TECHNISCHE UNIVERSITÄT DRESDEN

Studentische Arbeitsgruppe für Raumfahrt in Dresden STARD

Student's Oxygen Measurement Project
SOMP CubeSat

The entire project is organized and managed by students from a huge variety of different subjects. The development of SOMP started in 2006. Dresden University of Technology supports the project by providing consulting and guidance, motivated by the opportunity to provide hands-on experience and to enrich its curriculum. Students can write seminar papers and project theses to topics related to SOMP's development. The project is going to be funded through the German Space Agency (DLR), which is currently evaluating the project. SOMP is only one project within the "Student Research Group for Spacecraft Engineering" (STARD), founded in April 2005. Another group of students works on rocket propulsion, designing a 500N and 3kN rocket engine on the basis of historical drawings and documents.

Structure / TCS

The satellite's structure follows the CubeSat standard, established by CalPoly and Stanford. It is therefore limited to a maximum weight of 1000g and the cubic shape with edge dimensions of approx. 100mm each. Its design is modular, providing an easy assembly of all circuit boards and wires.

During orbit, the satellite will experience huge temperature differences due to the alternating exposure to sun light. To ensure thermal stability and proper working conditions for the used COTS hardware, the satellite's thermal design is made using ThermoCAD. All components are iteratively placed to ensure the best compromise between weight allocation and heat distribution. Current studies show the need of thermal insulation using Solithan.

SOMP will not need a special type of pod e.g. the P-POD, it is compatible to all existing systems.

Payload

FIPEX, the Flux (Phi) Probe Experiment, is a micro-sensor system developed for measurements of atomic and molecular oxygen. As a payload on-board SOMP, it allows a time resolved measurement of the atomic oxygen concentration in LEO, while the altitude of the satellite decreases during its life cycle. Since atomic oxygen shows significant interactions with spacecraft structures and surfaces, the acquired data is crucial for future spacecraft missions in LEO, since it will help to develop more precise estimations of its distribution. Preferably, SOMP will fly in a polar orbit, providing the first measurements in polar regions ever made.

FIPEX is also on-board the European Columbus module on ISS to provide the first long-term measurements of the oxygen distribution in LEO to date.

The satellite will also act as a technology demonstrator for thin film solar cells to measure their performance and degradation in space. Since these solar cells are flexible, they can be attached to multiple surfaces and hence provide more options for power generation on spacecraft.

On-board Computer / C&DH

The communication system demands real time conditions, therefore we decided to use a powerful micro controller – the AT91SAM9260. It is a ARM9 running at 180 MHz, having 32 KB ROM and 8KB SRAM.

In addition to the internal memory we us MRAM for the intermediate data and flash to store all information. The radiation in orbit requires additional protection of the data. We use an ECC checksum to detect and correct memory errors. Another method to ensure a failure free recording of our data is to shield the subsystem by a reasonable construction - for example a thin alloy layer, which will be applied in front of critical parts.

Attitude Determination and Control System

The SOMP's ADCS concept is based on magnetometers and sun sensors (photo diodes) for attitude determination and magnetorquers for de-tumbling in general and active attitude control. As a reference, we use an implementation of the International Geomagnetic Reference Field version 10 of 2005 and a celestial model describing the earth's orbit and rotation around the sun running in SOMP's on-board software. We intend to base the sensors' data processing entirely on the on-board computer without having further electronic components than the sensors themselves and analogue-to-digital converters. The satellite's requirement is to reach an accuracy of 5 degree or better.

The magnetorquers are an assembly of three electromagnetic coils also operated by the on-board computer. First, they will be used to initially de-tumble the satellite. Provided that the torque is sufficient, they will furthermore apply a slight spin for stabilisation. As an experimental feature we would like to allign the satellite's payload FIPEX to different orientations in respect to the direction of flight.

We want to locate the satellite using TLE data provided by NORAD. In case NORAD's data is not available, it is planned to continuously extrapolate the satellite's launch vehicle trajectory data and correct it based on regular radio contact. Besides, as an experimental on-board and ground software feature, we are currently working on locating the satellite by using magnetometer data, the earth's ICRF model and simplified pattern recognition algorithms.

Related with the SOMP's ADCS development, some ADCS team members recently submitted a proposal for testing and comparing a set of magnetometers and evaluating their data using the prospective SOMP's ADCS software within DLR's REXUS program. The so called Applied Geomagnetics for Attitude Determination Experiment (AGADE) successfully passed the selection process and was chosen for REXUS 5 to be launched in 2009.

