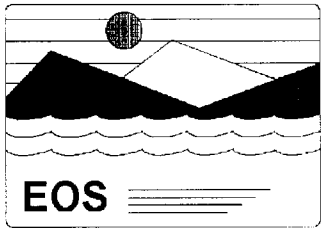
TECHNICAL CONCERNS OF MAY 1995
&
PRESENT STATUS



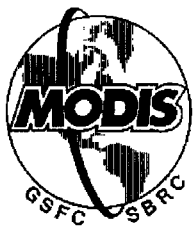
- TRANSIENT RESPONSE (NEAR-ANGLE SCATTER, GHOST & STRAY LIGHT)
  IMPLEMENTED PFM IMPROVEMENTS OVER EM:
    NEW PRESCRIPTION & LENS COATINGS FOR GHOSTING FIX
    PRE-FILTERS FOR S/MWIR AND LWIR OPTICS FOR GHOSTING FIX
    NEW DICHROIC 1 TO REDUCE SCATTER
    POINT SPREAD FUNCTION WILL BE MEASURED TO CHARACTERIZE

- SCAN MOTOR LIFETIME
  LONG-TERM BEARING LIFE TESTING CONTINUES WITHOUT FAILURE

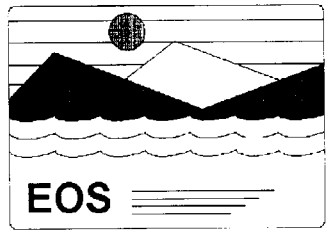
- BANDPASS FILTERS
  BAND 26 FILTER HAS BEEN REPLACED WITH COMPLIANT FILTER

- ELECTRONICS
  EM PROBLEMS IDENTIFIED AND CORRECTED FOR PFM

- RADIATIVE COOLER
  CONCERNS RETIRED BY SUCCESSFUL THERMAL VACUUM TEST IN OCT



OVERALL STATUS & OUTLOOK



- ENGINEERING MODEL TESTING AND ANALYSIS COMPLETED
  LESSONS LEARNED APPLIED TO PROTOFLIGHT MODEL

- PROTOFLIGHT MODEL BUILD-UP WELL UNDERWAY
  OPTICS COMPLETED, BOTH MIRRORS AND LENSES
  RADIATIVE COOLER COMPLETED AND SUCCESSFULLY TESTED
  DETECTORS COMPLETED AND INSTALLED
  MAINFRAME REFURBISHED
  SCAN MOTOR ENCODER DUE IN DECEMBER
  ELECTRONICS IN ASSEMBLY
  ON-BOARD CALIBRTORS: SDSM DUE DECEMBER; SRCA DUE FEBRUARY

- COST AND SCHEDULE ARE ALWAYS A CONCERN
  TIGHT FUNDING IN FY96 PARTICULARLY CHALLENGING

- HUGHES HAS REVERSED ITS PLAN TO MOVE THE SBRC OPERATION
  TO EL SEGUNDO

MODIS SCIENCE TEAM MEETING

Tom Pagano

November 1995

HUGHES
AIRCRAFT

11/95
95-0483-01

AGENDA

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- SBRC to Remain in Santa Barbara Remote Sensing!
- EM Significant Accomplishments
- PFM Performance Predictions
- Calibration Highlights
- PFM Nearing Completion: Video
- Looking Ahead–Plans through Delivery

ENGINEERING MODEL SIGNIFICANT ACCOMPLISHMENTS

EM HIGHLY SUCCESSFUL EFFORT

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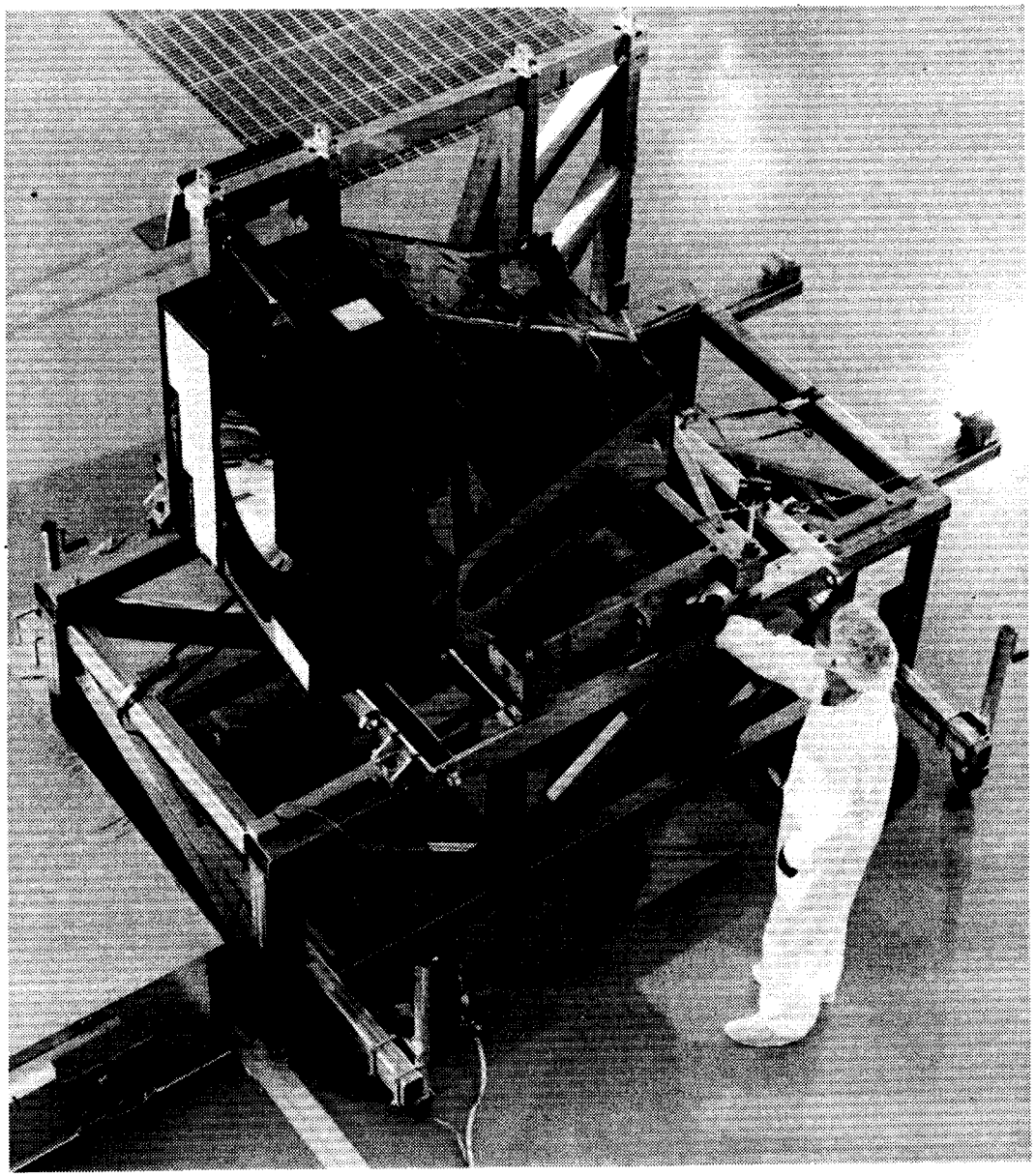
- Objectives accomplished
  - To prove out instrument design
  - To debug development and build cycle
  - To demonstrate GSE and test method effectiveness
  - To identify problem areas
  - To develop an experienced instrument team
- MODIS design proves robust
  - No instrument failures during thermal vacuum
  - No need to break vacuum–instrument functioned well
- Note: Three EM subsystems reused for PFM
  - Scan Mirror
  - Mainframe
  - Radiative Cooler



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95-4-75(10)

EM MODIS FULL BUILD-UP OF MAJOR SUBSYSTEMS

MODIS

GSFC SBRC

MODIS GROUND SUPPORT EQUIPMENT IN-PLACE

95-6-47

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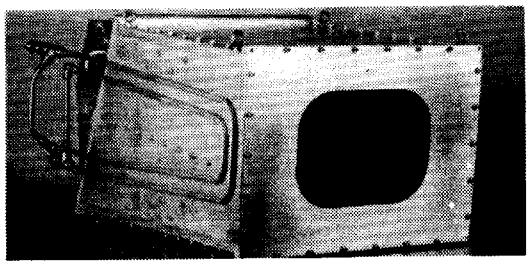
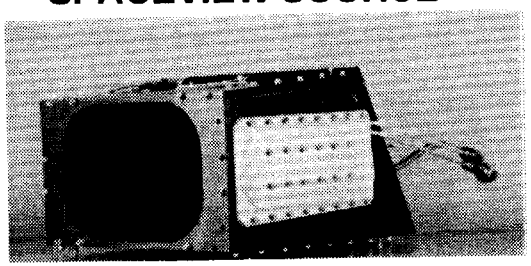
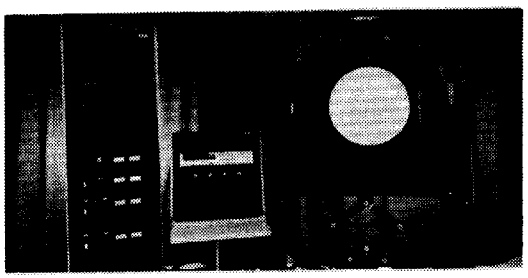
BLACKBODY CAL SOURCE



