Results from SMOG-1 PocketQube

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Delft
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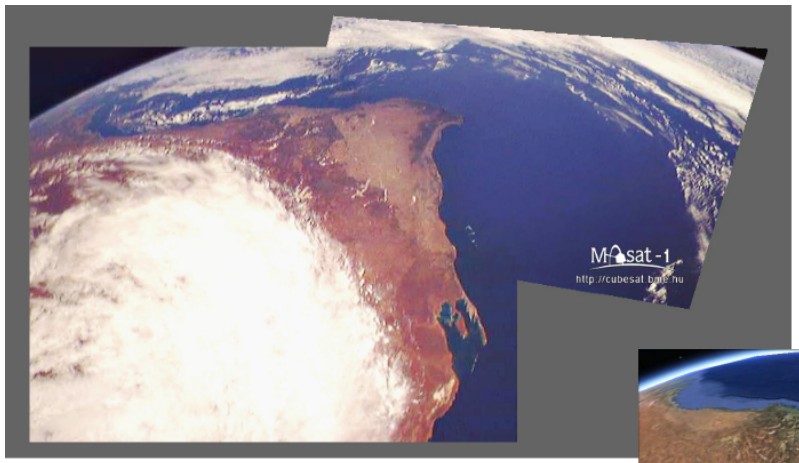
SMOG-1

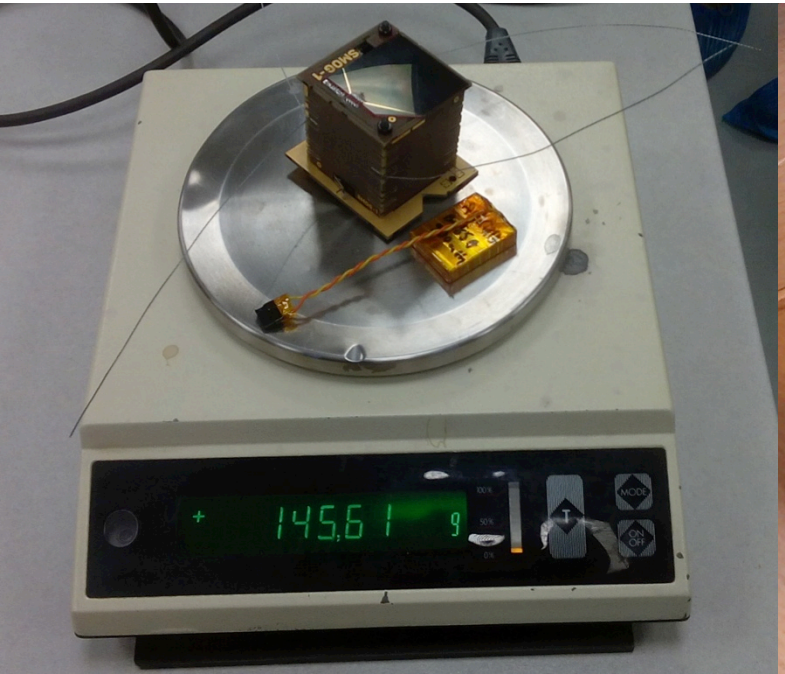
The father – MASAT-1

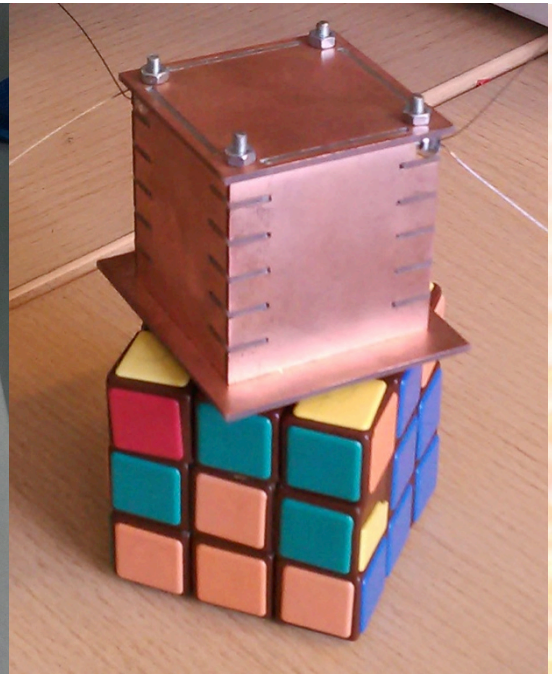
- The first Hungarian Satellite
- 1 U CubeSat (10 × 10 × 10 cm size)
- 998.5 g mass
- Designed and built by students and lecturers of Budapest University of Technology and Economics (BME)
- Development: 2007 – 2012, Launch: 13. 02. 2012
- 1062 days in operation
- Fully successful mission (Trigger for Hungary to join ESA)



SMOG-1, the successor

- The next Hungarian Satellite
- Student satellite like MASAT-1
- PocketQube class (5 × 5 × 5 cm size)
- 250 g maximal mass (currently 150 g)
- Radioamateur (HAM) Satellite,
  HA5BME, 437.345 MHz (ITU, IARU)
- More scientific goals:
  - Primary mission: measurement of electromagnetic pollution (RF smog)
  - Secondary mission: measurement of Total Ionising Dose

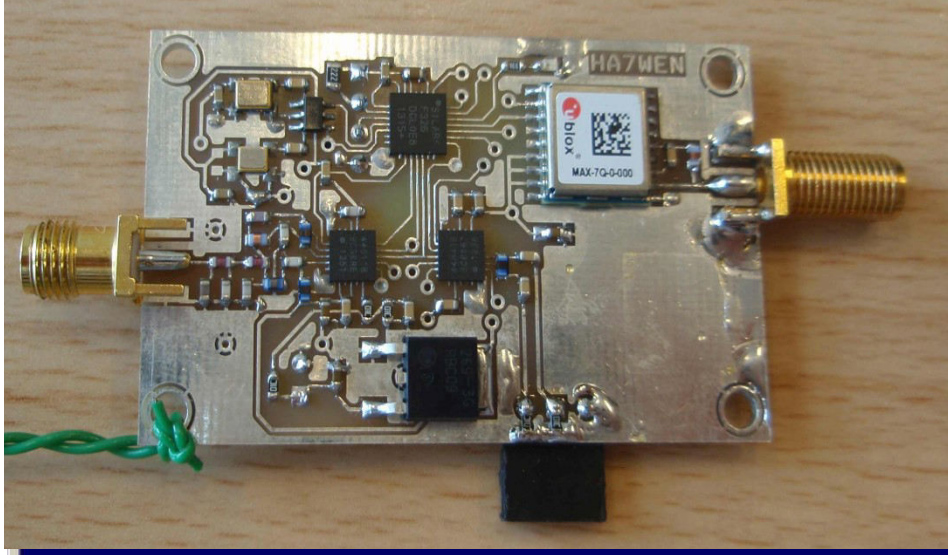


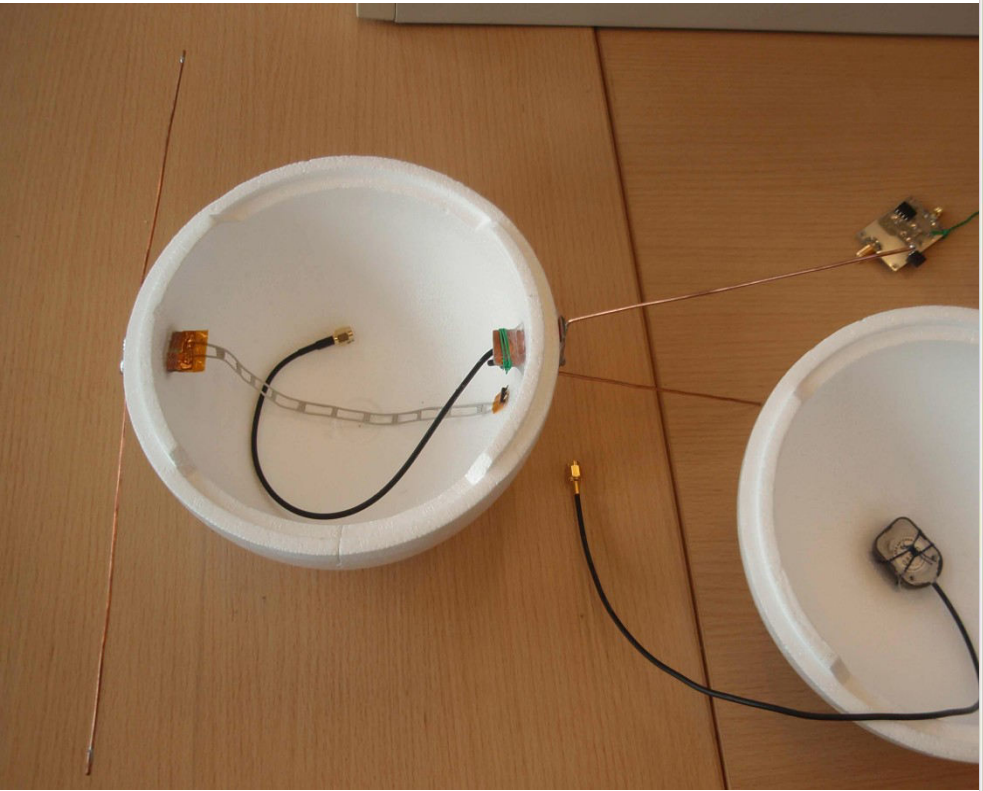


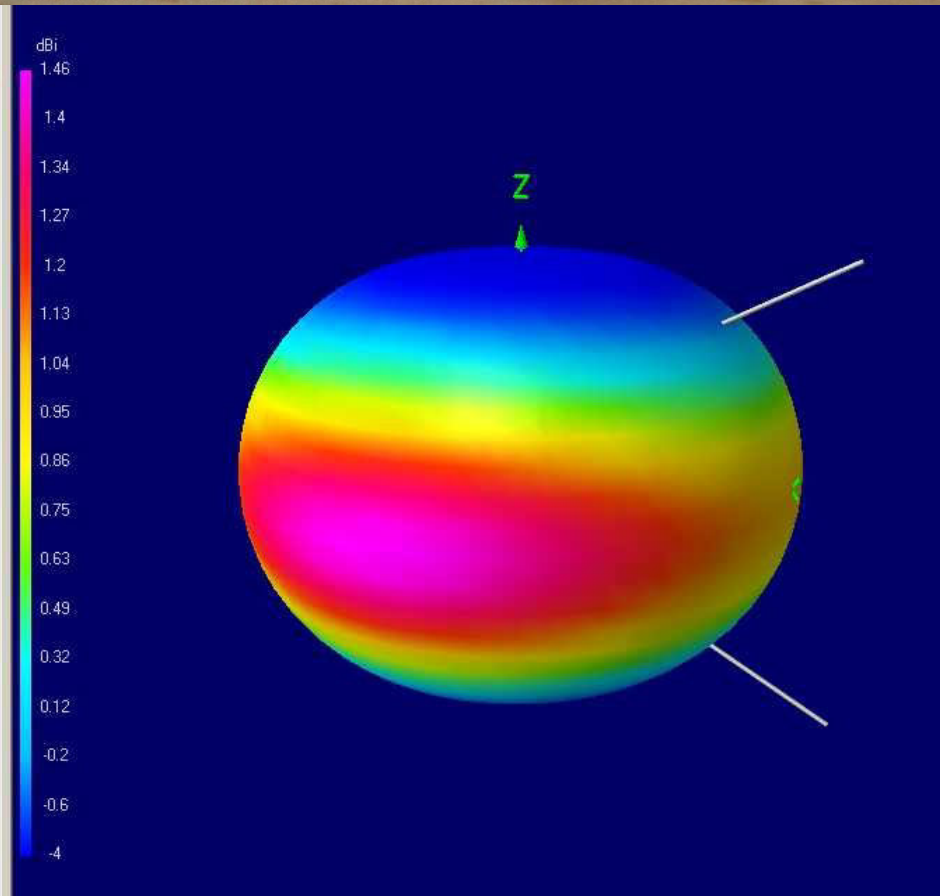
SMOG-1 mission – Spectrum analysis

- Huge emitted RF power from terrestrial TV broadcasting (DVB-T 430–830 MHz)
- This emitted power means wasted energy “electro-smog” and escapes to space
- It’s a known effect, this power disturbs all satellite communications
- Nobody has published any measurements about this

