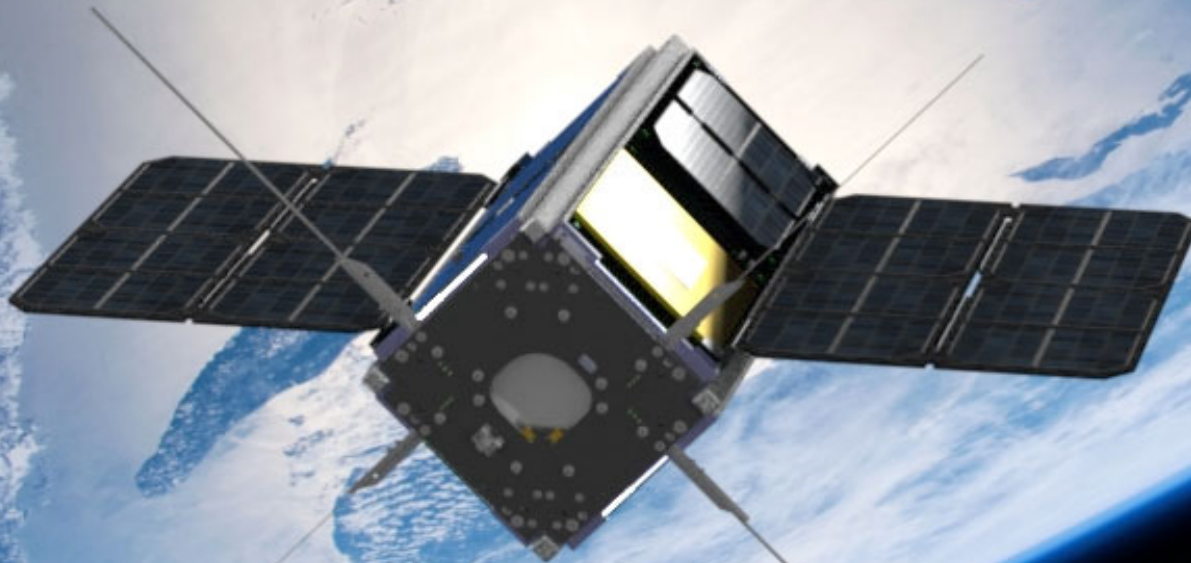


CubeSats: the next step in the evolution

The Brijuni Conference: Deep space communication, navigation and propulsion, August, 2022



**FACHHOCHSCHULE
WIENER NEUSTADT**

Austrian Network for Higher Education

University of Applied Sciences



Key Facts - University of Applied Sciences Wiener Neustadt

- Founded in 1994 as the first University of Applied Sciences in Austria
- Largest University of Applied Sciences in Lower Austria
- 4 Campuses
 - Wiener Neustadt, Wieselburg, Tulln, Vienna
- 5 Faculties
 - Business, Engineering, Health, Sport, Security
- 37* Bachelor's & Master's degree programmes
 - Full-time & part-time
 - German & English
- More than 12,000 graduates
- Currently about 3,800 students
- 350 employees
- More than 1,300 external lecturers

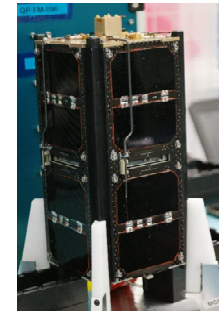




Aerospace Engineering at the FHWN

Aerospace Engineering at the FHWN....

- a 2 year Master's program
-is offered completely in english
-combines classic education (teaching) with hands-on projects



Aerospace Engineering at the FHWN



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Network for Higher Education

CubeSat Program CLIMB PEGASUS News Contact

Welcome to the FHWN CubeSat program!

Click here to explore our programs Climb and Pegasus



<https://cubesat.fhwn.ac.at/>

CubeSats & International Networking



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ESA: Concurrent Engineering



ESA: CubeSat workshop



Summer School CVA



Summer School Alpbach

Alpbach 2019 (FFG/ESA) © 2019 MA Jakob/WINart AT



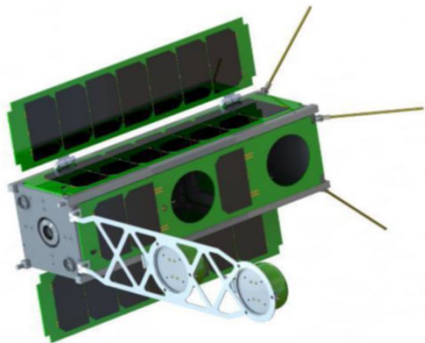


Applying the CubeSat concept

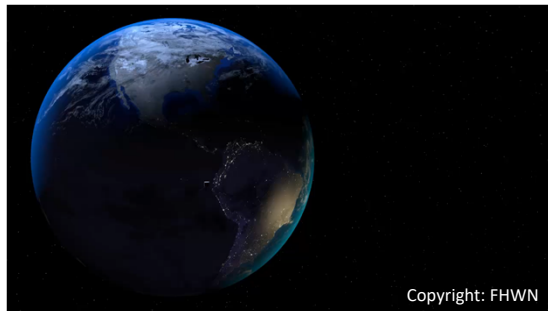
- S³ (Solar Sentinel Sat): CubeSats as early warning systems for solar storms
- Qube: Cubesats to test quantum communication
- Magneto: CubeSat swarm to assess Earth/Sun's magnetic fields
- Moonraker: CubeSats to support the exploration of the Moon
- Ancile: CubeSats to protect the crewed missions to Mars
- CLIMB: CubeSats to go where no one dares to go



MAGNETO

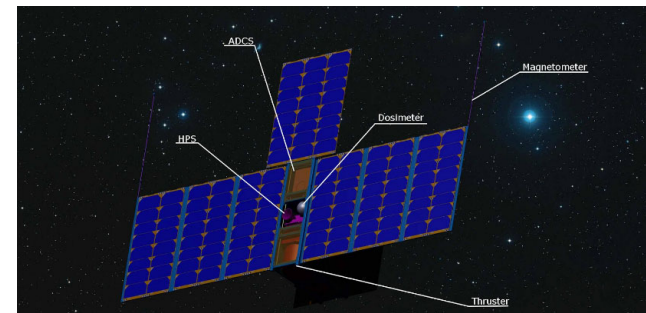


QUBE

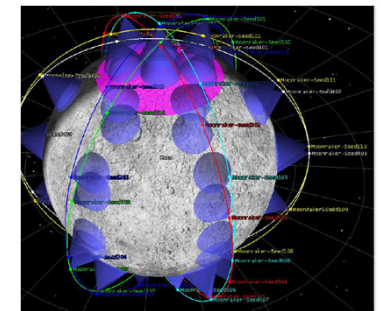


Copyright: FHWN

Ancile



Moonraker

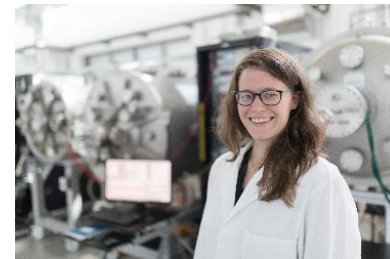


CubeSat development



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- The FHWN has all necessary facilities to develop and qualify CubeSats:
 - ALM facilities
 - Vibration facilities
 - Shock table
 - Thermal vacuum chambers
 - Solar Simulator
 - Helmholtz cage
 - Outgassing facilities
 - etc.



