FAR ULTRAVIOLET SPECTROSCOPIC EXPLORER SPACECRAFT DEVELOPMENT

FUSE Program Description

- NASA Mid Explorer Satellite Program Headed by Principal Investigator, Dr. Warren Moos and Project Manager, Dennis McCarthy of Johns Hopkins University

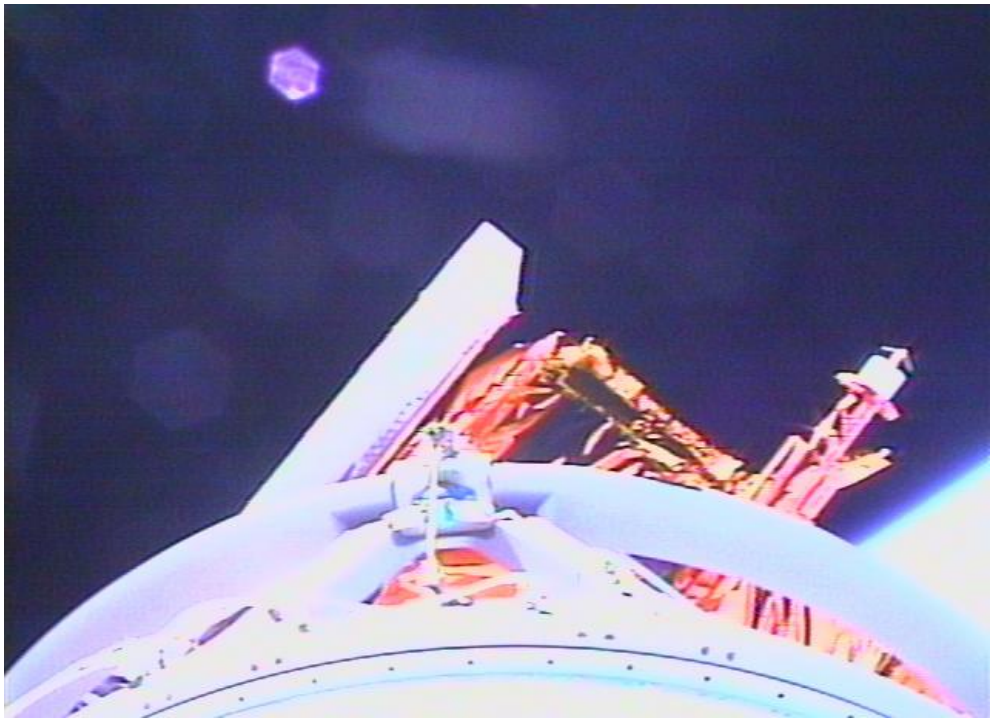
- Objective was Production of High Resolution Spectra of Faint Objects in the Far Ultraviolet (900 - 1200 Angstroms)
  - Launched from Cape Canaveral on a Delta 7320-10 on June 24,1999
  - 760 km, 25° Inclination Orbit
  - 3 Year Mission Design Life

- Satellite Program Partitioned
  - Instrument Developed by Johns Hopkins University
  - Spacecraft Bus Developed by Orbital Sciences Corporation Under Contract to Johns Hopkins University / Applied Physics Laboratory

FUSE Satellite at Cape Canaveral - Building AE

FUSE Satellite on Delta 7320-10

FUSE on Delta Launch Vehicle



Television Camera View From Delta 2nd Stage Showing FUSE After Fairing Separation

