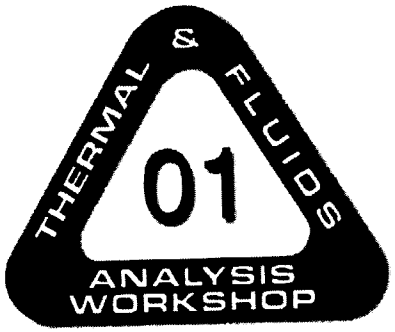
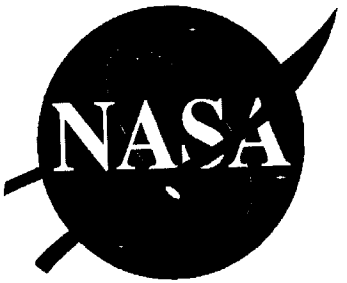




X-38 De-orbit Propulsion Stage MLI Performance Test

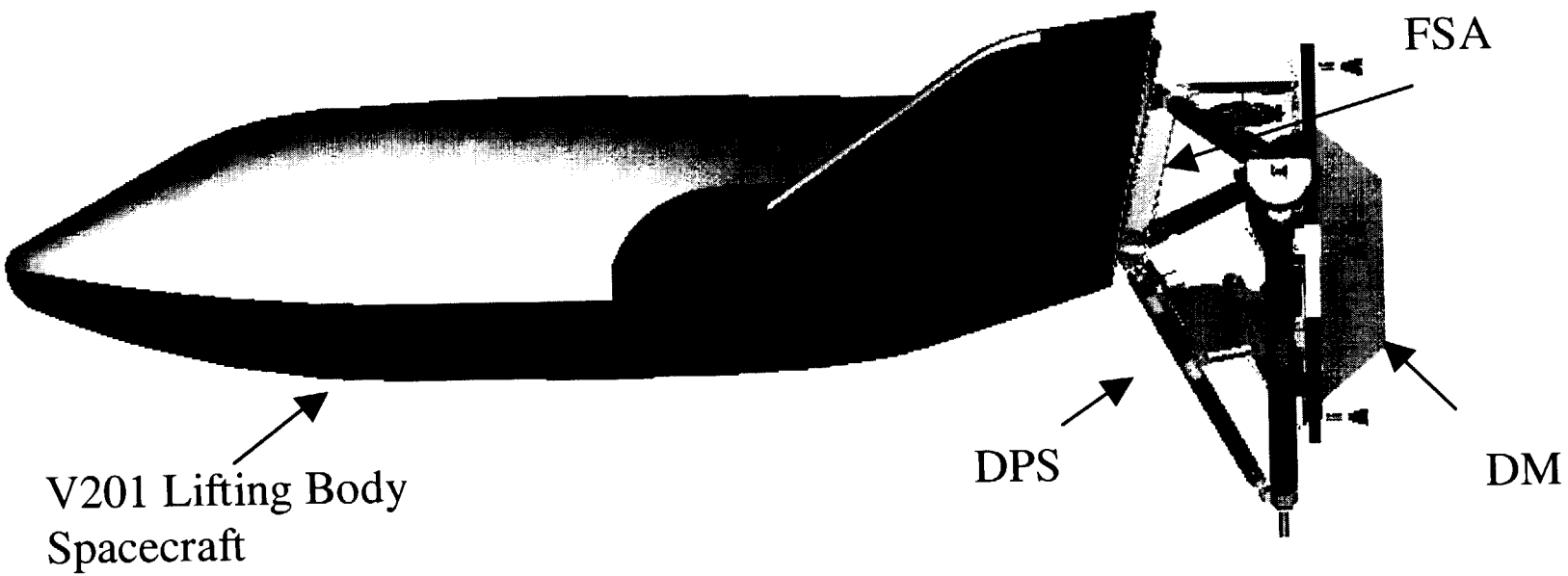
Sept 10-14, 2001

Ken Kittredge
NASA/MSFC

Background

- X-38 is Pathfinder for Space Station Crew Return Vehicle
- X-38 Launched in Space Shuttle
- De-Orbit Propulsion System (DPS) Maneuvers X-38 in Descent Trajectory and is Jettisoned Prior to Re-entry
- X-38 DPS design hot biased to reduce power and energy requirements
- Black Beta Cloth selected as outer layer on MLI
- Analytical Margin is Small and no DPS Thermal Testing Planned.

