A satellite's final safehouse: The deployer

SPACE LIBRE FOUNDATION PICOBUS

Libre Space Foundation

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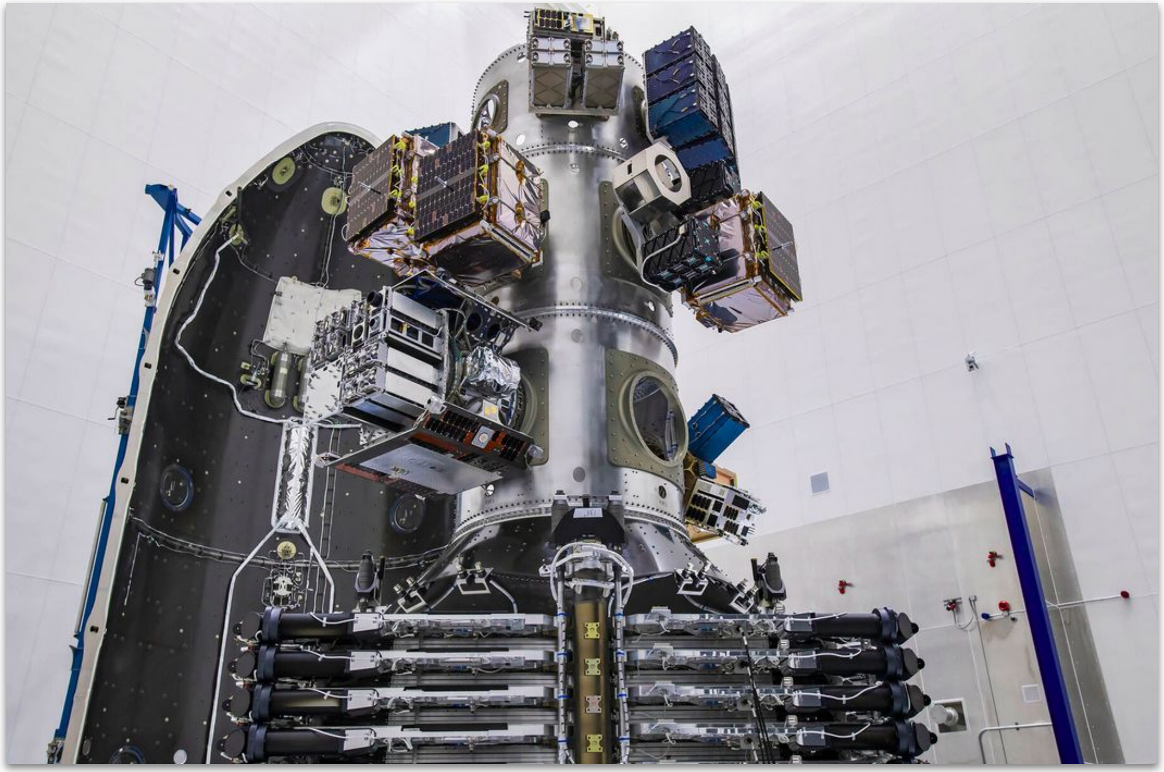
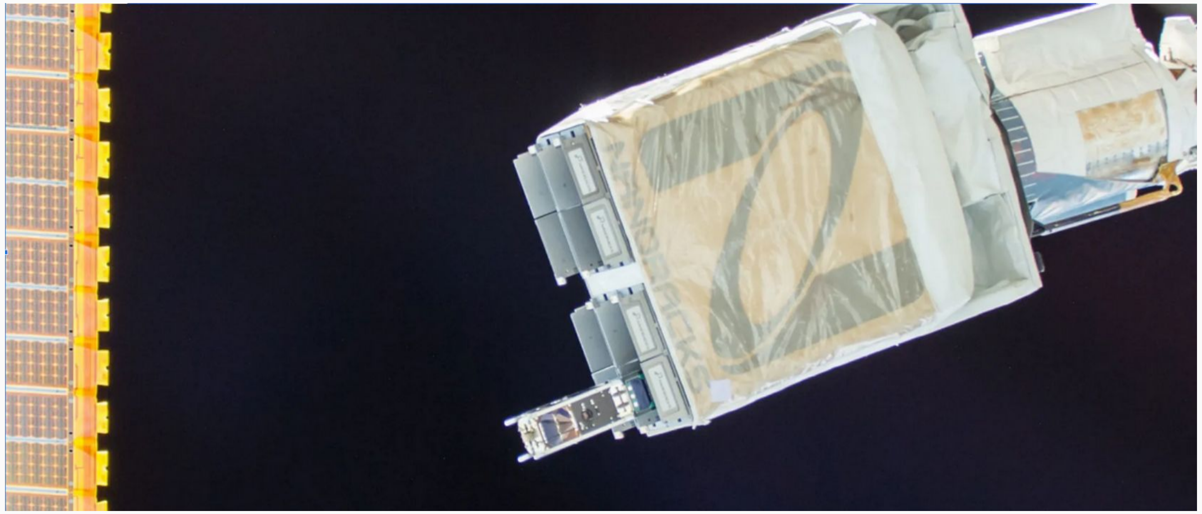
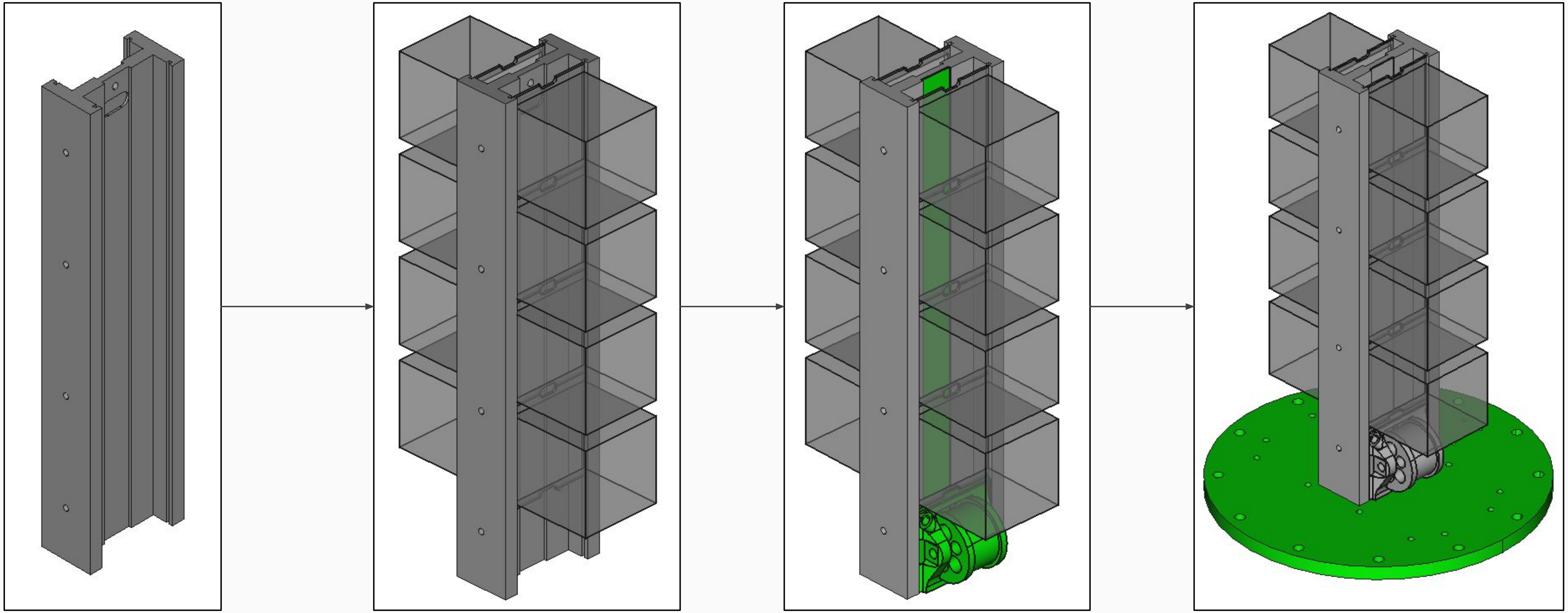
What is a satellite deployer?

- The satellite's final safe house
  - Mounted on the rocket's payload bay (most of the times)
  - Stores the satellites safely inside
  - Deploys the satellites when the time comes

