Magnetic Attitude Control of a Spinning Spacecraft

Flight Results and Lessons Learned from DLR's Compact Satellite Eu:CROPIS

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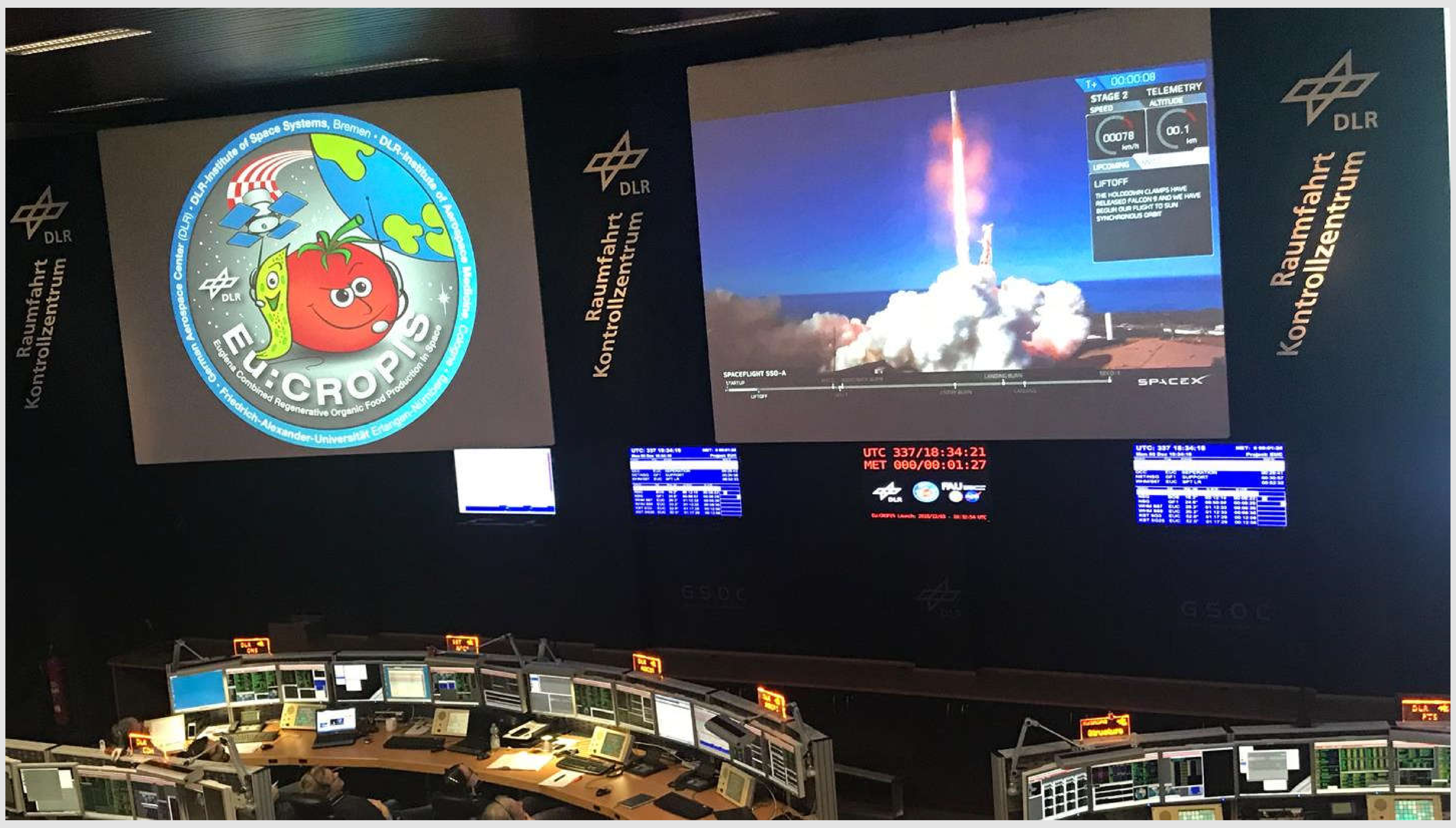

Figure 1: Eu:CROIPS satellite launch on 3rd December 2018 monitored from DLR GSOC control room. Eu:CROPIS is launched on the SSO-A rideshare mission on a Falcon 9 rocket by SpaceX. Source: DLR, CC-BY 3.0

Introduction

Eu:CROPIS is the latest mission within German Aerospace Center's (DLR) compact satellite program. Its major scientific goals are to test and characterize a sustainable biological life support system within harsh space environment at different levels of gravity. Beside the scientific goals DLR wants to establish key engineering capabilities in house to fully develop and lead a compact satellite program.