Balloon experiments for testing the measurement system







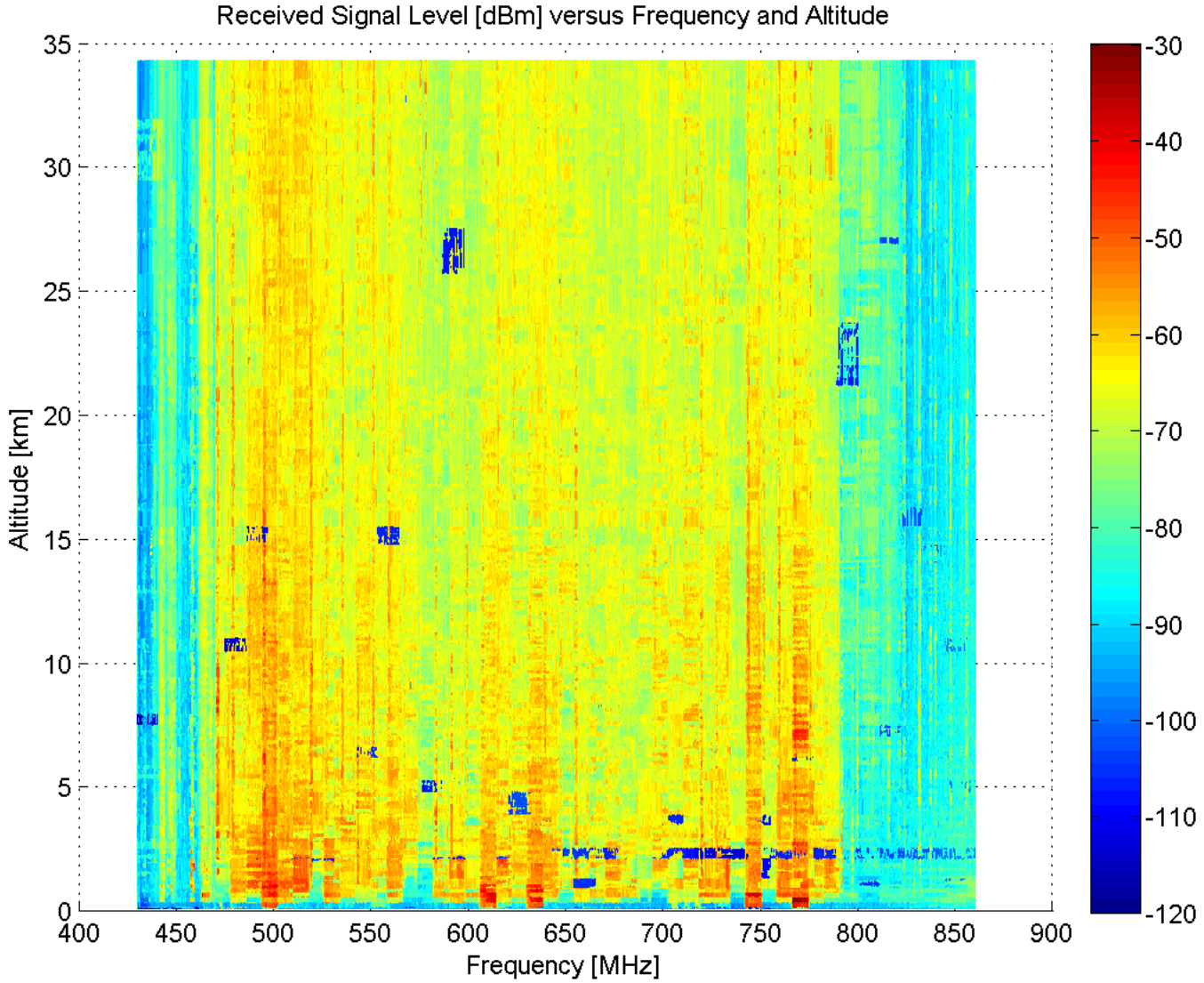
Maximal altitude:

30 .. 34 km

Balloon experiment results

SMOG-1

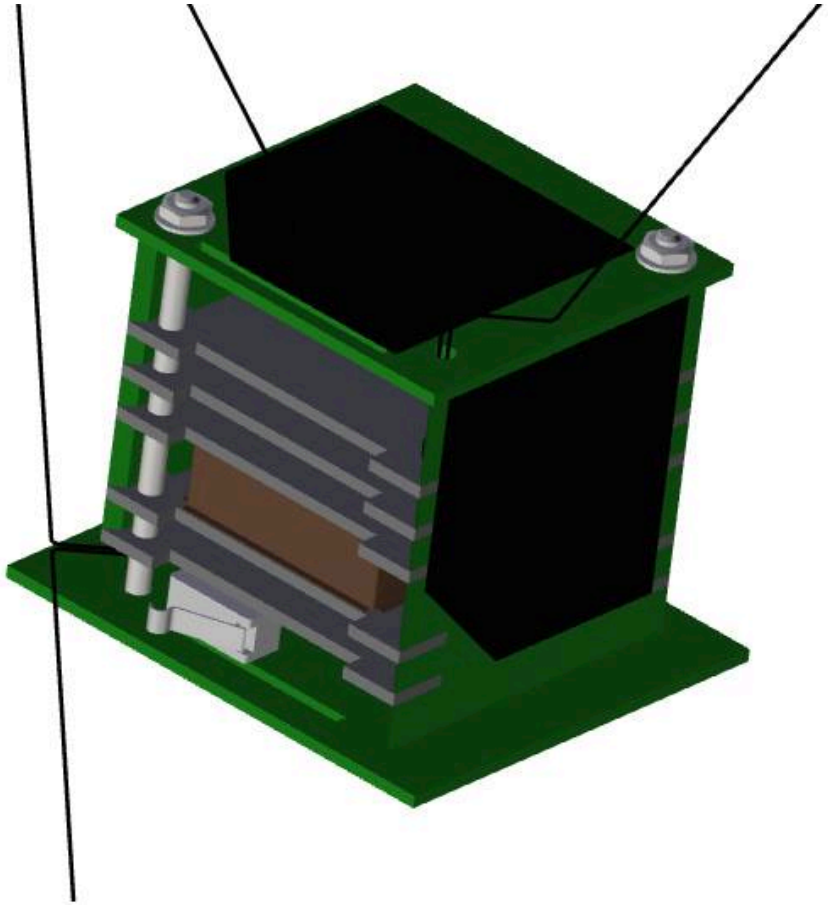
- The received RF power form Budapest's main TV towers clearly outstanding



SMOG-1

Structure

- Standard FR-4 PCBs with 4, 6 and 8 signal layers
- Electrical subsystems soldered on the PCBs
- 6 outer-, 5 inner boards
- Solar cells on the outer PCBs

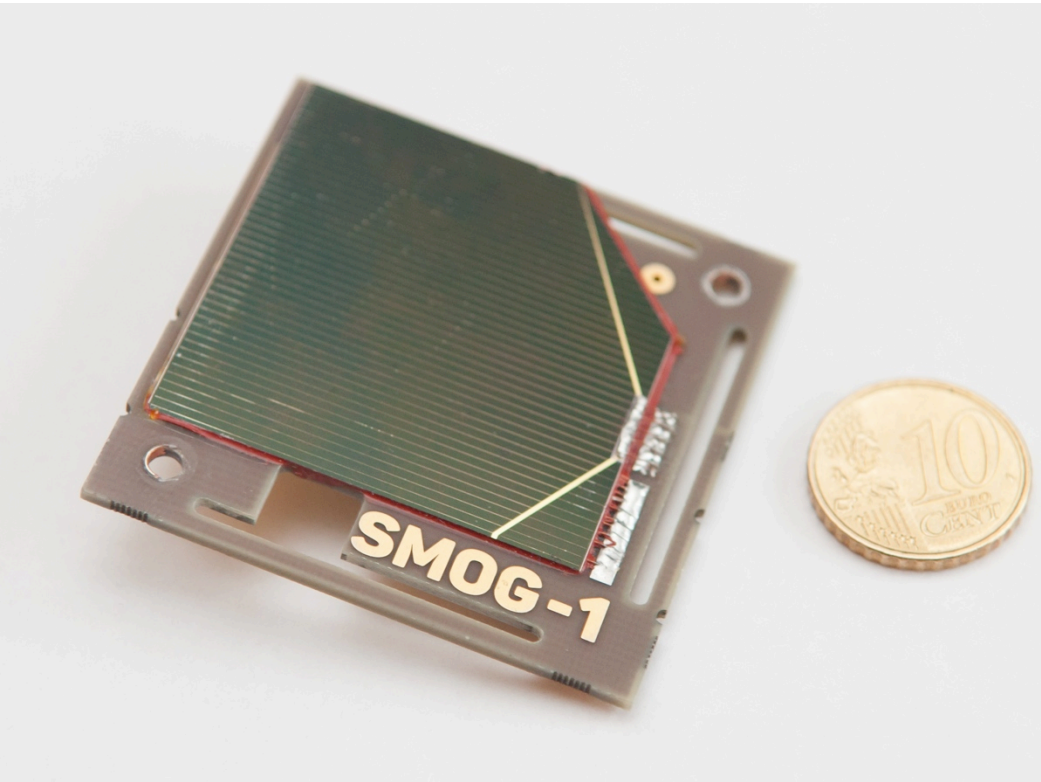


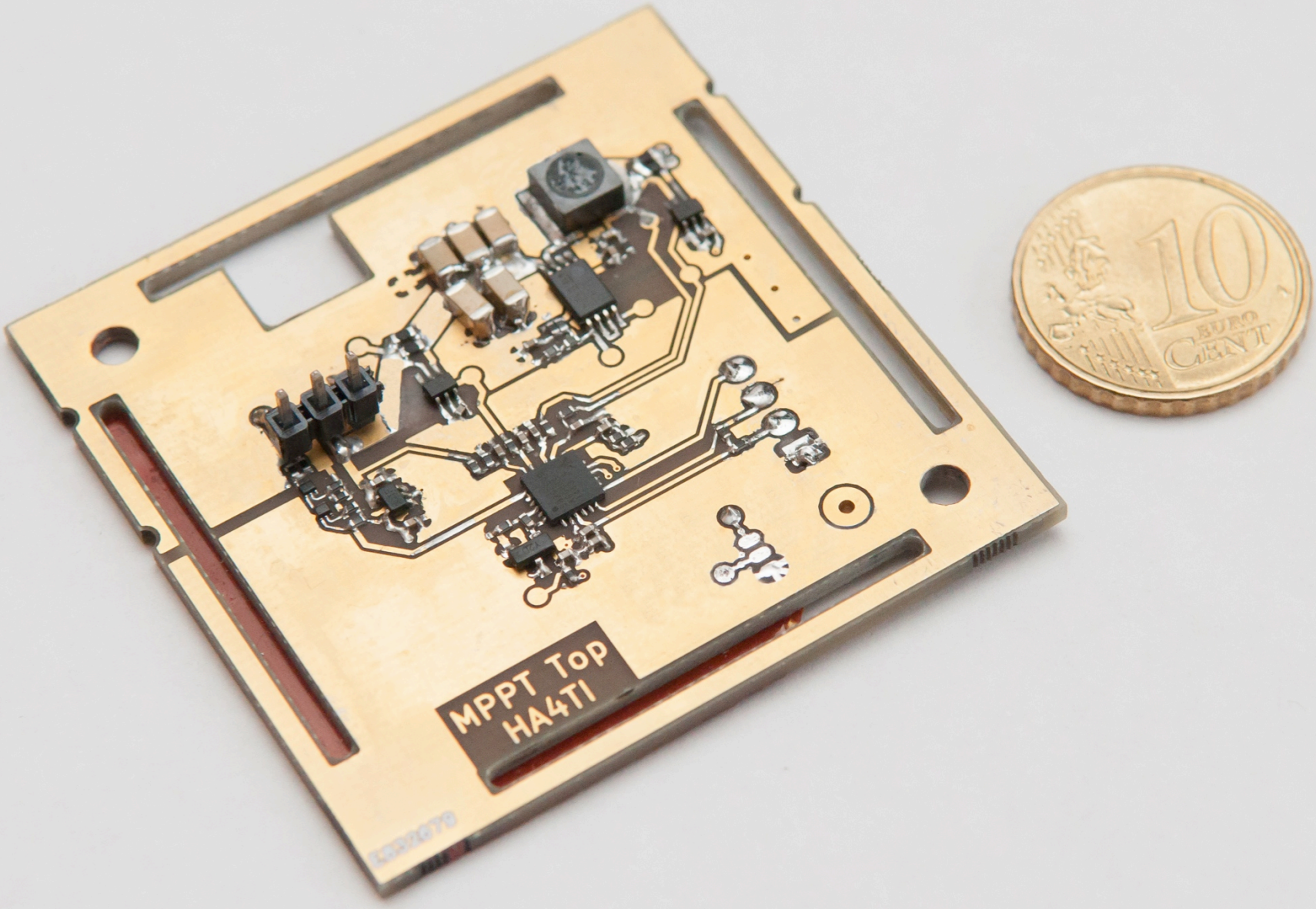
Subsystems

- EPS-1 (MPPT)
- EPS-2
- OBC
- COM (+Spectrum)
- TID

Primary Electrical Power System (EPS-1)