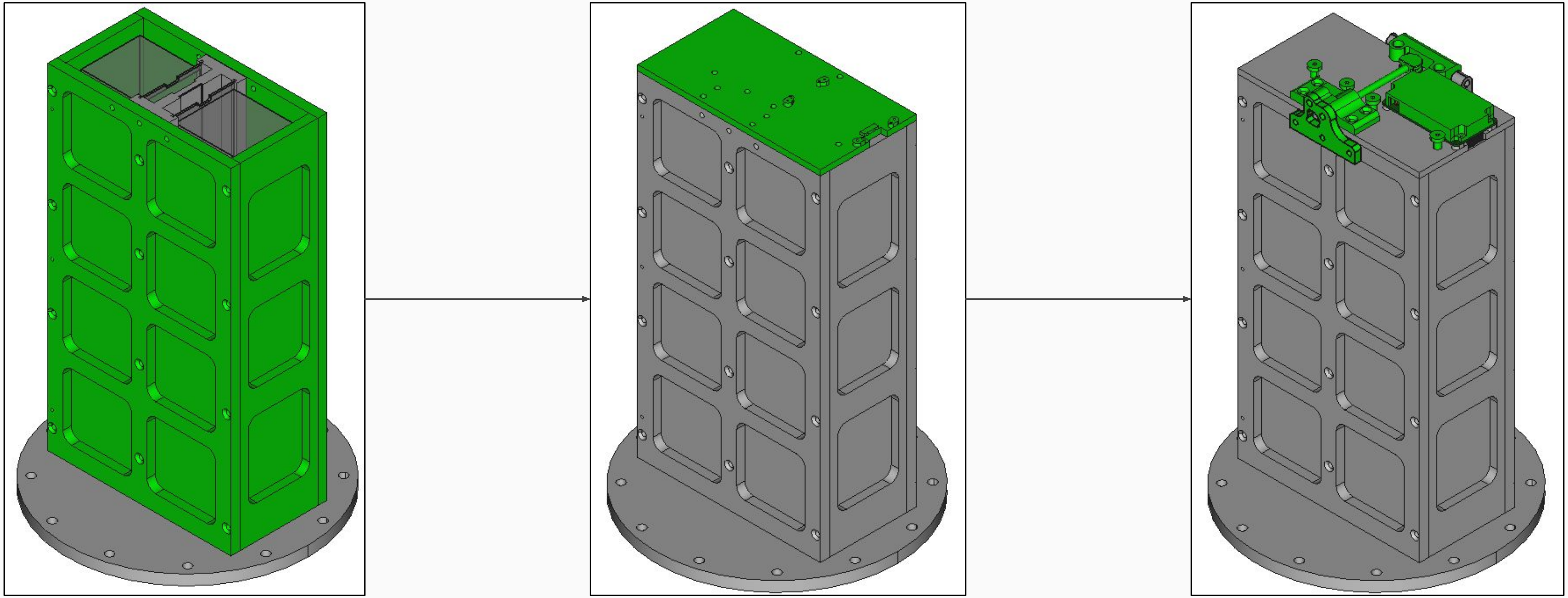




System overview of the PICOBUS deployer



System overview of the PICOBUS deployer

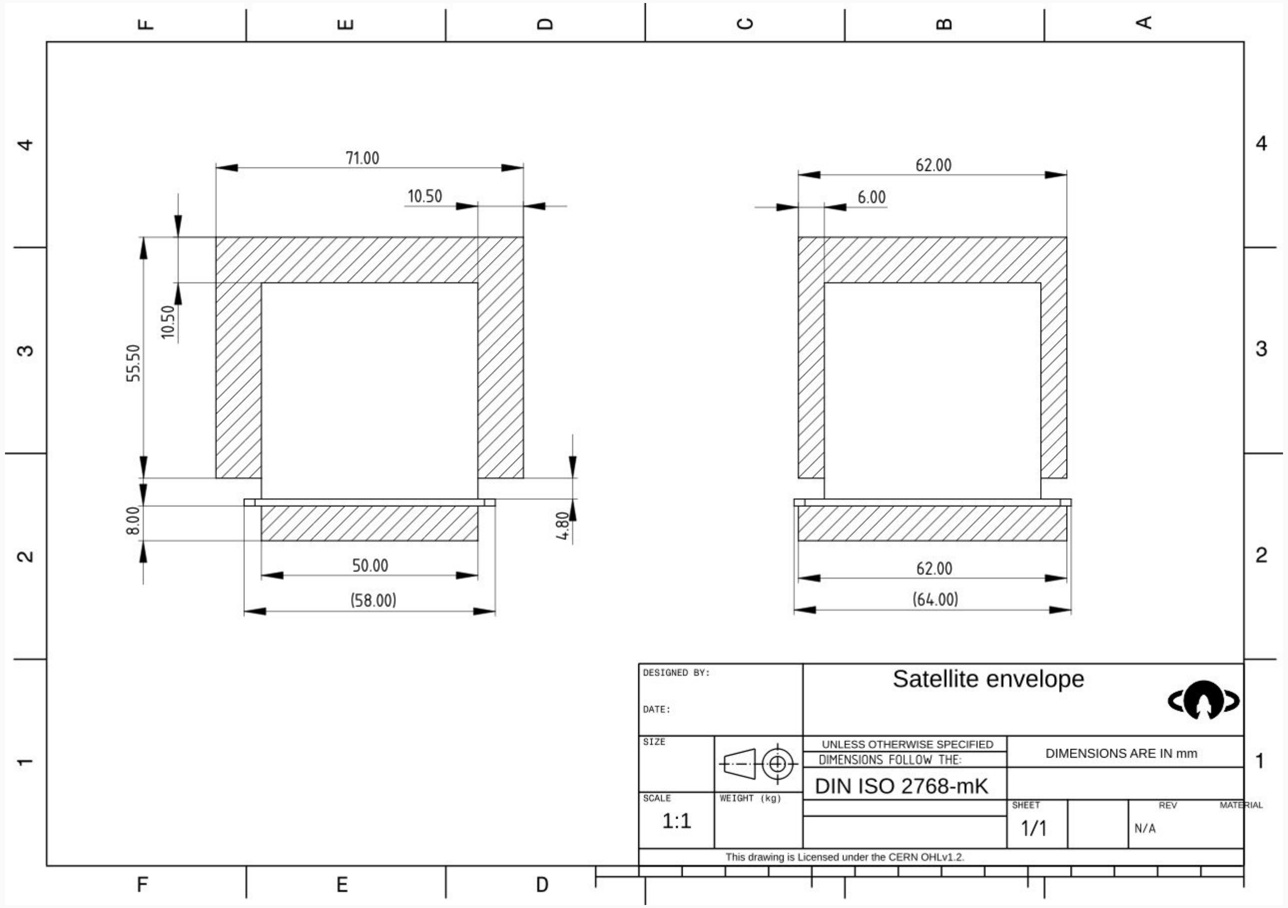


A deeper dive inside PICOBUS

Rail

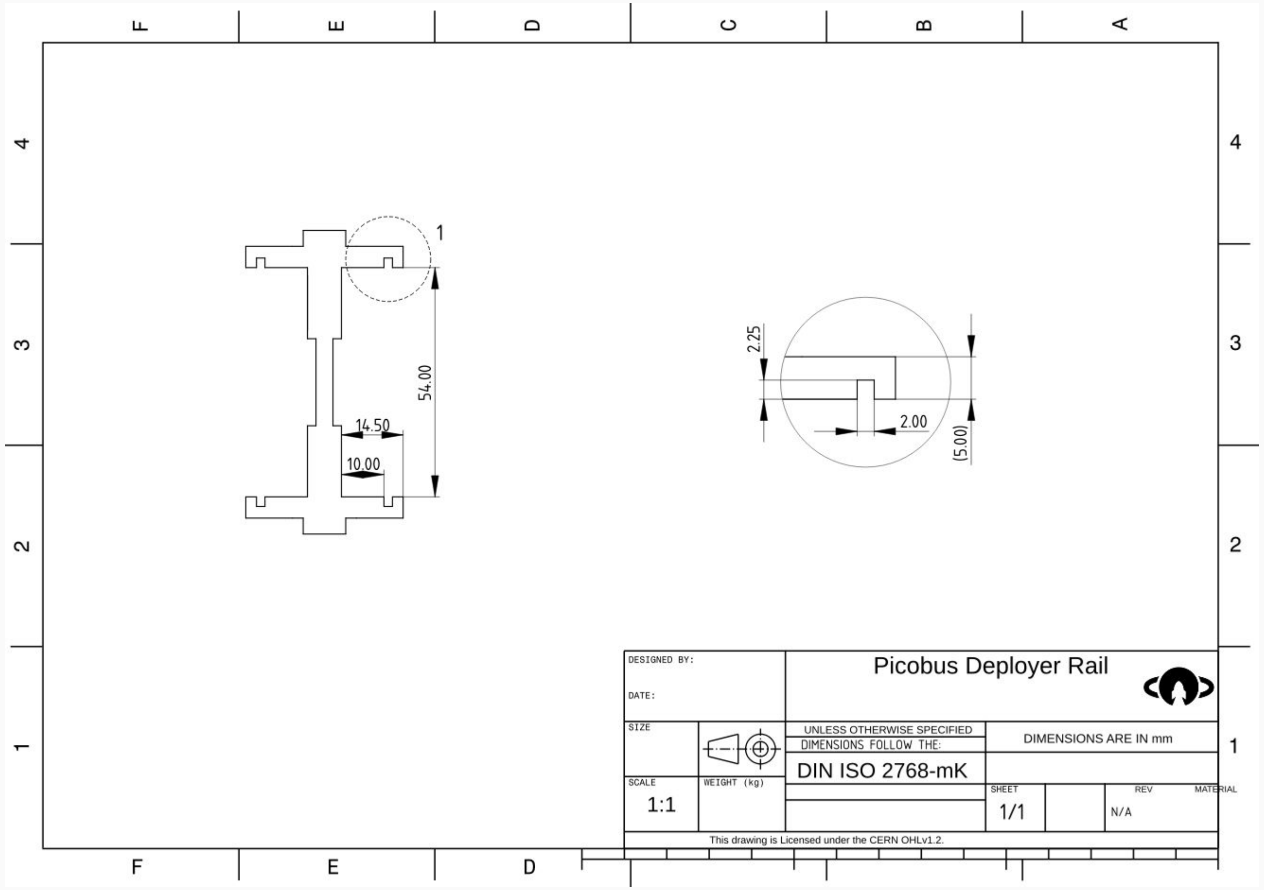
- The rail is the part that comes in contact with the satellites.

- We followed the Pocketqube standard, which gave us the standard dimensions of one pocketqube.



