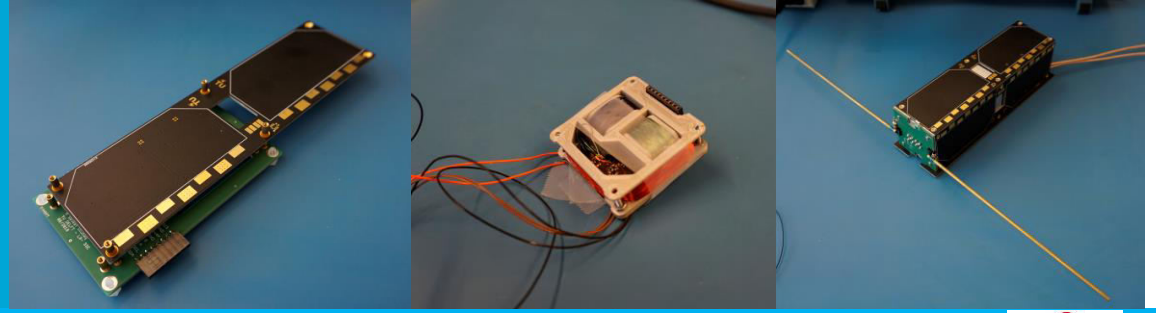
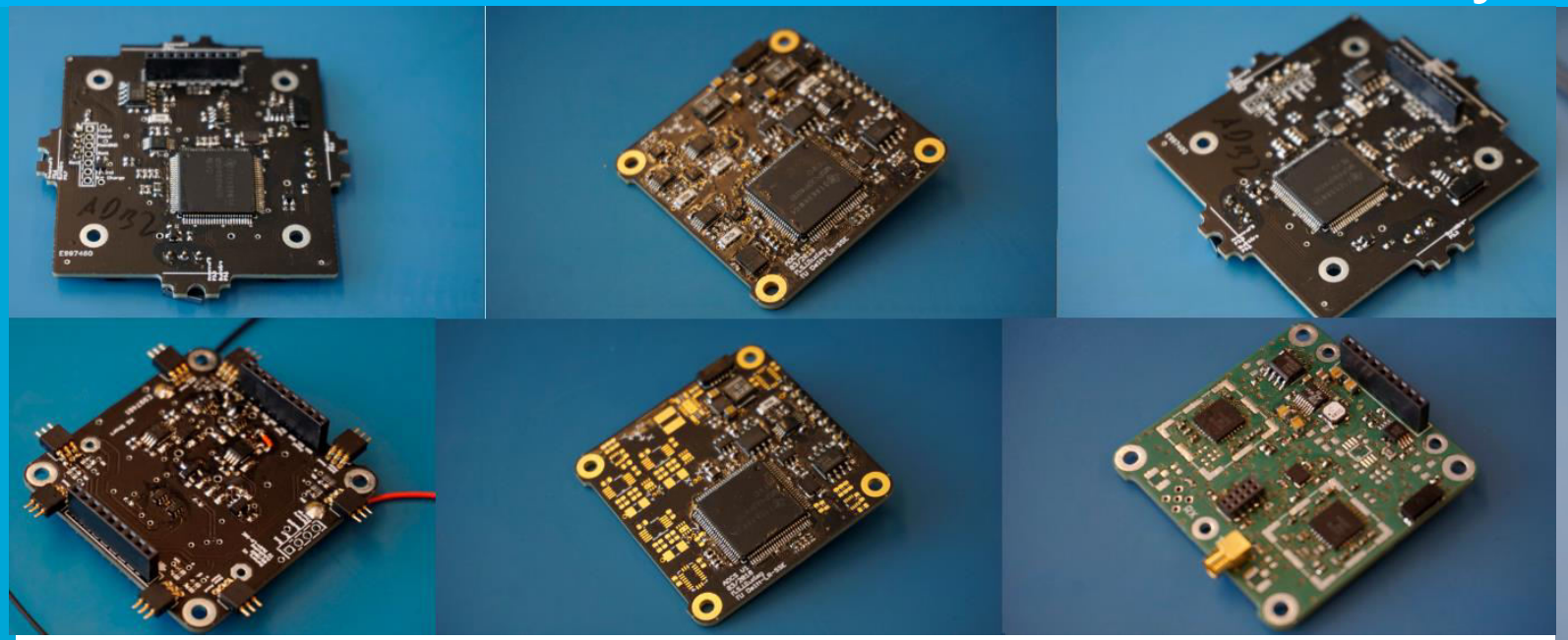
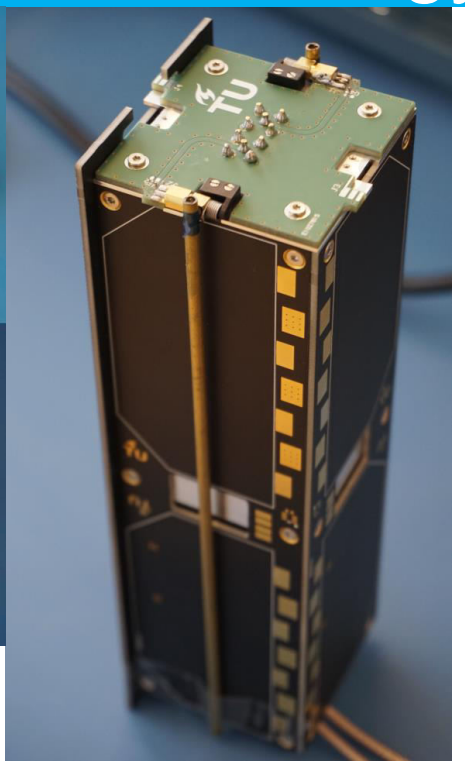


Silvana Radu

The PocketQube Standard issue 1

Delfi-PQ: The First PocketQube of Delft University of Technology





Delfi Core Team:
M.S. Uludag, S. Speretta, N. Foteinakis, J. Bouwmeester

Content:

1. Delft University of Technology – AE - SE
2. The PocketQube Standard
3. Delfi-PQ: Mission Description
4. Delfi-PQ: Operational modes
5. Testing
6. Launch
7. Future Work

