Astro-
und Feinwerktechnik
Adlershof GmbH

µCMG
Micro Control Moment Gyroscope

GSTP Contract "Development of a Micro-CMG"
ESA Contract No.: 4000123641/18/NL/GLC/fk

Space Mechanisms Final Presentation Day

13th April 2023, Online

Notes

Acknowledgment

Thank you very much to ESA GSTP:

ESA Contract No.:
4000123641/18/NL/GLC/fk

The aim of the activity was the development of a micro Control Moment Gyro (µCMG) to Technology Readiness Level (TRL) 5 for agile satellite attitude control.

The CMG consist of a flywheel (spinning rotor) and one motorized gimbal that tilt the flywheel's angular momentum. As the rotor tilts, the changing angular momentum causes a gyroscopic torque that rotates the spacecraft. Based on the performance parameter the µCMG is intended for use in small satellites.

During this development, the mechanics as well as the electronics and the software have been developed to a higher maturity.

Result of this activity was a full-scale Engineering Model (EQM), that is representative of the critical functions of the µCMG. Critical functions were demonstrated in a full environmental test campaign.

Agenda

1. **Introduction**

2. **Current state**
   a) Project phase
   b) Technical specifications

3. **Insight on test campaign**

4. **Prospect**

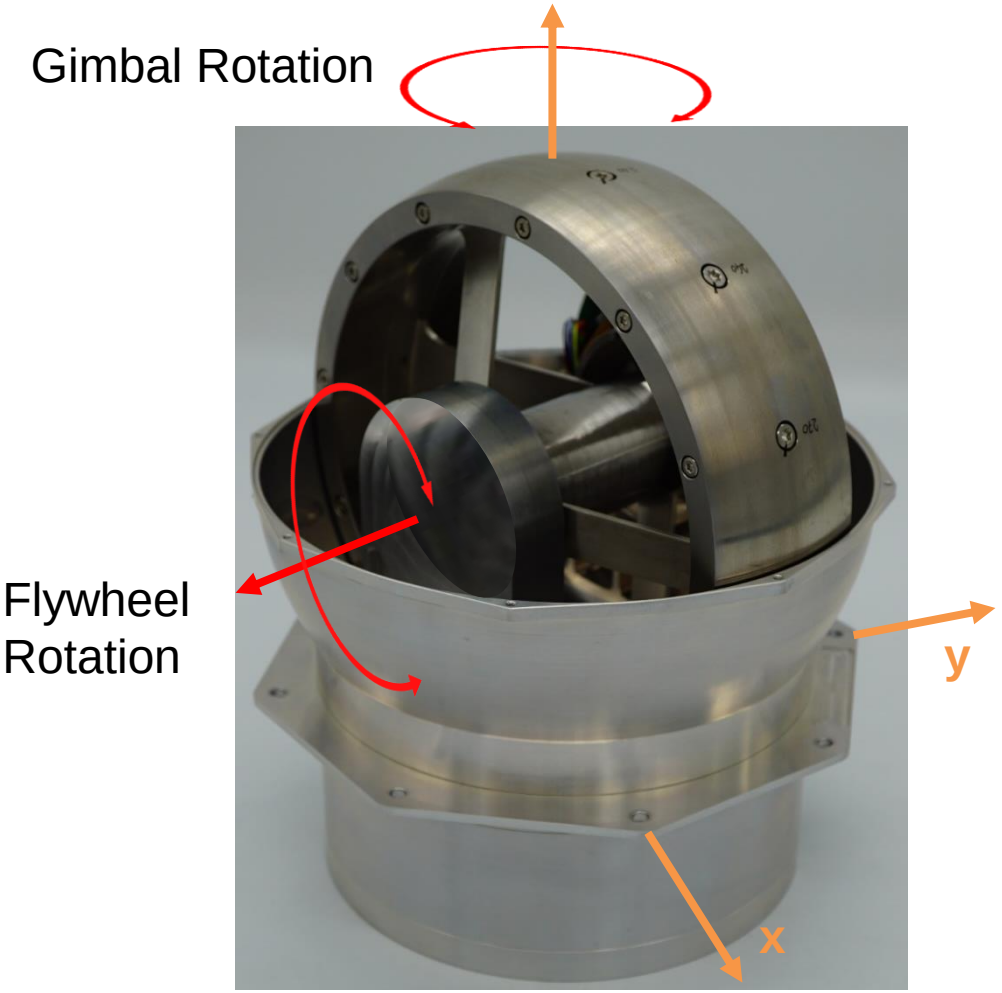
5. **Interactive Q&A**

1. Introduction

Functional Principle

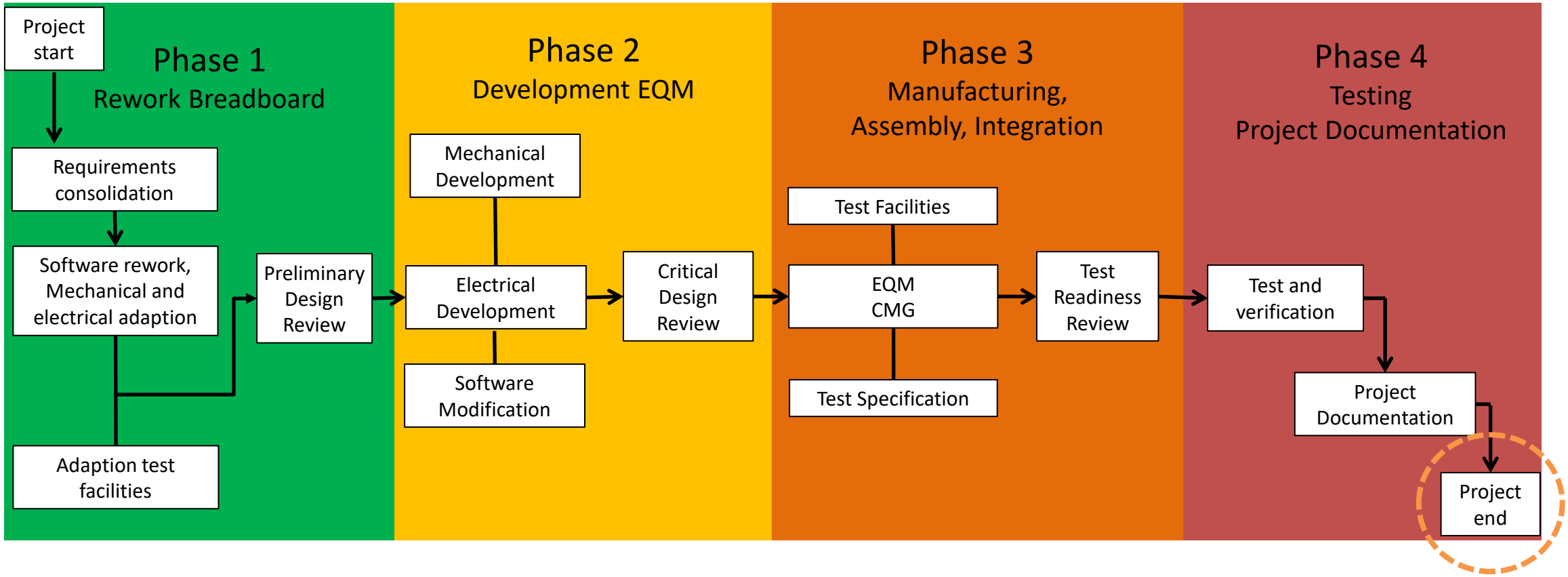
- RW: apply torque by changing rotor spin speed
- CMGs: The flywheel speed remains constant whereas the CMG gimbal axis rotates in order to create a gyroscopic output torque

- Major benefit:
  - ➢ highly agile operations (e.g., ACS for EO missions)
  - ➢ far more power efficient (FW mass maintains rotation)