Rail

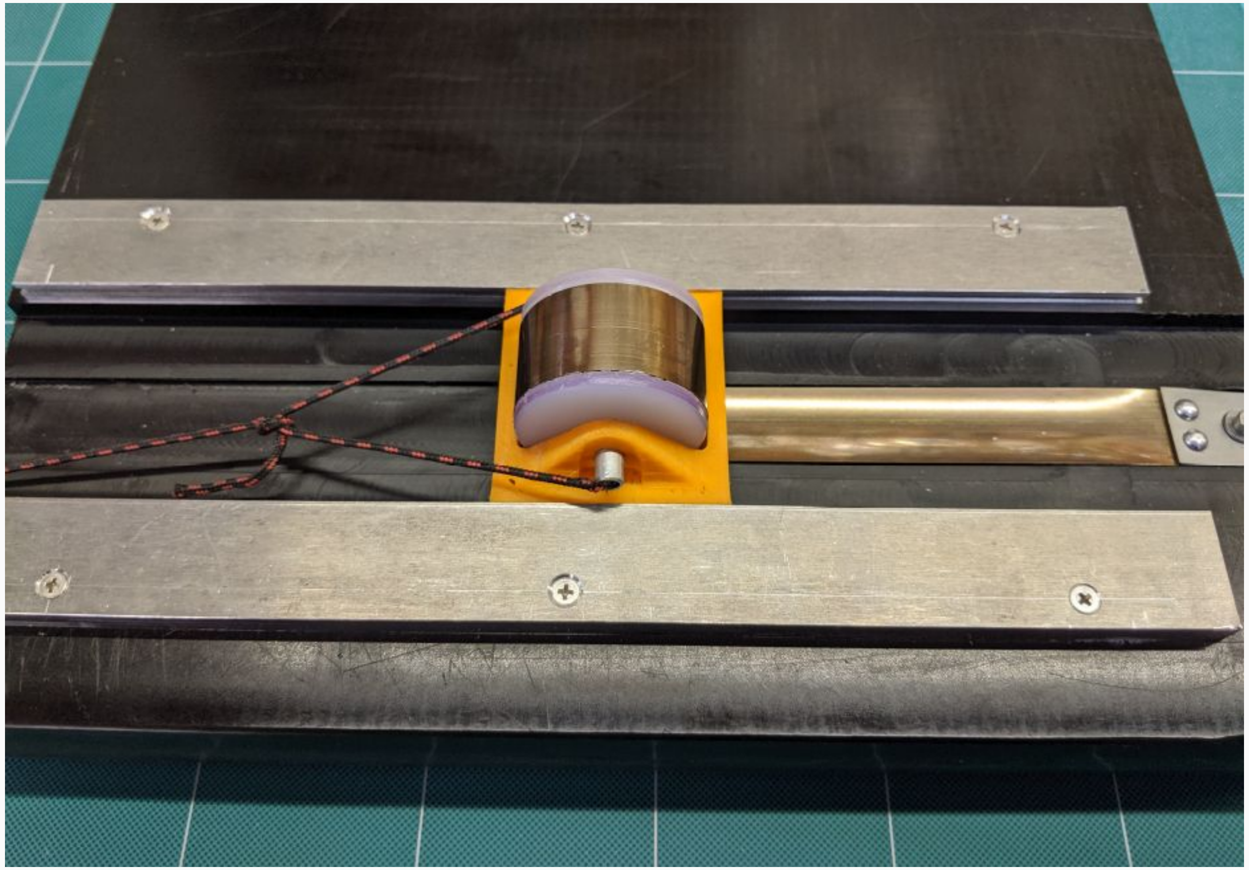
- The rail was a machined out of 7075-T6 space grade aluminum alloy and had a 2mm slot for the satellites to slide onto.
- It was hard anodized in order to give as much strength to the surface as possible.



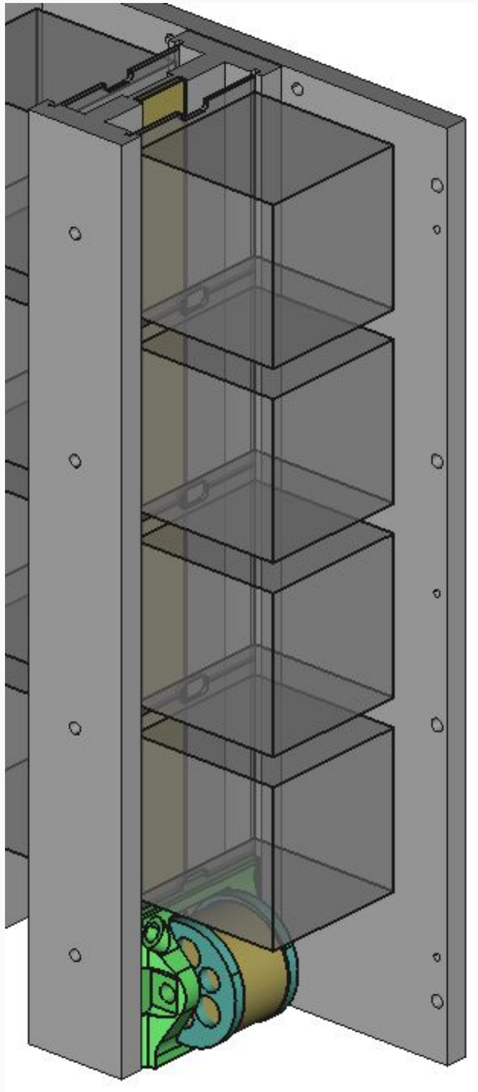
Pusher sub-assembly

- Constant force springs were used for the deployment of the satellites.
- Quick paper-towel calculations gave us a rough estimate of the spring strength and satellite exit velocity.
- Finally we machined a dummy rail, 3D printed pushers and attached a spring in order to have the complete assembly for testing.

Let's see the pusher in action

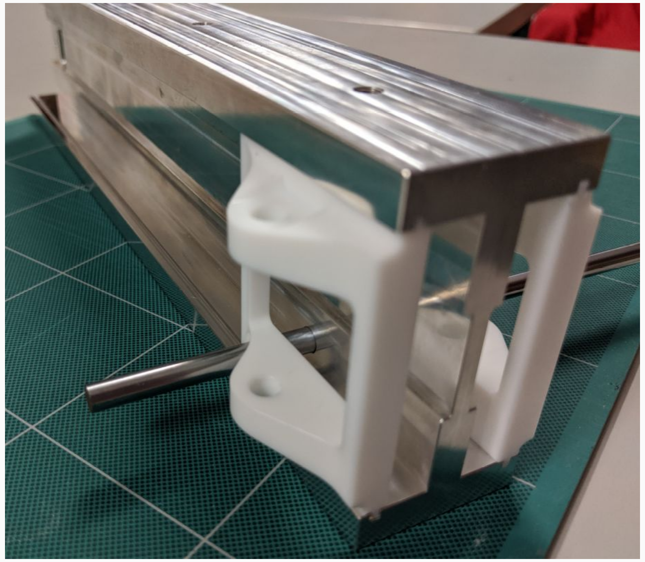


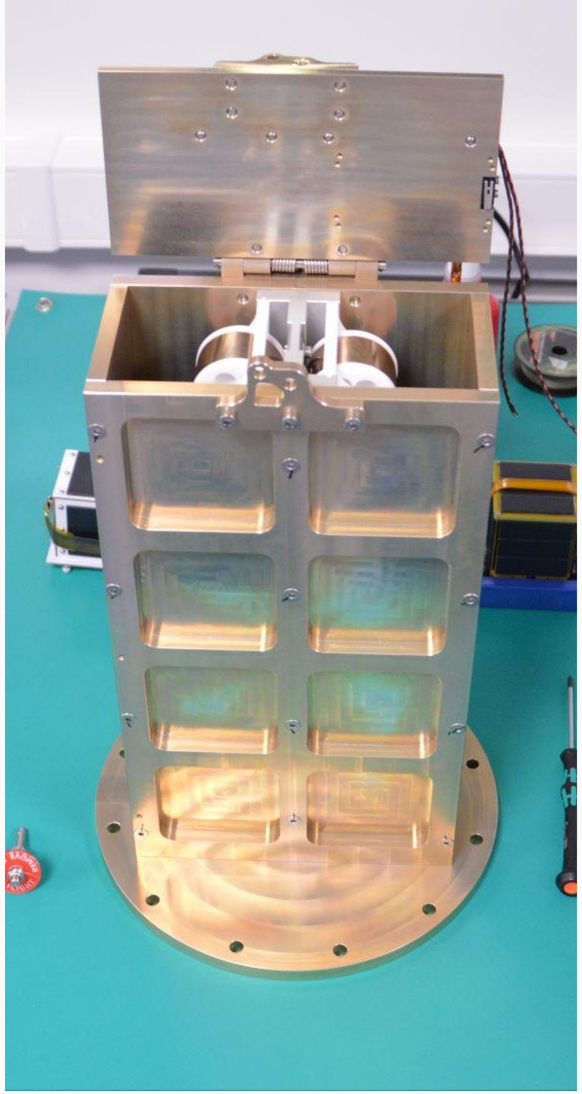
Pusher sub-assembly



After multiple iterations and broken 3d printed parts, the design closed, and the final parts were manufactured.

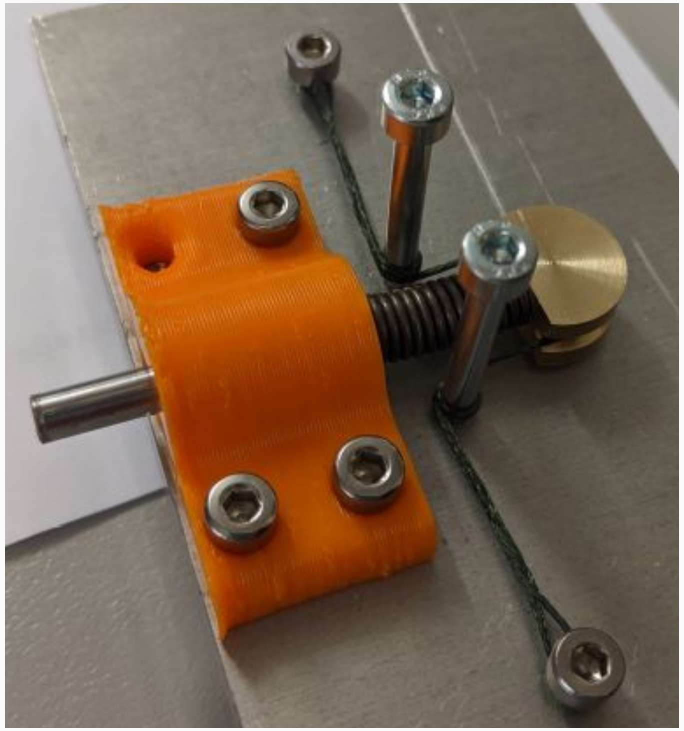
- Pusher part was made out of a single PTFE (teflon) block interfacing with the aluminum deployer rail
- Barrel part made of a single PTFE block too
- The constant force (linear) spring was wrapped around the barrel part and secured on top of the rail.



