MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

October 18, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator (MAS)
3. MODIS SDST Project Plan
4. NetCDF Schedule and Status

ACTION ITEMS:

08/30/91 [Lloyd Carpenter and Team]: Draft a schedule of work for the next 12 months. Include primary events and milestones, documents to be produced, software development, MAS support, etc. (An updated version is included in the handout.) STATUS: Open. Due date 09/27/91.

10/04/91 [Phil Ardanuy and Team]: Prepare questions for the project to characterize the spacecraft position and attitude knowledge and the MODIS pointing knowledge in a way that will facilitate the evaluation of methods such as image registration to meet the science team requirements for earth location. STATUS: Open. Due date 10/18/91.

10/04/91 [Tom Goff]: Examine and describe the Miami DSP navigation scheme in relation to MODIS navigation. Status: Open. Due date 11/15/91.

10/04/91 [Tom Goff]: Contact Angel Li (currently at GSFC) to ask questions regarding the DSP. Status: Open. Due date 10/18/91.

Progress on MAS Level-1B processing system development

Progress up to 17 October 1991

(1) MAS software development

Testing of the processing software against Wisconsin computed results has continued. Consultation with Chris Moeller at Wisconsin and independent study identified several software fixes that were necessary. In summary

(a) Align pixel numbers with next pixel along the scanline (Wisconsin pixel count starts at 2),

(b) Change degrees C to degrees K conversion from $T(K) = T(C) + 273.15$ to $T(K) = T(C) + 273.16$,

(c) Change scan angle units to radians in computation of nadir to pixel range,

(d) Change sign of longitude passed to subroutine RATOLL (range/azimuth to lat/long) since this expects West +ve, East -ve.

A new set of test numbers was then generated, and is included overleaf. It can now be seen that the GSFC/MAS computed 8-bit radiances match the Wisconsin computed 8-bit radiances to the second decimal place (after rounding). The GSFC/MAS 10-bit radiances are also closer to the Wisconsin 8-bit radiances. This indicates that the calibration software is working correctly.

The latitude and longitude comparison is now also more consistent. The GSFC/MAS latitudes are consistently about 1 min. 23 sec. less than the Wisconsin latitudes. Chris Moeller advised me that the Wisconsin latitude bias in this case was 1 min. 20 sec. The GSFC/MAS longitudes are consistently about 3 sec. less than the Wisconsin longitudes. Chris Moeller advised that the Wisconsin longitude bias in this case was zero. This indicates that the geolocation software is working correctly.

I talked briefly to Mike King regarding the issue of processing Level-1B data on a flight-track basis. This is his preferred option. On the output tape for one flight, he would like to see separate files for each straight line flight-track. It is understood that it is still possible to calibrate (but not geolocate) MAS data during turns, however this Level-1B product will not be distributed initially unless requested by the user. All Level-1A data will be routinely archived.

(2) MAS Houston deployment for FIRE

Mike King reports that the MAS is now back at Ames for testing. The ER-2 and MAS are scheduled to arrive in Houston on November 12th. The first possible FIRE flight is on November 13th. I have arranged to be in Houston from the 12th until the 15th. A test flight out of Ames has tentatively been scheduled for October 24th.

(3) MAS GSFC investigator computing platforms.

In order to determine requirements for netCDF support, I contacted Mike King, Yoram Kaufman and Chris Justice to determine what computer system(s) they are likely to use for MAS processing. The following is a summary (information from Chris Justice is pending)

Mike King	
Processing system	- IBM 3090 mainframe, MVS operating system
Display system	- Apple Macintosh, and possibly Silicon Graphics Iris
Yoram Kaufman	
Processing system	- Cray, Unicos operating system (possibly IBM 3090)
Display system	- Silicon Graphics Iris

MAMS TEST DATA SUMMARY (17 OCT 91)

Flight Date : 15 April 1990
Location : Atchafalaya Bay, Louisiana
Start scanline : 40808 (record 13014 on first MAMS test tape)
Start time : 14:42:19 GMT
MAMS band : 11 (center wavelength 11.12 microns)
Radiance units : milliWatts per square meter per steradian per wavenumber