2. Current State

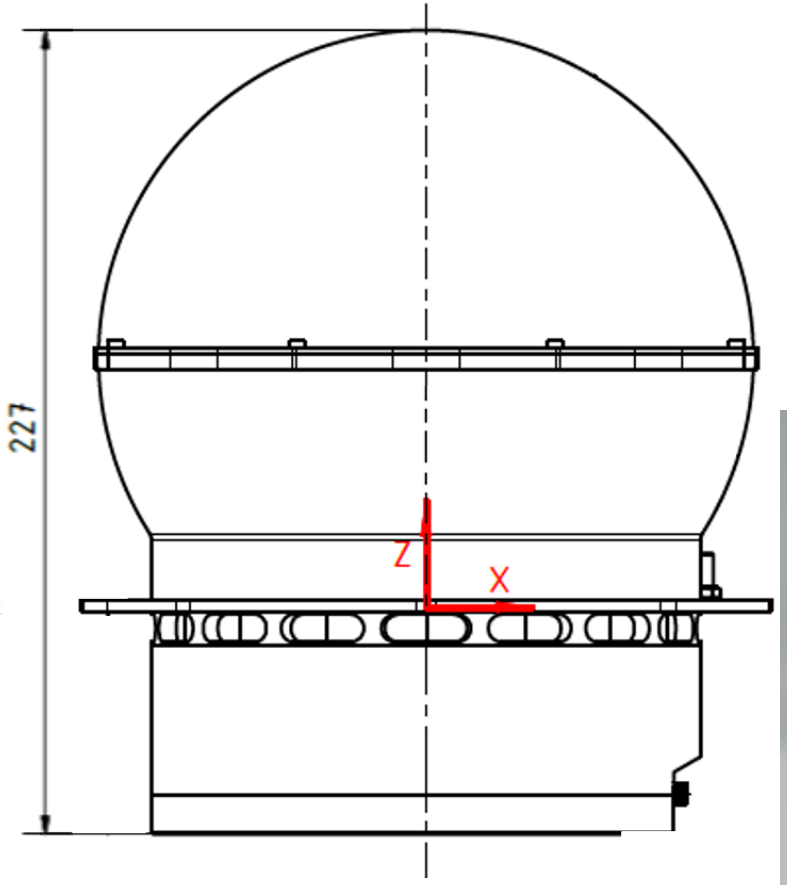
Project Phase: EQM Development



2. Current State

Technical Specifications

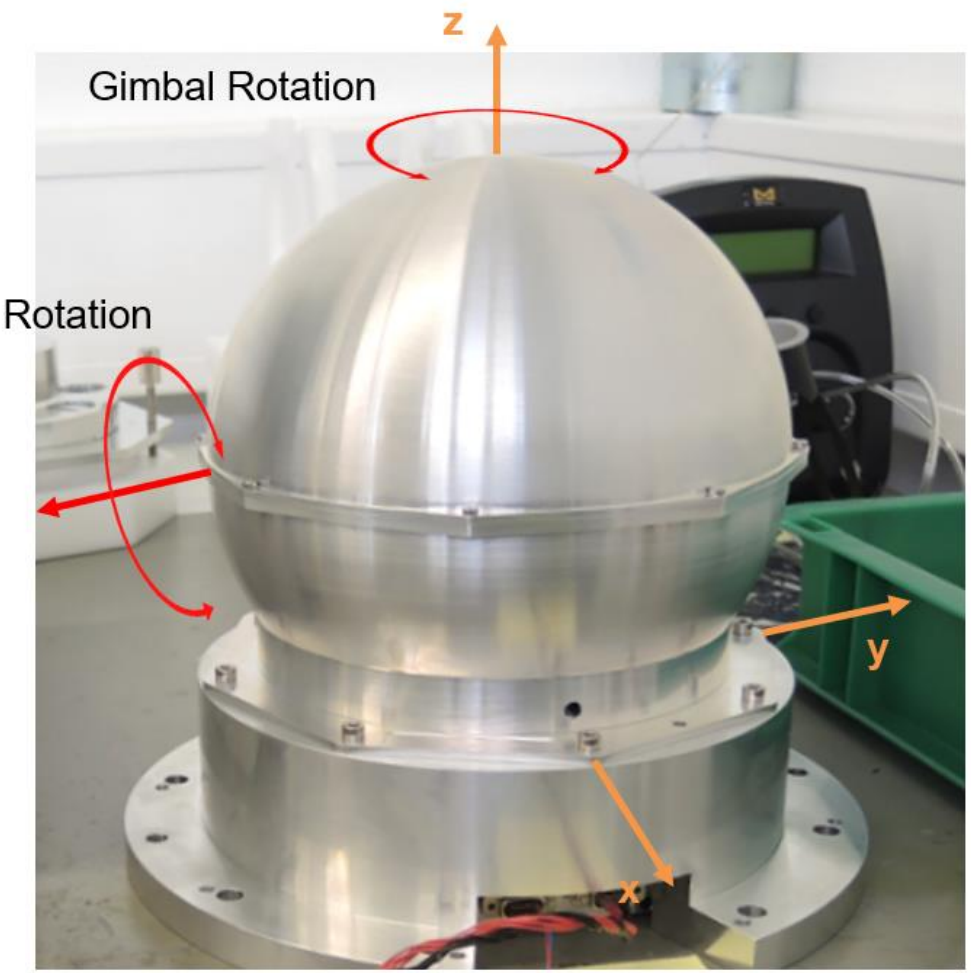
- Dimensions
  - ➢ Height: 227 mm
  - ➢ Width: 195 mm (@ main flange)
- Mass:
  - ➢ 6.5 kg
- Maximum Output Torque:
  - ➢ 14 Nm
- Angular Momentum (FW):
  - ➢ 8 Nms



