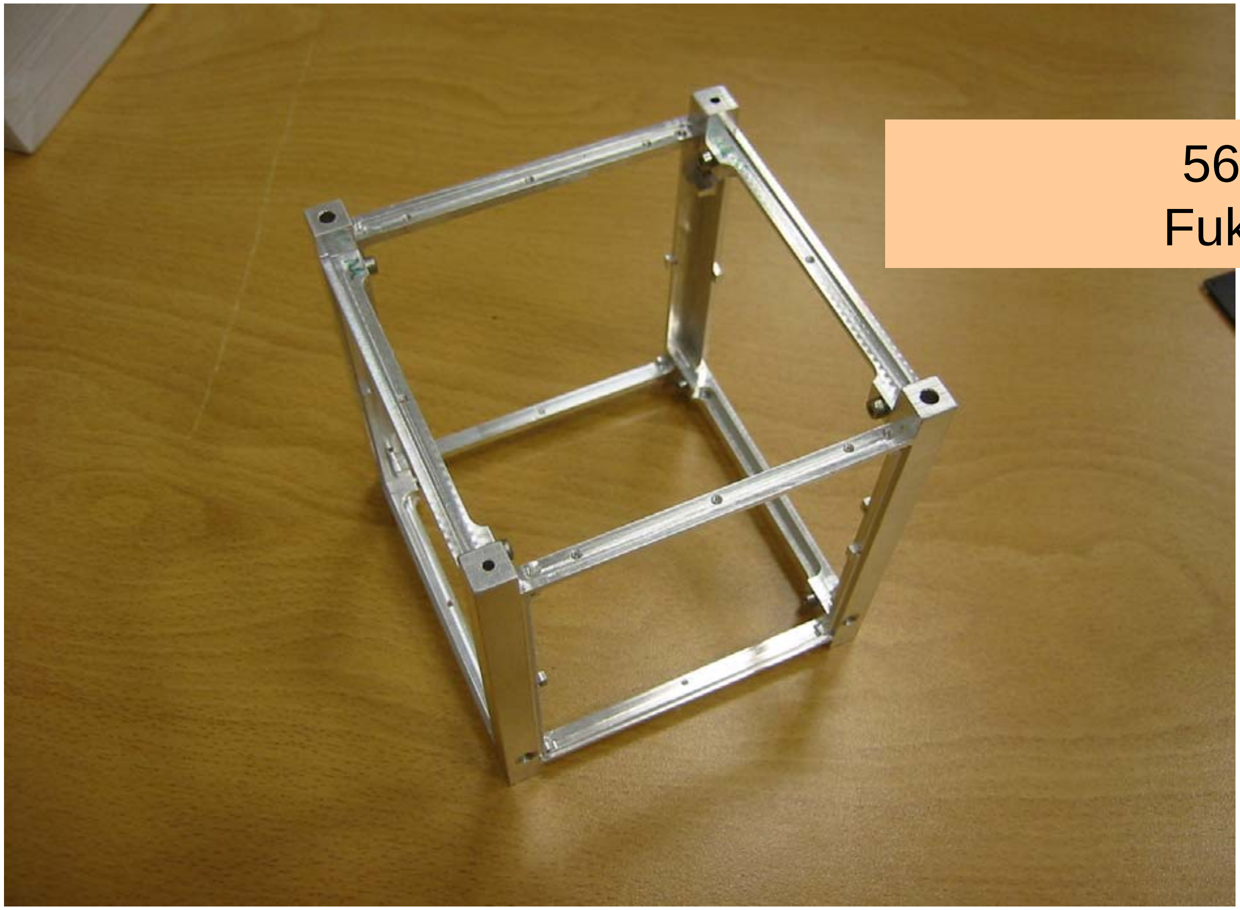
Structure & Mechanisms
Compass 1 Cubesat



