory


E1584073
NTC
OSR
Adrelys



Uvsq-Sat NG





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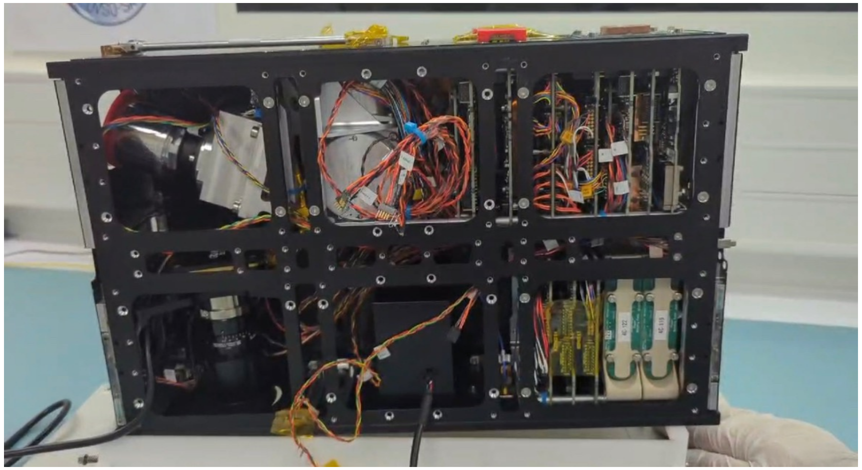

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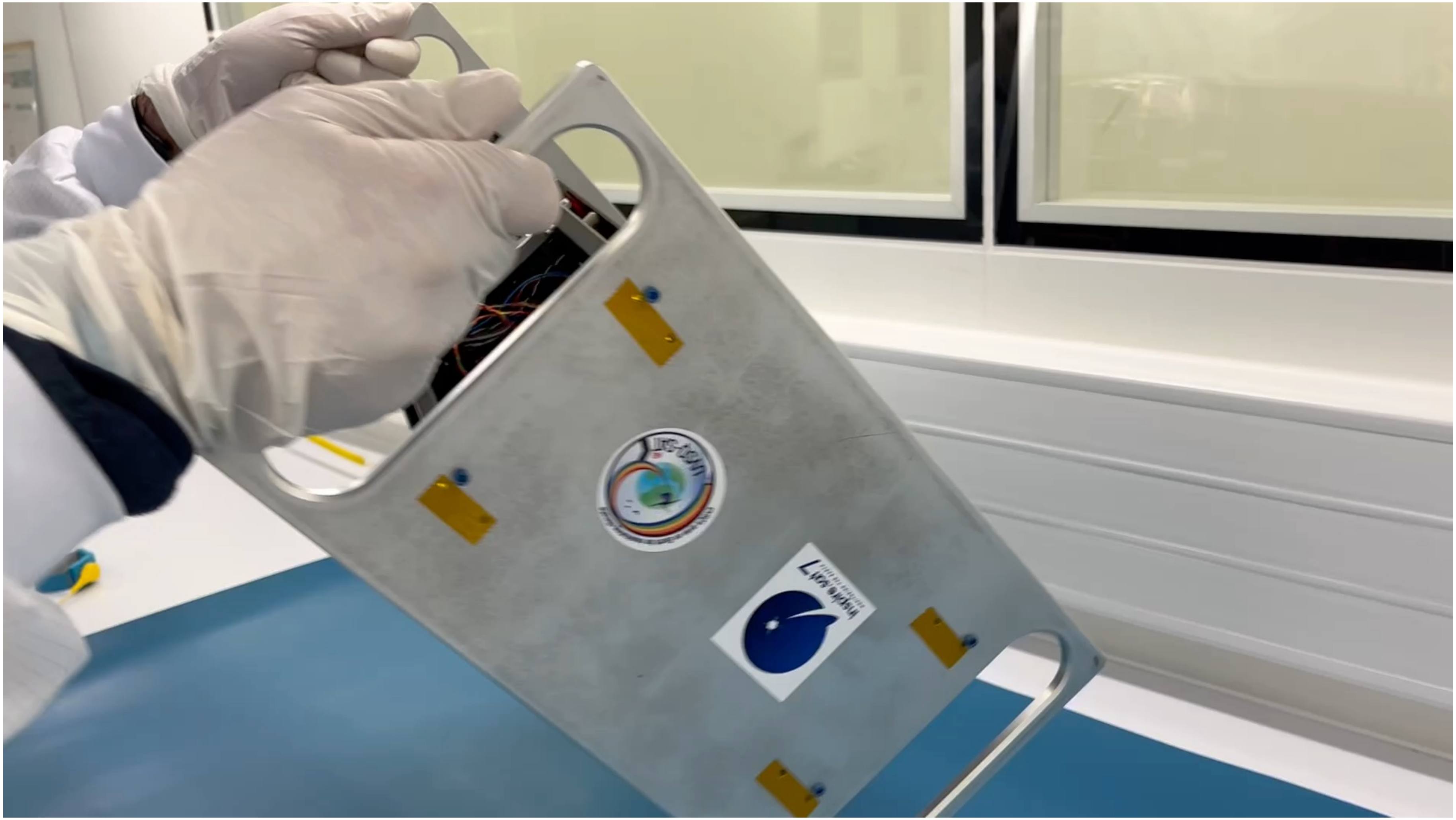

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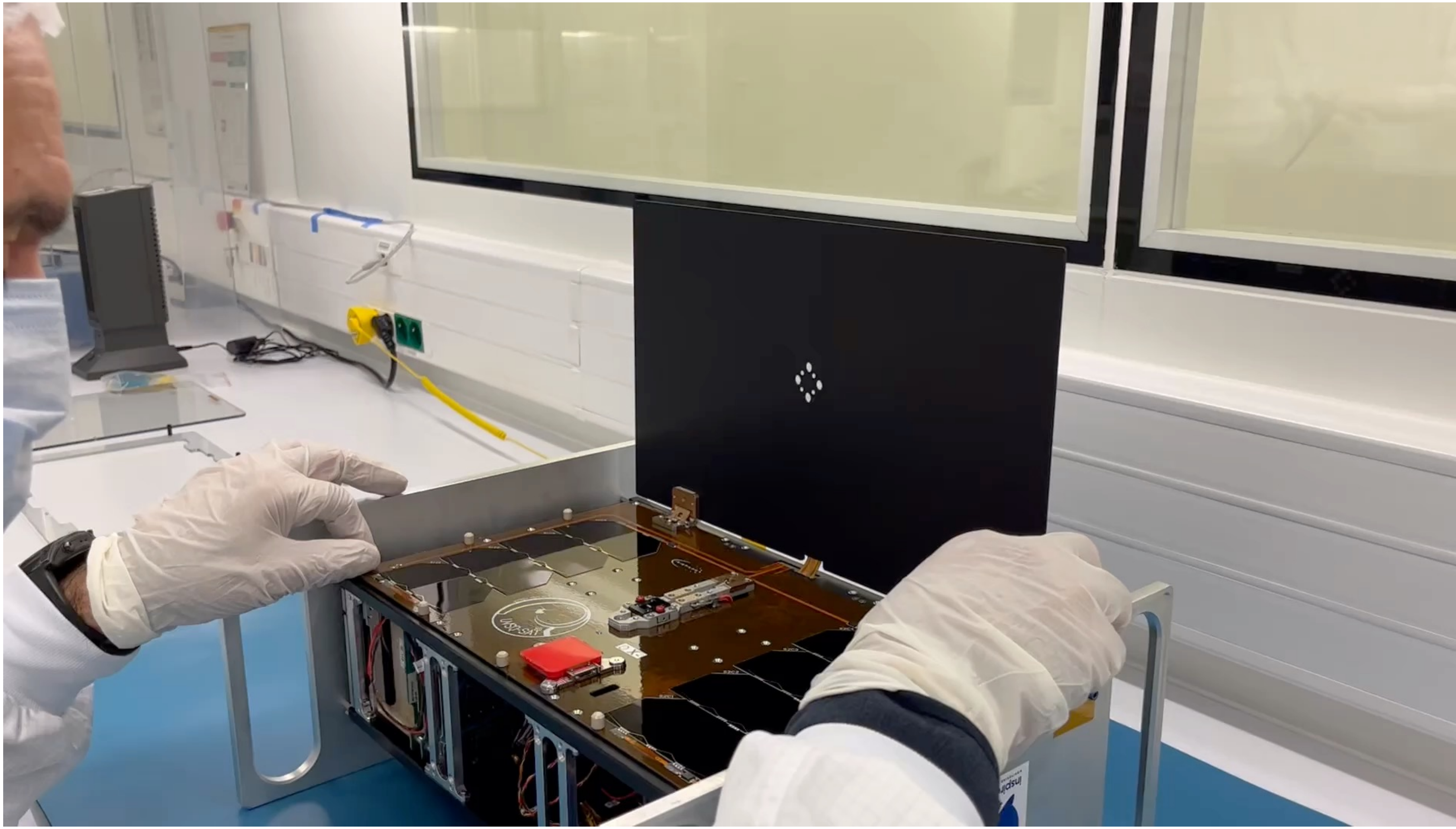

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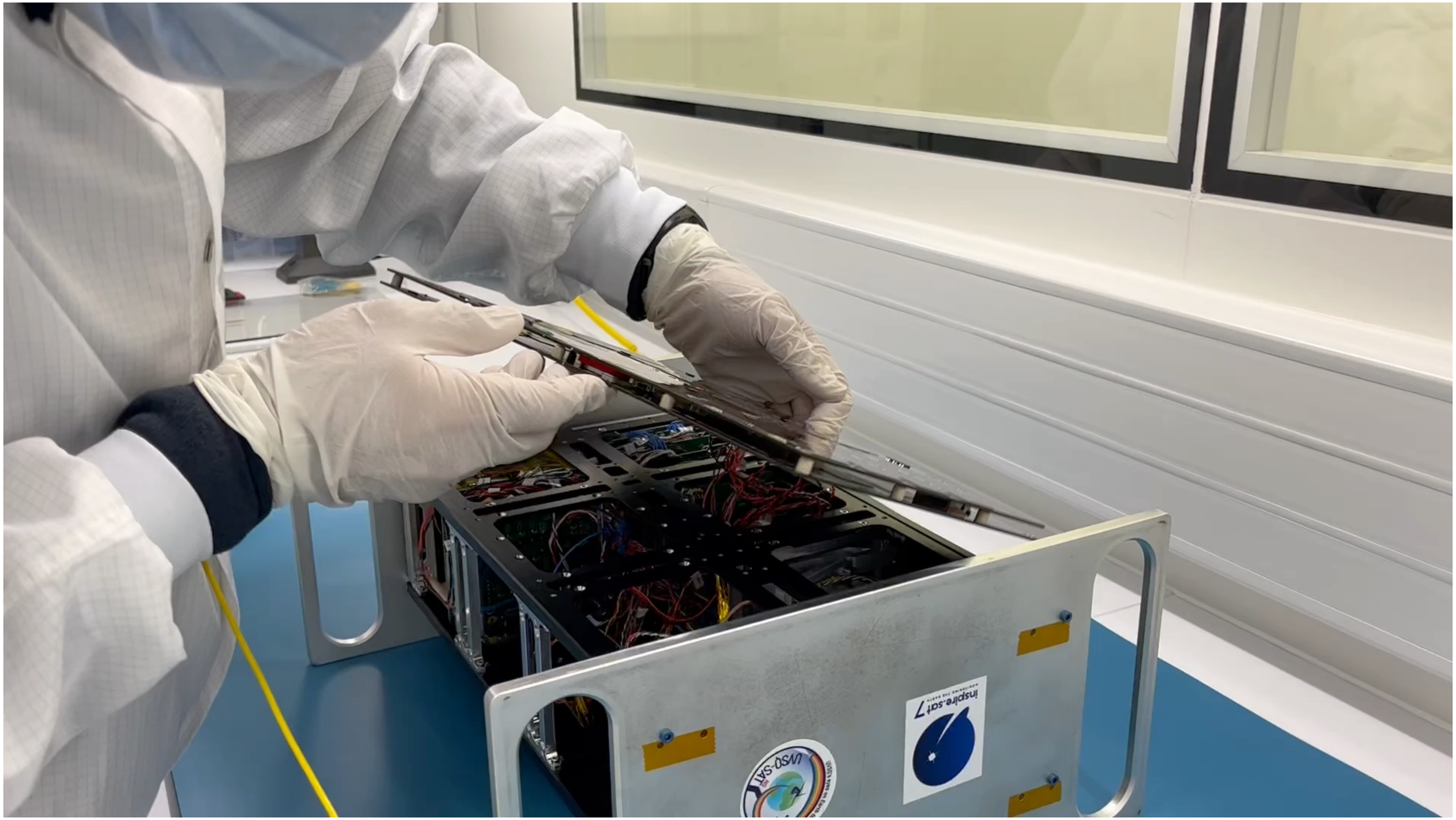
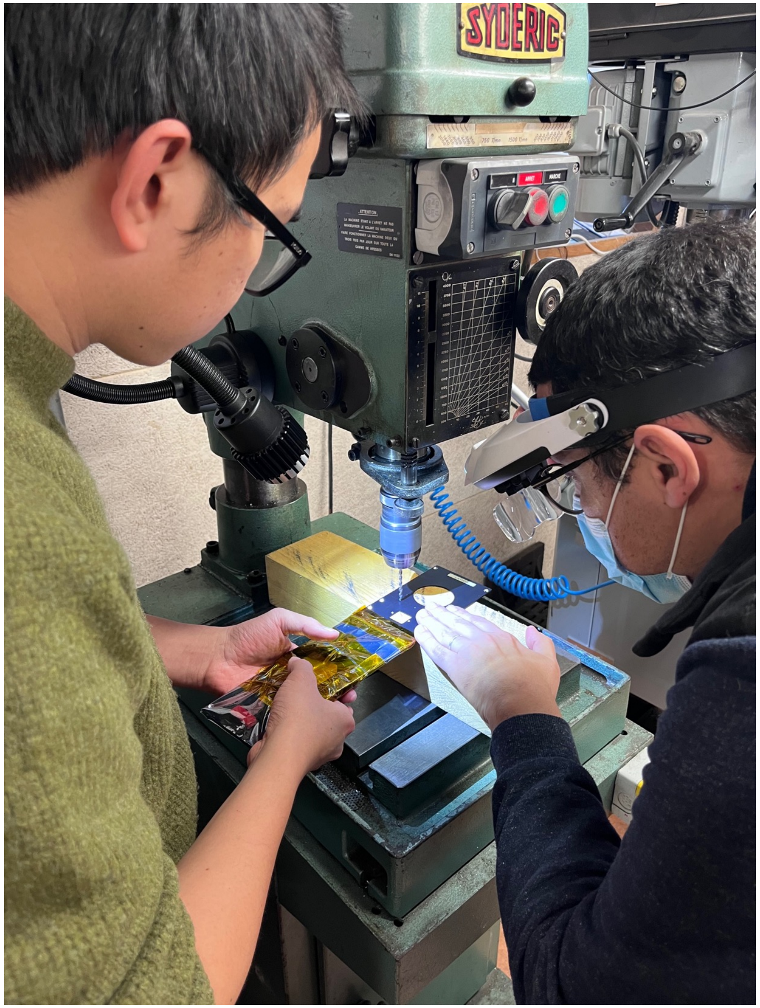


