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Educational Payload on a Commercial CubeSat

Project STONCS - Student Technology on CubeSat

Christian Schindler, Danila Dudkin, Friedrich Kempen, Zeyu Zhu
Scientific Workgroup for Rocketry and Space Flight (WARR), Technical University of Munich, Germany

The project:

- **A 60mm x 60mm PCB on the outside of a commercial CubeSat**
- **Opportunity from OroraTech GmbH under the name Innovation Launchpad**
- **Project has an educational goal in developing and testing a real satellite payload**

Figure 1: STONCS PCB with the shield and apertures installed

Positive effects of flying as a payload:

- **Low-stakes testing of critical subsystems**
- **Get space heritage of critical components**
- **Faster and cheaper iterability**
- **More accessible for educational projects**

HARDWARE

BNO055:

The BNO055, an IMU by Bosch, was chosen for its proven reliability. Both the hardware and software performed well in the MOVE-III Balloon test flights. It includes a magnetometer, gyroscope, and accelerometer, though the accelerometer isn't used in this application.

Sun Sensor 1:

The sensor consists of a large photodiode with a resistive layer on top, with an small aperture casting a dot of light on the surface. Four currents are created by the photodiode, which are then digitized by a transimpedance amplifier and an ADC. Based on the proportions of the currents relative to each other, a simple formula can be derived, that tells us where on the sensor the dot is cast. From that and the position of the aperture opening, as well as some calibration, a very high degree of accuracy can be acheived.

Microcontroller (STM32L4R5ZIT6P):

The STM32L4R5 is a microcontroller chosen for its high performance, a large flash capacity, and its low price and power consumption. It is also used on all MOVE-III subsystems, so it is also useful to get space heritage.

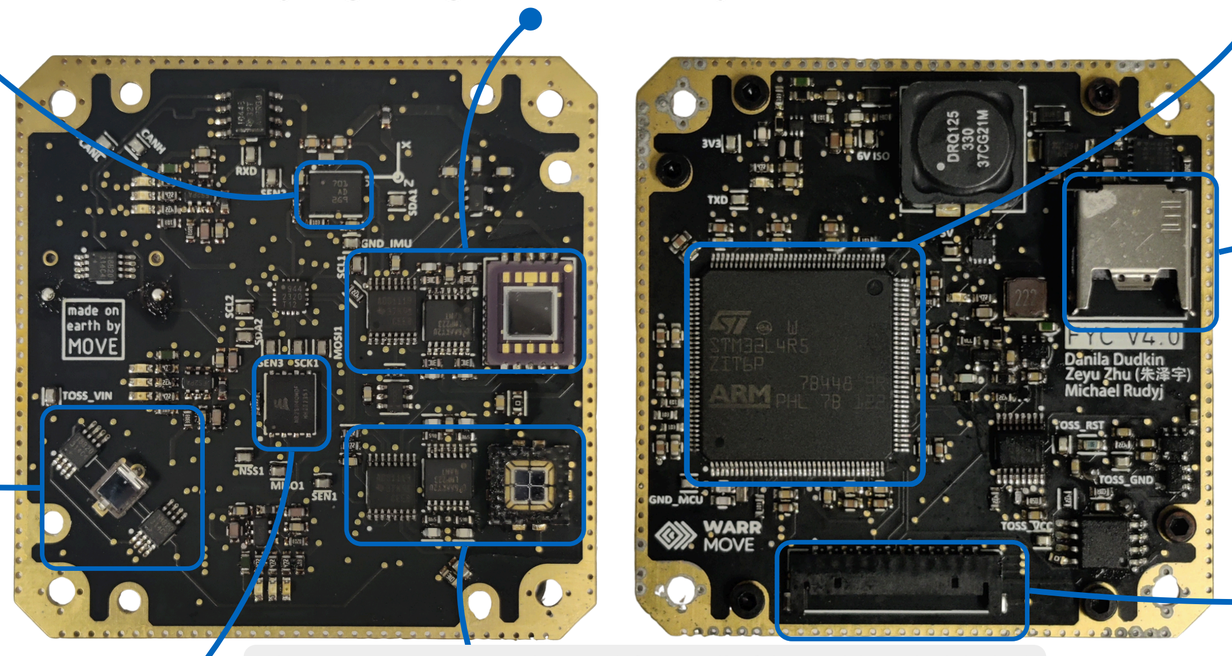

Figure 2: STONCS board front (left) and back (right)

TOSS (Thermo-Optical Sun Sensor):

The thermo-optical sun sensor is a sun sensor developed at the LRT by Martin Dziura. The sensor is a cheap and simple way to determine if the light source pointed at the device is coming directly from the sun, or is reflected by Earth. This is done with a single photodiode, and 2 temperature sensors, one with a coating that reflects certain wavelengths. Depending on the temperature curve of each termperature sensor, the origin of the light can be determined.

MRAM (Magnetoresistive Random-Access Memory):

The MRAM offers persistent storage of mission data, as well as radiation safety. It is 4Mb in size.

Sun Sensor 2:

This sun sensor consists of a 2x2 array of photodiodes, with an aperture placed in front of the array, which produces a single spot on the surface. Each diode is connected to a transimpedance amplifier, which determines the proportion of the spot on each photodiode. From those readings a good estimate can be made about the relative angle between the surface of the array and the sun.

External interfaces:

The board communicates with external hardware via 2 connectors. One of them, being the SAMTEC ARF6, is connected to the satellite, and carries CAN and power, as well as some debug signals. The other one is a MOLEX PicoLock connector, which carries UART signals from the Microcontroller, as well as all the necessary data lines to facilitate JTAG communication and flashing.

SOFTWARE

This project also provides the possibility for the software team to test mission-critical software for the next generation of satellites of WARR move. Especially noteworthy are:

DOSIS (Distributed Operating System Initiative for Satellites):

DOSIS is a partially open-source and self developed platform for distributed embedded systems, written in C++. It is based on the RODOS operating system, developed at the University of Würzburg, and is the foundation for all our satellite software apart from the Bootloader.

Figure 3: DOSIS logo

Bootloader (moveloader):

The bootloader is also developed completely in-house. Its goal is to ensure proper firmware being booted on the microcontroller, by offering multiple images (3+) for redundancy, and safe software updates. The bootloader is formally verified, continuously hardware tested and uses less then 8KiB of flash. It is developed in Rust.

www.warr.de/move
satelliten@warr.de