MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

September 6, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator
3. Revised Assumptions List to Team Members
4. Impact of Schedule Specifications on MODIS Processing Design
5. Topics for Presentation

ACTION ITEMS:

05/03/91 [Lloyd Carpenter and Tom Goff]: Prepare a Level-1 processing assumptions, questions and issues list, to be distributed to the Science Team Members and the MCST for comment. (Returned for updating on August 30, 1991. An updated list is included in the handout.) STATUS: Open. Due date 06/07/91.

06/07/91 [Liam Gumley]: Speak to Alan Strahler, when he returns, regarding his MAS requirements. (Strahler is away on a field experiment.) STATUS: Open. Due date 07/05/91

05/31/91 [Al McKay and Phil Ardanuy]: Examine the effects of MODIS data product granule size on Level-1 processing, reprocessing, archival, distribution, etc. (Reports were provided on June 21 and 28, 1991.) STATUS: Open. Due Date 06/21/91

06/28/91 [Lloyd Carpenter and Tom Goff]: Prepare a detailed list of scheduler assumptions in relation to Level-1 MODIS processing scenarios. (Lists were provided on July 26 and August 16, 1991.) STATUS: Open. Due date 07/26/91.

08/23/91 [Lloyd Carpenter]: Prepare a response to Dr. Charles Gary at Ames providing copies of existing descriptions of MODIS data flow and processing. This information was requested in connection with the Ames study of using optical processors on EOS instrument data. (A response has been prepared.) STATUS: Open. Due Date 09/06/91.

08/23/91 [Lloyd Carpenter]: Obtain a sample Data Management Plan from Barbara Walton. (Barbara Walton recommended Ed Chang as the source. A meeting with Ed Chang has been set to discuss the sample plan.) STATUS: Open. Due date _____.

08/30/91 [Team]: Determine what the SDST should present at the Science Team Meeting, and who should make the presentations. (A list of suggested topics is included in the handout.) STATUS: Open. Due date _____.

08/30/91 [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. STATUS: Open. Due date _____.

08/30/91 [Team]: Contact Sol Broder regarding the MODIS interface with the scheduler. STATUS: Open. Due date _____.

08/30/91 [Team]: Examine the impact of the EOSDIS scheduler specifications on MODIS processing design. (A report is included in the handout.) STATUS: Open. Due date _____.

Progress on MAS Level-1B processing system development

Progress up to 5 September 1991

(1) Calibration

The MAS calibration code has been changed as suggested in the SDST meeting of 08/30/91. The checks on the black body counts now set the calibration slope and intercept to zero only for the channel which has bad data - other channels in the scan line are unaffected. The user is notified which channels have bad black body counts or temperatures in a given scan line. The output calibration file now includes the instrument scan line number for every scan line as a means of referencing the slope and intercepts. Means of checking the assumed instrument configuration (spectral band assignment, number of bits per channel etc.) are under investigation.

(2) Geolocation

The code used for computing linear regressions for the INS latitude, longitude, altitude, heading and pitch has been updated. This was done because of differences noted between the results generated on the IBM-PC and those generated on the VAX. The problem appears to have been due to roundoff error.

Chris Moeller at Wisconsin was contacted regarding specific portions of the MCIDAS geolocation code. Some subroutines and functions were missing from the supplied source code and Chris will send these by email in the next few days.

(3) General

Mike King was contacted and a meeting arranged for Friday 09/06/91. Topics for discussion include
- Likely MAS instrument configuration in November
- MAS calibration strategy and assumptions
- MAS geolocation strategy and assumptions
- Inclusion of INS data as a separate part of the Level-1B data
- Topics to be discussed at Science Team meeting relevant to MAS

(4) Schedule

The schedule is unchanged from that presented in the SDST meeting of 08/30/91.

Processing Overview
of the
MODIS Level-1A and 1B
Data Products

5 September 1991

MODIS instrument data is processed by a chain of programs that create various levels of data products. At each level, each data product consists of the MODIS data set with an accompanying metadata. The data set is self contained and includes all instrument (science and engineering) data, and full dataset header information. The metadata duplicates the data set header with additional information added by the MODIS processes and other processes external to MODIS (the IMS for example). This document summarizes the contents of the Level-1A and Level-1B data products that will be available to the user community. Also included is background information describing the flow of the MODIS data from the instrument to the various end products.

