ST3LLARsat1 BOIRA: The first CubeSat at UC3M

Presentation based on ST3LLARsat1 team presentation at ESA FYS! Design Booster FDR, 7th June 2024

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ST3LLARsat1 BOIRA – Our Mission

1st student CubeSat program at UC3M

Start Date: September 2022 (expected launch 2026-27)

Required Skills: Multidisciplinary (aero, telecom, signals, SW, HW …)

Director: UC3M / Aero – Dr. Andrés Marcos

First mission: **ST3LLARsat1 "BOIRA"**

"Boira" means fog in two of Spain's official languages: Galician & Catalonian

ST3LLARsat1 BOIRA: Project Goals

EDUCATIONAL

1st **UC3M** CubeSat student programme

To provide students with **hands-on experience in a real space project**

SCIENTIFIC

Aim is to **design, build, launch and operate a 2U CubeSat**

to monitor climate change by measuring local atmospheric moisture

TECHNOLOGICAL

IOD of

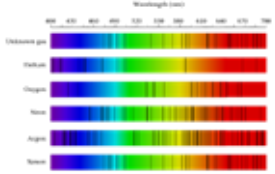
1. **All the operating equipment** (except payload) fitting in about **1U**
2. **A weather-observing scientific instrument** fitting in about **1U**
3. An in-house **state-of-art compact communication antenna**
4. An in-house OBC software for **advanced AOCS/ADCS algorithms**

ST3LLARsat1 2U structure & internal config

@ BDR (March'23) @ FDR (Feb'24) @ Jun'25



ST3LLARsat1 science: measure water vapor (WV)

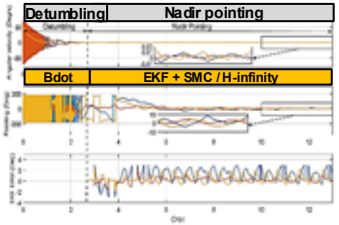


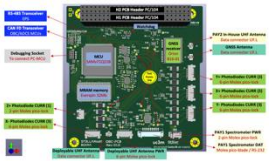


ST3LLARsat1 in-house technologies:

Compact antenna Advanced ADCS OBC & ADCS PBCs

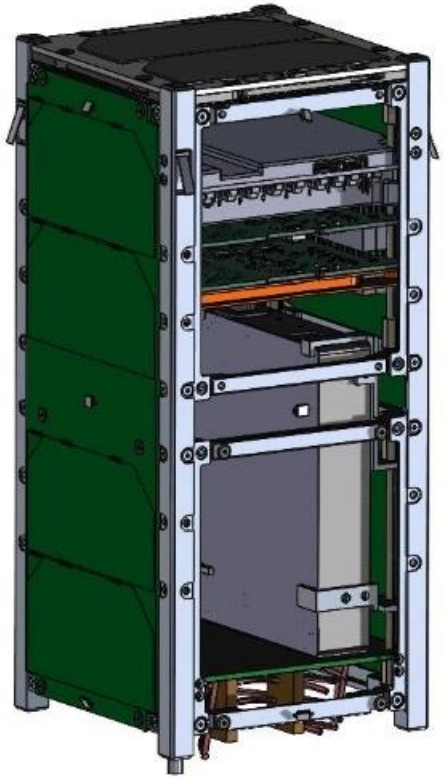






ST3LLARsat1 BOIRA – 2U CubeSat Configuration

ST3LLARsat1: 2U configuration



Mass (Kg) w/ 20% margin	2.083

Structure: 2U SpaceMind SM-02 *

Solar cells (16): 1x SpaceMind-SP1X *
3x SpaceMind-SP2X *
1x Endurosat-SP1Z (part of Deply.Ant) *

Deployable UHF antenna: Endurosat 1U *

PCDU+Battery: Endurosat EPS-1 *

OBC-PCB: MCU SAMV71Q21B-AAB

- **GNSS Antenna**: Molex 206640-0001
- **GNSS Receiver**: Skytraq Orion B16C1 *
- **RF transceiver**: Semtech SX1276 *
- **Coarse Sun Sensor**: 13x OSRAM SFH 2401 *

ADCS-PCB: same MCU as OBC-PCB

- **3-axis gyro**: MEMS ADIS 16500 (never flown)
- **Magnetometer**: PNI RM3100 *
- **Magnetorquers**: 2x CubeSpace rods CR0002 *
  1x CubeSpace Coil *

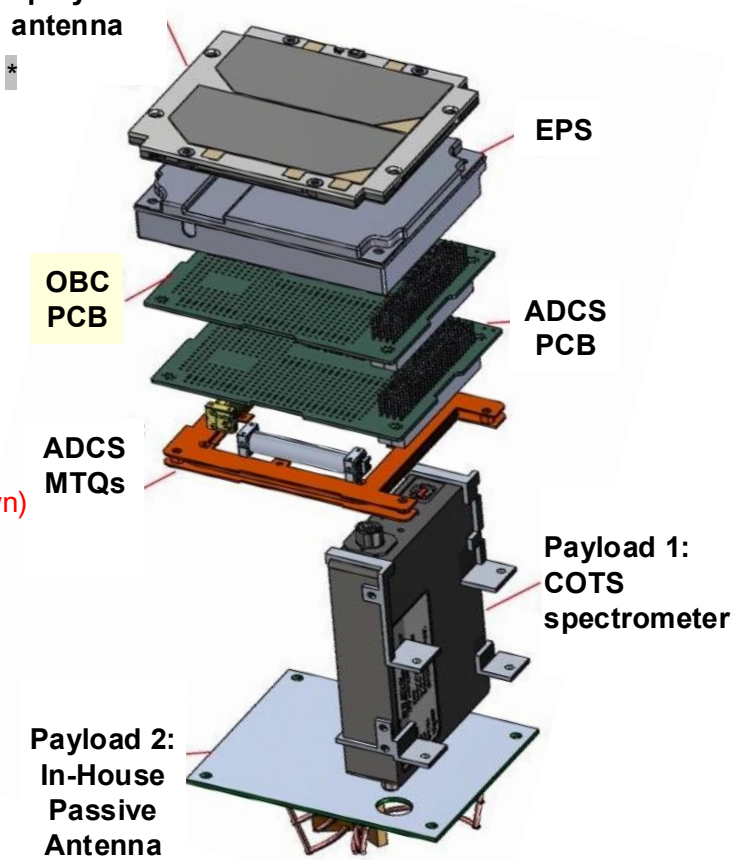
Payload1: Avantes AvaSpec-Nexos Spectrometer *

Payload2: **In-House** non-deployable UHF antenna

OBSW: freeRTOS / C & C++

In-House	Procured	In-process	* Flight-heritage

ST3LLARsat1: Internal configuration



ST3LLARsat1 Obj1: Education – Formal program

https://www.uc3m.es/master/space-engineering

UC3M's Student CubeSat programme

is structured around its 1.5-years / 90 ECTS

Master in Space Engineering (MISE)

1 of only 5 (out of 192) masters in Madrid region accredited with 2 A's
1 of only 2 with an A in "Learning Results"

1st year

* Core classes in space engineering
* **[C] Space Pre-Design (SPD) Team Course**
  Feasibility study of a Cube/Nano-sat mission

2nd year

* Optional classes & industry internships
* **[C] Master Thesis (TFM):** Advanced developments
* **[O] Integral Project (IP) Team Course:** Consolidation

UC3M ST3LLARsat1 "BOIRA"

Dec'22: Selected by ESA for pilot FYS! DB
1st CubeSat from a University in Madrid!!

