

EIRSAT-1: A 2U CubeSat with a Compact, Novel Gamma-ray Detector

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The EIRSAT-1 Project

The Educational Irish Research Satellite (EIRSAT-1) is a 2U CubeSat developed and built by students and staff at University College Dublin. The project began in 2017 when EIRSAT-1 was accepted into the ESA Academy's 'Fly Your Satellite!' programme.

The spacecraft, which measures just 22.7cm long, carries 3 novel payloads:

- GMOD: A miniaturised gamma-ray detector designed to detect Gamma-ray Bursts.
- EMOD: A thermal management materials experiment.
- WBC: 'Wave Based Control', a control algorithm developed at UCD which will be tested by controlling EIRSAT-1's attitude.

The flight model was assembled in June 2022, with extensive functional, environmental (vibration and TVAC), and mission testing being conducted between June and October. Flight Acceptance status was achieved in December 2022.

Spacecraft Components

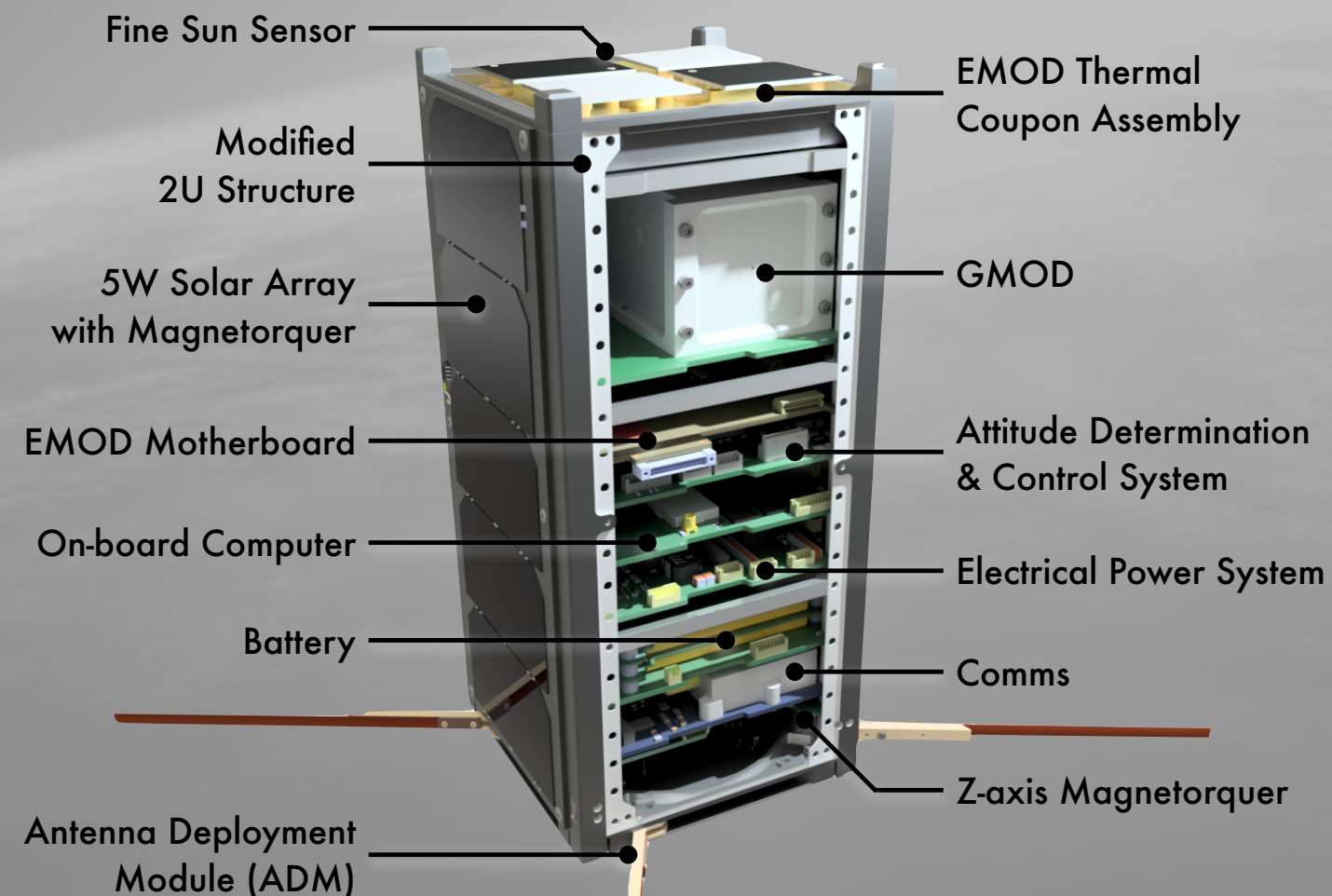


Fig 1: The EIRSAT-1 spacecraft with one side panel removed to show internal layout.