MODIS Level-1A Data Product. The Level-1A product is derived from the Level-0 Data Product, defined to be the instrument data in packetized form as received from CDOS. A telemetered packet of data is a convenient amount of instrument data that has been bundled into a data transmission unit. The packet has an origination identifier (ID) and a cyclic redundancy code (CRC or similar technique) to provide the ability to detect and correct data transmission errors. Data packets originate at the instrument and are passed through the spacecraft data handling system, the TDRSS satellite, and the White Sands receiving station, ultimately arriving at the GSFC Information Processing Technology Group (IPTG). Processed packets are then directed by the IPTG CDOS subsection to the DADS, which stages the data for the various MODIS processing programs. The data consists of the MODIS instrument packets and the separate spacecraft ancillary data packets containing position and attitude information. These are the only data required for MODIS Level-1A processing.

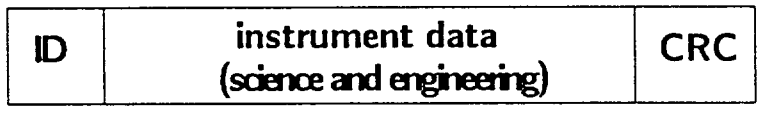

Fig 1. Packetized Data

The MODIS instruments collect data using a data frame. A frame of data is a two dimensional array of data generated by a solid state detector array. One dimension consists of along track data and the other consists of wavelength (band or channel) data. All frame data is clocked synchronously. House keeping ancillary data are added to each frame. Multiple frames of data are then taken as the mirror rotates in the across track direction to form a scan cube. A frame of data is divided into telemetry packets for transmission to ground receiving stations.

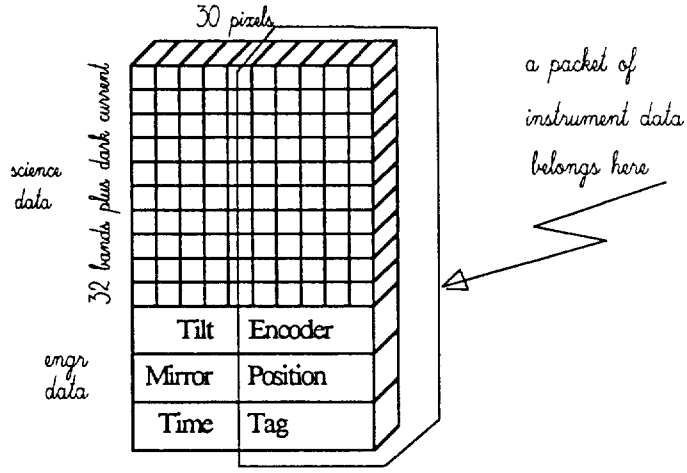

Fig 2. Data Frame

MODIS processing places the packets of data into computer memory, represented as scan cubes contained within a data product. The concept of a scan cube is illustrated in Figure 3. As an example, the MODIS-T (daylight) scan frame is composed of the pixel data from one readout of the solid state detector array, plus tilt angle, scan angle, and a time tag. Successive readouts of the detector array frames occur as the scan mirror rotates in the across track

direction to produce a scan cube. Included in each scan cube (swath) are the engineering house keeping data and instrument ancillary data (voltages, currents, thermistor readouts, status bits, etc).

The spacecraft position and attitude data are obtained from separate telemetered packets of data that are archived by the DADS. These data are localized by time and are appended within the scan cube ancillary data.

Two components of the data product are produced. The data set component contains the scan cubes of data with a data set header. A separate second component of the data product will be derived that contains the MODIS metadata, a superset of the data set header. The scan cubes are placed into an internal data structure (granule), ordered by time, as illustrated in Figure 4. The data set header contains algorithm version numbers, data quality assurance indicators, data synopsis and descriptors,