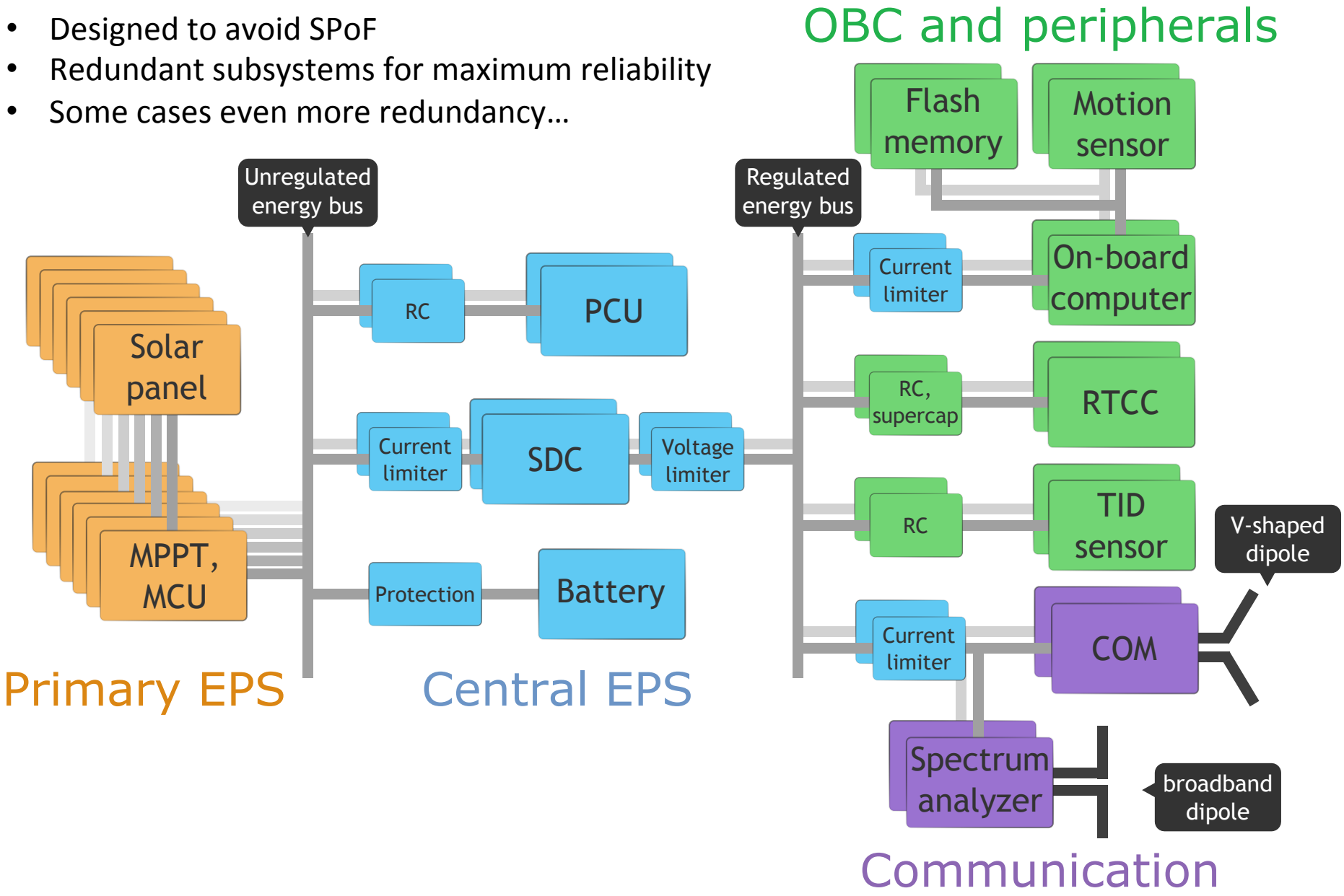
- Generates usable electrical power from solar radiation
- Nearly 40 x 40 mm solar cells with 28.5 % efficiency
- MPPT algorithm for maximal power
- 300 mW mean output power (500 mW peak)
- Microcontroller based measurement system
- Light sensor, temperature sensor




MPPT Top
HA4TI
10
EURO
CENT

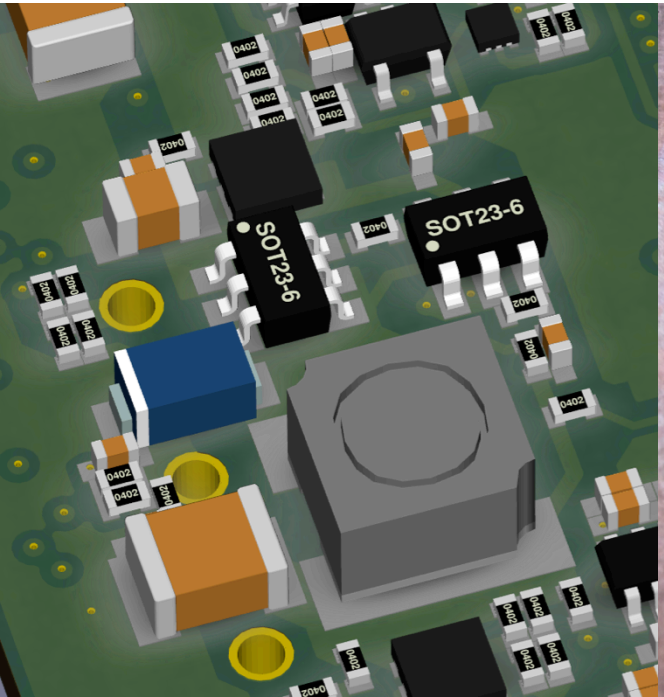
SMOG-1 subsystems

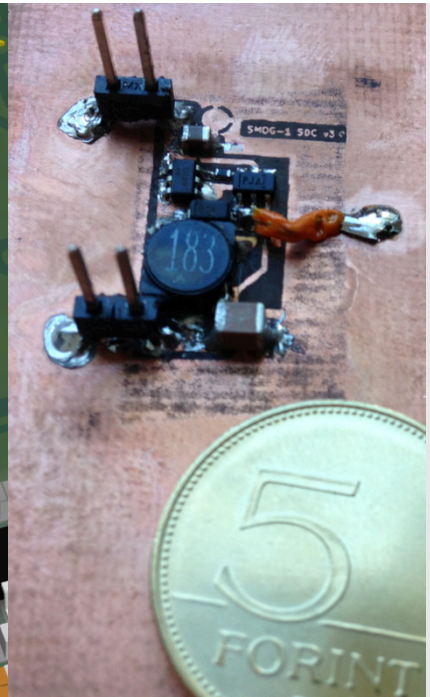
- Designed to avoid SPoF
- Redundant subsystems for maximum reliability
- Some cases even more redundancy…

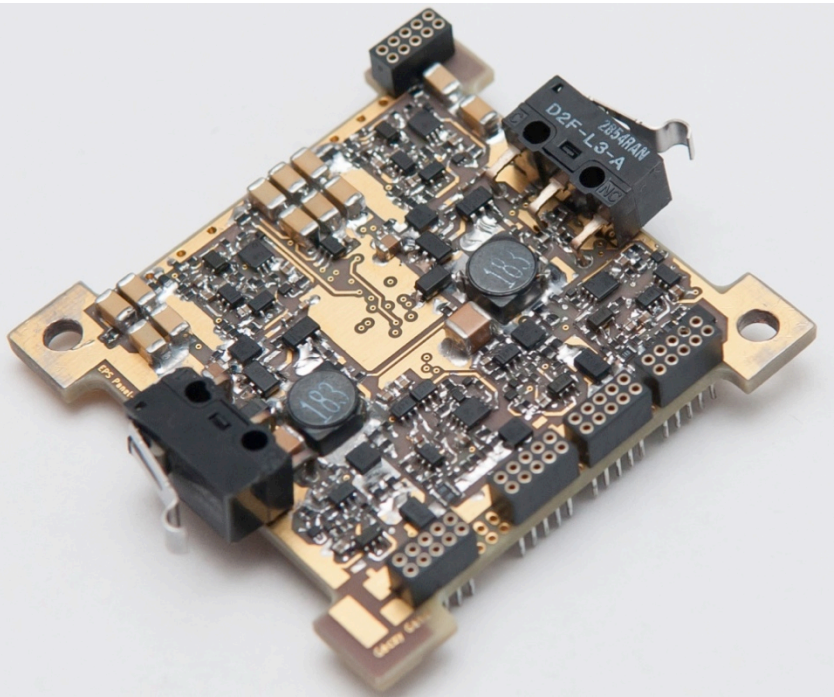


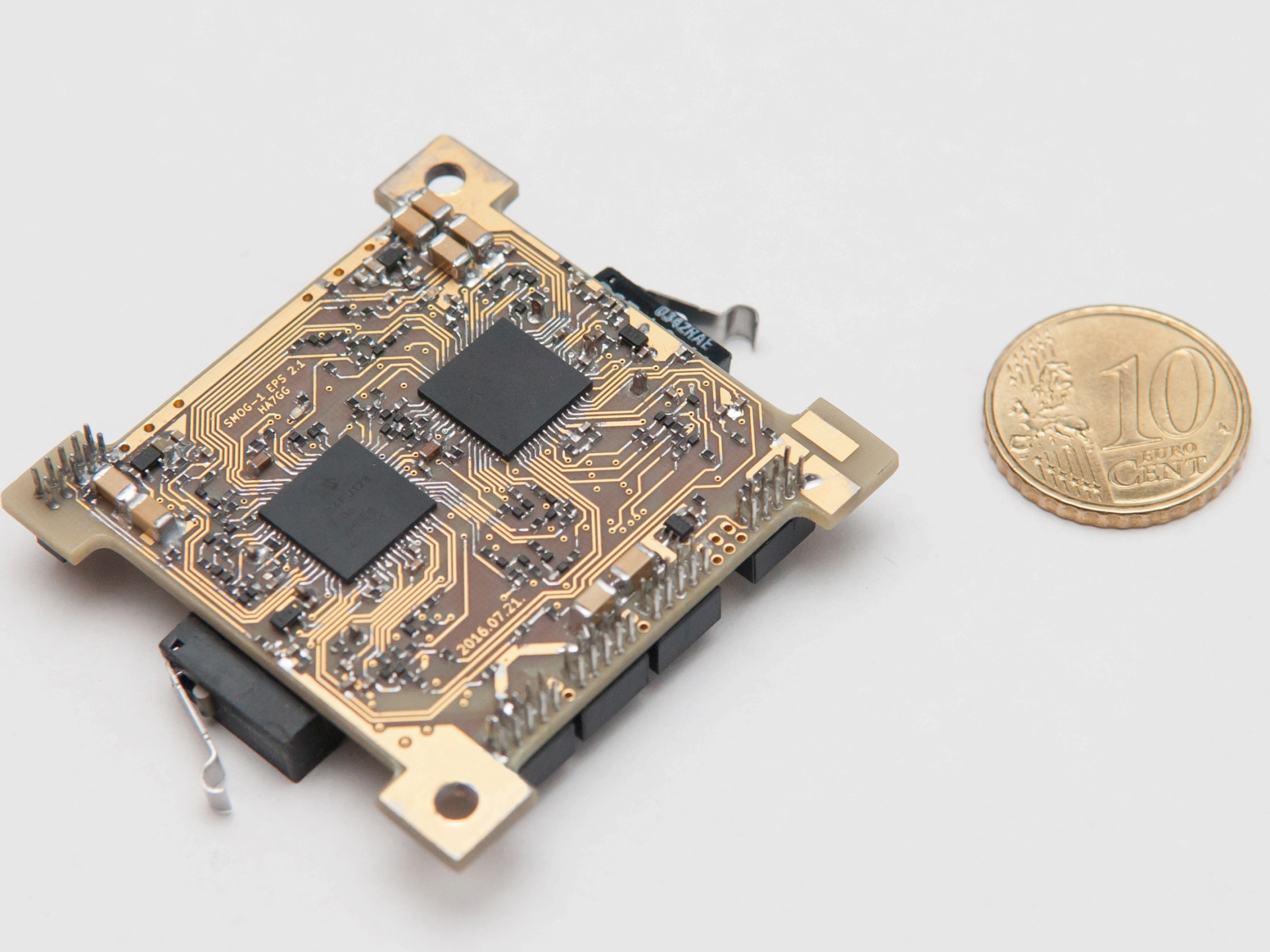
Central Electrical Power System (EPS-2)