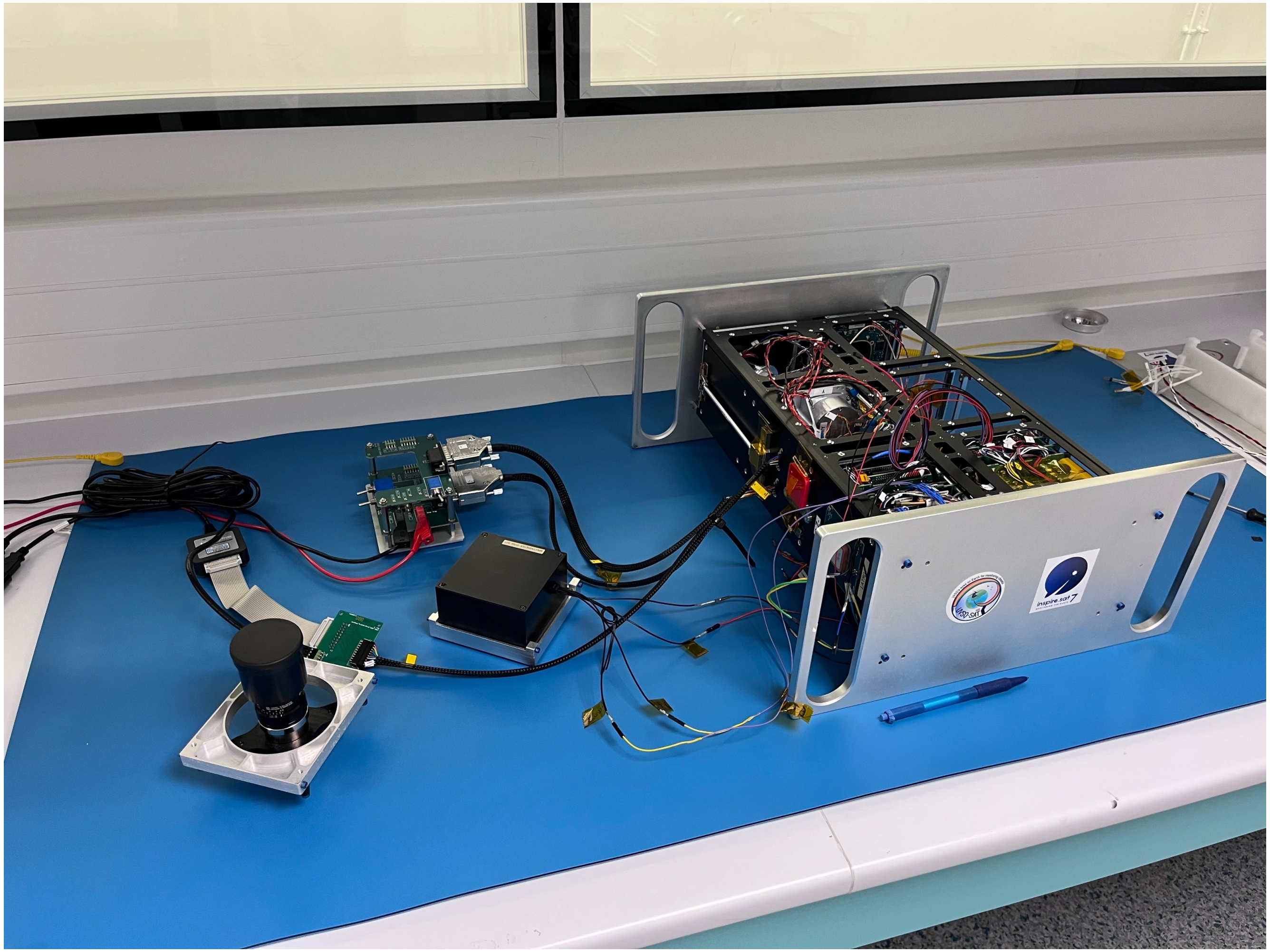
Uvsq-Sat NG


LATMOS
UVSQ-SAT NG
LATMOS
UVSQ-SAT NG
LATMOS
UVSQ-SAT NG


SYDERIC

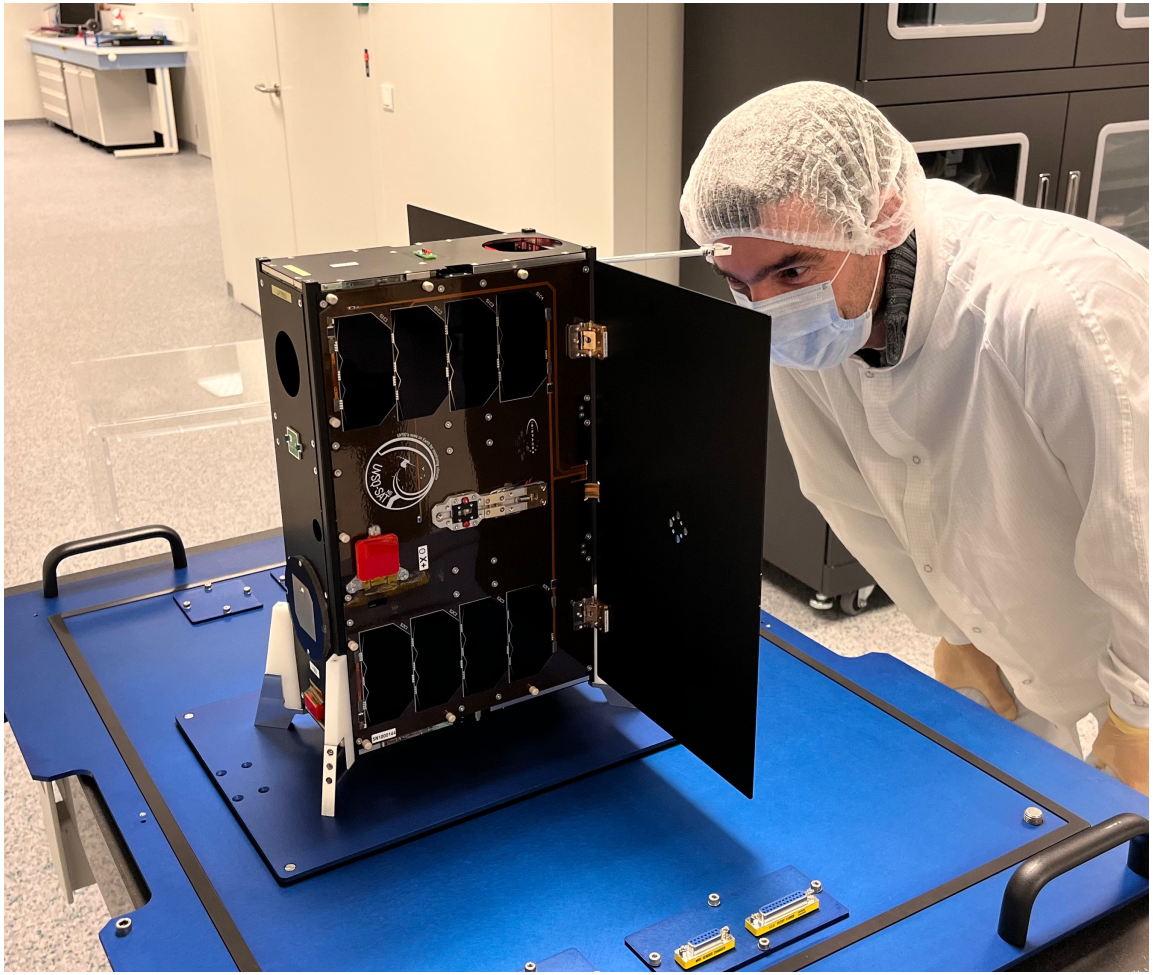
Uvsq-Sat NG

Uvsq-Sat NG



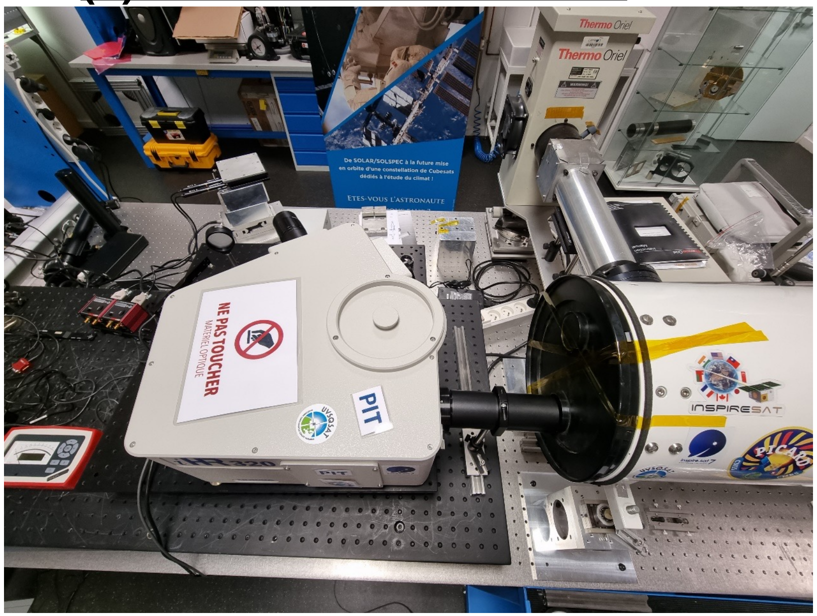
Uvsq-Sat NG

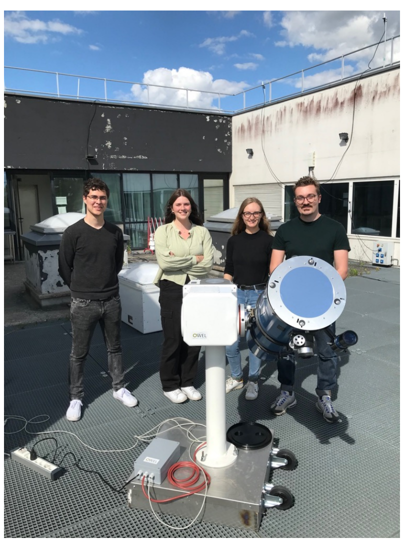
Uvsq-Sat NG, a New CubeSat Pathfinder for Monitoring Earth Outgoing Energy and Greenhouse Gases

