Student's Research Group for Spacecraft Engineering

c/o Technische Universität Dresden
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CubeSat in Dresden:
STUDENTS' OXYGEN MEASUREMENT PROJECT - SOMP

SOMP is a picosatellite following the established CubeSat form factor (dimensions of $10x10x10cm^3$, mass not exceeding 1kg). Initiated, organized and managed by a group of students from various backgrounds, the development of SOMP started in 2006 and has currently reached phase C (hardware development and implementation). Dresden University of Technology is supporting the project by providing consulting and guidance, motivated by the opportunity to provide hands-on experience in spacecraft design and to enrich its curriculum. In addition, students are offered to write seminar papers and theses on topics related to SOMP's development.

Mission objective: The satellite's primary payload is the micro-sensor system "FIPEX" (Flux (Phi) Probe Experiment) developed for measurements of atomic and molecular oxygen. While the satellite's altitude is continuously decreasing during its life cycle, time resolved measurements of the atomic oxygen concentration in different atmospheric layers will be possible. 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. 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 future spacecraft.

Current state of development: The satellite's subsystems are fully defined. Prototypes of the satellite's subsystems are currently being built and tested. Launch is currently targeted at the end of 2010.

How AGI's STK is supporting the project: STK plays a key role in mission design and analysis of possible launch opportunities and resulting orbits. Students are currently analyzing different mission scenarios in order to estimate worst case scenarios and edge conditions directly influencing satellite design and operations. The satellite's eclipse period is crucial for the design and dimensioning of the thermal control system and the prospective possible amount and frequency of measurements due to the very limited power budget and area of the solar array. The orbit also directly influences contact times and durations enabling communication. Requirements on data rates and ground station infrastructure are being derived using AGI's software. Another major help is the use of STK to verify the satellite's life time in LEO. Compliance with the European Code of Conduct for Space Debris Mitigation has to be verified prior to launch as a requirement by the German Space Agency. Calculations done with STK, demonstrating the satellite will not stay longer than 25 years in orbit, are fulfilling this requirement, since STK is widely approved by officials and authorities as a reliable tool. Overall, STK is saving us lots of time in the design process which can be allocated to the implementation of the system, project management and education. Last but not least, STK is a big help in compiling a comprehensive and plausible system documentation as required by the launch provider and space agency and to create descriptive graphs for public outreach. Beside the direct use for SOMP, STK enables students to develop and improve skills in orbit dynamics, since STK's powerful GUI gives an immediate visual feedback and impression which factors are influencing a satellite's orbit and constraints on ground operations.

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The following figures shall give examples of results gathered with STK to date.

The satellite's life time is mainly influenced by the drag coefficient and cross section in flight direction. However, a correct estimation of these two factors is a major problem: Since the satellite has only the ability to detumble but will likely not reach a stable controlled attitude, its cross section is constantly changing. Based on the kinetic theory of gases and empirical determinations, the drag coefficient cannot be less than 2; however, an estimate of the final value can only be derived empirically. In order to meet requirements to proof the satellite's life time is definitely not exceeding 25 years, the life time of the satellite was analyzed as a function of the drag coefficient and orbit altitudes on relevant launches for our mission using the NRLMSISE 2000 and Standard 1976 atmospheric models in combination with a J4 propagator. Figure 1 and 2 are illustrating that even worst case assumptions (c_D = 2.0, 600km altitude, average cross section of 0.0141m², mass 1kg) will lead to life times less than 22 years.

Figure 3 is illustrating the ground track of an exemplary polar orbit with an inclination of ~98°, as it was commonly used by CubeSat missions in the last months. The attached movie file was created for presentation purposes, illustrating the first hours of the satellite in orbit after injection as a piggy-back payload on an exemplary launch from Sriharikota, India on March 25th 2009.

