MODIS DATA STUDY
TEAM PRESENTATION

November 16, 1990

AGENDA

1. Action Items
2. MODIS Level-1B Processing System Functional Requirements Overview
3. MODIS Level-1A and -1B Metadata Attributes
4. Revised MODIS Level-1A Processing System Functional Requirements Overview
5. MCST/MSDST Interface
6. MODIS Anchor Point Accuracies: Progress Report

ACTION ITEMS:

10/5/90-2 [Doug Hoyt]: Review the interface between MODIS Level-1 processing and the MCST and identify unresolved issues or points requiring clarification. Prepare a list of needed information items and relate each item to a corresponding Level-1 required activity or design requirement. STATUS: Report included in this week's handout. Open.

10/12/90-2 [Watson Gregg]: Prepare a report on MODIS anchor point requirements. Analyze the utility of alternative parameters to describe MODIS observation and solar geometry. STATUS: Report in this week's handout. Open.

10/19/90-1 [John Blaisdell]: Expand introductory material in Earth Model write-up to include broad discussion of MODIS geolocation and need for Earth model. Coordinate with Al Fleig to distribute report. STATUS: Met with Al Fleig. Open.

10/26/90-1 [John Blaisdell]: Scope a brief error analysis and impact study on the merits of a geoid model as opposed to an ellipsoid. STATUS: Open.

MODIS LEVEL-1B PROCESSING SYSTEM FUNCTIONAL REQUIREMENTS OVERVIEW

Requirements for the functions are derived from the ECS Requirements Specifications document (reference may be found at the end of the data dictionary), and are stated verbatim from the reference.

A. INPUT

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL RECEIVE:

1. Level-1A Data

   (Page 7-23, 3PGS-00440: The PGS shall accept from the DADS L0-L4 Data Sets.)

2. Quick-Look Data

   (Page 7-24, 3PGS-00530: The PGS shall generate quick-look products in support of field experiments, event monitoring, and instrument monitoring using algorithms and calibration coefficients provided by the scientists.)

3. Locally Maintained Data Bases

   (Page 7-23, 3PGS-00490: The PGS shall have the capability to access and use for the generation of standard data products information stored in locally maintained data bases. Examples of such databases are: (a) Digital Terrain Map Database, (b) Land/Sea Database, (c) Climatologies Database, and (d) Digital Political Map Database.)

B. CONTROL

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL RESPOND TO CONTROL:

(Page 7-21, 3PGS-00270: The PGS shall provide a scheduler with the capacity to perform the following functions, at a minimum: (a) Add tasks to the job queue, (b) Allocate tasks among processors, (c) Initiate execution of tasks in the job queue, (d) Suspend execution of tasks, (e) Resume execution of a suspended task, (f) Cancel execution of tasks, and (g) Request and verify the staging and/or destaging of data stored in the DADS.)

C. PROCESSING STATUS INFORMATION

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL GENERATE FAULT INDICATIONS:

(Page 7-22, 3PGS-00320: The PGS shall display detected faults to the system operators.)

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL PROVIDE STATUS INFORMATION

(Page 7-22, 3PGS-00380: The PGS shall monitor its internal operations and generate a status report periodically.)

D. OUTPUT

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL PRODUCE:

1. Level-1B Data Products

   (Page 7-13, 3DAAC00070: The DAAC shall generate Levels 1, 2, 3, and 4 data products, archive, manage, quality check and account for archived data products.)

2. Processing Log

   (Page 7-22, 3PGS-00360: The PGS shall generate a PGS Processing Log periodically that accounts for all data processing activities.)

3. Metadata

   (Page 7-24, 3PGS00510: The PGS shall have the capability to generate metadata according to the algorithms provided by the scientists and associate this metadata with each standard data product generated.)

   (Page 7-14, 3DAAC00220: The DAAC shall generate browse data and metadata for routing to the requested users, through the coordination of IMS.)

