On-Board Calibration Algorithms

Harry Montgomery

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Pre-Launch On-Board Calibration (OBC)

- **Transfer Ground Calibration to OBC**
  - *MODIS (All Bands)*
    - -Spectral
    - -Spatial
    - -Radiometric
  - *On-Board Calibration*

    SRCA
    - -Spectral (Reflective Bands)
    - -Radiometric (Reflective Bands)
    - -Spatial (All Bands)

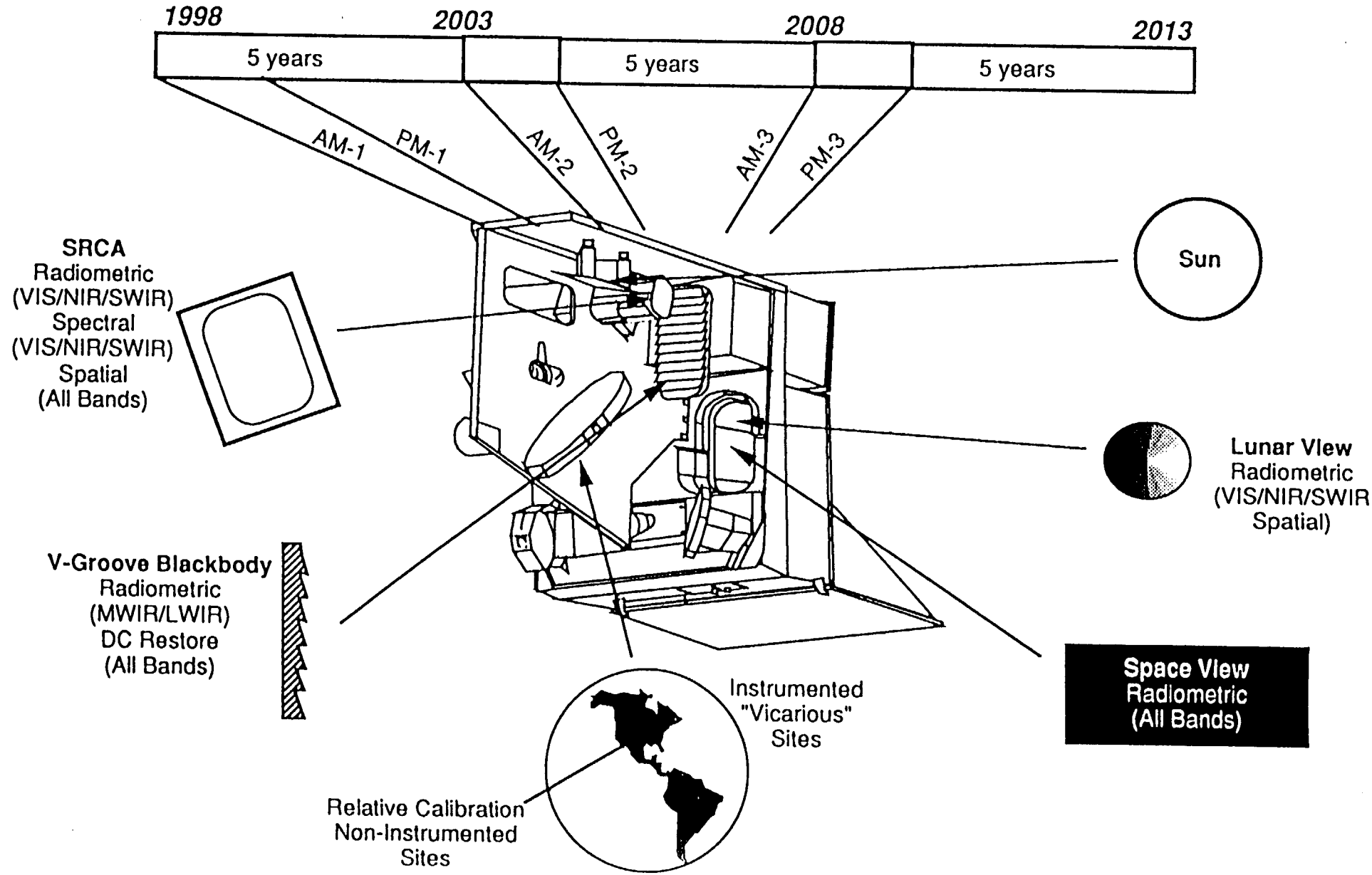
    SD/SDSM
    - -Radiometric (Reflective Bands)