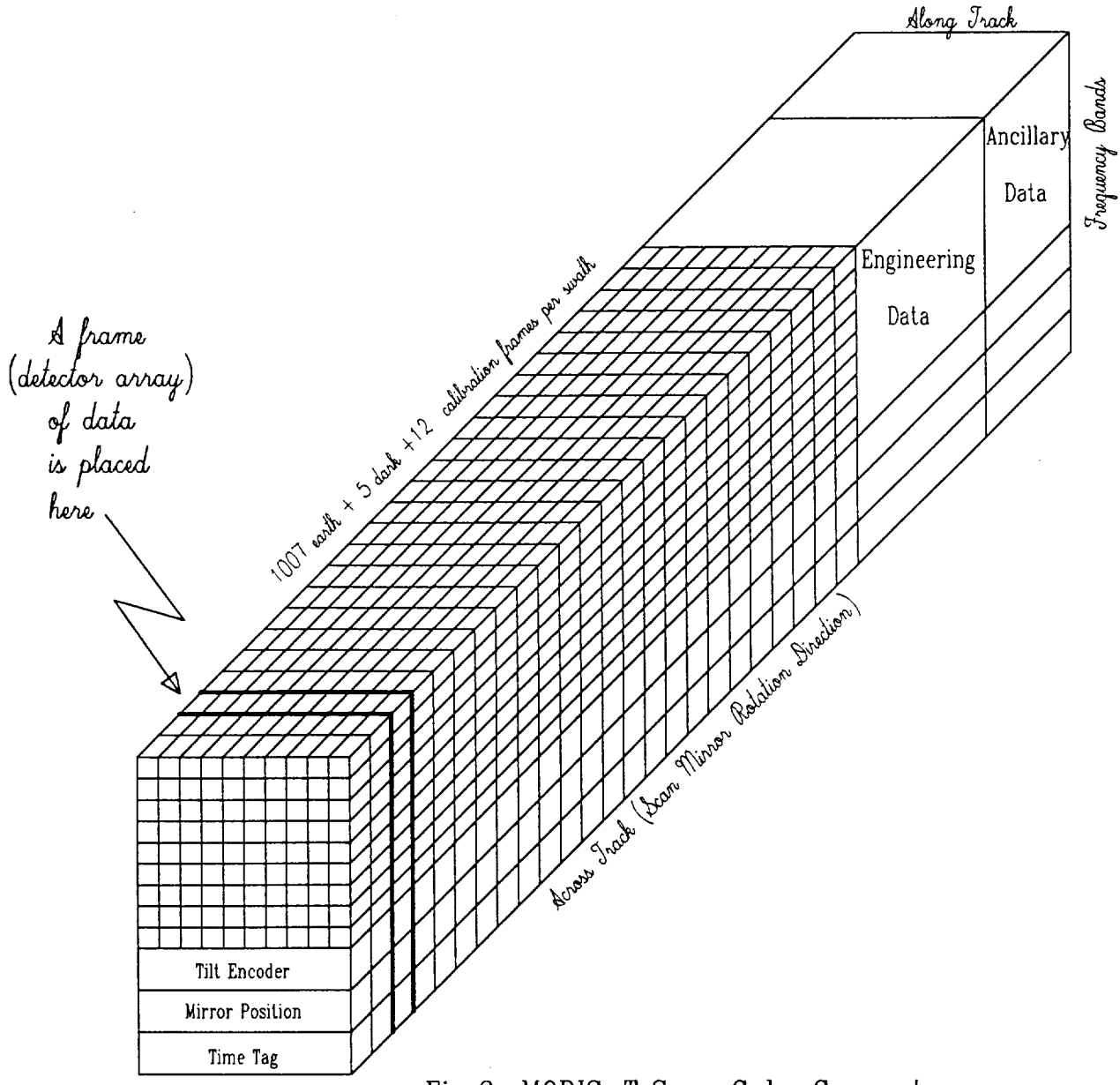

Fig 3 MODIS-T Scan Cube Concept

etc. The scan cube header contains scan cube related items. The Level-1A data will not be unpacked (13 bits into 16 bits) or altered in any way. The data set contains the raw instrument data with duplicate packets removed and ancillary information appended.

Level-1B Data Product. At-satellite radiances are provided in the Level-1B Data Product. These radiances will be calibrated using an algorithm agreed upon by the MODIS Team members. No

ground looking data (in-situ) will be used in the calibration. The calibration algorithm may include a smoothing effect over a plus or minus six hour time period to minimize spatial data discontinuities.

Ground location at selected anchor points will be appended to the data product using the WGS84 (or similar) ellipsoidal Earth model. This does not include a digital elevation model (DEM). Apriori ground location computations based on instrument geometry are expected to provide location accuracies to several kilometers. Further accuracy improvement to sub-pixel specifications will be provided by a satellite position and attitude deviation database derived from ground point convolutions.

No correction for atmospheric effects will be included or applied to the radiance values. or the anchor point determination. No scene characterization flags (cloud, land, ocean, etc) will be included in the Level-1B data product. Metadata from Level-1A will be upgraded and appended to produce the Level-1B metadata.

