Pa Lolek

To: the MODIS Science Team

From: V. V. Salomonson

Subject: Comments on MODIS descopes being considered.

What follows is my compilation of the comments recieved regarding various MODIS descope possibilities proposed by the Project. Please excuse any typos because I typed these myself and did it in a hurry.

We will need to discuss these at the PDR and at the Science Team meeting in California. Please feel free to discuss them on telemail or among yourselves prior to the meeting in California as you see fit.

Cost Reduction Measures for MODIS (Descopes)
(Commentary from Team Members/September 1992)

Descopes Recently Implemented

1. ($0.6M) Specification Paragraph 3.1.4

2. ($0.075M) Specification Paragraph 3.3.5

3. ($0.17M) GIIS

4. (0.02M) CRDL 509 5 copies of drawings

Descope Requirements/Design/Operations Under Considerations

5. ($4.35M) Full detector performance at delivery. Every detector element meets the specifications (2 dead elements per FPA with no more than 1 dead element per band).

Technical Team
Comment: There are only a total of 8 detectors involved in the worst case.

Barton
Possibly.

Carder
The impacts on science would likely be minor, but the impact on EOS/DIS may be larger in as much as special, application-specific smoothing functions would be needed to clean up the appearance and interpolate for the mssing data.

Slater
O.K.(? Phil's comment not absolutely clear).

Parslow
(Applies to item 6 also). I do not think it is acceptable to launch a MODIS instrument with any dead detectors. In the ocean colour bands, loss of a particular detector can mean loss of a product in the corresponding line, even loss of the most basic products such as chlorophyll. The prospect of dealing with products with missing lines at launch seems fairly amazing. The alternative (item 6) seems ambiguous to me. Are we talking about a loss of sensitivity as much as 50%, or no more than 50%. In any case, I wuld have thought a tighter constraint (say 25%) was more reasonable.

MODLAND

Undesirable (if this is selected for descope then further study is needed to identify which detectors are more likely to be dead at the time of delivery). A spec that allows every tenth line of an image to be "blank" seems to be less than one would hope to see in the "next generation" sensor.

King

Acceptable

MCST

Not acceptable. MCST is really willing to tolerate either #5 or #6; but prefers #6. The difference between these two options is that #5 allows up to 2 dead detectors per FPA with no more than 1 per spectral band (i.e., up to 8 detectors dead detectors , all in different spectral bands) and #6 allows 2 "sick" (50% response) detectors per spectral region (i.e., up to 10 sick detectors, all in different spectral bands. In either case, the worst case scenario is defective 1000-meter pixels, every one of which affect 10% of the data in a swath. Defective 500-meter pixels would affect 5% and 250-meter pixels would affect 2.5% of the data per swath. In all cases the effect is a reduced or missing line of data. MCST finds these options preferable to relaxing registration requirements or deleting bands. Dead or sick detectors influence how often the scientific parameters can be calculated for any particular site, thereby increasing the amount of time required for true global coverage; on the other hand, loss of inherent band-to-band registration or loss of bands degrades the scientific content of the dta rather than frequency of access. In addition, MCST anticipates a low actual loss of data from this number of dead or sick detectors provided increased computational resources are available to perform spatial, spectral and temporal interpolation during ground processing.

6. ($0.75M) Sames as above except two detector elements per speactral region may have a response as much as 50% below the other detector elements.

Technical Team

This requirement also includes no more than one deficient detector per band.

Barton

Maybe

Carder

Same as for 5

Menzel

I think this is acceptable (preferable to item 5).

MODLAND

Undesirable (but more acceptable than 5 (if this is selected for descope then further study by SMRC is needed to identify the detectors more likely to be bad at time of delivery).

King

Acceptable

MCST

Acceptable. See response in #5.

7. ($4M) Registration to 0.1 pixel--specify the stablility of registration to 0.1 pixel, but relax the maximum absolute registration requirement to 0.3 pixel between warm focal planes or between cold focal planes and 0.5 pixel from warm to cold focal planes.

