National Aeronautics and Space Administration
Goddard Space Flight Center

Universität Stuttgart

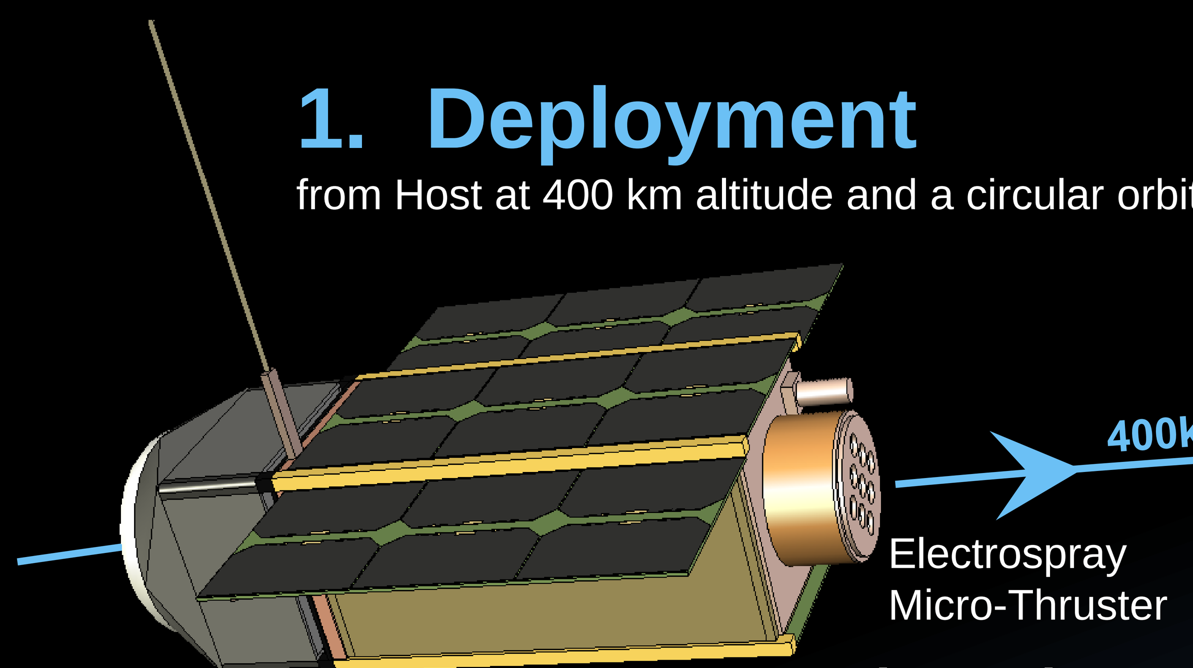
CAPE - MIRKA2

(Cubesat Application for Planetary Entry Missions - Micro Return Capsule 2)

Small Re-entry Demonstrator for Advanced Miniaturized Sensors

1. Deployment

from Host at 400 km altitude and a circular orbit.



Dimensions of vehicle configuration:

10mm x 10mm x 262mm (According to the Cubesat form-factor for the P-POD)
Mass = 3.777 kg, C_D = 2.3

2. Operations and De-orbiting

Altitude: 400km – 110km (by definition)

1. Orbit changes: **Micro-propulsion** demonstration
2. **Communications test** with orbiting assets and the ground (DTN demonstration)
3. **De-orbiting** down to an altitude of 110 km (where re-entry is defined to begin)

110km altitude

3. Re-entry Phase

Altitude: 110km – 20km (by definition)

- C_D of re-entry-capsule and cubesat after separation: 1.5 each
- Mass of capsule: 1.644 kg
- Nose radius of capsule: 0.09m
- Entry velocity: 7.3 km/s
- **Max. deceleration: 12g**
- **Max. heat flux: 1.8 MW/m²**
- **Inegral heat load 0.826 MJ**