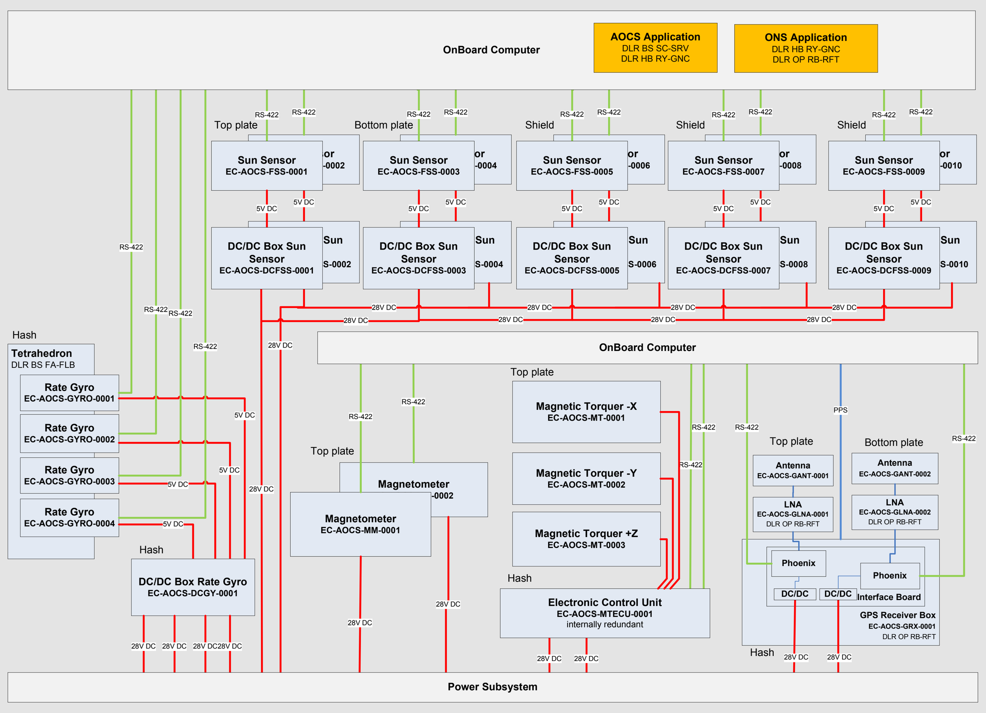

Figure 2: Attitude and Orbit Control System block diagram.

Attitude Control System

The attitude control system is realized by a set of three electromagnetic torquers, which interact with the Earth geomagnetic field. In addition a classical sensor suite is added.

Launch and Early Operational Phase

After lift-off Eu:CROPIS was separated from the launch vehicle and started an autonomous detumbling, see Fig. 3. For this a classical B-dot control law was used. The detumbling took about four hours. The reason for this long time could be traced back to an anomaly at separation, which induced an angular rate of ~10 °/s on the spacecraft. Although the attitude control system was never explicitly