X-38



Objective

- Test DPS MLI
  - Sample Available
  - Test Facilities Available
    - Performed in MSFC Thermal Development Facility
- Determine if MLI Performance Meets or Exceeds that Assumed in Thermal Analyses
- Determine Performance Degradation due to Seams

Prep Work

- Literature Search of Potential Test Methods
- Test Fixture Conceptual Design
- Thermal Modeling and Analysis
- Design Modification
- Procurement/Manufacturing and Assembly
- Optical Property Measurement
- Instrumentation Acquisition
- Data Acquisition System Setup

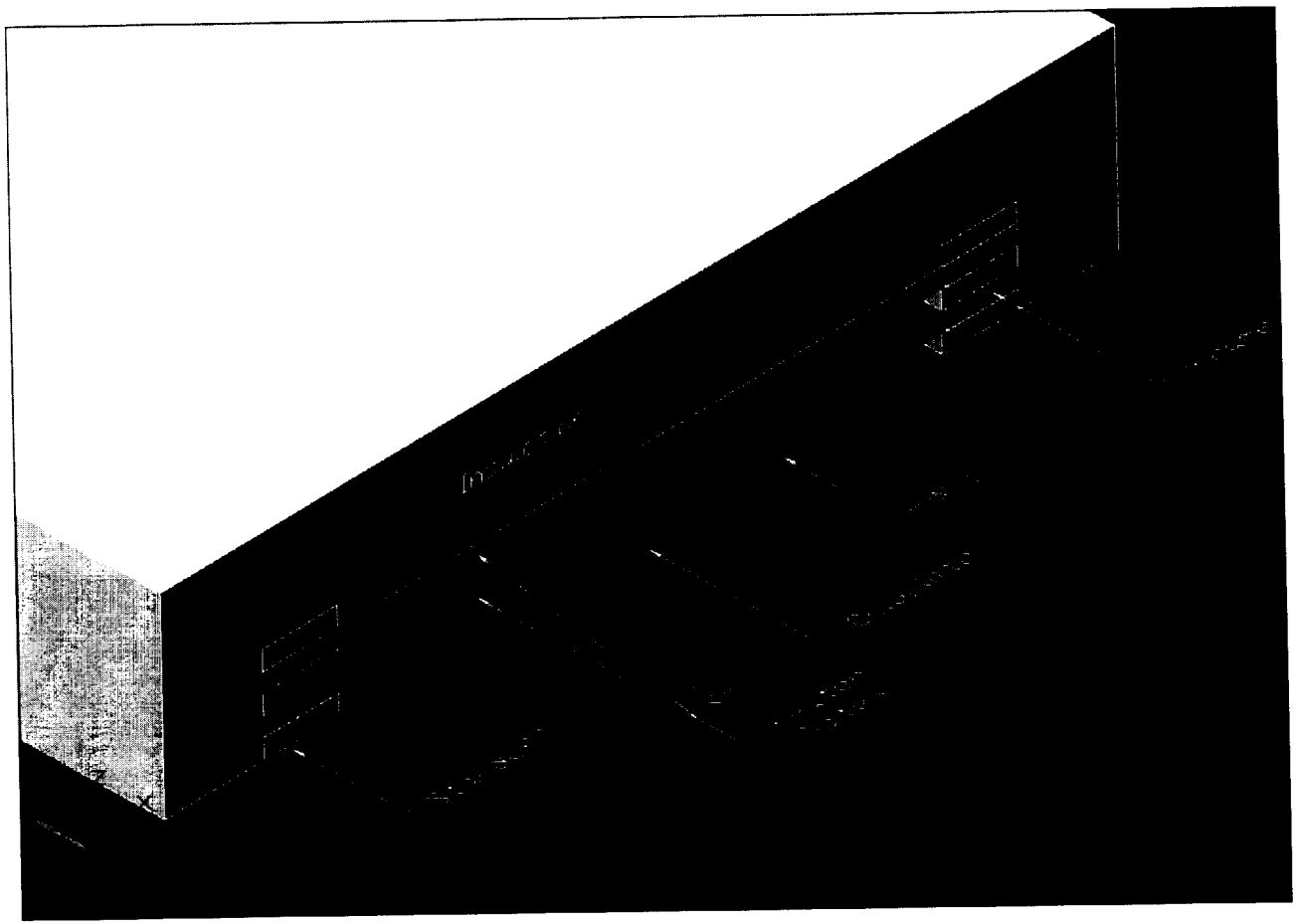
Initial Test Methodology

- Guarded Heat Flow Technique Loosely Based on ASTM-177-97
- Use Temperature Difference Between Primary Heater Plate and Coldplate, Measured Emissivity for the Primary Heater and MLI, and the Primary Heater Power Draw to Calculate Effective Emittance (ε^*)
- Black Anodized Aluminum Heater Plate, $\varepsilon = 0.83$
- MLI Black Beta Cloth Outer Surface, $\varepsilon = 0.87$, $\alpha = 0.96$

Test Fixture

- Test Fixture Composed of Polysulfone Plastic Frame and two Black Anodized Aluminum Heater Plates
- Mounted to Space Station –1 Coldplate with Teflon Isolators
- Insulated with four inches of Cryolite Fiberglass Matte
- MLI Sandwiched in Interface Between Heater Plates and Coldplate
- One Square Foot Test Area