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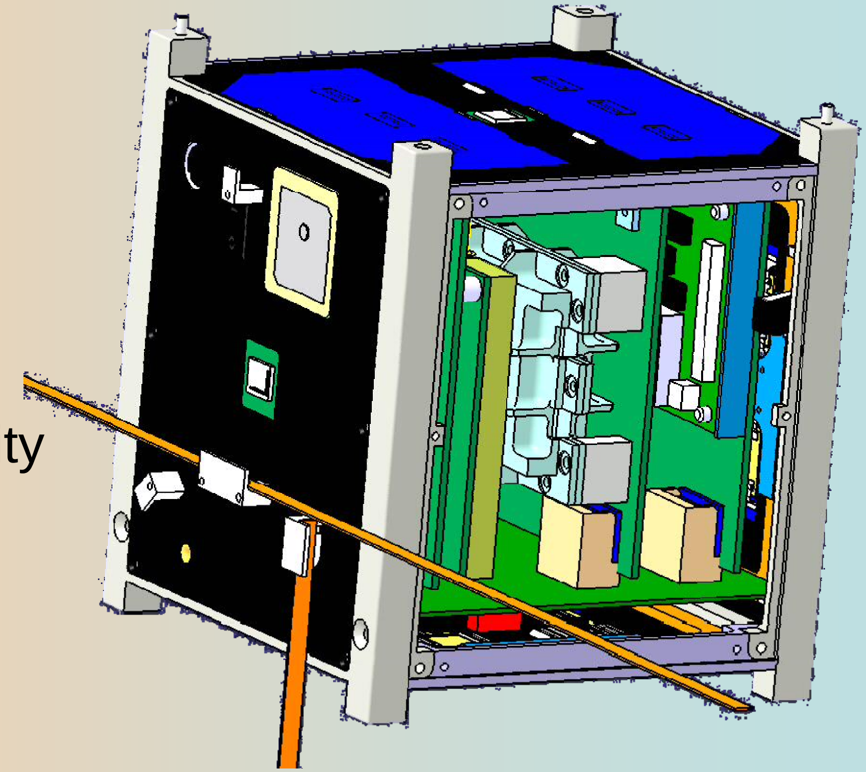
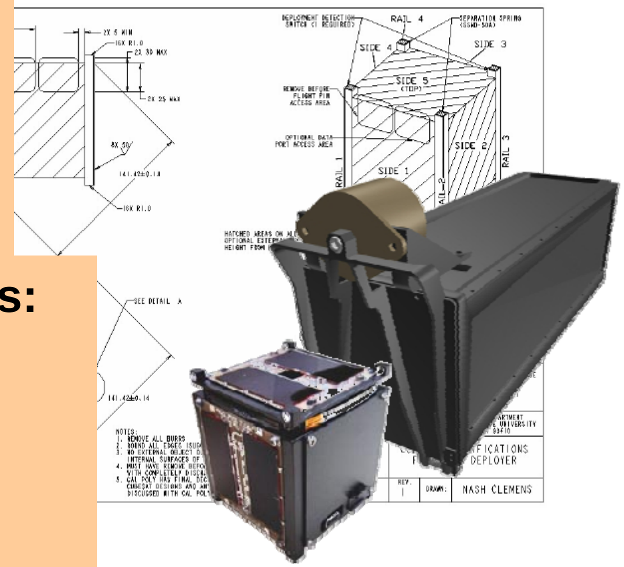


Overview:

COMPASS-1 is the first satellite developed at Aachen University of Applied Sciences, which started in October 2003. It is build according to the CubeSat standard and implements a full range of new technology. In parallel to its technical aims, the project objectives are to promote and foster space technology within this region and to improve the students practical experiences.

CubeSat Concept

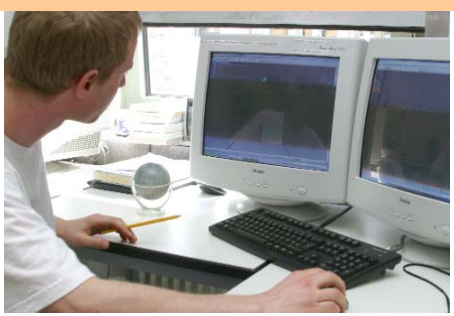
- 1 kg of total mass,10cm x 10cm x 10cm
- Launched inside P-POD with other CubeSats



Aachen University of Applied Sciences:

- Students from Departments of Astronautical, Mechanical and Electrical Engineering participate
- Several years of experience with space technology and µG research
- Possesses in-house space testing facilities