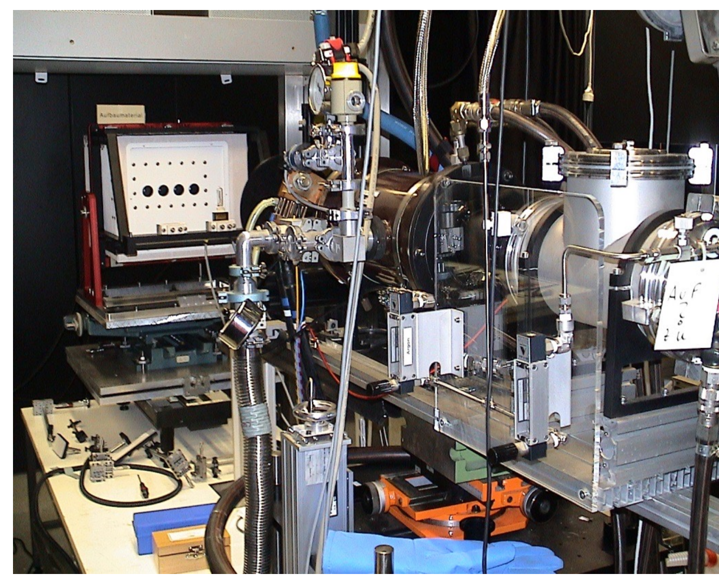


Uvsq-Sat NG

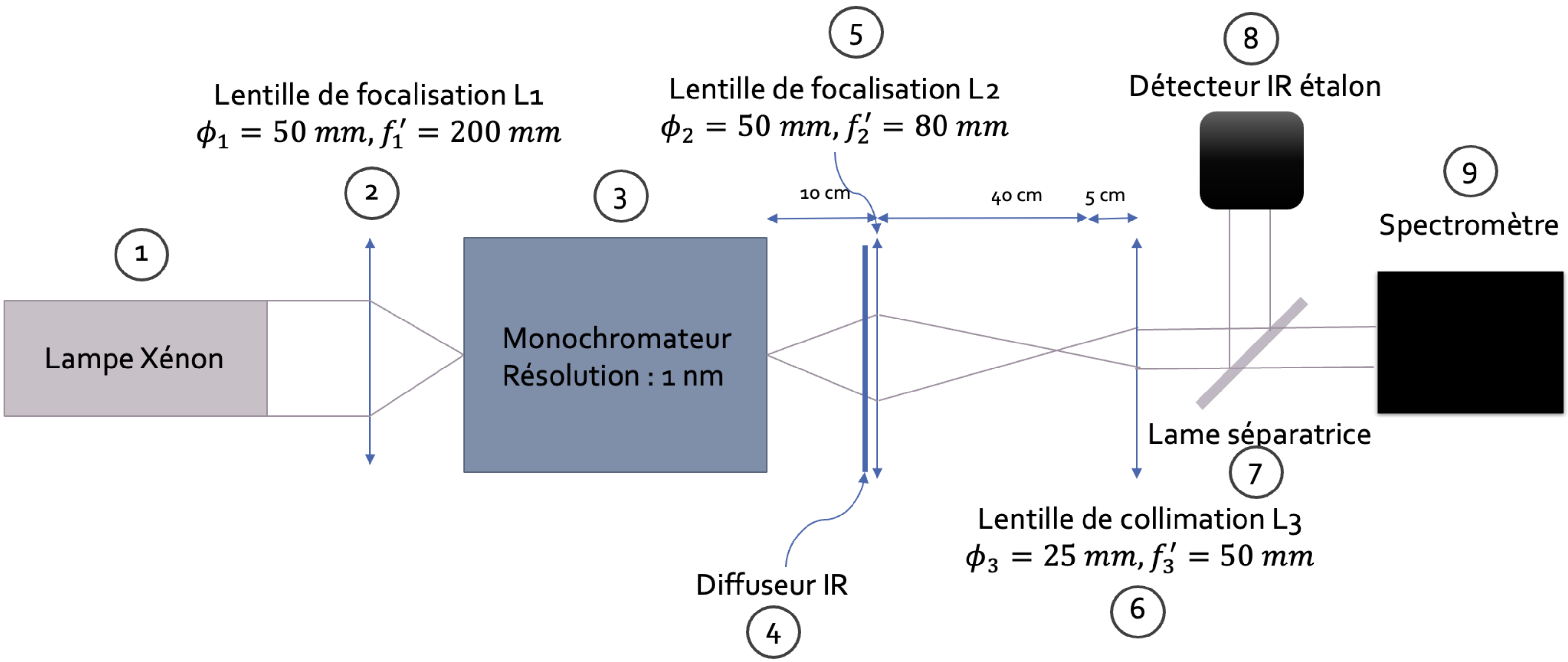
❑ (4) Calibration and tests





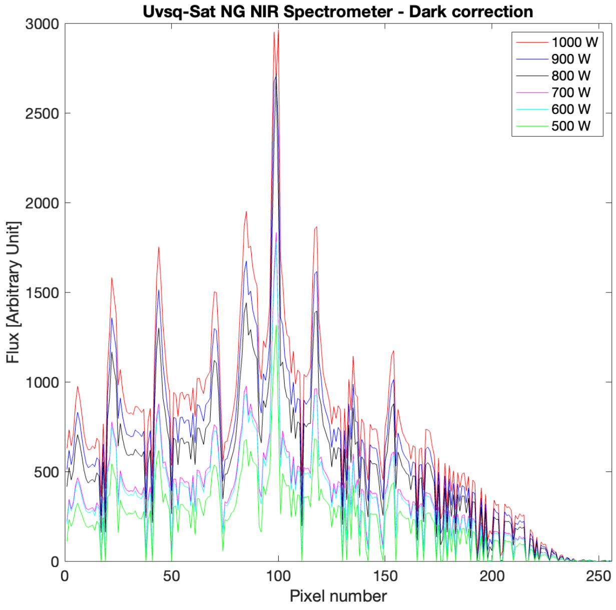


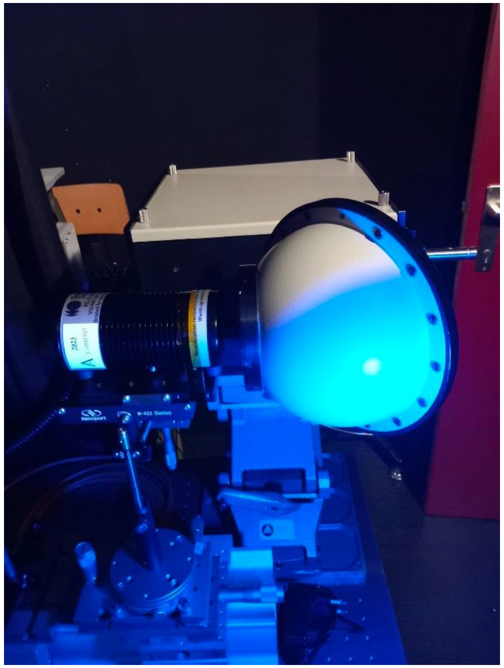
Uvsq-Sat NG

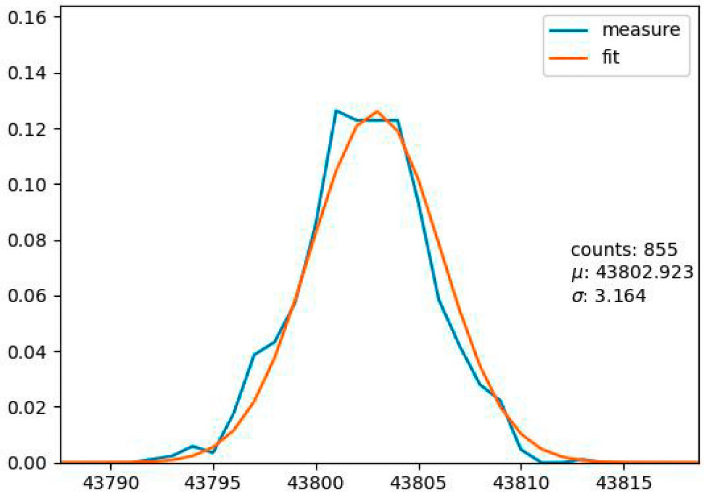


1
Lampe Xénon
2
Lentille de focalisation L1
$\phi_1 = 50\ mm, f_1' = 200\ mm$
3
Monochromateur
Résolution : 1 nm
4
Diffuseur IR
5
Lentille de focalisation L2
$\phi_2 = 50\ mm, f_2' = 80\ mm$
10 cm
40 cm
5 cm
6
Lentille de collimation L3
$\phi_3 = 25\ mm, f_3' = 50\ mm$
7
Lame séparatrice
8
Détecteur IR étalon
9
Spectromètre

Uvsq-Sat NG

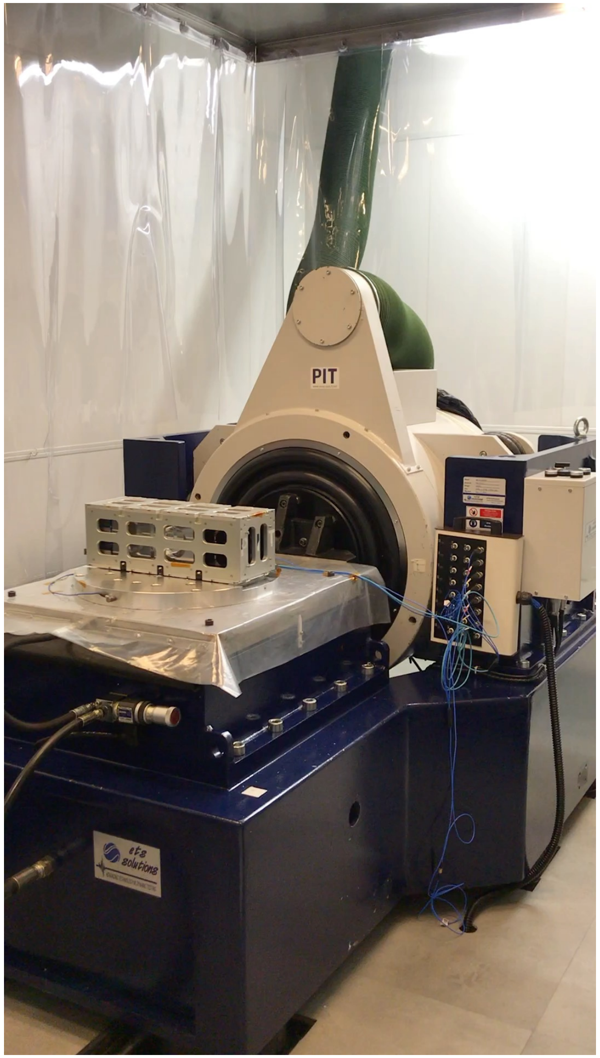

Uvsq-Sat NG NIR Spectrometer - Dark correction
1000 W
900 W
800 W
700 W
600 W
500 W
Flux [Arbitrary Unit]
Pixel number
0
500
1000
1500
2000
2500
3000
0
50
100
150
200
250

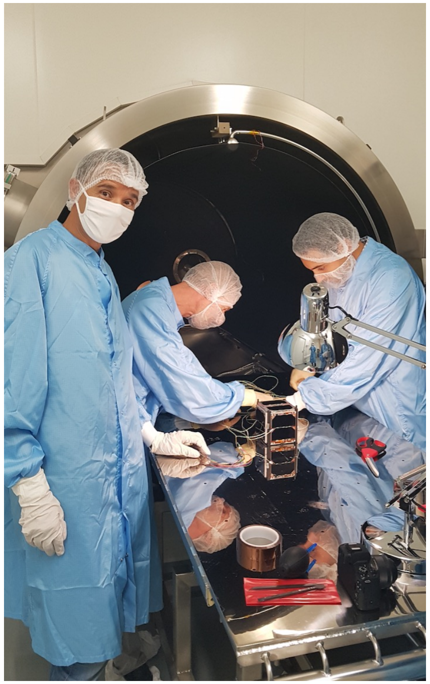


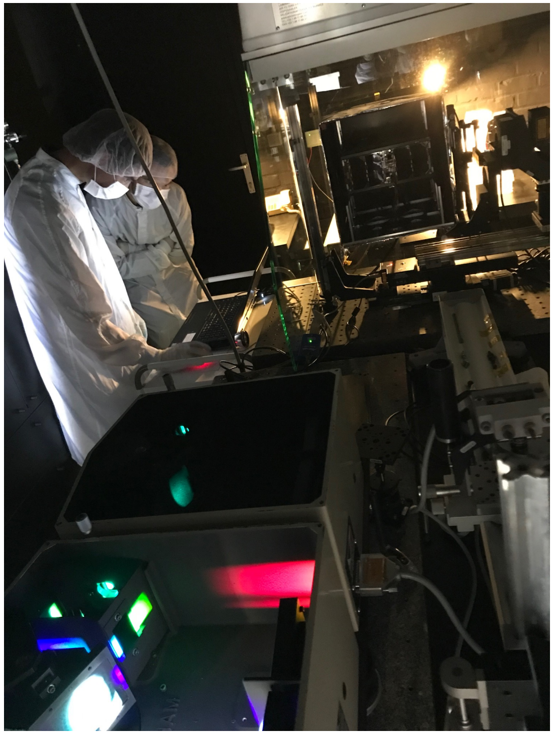

measure
fit
counts: 855
μ: 43802.923
σ: 3.164
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
43790
43795
43800
43805
43810
43815