- Energy distribution
- Battery protection and management
- Voltage regulation
- Current sensing, limitation and short circuit protection with unique redundant limiters
- Over-, and undervoltage protection circuits
- Self control and diagnostics by the Power Control Unit
- Optimized for high efficiency (99 % peak efficiency)
- Consumption optimized control software








SMOG-1 EPS 2.1
HA7GG
2016.07.21.
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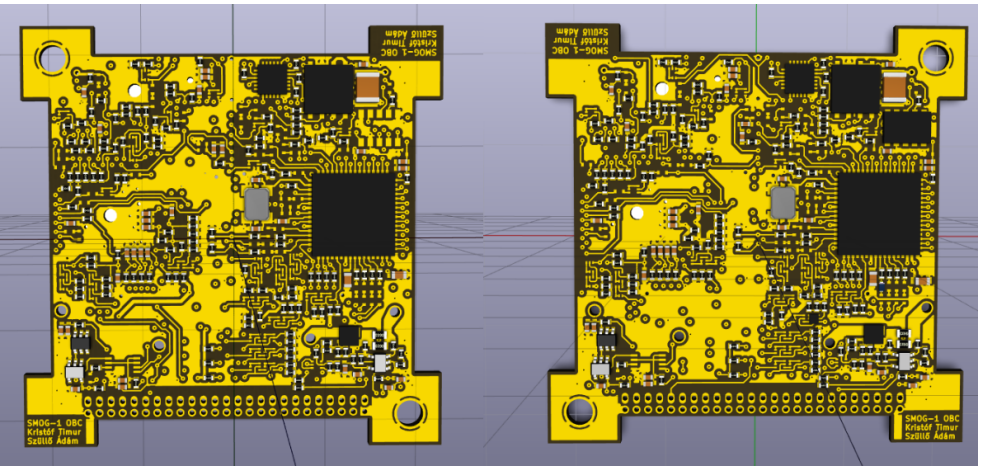
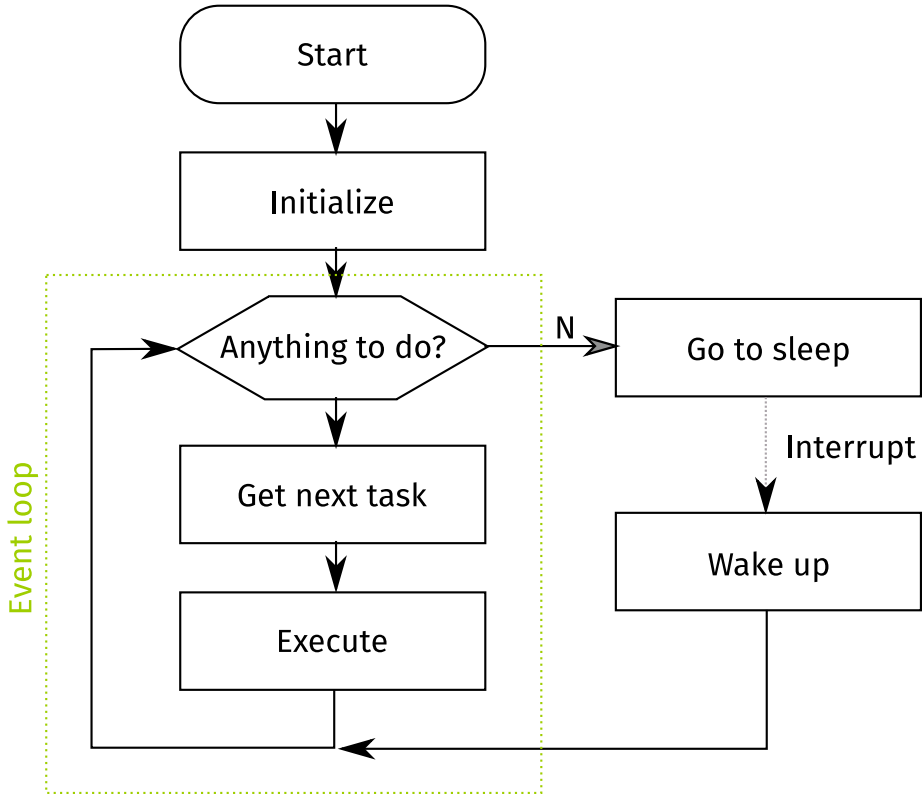
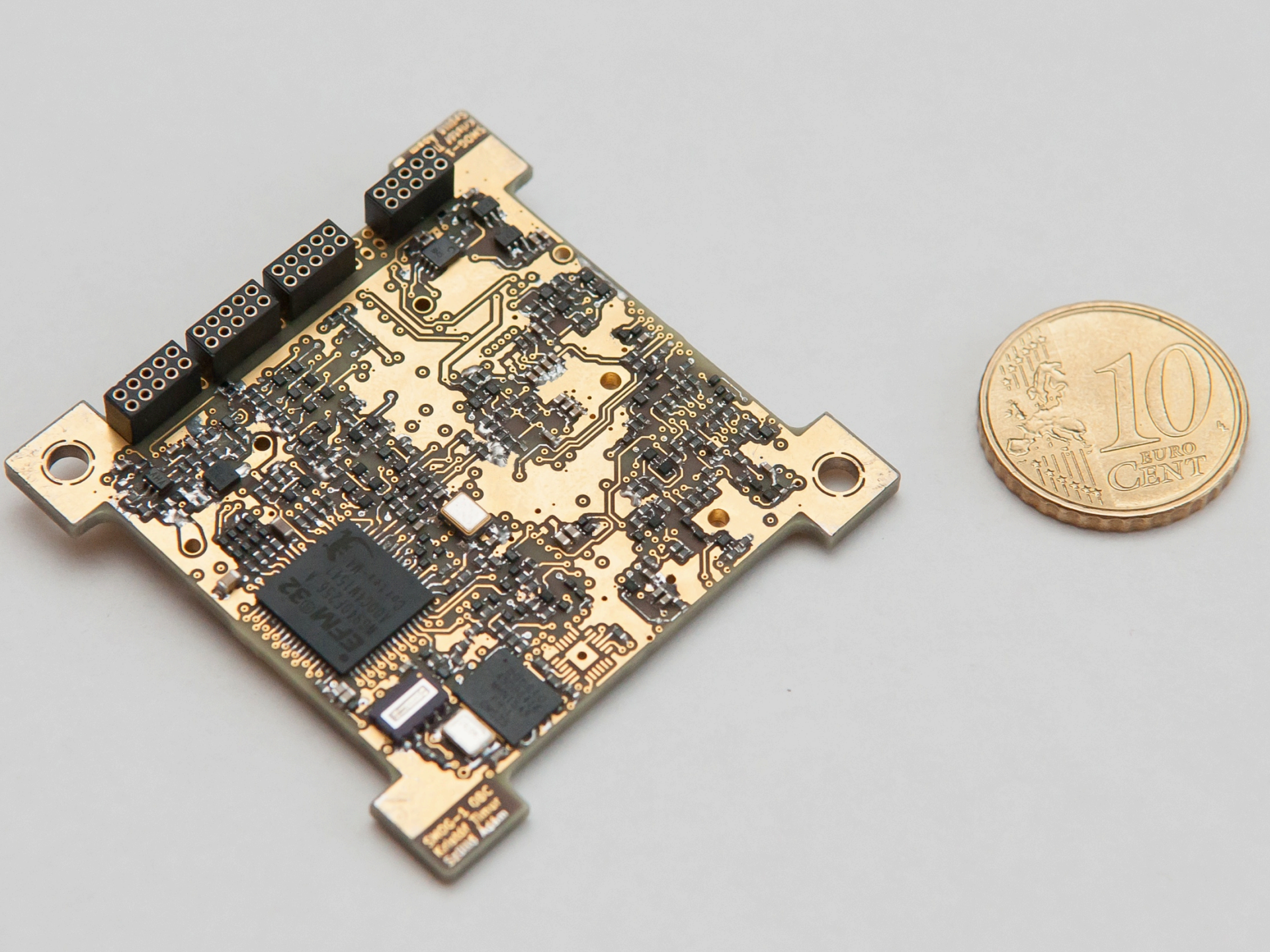
EURO
CENT

On-board Computer (OBC)

- Coordinates every subsystem on the satellite
- Schedule measurements
- Data storage in a 8 MB flash memory
- Microcontroller based subsystem with ARM Cortex-M4 core
- Consumption optimized control software
- RTCC (real time clock and calendar)
- Magnetometer



