MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

October 11, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator (MAS)
3. MODIS SDST Workplan
4. NetCDF (Status)
5. MODIS Image Registration (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. (A draft 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 Lee (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 10 October 1991

(1) MAS software development

The software is now at the stage where calibrated radiances and geolocation parameters can be computed for any given MAS pixel on any scanline (only within straight line flight tracks for geolocation).

Testing of the results against data obtained at Wisconsin has commenced. A summary of results to date is included.

It is proposed to deal with the MAS Level-1B data on a flight-track by flight-track basis for processing, storage and distribution. This allows a simple method for subsetting and classifying the data from a flight, and provides an output Level-1B netCDF file which will in most cases fit easily onto a 2400 ft 6250 bpi magnetic tape.

(2) MAS Houston deployment for FIRE

I talked to Mike King briefly regarding the possibility of my taking part in the MAS field deployment in November. Mike seemed to think it would be useful to have me in the field for 3-4 days in the first stage of the deployment (probably the first week). He has an information packet from G. Shelton at Ames which he will copy for me.

(3) MAS Data Catalog

The MAS Data Catalog should provide a brief summary of each MAS flight in a form that is understandable to users. This may take the form of an ASCII file which would be the first file on distributed MAS tapes. Items for inclusion would be

Deployment site (e.g. Houston)
Deployment experiment (e.g. FIRE)
Takeoff time
Landing time
Pilot's name
Brief summary of flight (instrument failures, weather conditions etc.)
Instrument configuration (configuration file used in processing)
Start and end times of straight line flight tracks
Latitude and Longitude at start and end of straight line flight tracks
Brief description of the region imaged in each straight line flight track

Liam E. Gumley.

MAMS TEST DATA SUMMARY (10 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	1	104.66	104.6460	104.4978	29:29:44	29:03:28	-91:08:54	-91:05:15
13059	40943	509	108.31	107.9875	107.9119	29:18:32	29:29:39	-91:17:41	-91:20:52
13164	41258	191	99.53	99.5201	99.4325	29:27:37	29:54:58	-91:19:37	-91:38:30
13209	41393	39	107.70	107.3830	107.3094	29:32:45	29:31:48	-91:19:48	-91:28:02
13269	41573	359	101.05	101.0307	101.1730	29:26:23	29:24:27	-91:26:59	-91:26:36
13361	41849	489	52.32	102.2396	102.1028	29:25:45	29:27:21	-91:33:16	-91:31:51
13392	41944	127	105.87	104.9471	105.1722	29:34:18	29:23:02	-91:30:46	-91:30:53
13448	42112	633	103.14	103.1232	102.9731	29:24:06	54:21:01	-91:39:40	-136:50:51

(Note: Wisconsin radiance for scanline 13361, pixel 489 corresponds to zero counts.
Zero count GSFC/MAS radiance is 52.31435 (8 bit), 52.35527 (10 bit))

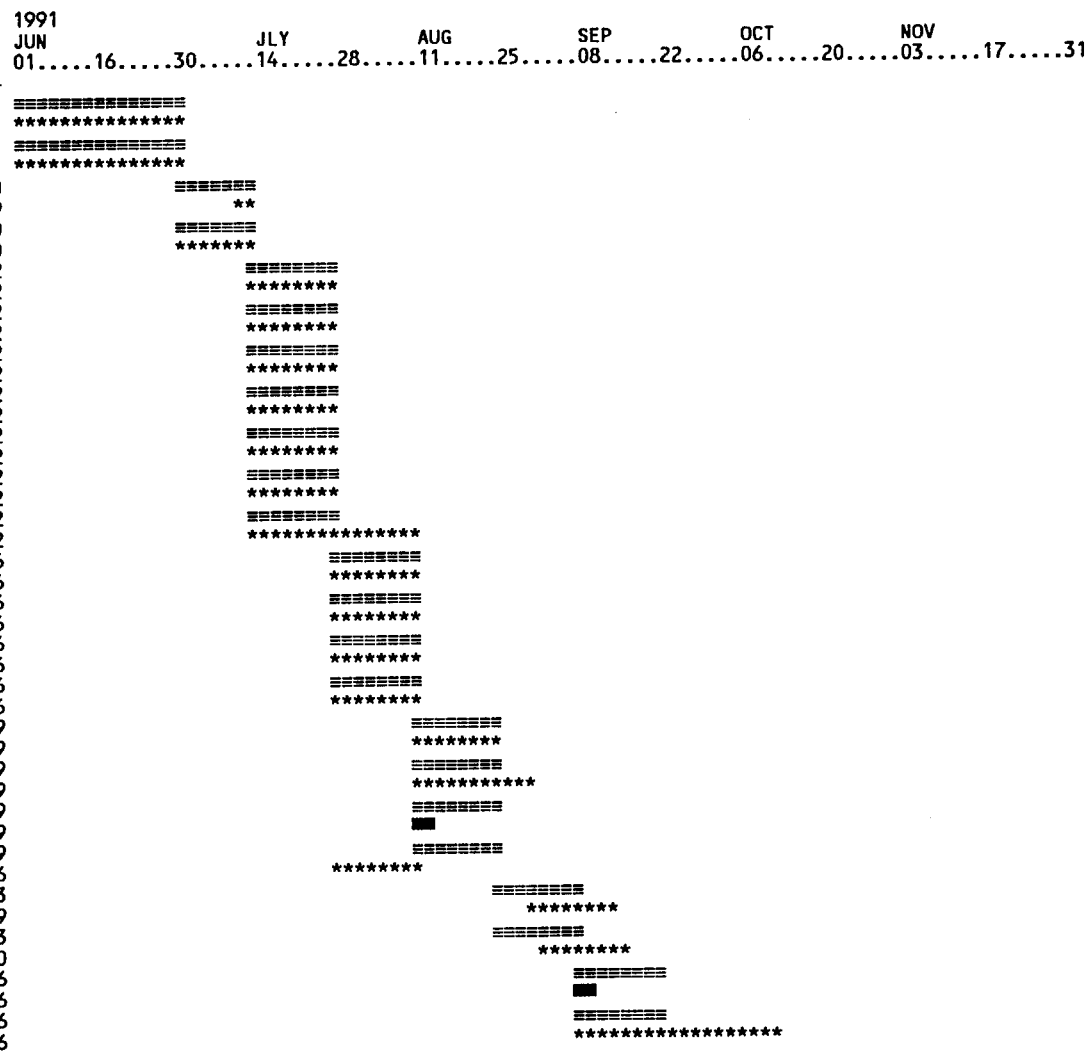
Date: 10/10/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

