MODIS SCIENCE TEAM MEETING

October 1-3, 1991

MINUTES

of the

MEETING

NASA / Goddard Space Flight Center

Greenbelt, Maryland

Prepared by : Ressler Associates, Inc.

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LIST OF ATTENDEES

The following persons registered at and attended the MODIS meeting. Those flagged with ' * ' are secretarial staff and support personnel. Telephone numbers were supplied by the participants.

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25.	Jy-Tai Chang	GSC	301-953-2700
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34.	Bob Evans	Universoty of Miami	305-361-4799
35.	Gene Feldman	NASA/GSFC	301-286-9428
36.	Nelson Ferragut	GSFC	301-286-8453
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38.	Al Fleig	GSFC	301-286-7747
39.	Alvin Forehams	NASA/HQ	202-453-9121
40.	Kate Forrest	GSFC/726	301-286-7138
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42.	Sig Gerstl	UC/LANL	505-667-0952
43.	Tom Goff	MSDST	301-982-3704
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49.	Dorothy Hall	NASA/GSFC	301-286-6892
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59.	Tony Janetos	NASA	202-453-8195
60.	Willis Jenkins	MDSSC	464-7400 x7751
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65.	Jeff Key	CIRES/Univ. Colorado	303-492-3450
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67.	Michael King	GSFC	301-286-5909
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69.	Ravi Kumar	STX	301-513-1630
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72.	James D. Love	EOSAT	301-552-0539
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121. Zhengming Wan	UCSB	805-893-4541
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123. Richard Weber	GSFC	301-286-5992
124. Ming Ying Wei	NASA HQ	202-453-1725
125. Diane Wickland	NASA HQ	202-453-8195
126. Darrell Williams	NASA/GSFC	301-286-8860
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128. Phil Zion	TRW	301-982-5606

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GLOSSARY OF ACRONYMS

ADEOS	Advanced Earth Observing Satellite
AGU	American Geophysical Union
AIRS	Atmospheric Infrared Sounder
APAR	Absorbed Photosynthetic Active Radiation
ASAS	Advanced Solid State Array Spectrometer
ATMOS	Atmospheric Trace Molecule Spectrometer
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS	Advanced Visible and Infrared Imaging Spectrometer
BOREAS	Boreal Ecosystem Atmospheric Study
BRDF	Bidirectional Reflection Distribution Function
CCRS	Canadian Center for Remote Sensing
CDR	Conceptual Design Review
CEES	Committee on Earth and Environmental Sciences
CNES	Centre National d'Etudes Spatiales (French Space Agency)
CZCS	Coastal Zone Color Scanner
DAAC	Distributed Active Archive Center
DEM	derive digital elevation model
DoD	Department of Defense
DOE	Department of Energy
DPWG	Data Processing Working Group
EDC	EROS Data Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EPA	Environmental Protection Agency
ERS-2	ESA Remote Sensing Satellite
ESA	European Space Agency
ESTAR	Electronically Steered Thinned Array Radiometer

GIFOV	**ground instantaneous field-of-view**
GLI	**Global Imager**
GSFC	**Goddard Space Flight Center**
GSOP	**Ground System Operations**
HAPEX	**Hydrological-Atmospheric Pilot Experiment**
HRPT	**High Resolution Picture Transmission**
HRV	**high resolution, visible**
IDS	**Interdisciplinary Science**
IFOV	**instantaneous field-of-view**
IGBP	**International Geosphere-Biosphere Program**
IWG	**Instrument Working Group**
JERS	**Japanese Earth Resources Satellite**
JPL	**Jet Propulsion Laboratory**
JRC	**Joint Research Center**
LARS	**Laboratory for Applications of Remote Sensing**
LTER	**Long Term Ecological Research**
MAB	**Man and Biosphere**
MODIS	**Moderate-Resolution Imaging Spectrometer**
MODIS-N	**MODIS-Nadir**
MODIS-T	**MODIS-Tilt**
MOU	**Memorandum of Understanding**
MSS	**Multispectral Scanner (LANDSAT)**
NASA	**National Aeronautics and Space Administration**
NDVI	**Normalized Differential Vegetative Index**
NE∆L	**Net Effective Radiance Difference**
NESDIS	**National Environmental Satellite Data Information System**
NIR	**near-infrared**
NIST	**National Institute of Standards and Technology**
NOAA	**National Oceanographic and Atmospheric Administration**
NPS	**National Park Service**
NSF	**National Science Foundation**
OCTS	**Ocean Color and Temperature Scanner**
OSC	**Orbital Sciences Corporation**
OSTP	**Office of Science and Technology Planning**
PDR	**Preliminary Design Review**
PGS	**Product Generation System**
QCAL	**calibrated and quantized scaled radiance**
RAI	**Ressler Associates, Inc.**
RDC	**Research and Data Systems Corporation**
SBRC	**Santa Barbara Research Center**
SDSM	**Solar Diffuser Stability Monitor**

SDST	**Science Data Support Team**
SNR	**Signal-to-Noise Ratio**
SRCA	**Spectroradiometric Calibration Assembly**
STIKSAT	**Stick Scatterometer**
SWIR	**shortwave-infrared**
TBD	**To Be Determined**
TDI	**time delay and integration**
TIR	**thermal-infrared**
TM	**Thematic Mapper (LANDSAT)**
TMS	**Thematic mapper Simulator**
TOMS	**Total Ozone Mapping Spectrometer**
TRMM	**Tropical Rainfall Measuring Mission**
UARS	**Upper Atmosphere Research Satellite**
VIRSR	**Visible/Infrared Scanning Radiometer**
VIS	**visible**

OPENING PLENARY SESSION

1. WELCOME AND MODIS STATUS OVERVIEW

The welcome and MODIS status overview were given by Dr. Vince Salomonson. He presented a copy of the meeting agenda, Attachment A, which was also provided as part of the information packet supplied to meeting participants upon arrival. Dr. Salomonson remarked that the Mission to Planet Earth has officially begun with the launch of UARS, which has had positive results so far. TOMS/METEOR has also been launched, is doing well, and returning good data.

He noted that the highlight of the meeting is to be the first public briefing on MODIS-N, which will be presented by Jack Engel and Jim Young of Santa Barbara Research Center (SBRC). MODIS-T and the EOSDIS milestone schedule will be discussed after lunch. The meeting will then focus on Discipline Group issues.

Dr. Salomonson presented a list of meeting objectives, Attachment B. The first objective is to review MODIS-N information, and for the full Science Team to consider requests by SBRC for changing some of the specifications. He requested firm decisions be reached on these issues now so that SBRC could effectively start development of MODIS-N. He offered a ground rule for discussion of the MODIS-N specifications, in that if any requests for tightening of the specifications are made they must be accompanied by the willingness to give up something else to stay within budget. The exception is the infrared specifications, where a project supported study is under way to determine if a change from 1% to 0.3% can be accomodated so MODIS will more nearly match the performance of the ATSR (Along Track Scanning Radiometer).

Another important issue posed for the Science Team to consider is if there are compelling scientific arguments in support of MODIS-T. Inclusion of MODIS-T on the EOS

platforms is not one of the scenarios developed from the Seattle IWG meeting. The MODIS team was asked to look at this issue and attempt to formulate credible, rigorous, and consistent arguments to present to the Payload Panel, which will meet in late October. The favorable arguments for continued consideration of MODIS-T should come from the Oceans and Land Discipline Groups, although the arguments are perceived to be different between the groups. A decision on MODIS-T is crucial since GSFC management needs to decide whether to keep or dissolve the engineering team working on MODIS-T.

Another consideration that was presented, and which also has its roots in the results of the Seattle IWG meeting, is the possibility that two MODIS-Ns may be flown on EOS platforms having morning and afternoon orbits. Team members were asked to consider the utility of this scenario. The effects of two MODIS-Ns on data products and on the final science output was posed to the team members.

Dr. Salomonson asked Science Team members to develop an approach for meeting the algorithm delivery schedule under the current funding scenario. Because MODIS funding is expected to be a continuously evolving picture, the team was asked to consider ways to adapt to funding changes. Dr. Salomonson rounded out his review of meeting objectives by asking the team to develop specific plans for review of team member algorithm development progress and for the peer review process.

Members are currently asked to produce a substantive report every 6 months. They were asked to consider practical ways to incorporate the results of these reports into the framework of the Science Team meetings. Even a 10 minute report by each of 24 members would result in a 4 hour session.

Dr. Salomonson added two supplemental meeting objectives which were not covered by Attachment B. He noted that a review of the action items from the previous Science Team meeting has been done, and that all items appear to be completed, underway, or out-of-date. A copy of the action items was included in the team folders, and members were

asked to review them to verify that nothing has been missed. A copy of the algorithm development and validation plans (Attachment C) devised at the previous meeting was also included in the folder, and team members were asked to review and update them as needed. There have been some recent developments on how NASA will approach other agencies for funding, and these affect the validation plans. Some significant changes since the last meeting were noted in the plans for the Calibration Group.

2. TILFORD REVIEW of the EOS PAYLOAD SELECTION PROCESS and BUDGET

Shelby Tilford presented a brief overview of the EOS budget picture and the status of the EOS payload selections. He noted a busy summer period with the UARS and TOMS launches, a National Academy of Science review, an Engineering review, the House of Representatives debate on the NASA budget, and the guidelines adopted by the Senate that reduced the EOS program by $^1/_3$. The recent IWG meeting in Seattle and the final markup last Thursday of the NASA budget by the Appropriations Committee added to the flurry of activity for the Mission to Planet Earth program.

Tilford stated that the EOS program has entered into a period where extensive review is needed of the mission and its content, scope, and concepts. This has been brought about by three events:

1. The Air Force has announced that the Atlas 2AS will be available for launch from the west coast.
2. The total EOS budget has been reduced by $5 billion through 2000.
3. The recent discussions by the IWG in Seattle.

The Payload Panel discussions in October are an important part of the process of introspective review. Participants will be looking at the payload and its implementation. They will need to clarify the issues, and consider potential trade-offs. As an example of the type of choices that will need to be made, Tilford noted that the Oceans group

endorses morning and afternoon flights for MODIS-N. This idea has merit, but it implies extensive discussions of MODIS-T and an understanding of the budget and science ramifications.

Other issues are involved in the review. The Senate guidelines provide language limiting what can be done and when, and need to be carefully weighed in the review process. Last Thursday the EOS budget was settled at $ 65 million less than was requested for FY 1992. The total budget is limited to $ 11 billion through 2000. It is an unusual funding profile, but it is one we need to live with and one that the review process must take into consideration. Trade-offs in time and program magnitude need to be expected as the review process proceeds; however, Tilford hopes that the major issues can be resolved before the end of this calendar year.

The engineering review has recommended that the EPA and DOE should be invited to play an enhanceed role in global change research. It will be necessary to try to work more closely with these and other research groups.

3. TILFORD Q/A SESSION

Shelby Tilford opened the session to questions from the floor.

Q1: *Ravi Kumar* - Kumar cited the large amount of unfavorable press that NASA has received recently. He inquired what can be done to improve NASA's image.
A1: *Tilford* - Tilford perceives the problem as one which is felt through the total government community. He made the observation that NASA receives far more publicity for its failures than its successes. The Savings & Loan bail-out problem, the declining budget, the deficit, and the status of the military budget imply that there is a decline in total dollars available. The competition for those dollars is getting stiffer and will continue to get worse. Tilford has few ideas to counteract the problem, except to try to stress the successes achieved by all levels of NASA activities.

Q2: *Mark Abbott* - In the Freeman Report there were some interesting negative paragraphs on EOSDIS and its award to a single outside contractor. What is Headquarter's thinking on why this happened?
A2: *Tilford* - Tilford stated that the reason is hard to assess, and declined to speculate. EOSDIS is a very big system, and it requires lots of input from the scientific community. It was his opinion that Headquarters had tried to include the scientific community at a level never before achieved. They had attempted to maximize the input by the advisory structure by having scientists on the review board. Tilford stated that he was surprised by the magnitude and extent of the Freeman Report's recommendations. He does not feel that the EOS review team spent much time on EOSDIS, and that possibly none of the EOS engineering review team understood EOSDIS because they are engineers and not part of the science community.

Q3: *Renny Greenstone* - Greenstone requested further elaboration on the recent Congressional activities related to NASA.
A3: *Tilford* - Tilford noted that the dust has not yet settled, but reviewed his understanding of the Congressional budget actions. The overall NASA budget was submitted at $15.4 billion in FY 92, but was conference committee approved at only $14.3 billion. Space Station was fully funded at $2 billion, resulting in an increase for the rest of NASA of under $500 million. Most ATD efforts and life sciences budgets were significantly reduced or eliminated. CRAF-Cassini was significantly reduced, and EOS was reduced by $65 million. There was also a $4 million enhancement for modelling. The UARS operations were funded for $18.2 million; however, this is likely to change because the funding is so low it probably implies the spacecraft would be turned off after 6 months. The budget holds EOSDIS constant at $11.6 million, and places a cap on EOS through the year 2000.

Q4: *Renny Greenstone* - Has NASA been instructed on how they should cooperate with other agencies like EPA and DOE?

A4: *Tilford* - NASA has received instructions as part of the engineering review on guidelines for cooperative efforts with fellow science-related agencies, and several meetings have been set with EPA, DOE, and NOAA.

Q5: *Mike King* - Has CLIMSAT been established as a definite NASA program?
A5: *Tilford* - There were several different versions of CLIMSAT considered by the engineering review panel. They considered it a high priority to fly a follow-on Earth radiation budget experiment as soon as possible, and instructed NASA to work with DOE on it; however, Jim Hanson has indicated that CLIMSAT has increased in scope and cost since its inception. Tilford's assessment of the situation is that unless it flies earlier than expected, CLIMSAT will not be as important as it seems to be at this time. There has been no resolution of things to be worked out with DOE.

Q6: *William Barnes* - Barnes noted that there had been lots of discussion in the engineering review about remotely piloted vehicles. He asked if Tilford could comment on this issue.
A6: *Tilford* - JASON vehicles have been under discussion by NASA, DOE, and the CEES (Committee on Earth and Environmental Sciences). It is his understanding that DOE will take the lead in pursuing studies involving these vehicles, but that NASA will be working closely with DOE. Budgets for this project have not been finalized.

Q7: *Wayne Esaias* - Esaias asked Tilford to comment on the relationship of the Earth Probes program, EOS, and EOSDIS. He noted that the Earth probes are very important to the total EOS concept.
A7: *Tilford* - In his perspective, he does not see them separately. The current plans call for folding UARS data, EOS, and Earth Probes data together to form a common data base. The long term objective is to have the capability to archive all Earth-science data sets into EOSDIS. It will be an evolutionary process that will eventually lead to an integrated system of Earth-sciences data. The question is not one of "if" but of "how fast" the program can be implemented. It will take several years to work out the

details, and it is his expectation that the first full-up application will be the Japanese ADEOS in 1995.

Q8: *Vince Salomonson* - Salomonson requested an overview of the status of the foreign efforts involved in the Mission to Planet Earth, including funding implications.
A8: *Tilford* - Tilford answered with a brief overview of the current cooperative programs. ESA's ERS-2 has been approved. The United States will provide a launch vehicle for the Canadian RADARSAT in about 1995. A TOMS follow-on in 1993 is planned to complement METEOR3/TOMS, and another TOMS mission is planned in 1995. The TRMM satellite (Tropical Rainfall Measuring Mission) will measure clouds, precipitation, and the Earth radiation budget in 1997. The Japanese are working on a follow-on to ADEOS. European plans are unclear after ERS-2. They have intentions to present plans for a series of polar orbiting satellites to a ministerial meeting in December. Until the results of that critical meeting are known, it will be difficult to quantify any kind of cooperative instrument selections. Some discussions have been conducted with the French for BEST and with the Germans for ATMOS.

Q9: *Vince Salomonson* - Salomonson requested Tilford's view of how the Mission to Planet Earth relates to other R&D programs.
A9: *Tilford* - It has been an objective of NASA Headquarters for several years to integrate most programs supported by NASA and other agencies into a more coherent package. Restructuring has been done to focus R&D programs so that they complement flight programs. An attempt has been made to model the system into a closely knit operation; however, the goal has not been completely achieved and many issues remain to be resolved. He sees NASA's efforts as complementary to and consistent with CEES goals, and feels it is important to work with other agencies on activities like scheduling ship time, and collection of ocean color and of land surface measurements. Tilford remarked that an intense effort is involved to make the diverse elements of the Earth science community work together as interdisciplinary investigators. Tilford views the MODIS program as part of the continuing trend toward close integration of R&D and aircraft

programs. He anticipates even more close couplings over the next decade.

Q10: *Vince Salomonson* - Salomonson volunteered an instructional question for the benefit of the audience. He requested that Tilford describe the interactive processes that go on between the OSTP (Office of Science and Technology Planning), the Space Council, the National Academy of Sciences, and NASA.
A10: *Tilford* - The National Academy of Sciences has many diverse committees and panels, totalling approximately 18 groups. The Earth Sciences discipline is highly fragmented, which is different from other groups like planetary astronomy which has only one administrative group. Such fragmentation has always been characteristic of Earth sciences. The situation has been aggravated by the common bureaucratic circumstance that it is historically easy to add committees and hard to delete them. Tilford noted that the Academy anticipates change over the next few years and offered hope that the situation would be rectified. For the moment, the usual procedure is to deal with each committee or group on an ad-hoc basis. The CEES is an initiative by the OSTP to integrate efforts of the various committees for Earth sciences. For several years the OSTP has been involved in an intensive effort to coordinate in a cross-track fashion the various committee functions by task and budget, with its first report being issued in 1984. Sometimes this results in two opposing groups being involved in deriving a budget. There have been controversial problems, but as a result of the success of CEES there have been five other similar cross-track structurings. Some recent White House initiatives, like the superconducting super-collider are obligated to reflect this process. The period from August through January is the most intense in the budget formulation process. Tilford suggested further questions be referred to Tony Janetos.

Q11: *Mark Abbott* - If MODIS-T gets cancelled, there is a strong probability that there would be a follow-on SeaWiFS. Would this be classified as an Earth probe, placed under EOS, or administrated in some other fashion?
A11: *Tilford* - The current SEASTAR/SeaWiFS was handled in a unique fashion for NASA. A joint committee of

scientists was selected to write specifications and requirements for a data purchase by NASA. The situation is unique because NASA has no oversight function, and acts only as the end data recipient. The industrial agents fulfilling the contract supply all oversight. A follow-on SEASTAR/SeaWiFS would be handled very much like the current one. If there is no MODIS-T, Tilford expects a similar negotiated deal with identical data rights. The data are commercially marketable for the first 10 days, then become available for research purposes. He feels that these data will go to EOSDIS, and that the same could be said for data from a follow-on mission. SeaWiFS is not a development program like the Earth probes.