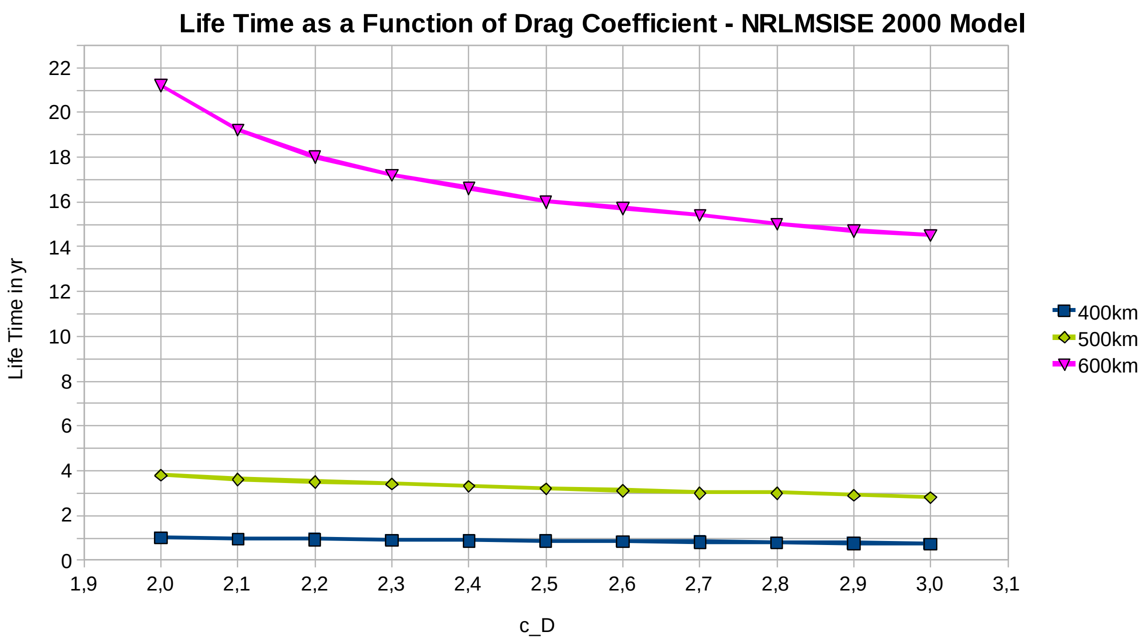

Figure 1: Life time calculations using the NRLMSISE 2000 atmospheric model. Worst case assumptions verify a maximum life time of approximately 22 years before reentry.

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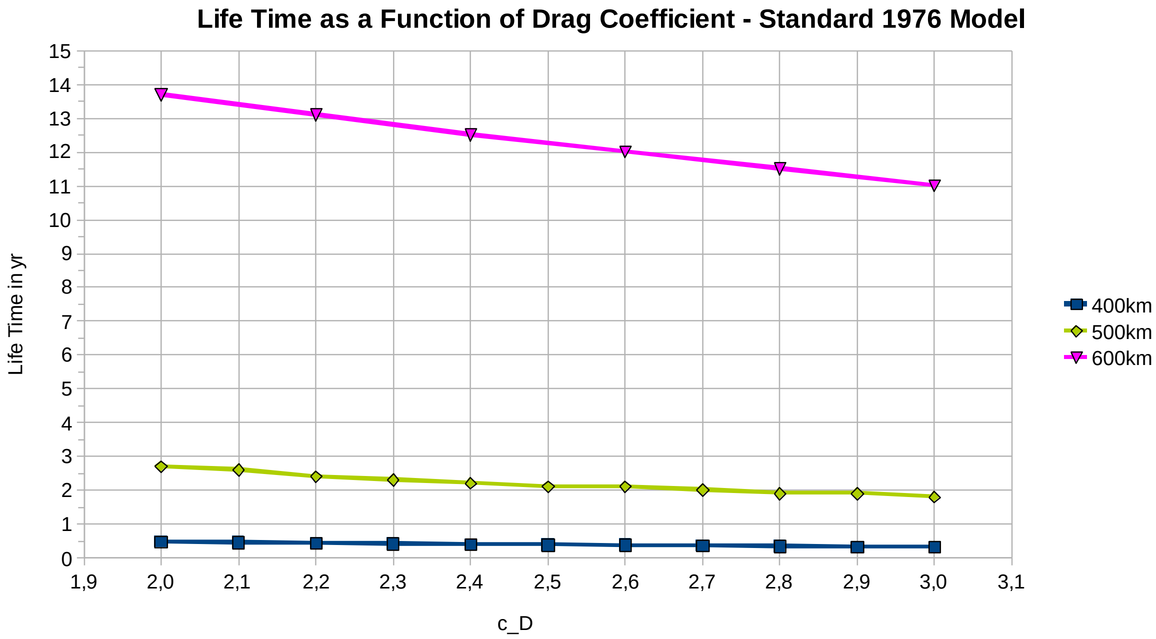