Communication / CS

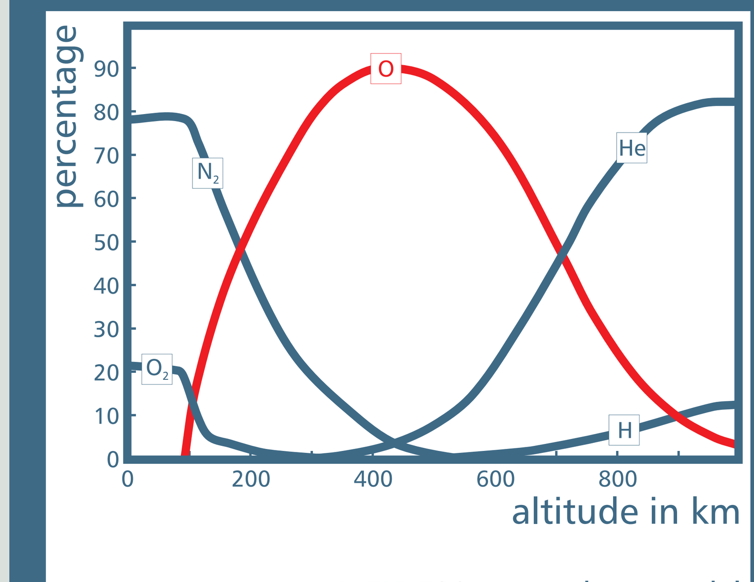
SOMP's communication system will use the 70cm amateur radio band. Beside the obligatory restrictions and "hard" requirements (i.e. spectral purity, public knowledge of coding and so on) there are other, "soft" requirements: lightweight, low power consumption, high sensitivity, flexible modulations, support for different bandwidth/data rates, forward error correction and standardized (packed) protocol (i.e. GENSO). Based on these hard and soft requirements, we did a market analysis of currently available solutions. Unfortunately, there have been no products available which fulfil even our minimum requirements. Therefore, we decided to develop a new, customized, state-of-the-art, Software-Defined-Radio communication system for our CubeSat. With the obtained flexibility regarding modulation, bandwidth, error-correction and packet format we are able to adapt to most communication standards. (i.e. 1200AFSK with AX.25, 9600FSK with AX.25, CCSDS 101.0-B-5 and most likely also the GENSO standard.)

Estimations based on link-budget obtained average data-rates of about 25kBit/s when using a standard 25kHz channel spacing using QPSK modulation and FEC. The maximum data rate is about 600kBit/s (200kHz channel, 8-PSK modulation, no additional coding). All digital signal processing will be done on the C&DH-System through the main ARM9 processor. The antenna consists of four monopoles on each side except the top and bottom of the CubeSat. The two opposite monopoles will be driven by in-, the other two by quadrature-phase. This results in a nearly isotropic, circular polarized radiation pattern. The transmit-receive switching will be done by GaAs FETs or PIN-diodes. Dividing the received signals to two receivers will be done after the LNA and filter.