Carder

For spatial pixels impact will be minor, but spectral-pixel registration stability is very important for spectral ratios, especially among bands 9-13. For bands 13 and 14, atmospheric absorption lines butt against the bands, making tolerances tight. It is less important that all spectral pixels see exactly the same parcel of water, for in the open ocean spatial patch scales are large and gradients are relatively small.

Slater

The 0.2 and 0.3 pixel values are compromises that are unsubstantiated and based on discussions with Bob Schowengerdt who has coauthored the seminal work on sampled imagery. There are a number of questions we have on the omissions in that study. For example aliasing is not addressed and the fact that characteristically the modulation of the scien decreases as the inverse square of the spatial frequency content has not been taken into account. There are likely to have significant effect on the results of the analysis.

MODLAND

Undesirable. Multispectral analysis is a major requirement fo MODIS data and innate registration between bands is required (if this is selected for descope then every means should be undertaken to ensure that spectral channels which are to be used together have the best possible registration). The MODLAND team is very concerned about band-to-band registration in teh MODIS instrument. Yoram Kaufmann has provided the basis arguments concerning resampling to you already in his e-mail of August 27. Resampling will not be applied to the 1-B products that land multispectral algorithms use. Rather, the output products will be resampled. This ensures the accuracy of calculations while still providing a geometrically rectfied product. The accuracy of multispectral products cannot be assured withouth good band-to-band registration, and , in fact, will be severely compromised without it. It might be possible to relax the band to band registration by 0.05 of a pixel)to 0.15), but further research is needed to fully evaluate the science implications of decreased registration accuracy.

King

Acceptable

MCST

Not acceptable. Taking these as along-track mis-registrations and using 0.1 pixel as the accross-track miregistration, these values would result in as little as 63% overlap for "co-registratered" pixels between same-temperature focal planes (warm to warm or cooled to cooled) and 45% overlap for "co-registered" pixels between warm and colled focal planes. MODIS would no longer have inherent band-to-band spectral registration between all spectral bands. At least some geophysical parameters (such as the cloud utility mask, which involves bands from all four focal planes and will be used by most other products) could no longer be calculated before lever-3, that is, would require re-sampling of the data before they could be calculated, with an attendant loss in accuracy. It is important to note that the geophysical parameters are currently sltaed to be level-2 products; i.e., they will be calculated ona per-pixel basis using the inherent registration of the pixels.

MCST conducted an analysis of the effect of mis-registration on the NDVI vegetation index using simulated MODIS data generated from Thematic Mapper data. This index is a key element in the application of MODIS data to global change studies. TM data was mis-registered by multiples of 28.5 m pixels and the MODIS MTF applied to creat simulated MODIS at-nadir imagery for the 250 m bands (Bands 1 and 2). The NDVI transformation

was calculated for four dates over a 1024 by 1024 TM subscene and plotted. The results indicate a high sensitivity to mis-registration. The error for 0.1% misregistration produces 4.3% error, 0.2% misregistration gives 9% error, 0.3 pixel give 12% error and 0.5 pixel gives 30% error. The radiance accuracy specification of 5% implies that the product error due to mis-registration should be in this range thus the 0.1 pixel misregistration accuracy specification is appropriate.

Gordon

For the ocean this may pose a significant degradation in the performance of the fluorescence bands and the atmospheric correction of all of the bands. It means that as little as 50% of the signal received by two differenc bands might come from a common area on the surface/atmosphere. The actual science impact is difficult to assess; however, it is not necessarily "moderate".

Incidentally, contrary to the Diner/Barker plan, the oceans people do NOT plan to resample at or below Level II.

8. ($1.1M) Spec. 3.4.6.3: Relax registration requirement by a factor of 1.5 (0.15 pixel) between warm focal planes, and by a factor of 2 (0.2 pixel) for warm to cold focal planes.

Barton

Maybe

Carder

Same as for 7

Menzel

I think this is acceptable (versus item 7). For the cloud work (temp, height, and amount), I need the LWIR bands to be registered within 10% of an LWIR pixel of each other, and the VIS to be within 50% of a VIS pixel wrt the LWIR pixel.