Column 01 : MAMS test tape record number
Column 02 : MAMS instrument scanline
Column 03 : MAMS pixel number (ranges from 1 (right side of aircraft) to 716 (left side of aircraft))
Column 04 : Wisconsin radiances computed with 8 bit blackbody and video radiance counts
Column 05 : GSFC/MAS radiances computed with 8 bit blackbody and video radiance counts
Column 06 : GSFC/MAS radiances computed with 10 bit blackbody and video radiance counts
Column 07 : Wisconsin computed latitudes (degrees, minutes, seconds : North +ve, South -ve)
Column 08 : GSFC/MAS computed latitudes (degrees, minutes, seconds : North +ve, South -ve)
Column 09 : Wisconsin computed longitudes (degrees, minutes, seconds : East +ve, West -ve)
Column 10 : GSFC/MAS computed longitudes (degrees, minutes, seconds : East +ve, West -ve)

Record	Scanline	Pixel	Radiance	Rad(8)	Rad(10)	Lat	Lat(C)	Lon	Lon(C)
13014	40808	2	104.66	104.6619	104.7400	29:29:44	29:28:21	-91:08:54	-91:08:51
13059	40943	510	108.31	108.3062	108.1550	29:18:32	29:17:10	-91:17:41	-91:17:38
13164	41258	192	99.53	99.5356	99.6751	29:27:37	29:26:14	-91:19:37	-91:19:34
13209	41393	40	107.70	107.7018	107.7802	29:32:45	29:31:22	-91:19:48	-91:19:45
13269	41573	360	101.05	101.0463	100.9613	29:26:23	29:25:01	-91:26:59	-91:26:56
13361	41849	490	52.32	102.2553	102.1939	29:25:45	29:24:21	-91:33:16	-91:33:09
13392	41944	128	105.87	105.8706	106.0973	29:34:18	29:32:55	-91:30:46	-91:30:42
13448	42112	634	103.14	103.1390	102.9138	29:24:06	29:22:42	-91:39:40	-91:39:36

Note: Wisconsin radiance for scanline 41849, pixel 490 corresponds to zero counts.
Equivalent zero count GSFC/MAS radiances are 52.3252 (8 bit), 52.3661 (10 bit).

Date: 10/17/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

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                                          1991
                                          JUN                  JLY           AUG           SEP           OCT           NOV
    Task             Resource/Status Date 01.....16.....30.....14.....28.....11.....25.....08.....22.....06.....20.....03.....17.....31
MAS data user requirements survey   06/01 ≡≡≡≡≡≡≡≡≡≡≡≡≡≡≡
                      LG         C  06/01 ***************
Investigate hardware requirements   06/01 ≡≡≡≡≡≡≡≡≡≡≡≡≡≡≡
                      LG         C  06/01 ***************
Visit Wisconsin to obtain code/data 06/30               ≡≡≡≡≡≡≡
                      LG         C  07/09                    **
Specify contents of Level-1B output 06/30               ≡≡≡≡≡≡≡
                      LG         C  06/30               *******
Obtain accounts on LTP VAX and IRIS 07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Transfer MAMS source code to VAX    07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Transfer MAMS/INS data to VAX       07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Decode INS data file                07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Get straight flight tracks from INS 07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Find regressions of heading vs time 07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ********
Investigate PCI software on IRIS    07/12                     ≡≡≡≡≡≡≡≡
                      LG         C  07/12                     ***************
Write code to compute regressions   07/26                            ≡≡≡≡≡≡≡≡
                      LG         C  07/26                            ********
Write code to unpack 8-bit imagery  07/26                            ≡≡≡≡≡≡≡≡
                      LG         C  07/26                            ********
Write code to get straight imagery  07/26                            ≡≡≡≡≡≡≡≡
                      LG         C  07/26                            ********
Display 8 bit imagery on PC, IRIS   07/26                            ≡≡≡≡≡≡≡≡
                      LG         C  07/26                            ********
Examine MAMS calibration code       08/09                                   ≡≡≡≡≡≡≡≡
                      LG         C  08/09                                   ********
Develop calibration modules, driver 08/09                                   ≡≡≡≡≡≡≡≡
                      LG         C  08/09                                   ***********
Test calibration against MAMS data  08/09                                   ≡≡≡≡≡≡≡≡
                      LG         C  08/09                                   ***********************************
Prepare subsampled data for IRIS    08/09                                   ≡≡≡≡≡≡≡≡
                      LG         C  07/26                            ********
Examine MAMS geolocation code       08/23                                          ≡≡≡≡≡≡≡≡
                      LG         C  08/29                                             ********
Develop geolocation modules, driver 08/23                                          ≡≡≡≡≡≡≡≡
                      LG         C  08/30                                              ********
Test geolocation against MAMS data  09/06                                                 ≡≡≡≡≡≡≡≡
                      LG         C  09/06                                                 *********************
Integrate calibration, geolocation  09/06                                                 ≡≡≡≡≡≡≡≡
                      LG         C  09/06                                                 ******************
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ICI4PRINT

