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Development of a CubeSat communications system based on CCSDS and ECSS standards

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TU Darmstadt Space Technology e. V. is a group of students at the *Technical University of Darmstadt*. Its purpose is to get students in contact with space technology. To give students the opportunity to get first hands on experience in practical projects, there are currently a CubeSat and experimental rockets in development. Because also others should benefit from this work, all the CubeSat Hardware and Software are published as open source. The licenses used are CERN OHL v1.2 for Hardware and GPLv3 for Software.

The mission of the CubeSat is to test a transparent reflectarray, a combination of a solar cell and a reflectarray antenna. The mission is being developed in cooperation with the *Institute of Microwave Engineering and Photonics* at the *Technical University of Darmstadt*.

The focus, when developing a communications system for CubeSats, should always be on the reliability of the overall system, to be always in control of the satellite. To ensure this, the *Consultative Committee for Space Data Systems* (CCSDS) and the *European Cooperation for Space Standardization* (ECSS) developed standards for reliable communication systems. Using these standards, it is possible to realize all kind of mission concepts and control multiple satellites with one or more groundstations. The ECSS standards for communication are derived from the CCSDS standards, with a focus on user friendliness and they are in most parts compatible with each other.

To get fast results in the development process, software defined radios (SDR) are used with GNUradio and Python scripts for data processing. The printed circuit boards (PCB) are developed using the open source PCB design software KiCAD and build with commercial of the shelf parts, to keep the development and production costs low.

In a first step of the development the low layer data transmission is being implemented in GNUradio. A demonstration was presented at the *Open Source CubeSat Workshop 2017*, with packet detection inside of GNUradio. The overhead and the complexity of the project made it hard to continue with the development, so the processing inside of GNUradio is now just done until the step where the raw bit stream is created. After this is done the bits are passed via zero message queue protocol (ZeroMQ) to Python scripts that implement the standards for Synchronization and Channel Coding (CCSDS 131.0-B-3, 231.0-B-3), Communications Operation Procedure-1 (CCSDS 232.1-B-2) and the still not finally reviewed Unified Space Data Link protocol (CCSDS 732.1-R-3).

For the operation of the CubeSat the possibilities offered by the Message Abstraction Layer (CCSDS 521.0-B-2) and the Mission Operations Services concept (CCSDS 520.0-G-3) are currently being reviewed.

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