MODLAND

Undesirable (but more acceptable than 7)

King

Acceptable

MCST

Acceptable. This level of mis-registration is more acceptable than option 7, although we have no scientfic argument for acceptance. The original specification provided for a minimum of 81% overlap; this would relax it to 76.5% overlap between same-temperature focal planes and 72% between warm and cooled focal planes. Our understanding is that the mis-registrations of 0.15 pixels between same-temperature focal planes and 0.2 pixels between warm and cooled focal planes are along-track, 3-sigma numbers and that the cross-track registration will continue to be 0.1 pixel or better (3-sigma) between any two bands. Further, we understand these numbers to be the total mis-registration from both absolute mis-registration and from lack of stablility of the registration.

9. ($2.6M) Spec 3.1.4.1: Revise the contract so that the specs for EM SNR, polarization, radiometric accuracy and stability, regestration and calibration requirements are reduced by 25%. Retain present specs as goals.

Techical Team

This descope is a probable one.

Barton

Possibly

Carder

O. K. as long as Item 17 is not relaxed!

Menzel

I think this is acceptable. We should use the engineering model (EM) as a learning tool for the flight model. Relaxed specs are in order, provided we don't end up flying the EM.

Slater

Relax the specifications for the EM by 25%. I think this is appropriate if: a. the EM is never going to be consideres as a backup to, or an additional, FM; b. Item number 17, the reduction in the performance of the PFM, is not implemented.

Parslow

My initial reaction was that relaxing specs in the EM would enevitably lead to their relaxation in the FM (i.e., item 17)

MODLAND

Acceptable

King

Acceptable

10. ($4.5M) PAR Rev A: Procure selected integrated circuits and hybrids to Grade 2 requirements instead of Grade 1. Cost of Grade 1 parts approximately 4 times that of Grade 2.

Technical Team

O. K.

Barton

Possibly

Carder

Dangerous precedent if 5-year life is required. Absolutely not!

Slater

The purchase of grade 2 components is self-defeating and I am very much against it. We need a MODIS family, each member of which operates for at least five years in space. We have witnessed the successes of MSS, TM, and SPOT in operating longer than their design lifetimes. In some cases that has been a blessing because there was alternative available to provide continuite of data. The same could be the case here, or at least it might extend the program a useful few years.

MODLAND

Acceptable, assuming performance specifications are met.

King

Acceptable

11. ($0.5M) 420-05-01: Delecte requirement to base and document derived contamination allowance levels on analyses

Barton

Maybe

Carder

No.

Slater

Not sure I understand what this implies. However, the contamination question both at GE and elsewhere prelaunch, and the conditions on orbit, are probably not known well enough to form the basis of any meaningful or reliable analyses.

MODLAND

Acceptable, assuming performance specifications are met.

King

Acceptable

12. ($3M) Spec 3.4.9.1 Inflight Calibration: Delete radiometric function of SRCA.

Technical Team

Maybe.

Barton

No.

Slater

Not in favor. I have spoken to Dick Weber about this and understand the difficulties of heat dissipation and thermal drift of the lamp. I should like to see SBRC pursue a more detailed study of the problems and present their solutions to the MODIS cal group. I think we can rely on that being an objective appraisal as it was for the proposed mirror contamination monitor. The only reason I would eliminate it out of hand would be if it was agreed that there would be no accurate preflight absolute calibration of MODIS.

Parslow

Calibration is critical for the ocean colour algorithms, and I would be concerned about the combined effects of items 12 and 15 on calibration. This seems to leave us very heavily dependent on the lunar calibration as the only technique unaffected by atmospheric effects. Others may be better able to comment on the risks.

MODLAND

Unacceptable.