4. Standard Browse Data

   (Page 7-24, 3DAAC00220: The DAAC shall generate browse data and metadata for routing to the requested users, through the coordination of IMS.)

5. Quick-Look Product (Level-1B)

(Page 7-24, 3PGS-00530: The PGS shall generate quick-look products in support of field experiments, event monitoring, and instrument monitoring using algorithms and calibration coefficients provided by the scientists.)

E. OTHER

MODIS LEVEL-1B PROCESSING SHALL BE ACCOMPLISHED USING TWO DISTINCT SETS OF STAND-ALONE SOFTWARE: ONE SET TO SUPPORT MODIS-N PROCESSING AND ONE SET TO SUPPORT MODIS-T PROCESSING.

(Unreferenced)

THE MODIS LEVEL-1B PROCESSING SYSTEM SHALL BE CAPABLE OF REPROCESSING

(Page 7-24, 3PGS-00540: The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists.)

(Page 7-24, 3PGS-00550: The PGS shall reprocess science data using the original or updated (provided by the scientists) calibration coefficients.)

MODIS LEVEL-1B PROCESSING SYSTEM FUNCTIONAL REQUIREMENTS OVERVIEW: DATA DICTIONARY

In the following, statements enclosed in quotations are quoted verbatim from the ECS Requirements Specifications document (reference may be found at the end of the data dictionary). Statements not enclosed in quotations are attributed to the MODIS Data Study Team.

Anomaly Reports: A report identifying a discrepancy between two or more sources of information. (Unreferenced).

Audit Trail: A record that describes the processing history of data and its identification. Contained within the metadata. (Unreferenced).

Browse Data: "Data produced primarily to provide other investigators with an understanding of the type and quality of data available. Typically, browse data sets are limited in size or resolution. The specific form of browse data depends on the type of instrument or discipline with which the browse data are related. Browse data are sometimes considered to be a sample of available data." (Page A-3).

Completeness: A data quality indicator determining whether a particular data increment is present in finished form or whether there are missing items. (Unreferenced).

Control: "The PGS shall provide a scheduler with the capacity to perform the following functions, at a minimum: (a) Add tasks to the job queue, (b) Allocate tasks among processors, (c) Initiate execution of tasks in the job queue, (d) Suspend execution of tasks, (e) Resume execution of a suspended task, (f) Cancel execution of tasks, and (g) Request and verify the staging and/or destaging of data stored in the DADS." (Page 7-21). In addition are (h) Select processing mode and (i) Request processing status information.

Data Quality Check: The process by which data quality information is generated. (Unreferenced).

Data Quality Information: Information on data quality, including existence, completeness, and the presence of anomaly reports, at a minimum. (Unreferenced).

Existence: A data quality indicator determining whether a particular increment of data is present or absent. (Unreferenced).

Fault Indication: An unsolicited flag denoting that a hardware or software error has occurred (e.g., a disk drive failed during data transfer or data header identifiers are not correct), or an "alarm event." (Unreferenced).

Instrument Data: "Data specifically associated with the instrument, either because it was generated by the instrument or included in data packets identified with that instrument.

These data consist of instrument science and engineering data, and possibly ancillary data. These data may be assembled for transmission by the instrument, or by an on-board processor of the instrument data." (Page A-9). "Data created by an instrument including scientific measurements and any engineering or ancillary data which may be included in the instrument data packets." (Page A-9).

Level-1A Data Product: "Level-0 data, which may have been reformatted or transformed reversibly, located to a coordinate system, and packaged with needed ancillary, engineering, and auxiliary data." (Page A-4). Includes instrument data, a header, and data quality information.

Level-1B Data Product: "Irreversibly transformed values of the instrument measurements (e.g., radiances, marine conductivity). For in-situ observations, the Level-1B product is also the geophysical parameter of interest (e.g., particle flux, ambient magnetic field vector, radiosonde-generated atmospheric temperatures)." (Page A-4). Includes instrument data, a header, and data quality information.