Hochschule Aachen University of Applied Sciences

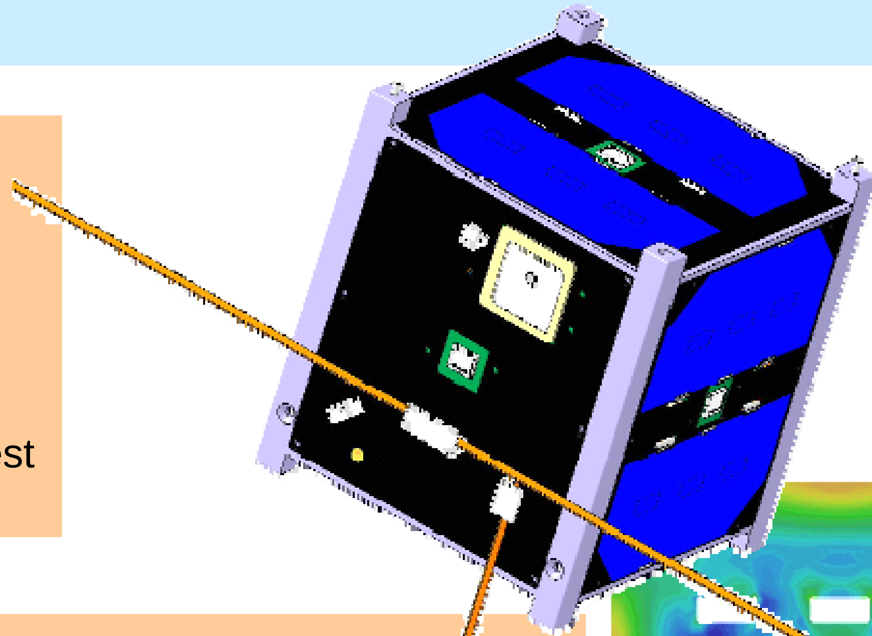


Launcher:

- To be ready for launch summer 2006
- No fixed launch yet, but likely DNEPR
- Assumed altitude is 700 km
- Sun-synchronous, circular orbit

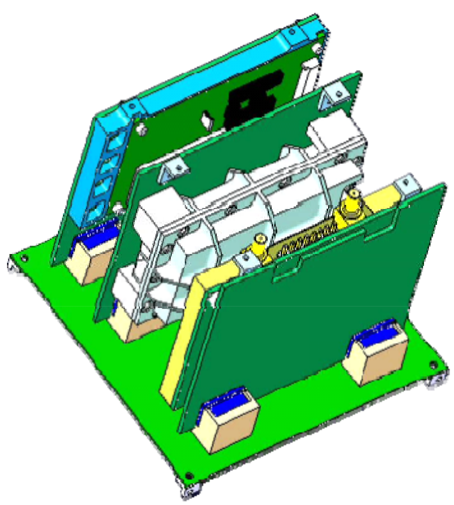
Structure and Mechanisms (STR):

To protect the electronics and other parts of the satellite against the launch loads and to allow thermal control of the inner components, a rigid structure with special surface properties is used. The structure is highly modular for easy assembly. The mechanisms to deploy the UHF/VHF antennas and to close the power circuit of the satellite are highly critical and important.



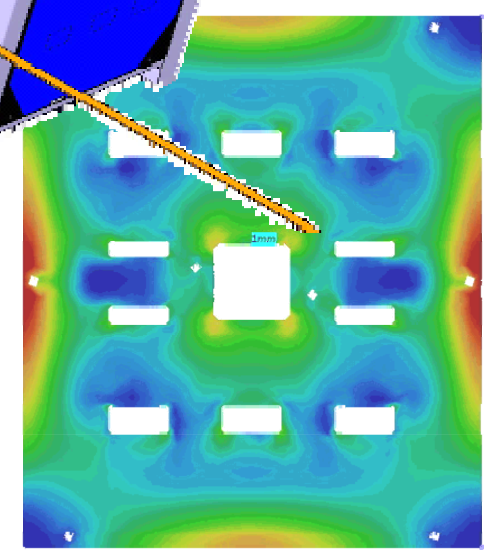
In general :

- mounting aids for PCBs and other parts
- be disassembled and re-assembled quickly
- the center of mass can be better positioned
- it facilitates the replacement of parts during test phase



Mechanisms:

- Kill-Switch to secure power off during launch
- Separation springs
- Antenna deployment through wire melting
- Remove Before Flight Switch

