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Author: Ms. Greta De Marco
RHEA for European Space Operations Centre (ESA/ESOC), Germany

Mr. Thomas Godard
RHEA for European Space Operations Centre (ESA/ESOC), Germany
Mr. Richard Southworth
European Space Agency (ESA), United Kingdom
Mr. Liviu Toma
TelespazioVega Deutschland, Germany
Mr. Jim Martin
European Space Agency (ESA), Germany
Mr. Stefano De Padova
Serco, Germany
Mr. Dave Salt
Telespazio VEGA Deutschland GmbH c/o ESA-ESOC, Germany, Germany
Mr. Patrick Chapman
Airbus Defence and Space Ltd, United Kingdom

REACTION-WHEEL BASED SAFE MODE FOR INTEGRAL MISSION

Abstract

The International Gamma-Ray Astrophysics Laboratory (INTEGRAL) is a European space observatory mission that can observe objects in gamma/X-ray and visible wavelengths. The spacecraft was launched in 2002 and it is currently in its extended mission phase.
In the past two years, INTEGRAL underwent two major anomalies, which have dramatically changed the way of operating the spacecraft. After the first one, the thrusters were considered unreliable to perform reaction wheels (RW) angular momentum dumping. As alternative solution, the external perturbations due to the solar radiation pressure and the Earth gravity gradient were exploited to keep RW angular momentum under control. However, it was believed that the satellite would be capable of supporting one or two thruster-based safe mode (called ESAM, Emergency Safe Attitude Mode). The second anomaly, so-called ESAM9 (the 9th ESAM since launch), resulted in high spacecraft rates and intermittent loss of Sun illumination on the body-fixed solar arrays. ESAM9 highlighted the need of a thrusterless reaction, relying only RWs, to recover any future loss of attitude control. For this purpose, the INTEGRAL team, together with industry, is currently designing an on-board software patch which will bring an entirely new safe mode (NSM) to life. The strategy, based on ESAM9 recovery and currently already implemented with ground-based automation, consists of first bringing the satellite rates down to zero before re-orienting the spacecraft into a sun-facing attitude assuring that enough power is generated on board from the solar panel and at the same time respecting instruments heating constraints.
The study presented here goes through the basic principle of the original ESAM design, before tackling ESAM9 attitude control loss and recovery. Different contingency scenarios to determine the range of initial angular momentum that can physically be recovered will be analysed in this work. The main failure considered in this frame will be reaction wheel Single Event Upset (SEU) and transferring of momentum from the wheels to the spacecraft. The impact of a non-immediate reaction will be also analysed considering the effect of Solar Radiation Pressure torque. Lastly an analysis of the control algorithm to find a path

to acquire solar arrays Sun-pointing attitude is outlined together with the status of the implementation of this algorithm in the NSM onboard software.