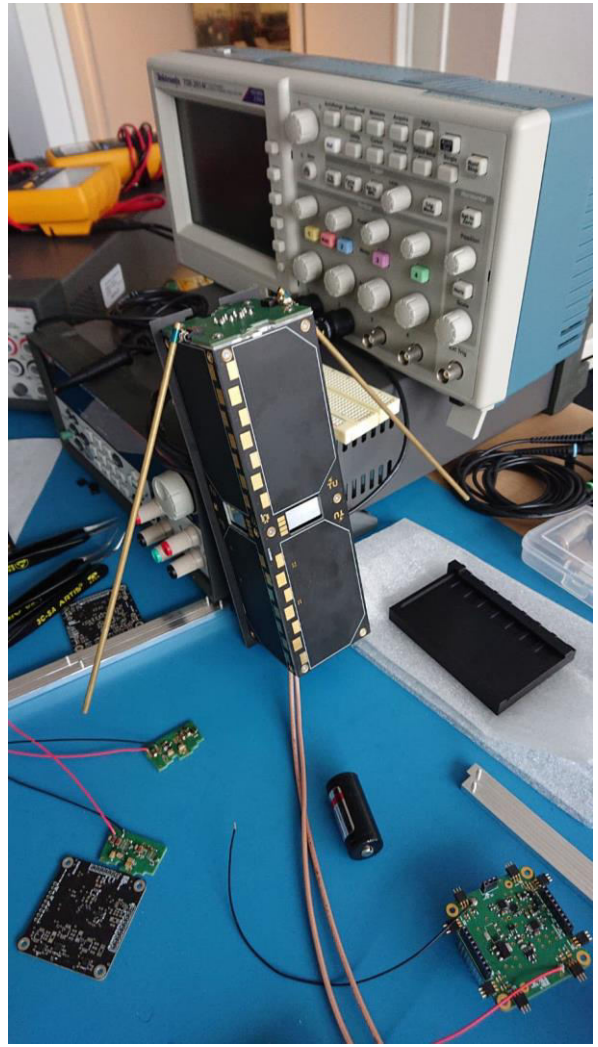
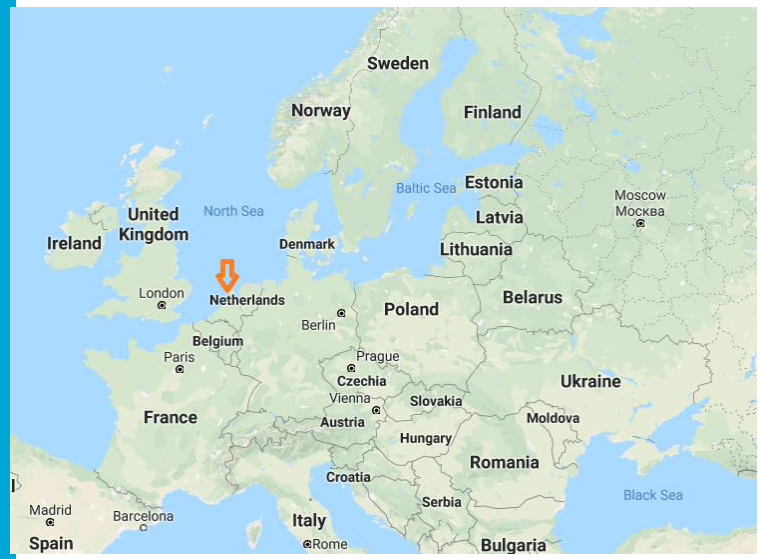


Figure 1: First assembly Delfi-PQ

1. Delft University of Technology - Aerospace Engineering -

TU Delft Space Engineering department

Who are we?



Contact Person: Dr. Prof. Eberhard Gill (E.K.A.Gill@tudelft.nl)

1. Delft University of Technology - Aerospace Engineering -

TU Delft Space Engineering department

What are we researching (@Space Systems Engineering chair)**?**

✓ Miniaturization of Space Systems (Satellites, Thrusters, ADCS, etc);

✓ Distributed Space Systems;

Past, present and future projects (highlights):

Delfi Program (2005-present)

✓ DelfiC3 (in space and operational for 10 years)

✓ Delfi N3xt

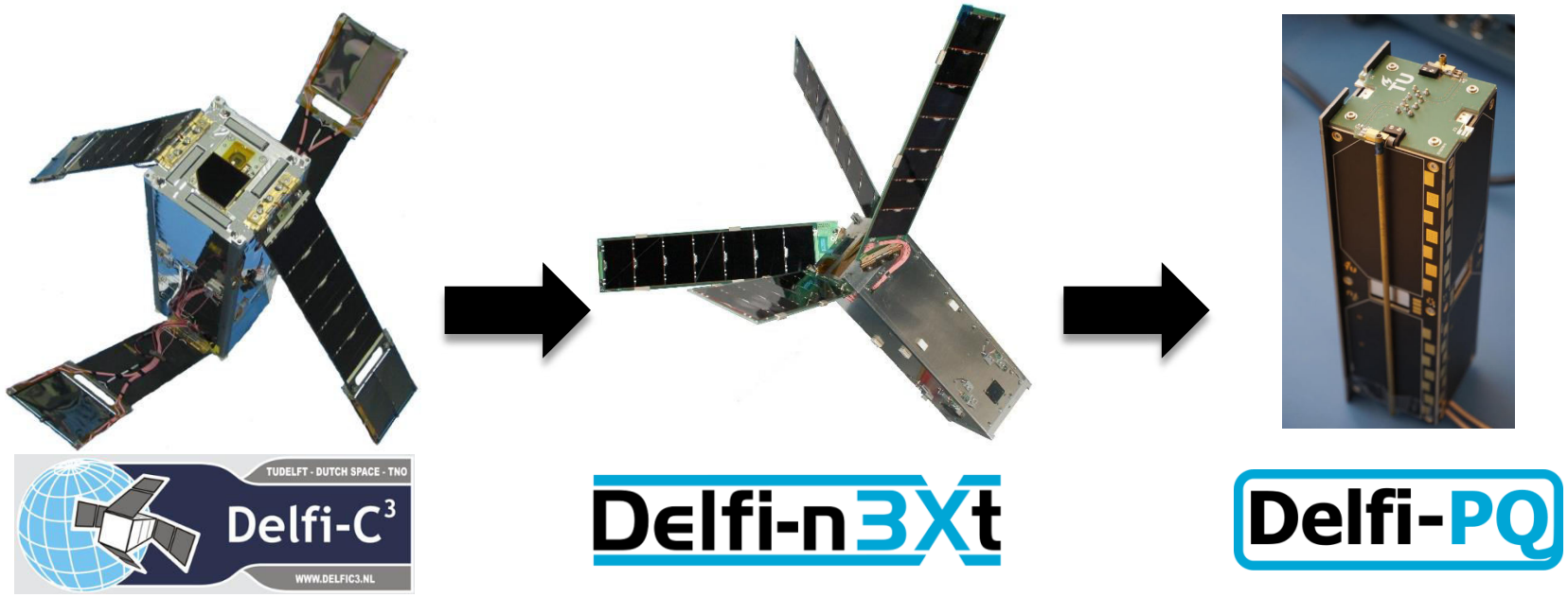
✓ Delfi-PQ

1. Delft University of Technology - Aerospace Engineering -

TU Delft Space Engineering department

Past, present and future projects (highlights):

Delfi Program (2005-present)