GMOD - The Gamma-ray Module

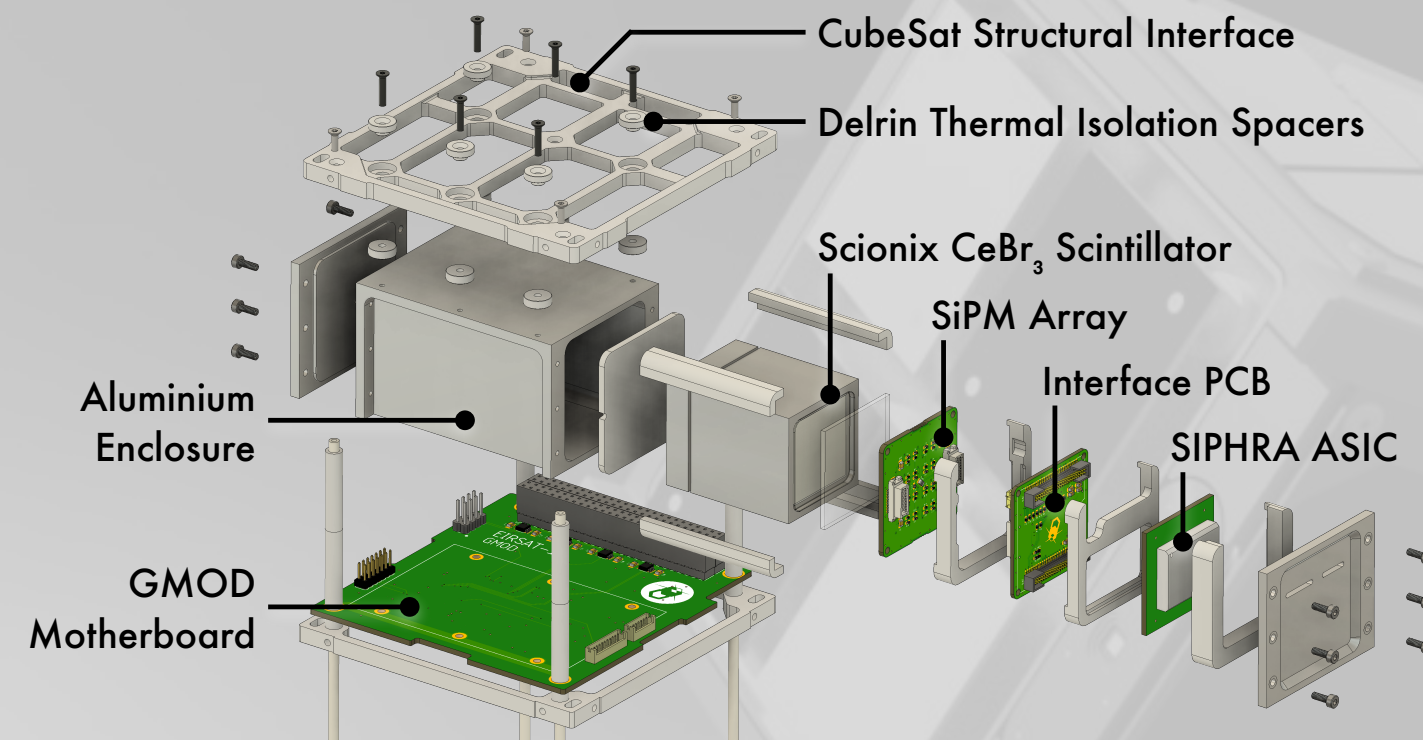


Fig 2: Exploded view of the GMOD payload.

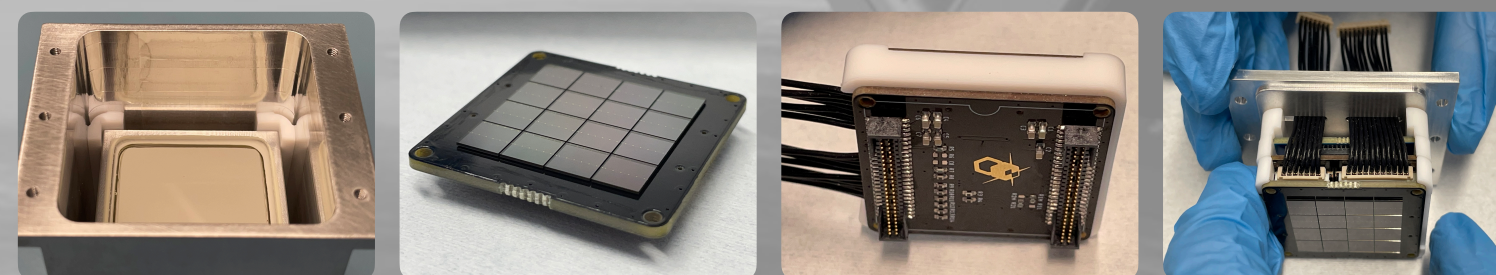


Fig 3: Various GMOD flight model components during integration. (L-R): CeBr₃ scintillator in housing, SiPM array, Interface PCB, detector assembly electronics with spacers and aluminium end-cap.