Q12: ***Mark Abbott*** **- Abbott raised the issue that some aspects of the SeaWiFS data rights agreements are at odds with the principle of free distribution of scientific data. He cited a specific example from personal experience with OSC (Orbital Sciences Corporation), the SEASTAR prime contractor, which has resulted in his inability to disseminate information to NOAA.**
A12: ***Tilford*** **- Tilford felt that only the 10 day marketing period was at odds with scientific study of the data. He was unaware of the details of Abbott's grievance, but requested further discussion of the problem off-line.**

Q13: ***Darrel Williams*** **- Williams noted that EOS is still in Phase B and seems to be stuck there. He commented on the frustration felt by GSFC and by Headquarters, and asked Tilford to comment on when things would start moving.**
A13: ***Tilford*** **- Tilford stated that he doesn't want EOS to be run like Space Station, with yearly review and revision of the program. He feels there needs to be some motion soon, or that the program should be cancelled so we can go on to something else with a smaller and more focused objective. It is his opinion that there needs to be solid commitment to a selection of instruments within the next three months, and that the persistent modifications to the EOS program should stop.**

Q14: ***David Carneggie*** **- Carneggie noted Tilford's earlier comments about special funding for LANDSAT. He asked what is the relationship of LANDSAT to EOS.**

A14: *Tilford* - Many options are under consideration by the Space Council and by Congress. There are many diverse opinions about how LANDSAT should be implemented, and a seesaw battle is underway to determine its status. There are hearings underway in Congress, lots of committee activity, and a very uncertain schedule. He anticipates some action soon on LANDSAT 7, but the situation is so uncertain that he declined to speculate on the outcome.

Q15: *Renny Greenstone* - Greenstone inquired if there were any noteworthy developments regarding the option to use a Titan 3 booster for EOS.
A15: *Tilford* - Tilford stated that there is still controversy regarding the choice of an Atlas 2AS or a Titan 3 booster. It is a subject which requires further deliberation by the Project Office, and he declined to speculate upon the outcome.

Q16: *William Stabnow* - EOS has had various platforms sizes called for during its conceptualization history. We have most recently drawn back from a large EOS platform. Could NASA adopt a large platform approach again or will we stick with small satellites in the foreseeable future?
A16: *Tilford* - EOS started as a planned part of Space Station, at which time it consisted of medium-sized modules. When it was divorced from the Station, there were limited choices available for launch capability. Large EOS launches could be done with the Titan 4 on the West Coast or small launches could be done with the Delta on the East Coast, but there was nothing in-between. The original decision was to try for a large platform because it would be less expensive in the long run. Because Congress and the Air Force have agreed that the Atlas 2A or 2AS will now be available for West Coast launches of medium-sized payloads, it provides a more open choice regarding launch vehicle. The answer also depends in part on what NASA's end goal would be for the project. History shows that both large and small platforms have flown with success. There is no guarantee which is best for EOS, and there are advocates for both.

Q17: *Wayne Esaias* - Esaias remarked that at the Seattle payloads conference, the possibilities of an ocean altimeter

on a foreign satellite were discussed. He requested Tilford's comments on this subject.
A17: *Tilford* - The question concerns discussions that are taking place with CNES. There is a continuing dialog with no current time restrictions, and a final agreement is far away. It is necessary to take care who in CNES is consulted, because conflicting information may result. There is also a very real need to see how well foreign altimeters perform with respect to precision and accuracy before any commitment to them is made by NASA.

Q18: *Al Fleig* - Between the tight EOS time schedule and mission objectives, which takes precedence if there's a conflict?
A18: *Tilford* - It depends on who you talk to. He feels that the policy makers are under great pressure for NASA to launch something in 1998. These are also strong hopes DoD can manage a launch in 1995 to measure the Earth radiation budget.

Q19: *Robert Evans* - Responsibility for taking many of the global measurements will be shared with foreign groups. What kinds of activities like calibration are expected to assure consistency of data between diverse contributors?
A19: *Tilford* - Calibration consistency is certainly a very big issue, and one which he has pushed from the start of the global change research program. The EOS program must rely on international validation plans to assure consistency. There must be a high priority for each instrument to make cooperative international agreements. As an example, he offered the recent joint calibration discussions conducted with the Soviets with regard to calibration of ocean, land, and atmospheric sensors.

Dr. Tilford closed the question and answer session by wishing the MODIS investigators success with the meeting. He reminded the participants that other Headquarters representatives would be available to answer questions. Dr. Salomonson thanked him for his time and cooperation.

4. DOZIER PROJECT SCIENCE OFFICE REPORT

Jeff Dozier presented the Project Science Office Report. The report was accompanied by the slides shown in Attachment D. He reviewed the EOS Goals, stressing the existence of non-science issues and related mission expenses. He reviewed the IPCC Priorities as proposed by Bob Watson at the Seattle IWG meeting, and added priorities for stratospheric chemistry and a solid earth. Abbott interjected that energy transport ramifications of sea ice should have also been added.

Dozier presented his interpretation of the prevailing opinions that emerged from the Seattle meeting regarding what NASA's positions should be. He added that the 1998 launch should not be slipped for political reasons, and that there should be 12 to 24 months between launches. These opinions were presented as a series of 10 recommendations. Recommendation 1 is a list of instruments that should be flown. Dozier made a point of not suggesting which instruments should be placed on morning or afternoon platforms. He made note of Bruce Wilicki's letter advocating consideration of instruments other than MODIS-N for afternoon cloud studies, e.g. AVHRR. It was Dozier's opinion that anyone wanting MODIS-N on the afternoon platform bore the burden of convincing the EOS community of the need. If MODIS-N is not used, the limiting resource for potential replacements is money since there is currently plenty of room on the platform. The exception is if an Atlas 2AS is used as a booster. In that case, volume constraints become important.

Recommendation 2 was prompted because MODIS-T appears nowhere in the list. Dozier held the opinion that STIKSCAT has only one potential alternate, and therefore should hold a higher priority than MODIS-T. He felt that a high spectral resolution instrument for mapping ocean color might be unnecessary, and that SeaWiFS plus scatterometer data could be substituted. Abbott strongly disagreed, because the OCTS and MERIS instruments which are considered to be alternates are inadequate or questionable. A related issue raised by Dozier is the expense of maintaining support staff in a holding pattern. While immediate budget cuts are not required, trimming will be needed very soon. Fleig raised

the issue of access to data from foreign instruments, a problem which Tilford admitted has not yet been resolved.

The remaining recommendations prompted only one question from Abbott regarding the Freeman recommendation that HIRIS should be built by the DOE. The Dual Use Initiative calls for instruments that could do double duty for science and for defense. Dozier felt that it would be very beneficial if DOE could build one of the instruments covered in the set of recommendations. A meeting has been set for October 16 to discuss the issues involved. All of the recommendations will be considered at the Payload Panel meeting in Easton, MD on October 20 and 21. Very specific final recommendations will be derived by the meeting participants and forwarded immediately to Fisk.

Dozier reviewed the results of the EOS External Engineering Review which was held several weeks ago. The review essentially endorses the Watson position. Dozier and others were puzzled and disappointed by recommendations regarding downsizing and fragmenting EOSDIS, but he rationalized that no data systems experts were on the panel and insufficient time may have been given to review of available information. The EOSDIS recommendations are thought to reflect a summary of preconceived notions of some members of the panel. The suggestion that the program be broken into smaller pieces is an extension of the need to be resilient to budget fluctuations. Dozier expressed skepticism that the recommendation to include other agencies in the global change program would be fruitful. Clark noted that the Committee was interested in moving up the launch to flesh out the data base; however, there was no equivalent thrust to move up the data processing capabilities.

Dozier presented a synopsis of the current status of the NASA budget and the changes to the budget from the original presidential request as reflected by the House-Senate Conference Report. Esaias inquired if there was any chance the budget numbers might change, to which Tilford responded that the budget had passed a voice vote in the Senate and that he felt the House was very unlikely to

change it. Meeting participants noted that several aspects of the budget were illogical, and that other allocations were blatant pork-barrel awards prompted by influential legislators. The EPA report to which NASA has been asked to respond to was described by Thomas Mace as written by someone knowing very little about Earth sensing. Tilford promised to get a copy of the report to the appropriate scientists for comment.

5. DOZIER Q/A SESSION

Dozier opened the session to questions from the floor.

Q1: *Chris Justice* - Justice inquired if there is still any flexibility in funding for next year.
A1: *Dozier* - Dozier responded that the 1992 budget is fixed, and Salomonson echoed this sentiment.

Q2: *Phil Slater* - Slater inquired how the budget cuts would affect AIRS and MODIS in 1998.
A2: *Dozier* - Continued budget constraints during the up-front years imply that two big-ticket items like MODIS and AIRS cannot be launched in 1998.

Q3: *Mark Abbott* - What are considered to be fiscally viable payload groupings for the platform?
A3: *Tilford* - We are currently trying to address what to do about the platform itself, and many options are still open. The primary uncertainty is the cost of the platform, not the cost of the instruments. Examples of fiscally viable payload groupings should be available by the Payload Panel meeting.

Q4: *Phil Teillet* - How will foreign EOS participants react to DoD participation?
A4: *Dozier* - If any portion of the large sums that are spent on defense can be diverted to beneficial uses it should be viewed as a good accomplishment. It should be possible to make such a case to foreign partners, but issues involving data access need to be resolved.

Q5: *Alfredo Huete* - Huete commented on the significant confusion associated with his 10 year contract and the need to have a detailed audit before his contract monitors will sign for 1992 funds.
A5: *Salomonson* - Problems will be handled on a case-by-case basis. Harold Oseroff is the MODIS contact for problems.

Q6: *Phil Slater* - Slater expressed his concern about the proposed use of DoD instrumentation in 1994/5. His experience with their equipment implied that many of their systems cannot be calibrated.
A6: *Salomonson* - Steps are currently being taken to establish a dialog to try to understand exactly these kind of problems. He suggested that John Vitko, who is attending this meeting, would be an excellent first point of contact for this issue.

Q7: *Mark Abbott* - Abbott noted that DoD has historically fought against any kind of publication of data, and inquired what the motivation is for their abrupt about-face.
A7: *Tilford* - Congressmen like Al Gore have been pushing to declassify things related to Earth sciences, especially since the apparent end of the cold war.

Q8: *Chris Justice* - Justice inquired what Dozier is doing to relieve the tensions that exist between the various disciplines within the EOS community.
A8: *Dozier* - Dozier disagreed with the premise that the community was discipline divided, and noted that he preferred to think of compartments within the joint Earth-system sciences. His approach favors a suite of instruments that has some satisfaction for all investigators rather than a comprehensive specialization for one discipline.

Q9: *Howard Gordon* - Gordon listed a variety of problems he and most other investigators have been having with their contracts. His complaints included two weeks answering to a GSFC-sponsored audit that was initiated without notice, and a requirement to file a small business/minority plan. Such activity cuts into research time and has not had time budgeted for it.

A9: *Salomonson* - These problems are new to the MODIS support staff also, but he and Oseroff will accept an action item to try to learn more about the process and to reduce the impacts that are being encountered. Dozier noted that the paperwork necessary to initiate a contract is formidable, but worth the effort because it will speed up the delivery of monies in later years.

6. INTRODUCTION TO MODIS-N

Dick Weber, Project Engineer for MODIS-N, presented a brief introduction and status report for MODIS-N. A contract to build MODIS-N has been established with SBRC, and a very positive kickoff meeting for the contract was held several weeks ago in California. Weber showed the current schedule for MODIS-N. The first major milestone is the SSR meeting (System Study Review) which will be held at GSFC in early December. He is in the process of assembling a team at GSFC to manage and oversee the contract. At the moment, most unfilled positions are for discipline engineers. Weber asked the audience to pay close attention to the issue of MODIS-N sensitivity specifications, because as currently written some have potentially significant negative implications. The contract is a cost-plus contract, and SBRC may be required to invest unwarranted sums to achieve some of the current specifications. He offered pixel registration as an example of a specification that could possibly be relaxed.

7. MODIS-N PRESENTATION

Jack Engel of SBRC presented a technical discussion of MODIS-N, which for many investigators was their first look at the instrument. His presentation dealt with the instrument concept, technical details, requirements overview, baseline design, performance overview, and lists of suggested changes and specification relaxations. Attachments E and F, provided by Engel, should be viewed to gain a detailed understanding of the instrument information. The attachments are fairly comprehensive;

however, a few additional technical details of note were recorded during the talk which do not appear, including:

- **Radiometric resolution is generally encoded at 12 bits; however, some is done at 10 bits.**
- **SBRC has been asked to improve the thermal calibration accuracy, and they think it can be done to 0.6% absolute calibration on-orbit for channels 29 and beyond.**
- **The spectral radiometric calibration assembly can be monitored, but cannot be changed.**
- **The solar diffuser stability monitor (SDSM) can look at the sun and the diffuser and make a comparison measurement.**
- **A second MODIS-N in a morning ascending orbit may require that the instrument be reconfigured as a mirror image of the first.**
- **The graphite-epoxy structure of MODIS-N must be carefully monitored for moisture absorption.**
- **One of the design deficiencies is that the optics introduce a fair amount of distortion.**
- **References in the handouts to near infrared imply wavelengths from 700 to 1000 nm.**
- **Mirror surface have an enhanced silver coating.**
- **It is expected that three mercury-cadmium-telluride sensor chip assemblies will be used, but they are studying the possibility of combining the sensors to reduce detector registration errors.**
- **The proposed specification change to use DC restoration on the blackbody rather than on cold space is expected to use up some of the instrument dynamic range, but only 3 to 4 percent.**
- **The reduced field angles and increased effective focal lengths for the imaging objectives may imply an optical crosstalk problem, but it is not expected to be a serious problem.**
- **The fire bands currently have linear gain and a 22% margin of required vs. expected signal-to-noise. Engel suggested that this can be improved to the desired 36% or better by the use of piecewise linear gains or non-linear gains.**
- **Some of the SBRC suggested changes will have a significant effect on the science, but further discussion is required and will be conducted in the discipline group sessions.**

- **Attachment F presents several suggested enhanced capabilities which were not part of the instrument specifications.**
- **Engel noted that modeling of radiometric accuracies on the thermal bands imply a 1% accuracy for band 22 and significantly better than that for bands 29 and beyond. SBRC is willing to accept this as a performance goal if the investigators so desire.**

8. MODIS-T STATUS REPORT

Bill Stabnow presented a status report (Attachment G) on MODIS-T, which is currently being developed in-house at GSFC. His report reviewed the instrument's science mission, the status of the hardware, and the current posture of resources and personnel. He stressed that even though there is a common perception of MODIS-T as an ocean instrument, MODIS-T is geared toward a product useful for land and ocean investigations. Stabnow showed a video tape and slides (Attachment H) showing the modes of operation of MODIS-T. The video is computer generated, based on the engineers' designs, and provides an excellent simulation and three-dimensional engineering study tool.

The presentation showed that the instrument is expected to perform below the Land Discipline's specifications for bands 28 through 31; however, these are ocean-dedicated bands so the problem is not of consequence. Stabnow noted that the radiation and temperature testing have been successful and that the power supply is in its second iteration breadboard stage. The audience was invited to examine the detector system or any of the other existing hardware.

Stabnow presented the current personnel levels and schedules, but acknowledged that the project is entering into a holding pattern. Although personnel are still working on the project, many of the hardware procurements are on hold which will mean that personnel will soon have to be reassigned. In keeping with what appears to be general sentiment to deselect MODIS-T,

Stabnow's group is exploring alternative packaging in case the instrument is flown on a non-EOS platform.

9. EOSDIS PROJECT STATUS REPORT

Rich Bredeson presented the EOSDIS project status report. His talk is summarized in Attachment I. He outlined the overall context of the ground system and the approaches they are developing to deal with the prodigious quantities of data expected from MODIS and other EOS instruments. Bredeson presented a high level Project milestone schedule, listed EOSDIS mission objectives, outlined the program core system, and showed the project organization and personnel already in place. The schedule presumes the EOSDIS facility will be occupied in 1994 and that the launch will be in December 1998. Information regarding the contracting process for the core system was presented. Bredeson also presented a milestone schedule which presents more detailed information than that available from Project, and briefly discussed his role in the investigators' algorithm development. The background behind Version 0 of EOSDIS was reviewed. Bredeson discussed the shift away from a standards document defining software procedures to a series of papers that provides a handbook describing how to produce EOSDIS-compatible software. The Ground System Operations (GSOP) Newsletter and the formation of the DPWG (Data Processing Working Group) were noted.

Considerable interest was shown by the investigators in the Product Generation System (PGS) Tool Kit which is under development by EOSDIS. The Tool Kit will assist investigators with data reduction and analysis, and will provide investigators with a simulation of their PGS target environment on their home-base computer. An incremental and evolutionary approach has been adopted to maximize resiliency. An interface study of the Tool Kit is approximately half completed. A first draft is expected by early 1992 for review, followed by initial specifications by November 1992, and then a polished set of specifications by the end of 1993. Software development should be able to start in earnest with these specifications, even though the kit itself will not be available until later. This is felt to

be the best scenario that can be achieved with given launch constraints, even though it is far from ideal. The UARS Tool Kit is similar, and was used as the starting point. Some prototyping work will be done at GSFC prior to contract assignment. Prototyping will be done on UNIX workstations, which will also be available for investigators' use on a limited basis.

The major questions addressed from the audience during and after the presentation included the following:

Q1: *Bob Evans* - When do you expect software algorithms to be available?
A1: *Bredeson* - The first release of a working version of EOSDIS, Version 1.0, is expected in the middle 1995. The first version of the software with algorithms is due March 1996. He noted his awareness of the concerns that there is very little time to get everything in place.

Q2: *Mark Abbott* - Abbott expressed a problem with understanding why the Tool Kit is not scheduled to be available to investigators until after Version 1 is due.
A2: *Bredeson* - He agreed that there is a definition problem which will be worked out, and added that no algorithm development is required for the prototype Version 0.

Q3: *Bob Evans* - For investigators to design algorithms, they require the shape of the computer structure and the outreach program representing the interface they will be linking with. Has a concept of the outreach program been defined?
A3: *Bredeson* - The outreach program has been defined and is now being implemented. In fact, one of Bredeson's major areas of responsibility is to figure out how to get the investigator's software into an undefined machine architecture.

Q4: *Mark Abbott* - What is the contractor schedule?
A4: *Bredeson* - There are no contractor schedules yet. All supplied schedules are government projections.

Q5: *Mark Abbott* - What is the role for Earth probe data sets in EOSDIS Version 0?
A5: *Bredeson* - There is a planned role, but it is not completely defined yet. For example, there are plans to ingest TRMM data.

Q6: *Wayne Esaias* - SeaWiFS algorithms should be ported to MODIS. How will this be done?
A6: *Bredeson* - He has not yet taken into account ported software, but there will be some way to translate it. He recommends making all software as portable and well-engineered as possible from the start, that way it will maximize the portion that can be salvaged.

Q7: *Al Fleig* - When will the hardware configuration be known?
A7: *Bredeson* - He does not know, but hopes it will be known at PDR.

Q8: *Strahler* - In addition to math and statistics libraries for the Tool Kit, Strahler suggested that graphics packages should also be considered.
A8: *Bredeson* - These are already covered under the category of image processing.

Q9: *Mark Abbott* - How will scheduling of data set X which is dependent on processing of data set Y be handled if Y is late?
A9: *Bredeson* - This is unknown; however, it is among a set of scheduling issues which have been under discussion.

Q10: *Tom Mace* - Will there be a Federal procurement mechanism for hardware for contractors?
A10: *Bredeson* - No. GSFC workstations will be made available, and efforts are underway to administratively avoid the procurement hassles.

Q11: *Chris Justice* - What are the major EOSDIS problems next year?
A11: *Bredeson* - The largest issues are the need to get a contractor on board, the tight time schedule, and the need to establish a solid Tool Kit study.

Q12: *John Parslow* - Parslow expressed the fact he was encouraged by the sound of the Tool Kit, but also expressed concern that the level of interaction of EOSDIS with the Science Team is still at a very bureaucratic level relative to the kind of sophisticated software that must be produced.
A12: *Bredeson* - There is some interaction, but it is most efficient to have substantive interactions channeled through Al Fleig.