2. Current State

Technical Specifications

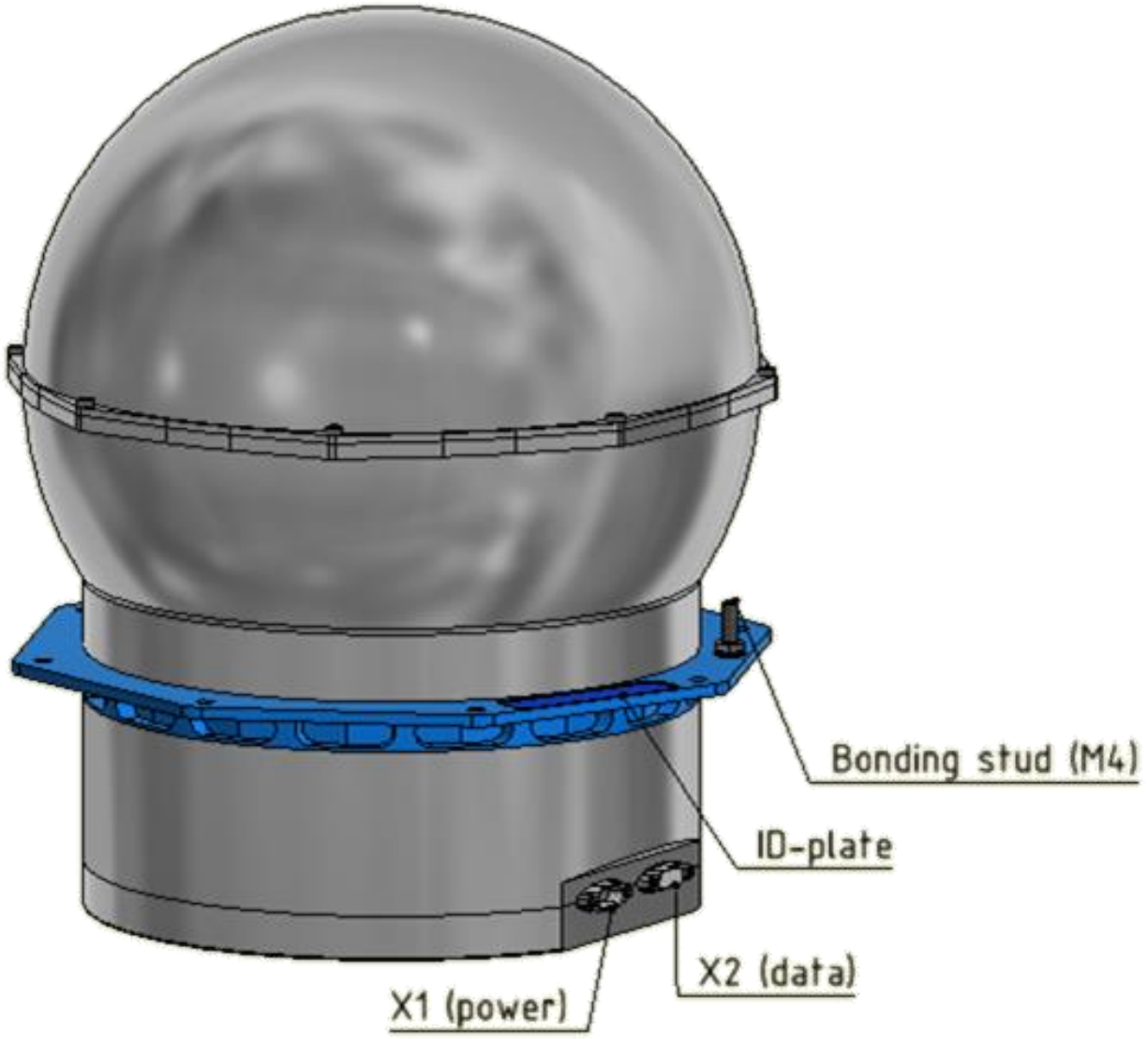
- Mounting: 8xM4
- Structure Materials:
  - ➢ Aluminum Alloy 7075
- Surface Finish:
  - ➢ Clear Chromated
- Temperature Ranges:
  - ➢ Operating Temperature: - 20°C to + 50°C