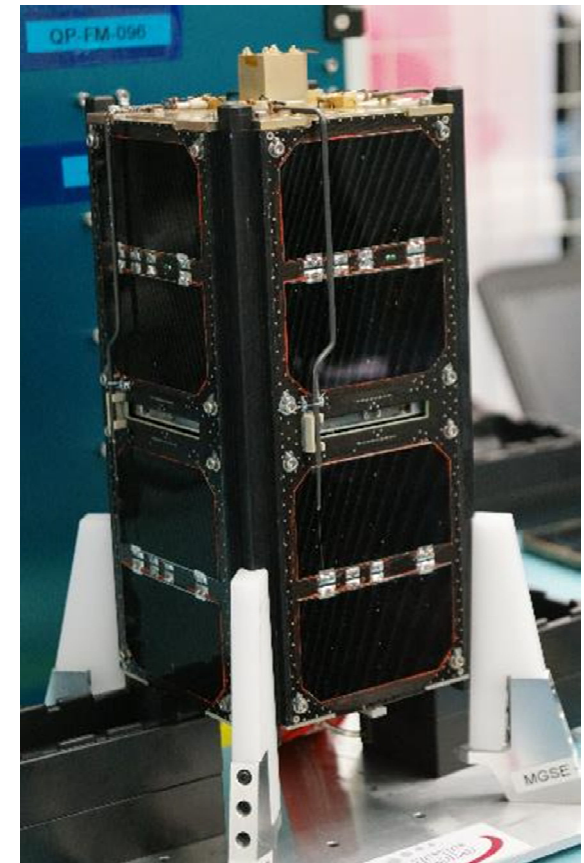
<https://cubesat.fhwn.ac.at/>

<http://spacedatacenter.at/pegasus/index.php>

The CubeSat PEGASUS

PEGASUS was initiated as contribution to the European Commission Projekt: QB50. With the exception of the GPS and the antennas all the satellite subsystems were developed by the PEGASUS team.

- PEGASUS is a 2U and weights 1960 g
- PEGASUS subsystems
 - Scientific instrument (mNLP)
 - GPS
 - On-board computer (OBC)
 - UHF transmitter and antennas
 - Power processing unit (PPU)
 - 2 re-chargeable batteries
 - 16 high efficiency solar cells
 - Experimental propulsion system
- Providing a in-orbit power between 2.5 and 3 W

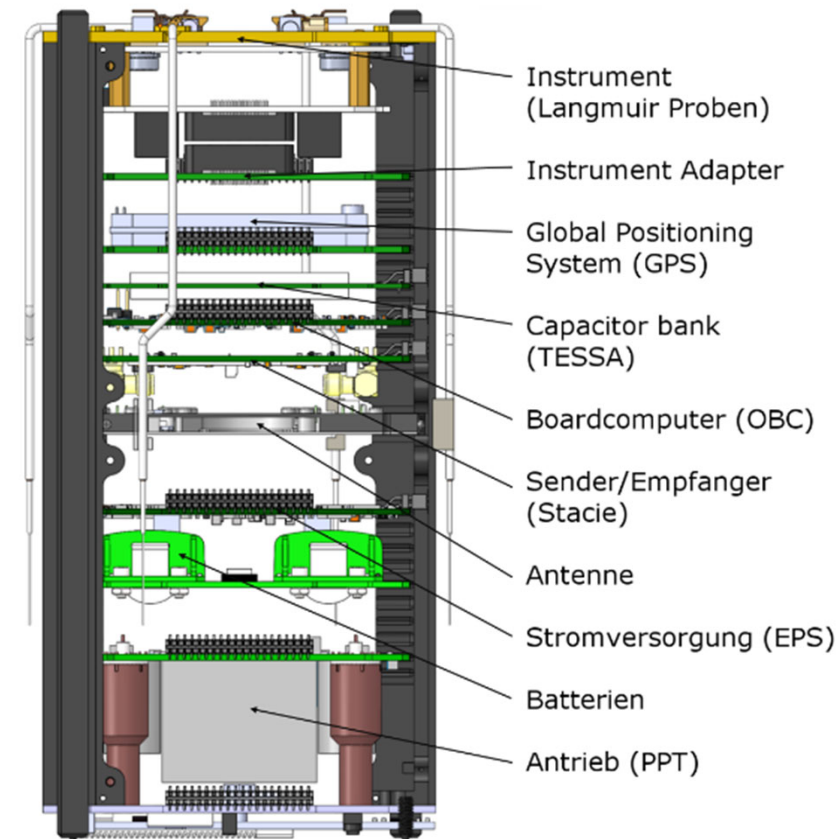




Special features of PEGASUS

CubeSats are great to try out innovative and new ideas!

- Multifunctional structure
 - Structure includes the bus system (no cables)
 - Magnetotorquer integrated into the structure
 - Supports the solar cells
- Redundant and partially autonomous communication system
- Redundant and highly efficient energy storage and distribution
- Autonomous error detection and recovery (Hardware and software) caused by radiation etc.



PEGASUS status



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Even after 5 years in orbit, PEGASUS is still functioning well.

Check out for yourself: <http://spacedatacenter.at/pegasus/index.php>

PEGASUS - Mission Control Center

Receiving Information for Radio Operators: Name: Pegasus - QB50 ID: AT03 - CallSign: ON03AT

Operator Manual PDF V1.1
TLE for PEGASUS

Pegasus is full working.
Langmuir-Probes are deployed.
Science Unit is working.

[Latest update: see UTC on right]
Who?: Florian_Deisl, Thomas_Dorn, Harald_Fauland, Stefan_Hauff, Georg_Janitsch, Dominik_Kehl, Robert_Kralofsky, Roswitha_Plotzfelder, Thomas_Riel, Carsten_Scharlemann, Margit_Schmid, Reinhard_Schnitzler, Bernhard_Spieler, Andreas_Sim, Cordula_Sleskinger, Reinhard_Stockinger, Michael_Taraba, Thomas_Turatschek, Renate_Zechner

Would you like to be part of our team? Ps contact info@stg-a.at



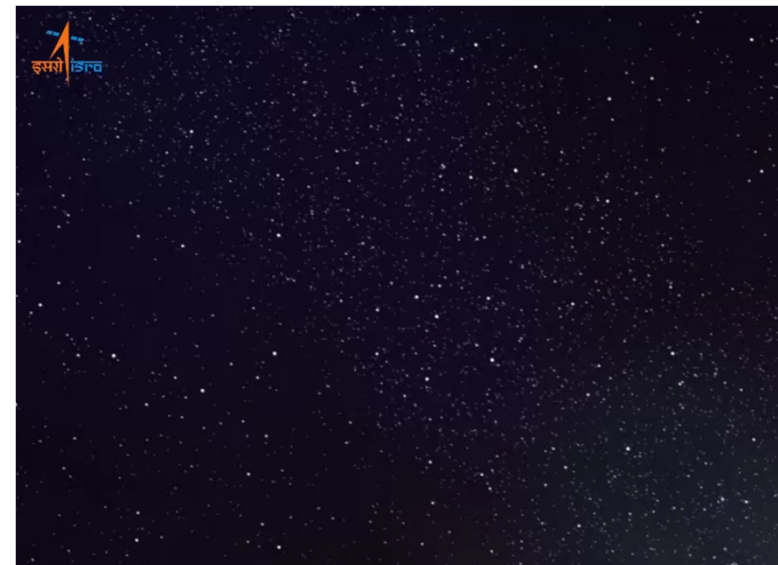
Actual position:

Karte Satellit

WOD Whole Orbit Data

QB50Time	714816411
UTC	2022-08-26 08:06:51
Voltage_PV1	3.96875 V
Voltage_PV2	4.15625 V
Voltage_5V_OUT	0 V
Voltage_3V3_OUT	0 V
Voltage_BAT1	3.96875 V
Voltage_BAT2	4.15625 V
Current_PV1_5V	0 mA
Current_PV2_5V	0 mA
Current_PV1_3V3	3625 mA
I_PV2_3V3	-3687.5 mA
I_PV1_BAT1	-8000 mA
Current_PV2_BAT1	7937.5 mA
Current_PV1_BAT2	0 mA