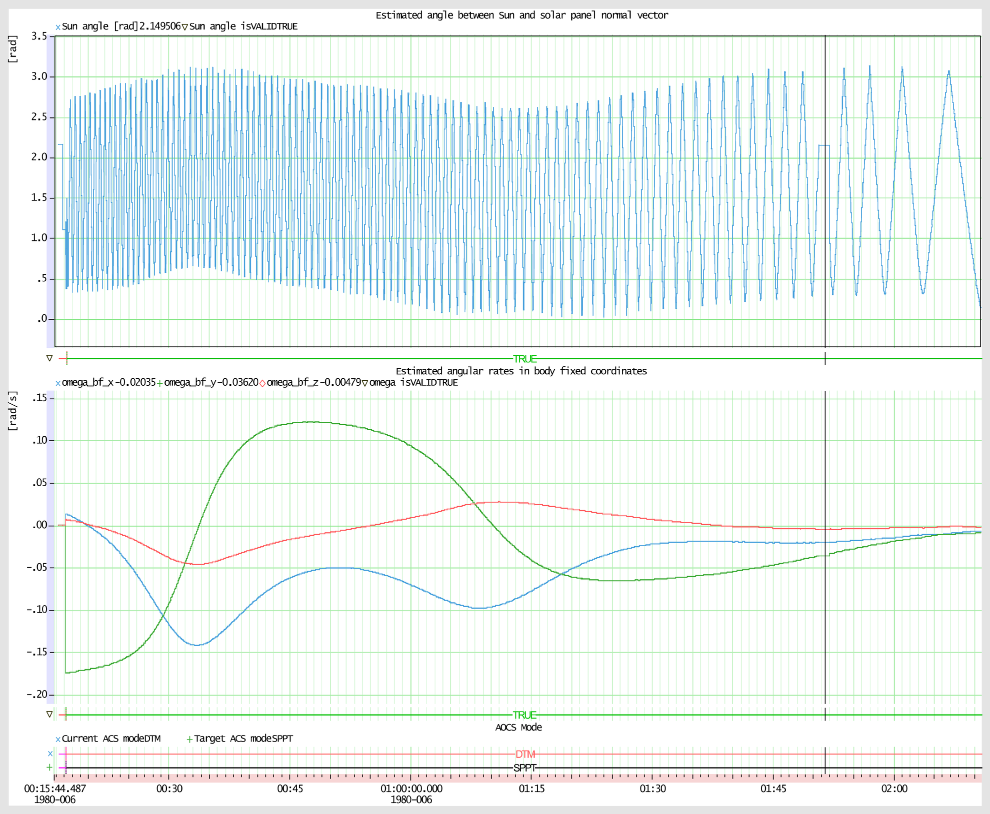

Figure 3: Detumbling phase of Eu:CROPIS showing the sun angle and angular rates directly after separation from the launch vehicle.

qualified for such a high initial angular rate, the task was performed successfully.

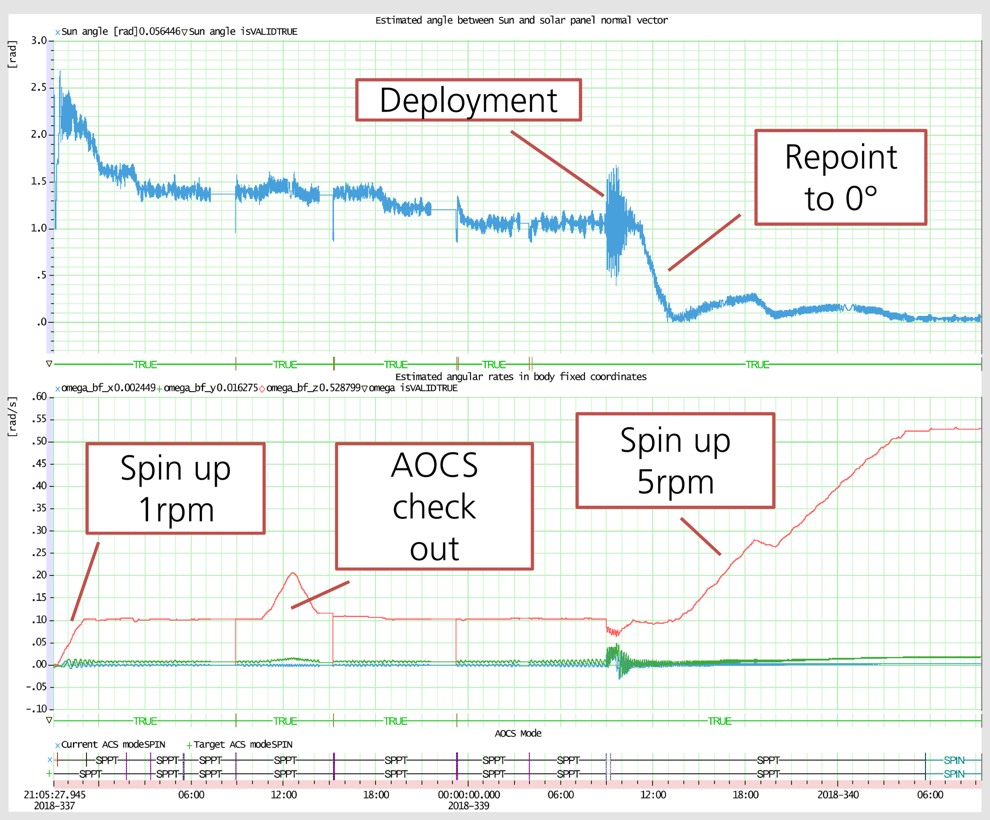

Figure 4: Acquisition phase of Eu:CROPIS showing the sun angle targeting for zero degrees and angular rates targeting for one revolution per minute around the major moment of inertia axis.

After detumbling the spacecraft spun up to 1 rpm and its rotational axis set orthogonally to the sun vector (so-called "Barbecue" attitude). At this attitude several check outs were executed, e.g. moment of inertia adjustments were uploaded.