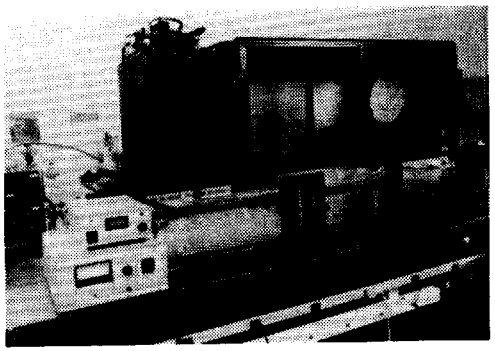
SPACEVIEW SOURCE



SPHERICAL INTEGRATOR SOURCE



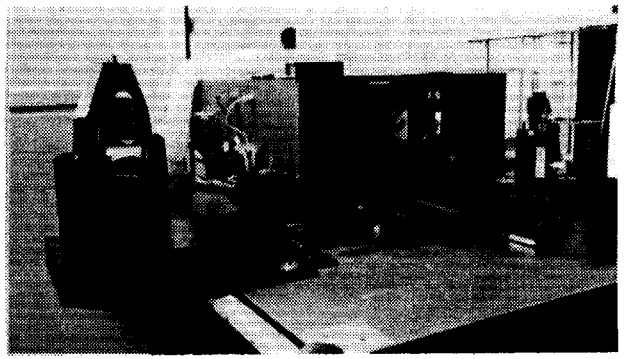
POLARIZED SOURCE ASSY



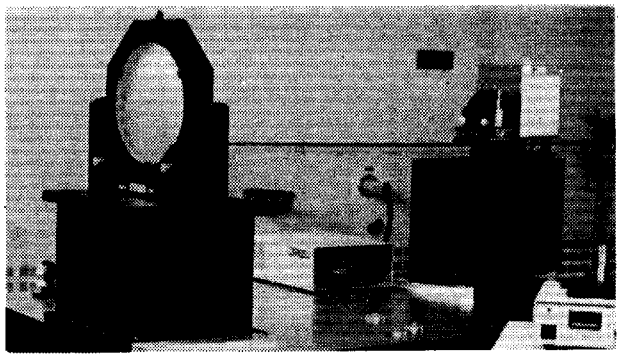
INTEGRATION AND ALIGNMENT COLLIMATOR

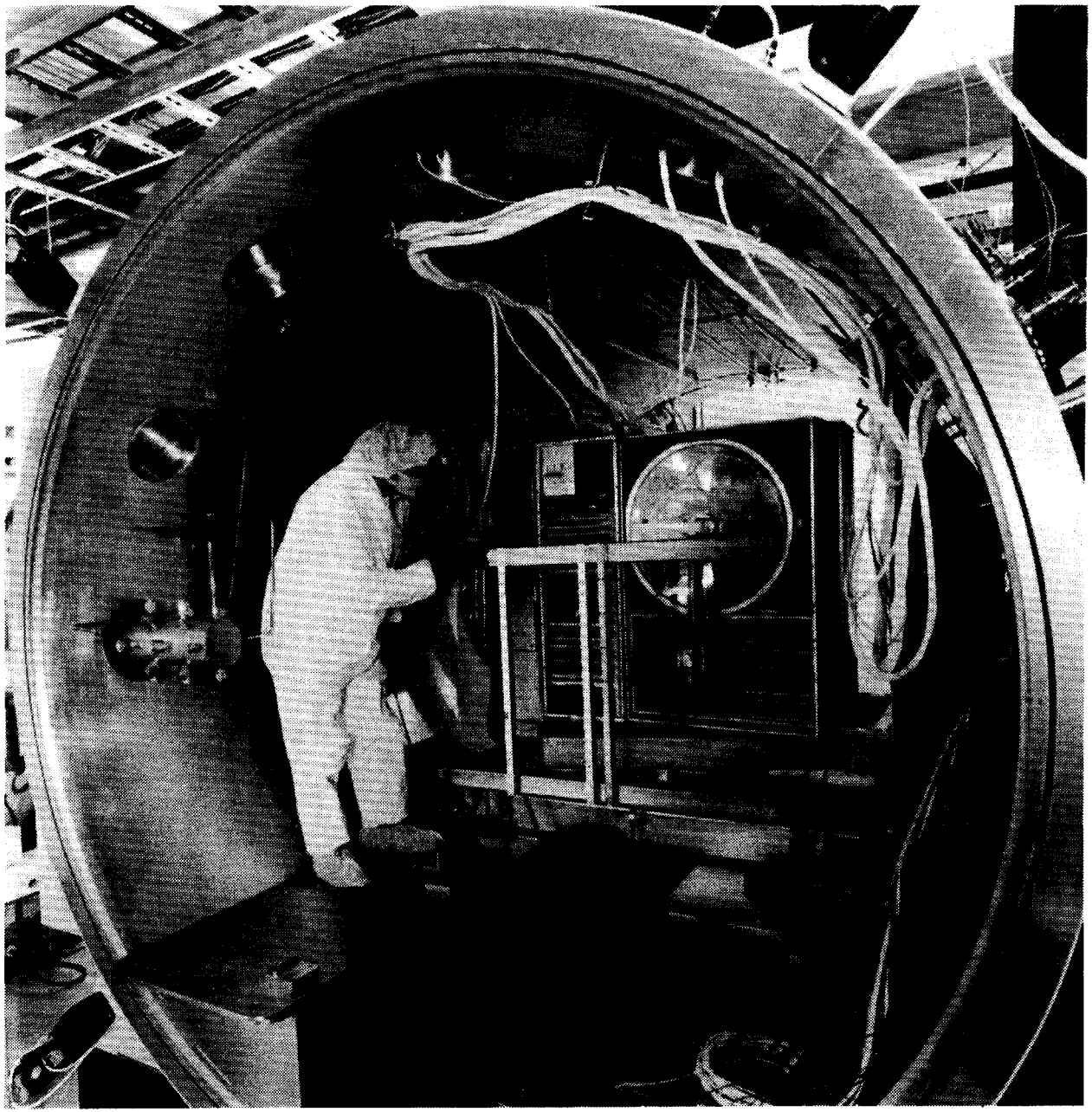
BENCHTEST COOLER SYSTEM TEST COMPUTERS

SPECTRAL MEASUREMENT ASSY



SCATTER MEASUREMENT ASSY





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95-03-079-8

MODIS E.M. INSTALLED IN MODIS CALIBRATION CHAMBER (INTERIOR)

MODIS

GSFC SBRC

EM PERFORMANCE RESULTS ENCOURAGING

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- Radiometric Performance: All bands met specs except 5, 6, 8, 29, 33, 35, 36
- EM detectors suffered premature saturation: Corrected for PFM
  - Higher capacitance of FPA readout circuits
  - Improved aft-optics background shielding
  - Reduced optics operating temperature
- Polarization < 3%; Most cases in spec. Proves out design approach
- Near Field Response out of specifications
  - Very challenging technical requirement
  - MODIS performance comparable or better than predecessors
  - Problem areas identified to fix on PFM
  - Expect characterization to be better than 1 in 10^{-4}
- Registration: Meets goal in VIS/NIR, spec in SW/MW; LW out due to dewar stem shift. Corrected for PFM
- Spectral response good. Monochromator problems fixed for PFM
- Excellent functional performance of the EM. Commands, telemetry, control systems, power dissipation

NEARLY ALL LESSONS LEARNED ON EM CORRECTED FOR PFM

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EM Lessons Learned	Fixed for PFM	REA	Comments
Polarization Sensitivity			
Noncompliant by ≤1% in Selected Bands	No	Optics	A few bands don't meet spec at a few Angles.
Near Field Response			
Dichroic Scatter	Yes	Optics	Replace OCLI with OFC
NIR ZnSe Lens Scatter	No	Optics	Most likely not going to change out E2 for PFM
Band 1, 2 Filter Leal	Yes	Optics	Flip Filter
Pixel 1, Band 1,2 Crosstalk	Yes	FPAs	Lines crossed in EM SCA
Leaks into Band 21 into 5, 6, 7, 26	Yes	Optics	Improved mask coating eliminated effect for PFM
LWIR Leak Between PV and PC	Yes	Optics	Paint a stripe at affected area.
Crosstalk 31 into 36	Yes	Optics	Reduced ghosting; Effect not seen during AOA tests
Crosstalk from Output Bias Supply	Yes	FPAs	Bias supply for EM tied to Analog supply
Window/Lens Ghosting	Yes	Optics	Tilted window; lens curvature modified
Radiometric			
Quantizing Resolution			
Differential Nonlinearity	Yes	Electronics	Bin uniformity within acceptable limits onEM
SNR Deficiencies			
Low Transmissions in LWIR	No	Optics	Limited by internal absorption in optics materials
High Analog Electronics Noise	Yes	Electronics	Flow down is 0.5 DN we're seeing about 1 DN
Low Dynamic Range			
Inoperative Cold Shielding	Yes	Opto/Mech	Improper implementation for EM
Small-Detector Feedback Capacitors	Yes	FPAs	Manufacturing effect. Larger Cfb for PF
Offset Irregularities			
Band 5 Offset High	Yes	FPAs	Fixed for PFM
PV LW Offset High	Yes	FPAs	Can be accommodated on PFM
PC Offset Response (Band 33 Pixel 5)	Yes	Electronics	Neighboring dead pixel affects offset
Spatial			
Band 25, 26 Positional Error	Yes	FPAs	Result of Filter swap for EM to PFM configuration
Sample to Sample Offset Error, 250m,500m	Reduced	FPAs	Effect reduced for PFM, removable in calibration
Channel to Channel Offset Error	Yes	Electronics	Improved reset in SAM electronics
Anomalous Signal Spikes	Yes	FPAs	Out of operating range for PFM
LWIR Misregistration	Yes	Electronics	PV LW bands off due to oversampling
Large Phase Delay Not Operational	Yes	Electronics	Required significant software modifications to test
Radiative Cooler Dewar Stem Shift	Yes	Opto-Mech	Observed 0.15 pixels; Accommodatable by Ø delay
Spectral			
Several Center W.L, BW, Edge Range Errors	No	Optics	Filter waivers submitted or planned. No surprises
Ecal			
Not Operating on EM	Yes	Electronics	Not Operating on EM
Bands 5, 6, 7 FPA Ecal Improper	Yes	FPAs	Readout Error
Functional Errors			
FIFO Swap	Yes	Electronics	Corrected for PFM
Telemetry Items	Yes	Electronics	Several minor items not implemented on EM