Locally Maintained Data Bases: "Examples of locally maintained data bases are: (a) Digital terrain map database, (b) Land/sea database, (c) Climatology database, and (d) Digital political map database." (Page 7-23). Required for Level-1B are (1) Land/Sea Database and (2) Digital Political Map Database. These are required for metadata and as header information.

Metadata: "Information which is obtained from data sets, and which provides an understanding of the content or utility of the data set. Metadata may be used to select data for a particular scientific investigation." (Page A-11). Metadata will include an audit trail. (Page 7-18). A more detailed description of the Level-1B metadata product is contained in the Appendix.

Processing Log: "Periodically accounts for all data processing activities." (Page 7-22, 3PGS-00360). A record of the time-ordered processing events. An event may be the completion of the processing activity or the generation of an anomaly report.

Processing Mode: There are three types:

a. Standard Product Processing: "The PGS shall have the capability to produce each standard product as specified in that product's Standard Product Specification." (Page 7-23, 3PGS-00470).

b. Reprocessing: "The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists." (Page 7-24, 3PGS-00540).

c. Quick-Look Data Processing: "The PGS shall send the DADS quick-look data for routing to the appropriate destination (e.g., ICC, SCF). Quick-look data shall contain the following information at a minimum: (a) Product

identication, (b) quick-look data, (c) associated metadata, (d) process facility identification, and (e) current date and time." (Page 7-30, 3PGS-01260).

Processing Performance: A statement of the amount of data processed; will include a record during processing (dynamic status) and a post-event record (static status). (Unreferenced).

Processing Status Information: "Information regarding schedules, hardware and software configuration, exception conditions, or processing performance." (Page 7-18). The MODIS Level-1 Processing System is concerned only with fault (exception) conditions and processing performance.

Quick-Look Data: "Real-time or priority playback data which receive minimal processing and are forwarded to the user for his review/use. The user may provide additional processing to suit his requirements." (Page A-14). "Data Received during one TDRSS contact period which have been processed to Level-0 (to the extent possible for data from a single contact). This is data that have been identified as requiring priority processing on the order of a few hours. It is routed to the PGS from the DADS." (Page 7-18).

Quick-Look Product (Level-1B): "Quick-look data that has been processed by a PGS prior to being sent to an ICC." (Page 7-35). For MODIS Level-1B processing, the restriction on being sent to an ICC is relaxed--it may be sent elsewhere (e.g., field experiment investigators).

REFERENCE

Functional and Performance Requirements Specification for ECS, Fourth Preliminary, September 14, 1990.

Table 1. Level-1A Metadata

The following list of metadata parameters is taken from the list provided in Appendix C of the current EOSDIS specification[1]. The original list has been sorted into categories containing related items. In a few cases items or definitions have been changed; such changes are noted in the notes appended to the tables.

Granule Identification	
Project ID	Supported project that collected the data
Platform ID	Platform on which sensor was located
Sensor ID	Sensor which captured data
Granule ID	Granule identifier
Time & Orbit Data	
Start Time	Date and time data collection started
Stop Time	Date and time data collection stopped
Ephemeris Information	
Attitude Information	Min & max yaw, pitch and roll
Start Orbit Number	Orbit number at start of data collection
Stop Orbit Number	Orbit number at end of data collection
MODIS Instrument Operation	
Operation Mode	Description of operation mode
Footprint	Bounding shape (rect., elliptical, circ.)
Tilt Angle	
Product Identification	
Investigator	Investigator ID
Data Type	Data type (ancillary, housekeeping, etc.)
Processing Level	Level of processing
Product Sequence Number	Product identifier
Product Generation Parameters	
Algorithm Version Number	Version number & algorithm name
Processing Date	Date the product was processed
Processing Location	PGS where product processed
Audit Trail[2]	Input data identifier[3]