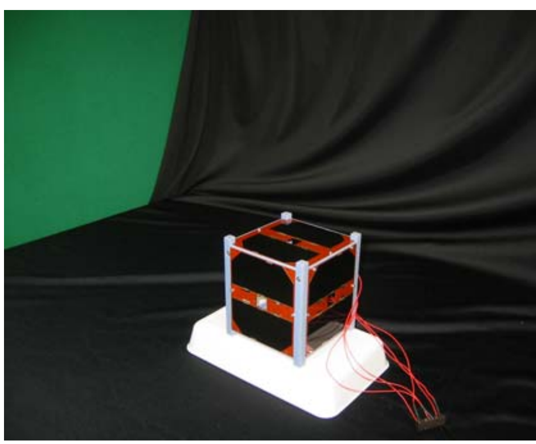


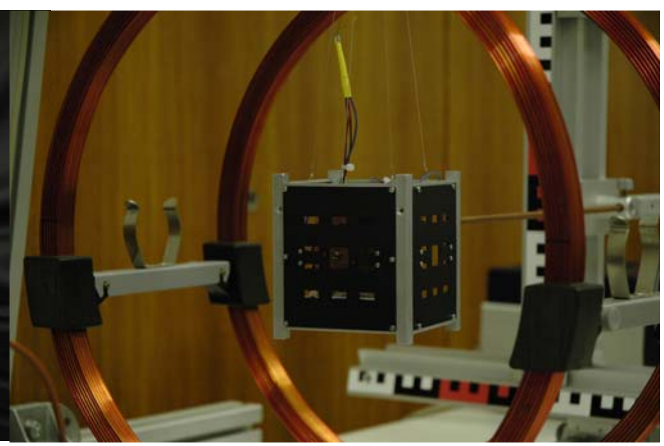
Structure Overview:

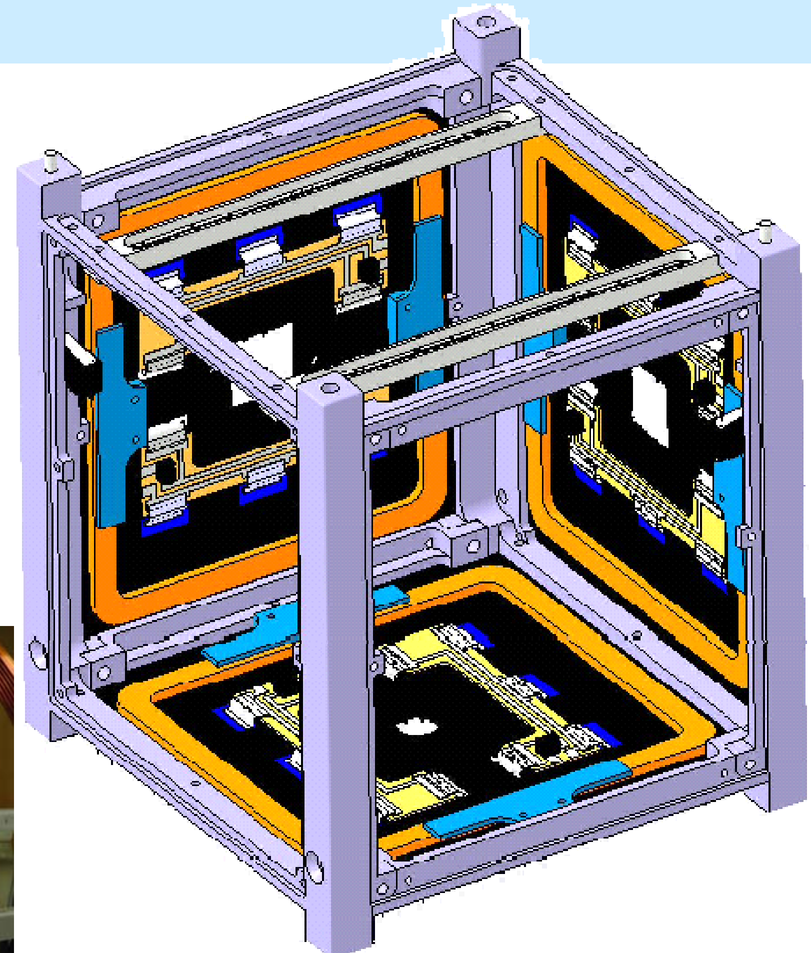
Important key element of the structure design was the philosophy of modularity. Thus the COMPASS-1 structure was designed to be completely modular. In essence, it is a stand-alone frame structure which is covered with an alloy panel on each side. The integrated mechanisms of the satellite follows the aspect to fulfill reliably its function under space conditions.