Major FUSE Satellite Issues

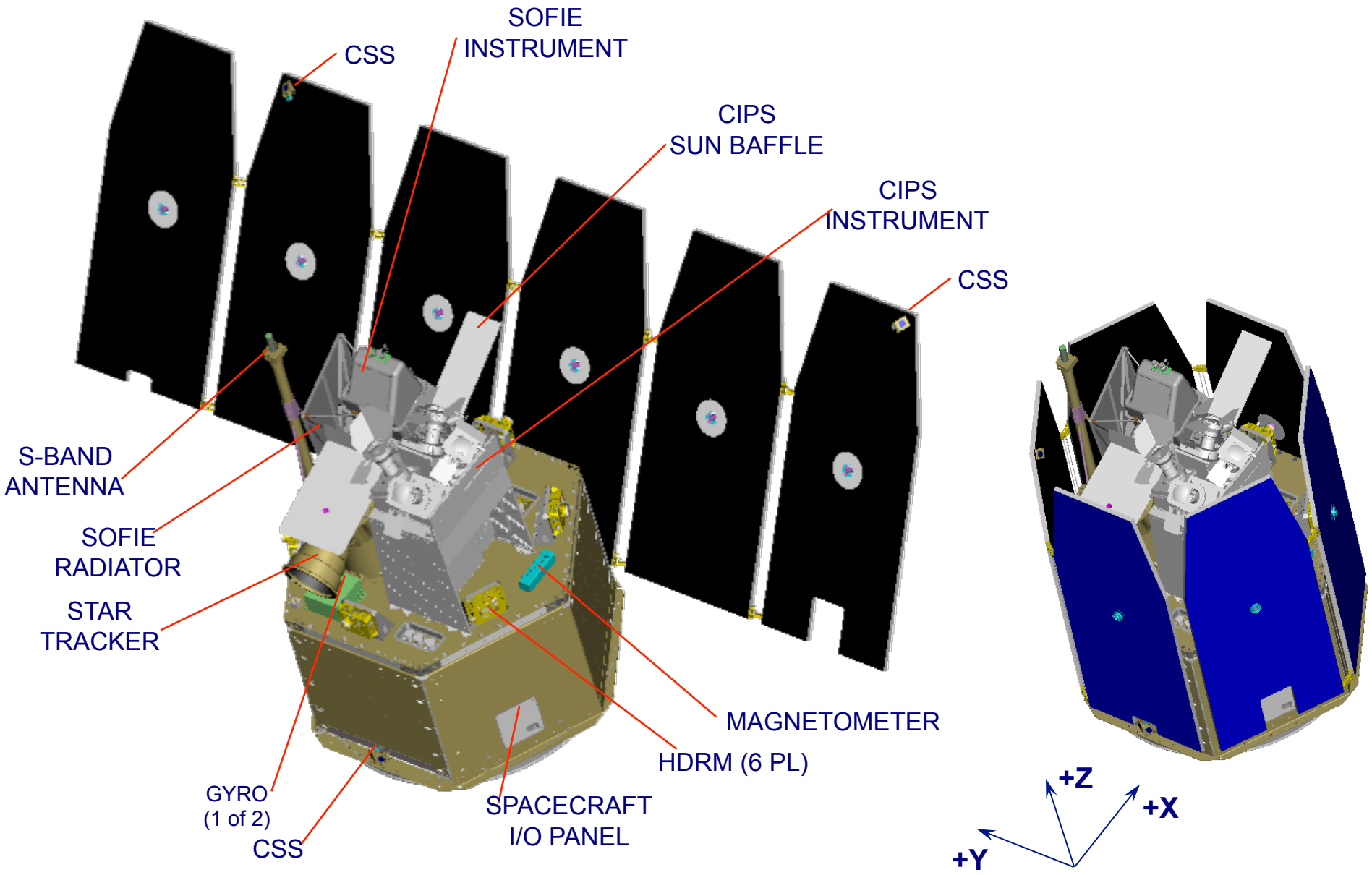
- Inertial Reference Units (Ring LASER Gyros) Went Through Late Hardware Change 6 Months Before Launch Due to Limited Life Concern
  - Worked Closely with JHU, NASA, External Consultants, IRU Vendor, and Other IRU Customers to Develop and Evaluate Design Change Before Launch
  - Accelerated Life Testing Completed Before Launch Predicted Acceptable Performance
- Inertial Reference Units Decreased LASER Intensity caused failure one channel of Primary IRU and one channel of Redundant IRU
  - Operated on Redundant Unit with One Failed Axis, and Both Units to Get All Three Axes When Necessary
  - Developed and Utilized New Software for Gyroless Operations for Extended Mission Operations with Continued Precision Pointing Performance
  - Continued FUSE Extended Mission Beyond 3-Year Prime Mission to more than 7 Years of Science Gathering
- Reaction Wheels Ceased Operation
  - Two of Four Reaction Wheels Exhibited Sudden Friction Increase and Stopped Spinning
    - Similar Problems Experienced in Subsequent Missions
  - Developed Modified ACS Algorithms and Software to Operate Using Two Wheels or One Wheel and Magnetic Torque Rods for Control
    - Limitations on Science Targets due to Limited Magnetic Torque Authority Dependent on Attitude
- In Spite of these Issues, the FUSE Science Team Achieved >7 Years of 50% Science Efficiency, Compared to Baseline Plan of 3 Years at 25%
- Extended Mission Ended 10/18/2007 Due to Failure of Final Wheels