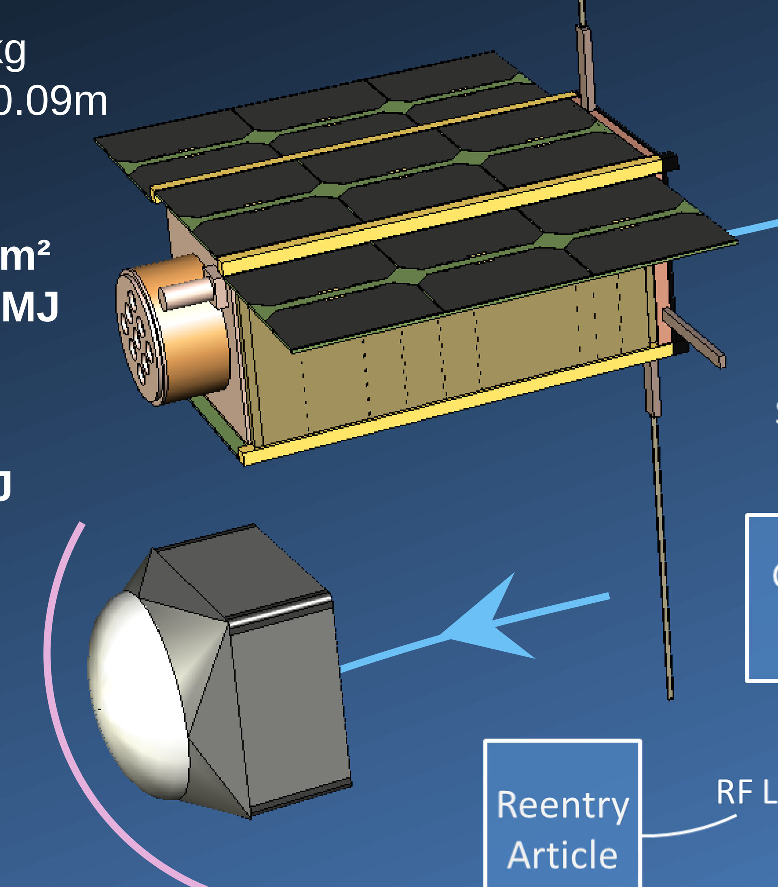
Assumed ablating depth of **RICA**: 1mm
→ Absorbed energy: **1.09MJ**

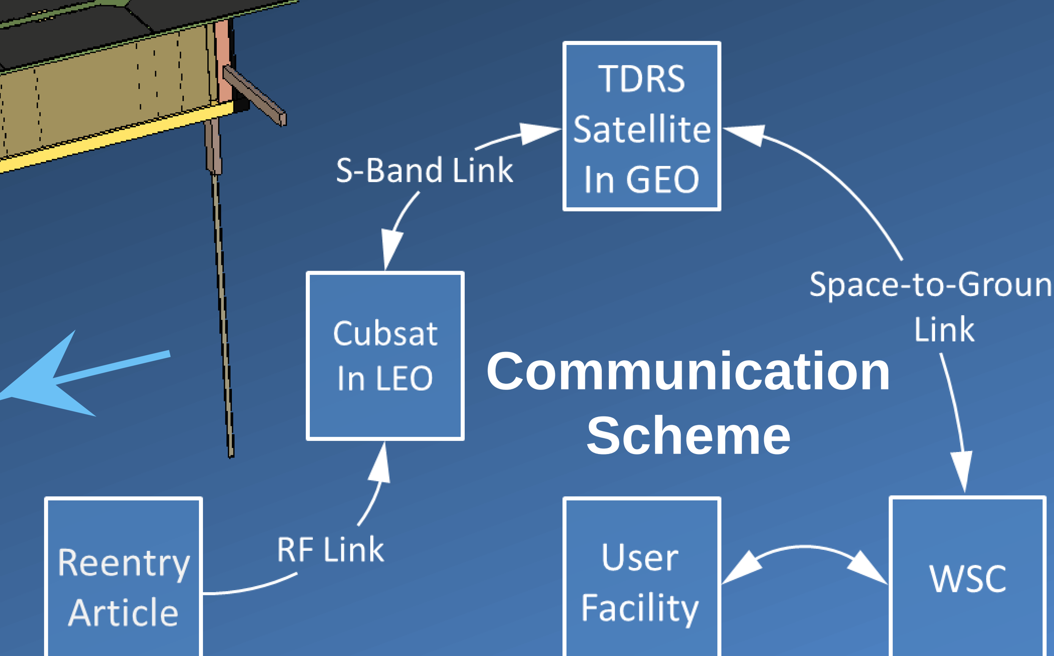
Integral heat load: **0.826 MJ** (through simulated re-entry)