***Sept'22**: Official start of the 1st UC3M student CubeSat program*

***Oct'22**: Submitted mission feasibility study proposal to **ESA's FYS Design Booster** program*

***Dec'22**: **Selected by ESA for its FYS-DB program** (only 5 out of 12 EU university teams)*

Jan'23-Jun'23**: **Baseline Design Review (BDR)** **Jun'23-Jun'24**: **Final Design Review (FDR)

Phase 1:	[Sept'22 – Jun'23]	**Feasibility** & ESA-FYS-DB **BDR**
Phase 2:	[Sept'23 – Jun'24]	ESA-FYS-DB **FDR**
Phase 3-A/B:	[Sept'24 – Jun'25 / Jun'25 – Jun'26]	**Consolidation** & Prelim-AIVT activities
Phase 4:	[Sept'26 – Jun'27]	**AIVT activities (STM vibration & TVAC)**
Phase 5:	[Sept'27 – Dec'28]	End of AIVT activities & launch preparation

Nov'26: Selected by ESA / EU-Horizon for launch opportunity
In IOD "Ready-to-Fly" program

ST3LLARsat1 Obj1: Education – A truly student-centered CubeSat

STRONG STUDENT INVOLVEMENT

Over 190+ students in 5 years!!!

completed (20): 7 TFGs + 13 TFMs **Dissemination(25)**: 6 oral presentations

ongoing (1): # TFGs + 1 TFMs 14 posters + 5 articles

Continuous knowledge hand-over due to strong participation of 1st yr MISE volunteers in each phase

Phase 1 [Sept'22 – Jun'23]: **2** professors + **26** grad-students + **30** 1st year MISE SPD

Phase 2 [Sept'23 – Jun'24]: **4** professors + **36** grad-students + **3** undergrad + **34** 1st year MISE SPD

Phase 3-A [Sept'24 – Jun'25]: **5** professors + **28** grad-students

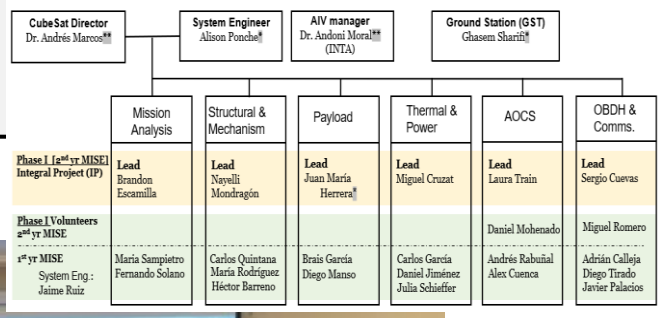
Phase 3-B [Sept'25 – Jun'26]: **6** professors + **19** grad-students + **3** undergrad

Phase 4 [Sept'26 – Jun'27]: **6** professors + **21** grad-students (as of Oct'2026)

ESA Training opportunities:

- Processes & docs & RIDs
- Sites' visits
- On-site training

38+ students / 1100+ training hours









ST3LLARsat1 Obj1: Education – MGT & training

Overview of activities within ESA FYS-DB program

2022 | 2023 | 2024

Training opportunities:
* Conference participation
* Public speaking
* Networking
* Team leadership abilities
* Documentation
* Engineering trade-offs

Sept'22

1 oral presentation — Feb 21-23 SSSIF Forum

1 article — Jul 3-5 EDULEARN conference

1 oral pres. 2 posters — Dec 11-13 European CubeSat Symposium

1 oral pres. 4 posters — Feb 20-22 SSSIF Forum

1 oral pres. 1 poster — May 27-31 4S symposium

BOIRA Phase-I BDR — IPMs every 2 weeks

Concurrent Design Session — Feb 26

BOIRA Phase-II FDR — Summer (no IPMs)

BOIRA Phase-II FDR — IPMs every 2 weeks

ITU/API meeting — Dec 15

BOIRA Phase-III AIV

Nov 7-11 FYS-DB training week — A. Ponche, J.M. Herrera, S. Cuevas, B. Escamilla, A. Rabuñal, B. García, M. Sampietro

Dec 6-7 FYS-DB Selection workshop

Jan 17 FYS-DB Kick-off

Jan 24 ESA PAY expert meeting

Feb 16 ESA PM01

Mar 2 ESA PM02

Apr 4-24 BDR collocation videoconfs

May 8-12 ESA Training Space-Weather — A. Rabuñal

May 16 ESA PM03

Jun 1 ESA PM04

Jun 5-9 ESA Training AIV — C. García

Jul 19 ESA PM05

Aug 10 ESA PM06

Sep 4-8 ESA Training Space Debris — J. Ruiz, D. Tirado

Sep 21 ESA PM07

Oct 19 ESA PM08

Nov 24 ESA PM09

Nov 28-Dec 1 ESA Training Sat-Comms — V. Cegarra, A. Ruiz

Nov 29 PAY expert meeting

Dec 19 ESA PM10

Jan 11 ESA PM11

Jan 18 ESA SW expert meeting

Jan 23-26 ESA Training Tech-Trnsfr — L. Lobera

Feb 5-9 ESA Training Space Law — L. Pérez

Feb 8 ESA PM12

Feb 29 ESA PM13

Apr 8-12 FDR collocation Meeting — F. Solano, D. Jiménez, A. Hernández, E. Flores, M. Sarahi, J. Palacios, A. Infante, F. Ezzahra

Oct 2 FYS-DB proposal

Nov 23 FYS-DB updated proposal

Mar 12 BDR submission

Jun 7 EMC webinar

Oct 4 ITU webinar

Nov 2 IARU webinar

Dec 6 SDM webinar

Jan 21 FYS!4 proposal

Mar 10 FDR submission

May 22 FDR final presentation

Training opportunities during ESA-FYS DB:
* ESA processes & documentation & RIDs
* ESA sites' visits
* ESA in-site training (**30 students ~ 900+ hrs**)

ST3LLARsat1 Obj1/2/3: Develop a first 2U CubeSat

From beginning to FDR: Mission Analysis evolution

Always analyze the desire orbit … and many more ➔ ranges!!

MiSE

2022 — 2023 — 2024

- Oct 2 — **FYS-DB proposal**
- Nov 23 — **FYS-DB updated proposal**
- Mar 12 — **BDR submission**
- Oct 10 — **New ESA SDM Requirements**
- Dec 6 — **SDM webinar**
- Jan 21 — **FYS!4 proposal**
- Mar 10 — **FDR submission**
- Apr 8-12 — **FDR collocation meeting**
- Jun 7 — **FDR final presentation**

Sept'22

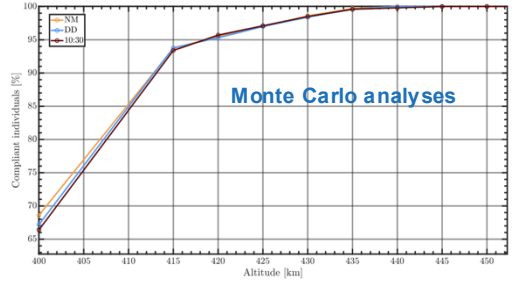
1st MA iteration

- **9 orbits** (300, 500, 600 km)
- **Preliminary analyses:**
  - Lifetime
  - Spain coverage
  - GS contact (3 GSs)
  - Spain daytime contact
  - Eclipses
- **25 years re-entry limitation**

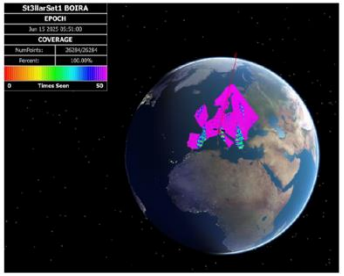
New ESA's Zero Debris Approach
5 years re-entry limitation