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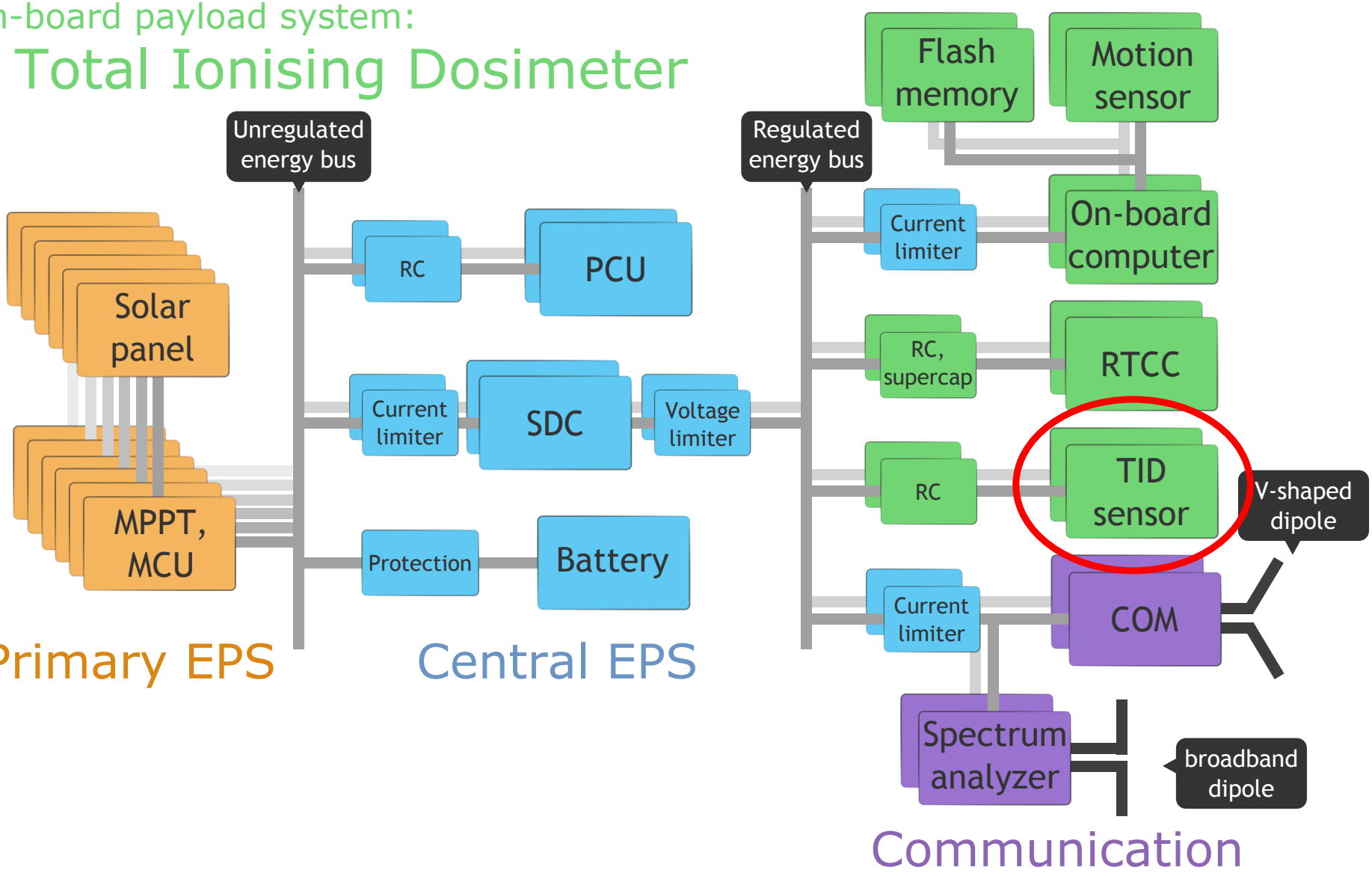
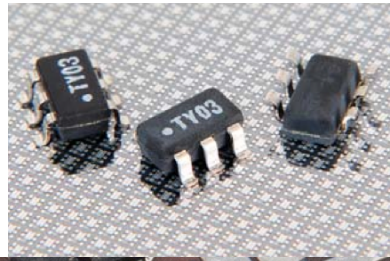
On-board payload system:

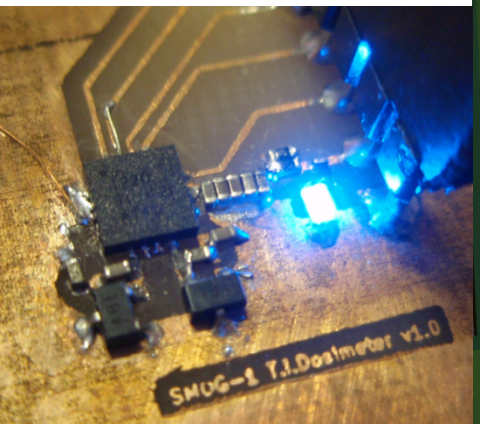
Total Ionising Dosimeter

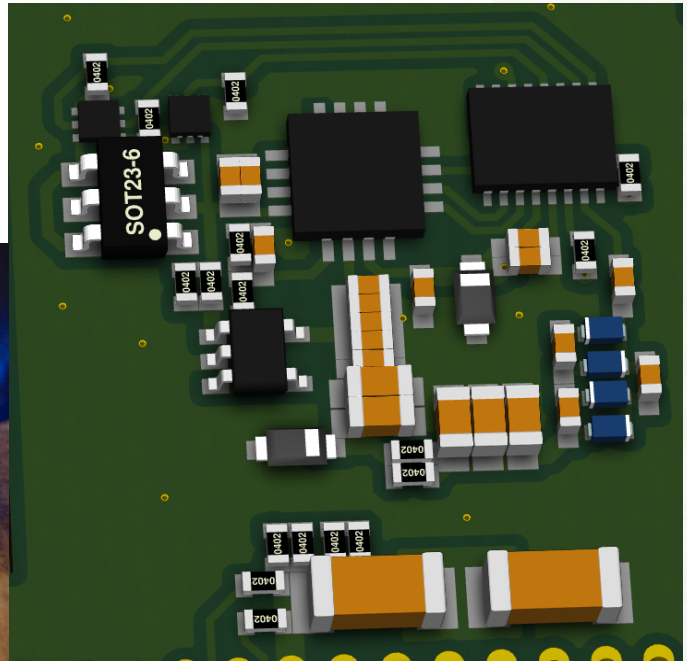


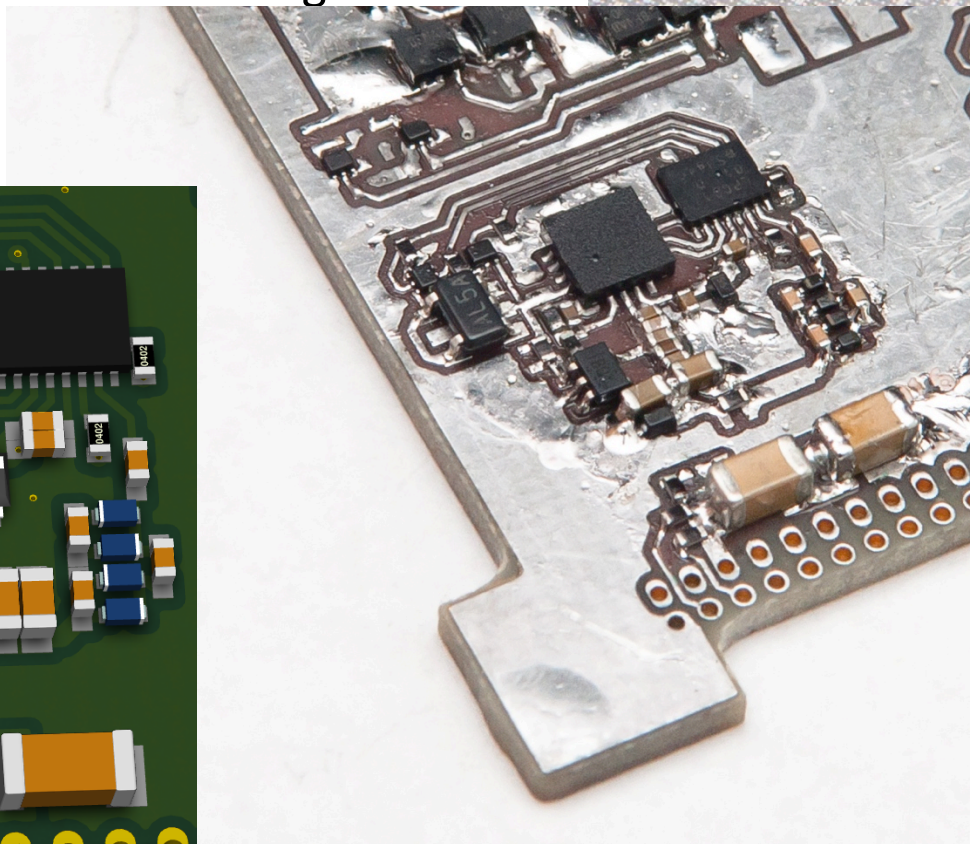
Total Ionising Dosimeter (TID)

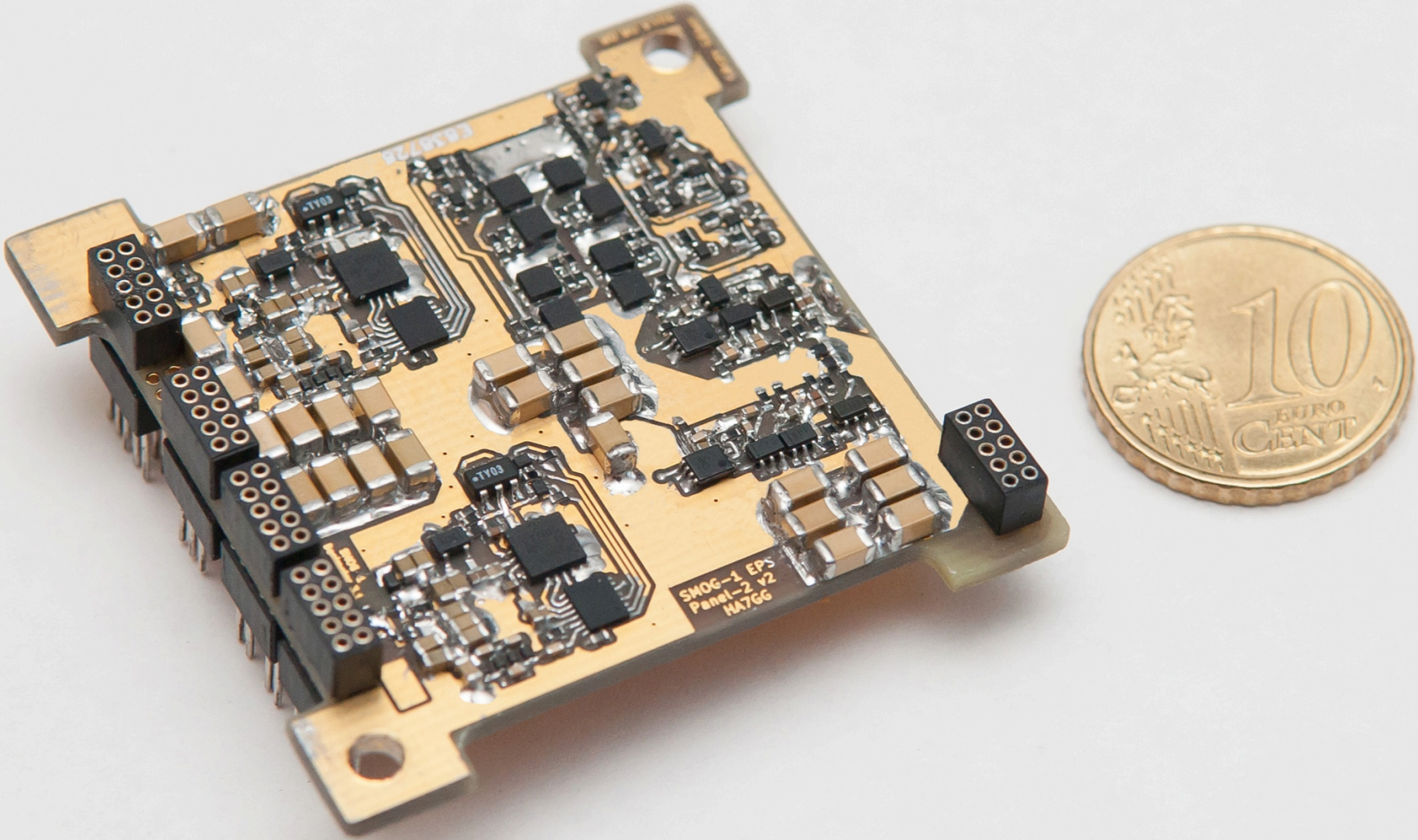
- The world's smallest dosimeter (~13x13 mm)
- 0-40 krad measuring range
- Negligible consumption (1 mW average used DC power)
- 600 km LEO: estimated to 11 krad/years total ionising dose
- ~2-6 years lifetime