10. AGENDA FOR DISCIPLINE GROUPS

Each of the Discipline Group leaders gave a short presentation on their intended agenda and their major concerns which they wished to address during the Discipline Group sessions. All noted that time had been allocated for a presentation by John Barker on MCST activities, for a presentation by Al Fleig on SDST activities, and for discussion of MODIS-N specifications changes.

Land Discipline Group Leader Chris Justice presented a short presentation (Attachment J) on the intended agenda for the Land Group's discussions. He note that a printed version of the agenda was available, but it was not presented. One of his largest concerns is achieving a consensus statement on platform issues, especially registration accuracy. The discussion topics listed included:

- **Relative merits of MISR and MODIS-T for Land Group**
- **BRDF**
- **Atmospheric corrections**
- **Spectrometry issues**
- **Snow/ice**
- **Test sites**
- **Land DAAC requirements**
- **Topo requirements**
- **Vegetation indices**
- **MAS simulator data for Land Group**

- **Townshend's talk on the geometry issues**
- **Payload discussions : ascending vs descending mode**
- **Time of overpass**
- **ASTER vs Enhanced Thematic Mapper**
- **Registration accuracy**
- **Review paper status**
- **Summary of field experiments**

Atmosphere Discipline Group Leader Mike King presented his agenda (Attachment K) for the Atmosphere Group's discussions. He noted that his desire to discuss AVHRR was prompted by Dozier's statement that AVHRR was an adequate cloud sensor. This concept has been introduced since the Seattle IWG meeting. There is also very recent information on the MAS that is available today. The other discussion topics listed included:

- **A presentation by Nakajima of the University of Tokyo about the Japanese equivalent of the FIRE experiment**
- **Choices for Atmospheric aerosols, prompted by discussions at the Atmosphere Panel meeting**
- **The 10-bit thermal channels**

Ocean Discipline Group Leader Wayne Esaias presented his draft agenda (Attachment L) for the Ocean Group's discussions. He noted that oceans does not favor a 10:30 ascending orbit, and that they strongly desire to avoid a complete loss of MODIS-T. His other topics to be covered were:

- **Changes in the SeaWiFS bands**
- **What is lost if MODIS-T is deselected**
- **Alternatives to MODIS-T**
- **Reports on 2 recent meetings with oceanographers, including one by Marlon Lewis**
- **Ways to coordinate MODIS and SeaWiFS activities**
- **A definitive statement of where they stand on the payload**

Calibration Group Leader Phil Slater reported that Calibration's main meeting was held yesterday, and presented the agenda which was covered at the meeting (Attachment M). Highlights included:

- **Alternatives to MODIS-T**
- **MCST report by John Barker**

- **Bruce Guenther's report on the CalVal meeting in Baltimore**
- **SBRC's report by Jim Young on the MODIS-N calibration system**
- **MODIS-T calibration**
- **Barnsley's report on modeling of MODIS sensors**

Team Leader Vince Salomonson noted that if any group was compelled to consider large changes to MODIS-N they should also consider probable financial ramifications. He added a review of the points he was requesting each of the groups to consider. These were:

- **MODIS-N specification changes, needed by end of meeting**
- **Advocacy position for MODIS-T**
- **What to do with 2 MODIS-Ns, morning and afternoon**
- **Issues for EOSDIS and algorithms**

11. CLOSING COMMENTS

Salomonson gave NASA Headquarters representatives the opportunity to make closing statements. Diane Wickland noted only that their primary function was to listen. Robert Murphy added that they are extremely interested in ramifications of the platform reorganization, most especially those involving the Oceans group.

MINUTES OF THE MEETING
OF THE

ATMOSPHERE

DISCIPLINE GROUP

AT THE

MODIS SCIENCE TEAM MEETING

October 1-3, 1991

Meeting Participants:
Michael King - Group Leader
Yoram Kaufman
Paul Menzel
Didier Tanre
Steve McLaughlin - Executive Secretary

Peter Abel
William Bandeen
John Barker
William Barnes
Andy Boye
Ken Brown
Dave Diner
Jack Engel
Al Fleig
Harold Geller
Sig Gerstl
Liam Gumley
Doug Hoyt
Norm O'Neill
Lorraine Remer
Les Thompson
Si-Chee Tsay
Philip Vermote
John Vitko
Richard Weber

(note that some participants attended for only short portions of the meeting)

SCHEDULE

King presented the schedule (Attachment K) for the meeting of the Atmospheres Discipline Group. The schedule was coordinated with the other Discipline Groups so that shared discussions could be held for issues of mutual interest. At

the request of Team Leader Vince Salomonson, an examination of the specifications for the MODIS-N contract was added to the schedule.

DELIBERATIONS ON THE USE OF AVHRR

King presented a brief review of the results of the Seattle IWG meeting, at which several new payload configurations were suggested. The new configurations were designed to meet the goal of descoping the EOS program through a reduction of the size of the spacecraft involved and a minimization of the number of flights. Near the end of the meeting, a new payload concept was proposed which called for MODIS-N to be flown on both a morning and an afternoon orbiter. The afternoon orbiter was proposed with a 1:30 PM equatorial passage. It contained an instrument complement oriented toward the study of clouds and atmospheric radiation, and represented no significant deviation from previous proposals. The proposed morning orbiter is oriented toward the land discipline studies, and the use of MODIS-N in this package was one of the more significant developments of the Seattle meeting.

Some challenges have arisen to the placement of MODIS-N on the afternoon platform. An alternative proposal is under consideration in some circles which calls for using AVHRR instead of MODIS-N. King presented a memorandum from Bruce Wielicki (Attachment N) on the efficiency of AVHRR over MODIS-N. This memo has been circulated to the full CERES Science Team and to NASA Headquarters. King and Menzel expressed deep concern that AVHRR might be accepted as a replacement, and presented the issue for discussion by the Atmospheres Discipline Group.

During the discussion, some of the most pertinent aspects included:

- **AVHRR cannot do the characterization of the atmosphere, and cannot be considered as a replacement in the afternoon package. It lacks the ability to measure water vapor and cloud top altitude, which would be supplied in the current Seattle plan from a**

combination of AIRS/AMSU plus MODIS-N. Without MODIS-N, the accuracy of cloud radiative, microphysical, and geometric properties would be compromised.

- **Many of the AIRS principle investigators are counting on MODIS-N for support, so they also have a strong interest in keeping MODIS-N on the afternoon package.**
- **In spite of the change in thrust favoring smaller platform configurations, the study of clouds is still a priority scientific issue. In general there are more clouds available for study with an afternoon platform, and no attempt should be made to shift the cloud study activities to the morning platform.**
- **CERES is currently scheduled for the European morning platform. It is currently the only U.S. instrument on that platform, and thus its status is complicated by international agreements. Its current status on the afternoon platform is scientifically justified, and the possibility of moving the CERES instrument from the European platform to the U.S. morning orbiter is recommended.**
- **The only major EOS participant known to favor AVHRR over MODIS-N is Dickinson.**
- **MODIS-N is technically far superior to AVHRR. It will have a visible calibration, whereas AVHRR will not unless there are instrument modifications. MODIS-N has 36 channels versus only 6 for AVHRR. MODIS-N has an infrared sounding capability which is good for detection of cirrus clouds.**
- **The argument that one only needs to know where the clouds are for the morning instrument package is irrelevant.**
- **Without MODIS-N, the morning platform would be left with no temperature sounding capability. MOPITT requires temperature measurements for its moisture determinations. If MODIS-N is maintained on the morning platform, then it can support MOPITT.**
- **AVHRR costs 3 to 4 times less than MODIS-N, which is public knowledge. This cost differential is thought to be a major portion of any argument favoring AVHRR over MODIS-N.**

In summary, the group decided that there is no apparent scientific argument in favor of the use of AVHRR over MODIS-N for either platform. This is especially true for the afternoon platform. MODIS-N is considered to be scientifically advantageous for both the morning platform's land- and aerosol-oriented studies and the afternoon platform's cloud-oriented studies. All arguments favoring the AVHRR replacement appear to be financial in origin. The MODIS Atmospheres Discipline Group is firmly opposed to the proposed replacement.

GLRS-A DISCUSSIONS

King introduced the topic of the Geodynamics Laser Ranging System-Altimeter (GLRS-A) for consideration by the Atmospheres Discipline Group. The system was originally conceived by Jim Smith with retroflectors on the Earth's surface for measurements involving plate tectonics, but a laser system for cloud measurements was later added. Current EOS documentation incorrectly shows the GLRS-A instrument as an ice sheet topography sensor. Portions of the instrument are still in the study phase, so the instrument costs are uncertain; however, it would probably be possible to build it in house at GSFC as a follow-up to the lunar MOLA program. King endorsed the idea of flying GLRS-A in some configuration with MODIS-N, because it would be a significant scientific addition to the program. He solicited responses to this proposal from the other members of the Atmospheres Discipline Group.

King briefly reviewed (Attachment O) a presentation he recently gave to the Atmospheres Panel meeting at GSFC on the cloud sensing properties of GLRS-A. His presentation reviewed the objectives that could be achieved with GLRS-A, the particular advantages and disadvantages, and a set of suggested recommendations. Several additional points were touched on in the discussion.

- **Any airborne field experiment involving thin clouds would normally employ lidar in a similar fashion.**

- **Data would be available only for nadir points relative to the spacecraft; however, this would still provide a good reference point for algorithm verification.**
- **GLRS-A would not necessarily need to be on the same spacecraft as MODIS-N; however, it would need to be in close formation.**
- **It would be helpful in determining cloud structure in areas where cloud studies are characteristically difficult, as in areas over snow cover.**
- **One of the CERES objectives which is not well publicized is its determination of the radiation budget at the surface, and the heating and cooling rate profiles within the atmosphere. A lidar would improve the accuracy of radiation budget calculations based solely on MODIS-N and CERES.**

In summary, the group decided that GLRS-A would very nicely complement EOS cloud sensors, and it would provide enhanced confidence in the derived cloud structure data, especially for multi-layered sets of clouds. It represents far more than just a geodynamics laser ranging system for ice sheets, as it has been characterized. There was agreement that GLRS-A would be a scientifically advantageous instrument to have on the instrument package and that its deployment with MODIS-N should be recommended; however, financial and accommodation implications have not been taken into account.

TRUE INSTRUMENTAL COSTS

As a by-product of the effort to formulate a recommendation regarding the GLRS-A instrument, the Atmospheres Group discussed the issue of how best to understand the costs of EOS scientific programs. Kaufman voiced the opinion, with the agreement of the other investigators, that it is very difficult to make specific recommendations regarding whether a major instrument should be added or deleted, or how it should be prioritized when the whole picture regarding instrumental costs is unclear and apparently unavailable. There is a sense that large portions of instrumental costs are secretive, or so

deeply entrenched as to be invisible. The issue of costing multiple copies of an instrument also serves as a source of confusion. Some procurements, like rockets, have each unit costing the same. The first copy of a sensor instrument is built for a fixed cost, but subsequent copies are built for only 20 to 30 percent of that cost.

ORBIT SELECTION

The MODIS-N instrument in its current configuration can be flown with a local time of equatorial passage of 1:30 PM for an ascending orbit or with a 10:30 AM descending orbit. These two orbits are acceptable for the current configuration of the shield and cooler relative to the solar location for a given orbit. Other orbits may require a mirror image flip of the instrument, a move which is undesirable because additional costs would be involved. If any reason became apparent that implied a need to change the orbits, there might also be serious implications for the SAGE III instrument.

The local times of passage (Attachment P) were examined to ascertain if there were any undesirable implications for the investigations intended by the Atmospheres Group. The charts in Attachment P provided useful information for the discussion; however, they were found to be conceptually difficult because of the shift in local time caused by the change in earth longitude from the satellite motion. Bill Bandeen sketched additional graphic tools (Attachment Q) that were helpful in interpreting the orbits. It was determined that the 10:30 AM descending orbit and 1:30 PM ascending orbit were desirable for MODIS-N. Kaufman observed that these orbits also fortuitously imply better diurnal coverage for polar observations.

GAIN LINEARITY OF CHANNEL 21

Kaufman asked to discuss again an issue that has been raised several times within the past two years, but never adequately resolved. The linearity of the gain for band 21

is a cause for concern because it is scientifically wasteful. Although most of the desired analysis can be done with the current configuration, better science could be achieved with a non-linear gain. Confusion exists regarding where the current specification originated and why a change was not made, but appears to stem from a desire on the part of the engineering crew to keep the gains consistent among the three temperature channels. Confusion also seems to exist regarding the function of channel 21, which is used for temperature sensing but does not contribute to the fire algorithms. Currently the count-to-temperature sensitivity is the same throughout the full dynamic range for band 21, even though the same granularity is unnecessary at high temperatures.

The group agreed to add this issue to the list of specifications issues which they had already been asked to address. If a significant cost expenditure is required to achieve the non-linear gain, then no change is desired. Later in the session, the possibilities of incorporating a logarithmic A-to-D response for channel 21 were discussed with Jack Engel of SBRC. He responded that a move to achieve $^1/_2$ degree resolution for the lower end of the temperature scale should be possible; however, he seemed to favor a piecewise linear response or stair-step gains.

MISR PRESENTATION

The Atmospheres Discipline Group broke and joined the Land Discipline Group for a joint presentation and discussion of MISR. Prior to this action, Kaufman noted that he was particularly interested in discussing use of one of the blue channels in conjunction with the near infrared channels to form a semi-independent vegetation index. He also wished to discuss ground-based formation of a similar index with TM images.

Additional details regarding this discussion are available in the Land Discipline portion of the minutes of the meeting; however, the majority of the presentation dealt with a comparison of MISR versus MODIS-T as viewed from the

perspective of the requirements of the Land and Atmosphere groups. Time intervals required for global coverage were considered a critical issue. MISR personnel indicated that their instrument achieved global coverage in 9 days (slightly less at the poles), and that MODIS-T achieved similar results in 53 days. Seasonal revisit statistics over land areas were presented. Chris Justice of the Land Group was interested in whether MODIS-N and MISR could be combined to produce albedo data, and whether MODIS-T could be used to provide atmospheric corrections. Kaufman was again interested in the "hidden" costs of the instruments, which he felt would make it easier for him to compare the relative merits.

MODIS-N AIRBORNE SIMULATOR STATUS

King presented a report on the status of the MODIS-N Airborne Simulator (MAS), some information of which has appeared previously. Several last-minute updates were included as part of the status report. An extensive memorandum (in two parts, Attachments R and S) has already been circulated via the meeting information packets which describes the instrument.

The report was presented as a set of slides (Attachment T). The objectives of the MAS were presented, the foremost of which is to fly an airborne radiometer that will allow testing of MODIS-N algorithms and techniques prior to the launch of MODIS-N. King described the basic instrument, and some of the evolutionary steps which preceded it. The MAS will nominally be flown on a NASA ER-2 aircraft, and will have 50 channels, a spatial resolution of 2.5 milliradians (45 meters), and a 86 degree swath width. It is being derived through modification of an existing instrument called WILDFIRE. The current system consists of three components: a spectrometer(hat), a scanner, and the data system. It was designed for measurements of hot fire targets, but was found by Ames to have too much noise for normal terrestrial signals and no channels in the visible wavelength regions. The MAS represents a $200 K program

with Daedalus Enterprises, Inc. to modify two spectrometer ports in order to achieve a MODIS-N simulator.

King reported that a partially modified version of the instrument will be flown in November. Only 43 channels will be available, with the largest omission being in the visible wavelength region. Only one visible channel, derived from a single interference filter, will be available. For selected channels, the normal 8 bit digitization is enhanced using a "bit bucket" processing scheme. Attachment T shows the 11 channels closest to MODIS-N equivalents that will be operational in November on the MAS. The full MAS instrument will have two water vapor channels that have never been flown from an aircraft before, as well as carbon dioxide slicing channels. It will be capable of measuring aerosols and the optical thickness of clouds like MODIS-N. The instrument has two configurable boards which can be selected by the ER-2 pilot.

Ken Brown (instrument manager) presented some additional very recent information regarding the MAS status. The first channel is at 0.680 micron. Channels from 1.63 to 4.5 microns were derived by repositioning gratings. The channels from 8.8 to 12.95 microns are spread over nine detector elements; however, the 8.8 micron detector has gone bad. It is not known why the detector went bad, but noise characteristics are known to be larger than expected. Even though this detector will not be used in the final instrument, temporary options to work around this problem were discussed. All detectors can be shifted so that either of the endpoint channels can be dropped. Alternate locations on the array may be tried. The possibility was offered that the manufacturer may have a spare dewar to substitute.

An off-line telephone conversation was held with Fred Osterwisch (the optical engineer at Daedalus) later in the meeting. Menzel and Brown reported that replacing the failed detector is not an option, making 9 channels available for 10 detectors. Menzel is still in the process of selecting an option, but the choices have been reduced to

swapping the 8.8 micron channel for the 9.2, or deleting the 12.95 channel to recover the 8.8. These choices complicate the CO_2 cloud top altitude measurements; however, it may still be possible to accomplish the desired science with short wavelength channels. Daedalus has shown interest in the project since its inception and is continuing to take initiatives to keep the project moving. The investigators are pleased with progress on the hardware.

At the previous Science Team meeting, a proposal was made to the SDST to have them process the MAS data because of the strong similarities to the expected MODIS-N data. Liam Gumley was hired to support Al Fleig's SDST group because of his experience with MAMS data processing. MAMS software has a similar software heritage. The data format will be the equivalent of MODIS-N Level 1B data, and is expected to include MAS data, calibration data, geolocation data, and normal housekeeping data. Data distribution to Science Team investigators will be done from GSFC. A common ER-2 configuration involves the use of ground plots taken in a mosaic pattern. A metadata database of the plots will also be available as part of the delivered data.

The current schedule calls for MAS to be delivered to Ames on October 15, at which time it will be integrated onto the ER-2 right wing superpod. Preflight assessment will be done only on data channels to be recorded. The aircraft leaves November 11 for Houston and the FIRE experiment starts the next day. Bruce Guenther will be responsible for performing the calibration at Houston. A preliminary calibration is considered necessary for at least the determination of the gain values. MAS will be returned to Daedalus for final conversion to a 50 channel spectrometer in February or March. The first full-up MAS flight is expected with the ASTEX program in June 1992. King considers this to be a very tight schedule, considering that the instrument has never flown before, has one failed detector, and has a high degree of visibility. He expressed a justifiable nervousness about the initial tests.

The MAS status report was concluded with a discussion of problems inherent in the initial calibration efforts. Menzel

expects the thermal calibration to be good, but the visible wavelength calibrations will be poor due to temperature sensitivity of the electronics and optics components. A thermally controlled instrument would be preferable to control the environmental changes; however, no funding is available to do it and the consequences will have to be tolerated. Thermal controls are expected later on. The suggestion was made that exposure of the instrument to a simulated environment might help in understanding its performance, but this was not deemed to be feasible under the circumstances. Vitko noted that the failed detector adds an element of uncertainty to the calibration.

MCST PRESENTATION

John Barker presented a report on current activities being carried out by the MCST group and characterized the support which investigators should expect in the future. This information was presented in Attachments U and V. Attachment U is a very preliminary version of the calibration handbook for MODIS-T, which should serve as a model for other similar documentation. When completed, it is the author's intention that this document will contain essentially everything that a scientist needs to know to use MODIS-T data. Attachment V is a report on the MCST which was presented at the MODIS Calibration Panel Meeting that preceded the current Science Team meeting. With the exception of a few highlights, a few questions, and some minor supplemental information provided during the meeting, the Attachment V report is self-explanatory and no further summary in the minutes is required for the reader.