    Blackbody
    - -Radiometric (Emissive Bands)

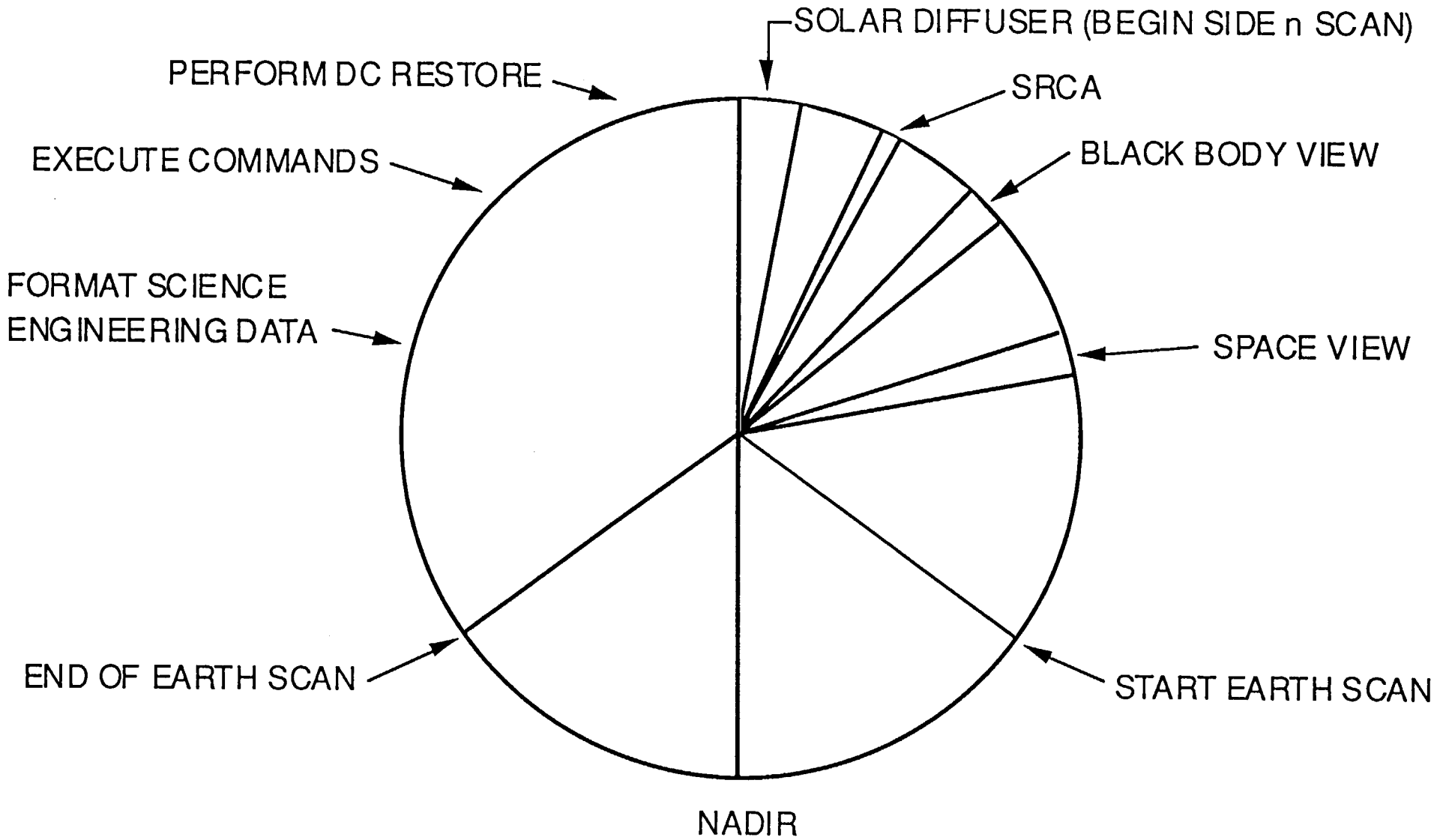
    Space View
    - -Zero Radiance Level (All Bands)

