University of Stuttgart
Germany

Markus
Koller

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The EIVE CubeSat – Developing a Satellite Bus for a 71-76 GHz E-Band Transmitter Payload

Introduction

- Consortium
- Roadmap
- Objectives
- Payload Configuration

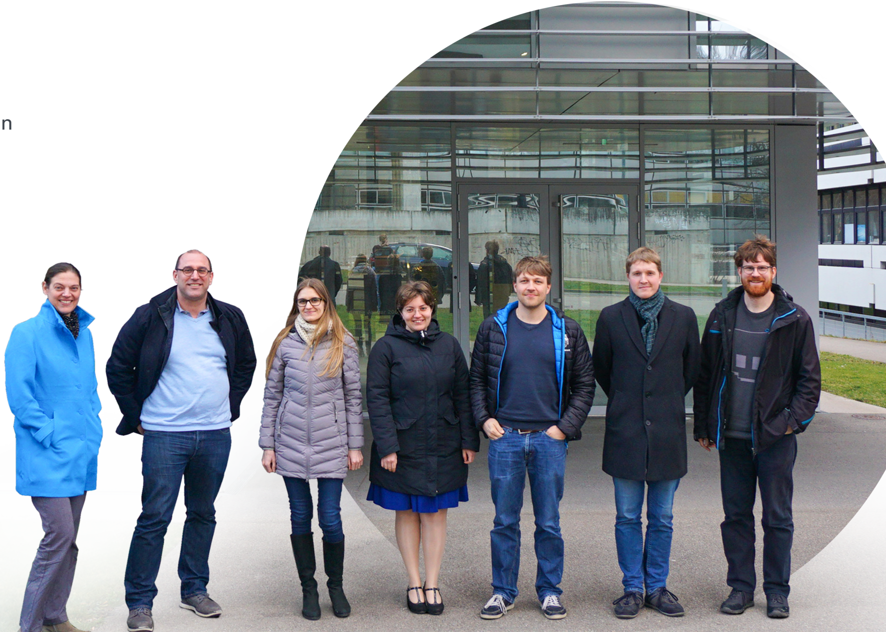
Satellite Platform

- Exterior Design
- Interior Design

Methods and Approach

- Dynamic Power Simulation
- Thermal Design and Verification
- Orbit Selection

Conclusion and Outlook



Introduction

1

Consortium

- Institute of Robust Power Semiconductor Systems (ILH), University of Stuttgart: Project coordination, payload, operations
- Institute of Space Systems (IRS), University of Stuttgart: Bus, commissioning, operations support
- Fraunhofer Institute for Applied Solid State Physics (IAF): MMICs supplier, payload integration
- Radiometer Physics GmbH (RPG): Antenna design, E-Band ground station
- TESAT Spacecom Technical support, consulting

Roadmap

2019
- April: Kick-off
- April-September: Phase A/B
- October-December: PDR

2020
- Procurement of bus components
- Final bus design
- Component tests

2021
- FlatSat phase
- Test campaign at IRS and external facilities
- Integration in IRS cleanroom

2022
- Launch - Q2 2022
- LEOP
- Operation (1 year)

2023
- End of mission - Q2 2023

Figure 1: EIVE mission patch

The Big Picture

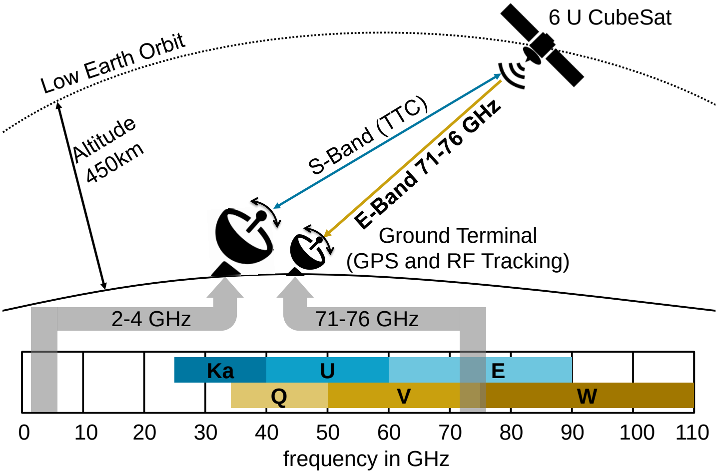


Figure 2: EIVE operational concept and TM/TC links [Schoch et al. 2020]