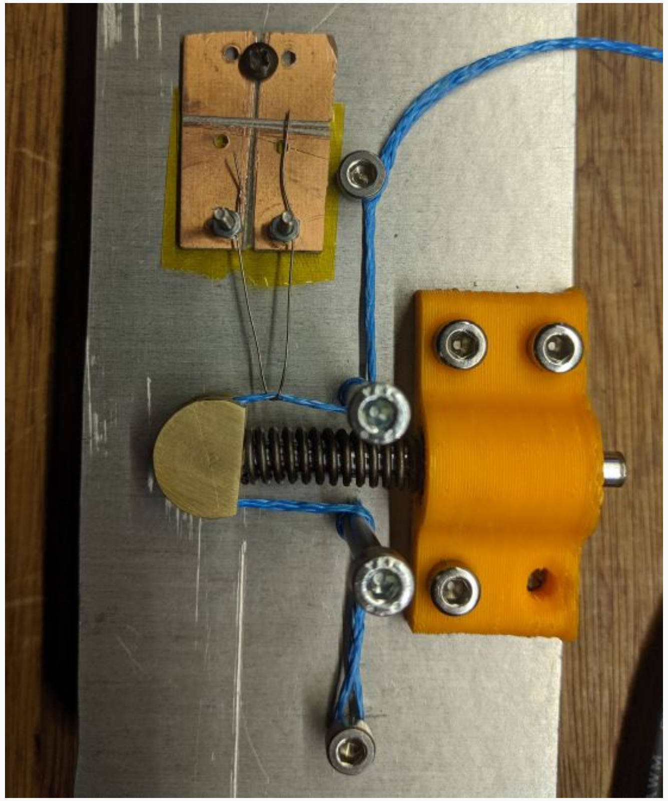


Door sub-assembly and thermal knives mechanism

- A pin is used to hold the door shut.
- For holding the pin in place, we used a spring and dyneema string to keep the spring compressed.



- When signal is given from the rocket, nichrome wire is used to cut the dyneema string

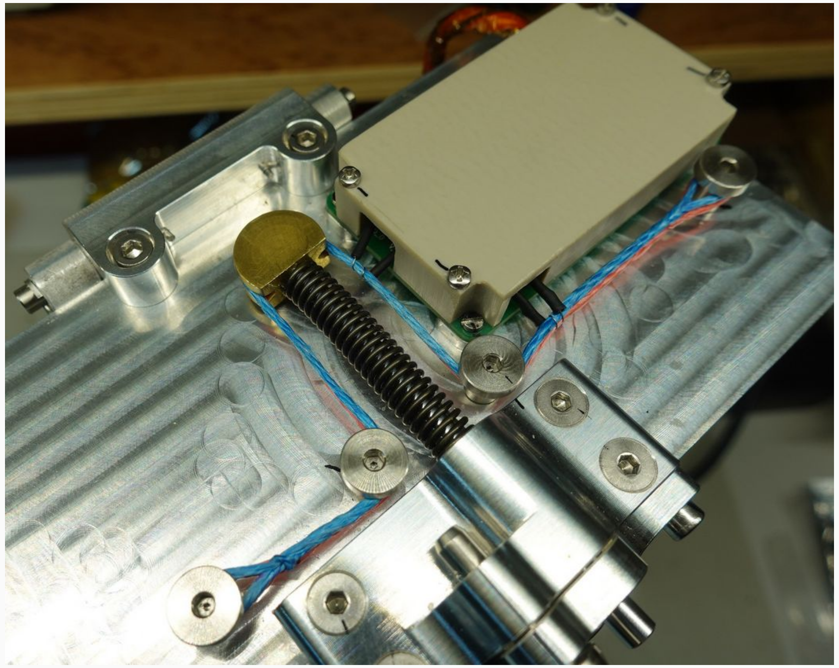


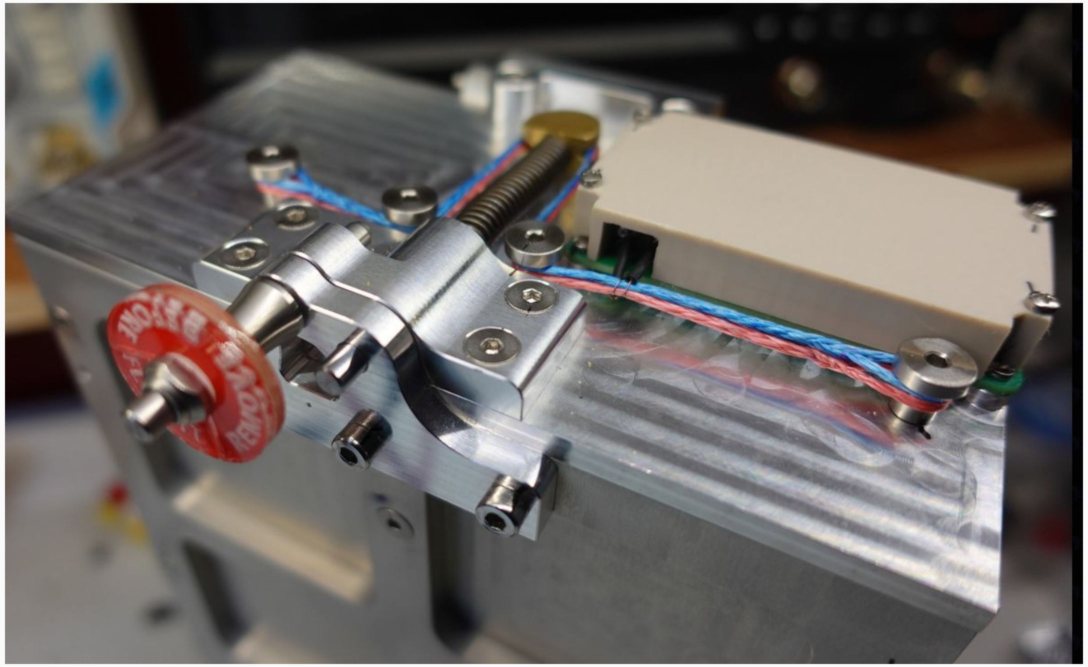
Door sub-assembly and thermal knives mechanism

- The use of dedicated electronics was obvious. This PCB would handle communication with the rocket, the thermal knives and the deployment switch.

- Two thermal knives were used to cut the dyneema string attached to the PCB itself. This made the system redundant, because only one thermal knife was needed for deployment.

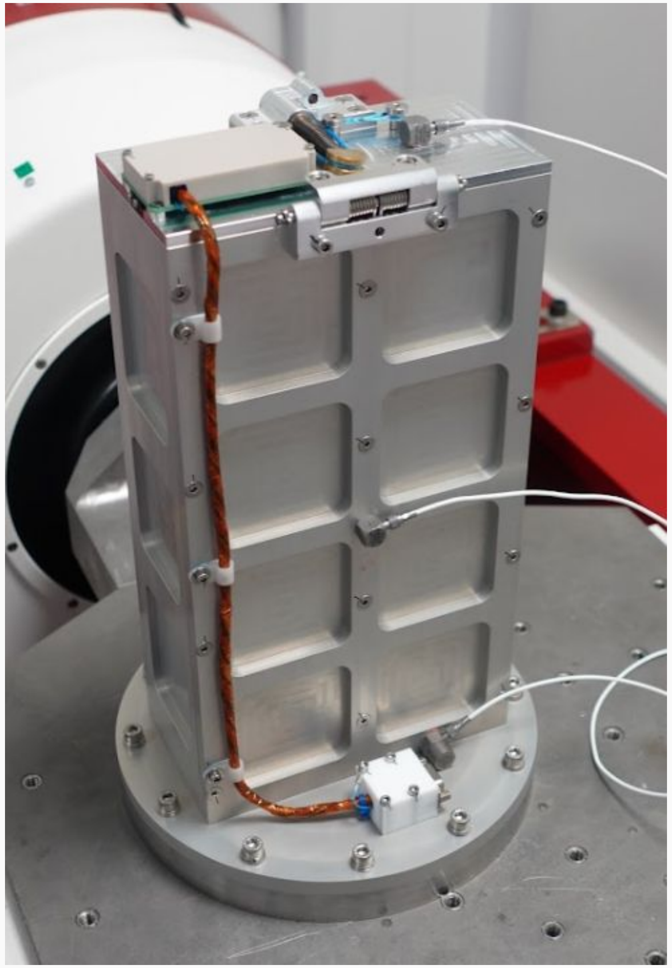
Door sub-assembly and thermal knives mechanism