SMOG-1 EPS
Panel-2 v2
HA7GG
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EURO
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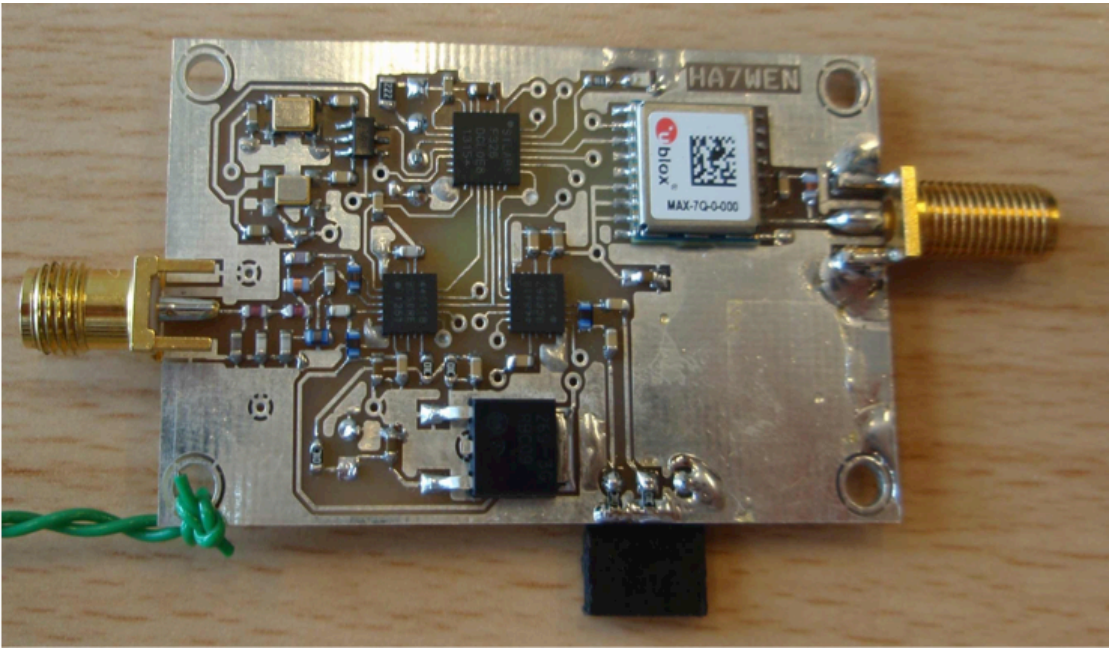
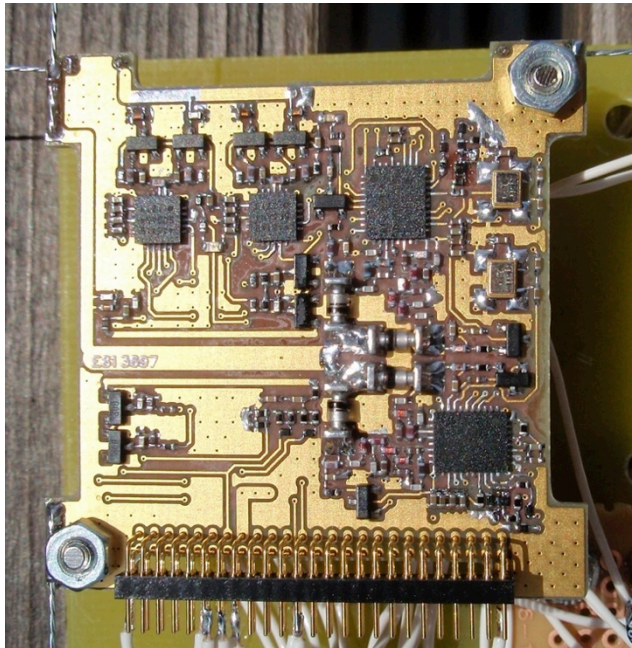
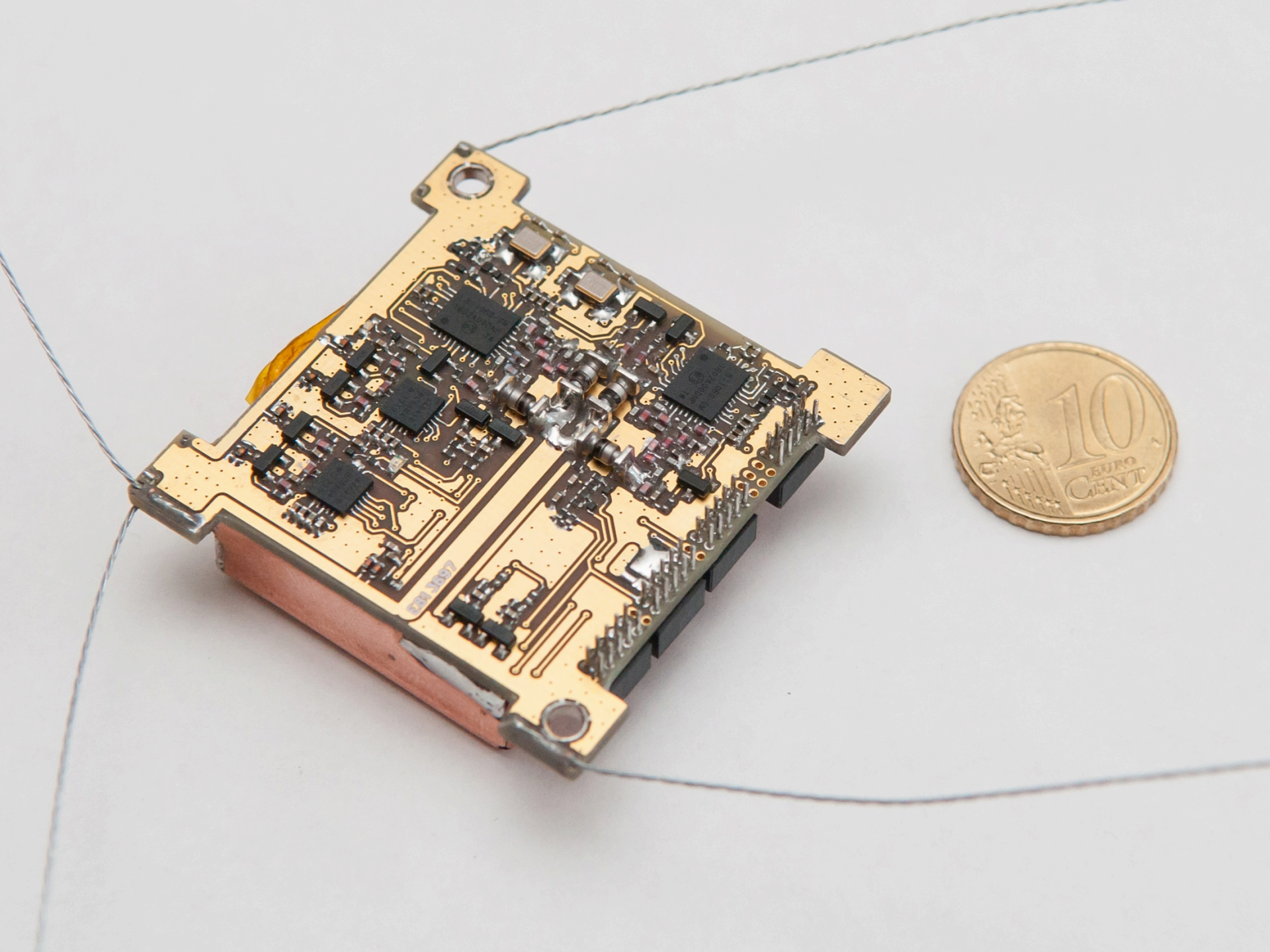
COM (& SP)

Contains the communication system (COM) and the spectrum analyzer (SP)

- Spectrum analyzer
  - 119 – 960 MHz frequency range
  - -10 … - 120 dBm dynamic range
- COM: connection between ground station (GND) and SMOG-1
  - 437.345 MHz
    amateurs will able to track and receive all transmissions worldwide
  - +20 dBm (100 mW) RF transmit power to communicate