Payload Configuration and Requirements

Primary payload requirements

- E-band modules:
  - 1120 g, 1500 cm^3, 36 W
  - 3.3 V, 6 V, 11 V, −6 V
  - Antenna gain 33 dBi
- Payload computer + high-speed digital analog converter (DAC):
  - 325 g, 335 cm^3, 4-17 W
- 4k video camera
  - 325 g, 846 cm^3, 7.5 W
  - 3x SDI video data interface

Main challenges

- Power consumption of 40-50 W for payload alone
  ⇒ power/thermal constraints
- Pointing accuracy <1 °
  ⇒ accurate attitude sensing and control necessary

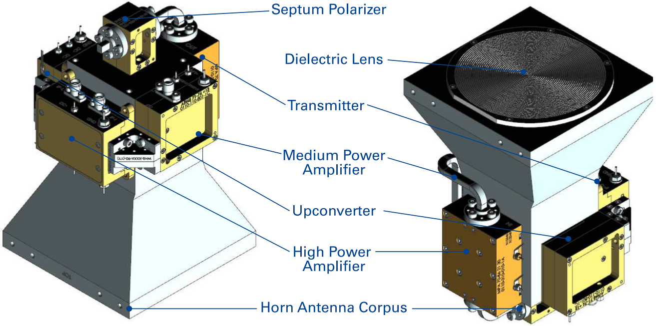


Figure 3: RF Modules are mounted directly on horn antenna

Satellite Platform

2

Satellite Platform - Exterior Design

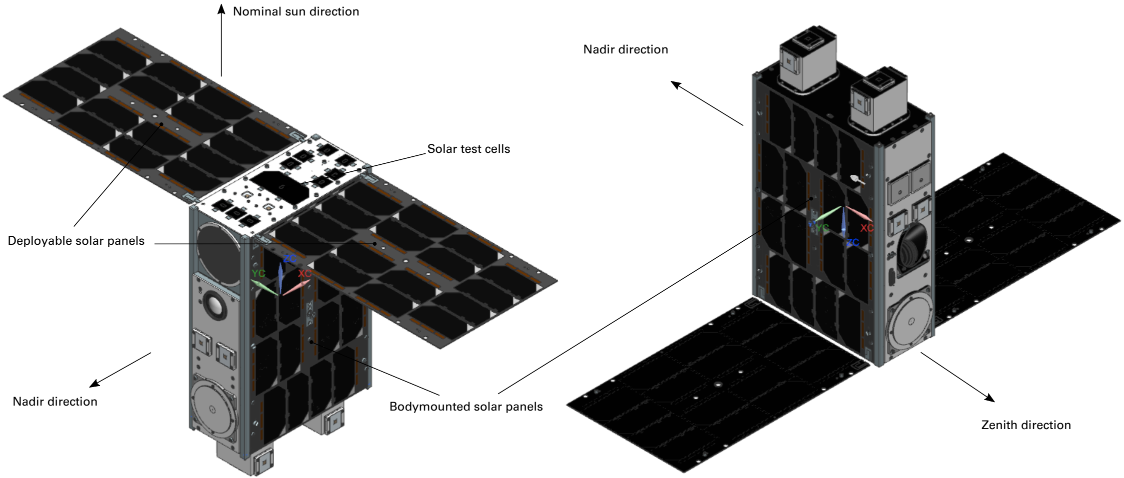


Figure 4: EIVE CubeSat - CAD exterior view

Satellite Platform - Interior Design

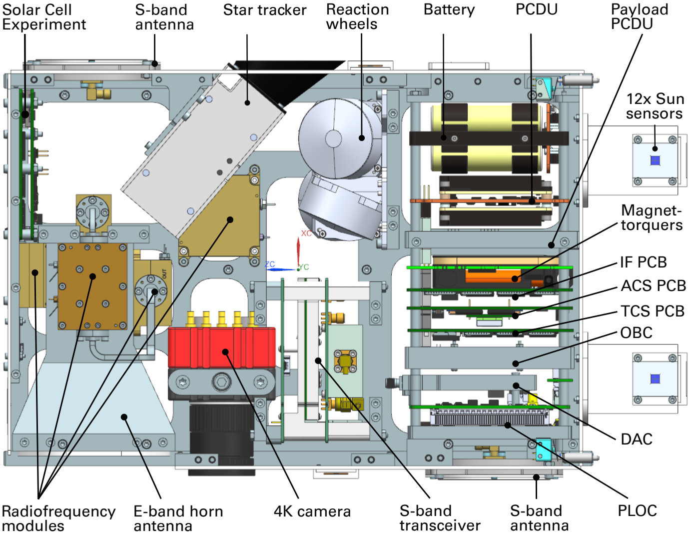


Figure 5: EIVE CubeSat - CAD interior view

Methods and Approach

3

Dynamic Power Simulation - Preparation

- Simulation framework:
  - Generic AOCS/GNC Techniques & Design Framework for FDIR (GAFE) [gafe.estec.esa.int]
- Critical scenarios
  - Power generation in launch configuration (not covered here)
  - Power budget at peak power demand during E-band passes
- Simplified power draw

Table 1: Summary of the power consumption of the most relevant modes of operation

Mode	**Power consumption***	
	expected	**+15% margin**
Safe / charge	10.17 W	11.70 W
S-band pass	35.07 W	40.33 W
E-band pass with DAC	93.02 W	106.97 W
E-band pass with 4K camera	98.27 W	113.01 W