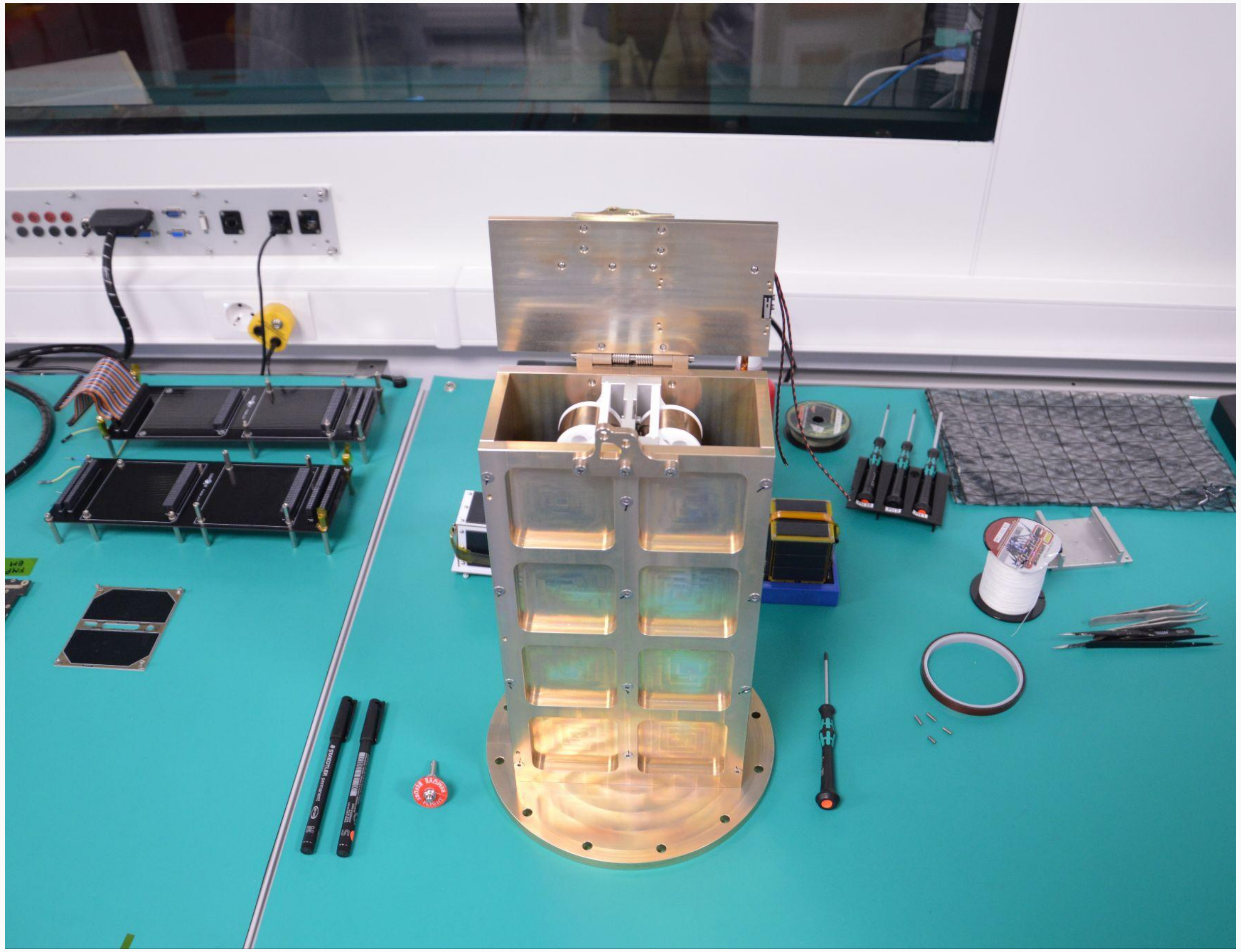




So the door sub-assembly was complete and was ready to be integrated to the rest of the deployer

PICOBUS

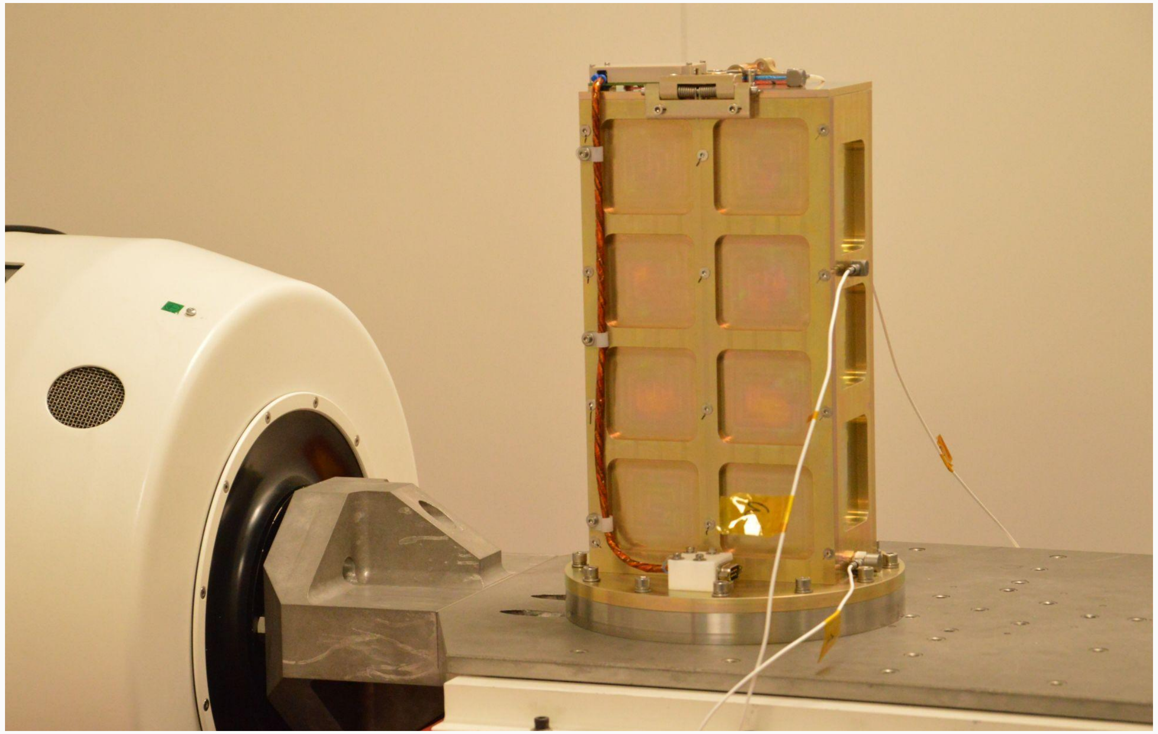




Let’s see PICOBUS in action

Protoflight testing

- Protoflight == prototype + flight hardware
  - The qualification model is the same as the flight hardware
  - The satellites were integrated inside PICOBUS during the test



Vibration testing procedure

Step 1: Resonance survey

Identifying the resonance frequencies of the device under testing
Usually >100-150Hz depending on the launcher requirements

Accelerometer #2 (Red)		Pre Survey	
		Frequency (Hz)	Amplitude (g)
X	Resonance 1	300	3.2
	Resonance 2	400	1.2
	Resonance 3	900	1.1
Y	Resonance 1	220	1
	Resonance 2	500	2
	Resonance 3	2000	1.1
Z	Resonance 1	400	2
	Resonance 2	800	3
	Resonance 3	1600	1.1

Accelerometer #3 (Green)		Pre Survey	
		Frequency (Hz)	Amplitude (g)
X	Resonance 1	300	1.2
	Resonance 2	400	500.0 m
	Resonance 3	1400	600.0 m
Y	Resonance 1	400	1
	Resonance 2	700	1
	Resonance 3	2000	1.3
Z	Resonance 1	500	4
	Resonance 2	1030	600.0 m
	Resonance 3	1600	2

Step 2: Sine vibration profile

Passing from 5Hz to 125Hz with a sine wave profile

Table 3 - Resonance survey profile

Frequency (Hz)	Level (g)
5 – 2000	0.4

Table 4 - Sine Vibration

Frequency (Hz)	Level (g)	Sweep Rate (oct/min)
5 – 100	2.5	4
100 - 125	1.25	

Table 5 - Quasi Static Shock

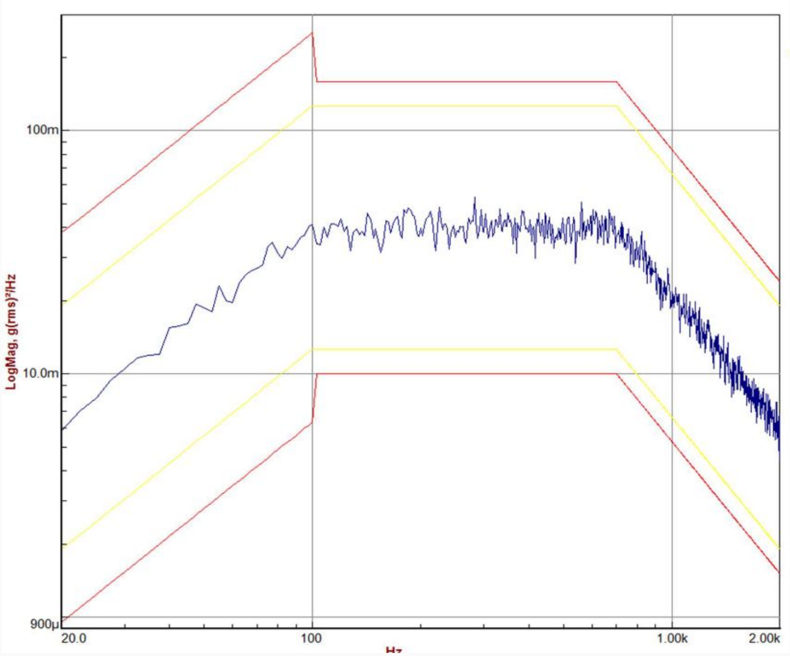
Frequency (Hz)	Level (g)	Full Cycles
50	9.6	5

Table 6 - Random Vibration

Frequency (Hz)	Level (g^2/Hz)	Overall (g_{rms})	Test Time (s)
20	0.006	10.0	60
20-100	0.006 + 6 dB/oct		
100-700	0.04		
00-2000	0.04 – 6 dB/oct		
2000	0.006		