Launch with a Indian PSLV, 23.06.2017





PEGASUS is one of 2068 CubeSats* launched since 1998

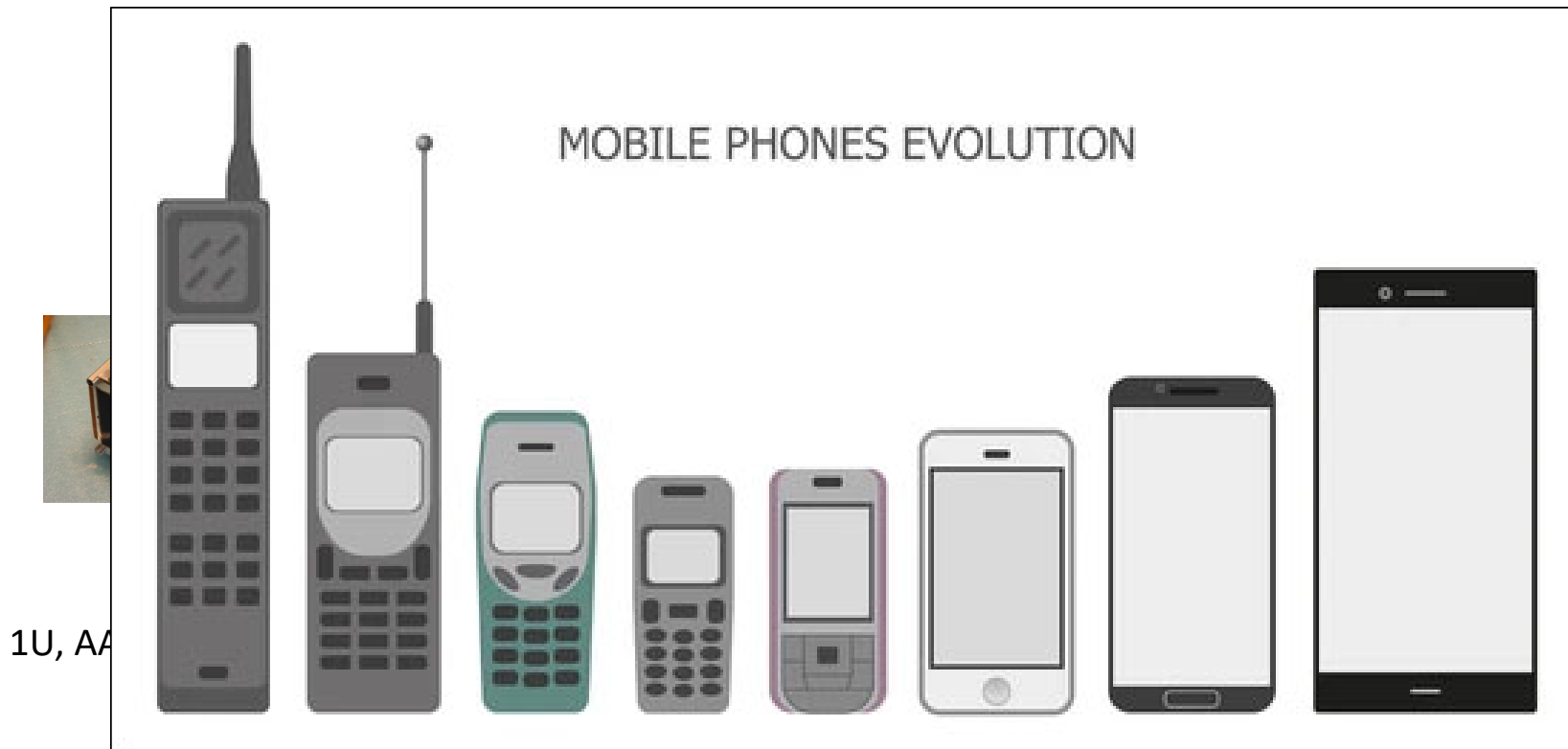
What are the next steps in the CubeSat Evolutions?

(*) between 1998 and 1st of August 2022 according to <https://www.nanosats.eu/>

Quo vadis CubeSat?



- General trend to larger CubeSats (1U to 12/16U)

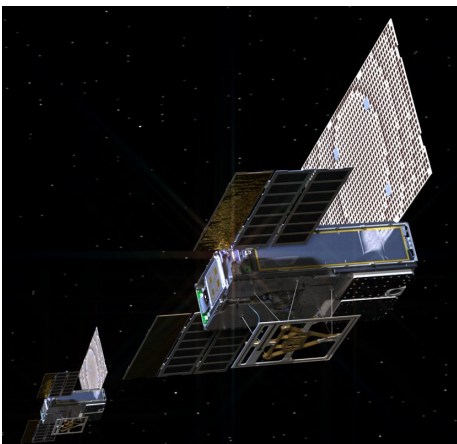


Quo vadis CubeSat?

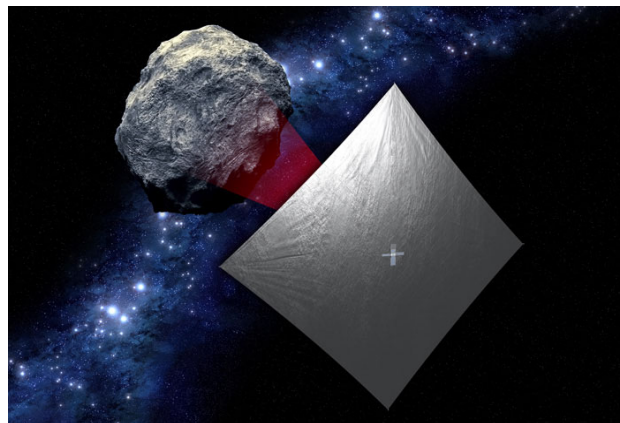


- General trend to larger CubeSats (1U to 12/16U)
- More challenging missions scenarios for space agencies and industry
- Longer missions durations

Mars Cube One (2018)



NEA Scout (2022-2023)*



Hera mission (2024-26)



(*) one of 10 CUbeSats which will be launched on Artemis (29th of August, 2022)

Quo vadis CubeSat?

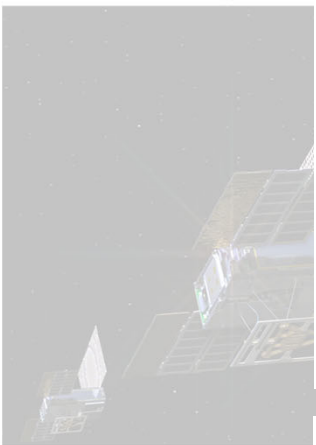


- General trend to larger CubeSats (1U to 12/16U)
- Longer mission
- More challenging

CubeSats of the future need:

- Lifetime increase
- Performance and reliability increase
- Radiation mitigation (hardened)
- Propulsive capabilities

Mars Cube One



Mission (2024-26)

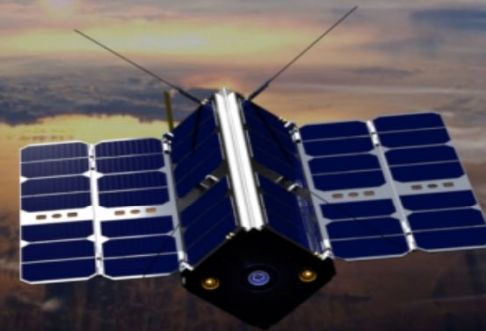


...and all this on a CubeSat budget!



