Terrestrial RaYs Analysis and Detection (TRYAD) Cubesat Mission

JM Wersinger, Auburn Univ.
Mike Fogle, Auburn Univ.
Michael Briggs, Univ. of Alabama - Huntsville
Pete Jenke, Univ. of Alabama - Huntsville
Georgia De Nolfo, NASA Goddard Space Flight Center
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 Science Overview

TRYAD uses two 6U CubeSats to make coincident measurements of TGFs and correlates to ground-based lightning detection data.
Lightning Density

WWLLN Real Time Lightning Locations

http://wwlln.net/new/map/lightning_map.html
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/ programmable realtime units

Attitude Determination and Control System (ADACS)
- Magnetometers, rate gyros, sun angle sensors, orbit propagator
- Novatel GPS
- Magnetorquers & reaction wheels

Electrical Power System (EPS)
- 60 solar cells (29% eff.)
- Max power point trackers
- 10 Li-ion batteries

Communications
- Globalstar bent pipe COMM
- Full Duplex Command & Control @ 256 kb/s over 45% of orbit
- Simplex telemetry 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 2 µs accuracy in real time (slaved to GPS clock)
- ROI’s commanded based on weather and lightning data
Science Payload

- Hamamatsu Si Photomultiplier (SiPM) Array
- Eight arrays per CubeSat (240 SiPMs)
- 5% Lead-doped Plastic (40 x 51 x 166mm)
- Four per CubeSat

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

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

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

**Duplex Radio**

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

Reaction Unit:
- Magnetorquer
  - Size: 180 x 60 x 5 mm
  - Magnetic moment: $\mu = 0.91 \text{ Am}^2$

- Reaction Wheel
  - Size: 45 mm brushless DC
  - Speed: 8,000 rpm

GPS

Sun Angle Sensor

Hamamatsu PSD

Magnetometer

Rate gyro

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

Min Drag

Max Drag
Thank You!

Funded by

Division of Atmospheric and Geospace Sciences (AGS)