PERFORMANCE PREDICTIONS FOR PFM

Radiometric Sensitivity (SNR, NEΔT)
Polarization
Spatial: NFR, IFOV, MTF, Registration
Spectral: Center Wavelength, Bandwidth, Edge Range

PFM SNR/NEΔT CALCULATIONS HIGHLIGHT CRITICAL AREAS

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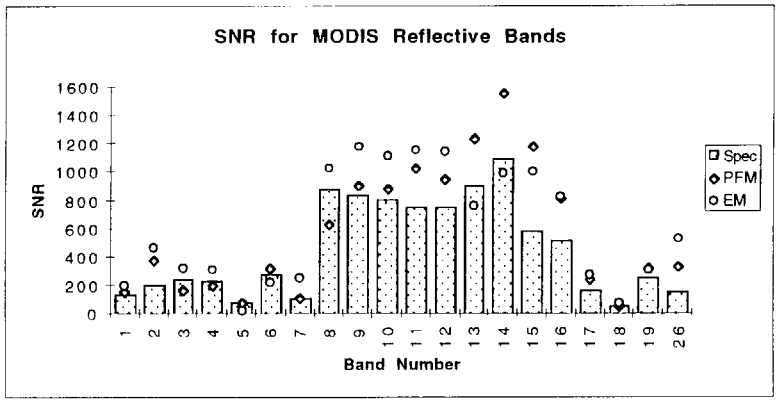
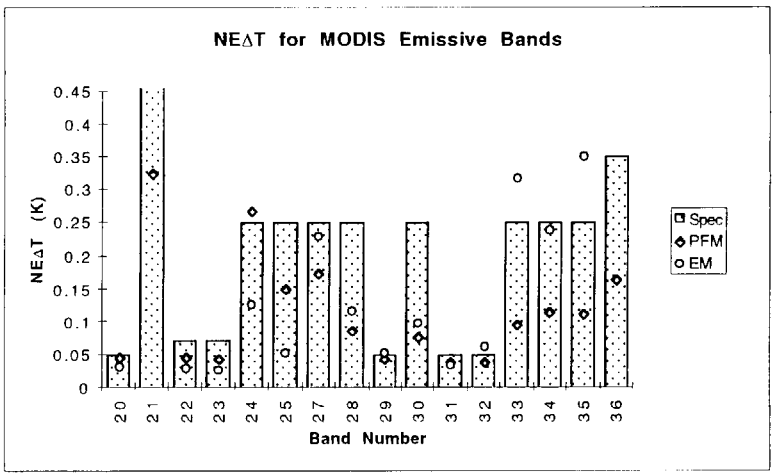
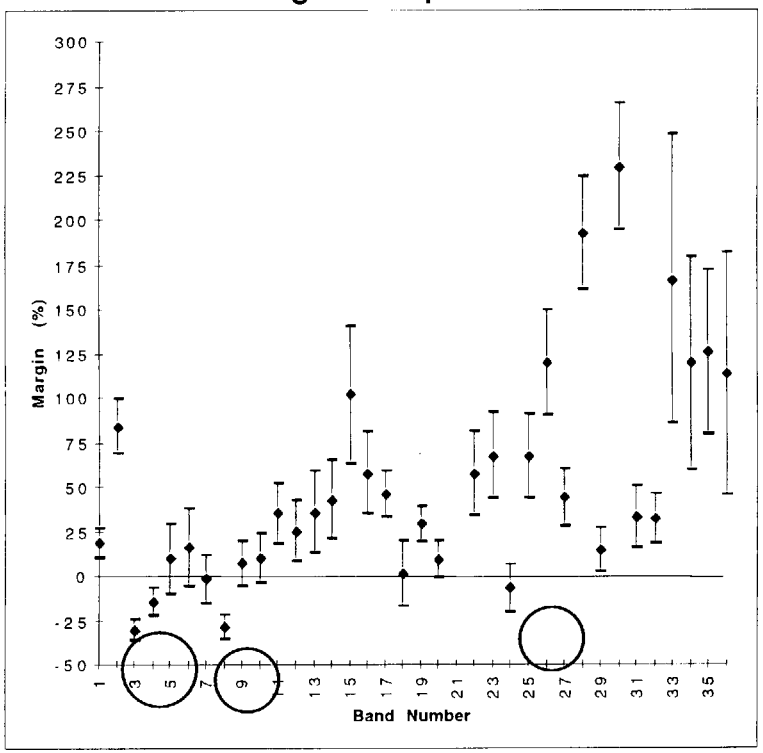




PFM Margins to Specifications



- Wide dynamic range bands limited at Ltyp by low gain
- EM noise values used – may improve with PFM noise values

NONCOMPLIANT SNRs IN VIS/NIR BELIEVED TO BE SOURCE RELATED

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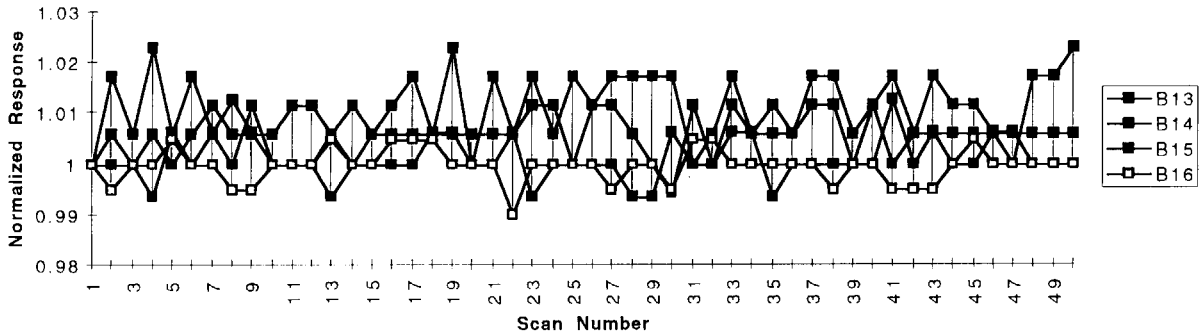
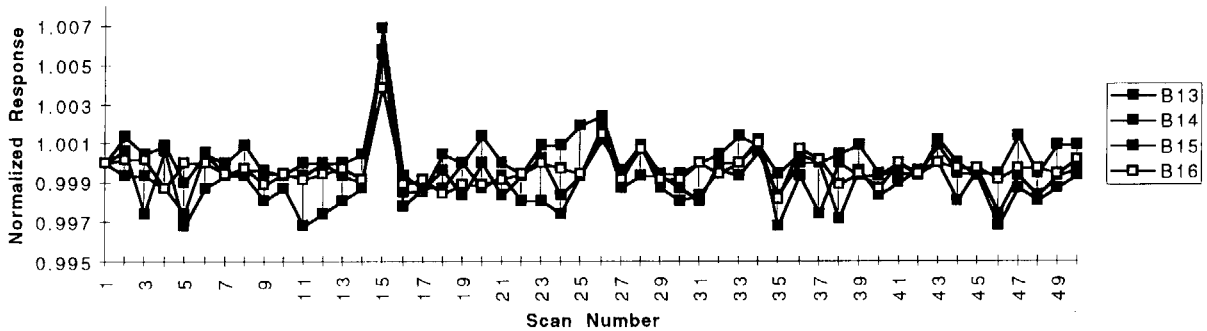
Space Viewport: No correlation between bands



Signal Viewport: Correlation between bands



- >1000:1 SNRs require source stabilities to better than 0.03% for < 5% error
- Observed ≈ 0.2% likely due to power supplies. Controllers on order for PFM. Test will verify.