GMOD is a miniaturised gamma-ray spectrometer payload. It comprises a detector assembly (Figs 2, 3) which is located at one end of the spacecraft (Fig 1). The detector assembly is supported by a motherboard which contains data processing and power supply components and which interfaces to the spacecraft bus.

The detector assembly utilises a 25mm × 25mm × 40mm Cerium Bromide (CeBr₃) scintillator paired to a custom-built 4×4 array of OnSemi J-series silicon photomultipliers (SiPMs). The analog signals from the 16 SiPMs are digitised using an IDE3380 'SIPHRA' ASIC from IDEAS.

GMOD is based on designs for a Compton telescope calorimeter module developed at UCD for a larger gamma-ray observatory. The knowledge gained from developing, manufacturing, and qualifying GMOD is now being used in the COMCUBE project which will implement a Compton telescope in a CubeSat format.

GMOD Architecture

With limited power available on a small CubeSat, an important design constraint for GMOD was to maintain a low power consumption. The final GMOD payload design consumes just 400mW during operation.

The SIPHRA ASIC is key to this low power usage, but also presents a challenge to interface and readout. Programmable logic was required to process the unusual format of the serial stream of digitised data.

Rather than using a power-hungry FPGA or system-on-chip, GMOD utilises a Xilinx Coolrunner XC2C256 CPLD which converts the data-stream to a standard serial format allowing the data to be processed by a low-power Texas Instruments MSP430FR5994 microcontroller which has the benefit of using radiation immune ferroelectric RAM.

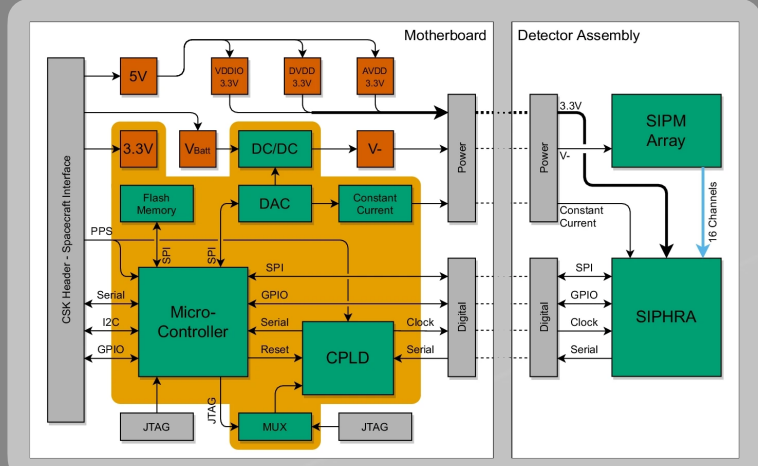


Fig 4: Block diagram of the GMOD payload. [Murphy et al. 2022]

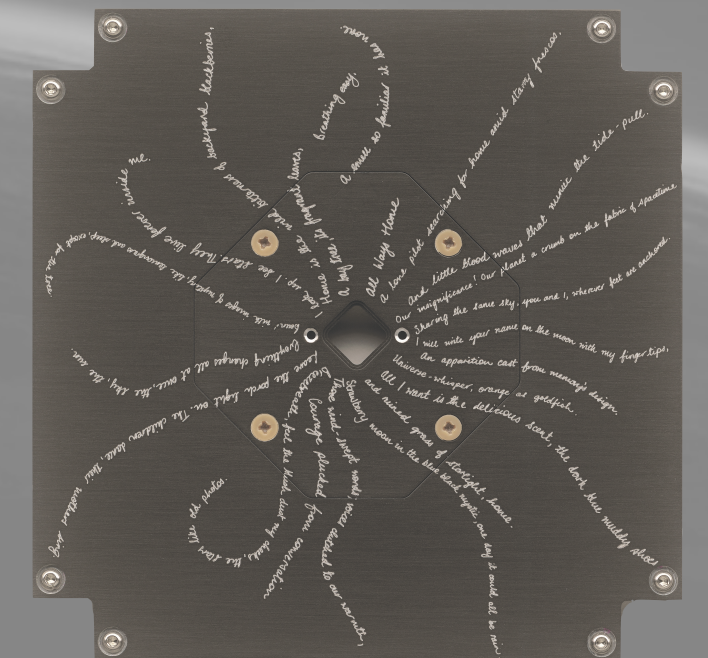
Space Poetry

EIRSAT-1 carries a poem, 'All Ways Home', inscribed on the cover of the ADM.

The poem was written by 12 school pupils from all over Ireland that took part in online creative writing workshops during the Covid-19 lockdown.

The project brought writers, students, teachers, librarians, engineers, scientists and artists together in a collaborative, creative way.

<https://eirsat1.ie/space-poetry>



Acknowledgments

The EIRSAT-1 project is carried out with the support of ESA's Education Office under the Fly Your Satellite! 2 programme. This study was supported by The European Space Agency's Science Programme under contract 4000104771/11/NL/CBi. DM acknowledges support from SFI under grant 19/FFP/6777. We acknowledge all students who have contributed to EIRSAT-1.