Date: 10/17/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

1991
JUN 01.....16.....30.....JLY 14.....28.....AUG 11.....25.....SEP 08.....22.....OCT 06.....20.....NOV 03.....17.....31

Task	Resource/Status	Date
Introduce users to IRIS imagery	LG	09/06
Convert Level-1B to netCDF (TEG)		09/20
	LG I	09/13
Process new MAMS data set	LG	09/20
Fix any bugs found		09/20
	LG I	09/30
Incorporate any changes from users	LG	09/20
Integrate documentation, user guide	LG	10/04
Create netCDF output, write to tape	LG	10/04
Test netCDF access routines (TEG)	LG	10/04
Confirm MAS delivery with Ames	LG	10/04
First MAS flight for FIRE	LG	11/13

DRAFT

MODIS Science Data Support Team (SDST)

Project Plan

Version 0

MODIS\WORKPLAN\PROJPLAN.001
October, 1991

Table of Contents

1. Summary

This project plan documents the support to be provided by the MODIS Science Data Support Team (SDST) to the MODIS Science Team and the Team Leader within the context of the EOS objectives, the MODIS objectives, and within the EOSDIS structure. The SDST provides support for the development of a science data processing system for the MODIS instruments and science algorithms. This entails identification of data requirements, operational scenarios, instrument data rates, duty cycles for observations, science data products, data volumes, and processing algorithms and requirements. Specific areas of support are identified in section 4, Technical Plan.

2. Objectives
   - 2.1 EOS Objectives
   - 2.2 MODIS Objectives
   - 2.3 MODIS Science Data Support Team (SDST) Objectives

3. Related Activities
   - 3.1 EOSDIS
   - 3.2 MODIS Characterization Support Team (MCST)

4. Technical Plan

4.1 MODIS Team Leader Computing Facility (TLCF)

The MODIS Team Leader Computing Facility (TLCF) work area involves the development of functional, operational and performance requirements, operations concept, science scenarios and preliminary design for the TLCF.

> The TLCF must support pre and post launch algorithm development, integration, testing, validation, modification and evolution. It must also provide computing resources for the MODIS Team Leader and Goddard Team Members, and it will provide support for quality control and test of the MODIS products. Special products for the Team Leader and some of the Goddard team members, will be generated on the TLCF.
>
> To meet these requirements, the TLCF must be capable of processing MODIS data at twice the full rate, and it must have total storage adequate to hold the data from one orbit per week for a ten year period (of the order of 2 Terabytes). The requirements for communications, displays, I/O, etc. will be based on a more complete definition of the TLCF operating environment.

The requirements will be refined, and the MODIS science scenarios and TLCF operations concepts will be developed and used as the basis for the preliminary design.

4.2 MODIS Algorithm Development Plan

The MODIS algorithm development plan will describe the manner in which MODIS algorithms will be developed, tested and integrated into the system for generating science data products. Algorithms involved in all stages of the MODIS processing will be included.

MODIS Level-1A, Level-1B, and some of the higher level algorithms will developed, tested, and integrated on the TLCF by the SDST. Many of the utility algorithms will be handled in the same way.

The MODIS Science Team Members will develop their own algorithms for generating special products and some of the core products. These algorithms will be tested and integrated on the TLCF by the SDST.

A configuration management system will be provided for the protection and assurance of all operational algorithms.

4.3 Porting Science Team Members Algorithms to the TLCF

Guidelines must be written for team members and others generating MODIS processing algorithms to facilitate porting to the TLCF. Priorities will be set for coding, e.g.

(1) Understandability

(2) Portability

(3) Accuracy/precision

(4) Efficiency.

Sample code will be developed for templates. Team Members must provide information on test cases so that the performance of algorithms on the TLCF can be evaluated. Use of standard software development tools/libraries, will help in porting to the TLCF. The SDST will investigate such tools and libraries.