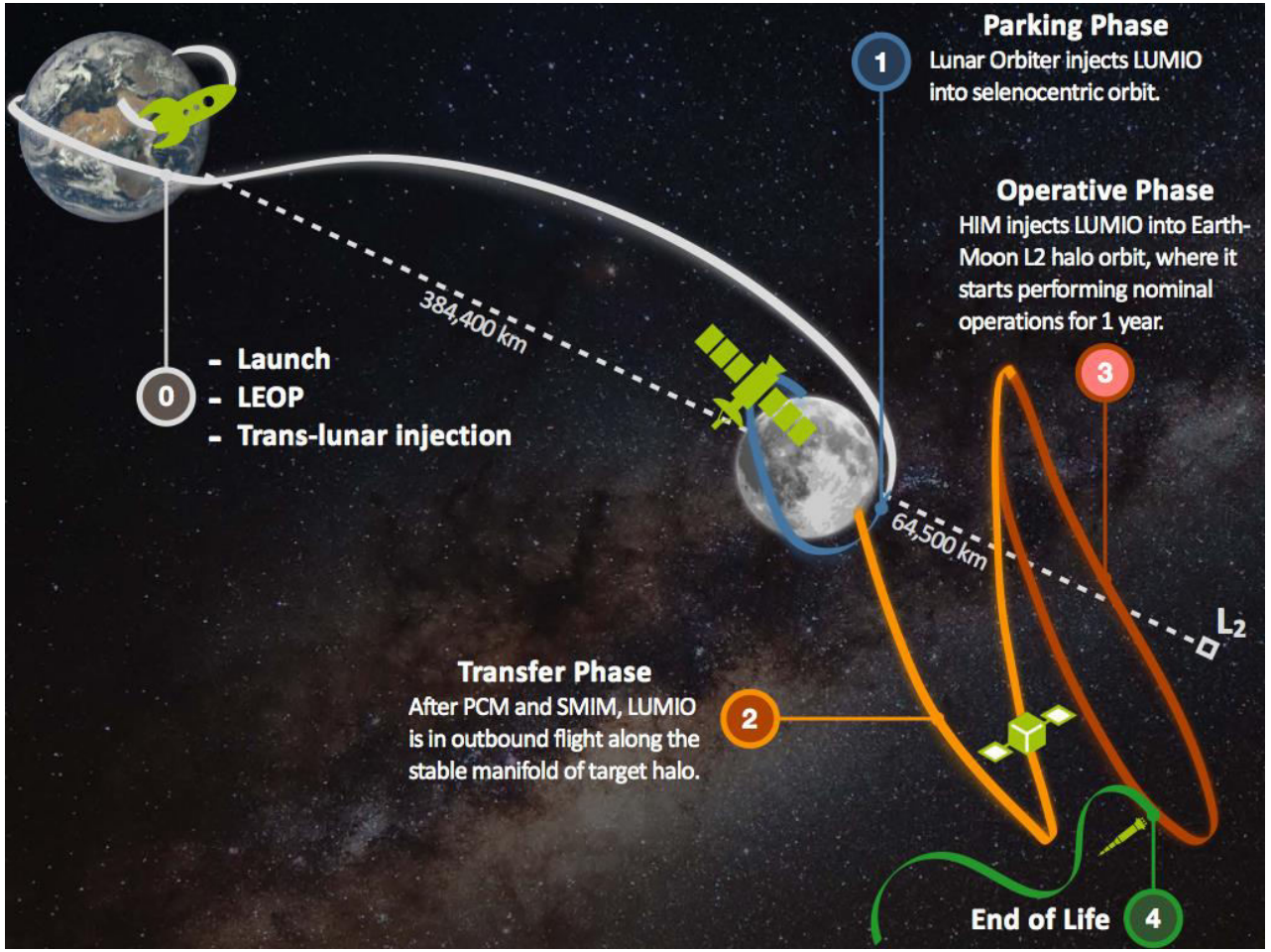


Contact Person: Silvana Radu (s.radu@tudelft.nl)

1. Delft University of Technology - Aerospace Engineering - TU Delft Space Engineering department

Lumio (12U Lunar CubeSat)

Study the micro-meteoroids impacting the far side of the Moon and contributing to Lunar Situational Awareness.



Contact Person: Dr. Angelo Cervone (a.cervone@tudelft.nl)

1. Delft University of Technology - Aerospace Engineering -

TU Delft Space Engineering department

Brik-II (Dutch Airforce, TU Delft, NLR, Innovative Solutions In Space)

- ✓ 6U CubeSat;
- ✓ Expected time in space: 3y;
- ✓ Orbit Period 90 min;
- ✓ Detecting radio waves from sources (radar installations);
- ✓ Study Earth's ionosphere;
- ✓ Digital mailbox;
- ✓ Acquire knowledge space military applications;

Contact Person: Dr. Stefano Speretta (s.speretta@tudelft.nl)

1. PocketQube Standard[1]

What is a PocketQube?

- ✓ Idea of Prof. R.J. Twiggs (collaboration MSU & Kentucky Space);
- ✓ Represents one eight of a CubeSat in volume;
- ✓ One unit (1P) Consists of roughly 50x50x50 mm;