- **King inquired if any instrument models would be developed by contractors. The response was affirmative--in fact, the manufacturers models will be used as starting points for MCST modeling.**
- **Menzel inquired if the MODIS pointing requirements could be compared to AVHRR requirements. Barker was uncertain of the specifics, but was inclined to consider AVHRR requirements far less stringent than MODIS because AVHRR has a far smaller platform.**

- **Barker does not have his cloud masking algorithm working yet, but only because he has had insufficient time to devote to the problem. No special problems are anticipated.**
- **Approximately 90% of the spacecraft pointing error is expected to be bias, not random error; therefore, it is expected that it can be modeled out.**
- **Band-to-band registration sensitivity studies imply registration to better than 0.1 pixel is unlikely.**
- **MCST will be formulating all plan materials in the same form as the reference handbooks, so that the two can map to one another.**
- **The calibration handbooks version 1 can be expected to be available at the next Science Team meeting.**
- **SBRC's preliminary plans for MODIS-N are also available from MCST.**
- **MCST is using 1 km data from the EDC to look for calibration sites that are homogeneous throughout the year.**
- **Barker presented the current numbering scheme for the 10 detector elements, and inquired if any of the investigator's had a preference regarding the ordering of the numbering scheme. Only Menzel expressed any preference, which was to set the numbering and freeze it.**

ATMOSPHERIC AEROSOLS

King offered the topic of the pros and cons of aerosol sensing using MODIS-N, MISR, and EOSP as one which warranted general discussion because it has been a recurrent theme at recent meetings of the Atmosphere Panel. The topic is less a MODIS issue than it is a topic of interest to the Atmosphere Discipline Group. The ensuing conversation lacked a directed focus and frequently entered into technical detail, making the results most easily summarized by a listing of the most significant points raised during the discussion rather than by a paraphrased summary.

1. **MODIS-N is extremely useful for the study of atmospheric aerosols, which may be contrary to the common perception.**
2. **General consensus seemed to be that MISR would be more advantageous than MODIS-T for the study of aerosols; however, MODIS-T was not entirely without its strong points. The deciding factor appeared to be that MODIS-T would be dominated by ocean-studies at the expense of aerosol and other atmospheric studies.**
3. **The Atmospheres Discipline Group expressed only small interest in MODIS-T. They preferred the combination of MODIS-N and MISR for atmospheric, cloud cover, and aerosol studies. Either is useful on its own, but together they make a strong complementary pair of measurement instruments. They view MISR's greatest strengths to be its stereo-capability, the multi-angle viewing, and its resolution.**
4. **Dave Diner made the argument that one of MISR's strengths was that it allowed a one day repeat cycle.**
5. **Diner commented that what MISR does with multiple angles is conceptually similar to what MODIS-N does with observations on multiple days, making the two instruments complementary. The physics is similar, but the approach is different.**
6. **Sensor sensitivity has been a recurrent theme at the Atmospheric Panel meetings during discussions of aerosols.**
7. **Diner commented that the issue of sensitivity should be considered in conjunction with retrievability. If it is not possible to separate the effects of several phenomenon to which an indicator is sensitive, then the sensitivity is of minimal value.**
8. **The more MISR is looking off-nadir, the more sensitive it is to aerosols. This represents a significant MISR advantage because it is equivalent to an increased sensitivity of the retrieval mechanism. However, if the look-angle is too far off-nadir, it becomes difficult to avoid cloud cover.**
9. **MISR has two categories of algorithms: single coverage algorithms (like the dark target algorithm) and those that require simultaneous coverage with another instrument.**

10. **MISR argues that they can provide MODIS-N investigators all the complementary observations they require, but so too would EOSP argue. It is King's opinion that EOSP would be at a disadvantage because unravelling the atmospheric polarization from the surface polarization would be extremely difficult. Clouds in particular have a very weak polarization signature.**
11. **Tanre presented some observational analysis which supported King's position. Aircraft observations of the polarized reflectance at 550 nanometers were taken of a 12 km by 10 km area near La Crau, France. The results showed a Rayleigh model and an aerosol model of the reflectance compared to the observations. The research demonstrated that polarization can be a useful tool; however, the 4 years of analysis needed to go from observations to model was offered as proof of how difficult it can be to move from raw observations to an effective model of the results.**
12. **EOSP is currently slated to fly on CLIMSAT for the purpose of measuring aerosols, but lobbying is still being done to earn it a spot on an EOS payload.**
13. **An analogy was drawn between EOSP and instruments used to measure the optically thick atmosphere of Venus and the thin atmosphere of Mars. Although such polarization instruments work very well in the Venusian atmosphere, Mars was thought to be a better analogy.**
14. **There is a significant drop-off in sensitivity as reflection goes up, but EOSP should be capable of measuring sensitivity at the 0.2 percent level.**
15. **Polarization is sensitive to many factors, which is both its greatest strength and its greatest weakness.**
16. **King expressed the sentiment that he would like to see GLRS-A as a rider rather than MODIS-T because it would be beneficial to his research.**

DISCUSSION OF SUGGESTED MODIS-N SPECIFICATION CHANGES

Attachment W provides a list of potential specification relaxations requested by SBRC. Team Leader Salomonson asked all Discipline Groups to discuss, to comment on, and to refer recommendations regarding these changes through channels. There are four issues to deliberate, with item 1 broken into sections A through D.

Menzel summarized the feelings of the group regarding issue 1A. This change deals with individual pixels on a swath. If there is an image misregistration, especially in the thermal bands, any cloud edge can cause serious changes in perceived radiance. Experience with GOES-I has shown that registration to better than 0.1 of the instantaneous field-of-view should not be expected, although it is important to strive for it. The suggested approach is to maintain the specification for now and to ask for the manufacturer's best effort, but to also monitor the situation closely. The danger is that they may end up spending too much money to achieve the specification, and it may be necessary to hedge later on.

Issue 2 seemed to meet with general acceptance, although there was concern that additional clarification might be warranted and that there might be some misinterpretation of how the channels were intended to be used. Menzel noted that it would be preferable to discuss the problem in terms of NE DR, which is how the specifications were written, rather than NE DT. He also cautioned that he does not want all the dynamic range for this channel at the cold end, and that he does not want to see band 21 specifications creep into band 20.

Issue 3 concerns band 29, which is a compromise "window" channel. It is used by atmospheres for viewing thin cirrus and monitoring the the cool end of fire temperatures, but is also used by Z. Wan as a land surface viewing channel. SBRC seems to be requesting more margin for this channel, which does not meet with atmosphere's approval. The

dynamic range should not be allowed to extend to 400 degrees. The temperature maximum should extend to only 335 degrees.

After significant discussion, issue number 4 was judged to be a reasonable request. During the discussion, it was noted that TDI stands for Time Delay and Integration. This is a technique that looks at the same target on the ground twice, and then sums signals directly at the focal plane.

IMAGE REGISTRATION

Al Fleig presented information on four issues related to the Science Data Support Facility (SDSF) which are of interest to the investigators. The first of these topics was image registration, which is summarized in Attachment X. Image registration deals with consistently locating pixels from one or more scenes relative to a reference image. There is already a fair amount of existing documentation on this subject. Studies for the defunct 1A platform show that a 3 sigma error equates to approximately 480 meters of error at the surface. For smaller platforms, this is expected to improve. For comparison, Menzel noted that a geostationary spinning satellite has RMS error of approximately 1 km. For many applications, this resolution is very good--especially when compared to a 1000 km swath width. It is good enough that band registration is not a critical issue for the atmospheres or ocean groups. The land group, however, does consider it critical and would like even finer registration than projected. Although there are no specific plans formulated yet, SDSF intends to do whatever is possible within budgetary constraints to improve the band registration. This could be done on a case-by-case basis or by systematic long-term registration of all data.

TOOL KIT

Fleig clarified several misconceptions regarding the tool kit that will be supplied by project and which was described at yesterday's meetings. The EOS Project's current plan is that

they will provide no funding for off-the-shelf commercial software. Any such software must be obtained through the investigator's individual budget, including licensing fees and copies to be used on whatever number of nodes on which it will be utilized. Project's tool kit will provide only the interfaces to use the various possible tools. The Team Leader Computing Facility (TLCF) will provide single copies of the software on their machine for production algorithm testing only. The Project intends to make the EOS processing computer (Product Generation System, PGS) structure transparent to the investigators. However, in reality the investigators will have to know the structure to be able to write their algorithms to process efficiently. SDSF is not supposed to develop the expertise to advise investigators on the scientific aspects of algorithm writing, but will provide coding optimization support.

TEAM LEADER COMPUTING FACILITY

Fleig distributed Attachment Y which provides background on his current conceptualization of the MODIS TLCF. Due to rigid configuration controls, the PGS cannot be used to experiment with and develop algorithms. Therefore, the TLCF must be big enough to be used for algorithm development. Algorithm development is expected to be an extremely iterative process. Fleig's concept has the investigator developing prototype algorithms on a powerful local workstation. The algorithm can then be used on the TLCF to test increasingly larger batches of data until algorithm confidence is achieved. At that time it gets transported to the full-up machine for production processing. This concept should provide an acceptable working environment for MODIS, where it is expected that every pre-launch algorithm will be modified after real data are available.

Fleig attempted to emphasize that the investigator's interface to and activity within the TLCF could largely be selected by the investigator. The oceans investigators have elected to channel most of their computer work through a facility in Miami; however, they can also interact with the

TLCF. Fleig stressed the concepts of flexibility and service. Fundamental implications and quality control (QC) of the data will be the responsibility of the investigator; however, the TLCF can be educated to perform some elementary level QC. Daily operator processing and delivery of data are anticipated. In some very selected cases, data reprocessing may be done on the TLCF. In response to a question from Tanre, Fleig pointed out that EOSDIS will pay the costs of data links for U.S. investigators. However, the situation for investigators not located in the U.S. is less clear and their sponsor may have to pay some or all of their data link costs.

DATA PROCESSING OVERVIEW

Fleig distributed Attachment Z, which provides a draft description of the Level 1 data products. Level 1 data products have no cloud identification and no atmospheric correction applied. The investigators considered this to be a plus because almost everyone seems to have their own interpretation of what the correction should be. There is also no land versus ocean identification, although it is possible to independently make this differentiation by looking at the ephemeris. The attitude data is determined on-board the spacecraft and will be attached to the level 0 data. Level 1A data products are not designed for use by the investigator. They are not earth-located, not unpacked, and not calibrated. Most investigators will start their processing with Level 1B data products. Assumptions which were made to determine the product descriptions are included at the end of Attachment Z, and are still very flexible.

During the discussion of Attachment Z, the following points were raised:

- **The TLCF computer is likely to be the same "brand" of computer as the PGS so that software is easily transportable.**

- **Fleig projects two separate procurements for the TLCF, in 1993/4 and 1998.**
- **Project is prepared to process 5 to 10 percent of the MODIS data in near real time for quick look tasks.**
- **A variety of opportunities exist regarding data that can be processed before launch. These include SeaWiFS data, simulated data (by Barker) using LANDSAT TM data, forward transfer models of a simulated Earth by Barnesley, MAS data, MAS data convolved with TM data, and Pathfinder datasets.**
- **Fleig suggested a working group for data collection and comparison, comprised of members from the existing Land, Ocean, and Atmospheres Discipline Groups.**
- **MODIS should take the lead in formulating data structures.**

VIRSR

The group considered one last potential substitute for MODIS-N in the afternoon platform. King distributed Attachment AA, which shows the proposed spectral characteristics of the channels for the VIRSR (Visible/Infrared Scanning Radiometer) instrument. It will be flown as a follow-on to AVHRR on NOAA-O in 1997 or on the European Polar Platform. It has a cloud sensor that would be available, and with a $ 17 M instrument cost it is considered operationally inexpensive. The group decided that VIRSR was lacking in too many areas relative to MODIS-N that it would not be a reasonable substitute for atmospheric science. It does address some of the capabilities that AVHRR was found to be lacking, but was considered inadequate for other reasons. Commonality with measures from other afternoon platform instruments would be a problem. It is missing atmospheric stability, has poorer spatial resolution, and would be inadequate for cloud heights, ozone measures, aerosols, fire studies, and water vapor.

ACTION ITEMS

Barker - Investigate AVHRR pointing requirements and make them available to Atmospheres Discipline Group investigators.

Salomonson - Consider formulation of a working group for data collection and comparison, comprised of members from the existing Land, Ocean, and Atmosphere Discipline Groups.

MINUTES OF THE MEETING
OF THE

MODIS

CALIBRATION

PANEL

PRIOR TO THE

MODIS SCIENCE TEAM MEETING

September 30, 1991

MEETING PARTICIPANTS:

Name	*Affiliation*
Harold Geller	GSFC/925/RDC
Mike Barnsley	University College London
Bill Browne	GSFC/EOS/422
Bruce Guenther	GSFC/920.1
Bob Barnes	Chemal, Inc.
Ann Mecherikunnel	GSFC/920.1
Shelley Petroy	GSFC/925/RDC
Lloyd Carpenter	RDC
Thomas Goff	RDC
Liam Gumley	RDC
John Shumaker	RAI
Stuart Biggar	University of Arizona
Jim Young	SBRC
Jack Engel	SBRC
Peter Abel	GSFC/920.1
Douglas Hoyt	RDC
Jonathan Burelbach	GSFC/925/RDC
Samuel Hetherington	GSFC/717.3
Phil Slater	University of Arizona
John Barker	GSFC/925
Bill Barnes	GSFC/970

Al Fleig	**GSFC/900**
Phil Ardanuy	**RDC**
Bob Evans	**University of Miami**
Carol Johnson	**NIST**
Bill Eichorn	**GSFC/717.3**
Brian Markham	**GSFC/923.0**
Dick Weber	**GSFC/422**
Steve Ungar	**GSFC/923**
Catherine Trout	**GSFC/717.4**
Harvey Safren	**GSFC/725.2**
Ken Brown	**GSFC/925**
Paul Menzel	**NOAA/NESDIS**

Phil Slater opened the meeting. Slater showed a copy of the agenda and stated that the four main areas of discussion were to be MODIS-N, MODIS-T, MCST and a report from Guenther on the EOS Calibration/Validation panel meeting that occurred in Baltimore the previous week.

BARKER'S REVIEW OF MCST ACTIVITIES

John Barker presented a copy of his presentation entitled "MODIS Calibration Panel Meeting Report on the MODIS Characterization Support Team (MCST)." (Attachment V). Barker began his presentation with the MCST Presentation Topics. He then continued with the MODIS Science Team Organization Chart.

Barker continued with the "Primary MCST Responsibilities to Instrument-Related System Characterization/Calibration". He noted that the view-graphs were being presented as a review of his presentation and talk at the February MODIS Science Team meeting. Barker continued with the "Calibration Plan". A question arose regarding why "official algorithms" was in quotes. Barker replied that he was trying to highlight the fact that this algorithm will exist as a unique algorithm that will represent the method for converting raw Level-1A digital numbers into calibrated Level-1B digital numbers, QCAL (calibrated and quantized scaled radiance). This algorithm will be under configuration management. Barker continued with the

"Calibration Plan" Assumptions. He noted that the precision of the instrument would take on the time scale of months to characterize properly. He also noted that the accuracy would take on the order of years and that models would take on the order of a decade.

Barker then discussed the "MCST Produced Responses and Documents" view-graph which represented the documents generated since the February meeting. Phil Slater had questions regarding the response to the GE Platform Questionnaire. He asked Barker if all members of the MODIS Science Team had been given a chance to review the response before it was sent to GE. Barker mentioned his contact with members of the Land Group (Justice and Townshend) and his numerous presentations to the MODIS Technical Team but noted that not all members might have seen the questionnaire. Slater asked for general distribution of the response before another version goes out to GE. In discussing the Response to "EOS Cross-Calibration Questionnaire" view-graph, Guenther noted that he felt the VIS/NIR (visible/near-infrared) and TIR (thermal infrared) responses should be separated by instrument rather than wavelength. The reason that the responses were separated by wavelength was because it was the way the questionnaire was received from the EOS Cal/Val Panel.

Barker continued by discussing the MODIS-N and -T Science Calibration Plans. He expressed thanks to Bill Eichorn and Sam Hetherington for their help on the MODIS-T plan. He stated that Version 1 of these plans will be released at the next MODIS Science Team meeting (expected to be in March 1992).

Barker then discussed the MODIS-N and -T Calibration Handbooks. It was explained that these were to be input to an EOS Reference Handbook that the EOS Reflected Solar Panel A of the Calibration/Validation Panel was assembling. Barker continued by discussing the Scientific Requirements defining Instrument Specifications. He mentioned the development of an instrument Science Requirements document by MCST to start capturing scientific rationale for some of the decisions associated with the instrument specifications. Guenther began a discussion of the names of the documents. Guenther felt, and there was a consensus from the group, that these documents

should be renamed to "Science Requirements Supporting Instrument Specifications."

Barker continued with "Documents Expected from MODIS-N (SBRC)". A discussion followed regarding the delivery dates of the noted plans. SBRC noted that the Preliminary Plans were actually written in December 1990, being delivered to MCST at the Kick-Off meeting September 17, 1991. Dick Weber joined Jack Engel in a discussion of the expected delivery dates for the final plans. Although contractually due at PDR (about October 23, 1992), it was expected that the government would ask for the opportunity to review the plans as much as 60 days prior to PDR. This was to be worked out by Dick Weber and SBRC.

Barker continued with the "Documents Expected From MODIS-T (Code 700)", and noted that the expected documents paralleled those required from SBRC for MODIS-N.

Barker continued by presenting the "MODIS Geometry Requirements Table from response to GE questionnaire". It was quickly noted that the fact that the table presents 3-sigma values should be added to the title. A discussion of the table and its significance was participated by Bob Evans, Al Fleig and Barker. Barker then presented the "MODIS Geometry Goal Table from response to GE questionnaire". Bill Barnes noted that these goals were more achievable with a smaller platform. Also, GE is not responsible for achieving these "goals."

Barker continued his presentation with his summary view of the "MCST Activities and Status". Phil Slater asked for further details on the "MODIS Radiometric Models". Barker described the spreadsheet model developed by RAI contractors under Harry Montgomery, the spreadsheet model of Mike Roberto and the spreadsheet model of Bill Eichorn. In regards to the MODIS end-to-end model development, Guenther noted that this was something originally agreed with Tom Magner, who was then the MODIS-T instrument manager for Code 700. He thought that Barker would have to pass this by the current manager, Bill Stabnow, in order to determine if this was still the general consensus regarding the end-to-end modelling efforts.

Barker then presented the MCST Action Items From February MST Meeting and Status Thereof. In regards to item one

(Perform a first cut selection of the uniform "super" test sites on the North American continent using available AVHRR data sets), Slater raised questions about the weather conditions. The AVHRR data being examined was believed to be clear NDVI (Normalized Differential Vegetative Index). Regarding Item two (Look at MODIS snow and cloud masks), Barker mentioned his work with Dorothy Hall and Vince Salomonson. Regarding the third item (discuss incorporation of higher level data products in the calibration algorithms at greater length at the next science team meeting), Barker needed clarification from the panel as to what issue this really referred to. It was determined that this item dealt with the higher order data that can be used for calibration purposes and was an Ocean group action. The last item (verify methodology used by SDST in cooperation with Paul Menzel) was considered to be self explanatory.