King

Unacceptable

MCST

Not Acceptable. This would eliminate the NIST-traceability of the radiometric calibration and would risk and uncalibrated data set. The MODIS specification requires in-flight absolute radiometric accuracy of 5% for wavelengths less than or equal to 3 micrometers and 1% for wavelengths above 3 micrometers. It further requires that "more than one approach shall be used to verify the calibration accuracy and provide additional confidence in the measurements" and that "all accuracy's shall be established relative to NIST standards and standard procedures. From a scientific standpoint, the mission requirement for 15-year continuity and intercomparability of datasets from six individual MODIS instruments can only be met if there is always direct NIST-tracebility of thes instruments' radiometric response. Prior to launch the SRCA will be radiometricall calibrated using NIST-traceable sources in the NIS, NIR, and SWIR portions of the spectrum. On orbit, the SRCA will be used to spectrally shape and direct a collimated beam to the MODIS aperture. The output of the MODIS sensor under these conditions will be ocmpared with the pre-flight values, and any changes will be quantified. In this manner, the SRCA will provide continuous NIST-tracebility of the radiometric calibration of the instrument from pre-launch through its operational lifetime. The SRCA provides the only link to NIST-traceability after launch; therefore, it is crucial to mission success that the SRCA be included

on MODIS. Based on these considerations we cannot support deletion of the radiometric function of the SRCA.

Gordon

Does this mean SRCA is still there, but not radiometrically calibrated? If so i might be OK; however, I would like to hear from Phil Slater.

13. ($0.3M) Specification paragraph 3.3.4.2 requires bands 31 and 32 have extended range to 400 K.: Eliminate the extended dynamic range in bands 31 and 32 required for fire detection. A 30% relaxation in detector performance can be accepted.

Technical Team

O.K.

Barton

O.K.

Carder

O.K. for oceans

Menzel

Not acceptable. Analyzing biomass burning quantitatively requires estimating temperature and area of the fires. Saturation at 324 K prevents this, and leaves us in the same situation we are in with AVHRR. MODIS offers a unique opportunity to do more, and we syold. The savings are not that great anyway.

Slater

Eliminate present extended linear dynamic range, substitute non-linear gain.

MODLAND

Unacceptable

King

Unacceptable.

MCST

Not acceptable. We will accept best-effort perfoormance if necessary, but eliminating them is a small cost savings for a difinite loss in scientific capability.

14. ($0.3M) GSFC must approve NSPARS 420-05-01: Approve NSPARs in-house and provide notification to GSFC

Technical Team

O.K.

Barton

Possibly

Slater

Approve NSPARs in house. Let's strive to reduce the paper chase.

MODLAND

Acceptable

King

Acceptable

15. ($1.75M) Specification paragraph 3.4.9.3 requires solar diffuser stability monitor (SCSM): Eliminate the requirement for SDSM.

Technical Team

NO.

Barton

Possibly

Carder

It's not entirely clear how well the lunar method will work. Hold off on this for now.

Slater

Not in favor of eliminating the SDSM for two reasons.

a. It iliminates an important independent check on the absolute calibration of the sensor. If you eliminate the SDSM you might as well eliminate the solar diffuser, because I do not think the earth- or moon-reference methods are potentially as accurate in tracking the diffuser degreadion or stray light problems.

b. With the correct design and preflight calibration (and SBRC is looking into the accurate absolute calibration of the system) it offers the potential of a lower absolute uncertainty than either earth- or moon-referencee calibrations.

Parslow

Same as item 12.

MODLAND

Unacceptable

King

Unacceptable. Requires use of too many ancillary data, thereby complicating calibration.

MCST

Not acceptable. Multiple approaches to calibration are required to reduce the scientific risk of the mission. Eliminating the SDSN removes an important redundancy. This option would have a major impact upon assuring the long-term stability and internal consistency of the measurements within the initial mission and between missions. The sun is a stable source to within a couple of tenths of a percent. It is viewed using a diffuser whose properties are certain to change over time (as they have with Nimbus-7 TOMS, for example). The change indiffuser properties must be monitored if traceability to the sun as a source is to be successful, and if MODIS is to be used to study global change. The SDSM fulfills this role.

