Aeronomy of Ice in the Mesosphere (AIM)

Science Objective:
- Quantify the connection between Polar Mesospheric Clouds (PMCs) and the meteorology of the polar mesosphere
- Study the long-term change in the mesosphere and its relationship to global change

Science Data
- 1.3 Gbits/day science

SMall EXplorers (SMEX)

Cost: $140M including launch vehicle
- Class C

Mission: 2 year nominal, still flying

Launch: April 2007

Orbit: 600 km polar orbit
- Noon/noon sun synchronous

Observatory Summary

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<tr>
<th>Mass</th>
<th>195 kg</th>
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<td>Power</td>
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<td>Attitude</td>
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Hampton University

*PI*: James Russell III

University of Alaska

*Co-I*: Scott Bailey

Laboratory for Atmospheric and Space Physics (LASP), University of Colorado

*Project Manager*: Michael McGrath

(image credit: OSC)
AIM Mission Concept

SMEX: PI-led free-flyer mission
• PI: James Russell III, Hampton University

• Project Management: LASP, University of Colorado Boulder

Accommodation:
• Spacecraft, LEOStar-2: Orbital Sciences Corporation (now Northrup Grumman)
• Launch: Pegasus-XL

Science Payload: 3 instruments
- Solar Occultation For Ice Experiment (SOFIE): SDL, Utah State University
- Cloud Imaging and Particle Size (CIPS): LASP
- Cosmic Dust Experiment (CDE): LASP
Global-scale Observations of the Limb and Disk

Explorer Mission of Opportunity (MOO)

**Contract Value:** $63.5M
- Class C, Category 3 per NPR 7120.5E

**Mission:** 2 years ongoing
- Hosted on SES-14 GEO commercial satellite

**Launch:** January 2018
- Hosted on SES-14 GEO commercial satellite

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**Instrument Summary**

- **Mass:** 37 kg
- **Power:** 72 W
- **Size:** $51 \times 55 \times 69 \text{ cm}^3$
- **Data:** 6 Mbps continuous

Study the temperature and composition structure of the thermosphere

**Observations:**
- Disk maps of temperature, O/N$_2$ ratio
- Limb scans (for temperature)
- Disk maps of peak electron density
- Stellar occultations

**UV Imaging Spectrograph:**
- Two independent, identical channels with MCP, delay line anode

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**Florida Space Institute (FSI) University of Central Florida (UCF)**
- **PI:** Richard Eastes (now at LASP)

**Laboratory for Atmospheric and Space Physics (LASP)**

**University of Colorado Boulder**
- **Deputy PI:** William McClintock
- **Project Manager:** Rory Barrett
**GOLD Mission Concept**

**Mission of Opportunity:** PI-led mission, collaborating 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: LASP (USA)
- Science Operations Center: LASP (USA)
- Science Data Center: UCF (USA)
- Launch: Ariane-5 (ESA, French Guiana)

**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
LESSONS LEARNED
Lesson: Operations personnel are valuable contributors in development and test

• AIM: Future instrument operators were actively involved by CPT-design stage (prior to PER), participated in I&T
  - Model repeated on GOLD, working even earlier, with SES for planning
• Why it worked
  - Engineers learned from operators how to design with operations in mind
  - Operators were be better prepared when given opportunity to work side-by-side with design engineers
Lesson: An engineering model can make for a smoother flight build and help identify problems ahead of environmental test

• GOLD built a single optical channel, simple structurally but with optical layout
• EM electronics also built
• Why it worked
  - Used it to dry run alignment and calibration processes
  - Validated science measurement performance early
  - Tested flight boards with EM boards to even out schedule mismatches
  - Flight software was developed on real hardware
  - Operations tested procedures on EM electronics prior to flight model
• What could have been improved
  - Two-channel would have been nice for electronics testing
Early Science Requirements Freeze

Lesson: Concentrating efforts early to freeze science requirements prevents scope creep

• GOLD measurement requirements were set early and remained steady
  - PI & Deputy PI led the effort to gain consensus with science team on what the science requirements were
  - Traced science to instrument requirements
  - Much of this effort took place during the Concept Study

• Why it worked
  - Instrument design concept did not change from proposal
  - Allowed engineers to move forward with correct design from start of project
  - PI continued effort to maintain consensus on science requirements
Managing MOO Workload

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

• MOO and Host Mission needs both need to be satisfied
  - Receives more scrutiny
    • From NASA management & Host management
  - Increased documentation required
    • NASA & Host required documentation not complete overlap
    • Tailored ERD to work with both NASA and commercial expectations
  - Increased reporting

• Required more systems engineering effort than a single instrument
  - ICD development from the ground up
  - More negotiations with SC

• Why it worked
  - All parties wanted to make the hosted payload model work
  - SES, Airbus were interested in GOLD science
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
  - Allowed early and continuous incremental development and test for both FPGA and FSW

• Why it worked
  - The hardware is inexpensive
  - FSW always had access to a board so the FSW design was up and running quickly
  - Scheduled releases were aligned with arrival of EM & FM hardware for both FPGA and FSW

• Word of caution
  - Simultaneous development needs to be managed carefully so changes in FSW or FPGA does not required changes in the other
Lesson: Having an on-site project and/or instrument(s) representative(s) streamlines process

- LASP Mission SEs were on-site at Orbital during AIM I&T
  - Instrument engineers and SEs joined MSE team following delivery
- GOLD Mission SE was on-site at Airbus during SES-14 I&T

Why it worked

- Face-to-face interaction invaluable
- Management and instrument teams remained more informed of plans and potential issues
- Decisions could be made more quickly
  - Not all questions were answerable or decisions able to be made by representative, but they could provide some guidance
- Small activities can be fit in when opportunities arise if the task matches the representative’s skill set