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INTERNAL MEMORANDUM

TO: Gary Barnett
CC: Lloyd Candell, Rod Durham
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REF: PL3095-N01790, 92-8222-2526
SUBJ: Review of MODIS Characterization and Calibration Philosophy
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This memo is an attempt at documenting a dynamic, evolving calibration/characterization review. This review process is a multidimensional task. When one assumption is made the ramifications of it are felt in many areas. My initial intent was to document numerous paths with multiple decision branches. I finally decided that I could not do this. It was a larger task than I initially thought. The documentation below is a more linear approach. Hopefully, it will aid in finalizing this review. It is a strawman that we can talk about, tear apart, and hopefully achieve something better in the process.

INTRODUCTION

The MODIS characterization and calibration philosophy is under extensive review. The reason for this review is projected costs for FY'93 are in excess of the available funding. The MODIS FY 93 cost were discussed at the science team meeting in October.

Since a significant part of the 1993 cost problem was due to increased projected costs for the optical stimuli a special meeting of the calibration panel was held at the science team meeting to address cost issue. In general, the science team wanted to retain the on-board calibration capability of MODIS and, as necessary, reduce the scope and complexity of the preflight calibration.The following guidelines were proposed.

1. Rethink the characterization / calibration philosophy
2. Accept an approach that will have added risk
3. Place higher importance on the OBC mechanisms
4. Use the OBC mechanisms as much as possible for preflight testing.
    a. Use SRCA for preflight in vacuum measurement of spectral response
    b. Use SRCA for preflight in vacuum measurement of SBR
5. Retain radiometric calibration using SIS(100) for ambient & vacuum tests
6. Retain BCS / SVS concept for IR thermal calibration
7. Eliminate Calibrator #2
8. Modify and simplify Calibrator #1 to the extent possible
9. If 4a and 4b are fully successful eliminate calibrator from T/V tests.
10. Do not need MTF in the T/V tests.

The above suggestions should only be used as guidelines. At this time the only major relaxation of specifications being considered is a reduction in the spectral band registration requirement from 0.1 IFOV to 0.2 IFOV. There are no changes in the other specifications. Although it is true that the MODIS program climate is such that greater risks will be acceptable.

Attachment #1
Tech Team Mtg - 11/19/92

LISTING OF GENERALIZED APPROACHES

We need to outline and define some alternative approaches to the characterization and calibration of the MODIS system. These approaches need to be defined in a manner such that several factors can be evaluated :

- Associated costs can be quantified. This evaluation needs to address hardware costs, cost savings in one area may have cost impact in other areas, cost may be deferred in time
- How is the characterization and calibration hardware concepts modified?
- Quantify the relative risks for the various approaches
- Denote any required NASA specifications changes.

It will be difficult to define unambiguously. Nevertheless an attempt is made below. There are four approaches outlined. The initial emphasis will be focused on the GSE optical stimuli.

Common to all four approaches is a on-going review of combining two collimators, EFL/MTF and IA. Combining these two collimators into one is technically feasible and reduces equipment cost. Scheduling aspects are under review. If objective lens assembly build up and Integration and Alignment activity need to be done concurrently then it will be necessary to have two collimator devices.

Approach I GSE optical stimuli baseline at the time of PDR

Approach II Retain the basic characterization / calibration capabilities of the optical stimuli with the following modifications.

a. The solar test source is eliminated.

b. The calibrator #1 "point source assembly" is eliminated.

c. The calibrator #1 pointing capability is to be manual (the automated portion will be eliminated).

d. The in vacuum calibrator #1 focus capability is eliminated.

e. The calibrator #1 will still be vacuum compatible but will not have the self spectral check that Approach I has.

f. Analyses associated with using the optical stimuli and MODIS instrument on a common vibration isolated table has been deleted from the optical stimuli work area.

g. Calibrator #2 is eliminated.

h. There is a major reduction of design and analyses tasks. Some of which would be picked up by system engineering and the remainder increases the residual risks.

In addition to the above, address changes in the following areas.

i. Change "IA collimator" from a narrow field to a 1 by 1 degree field.

j. The MODIS will be fixed in the thermal vacuum chamber. Thus a vacuum compatible rotary table is not required. In addition a sophisticated structure to permit motion of cable and plumbing is not required.

