GUVI Spectrograph Thermal Design and Analysis

C.J. Ercol

JHU/APL

C.J.Ercol@aplmail.jhuapl.edu

23-394

301-953-5105

Agenda

- Requirements
- Design Overview
- Analysis Parameters
- Description of Thermal Models
- Results
- Efforts Leading to CDR

Temperature Requirements

Component	Thermal Design Range (C)		Test Range (C)	
	Operational	Survival	Operational	Survival
Scan Motor	-40 to 75	-50 to 80	-50 to 85	-55 to 90
Detector #1*	-10 to 25	-20 to 40	-20 to 35	-30 to 50
Detector #2*	-10 to 25	-20 to 40	-20 to 35	-30 to 50
Electronic Boxes	Controlled by Spacecraft interface			

Additional Requirements: Maintain less than a 10° C gradient within the spectrograph during operation

Note: * SIS hot operation limits were 40° C

Thermal Design Overview

Spectrograph

- Survival Temperatures maintained by survival heater circuit during non-operation mode
- Heaters and thermostats maintain operational temperatures during cold conditions
- Hot case temperatures driven by Scan Motor power and worst case environmental constants
- 2x Copper Strap thermally sinks Scan Motor to Spectrograph Housing (1x per SIS design)
  - Scan motor case and coupler will be used as a radiator
- Spectrograph is hard mounted to +Z deck but is thermally isolated due to Titanium feet ($1/G > 50\ ^{o}C$/watt per foot)

Thermal Design Overview (2)

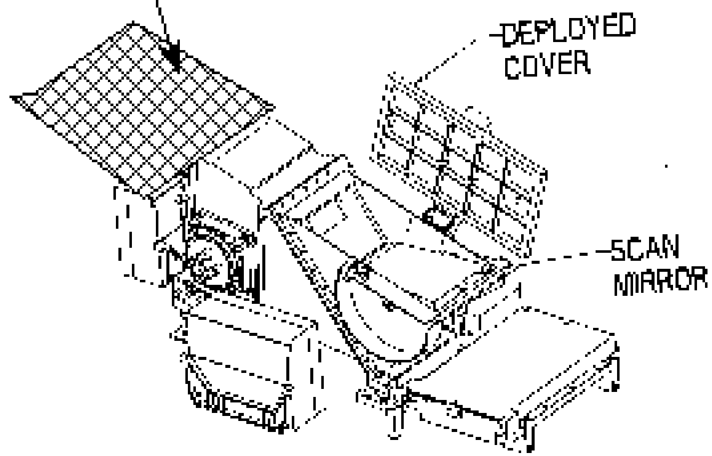
- MLI to cover entire spectrograph except for
  - internal aperture and mirror
  - chassis radiator
  - motor case

Detectors

- Thermally mounted to spectrograph
- Have a radiator mounted to aft spectrograph chassis to maintain hot case temperatures at or below 25° C

Thermal Design Overview (3)

Silver Teflon Detector Radiator mounted to aft chassis:
-22 sqin used in thermal modeling
-30 sqin available



MLI coverage everywhere except radiators, aperture, and hinges

Spectrograph hard mounted to but thermally isolated from (due to titanium feet) the +Z deck

Analysis Parameters

Parameter	Hot Case	Cold Case
Solar Constant	450.0*	408.0*
Albedo Constant	0.4	0.2
Earth Constant	85.0*	60.0*
+Z Deck Temperature	+55 C	-35 C
Blanket Thru-Emittance	0.01	0.04

Notes: * Units are BTU/Hr-SqFt

Analysis Parameters (2)

Component	Hot Operation Power (W)	Cold Operation Power (W)	Survival Power (W)
Scan Motor	4.000 *	2.000 *	0.0
Detector #1	0.100	0.000	0.0
Detector #2	0.100	0.000	0.0
Total:	4.20	2.000	0.0

Notes: * Scan Motor Hot Case assumes 100% Duty Cycle with peak power of 4.0 W ; Cold Case assumes a 50% Duty Cycle.

