EIRSAT-1, a 2U CubeSat Mission including the Gamma-ray Module (GMOD)

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DUBLIN

fly your satellite!

Monitoring the High-Energy Sky with Small Satellites September 6-8 2022, Brno, Czech Republic



IRISH RESEARCH COUNCIL An Chomhairle um Thaighde in Éirinn



EIRSAT-1

2U CubeSat ESA Fly Your Satellite!

COTS Fundamental systems e.g. OBC, Comms, ADCS procured from AAC Clyde Space

Payloads

GMOD - GRB detection EMOD - Thermal surface treatment WBC - Novel attitude control algorithm

Prototype Model Philosophy

Engineering Qualification Model Qualify the design for flight **Flight Mode** Acceptance level testing, launch and operations



The Gamma-ray MODule

Detector Assembly

Tiled array of 16 J-Series OnSemiconductor SiPMs is coupled to the CeBr₃ crystal

SiPMs are readout and digitised by SIPHRA, an ASIC produced by IDEAS

GMOD Motherabord

Hosts electronics to power and operate GMOD Detector Assembly (SiPMS and SIPHRA)

Processing of SIPHRA data using CPLD (Complex Programmable Logic Device) to be read by the Texas Instruments MSP430FR5994 micro-controller

MSP converts data into time tagged events which are sent to the On-Board Computer (OBC)

Publications Murphy et al., Exp. Astron., 2021 Murphy et al., Exp. Astron., 2022



Flight Performance Simulations

- Simulations performed using MEGAlib
- Simulated effective area as a function of direction (50keV 300keV energy range)
- GRB detection rates of 15-18 GRBs/yr @ 10σ (Murphy et al., 2021)



GMOD Environmental Requalification

Post EQM Vibration Functional Test

GMOD Anomaly

- Test script running GMOD functional test terminated early
- High trigger rate from SIPHRAASIC overwhelming microcontroller
- Issue isolated to bias PSU on the EQM motherboard
- Microscope inspection revealed a crack between the solder fillet and capacitor termination on a terminal of one capacitor.

Solutions Implemented

GMOD Top Reinforcement Bracket (GTRB) added to structure - GMOD detector assembly mounted to S/C structure, NOT the GMOD PCB.
Replace the large multilayer ceramic capacitors with metal-framed capacitors which are more robust against damage under PCB flexure.

Requalification Test Campaign

Passed - New design qualified for spaceflight!





FlatSat

Flat lay, flight-like, configuration of satellite to access individual subsystems.

Reilly et al., 2022



Full Functional Test

After assembly and after environmental testing

Flashing new firmware to MSP and CPLD, configuration checks, production of light curves and spectra and burst triggering.

Walsh et al., 2021



Environmental Test

ESA CubeSat Support Facility

1. Vibration

2. Thermal Vacuum Cycling

Dunwoody et al., Aerospace, 2022



Mission Test

4 weeks, simulating nominal and off-nominal mission scenarios

GMOD Commissioning and Experiment Running

Doyle et al., Aerospace, 2022



Characterisation

Single axis turntable and python scripts control rotation and record data over long durations

Reference sources spectra

- 12-hour integrations at 22.5 cm from centre of scintillator
- Mixed source spectrum recorded with same set up

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Angular Measurements

- 6 hour integrations at 22.5 cm
- Taken at each face of S/C

Future Work

- Finer angular resolution measurements
- Payload only In S/C (EQM? No time with FM)

Angular measurement source set up



Operations and Launch

Challenges

- Unpredictable nature of GRBs
- Communication windows are short and only a total of ~30 mins/day to check health of S/C and downlink data
- GMOD generate more data than feasible to downlink

Operational Strategy

- GRB Triggering: OBC trigger on significant signals and store data around events in protected storage channels
- Beacons: Trigger information, low resolution lightcurve and spectrum



2022 and beyond ...

Flight Model (FM) was built in June 2022

Testing on-going:

- July 2022: Environmental test
- Aug/Sept 2022: Full functional test
- Sept/Nov 2022: FM mission test

GMOD Characterisation

- Payload on turntable
- Finer angular resolution 15°/20° increments

Launch and Operations

- Early 2023
- Student-led operations