The alternative suggestions for maintaining lont-term repeatability of the measurments have drawback compared to using the sun. These limitations, using ground-truth targets, are: 1) Both the atmosphere and background target must be stable for this approach to work. Since neither are as stable as the sun, many more measurements will be required to attain the same level of stability. The increased analysis effort will add costs later in the project. 2) It is not certain that the ground-truth targets will remain stable all the time. For example, after a major volcanic eruption, such as Mt. Pinatubo, the atmosphere apears brighter, first regionally and eventually on a global scale. Thus, all the ground-truth targets may change simultaneoulsly, making the ground-truth targets inadequate. Using the moon as a calibration target also presents problems: 1) It is a weak source which illuminates only a few pixels at a time. 2) It can only be used a few times per year and thus provides inadequate temporal sampling. 3) After a major volcanic eruption, the moon changes brightness due to differences in the amount of Earth-shine. The moon may not be as stable a reference as is commonly assumed.

In summary, The sun as seen through a well-monitored diffuses is the most stable reference available. Proposed alternative radiation sources all have drawbacks compared to the solar calibration technique.

Gordon

Remember, calibration/stability information is critical to oceans. MODIS lunar data will NOT be sufficient to make up for th eloss of the monitor. We should ot have to rely on surface truth because in the long run it is much more expensive.

16. $0.125M) Spec 3.3.5 Polarization spec 2.0%: Relax polarization spec to 2.3%

Technical Team

O.K.

Barton

Possibly

Carder

Savings achieved is not worth the scientific cost, especially if measuring the globe every two days is required, for which large viewing angles and more atmospheric thickness must be dealt with.

Slater

I am not in favor of reducing the polarization spec. There has bee a great deal of discussion on this point both at MODIS and HIRIS meetings and the oceanographers have not wavered on this issue.

MODLAND

Acceptable

King

Acceptable. Makes spec consistent with MODIS-T.

MCST

Not acceptable. Cost savings are too small to justify the degradation in science.

Gordon

OK at 412 nm. Note SeaWiFS is 2 %

17. ($3M) Spec requires full performance: Revise the contract so that the specs for PFM, SNR, Polarization, radiometric accuracy and stability, registration and calibration requirements are reduced by 25%. Retain present specs as goals.

Barton

No.

Carder

No! If the EM spec is relaxed, then this is the last shot at doing it right before "show time".

Menzel

This is not acceptable. We should keep the original specs for the flight model and review waiver requests as necessary. Blanket relaxation is inappropriate. However, we should monitor progress on meeting difficult specs closely and prevent excessive spending.

Slater

I am strongly opposed to an almost across-the-board reduction by 25% in the performance of the PFM. Some of the earlier items on this list, particularly the GE calibration, can provide a greater cost saving without much, if any, impact on the performance and the quality of the science data from MODIS.

Parslow

I am very dubious about this kind of blanket "cut everything by 25%" approach. A lot of work went into establishing the original specs: a lot more is needed to look at the tradeoffs involved in reductions in specs.

MODLAND

Unacceptable.

King

Unacceptable. Compromises radiometric integrity of data--thereby impacting science quality.

MCST

Not acceptable. The PFM will be flown on EOS AM-1; up to 25% reduction in performance would seriously degrade the quality of the data collected by that instrument, and could result in not meeting the mission equirement of a 15-year calibrated data set.

Gordon

On reduction of the specs by 25% I only have a comment. If SeaWiFS performs as expected (not as spec.) a descoped MODIS may not perform as well for the oceans as SeaWiFS (which can also tilt and view the moon at full phase.)

18. ($3M) Spec 3.3.3, 3.3.4: Remove observing bands 24, 25, 26, and 30.

Barton

O.K.

Carder

No effect on ocean color.

Menzel

Maybe. The shortwave IR Channels 24, 25, and 26 are useful, but not essential for total precipitable water vapor, total ozone, and atmospheric stability. These parameters could be determined from the longwave IR channels alone. Total ozone needs channel 30. If we have any aspirations to do ozone work with MODIS, we must keep this channel.

MODLAND

Acceptable, however, the original choice of MODIS spectral was based on the recommendations from a broader community than those currently represented by the science team, i.e., the sounding bands proposed by Joel Susskind #24-28 have been retained on MODIS. The desirability of retaining these channels should be discussed with the AIRS science team before they are removed. However, from the land teams perspective we will not be using channels 24, 25, 26, 30 and suggest that the potential user community be consulted further concerning their utility. Similarly, for channels 27 and 28.