Step 3: Random vibration

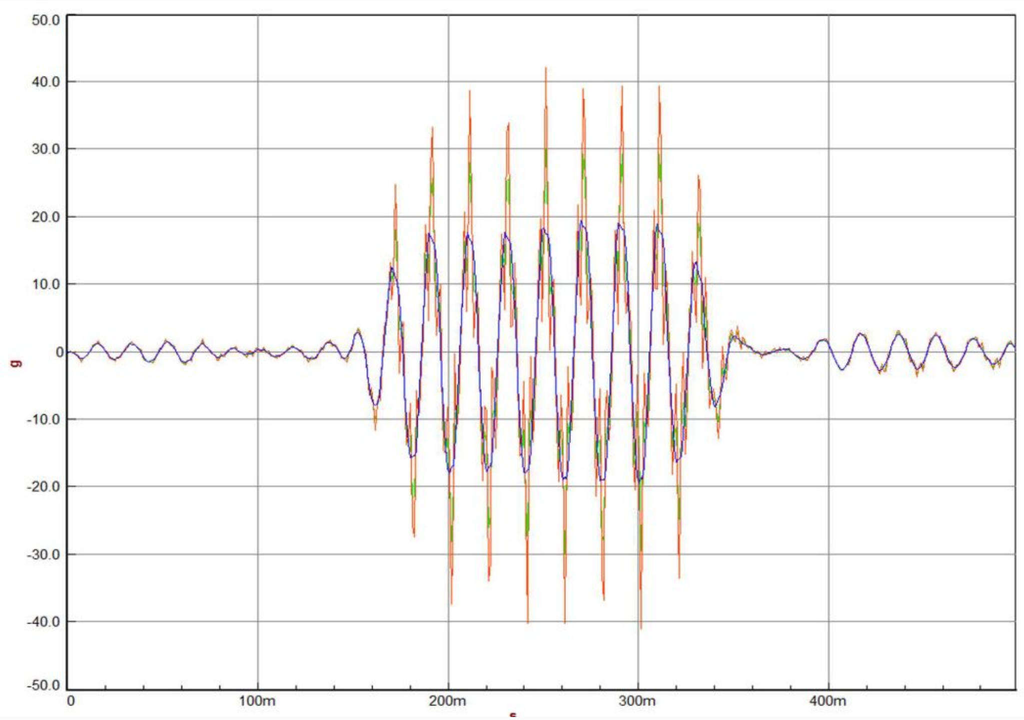
Passing through the whole spectrum from 20Hz up to 2kHz at once for a specific amount of time



Vibration testing procedure

Step 4: Quasistatic

Simulates the static loads exerted on the deployer during launch



Step 5: Resonance survey

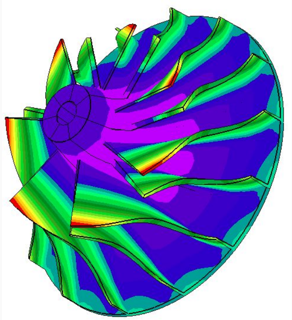
Identifying the resonance frequencies of the device under testing again and comparing them with the ones found at the beginning of the test

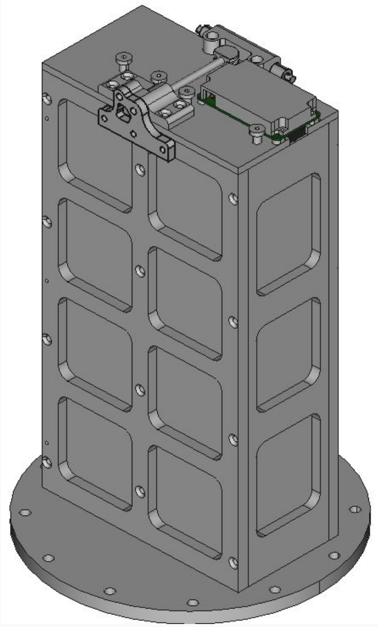
Table 7 - Spacecraft resonance frequencies

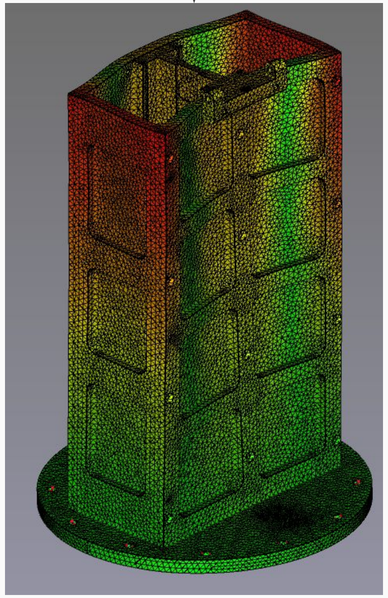
Accelerometer #2 (Red)		Pre Survey		Post survey	
		Frequency (Hz)	Amplitude (g)	Frequency (Hz)	Amplitude (g)
X	Resonance 1	300	3.2	300	3.2
	Resonance 2	400	1.2	400	1.2
	Resonance 3	900	1.1	900	1.1
Y	Resonance 1	220	1	220	1.1
	Resonance 2	500	2	500	2
	Resonance 3	2000	1.1	2000	1.1
Z	Resonance 1	400	2	400	1.2
	Resonance 2	800	3	800	3.2
	Resonance 3	1600	1.1	1600	1.1

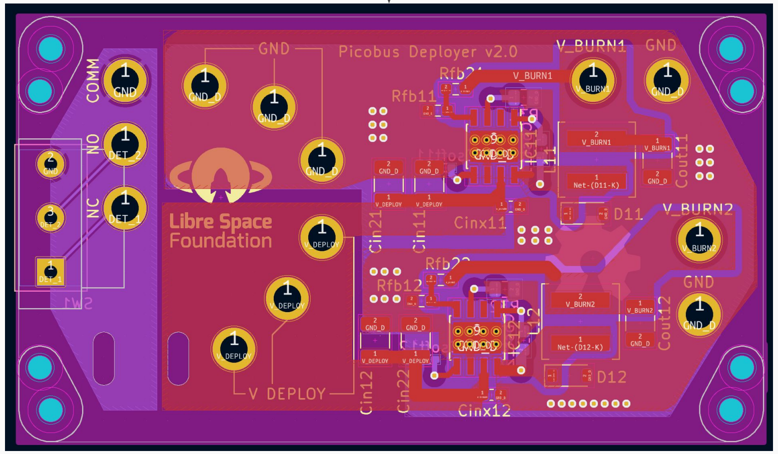
Accelerometer #3 (Green)		Pre Survey		Post survey	
		Frequency (Hz)	Amplitude (g)	Frequency (Hz)	Amplitude (g)
X	Resonance 1	300	1.2	300	1.2
	Resonance 2	400	500.0 m	400	500.0 m
	Resonance 3	1400	600.0 m	1400	600.0 m
Y	Resonance 1	400	1	400	1
	Resonance 2	700	1	700	1
	Resonance 3	2000	1.3	2000	1.6
Z	Resonance 1	500	4	500	2
	Resonance 2	1030	600.0 m	1030	1
	Resonance 3	1600	2	1600	1.8