AERONOMY OF ICE IN THE MESOSPHERE (AIM) SPACECRAFT DEVELOPMENT

AIM Program Description

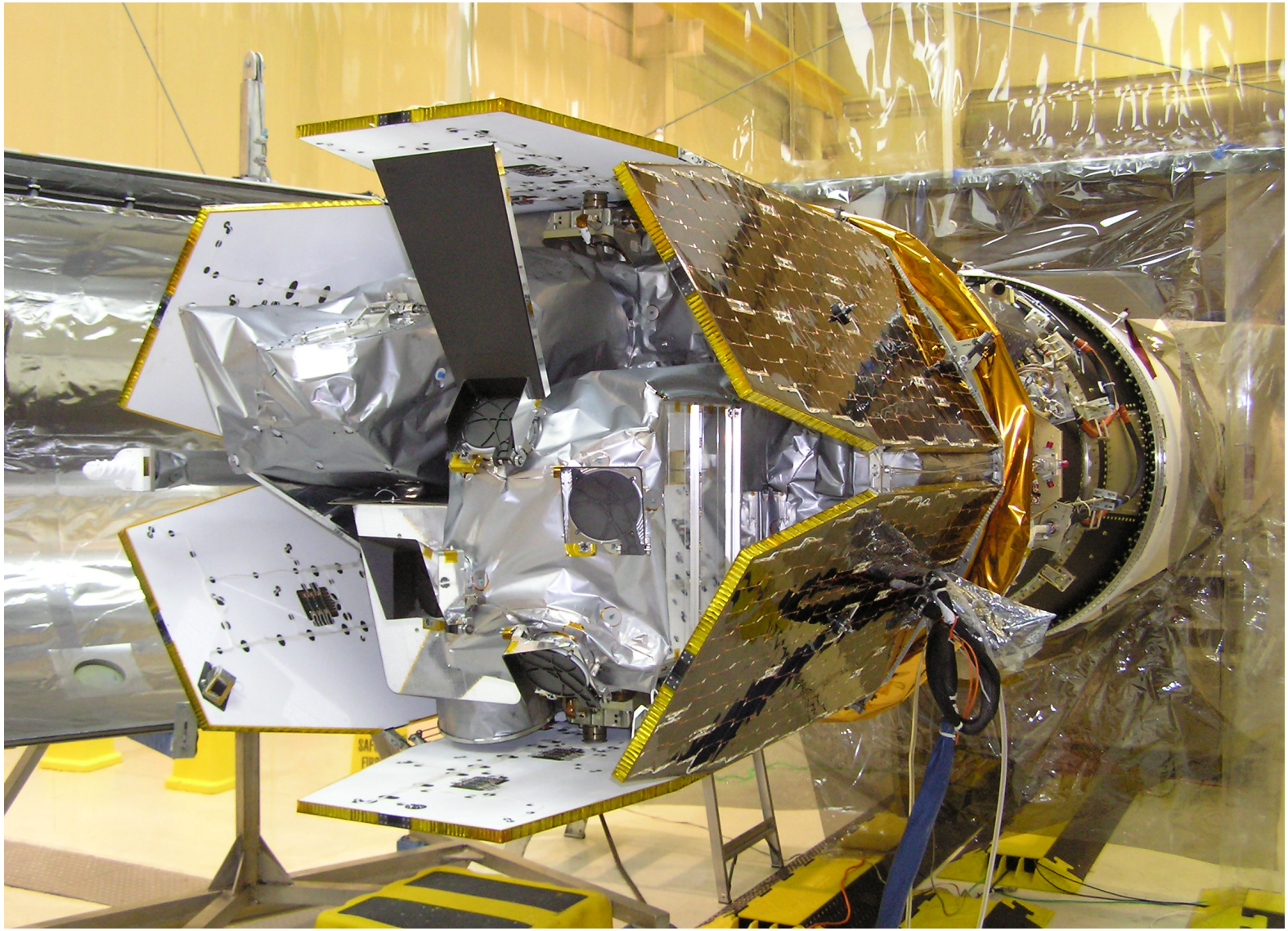
- NASA Small Explorer Satellite Program Headed by Principal Investigator, Dr. James Russell of Hampton University and Project Manager, Mike McGrath of the University of Colorado Laboratory for Atmospheric and Space Physics (LASP)
- AIM Science Goals:
  - Resolve why Noctilucent Clouds (NLCs) form (also known as Polar Mesospheric Clouds or PMCs) and how and why they vary
  - Quantify the connection between the clouds and the meteorology of the polar mesosphere by measuring the thermal, chemical and dynamical environment in which NLCs form
  - Provide the basis for study of long-term variability in the mesospheric climate and its relationship to global change
- Launched from Vandenberg AFB on April 25, 2007
  - 600 km, 97.8° Inclination Orbit
  - 24 Month Mission Design Life, Covering 4 PMC Seasons
- Satellite Program Partitioned
  - Space Segment
    - Bus — Orbital: LEOStar-2
    - Instruments — LASP: CIPS; LASP: CDE; SDL: SOFIE
  - Ground Segment
    - Mission Operations Center (MOC) is at LASP
    - Project Data Center (PDC) is at HU
    - Payload Operations Centers (POC) at LASP and GATS