Conceptually, the MODIS Level-1B scan cube within the data set is the same as the Level-1A scan cube illustrated in Figure 3, with the anchor points appended. For example, the Level-1A data product could cover a spatial scene with the along track dimension approximately equal to the across track dimension. The spatial coverage of the data products is to be determined (TBD).

Each individual data product will be under configuration management (CM). Calibration algorithms and coefficients, earth location criteria, or platform position and attitude will not be altered without forcing a revision to the software and/or data product. A Level-1B Data Product is derived only from the information contained within the Level-1A data product. Revisions of Level-1B programs will exactly track the corresponding revisions of the Level-1A programs.

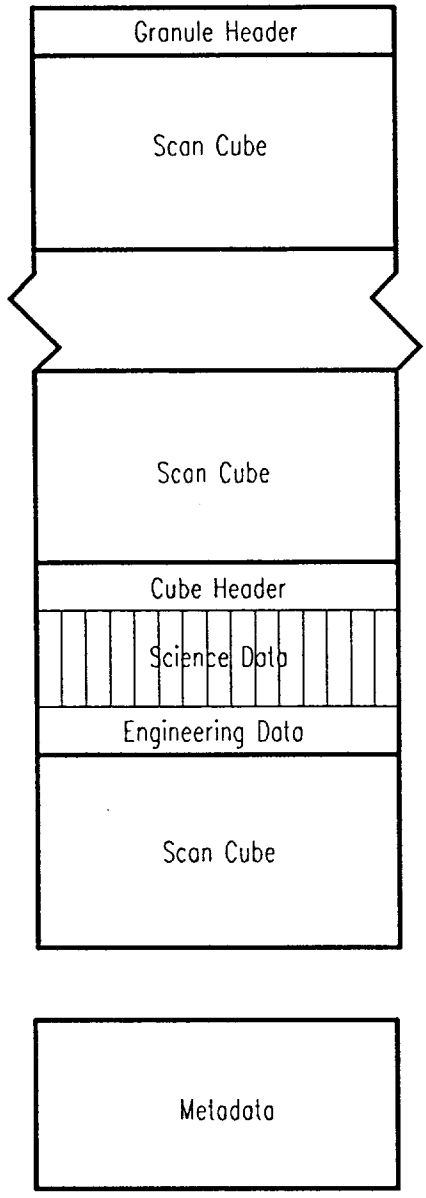

Fig 4 Data Products

General Considerations. The MODIS processes will monitor predetermined instrument items and will generate messages that can be transmitted to other processes or projects. These will inform other processes of problems or anomalies detected from the MODIS telemetry data. Solicited and unsolicited messages will be sent to the scheduling activity for status responses and data completion problems respectively. In addition, a MODIS Processing Log will contain all MODIS scheduling times, problems, or event items.

One definitive set of MODIS software will handle all MODIS instrument and product modes. There will not be a separate program for quick_look or reprocessing modes. Production of a browse data set (once defined) is a separate process which may be executed either concurrently or on demand (TBD). Any browse product generated by subsampling, either spatially, temporally, or in wavelength will be performed by processes separate from the main chain of processing programs.

MODIS processing algorithms and code will be freely available to interested parties.

MODIS Level-1 Processing Assumptions

compiled by the
MODIS Science Data Support Team
5 September, 1991

This list of assumptions is associated with the design of the MODIS Level-1 data processing. The assumptions may change as comments are received, and as refinements are made to the Level-1 processing system design. The numbering of items comes from a master list being tracked by the MODIS Science Data Support Team. Only those items which may be of interest to MODIS Science Team members are included in this abbreviated list.

Unpacking Data (016). MODIS data will not be unpacked (byte aligned) at Level-1A.

> Leaving the data in a packed form minimizes the size of the data set in the absence of data compression. It also minimizes the time and complexity of Level-1A processing. Unpacking the data at Level-1A increases the probability of error in the basic level of permanently archived data.

Level-1A Navigation (017). Earth locations of MODIS pixels will not be determined at Level-1A.

> This function is contained in the Level-1B process.

Required Ancillary Data (042). All data required for MODIS Level-1B processing will be included in the MODIS Level-1A product.

> This assumption says that all data required to process to the Level-1B product (including metadata) will be contained within the Level-1A data product. This means that no in-situ data is required, and that no auxiliary data sets are required (i.e. other instrument motions causing momentum effects, platform thermal deformation data not in the MODIS packets, previous MODIS data products, etc.). See also: Engineering Data.

