LSF
SLIDE 1

LSF
SLIDE A

QUBIK a 1p PocketQube satellite platform

Ilias Daradimos

From Zero to LEO

It was a quiet summer evening

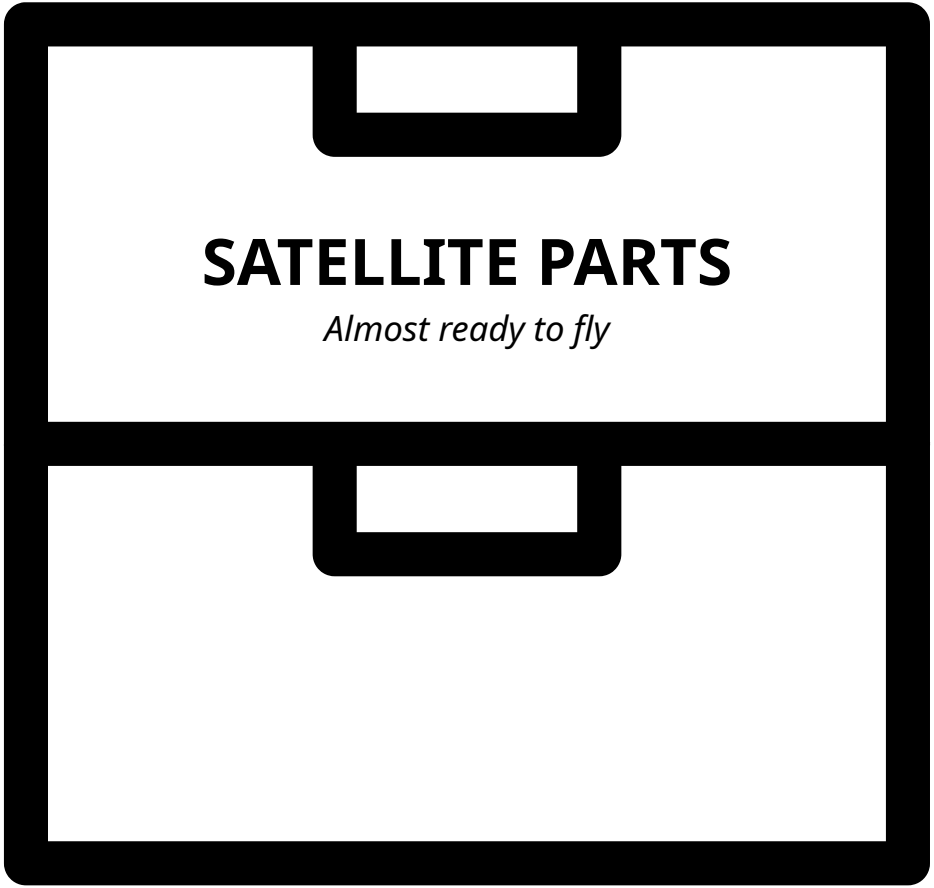
We got a phone call

(it was an email)

- *We have a FREE 1p slot available for a PocketQube, are you interested?*

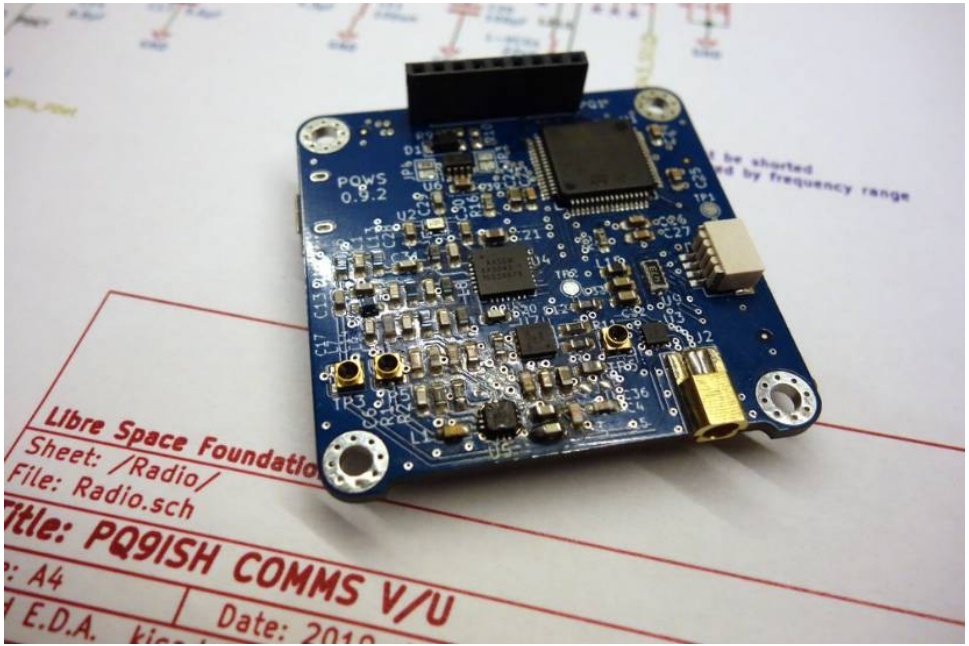
...

- Great have it ready to go to space by December. BYE



Clipart by Jasfart from the Noun Project

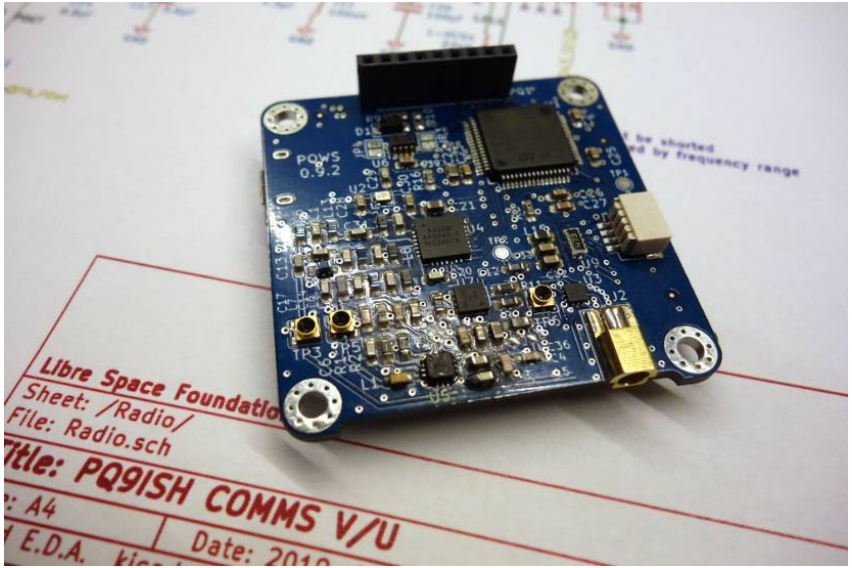
There is a COMMS available



aaaand that’s it..