Task	Resource/Status	Date
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 I	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 I	09/06
Integrate calibration, geolocation		09/06
	LG C	09/06



1C714PRINT

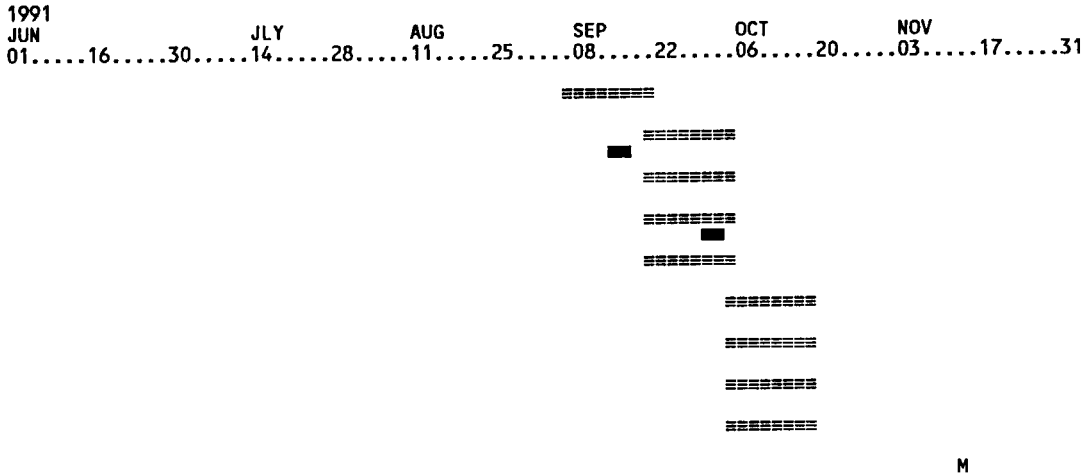
Date: 10/10/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

Task	Resource/Status	Date
Introduce users to IRIS imagery	LG	09/06
Convert Level-1B to netCDF (TEG)	LG I	09/20 09/13
Process new MAMS data set	LG	09/20
Fix any bugs found	LG I	09/20 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	11/12



DRAFT October 10, 1991

MODIS Science Data Support

Work Plan

October 1, 1991 to September 30, 1992

INTRODUCTION:

The objective of this work plan is to identify the areas of support to be provided to the MODIS Science Team Leader by the MODIS Science Data Support Team (SDST) during FY 1992. 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. The main areas of work are:

1) Functional, operational and performance requirements, operations concept, science scenarios and preliminary design for the MODIS Team Leader Computing Facility (TLCF)

2) MODIS science data product algorithm development plan

3) Plan for porting science team members algorithms to the TLCF

4) Science data support for MODIS Airborne Simulator (MAS) experiments

5) Definition of the data structure/format for MODIS Level-1A and 1B products

6) Identification of the issues, options and accuracy requirements involved in MODIS image registration

7) Identification of MODIS Level-2 and Level-3 processing design issues

8) 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

9) Development and delivery of the MODIS Data Management Plan.

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.

MODIS science data product 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.

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.

Science data 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.

Definition of the data structure/format for MODIS Level-1A and 1B 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.

Identification of the issues, options and accuracy requirements involved in 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.

Identification of MODIS Level-2 and Level-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.

Development and delivery of the MODIS 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.