Platform Position and Attitude Knowledge (037). MODIS Level-1B processing will use the satellite position and attitude knowledge supplied by the EOS project and appended to the Level-1A data.

> The MODIS Level-1A processor appends the satellite position and attitude to the Level-1A data product. If the spacecraft position or attitude are updated after the MODIS data product has been generated, a MODIS reprocessing may have to be initiated by an outside authority.

Position and Attitude Knowledge for Quick-Look (052). MODIS Quick-Look processing will use the best available satellite position and attitude data.

> It is assumed that the best available position and attitude information will be available for MODIS quick_look processing. The

data will be produced with the appropriate data quality indicators.

Orbit and Attitude Correction (022). The process of updating instrument position and attitude information already appended to Level-1A data will be performed in a separate utility process.

Coordinate System (031). Coordinates will be represented in the geodetic latitude-longitude coordinate system on a standard ellipsoid.

Coordinate transformations from the EOS platform coordinate system to the ground based geodetic latitude-longitude coordinate system will be performed by the MODIS process using standardized transformation routines. Latitude will be given in the geodetic coordinate system.

Anchor Point Selection (032). For each scan, a set of anchor points will be selected for interpolating the ground locations of pixels within the scan.

See the report "An Analysis of MODIS Anchor Point Accuracies for Earth Location", MODIS Data Study Team, Revised: April 5, 1991 for details of the anchor point method. The ground locations of the selected pixels are determined solely from the satellite position, attitude, and instrument geometry without the use of ground (in-situ) control points.

Anchor Point Parameters (033). The following parameters will be provided in the Level-1B data set for each anchor point: earth location (geodetic latitude-longitude) of the pixel, satellite slant range, satellite azimuth and zenith angles, and solar azimuth and zenith angles (all with respect to the pixel).

The zenith angles are relative to the normal to the local geodetic surface at the pixel.

Anchor Point Error Statistics (034). No statistical measure of earth location accuracies will be included in the Level-1B data product.

A determination of anchor point statistical accuracies can be derived separately form the MODIS processes. Anchor point locations are to be calculated from platform knowledge parameters initially. They can be further improved via off-line methods to be available after the MODIS data has been disseminated, or by incorporating an automatic ground point convolution capability.

Feature Identification (035). No Feature Identification/Ground Control Points will be used at Level-1B for earth location.

No in-situ data, derived either from ground feature selection or a-priori positioning, will be required to produce the Level-1B data product.

Land/Ocean Flags at Level-1A (024). Land/Ocean, Cloud, or other derived flags will not be included in the Level-1A data product.

The scan data is in uncalibrated digital (raw) count form thereby precluding the use of any cloud detection algorithm at Level-1A.

Land/Ocean Level-1A Products (025). The Level-1A product will be supplied without separation into land/ocean or other categories.

Navigation is not performed in the Level-1A process. Therefore, earth referencing information is not available to allow a land/ocean flag to be generated.

Level-1B Land/Ocean Flags (039). Land/Ocean flags will not be included in the Level-1B data product.

The current Level-1B design contains no provision for data flags. Generating a land/ocean flag would require a Team Member agreed upon coast line database.

Level-1B Cloud Flags (051). Cloud flags will not be included in the Level-1B data product.

Cloud flags are a level-2 function. These flags are based upon the properties of the atmosphere which are not a consideration for at-satellite radiances. These flags may also be an interdisciplanary function that occurs at later stages in the MODIS chain of processes. Multi-instrument registration may also be required.

Land/Ocean Level-1B Products (040). The Level-1B product will be supplied without identification of land vs ocean.

Level-1B MODIS data products will not be categorized by spatial parameters. Headers and Metadata, however, will contain statistical indicators of this characterization.

Level-1B Elevation Correction (036). There will be no terrain elevation correction (beyond the reference ellipsoid) to earth location at Level-1B.

Any use of a Digital Elevation Model (DEM) will be performed in follow-on processing upon the determination of a DEM procedure and appropriate model.

Atmospheric Correction (038). No atmospheric correction of any kind will be applied to the MODIS level-1B data.

The definition of MODIS Level-1B data is at-satellite radiances, uncorrected for atmospheric effects such as absorptive, scattering, and refraction.

Level-1A Browse (026). There will be no Level-1A browse product.

It is assumed that browse data derived from raw packed instrument counts with no earth referencing would be of very limited use.

Level-1B Browse (041). The Level-1B process will not generate browse products.