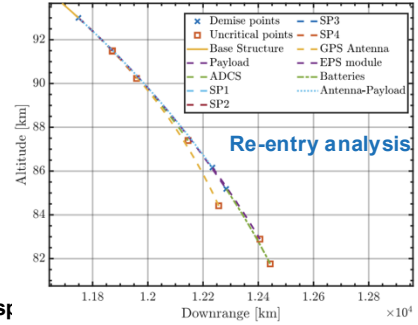
2nd MA iteration

- **8 orbits** (415 - 450 km)
- **5 years re-entry limitation**
- **Consolidated analyses:**
  - Lifetime (+Montecarlo)
  - Spain + Europe coverage
  - GS contact (+17 GSs)
  - Spain daytime contant
  - Eclipses
  - Radiation analysis
- **Updated ESA Zero Debris Approach**
- **+3 Space Debris Mitigation analyses:**
  - Collision risk + vulnerability to impacts
  - Safe re-entry & assessment of casualty risk



Europe coverage analysis





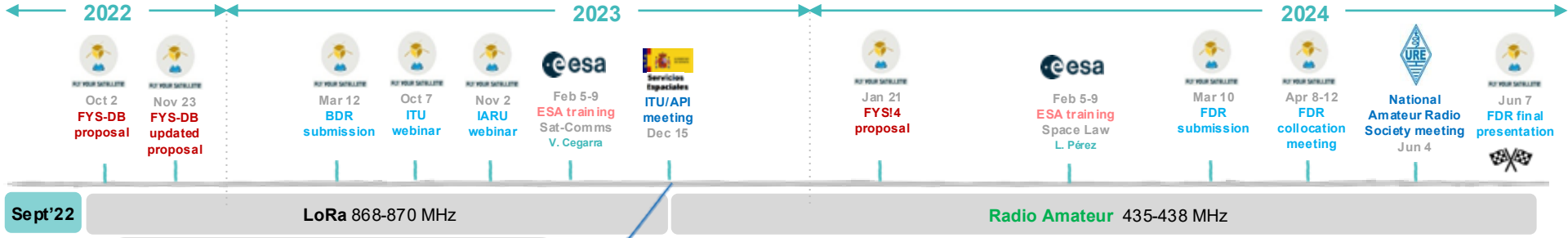
Parameter	Range
Altitude	350-600 km
Inclination	96-98 degrees
Orbit type	SSO
LTAN	NM, DD & 10:30

ST3LLARSat1's orbit ranges for analysis

ST3LLARsat1 Obj1/2/3: Develop a first 2U CubeSat

From beginning to FDR: Legal and TT&C evolution

Legal is important, do not forget to tackle it early



First contact with Spanish authorities

868-870 MHz band potential issues:

- 15k€ deposit for ITU-API process
- Landing rights at each country potentially needed

To avoid above issues, on-board antenna was redesigned to **amateur-satellite band**

Legal and regulatory compliance plan status



ITU

- Attended ITU webinar
- Review of applicable ITU Radio Regulations
- Request and Completion of Anticipated Publication Information (In process)
- Evaluated ITU BR software

BrSis SpaceCap GIMS

IARU

- Attended IARU webinar
- Contacted and met with Spanish National Amateur Radio Society
  - They mentioned **our mission might not be** considered as **amateur**.
  - Preliminary contact with IARU to confirm amateur-satellite compliance

TT&C status

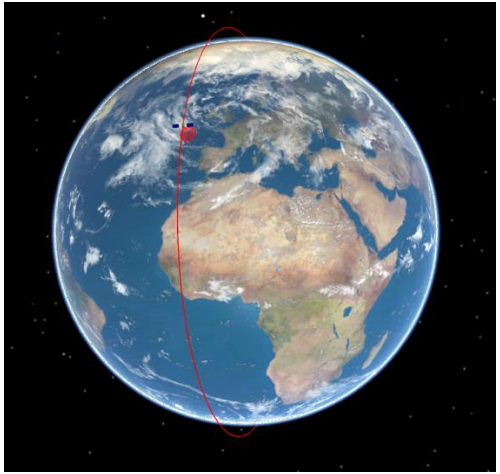
- GMSK modulation
- CCSDS Space Packet Protocol
- Coding techniques (Reed-Solomon and BCH)
- Positive link budget margins

Table 1. TT&C quick facts table

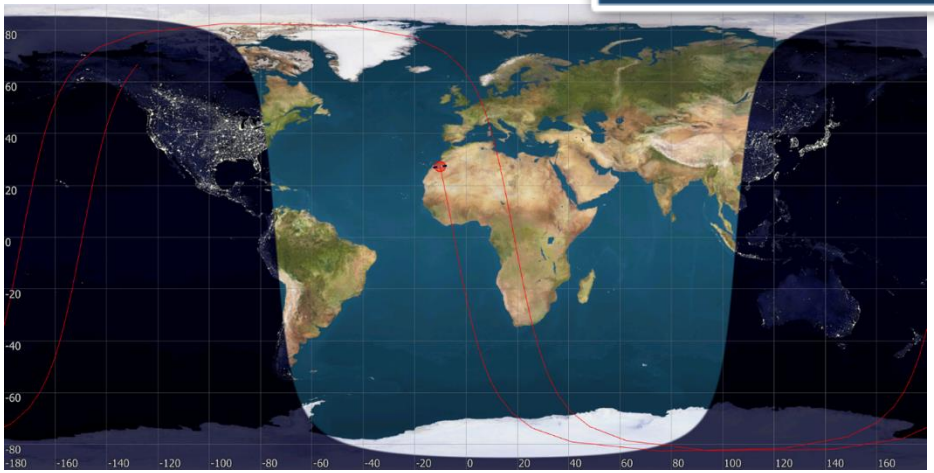
	Downlink	Uplink
Frequencies	435-438 MHz (UHF)	435-438 MHz (UHF)
Modulation	GMSK	GMSK
Coding	Reed-Solomon (255, 223) with I = 5	BCH
Frame format	ASM + CCSDS SPP + RS	CCSDS SPP (inside CLTU with BCH applied)
Bit-rate	2.4 kbps / 4.8 kbps	2.4 kbps / 4.8 kbps
RF bandwidth	25 kHz	25 kHz
BER	10-5	10-5
Signal power at LNA input	17 dBm (0.05W)	30 dBm (1W)
Link margin (nominal)	13.43 dB / 10.42 dB	6.99 dB / 3.08 dB

ST3LLARsat1 Obj2: Science – Measure Water Vapor

Make sure your science goal is feasible



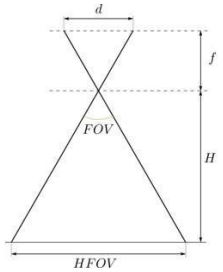
ST3LLARsat1's orbit @ FDR (SSO-450-10:30 case, J2000 frame)

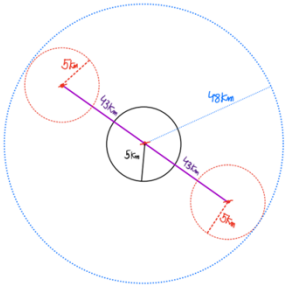


ST3LLARsat1 Ground Track @ FDR (SSO-450-10:30 case)

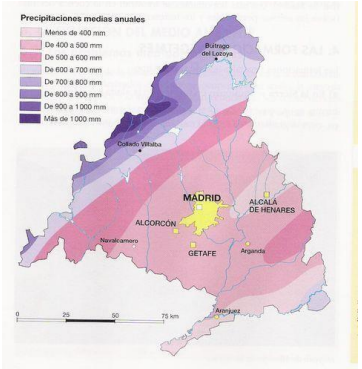
Payload: We considered an **In-House MW radiometer** and subsequently chose a **COTS spectrometer**

