Overview

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Introduction and Motivation

- Precursor project of CAPE (CubeSat Atmospheric Probe for Education)
- CAPE serves as a demonstration and qualification platform for electric propulsion and atmospheric re-entry technology
- Characterization of Earth’s lower thermosphere
- Development of general system engineering as well as specialized expert skills of students

3 Unit Service & De-orbit Module 1 Unit Separation Mechanism & Re-Entry Capsule
Introduction and Motivation

Experiment to validate:

• Flight behavior, communication and electronic system of the MIRKA2 capsule

• Performance of the specially developed ejection-mechanism LOTUS (Low Orbit Technical Unit Separator)

• Launch March 2016 on REXUS-19

(ESA 2007)
Mission Scenario

- T ≈ 26 s: burn-out
- T ≈ 120 s: Ejection
- T ≈ 800 s
- T < 800 s

- Cameras operational, recording starts
- Data collection starts (Capsule/Mirror System)
- Ejection at apogee
Capsule MIRKA2-RX

Dimensions:
- Diameter: 100 mm
- Height: 79 mm
Capsule MIRKA2-RX

Aft Shell (WHIPOX)
Battery Case
Deactivation Mechanism
Outer Front Cone (Heat Shield Dummy)
Tungsten Weight
Aluminum Tip
Capsule MIRKA2-RX

- **2x Pressure Sensor** (Static Pressure)
- **6x Thermocouples**
- **Pressure Sensor** (Stagnation pressure)
- **IMU**
- **GPS + Antenna**
- **Thermopile**
Capsule MIRKA2-RX

Antenna (Iridium)

Transmitter (Iridium)
LOTUS
Low Orbit Technical Unit Separator
Separation Test
Conclusion

- Development of the following subsystems of CAPE:
  - Capsule MIRKA2: electronics, communication, software, structure
  - Separation Mechanism LOTUS
- Measurement of the flight stability and the stagnation pressure to improve simulations
- Opportunities for students
  - Application of knowledge
  - Improvement of project management skills
  - Better understanding of space systems

Team (2014)
Outlook

- Analyzation of the experimental data
- Improvement of the performance of the capsule and the Separation Mechanism and further experiments to rise the TRL
- Designing, building and testing of the Service and De-Orbit Module
Thank you for your attention!
References


References


APPENDIX
CAPE Mission Scenario

1. **Deployment**
   - e.g. from ISS

2. **De-orbit**
   - De-orbit down to separation altitude
   - Atmospheric measurements
   - PPT demonstration

3. **Separation**
   - at approx. 150 km altitude

4. **Re-entry of the capsule**
   - Measurement of the ambient conditions and the re-entry performance of the capsule

5. **Transfer of re-entry data via satellite**
   - Transmission of data through Iridium communication system

6. **Demise of SDM, impact of capsule**
   - Potential for monitoring of break-up and demise

Potential for monitoring of break-up and demise.
On-Board Computer

The diagram illustrates the interconnections between various boards and components of the on-board computer system. The Communication Board contains an Iridium Transceiver and communicates via UART to the CommBoard Microcontroller. The IMU Board hosts Peripherals such as a Thermopile, IMU, GPS, and Buzzer, as well as Storage options like an SD Card. The IMU Board Microcontroller connects through SPI to the Communication Board and Sensor/SPI Master Board. The Sensor/CHIP Master Board features Sensors including TCs (6) and Pressure Sensors (3), which communicate through SPI connections with the IMU Board and other systems.
On-Board Control Unit

OCU

Peripherals
- LEDs
- Camera activation switch

Output
- Iridium Interface (Emulator)

aOut

UART

OCU microcontroller

REXUS Down/Uplink (RS-422/RS-232)

Ground Station Software
Qualification Tests

- Mock-Up capsule with adjustable center of mass to analyze the flight stability of the different configurations
Qualification Tests

- Drop test from a crane with a height of 20m
- Vertical Wind tunnel test
Qualification Tests

- Iridium test board

Schematics

Board layout

Production

Testing
Small Satellite Student Group University of Stuttgart

nonprofit student association for education and development within space engineering

Founded: 08.04.2014
Members: 25+

Objectives:
Participation in space projects, collect practical experience, interface industry & research

Team (2014)