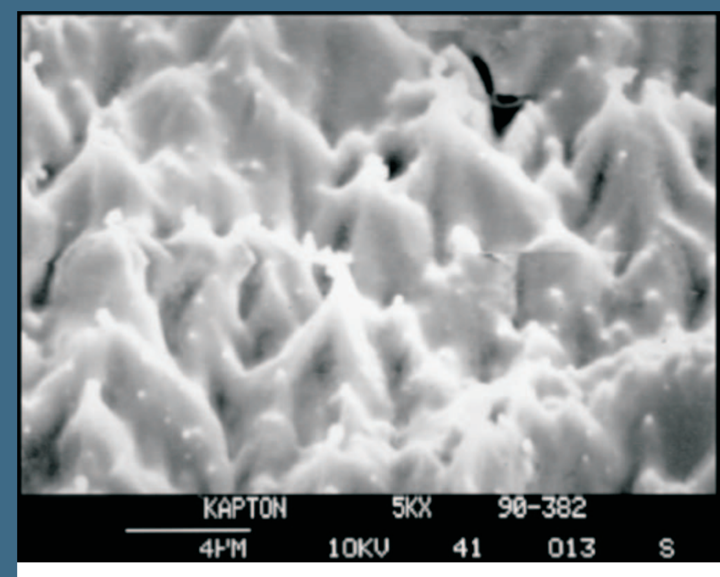
Power Supply / EPS

The power supply of the different subsystems will be realised with solar cells in connection with batteries. As the only power source, GaAs PV cells will be used. The proposed thin-film solar cells will not be used as a power source due to expected low efficiency and unpredictable behaviour. For operation of the FIPEX sensors, a maximum power consumption of more than 3 W is estimated. Thus, even with the advantage of a sun-synchronous orbit, it is not possible to generate the amount of power needed for full operation with the small area usable for solar cells. Using two GaAs standard space cells a maximum input power of approximately 2.2 W can be harvested. Thus, the satellite will be operated in cycles of constant charging (most subsystems are turned off) and discharging (measurements, communication, etc.), which will cause the batteries to degrade and be a limiting factor for satellite life. The batteries will be selected and dimensioned according to the scheduled life-cycle. A model favoured at this point is Panasonics CGA 523436B, with a weight of 15g and a nominal capacity of 760 mAh. Usage of four such batteries allows a redundant design. A failure of one or more batteries will only cause a shortening of system life, since the batteries cannot be operated in their optimum state of charge (approximately 50 to 70 %) anymore. The solar cells will be connected to the batteries via a protection diode and a converter (at this point a synchronously rectified boost converter is favoured), which can be adjusted to operate the cells close to their operating point of maximum power output. The design of this charging system will be redundant and allows the input converter to fail without causing the complete system to fail. The various subsystems will be supplied through several switch mode power supplies and electronic fuses. For subsystems which require a higher power voltage, an option to access the battery voltage directly via an electronic fuse will be provided.

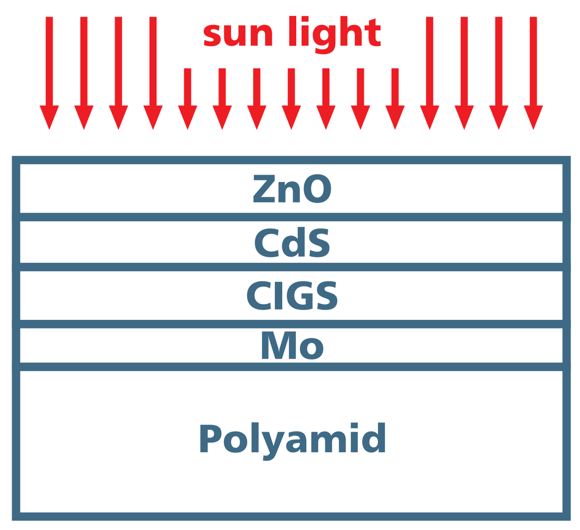
Student's Research Group for Spacecraft Engineering at Dresden University of Technology



MSIS-E90 atmosphere model

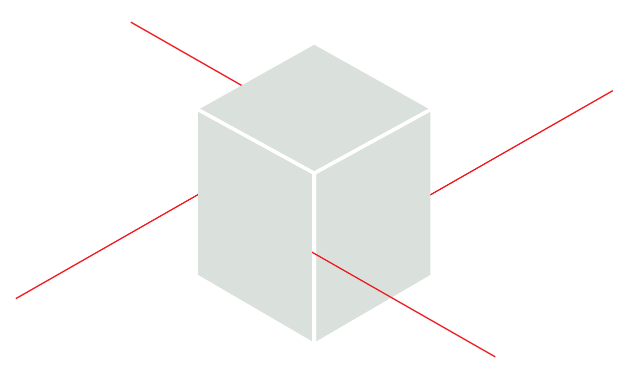


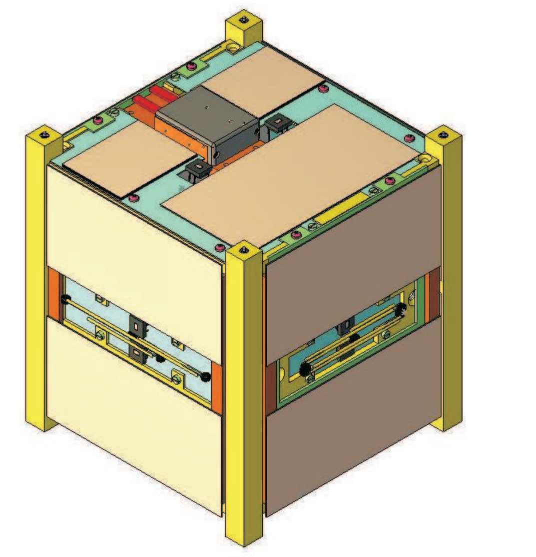
degradation of Kapton caused by atomic oxygen