- $HFOV$: horizontal field of view (m)
- FOV: field of view (deg)
- GSD: ground sampling distance (m)
- H: altitude (m)
- d: sensor width (m)
- f: sensor focal length (m)
- n_p: resolution, number of pixels

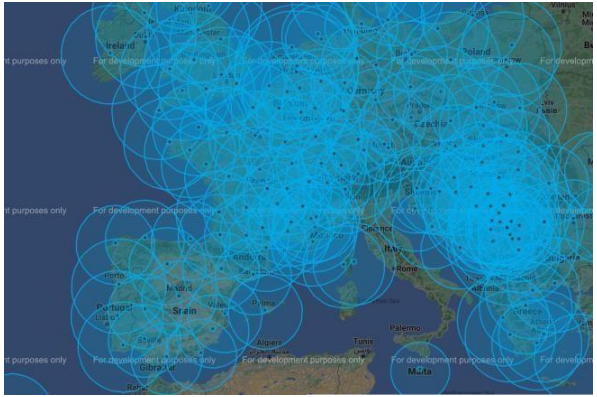




ST3LLARsat1 science footprint analysis @ BDR



Madrid annual rain zones [Lopez-Bueno'21]



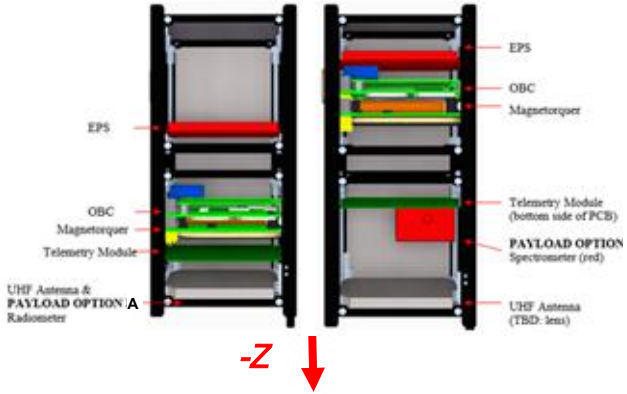
OPERA weather stations' coverage [Overeem'23]

ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

From beginning to FDR: Configuration

Do not be afraid to change.
Be flexible, but justify the changes

@ Proposal (Dec'22)



ADCS: **STM32H7** CPU

3-axis gyro: ADIS 16460

Magnetorquers: 1x iMTQ board

Magnetometer: 1x HMC5883L

Photodiodes: 6x SLCD-61N8

Solar cells: 1x SpaceMind-SP1X
2x SpaceMind-SP2X

PCDU+Battery: ENDUROSAT EPS-I

GNSS receiver: Orion B16C1

RF transceiver: Semtech SX1277

Structure 2U: **In-House**

Payload: **In-House MW radiometer**
or COTS Spectrometer (Ocean Insight ST-NIR-25)

OBDH: **STM32F4** CPU

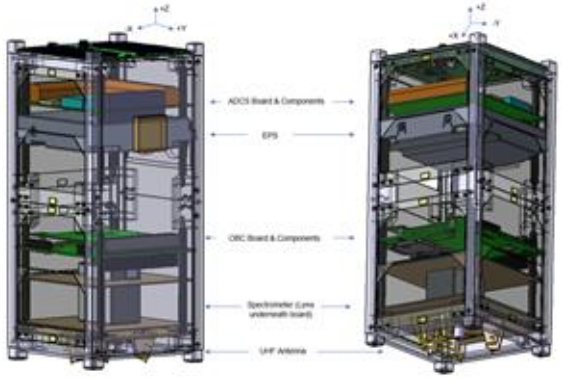
Watchdog: 2x MAX6320PUK

MRAM: 1x M10162040108X0PWAY

OS: **freeRTOS**

CoM Opt-B	cm
X	-1.41
Y	0.04
Z	1.74
Mass (Kg)	1.948

@ BDR (March'23)



ADCS: STM32H7 CPU

3-axis gyro: ADIS 16500

Magnetorquers: 2xNCTR-M003

Magnetometer: 1x RM3100

Photodiodes: 6x SLCD-61N8

Solar cells: 2x SpaceMind-SP2X
2x SpaceMind-SP2X
1x SpaceMind-SP1Z

PCDU+Battery: ENDUROSAT EPS-I

GNSS receiver: Orion B16C1

RF transceiver: Semtech SX1276

Structure 2U: **In-House**

Payload: COTS Spectrometer

OBDH: STM32F4 CPU

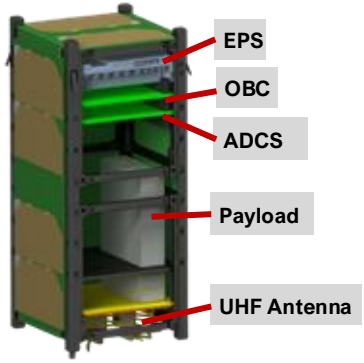
Watchdog: 2x MAX6320PUK

MRAM: 2x M100424204

OS: RTEMS

CoM	cm
X	0.4
Y	-0.27
Z	0.42
MoI	**kg•m²**
Ixx	0.005
Iyy	0.005
Izz	0.002
Mass* (Kg)	2.439

@ FDR (Feb'24)
[as per ST3_DML_2024-03-10_v1.0.xlsx]



ADCS: SAMV71Q21B-AAB CPU

3-axis gyro: ADIS 16500

Magnetorquers: 2xCR0002 + 1xCoil

Magnetometer: 1x RM3100

Photodiodes: 15x SFH 2401

Solar cells: 1x SpaceMind-SP1X
3x SpaceMind-SP2X
1x SpaceMind-SP1Z

PCDU+Battery: ENDUROSAT EPS-I

GNSS Antenna: Molex 206640-0001

GNSS receiver: Orion B16C1

RF transceiver: Semtech SX1276

Structure 2U: SpaceMind SM-02

Payload: COTS Spectrometer

OBDH: SAMV71Q21B-AAB CPU

Watchdog: 2x MAX6320PUK

MRAM: 2x MR5A16ACYS35

OS: freeRTOS

CoM	cm
X	0.26
Y	0.5
Z	0.12
MoI	**kg•m²**
Ixx	0.0046
Iyy	0.0046
Izz	0.00145
Mass (Kg)**	1.366

ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

From beginning to FDR: Structure evolution

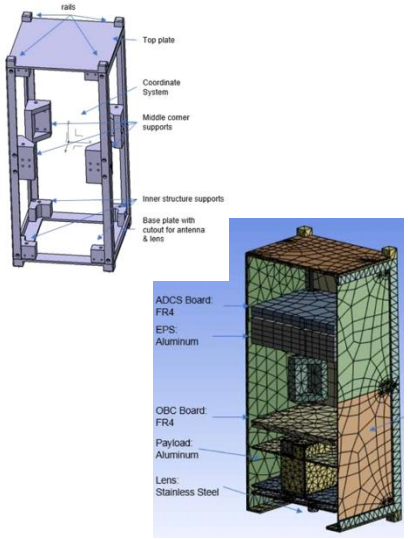
Do not be afraid to change.
More than the change itself, the important thing is to analyze & justify it.