COMMS/OBC Capabilities (v0.9.7)

- PQ9ish format
- STM32L476
- I2C, CAN Bus, 1-Wire
- Micro SD card
- FSK, 4−FSK, GFSK, MSK, GMSK, ASK, AFSK, FM, PSK
- Data Rates from 0.1 kbps to 125 kbps
- Optional Forward Error Correction (FEC)
- Output power ~27dBm
- Backup 16dBm TX channel
- AUX GPIO



The orbit

- Advertised orbit 300km
- Expected lifetime for maximum payload mass ~1-2 weeks
- First orbital vehicle flight (High probability of fireworks)

The Plan

HARDWARE

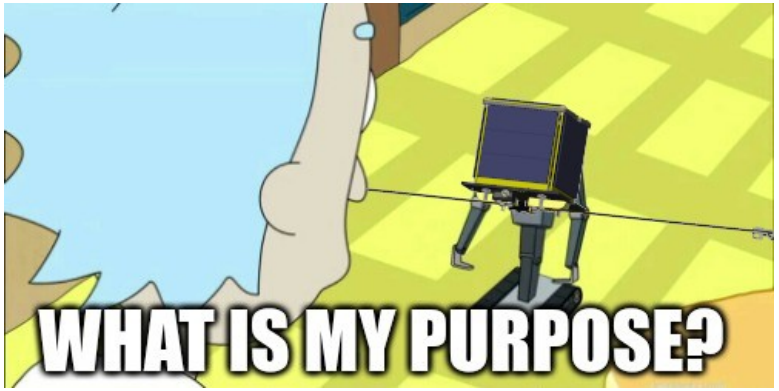
1. Test COMMS
2. Add power
3. Add PV panels
4. Add structure
5. Bolt everything on a plate
6. Bakeout
7. Protoflight campaign
8. Send it to be integrated to the deployer
9. Have pizza

SOFTWARE

1. Write some code that at least transmits what needed by mission
2. Test software
3. Flash the final firmware
4. Have pizza

BUREAUCRACY

1. Coordinate frequencies
2. Manage Export
3. Have Pizza


WHAT IS MY PURPOSE?

YOU ARE GOING AROUND EARTH DOING BEEP BEEP BEEP

AND THEN YOU BURN AND DIE
imgflip.com

The experiment

A LEOP satellite identification and orbit determination experiment

1. Unambiguously identify satellites as soon as possible after deployment
2. Generate or update existing orbital elements based on Doppler curve tracking of satellite transmissions

   https://librespacefoundation.gitlab.io/qubik/qubik-docs/

Identification via:

- Beacon preamble/post-amble
- Beacon decoding
- Beacon length
- Beacon cadence
- Spread spectrum low power beacon

Meanwhile on the hardware department

Power system

- Power budget
- Design solar panel circuits
  Built around SPV1040
- Design power management board
  Using MAX17261

COMMS

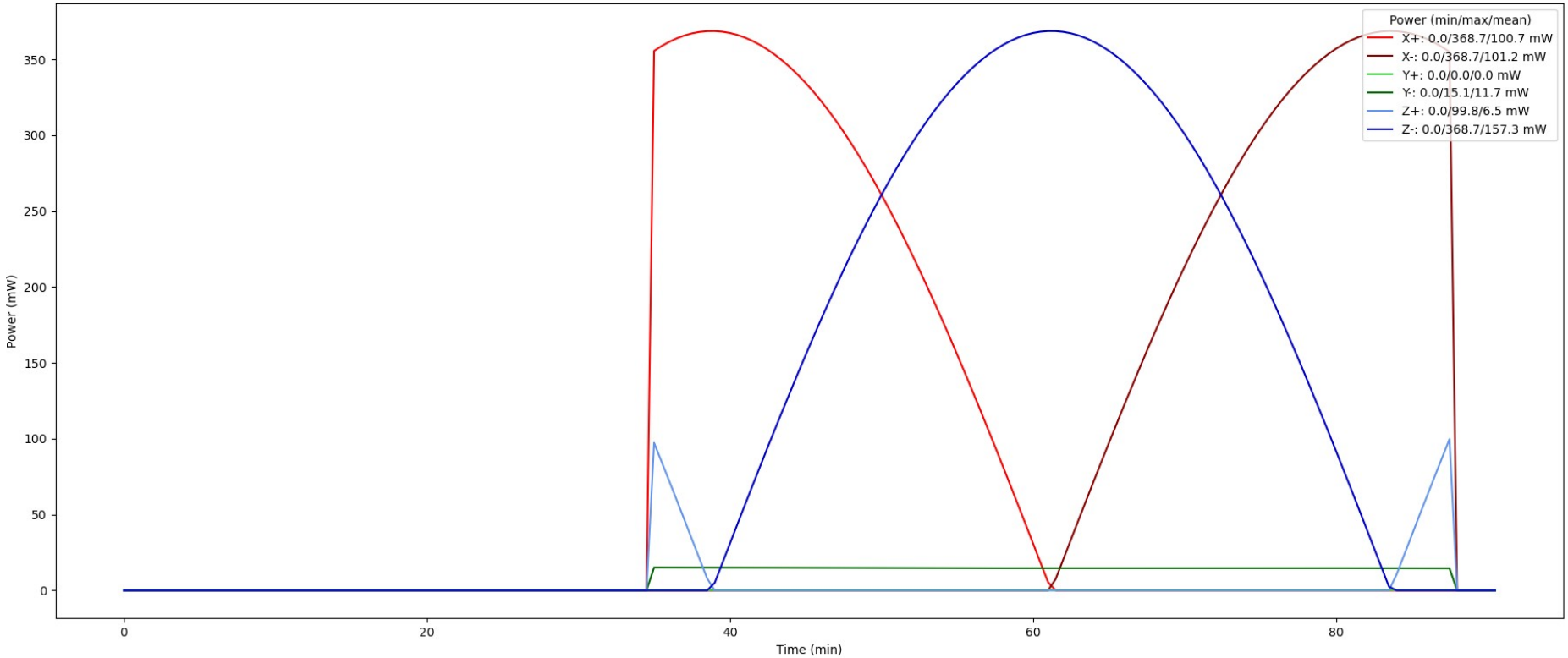
- Minor modifications to suit mission

Mechanical

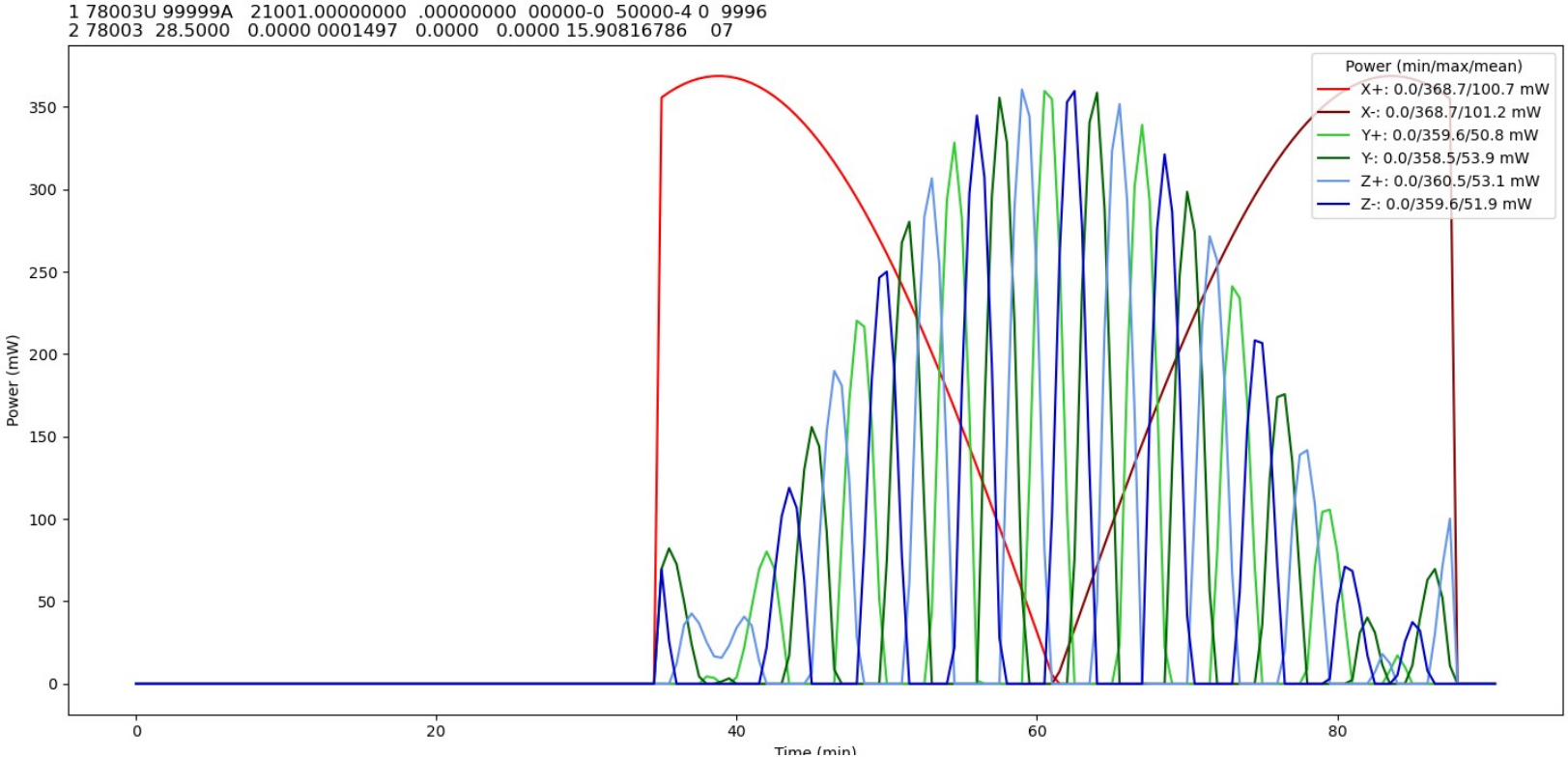
- Design bottom plate to fit deployer
- Antenna release mechanism
- Structural design

