EO-1 Advanced Land Imager (ALI)
Technology Transfer Forum

Payload Mechanical Engineering

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Outline

Organization

- System Configuration, Requirements & Changes
- Payload Engineering Elements
  - Optomechanics and Structures
  - Thermal Design
  - Mechanisms
  - Electronics Packaging
- Summary
Payload Engineering Organization

System Level Configuration Engineering
- Interface Control Documentation (ICD’s)
- Mass and CG Tracking
- Environmental Spec and Testing
- Mission Assurance

Control Electronics Engineering
- ALICE Electrical Requirements Definition
- Mechanism and Thermal Control System Design
- Mechanism Motors Evaluation & Procurement
- Cabling and Connector Design & Selection

Thermal Design and Engineering
- System Thermal Requirements
- Thermal Design, Analysis and Testing
- Radiator Design
- Evaluate Thermal Aspects of Subcontracts
- Thermal Interface Design

Structure and Mechanism Engineering
- System Structural Analysis
- Mechanism Design, Analysis and Test
- Materials Testing
- Evaluate Structural Aspects of Subcontracts
- Structural Interface Design
- MGSE
- ALICE Chassis Design

Fabrication Planning and Engineering
- Parts Procurement
- Materials Procurement
- Electrical and Mechanical Fabrication and Assembly
- Fabrication Programming

Telescope Engineering
SSG

Focal Plane Engineering
SBRS
Outline

• Organization

System Configuration, Requirements & Changes

• Payload Engineering Elements
  – Optomechanics and Structures
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• Summary
ALI System Components

• Instrument Assembly
  – Telescope Optics, Structure and Housing
  – Main and Grating Focal Plane Assemblies
  – Focal Plane Support Structures
  – Reclosable Aperture Cover
  – 2 Calibration Mechanisms
    • Variable Aperture Selector
    • Secondary Mirror Diffuser
  – Focal Plane and Electronics Radiators
  – Flood Lamp Assembly

• Electronics Assemblies
  – Focal Plane Electronics (FPE)
  – Advanced Land Imager Control Electronics (ALICE)
ALI Covered with Multi-Layer Insulation
ALI Instrument Configuration
(Multi-Layer Insulation removed for clarity)
ALI Views

ALI Instrument without MLI
ALI Instrument Cross Section

- Aperture Cover Assy (Open)
- Radiator
- Calibration Plate Assy
- Telescope Assy
- LEISA
- Instrument Pallet
- MFPA
- +Z
- +X
- FPE and Radiator
Major Changes During Program

- **Launch Vehicle**
  - Changed From Taurus to Delta
    - Reduced Loads by Factor of 3 to 5
    - Increased Mass Allotment From 64 to 90 kilograms
    - Reduced Minimum Frequency From 80 to 65 Hertz

- **Spacecraft**
  - Changed From Composite to Aluminum

- **Instrument**
  - Metering Truss: Silicon Carbide to All Invar
    - Fabricated at Lincoln
  - Housing and Pallet: Composite to Aluminum
    - Thermally Coupled to The Spacecraft
  - Grating Optics/Focal Plane added, then deleted
Environment and Mass Requirements

- Launch Vehicle: Delta 7320
  - Co-manifested with Argentine SAC-C Spacecraft

- Launch Loads and Dynamics
  - Quasi-Static Design Limit Loads
    12.5 G Axial Direction
    10 G Lateral Directions
  - Minimum Natural Frequency: 65 Hertz

- Mass Allotment: 90 kilograms

- Expected On-Orbit Average Temperatures
  - Telescope: -10° to +40° C (253 to 313 K)
  - Focal Planes: 220 K

- Minimum 1 Year Operational Life
Mass Properties

• ALI weight & center of gravity
  – Weight 197.8 pounds (~90 kg)
    FPE to WARP data cable not included
  – Center of Gravity at x = - 0.5 in., y = 5.7 in., z = 10.5 in.
  – All measurements within ICD allowables

• Weight Distribution
  – Telescope (Truss, Diffuser, Wiring) 76 pounds
  – Housing (Structure, Mechanisms, Wiring) 30
  – Pallet (Structure, Wiring) 40
  – Focal Plane Radiator (Structure, Wiring) 16
  – Focal Plane Electronics (Structure, Wiring) 17
  – ALICE (Including Filter Box) 19
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Component Optomechanical and Structural Analyses and Tests