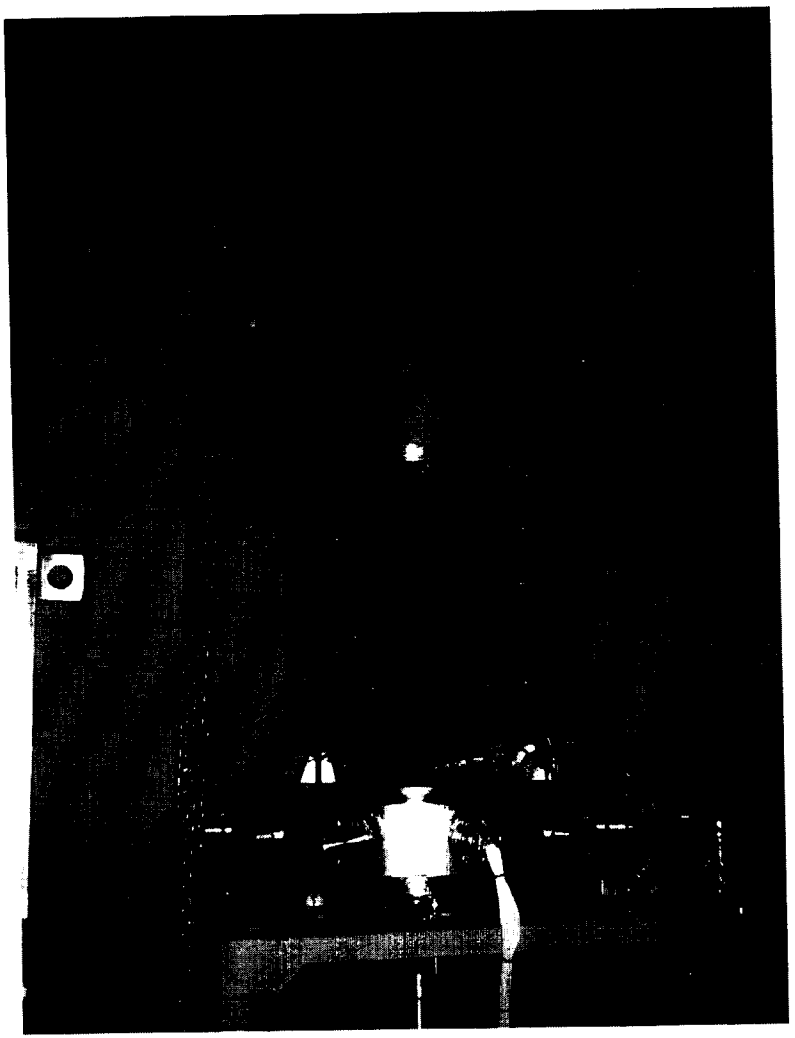
Test Fixture Cross-Section



Test Setup

- 9 Minco Thermofoil Heaters per Heater Plate
- Temperature Sensors Mounted on Heater Plates, Coldplate, Frame, and Chamber Shell
- Fixture Isolated from Coldplate with Teflon Standoffs
- MLI Between Test Fixture and Coldplate
- Vacuum Chamber
- Johns Manville Cryo-lite Fiberglass Insulation
- ISS –1 Coldplate and Neslab Low Temperature Chiller
- Residual Gas Analyzer
- DAQ System and Power Supplies

Test Setup



Test Setup

Test Procedure

- Assemble MLI, Test Fixture, Insulation, and Coldplate in Vacuum Chamber
- Evacuate Chamber – Control Heaters to 300°F, Chiller set to 5°F.
- Adjust Heater Power so that Heater Plates are at the Same Temperature
- Record Primary Heater Plate Temperatures and Voltage and Current and Coldplate Temperature

Modifications

- Heater Plate Thermocouples Replaced with RTD's wired to HP DAQ System
- RTD's Bonded to the Heater Plates using Conductive Epoxy
- Fixture Re-oriented on Coldplate so the Open End was to the Left Rather than Top
- Aluminized Kapton Tape Applied to Fixture Exterior

Retest

- Reconfigured Test Yielded more Uniform Temperatures
- Primary Heater Temperature of 297°F and Coldplate Temperature of 12°F yielded ε^* of 0.028 based on full heat load of 13.0 btu/hr across MLI
- ε^* of 0.016 – 0.019 used in DPS Thermal Analyses.
- Assessment of Test Results Indicates much more Heat Leak from Test Fixture than Expected Causing Over-Estimation of ε^*

Reconfiguration for Seam Test

- Removed MLI from Test Fixture and Quartered it.
- Each Piece was then Reversed and laid out so the Seams of Adjacent Pieces Overlap then Taped in Place
- 8 RTD's added to MLI side of Test Fixture Frame.
- Configuration then Reassembled.