Product Storage Parameters[4]	
Inventory Date	Date granule ingested into inventory
Storage medium[5]	Storage media
Archive ID	Archive location identifier
Data Completeness & Quality	
Number of Bands	Number of spectral bands
Number of Lines	Number of lines or scans in the data
Number of Samples	Number of samples or pixels in a line
Number of Observations	Number of observations included in data
Data Gap	Includes orbit no., lat/long, time span
Number of Data Gaps	Number of missing lines in image
Data Quality	Quality assessment of data granule
Band Quality	Indicator of band quality

Table 2. Level-1B Metadata

MODIS Level-1B metadata includes all items listed in Table 1 for Level-1A plus the following Level-1B specific items:

Earth Location	
Geographic Location Keywords	Continent, ocean, or global location
Coverage	Rect., circular, or elliptical coordinates
Min. Geocorrected Latitude	Minimum latitude of the image after geocorrection
Max. Geocorrected Latitude	Maximum latitude of the image after geocorrection
Min. Geocorrected Longitude	Minimum longitude of the image after geocorrection
Max. Geocorrected Longitude	Maximum longitude of the image after geocorrection
Observation Geometry	
Min. Satellite Azimuth Angle[6]	Minimum azimuth of the observation path
Max. Satellite Azimuth Angle	Maximum azimuth of the observation path
Min. Satellite Zenith Angle	Minimum angle between observation path and zenith
Max. Satellite Zenith Angle	Maximum angle between observation path and zenith
Min. Sun Azimuth	Minimum sun azimuth for the data
Max. Sun Azimuth	Maximum sun azimuth for the data
Min. Sun Zenith	Minimum sun angle with the local zenith[7]
Max. Sun Zenith	Maximum sun angle with the local zenith
Observation Conditions (Level-1)	
Day/Night Flag[8]	Indicates image obtained day or night
Land/Ocean Tag	Percentage land/ocean

MODIS LEVEL-1A PROCESSING SYSTEM FUNCTIONAL REQUIREMENTS OVERVIEW

Requirements for the functions are derived from the ECS Requirements Specifications document (reference may be found at the end of the data dictionary), and are stated verbatim from the reference.

A. INPUT

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL RECEIVE:

1. Level-0 Data

   (Page 7-23, 3PGS-00440: The PGS shall accept from the DADS L0-L4 Data Sets.)

2. Ancillary Data

   (Page 7-23, 3PGS-00450: The PGS shall accept from the DADS Ancillary Data Sets.)

   (a) Instrument Status Information required for data quality information
   (b) Spacecraft Ancillary Data required for navigation and data quality information

3. Quick-Look Data

   (Page 7-24, 3PGS-00530: The PGS shall generate quick-look products in support of field experiments, event monitoring, and instrument monitoring using algorithms and calibration coefficients provided by the scientists.)

B. CONTROL

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL RESPOND TO CONTROL:

(Page 7-21, 3PGS-00270: The PGS shall provide a scheduler with the capacity to perform the following functions, at a minimum: (a) Add tasks to the job queue, (b) Allocate tasks among processors, (c) Initiate execution of tasks in the job queue, (d) Suspend execution of tasks, (e) Resume execution of a suspended task, (f) Cancel execution of tasks, and (g) Request and verify the staging and/or destaging of data stored in the DADS.)

C. PROCESSING STATUS INFORMATION

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL GENERATE FAULT INDICATIONS:

(Page 7-22, 3PGS-00320: The PGS shall display detected faults to the system operators.)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL PROVIDE STATUS INFORMATION

(Page 7-22, 3PGS-00380: The PGS shall monitor its internal operations and generate a status report periodically.)

D. OUTPUT

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL PRODUCE:

1. Level-1A Data Products

   (Page 7-13, 3DAAC00070: The DAAC shall generate Levels 1, 2, 3, and 4 data products, archive, manage, quality check and account for archived data products.)

2. Processing Log

   (Page 7-22, 3PGS-00360: The PGS shall generate a PGS Processing Log periodically that accounts for all data processing activities.)