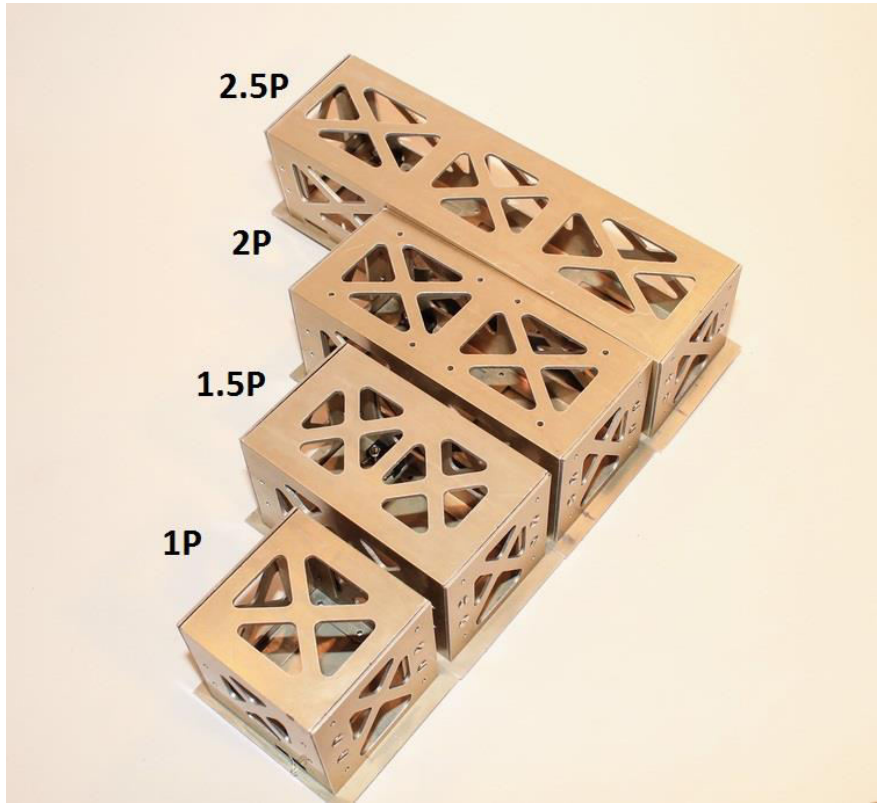


Figure 2 Photo credit: Alba Orbital

1. PocketQube Standard[1]

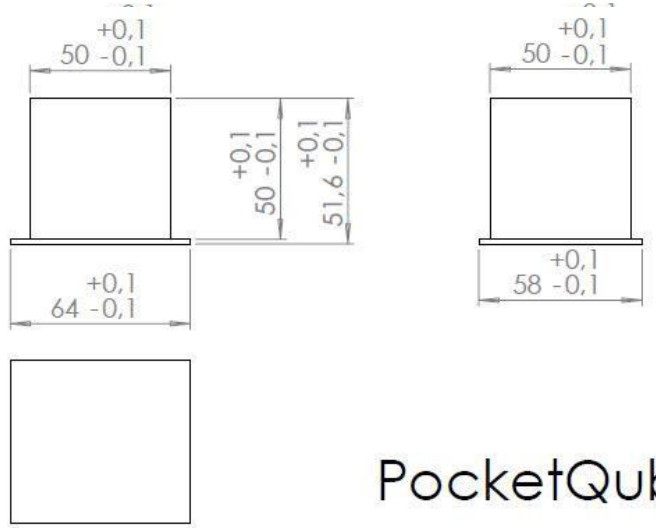
Why was the PocketQube Standard needed?

- ✓ Some specifications were initially defined, however a complete definition was missing;
- ✓ To reach common numbers (specifically exterior dimensions);
- ✓ To facilitate the development of PocketQubes;
- ✓ To assure the developed PocketQubes are compatible with the current Launch Service Providers (Alba Orbital & Gauss Srl.);
- ✓ To enlarge launching opportunities for PocketQubes;
- ✓ To contribute to the growth of the PocketQube community.

1. PocketQube Standard[1]

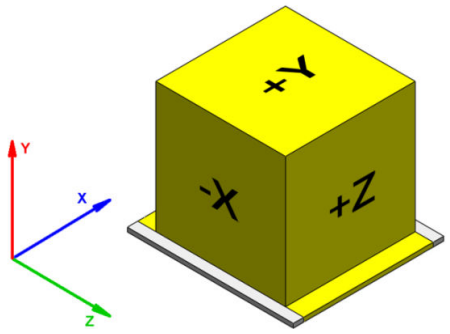
PocketQube Standard – Issue 1[1]:

- ✓ General Requirements
- ✓ Mechanical Requirements (Exterior dimensions, Mass, Materials)
- ✓ Kill switches locations, minimum contact surface.



PocketQube 1P

Number of Units (P)	External dimensions without backplate (mm)	Sliding backplate dimension (mm)
1P	50x50x50	58x64x1.6
2P	50x50x114	58x128x1.6
3P	50x50x178	58x192x1.6



[1]"The PocketQube Standard", TU Delft, Alba Orbital, GAUSS Srl., July 2018: https://hdl.handle.net/10411/L0QQ5S_https://dataverse.nl/api/access/datafile/11680

1. PocketQube Standard[1]

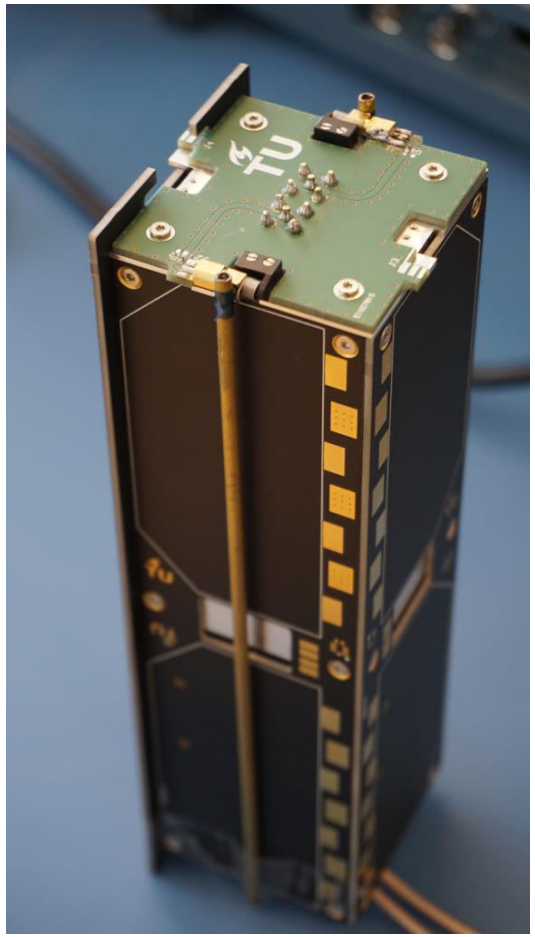
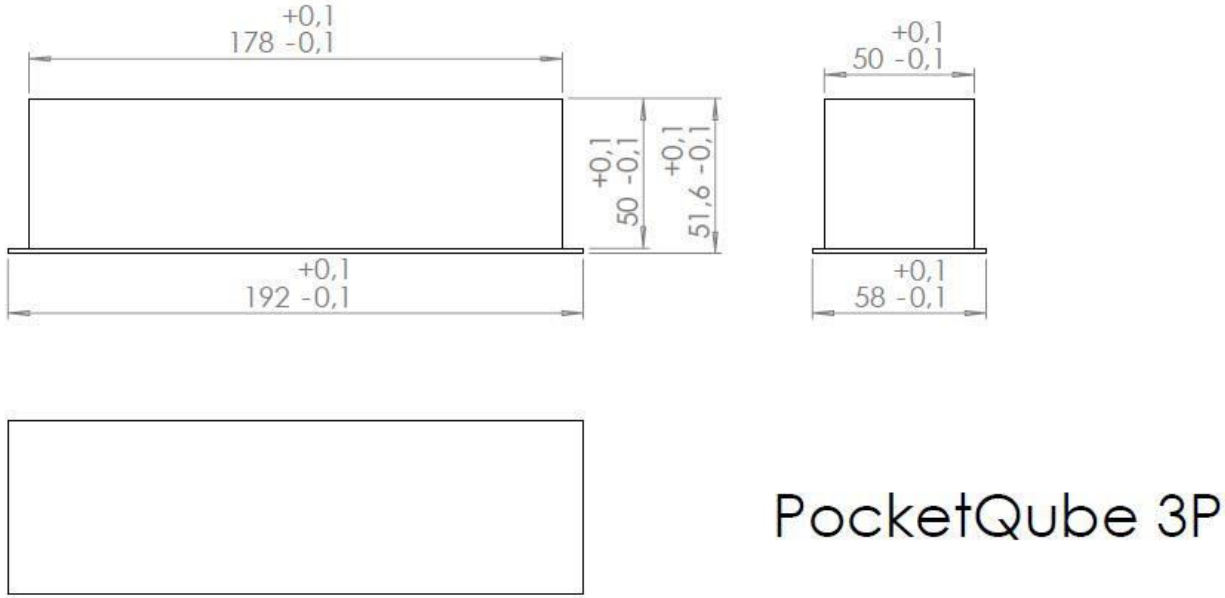


Figure 3. Delfi-PQ – 3P



Number of Units (P)	Mass (g)
1P	250
2P	500
3P	750

[1]"The PocketQube Standard", TU Delft, Alba Orbital, GAUSS Srl., July 2018: https://hdl.handle.net/10411/L0QQ5S_https://dataverse.nl/api/access/datafile/11680

1. PocketQube Standard[1]

As described in [1], envelope is as it follows:

NO more than 7 mm for components.
NO more than 10 mm for appendages if the LSP can adapt to this req. In order to comply to this, a waiver is attached in [1]. The waiver provides the relevant dimensions not to be exceeded.