2. Current State

Technical Specifications

- Electronics:
  - integrated wheel drive electronic/digital wheel
- Power:
  - Operating Voltage: 28^{+10}_{-6} V
  - Max. Dissipation: 40 W
  - Stand-by: ≤ 4 W
  - Main. Max Angular Mom.: ≤ 18 W
  - Max. Output Torque: ≤ 21 W
- Data:
  - Micro-D15
  - RS485 (Redundant)
  - Option: RS422/CAN



3. Insights on test campaign

EQM Test Campaign

- Short Functional Test
- Vibration & Pyroshock
- Short Functional Test
- Short Functional Test
- Thermal-Vacuum Test
- Microvibration Test
- Short Functional Test
- Assessment of Tests

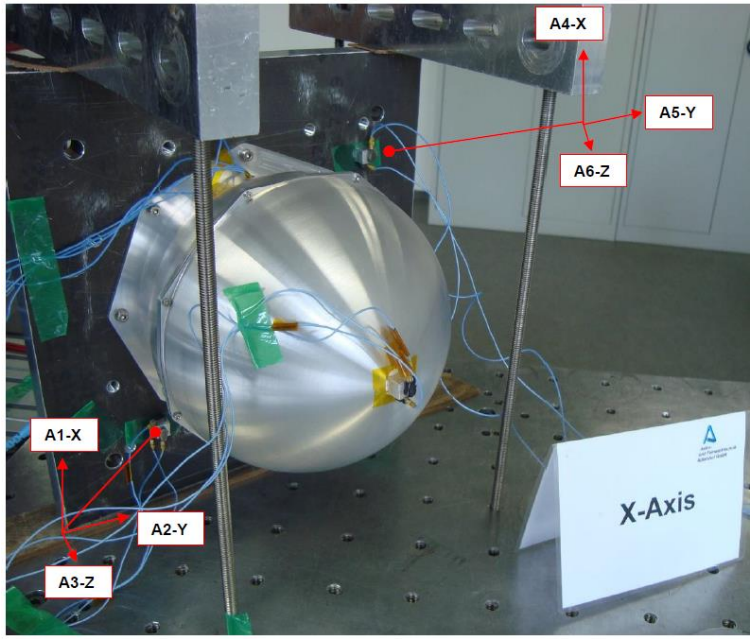
3. Insights on test campaign

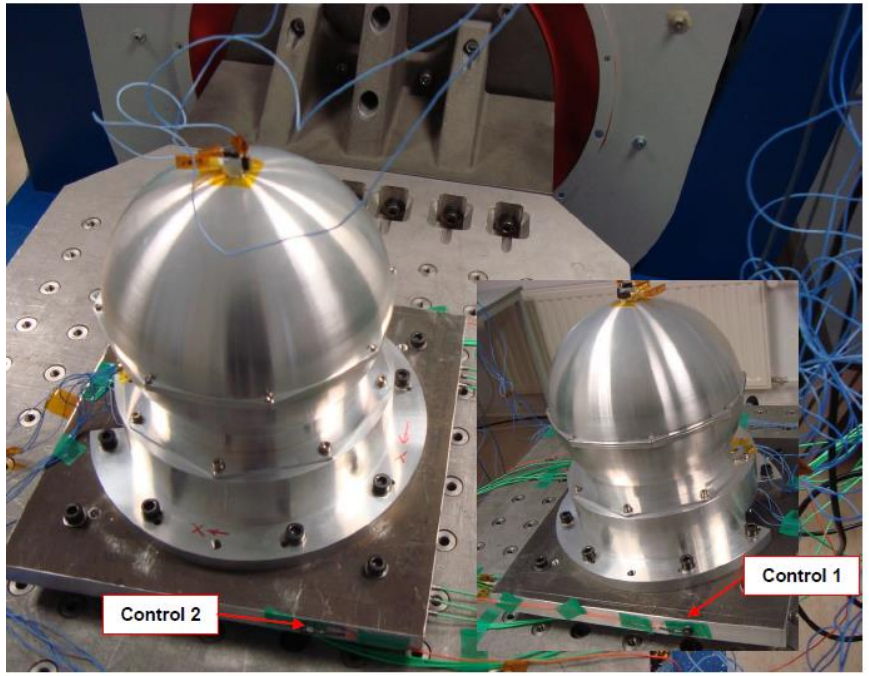
Vibration Test (Sine/Random/Reso) & Pyroshock

- vibration campaign was conducted
- all three axes
- Including resonance search before/after each axis