Approach III In addition to the reductions given under Approach II the calibrator #1 would not be usable in the thermal vacuum.

a. System level MTF would not be measured in thermal vacuum.

b. Full aperture system level spectral band registration would not be measured in the thermal vacuum.

c. Full aperture relative spectral response would not be measured in thermal vacuum.

Approach IV Eliminate the unobscured wide field calibrator #1. Subsystem tests are devised as substitute for system level tests. The MODIS OBC mechanisms are used extensively in tracking preflight characterization and calibration in ambient and vacuum environments.

DISCUSSION OF VARIOUS APPROACHES

Approach I has the least associated risk factors. However there has been a significant projected cost growth. A portion of these costs would be expended in FY'93. These costs when added to other MODIS projected increases results in our exceeding the MODIS funding caps for FY'93. This is unacceptable. Thus, nothing more will be said about this approach. Table I shows the System Performance Test Matrix, from Calibration Management Plan, which is consistent with Approach I.

Approach II has increased risks over Approach I. Each item listed under Approach II down-scope is addressed below. No detailed analyses have been made to quantitatively assess various down-scope items. Responses are keyed to corresponding items listed in "LISTING OF GENERALIZED APPROACHES".

a Relatively simple subsystem tests can be devised that will give more quantitative results than the solar test source(STS) would have provided. STS was used in a portion of the stray light measurement strategy. A high intensity strobe light may be an alternative.

b. Elimination of the point source from the calibrator will require the measurement of crosstalk to be done at the filter-detector subsystem level.

c. We have used manual pointing capability in past calibrator assemblies, thus I find this acceptable.

d. The elimination of the calibrator focus capability requires that we use materials such that there will be acceptable focus shifts over the Calibrator thermal vacuum temperature range.

e. Removal of the calibrator self spectral check in vacuum does add risk to us not being able to identify ambient to vacuum shifts unambiguously. To reduce this risk silver mirrors will be measured in a multiple pass White cell in an attempt to characterize ambient to vacuum shifts. We will better understand the real risks associated with this after the White cell ambient/vacuum silver mirror reflectance data is available.

f. System analyses (modeling) should be done to reduce risks associated with measurement of SBR when MODIS and Calibrator #1 are mounted on a common vibration isolated platform.

g. Elimination of Calibrator #2 may pose a short term schedule problem if and when a Calibrator is needed at spacecraft integrator (GE). Currently the required testing back at GE is not well understood, thus the risk associated with it is unknown.

h. The reduction of design and analyses increases associated risks.

i. The IA collimator is currently viewed as a narrow field collimator. This sources at the collimator focal plane are scanned via a pointable mirror in between the IA collimator and the MODIS optical assembly being measured and / or assembled. This is a technically feasible approach and the collimator optics will be inexpensive. However the use of the IA collimator in this mode will be time consuming. This may result in measurement stability limitations and will certainly take longer to obtain all of the needed data. Thus we should consider a collimator that has a 1 by 1 degree field coverage. For the remainder of this review memo I will assume that the IA collimator has a 1 by 1 degree field of view coverage.

j. Secondly, although not related to the optical stimuli budget we have assumed that the MODIS is rotatable in the thermal vacuum chamber. I understand that this requires a sophisticated set up to be able to permit motion of MODIS cabling and the plumbing that is connected to space view source and the radiative cooler space background simulation.

My overall assessment of this approach is positive. The risks are increased but they seem reasonable to me. Table II is a modified System Performance Test Matrix that is consistent with Approach I

Approach III as indicated above is similar to Approach II with the exception that the Calibrator #1 will not be used in the thermal vacuum chamber. The Calibrator would be used in ambient environment to characterize the initial MODIS system level spectral band registration performance and relative spectral response.

a. The MODIS MTF performance is not a system driver. Thus the exclusion of T/V measurement is not considered a serious risk item. The SRCA functional capability could be extended to measure MTF performance. No addition hardware would be required. The limitations relate to the SRCA partial aperture and the measurement would be restricted to cross track. The methodology employed would be a knife edge measurement with the knife edge phase being changed using the on-board sampling phase adjustment capability.

b. The spectral band registration performance is a major driver in the MODIS characterization and calibration. The thermal environment of the radiative cooler is different between ambient and vacuum since a bench test cooler is used to cool the detectors in ambient testing and the radiative cooler is cooled radiatively in the vacuum chamber. On past programs there have been focal shifts between the two methods of cooling. The radiative cooler would be tested as a subsystem to quantitatively assess the difference between bench test and radiative cooling.