Thermal Model Description

- Nodal Summary
  - 4 internal Aperture nodes
  - 2 Nodes for the mirror
  - 1 Node for the scan motor and coupler
  - 1 Node for each detector interface
  - 2 Nodes representing internal/external chassis radiator
  - 8 Nodes representing the internal spectrograph

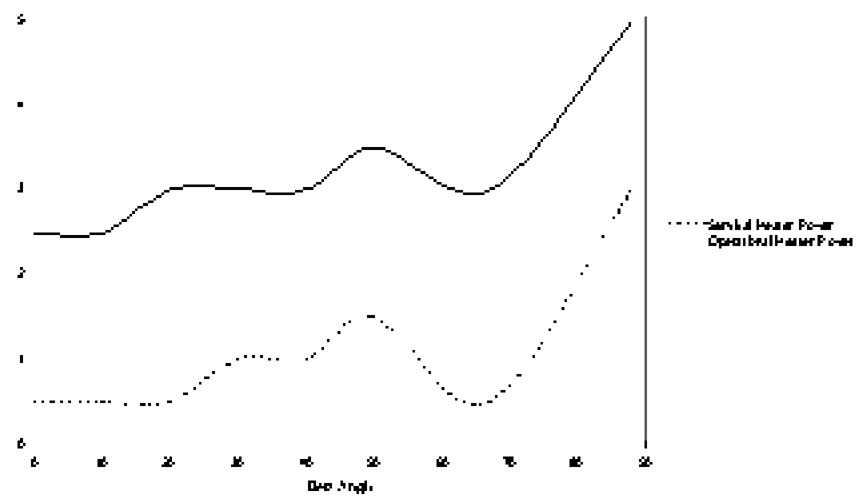
Thermal Model Description (2)

- Trasys generated radiation environments representing
  - internal spectrograph housing and aperture radiation couplings
    - Scan mirror fixed in at zero position
    - all modeling done with door open
  - external MLI and radiator to spacecraft radiation couplings
  - heating rates for 8 independent beta angle cases (0,10,20,30,40,50,67,88)
- Hand calculated MLI through couplings based on effective emittance and area