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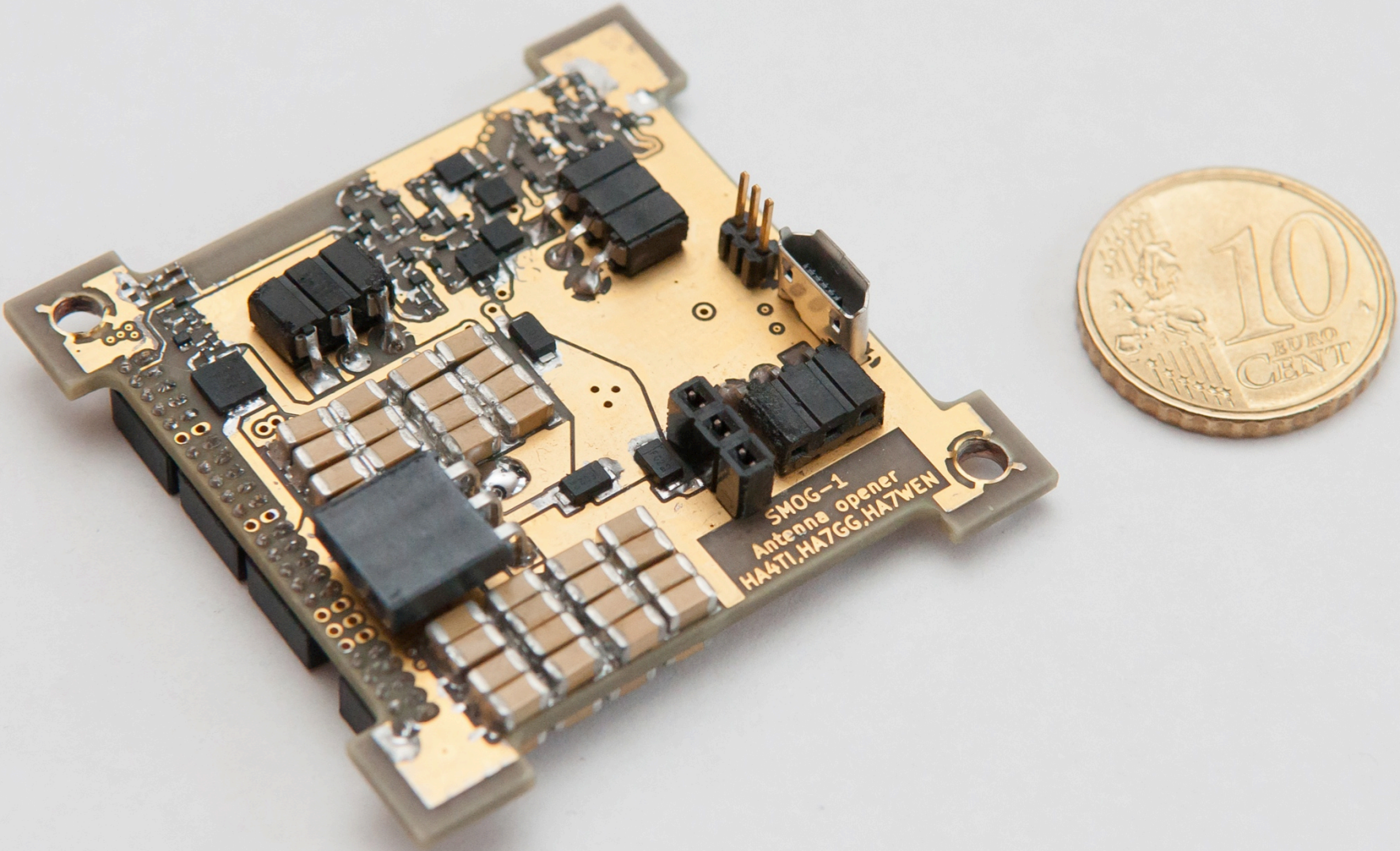
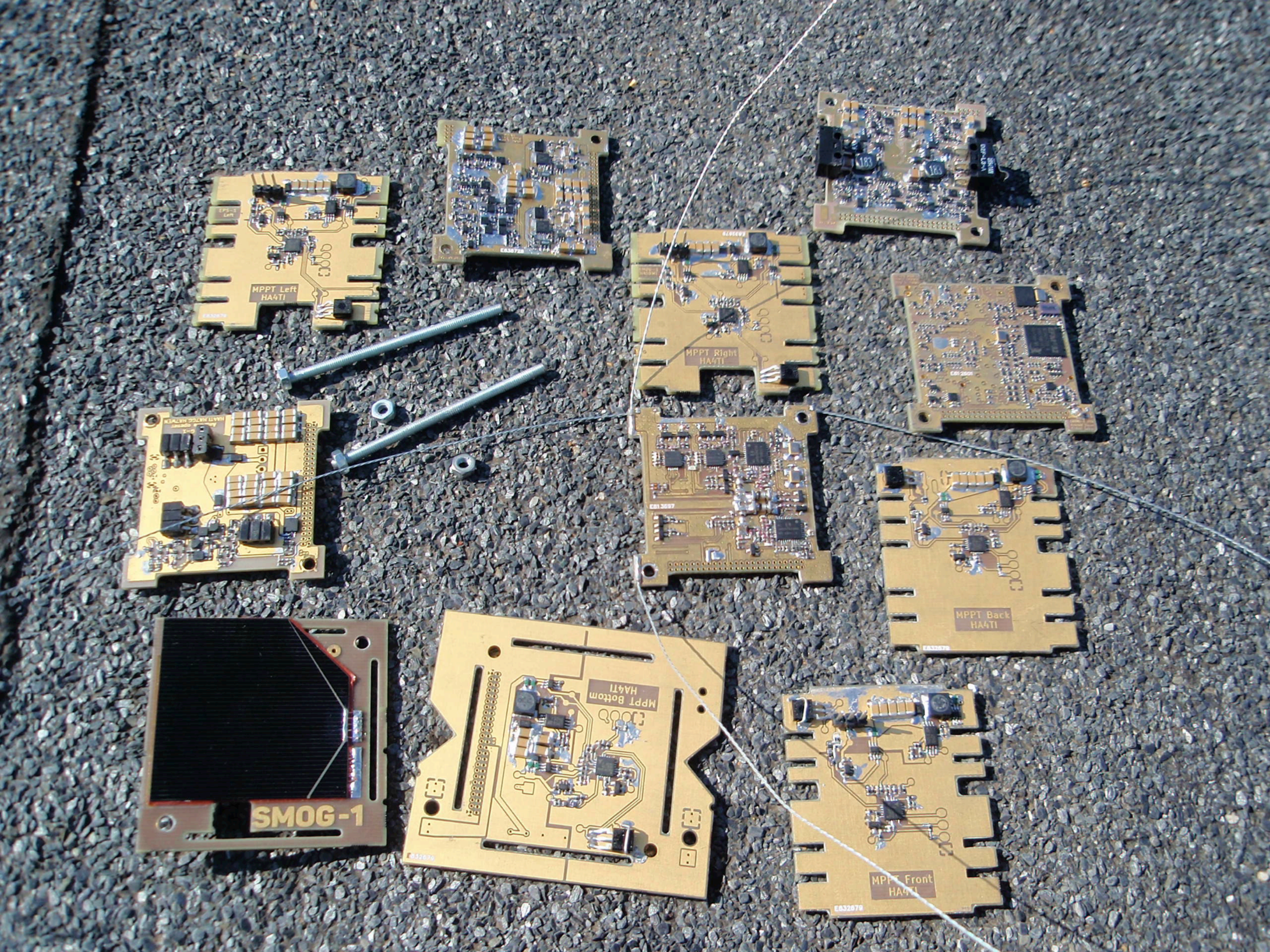
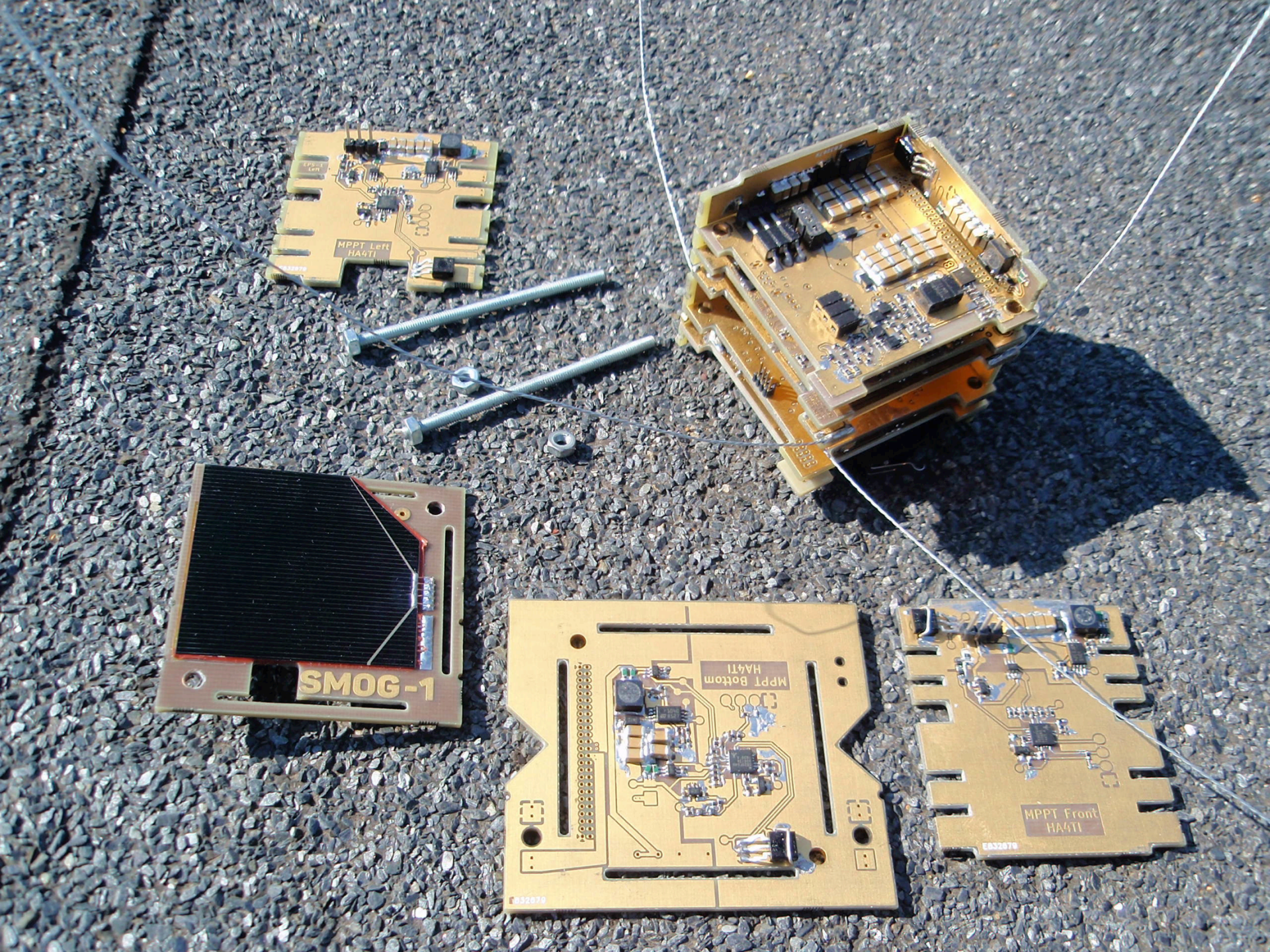
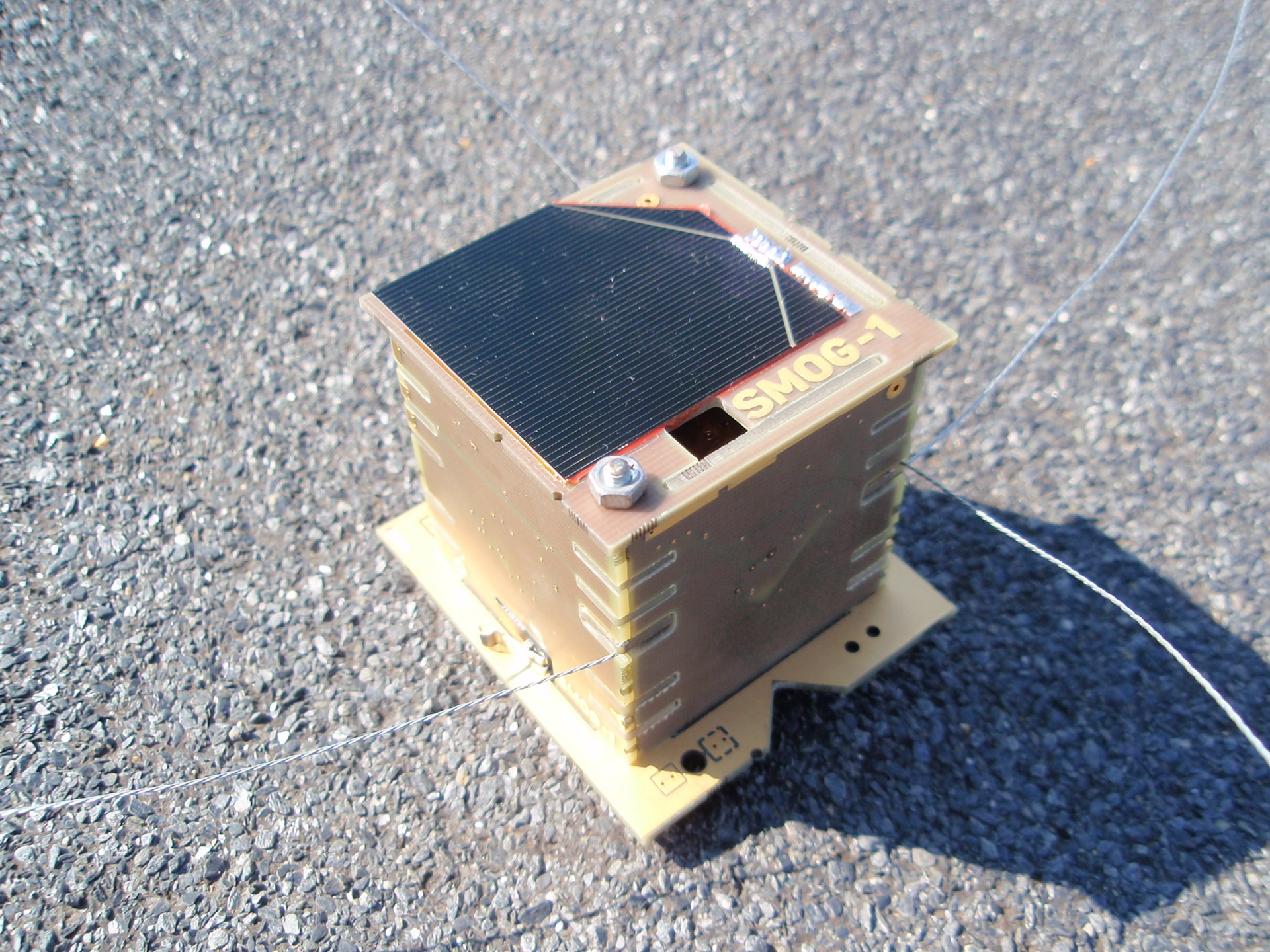
SMOG-1 Ground Control Station (GND)

