Initial Results from the TechnoSat in-Orbit Demonstration Mission

Content

- TU Berlin’s satellites
- TechnoSat mission
- TechnoSat’s platform
- TechnoSat’s payloads
- Conclusions
• 12 missions - 16 S/C up until today
• 5 future missions are currently being developed
TechnoSat Mission

Technology demonstration of 7 payloads and the TUBiX20 platform

- Launched on July, 14th 2017 with a Soyuz 2.1a Fregat from Baikonur
- 600 km SSO (LTAN 11.50 a.m.)
- 1 year design lifetime
- 20 kg S/C mass
- Dimensions (without antennas) 465 x 465 x 305 mm
- UHF communication, 3-axis stabilized
TechnoSat - System Architecture
TechnoSat’s Payloads

- Fluid Dynamic Actuator (FDA) – [TU Berlin]
- Reaction wheels – [TU Berlin]
- Solar Generator based Impact Detector (SOLID) - [DLR Bremen]
- S band transmitter HiSPiCO – [IQ wireless, TU Berlin]
- Star tracker STELLA – [University Würzburg]
- Laser retro reflectors – [TU Berlin, GFZ, ÖAW, GSOC]
- CMOS camera – [TU Berlin]
HiSPiCO

- S band transmitter
- Ground station at TU Berlin
- Satellite can send payload and bus telemetry via HiSPiCO
- HiSPiCO is feed data directly by TechnoSat‘s PDH node
- Downlinked over 70 Mbyte of payload data
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>2.263</td>
<td>MHz</td>
</tr>
<tr>
<td>Data rate (nominal)</td>
<td>1.02</td>
<td>Mbps</td>
</tr>
<tr>
<td>Data rate (extended)</td>
<td>0.68 and 1.39</td>
<td>Mbps</td>
</tr>
<tr>
<td>RF Power Output</td>
<td>+27</td>
<td>dBm</td>
</tr>
<tr>
<td>Power consumption</td>
<td>5</td>
<td>W</td>
</tr>
<tr>
<td>Antenna type</td>
<td>patch</td>
<td>-</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>6</td>
<td>dBi</td>
</tr>
<tr>
<td>Antenna opening angle</td>
<td>85</td>
<td>degree</td>
</tr>
</tbody>
</table>
Reaction Wheel System

- 4 reaction wheels in tetrahedron configuration
- Torque or wheel rates are controlled by TechnoSat’s ADCS node
  - Via the satellite’s CAN bus
- Integrated rate sensor for satellite rate mode
- Pressurized housing for use of COTS lubricants
### Reaction Wheel System - Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>280…315 g</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>65 x 65 x 55 mm³</td>
<td></td>
</tr>
<tr>
<td>Operation temperature range</td>
<td>-20…+50 °C</td>
<td></td>
</tr>
<tr>
<td>Angular momentum (6000 rpm)</td>
<td>up to 45 mNm s</td>
<td></td>
</tr>
<tr>
<td>Max. rotation speed (steady state)</td>
<td>6000 rpm</td>
<td></td>
</tr>
<tr>
<td>Nominal torque (ramp mode)</td>
<td>0.1 mNm</td>
<td></td>
</tr>
<tr>
<td>Moment of inertia (rot. mass)</td>
<td>up to 730 gcm²</td>
<td></td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>12 V</td>
<td></td>
</tr>
<tr>
<td>Standby power</td>
<td>220 mW</td>
<td></td>
</tr>
<tr>
<td>Power at max. rotation speed</td>
<td>1.35 W</td>
<td></td>
</tr>
<tr>
<td>Max. power</td>
<td>&lt; 20 W</td>
<td></td>
</tr>
</tbody>
</table>

Reaction wheel assembly
Satellite Laser Ranging

• COTS Corner Cube Reflectors
  • 10 mm diameter
  • Tested and verified by Helmholtz Centre in Potsdam
• Used for precise orbit determination & attitude and attitude motion detection
  • Different arrangement of up to 4 reflectors per satellite face

Corner cube reflector with 1 Euro coin
Satellite Laser Ranging

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  - 10 mm diameter
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Satellite Laser Ranging - Simulation

![Graph showing distance vs rotation angle](image-url)
Satellite Laser Ranging - in-orbit results
Fluid Dynamic Actuator

- One axis attitude actuator
- Uses a fluid as rotational mass
- Electromagnetic pump
- No moving parts - except the fluid

TechnoSat with Fluid Dynamic Actuator depicted red
### Fluid Dynamic Actuator - Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular momentum capacity (at 12 V)</td>
<td>0.035 Nms</td>
</tr>
<tr>
<td>Max. torque (at 12 V)</td>
<td>0.100 Nm</td>
</tr>
<tr>
<td>Max. power consumption (at 12 V)</td>
<td>5 W</td>
</tr>
<tr>
<td>Working medium</td>
<td>Ga-In-Sn</td>
</tr>
<tr>
<td>Loop diameter</td>
<td>300 mm</td>
</tr>
<tr>
<td>Total mass</td>
<td>1085 g</td>
</tr>
<tr>
<td>Data interface</td>
<td>CAN 2.0 (1 Mbit/s)</td>
</tr>
</tbody>
</table>
Fluid Dynamic Actuator - 20 step manoeuvre

Graph showing angular rate on the z-axis from 00:11:29 to 00:15:39, with values ranging from -2 to 1.5 degrees per second, and time marked in hh:mm:ss format.

9th November 2017
Fluid Dynamic Actuator - 20 step manoeuvre

- 5V mode
- 0.75 W
- 2 Hz rate telemetry
- 2.3 °/s in one second → ~ 40 mNm
Camera

- COTS camera connected to TechnoSat’s PDH via I²C
- Picture data can be downloaded via S Band and UHF
- Used for outreach purposes and ADCS verification

Photographs taken by TechnoSat
Camera

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- Picture data can be downloaded via S Band and UHF
- Used for outreach purposes and ADCS verification

Moonset over Chile - photographed by TechnoSat
Conclusions

• Every payload and the platform have been successfully commissioned
• Experiments are undertaken regularly
• Due to TUBiX20 platform, TechnoSat software development and operations are benefitting the preparations for the upcoming TUBIN mission
Acknowledgements

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