2022 | 2023 | 2024

- Oct 2 — **FYS-DB proposal**
- Nov 23 — **FYS-DB updated proposal**
- Mar 12 — **BDR submission**
- Jan 21 — **FYS!4 proposal**
- Mar 10 — **FDR submission**
- Apr 8-12 — **FDR collocation meeting**
- Jun 7 — **FDR final presentation**

Sept'22 | **BDR preliminary analyses** | **FDR Analyses for design** | **Post RIDs**

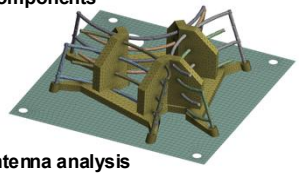
BDR: Prelim. analysis for in-house structure



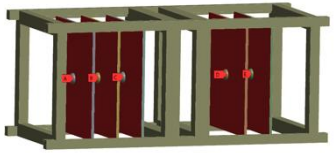
FDR: Towards the use of COTS components

- SPACEMIND SM-02 structure
- Analysis driven design

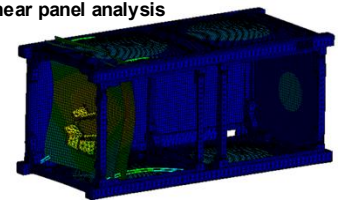




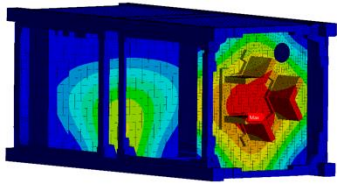
Antenna analysis



Shear panel analysis



Close-off analysis



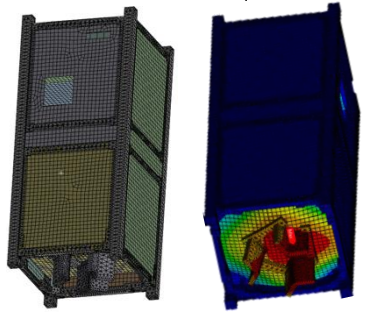
Cubesat Analysis



Final model

Finalising the analysis

- Load profile revision
- Model checks
- Sine vibration analysis
- New material requirement



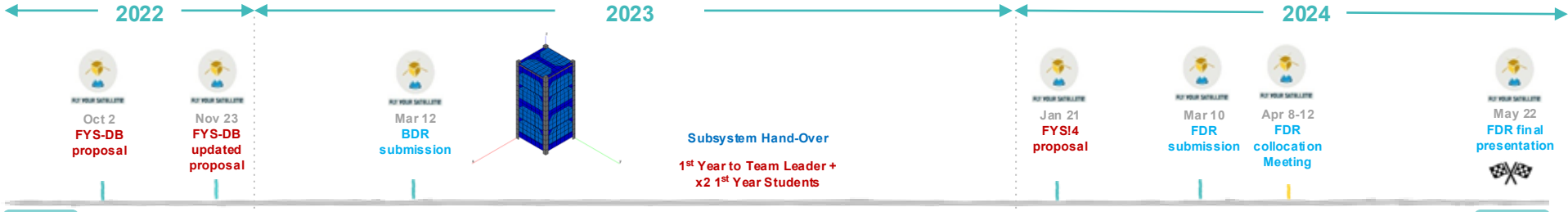
Future Work

- Torque analysis on structure
- Integrate payload into model
- Towards a less discretised model

ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

Recognize when something is wrong and then look to improve it.

From beginning to FDR: EPS evolution



1st Iteration

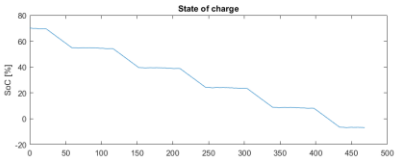
- Components Trade-Off and Selection
- Preliminary Design:
  - Solar Panels Sizing Analysis
  - Battery Sizing Analysis
  - Power Budget Analysis
  - Energy Budget Analaysis
- Proposed Configuration:
  - x3 Faces covered in panels
  - Endurosat EPS I
  - Spacemind Solar Panels

MATLAB

ESATAN-TMS thermal modelling suite

Insufficient Power Generated!!!

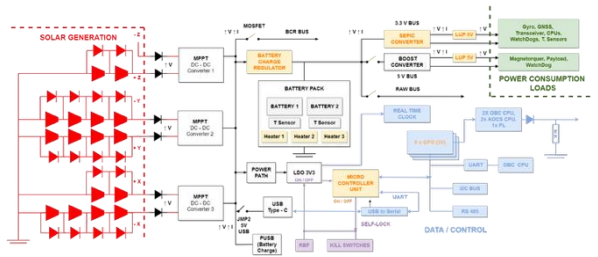
Value of Innefficiencies obtained after further contact with Suppliers



WCS: Detumbling Case for BDR Configuration

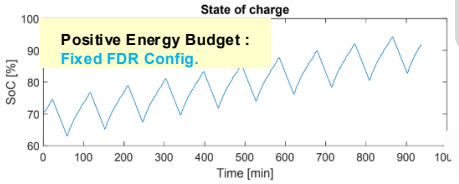
2nd Iteration

- Trade-Off Re-Iteration + Supplier Contact
- Consolidated analyses and Design:
  - Final Input Orbits from MA
  - Updated Orbital Detumbling Analysis
  - Duty Cycles stablished for the different modes
  - Inhibits Update between SP and EPS Module
  - Analysis Iteration with all above information
- RIDs Solving
- New Proposed Configuration:
  - x5 Faces Covered in Panels

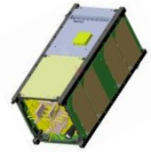


Final EPS Architecture

FDR Configuration:
x4 Lateral Panels (x3 2U + x1 1U)
+ Top Panel



WCS: Detumbling Case for FDR Configuration



ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

From beginning to FDR: Thermal control subsystem evolution

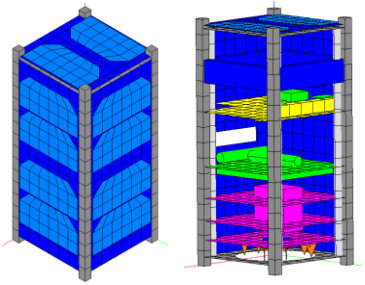
In the first design phase, always from top (system-level) to bottom (unit-level)

2022 | 2023 | 2024

- 2nd Oct 22 — FYS-DB proposal
- 23rd Nov 22 — FYS-DB updated proposal
- 2th Mar 23 — BDR ubmission
- 21st Jan 24 — FYS!4 proposal
- 10th Mar 24 — FDR submission
- 7th Jun 24 — FDR final presentation

Sept'22 — **Jun'24**

Implementation of preliminar ESATAN GMM and TMM model:
- Preliminar Heat load dissipation
- Estimated conductances
- SOLCYC algorithm
- Identification of critical components: battery and payload.



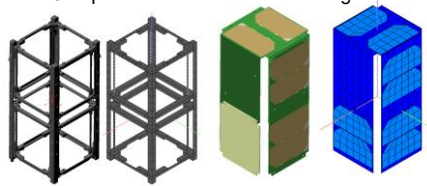
Passive thermal control:
- White paint for solar panels

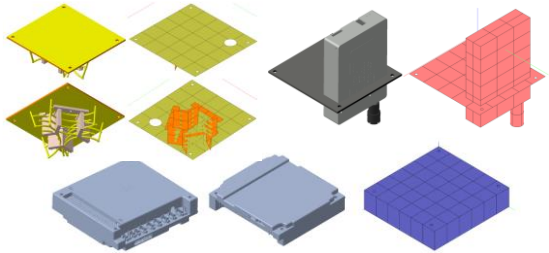
Active thermal control:
- Heaters in battery module

CubeSat Configuration and thermal environment:
- Missing geometry and materials now gathered
- Thermo optical and bulk properties more accurate (references to values collected)
- Orbit parameters, altitude and attiude detailed.
- Temperature limits of design drivers components identified.

