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Verification of Miniaturized Reaction Wheels for Pico and Nano Satellites

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Background

- Launch of 7 CUBESAT's on 17th April 2007 by DNEPR, including 3 companies: Boeing, Aerospace Corporation, Tethers Unlimited
- Most CUBESAT's have no proper attitude control system yet, which is required for many applications such as earth observation or exploration
- Main reason: lack of suitable sensors and actuators (size, mass, power, performance)
- Miniaturization is essential for future constellations and formations of pico and nano satellites



Engineering model of a micro wheel



Stone wheel (Source: Foto search Lizenzfreie Fotografie Bildagentur)

8-12 October 2008





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Micro Wheels

- TU Berlin developed new micro wheels for ٠ pico satellite applications
- First of a series of miniaturization efforts ٠ (S-Band transmitter for pico satellites being currently the second one)
- Funded by DLR (FKZ 50JR0552) ٠
- In cooperation with industry and research • organizations
- Main parameters of a single wheel: •
 - 4 x 10⁻⁵ Torque Nm
 - Angular Momentum 3.4 x 10⁻⁵ Nms
 - Moment of inertia 117 20x20x15 mm³
 - Size (max.)
 - Mass 9.2



gmm²

g





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Overall Wheel System Characteristics

- Mass
- Power
- Interface
- Rotation rate

- 115 g
- 0.3 1 W
- CAN 2.0B
- 16000 rpm max.



Engineering model of the micro wheel system in vacuum chamber at TU Berlin



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BeeSat (Berlin Experimental and Educational Satellite)

Mission Objectives:

- On-orbit-verification of newly developed reaction wheels for pico satellites
- Verification of other pico satellite technologies
- Education of students

Orbit:	LEO 500–850 km	
Dimensions:	10 x 10 x 11.35 cm ³ , max. 1 kg	
Radio frequency:	UHF	
Attitude control:	3-axis stabilized	
Operation:	TU Berlin	
Lifetime:	1 Year	
Launch:	2008	



Early engineering model of BeeSat





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Mission Scenario



Dr.-Ing. Hakan Kayal





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Functional Block Diagram



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BeeSat On Board Computer

Two cold redundant systems on a single PCB (10 layers, 94 x 94 mm²)

Each board computer has:

- 60 MHz clock rate
- 2 MByte RAM
- 4 MByte flash (Telemetry)
- 16 MByte flash (program)
- 36 Analog channels
- Terminal Node Controller (TNC)
- Redundant CAN 2.0B interface
- TinyBOSS operating system

Additionally integrated: Watchdog, 2 magnetometers, 3 gyros, temperature sensors

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Attitude Determination and Control Subsystem

Sensors

Software

- Command interface
- Attitude determination
 - Orbit propagator
 - Magnetic field model
 - Sensor data interpretation
 - Configuration and calibration
 - Coordinate transformations
- Magnetic coil control
- Wheel control
- Telemetry data generation
- In orbit software update

Actuators

Dr.-Ing. Hakan Kayal

6th ESA Round Table on Micro & Nano Technologies for Space Applications

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Configuration

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Communications Test

- The Radio Link Test Model of BeeSat has been flown in September on a weather balloon of the German Weather Service (DWD)
- Reached an altitude of 34.8 km in 47 min.
- More then 2800 data sets has been received by two ground stations

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Ground Segment

BTM-42EB8CAA DB FC 69 Limits Filt TTS Frame C Main Graphs Errors Frame	GS 03.07.200 S/C 14.05.204	_□× 7 22:21:28 5 02:09:25
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OK all	1 Main	

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Roadmap for Pico and Nano Satellites

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Outlook and Perspectives

- Highly autonomous and operational services, sensor webs
- Use of pico satellite technologies in larger satellites (e.g. nano satellites)
- Synergy between satellite technologies and rovers
- Exploration

Design study of a Micro Mars Rover