CLIMB

A mission to the Van Allen Belt

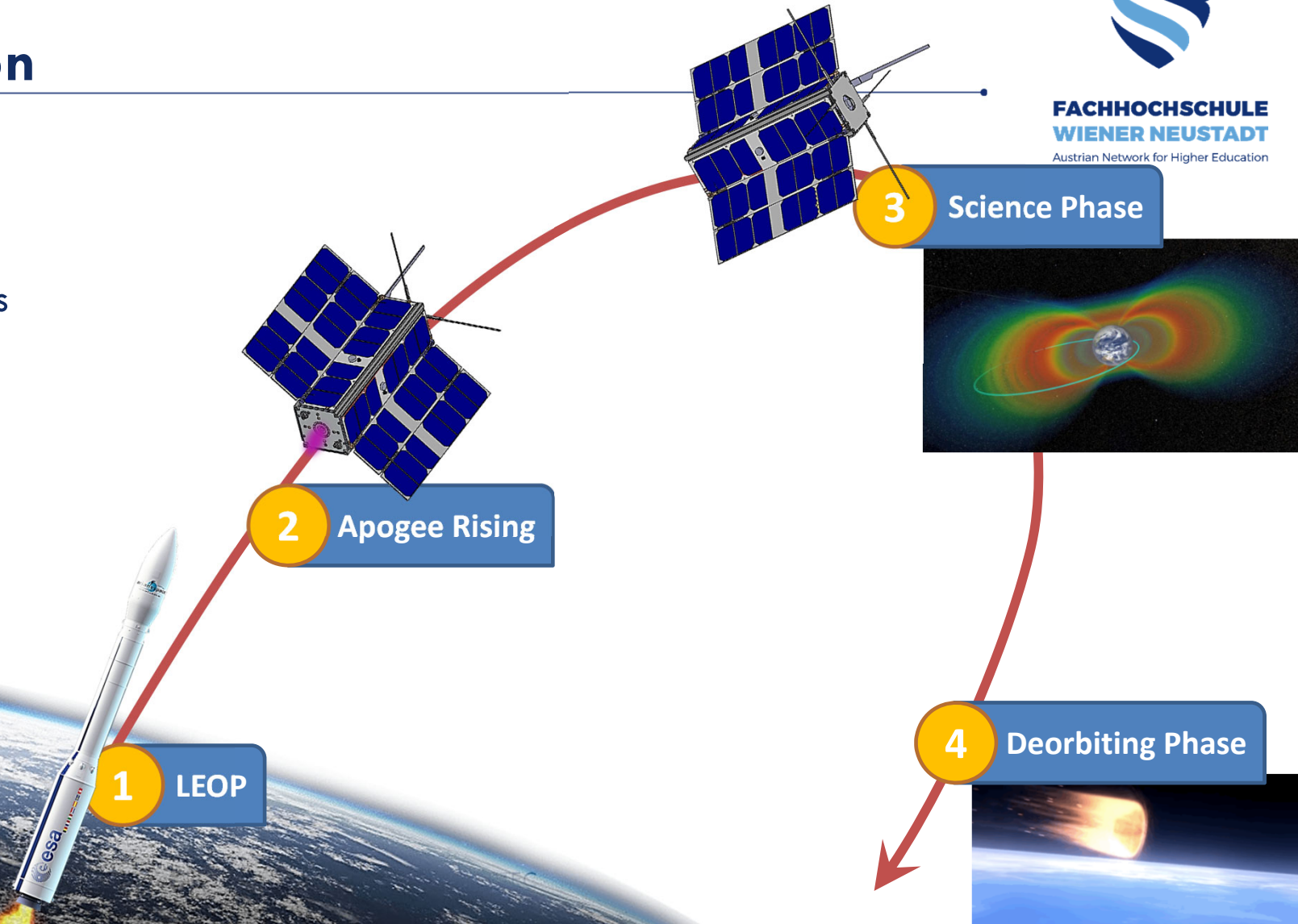


Overall project objective is to educate students and to develop CubeSats for future missions

The CLIMB mission

Duration

- Phase 1: < 1 month
- Phase 2: 12-15 months
- Phase 3: ~ 6 months
- Phase 4: ~ 9 months





The CLIMB mission

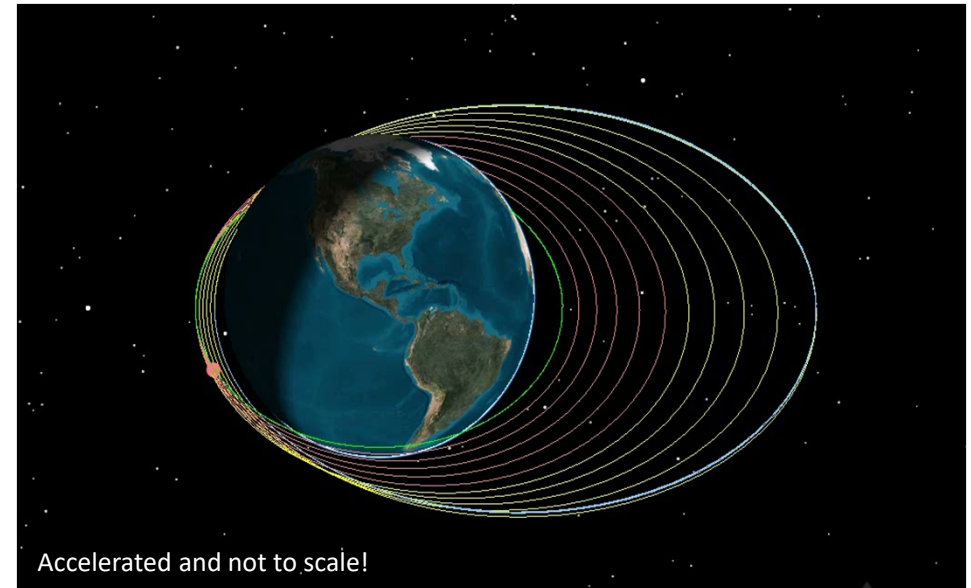
Mission objectives

- Education of students in satellite system engineering
- Using a propulsion system to reach the Van-Allen Belt (~1,000 - 1500 km)
- Using a CubeSat to measure Earth's magnetic field in high accuracy
- Monitoring the total accumulated radiation dose and its impact on subsystems

Technology and mission challenges

- Propulsion (power, thermal)
- Radiation (design for and mitigation of radiation effects)
- Communication (higher data rate)
- Operation (24/7, collision avoidance)