PFM POLARIZATION EXPECTED TO BE SIMILAR TO EM

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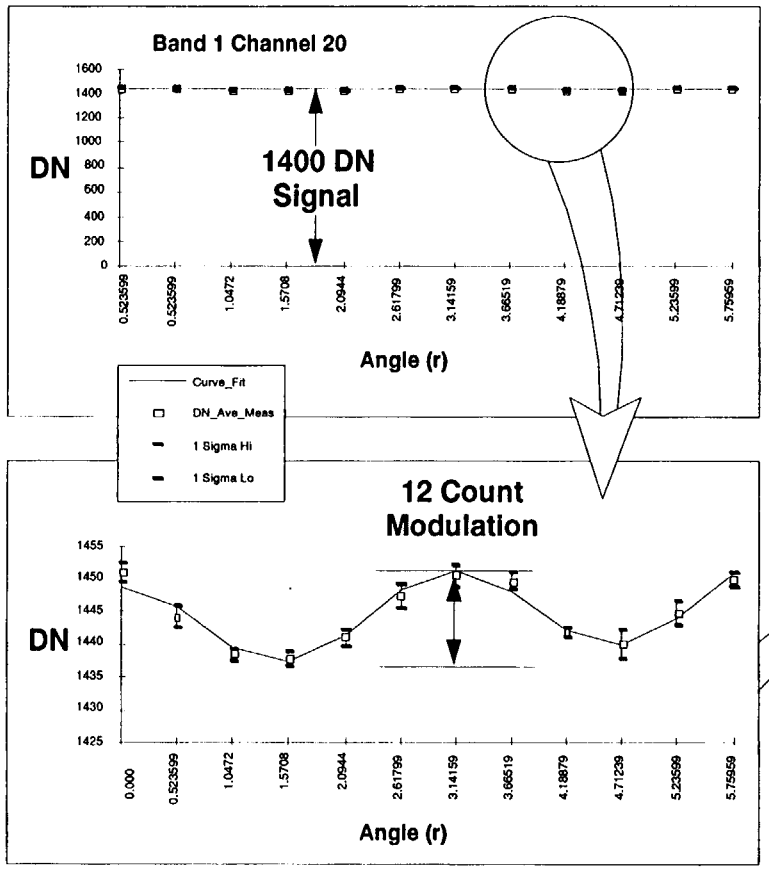
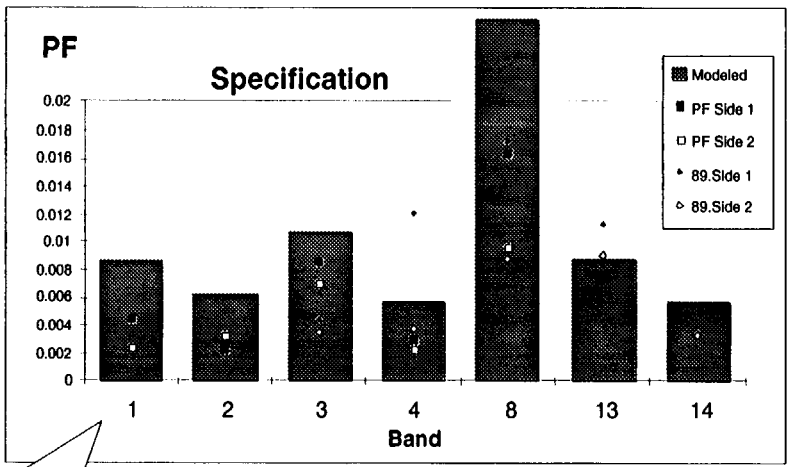
Raw Data Averaged Over 5 Scans



Polarization for MODIS at 45°



- All bands less than 3%
- Most meet 2% Requirement
- Correlation with model good
- PFM Test results expected to be better with improved alignment of source to MODIS

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MODIS NEAR FIELD RESPONSE COMPARED TO OTHER SENSORS

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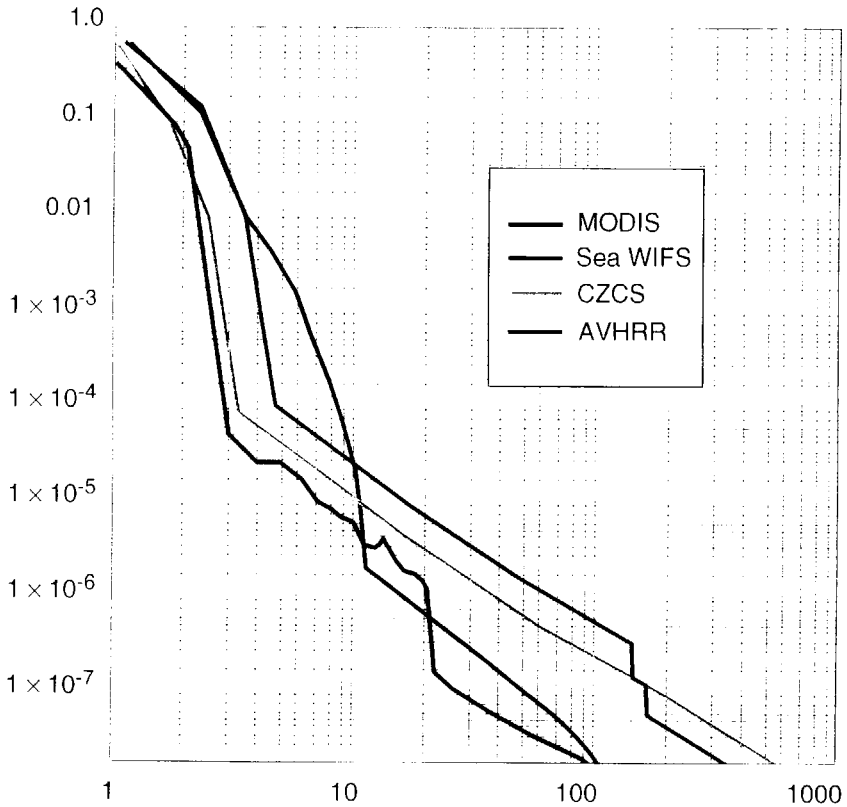

- Response to 1 x 10 km cloud
- Less than 10^{-4} response for MODIS at 3 km
- Contamination is a major player
  - MODIS must maintain approximately level 300
  - Sea WIFS as measured data
  - AVHRR & CZCS modeled at level 500
- Data generated by GSFC

EM AND PREDICTED PFM INTEGRATED NFR 2 KM FROM A 10 × 20 KM CLOUD

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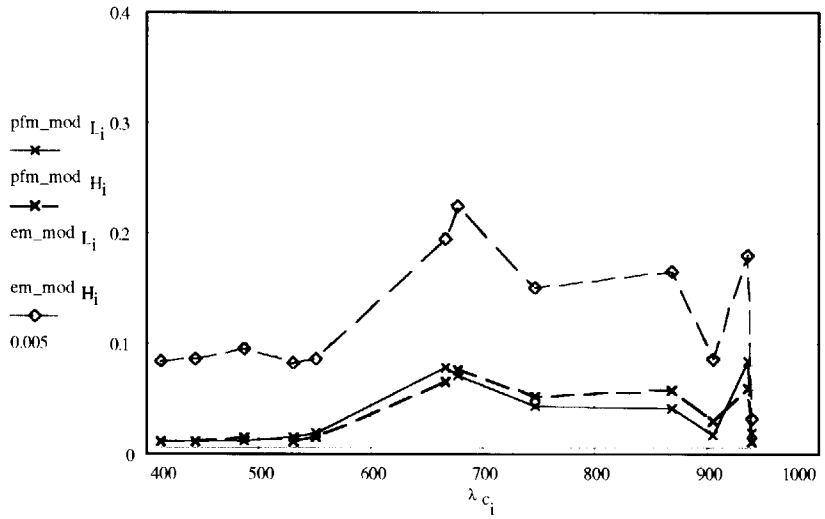
band	EM meas.		EM simulation		PFM simulation	
	low FD	high FD	low FD	high FD	low FD	high FD
8	0.070	0.096	0.078	0.083	0.011	0.012
9	0.064	0.092	0.074	0.086	0.011	0.012
10	0.056	0.104	0.070	0.095	0.011	0.014
11	0.103	0.076	0.099	0.082	0.014	0.012
12	0.135	0.078	0.125	0.085	0.018	0.014
13	0.275	0.243	0.227	0.195	0.078	0.065
14	0.265	0.316	0.211	0.224	0.071	0.076
15	0.142	0.221	0.129	0.150	0.043	0.051
16	0.110	0.181	0.121	0.164	0.040	0.057
17	0.049	0.102	0.051	0.086	0.017	0.030
18	0.064	0.186	0.245	0.180	0.084	0.059
19	0.018	0.037	0.054	0.032	0.018	0.011



- **Values normalized to Ltypical**
- **Spec - 0.005 Ltypical**
- **PFM values based upon replacement of dichroic 1 only**

EARLY MEASURE OF MTF MEETS SPEC– REGISTRATION MEETS "GOAL"

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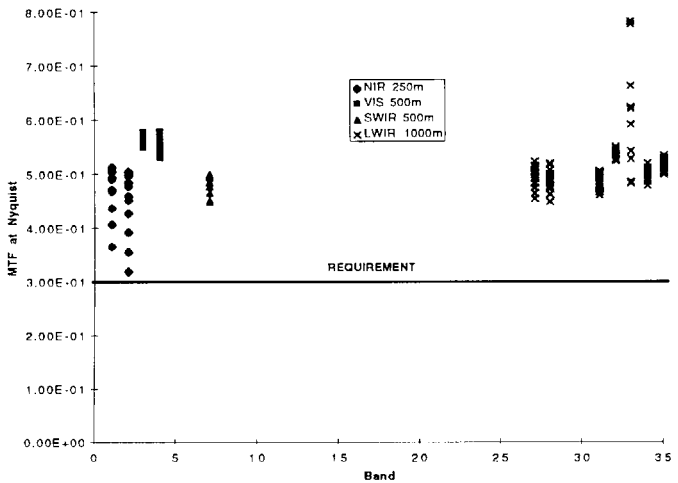
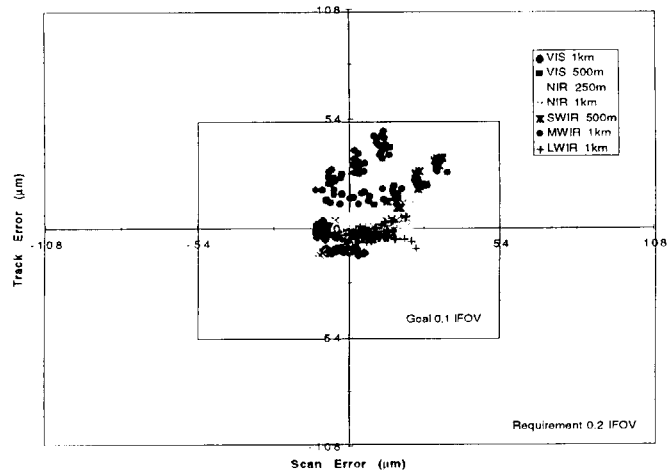
- MTF measured during AOA Integration
- MTF calculated for smallest pixels on FPA