3. Metadata

   (Page 7-24, 3PGS00510: The PGS shall have the capability to generate metadata according to the algorithms provided by the scientists and associate this metadata with each standard data product generated.)

   (Page 7-14, 3DAAC00220: The DAAC shall generate browse data and metadata for routing to the requested users, through the coordination of IMS.)

4. Quick-Look Product (Level-1A)

   (Page 7-13, 3DAAC00050: The DAAC shall provide the ICC with quick-look products for further evaluation of instrument operations and data quality.)

   (Page 7-14, 3DAAC00260: The DAAC shall produce quick-look products for priority transfer to the ICCs.)

   Do these requirements infer that Level-1A Quick-Look Products be sent to the ICC?

E. OTHER

MODIS LEVEL-1A PROCESSING SHALL BE ACCOMPLISHED USING TWO DISTINCT SETS OF STAND-ALONE SOFTWARE: ONE SET TO SUPPORT MODIS-N PROCESSING AND ONE SET TO SUPPORT MODIS-T PROCESSING.

(Unreferenced)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL BE CAPABLE OF REPROCESSING

(Page 7-24, 3PGS-00540: The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists.)

(Page 7-24, 3PGS-00550: The PGS shall reprocess science data using the original or updated (provided by the scientists) calibration coefficients.)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL BE CAPABLE OF PRODUCING LEVEL-0 DATA FROM LEVEL-1A DATA

(Requirement inferred from definition of Level-1A data)

MODIS LEVEL-1A PROCESSING SYSTEM FUNCTIONAL REQUIREMENTS OVERVIEW: DATA DICTIONARY

In the following, statements enclosed in quotations are quoted verbatim from the ECS Requirements Specifications document (reference may be found at the end of the data dictionary). Statements not enclosed in quotations are attributed to the MODIS Data Study Team.

Ancillary Data: "Any data, other than standard products, that are required as input in the generation of a standard product. This may include ancillary data from the EOS platforms and the attached payloads, as well as non-EOS ancillary data. All ancillary data are received by the PGS from the DADS." (Page 7-17). For Level-1A, ancillary data includes (a) Instrument Status Information and (b) Spacecraft Ancillary Data. For Level-1A, Ancillary data does not include Locally Maintained Databases.

Anomaly Reports: A report identifying a discrepancy between two or more sources of information. (Unreferenced).

Audit Trail: A record that describes the processing history of data and its identification. Contained within the metadata. (Unreferenced).

Completeness: A data quality indicator determining whether a particular data increment is present in finished form or whether there are missing items. (Unreferenced).

Control: "The PGS shall provide a scheduler with the capacity to perform the following functions, at a minimum: (a) Add tasks to the job queue, (b) Allocate tasks among processors, (c) Initiate execution of tasks in the job queue, (d) Suspend execution of tasks, (e) Resume execution of a suspended task, (f) Cancel execution of tasks, and (g) Request and verify the staging and/or destaging of data stored in the DADS.)" (Page 7-21). In addition are (h) Select processing mode and (i) Request processing status information. Two types of cancel operations are provided: (1) non-graceful (no output generated) and (2) graceful (output up to the cancellation point generated).

Data Quality Check: The process by which data quality information is generated. (Unreferenced).

Data Quality Information: Information on data quality, including existence, completeness, and the presence of anomaly reports, at a minimum. (Unreferenced).

Existence: A data quality indicator determining whether a particular increment of data is present or absent. (Unreferenced).

Fault Indication: An unsolicited flag denoting that a hardware or software error has occurred (e.g., a disk drive failed during data transfer or data header identifiers are not correct), or an "alarm event." (Unreferenced).

Instrument Data: "Data specifically associated with the instrument, either because it was generated by the instrument or included in data packets identified with that instrument. These data consist of instrument science and engineering data, and possibly ancillary data. These data may be assembled for transmission by the instrument, or by an on-board processor of the instrument data." (Page A-9). "Data created by an instrument including scientific measurements and any engineering or ancillary data which may be included in the instrument data packets." (Page A-9).