• Telescope
  – Silicon Carbide Optics
    Working Stresses for Silicon Carbide
    Thermal Stability of Invar Mirror Mounts
    Vibration Testing of 1/2 Scale, STM & Flight SiC Mirrors
  – Invar Metering Truss and Aluminum Housing and Pallet
    Trade Studies of Stiffness, Mass, Peak Stress, Wavefront Error, 1 G Release, Thermal Gradients
  – Analyses of Static and Dynamic Responses to Launch Loads

• Focal Plane
  – Optimization of Structural Response to Launch Loads
    Includes FP, FP Electronics and FP Radiator Support Structures

• Mechanisms
  – Optimization of Structural Response to Launch Loads
Metering Truss Designs

Silicon Carbide Design

DCR Invar Design

Current Invar Design
ALI Invar Metering Truss

CAD Model

Flight Truss Photos
Main Focal Plane Assembly

- Warm Shield
- SCA & Be Rail
- Invar Housing
- G-10 Isolators
- Titanium Flexures
- Thermal Conductor Bar
Main Focal Plane Assembly

- Invar Warm Shield
- Single Layer Aluminized Kapton
- Invar MFPA Mounting Frame Assembly
- Aluminum Conductor Bar
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Thermal Engineering

• Design Conditions and Features:
  – Instrument Assembly: -50 to +50°C
    Pallet, Housing & ALICE Thermally Coupled to Spacecraft
    Metering Truss Isolated From Pallet
    Top-to-Bottom Truss Gradients limited to ≤ 10°C
    Focal Plane Electronics isolated from pallet
  – Focal Plane: 220 K
    Solid Aluminum Conductor With Flexible Link Between Focal Planes and FP Radiator
  – Radiators:
    ~ 0.4 m² at 200 K for Focal Planes (White Paint)
    ~ 0.02 m² at 300 K for Focal Plane Electronics Box (Silver Teflon)
  – Thermal Control:
    System Level Provided by ALICE
Focal Plane Thermal Control System

Tapered Radiator (White Paint)
27" X 27" (69 cm X 69 cm)

Flexible Link
100 2-mil (0.05 mm) Thick Aluminum Foils
1.5” x 1” (3.8 cm x 2.5 cm)

Cross Section

Main FPA
200 K

Heater
220 K

Heaters
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Mechanism Characteristics

• Reclosable Door
  – Lightweight Aluminum With Open-Close Stepper Motor*
    Fail-Safe Torsion Spring Release
    “One Time Only” Launch Latch

• Variable Aperture Selector
  – Array of Slits in Aperture Door Over Movable “Blocker” Plate
    Plate Driven by Stepper Motor* and Lead Screw

• Secondary Mirror Diffuser
  – Reflective Spectralon Disk Moved Into or Out of Optical Path
    Driven by Stepper Motor*
    “One Time Only” Launch Latch
    Fail Safe Torsion Spring Release

* Motor Vendor: Astro Instrument Corporation
ALI Aperture Cover

- Cover Fail Safe
- Aperture Cover
- Aperture Selector
- Launch Latch
Cover Launch Latch

Starsys EP-5025 HOP Pin Puller
Aperture Selector Mechanism

Top View

Bottom View

Lead screw

Cover Plate

Guide Rail

Slit arrangement

2.50
0.10 lands
9 pics

(Slot 1) 0.021 in
(Slot 2) 0.042 in
(Slot 3) 0.148 in
(Slot 4) 0.42 in
(Slot 5) 0.42 in
(Slot 6) 0.42 in
(Slot 7) 0.42 in

Blocking Plate Profile

2.56

6 INCHES

6 INCHES
Secondary Diffuser Calibration Plate

Closed

Open
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ALICE Packaging

• ALICE Chassis Size: 30.5 cm x 25.4 cm x 15.2 cm

• Three Printed Circuit Board Assemblies
  – Each Assembly Includes:
    Two Single Sided Boards Bonded to Metal Core
    Two Wedge Clamp Retainers
    Backplane Connectors

• Backplane Design Connects PC Boards

• Flight Parts Selected from NASA Preferred Parts List

• Thermally coupled to pallet
Summary

EO-1 on Dual Payload Adaptor Fitting

Mounted in the Delta Shroud

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Q.E.D.