- Registration plotted for all FPA's and sizes
- Includes dewar stem compensation



36 MODIS SPECTRAL BANDS INDIVIDUALLY TAILORED FOR BEST RESPONSE

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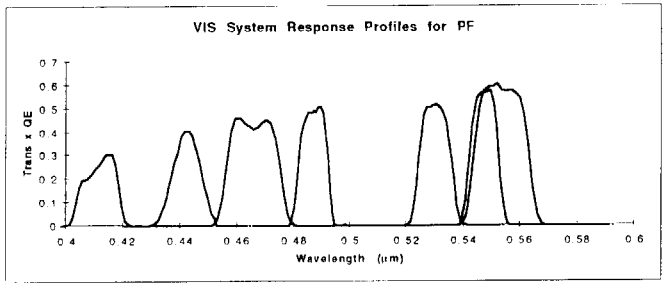

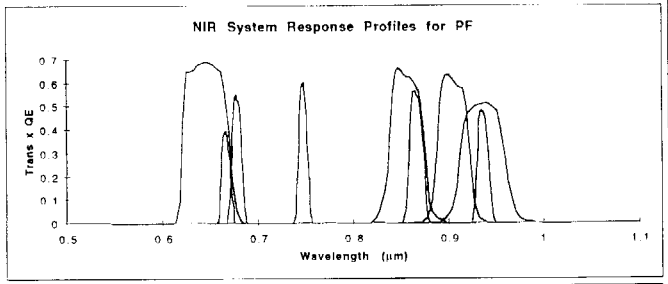

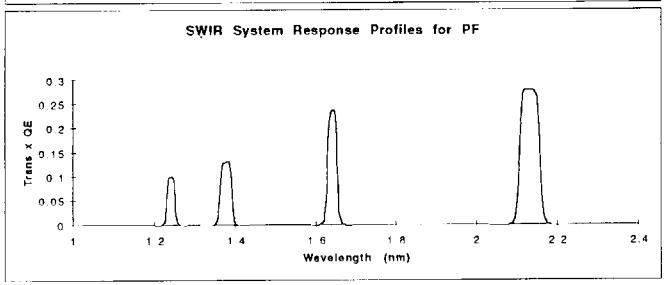

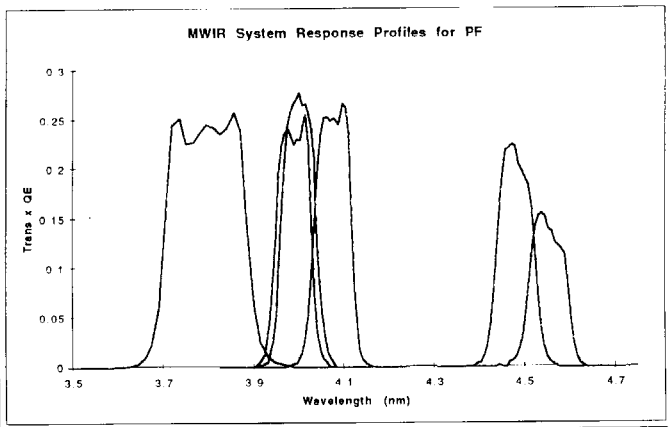

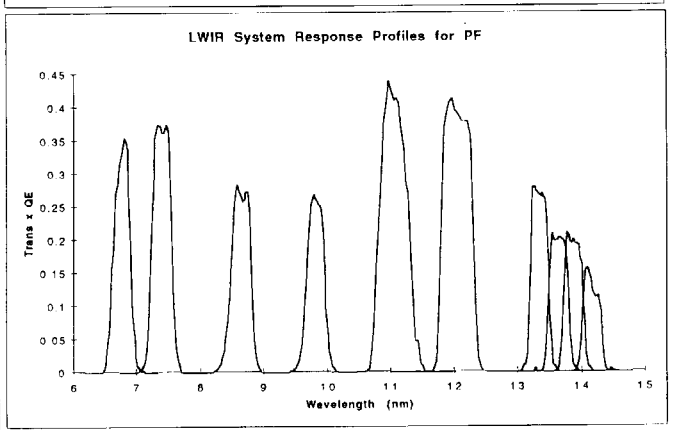

- **All profiles modeled for PFM based on component data**

PFM SPECTRAL NONCOMPLIANCES IDENTIFIED – WAIVERS SUBMITTED

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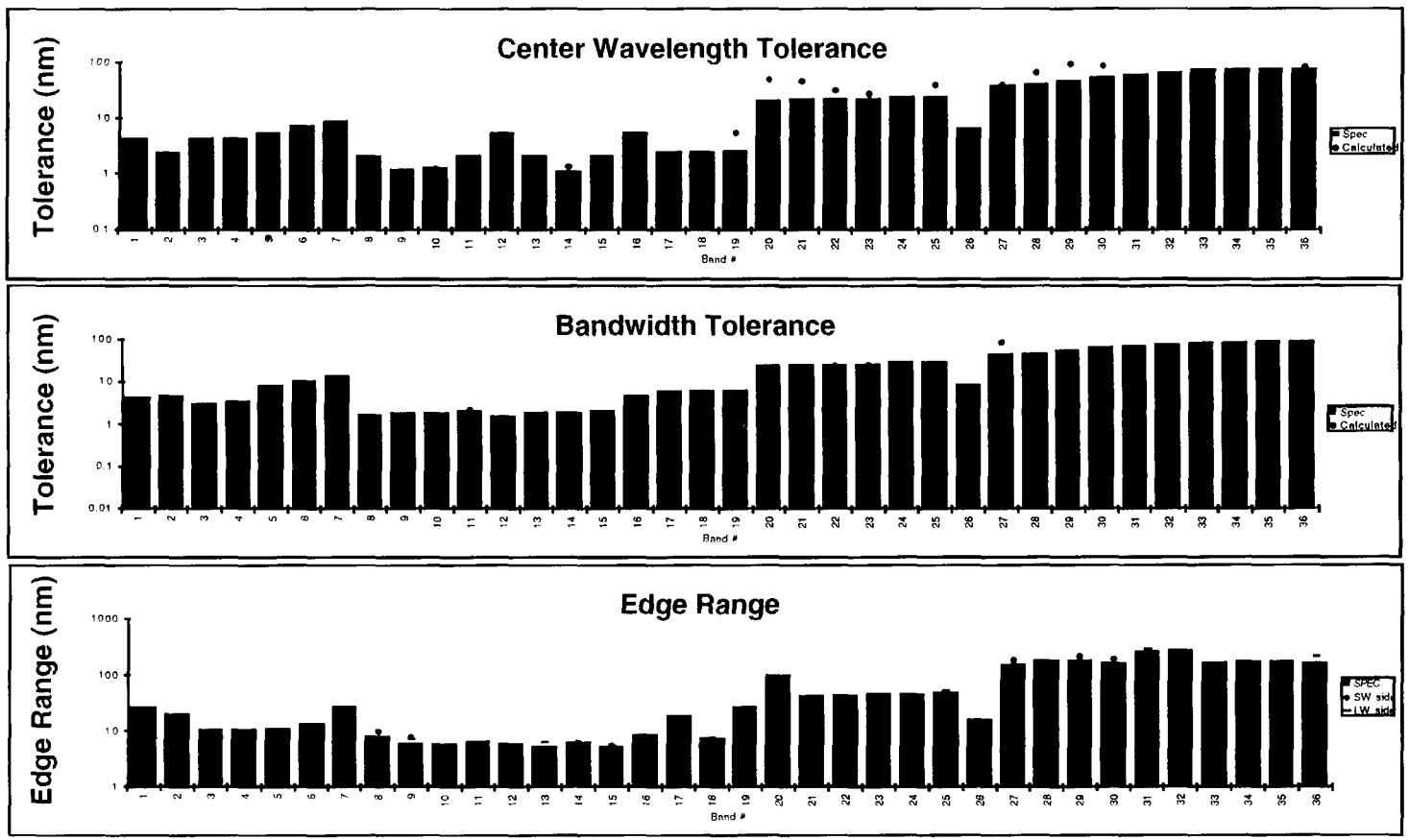

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CALIBRATION HIGHLIGHTS

IMPROVED RADIOMETRIC ACCURACY EXPECTED FOR PROTOFLIGHT MODEL DATA

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- Comprehensive test plan developed. Includes stability testing. Reviewed and refined at Calibration Peer Review
- Master curve approach demonstrated. Improves accuracy
- On-board blackbody (BB) performance looks good
- Ground based solar reflectance calibration in current plan. Provides calibration data for SD and SDSM. Improves accuracy
- SRCA to provide much useful data