Power budget

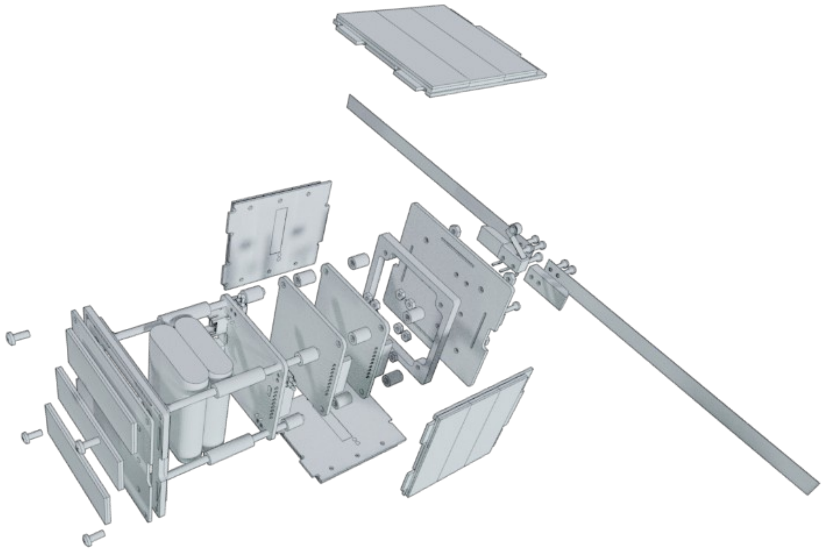
1 78003U 99999A 21001.00000000 .00000000 00000-0 50000-4 0 9996
2 78003 28.5000 0.0000 0001497 0.0000 0.0000 15.90816786 07