Satellite Structure:

- 6061-T6 aluminum, hard anodized (black)
- 8pol Access Port (for interfacing and battery charging)
- Mounting for GPS antenna and UHF/VHF antennas
- Diverse holders (GPS, magnetic coils, sun sensors, subsystem boards)
- Total mass of 280 grams

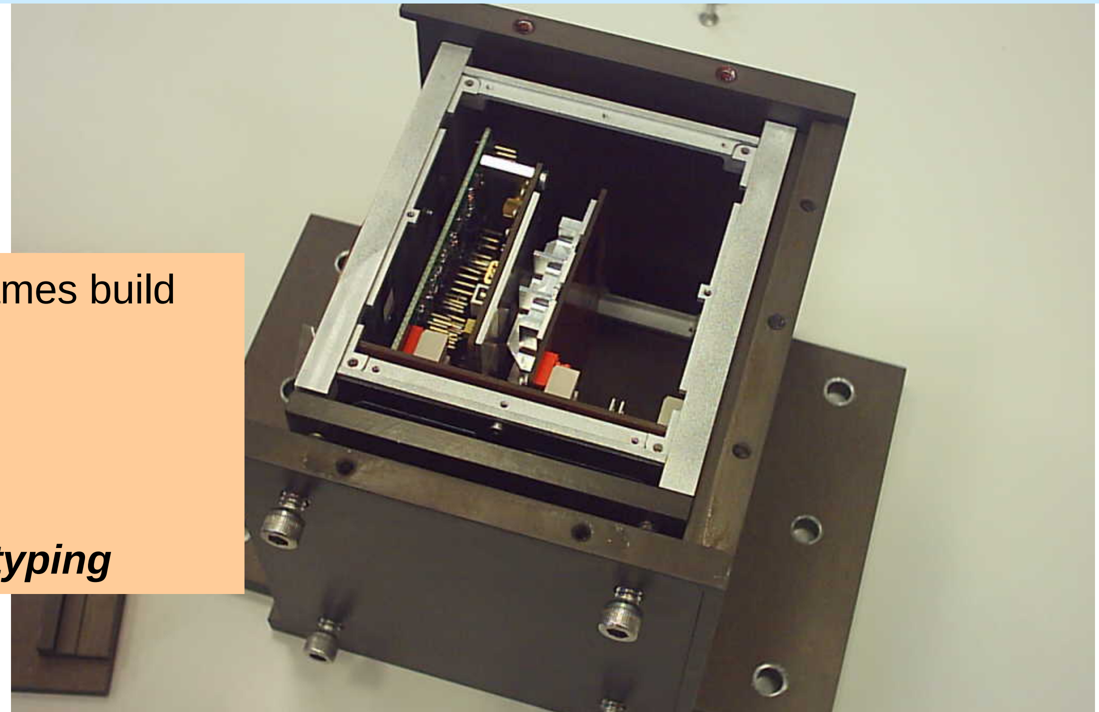






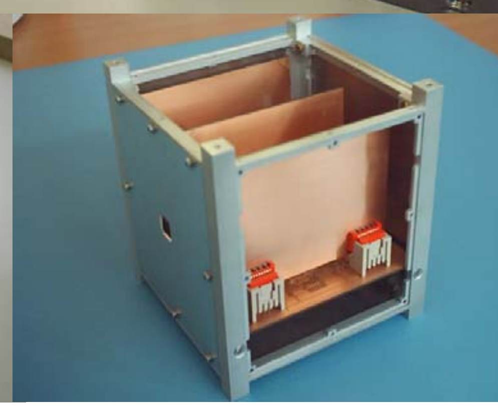
Main Frame:

The frames are the most important parts of the structure. They take up all mechanical loads during launch and are used during the deployment out of the P-Pod. In addition they built up the platform for all integrated subsystem parts.



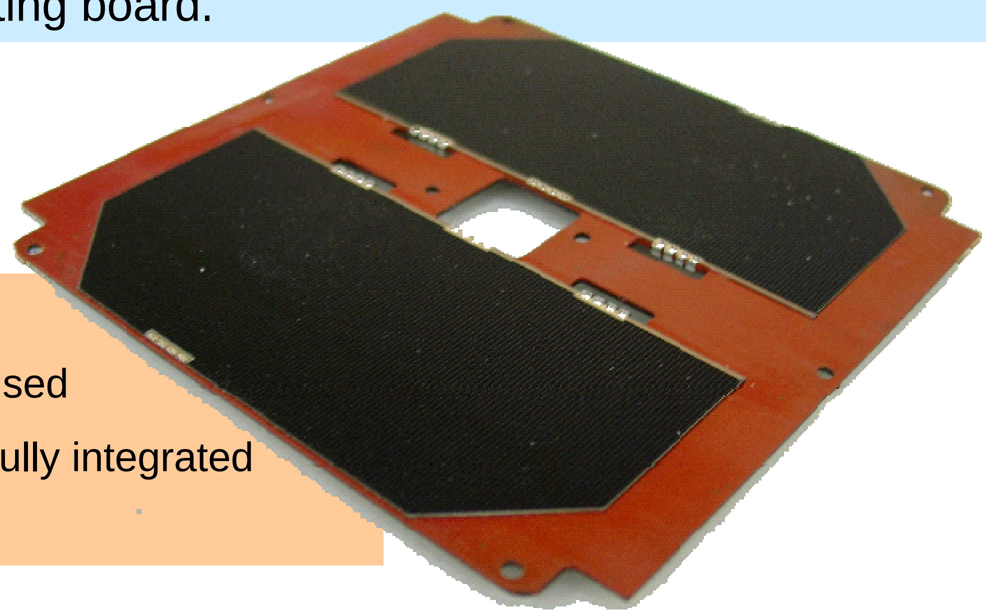
- The four beams connected with the two frames build up the main body.
- Build up around the electronical core
- Milled out of 6061-T6 aluminium
- Prototypes manufracted with ***Rapid Prototyping***