EOS MODIS MISSION ELEMENTS

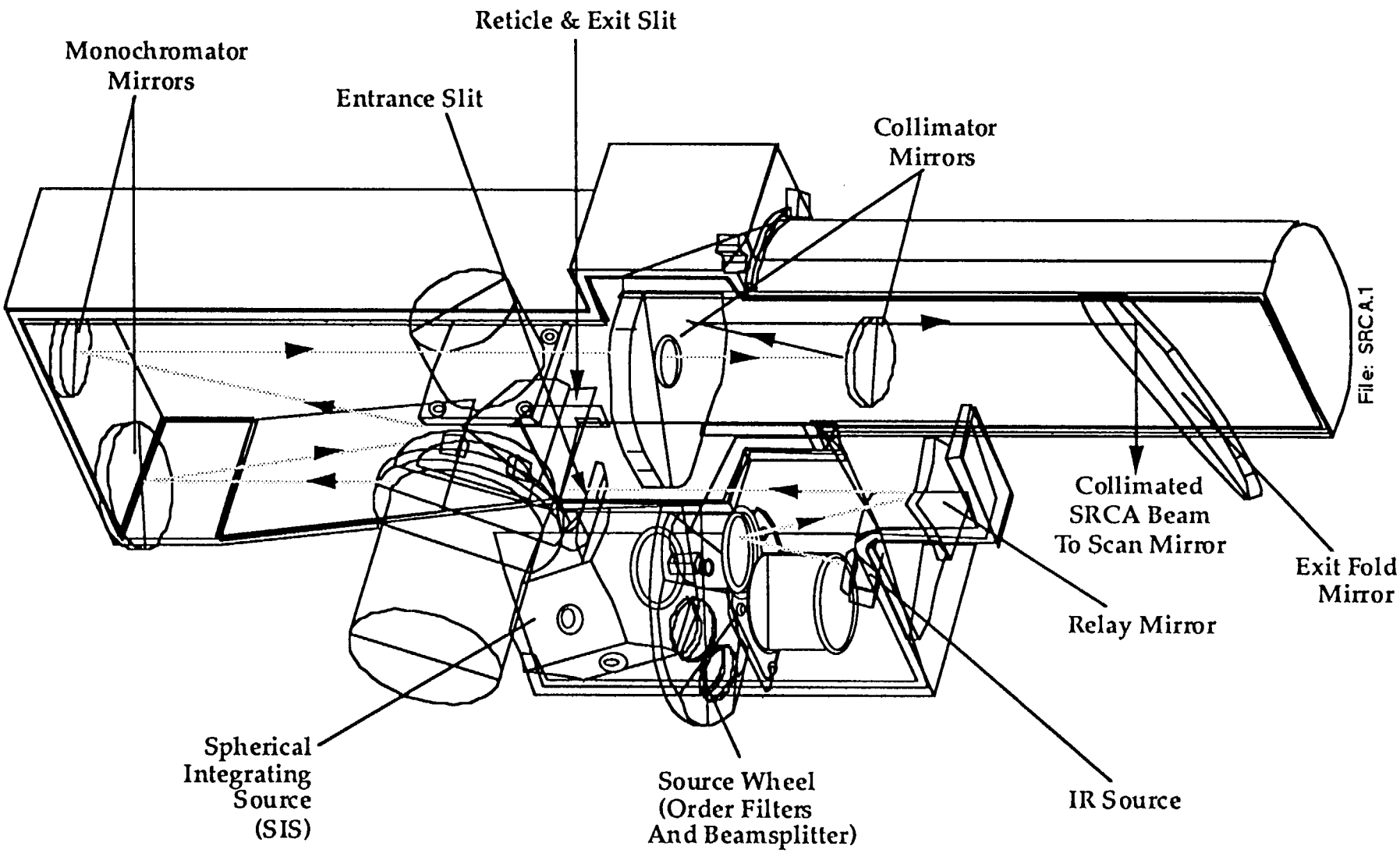
6 INSTRUMENTS
15 YEAR MISSION
6 CALIBRATION SOURCES



Data Sequence for One Scan (Mirror Side 1 or 2)



MODIS Spectral Radiometric Calibration Assembly (SRCA)



SRCA Processing

•~5 Frames per Scan •~800 Scans per Orbit
(Assuming 20% Duty Cycle)