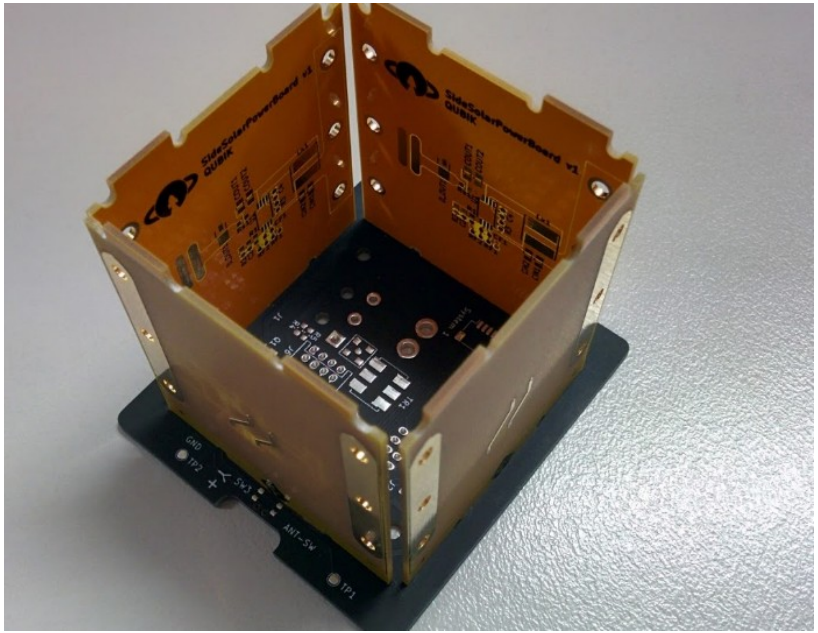


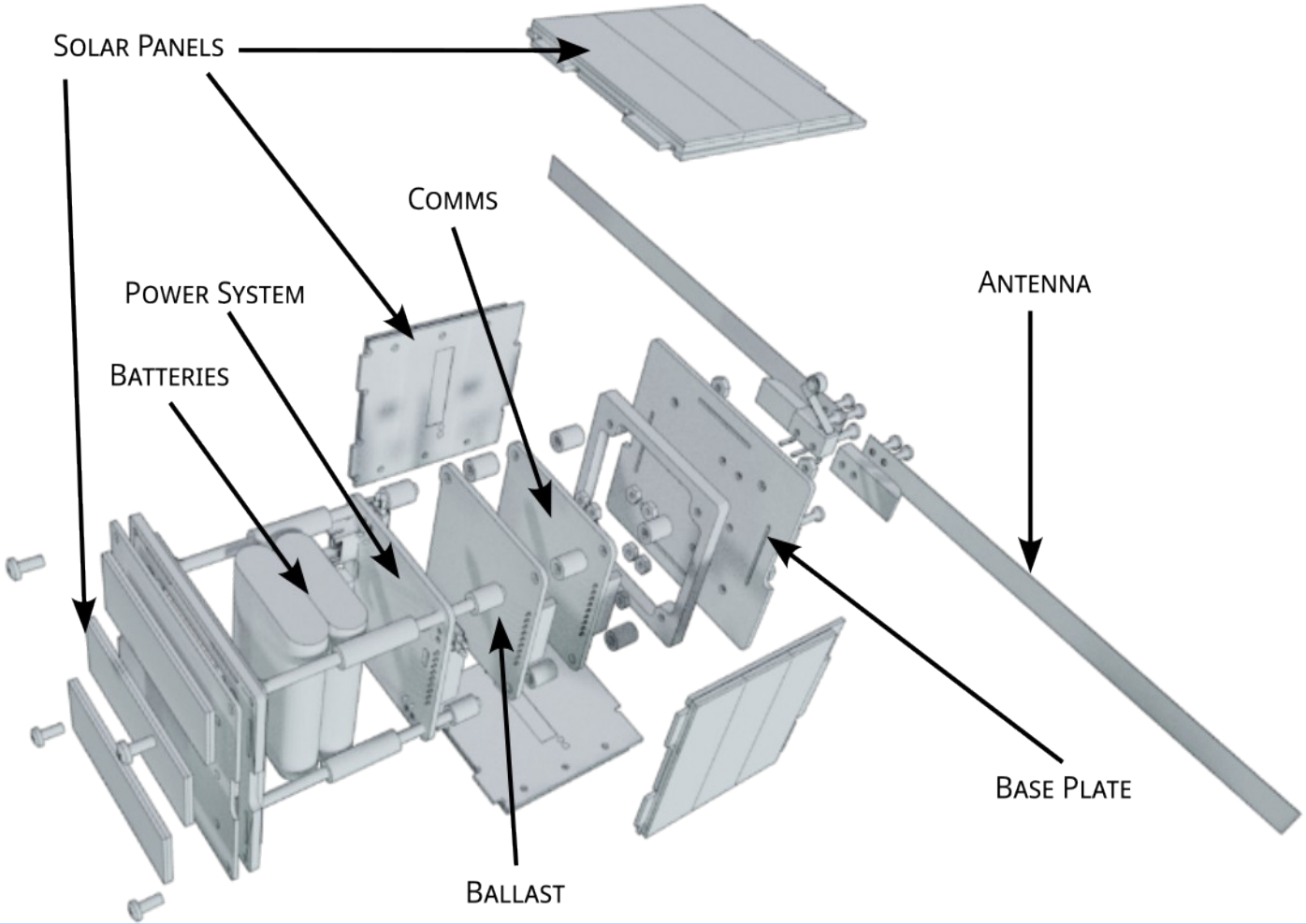
Power budget



PCBs as a structural element

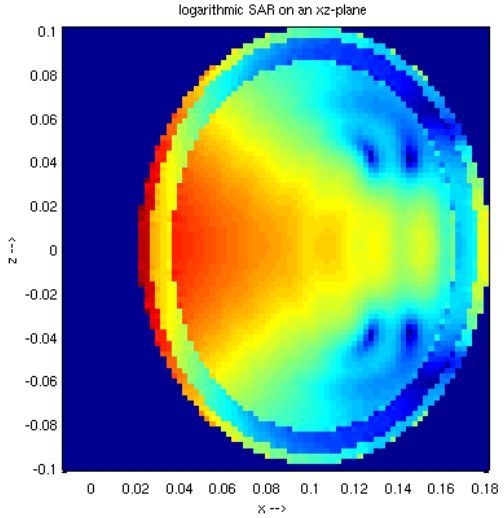


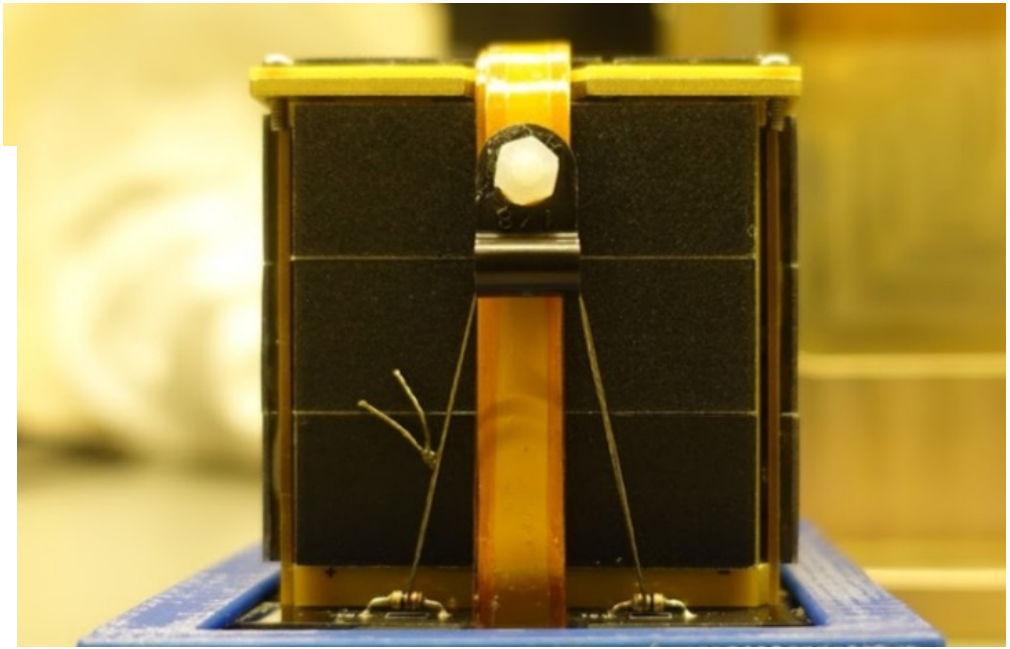



SOLAR PANELS
COMMS
POWER SYSTEM
BATTERIES
ANTENNA
BASE PLATE
BALLAST

Antenna

- Dipole antenna
- Release by dual thermal knife





Good news everyone…

- There is an extra slot available on the deployer if you want it

Sure, we'll just build 2

- Oh and the deployer, well it's more of a concept, so could you…?

…

- Great, have a mass simulator for everything ready by next week. BYE

The Revised Plan

HARDWARE

1. Test COMMS
2. Add power
3. Add PV panels
4. Add structure
5. Bolt everything on a plate
6. Bakeout
7. Protoflight campaign
8. Send it to be integrated to the deployer
9. Have pizza

SOFTWARE

1. Write some code that at least transmits what needed by mission
2. Flash the firmware
3. Have pizza

BUREAUCRACY

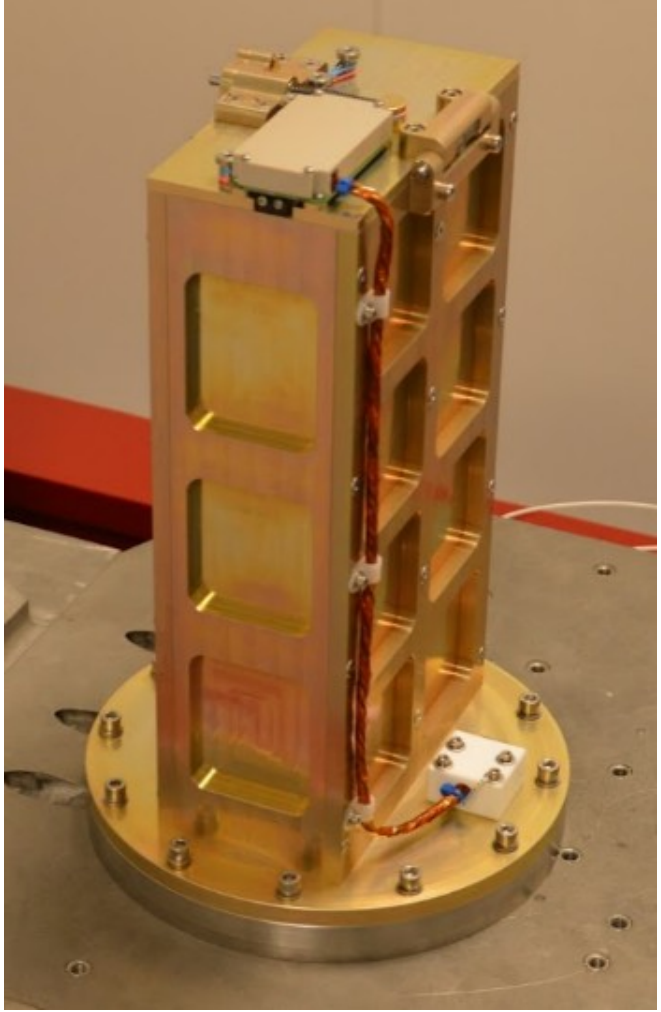
1. Coordinate frequencies
2. Manage Export
3. Have Pizza