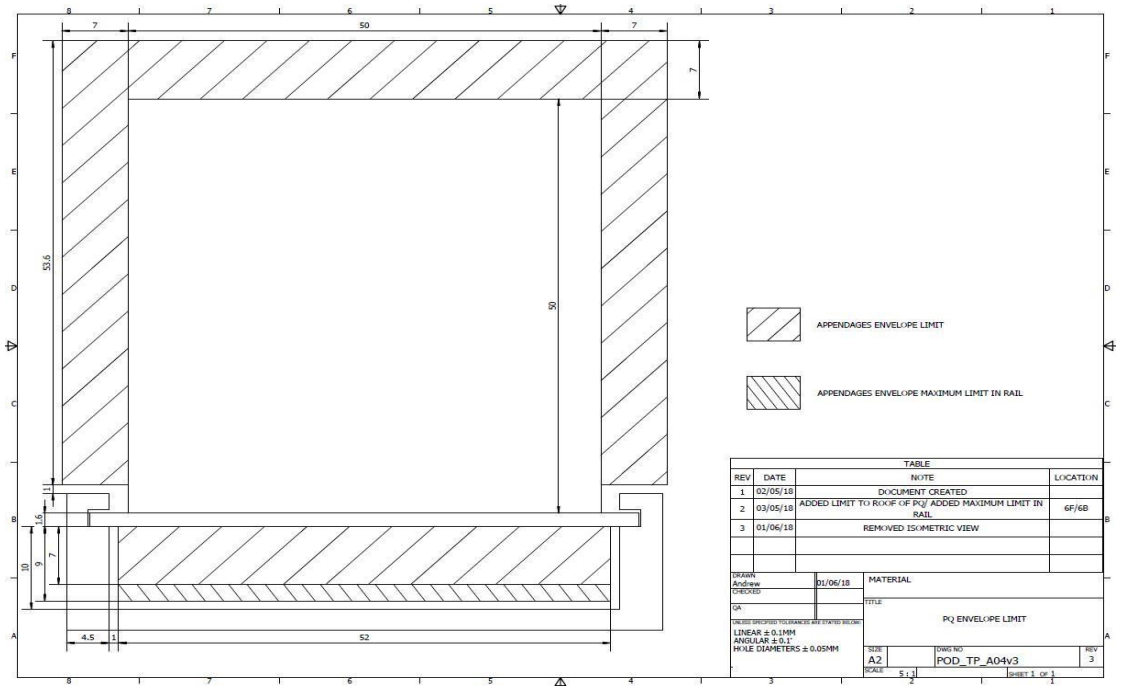


Figure 4. Envelope and Allowable Additional envelope for deployables

[1]"The PocketQube Standard", TU Delft, Alba Orbital, GAUSS Srl., July 2018: https://hdl.handle.net/10411/L0QQ5S_https://dataverse.nl/api/access/datafile/11680

1. PocketQube Standard[1]

- ✓ **Kill switches** shall be located only on Z- axis. There are two different possible placement areas:

1. Lateral side within 20 mm from Z- faces and touching the deployment rails (see figure lateral green area);
2. Aligned with the sliding backplate in Z- face in contact with the PocketQube below or the pusher plate (see figure blue area).

- ✓ **Minimum contact surface** of the PocketQube backplate hall be 21.5 mm from both sides on the Z+ axis (see figure red area),

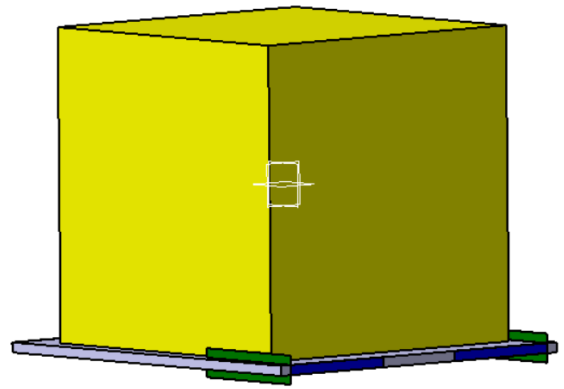


Figure 5. Kill switches location

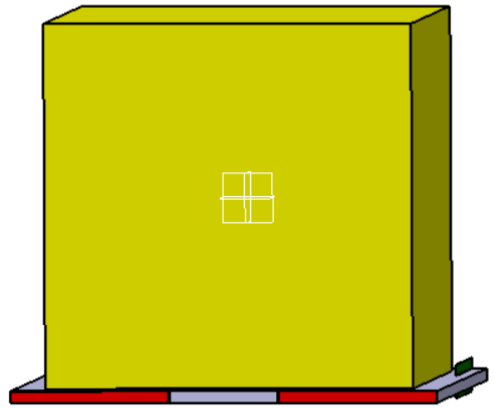


Figure 6. Min. contact surface

[1]"The PocketQube Standard", TU Delft, Alba Orbital, GAUSS Srl., July 2018: https://hdl.handle.net/10411/L0QQ5S_https://dataverse.nl/api/access/datafile/11680

1. PocketQube Standard[1]

PocketQube Standard – Issue 2 (To Be Continued):

As part of the same collaboration involved in [1] – Alba Orbital, TU Delft and GAUSS Srl:

- ✓ Electrical requirements
- ✓ Operational Requirements
- ✓ Testing Requirements

albaorbital

TU Delft

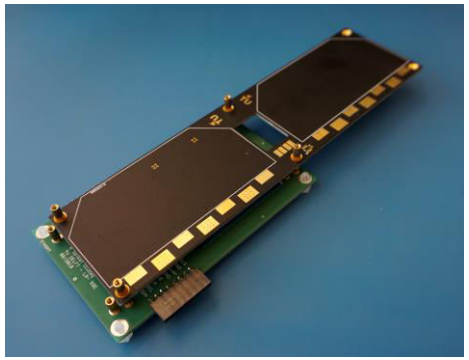
GAUSS

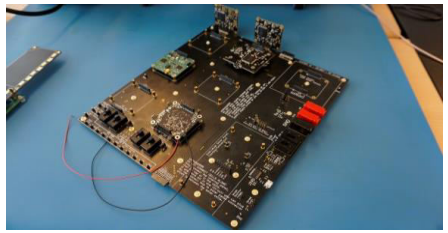
Group of Astrodynamics for the Use of Space Systems