→ Friction energy of re-entry fully asorbed.

Separation:

Four springs at the backside of the caspsule yielding an impulsive acceleration when Capsule is released. → **Delayed Re-entry** of the Cubesat by a few minutes to provide an **information relay** when the Capsule passes the **ionization zone**.





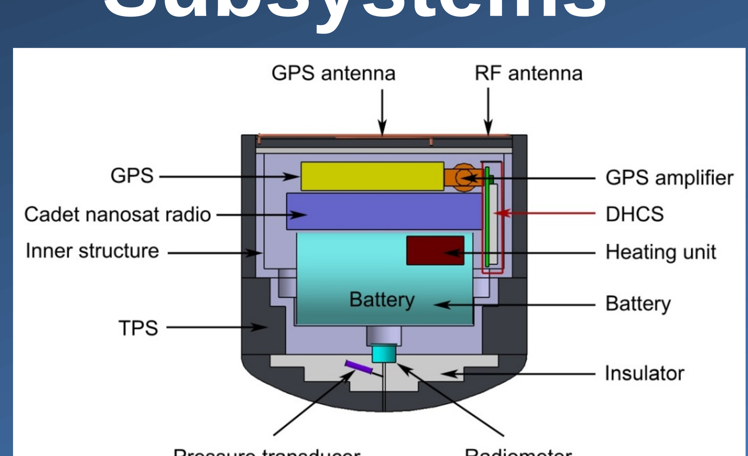
TPS material RICA

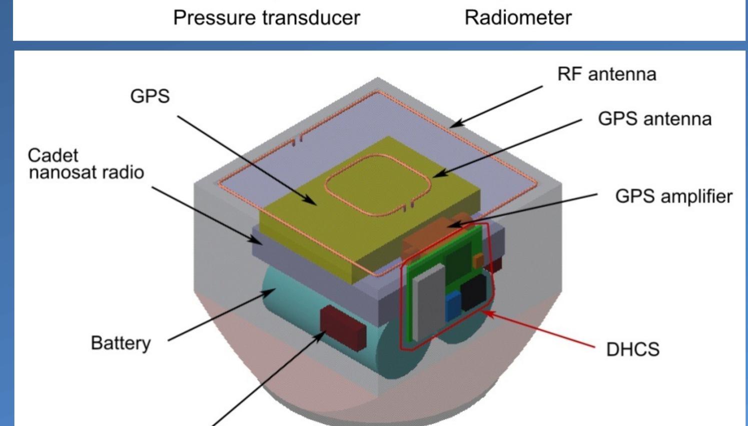
Thermal Protection System material **RICA** was tested in a Plasma Wind Tunnel of Institute of Space Systems (University of Stuttgart)

→ Determining the energy (J/kg) that can be absorbed (Heat of Ablation)

Instrumentation – Scientific Payload

Subsystems





Required for re-entry:
- Power: 4.4 W
- Energy: 1.15 Wh

Batteries during re-entry:
- Power: Max. 12.96 W
- Energy: Max. 46.8 Wh

Power and energy during deorbit is assumed to be provided **by the Cubsat.**

Analog Resistance Ablation Detectors (ARAD):

Direct measurement of TPS recession rate.
→ Recession rate distribution

Radiometer: Detection of Cyanide-emission, which is a chemical product of the ablation process
→ Indirect observation of TPS degradation