MULTIPLE CALIBRATION SOURCES USED TO CALIBRATE MODIS: PREFLIGHT AND IN-ORBIT

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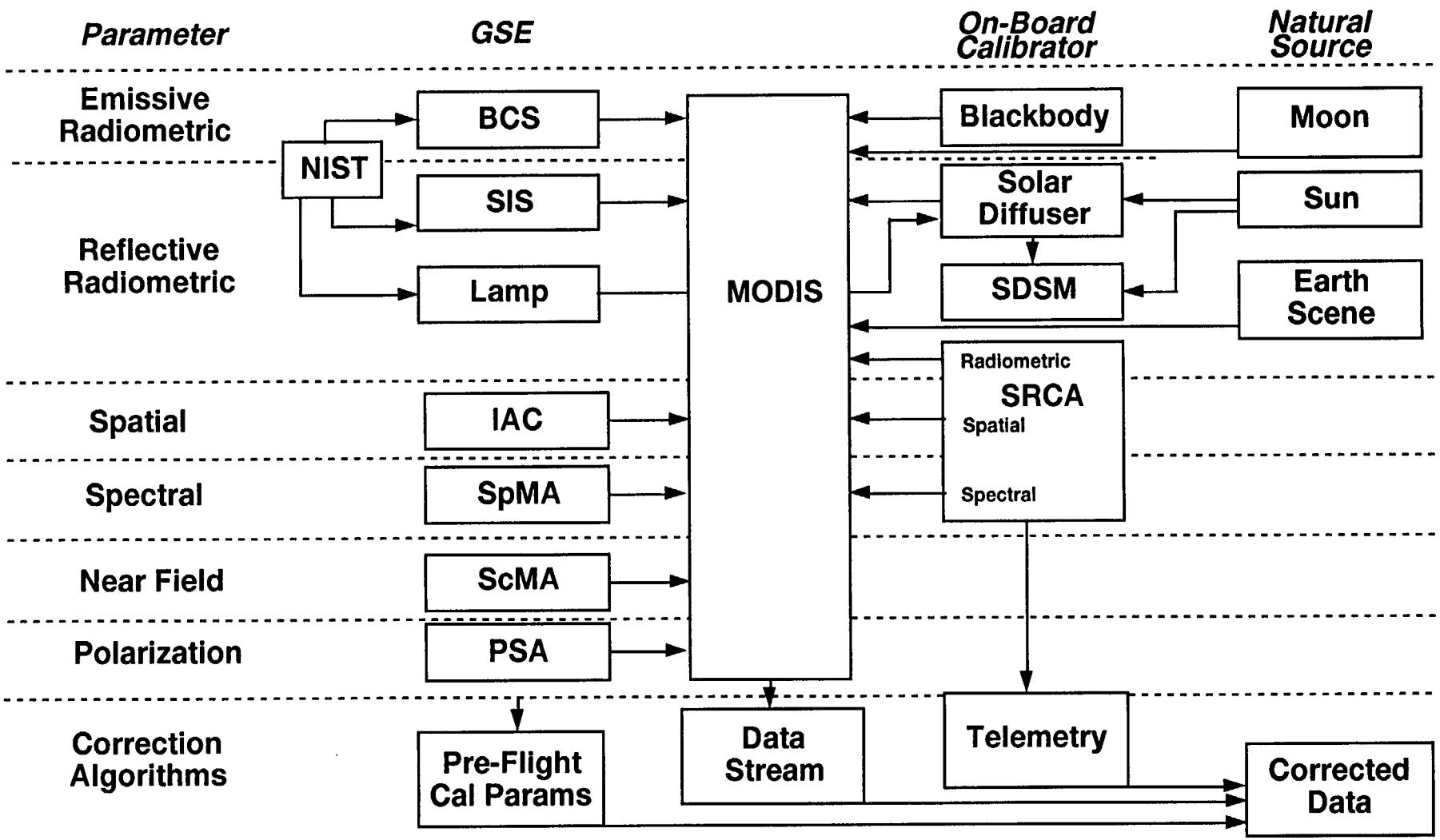

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TEST PLAN COVERS MAJOR PERFORMANCE AREAS

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- Radiometric Performance
  - Sensitivity: SNR, NEΔT
  - Linearity
  - Accuracy
  - Stability
- Spatial Performance
  - IFOV, MTF
  - Registration
  - Pointing Accuracy
  - Field of View, Response vs Scan Angle
- Polarization Insensitivity
- Spectral Response
  - In-Band
  - Out-of-band
- Stray Light
  - Near Field Response
  - Far Field Response
  - Spurious Response
- Electrical Tests
  - Fixed Pattern Noise
  - Differential Nonlinearity of A/Ds
  - Electronic Calibration
- On-Board Calibrators
  - Solar test for SD and SDSM
  - Blackbody Calibration
  - SRCA Cross Calibration
- Functional Tests
  - Command and Telemetry
  - Data Stream Verification
  - Door Functional
  - Redundancy
  - Control Systems
- Environmental
  - Temperature cycling; thermal balance
  - Vibration
  - EMC, EMI, Acoustics, Etc.

MASTER CURVE APPROACH DEMONSTRATED ON EM

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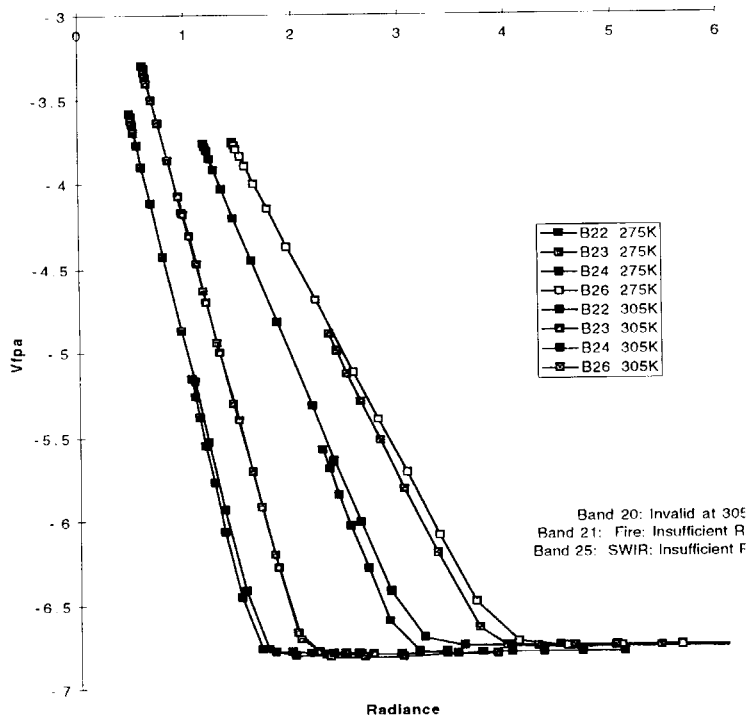
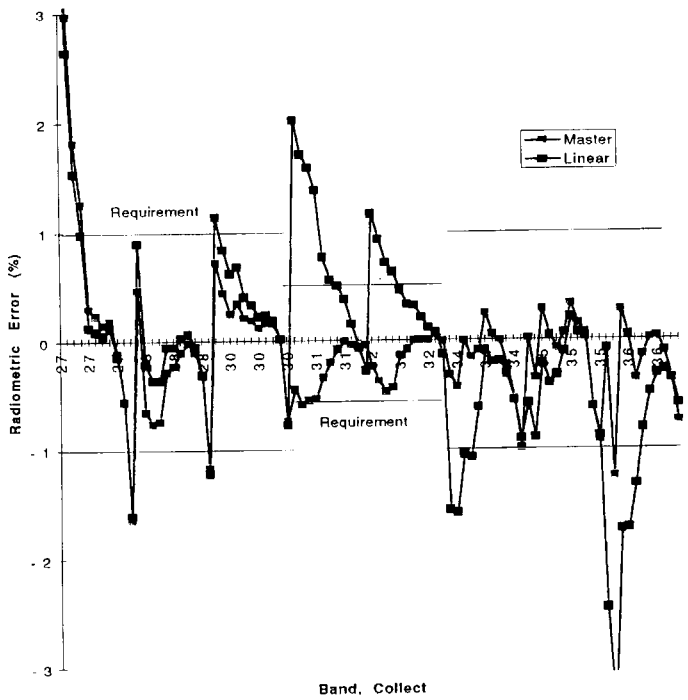
- Master curve independent of optics temperature