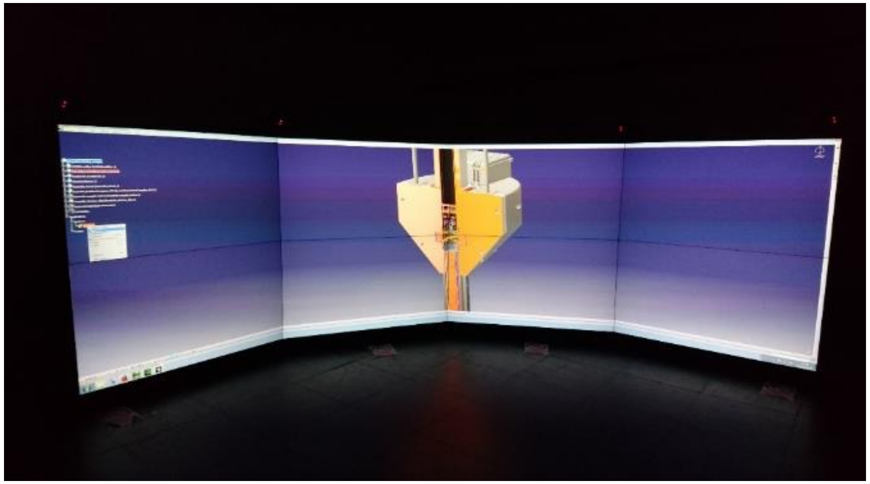

UVSQ-SAT

Uvsq-Sat NG

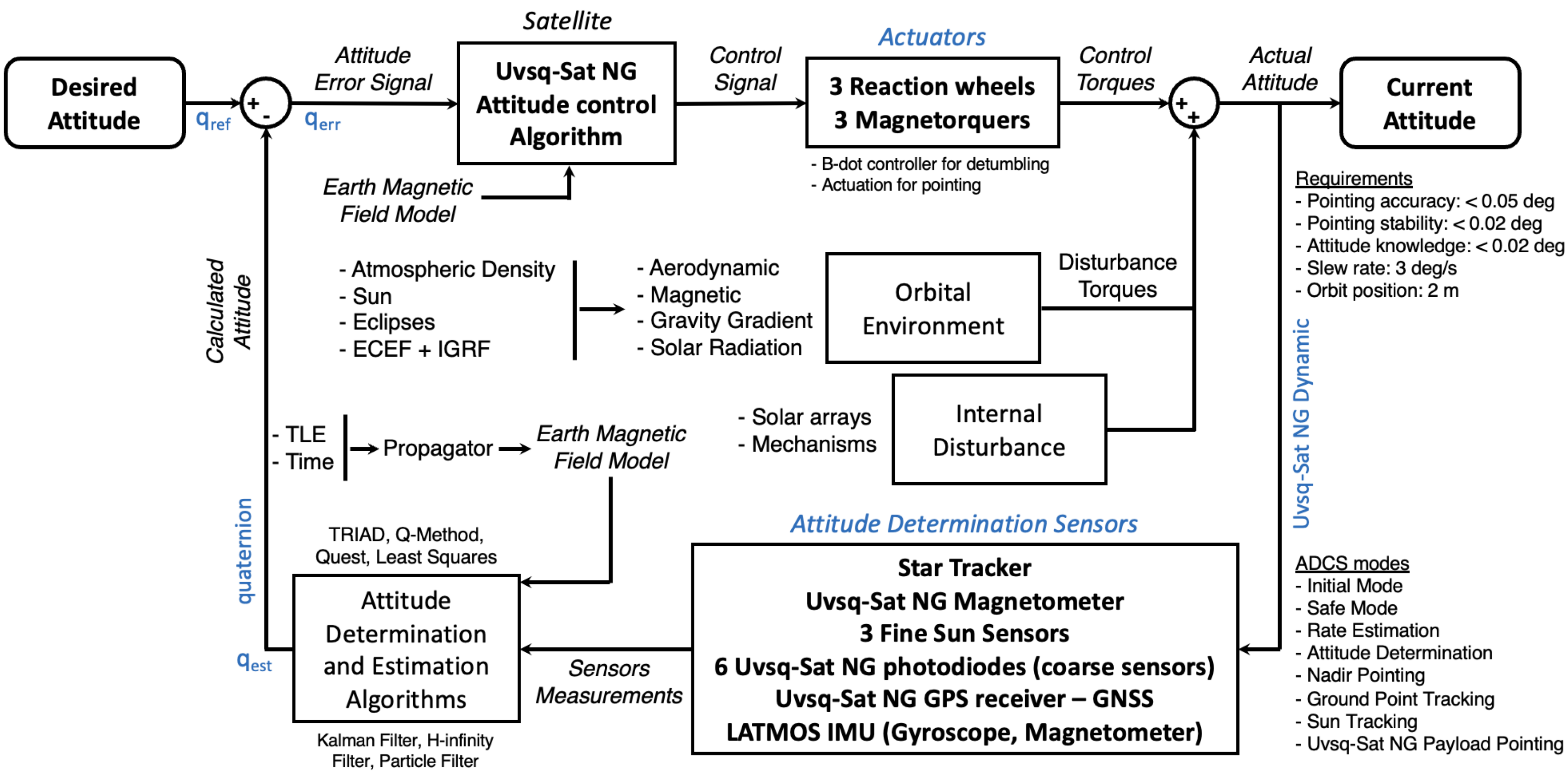






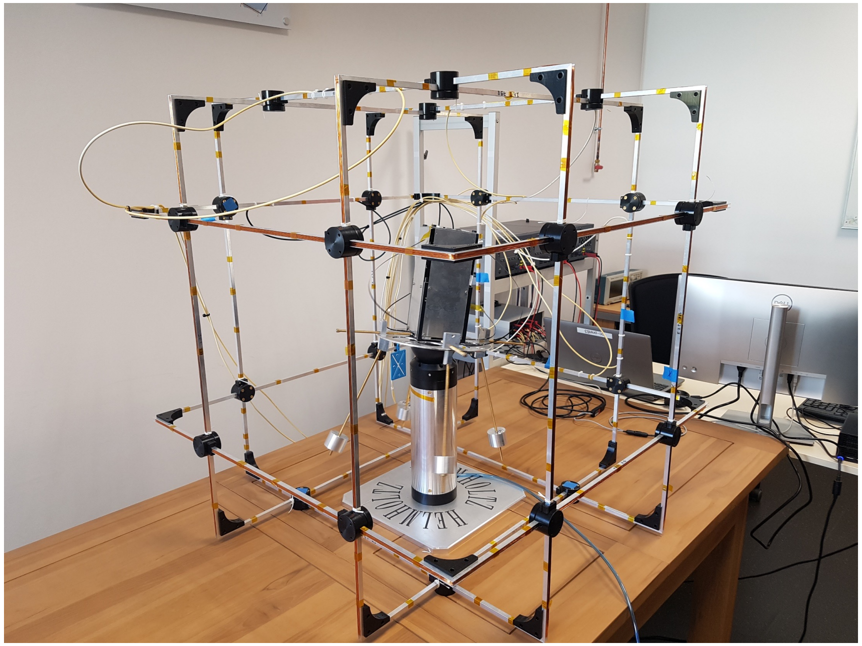


Uvsq-Sat NG

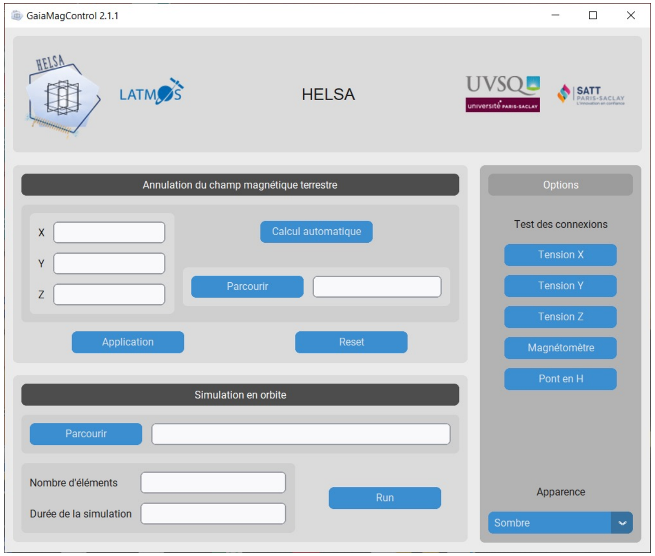


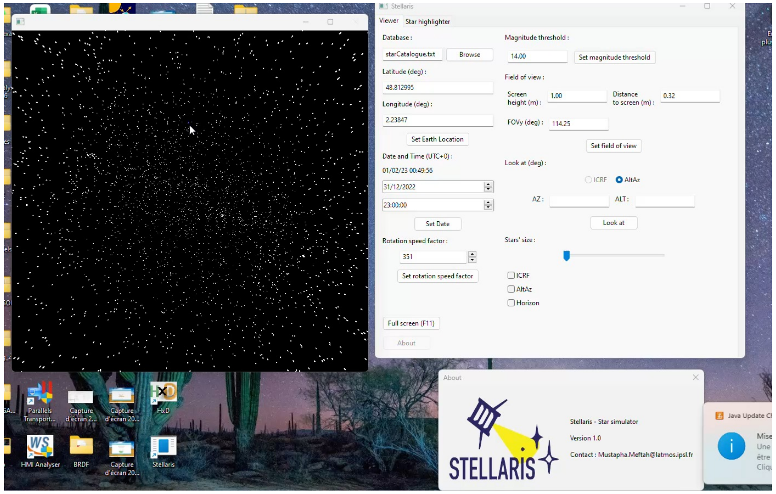
Satellite
Desired Attitude
q_{ref}
+
-
Attitude Error Signal
q_{err}
Uvsq-Sat NG Attitude control Algorithm
Control Signal
Actuators
3 Reaction wheels
3 Magnetorquers
- B-dot controller for detumbling
- Actuation for pointing
Control Torques
+
+
Actual Attitude
Current Attitude
Earth Magnetic Field Model
Calculated Attitude
- Atmospheric Density
- Sun
- Eclipses
- ECEF + IGRF
- Aerodynamic
- Magnetic
- Gravity Gradient
- Solar Radiation
Orbital Environment
Disturbance Torques
- TLE
- Time
Propagator
Earth Magnetic Field Model
- Solar arrays
- Mechanisms
Internal Disturbance
Uvsq-Sat NG Dynamic
quaternion
TRIAD, Q-Method, Quest, Least Squares
Attitude Determination and Estimation Algorithms
q_{est}
Kalman Filter, H-infinity Filter, Particle Filter
Sensors Measurements
Attitude Determination Sensors
Star Tracker
Uvsq-Sat NG Magnetometer
3 Fine Sun Sensors
6 Uvsq-Sat NG photodiodes (coarse sensors)
Uvsq-Sat NG GPS receiver – GNSS
LATMOS IMU (Gyroscope, Magnetometer)
Requirements
- Pointing accuracy: < 0.05 deg
- Pointing stability: < 0.02 deg
- Attitude knowledge: < 0.02 deg
- Slew rate: 3 deg/s
- Orbit position: 2 m
ADCS modes
- Initial Mode
- Safe Mode
- Rate Estimation
- Attitude Determination
- Nadir Pointing
- Ground Point Tracking
- Sun Tracking
- Uvsq-Sat NG Payload Pointing

