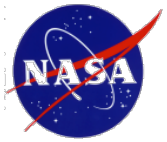
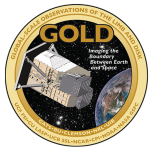
Astrophysics Explorer PI Masters Forum #6

Susan Batiste



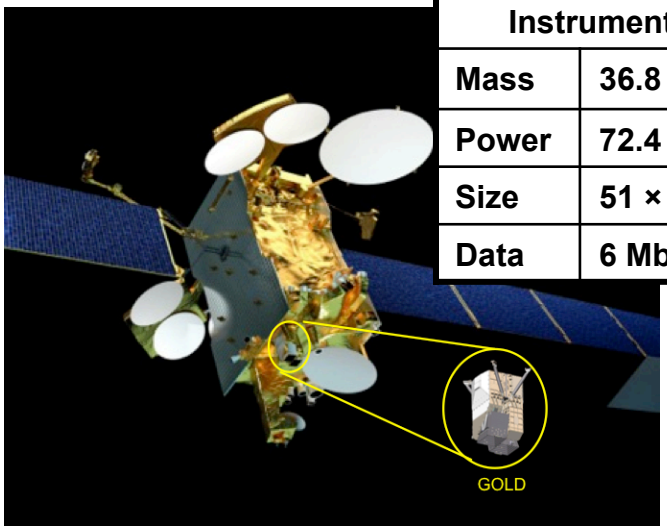


Outline

GOLD

- **Project Summary**
  - GOLD Science Goals
  - GOLD Mission Concept
  - Instrument Overview
- **Lessons Learned**
  - Set science requirements early
  - EM instrument helpful
  - Early processor development board
  - Working with foreign partners
  - Missions of Opportunity

Global-scale Observations of the Limb and Disk



Instrument Summary	
Mass	36.8 kg (CBE)
Power	72.4 W (CBE, avg)
Size	51 × 55 × 69 cm^3
Data	6 Mbps

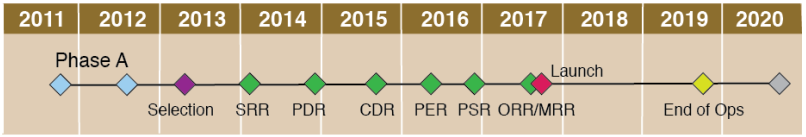
Explorer Mission of Opportunity

Contract Value: $63.5M

- Class C, Category 3 per NPR 7120.5E

Target Launch: Q4 2017

- Hosted on SES-14 geostationary commercial satellite



Florida Space Institute (FSI) University of Central Florida

PI: Richard Eastes

Laboratory for Atmospheric and Space Physics (LASP)

University of Colorado

Deputy PI: William McClintock

Project Manager: Rory Barrett

Observations:

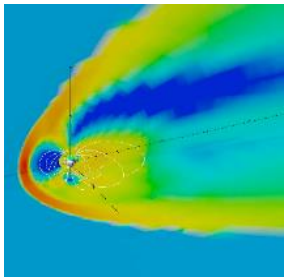
- Disk maps of neutral temperature
- Disk maps of O/N_2 density ratio
- Limb scans (for temperature)
- Disk maps of peak electron density
- Stellar occultations

Imaging Spectrograph:

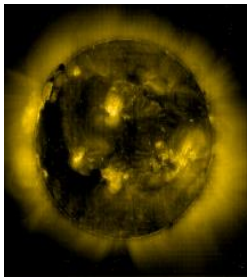
- Two independent, identical channels
- Wavelength range: 132 – 160 nm
- Detectors: Microchannel plate, 2-D crossed delay line anode

Weather in the Thermosphere-Ionosphere

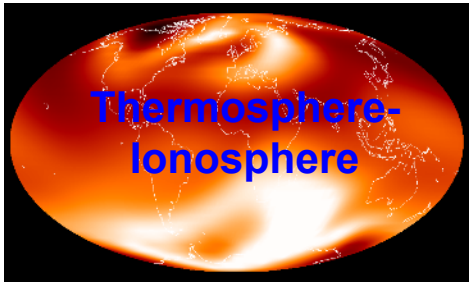
Forcing from Above



Science Question 1 (Q1). How do geomagnetic storms alter the temperature and composition structure of the thermosphere?