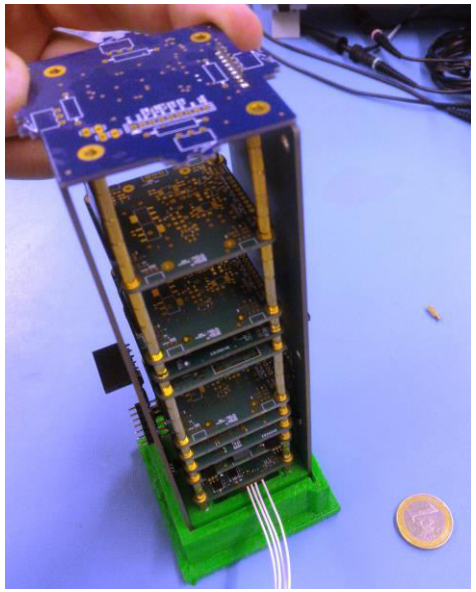
[1]"The PocketQube Standard", TU Delft, Alba Orbital, GAUSS Srl., July 2018: https://hdl.handle.net/10411/L0QQ5S_https://dataverse.nl/api/access/datafile/11680

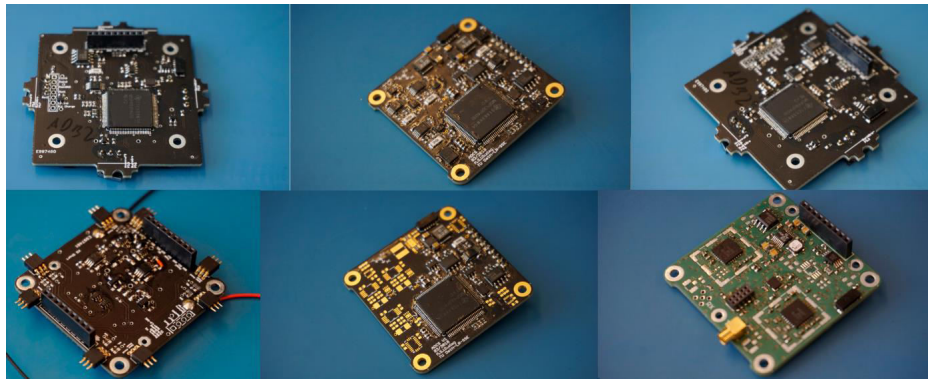
2. Delfi-PQ: Mission Description

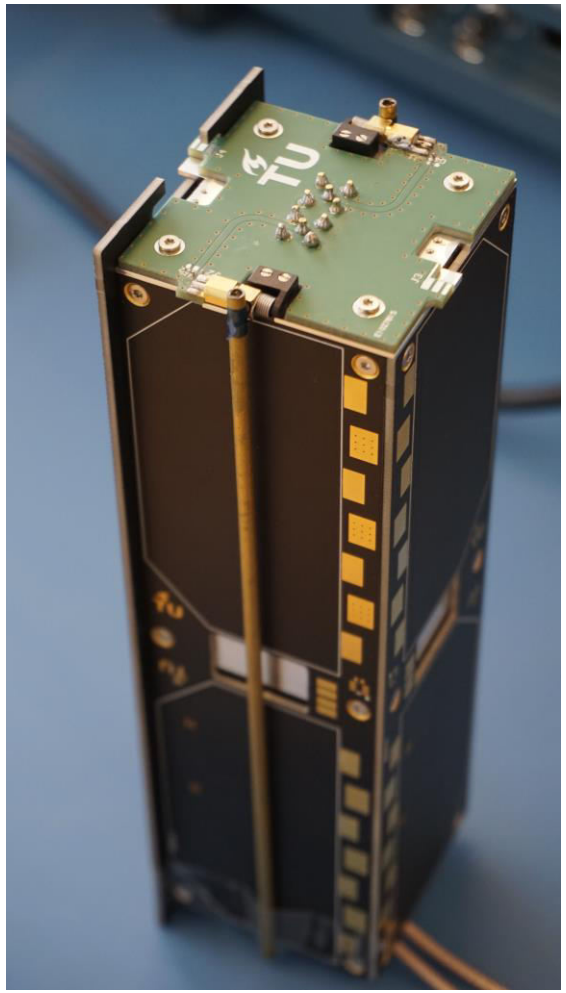
The first PocketQube of Delft University of Technology – Delfi-PQ











Contact Person: Silvana Radu (s.radu@tudelft.nl)

2. Delfi-PQ: Mission Description

Delfi Program:

1. Education:
    - Pass know-how to students;
    - Long-term goal – have students experiencing end-to-end development of components/subsystems;
2. Technology Demonstration:
    - Demonstrate payloads developed by faculty teams or other partners;
3. Innovation
    - Constellations for radio applications (radar calibration, optical reflector,etc.);

Target of first PocketQube: demonstrate a reliable core bus platform that can fit in 1P and test the overall integrity of the structure of this form factor.

2. Delfi-PQ: Mission Description

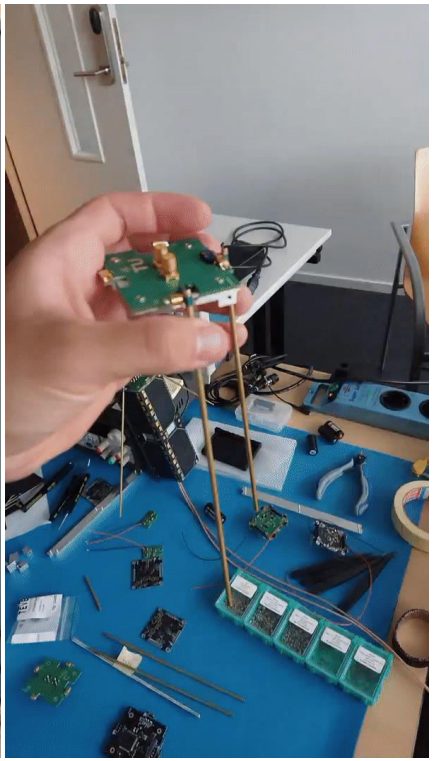
Antenna:

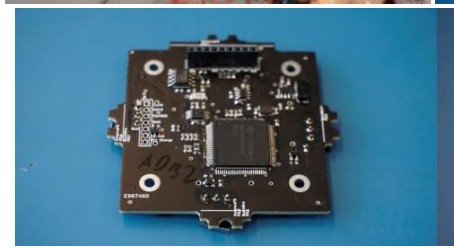
- ✓ UHF and VHF (downlink/uplink);
- ✓ Omnidirectional radiation pattern;
- ✓ Configuration dipole with linear polarization
- ✓ Deployment consists of 6 components manufactured and assembled in house (As presented in the animation on the right).