Uvsq-Sat NG




UVSQ-SAT NG

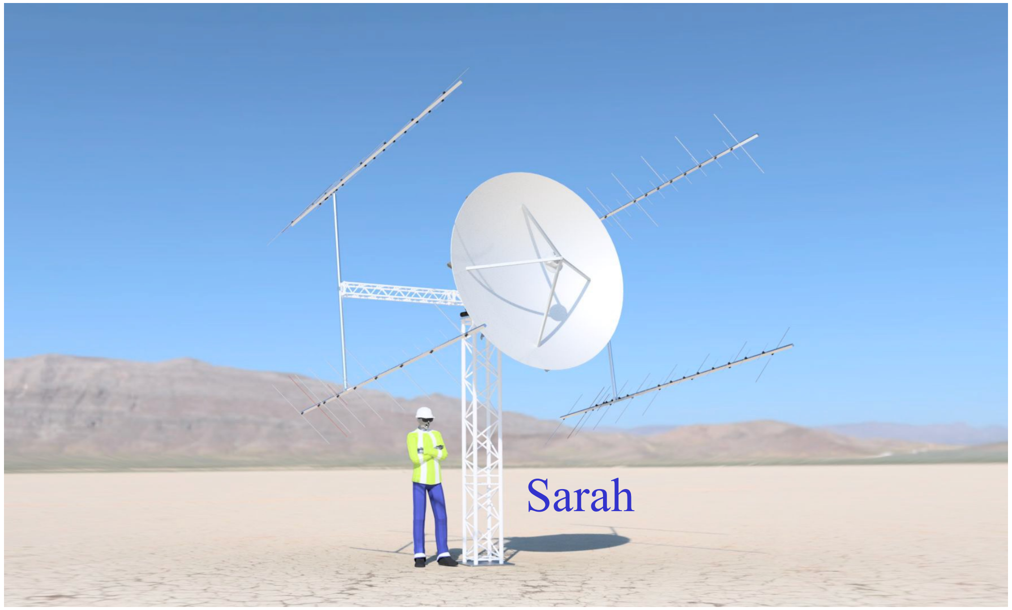

GaiaMagControl 2.1.1
HELSA
LATMOS
HELSA
UVSQ
université PARIS-SACLAY
SATT PARIS-SACLAY
Annulation du champ magnétique terrestre
X
Y
Z
Calcul automatique
Parcourir
Application
Reset
Simulation en orbite
Parcourir
Nombre d'éléments
Durée de la simulation
Run
Options
Test des connexions
Tension X
Tension Y
Tension Z
Magnétomètre
Pont en H
Apparence
Sombre

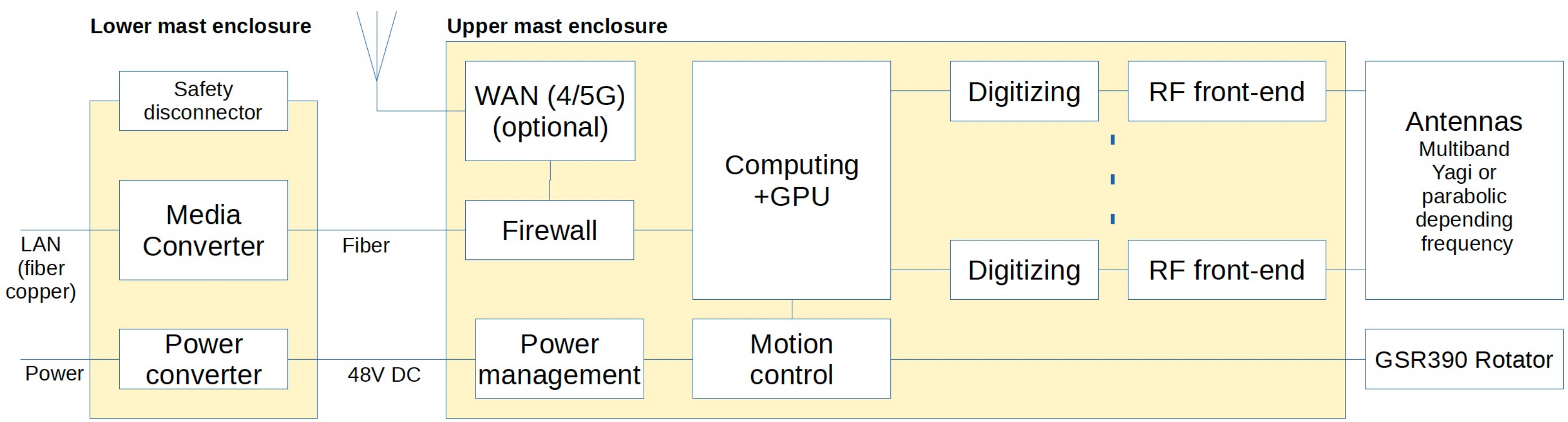

Stellaris
Viewer
Star highlighter
Database :
starCatalogue.txt
Browse
Latitude (deg) :
48.812995
Longitude (deg) :
2.23847
Set Earth Location
Date and Time (UTC+0) :
01/02/23 00:49:56
31/12/2022
23:00:00
Set Date
Rotation speed factor :
351
Set rotation speed factor
Full screen (F11)
About
Magnitude threshold :
14.00
Set magnitude threshold
Field of view :
Screen height (m) :
1.00
Distance to screen (m) :
0.32
FOVy (deg) :
114.25
Set field of view
Look at (deg) :
ICRF
AltAz
AZ :
ALT :
Look at
Stars' size :
ICRF
AltAz
Horizon
About
STELLARIS
Stellaris - Star simulator
Version 1.0
Contact : Mustapha.Meftah@latmos.ipsl.fr
Java Update

Uvsq-Sat NG

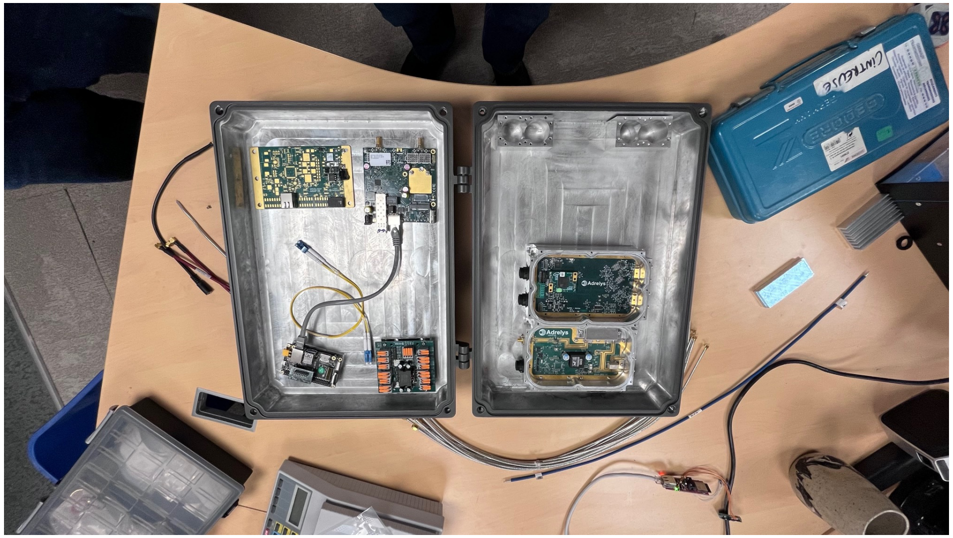
❑ (5) MOC

Uvsq-Sat NG


Sarah


Lower mast enclosure
Upper mast enclosure
Safety disconnector
Media Converter
Power converter
LAN (fiber copper)
Power
Fiber
48V DC
WAN (4/5G) (optional)
Firewall
Power management
Computing +GPU
Motion control
Digitizing
RF front-end
Digitizing
RF front-end
Antennas
Multiband Yagi or parabolic depending frequency
GSR390 Rotator

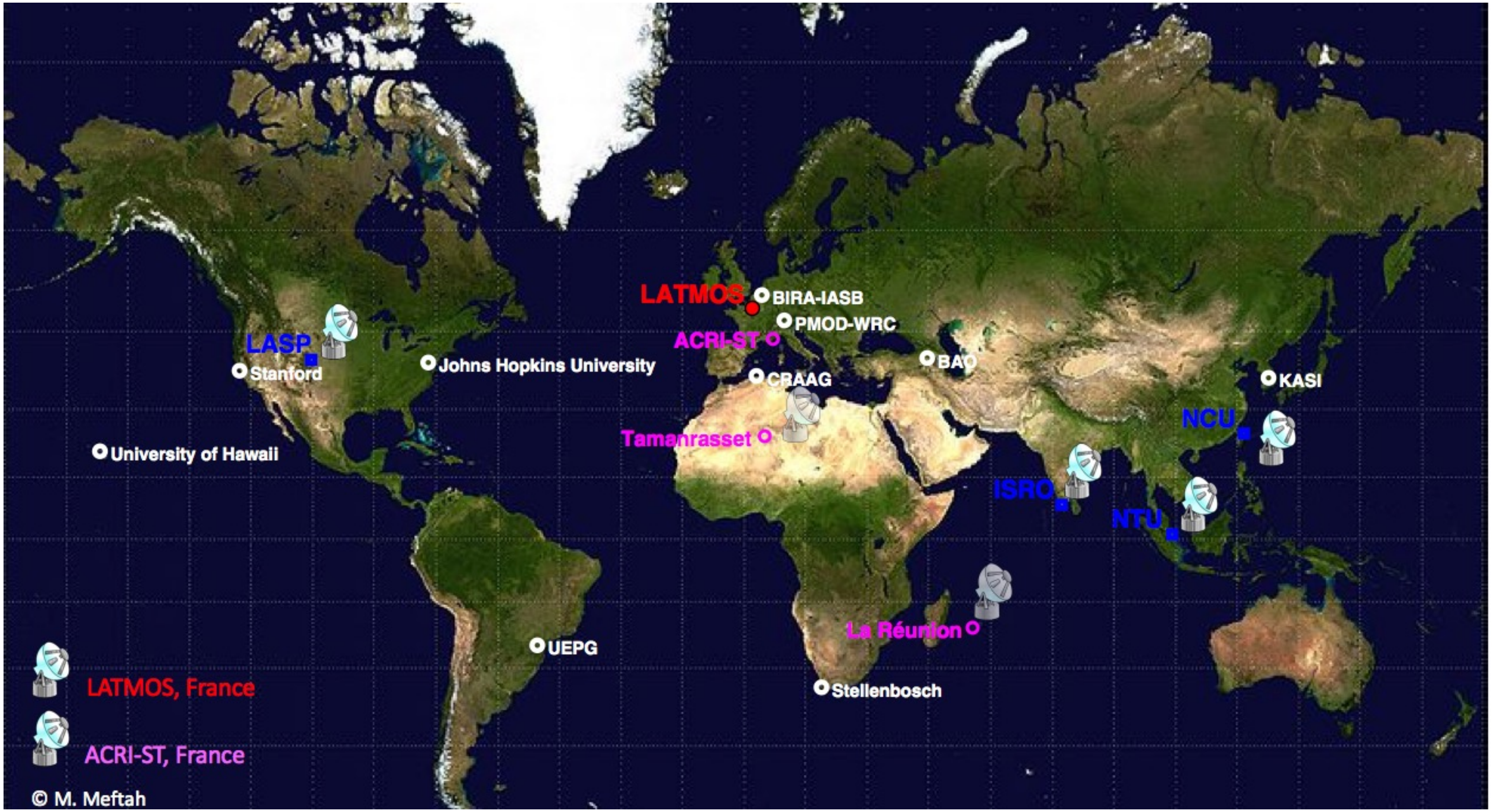
Uvsq-Sat NG



Uvsq-Sat NG

Uvsq-Sat NG

Uvsq-Sat NG


LATMOS
BIRA-IASB
PMOD-WRC
ACRI-ST
LASP
Stanford
Johns Hopkins University
CRAAG
BAO
KASI
NCU
Tamanrasset
University of Hawaii
ISRO
NTU
La Réunion
UEPG
Stellenbosch
LATMOS, France
ACRI-ST, France
© M. Meftah