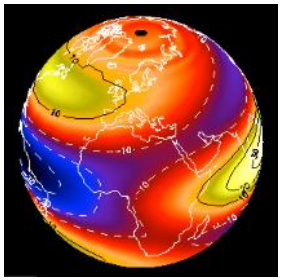


Q2. What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability?



Q4. How does the nighttime equatorial ionosphere influence the formation and evolution of equatorial plasma density irregularities?

Q3. How significant are the effects of atmospheric waves and tides propagating from below on thermospheric temperature structure?



Forcing from Below

GOLD Mission Concept

Mission of Opportunity: Partner with SES to accommodate an instrument in Geostationary orbit on a commercial communications satellite

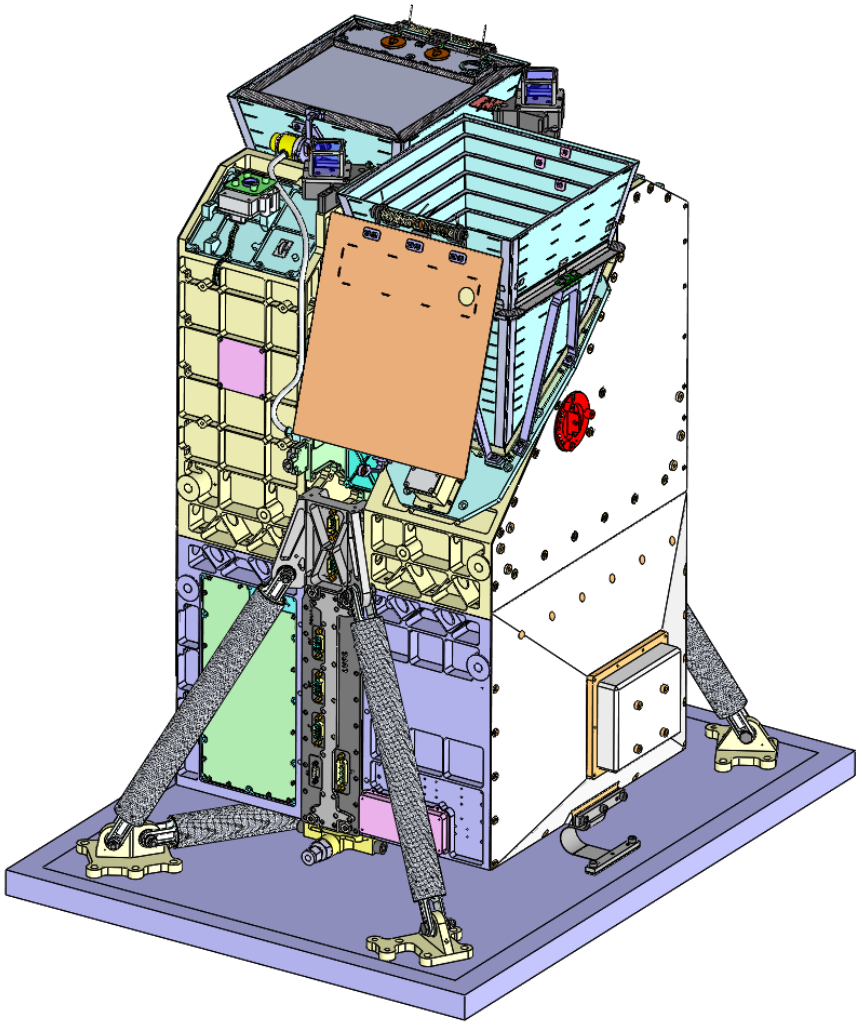
- Owner - Operator: SES (Luxembourg)
- Spacecraft: Airbus DS (France)
- GOLD Data Handling: SES-GS (USA)
- Instrument & SOC: LASP (USA)
- SDC: UCF (USA)

Accommodation: SES included GOLD on RFP for SES-14 mission

- SES saw this as a good mission to accommodate GOLD

Science Payload: Single instrument

- Single package for easy accommodation
- Two identical imaging spectrograph channels
  - Operate independently
- Electronics sandwiched between channels

