

BeeSat Attitude Determination and Control System

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Abstract Berlin Experimental and Educational Satellite (BeeSat [1]) is a highly innovative pico satellite project of the Department of Astronautics at Berlin Technical University. Main objective of BeeSat is the on-orbit verification of miniaturized reaction wheels suitable for pico satellites which have been developed with our main industrial partner Astro- und Feinwerktechnik Adlershof GmbH [2]. Work is done to provide a number of additional pico satellite technologies. This paper outlines motivations for equipping a pico satellite with an attitude determination and control system (ADCS) based on reaction wheels. BeeSat's ADCS is exposed briefly alongside some of the solutions the research team at TU Berlin developed. A sun sensor system based on Position Sensitive Detectors is introduced, a new design principle for magnetic coils is explained and the Microwheel system is displayed.

1 Introducing Pico Satellites

At TU Berlin good experiences with micro satellites have been made. The series of TUBSAT [3] micro satellites has shown remarkable results and provided students with hands-on experience ever since the micro satellite TUBSAT-A was

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launched in 1991. Regarding the overall increase in capability, performance and efficiency of electronics pico satellites become a more and more serious subject to research.

CubeSats [4] are pico satellites, which means, that their total mass may not exceed 1kg. They have a cubic shape and standardized outer dimensions of $10 \times 10 \times 11.3\text{cm}^3$. Furthermore they have to meet special requirements to ensure the safety of launch vehicle and primary payload. Those limitations make it hard to realize features already taken for granted on larger satellites but on the other hand offer universities cheap and easy access to space.

Technologies for pico satellites can be used on larger satellites as well, one example being the reaction wheel developed for BeeSat which can easily be equipped with a larger flywheel mass and then meet the needs of nano satellites.

2 Beesat's Goals

The goals of the BeeSat project can be divided into three different groups:

2.1 Technology Demonstration

First and foremost BeeSat is a technology demonstration and evaluation satellite platform. The main goal is the on-orbit verification of newly developed reaction wheels for pico satellites. On the side of the ADCS also a new design principle for magnetic coils is evaluated as well as a sun sensor system based on Position Sensitive Detectors (PSD). Technologies tested on BeeSat also include: An in-house developed on-board computer, modified transceivers, a power control and distribution unit. The dependable operating system and middleware TinyBoss [5] developed for BeeSat eases programming and adds to overall security.

2.2 Widening the Field of Possible Pico Satellite Applications

Due to limited technological resources only few applications are suitable for the current generation of pico satellites. Acquiring technologies for pico satellites also means enabling them to fulfill the more demanding missions already envisaged at TU Berlin [6]. Possible applications and capabilities include:

- Occultation measurement
- Remote sensing and target pointing with one or more satellites
- High bandwidth communications
- Constellations
- Formation flight