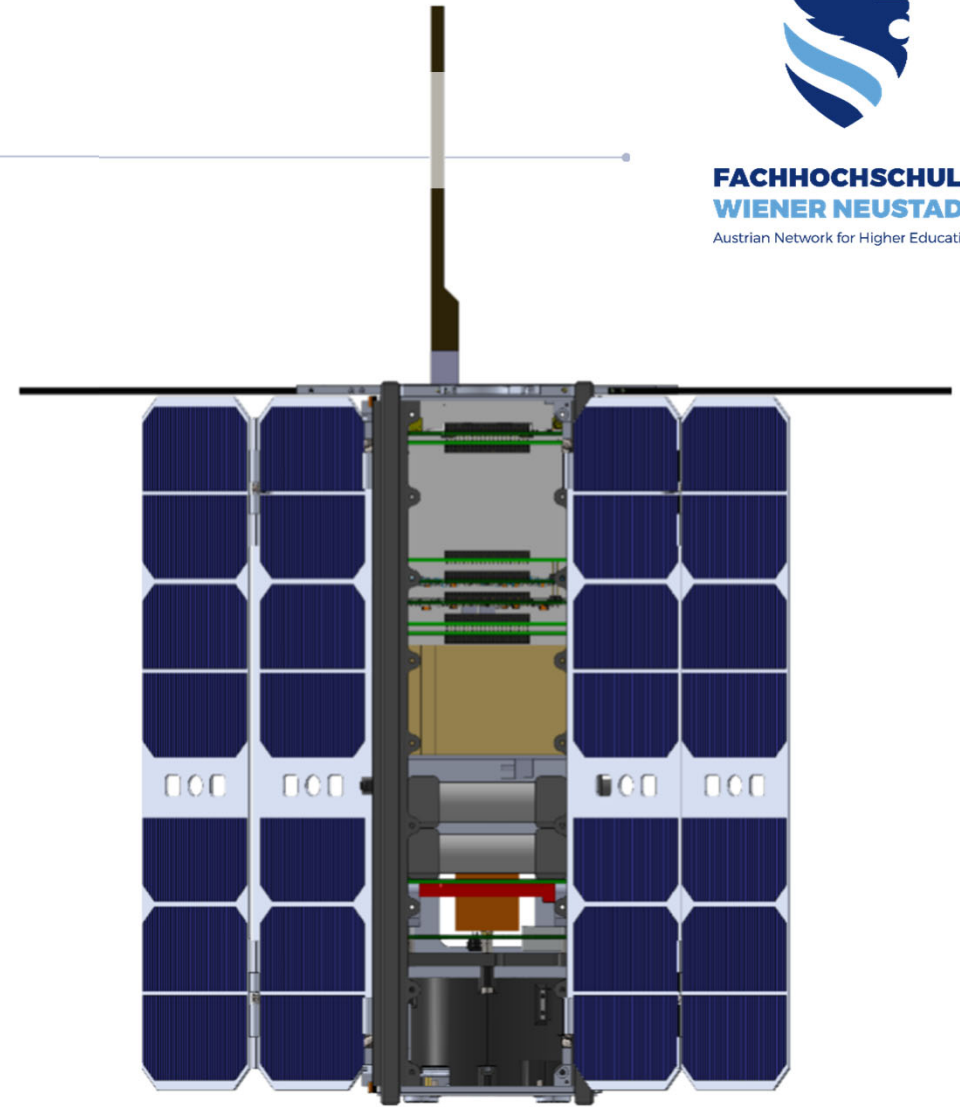
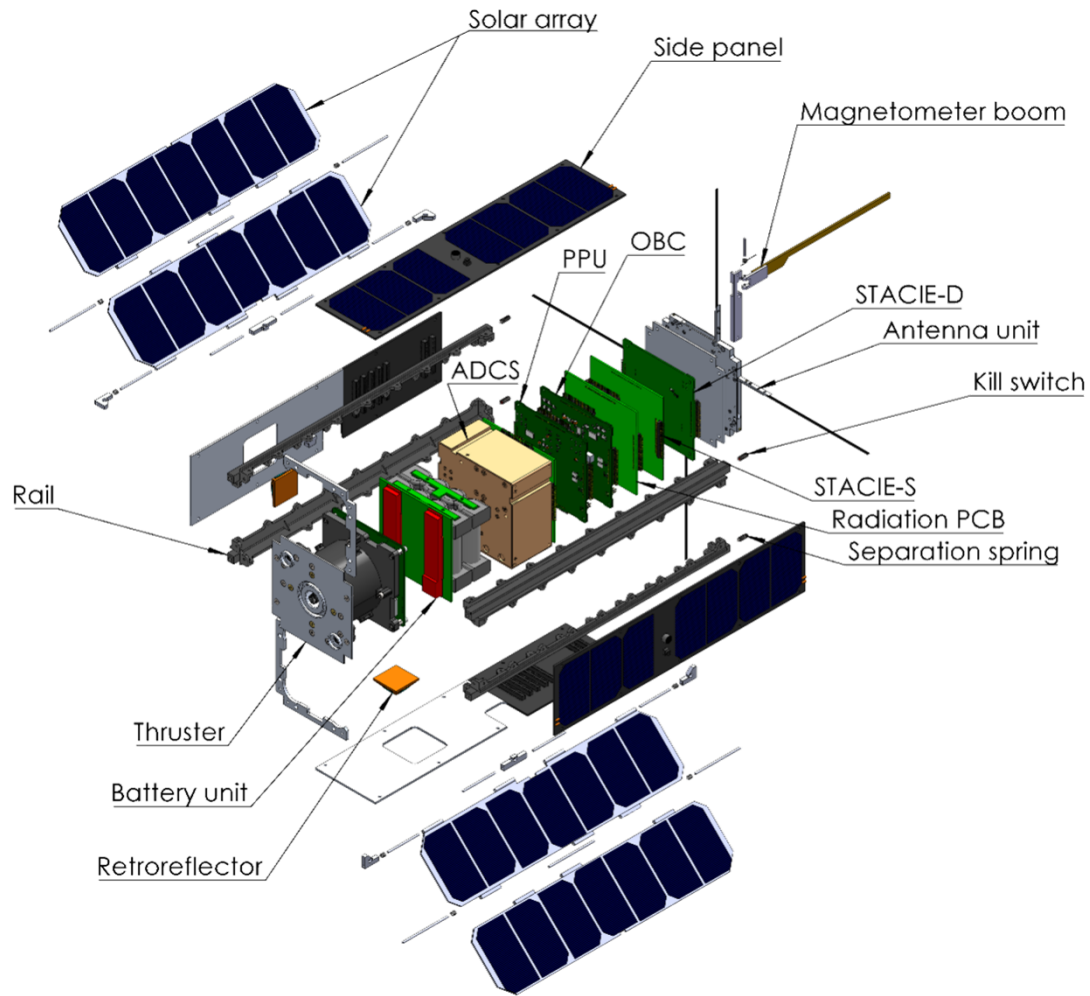
Phase 1 & 2 – LEOP and apogee increase



CLIMB Design



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Propulsion for CLIMB



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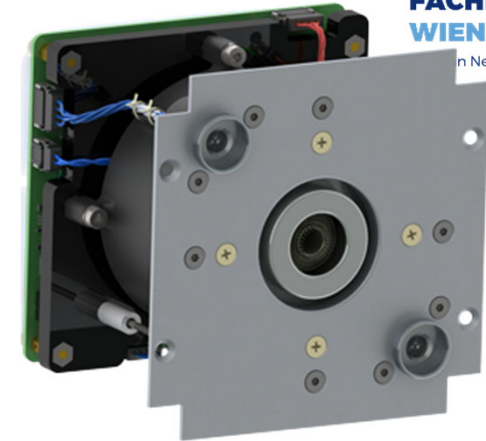


ENPULSION
SPACECRAFT TECHNOLOGY

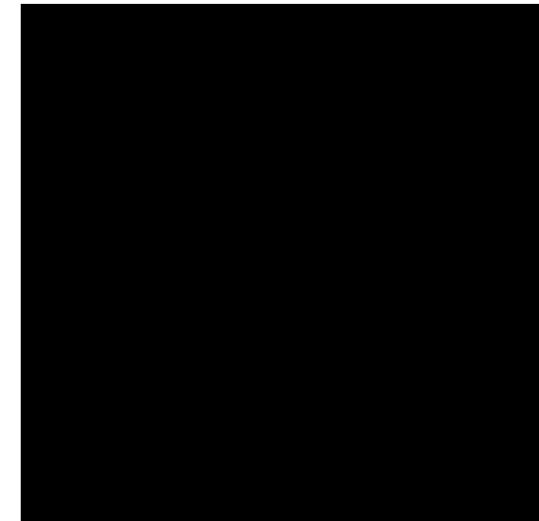
IFM FEEP technology by ENPULSION is flight proven (>100 units in space)

Propulsion on a CubeSat introduces several challenges:

- High el. power requirements
- High thermal dissipation
- Increased spacecraft alignment requirements
- Challenging operation (24/7, collision avoidance)
- Spezialized testing facilities required