Open source design and simulation tools

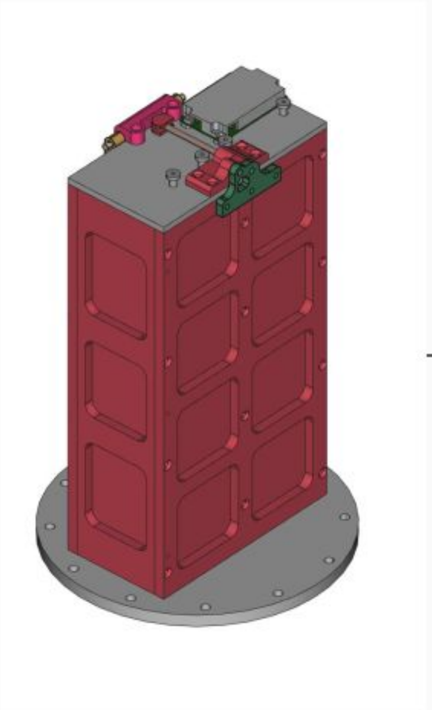


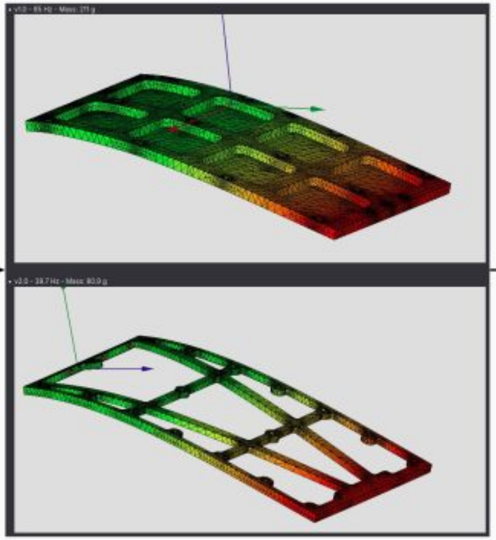


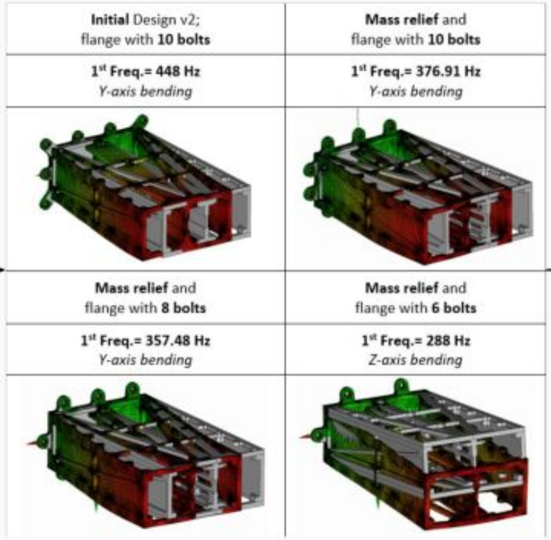


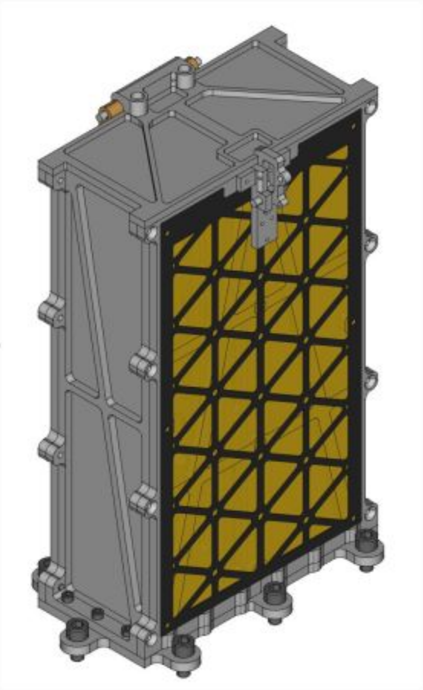


PICOBUS V2

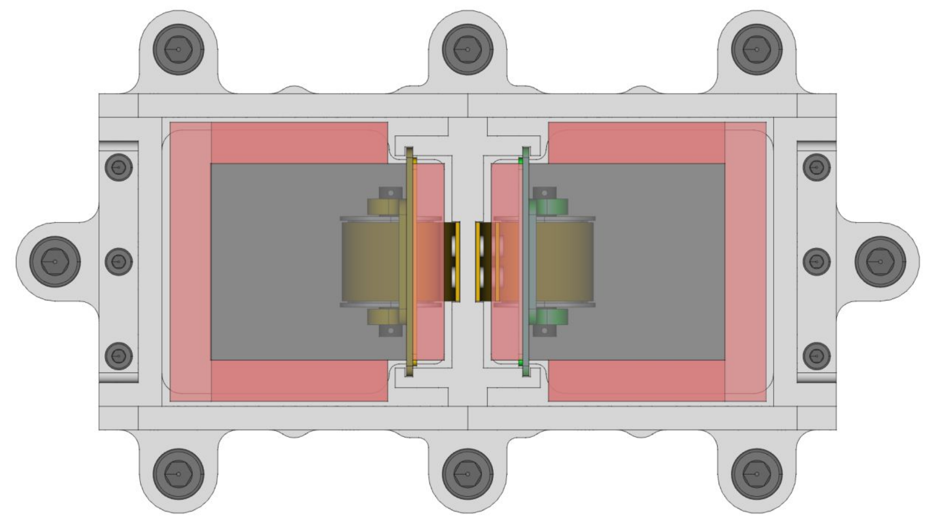


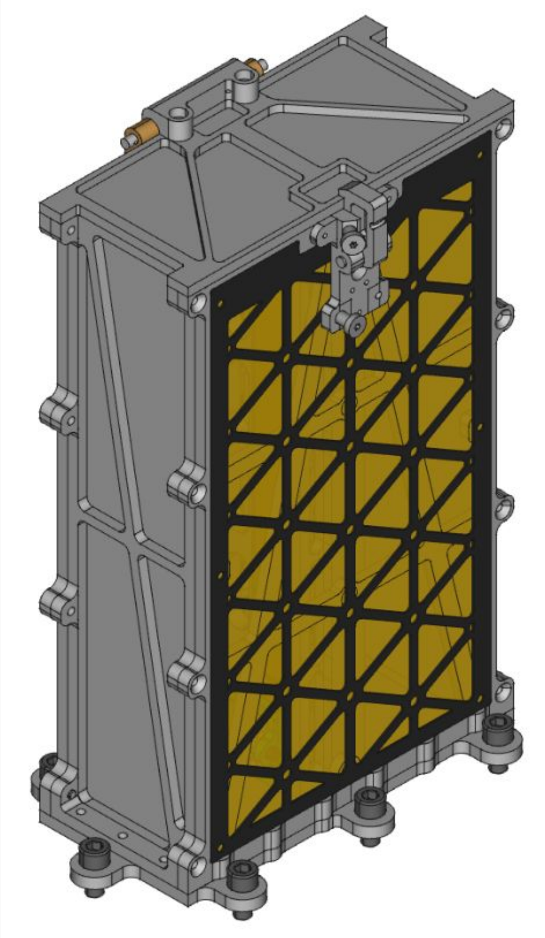


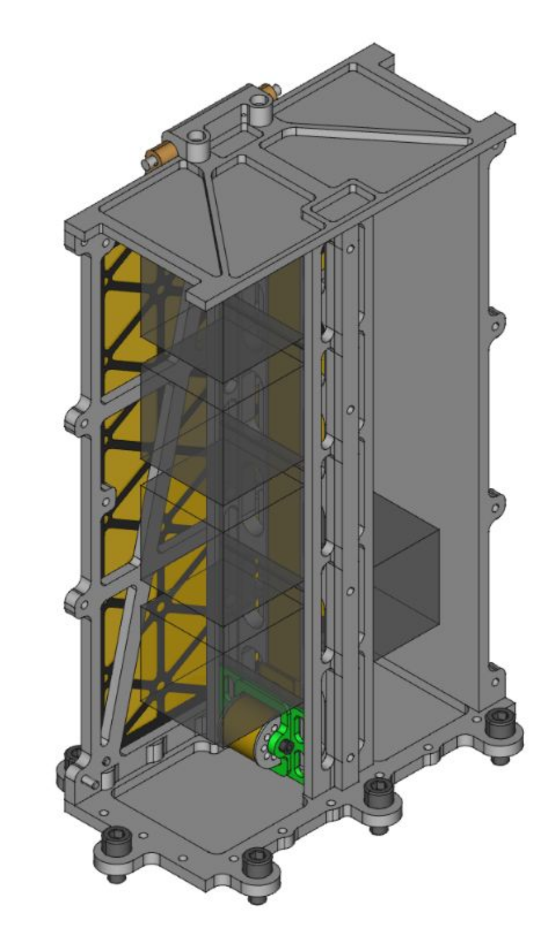

Initial Design v2; flange with 10 bolts
1st Freq.= 448 Hz
Y-axis bending
Mass relief and flange with 10 bolts
1st Freq.= 376.91 Hz
Y-axis bending
Mass relief and flange with 8 bolts
1st Freq.= 357.48 Hz
Y-axis bending
Mass relief and flange with 6 bolts
1st Freq.= 288 Hz
Z-axis bending



- PICOBUS V2
    - 8p capacity
    - Half the mass of V1
    - Smaller deployer envelope
    - Larger satellite envelope
    - Updated electronics