Radio:

- ✓ Main board (hosting the modulation and demodulation)
- ✓ RF front-end (hosting the power amplifier and low noise amplifier)
- ✓ Approach selected to allow the system to operate in different bands Full-duplex over 2 separated bands (UHF downlink and VHF uplink)

Figure 3. Antenna Board





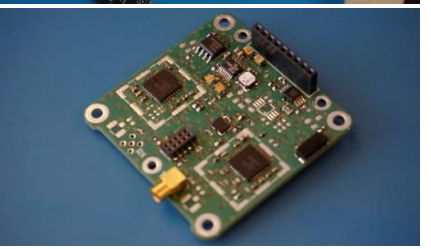


Figure 4. Radio Board

Acknowledgment: Dr. Stefano Speretta – Comms Engineer of Delfi-PQ

2. Delfi-PQ: Mission Description

Electrical Power System:

- ✓ Battery board (2 batteries of 3.7 V)
- ✓ Main EPS board (due to limited space, MPPTS were added on each solar panel)
- ✓ Solar Panels

On-Board Computer:

- ✓ MSP432 microcontroller;
- ✓ Operational modes;

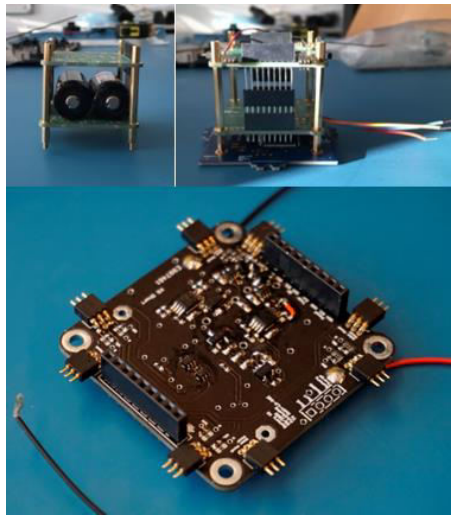


Figure 5. Battery and EPS Board

Figure 7. OBC

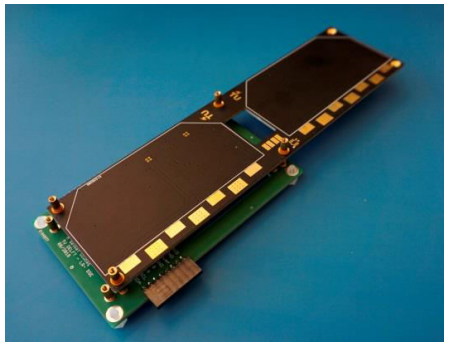


Figure 6. Solar Panel

Acknowledgment: Sevket Uludag – Electronics Engineer of Delfi-PQ

2. Delfi-PQ: Mission Description

ADCS:

- ✓ Three magnetorquers
- ✓ Two IMU
- ✓ Stabilizing the satellite from a max. rotational speed of 180deg/s

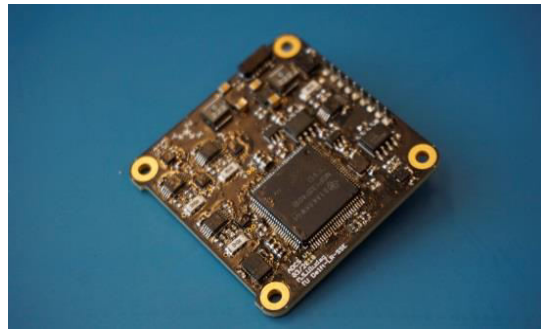


Figure 8. ADCS

Potential Payloads (depending on TRL):

a) *Thermal Payload* (heat source, power sinked to another component with sufficient heat capacity);

- ✓ Temperatures measured in various locations – determine heat flow;
- ✓ Additional battery board might be added.

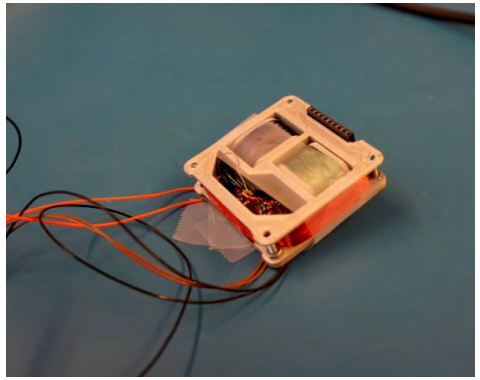


Figure 9. Magnetorquers

Acknowledgment: Sevket Uludag – Electronics Engineer of Delfi-PQ & Michael van den Bos – Student (Magnetorquers)

2. Delfi-PQ: Mission Description

Potential Payloads

b) *Micro-propulsion*:

- ✓ Developed in-house by micro-propulsion team;
- ✓ Micro-resistojet-vaporization of pressurized liquid water and free molecular acceleration of propellant molecules stored at low pressure.
- ✓ Mass 75 g, volume (42x42x30 mm), max power 4 W.

c) *GPS* (already part of Delfi-PQ1):

- ✓ Receiver based on commercial dual-frequency hardware with modified firmware.

d) *Radio experiment*:

- ✓ Test protocols and schemes not designed for satellite use and estimate in-flight performances.

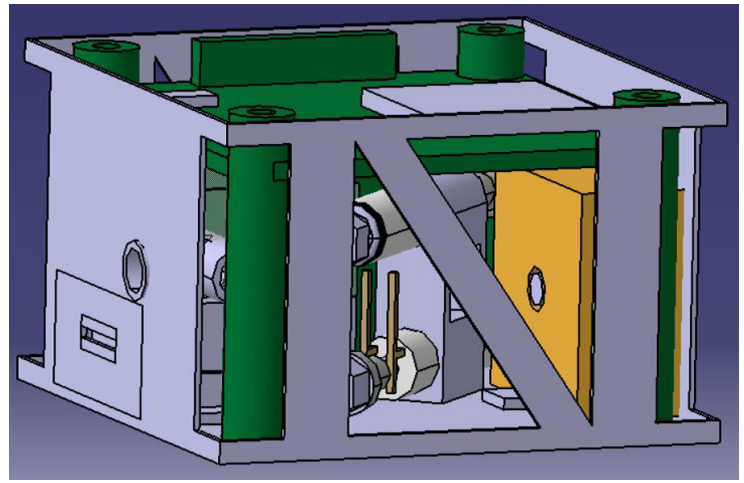


Figure 10. Micro-propulsion system

Acknowledgment: Sevket Uludag – Electronics Engineer of Delfi-PQ & Michael van den Bos – Student (Magnetorquers)

3. Delfi-PQ: Operational modes

Aim for first PocketQube of TU Delft: keep the functionality as simple as possible:

OFF Mode:

- Satellite turned off until the kill switches get unpressed and satellite is powered.

Activation Mode:

- Limited subsystems are on;
- The purpose is to determine if it is the first time the satellite activates.