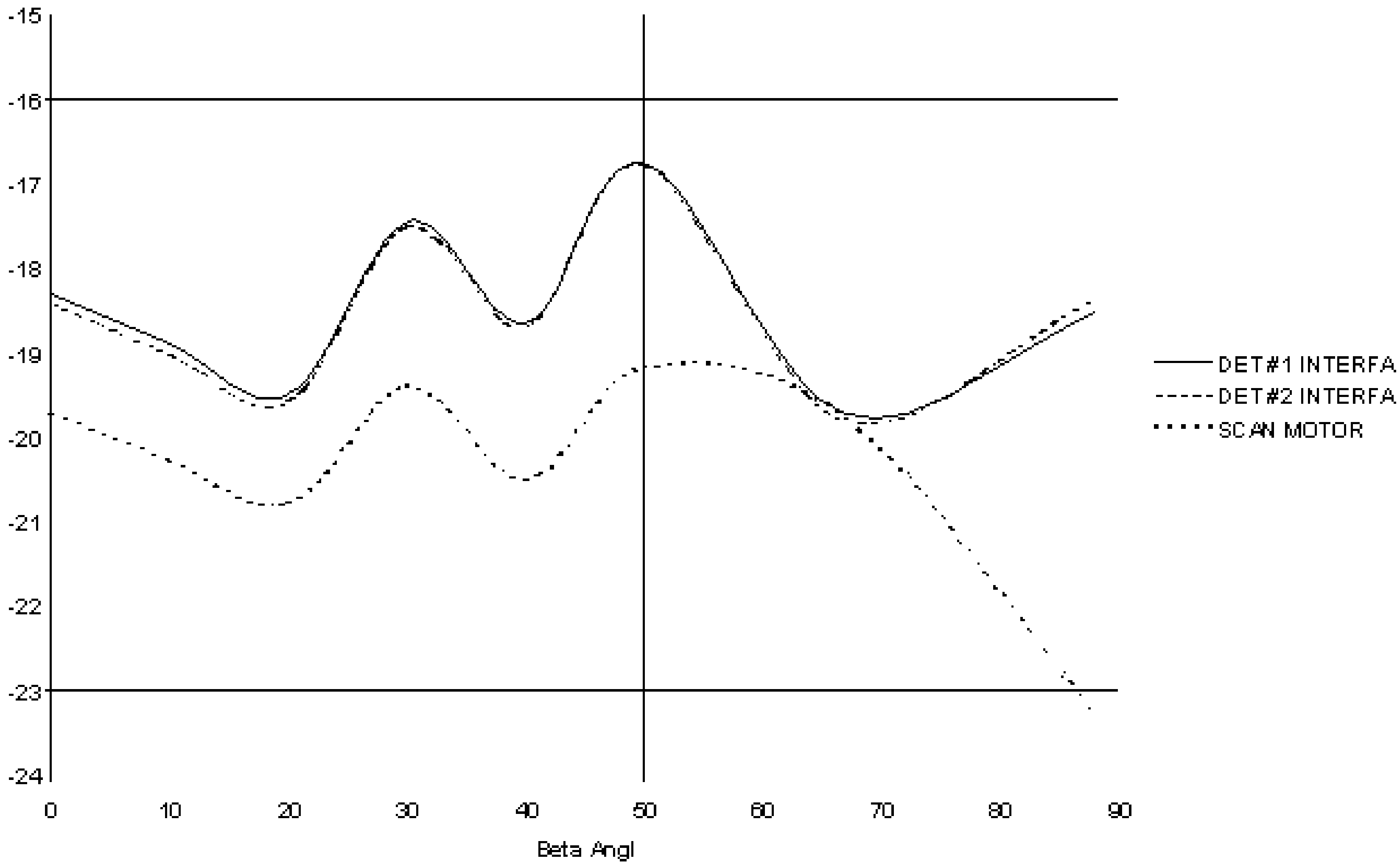
Results Summary

- Maximum predicted operational gradients:
  - < 5 °C within spectrograph (<10 °C Req)
- All operational temperature predictions are within upper and lower limits except
  - detector temperatures very close to the 25° C prediction upper limit during low beta angle hot operation
- Heater power:
  - Worst Case Survival predicted is 3.0 vs. 2.5 allocated
    - But peak occurs during full Sun orbits