   The SRCA is a partial aperture device that can measure spectral band registration. However to the degree that those effects depend upon full aperture illumination the SRCA has limitations. This is considered a high risk at this time.

c. We believe that some of the ambient to vacuum radiometric calibration shifts observed in past sensors are in part due to spectral shifts. Very little information is available for us to make projections on what is a reasonable risk model. The SRCA can measure MODIS spectral band centers which would provide useful data. However, the SRCA has definite limitations in measuring spectral band profiles. This limitation is associated with the grating positional drive motor non-linearity and repeatability. Currently to obtain the needed measurement accuracy of band centers we have to use a centroid approach. The SRCA capability meets the requirements associated with checking MODIS spectral stability on orbit. However the SRCA capability leave a lot to be desired relative to unambiguously measuring MODIS preflight spectral performance. There are significant differences between the SRCA and the preflight double monochromator measurement capabilities.

Approach IV Is considered the second level of descope which uses "extreme measures". The following items form a basis for this descope scenario.

1. There is no full aperture wide field calibrator.
2. No thermal vacuum system level measurements are made across the scan line.
3. Radiometric calibration in ambient conditions will be made at three locations across the scan line (equivalent to start, mid and end of earth scene) using full aperture blackbody and SIS(100).
4. Other performance parameters that may depend upon scan line location, such as, relative spectral response, spectral band registration, and polarization, shall be constructed from individual piece , subsystem measurements and analyses to obtain a composite characterization.
5. The only system level spectral band registration and relative spectral response will be accomplished with SRCA in ambient and / vacuum.
6. The MODIS system will be stationary in the vacuum chamber, viz., there will be no rotary table.
7. With the above assumptions the thermal vacuum chamber size will be minimized.

The full aperture blackbody source (BCS), space view source (SVS) and the large spherical integrating source, SIS(100) are the same as those assumed for the other approaches. These can be used in ambient and vacuum.

The effects of the above assumptions impact performance parameters of spectral band registration, relative spectral response, and polarization to the greatest extent. This impact is discussed below. A detailed discussion will not be provided but the intent is to point to areas that are critical in assessing the adequacy of this approach.

Spectral band registration (SBR)

The non scanning SBR registration will be accomplished at full up optical train level. The 1 by 1 degree field collimator will be used in this characterization.

1. Measure SBR for all channels and bands along track and cross track for full optical system of stationary scan mirror, fold mirror, ATA, beamsplitters, objectives, and FPAs. This characterization is done with the MODIS aperture fully illuminated and then a reduced aperture illumination to simulate SRCA configuration.
2. Measure scan mirror subsystem scanning performance.
3. Model 250 / 500 / 1000 meter electronic integration times effects on SBR performance.
4. Combine data from items 1, 2, and 3 to provide a composite system level SBR.
5. Subsystem testing of radiative cooler provide x-y-z motion characterization between using bench test cooler and radiative cooling.
6. Determine the limitations of the SRCA to characterize SBR. This is principally a modeling exercise.
   - Nominal design effects of partial aperture
   - Effects of SRCA wandering obscuration
   - Effects of focal shifts
   - Set up measurement model, assume a change of SBR vibration, determine how well SRCA can track the effect.
7. Use SRCA to measure SBR in ambient environment
8. Use SRCA to measure SBR in thermal vacuum environment

Relative spectral response (RSR)