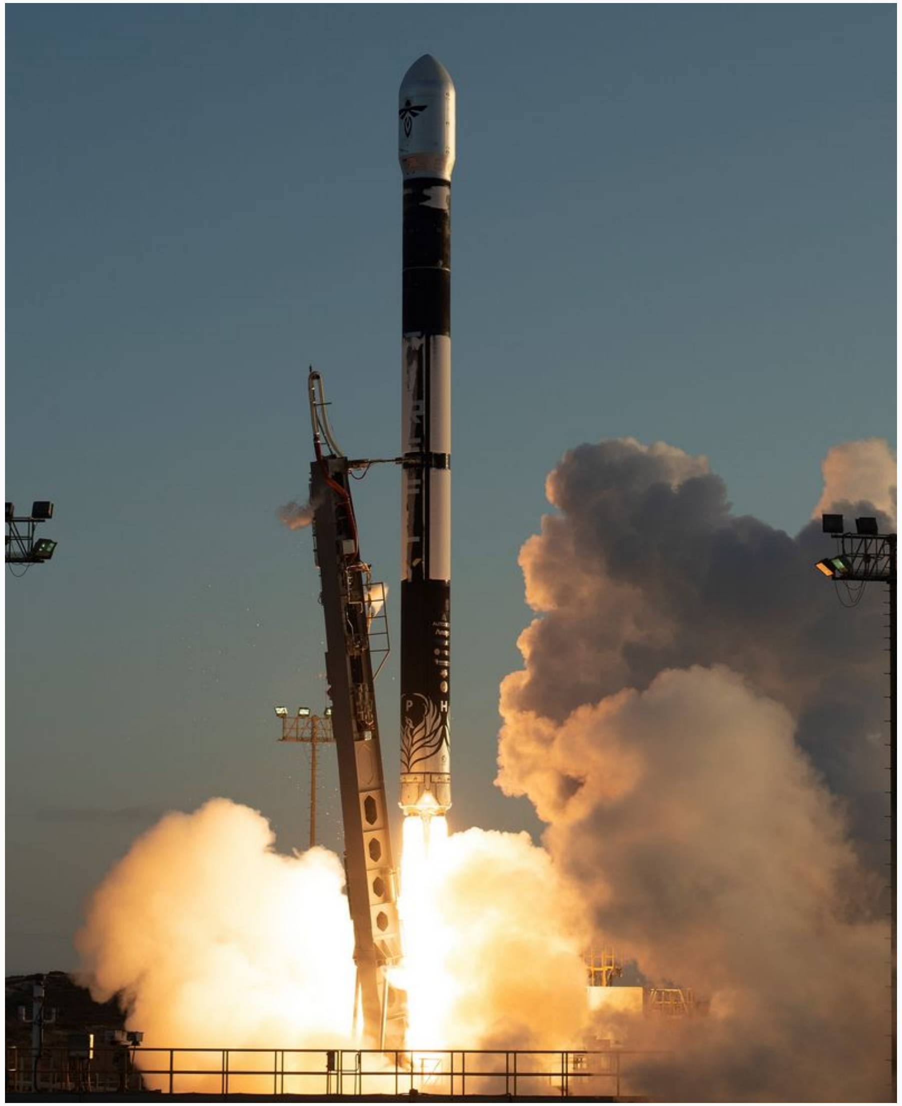






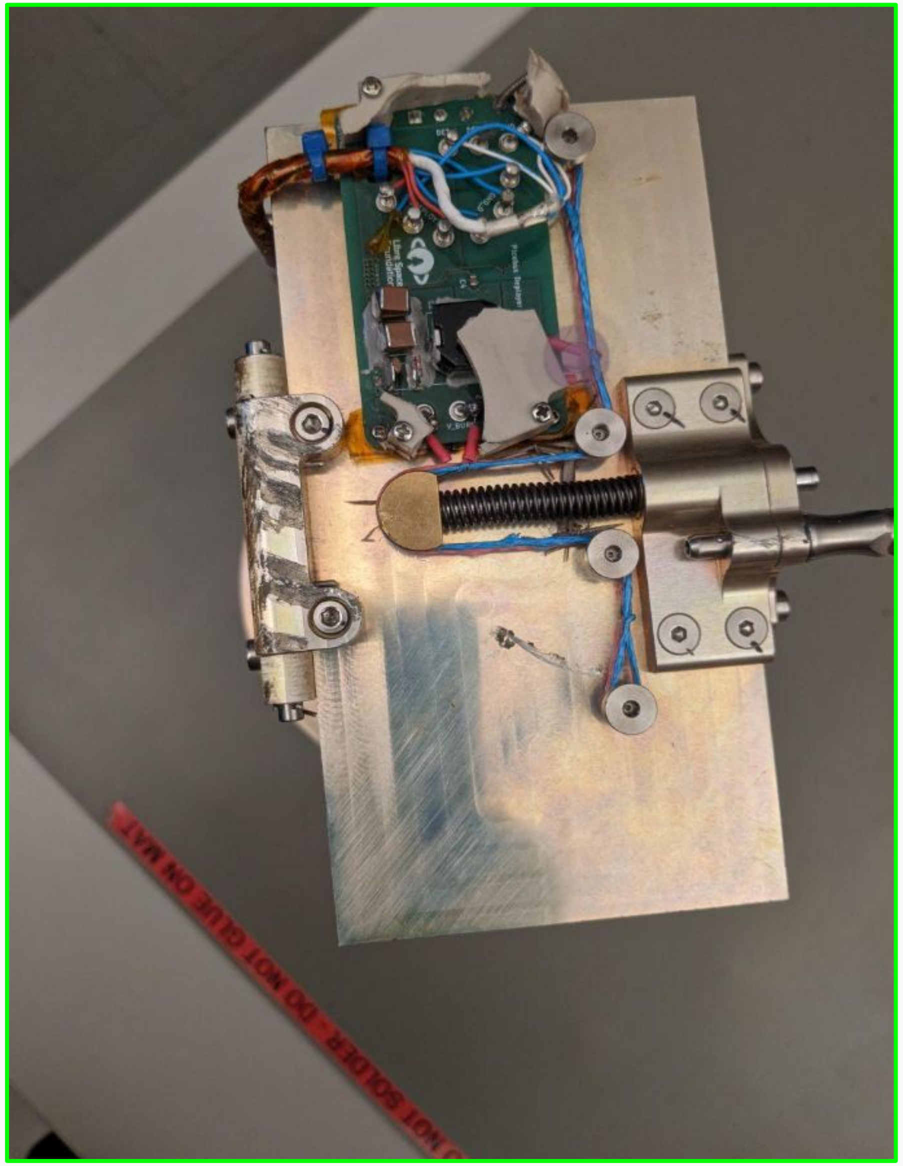
Before we leave, a few words about the picobus story

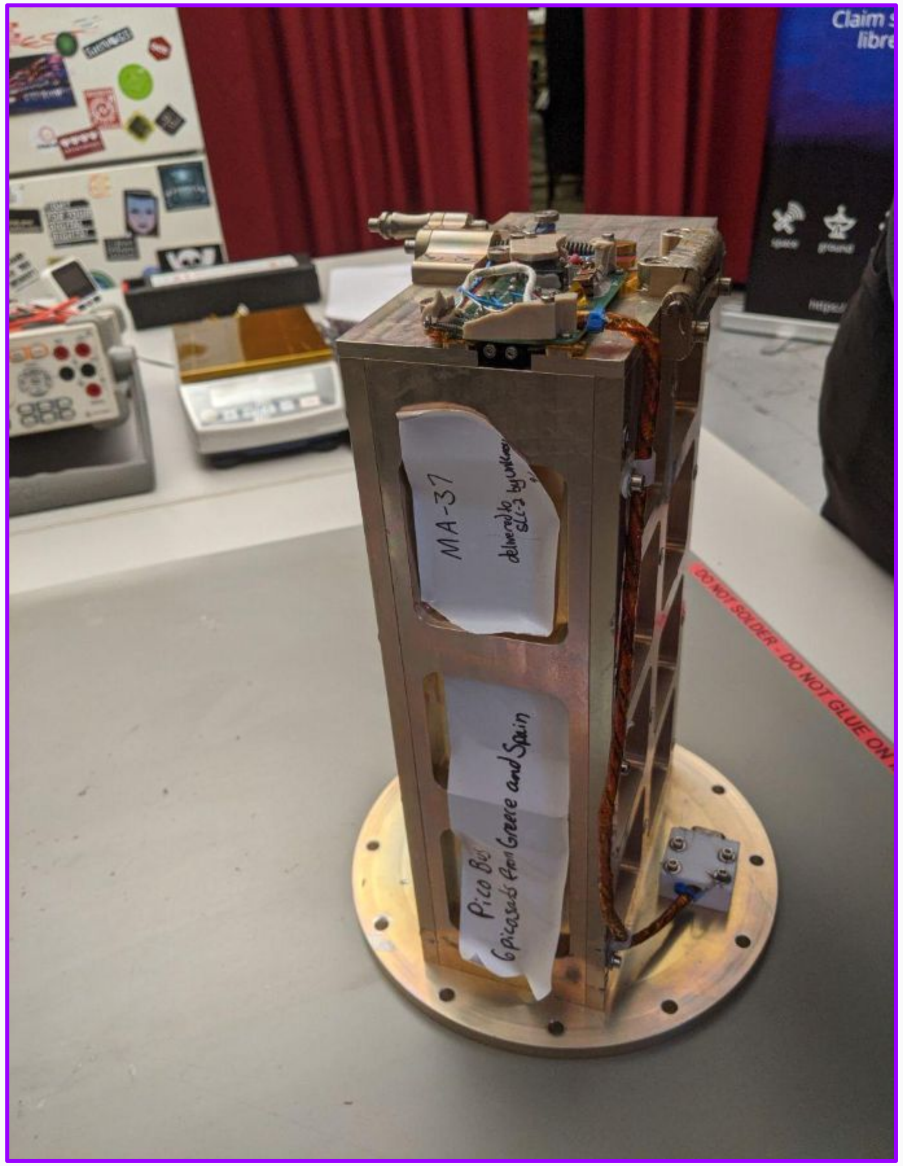
Launch



Explosion..........

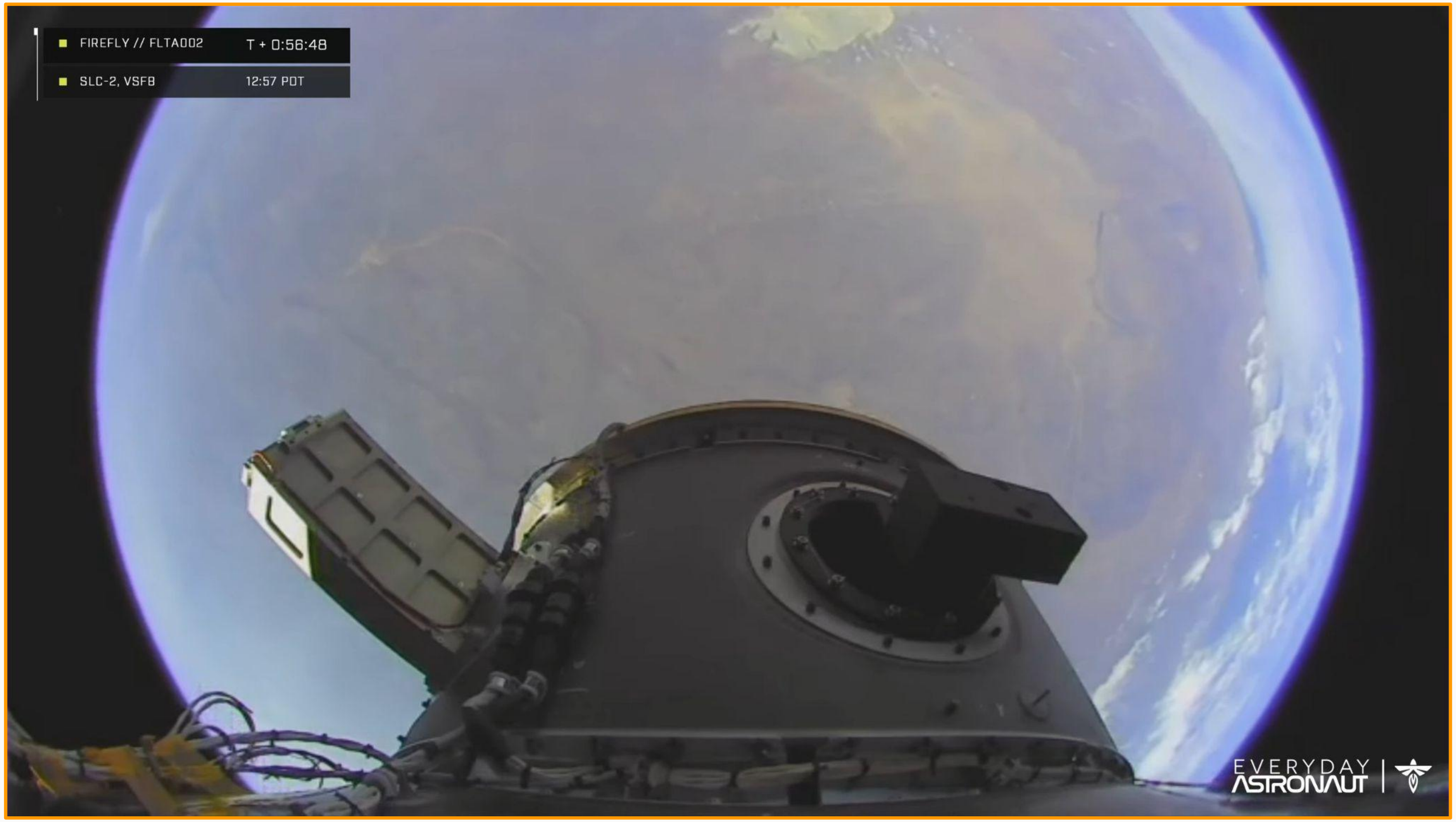
Picobus





Space is hard, PICOBUS IS HARDER

Orbital PICOBUS



per liberum ad astra!

Site	https://libre.space/
OS Repositories	https://gitlab.com/librespacefoundation/picobus

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