- Technique improves accuracy over standard approach. Best in 31-36



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95-0483-23

ON-BOARD BLACKBODY "EFFECTIVE" EMISSIVITY MEETS SPECIFICATIONS

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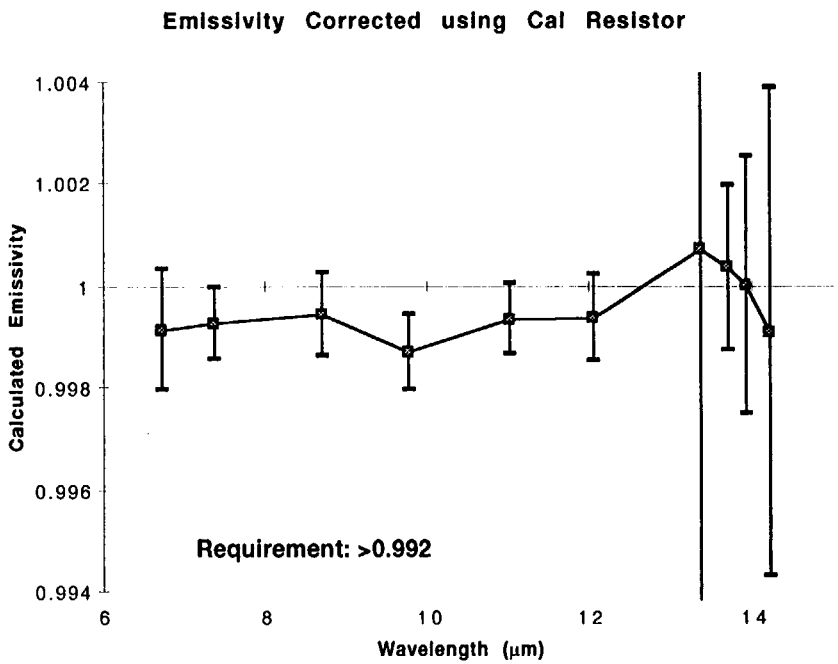
- Measured during EM system test
- OBC BB radiance calculated based on average temp of 12 sensors
- Sensors corrected using cal curves and reference resistors
- External Blackbody Calibration Source (BCS) radiance calculated
- MODIS used as transfer system
- "Effective Emissivity" determined relative to BCS. Includes temperature errors
- Error bars represent system noise
- Emissivity meets specifications



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SOLAR STIMULATION IS BEST METHOD FOR SDSM AND SD TESTING

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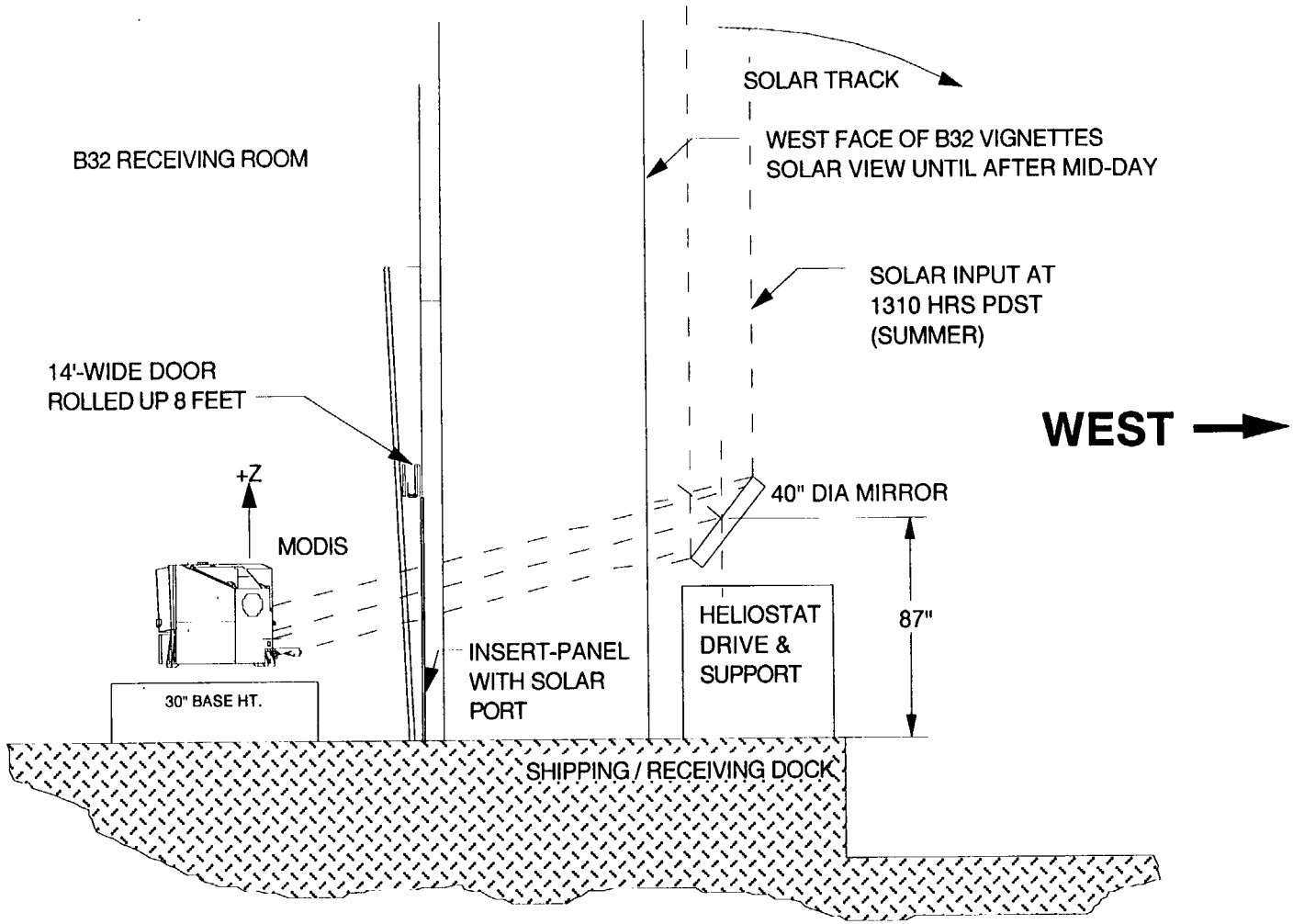

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SRCA PROVIDES TESTING AT MANY LEVELS

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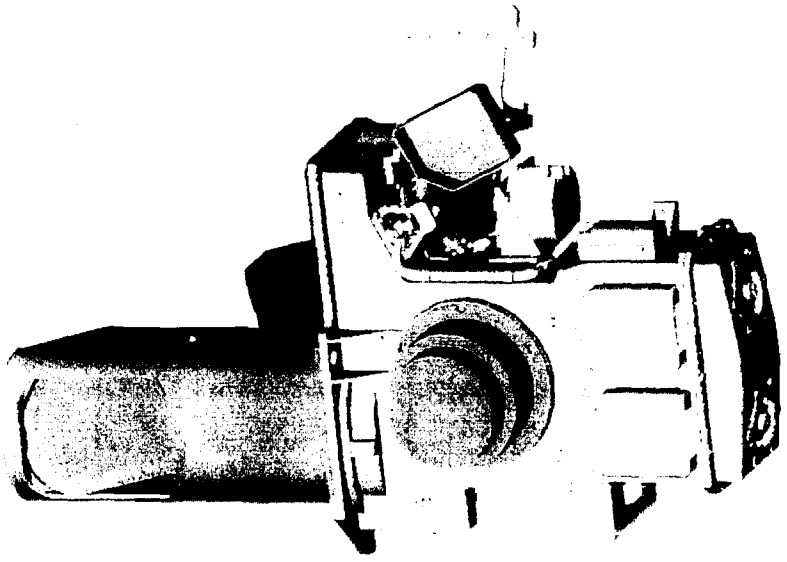
- **Thermal Vacuum at SBRC**
  - Cross-calibration of radiometric, spatial and spectral performance
- **Post delivery testing at LMAS**
  - Only source for VNIR/SWIR testing at LMAS
  - Testing can be performed with or without all doors closed in any environment
- **In-orbit testing**
  - Spatial, Spectral, Radiometric stability monitoring
  - Possibly contamination/scatter monitoring



PFM DEVELOPMENT STATUS: VIDEO

MODIS PRIMARY SUBSYSTEMS COMPLETE

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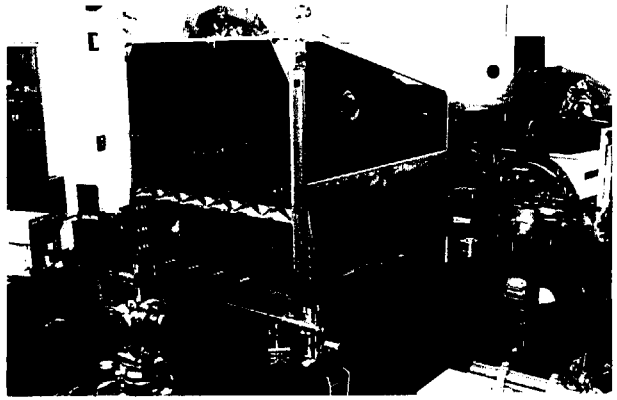
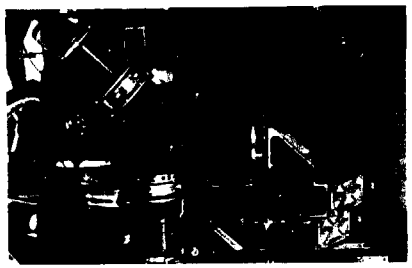
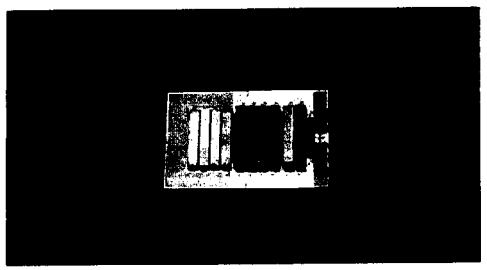
RADIATIVE COOLER



MAINFRAME

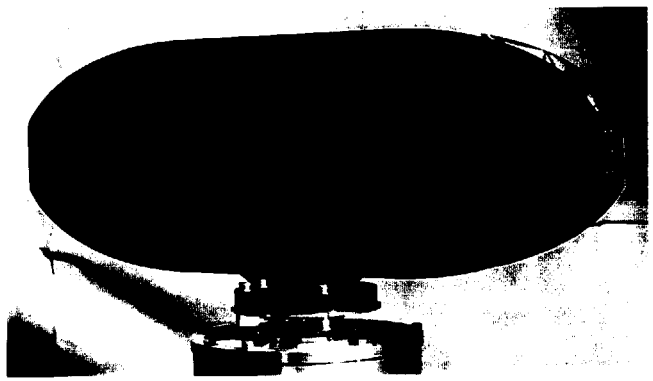


RE-IMAGING OPTICS

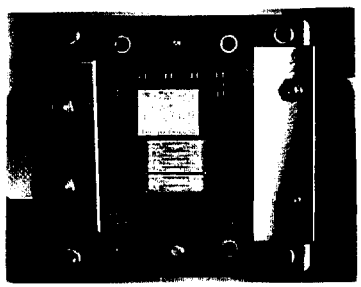


FILTER/DICHROICS

AFOCAL TELESCOPE



SCAN MIRROR ASSY.