1. The system RSR will be measured with MODIS fully assembled using double monochromator with a lab collimator.
    - In band and out of band filter performance
    - Measure scan mirror spectral reflectance as a function of angle of incidence.
    - Is filter cooled in the same manner with bench test cooler and radiative cooler?
2. Under ambient lab conditions contrast measurement of RSR using SRCA and lab collimator and double monochromator. Note: Some deviations are expected because SRCA is a partial aperture configuration whereas lab collimator will be full aperture. Deviations noted will be used as correction data for on-orbit implementation of the SRCA measurements.
3. Subsystem characterization and calibration of SRCA
    - Compare the measurement of spectral transmittance of didymium glass using SRCA and lab spectrophotometer.
    - Correlate the spectral calibration of SRCA monochromator using emission lines and didymium glass.
    - Measure representative MODIS filter transmittance with SRCA and compare results with lab spectrophotometer.
    - Demonstrate the adequacy of the SRCA SIS spectral radiance. Standard SBRC spectral radiance calibration will be used.
    - Demonstrate the SRCA SIS radiance output stability in the SiPD optical feedback mode and constant current operation over the operational temperature range.
4. A computer model simulation has been developed as an aid in understanding SRCA strengths and limitations. This modeling will continue. It becomes even more important now since there is no independent system check of RSR in the thermal vacuum.

Polarization insensitivity performance

Polarization performance will be a composite of piece part and subsystem measurements.

1. Measure polarization of scan mirror over all angle of incidence values that will be seen in operational condition.
2. Measure MODIS system level polarization performance using IA collimator (or lab collimator).
3. Combine items 1 and 2 together to give polarization performance across the scan line.

A modification of the System Performance Test Matrix for Approach IV is given in Table III

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Table I System Performance Test Matrix (Approach I)

TEST PARAMETER	SPEC PARA	TEST ENVIRONMENT	Scan mirror status	GSE optical stimuli
Spatial - IFOV	3.3.1	Amb lab	non-scanning	Calibrator #1
Response uniformity	3.4.5.4			
Spectral	3.3.3	Amb lab & T/V	non-scanning	Calibrator #2
wavelength tolerance	3.3.3.2	Amb lab & T/V		
out of band	3.3.3.3	Amb lab		
ripple	3.3.3.4	Amb lab & T/V		
wavelength stability	3.4.7.4	Amb lab & T/V		
wavelength accuracy	3.4.7.5	Amb lab & T/V		
Polarization	3.3.5	Amb lab	non-scanning	Calibrator #3
MTF	3.4.2	Amb lab & T/V	scanning	Calibrator #1
Transient response	3.4.4	Amb lab	scanning	Calibrator #1
Radiometric performance	3.4.5	Amb lab & T/V	scanning	SIS (100) & BCS
Dynamic range	3.4.1			
SNR	3.4.1			
System noise meas	3.4.5.5			
Ch to ch uniformity	3.4.5.3.2			
System noise	3.4.5.5			
System crosstalk	3.4.5.3.3	Amb lab	non-scanning	Calibrator #1
Geometric performance	3.4.6			
Pointing knowledge	3.4.6.1	Amb lab	non-scanning	Calibrator #4
Alignment change	3.4.6.2	Amb lab	non-scanning	Calibrator #4
Spectral Band Reg.	3.4.6.3	Amb lab & T/V	scanning	Calibrator #1
Radiometric stability	3.4.7		scanning	
short term	3.4.7.1	Amb lab		SIS(100) & BCS
long term	3.4.7.2	analysis		NA
spectral band to band	3.4.7.3	Amb lab & T/V		SIS(100) & BCS
Stray light	3.4.8	Amb lab	scanning	
Direct sunlight	3.4.8.1	Amb lab		Solar Test Source
Bright target	3.4.8.2	Amb lab		SIS(100)&Cal #6
Dark target	3.4.8.3	Amb lab		SIS(100)&Cal#6
Warm target	3.4.8.4	Amb lab		Calibrator #5

Table II System Performance Test Matrix (Approach II)