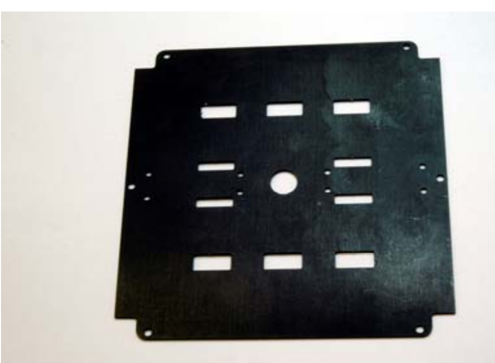


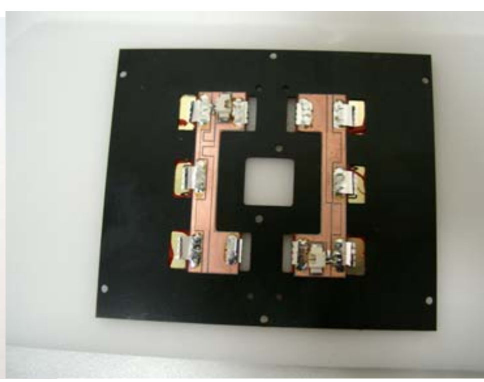

Panel Design:

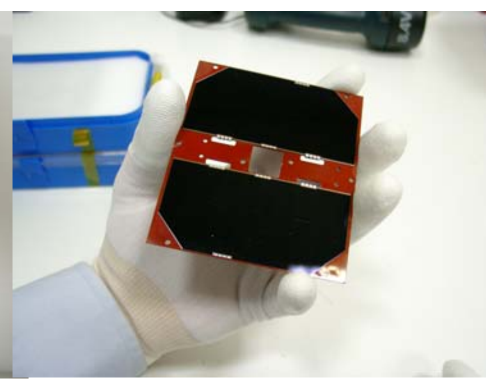
The panels are designed multifunctional around the main body. The outer surface is in use for the solar cells, which are special glued directly on the panel.
The panels also granted all holding possibilities for the sun sensors, magnetorquer, GPS Antenna; Communication antenna release mechanism; remove before flight pin, data access port and last but not least the solar cell connecting board.

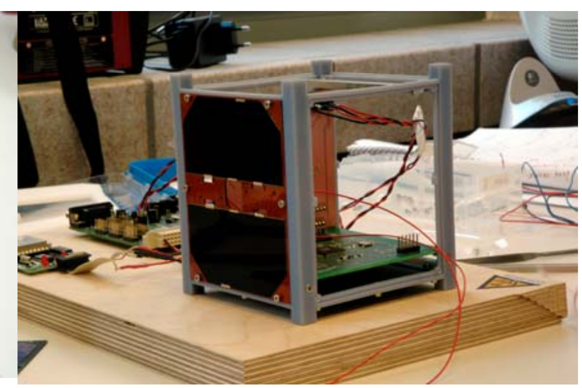


- Made of 6061-T6 aluminium 1mm Sheets
- All panels are completely laser cut and black anodised
- New Triple Junction solar cells from RWE Space, fully integrated on the panels by Astrium GmbH (Germany)