Source: enpulsion.com

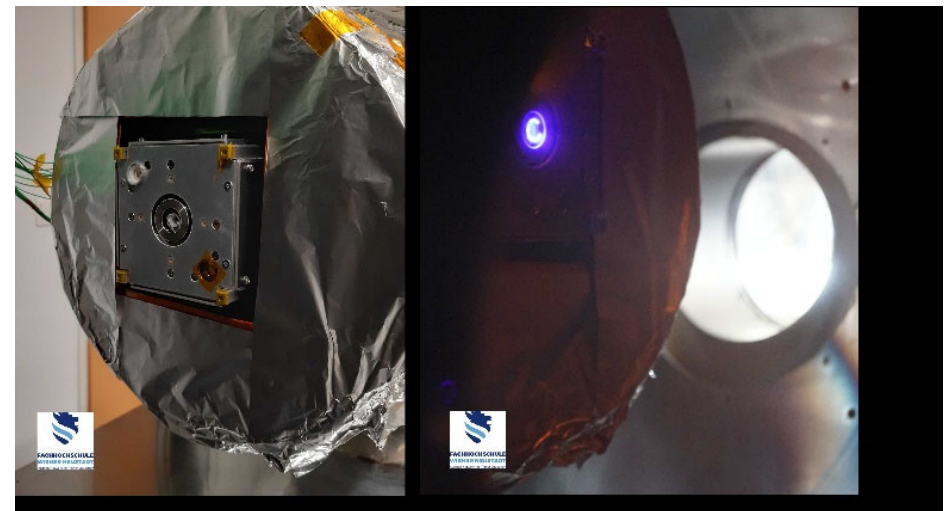
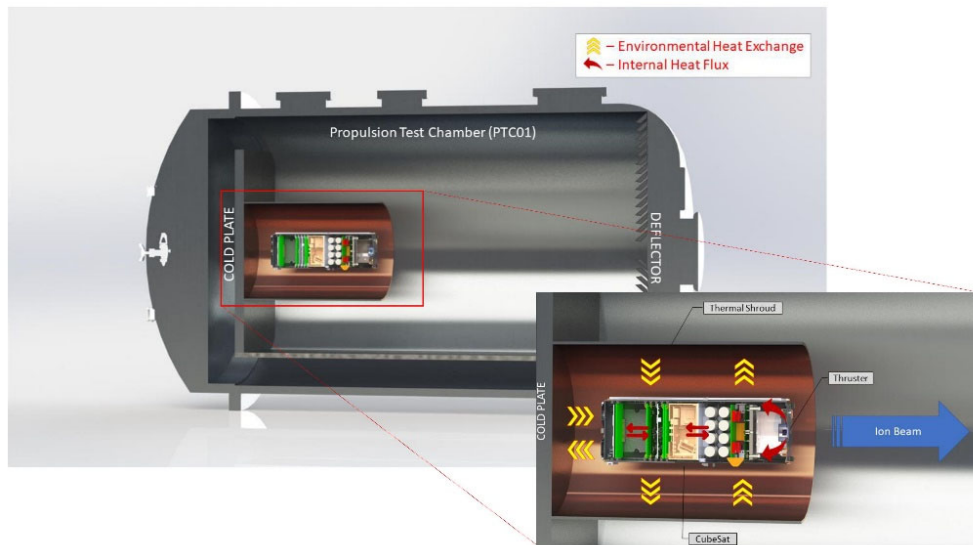


Source: enpulsion.com

CLIMB: the second CubeSat mission of the FHNW



Propulsion Testing

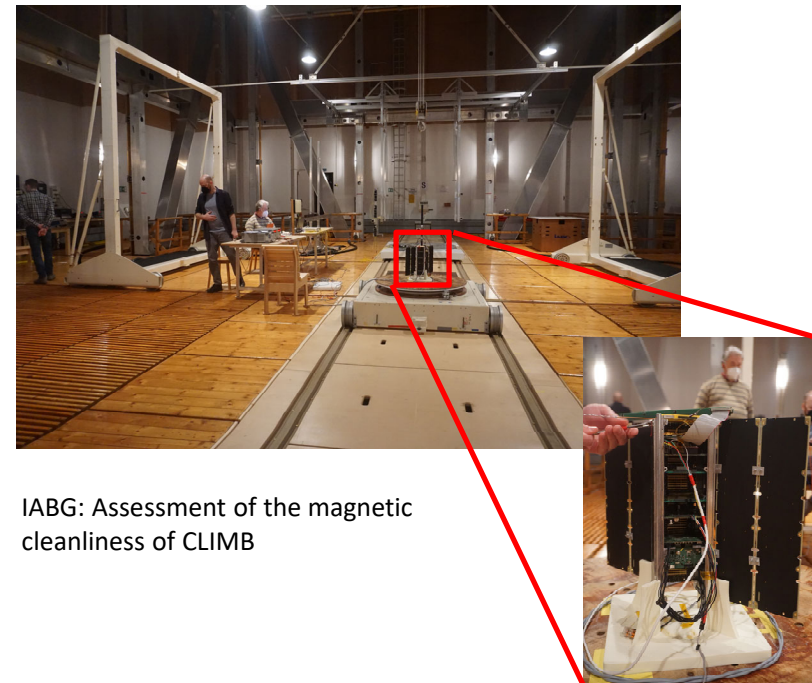
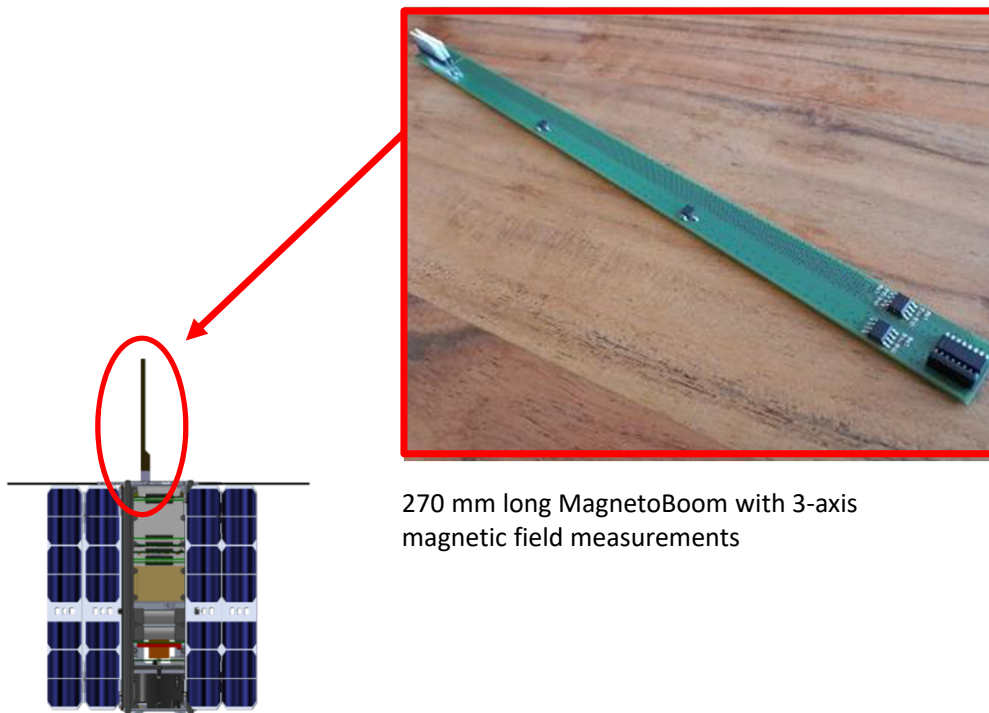


Thermal vacuum chamber: Assessment of the thermal properties with operating thruster



Magnetic field measurements

Measurement accuracy of 1-5 nT requires to assess and control the magnetic cleanliness of the CubeSat