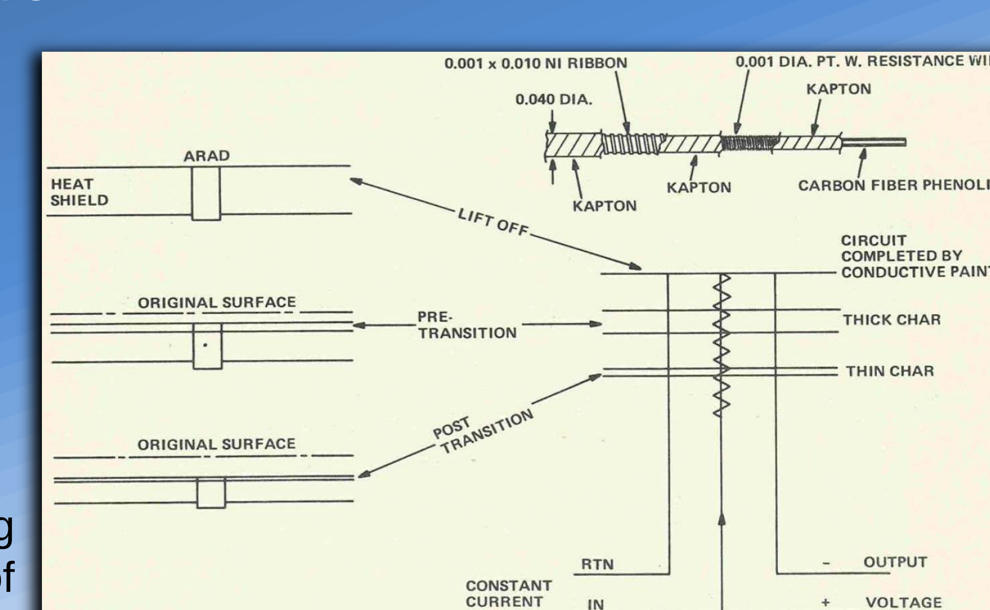
Thermocouples:
→ Heat flux and temperature distribution

Pressure Transducers:
→ Dynamic pressure measurements near and at stagnation point.

GPS: Trajectory Data

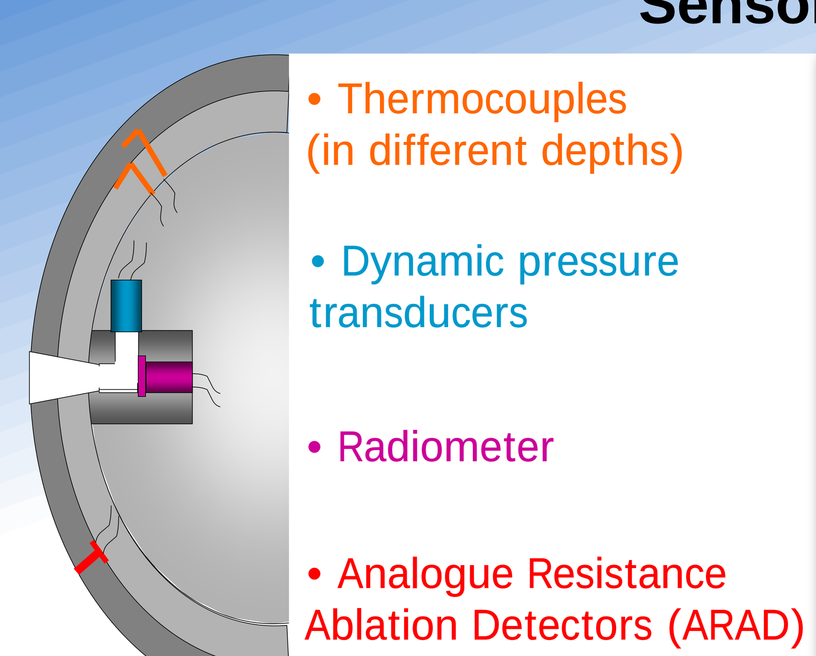
IMU: Acceleration and rotation rate sensors
→ Position and Altitude

Two FIPEX gas sensors (optional):
Flux Probe Experiment, miniaturized solid electrolyte gas sensor.
→ Distinction and measurement of atomic and molecular oxygen.