TEST PARAMETER	SPEC PARA	TEST ENVIRONMENT	Scan mirror status	GSE optical stimuli
Spatial - IFOV	3.3.1	Amb lab	non-scanning	Calibrator #1
Response uniformity	3.4.5.4			
Spectral	3.3.3	Amb lab & T/V	non-scanning	Calibrator #2
wavelength tolerance	3.3.3.2	Amb lab & T/V		
out of band	3.3.3.3	Amb lab		
ripple	3.3.3.4	Amb lab & T/V		
wavelength stability	3.4.7.4	Amb lab & T/V		
wavelength accuracy	3.4.7.5	Amb lab & T/V		
Polarization	3.3.5	Amb lab	non-scanning	Calibrator#3 scan mirror reflectance
MTF	3.4.2	Amb lab & T/V	scanning	Calibrator #1
Transient response	3.4.4	Amb lab	scanning	Calibrator #1
Radiometric performance	3.4.5	Amb lab & T/V	scanning	SIS (100) & BCS
Dynamic range	3.4.1			
SNR	3.4.1			
System noise meas	3.4.5.5			
Ch to ch uniformity	3.4.5.3.2			
System noise	3.4.5.5			
System crosstalk	3.4.5.3.3	Amb lab	detector level	~~Calibrator #1~~
Geometric performance	3.4.6			
Pointing knowledge	3.4.6.1	Amb lab	non-scanning	Calibrator #4
Alignment change	3.4.6.2	Amb lab	non-scanning	Calibrator #4
Spectral Band Reg.	3.4.6.3	Amb lab & T/V	scanning	Calibrator #1
Radiometric stability	3.4.7		scanning	
short term	3.4.7.1	Amb lab		SIS(100) & BCS
long term	3.4.7.2	analysis		NA
spectral band to band	3.4.7.3	Amb lab & T/V		SIS(100) & BCS
Stray light	3.4.8	Amb lab	scanning	
Direct sunlight	3.4.8.1	Amb lab		~~Solar Test Source~~
Bright target	3.4.8.2	Amb lab		SIS(100)&Cal #6
Dark target	3.4.8.3	Amb lab		SIS(100)&Cal#6
Warm target	3.4.8.4	Amb lab		Calibrator #5

NOTE: Underline and strikethrough indicates a change in baseline "Calibration Management Plan".

Table III System Performance Test Matrix (Approach IV)

TEST PARAMETER	SPEC PARA	TEST ENVIRONMENT	Scan mirror status	GSE optical stimuli
Spatial - IFOV	3.3.1	Amb lab	non-scanning	Lab collimator
Response uniformity	3.4.5.4			
Spectral	3.3.3	Amb lab	non-scanning	Lab collimator plus monochromator
wavelength tolerance	3.3.3.2	Amb lab		
out of band	3.3.3.3	Amb lab		
ripple	3.3.3.4	Amb lab		
wavelength stability	3.4.7.4	Amb lab &T/V		
wavelength accuracy	3.4.7.5	Amb lab		
Polarization	3.3.5	Amb lab	non-scanning	Lab collimator plus scan mirror refl
MTF	3.4.2	Amb lab	non-scanning	Lab collimator
Transient response	3.4.4	Amb lab	non-scanning	Subsystem test
Radiometric performance	3.4.5	Amb lab & T/V	scanning	SIS (100) & BCS
Dynamic range	3.4.1			
SNR	3.4.1			
System noise meas	3.4.5.5			
Ch to ch uniformity	3.4.5.3.2			
System noise	3.4.5.5			
System crosstalk	3.4.5.3.3	Amb lab	non-scanning	Subsystem test
Geometric performance	3.4.6			
Pointing knowledge	3.4.6.1	Amb lab	non-scanning	Lab setup
Alignment change	3.4.6.2	Amb lab	non-scanning	Lab setup
Spectral Band Reg.	3.4.6.3	Amb lab & T/V	non-scanning	Subsystem composite tests
Radiometric stability	3.4.7		scanning	
short term	3.4.7.1	Amb lab		SIS(100) & BCS
long term	3.4.7.2	analysis		NA
spectral band to band	3.4.7.3	Amb lab & T/V		SIS(100) & BCS
Stray light	3.4.8	Amb lab	scanning	
Direct sunlight	3.4.8.1	Amb lab		Strobe source
Bright target	3.4.8.2	Amb lab		SIS(100)&lab coll
Dark target	3.4.8.3	Amb lab		SIS(100)&lab coll
Warm target	3.4.8.4	Amb lab		Lab collimator

NOTE: Underline indicates a change in baseline "Calibration Management Plan".

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