Instrument Status Information: "High level information about the status of an instrument stored in a designated DADS. These are redundant backup copies only. Primary backup copies are maintained at the ICC." (Page 7-34).

Level-0 Data: "Raw instrument data at original resolution, time ordered, with duplicities [sic] removed." (Page A-4) .

Level-1A Data Product: "Level-0 data, which may have been reformatted or transformed reversibly, located to a coordinate system, and packaged with needed ancillary, engineering, and auxiliary data." (Page A-4). Includes instrument data, a header, and data quality information.

Metadata: "Information which is obtained from data sets, and which provides an understanding of the content or utility of the data set. Metadata may be used to select data for a particular scientific investigation." (Page A-11) Metadata will include an audit trail. (Page 7-18). A more detailed description of the Level-1A metadata product is contained in the Appendix.

Processing Log: "Periodically accounts for all data processing activities." (Page 7-22, 3PGS-00360). A record of the time-ordered processing events. An event may be the completion of the processing activity or the generation of an anomaly report.

Processing Mode: There are three types:

a. Standard Product Processing: "The PGS shall have the capability to produce each standard product as specified in that product's Standard Product Specification." (Page 7-23, 3PGS-00470).

b. Reprocessing: "The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists." (Page 7-24, 3PGS-00540).

c. Quick-Look Data Processing: "The PGS shall send the DADS quick-look data for routing to the appropriate destination (e.g., ICC, SCF). Quick-look data shall contain the following information at a minimum: (a) Product identication, (b) quick-look data, (c) associated metadata, (d) process facility identification, and (e) current date and time." (Page 7-30, 3PGS-01260).

Processing Performance: A statement of the amount of data processed; will include a record during processing (dynamic status) and a post-event record (static status). (Unreferenced).

Processing Status Information: "Information regarding schedules, hardware and software configuration, exception conditions, or processing performance." (Page 7-18). The Level-1A Processing System is concerned only with fault (exception) conditions and processing performance.

Quick-Look Data (Level-0): "Real-time or priority playback data which receive minimal processing and are forwarded to the user for his review/use. The user may provide additional processing to suit his requirements." (Page A-14). "Data Received during one TDRSS contact period which have been processed to Level-0 (to the extent possible for data from a single contact). This is data that have been identified as requiring priority processing on the order of a few hours. It is routed to the PGS from the DADS." (Page 7-18). At Level-0, these data are not necessarily time-ordered, complete, nor have duplicates removed, but are at original resolution.

Quick-Look Product (Level-1A): "Quick-look data that has been processed by a PGS prior to being sent to an ICC." (Page 7-35). At Level-1A, Quick-Look Products are not necessarily time-ordered, with duplicates removed, but are at original resolution, and are packaged with necessary ancillary and engineering data. The product is reversible to Level-0 Quick-Look Data. It includes instrument data, a header, but may not have data quality information.

Spacecraft Ancillary Data: "Data available on board a spacecraft, derived from spacecraft parameters, or resulting from the on-board substitution of backup spacecraft parameters, but not produced by an instrument, which are needed for the processing or interpretation of instrument data. Spacecraft ancillary data comprises data referred to as "engineering", "core housekeeping" or "subsystem" data and includes parameters such as orbit position and velocity, attitude and its rate of change, time, temperatures, pressures, jet firings, water dumps, internally produced magnetic fields, and other environmental measurements." (Page A-15).

REFERENCE

Functional and Performance Requirements Specification for ECS, Fourth Preliminary, September 14, 1990.

ACTION ITEM 10/5/90-2. "Review the interface between MODIS Level-1 processing and the MCST and identify unresolved issues or points of clarification. Prepare a list of needed information items and relate each item to a corresponding Level-1 required activity or design requirement."

Issue #1: Geo-location of Level-1A data.