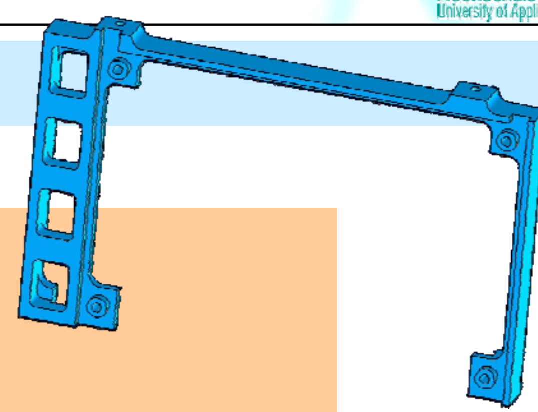


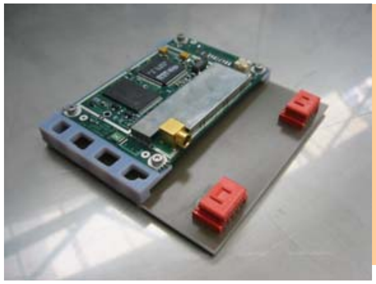






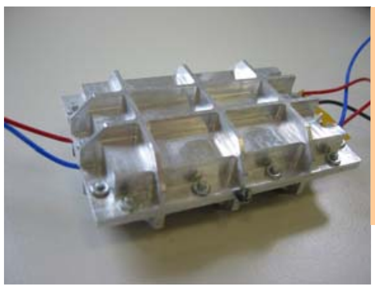
Holdings and Features





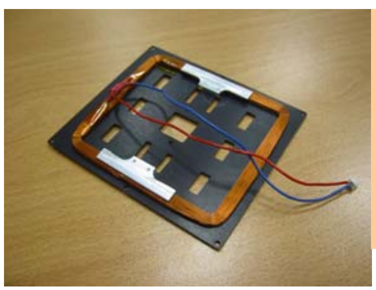
GPS Board Holder

- Allows an easy integration of the GPS receiver
- Provides enough surface area for electronic components



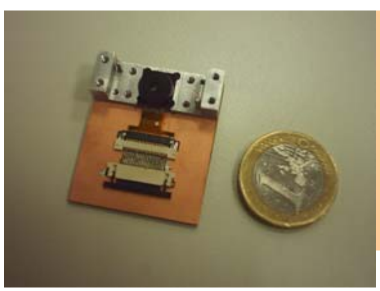
Battery Box

- Take up all pressure loads from the batteries
- Combines high stiffness with low weight



Coil Holder

- Allows an easy integration of the magnetorquer
- Fix the coils into a defined position



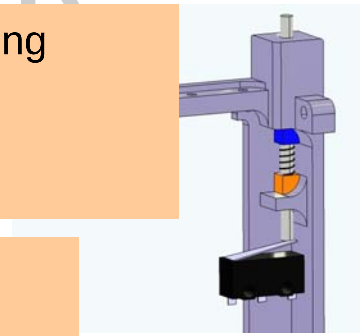
Camera Holder

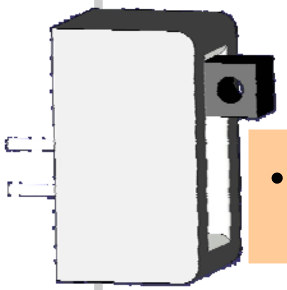
- Is designed to fix and align the Camera Module to the Structure
- Provides holding possibility for an adapter PCB

Mechanisms:

Normally you have to avoid mechanisms and complex systems. Every mechanism enables new sources of errors. Because of service and security reasons, on the CubeSat, a few mechanisms are needed. Additionally the entire Structure is connected to power ground.

- The ***Kill-Switch*** mechanics and the Separation Spring mechanism are integrated into the frame.
- One mechanic and one micro switch in each frame

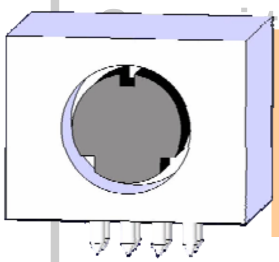




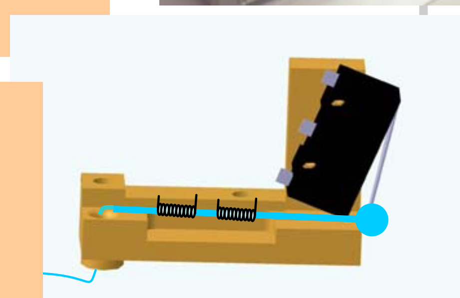
- **Remove Before Flight Pin** is a miniature slide switch with very high self holding capability.

- **Seperation Springs** are Spring Punger to take up vibrations during launch and seperates the Cubesats in the deployer.