IABG: Assessment of the magnetic cleanliness of CLIMB

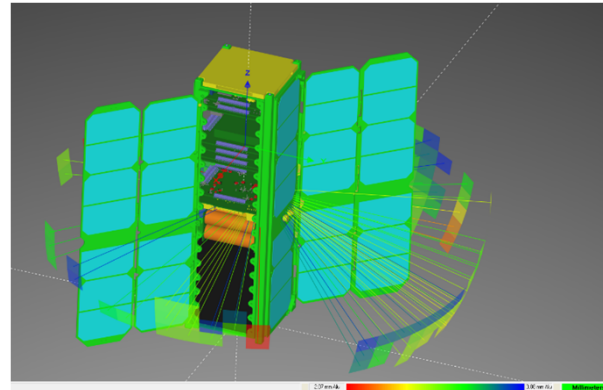
Radiation assessment



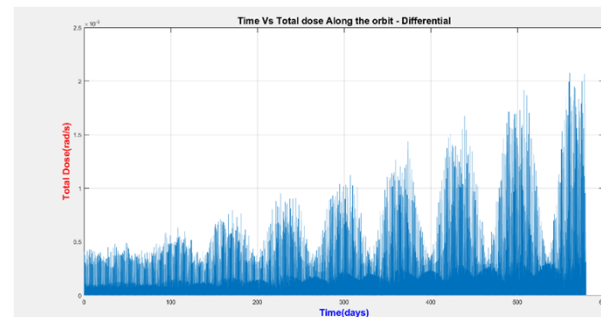
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Radiation assessments

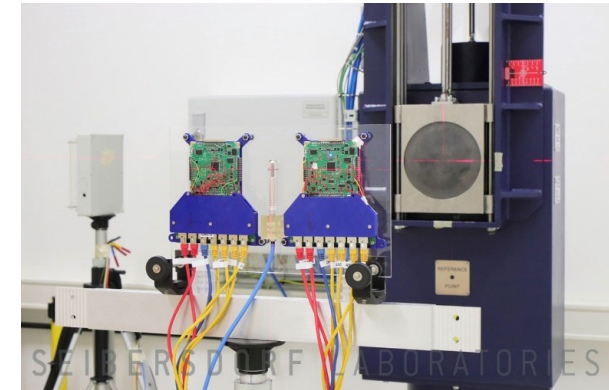
- Due to electrons as major contributor, effective shielding has to be considered and optimized
 - Complement materials at CAD model
 - Ray tracing analysis (define shielding in direction in Al thickness equivalent) calculated as worst case estimation
 - Monte Carlo calculation (based on GEANT4 implementation for interaction with matter, localize deposited dose)
- Place sensitive components on proper positions
- Find out positions, which require additional shielding
- Define dose to be taken into account at test irradiation



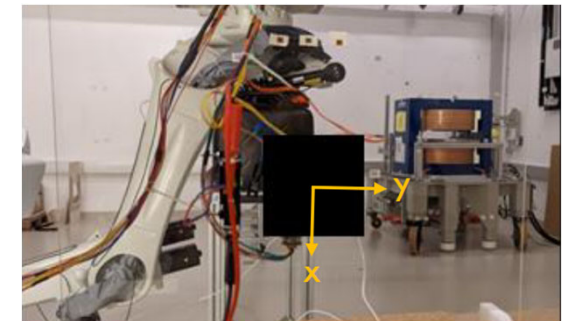
FastRad: Simulation of the received total dose



FastRad: Accumulated dose as a function of mission days



Seibersdorf Laboratories: OBC sustaining 50 krad

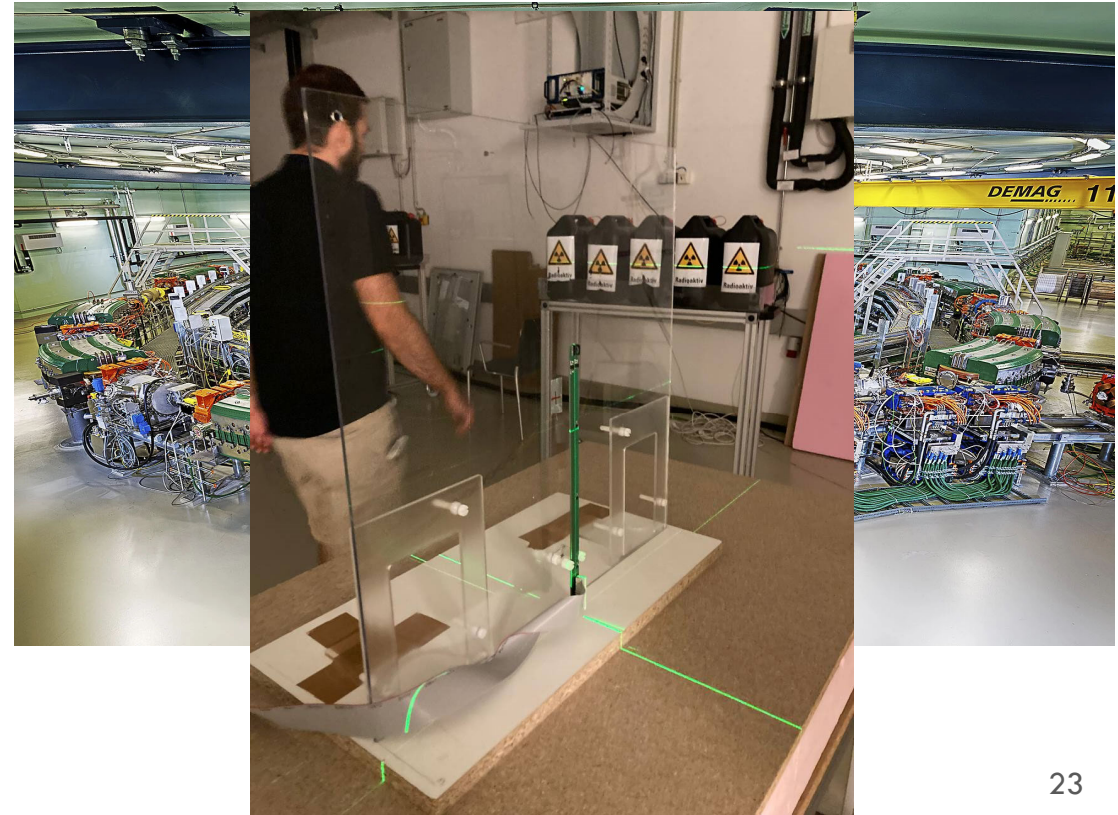


Medauston: Assessment of Single Event Effects (SEE)

Radiation assessment



Testing for single event effects (SEE) at the MedAustron in Wiener Neustadt





CLIMB communication

- CLIMB produces a large amount of data which need to be sent back
- CLIMB s/c operational software shall be updated and upgraded during the mission