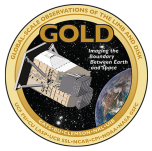


Freeze Science Requirements Early

Lesson: Concentrate efforts early to freeze science requirements and prevent scope creep

- Measurement requirements were set early and remained steady
  - Traced science to instrument requirements
  - Instrument design concept did not change from proposal
- Allowed engineers to move forward with correct design from start of project
  - Hands-on systems engineering presence provides link between engineering and science and keeps engineers focused on meeting requirements

Engineering team has not had to make any design modifications because of changes to the science requirements or goals



Fabricate an Engineering Model

- **Lesson: Build an engineering model to make for a smoother flight build**
  - Allows one to identify problems well ahead of environmental test
  - What has worked well
    - Optical channel
      - Kept simple enough structurally to produce early with optical layout
      - Allows calibration team to dry run alignment and calibration processes
      - Validated science measurement performance early
    - Electronics
      - Can test flight boards with EM boards to even out schedule mismatches
    - Flight Software and Operations
      - Allows development of software on real hardware
      - Can test procedures on EM electronics prior to flight model
  - What could work better
    - GOLD has 2 identical optical channels but only 1 EM optical channel
      - Prevents good testing of electronics running 2 channels simultaneously
      - Based on resources, would not change the current path, but it has drawbacks

Can't have too much high-fidelity EM hardware

Processor Development Board

Lesson: Development boards provide a boost for FPGA and FSW early development

- Prior to an engineering model GOLD built 2 development boards: reprogrammable FPGA with embedded processor
  - Inexpensive
  - FSW always has access to a board
  - Allows early and continuous incremental development and test *for both FPGA and FSW*
    - FSW design up and running quickly
  - Scheduled releases can be aligned with arrival of EM & FM hardware *for both FPGA and FSW*

Managing Workload

Lesson: Single-instrument Mission of Opportunity significantly more effort than a single instrument on a SC

- Required more systems engineering effort than a single instrument
  - ICD development from the ground up
  - Required more negotiations with SC
- Increased documentation required
  - Receives more scrutiny
  - SC and NASA required documentation not complete overlap
  - Tailored ERD to work with both NASA and commercial expectations
- Increased reporting

Resource Management

Lesson: Staff up early

- Allows the engineering model to be made early
- Provides consistency in design and fabrication

Lesson: Establish realistic resource requirements early

- Ran into mass allocation uncertainty issues prior to PDR

Lesson: Mass goes up early in designs

- When you staff up early, mass goes up early
- Strict adherence to GOLD rules (GSFC-STD-1000) did not recognize true maturity of instrument at life cycle reviews

Optimize working with Foreign Partners

- **Lessons**
  - Start ITAR/EAR processing early
  - Language and time differences are challenging
  - Face-to-face meetings with partners are essential
  - Time and expense of travel is worthwhile
  - With limited time, meetings are intense
- What has worked
  - Central message-board archives all communication
    - Works well for the multiple organizations
  - Small topics and action items can be covered via phone
  - Stepping through documents best in person provides a good framework for prompting discussions
    - Written material effective with foreign English speakers
  - As technical lead and leading meetings, starting well-rested critical
- What could work better
  - Select message-board tool that works well for all parties
  - Material availability and selection in Europe vs US differs (EEE parts, polymerics, connectors, specialty items, metric vs imperial)

Mission of Opportunity

- **Lesson: Partner with host early results in collaboration for mission architecture**
  - GOLD proposed with commercial communications SC owner-operator (SES)
    - Have an established relationship as partners
  - SES looked over their projects to help find a good fit
  - Provide advice on expected accommodation details
    - SC resource availabilities (mass, power, data)
    - Interface details (communications, power, mechanical, thermal)
- **Lesson: Expect to be surprised**
  - Commercial hosts operate differently than NASA
    - Product is quality and high reliability, but may use different methods
    - Flow optimized for a standard bus that is modified for communications payload, not built from ground up for a specific mission
  - Be prepared to comply with commercial provider and NASA practices