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ATTITUDE AND ORBIT CONTROL OF THE GRACE SATELLITES AT EXTREMELY LOW POWER

Abstract

The two Grace satellites were successfully launched on March 17, 2002 by a Russian Rockot. GRACE not only was the first dual-satellite mission operated by GSOC, but it also was the first formation-flying occurring at an altitude below 500 km. The mission was successful from a scientific point of view (over 4100 peer reviewed papers so far) and the originally envisaged mission duration of 5 years had more than tripled by the time the mission ended in October 2017. A follow-on mission was launched by the same partners in May 2018 and JPL projects a new generation of space-based gravity-field measurements in the next decade.

Several components had deteriorated or were defunct towards the end of the mission. Nevertheless, the scientific goals could still be obtained to a level that is unattainable with other missions. The major challenge for prolonged operations was posed by the degradation of the NiH_2 batteries. These were comprised of 20 cells packaged in the common pressure vessel (CPV) configuration. When the mission ended two cells had shorted out on Grace 1 and eight on Grace 2. Also, the charge capacity of the operational cells was severely degraded. The amount of fuel that remained on both satellites was lower than the original specification for the end of mission. This was a consequence of using the satellites ten years longer than originally designed, but was also due to the higher expenditure at low power.

Two complementary paper presented at this conference describe the special effort needed to continue the Grace mission. One concentrates on the handling of the power/thermal system, whereas this paper emphasizes the challenges for attitude and orbit control under conditions of extremely low power

The first Section starts with a general overview of the mission and describes the state of the power system, the fuel budget, and the hardware close to end-of-life. The interdependency of the low power, low fuel situation is discussed in Section 2. The influence on the payload is summarized, as well as those steps taken to maintain and maximize scientific return under the circumstances. The third Section contains a detailed description of all mitigation measures that were implemented specifically for AOCS. The fourth Section contains a summary and a few useful insights for the GRACE Follow-On mission.