- For **Data Access Port** chosen is a simple 8 pole mini DIN socket.
- To assure access to housekeeping data or for software modifications and updates during phase of integration.



- For the **Antenna Release Mechanism** the antenna system is packed and fixed with a nylon wire.
- Nylon wire will be melt by an heating coil.
- Micro Switch to protect the batteries

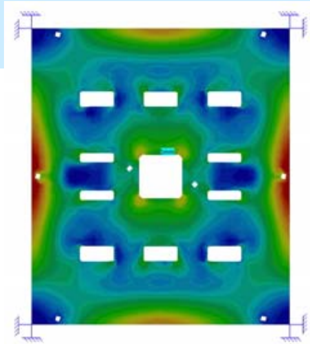


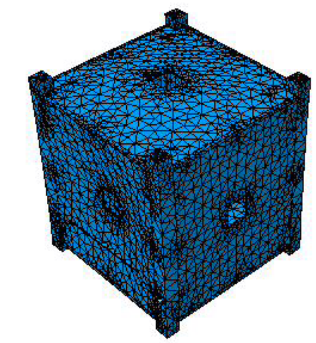
Simulation and Testing:

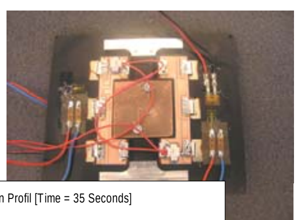
The dynamic analysis and simulation of the CubeSat structure is to verify the structural integrity and localize weak points in the structure at an early design stage to prevent major modifications later. The structure of the satellite must assure integrity during the whole life cycle. Especially the high loads acting during the launch must be considered. A software-based analysis and simulation with appropriate programs is able to compute stress values under static load and behavior of the structure under dynamic loads. These computed values have to be in accordance with the material properties and the launcher requirements. The next step is going to the tests with real hardware.

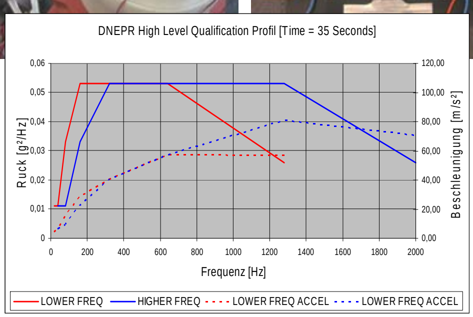
Static & Dynamic Analyses with CATIA

- first modal frequencies of the parts and the assembled structure
- maximal deflection and stresses under static loads









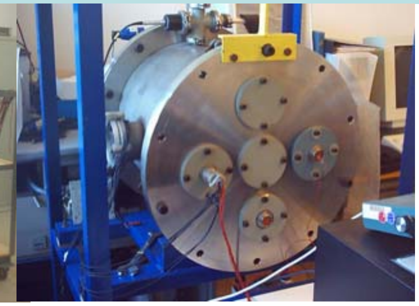
Vibration Tests on Shaker

- Diverse launcher scenarios
- natural frequency and damping tests
- High and Low Level Qualification Profile tests from the DNEPR launcher.

Test Facilities at Aachen University:

Vacuum Chambers

- A small and a medium-sized vacuum chamber allow exposure of devices to high vacuum for the purpose of testing outgassing, degradation etc.



Sun Simulator

- The BOSCH Sun Simulator simulates extraterrestrial sunbeams with an adjustable intensity in the range from 0.5 to 2.5 solar constants.

Thermal Vacuum Simulator

- Smaller specimen (such as solar cells and computer boards) can undergo thermal cycles in the thermal vacuum simulator within a temperature variation of up to 250°C.

Small Shaker

- In particular for very small satellites and parts thereof, this shaker is a very good low-cost alternative to simulate the launch conditions in terms of mechanical stress due to vibration.

Supporter:

- DLR – sponsor
- Altium – License for Protel 2004 PCB design
- Ansoft – License for Maxwell 3D
- RWE Solutions – solar cells
- Astrium – Integration of solar panels
- Nanyang Technical University – support of Diploma thesis
- Royal Melbourne Institute of Technology – support of Master thesis
- Denmark Technical University – sun sensor chip
- Deutsche Amateur Radio Club – frequency and groundstation
- Omnivision Technologies – camera module
- RS Components – sponsor of equipment
- Honeywell – magnetometers
- RTC – rapid prototyping models
- Elektrisola – coil materials
- and more…

Thank you for your attention !

Questions ?

Additional Info´s under :

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