AIM Spacecraft Stowed & Deployed Configurations



AIM Satellite in Cleanroom

AIM Satellite Mated with Pegasus



Major AIM Satellite Issues

- SOFIE Instrument Experienced Vibration Failure During Satellite-Level Testing
  - Instrument Design Utilized Moving Mirror for Precision Pointing
    - Moving Mirror Design Had Limited Dynamic Load Capability
  - Non-Linear Behavior of Instrument Moving Mirror Assembly Not Well Understood by Combined Analysis and Test Team
  - After Failure, Determined Spacecraft Pointing System to be Adequate without Need for Moving Mirror in Instrument
  - Instrument Repaired Utilizing Fixed Mirror to Achieve All Mission Pointing Requirements
- Spacecraft Receiver Experienced Intermittent Uplink Soon After Launch, Which Continues Today, But Full Mission Science is Being Returned
  - Spacecraft Transceiver Required Multiple Instances of Rework and Testing, But Nothing Points to Failure That Could Have Been Detected Before Launch
  - Satellite Autonomy Worked Very Well to Maintain Safe Operations
  - Tiger Team Formed with LASP, Orbital, NASA, and Consultants to Evaluate Anomaly
  - Developed Improved Software, Longer Duration Stored Command Sequences, and Simplified Automated Sequences for Operations Requiring Less Uplink
  - Developed “Morse Code” Approach for Commanding Simplified Sequences in Cases of Prolonged Uplink Outage
- The AIM Team has Dealt well with the Issues, with the AIM Mission Continuing to Perform Well After 14 Months On-Orbit, Returning Full Science, and Approved for Extension for 3 more Years of Science