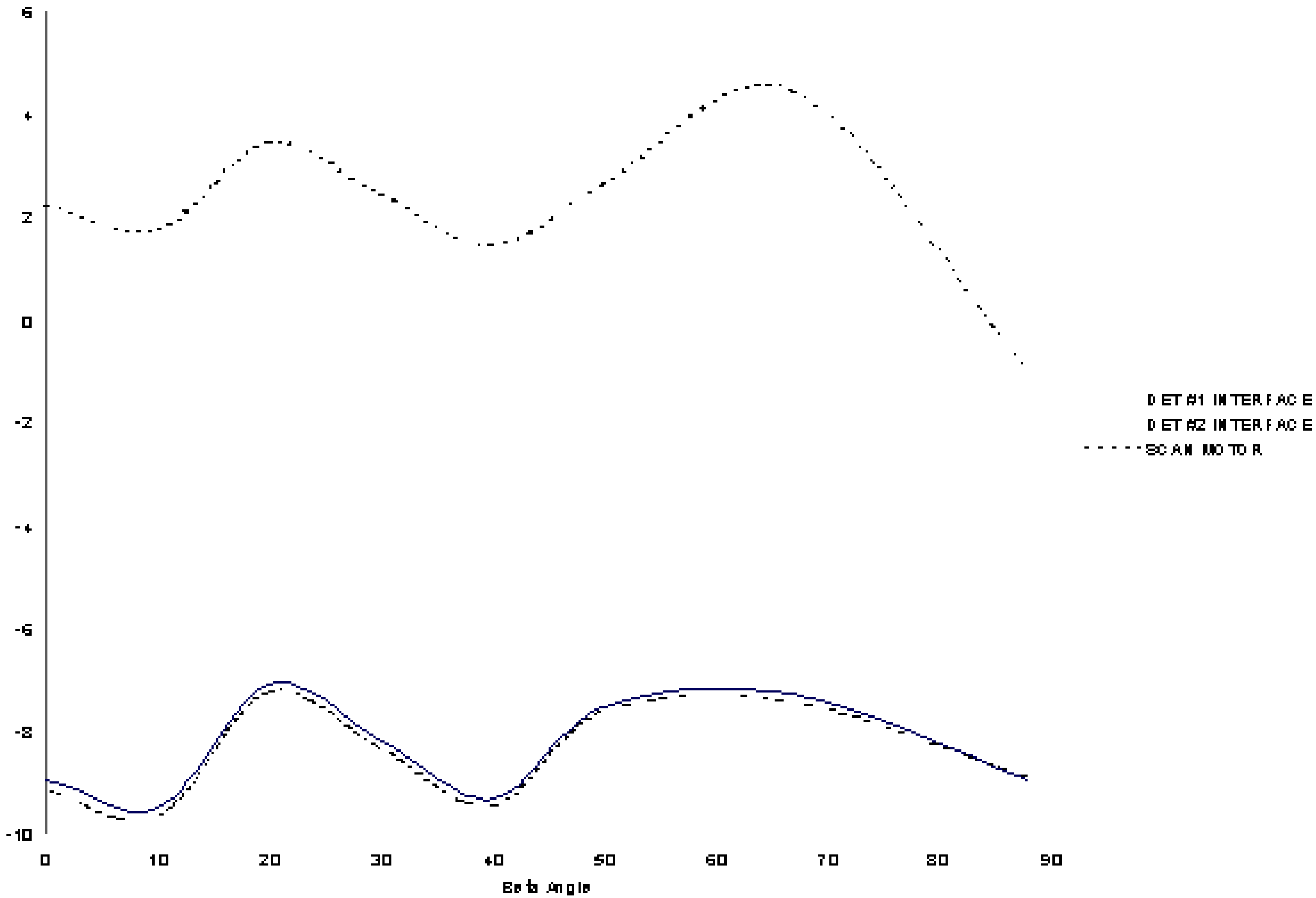
Heater Power Predictions



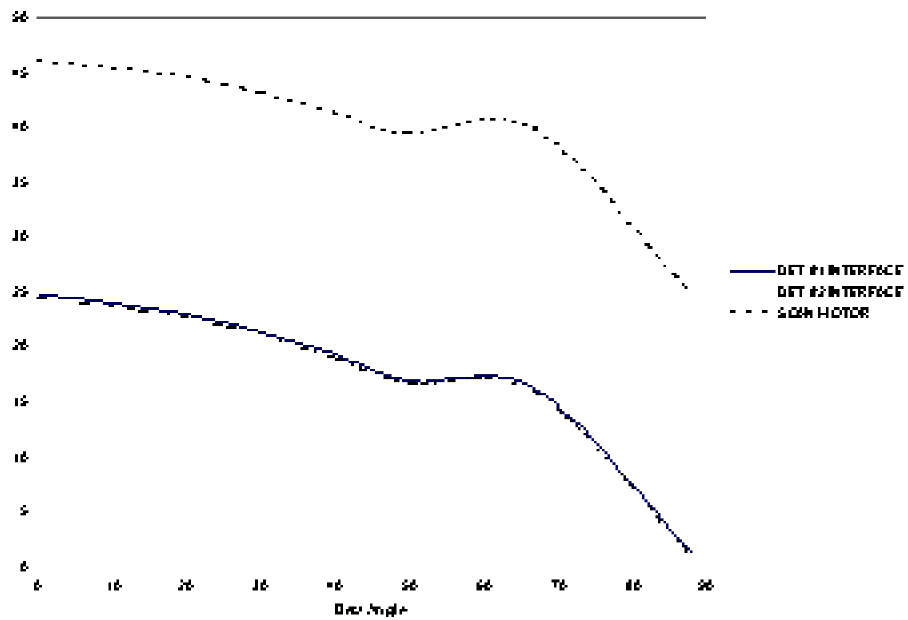
Survival Temperature Predictions



Cold Operation Temperature Predictions



Hot Operation Temperature Predictions



Efforts Leading to CDR

- Perform operational transient analysis
  - orbital heating rates
  - effects of heater cycles on gradients
  - heater and thermostat / temperature sensor placement
- Finalize Spectrograph heater circuits and power levels
- Finalize all testing issues
  - thermal balance
  - acceptance / workmanship
- Complete thermal modeling
- Evaluate board level thermal analysis tasks