A discussion ensued on the use of calibration spheres. It was noted that the AVHRR Pathfinder was a good place to see an example of how things might be done. It was noted by Guenther that cross calibration issues among international instruments had to be addressed in the Memorandums of Understanding (MOU).

Barker continued with a brief look at the "Material Available from MCST" and completed his presentation with a request that questions, concerns, suggestions, and actions for the next meeting be addressed either by filling out the MCST Feedback Sheet or contact made by E-mail with either Harold Geller, Joann Harnden, or himself.

CALIBRATION/VALIDATION PANEL ISSUES

Bruce Guenther presented an overview of the Thermal Infrared Workshop Topics. He highlighted the importance of cross-calibration and summarized by noting that pointing precision and accuracy may cut across several spectral intervals and that this topic might be considered for a separate short workshop.

Guenther (Attachment BB) then presented "Recommendations for Peer Calibration PDR and CDR". He highlighted the goal to perform an in-depth, technical review in a format that allows inputs from a peer panel of experts. The present view of

participants includes team members, calibration working group members, project engineers and NIST personnel. Current schedules held the timing of the review to be no later than PDR and CDR, and that the panel should submit a formal report to the engineering panel including action items and suggestions.

Guenther mentioned the questions about ASTER regarding the overlapping of 2 channels of MODIS-N and the unknown relationship of 3 other channels. Barker emphasized that the pre-launch calibration must be understood. Carol Johnson highlighted the role of cross-calibration.

MODIS-N CALIBRATION

Jim Young from Hughes SBRC (Santa Barbara Research Center) presented an overview (Attachment CC) of the calibration of MODIS-N. Young pointed out that the requirements being presented were not quite as good as the Phase B study. He noted the 5% calibration in Phase C/D requirement versus the Phase B study goal of 2%. Phil Slater noted the difference in the on-orbit calibration of 3% versus 2%.

Slater posed a question as to whether or not SBRC was doing a complete pre-flight calibration using the solar diffuser. Jim replied that the solar diffuser was to be characterized on the ground. Guenther questioned the band-to-band registration requirements in regard to the 0.1 IFOV (instantaneous field-of-view, for 1 km resolution) for between-all-bands. Al Fleig expressed concern on the image registration and wondered about an analytic description of pixel shape. Phil Slater asked about the absolute radiometric measurement on both sides of the mirror. Guenther brought up the out of field geometry which led to a discussion of the possible out of field stray light effects.

Jim Young spoke about the calibration effort required to obtain field effects, and emphasized that it was not a simple matter to perform an absolute BRDF (Bidirectional Reflection Distribution Function).

Phil Slater asked why there was a break in the requirements at the 2 mm band and Jim Young offered an explanation. Slater asked about spectral stability of the thermal IR filters. Jim

stated that this was not a problem and that the VIS/NIR was different because of the use of oxides in filter manufacturing and the porosity effects on water absorbance of these oxides.

Guenther questioned whether or not the blackbody's emissivity will degrade in-orbit. Jim Young replied that he did not have that information. Al Fleig brought up the question of the paint used. Stuart Biggar brought up a question about polarization effects.

It was stated that SBRC was said not to have a means to measure the paddlewheel scan mirror characteristics. Jim Young stated that he would present a conceptual design for reflectance check across the surface of the scan mirror. This led to a discussion of the concepts as presented by SBRC. Two methods were presented by Jack Engel. Questions were raised and Jack Engel mentioned that a movement of the solar diffuser FOV will encroach on the next instrument on the platform. Guenther raised question about the possible contamination on the grating.

A discussion arose of the approximately 300 steps needed for the monochromator to scan all of the filters. The derivation of the shape was considered iffy although Jim Young felt that the center wavelength could be determined accurately.

The expected lifetime of the incandescent light source was discussed. It was mentioned that a 10% duty cycle was expected. Barker questioned the use of 2 lamps versus 3 lamps. He also asked whether or not the 2 lamps could be used at once or only alternately. The answer was alternate use only, and Jack Engel stated that to have 2 lamps on at once would use too much power. The TM lamp was said to be only a 2 watt lamp.

Discussions continued regarding the Solar Diffuser Stability Monitor. Barker asked if the sun and the diffuser would be viewed in different scans. This apparently was the case. Phil Slater asked about the angle of incident light on the solar diffuser. This information was not available to Jim who said he would get back to Slater with the answer.

There was talk about the wide dynamic range of the optical system where F-stop value F5 was the effective beam width in accordance with specification and F-stop F100 is the sun. The

question about the spectrometer being non-uniform was said to require further examination.

Bill Eichorn asked if there had been an analysis on the tolerance to heating. Jim Young mentioned some work and that he expected no problems. Eichorn asked if analyses were planned for the future and Jim responded that it would depend on a number of things, i.e. maybe.

Phil Slater asked about the possibility of stray light in regards to the SDSM. Jim noted that you certainly don't want a portion of the Earth illuminating the subsystem. The MODIS-N in-flight calibration capability was discussed as well as the ground support equipment and bench test equipment functions. Barker mentioned the MCST computer link to SBRC in regards to calibration test results. Guenther brought up the question about the use of the metric system versus the British units.

Questions were raised about the thermal vacuum testing of MODIS-N. A discussion ensued regarding the necessity of chamber modifications so that there was an ability to look at the integrator at the same time.

There was a discussion about the concerns regarding spectral band shifts. Jack Engel mentioned that spatial and spectral effects were of equal concern and Stuart Biggar expressed concern for proper monitoring. Guenther and others discussed multi-layer dielectric filters and associated contamination during assembly. Also discussed was the sealing of the filters.

There was a discussion on the selection of diffuser material. The two main candidates seemed to be Spectralon and YB71. This was determined to be an open issue that needed further study.

Jim Young discussed the lunar calibration of MODIS-N. Of note was the fact that there will be no DC restore in space, the DC restore level will use the blackbody. There were concerns about the validity if the optical paths were not identical. Also discussed was the work of Robert Wildey and Hugh Kieffer and the fact that SBRC needed to contact these investigators regarding the use of the moon as a calibration source.

MODIS-T CALIBRATION

Barker presented his Report on the MODIS-T Instrument Calibration/Validation (Attachment DD). He stated that this presentation is a conglomeration of material from Bill Eichorn, Sam Hetherington, Bill Stabnow, Mike Roberto, Hugh Kieffer, Dennis Evans, and himself.

The following topics were presented briefly as background material, and Barker suggested that each person may read the material on his or her own:

- **MODIS Science objectives,**
- **Overview of MCST role,**
- **Background information on MODIS-T being built in the in-house mode,**
- **An organizational chart showing who's who, including the top three,**
- **Science requirements,**
- **Land signal to noise (note differences in specifications),**
- **Ocean signal to noise (met requirements with some margin),**
- **Top level instrument parameters,**
- **Review of instrument layout including,**
  - **MODIS-T periscope scan mechanism**
  - **scan mirror**
  - **tilt axis**
  - **diffuser plate (when deployed)**
  - **calibration system (changed slightly from original layout)**
  - **aperture mechanism**
  - **solar calibrator (noting that it is in the same place).**

Regarding the whiskbroom scan review, Barker noted the following:

- **30 detectors**
- **FOV swath 1500 km / (4.04 sec.)**
- **AIRS suggested that we have all scanners connect to spacecraft scanner. For MODIS-T this would be easy, but there is some question for MODIS-N.**

Note to SBRC - feasibility of 8 second multiples for time related pixels.

The optical layout for MODIS-T was discussed, noting that the sphere is off to one side.

In discussing the flight calibration system Barker noted that there are three different flux levels, which is to be changed to two. He also discussed the images from the integrating sphere to the coupler.

The internal calibration system concept was presented as a schematic which was provided by Bill Eichorn. It was noted that the solar filter has the ability to check degradation in transmission characteristics. Phil Slater asked if this was to be done by moving the filter. Al Fleig brought up the question that if degradation is detected, then what? Barker's response was that the ratio of the filtered vs. unfiltered radiance is the correction. Whether the filter will darken is TBD. The main point is that the filter should not degrade with time.

Barker continued, noting that the main question to be raised here is where are the sensitivities in the internal calibration system? The sensitivities are:

1) **Degradation on internal part of sphere was a concern so the sphere coating and solar filter were revised. DON'T EXPECT DEGRADATION.**
2) **Filter mechanism protects the sphere and has to be maintained over time.**
3) **Provide another intensity level (using a smaller aperture) for linearity checks on degradation of sphere coating (probably not possible due to low intensity).**

Additional concerns included:

- **Sphere to cone coupling (this is presently undefined),**
- **Diffuser plate materials (doped vs. undoped Spectralon)**
- **Scattered light reflected to optics**

Bill Eichorn noted that the concentrator and aperture are not in line.

Al Fleig asked if we can use the same figures for both apertures regarding degradation of solar filter. Bill Eichorn's answer was yes, when and how long we do it is controlled by the stability of the filter. Slater asked how the uniformity of the diffuser plate varies with tilt position. Barker responded that he has charts on

this which will be shown later in the presentation. (Eichorn noted that there is one other still to do: the response to non-uniform near field radiance.)

Regarding operating MODIS-T, it was brought up that on each orbit some land viewing is possible, if we change the tilt. This is not worked out yet. A standard mode will be worked out, as a function of latitude. Guenther noted that this is a strong rationale for MODIS-T, i.e. include greater use for land for BRDF studies. How to tilt each orbit for land observation is important for determining future science products. There is a need to support the Land Group to get MODIS-T on the platform, so emphasize more observing time for land folks.

Barker discussed the periscope tilt and various diffuser locations, noting that the lens has been removed from the design, and that the diffuser is illuminated directly by radiation from the Winston Cone, providing a diffuse source of known radiance to the detector. In response to those who ask why the periscope should tilt even more (>55 ^{o}), the desire is to look at the solar diffuser and do lunar calibration.

On the 1998 EOS Beta angles, the minimum (~11 degrees) and maximum (~32 degrees) were noted, and it was noted and generally agreed that 22 degrees is used nominally.

A discussion followed regarding materials, particularly the paint to be used on the sphere. At this point it is to be MS-74. Halon (100% undoped) may have very little degradation, but adds to mass. According to Eichorn, the thermal impact is still to be determined.

At this point, Slater expressed his concerns regarding the math model:

1) stability of components within the ICS
2) radiance level (through-put)
3) sphere to cone coupling
4) efficiency of spheres

He further elaborated on two concerns:

1) Stability : The derivation of the equations are OK (the equations are listed in the science calibration plan). However, Equation 7 described the reflectance of the transmission diffuser not the transmittance through the diffuser.

2) Radiance level may be one-half of what Eichorn predicts, thus expected radiances drop by one-half. In response Eichorn replied that the actual diffuser is like ground or dusty glass - forward scattered. He noted that we do not want a Lambertian diffuser. The final model will have the transmittance of the diffuser and will be based on actual data, not assumptions.

Phil Slater spoke about the assumption of the sphere to cone coupling, noting that 98 or 97 efficiency is very optimistic.

Slater made note of two points:

1) Energy though system is low (i.e., through-put).
2) Sensitivity is high.

Eichorn replied that over next six months they will update the calibration model, build a model of the instrument in the Lab and make measurements of through-put, sensitivity, etc, including the effects of the size of the integrating sphere and apertures.

Slater brought up his other concern of whether there is a problem of the dome-shaped solar filter reflecting light onto the solar diffuser panel. Eichorn replied that there have been no studies, regarding baffling between the solar diffuser and the rest of the instrument yet.

Barker reiterated the group's concerns:

1) through-put of the ICS,
2) potential degradation of different components over time, and
3) stray light radiation scattered onto the solar diffuser.

Stuart Biggar asked about the coating on the cone. Eichorn replied that it is difficult to determine - it's a specular coat.

Slater remarked that he is very glad to hear that a model will be built. Guenther requested that if budget becomes a problem and managers withdraw resources for breadboarding, Eichorn should notify the panel, so they can help with resources. Eichorn felt that the situation seems stable, but agreed to notify the panel if anything changes. Guenther reiterated that "we will support you with resources".

Continuing with the top view of the MODIS-T Calibration System, Barker mentioned that there are three types of material on the solar diffuser. Guenther brought up the studies of the PTFE (chemical formula for Teflon) material at JPL, asking if JPL were considering studies of doped Spectralon. Slater said that the pure Spectralon doesn't show degradation to unaided eye when exposed during a shuttle flight. Carol Bruegge had previously expressed that a concern of hers was that there have been no tests of doped Spectralon. Guenther said we should ask for custom development of undoped or pure Spectralon. If we add carbon (dope the spectralon), is it stable? Guenther requested that a proposal from Bruegge and/or Slater be written to help fund this study of doped Spectralon. The proposal should be sent to Guenther.

With respect to the MODIS-T solar diffuser plate, the question arose of whether the entire panel was viewed during one scan, to which the answer is yes. Slater questioned the nature of aluminum and it's stability. Eichorn replied that a stable material is yet to be determined. Eichorn wants a material that is spectrally stable, even with a 'glop' coating.

Guenther noted that a thin film will collect more contamination. Guenther likes using aluminum because it has been shown that with proper handling it doesn't change with UV. Slater asked about how we test materials; do we try to test for them attracting contaminates? Guenther said that PTFE tends to develop a static charge which may attract contaminants - this needs to be studied. Al noted that solar illumination angle changes, thus changing the radiance on the plate.

Continuing with MODIS-T flight calibration system expected radiances, Barker noted that there is 5% solar irradiance relative to L-typical ocean.

In discussing scene brightness, it was noted that there is between 50% and 100% solar irradiance relative to land max (L-typical land). Guenther mentioned that the radiance levels of the internal calibrator are down low on the chart, and that a 50% level is a good indicator of aluminum.

In reviewing the schematic diagram of the Band 1 MODIS-T detector, it was noted that there is no totally continuing coverage on the detector.

In discussing lunar calibration, Barker pointed out that the key is 6 of 32 detectors exposed to lunar radiation. It was noted that there is more direct applicability to lunar calibration of MODIS (N) than (T).

In response to the question of the degradation of the photo-diode monitors in the ICS during orbit, Guenther stated that as long as the degradation time remains constant in a large portion of the year (i.e., slow) it is possible to track the degradation.

Continuing with the material planned for the solar diffuser, it was noted that Shelley Petroy is to devise a materials test program for the Russian opal material (a possible solar diffuser material).

PRESENTATION BY DR. MICHAEL BARNSLEY

Mike Barnsley's presentation is contained in these minutes (Attachment EE).

Slater asked if Barnsley is using LOWTRAN. Mike responded that it has been ruled out. Barker stated that the 5S code and LOWTRAN 6 comparisons are going on, and asked about the need to communicate between different research groups. He stated that input is needed for orbital model and information on geometry.

CONCLUSIONS

Slater Slater concluded the meeting noting that everyone would be available for input for the remainder of the three day MODIS Science Team Meeting.

OTHER ATTACHMENTS

Attachments FF and GG were distributed at the meeting, but are not referenced in the minutes.

ACTION ITEMS

1. ***MCST*** **- Provide general team member distribution of the Response to GE Platform Questionnaire before another version goes out to GE.**

2. ***MCST*** **- Separate the VIS/NIR and TIR responses by instrument rather than wavelength on the Response to EOS Cross-Calibration Questionnaire.**

3. ***MCST*** **- Release Version 1 of the MODIS-N and -T Science Calibration Plans at the next MODIS Science Team meeting (expected to be in March 1992; NOTE: amended to April 1992).**

4. ***MCST*** **- Input MODIS-N and -T Calibration Handbooks to an EOS Reference Handbook that the EOS Reflected Solar Panel A of the Calibration/Validation Panel is assembling.**

5. ***MCST*** **- Develop a "Science Requirements Supporting Instrument Specifications" document to start capturing scientific rationale for some of the decisions associated with the instrument specifications.**

6. ***Dick Weber and SBRC*** **- Prepare "Documents Expected from MODIS-N" by expected delivery dates for the final plans, which are contractually due at PDR about October 23, 1992, and allowing 60 days prior to PDR for government review.**

7. ***Bill Stabnow*** **- Prepare "Documents Expected from MODIS-T" by expected delivery dates for the final plans, which are contractually due at PDR about October 23, 1992, and allowing 60 days prior to PDR for government review.**

8. ***MCST*** **- Add to the title of the MODIS Geometry Requirements Table from Response to GE Questionnaire the fact that the table presents 3-sigma values.**

9. ***Guenther*** **- Address cross calibration issues among international instruments in the Memorandums of Understanding (MOU).**

10. ***Guenther*** - **Regarding the recommendations for Peer Calibration PDR and CDR, perform an in-depth, technical review in a format that allows inputs from a peer panel of experts, no later than PDR and CDR, with the panel submitting a formal report to the engineering panel including action items and suggestions.**

11. ***Jim Young*** - **Provide answer to Slater (regarding the Solar Diffuser Stability Monitor) about the angle of incident light on the solar diffuser.**

12. ***SBRC*** - **Continue examination of the spectrometer being non-uniform. (There was talk about the wide dynamic range of the optical system where F5 was the effective beam to specification and F100 is the sun.)**

13. ***Carol Bruegge, Guenther*** - **Regarding the selection of diffuser material, provide further study of two main candidates, Spectralon and YB71.**

14. ***Carol Bruegge or Phil Slater*** - **Write a proposal to help fund the study of doped Spectralon, sending to Guenther.**

15. ***MCST*** - **Devise a materials test program for the Russian opal material (a possible solar diffuser material).**

16. ***John Barker*** - **Provide general distribution of the response to the GE Platform Questionnaire before another version goes out to GE.**

17. ***Jim Young*** - **Reply to Phil Slater regarding the angle of incident light on the solar diffuser.**

MINUTES OF THE MEETING
OF THE

LAND

DISCIPLINE GROUP

AT THE

MODIS SCIENCE TEAM MEETING

October 1-3, 1991

Meeting Participants:

C. Justice - Group Leader
A. Huete
J.-P. Muller
S. Running
V. Salomonson
A. Strahler
V. Vanderbilt
Z. Wan
D. Toll - Executive Secretary

J. Barker
D. Carneggie
D. Hall
T. Mace
D. Tanre
J. Townshend
M. Barnsley
A. Fleig
Y. Kaufman
R. Murphy
P. Teillet (CCRS)
M. Verstraete (JRC)

MISR vs. MODIS-T

A. Strahler gave a presentation on "Multiangle Directional Measurements in Support of the MODIS-N Land Mission" (Attachment HH). The paper is in draft form and is authored by A. Strahler and M. Barnsley, with an endorsement by the MODIS Land Team.

Hot Spot : A. Strahler said a key advantage of MODIS-T is its ability to scan and tilt towards the surface "hot spot" (a peak in the BRDF (Bidirectional Reflection Distribution Function) where the sensor is in alignment with the Sun position thereby producing a minimum in the shadow cast by the target). He said data on the "hot spot" will provide critical information on the structure of the surface. He said the MISR will not permit data collection of the hot spot because of its small off-nadir viewing capability. S. Gerstl commented the information on the hot spot at the spatial resolution of MODIS-T may be only marginal, requiring instead a higher spatial resolution sensor. A. Strahler said theoretically the hot spot should be present regardless of the spatial resolution, but said he is concerned about complicating factors such as from topography. D. Diner indicated the hot spot is characterized by a strong atmospheric effect, significantly reducing the utility of MODIS-T for sensing the hot spot. A. Strahler indicated atmospheric effects in the near-IR should be reduced due to lower atmospheric scattering.

