Presented by Dr. T. Gregory Guzik, La Space Grant Director
Louisiana State University, USIP PI
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NASA Supported Undergraduate Student Instrument Project (USIP):
Terrestrial Gamma Flash Research

Prepared by Victor Fernandez-Kim, COTEL Team Lead
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Undergraduate Student Instrumentation Project (USIP)

- Joint solicitation from NASA Science Mission Directorate (SMD) and Office of Education (OE)
- Undergraduate students must research, design, develop, and construct a scientific flight payload

**Timeline from Solicitation through PIC**

- August 27, 2015: Announcement of participation
- **September 28, 2015: Topic selection, preliminary research, and feasibility report**
- October 15, 2015: Notice of Intent submitted
- November 20, 2015: Proposal submitted
- April 6, 2016: Received Accepted Notification Letter
- June 16, 2016: Received funding from NASA Shared Services Center (NSSC)
- September 15, 2016: Project Initiation Conference (PIC)
USIP Project Proposal: COTEL

“Correlation Of Terrestrial gamma flashes, Electric fields, and Lightning Strikes (COTEL) in thunderstorms using networked balloon payloads developed by university and college students”

**COTEL Mission Objectives:**

- Detect, record, and timestamp terrestrial gamma flashes (TGFs), electric fields, lightning strikes
- Utilize a network of hand-launched balloon-borne payloads across a thunderstorm
- Correlate the data recorded with ground arrays and lightning detection networks
Current Project Team

**Project Administration**

**Principal Investigator:**
T. Gregory Guzik

**Faculty/Staff Advisors:**
Michael L. Cherry
Brad Ellison
Colleen H. Fava
Douglas Granger
Michael Stewart

**Student Participation**

**Senior Design Students:**
Victor Fernandez-Kim (ME)
Joshua Collins (EE)
Christopher LaForge (ECE)
Elaine Turk (ME)

**LSU Ballooning Students:**
Adam Majoria (PHYS)
Brad Landry (PHYS)
Jordan Causey (ME)
Allen Davis (ME)
Chris Schayer (CS)
Robert Cottingham (PHYS)
Science Background: Terrestrial Gamma Flashes (TGF)

• Anomalous, rapid bursts of energetic gamma radiation (up to ~100 MeV)
• First detected by Burst and Transient Source Experiment (BATSE) on Compton Observatory (CGRO) 1991-2000
• Appears to be associated with terrestrial lightning and thunderstorm activity
TGF and Energetic Thunderstorm Rooftop Array (TETRA I)

- Array of NaI scintillators on rooftops on LSU campus
- Used to detect TGFs and surrounding lightning strikes from near ground level
- Led by Dr. Michael L. Cherry, LSU

Scintillator and Photomultiplier Tube Assembly Used in TETRA I
Details of TGF production still needs to be understood

- Thunderstorm has an intense electric field
- An initial cosmic ray can start a particle shower or Relativistic Runaway Electron Avalanche (RREA)
- The RREA, driven by the electric field, leads to lightning flashes
- The high energy electrons interact with atmospheric nuclei to produce gamma
- How intense is the electric field in thunderstorms? Is the intensity consistent with the TGF production theory?
Most TGF observations have only been made from orbiting satellites or ground arrays

- Understudied region approximately \textit{50,000 ft above the surface}
- Necessity to launch detection equipment into or nearby a thunderstorm
- Important to determine the position and orientation of TGF events, lightning strikes, and electric fields
  - Requires multiple payloads to triangulate and correlate detected events
COTEL Weather-Related Mission Challenges

1. Launching into high-speed, turbulent wind conditions
2. Increased risk of lost payload hardware and onboard data
3. Communication interference due to radio wave emissions from nearby lightning strikes
### Flight Systems Team Objectives:
- Develops the launch system responsible for balloon inflation and payload deployment
- Develops a base payload that interfaces with the launch system, balloon vehicle, detector modules
- Responsible for positioning the payload(s) into a target location within a thunderstorm
- Focus of the 2016-2017 LSU Capstone Senior Design Students

### Payload Development Team:
- Develops the ground station that complements the airborne payload
- Develops the payload detector modules for electric fields, lightning strikes, and TGFs
- Responsible for measuring and retrieving data from the payload(s)
USIP is over two years

**COTEL Year 1 Goal**: Develop and test a flight platform that deploys and supports multiple balloon-borne payloads specialized for testing in thunderstorm environments.

**COTEL Year 2 Goal**: Finalize and integrate detector modules into the flight system, perform full system tests, and reproduce the systems to create a network of balloon-borne payloads.
September-October 2016: Develop project objective statements, qualitative constraints, engineering specifications, functional decompositions, testing and safety plan; perform test launches

- 9/20/16: Objective Statement and Engineering Specifications Report Outline
- 10/3/16: Engineering Specifications Report
  - Functional requirements
  - Qualitative constraints
  - Measurable engineering specifications
  - Preliminary schedule/timeline
- 10/24/16: Embodiment Proposal Outline (Pre-PDR)
November 2016: Finalizing design concepts, high-level system design, engineering analysis, budget, and timeline

- 11/04/16: USIP Requirements Review
  - functional decomposition
  - concept generation
  - evaluation and selection
  - system description
  - engineering analysis and materials selection
  - project management
- 11/21/16: Final Prototype Proposal Outline (Pre-CDR)
- 11/25/16: Project Poster Due
COTEL Project Timeline (3/4)

**December 2016**: Design review and transition into project embodiment
- 12/7/16: Final Prototype Proposal Report (CDR)
- 12/12/16: Place orders on parts, materials, equipment, components and take inventory
- December 2016: USIP Preliminary Design Review

**January – May 2017**: Project system construction, testing and troubleshooting
- January 2017: Assembly of base payload and ground station; begin payload and ground station integration and testing
- February 2017: Assembly of launch system and preliminary testing of detector hardware
- February 2017: USIP Critical Design Review
- March 2017: Launch system and payload integration; begin test launches
- April – May 2017: Payload testing, calibration, continue practice launches, solidify mission launch procedures
June 2017 – May 2018: Finalizing detector module design, integration of systems, system testing, more practice launches

- September 2017: Finalized detector modules and integration with base payload
- September – October 2017: Testing and calibration of single payload; begin construction of duplicate systems; practice launches
- November 2017 – February 2018: Multi-payload launch operations testing and troubleshooting
- February – March 2018: Reserved for delays
- March 2018: USIP Mission Readiness Review
- April 2018: Target Launch Campaign
Conclusions

• A multi-disciplinary, undergraduate, student team from LSU successfully composed a proposal and was awarded funding by NASA to conduct Terrestrial Gamma Flash research at altitude using a network of balloon-borne payloads

• Over the course of 18 months, the student team will develop a system to measure electric field intensity, detect and locate lightning strikes, and measure nearby gamma radiation from within a thunderstorm

• It is expected that analyzing the collected data will provide new information to verify or reject current theories around TGFs to ultimately better our understanding of the mechanisms driving TGF production
References