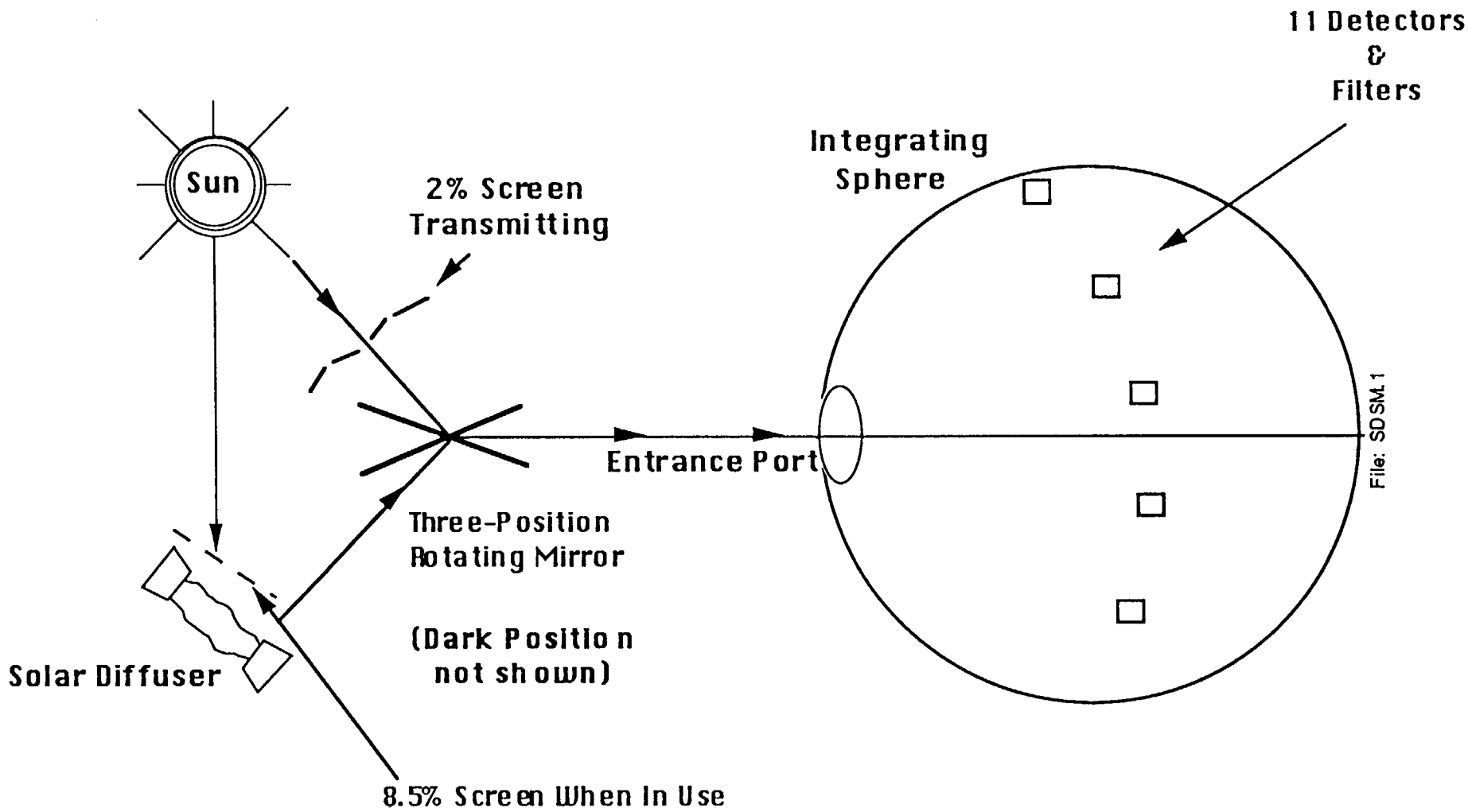
•One Lamp State at a Time

	TIME (min)	BAND
Radiometric Calibration	17	Reflective
Spectral Characterization (Center Wavelength)	75	Reflective
Spatial Registration*	37	ALL

*Both Along Scan and Along Track

•Compute Radiometric Calibration, Center Wavelength or Spatial Registration

MODIS Solar Diffuser Stability Monitor



Solar Diffuser Processing

(~35 Frames per Scan)
(~30 Scans per Orbit)

- Analyze SDSM Data
- Obtain Degradation Constant for SD
- Correct SD Observations for BRDF and Degradation Effects
- Calculate Average SD Values

Check SD Stability: Analyze SDSM Data

SDSM Calculations:

$$Q_{SD}(\lambda,t) = R'(\lambda)\, K' K(\theta)'\, f(\lambda,\theta,\phi,\theta',\phi',t) \cos\theta\, S(\lambda)$$

$$Q_S(\lambda,t) = R'(\lambda)\, K(\lambda)\, S(\lambda)\, K(\theta)$$

$$K(\lambda) = \frac{Q_S(\lambda,t_0)\, f(\lambda,\theta,\phi,\theta',\phi',t_0)\, K' K'(\theta) \cos\theta}{Q_{SD}(\lambda,t_0)\, K(\theta)}$$

$$f(\lambda,\theta,\phi,\theta',\phi',t_1) = \frac{K(\lambda)\, Q_{SD}(\lambda,t_1)\, K(\theta)}{Q_S(\lambda,t_1)\, K' K'(\theta) \cos\theta}$$