Deployment Mode:

- Determine if antennas were deployed;
- Deploy antennas or force deployment;

	OFF	Activation	Deployment	Safe	ADCS	Nominal
EPS	Off	On	On	On	On	On
OBC	Off	On	On	On	On	On
COMMs	Off	Receive	Receive	Receive/ transcieve	Receive/ transcieve	Receive/ transcieve
Mech s	Off	Idle	Deployment	Idle	Idle	Idle
ADCS	Off	Off	Off	Off	On	Sensing

TU Delft

3. Delfi-PQ: Operational modes

Safe Mode:

- Satellite automatically switches to safe when certain trigger parameters are flagged;
- Drop of voltage parameters;
- Other failures;

ADCS Mode:

- Sensing
- Actuating (up until 5deg/s rotational speed)

Nominal Mode:

- Perform general tasks (check and execute commands, collect and store telemetry, send telemetry, ADCS sensing);
- Payload;

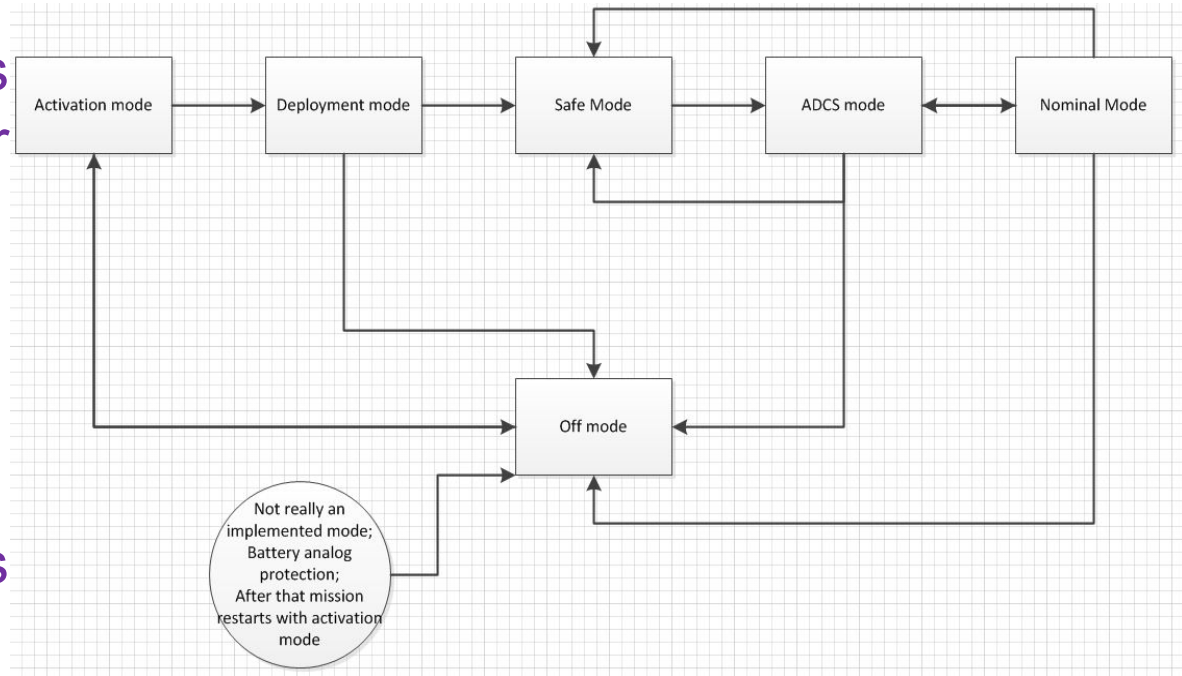


Figure 11. Boot Sequence

Boot Sequence loop explain the modes in which the satellite needs to pass before reaching nominal mode, after a general reset was performed.

4. Testing

Subsystem Level Testing:

- ✓ Use of a FlatSat
- ✓ Check all electrical connections;
- ✓ Check all communications between components;
- ✓ Check overall system and perform duration test before integration.

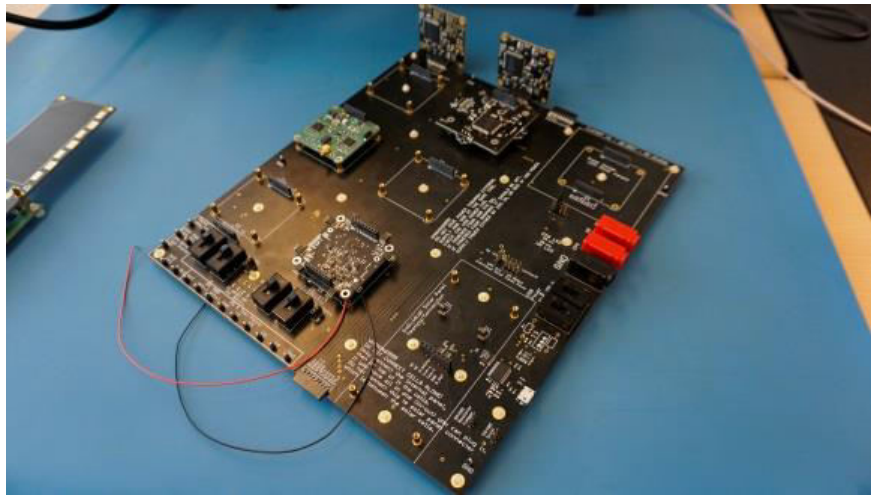


Figure 12. FlatSat of Delfi-PQ

Environmental Testing:

- ✓ Previously used ranges in CubeSat missions were used for Qualification and Acceptance;

Type of Test	Qualification	Acceptance
Random vibration	Required	Required
Sinusoidal vibration	Required for contents that were not covered by random vibration	Required for contents that were not covered by random vibration
Shock	Not required	Not required
Thermal vacuum Cycle	Recommended	Recommended
Thermal vacuum Bake-out	Not required – unless it is demanded prior to vacuum	Required
Duration test	Not required, but recommended	Not required, but recommended

Will not be done

TBD

Will be done in January

4. Testing

- Planned duration test – December (flat sat)
- Planned vibration test – End of January – Beginning of February
- Planned Thermal and thermal vacuum bake-out - January

Shock test for structure: Passed!

Acknowledgment Shock Test Engineer: Aurora Cervone

5. Launch

First Launch opportunity came earlier than expected (2019 instead of 2020).

- **Vector-R Rocket - small launcher for payloads up to 65 kg.**
  Company: Vector [2]
- Orbit: Sun Synchronous;
- Expected Altitude: 350km;
- Orbital Lifetime of Delfi-PQ 150days;

Launch Service Provider: Alba Orbital

- Currently developing a deployer that can host 2 pocketqubes of 3P each (AlbaPOD[3]);
- Shared Launched with Uncorn-2 (Alba Orbital's PocketQube);
- Placement of Delfi-PQ in deployer: top;
- Expected vibration testing end of January;
- Expected Integration in AlbaPOD end of February.

[2] Vector Company: https://vector-launch.com/;
[3] http://www.albaorbital.com/launch/

6. Future Work

- ✓ Create a complete baseline with up to date documentation, using Delfi-PQ;
- ✓ Next iterations to be done by students using the created baseline;
- ✓ Write and publish based on the same consortium the 2nd issue of the PocketQube Standard in order to help with the growth of the PocketQube Community .

2nd PocketQube Workshop TU Delft

Do not forget to join us at the 3rd PocketQube Workshop of TU Delft!!! ~ October 2019!

Thank You!

TU Delft