King

Unacceptable. Jeopardizes determination of precipitable water and atmospheric stability.

MCST

Not acceptable. MCST opposes the deletion of bands on the grounds that it will degrade the inter-comparability of the data sets and permanently remove scientific capability from the mission.

19. ($1.2M) Spec 3.3.3, 3.3.4: Remove observing bands 27 and 28 from the AM MODIS; remove bands 33 and 35 from the PM MODIS.

Barton

O.K.

Carder

See 18.

Menzel

This is not acceptable. Channels 27 and 28 are necessary for total precipitable water vapor and atmospheric stability; these should be monitored from both the AM and PM MODIS. Channels 33 and 35 are crucial for the cloud parameters (temp, height, amount); if any channels must go it should be 34 and 36. Again cloud properties should be monitored from both the AM and PM MODIS.

MODLAND

See reply for item 18.

King

Unacceptable. Impact scientific analysis of cloud top pressure (PM1) and precipitable water (AM1)

MCST

Not acceptable. Same as for Option 18.

20. ($5.4M) Procure EEE parts simultaneously for PF, FM1 and FM2

Barton

Maybe

Carder

Fiscal decision.

Slater

Supports. It looks like a budget buster in FY 93, but if the savings are $5.4M over and above the $5M required in FY93 then the simultaneous purchase is well worthwhile.

MODLAND

Acceptable

King

Acceptable

21. ($1.3M) Focal Plane assemblies (FPA's) produced sequentially.: Assemble all flight model FPA's (PF, FM1, FM2, and Spares) and deliver concurrently.

Barton

Maybe

Carder

Fiscal decision.

Slater

Supports

MODLAND

Acceptable

King

Acceptable

22. $0.35M) Scan mirrors for up through PFM allowed to proceed now.

Barton

Maybe

Carder

Fiscal decision.

Slater

Supports

MODLAND

Acceptable

King

Acceptable

23. ($1M) Filters up through FM2 now on subcontract: Increase current purchase orders for filters and dichrois to include quantity for FM3, FM4, and FM5

Barton

O.K.

Carder

Do it!

Slater

Suppports.

MODLAND

Acceptable

King

Acceptable

24. ($0.20M) FPA cables for EM and PFM allowed to proceed now.

Barton

Possibly.

Carder

Fiscal decision.

Slater

Supports

MODLAND

Acceptable

King

Acceptable

GENERAL COMMENTS

Kaufmann

1.In the memorandum there is a statement by C. Scolese that since MODIS data will be resampled "it is har to justify the very difficult and expensive band to band registration". I would like to comment regarding the relation between resampling and rgistration. My understanding is that resampling does not distort the spectral information of the image though it decreases its effective spatial resolution. For applications that use products of several bands, such as the NDVI or precipitable water vapor, good registration between bands is very important. To prove my point we can look on 2 pixels with reflectance r1 and r2 that are averaged in the process of resampling (for perfect registration to result in r3=0.5(r1 + r2). If r1 and r2 have the same spectral dependence then r3 will have exactly the same spectral reflectance as well despite the resampling. But if misregistration between the bands occurs, the weighting of r1 and r2 in r3 will be different in each spectral gband, and the spectral dependence of r3 will be different from that of r1 and r2. Therefore derivation of NDVI or precipitable water vapor will be affected.

2. Relation between MTF and misregistration. Lower MTF means lower effective spatial resolution. But for the reason mentioned in (1) good band to band registration is required independently of the real or effective spatial resolution.

3. Calibration accuracy: If the ration of the calibration betwen spectral bands is very noisy (the ratio of calibration fluctuates with time) then it will dominate the time dependence of the spectral functions and a very good registration is not justified. But errors in the absolute calibration, or constant error in ration of calibration between bands does not have a strong impact on problems of registraton.

4. I have a question regrading item 7. Does this relaxation affect the registration between the 2 250m channels and the 905, 940, and 935 micron channels? Is it possible that the registration betwen bands will be better for bands that require it?