$$C(\lambda,t_1) = \frac{f(\lambda,\theta_1,\phi_1,\theta_1',\phi_1',t_1)}{f(\lambda,\theta_1,\phi_1,\theta_1',\phi_1',t_0)}$$

$$\langle C(\lambda,t_1)\rangle = 1/N \sum_{i=1}^{N} C_i(\lambda,t_1)$$

Solar Diffuser Calculations:

$$L(\lambda) = \langle C(\lambda,t_1)\rangle f(\lambda,\theta_1,\phi_1,\theta_2',\phi_2',t_0)\, S(\lambda)$$

$$\langle L(\lambda)\rangle = 1/N \sum_{i=1}^{N} L_i(\lambda)$$

t_0, t_1	= Time Before, After Launch
N	= Number of Data Points
Q_{SD}	= Solar Diffuser Counts from SDSM minus offset
Q_S	= Sun Counts from SDSM minus offset
$R'(\lambda)$	= Spectral Responsivity of SDSM
offset	= offset from dark position of SDSM
$f(\lambda,\theta,\phi,\theta',\phi',t)$	= BRDF of Solar Diffuser
$S(\lambda)$	= Solar Spectral Irradiance
$K(\lambda)$	= Attenuation of SDSM sun-screen
K'	= 1 for no solar diffuser screen = 0.085 for solar diffuser screen
$K(\theta)'$	= obliquity factor for solar diffuser screen
$K(\theta)$	= obliquity factor for SDSM solar screen
$C(\lambda,t_1)$	= Degradation of SD panel
$\langle C(\lambda,t_1)\rangle$	= Average Degradation Value
$L(\lambda)$	= Spectral Radiance
$\langle L(\lambda)\rangle$	= Average Spectral Radiance