Solar Panel deployment

In preparation for solar panel deployment the satellite was aligned with its spin axis at a 60° angle to the Sun. During deployment actuators were inactive and the angular rate experienced a drop, as expected. After this the Sun angle was further decreased and the angular rate was recovered.

Transition to nominal Operations

The last task for the ACS was to increase the angular rate to 5 rpm which allowed for nominal operations to start and marked the end of the LEOP.

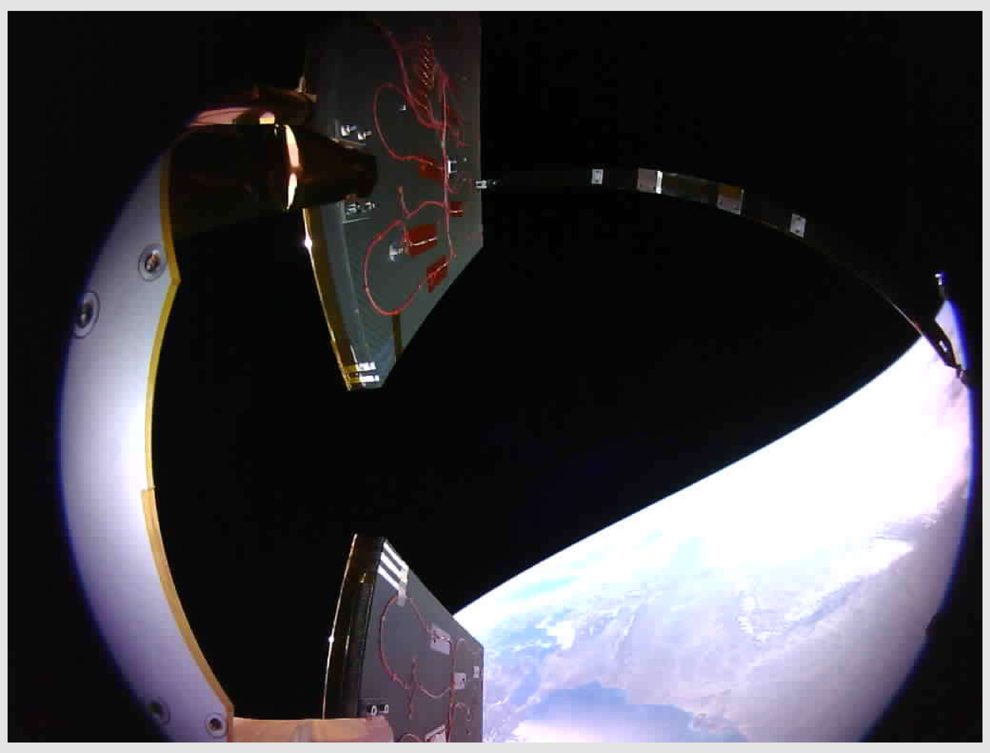

Figure 5: In orbit deployed solar panels of Eu:CROPIS. Photo camera was controlled by payload #4 SCORE.

References

[1] J. Hauslage et. al, „Eu:CROPIS – Euglena gracilis: Combined Regenerative Organic-food Production in Space - A Space Experiment Testing Biological Life Support Systems Under Lunar And Martian Gravity," Microgravity Science and Technology, Bd. 30, pp. 933-942, 9 2018.

[2] S. Richey und L. Rothschild, „Power Cell," 2015. [Online]. Available: https://www.nasa.gov/sites/default/files/atoms/files/powercell_fact_sheet_aug2015_0.pdf.

[3] S. Kottmeier, C. Hobbie, F. Orlowski-Feldhusen, F. Nohka, T. Delovski und G. Morfill, „The Eu:CROPIS Assembly, Integration and Verification Campaigns: Building the first DLR Compact Satellite," in 69th International Astronautical Congress, Bremen, 2018.

[4] J. F. Pedersen, „Power System for the Eu:CROPIS Satellite," in European Space Power Conference, Greece, 2016.

[5] A. Heidecker, T. Kato, O. Maibaum und M. Hölzel, „Attitude Control System of the Eu:CROPIS Mission," in 65th International Astronautical Congress, 2014.

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Eu:CROPIS is a shortcut for Euglena Combined Regenerative Organic Food Production In Space. It is the name of the mission as well as the primary payload onboard the DLR Compact Satellite platform. The primary payload is a biological life support system experiment, which deals with stability and self-sustainability of such systems under different levels of acceleration. http://www.dlr.de/eucropis

The DLR **Compact Satellite** is a small, highly customizable and high performance satellite bus providing a platform for scientific research as well as demonstration for innovative concepts in space technology. It is part of the DLR Compact Satellite Program.

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