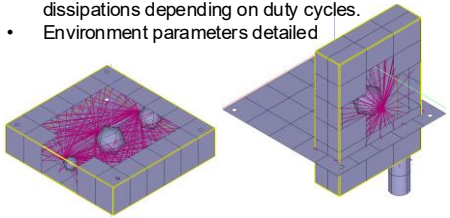
Conceptual analysis and design for rapid changes:
- Development of procedures (files and processing results) and methodological steps to asses if a change in other subsystem is critical,
- Steady and transient states analysis with Matlab

Geometrical Mathematical Model:
- Geometry redefinition of solar panels
- Structure geometry detailed
- Payload configuration changed
- PCBs design changed
- Individual GMM modules created to streamline changes
- Node numbering for debugging
- Groups for better conductance assignation

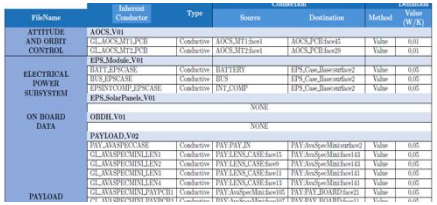




Thermal Mathematical Model:
- Computation of conductances and specific heats based on mass and volume ponderations
- User defined conductors enhanced to connect all missing nodes.
- New nongeometrical nodes created for dissipations depending on duty cycles.
- Environment parameters detailed



Big effort on traceability for information flow



FileName	Inherent Conductor	Type	Connected Source	Connected Destination	Method	Dimensional Value (W/K)
ATTITUDE AND ORBIT CONTROL	AOCS.V01					
	GL_AOCS_MT1_PCB	Conductive	AOCS_MT1:face1	AOCS_PCB:face45	Value	0.01
	GL_AOCS_MT1_PCB	Conductive	AOCS_MT2:face1	AOCS_PCB:face29	Value	0.01
ELECTRICAL POWER SUBSYSTEM	EPS.Module_V01					
	BATT_EPS:CASE	Conductive	BATTERY	EPS_Case_Base:surface2	Value	0.05
	BUS_EPS:CASE	Conductive	BUS	EPS_Case_Base:surface2	Value	0.05
	EPSINTCOMP_EPS:CASE	Conductive	INT_COMP	EPS_Case_Base:surface2	Value	0.05
	EPS.SolarPanels_V01		NONE			
ON BOARD DATA	OBDH_V01		NONE			
	PAYLOAD.V02					
	PAY_AVASPECCASE	Conductive	PAY:PAY_IN	PAY:AvaSpecMini:surface2	Value	0.05
	GL_AVASPECMINI_LEN1	Conductive	PAY:LENS_CASE:face15	PAY:AvaSpecMini:face143	Value	0.05
	GL_AVASPECMINI_LEN2	Conductive	PAY:LENS_CASE:face9	PAY:AvaSpecMini:face143	Value	0.05
	GL_AVASPECMINI_LEN3	Conductive	PAY:LENS_CASE:face11	PAY:AvaSpecMini:face141	Value	0.05
	GL_AVASPECMINI_LEN4	Conductive	PAY:LENS_CASE:face13	PAY:AvaSpecMini:face141	Value	0.05
	GL_AVASPECMINI_PAYPCB1	Conductive	PAY:AvaSpecMini:face105	PAY:PAY_BOARD1:face21	Value	0.05
PAYLOAD	PAY_AVASPECMINI_PAYPCB2	Conductive	PAY:AvaSpecMini:face107	PAY:PAY_BOARD2:face21	Value	0.05

Selection of possible temperature sensors: .

AIV procedures literature reviewed and subsystem representativeness in models assesed

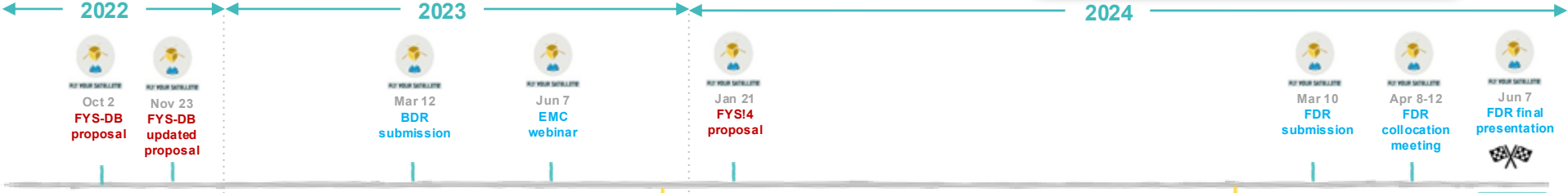
Now working on SENSITIVITY ANALYSIS:
- Parameter inaccuracies.
- Uncertainty Margins

Current TCS:
- Battery heaters
- Thermo optical properties of external surfaces
- Strategic distribution of elements
- Z-axis rotation for temperature gradients decrease

ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

From beginning to FDR: OBDH evolution

Read the regulations and previous CubeSat programs' references to identify common issues and solutions



MCU upgrade:

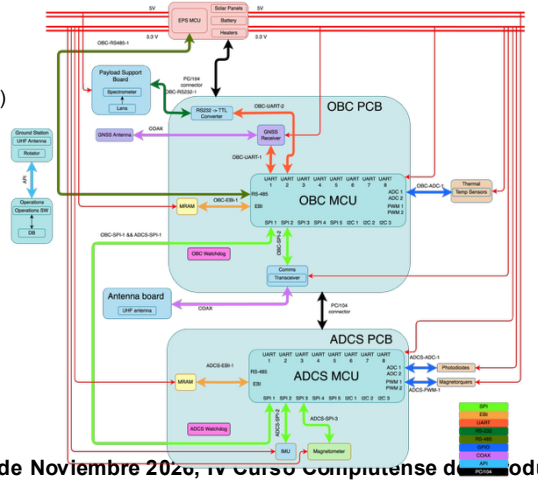
- Switch to SAMV71Q21
- Higher performance Cortex-M7 core (67 % MHz increase)
- 2MB flash memory (4x increase)
- ECC protection
- Good feedback on radiation tolerance properties

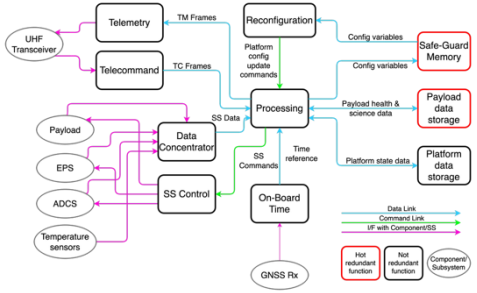
External memory upgrade:

- Switch to higher capacity MRAM (2x increase)
- Positive data on SEL tolerance for similar references

Other progress:

- Radiation effects mitigation assesment
- EMC/EMI initial assesment





Physical architecture update:

- Avoidance of I2C protocol, favoring SPI & Serial
- Centralized architecture

Functional architecture update:

- New functional architecture based on SAVOIR reference

ST3LLARsat1 Obj3: IOD1 – Fit all in a 2U CubeSat

From beginning to FDR: SW evolution

CubeSats are truly multidisciplinary, make every effort to involve SW students and experts

2022 | 2023 | 2024

F prime integration

- Oct 2 — **FYS-DB proposal**
- Nov 23 — **FYS-DB updated proposal**
- Mar 12 — **BDR submission**
- Jan 18 — ESA SW expert meeting Volkan Salma
- Jan 21 — **FYS!4 proposal**
- Mar 4 — ESA SW expert meeting Volkan Salma
- Mar 10 — **FDR submission**
- Apr 8-12 — **FDR collocation meeting**
- Jun 2 — **F prime ported successfully to SAMV71Q21**
- Jun 7 — **FDR final presentation**