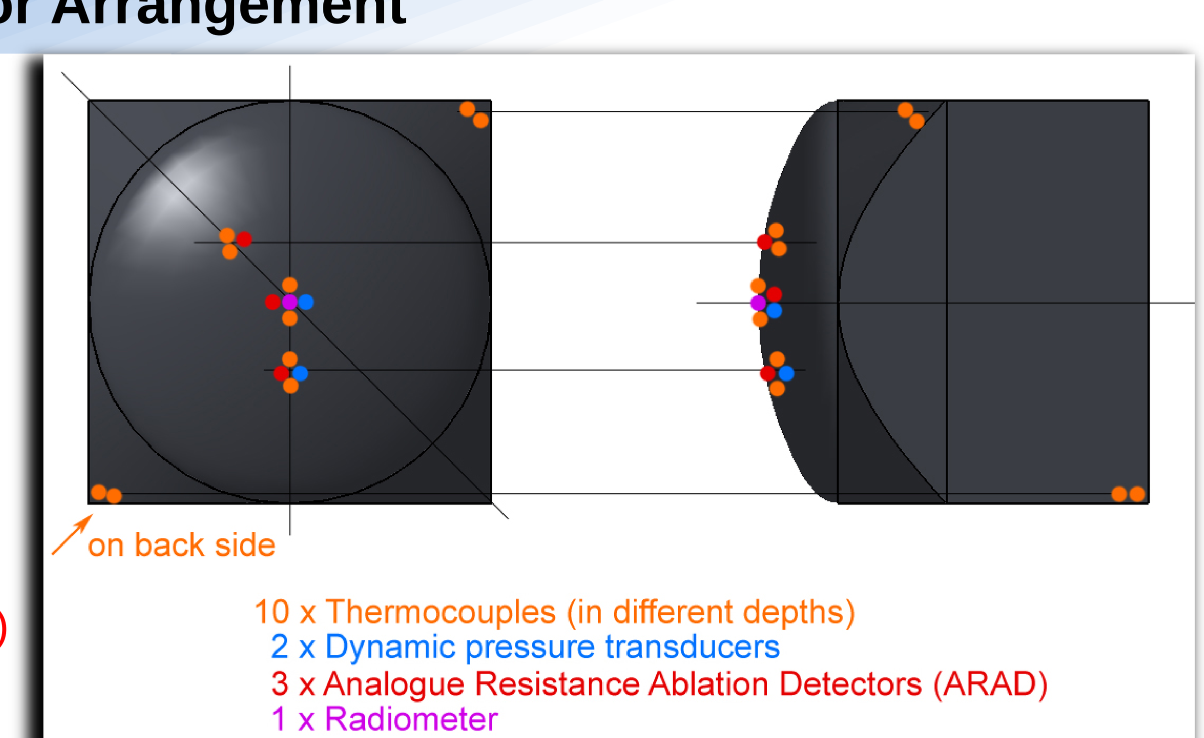


Operating principle of ARAD

Sensor Arrangement



(schematic)



Objectives

- **Flight qualification of** the **RICA** material developed by the **Institute of Space Systems** (IRS, University of Stuttgart) and **NASA Goddard** Space Flight Center.

RICA - Resin Impregnated Carbon Ablator: **High-temperature ablator** for entry into Titan's and other planetary atmospheres.

- Demonstration of **small probes and spacecrafts**:
  - Micro propulsion for **atmospheric entry** and **Earth de-orbit applications** (including Cubesats)
  - **Communications technology** and **architecture**
  - Commercial off-the-shelf (**COTS**) products, low cost

Outlook

- Full size (1:1 scale) capsule for **Plasma Wind Tunnel experiments**.
- Flight qualification of **other materials**
- **Aerothermodynamic investigastions**
- **Participation of universities and students**

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