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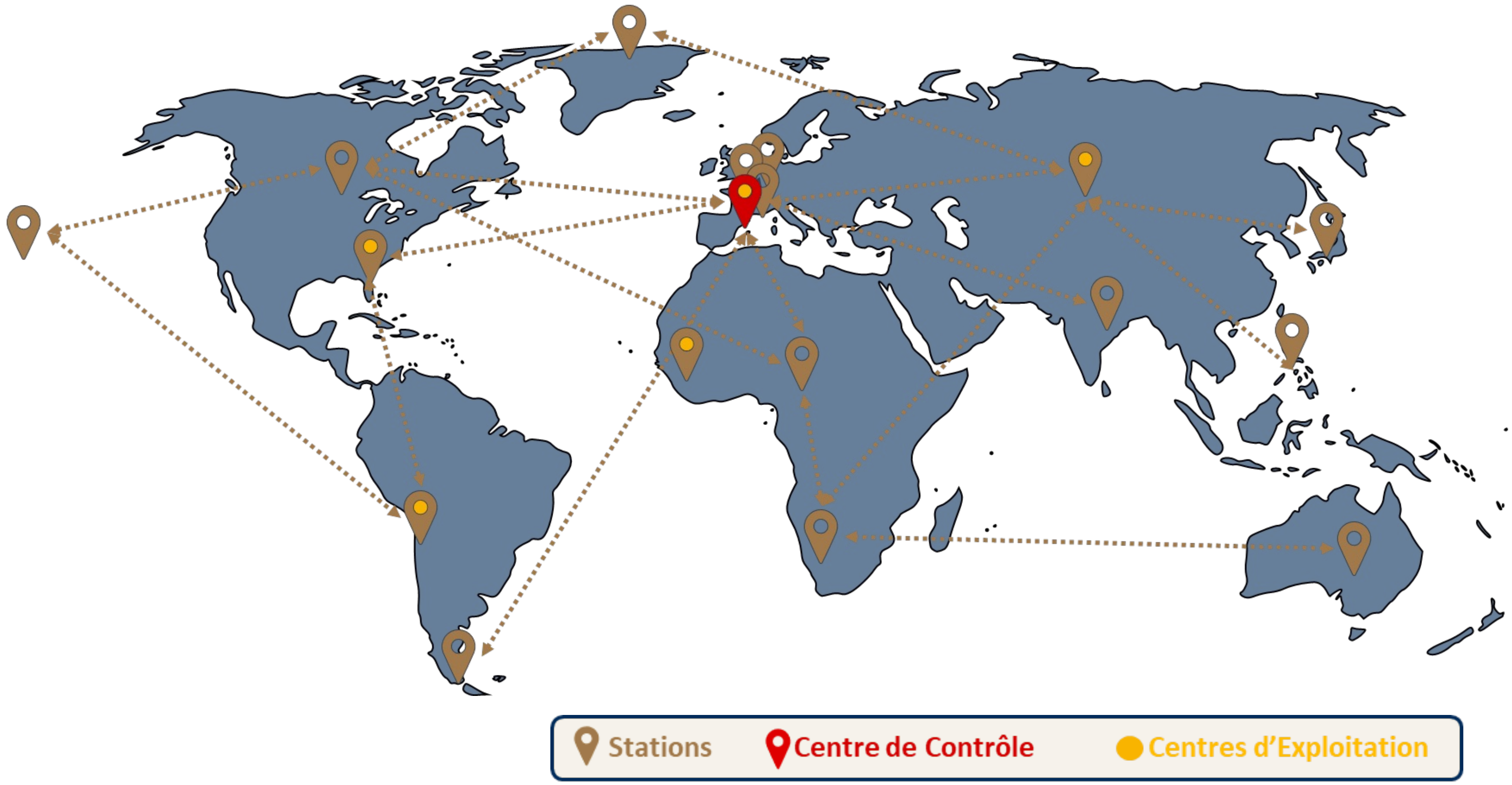


AstraLink Network - 2026

Uvsq-Sat NG

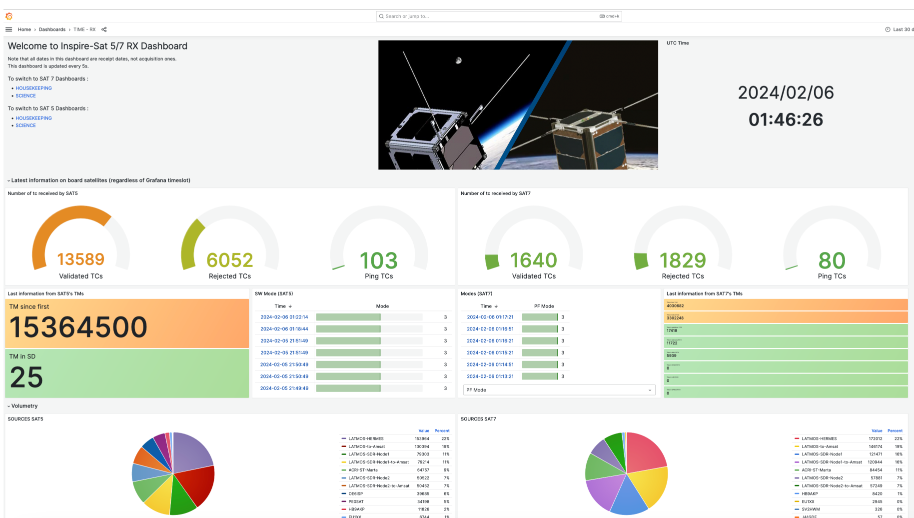
❑ (6) SOC

Database management system & compute server

- ✓ Intel Xeon Silver 4208 - 8C/16T
- ✓ 64GB RAM
- ✓ 2x1TB HDD + 2x1TB SSD RAID

Simulation and development

- ✓ 2xIntel Xeon Gold 5220R - 24C/48T => 48C/96T
- ✓ 128GB RAM
- ✓ 2TB SSD + 2xDTB HDD RAID
- ✓ Bi GPU: 2xNvidia RTX A5000



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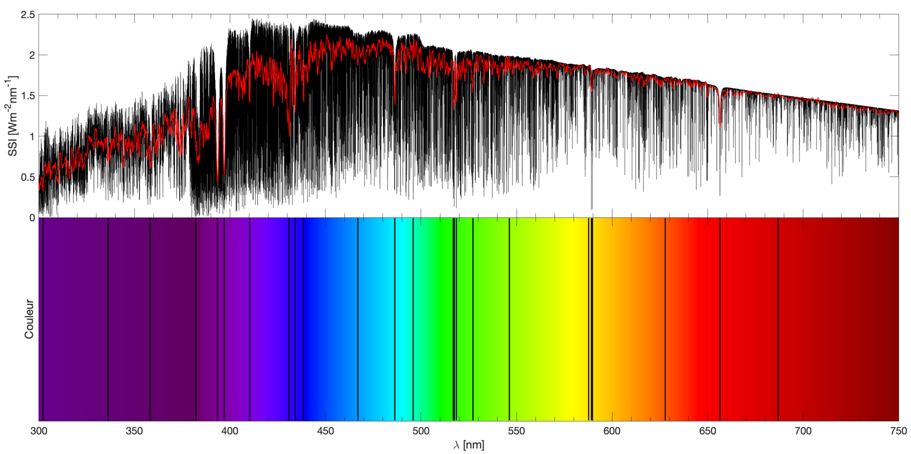
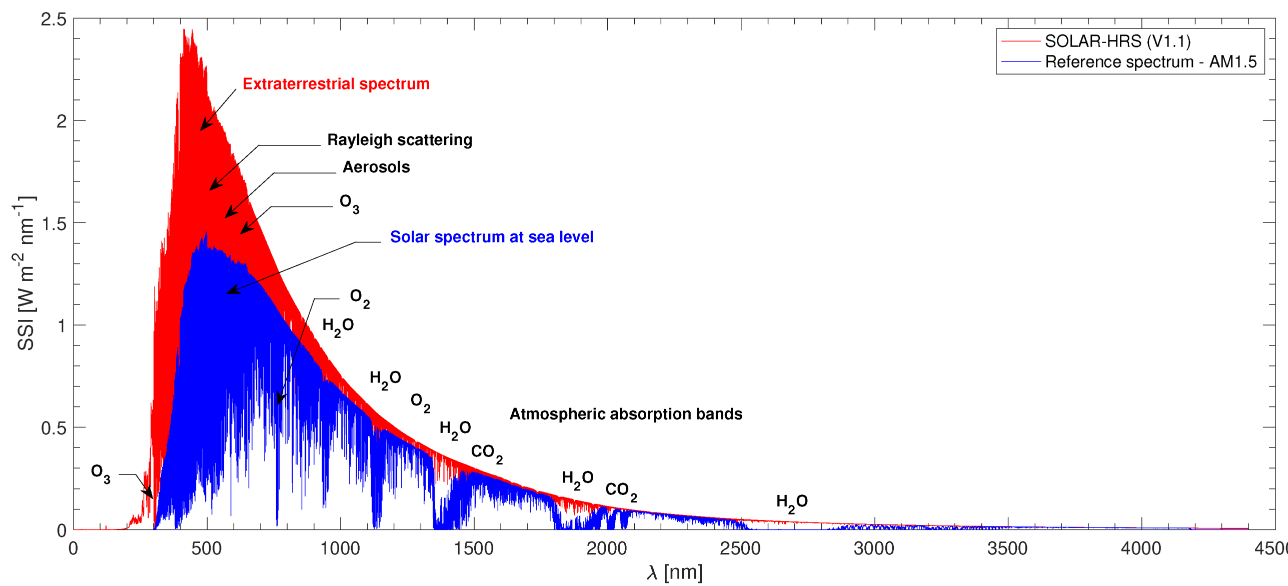
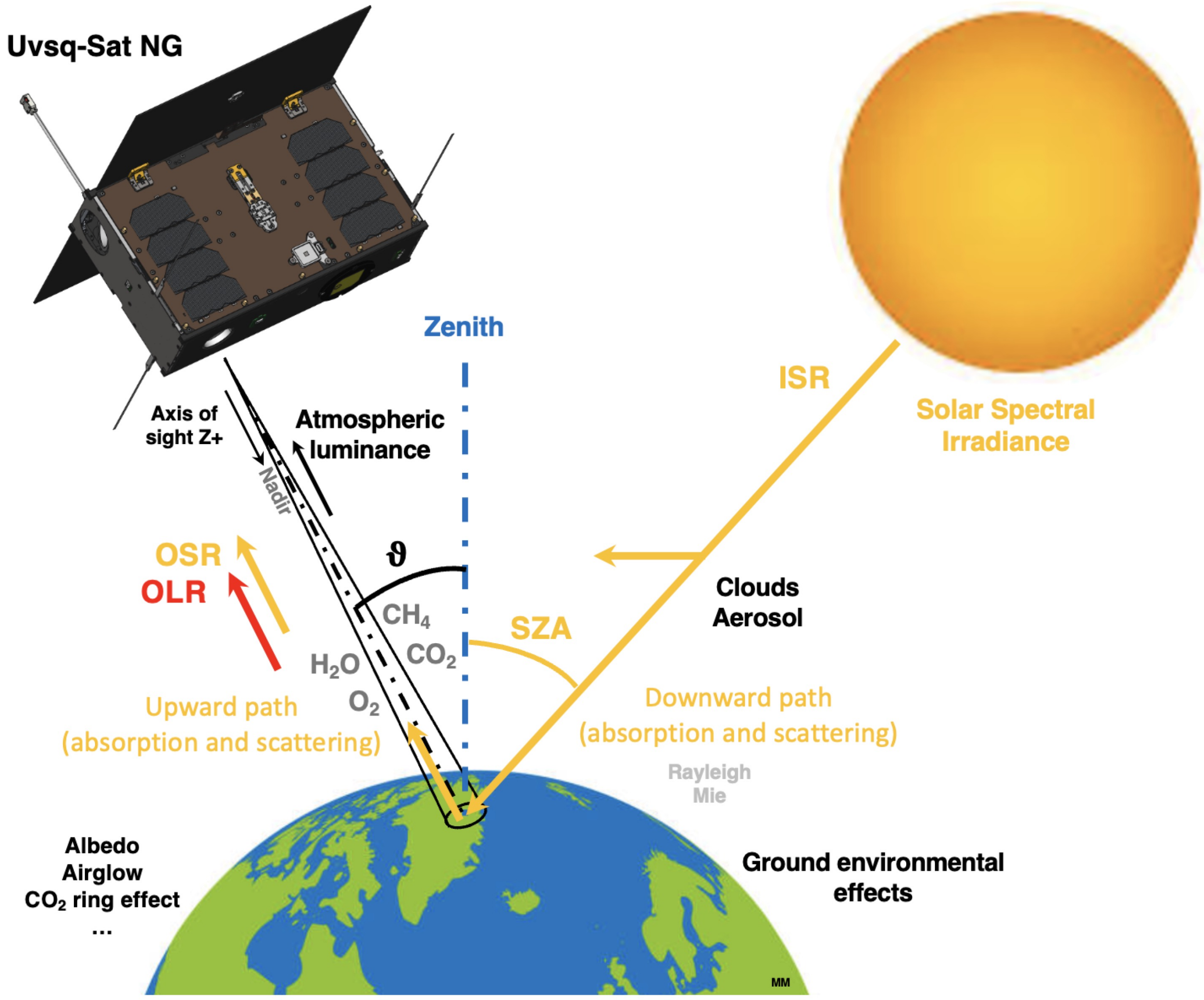
❑ Science



