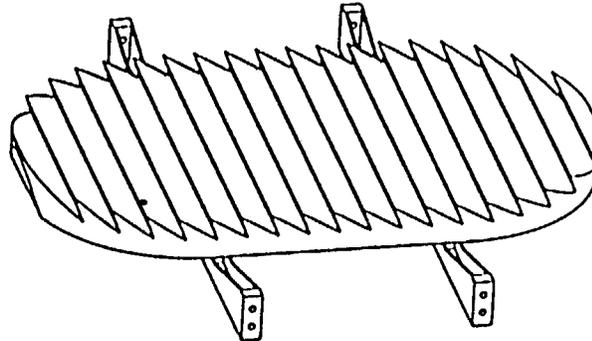


*The MODIS On-Board
Blackbody*

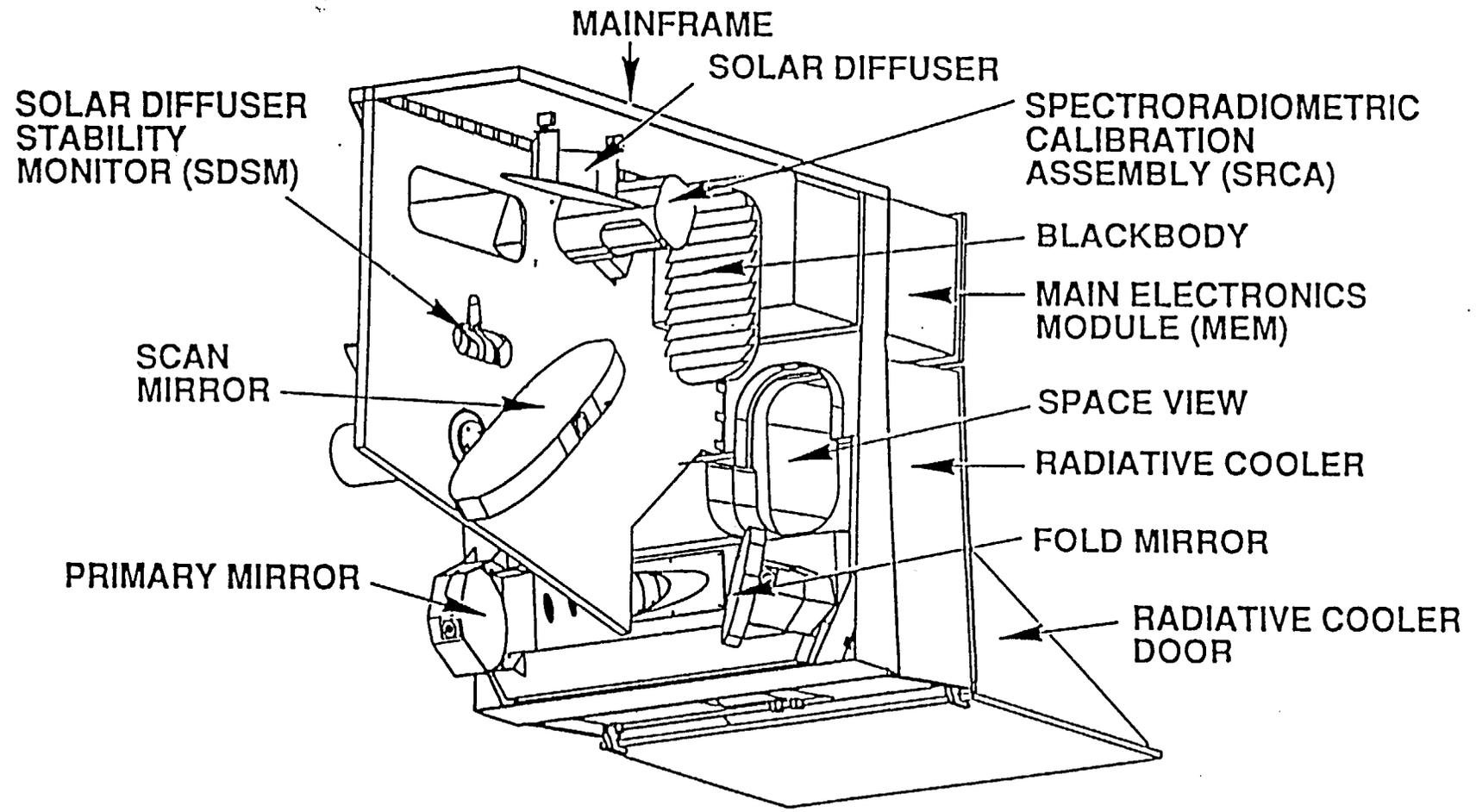
Calibration



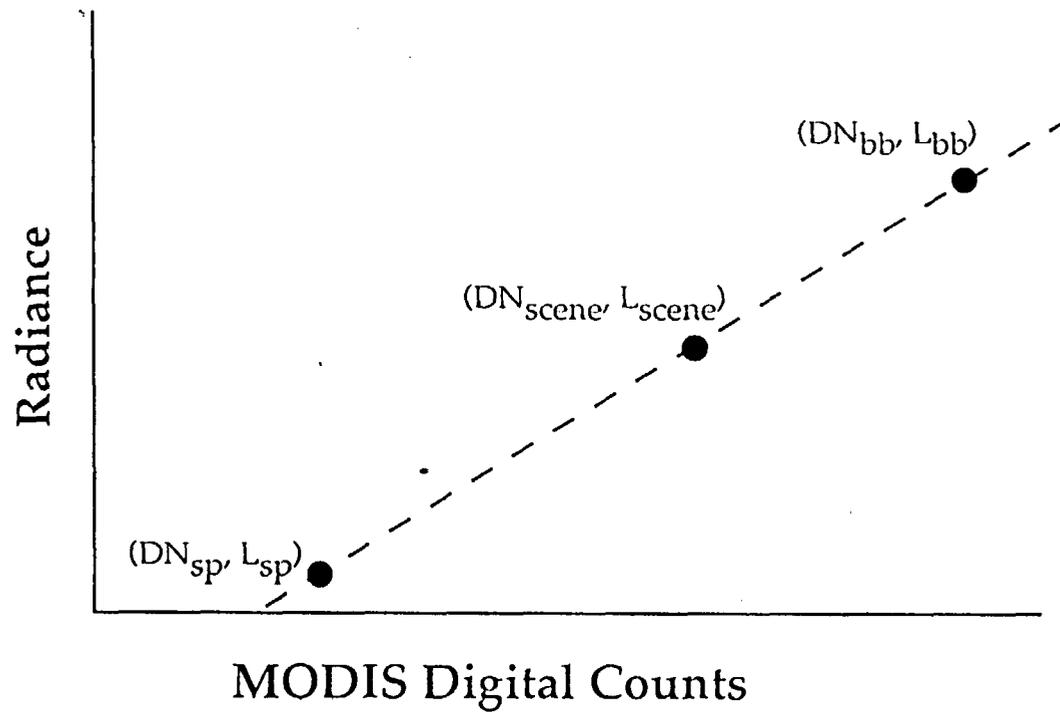
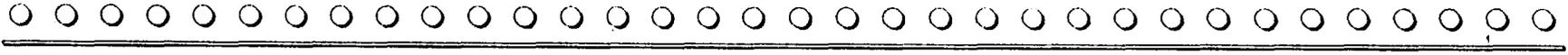
Dan Knowles Jr.

*MODIS Algorithm Team Meeting
16 Mar, 1994*

Physical Layout in Object Space



Linear Calibration



$$L_{scene} = L_{sp} + m(DN_{scene} - DN_{sp})$$

$$m = \frac{L_{bb} - L_{sp}}{DN_{bb} - DN_{sp}}$$

Illustration of Non-Linear Algorithm



Pre-Launch

The radiance observed when viewing scene and blackbody respectively are

$$L_{\text{scene}} = q \times \text{scene}^2 + m \times \text{scene} + b(\theta_{\text{scene}}) \quad (1)$$

$$L_{\text{bb}} = q \times \text{bb}^2 + m \times \text{bb} + b(\theta_{\text{bb}}) \quad (2)$$

where:

$$\text{xbb} = \text{DN}_{\text{bb}} - \text{DN}_{\text{sv}}$$

$$\text{xscene} = \text{DN}_{\text{scene}} - \text{DN}_{\text{sv}}$$

DN_{sv} = counts when viewing space

DN_{scene} = counts when viewing scene (external blackbody)

DN_{bb} = counts when viewing internal blackbody

Using eq. 1 & 2, determine q , m , $b(\theta_{\text{scene}})$, and $b(\theta_{\text{bb}})$ from pre-launch blackbody calibration. The quantities q , m , $b(\theta_{\text{scene}})$, and $b(\theta_{\text{bb}})$ will be determined for an array of MODIS cavity and detector temperatures. Because $b(\theta_{\text{scene}})$ is measured only at one angle, values for other angles will be determined from scan mirror reflectance properties as a function of angle.