DEPLOYER

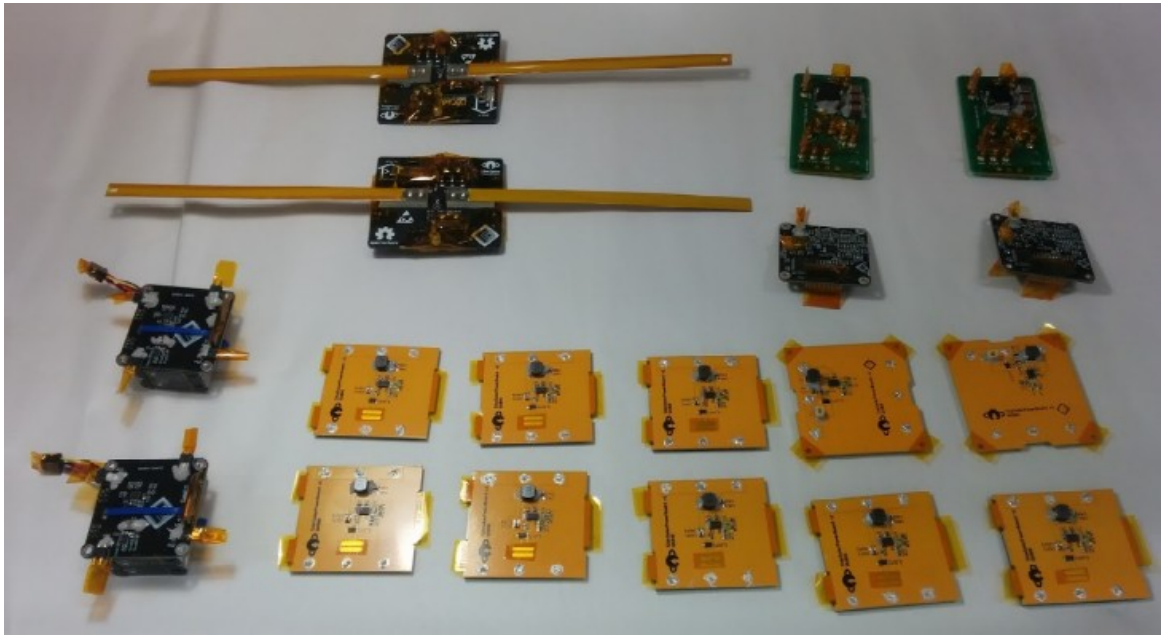
1. **Design the deployer**
2. **Design mass simulator**
3. **Build mass simulator**
4. **Build qualification deployer**
5. **Qualify qualification deployer (TVAC/Vibration)**
6. **Build Flight deployer**
7. **Protoflight campaign for all payload**
8. **Integrate payload**
9. **Have pizza**