*including duty cycles and component margins

- Formulate function for solar panel power generation

Dynamic Power Simulation - Generated Solar Power

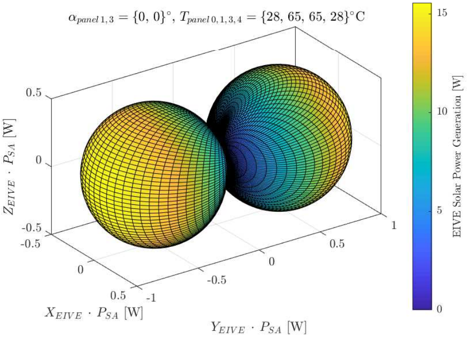


Figure 6: Folded / launch configuration

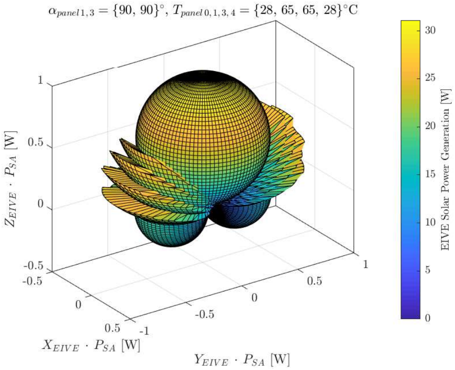


Figure 7: Unfolded / flight configuration

Dynamic Power Simulation - Results

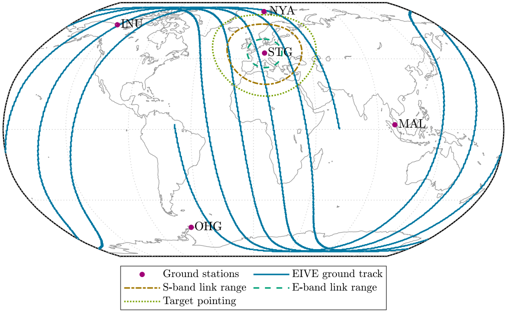


Figure 8: GAFE simulation results - ground path

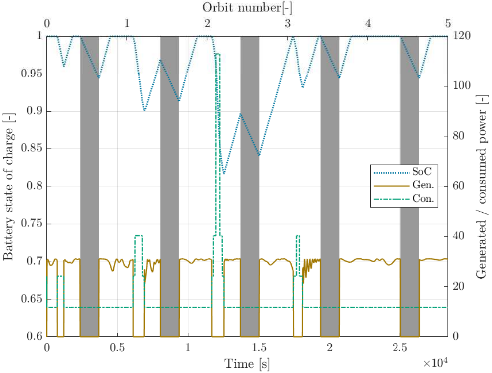


Figure 9: GAFE simulation results - SoC and power

Thermal Design and Verification

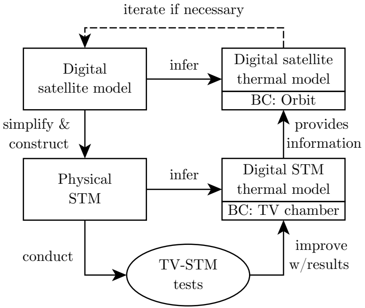


Figure 10: Thermal verification approach

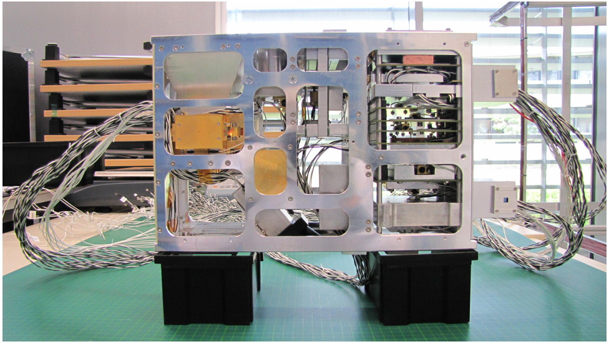


Figure 11: Structure and Thermal Model (STM) with integrated heaters and temperature sensors for thermal-vacuum testing

Orbit Selection

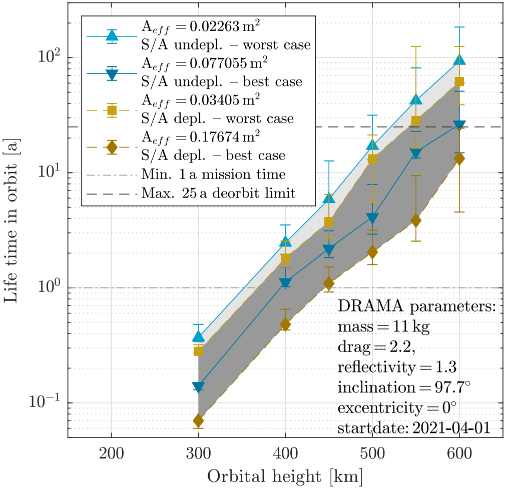


Figure 12: DRAMA simulation results in a circular SSO