Additional Comparisons : A. Strahler said mosaicking of image areas from MODIS-T may be complex due to non-continuous data collection. This is not a problem with MISR. C. Justice reported the loss of a high spectral resolution spectrometer on EOS-A by deleting MODIS-T will significantly impact the land community. A. Strahler indicated the secondary status of land to oceans for directing MODIS-N reduces the capability for land derived information, especially over coastal areas. A. Strahler indicated that MISR should provide a very good means to estimate albedo.

MISR Capabilities : D. Diner said that certain MISR cameras may convert to a local mode viewing areas at 240 m and then converting back to 1.9 km. He reported there is a possibility that MISR may be configured to provide a 960 m GIFOV (ground instantaneous field-of-view) global data. However, there is a concern about the available data transmittance rate on EOS-A. The land group strongly endorsed the need for a 1 km global data set.

Coverage Area : Strahler said another advantage of MODIS-T is that up to 59 tilts may be collected by MODIS-T for a 30 by 1500 km area (1-scan) as MODIS-T approaches and passes a target. Additional scans reduce the number of possible tilts. The 9 cameras of MISR provides information primarily in the view direction only, with limited coverage in the azimuthal plane. Strahler reported for a continental area such as S. America using a 7-angle mode will take 13 days for complete coverage. The MISR due to its continuous data collection will take complete coverage in 7 days. Global coverage of the hot spot by MODIS-T (assuming +/- 5^{o} scan for hot spot area) may occur approximately 3-4 times a year.

D. Tanre indicated MODIS-T is well suited for specific targets because of its pointing capability. However, MISR is good for coterminous areas. He said the 1500 km swath of T is a significant improvement over the 360 m swath of MISR. He said for aerosol studies the 4 bands of MISR are adequate.

Global Albedo Mapping : Justice said using MISR and MODIS-N to map global albedo will take 9 days. D. Diner indicated a possibility of going to 7 days (at equator). D. Diner indicated ground albedo information (primarily directional) may be modeled for pixels outside the swath width of MISR but within the larger swath width of MODIS-N. In addition, for broad band conversions MODIS-N spectral data may be used to complement MISR spectral information. A. Strahler said for MODIS-T to map albedo a 23-24 day period is required. D. Diner said if only a 750 km swath from T is useable (<20-30 ^{o} view angle restriction), then the repeat period is 53 days for MODIS-T to map global albedo.

Y. Kaufman said that consideration should be given to using both MODIS-T and MISR or a staggered use. R. Murphy said the next two years are funding limited.

Z. Wan reported that target shadowing is an important measurement to derive for land surface temperature estimation. The multi-angle provided by shortwave

visible/near-IR may assist with determining surface structure. He reported the 3.5 and 4.2 micron bands may also correct for shadowing.

A. Huete reported the MODIS-T high spectral resolution bands will better assist with the spectral vegetative index derivation in comparison to the MISR. He indicated a substantial loss of information will occur that may be useful in deriving land products if a high spectral resolution spectrometer is not included in EOS.

D. Hall reported the MODIS-T may be more useful for snow and ice albedo mapping than MISR (see Attachment II by Salomonson and Hall). She said the snow/ice albedo varies significantly spectrally and that the 4 bands on MISR may not be sufficient. In addition, the BRDF of snow and ice is more complicated than most people think, primarily because of the confounding effects of snow with vegetation (e.g., boreal forest). Hence, multiple directional measurements are needed. V. Salomonson indicated MODIS-T would permit a better analysis of the BRDF for specific snow/ice targets.

M. Barnsley said that MODIS-T data will not be used to derive digital elevation models (DEM). D. Diner indicated 6 months of MISR data may be used to map DEM data with a 100 m vertical resolution and a 500 m horizontal resolution. M. Barnsley reported Soviet satellite KFA 1000 data may be more effective to derive DEM than SPOT data.

M. Barnsley reiterated some of the points A. Strahler made about "T" providing improved spectral bands, better BRDF mapping for targets, and better hot spot mapping relative to MISR. In addition, "T" provides improved atmospheric correction for angular effects, more spectral information, and better "N" and "T" overlap. He indicated that MISR provides better global coverage of angular data. Attachment JJ is a one page summary by J-P. Muller giving support for MISR and MODIS-T.

<u>MISR-MODIS Working Group</u> : C. Justice and D. Diner said a working group between MISR and MODIS should be convened. Justice said issues for cooperation include: 1)

BRDF data from MISR for MODIS-N data correction; 2) a comparable 1 km spatial resolution in place of a 1.9 km resolution; and 3) DEM definition. A. Strahler is responsible for coordinating from a MODLAND perspective.

TEST SITES

A. Huete reported stratification of test areas by pristine sites (LTER=Long Term Ecological Research, NPS=National Park Service, and IGBP=International Geosphere-Biosphere Program); anthropogenic impacted sites; Interdisciplinary Science (IDS) sites; and EMAP sites (402 km test sites). Attachment KK summarizes potential MODIS sites for Africa, South America, and North America.

A. Huete reported the EROS Data Center (EDC) will make available AVHRR data of Africa and Arizona, Landsat TM of Niger and other parts of Africa, and 50 Landsat MSS scenes.

A. Huete said the Landsat MSS order to EDC is on hold for a few weeks. C. Justice said the present order should emphasize current research sites and not focus too much on future research sites.

Y. Kaufman gave a presentation on atmospheric correction and test sites. He said he needs Landsat TM, NOAA AVHRR, and ground (also aircraft) measurements of aerosols to validate over MODIS-N algorithms. He in particular would like TM data at low and high turbidities over a short time period. The aerosol data is needed for determining an optical depth and a scattering phase function.

Y. Kaufman reported that a downward determined path radiance may be used to estimate an upward path radiance (atmosphere to satellite).

Y. Kaufman said a key need is to have a network of Sun photometers to estimate aerosol properties (optical depth, size distribution and phase function), water vapor and ozone. He indicated a versatile and effective Sun photometer may be purchased for approximately $15k (+/- 4k). Kaufman said he wants information about different

aerosol types for various locations. Planned sites include N. America, Israel and Central Europe.

The estimated yearly funding requirements is for 3-5 new Sun photometers (45-75 k), 4-20 Landsat TM scenes (20-50 k), and data analysis (20-80 k, higher estimate allows for growth).

Y. Kaufman reported the MODIS Airborne Simulator (MAS) will not have a blue channel.

C. Justice said D. Tanre will be receiving only approximately 35-40 k/yr of funding from French sources to support atmospheric correction related work which will be inadequate to fulfill his role in developing MODIS atmospheric correction algorithms.

C. Justice said that where possible each TM scene purchased should be associated with Sun photometer data. Y. Kaufman stressed the importance of having a contrasting turbid and clear scene over a narrow temporal range.

EDC STATUS REPORT

D. Carneggie gave a presentation on the EDC DAAC (Distributed Active Archive Center) support to the MODLAND. He said for FY91 activities EDC has archived 1 km AVHRR data of central & south Africa, Niger and western Africa, and southern Arizona. EDC has 2 TM scenes and 50 MSS scenes of validation sites.

For FY92, EDC is working on compiling a global 1-km AVHRR data set. EDC is spending approximately 800 k of NASA money toward this activity. An additional 500 k to 1000 k is needed to purchase data or provide tapes for HRPT (High Resolution Picture Transmission) stations. The 800 k is to provide hardware, data archive and data transfer. He said there are two potential sites in eastern Europe that may assist with filling current acquisition gaps.

D. Carneggie is currently requesting the MODLAND group to provide recommendations on defining the Basic Raw

Products needed from the global 1 km data set. This includes information on segmented data requirements, specifications on deletion of duplicated data, stitched or edited data requirements, etc.

EDC is planning new ideas that include multiple years for the 1-km AVHRR data set; higher level data products; compiling historical AVHRR data; provide long-term storage; and provide standard preprocessing capabilities.

D. Carneggie said the N. American vegetation greenness index is available for the '91 growing season.

C. Justice reported that contract has been made with S. African receiving station concerning new data collection.

J. Townshend volunteered to coordinate activity for providing global 1 km data specifications to EDC. D. Carneggie said he would like the MODLAND recommendations within 6-months.

DIGITAL ELEVATION MODELS

EDC will have available 3 arc-second (3"/100 m) data for North America.

M. Barnsley said stereo tests with data from Russian KFA-1000 & MK-4 indicated a cheaper and better data set than SPOT HRV (high resolution, visible) data.

Barnsley and Muller have started work using MODIS spatial resolution data with respect to radiometric and topographic corrections.

C. Justice said an action item is required for completion of the planned demonstration of the DEM requirements for MODIS applications.

IMAGE REGISTRATION

J. Townshend reported small errors in image registration will lead to large errors in assessing changes between dates. He said the mean change between dates is not as important to image misregistration effects as are changes in variance. He said the types of change is required for many process studies. He indicated relaxing the band to band misregistration accuracy by SBRC from 0.1 to 0.2 pixels to ease their engineering would cause significant problems with conducting land surface change detection. Townshend showed results from deforestation that may go unnoticed with minor image misregistration.

A. Fleig said the MODIS-N data has a built-in 90 arc-second misregistration error that may cause an uncorrectable 300 meter random error. It was unclear if any of the error is systematic. The group may want to push for a combined 0.2 pixel misregistration for the platform, sensor and ground processing.

V. Vanderbilt said he will review the literature and summarize misregistration (band to band and spatial) effects for the group.

MODIS CHARACTERIZATION SUPPORT TEAM (MCST)

J. Barker outlined his MCST priorities to the MODLAND team.

1. **Instrument related system characterization/calibration.**
2. **Algorithms and hardware for ICC/MCST monitoring of in-orbit data.**
3. **Utility products.**
4. **Simulated MODIS imagery.**
5. **Cooperative TM-MCST discipline-related product sensitivity to calibration.**

J. Barker briefly summarized the responses and documents their team produced. This included calibration plans for "N" and "T", an EOS MODIS Calibration Handbook, MODIS

Science Requirements, MODIS Management Plan, and a User's Guide for operating MODIS-N.

J. Barker and Jon Burelback are looking for 20 sets of 1 km NDVI (Normalized Differential Vegetative Index) data with radiometric homogeneous sites for use in their MODIS simulation studies.

C. Justice said A. Huete and V. Vanderbilt are the designated MODLAND representatives to the calibration group. He also suggested that these representatives summarize calibration issues for the next meeting. Barnsley attended the Monday (30 Sept.) calibration meeting

D. Hall and J. Barker are working closely on calibration issues related to snow and ice.

LANDSAT TM and ASTER

Possible TM Improvements : J. Barker said the possible improvements EOSAT is considering for TM on Landsats 6 & 7 include: (1) the addition of 4 thermal bands; (2) the possibility of providing a pointable TM; (3) a change to a 1030 from a 0930 acquisition time; and (4) flying in formation with EOS-A for improved data compatibility.

Comparisons : J. Barker compared ASTER vs Landsat TM capabilities for providing support to MODIS studies. He said spatial resolution differences are comparable between the two sensors. He indicated Landsats TM 6 and 7 will have a 15 m panchromatic band, providing a similar spatial resolution to ASTER. He reported that both sensors provide spectral coverage in the visible (VIS), near-infrared (NIR), shortwave-infrared (SWIR), and thermal-infrared (TIR). He said ASTER is pursuing improved S/N in the SWIR bands, which is a current problem now. He said, for ASTER, there are three different vendors providing different focal planes for the VIS/NIR, SWIR, and LWIR that may cause serious radiometric calibration problems. In addition, C. Justice reported there is no blue band on ASTER, reducing the capability to provide atmospheric corrections. The ASTER has an advantage of being pointable. In addition, ASTER

could provide global DEM data which could assist MODIS investigators with registration (primarily location) accuracy. However, other sensors such as MISR may also provide assistance. In addition, the TM on Landsats 7 & 8 may be pointable. J. Barker reported the 60 km swath of ASTER versus the 180 km swath of TM limits compatibility with MODIS data.

Barker with Justice and Townshend reported the limited swath on ASTER will significantly reduce scientific information for assisting with MODIS science. A change in the acquisition time from 0930 to 1030 for TM will significantly increase the compatibility with MODIS. In addition, P. Sellers said there is a possibility that Landsat could fly in formation with the EOS platform including MODIS.

J. Barker summarized the improvements of ASTER over TM from: (1) ASTER has built-in stereo; (2) improved thermal bands; and (3) SWIR may be better if S/N improved. He said the improvements of TM over ASTER were primarily from: (1) fuller swath width of TM (180 km versus 60 km); and (2) radiometric calibration improvements.

J. Barker reported the ASTER thermal data may be calibrated from MODIS thermal data.

R. Murphy said the new management at EOSAT should in about a year help significantly reduce the cost of Landsat TM data for scientific research work.

Group consensus concluded that the MODIS needs compatible high spatial resolution data, but ASTER is largely an unknown system (e.g., possible calibration problems). In comparison, the TM has been demonstrated to be more useful and there may be additional changes to TM that will be useful to MODIS (1030 acquisition time, 4 thermal bands, pointable sensor).

See Closing Session minutes for a summary of the ASTER versus TM comparisons.

MODIS-N: BENEFITS OF DUAL 1030 & 1330 VERSUS 1030 ONLY

S. Running was responsible for summarizing the benefits of having MODIS-N fly on both a 1030 & 1330 platform. He indicated two primary areas of improvement: (1) improved coverage; and (2) diurnal climatology.

Improved Coverage: S. Running summarized improvements from having an additional 1330 MODIS-N from: (1) redundancy if there is a malfunction of one of the MODIS sensors or platforms; (2) increased probability of cloud cover; and (3) improved collection of global data.

S. Running said the addition of a 1330 MODIS-N will assist in situations, especially in higher latitudes where morning fogs and clouds are more prevalent that early afternoon clouds, thereby increasing the probability of obtaining cloud free conditions. Justice reported low light conditions at high latitudes also favors having a later overpass. In addition, he strongly emphasized the importance of two sensors for collecting cloud free MODIS-N data.

Diurnal Climatology: S. Running discussed (1) improved thermal inertia; (2) dew point temperature; and (3) vegetation stress measurements.

There was additional discussion that the diurnal MODIS-N data may assist with surface resistance estimation to heat fluxes, Bowen ratio estimation (sensible vs. latent heat energy flux partition), atmospheric sounding, and aerosol estimation. Also two a day measurements may improve the accuracy of MODIS land products such as land cover, surface albedo, and vegetation index. C. Justice reported there are more fires in p.m. versus a.m. for the MODIS-N fire product.

V. Salomonson said the land group should be aware of the possibility that the 1330 platform may have either a MODIS-T or an AVHRR and not a MODIS-N. He said the Ocean Group is strongly behind keeping a MODIS-T.

R. Murphy said previous work with thermal inertia has only demonstrated limited utility.

MODLAND JOURNAL PAPER

The MODLAND paper coordinated by S. Running is currently on hold due to the uncertainties about MODIS-T. The work should resume in December and a draft may be completed by February 1992. S. Running said he needs approximately one written page and one figure on product definition from each member. The information should include justification for the product and an approach.

TEST SITES

S. Running gave a handout in reference to his activity of establishing a link between MODIS and LTER (Attachment LL). He said the MAB (Man and Biosphere) sites appear dead. The IGBP site planning activity is just starting. He said in addition to the team members own test sites, the NSF LTER sites may hold the best potential for MODLAND study. T. Mace said the EPA EMAP sites have potential applicability. The group requested written information from T. Mace about the sites.

ATMOSPHERIC EFFECTS ON LAND REMOTE SENSING

Y. Kaufman reported on an atmospheric scattering correction algorithm when estimating a vegetation index. Analysis of results thus far indicated the atmospherically corrected vegetation index is not as sensitive to changes in atmospheric scattering in comparison to the uncorrected version. In addition he said the previously computed vegetation index has an uncertainty from 0.02 to 0.04 from atmospheric effects and may be corrected to 0.01 using a modification of the atmospheric correction algorithm.

A. Huete gave a brief presentation on the use of Y. Kaufman's atmospheric correction algorithm and effects from varying soil conditions.

A. Huete said probably two vegetation indices should be produced. One is the old NDVI and the other a correction for atmospheric, background and directional effects combined. Y. Kaufman said since the algorithms are dynamic we may need multiple vegetation indices.

C. Justice suggested A. Huete should work with Y. Kaufman on a Version 1 validation plan.

M. Verstraete reported that he is working on a vegetation index that has an atmospheric correction which will be presented. He is going to give a presentation at the next AGU (American Geophysical Union) this December in San Francisco. Preprints will be sent to MODLAND.

C. Justice said a MODLAND Vegetation Index workshop like the Land Cover Working Group should be held during the middle of next year.

MODIS AIRBORNE SIMULATOR (MAS)

M. King reported on the status of MAS to MODLAND. The preamplifier gain was increased to permit sensing of land and atmosphere targets. The cables were shielded to reduce radio interference. The spectrometer ports were modified.

King said the Science Data Support Team will prepare Level 1-B output data. Calibration data will be provided for pixel data on each scan line. In addition, black body and calibration coefficients will be provided.

King said each flight line will have a separate file. Every tenth pixel will have information on geolocation (latitude and longitude), Sun angle, and viewing geometry. The image data will be 8 to 10 bit information provided in 16-bit words. The geolocation information will be in 32 bit integers. The data will be available in 9-tack tape and 8 mm casette.

He said the MAS will be flown in Oct. for the FIRE Cirrus Experiment. After the experiment, MAS will be adapted for 50 bands for later use in the Sept. 92 Brazil experiment.

M. King and C. Justice agreed the MAS data collected over SE Kansas may be examined by the MODLAND group for characterization purposes.

C. Justice said MAS flight costs should be planned for the upcoming Brazil experiment.

EOS DATA INFORMATION

A. Fleig said the Science Team Members are personally responsible for purchasing any commercial software (e.g., ORACLE) that may be part of the "Tool Kit" described at the plenary. He said information on how to purchase the software will be provided.

A. Fleig said the SDST will act as a liaison between EOSDIS and the MODIS Science Team. He said the science team can work with algorithms on their own computer and that the SDST can convert to the proper and more rigid format of EOSDIS. He envisions the SDST rehosting and working out bugs for a year prior to moving the algorithms to EOSDIS. The SDST will not actually validate the scientific correctness of algorithms but will provide support to the team members.

A. Fleig said the SDST and Team Leader Computer Facility (TLCF) can provide day-to-day routine quality control. If told by the team members what to examine, the SDST can conduct an inspection of the processed data.

He said the Team Leader Computer Facility (TLCF) will assist with documentation of software. He said the TLCF will be structurally similar to the EOSDIS Product Generation System (PGS) facility. He said the input/output, image displays, communications and on-line storage requirements are TBD. He is looking for inputs from the MODLAND group.

A. Fleig said the TLCF will buy an IRIS type computer soon for initial work. He said they are planning on buying a clone of the ECS in 1994 and again in 1998 during launch.

A. Strahler said he would like assistance with forwarding of E-Mailing.

J. Townshend and C. Justice said EOSDIS should reduce their use of acronyms. EOSDIS is quickly "losing" the attention of the science team members during their presentations.

TEST SITES

D. Hall said field and aircraft measurements were taken last spring at Glacier National Park. Measurements included ASAS, field spectrometer, and Sun photometer measurements. Hall said field and logistical support provided by the NPS staff is excellent. She reported their

team is setting up a weather station. In addition, other meteorological data are available in the region.