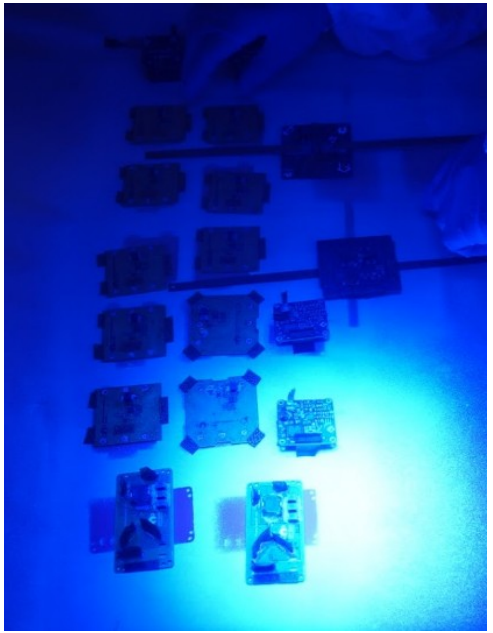
The birth of PICOBUS

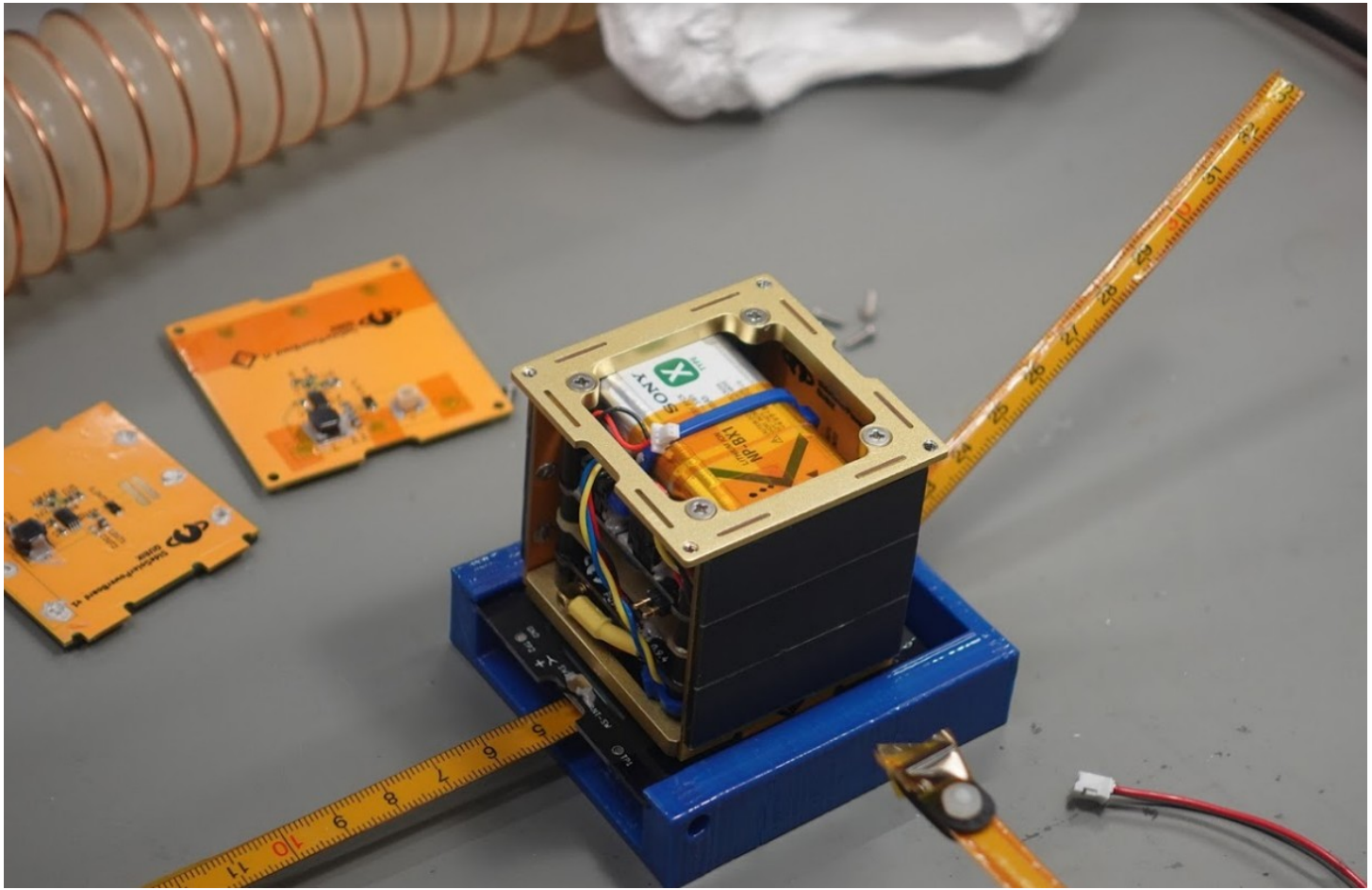
More on that on the PICOBUS talk



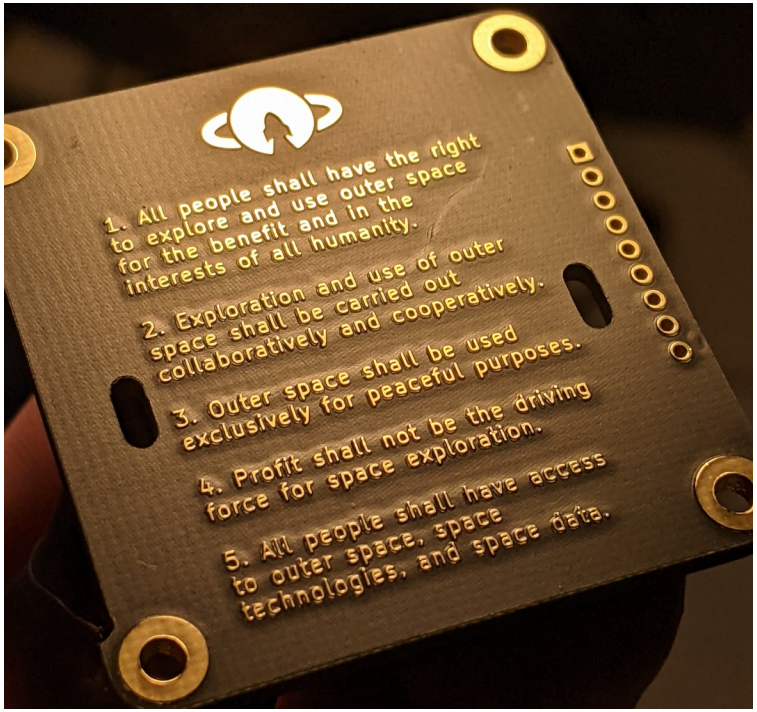
Conformal coating



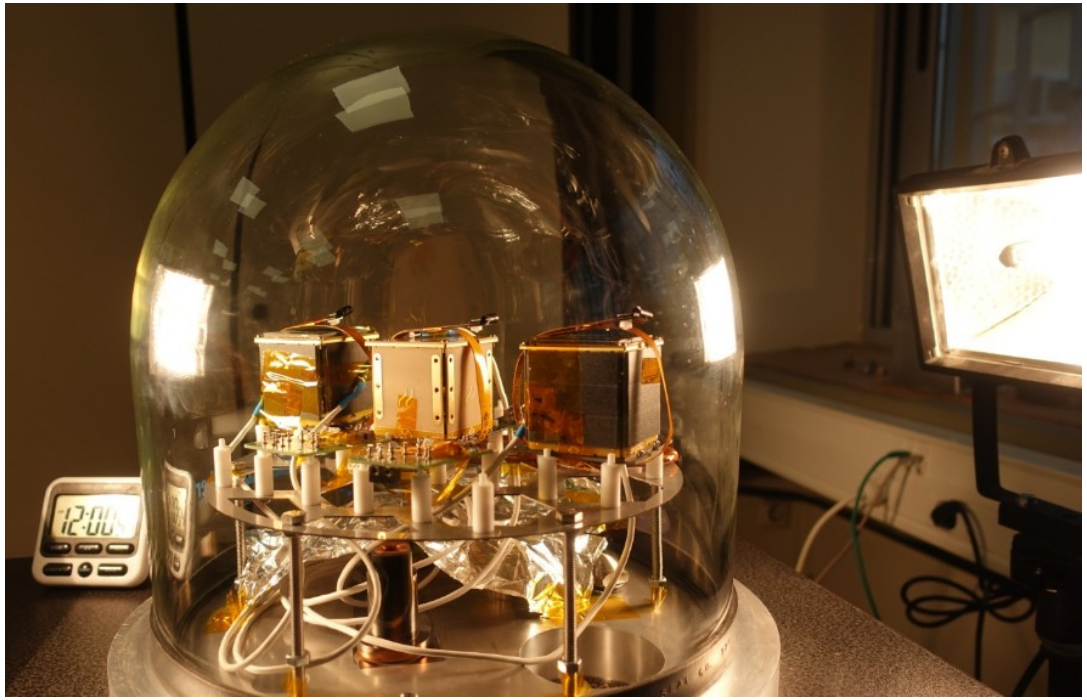



SONY
US18650VTC6
NP-BX1

Send ideas to space

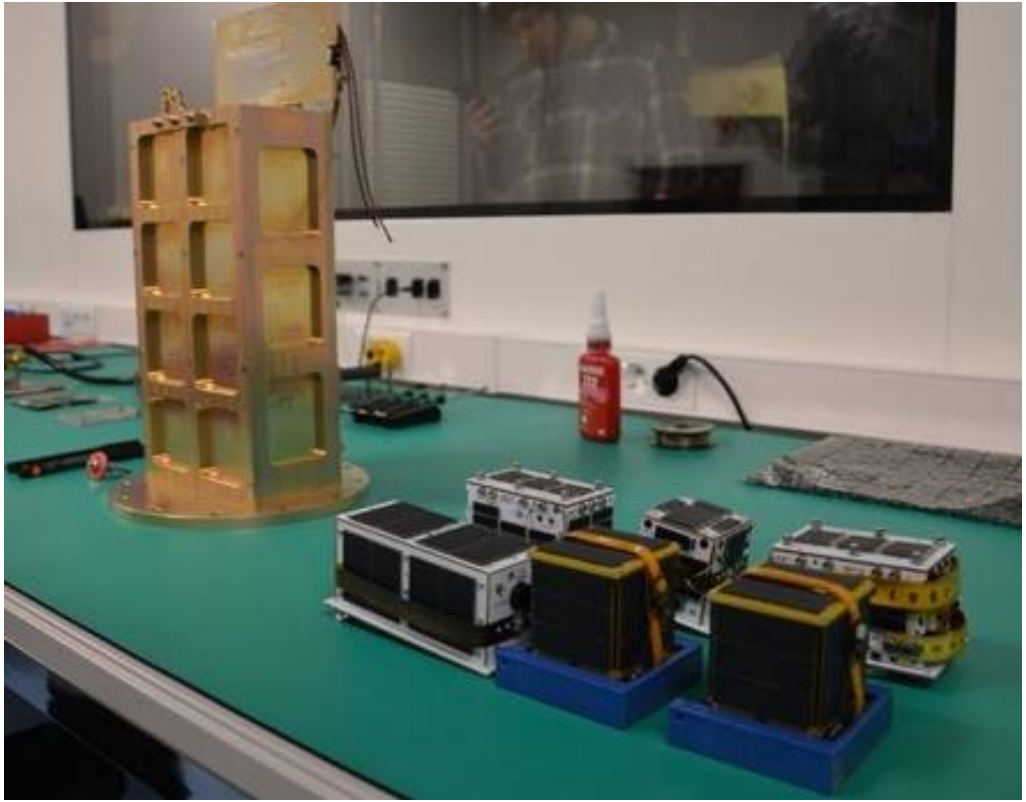


Bakeout



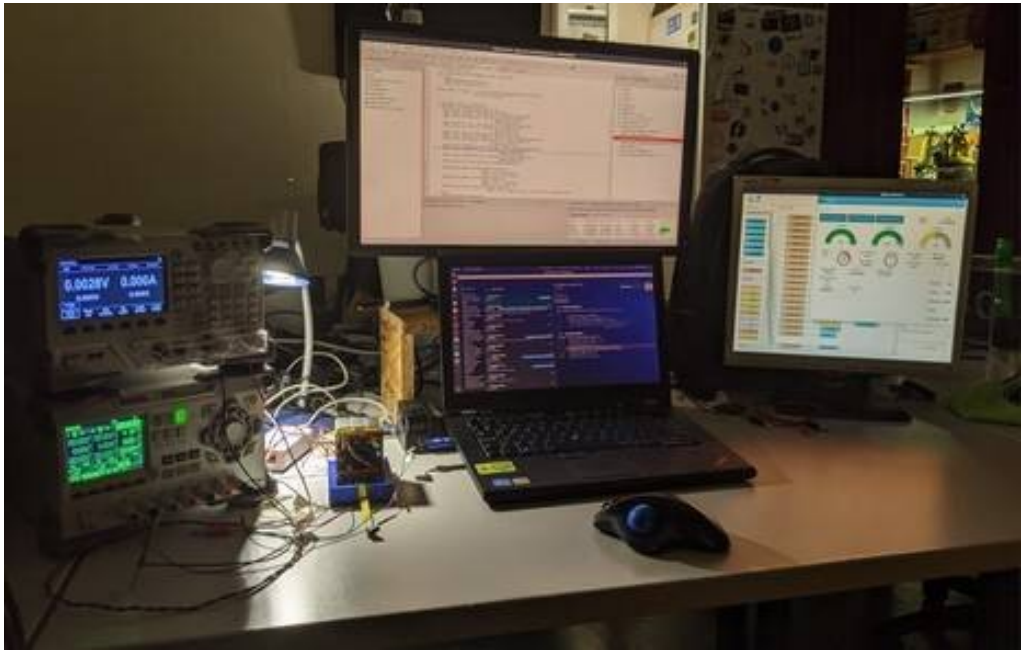
- Vacuum 10^{-5} mbar
- Thermal cycling

Protoflight campaign