Post-Launch

It is assumed that all functional dependencies are invariant except m which is determined from

$$m = \frac{L_{\text{bb}} - q \times \text{bb}^2 - b(\theta_{\text{bb}})}{\text{xbb}}$$

In-Flight Blackbody Radiance



$$L_{bb}(fd\#,b\#,ch\#) = \sum_{\lambda_{lower}(b\#)}^{\lambda_{upper}(b\#)} B_{\lambda}(\lambda, T_{bb}(ch\#,fd\#)) \epsilon_{bb}(\lambda) R(\lambda,b\#,ch\#) \Delta\lambda \quad (\text{emissive term} > 99\%)$$

$$+ \sum_{ext} F_{ext} \sum_{\lambda_{lower}(b\#)}^{\lambda_{upper}(b\#)} L_{ext}(\lambda,fd\#) (1 - \epsilon_{bb}(\lambda)) R(\lambda,b\#,ch\#) \Delta\lambda \quad (\text{reflective term} < 1\%)$$

where $\sum_{ext} F_{ext} = \pi$

L_{bb} = Effective radiance of the MODIS blackbody (W/cm²/μm/sr)

T_{bb} = Temperature of a spatial area of the MODIS blackbody (K)

F_{ext} = Solid angle weighting factors due to radiance sources external to the blackbody

ϵ_{bb} = emissivity of the MODIS blackbody

R = spectral responsivity of the MODIS band

$fd\#$ = spatially coincident frame of data

$b\#$ = MODIS band number

$ch\#$ = MODIS channel number

$\Delta\lambda$ = wavelength resolution (μm)

λ_{upper} = upper integration limit on λ (μm)