A. Huete reported on the status of 4 field experiments. He said for Walnut Gulch in May 1991 AVIRIS (Advanced Visible and Infrared Imaging Spectrometer) data were collected. In July ASAS (Advanced Solid State Array Spectrometer), TMS (Thematic mapper Simulator), and ESTAR (Electronically Steered Thinned Array Radiometer) data were collected. In September it was ASAS, TMS and Landsat-5 TM. The area is of grassland, shrubland, mixed vegetation, and riparian. P. Slater has taken atmospheric measurements.

A. Huete said a 1-week BRDF field measurement campaign was held at Maricopa in Arizona. PARABOLA, ASAS, SPOT (3 off nadir SPOT scenes) and TM data were collected. He said the ASAS bill was expensive (100 k) and would like assistance.

Huete reported on measurements in Niger during 1991. Measurements included ground BRDF, optical transects, and APAR (Absorbed Photosynthetic Active Radiation). He said Niger/HAPEX (Hydrological-Atmopsheric Pilot Experiment) field experiment is planned for May-Sept. 1992. C. Justice said MODLAND aircraft plans are cancelled, with possible future plans in 1992 for Brazil.

Y. Kaufman said atmospheric measurements are planned during May for Israel. Blue, green, red and near-IR measurements under and over haze are planned in the Azores. Atmospheric and cloud measurements may be taken by the U. of Washington in Brazil.

A. Strahler said he is initiating a collaboration with the Chinese. BRDF measurements were taken in China (primarily limited because taken "in-doors"). In addition, Chinese land cover and satellite data have been collected.

P. Teillet said a follow-on BRDF experiment to Maricopa is planned in Canada near Ottawa. He said the activity is pre-BOREAS (Boreal Ecosystem Atmospheric Study) and will take place near the summer solstice in 1992. C. Justice said

S. Running is closely linked to BOREAS and the team may want to consider proposing.

Z. Wan said he is pursing using an IR spectrometer thru NASA. C. Justice said Wan may want to work closer with existing campaigns and propose for funding from BOREAS and/or other sources to augment his program activities.

V. Vanderbilt is reconsidering his options, especially since no polarization measurements are planned for EOS-A.

M. Barnsley said 11 channel Daedalus and AADS multispectral channel data have been collected of Wytham, Oxford. He said multiple off-view angles have been collected. He reported off nadir radiance measurements significantly improved separation of ground spectral classes. He reported significant work is proceeding on simulating 3-dimensional BRDF work. BRDF work is including ground, aircraft, and modeling. Surface roughness work is also ongoing.

C. Justice then reviewed the vu-graphs planned from the group for the plenary discussion in the afternoon.

MODLAND ACTION ITEMS

1. ***John Townshend, Chris Justice, Vern Vanderbilt, and John Barker*** **- Continue to develop the case for improved scene to scene registration specifications.**

2. ***John Townshend*** **- Coordinate team definition of 1 km global data set specifications. Report progress at next team meeting.**

3. ***Mike Barnsley and J.P. Muller*** **- Coordinate and complete topographic requirement demonstration (December 1991).**

4. ***John Barker*** **- Band to band specification requirements; expand study from pixel to larger areas (December).**

5. ***Vern Vanderbilt*** **- Research the LARS (Laboratory for Applications of Remote Sensing) material on band to band specification requirements (December).**

5. ***Chris Justice and John Townshend*** **- Coordinate a Land Cover working group meeting (Spring 1992).**

6. ***Yoram Kaufman*** **- Provide additional information to team members on the sun-photometer network and instrument availability (December 1991).**

7. ***Alfredo Huete*** **- Vegetation Index Working Group meeting, possibly in conjunction with the land cover meeting (Spring 1992).**

8. ***Alfredo Huete*** **- Test site coordination for MODIS algorithm testing (ongoing).**

9. ***Alfredo Huete*** **- Complete EDC 1991 MSS data purchase (November).**

10. ***Steve Running*** **- Provide further information on LTER sites to Alfredo Huete (October).**

11. ***Steve Running*** **- Revitalize the MODLAND science rational document (December, with a draft by February 1992).**

12. ***Tom Mace*** **- Provide information to team members on EMAP test sites and their relevance to MODIS algorithm testing.**

13. ***Vern Vanderbilt and Alfredo Huete*** **- Provide summary of land calibration issues at the next MODLAND meeting.**

14. ***Alan Strahler*** **- Establish MODIS/MISR joint working group on BRDF and atmospheric correction.**

15. ***Zhengming Wan*** **- Attend all ASTER meetings and keep the group informed of problems with the specs for MODLAND and the intended ASTER research agenda (on-going) {If needed Vince Salomonson should be asked to send a letter requesting this participation at the ASTER meeting.}**

16. ***Vern Vanderbilt*** **- Review the literature and summarize misregistration (band to band and spatial) effects for the group.**

17. ***MODLAND Group members*** **- Provide to S. Running by February 1992 approximately one written page and one figure on product definition for the MODLAND paper. The information should include justification for the product and an approach.**

18. ***MAST*** **- Provide A. Strahler with assistance on forwarding of E-Mail.**

MINUTES OF THE MEETING
OF THE

OCEANS

DISCIPLINE GROUP

AT THE

MODIS SCIENCE TEAM MEETING

October 1-3, 1991

MEETING PARTICIPANTS

The Oceans Discipline Group meeting was chaired by Wayne Esaias, and attended by Mark Abbott, Ken Carder, Dennis Clark, Robert Evans, Howard Gordon, Frank Hoge, and John Parslow (team members), Greg Mitchell, Diane Wickland, and Robert Murphy (NASA HQ), Marlin Lewis (Canada - Dalhousie University), Tom Goff (RDC), Robert Barnes (Chemal), Vince Salomonson (occasional), Bill Barnes, Bob Kirk, and Locke Stuart. Presentations to the group were made by John Barker and Al Fleig.

MODIS-N SPECIFICATIONS

Suggested changes to the MODIS-N Specifications (Attachment W) were presented by Bill Barnes. The most serious consideration was given to the first recommendation (co-registration accuracies). Different focal planes result in difficulty in achieving 0.1 IFOV (instantaneous field of view) accuracies, a situation particularly notable in the case of the registration of the cold focal plane with the others. Acceptance of most of the focal plane co-registration relaxations was voiced, with the exception of the VIS/NIR planes, which need to be maintained at 100 meters (0.1 IFOV for a 1 km band). Thermal accuracies were also addressed in some detail, particularly in light of the quoted ERS-1 accuracy of 0.3%. A request was made

to relax Channel 22 to 2%. The MODIS accuracy is specified at 1%, which is considered marginal for ocean measurement. W. Barnes promised further investigation into the differences between MODIS and ERS-1, and will ask Santa Barbara Research Center (SBRC) to investigate why the Along-Track Scanning Radiometer (ATSR) accuracy is so much better than MODIS. Another recommendation was to maintain TDI (time delay and integration) for bands 13-14 (bilinear gain is hard to model). Band numbering was judged irrelevant to the Oceans Group.

Additional changes were discussed by the Group, foremost of which was the movement of ocean bands to different wavelengths. This is in concert with the selection of SeaWiFS bands, and the potential deselection of MODIS-T. Unfortunately, before the fate of MODIS-T is finally known, final band position for MODIS-N must be determined, in order for work under the SBRC contract to continue apace. The previously selected 653 nm MODIS-N band is contaminated by water vapor, and needs to move to 665 or 670 nm, or possibly 610 - 630 nm, depending on the need for avoiding water vapor, the possible need to avoid, or value of being located on, the fluorescence shoulder, the need for precision in solving the atmospheric correction problem, and the requirement to avoid moving toward the location of the dichroic beam splitter. Wayne Esaias averred that a decision needs to await a modelling effort, which hopefully can be done within the next couple of weeks. It was noted that MERIS has a band at 665 nm. 565 nm should probably be moved to 555 nm, to agree with SeaWiFS selection, and this in turn bumps the 531 nm band to 510 nm, again to agree with SeaWiFS. This latter move is deleterious to the measurement of gelbstoff fluorescence, according to Ken Carder.

MODIS CALIBRATION SUPPORT TEAM PRESENTATION

John Barker, leader of the MODIS Calibration Support Team, presented information on calibration and validation plans (see Attachments V, MM, NN, and U). Several comments were made: 1) The "New Products" listed on p. 5 of Attachment V should be included under Level 1-B of the at-launch characterization/ calibration products; 2) The term "Science" Calibration Plan may be misleading; 3) An input is needed from Bob Evans on the

Target-Based Calibration for Bio-Optical Oceans (p. 15 of Attachment V; 4) Dennis Clark is particularly interested in calibration site selection, and may suggest a potential site; 5) Wayne Esaias is concerned about the calibration disparity between MODIS and SeaWiFS; Barker indicated that contractual conditions complicate the problem of evolving SeaWiFS calibration plans in the direction of MODIS.

SCIENCE DATA SUPPORT TEAM PRESENTATION

The calibration presentation was followed by a report from Science Data Support, including Team Leader Computing Facility, led by Al Fleig (Attachments X, Y, and Z).

Tool kits (e.g., image navigation) were mentioned, and identified as the interface software between the EOSDIS computer and the science team member. As significant is the administrative interface between EOSDIS and the team member provided by the Science Data Support Team. This should be considered an informational interface, as well as the interface to enable the code developed on the team members' machines to run in EOSDIS, and to document the software to EOSDIS standards.

A significant concern expressed by Bob Evans in understanding the EOSDIS machinery -- the structure of the code depends upon the host machine. Further concern was expressed over the need to interface the MODIS (Oceans) processing requirements with EOSDIS plans -- EOSDIS needs avail itself of the MODIS experiences and concerns *before* designing the processing system. The Team Leader Computing Facility (TLCF) should play a key role in the next couple of years in creating a model for EOSDIS, and in providing input on data structures and system organization. Vince Salomonson felt that MODIS needs to be aggressive in offering advice on scientific requirements to EOSDIS.

Al Fleig further amplified the role of the TLCF as the facility to be used by the team for *iterative* algorithm development, wherein the machine will be designed to run through the data at twice real time speed. Data samplings are within the purview of TLCF, as are any out-of-the-ordinary processings. The TLCF is not designed to house data from other EOS platforms -- that should be done in EOSDIS, but the TLCF will be available to

investigate algorithm suites. Later discussions also focused on the possible use of the TLCF to take the SeaWiFS code and interface it to EOSDIS.

MODIS ORBITS AND COVERAGE

Wayne Esaias led a discussion of MODIS orbits and related sun glint patterns, the consequent time required for complete global coverage (assuming no clouds) and the comparison between MODIS-N and MODIS-T (in various combinations), and MERIS (Attachment OO). Orbits considered were 10:30 a.m. and 1:30 p.m., ascending and descending nodes both times. Scan angle was limited to 45°. Glint on the global Mercator coverage charts was set at a threshold of 10 W/m^2, and at 500 nm. Wind was set at a threshold of 2 m/sec. After 2 days, it is obvious that a tilting sensor is better. At 8 days, tilt no longer matters; full coverage is obtained with MODIS-N as well as -T, and MERIS. The table showing per cent. coverages (6-year mean winds) was generated at a pixel zenith angle of $\leq$48°, with glint threshold set equal to water-leaving radiance at 500 nm, with an SNR (Signal-to-Noise Ratio) of 25 NE ΔL's (Net Effective Radiance Difference) in the blue. It was noted that the MERIS 10:30 a.m. descending node gave poor southern ocean coverage.

Insofar as percent coverage is concerned, 2 MODIS-N's do quite well. However Esaias pointed out that, while MODIS-N gave acceptable NE ΔL's and glint coverage, some areas (particularly around the equator) are always viewed at a high nadir angle, and that the viewing angle is reduced with tilting. Esaias characterized nadir-viewing instruments as an inefficient way to collect ocean data.

Discussions ensued regarding cloud contamination, and the limitations to coverage due to cloud probabilities. Piers Sellers contended that if 2 MODIS-N's are phased correctly to view an area every other day, then cloud contamination probabilities are considerably reduced. Further discussion ensued; it appears unclear whether MODIS-T is superior to 2 MODIS-N's in minimizing cloud contamination.

Further deliberations addressed the combination of a MODIS-T in concert with a MODIS-N, particularly on 2 separate platforms. It

was recommended that a chart of this scenario be produced and studied. John Parslow averred that short-term (diurnal) phenomena need MODIS-T for satisfactory information. Watson Greg summarized that 2 MODIS-N's give good coverage, and that an argument favoring MODIS-T needs some other basis.

ALTERNATIVES TO MODIS-T

Spectral coverage may very well form this basis; and was tied to a more general discussion on the possible alternatives to MODIS-T, and their impact on the achievement of Oceans objectives and goals. The initial premise was that MODIS-T provides basic and frequent biomass data; MODIS-N does not. Ocean color sensing is a forte' of MODIS-T. MERIS is insufficient, partly due to the lack of tilt, and gives poor southern ocean coverage. OCTS and MERIS are still not stable in their designs; more iterations are expected on MERIS. SeaWiFS is unacceptable, due to the signal-to-noise ratio (SNR), band selection, and calibration. MODIS-T also is compelling because of its level of development, and may be considered a candidate for an Earthprobe, or ADEOS.

HIRIS was discussed in detail, and determined to be useful for sampling, for algorithm development, and particularly for coastal zone (Type I) work, but unsatisfactory for global coverage of Type II waters. Its narrow swath limits the frequent coverage required to identify important phenomena such as algal blooms and population structures, and their movement. Diane Wickland requested a formal response to the value of HIRIS to the (biological) ocean community.

MODIS-N and -T on 2 different platforms appears to be the most advantageous and supportable solution to the current payload posture. This scenario probably gives the best coverage, and is consistent with Oceans objectives and requirements. SeaWiFS continuity up to the time of launch of MODIS-T is important, which undoubtedly involves the launch of a second SeaWiFS -- possibly a clone of the first -- purchased at the same time as the first, to save costs. If not a clone purchased at the same time, some incremental improvements are worth considering: a tilt capability; extra bands; improved SNR, calibration, and product assurance. The data rate must fit within the EOS context. The second SeaWiFS should overlap with the first operationally, and

operate perhaps until 2003 -- the latest expected launch date for MODIS-T.

A strong appeal should be made to continue MODIS-T development uninterrupted until a definite plan for ocean coverage has been approved.

No matter what scenario is chosen, it is important that calibration and validation be uniform among the mixture of supporting instruments.

MODIS/SEAWIFS COORDINATION

The need for close MODIS/SeaWiFS coordination was addressed, with the objective of assuring that sufficient funding, task identification, and personnel utilization planning is done to support the objectives of both programs. As with the deselection impact, this discussion carried over both days of discipline group meetings, and is summarized here as a unit.

SeaWiFS is scheduled for launch in August, 1993. The initial identification of science objectives is the responsibility of the MODIS Oceans Discipline Group. While some MODIS Ocean Team Member funding (particularly in the cases of Evans, Gordon, Clark, and Carder) will be needed to develop the SeaWiFS algorithms, additional funds, above the level of MODIS funding, will be required in order to meet the SeaWiFS launch schedule. MODIS funding for these four team members will need to be largely devoted to SeaWiFS development for '92 and '93, and to SeaWiFS algorithm validation in '94. Locke Stuart emphasized that no "official" notification has been received to redirect MODIS contract efforts toward SeaWiFS. Such notification must come from EOS Project, and Dixon Butler would direct Project to do so. Howard Gordon felt that development of SeaWiFS algorithms did not necessarily satisfy the MODIS algorithm development requirements. The SeaWiFS algorithms might become the MODIS Version 1 algorithms by default, and may not answer the advantages provided by MODIS specifications. This delay in starting development of what very well may be an "orthogonal" (from SeaWiFS) MODIS algorithm may result in lack of a satisfactory algorithm in time for MODIS launch. Gordon advocated separate funding, and separate development, of the SeaWiFS and MODIS algorithms.

Ken Carder felt that SeaWiFS algorithms would serve well as placeholders in MODIS Version 1, with plenty of time to develop "correct" algorithms in MODIS Versions 2 and 3. Since the EOSDIS system definition will be a long time in coming, this scenario may be the best available anyway. Dennis Clark was concerned that MODIS funding alone was insufficient to support both MODIS and SeaWiFS requirements, and that it is *highly important* that a stable level of funding be supplied to those team members who are required to prepare for SeaWiFS. Bob Evans generally felt that the SeaWiFS and Pathfinder work would support MODIS in the long term.

Carder also emphasized the need to "synchronize" the milestones and meetings between MODIS and SeaWiFS; it will be impossible for those involved to serve both Projects on separate schedules.

All were concerned that they would be held responsible *both* for MODIS and SeaWiFS development, in spite of being told to devote the next 2 years of MODIS effort to SeaWiFS. Bob Kirk (SeaWiFS Project Manager) stressed that the SeaWiFS effort *directly* supported MODIS requirements during this development and validation period.

Diane Wickland commented that efforts *must* be redirected toward SeaWiFS, that MODIS work will have to be slipped in favor of SeaWiFS, and that NASA Headquarters has no magical pot of additional funds (most of the SeaWiFS money will come directly from money previously devoted to MODIS-T). It is important that written clarification be issued to the MODIS/SeaWiFS team members, describing their responsibilities under the combined MODIS/SeaWiFS effort.

Several team members interpreted the lack of additional funding, plus the mandate to "slip" MODIS in favor of SeaWiFS, as a likely indicator that many currently planned pre-launch MODIS algorithms will not be ready in time for MODIS launch.

Some discussion ensued on the distribution of SeaWiFS data. It is intended that these data will be archived in and distributed from EOSDIS. The DAACs will deliver the data to team members. It currently appears that team members will have no privileged

access to the data; they will receive it on the same schedule as everyone else.

Some discussion also centered on the January ('92) SeaWiFS Announcement of Opportunity for science research. MODIS Team Members who are involved in SeaWiFS were advised that they need to propose to the Announcement; if they do not, they will be "grandfathered" in to the SeaWiFS research without additional funding above their MODIS funding. The difficulty of the SeaWiFS advisory members proposing to the Announcement was addressed. They will need to resign from their advisory position in order to propose. Diane Wickland stated that it is advisable for legal counsel to be apprised of the need for advisory panel members to propose to the SeaWiFS Announcement, and to advise on the conditions under which they may apply. Wayne Esaias verified that the MODIS Ocean Discipline Group members were all *ex officio* SeaWiFS team members, unless they inform Wickland or Greg Mitchell to the contrary.

SEAWIFS FOLLOW-ON

A discussion of the characteristics of a SeaWiFS Follow-On (SeaWiFS II) was an essential part of later Oceans Group deliberations, and is included here for continuity. A major consideration was upgrade versus carbon copy. Costs incurred in each case (versus MODIS-T) were addressed. A tilt capability is an important possibility. An increase in data storage capability would be helpful. Additional bands would be effective, but would drive costs up by adding dichroics, focal planes, and larger optics to maintain the SNR. Currently the SeaWiFS instrument costs about $13M, with the Pegasus launch costing $36M. MODIS-T costs $65M (first copy) with $18M in recurring costs. It was noted, however, that it would cost considerably more to put SeaWiFS on EOS, and alternatively considerably less to put MODIS-T on a small Explorer-class (Earthprobe) platform. The other important consideration is to avoid a "gap" in oceans coverage; if modifying SeaWiFS is likely to result in such a gap, then modifications should be eschewed in favor of an immediate "carbon copy" buy.

Orbital Sciences' data rights were discussed. It is apparent that data for research purposes are free to the government, while

operational data must be purchased. Research data may be published, but may not be distributed in digital form; obviously operational digital data may not be distributed. Research data are *de facto* defined as after-the-fact data -- those data which are not needed immediately after acquisition. This was a subject of discussion (*i.e.*, a study of red tides), and it was again urged that an international data-sharing agreement (e.g., SeaWiFS and OCTS) would help clarify the issue of data rights. Wayne Esaias pointed out that after 5 years the data become public domain.