Figure 2: Life time calculations using the Standard 1976 atmospheric model. Worst case assumptions verify a maximum life time of approximately 14 years before reentry.

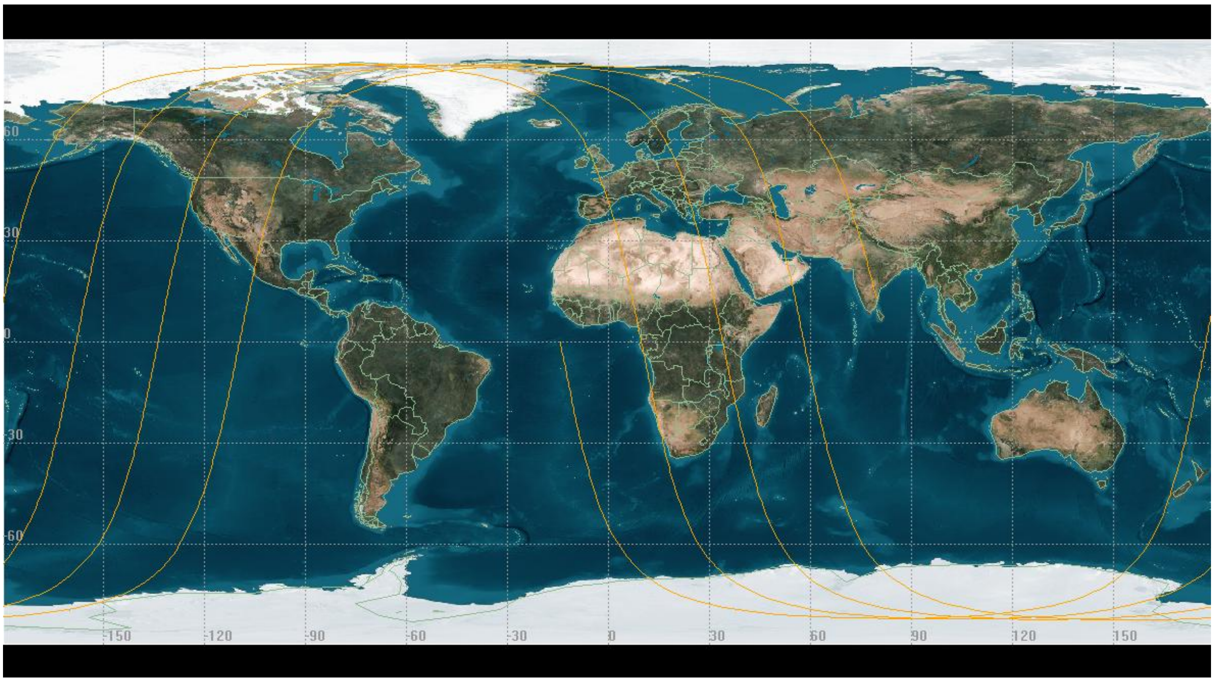

Figure 3: Illustration of an exemplary quasi-circular polar orbit (600km, 98°), as it is commonly offered to CubeSats being launched as a piggy-back payload on a PSLV launch vehicle.