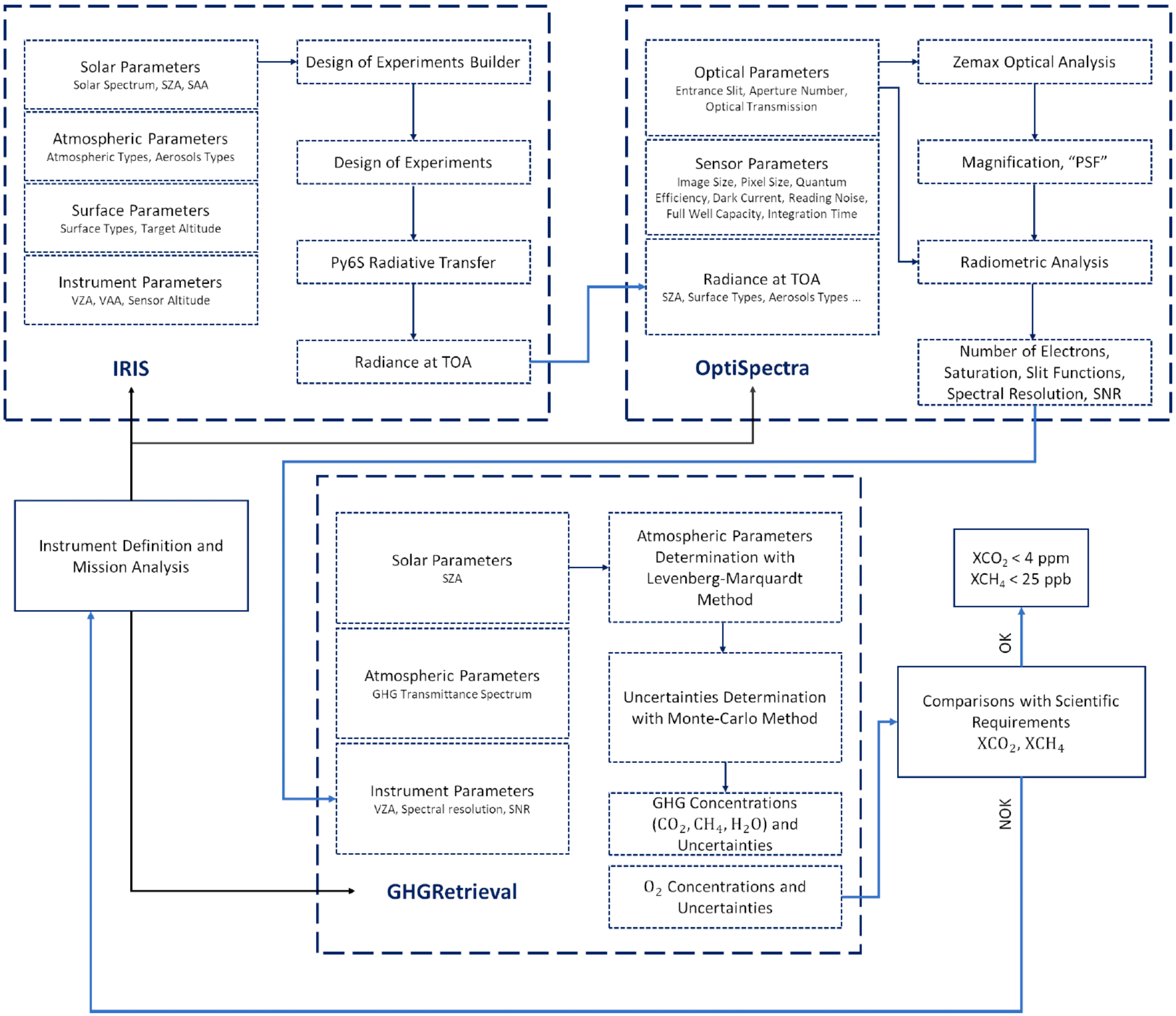
Data set name	Data type	Wavelength coverage	Spectral resolution	Sampling
SOLAR-HRS Disk-integrated spectrum	Composite Solar spectral irradiance	0.5 – 4399.1 nm	SOLAR-ISS (< 300 nm): < 1.0 nm QASUMEFTS (300 – 380 nm): < 0.025 nm SPTS (> 380 nm): <0.01 nm	< 0.02 nm
SOLAR-HRS Disk-center (μ= 1.0)	Composite Solar spectral irradiance	650.0 – 4399.1 nm	SPTS: < 0.01 nm	< 0.02 nm
SOLAR-HRS Intermediate cases Solar positions μ= 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0.05	Composite Solar spectral irradiance	650.0 – 4399.1 nm	SPTS: < 0.01 nm	< 0.02 nm
SOLAR-HRS AM1.5 Disk-Integrated Spectrum	Composite Solar spectral irradiance	0.5 – 4399.1 nm	SOLAR-ISS (< 300 nm): < 0.1 nm QASUMEFTS (300 – 380 nm): < 0.025 nm SPTS (> 380 nm): <0.01 nm	< 0.02 nm
SOLAR-HRS AM1.5 (air) Disk-Integrated Spectrum	Composite Solar spectral irradiance	0.5 – 4399.1 nm	SOLAR-ISS (< 300 nm): < 0.1 nm QASUMEFTS (300 – 380 nm): < 0.025 nm SPTS (> 380 nm): <0.01 nm	< 0.02 nm
MPS-ATLAS-Kurucz Disk-Integrated Spectrum	Solar Model	250.0 – 5000.0 nm	< 0.01 nm	< 0.01 nm
MPS-ATLAS-Kurucz Disk-center (μ = 1.0)	Solar Model	250.0 – 5000.0 nm	< 0.01 nm	< 0.01 nm
MPS-ATLAS-Vald3 Disk-Integrated Spectrum	Solar Model	250.0 – 5000.0 nm	< 0.01 nm	< 0.01 nm
MPS-ATLAS-Vald3 Disk-center (μ = 1.0)	Solar Model	250.0 – 5000.0 nm	< 0.01 nm	< 0.01 nm



Uvsq-Sat NG


Uvsq-Sat NG
Zenith
ISR
Solar Spectral Irradiance
Axis of sight Z+
Nadir
Atmospheric luminance
ϑ
OSR
OLR
CH_4
CO_2
H_2O
O_2
SZA
Clouds
Aerosol
Upward path
(absorption and scattering)
Downward path
(absorption and scattering)
Rayleigh
Mie
Albedo
Airglow
CO_2 ring effect
...
Ground environmental effects
MM

Uvsq-Sat NG


Solar Parameters
Solar Spectrum, SZA, SAA
Atmospheric Parameters
Atmospheric Types, Aerosols Types
Surface Parameters
Surface Types, Target Altitude
Instrument Parameters
VZA, VAA, Sensor Altitude
Design of Experiments Builder
Design of Experiments
Py6S Radiative Transfer
Radiance at TOA
IRIS
Optical Parameters
Entrance Slit, Aperture Number, Optical Transmission
Sensor Parameters
Image Size, Pixel Size, Quantum Efficiency, Dark Current, Reading Noise, Full Well Capacity, Integration Time
Radiance at TOA
SZA, Surface Types, Aerosols Types ...
Zemax Optical Analysis
Magnification, "PSF"
Radiometric Analysis
Number of Electrons, Saturation, Slit Functions, Spectral Resolution, SNR
OptiSpectra
Instrument Definition and Mission Analysis
Solar Parameters
SZA
Atmospheric Parameters
GHG Transmittance Spectrum
Instrument Parameters
VZA, Spectral resolution, SNR
Atmospheric Parameters Determination with Levenberg-Marquardt Method
Uncertainties Determination with Monte-Carlo Method
GHG Concentrations (CO_2, CH_4, H_2O) and Uncertainties
O_2 Concentrations and Uncertainties
GHGRetrieval
XCO_2 < 4 ppm
XCH_4 < 25 ppb
OK
Comparisons with Scientific Requirements
XCO_2, XCH_4
NOK

Uvsq-Sat NG

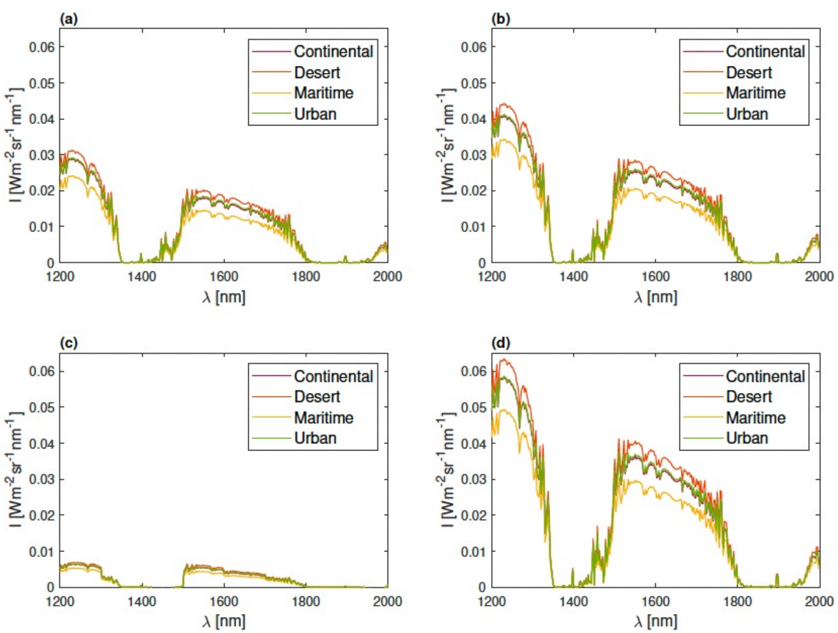
'Surface' / 'Aerosols'	Pine forest (a)	Deciduous forest (b)	Ocean (c)	Homogeneous snow (d)
Continental	X	X	X	X
Desert	X	X	X	X
Maritime	X	X	X	X
Urban	X	X	X	X

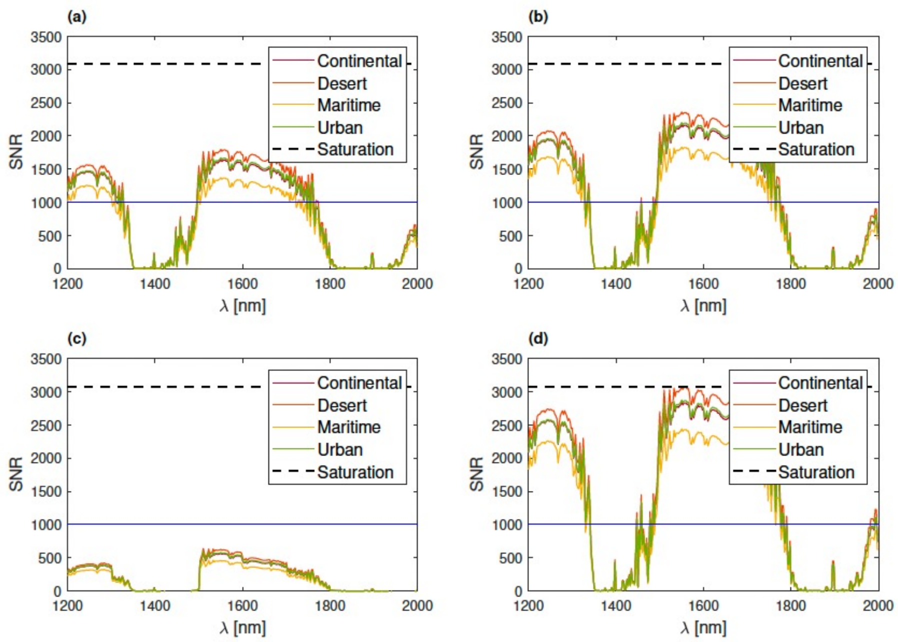
16 scenarios studied for different 'Aerosols' types and targeted 'Surface' – SZA of 20°

'Aerosols' / 'SZA'	Continental (a)	Desert (b)	Maritime (c)	Urban (d)
0°	X	X	X	X
20°	X	X	X	X
50°	X	X	X	X
70°	X	X	X	X

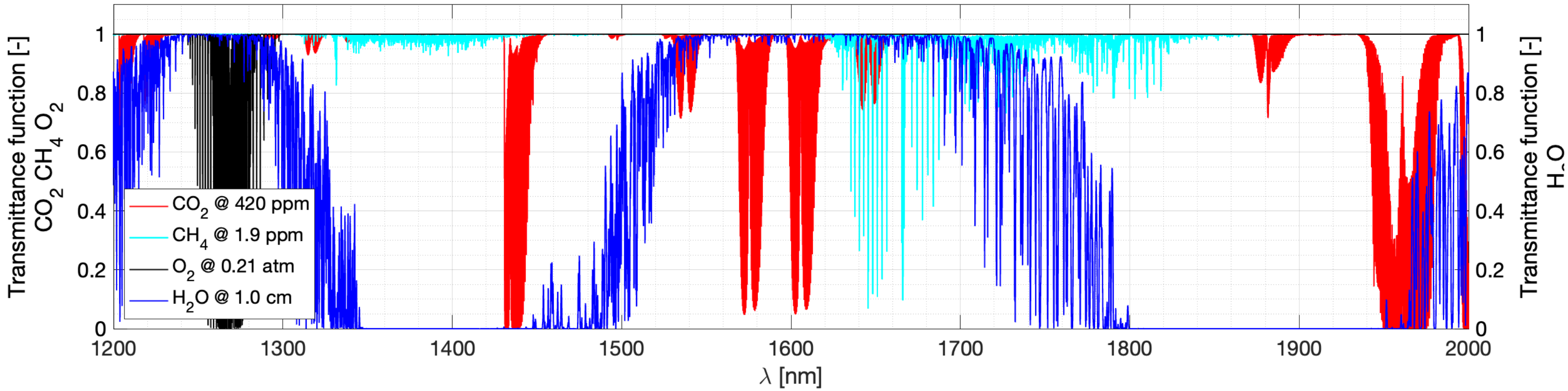
16 scenarios studied for different SZA and 'Aerosols' types – Pine forest targeted 'Surface'