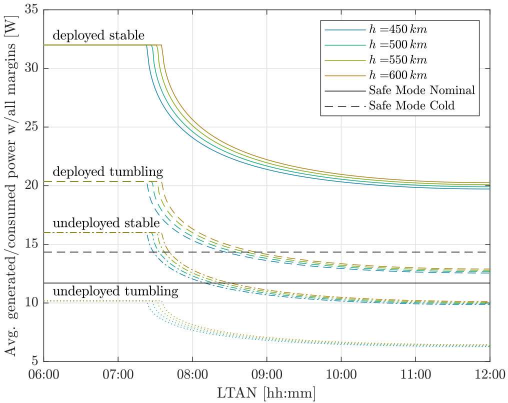


Figure 13: Power budget consideration in relation to the LTAN and the orbital height

Conclusion and Outlook

4

Conclusion and Outlook

Conclusion

- Implementation of a challenging high-frequency payload on a 6U CubeSat platform possible
- High-power demand investigated by dynamic ACS/power simulation with GAFE
- Detailed thermal verification model
- SSO best choice for EIVE mission

Outlook

- Thermal vacuum tests with STM about to start
- FlatSat phase is first step towards verifying the design of the satellite bus
- ACS/power simulation useful tool for planning of satellite operations
- Contract with launch broker EXOLAUNCH for launch opportunity in 2022 recently signed

Funding

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University of Stuttgart
Germany

M.Sc. Markus T. Koller
Institute of Space Systems (IRS), University of Stuttgart, Germany

eMail mkoller@irs.uni-stuttgart.de
Telefon +49-711-685 675 52