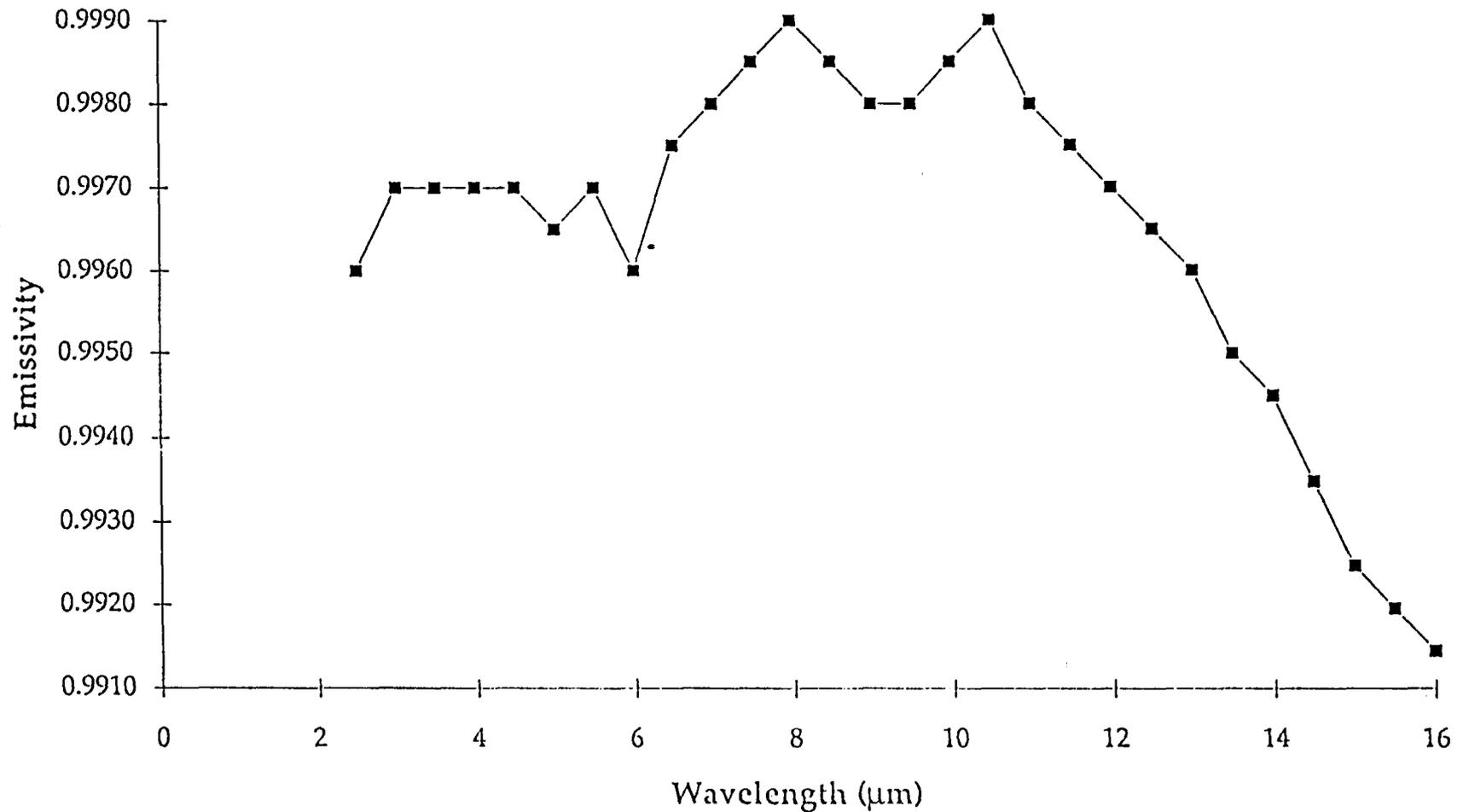
λ_{lower} = lower integration limit on λ (μm)

$$B_{\lambda} = \left[\frac{2hc^2}{\lambda^5 (e^{(ch/\lambda kT)} - 1)} \right] \text{ (W/cm}^2\text{/}\mu\text{m/sr)}$$

Blackbody Emisivity



This chart was based on a calculation of type II anodized aluminum data applied to the SBRC blackbody emissivity equation. It would be desirable to have the emissivity of the in-flight blackbody measured during pre-launch.



Blackbody Temperature



These charts represent an interpretation of the location of the data packet IFOV and the thermistor locations in terms of view angle. This is our understanding of the thermistor locations with respect to each of the 15 frames of blackbody data.

Blackbody Data Packet IFOV

BB Data Packet	Trail Edge Begin	Lead Edge End
1	230.750 deg	230.912 deg
2	230.831 deg	230.994 deg
3	230.912 deg	231.075 deg
4	230.994 deg	231.156 deg
5	231.075 deg	231.237 deg
6	231.156 deg	231.319 deg
7	231.237 deg	231.400 deg
8	231.319 deg	231.481 deg
9	231.400 deg	231.562 deg
10	231.481 deg	231.644 deg
11	231.562 deg	231.725 deg
12	231.644 deg	231.806 deg
13	231.725 deg	231.887 deg
14	231.806 deg	231.969 deg
15	231.887 deg	232.050 deg

Blackbody Thermistor Locations

Thermistor	Location
1,2	230.100 deg
3,4	230.669 deg
5,6	231.237 deg
7,8	231.806 deg
9,10	232.375 deg
11,12	232.943 deg

- all angles measured from nadir

Blackbody Parameter Summary

Material - anodized aluminum

Height - 14.875"

Width - 8.625"

Thickness - 1.091"

Weight - 8.3 lbs

Heaters - 4

Thermistors - 12 "bead in glass" thermistors

Blackbody "heat up" (285° - 315°) - 130 minutes

Blackbody "cool down" (315° - 285°) - 100 minutes

View Angle Range "clear view" - (230.750° - 232.050°)

Number of Frames of "clear view" Data - 15

Included Groove Angle - 40.5°

Index View Angle - 284°

Nominal Blackbody View angle - 231.4°

Angle of Incidence on Scan Mirror for Nominal View - 26.3°