Any required browse products will be generated by a separate browse process in order to take advantage of future technology advances without compromising the main data product processing. This allows technologies to be used as they are developed without changing the basic Level-1B product generation function. This also allows for the concept of 'on the fly' or demand browse to be implemented.

Calibration (043). Calibration algorithms and parameter values will be provided by the MCST.

Both algorithms and parameters (coefficients) will be incorporated into the Level-1B software by the SDST.

Engineering Data (044). MODIS Level-1B processing will extract instrument engineering values from each Level-1A scan cube individually.

The engineering values from the instrument will be used by calibration equations to be supplied by the MCST. These equations may have coefficients that vary with each scan cube. The coefficients are based on Level-1A data plus and minus six hours from the Level-1B scan cube.

(Clarification/modification of this assumption is to be provided by the MCST)

Quality Checks (010). Quality Assurance will be included in the MODIS processing programs.

The MCST will provide an integrated set of quality checks from all sources, including team members. The MCST will also provide a list of error messages to be generated when the data fail to pass the quality checks.

September 6, 1991

Impact of EOSDIS Scheduler Specifications on MODIS Processing Design

Scheduling Specification		Impact on MODIS Processing Design
The PGS production operations are data-driven.		No problem
PGS-0140	The PGS shall provide tools to help the PGS staff create and modify its plans.	No problem
PGS-0150	The PGS shall receive data availability schedules from remote DADS, CDOS, the IPs, the ADCs and ODCs.	No problem
PGS-0160	The PGS shall receive standing orders, changes to standing orders, and product requests from the IMS.	No problem
PGS-0165	The PGS shall accept priority processing requests from the IMS.	No problem
PGS-0170	The PGS shall receive priority assignments, schedule conflict resolutions, and other operational directives from the SMC.	No problem
PGS-0180	The PGS shall receive a notice from DADS when data that it has received is available.	No problem
PGS-0190	The PGS shall coordinate with the DADS on the staging of data for product production.	No problem
PGS-0210	Each PGS shall maintain a database of product specifications that contains the recipe for the generation of all Standard Products allocated to that PGS including, at a minimum: a. The algorithm(s) to be used b. The order in which algorithms are to be executed c. The input data sets required	No problem

	d. Time and other processing resources required	
PGS-0220	The PGS shall create a reprocessing plan containing, at a minimum: a. A list of processing tasks needed to carry out each product's reprocessing b. Estimated schedule for each task c. The order in which tasks will be executed	No problem
PGS-0230	The PGS shall base the PGS reprocessing plan on, at a minimum: a. Requests received from the IMS b. SMC directives c. The Standard Product specifications	No problem
PGS-0240	The PGS shall perform reprocessing according to the PGS reprocessing plan.	No problem
PGS-0250	The PGS shall schedule product generation when all inputs required to generate a Standard Product for which there is a current order (from IMS) are available. Entries in the schedule shall contain, at a minimum: a. The product to be generated b. The specific algorithm(s) and calibration coefficients to be used c. The specific data sets needed and their sizes d. Priorities and deadlines that apply to the order for the product	No problem
PGS-0260	The PGS shall schedule other functions, including, at a minimum: a. File backups b. File maintenance c. Calibration data handling	No problem
PGS-0270	The PGS shall provide the capability to perform the following functions, at a minimum a. Allocate tasks among processors	No problem

	b. Suspend execution of tasks c. Resume execution of tasks d. Cancel execution of tasks e. Request and verify the staging and/or destaging of data stored in the DADS	
PGS-0285	The PGS shall transmit to the IMS a status message to confirm or reject a processing order. The reason for rejection shall be included.	No problem
PGS-0290	The PGS shall make electronic copies of its plans and schedules available to the IMS, the SMC, and the collocated DADS.	No problem
PGS-0295	The PGS shall transmit a status message notifying the IMS of a revised completion time if processing will not complete per original schedule.	No problem

September 6, 1991

Candidate Topics for SDST Presentation
MODIS Science Team Meeting
October 1 - 3, 1991

1. MODIS Airborne Simulator, Level-1B Processing
2. MODIS Level-1A and -1B Processing Assumptions
3. MODIS Level-1A and -1B System Design
4. Towards MODIS Higher-Level Processing
5. MODIS Image Rectification
6. MODIS Data Granules
7. MODIS Processing Scenarios
8. Processing Impacts of MODIS-N Copies in 10:30 AM and 1:30 PM Orbits