4.4 Support for MODIS Airborne Simulator (MAS) Experiments

An upgrade to 50 channels will be made on the MAS next year. Processing code (currently at Version 1.x stage) must be upgraded to Version 2.x. We will also continue to modify and update code as required or requested after feedback from the Science Team, King and Menzel. For field experiments, it is valuable to have someone in the field, (or in close contact with those in the field) to keep tabs on data quality, instrument problems or failures, visible calibration, etc. This is especially important in early test stages. Support may also be required in flight planning; e.g. weather conditions at the site. If ground or in-situ data is taken in conjunction with MAS overflights, we may act as a central distributor. Registration of MAS imagery may require investigation. Integration of MAS processing into the V0 DAAC must also be investigated.

4.5 Data Structure/Format for MODIS Level-1 Products

The MODIS Level-1A product has been defined in terms of its contents and reversibility. It has also been decided that the sensor data will not be unpacked. The scan cube has been identified as a meaningful unit of data for some purposes, but the scan cube is too small as a unit for ordering and distribution. A suitable data structure for distribution will be determined.

For the MODIS Level-1B product, the data will be calibrated and earth-located. The scan cube is still a meaningful unit of data, but a larger unit is needed for distribution. With calibrated radiances, and with no further reversibility requirement, there is more flexibility in defining the format and structure. An examination of this issue will be coordinated with the science team members to assure that their requirements are met.

4.6 MODIS Image Registration

A survey will be made to identify the significant questions and issues associated with MODIS image-to-map registration (registering MODIS images to Ground Control Points (GCP)) for more precise earth location. In addition, image-to-image registration will also be considered for the purpose of providing a good basis for examining changes over time in the recorded sensor data. A plan for MODIS image registration will be developed and circulated to the science team for comments and modification.

Efforts to build an automatic image registration system for MODIS will take into account the lessons learned in the extensive work that has already been done with images from Landsat, AVHRR, and other systems. As a first step, discussions are being held with many persons who have experience in image registration from GSFC, JPL, CSC (EOSAT), and EDC. The discussions with EDC relate primarily to experiences with Advanced Very High Resolution Radiometer (AVHRR) image registration over the United States.

The basic plan for MODIS image registration is to provide improved image location information for each scene over land areas. This information will be included in the MODIS Level-1B data product. Several steps are involved in preparing for this task.

Identify promising techniques and algorithms. The Fast Fourier Transform (FFT) was applied successfully to Landsat 1, 2 and 3 images. Precise registration was achieved with edge detection methods on Landsat 4 and 5 data. A method which offers the best possibility of providing a fully automatic process (or nearly so) would be very desirable for use with MODIS images. The adopted technique, or algorithm, must provide for identification and work-around or rejection of problem scenes without human intervention. The algorithm must be suitable for production processing.

Identify tasks involved in selecting a good set of GCPs. This will involve the identification of 100-meter to

500-meter feature types with well defined edges. Existing sets of GCPs will be examined for their suitability in the MODIS application. Dependence on frequency bands, gain, radiance range, seasonal variations, atmospheric conditions, spatial resolution, etc. will influence the usefulness of different types of features. Geographical areas where additional work is needed will be identified.

Test various candidate algorithms using real data (AVHRR or MAS).

Identify the computer resources required to do production image registration.

4.7 MODIS Level-2 and 3 Processing Design Issues

The issues involved in the MODIS Level-2 and Level-3 processing designs will be identified and evaluated. Sample issues include:

Selection and installation of a precursor TLCF for CASE, C++ (or other object oriented language), MAS processing.

Refine Level-1A and 1B designs to include:

Dual ground location information

DEM

Calibration methodologies

Update MODIS Overview to include MODIS-N.

Implement imaging capabilities incorporating NetCDF on: VAS, IRIS, PC's, MAC, etc. as part of the Tools/Utilities suite.

Determine (and perhaps design) the Level-2 program - parallel, serial scheduler vs distributed processing. Investigate techniques.

Examine various data exchange formats (HDF, NetCDF, PDS, etc.) and identify their strengths and limitations.

Examine the Pathfinder computer implementations for land, air, and oceans and identify

processing techniques

location techniques and accuracies

mapping projection implementations

metadata and database index specifiers.