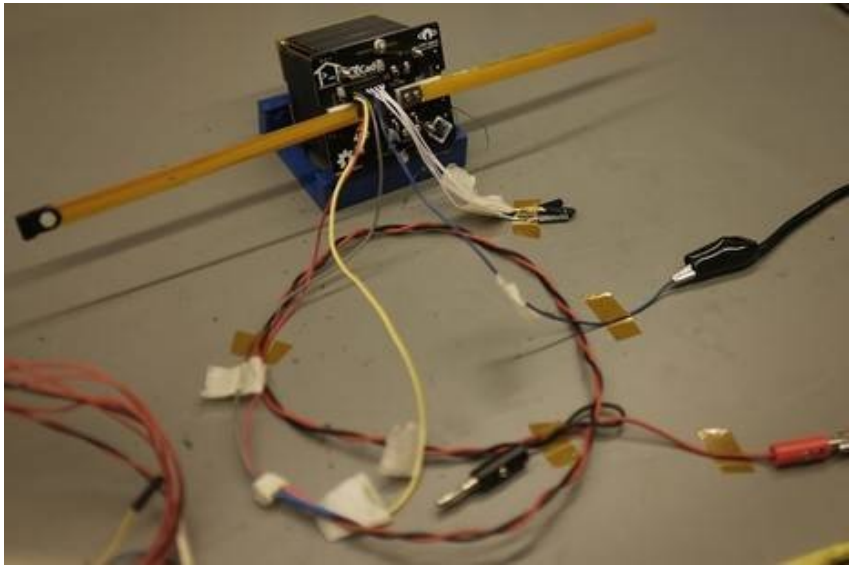
On the software side

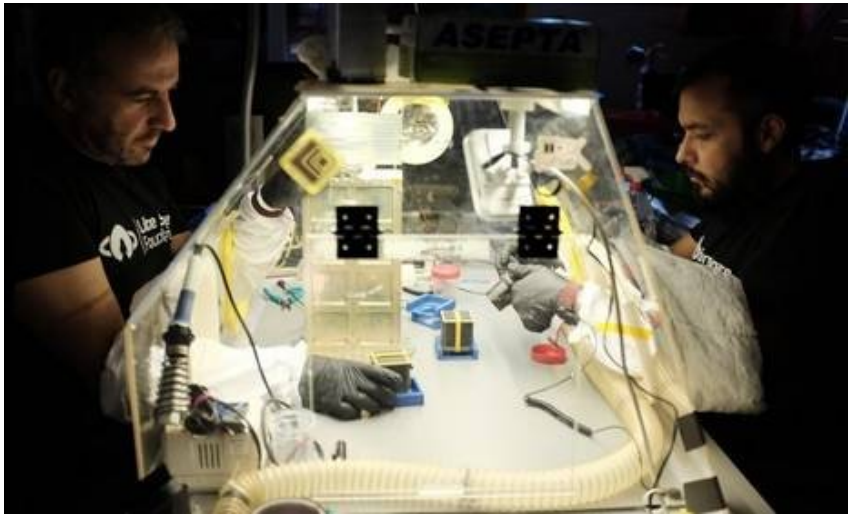
- Implemented fully functional AX5043 driver
- Telemetry and Telecommand
- FSM Control
- New project - Open Space Data Link Protocol
  - CCSDS Space Packet
  - CCSDS TM Space Data Link Protocol
  - CCSDS TC Space Data Link Protocol
  - Communications Operation Procedure
- MAX17261 Power supervisor driver
- GS Telecommand software