Calculate the MODIS SD Data

For all detectors for which the current solar diffuser mode will provide values within those detectors' dynamic ranges.

$$\langle Q\rangle = 1/N \sum_{i=1}^{N} Q_i$$

$\langle Q\rangle$	= Average Solar Diffuser Value for MODIS
N	= Number of Solar Diffuser Values for MODIS
Q_i	= i^{th} Solar Diffuser Values for MODIS

DK-0010

Space View Processing

- 15 Frames per Scan
- Occurs Every Scan

- Compute Scan Average Over 15 Frames for Two Consecutive Scans. Interpolate Throughout Scan.

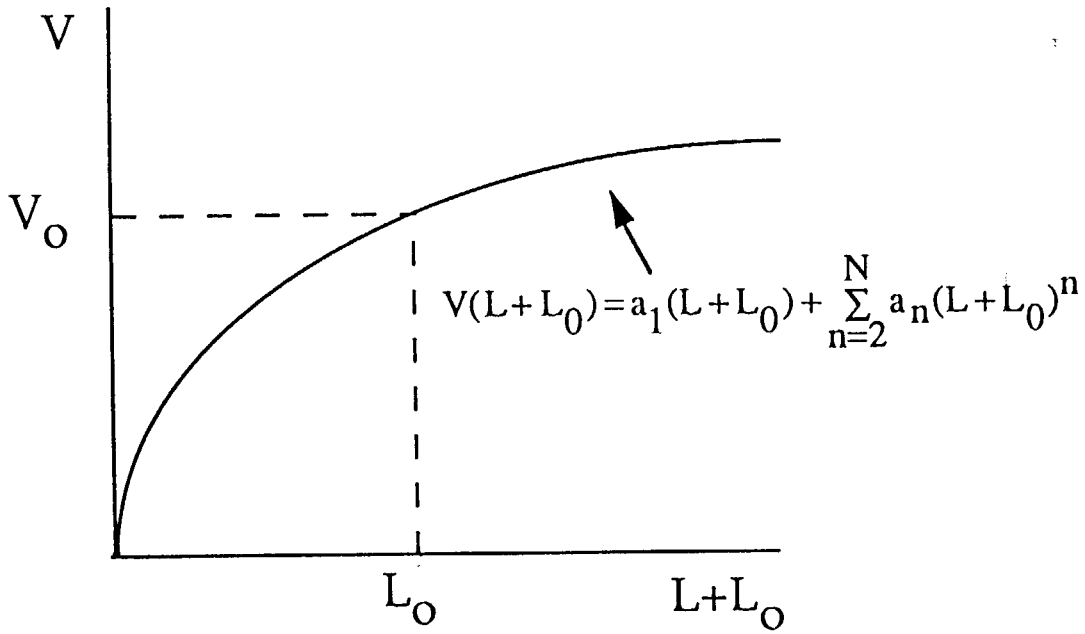
Black Body Processing

- 30 Frames per Scan
- Occurs Every Scan

- Correct each observation for gradient effects. Obtain effective temperature, radiance.

- Compute "Weighted" Average of all Observations for Calibration Every Scan for Two Consecutive Scans. Interpolate throughout Scan.

Emissive Band Calibration



Where: a_n =From Pre-Launch test; n=2, N

L_0=Effective Radiance At Aperture during Space Look

V_0=V(L_0)=Space View Signal

$$a_1=\frac{V_B-\sum_{n+2}^{N} a_n(L_B+L_0)^n}{(L_B+L_0)}$$

V_B=Blackbody Voltage

L_B=Blackbody Radiance

Post-Launch On-Board Calibration

- Use OBC to calibrate MODIS.

- OBC will Degrade.
  - .Need SD Characteristics (BRDF) With Age
  - .Need Lamp Characteristics (Intensity versus Wavelength) With Age
  - .Need "Best" Algorithm from Synthesis