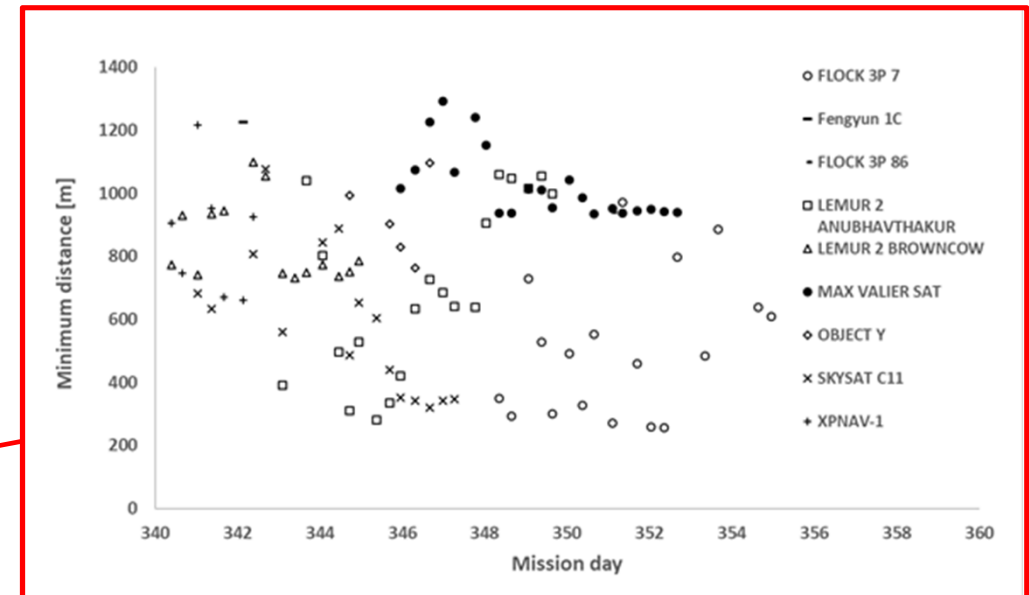
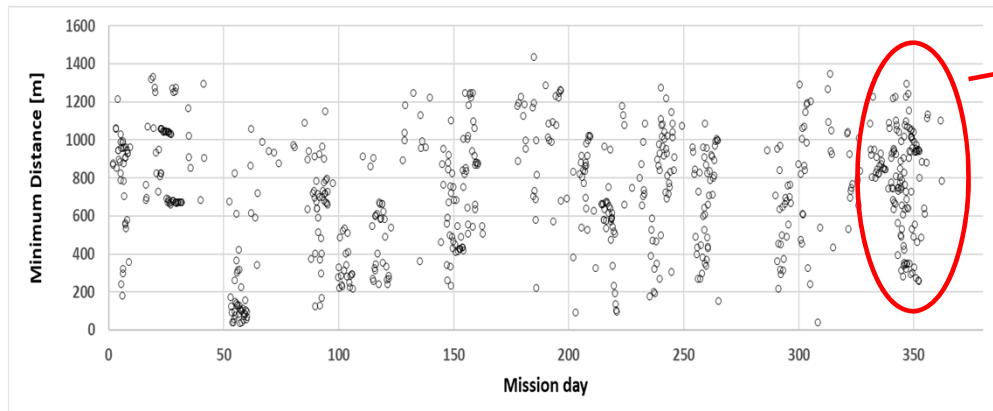




Operation planning and execution

CLIMB will require a 24/7 operation due to

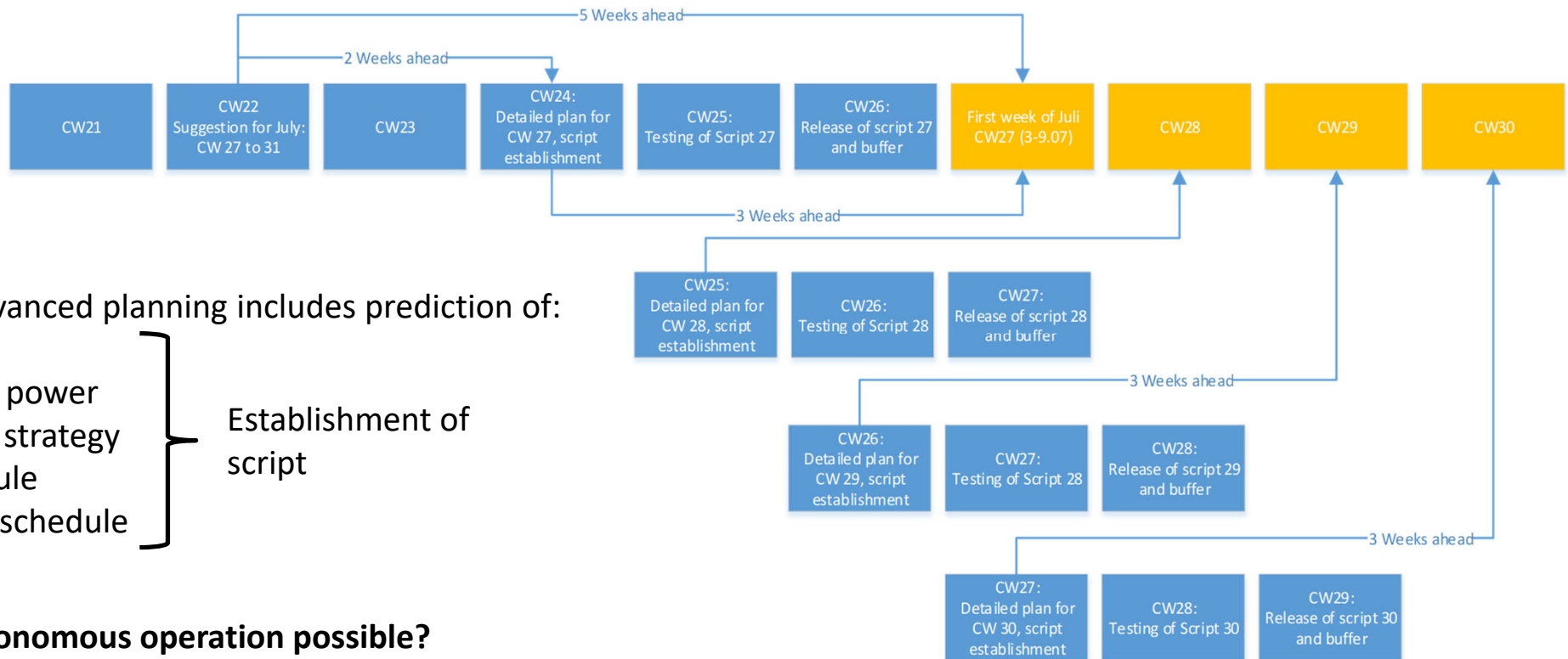
- Alignment requirements from:
 - Solar power
 - Propulsion
 - S-Band communication
- Collision avoidance requirements





Operation planning and execution

Advanced planning: Developing, testing, and uploading of scripts:

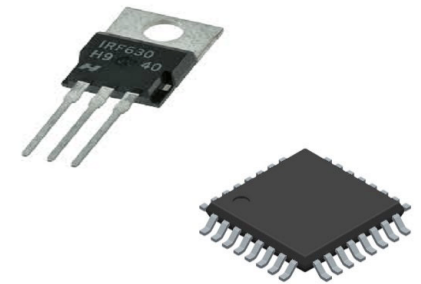
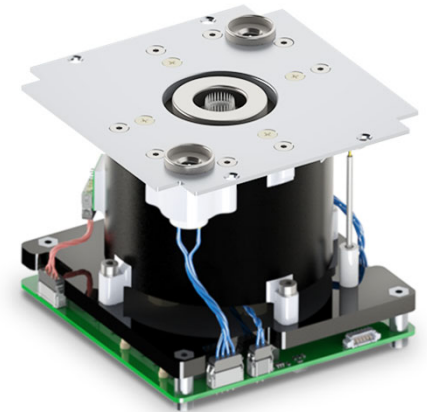


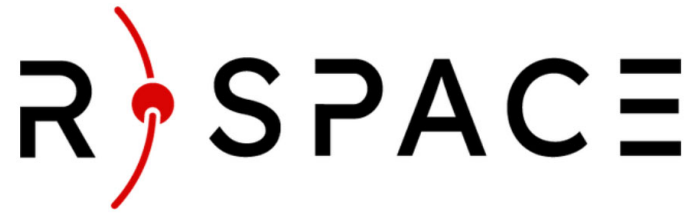
What's next?

From Education

to

Business





We accelerate Space

- The new way to conduct IOD/IOVs
- R-Space will ensure the launch of an IOD/IOV mission within **6 months**
- The GreenBox Service is a **one-stop shop service** using **strategic partnerships** with launch provider and ground station networks
- The GreenBox service can **accelerate the development** (by IOD) of upstream technologies and allows the customer to generate the required data to **proof functionality in space**



Fast

Smart

Easy

We accelerate Space