Examine auxiliary data sets (SeaWIFS etc.).

Establish a dialog link with the engineering data retrieval designer.

Identification of the implications of the use of a Digital Elevation Model (DEM) or a Digital Terrain Model on the MODIS Level-1 to Level-3 design and computing requirements

The MODIS Science Team is assuming that a global DEM will be available for use at launch. It is important to identify the implications for MODIS processing.

It is not necessary to consider earth topography at Level-1A, because the Level-1A data are not earth located. At Level-1B the use of a DEM would have a major impact on the required computer resources for earth location based on the spacecraft position and attitude and instrument pointing. The same is true for image registration/rectification. Use of a DEM is required in order to determine earth locations with the accuracy required by the science team.

The topography is involved in many aspects of the processing of MODIS Level-2 and Level-3 land products.

5. Management Plan

5.1 Organization

5.2 Project Managemant

5.3 Data Management Plan

The MODIS Data Management Plan will describe the manner in which the MODIS instrument data will be acquired, calibrated, validated, earth located, processed, archived and distributed to the science users, within the EOSDIS data management structure. The end-to-end data flow from its origin at the MODIS instrument to the science product archival and distribution will be described in the EOSDIS context.

The computer resources and software tools required for algorithm development, data processing, and generation of special products will be identified. A configuration management system will be provided for the protection and assurance of operational software and data products.

The collection and management of ancillary data and data from external sources will be described as they relate to the processing and production of MODIS products. The manner in which reference data for ground control points, digital elevation and terrain models, atmospheric models, coastline definitions, etc. will be collected and integrated into the system will be specified.

Consideration will be given to the processing and management of quick look data for field experiments, targets of opportunity and special investigations. A plan will be provided for the generation and delivery of metadata and browse products.

The responsibilities of the MODIS Science Data Support Team will be identified in terms of data product requirements, operational scenarios, algorithm integration and testing, design and implementation of the operational processing system, data product validation, integration of computer resources, and development of documentation during the definition, prelaunch and postlaunch phases.

PRELIMINARY DRAFT

DRAFT

October 17, 1991

MAS NetCDF Schedule

- At this time the NetCDF documentation, code and utilities have been downloaded to the LTP VAX (the target MAS machine). The code has been compiled, linked, and executed on the VAX.

- Write MAS to NetCDF routines (3/4 completed).

  18 October

- Generate simulated MAS data on the VAX.

  25 October

- Distribute listing of the MAS Level-1B NetCDF data product content (draft).

  1 November

- Validate NetCDF conversion routines using simulated MAS data.

  5 November

- On the Iris, read data in NetCDF and convert to EasyPace format and display data (may need to break up data into smaller sets).

  9 November

- Investigate possibility of reading NetCDF format on the IBM.

  12 November

- Have an independent check of data content and format.

  15 November

- Implement user comments to data product content.

  19 November

- Distribute Version 1 of the MAS Level-1B NetCDF data product content.

  22 November

- test MAS to/from NetCDF routines with FIRE experiment data.

  - on VAX

    2 days after receipt of data

  - on IRIS

    2 days after receipt of data

NetCDF Status

Thomas E. Goff

17 October, 1991

* The C program to create the MAS data set in NetCDF format is progressing on the LTP VAX. A small NetCDF file has been generated with the variables and dimensions specified. The anchor point index is also included. Multiple occurrences of radiance and other instrument data records will be added next. The NetCDF file contents have been verified with the ncdump utility and are correct.

* A FORTRAN program to create a simulated MAS data buffer with known variable contents is in place on the VAX. This will be used for validation of the NetCDF data set before MAMS or FIRE MAS data is processed.

* Will look into the possibility of placing NetCDF (if not all ready there) on the IBM mainframe that Mike King uses for data processing. Phone calls have not yielded an answer as yet. The IBM has a C compiler and the NetCDF documentation mentions that XDR (the NetCDF underlying format conversion routines) supports IBM data types.

* The investigation of the University of Miami RSMAS supplied DSP data format is on hold until the NetCDF programs are written and validated. Contacting Angel Li while he is located at GSFC has not yet occurred.

* The availability of NetCDF on other platforms needs to be investigated. This includes PC's and the Apple Mac.

* Discuss the incorporation of geolocation data types into the PCI EasyPace image processing system. This requires the conversion of anchor points to the gridded polynomial technique.