Sept'22

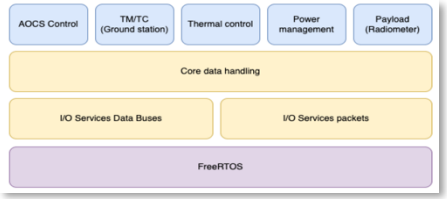
FYS proposal status
- Preliminary SW architecture
- FreeRTOS

BDR status
- Preliminary SW architecture
- RTEMS

FYS!4 proposal status
- In-house SW development
- FreeRTOS
- ECSS services

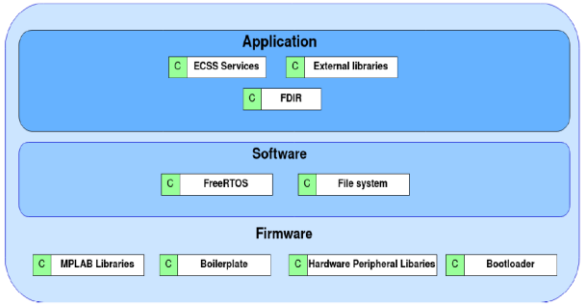
FDR status
- In-house SW development
- FreeRTOS
- Memory management
- Preliminary SW development plan

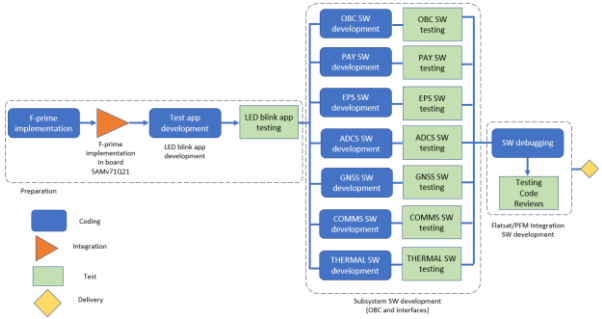
Next steps
- Fprime evaluation
- SW architecture selection
- SW development plan consolidation
- Preliminary SW verification plan



Discussion SW selection
In-house development
Vs
Flight software

Discussion SW selection
ESA expert recommended to evaluate a flight software in parallel, evaluate and decide





ST3LLARsat1 Obj3: IOD2 – A scientific instrument in 1U

From beginning to FDR: Payload evolution

Sometimes, things fail and all-hands onboard are required

2022

Sept'22

2nd Oct'22 **FYS-DB proposal**

23rd Nov'22 **FYS-DB updated proposal**

2023

12th Mar'23 **BDR submission**

19th Jul'23 **ESA PM05**

2024

8th Jan 24 **IPM08**

21st Jan 24 **FYS!4 proposal**

Mar 10 **FDR submission**

UC3M in-house 183GHz MW Silicon-Germanium radiometer

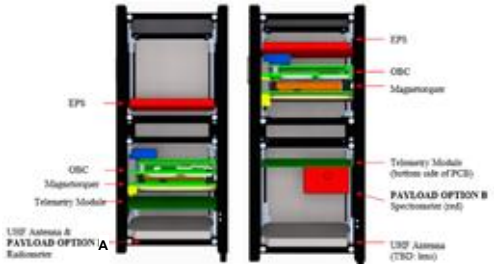
Opt-A. UC3M in-house 183GHz MW Silicon-Germanium radiometer

Opt-B. COTS ST-NIR25 spectrometer

PAY-1A. COTS ST-NIR25 → ST-NIR200 spectrometer

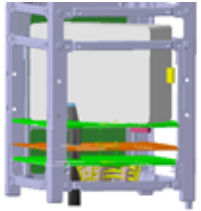
PAY-1C. COTS NEXOS™ spectrometer

PAY-1A. COTS ST-NIR200 spectrometer
PAY-1B. COTS Mini2048CL spectrometer





Recommendation by supplier to use a more space-ready version of spectrometer



Fiber optic cable for ST-NIR200
connectors are 6.5 cm long each and cable is 12 cm.



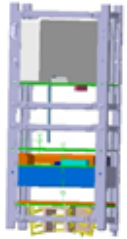








Sketch of possible cable implementation



Test with a new possible configuration





@ FDR (Feb'24)



ST3LLARsat1 Obj3: IOD3 – In-House compact antenna

Iterate, iterate, and iterate

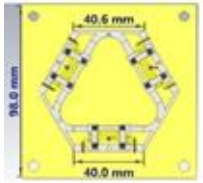
From beginning to FDR: Antenna evolution

2022 | 2023 | 2024

- Sept'22
- 23rd Nov'22 — FYS-DB updated proposal
- 12th Mar'23 — BDR submission
- 19th Oct'23 — Meeting with GREMA
- 24th Nov'23 — PM09
- Dec 11-13 — European CubeSat Symposium
- Dec 15 — LoRa meeting
- 8th Jan 24 — IPM08
- 21st Jan 24 — FYS!4 proposal
- Mar 10 — FDR submission

LoRa 860/870 MHz antenna

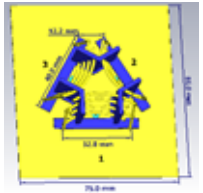
Standard UHF 435-438 MHz antenna





1ST DESIGN & PROTOTYPE:

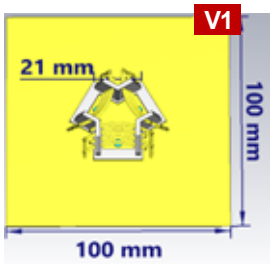
* Favoured size reduction and lower manufacturing cost
* Polylactic Acid (PLA) support at center of –Z face
* Prototype manufactured / tested





[V1] 2ND DESIGN – 1ST ITERATION:

* Fiberglass support instead of PLA => Space-ready
  + Large size reduction
* Possible new placements



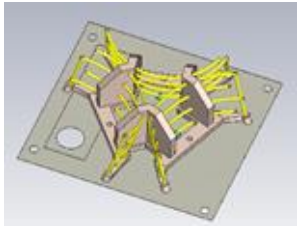
[V2] 2ND ITERATION:

* Improved coupling and element separation
* Increased directivity (3dB)
* Face centre free for lens



3RD DESIGN:

* Proven robust & flexible antenna design process (i.e. quickly produced a UHF 435-438 MHz design)
* Larger than 1st & 2nd designs, but still fits in –Z face
* Position accounts for new spectrometer (Mini2048CL)



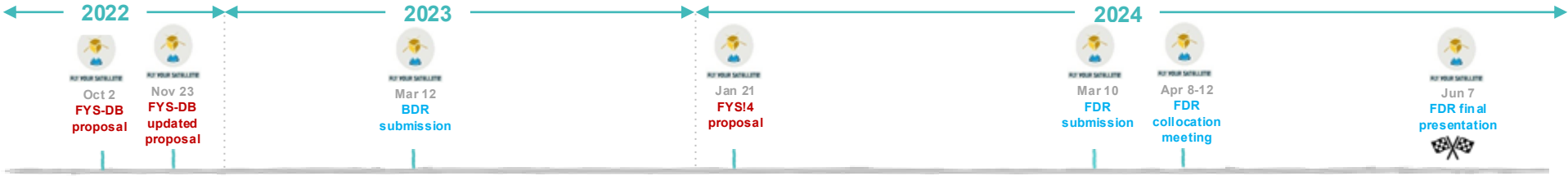
3RD DESIGN – 2ND ITERATION:

* Copper plates' stress levels in shock analysis **exceeded** yield ➔ change them to aluminium

ST3LLARsat1 Obj3: IOD4 – In-House ADCS / OBC

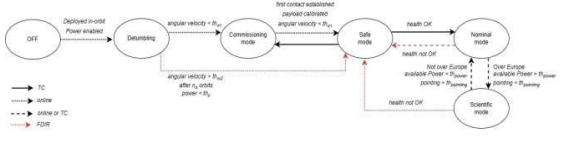
CubeSat simulators and basic Hardware-In-the-Loop are a must

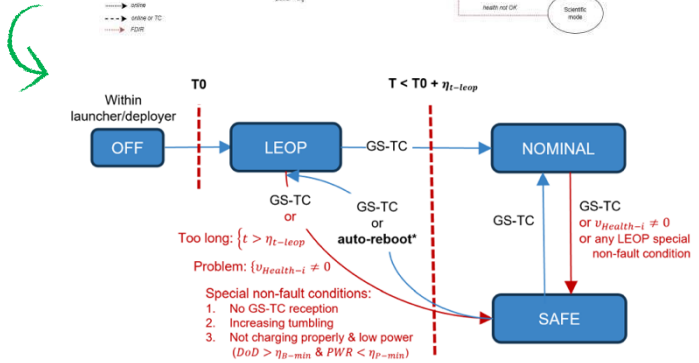
From beginning to FDR: Modes and ADCS evolution



Operational modes evolution

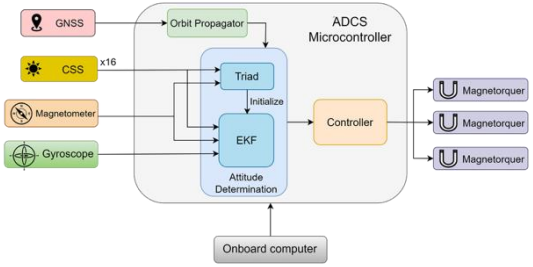
- Simplified operational modes flow:
  3 main operational modes
- Detailed mode transition triggers
- Detailed health tests for mode transition
- Consolidated activation sequence





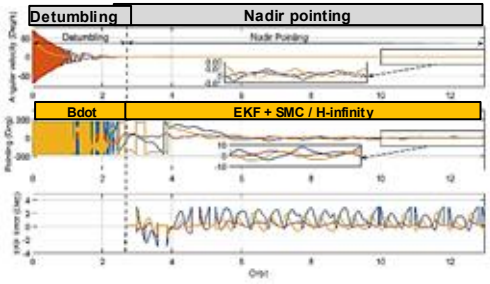
ADCS status

- Sensors (magnetometer, GYR GNSS, CSS)
- Actuators (2 magnetorquer rods and 1 coil)
- Navigation (Triad + EKF)
- ADCS modes:
  - Detumbling (b-dot algorithm)
  - Nadir pointing (sliding mode)



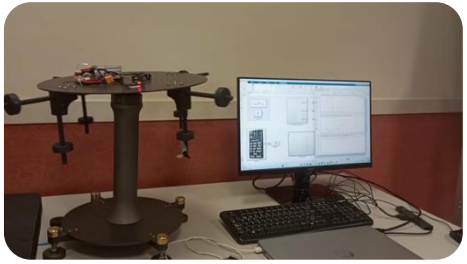
MIL Monte Carlo results

- Succesful detumbling < 6 orbits
- Pointing APE < 10 deg



HIL setup

- 3 DoF balancing system



ST3LLARsat1 – CSAT & Ground Station Status

Set at least the GS at your university (and If economically possible, an R&D / AIVT lab)

UC3M-CSAT

"*Centro de investigación e integración de tecnología espacial y nano/micro SATélites*"

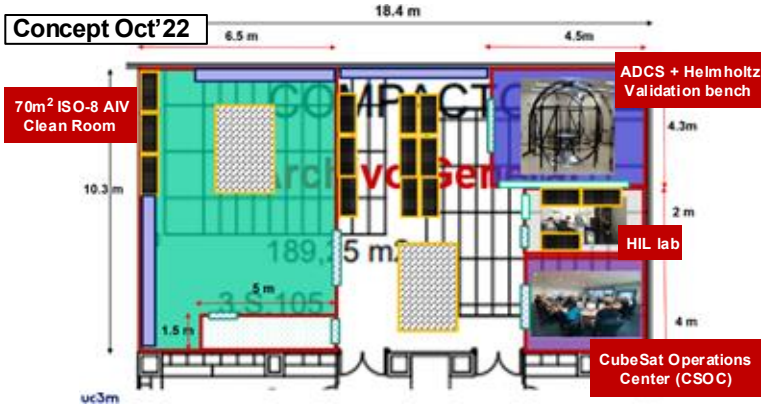
Spanish-Ciencia - Infraestructuras y Equipamiento award to Dr. A. Marcos (1.5 M€, Nov'21)

UC3M-GS

Collaboration between four actors at UC3M

1. UC3M-CSAT
2. St3llar
3. UC3-BASE
4. E.T.-PACK-F

Concept Oct'22











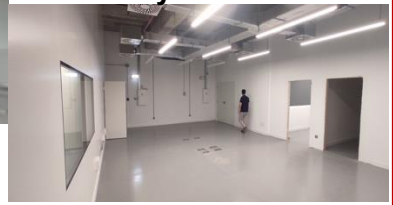
Status Feb'23



Status Jan'24



Status July'24



Status Dec'25



ST3LLARsat1 – Next steps and challenges/Risks

Be flexible, but …
Plan and identify the Risks

2024 | 2025 | 2026

Jun'24 — Sept'24 — Jun'25 — Sept'25 — Jun'26 — Sept'26

Phase III objectives Jun'24-Jun'2025
(MISE cohort 2023/24 & 2024/25 volunteers)

- **Smooth handover** (**Done.** Half of team at ESA-FDR collocation was 1st year 23/24 volunteers & they continued to MISE-IP 24/25)
- **Initial assembly and integration** (antenna, 3D printed structure, payload, ADCS HIL-test, design of ADCS & OBC PCBs)
- **Clarify amateur status & consolidate legal**
- **Operative ground station** (ongoing, aim is Dec-2024)
- **Specific SW development** (reach out to other masters and dept.)
- **First Flat-Sat** (main components)
- **Prepare to apply for ESA testing opportunities** (from Jan'25)

Phase IV objectives Jun'25-Jun'2026
(MISE cohorts 24/25 - 25/26)

- **Smooth handover**
- **Operative CSAT** (March'25, but Helmholtz/ADCS by Nov'25)
- **Main subsystems' AIV** (Antenna, Payload, PCBs)
- **Apply to ESA testing opportunities**
- **Final Flat-Sat**
- **First EQM**
- **Apply to FYS5! Proposal**
- **Look for launch opportunities**

Phase V objectives Jun'26→
(MISE cohorts 25/26 - 26/27)

- **Smooth handover**
- **Final EQM**
- **EQM AIV**
- **Apply to ESA testing opportunities**
- **FM**
- **Look for launch opportunities**

Challenges & Risks [criticality / probability]

- **[Major, High]** Maintain students' interest over the end of the 'novelty'
- **[Major, Med]** Regulatory status
- **[Major, Low]** Access to AIV testing facilities or finding launch opportunity
- **[Medium, High]** Need for subsystem redesign (e.g. prelim integration or AIV indicating a shortcoming)
- **[Medium, Med]** Involvement of experts and other professors (especially, SW & electronics)
- **[Low, Low]** Funding

Acknowledgements & THANK YOU FOR ATTENDING

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