Results

- function test after campaign successful





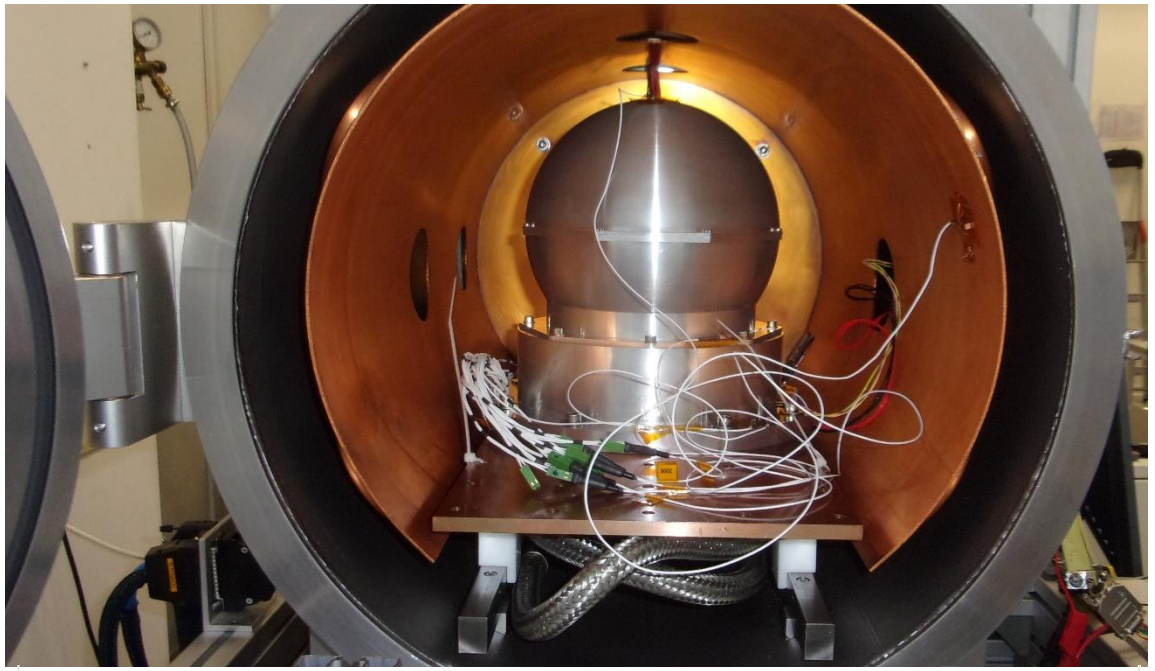
3. Insights on test campaign

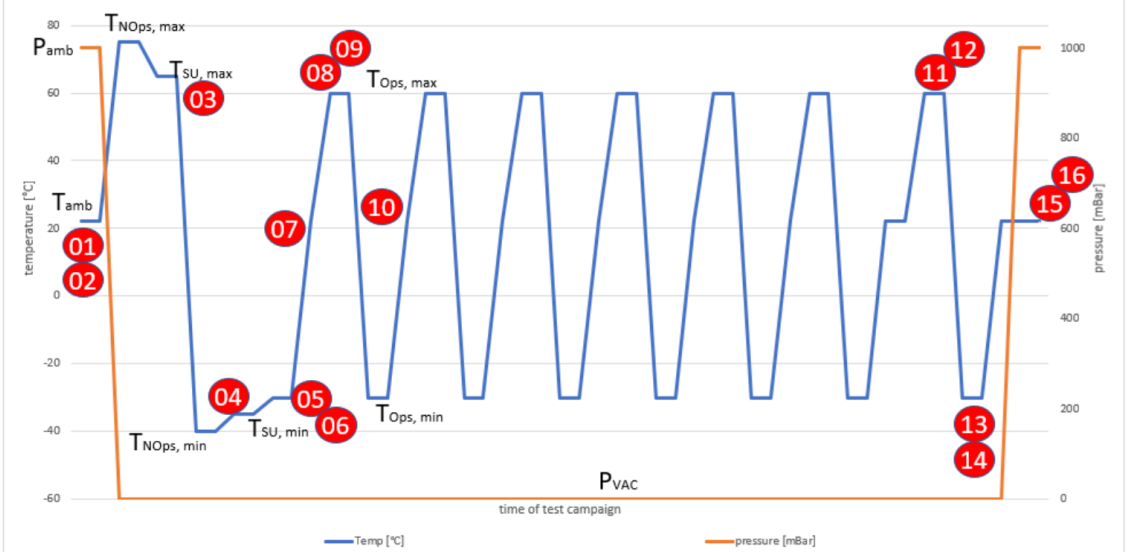
Thermal-vacuum test

- Platform within TVAC not stable enough to run test with full performance
- Thus decided to go with 1200 rpm (inst. of 3820)
- Last cycle $T_{ops,max}$ (60 → 50°C), TM issue?

Results

- Function shown, performance derivates slightly
- TM logging bug found
- DCDC temperature issue (to be revised within new campaign)

