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IN-ORBIT DEMONSTRATION OPERATIONS OF THE HIGH-PERFORMANCE ON-BOARD PROCESSING CAPABILITIES OF C3SATP

Abstract

C3SatP is a versatile computer developed by the Institut d'Estudis Espacials de Catalunya (IEEC) intended for scientific and in-orbit demonstration (IOD) hosted payloads in the context of small satellite missions. The device has been flying as a secondary payload on-board Menut (NORAD ID: 55010) since January 2023. The primary payload of Menut is a multispectral camera. Menut or GENEO-01 is the first Earth Observation Cubesat within the framework of the NewSpace Strategy of Catalonia promoted by the Government of Catalonia, in coordination with IEEC, i2CAT Foundation and ICGC (Institut Cartogràfic i Geològic de Catalunya).

C3SatP subsystem is formed by two boards, one with a ZynqUltrascale+ with 2 GB of RAM acting as an OBDH and one board with a SAMV71Q21 acting as an OBC. The OBC controls and manages power for both subsystems and gathers telemetry of all components. The subsystem as a whole communicates to

the satellite platform using a Ethernet-over-USB with IP as the main protocol for TC/TM and a UART interface as a system log and debug.

In-orbit tests have been performed running some CPU demanding applications: i.e. lossless and lossy data compression, while monitoring all subsystems. The tested algorithms have been FFLX developed by IEEC/UAB (Universitat Autònoma de Barcelona), FAPEC developed by Dapcom Data Services, and CNES lcnl_encoder which is the implementation of CCSDS-123.0-B-2 standard for lossless compression of multispectral/hyperspectral images. The tests consisted of acquiring an image $\sim 350MB$ with the primary payload and then compressing it on-board C3SatP. Every test lasted for about 15 minutes each. Some full-orbit tests were done. As a result, the compression ratios obtained for both FFLX and FAPEC were about 2.5 for lossless compression and about 6 for lossy. For CNES, not only a slightly lower compression ratio of 2.4 was obtained, but also with thrice the execution time $\sim 2min$ which demonstrates the performance improvement of both FFLX and FAPEC with respect to the standard implementation.

The results also indicate that Zynq+ can run in space with no faults and the behavior in-orbit is quite similar to that observed in the laboratory. We estimate that the total ionizing dose (TID) received by the PCB boards until now is approximately 2.2 krad. By the time of the presentation we are confident that about 100 hours of runtime will be achieved and a total TID of 2.3 krad.