SatNOGS Integration during development

Integration





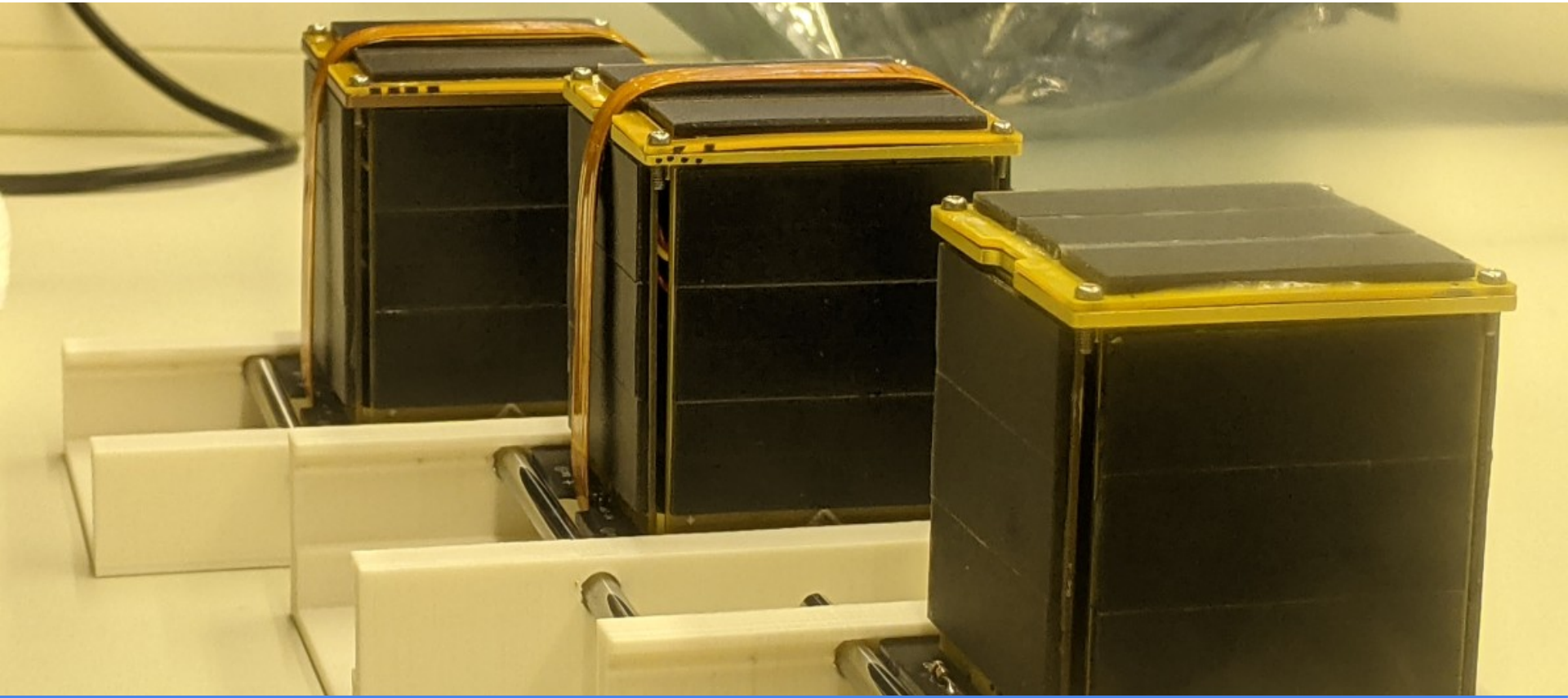
Launch

FIREFLY DREAM PAYLOAD

Firefly Alpha
© Firefly Aerospace

Fireball Alpha
© Firefly Aerospace

So we build more



Almost one year later
© Firefly Aerospace

© Firefly Aerospace

Early Operations

- Both QUBIKs (3&4) where successfully activated and received
- One minor issue with I2C solved by system reset indicating software origin
- TCC attempted
- Telemetry received via SatNOGS network

QUBIK 3 Telemetry Data

Spacecraft ID	Time to Empty
0xEC	4 d 06:23:00

Uptime	Battery Charge
11:20:34	100%

Reasons of Reset

Reasons of Reset Counters

Brownout	1
Independent Watchdog	1
Low Power	0
Software	0

Radio

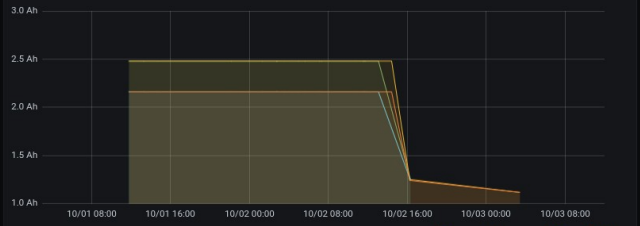
Tx Frames	1360
Rx Frames	262
Rx Corrected Bits	0
RSSI	-120
Dropped Frames	261

Ant Test Voltage	Antenna Status
4.034 V	Deployed
Ant Avg Voltage	**Ant Deployment Duration**
3.929 V	22 s
Ant Test Result	**Ant Retries**
No data	0
Ant Avg Current	**Ant Test Current**
-566 mA	0 mA

Power Monitor **Power Save**

RTC Battery Voltage	First Run	
676 mV	Deployed	Deployed
First Deploy	Ant First Deploy	

Battery

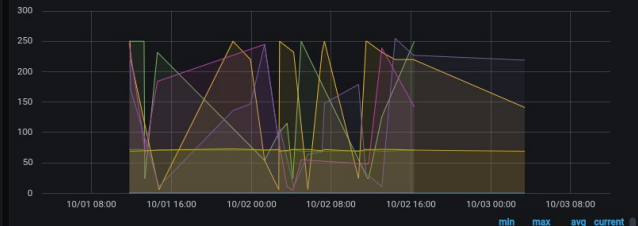


	min	max	avg	current
Capacity Full	1.252 Ah	2.480 Ah	2.386 Ah	1.252 Ah
Capacity Full	1.118 Ah	2.480 Ah	2.344 Ah	1.118 Ah
Capacity Remaining	1.241 Ah	2.161 Ah	2.090 Ah	1.241 Ah
Capacity Remaining	1.118 Ah	2.161 Ah	2.058 Ah	1.118 Ah

Currents

	current
Instantaneous Current	-21 mA
Instantaneous Current	0 mA
Average Current	-22 mA
Average Current	24 mA

Radio Statistics



	min	max	avg	current
Datarate Tracking	24	250	132	250
Datarate Tracking	6	250	174	141
Frequency Tracking	0	0	0	0
Frequency Tracking	0	0	0	0

Temperatures

Battery Temperature Max	28.00 °C
Battery Temperature Max	29.00 °C

Voltages

	current
Instantaneous Voltage	4.255 V

CLCW

Time ↑	VC2 VER	VC2 COP	VC2 TYPE	VC2 FARM B COUNTE	VC2 F
2022-10-01 11:48:16	0	1	false	0	
2022-10-01 11:52:16	0	1	false	0	
2022-10-01 11:53:16	0	1	false	0	
2022-10-01 11:56:16	0	1	false	0	
2022-10-01 11:57:16	0	1	false	0	
2022-10-01 13:18:20	0	1	false	0	
2022-10-01 13:20:20	0	1	false	0	
2022-10-01 13:23:20	0	1	false	0	
2022-10-01 14:39:23	0	1	false	0	

Outcome

- Platform operation success
- QUBIK platform is now TRL-9
- Target orbit not reached by firefly, mission life reduced to 3-4 days
- Orbit determination successful but unusable due to rapid orbit decline
- PICOBUS (Next Talk) https://gitlab.com/librespacefoundation/picobus
- SIDLOC (UB2.147 at 16:30) https://gitlab.com/librespacefoundation/sidloc
- Open Space Data Link Protocol https://gitlab.com/librespacefoundation/osdlp
- Satellite Solar Power Budget https://gitlab.com/librespacefoundation/satellite-solar-power-budget

Platform

- 1p PocketQube bus
- Room for 1-2 payloads depending on battery configuration
- 350-500mW of Power Generation
- Battery Monitor and management
- Documentation and Assembly Guide
- Cost effective for Research, Education, Radio Amateur

Future

- COMMS subsystem to reach version 1
- Finalize PQ9ish format
- Create ICD (Interface Control Document)
- Design a 4 channel power board
- Add more information documentation
- Explore larger setups (2p,3p,4p)
- Fly more QUBIKs

Open Source tools – Open Software – Open Hardware

Repos under https://gitlab.com/librespacefoundation/qubik

People

QUBIK Team

Agis Zisimatos

Alfredos-Panagiotis Damkalis

Andreas Ampatzoglou

Aris Nikas

Cees Bassa

Fabian P. Schmidt

George Tsagkarelis

George Vardakis

Ilias Daradimos

Kostis Triantafyllakis

Manolis Surligas

Manthos Papamattheou

Mike Biniaris

Panagiotis Chatzidakis

Patrick Dohmen

Pierros Papadeas

Vasilis Tsiligiannis

Photos

Manthos Papamattheou

Julian Fernandez

Ilias Daradimos

Aris Nikas

Facilities

TVAC at Instituto Nacional Técnica Aeroespacial, Madrid arranged by FOSSA Systems

Vibration test at Universitat Politècnica de Catalunya,Barcelona arranged by FOSSA Systems

Bake-out at IESL, FORTH, EDML UNIWA

Repos under https://gitlab.com/librespacefoundation/qubik

Thank You