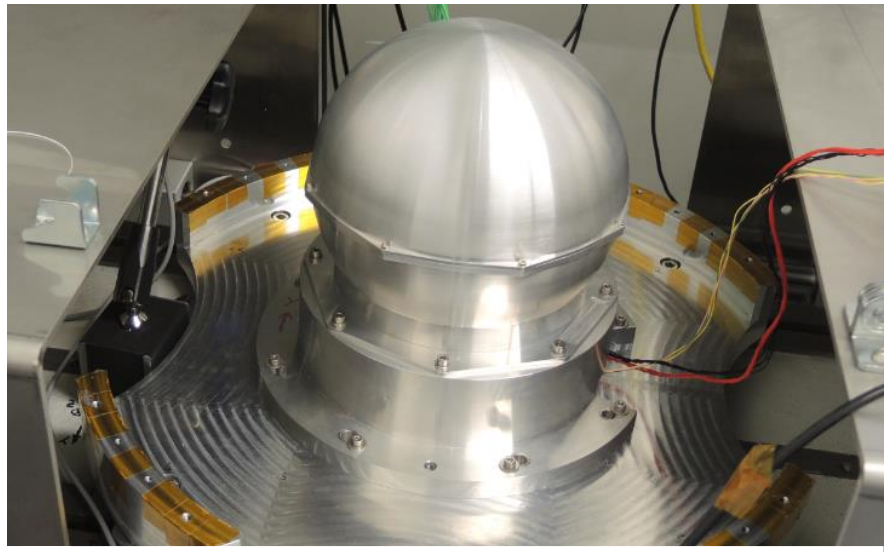




3. Insights on test campaign

Micro-vibration test

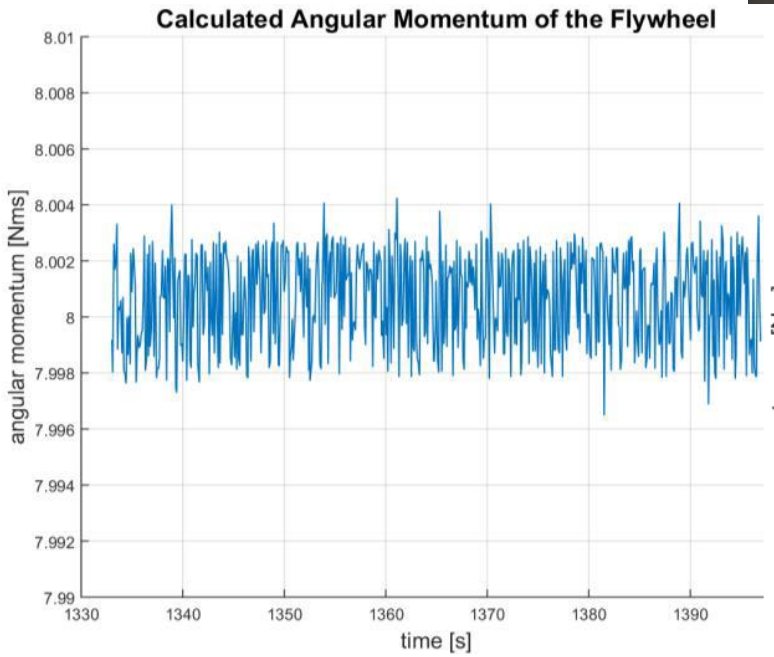
- 3 different use cases performed
  - ➢ Flywheel run-up, fixed gimbal angle
  - ➢ FW steady state, 90° gimbal turn
  - ➢ FW steady state, gimbal const. moving

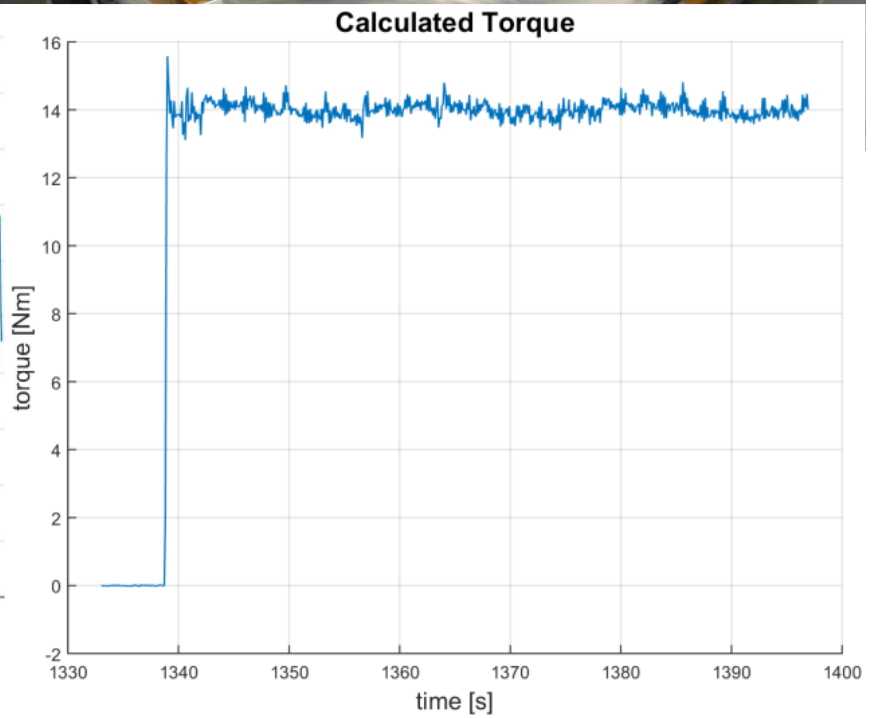


Results

- Angular momentum and torque

  i. a. w. design
- Calc. torque:
  - ➢ std. dev: 4 Nm / 2.9%
  - ➢ w/ initial controller





4. Prospect

Further activities

- Electronics
- Test adapter
- SW/TM logging revision
- Further performance testing and development

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5. Interactive Q&A

µCMG EQM

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