REPORT ON THE SEATTLE IWG MEETING

Mark Abbott reported on the Oceans Panel deliberations at the Seattle Instrument Working Group (IWG) Meeting (Attachment PP). Abbott remarked that almost all currently approved ocean instruments (except SeaWiFS and MODIS-N) are non-U.S.; it is important that agreements for data, and possible technology, sharing be effected, and that access to these data be facilitated. John Parslow seconded this need for data cooperation, and cited NASA and Europe as "holdouts" in the international arena. NASA needs to put emphasis on MOU's which will *assure* the efficient transfer of data, and its archive and distribution through EOSDIS. Wickland pointed out that NASA Headquarters is working on an EOS/Mission to Planet Earth policy. Abbott and others suggested that OCTS/SeaWiFS could be used as a test bed for data exchange. OCTS requires a high-latitude receiving station well separated from Japan in order to bring down global data. OCTS is CZCS-like in data quality (0.7 km IFOV resampled to ~1 km), and was characterized (along with MERIS) as a back-up oceans instrument, and not a replacement for 2 MODIS-N's plus a tilting spectrometer. OCTS data cannot be subsampled, and will all be processed in Japan. It seems important that U.S. investigators propose to foreign data use opportunities; Diane Wickland stressed that science teams are frequently formed from the proposers.

Abbott also recommended a SeaWiFS follow-on launch in '98, and an imaging spectrometer (GLI) on ADEOS in '01. This would guarantee 10-15 years of ocean color data. SeaWiFS II (follow-on) may indeed be supported out of EOS Project, rather than its own Project Office. Esaias noted that a SeaWiFS Follow-On, incorporating many of the characteristics of MODIS-T in

instrumentation, calibration, and data processing, would not be inexpensive. Marlon Lewis asked about difficulties with technology transfer to foreign instrument developments; Diane Wickland cited some problems in sharing cooler technology with ASTER.

The need for a scatterometer was addressed at the Seattle meeting, with STIKSAT (k_u band) flying on ADEOS II seeming to be the most satisfactory scenario. The ESA C-band scatterometer is embroiled in technology and budget problems. Altimetry was also addressed, and a joint US/CNES altimeter being Delta - launched as soon after TOPEX as possible ('97 or '98) is being worked by Chet Koblinsky.

There followed a brief discussion of the Joint Oceanographic Institutions (JOI) meeting activities, where it was stressed that the next 10 years will see a substantial number of oceanographic data sets, and that cross-calibration and evolution in the quality of the sets will be paramount. Esaias pointed out that the results of the meeting need to be forwarded to the Payload Panel; Abbott assured that he would see to it.

ALGORITHM DEVELOPMENT PEER REVIEW AND VALIDATION

Algorithm development peer review and validation was considered, in answer to concerns of the Team Leader, and was addressed largely in terms of the SeaWiFS algorithms, since these drive the algorithm development schedule to completion within the next 18 months. The relation of the SeaWiFS algorithms to MODIS development schedule was also considered. In general, it was determined that all oceans algorithms (including SST, fluorescence, phycoerythrin) will be reviewed on the same schedule, but that the same level of sophistication may not be expected of the non-SeaWiFS algorithms. It was also determined that review should take place at all developmental levels, from concept through operational code. A milestone schedule, which will be used as a yardstick by which to judge algorithm development progress, must be developed, and that a milestone schedule of reviews must apply both to MODIS and SeaWiFS. One point on that schedule is March 1993, when SeaWiFS code is due. All agreed that a baseline must be the

CZCS algorithms, with modifications and simulations considering the SeaWiFS bands, sun glint, wind fields, non-constant e, atmospheric pressure fields, *etc.* added as time permits. Standards and criteria for interface to the SeaWiFS processing system must be developed. Particular concern was given to Frank Hoge's phycoerythrin validation efforts. The Group felt it important that Hoge obtain aircraft flights during this SeaWiFS development period (and no later than '93). Esaias emphasized that aircraft support needs to be developed in the SeaWiFS budget, to include phycoerythrin data.

Algorithm reviews will be internal, and conducted by the SeaWiFS Pre-launch Science Working Team (the same as the previously mentioned *ex officio* team and advisory panel), with the MODIS Oceans Group and EOS Project invited. It was stressed by Evans that reviews must be considered as serving the Team's benefit, and not just a programmatic mandate.

ACTION ITEMS

1. ***Howard Gordon***: **Determine the impact of moving the 653 nm band to 665-670 nm.**
2. ***Bob Evans***: **Need input to the Calibration Support Team on target-based calibration for bio-optical oceans.**
3. ***Dennis Clark and John Barker***: **Get together on selected calibration site reviews.**
4. ***Al Fleig***: **Intercede on behalf of the MODIS Science Team in assuring that scientific requirements are made known to EOSDIS *before* the processing system is fully defined.**
5. ***Al Fleig***: **Act as exchange-of-information liaison between the Team and EOSDIS.**
6. ***Al Fleig***: **Create structures and system organization (environment and specifications) model for EOSDIS.**
7. ***Watson Greg***: **Develop coverage figure for MODIS-N & -T on different platforms, with MODIS-N descending node a.m. and MODIS-T ascending p.m.**
8. ***Bob Kirk, Locke Stuart, Harold Oseroff***: **Coordinate contract deliverables & meetings to eliminate duplication of SeaWiFS/MODIS effort.**
9. ***Wayne Esaias:*** **Complete modeling of MODIS water vapor bands.**
10. ***Wayne Esaias, et al.***: **Apprise Dixon Butler of the Oceans requirements in support of SeaWiFS and MODIS.**
11. ***EOS Project, SeaWiFS Project:*** **A liaison is needed among the Oceans Team members and the 2 projects to assure full cooperation and unification of the milestones, schedules, and research.**
12. ***EOS Project, SeaWiFS Project, MODIS Team Leader***: **Assure funding is stable over the next three years for SeaWiFS/MODIS Ocean Team members.**
13. ***H. Oseroff, EOS Project, SeaWiFS Project, MODIS Team Leader***:: **Assure rapid turnaround of MODIS & SeaWiFs funding to get Clark, Gordon, Carder, and Evans started.**
14. ***NASA HQ Program Office, EOS Project, SeaWiFS Project, MODIS Team Leader***: **Develop additional funding to move MODIS milestones forward to meet SeaWiFS requirements.**
15. ***Esaias, Stuart, Hamilton, Oseroff***: **Need to formally clarify what is expected of Team Members directly involved in both MODIS and SeaWiFS.**

16. ***Team Members***: Assess your potential of applying to the SeaWiFS Research Announcement; advise Greg Mitchell or Diane Wickland if you need to decline membership in the *Ex Officio* SeaWiFS Science Team.
17. ***EOS Project***: Advise Poston, Stuart, Oseroff of the need to modify the MODIS contracts to include SeaWiFS work.
18. ***Mark Abbott***: Forward JOI Meeting report to the Payload Panel.
19. ***Mark Abbott***: Determine the impact of moving the 653 nm band to 620 nm.
20. ***Bill Barnes***: Request that SBRC further review the ATSR blackbody -- why is it so much better than MODIS?
21. ***SBRC (Jack Engel)***: How much separation between bands is required, when separated by a dichroic (e.g., can 653 nm be moved to 620 nm?)?
22. ***Oceans Team***: Develop a set of standards and milestones for algorithm review and validation.
23. ***Oceans Team***: Draft letter for NASA Headquarters' (route through Greg Mitchell and Dixon Butler) distribution *back* to the Oceans Group defining the interaction of MODIS and SeaWiFS, and how the MODIS task must be restructured to meet the SeaWiFS milestones and deadlines.
24. ***Locke Stuart***: Determine the conditions driving the establishment of 2 contracts (SeaWiFS and MODIS) serving the same purpose: the development of SeaWiFS algorithms.
25. ***Locke Stuart, SeaWiFS Project***: Determine travel milestones, and assure that MODIS and SeaWiFS travel are coordinated to reduce Team Member travel requirements to a minimum.
26. ***Locke Stuart, SeaWiFS Project***: Issue letters to all Team Members, specifying their budget for the current year, as soon as it is known.
27. ***Harold Oseroff***: Assure that Dennis gets "stable" buoy funding as early as possible -- by December (November?) '91 and February '92 (roughly half & half).
28. ***Harold Oseroff***: Determine the vehicle for the transfer of equipment purchased under government contract from Evans to Clark. How will the disposition of obsolete equipment be handled (Evans)?

UNASSIGNED ACTIONS

1. **Develop cloud scenario for 2 MODIS-N's *versus* MODIS-T; for MODIS-N & -T on different platforms, etc. (Murphy).**
2. **Document a formal response to Diane Wickland on the value of HIRIS to biological oceanography (Wickland).**
3. **Assure that data exchange agreements are in place so that OCTS, MERIS, JERS, ADEOS, etc. data are easily exchanged and placed in EOSDIS (Abbott, Parslow, Esaias).**
4. **Clarify the legal position of Orbital Sciences in SeaWiFS data rights: what can and cannot be done with the data (Esaias, Parslow, Abbott)?**
5. **Assure Frank Hoge is funded for aircraft validation of phycoerythrin under the SeaWiFS budget (Esaias).**
6. **Assure that MODIS-T Calibration expertise is transferred insofar as possible to SeaWiFS (Esaias).**
7. **Provide written clarification to the MODIS/SeaWiFS team members describing their responsibilities under the combined MODIS/SeaWiFS effort.**

SUMMARY SESSION

1. CALIBRATION DISCIPLINE FINAL REPORT

Phil Slater presented a detailed report on the MODIS Calibration Peer Review Panel (Attachment QQ). The Panel met on September 30, prior to the MODIS Science Team Meeting.

One of their major discussion topics was the deliberations of the EOS Calibration/Validation Panel which had recently met in Baltimore and was chaired by Guenther and Chahine. They discussed the current status of cross-comparison calibrations of MODIS with other EOS instruments, both in-flight and pre-flight. Barker is pursuing site selection studies for suitable calibration sites. The Panel is requesting inputs from the MODIS Science Team on site-selection and cross-comparisons. There were presentations on the status of MODIS-N and MODIS-T, and a status report on Hugh Kieffer's preliminary work on lunar calibration. Presentations were made by the National Standards Laboratories, including the Japanese NLRM labs working for the ASTER team. They reviewed proposed experiments on the Shuttle which are similar to the LDEF (Long Duration Exposure Facility). The purpose will be to assist with evaluation of candidate solar diffuser material.

The Calibration Discipline Group heard from John Barker on work being done by the MODIS Characterization Support Team (MCST) on geometric knowledge and control, calibration site selection, and MODIS radiometric and end-to-end models.

Slater reviewed SBRC's MODIS-N calibration requirements, and presented diagrams of the Spectroradiometric Calibration Assembly (SRCA) and Solar Diffuser Stability Monitor (SDSM) subsystems which have been designed for performing the calibrations. The SRCA is a highly complex three mode unit, capable of providing a spectral check, a

radiometric check, or a check of the band-to-band registration. The SDSM has a wide field-of-view that provides a 30:1 ratioing of the solar diffuser panel and the sun to provide diffuser stability checks. Slater reviewed the concerns that exist for MODIS-N calibration. Because information on MODIS-N has only recently been generally released, most of the concerns have not yet been adequately studied.

Slater also presented a review of the progress which has been made toward calibration of MODIS-T. Two approaches have been investigated. The first is under development and continuing to evolve. It consists of an internal integrating sphere linked to a Winston cone. The second method linked to the solar diffuser panel has been proposed. Slater presented results of studies of performance of the two methods, proposed changes in the systems, and concerns regarding the calibration. He noted that there is a plan to build a working model to radiometrically test the calibration designs.

2. ATMOSPHERE DISCIPLINE FINAL REPORT

Mike King presented a summary of the discussions held in the Atmosphere Discipline Group meeting (Attachment RR). Payload discussions were influenced by the new information introduced by Dozier regarding possible substitution for MODIS-N in the afternoon package. MODIS-N was found to be advantageous over VIRSR for a variety of scientific reasons, with VIRSR's only advantage being its cost. The Atmosphere Group recommended including the GLRS-A laser altimeter in the EOS payload package for cloud studies, and expressed their preferences for ascending afternoon and descending morning orbits. King noted that after a discussion of the advantages of various instruments, they found MODIS-N plus MISR to be the most complementary instrument selections for aerosol studies. It is noteworthy that MISR was preferred over EOSP and MODIS-T. Brief status reports on the Atmosphere Group manuscript and on the MODIS Airborne Simulator (MAS) were presented. Flights of the MAS and the availability of level 1B MAS data were pointed out for investigators.

King reviewed the reaction of Atmosphere investigators to the action list from SBRC for MODIS-N specifications changes. They recommended no changes in spectral band registration, acceptance of the S/N change for band 6, and consideration of non-linear gains for Band 29 to avoid a waste of measurement precision in temperature. Menzel emphasized that Band 29 is not just a surface-viewing channel, and that good radiometric fidelity is desired for atmospheric studies.

3. OCEAN DISCIPLINE FINAL REPORT

Wayne Esaias summarized the Ocean Group's views of the proposed MODIS-N specifications (Attachment SS). As their experts on sea surface temperature were absent from the meeting, they asked that SBRC keep trying to match the ATSR blackbody performance. They prefer to keep parameters involved with spectral band registration essentially as is, but are requesting minor band changes for the ocean color bands. Some interference has been discovered in SeaWiFS bands due to water vapor, and the MODIS filters should be changed accordingly. Esaias also reviewed other MODIS/SeaWiFS interactions.

At the time of the Science Team meeting, MODIS-T was in danger of being deselected. Esaias utilized part of his summary time to present again the case for keeping MODIS-T, or for at least moving it to an alternative platform. He reviewed the Ocean Group's requirements for ocean color measurements, and noted that they are consistent with the entire ocean-studies community's requirements. Esaias presented the scientific advantages of SeaWiFS, and the further advantages of MODIS-T over SeaWiFS. There are two key arguments in favor of MODIS-T. The first is the need to differentiate types of ocean biomass rather than just quantities because of the different climatological effects on different species. Oceans feels they need continuous data, and a tilting sensor like MODIS-T to provide this. The other argument is the necessity of fully calibrated measurements.

Esaias offered a very specific set of five recommendations, foremost of which was to keep MODIS-T somewhere within the EOS program--preferably on the second EOS platform and launched with a 1:30 PM ascending orbit. He presented the results of studies of coverage by MODIS-T and other sensors that reinforced his arguments (Attachment OO). Limitations for coverage, especially in southern oceans, are related to darkness, clouds, and sun glint. The other sensors and scenarios that could be employed were categorically found to be insufficient or as yet inadequately defined. Mark Abbott echoed the sentiment of the Oceans Group in their unyielding support for flying MODIS-T.

The Ocean Group's final recommendation was to include a scatterometer for wind measurements. A suggestion was made from the floor that a knowledgeable Oceans representative should be sent to the Payload Panel meeting to act as consultant for technical inquiries.

4. LAND DISCIPLINE FINAL REPORT

After an introduction by Chris Justice, Alan Strahler briefed the Science Team (Attachment TT) on the critical payload issue of whether Land would profit most from flying MODIS-T or MISR. The Land Group expressed a qualified preference for MISR. Both instruments were seen to have strengths; however, his briefing included a review of the logic which led to the conclusion favoring MISR. Arguments were made that involved the competition with the Oceans Group for measurements, the critical need for multi-angle measurements for detection of the BRDF hotspot, problems with atmospheric corrections, and difficulties in accumulating measurements with MODIS-T to ensure global coverage in a timely fashion. Global coverage available from MISR is considered to be more important than the loss of spectral resolution if MODIS-T is not available. Many measurement issues are complicated by unknowns that are considered to be research areas. Strahler concluded by noting that if MISR is selected, then a joint working group of MODIS/MISR would be helpful and a change in resolution may be desirable to synchronize MISR with MODIS.

Chris Justice continued the Land Group's review (Attachment UU) with a discussion of the need for a high resolution instrument for validation and testing, and a comparison of ASTER versus an Enhanced TM to fulfill this need. The biggest single problem with ASTER is that it is an unknown quantity. The optimal choice was decided to fly ASTER on the 10:30 AM platform with the Enhanced TM flying in close formation. Land Group's view of the benefits of flying MODIS–N on both the morning and afternoon platforms was presented. The principle advantages are improved coverage and better diurnal climatology. Justice concluded with a specific listing of plenary issues and action items considered of significance by the Land Group. The most important issue is the addition of a specification to enhance the scene-to-scene registration capabilities of MODIS-N. There was also a closing discussion of MISR's involvement in platform pointing stability, and some additional reasons from Kaufman regarding why MODIS-N should fly on an afternoon platform.

5. CLOSING REMARKS

Team Leader Vince Salomonson closed the meeting by presenting his sense of the most important results of the Science Team meeting. With regard to the issue of instrument preferences, the Oceans Group is still staunchly and unanimously backing MODIS-T; however, they have considered alternatives. The Land Group has thrown its qualified support behind MISR. MODIS-T is of little consequence for the Atmospheres Group, so they also prefer MISR. The requested changes in specifications for MODIS-N are all easily handled, with the exception of registration between focal planes. With some groups preferring relaxation and the some opting for a hold-fast attitude, the issue remains open. Quantification of the repercussions of non-relaxation of this specification is required soon. Contract problems remain to be resolved in the areas of reporting, auditing, and available funding. There is a conflict between public laws and the universal desire to promote the scientific work of the team members. Problems should be reported to Locke Stuart and will be handled to the best of our support team's ability.

Salomonson thanked the Science Team members for the participation and for their cooperative attitude that promoted significant progress on several quite volatile issues and an overall very productive meeting. He reminded the investigators to keep March 1992 open on their calendars for the next meeting. (NOTE: Since the meeting, this has changed to April 1992.)

PLENARY SESSIONS
ACTION ITEMS

INDIVIDUAL ACTION ITEMS

1. ***John Barker*** **- Raise the priority level of MODIS-N simulations using TM data.**
2. ***Jeff Dozier*** **- Make copies of the NASA budget available to Howard Gordon.**
3. ***Harold Oseroff*** **- Address MODIS contract problems related to audits.**
4. ***William Stabnow*** **- Make figures on expense of the MODIS-T holding pattern available to Jeff Dozier.**
5. ***Alan Strahler*** **- If MISR is selected in place of MODIS-T, a joint MISR-MODIS working group should be formed to handle communications between the two groups.**
6. ***Shelby Tilford*** **- Transmit a copy of the EPA report "Policy Options for Stabilizing Global Climate (1990) " to scientists with appropriate knowledge of Earth sensing for their comments.**
7. ***Project Scientist*** **- At the request of the Land Discipline Group, reexamine polarization and spectrometry for EOS land sensing.**

GROUP ACTION ITEMS

8. ***Science Team*** **- Rich Bredeson requests feedback from the science community on how EOSDIS is shaping up and on the Tool Kit requirements.**
9. ***Science Team*** **- Channel comments and questions regarding the EOSDIS Tool Kit through Al Fleig.**
10. ***EOSDIS*** **- Reply to Land Group on EOSDIS plans to meet the overall topographic DEM requirement for EOS in general, and MODIS in particular.**
11. ***EOS Project Office*** **- At the request of the Land Discipline Group, assist in the resolution of the problem of multitemporal scene-to-scene misregistration.**