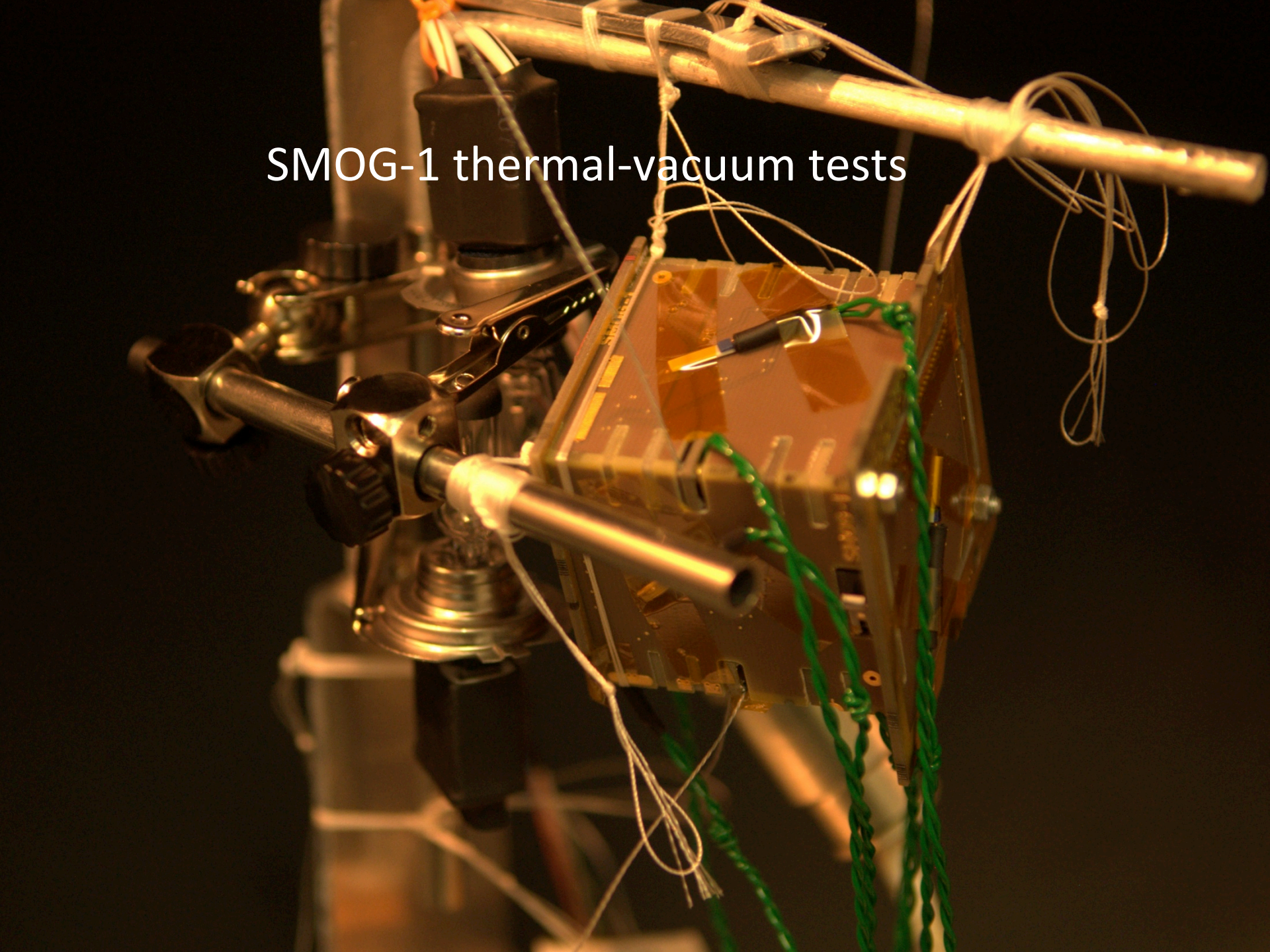
- Automated primary control station at BME
- Secondary control station at Érd
- Unique software client designed for tracking and support


SMOG-1
Antenna opener
HA4TI,HA7GG,HA7WEN
10
EURO
CENT


MPPT Left
HA4TI
MPPT Right
HA4TI
MPPT Back
HA4TI
MPPT Bottom
HA4TI
SMOG-1
MPPT Front
HA4TI


MPPT Left
HA4TI
SMOG-1
MPPT Bottom
HA4TI
MPPT Front
HA4TI


SMOG-1


SMOG-1 thermal-vacuum tests

t: 106 m
RadFET1 Vth: 1988260 uV
RadFET2 Vth: 1987145 uV

Dosimeter Temp: -57 C
t: 107 m
RadFET1 Vth: 1988335 uV
RadFET2 Vth: 1987177 uV

Dosimeter Temp: -57 C
t: 108 m
RadFET1 Vth: 1988411 uV
RadFET2 Vth: 1987234 uV

Dosimeter Temp: -57 C
t: 109 m
RadFET1 Vth: 1988468 uV
RadFET2 Vth: 1987350 uV

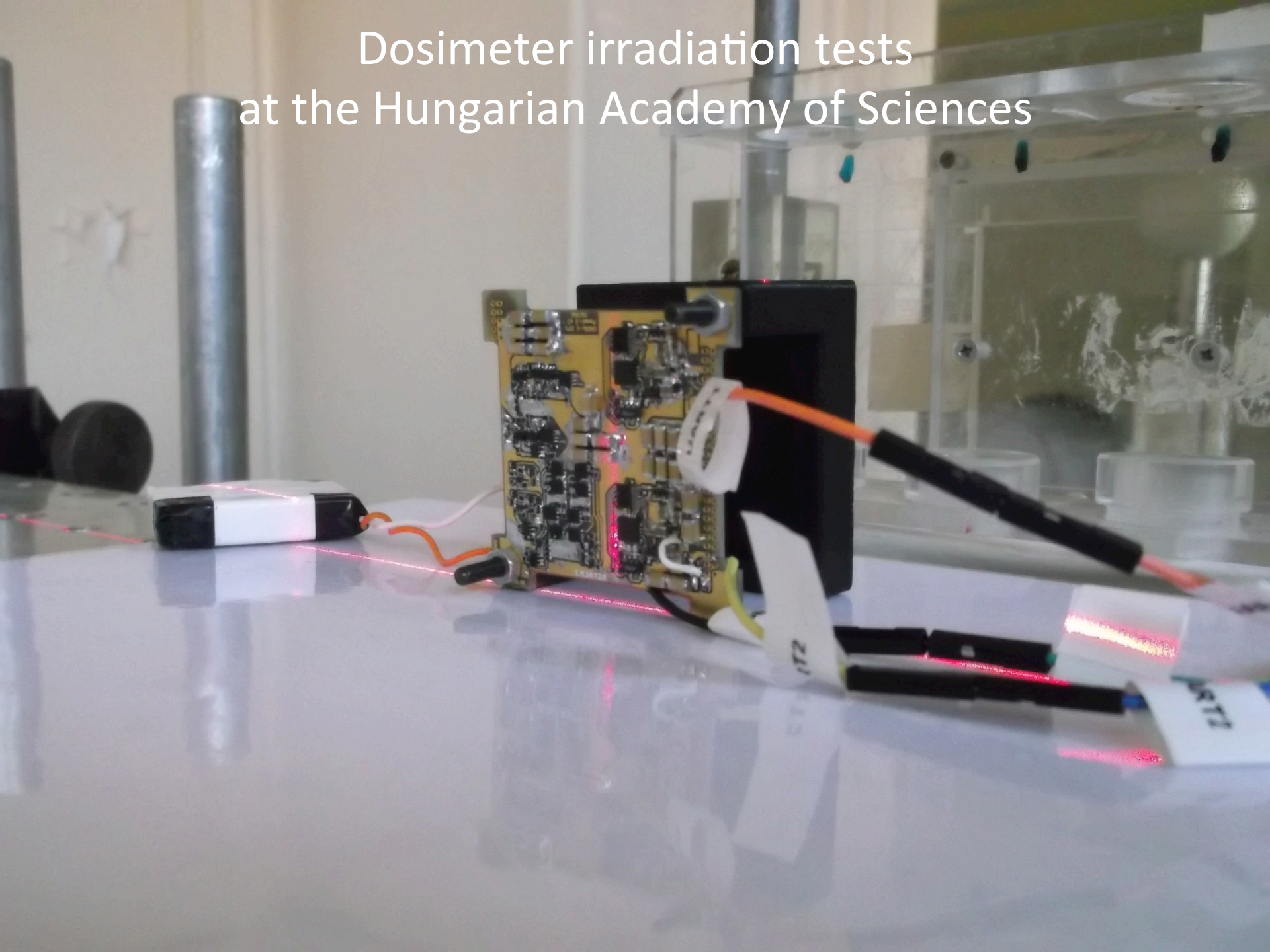
RadFET1
RadFET2

Dosimeter
t: 94 m
RadFET1
RadFET2

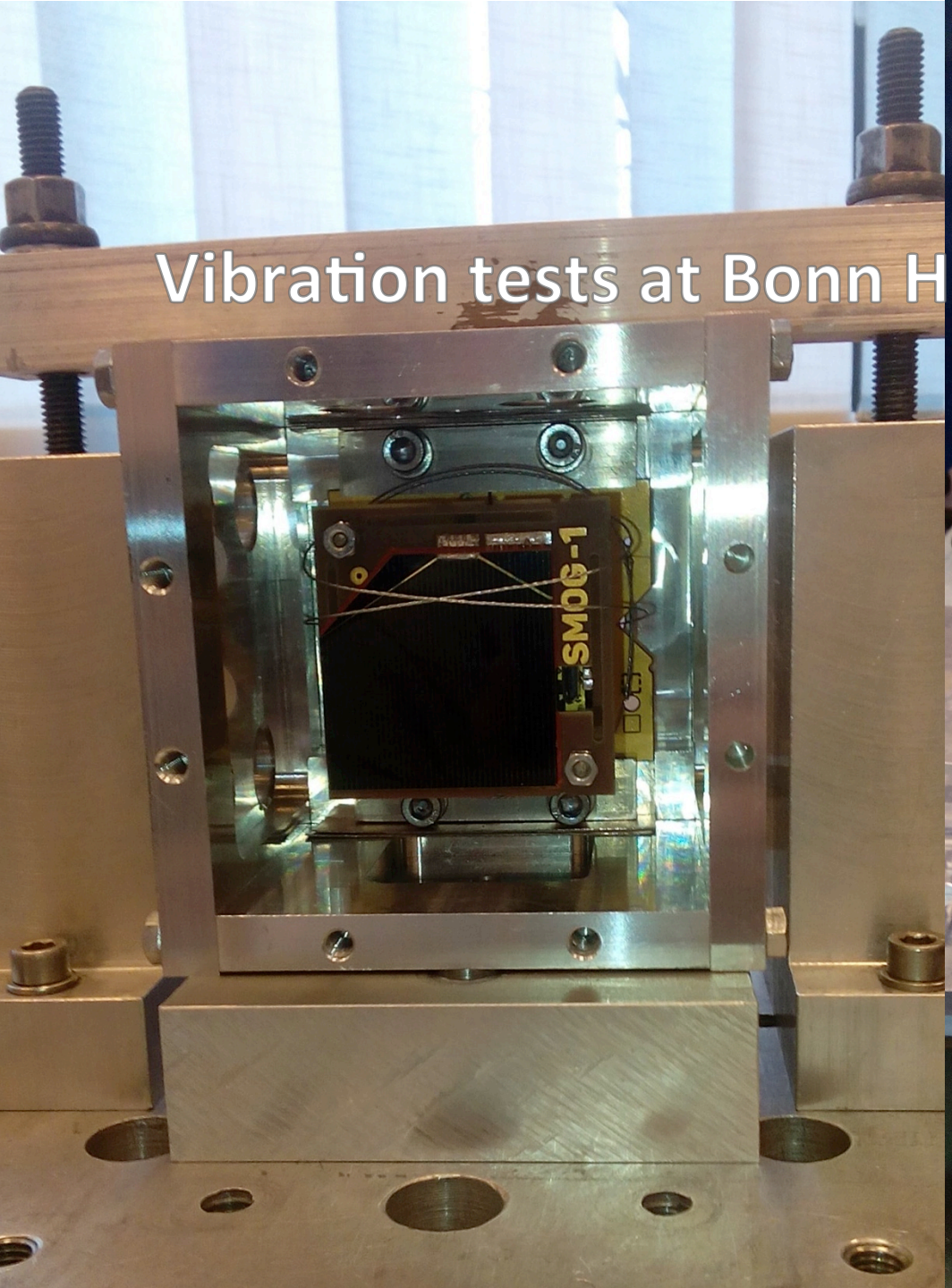
Dosimeter
t: 95 m
RadFET1
RadFET2

Dosimeter
t: 96 m
RadFET1
RadFET2

Dosimeter irradiation tests at the Hungarian Academy of Sciences



Vibration tests at Bonn Hungary Electronics



Launch, Orbit

- Scheduled launch at Q4 2017
- Orbiting with the aid of GAUSS team's UniSat-7 satellite
- 600 km (LEO) SSO
- 5-23 years lifetime
- 2-4 opportunities/day for communications with the ground station (GND)

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