FOCAL PLANES

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MODIS ON -BOARD CALIBRATORS IN HARDWARE DEVELOPMENT

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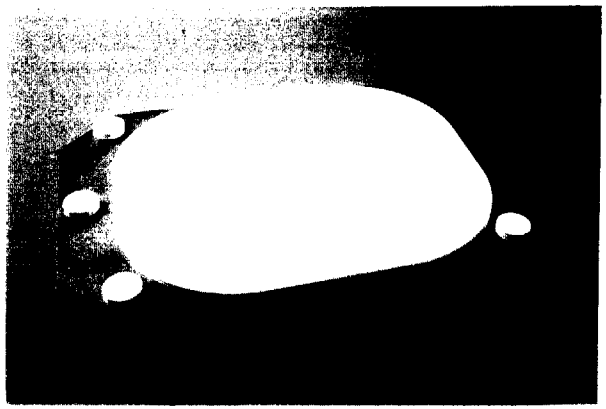
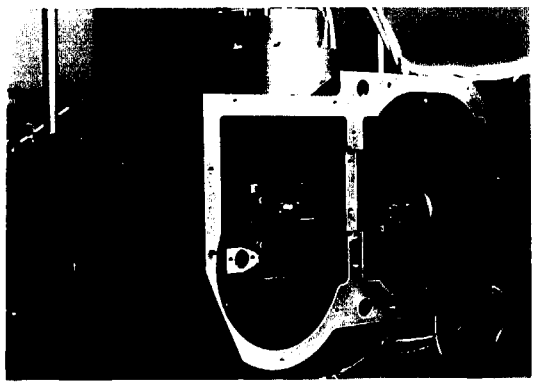
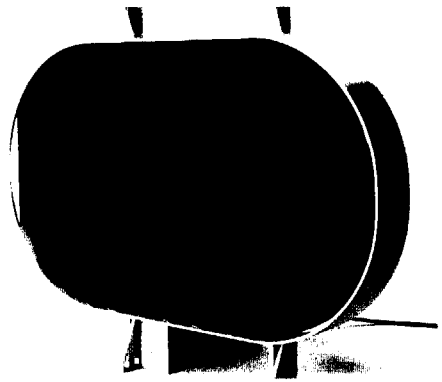


SOLAR DIFFUSER

SDSM SPHERE



SRCA



BLACKBODY

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PLANS THROUGH DELIVERY

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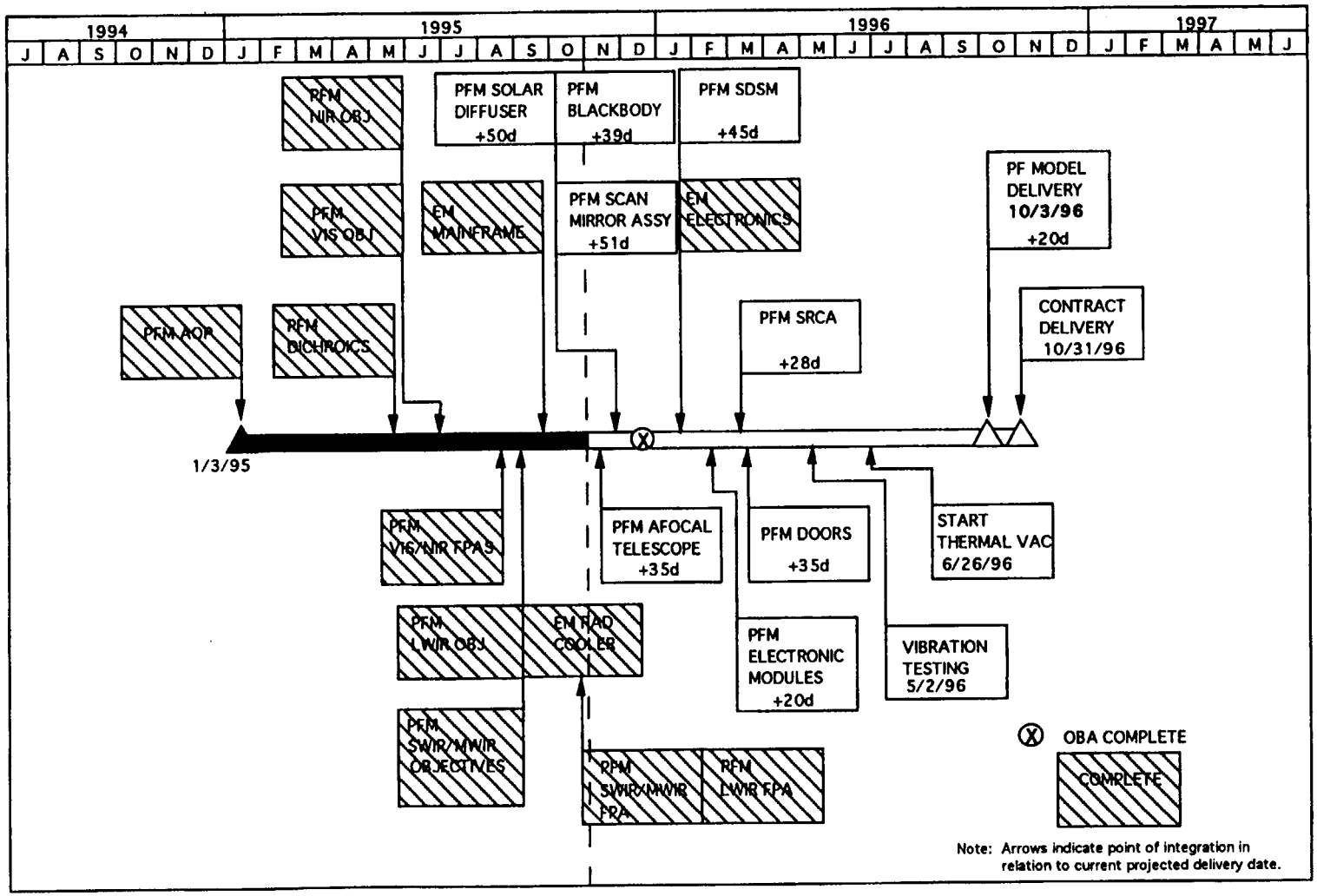

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Status as of Month End10/26/95

TECHNICAL CONCERNS OF MAY 1995
&
PRESENT STATUS

- TRANSIENT RESPONSE (NEAR-ANGLE SCATTER, GHOST & STRAY LIGHT)
  IMPLEMENTED PFM IMPROVEMENTS OVER EM:
    NEW PRESCRIPTION & LENS COATINGS FOR GHOSTING FIX
    PRE-FILTERS FOR S/MWIR AND LWIR OPTICS FOR GHOSTING FIX
    NEW DICHROIC 1 TO REDUCE SCATTER
    POINT SPREAD FUNCTION WILL BE MEASURED TO CHARACTERIZE

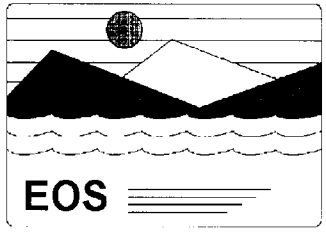
- SCAN MOTOR LIFETIME
  LONG-TERM BEARING LIFE TESTING CONTINUES WITHOUT FAILURE

- BANDPASS FILTERS
  BAND 26 FILTER HAS BEEN REPLACED WITH COMPLIANT FILTER

- ELECTRONICS
  EM PROBLEMS IDENTIFIED AND CORRECTED FOR PFM

- RADIATIVE COOLER
  CONCERNS RETIRED BY SUCCESSFUL THERMAL VACUUM TEST IN OCT

OVERALL STATUS & OUTLOOK



- ENGINEERING MODEL TESTING AND ANALYSIS COMPLETED
  LESSONS LEARNED APPLIED TO PROTOFLIGHT MODEL

- PROTOFLIGHT MODEL BUILD-UP WELL UNDERWAY
  OPTICS COMPLETED, BOTH MIRRORS AND LENSES
  RADIATIVE COOLER COMPLETED AND SUCCESSFULLY TESTED
  DETECTORS COMPLETED AND INSTALLED
  MAINFRAME REFURBISHED
  SCAN MOTOR ENCODER DUE IN DECEMBER
  ELECTRONICS IN ASSEMBLY
  ON-BOARD CALIBRTORS: SDSM DUE DECEMBER; SRCA DUE FEBRUARY

- COST AND SCHEDULE ARE ALWAYS A CONCERN
  TIGHT FUNDING IN FY96 PARTICULARLY CHALLENGING

- HUGHES HAS REVERSED ITS PLAN TO MOVE THE SBRC OPERATION
  TO EL SEGUNDO