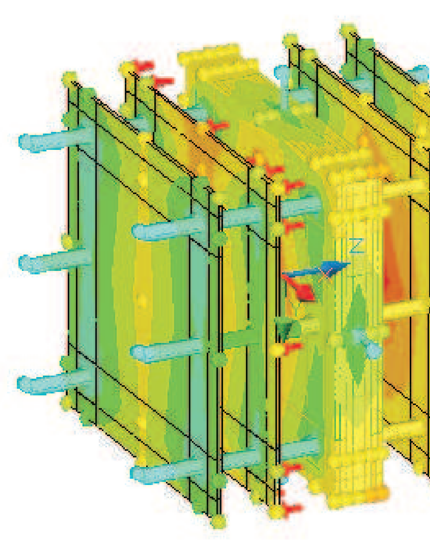


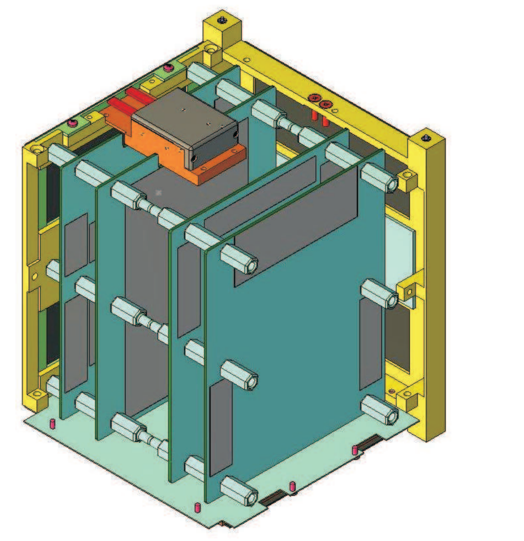
flexible thin film solar cell's layers

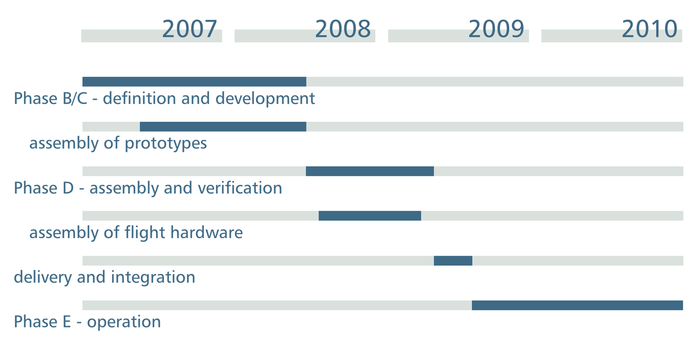
FIPEXonISS at Cape Canaveral


omnidirectional antenna layout

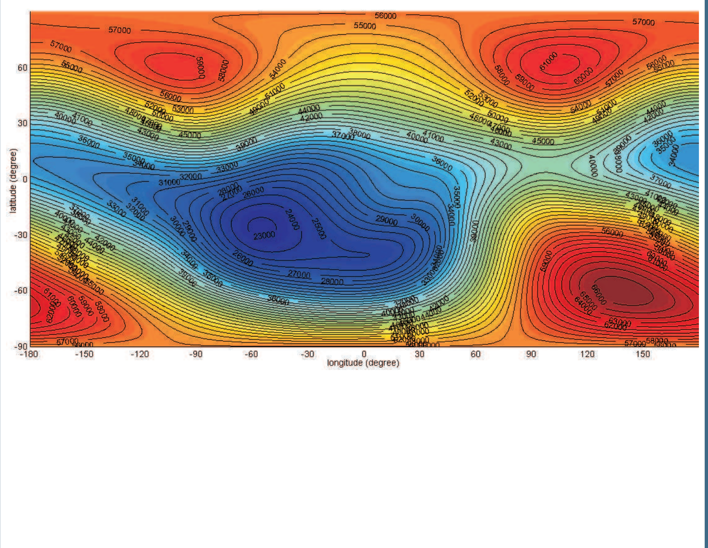

current strcture draft, closed


thermal FEM simulation


current strcture draft, open



latest schedule


plot of IGRF 10 in nT at 0m NN

Studentische Arbeitsgruppe für Raumfahrt
c/o Technische Universität Dresden
Fakultät Maschinenwesen
Institut für Luft- und Raumfahrttechnik
01062 Dresden, Germany

Web
http://www.stard-online.de
http://tu-dresden.de/ilr/rsn

Official point of contact: Andreas Weber
phone: +49 (0) 351 46 33 79 41
e-mail: andreas.weber@tu-dresden.de
stard@mailbox.tu-dresden.de

CalPoly CubeSat Developer's Workshop | 2008-04-08 | STARD