Terrestrial RaYs Analysis and Detection (TRYAD) Cubesat Mission

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TRYAD Science Overview

Primary Science Goal:
*Multi-point Observations of Terrestrial Gamma-ray Flashes (TGFs) to test TGF Beam Models*

- What are TGFs?
- History of detecting TGFs
- What is unique about the TRYAD mission?

Short History of TGF Detection
1994 – Burst and Transient Source Experiment (BATSE) on Compton Gamma-Ray Observatory
2005 – RHESSI satellite detected higher energy TGFs
2009 – Gamma-Ray Burst Monitor on Fermi Gamma-Ray Space Telescope first detects TGFs and positrons
Present – thousands of TGFs are detected routinely

- up to 10’s MeV Gamma Rays
- μs to ms timescale pulses
- Production models unverified
TRYAD uses two 6U CubeSats to make coincident measurements of TGFs and correlates to ground-based lightning detection data.
Lightning Density

http://wwlln.net/new/map/lightning_map.html
TGFs observed by Gamma Burst Monitor on Fermi

Typical TRYAD CubeSat Orbit

Orbit Inclination: 50°
Attitude: 500 km
Orbit velocity: 7.6 km/s
Orbit Period: 94.5 mins

http://wwlln.net/new/map/lightning_map.html
**Command and Data Handling System (C&DHS)**
- Embedded Linux
- Beagelbone w/PRUs

**Attitude Determination and Control System (ADACS)**
- Magnetometers, rate gyros, sun angle sensors, orbit propagator
- Novatel GPS
- 3-axis Magnetorquers
- 3-axis Reaction wheels

**Electrical Power System (EPS)**
- 60 solar cells (29% eff.)
- MPPTs
- 10 Li-ion batteries
- Sensing/ Fault detect

**Communications**
- Globalstar
- Duplex - 256 kbps over 45% of orbit
- Simplex - beacons over 90% of orbit

**Mechanical Systems**
- Monolithic Al structure panels
- Driven deployable solar panels
- Passive thermal design

**Station Keeping**
- Deployable “Dart” configuration for passive orientation augmentation
- Station keeping and satellite separation control via aerodynamic differential drag

**Science Payload**
- Plastic Scintillation gamma-ray detector w/ next generation Si photomultipliers (SiPMs)
- >1 M sample/sec event time tagging to 1 µs accuracy in real time (slaved to GPS clock)
- ROI’s commanded based on weather and lightning data
**Science Payload**

- **203 x 184 x 71mm**

- **5x6 6-mm SiPM array**
- - Hamamatsu Si Photomultiplier (SiPM) Array
- - Eight arrays per CubeSat (240 SiPMs)

- **Prototype Scintillator**
- - 5% Lead-doped Plastic
  - (40 x 51 x 166mm)
- - Four per CubeSat

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**Science Interface Board**

- Pulse height analysis
- Gain control

**Beaglebone**

- **PRU**
  - Event time tag
  - (>1 Msp) (≥1 Msp)
- **x2**

**GPS**

- DAQ start and stop
- Absolute timestamps
- Start/stop positions

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**Timing Accuracy Goals:**
- 2 µs relative event time tag
- 20 µs between CubeSats
- 200 µs w.r.t. ground-based VLF detection
**Communications**

**Globalstar Duplex Coverage**

- **Duplex Radio**
  - 256 kbps, full duplex
  - 40-50% orbital coverage
  - Science Data / Telemetry
  - Command & Control
  - Requires +/- 30° zenith antenna pointing

- **Simplex Radio**
  - Beacon for post-launch phase
  - 80-90% orbital coverage
  - Abridged telemetry
  - Broadcast mode (quasi-roll resistant)

*Radios provided by sci_Zone, Inc*
Attitude Determination and Control System (ADACS)

Reaction Unit:
- Magnetorquer
  - 180 x 60 x 5 mm
  - $\mu = 0.91 \text{ Am}^2$
- Reaction Wheel
  - 45mm brushless DC
  - 8,000 rpm

Hamamatsu PSD

Sun Angle Sensor

InvenSense ITG-3050

Rate gyro

Magnetometer

Reaction Unit: Magnetorquer + Reaction Wheel
Station Keeping via Differential Drag

Min Drag

Max Drag
Thank You!

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