Uvsq-Sat NG

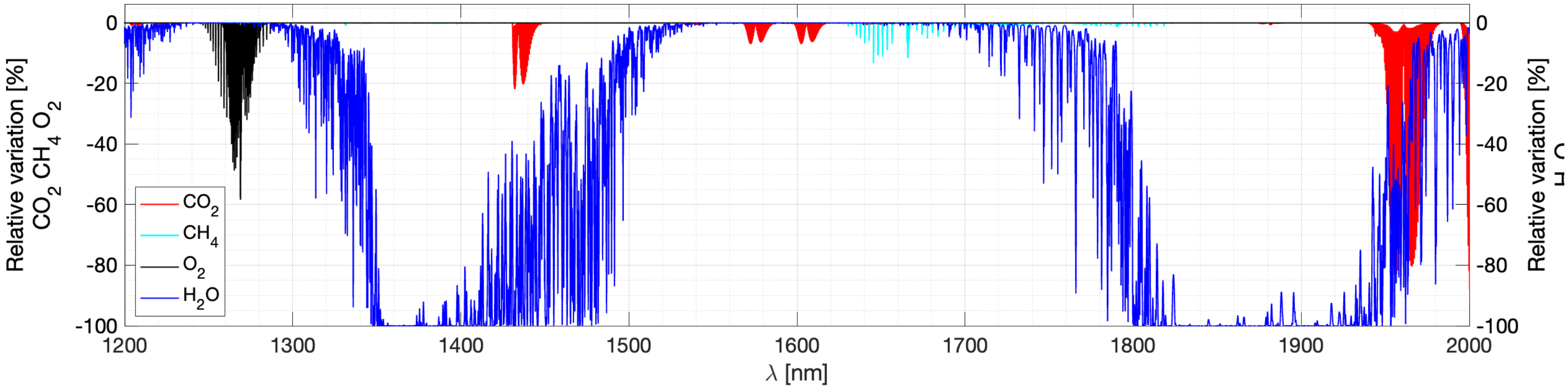

(a)
(b)
(c)
(d)
Continental
Desert
Maritime
Urban
I [Wm^{-2}sr^{-1}nm^{-1}]
λ [nm]
0
0.01
0.02
0.03
0.04
0.05
0.06
1200
1400
1600
1800
2000


(a)
(b)
(c)
(d)
Continental
Desert
Maritime
Urban
Saturation
SNR
λ [nm]
0
500
1000
1500
2000
2500
3000
3500
1200
1400
1600
1800
2000

Uvsq-Sat NG

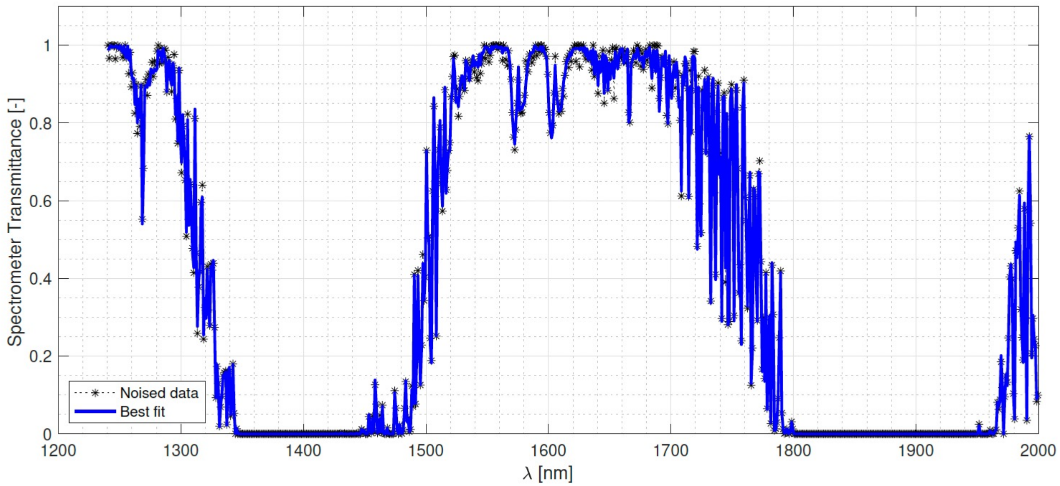


Transmittance function [-]
CO2 CH4 O2
Transmittance function [-]
H2O
CO2 @ 420 ppm
CH4 @ 1.9 ppm
O2 @ 0.21 atm
H2O @ 1.0 cm
λ [nm]



Relative variation [%]
CO2 CH4 O2
Relative variation [%]
H2O
CO2
CH4
O2
H2O
λ [nm]

Uvsq-Sat NG

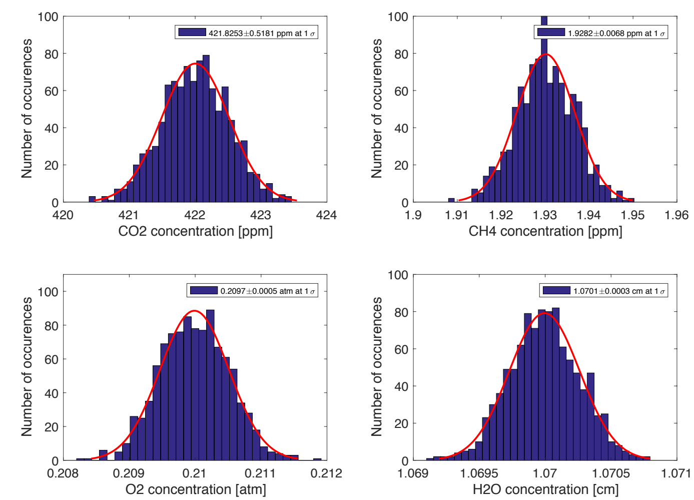


The Levenberg-Marquardt algorithm is used to fit a model that relates the observed dimensionless transmittance functions to the concentrations of the atmospheric gases.

The Monte Carlo method is used to perform multiple simulations with randomized inputs within specified uncertainty bounds. This helps to estimate the range of gases concentrations (CO_2, CH4, O_2, H_2O) and their associated uncertainties.

Table 5. Uncertainties of atmospheric gas concentrations (1–Sigma) for various data retrievals based on different instrumental characteristics.

Resolution: 1 nm						
SNR	50	100	250	500	1,000	2,000
CO_2 [ppm]	10.998	5.602	2.204	1.130	0.575	0.277
CH_4 [ppb]	125.028	66.209	25.245	12.302	6.625	3.108
O_2 [Ratio]	11.024E-3	5.921E-3	2.433E-3	1.165E-3	0.636E-3	0.299E-3
H_2O [cm]	4.746E-3	2.271E-3	0.877E-3	0.441E-3	0.207E-3	0.114E-3
Resolution: 6 nm						
SNR	50	100	250	500	1,000	2,000
CO_2 [ppm]	33.974	16.720	6.426	3.154	1.674	0.808
CH_4 [ppb]	431.491	198.877	88.926	40.973	21.593	11.317
O_2 [Ratio]	33.139E-3	16.209E-3	5.657E-3	3.169E-3	1.588E-3	0.850E-3
H_2O [cm]	12.474E-3	5.933E-3	2.518E-3	1.236E-3	0.609E-3	0.284E-3



Uvsq-Sat NG

Uvsq-Sat NG instrument spectral resolution: 1 nm				
Surface / Aerosols	Pine forest (a)	Deciduous forest (b)	Ocean (c)	Homogeneous snow (d)
Continental	0.5 ppm	0.4 ppm	77.6 ppm	0.3 ppm
Desert	0.5 ppm	0.3 ppm	82.8 ppm	0.3 ppm
Maritime	0.6 ppm	0.4 ppm	81.4 ppm	0.3 ppm
Urban	0.5 ppm	0.4 ppm	78.4 ppm	0.3 ppm
Uvsq-Sat NG instrument spectral resolution: 5 nm				
Surface / Aerosols	Pine forest (a)	Deciduous forest (b)	Ocean (c)	Homogeneous snow (d)
Continental	1.3 ppm	0.9 ppm	234.5 ppm	0.7 ppm
Desert	1.7 ppm	0.8 ppm	225.8 ppm	0.6 ppm
Maritime	1.4 ppm	1.1 ppm	228.6 ppm	0.8 ppm
Urban	1.3 ppm	0.9 ppm	233.2 ppm	0.7 ppm

CO_2 uncertainties (at 1σ) determination according to the various simulation cases (requirements: 1 ppm).

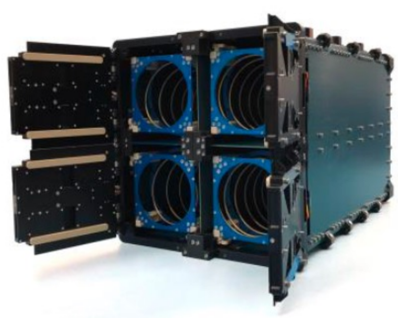
Uvsq-Sat NG instrument spectral resolution: 1 nm				
Surface / Aerosols	Pine forest (a)	Deciduous forest (b)	Ocean (c)	Homogeneous snow (d)
Continental	4.9 ppb	3.7 ppb	194.1 ppb	2.5 ppb
Desert	4.4 ppb	3.2 ppb	184.8 ppb	2.4 ppb
Maritime	5.8 ppb	4.2 ppb	202.2 ppb	3.2 ppb
Urban	4.7 ppb	3.4 ppb	193.4 ppb	2.8 ppb
Uvsq-Sat NG instrument spectral resolution: 5 nm				
Surface / Aerosols	Pine forest (a)	Deciduous forest (b)	Ocean (c)	Homogeneous snow (d)
Continental	12.2 ppb	10.2 ppb	735.6 ppb	7.8 ppb
Desert	10.5 ppb	8.5 ppb	710.8 ppb	7.0 ppb
Maritime	15.5 ppb	12.7 ppb	763.2 ppb	8.8 ppb
Urban	12.2 ppb	10.3 ppb	730.5 ppb	7.1 ppb

CH_4 uncertainties (at 1σ) determination according to the various simulation cases (requirements: 10 ppb).

Uvsq-Sat NG

❑ Launch

	Launch option
Launch vehicle:	Falcon 9 T13
Launch site:	CCSFS/ Vandenberg
Launch period:	From Feb 2025
Typical orbit parameters:	550 +/- 35 km SSO LTDN: 10:30 TBC



Conclusions

- Project in progress

- Frequencies – 2208 MHz, 149.02 MHz, 401.85 MHz

B1a Beam designation	B2 Emi-Rcp	BR8 Action code	BR7a Group id.	BR9 Action code	BR47 Frequency band (MHz)			BR62 Expiry date for bringing into use	C4a Class of station
UL148MHZ	R		3		148	-	150,05	27.10.2027	ED, EK
DL2GHZ	E		1		2207,2	-	2208,8	27.10.2027	EK, ER
DL401MHZ	E		2		401,7	-	402	27.10.2027	EK, ER

- Launch scheduled for February 2025 with Transporter 13

- Proposal to integrate a ready-to-use amateur radio payload

- Between 2019 and 2023, we supervised a multitude of students from various backgrounds (undergraduate, master's, and engineering schools): Patrick Lacroix, Juliette Antoun, Christophe Arnoult, Nicolas Vagnair, Josué Ngouma, Ivan Noukeu, Florian Lefevre, Minh Nguyen, Faustine Bouyssou, Vanessa Yahiaoui, Rania Makki, Gayane Karapetyan, Nicolas Duval d'Epremesnil, Fred Bocage, Hiro Classe, Cannelle Clavier, Loïc Njamen, Zinelabidine Loussaief, Pierre Vidal, Mathis Buet-Elfassy, Mickaël Galopeau, Paul Galey, Angèle Minet, Eleanore Fringian-Rupert, Louis Dechaseaux, Maiwenn Deniaud, Angsaran kenzhegaraeva, Eloi Baville, Maxime Huvelin, Gabriel Sousa Tavares, Kenny Ngo, Samuel Lhermitte, Aloïs Meckenstock, Hugo Jonnery, Hugo Teixeira, Anaïs Beckert, Oriane Rivier, Anthony Kalaydjian, Lyna Astito, ...

Conclusions

Merci pour votre attention …