The next two paragraphs represent how the MCST views the geo-location problem and the structure of the Level-1 processing, which may differ from the MSDST viewpoint and therefore is an issue that requires clarification.

The definition of a Level-1A data product is: "Level-0 data, which may have been reformatted or transformed reversibly, located to a coordinate system, and packaged with needed ancillary, engineering, and auxiliary data". According to the MSDST, it will include instrument data, a header, and data quality information. Also according to MSDST, metadata will be associated with the Level-1A data and "Metadata may be used to select data for a particular scientific investigation". Among the ECS baseline data set specific metadata attributes, the minimum and maximum geo-corrected latitude and longitudes are included. These requirements imply that the MODIS Level-1A data can be geo-referenced to an Earth coordinate system. A capability to geo-locate the Level-1A data is required and may be accomplished 1) by embedding the geo-location data in the Level-1A data, 2) by the generation of separate data products which provide the geo-location information, or 3) by providing the user with the geo-location software. The MCST prefers that separate geo-location information be maintained for ease of updating.

From the point of view of MCST, the Level-1A data, archived in DADS, will be reformatted Level-0 count data, which is packaged with needed platform and other data required for Level-1B processing. The level-1B processing will consist of converting the count values to radiance values and generating MCST support products. In this view of the processing, the Level-1A and Level-1B processing activities will be independent activities in the sense that the Level-1A reformatting processing and the Level-1B radiometric processing will be stand-alone software packages. MCST's role will be to supply the MSDST the calibration and characterization algorithms used in the Level-1B processing. At some point, MCST may need to know the format and content of the Level-1A data products stored in the DADS, if the MCST is involved in the coding of the algorithms.

Issue #2: MCST Support Product definition.

A previously unresolved issue concerned the definition of the MCST Support Products, which are defined here. According to present thinking, for each MCST instrument related and MCST discipline related data product, the MCST Support Products, generated using MCST supplied code, will consist of the following items:

1) Browse Products.
2) Metadata Products.
3) Quality Assessment Products.

These data products will be archived in the DADS and available to MSDST from the DADS.

Issue #3: Answers to action item questions previously presented.

1) An "Interface Control Document" will be written by MCST and contain a section on the MSDST/MCST interactions. This document will address the interface between the MSDST and MCST and provide answers in large part to the action item. It will contain sections on requirements, algorithms, data, and management. A first draft by April 1991 is planned.

2) The MODIS Calibration Plan, written by MCST, will be made available to MSDST.

3) The other questions previously presented were designed to aid MSDST in its estimates of data system sizing. The re-wording of the action item no longer makes their answers pertinent.

Issue #4: Specifications for ancillary, engineering, and auxiliary data.

In issue #1, the information content of the ancillary, engineering, and auxiliary data associated with the Level-1A data product needs discussion. Presumably this data includes platform data, sensor engineering data, and other sensor engineering data on the same platform. At issue is more precisely what the data is and how it is appended (i.e., in the header, trailer, or separate files).

Issue #5: Location of derived calibration parameters.

MCST feels that derived calibration parameters should be part of the Level-1A data product. MSDST feels this same data should be part of the Level-1B data product. This issue requires discussion and a decision.

MODIS ANCHOR POINT ACCURACIES

Definition: Anchor points are subsets of the total pixels in a given observation increment (granule) where navigation parameters are directly computed. The parameters determined at these anchor points may be interpolated to provide parameters for the entire observation increment.

Purpose: To reduce the size of archived data and the number of computations required for data processing. The anchor point method was used for CZCS and AVHRR processing.

Method: The observation increment used in the analysis of anchor point accuracies is the "scan plane", consisting of the across-track by along-track dimensions of a single scan. These are 1354 by 8 for MODIS-N and 1007 by 30 for MODIS-T.

First, each pixel in the scan plane was explicitly georeferenced. Georeferencing included latitude, longitude, solar zenith and azimuth angles, and spacecraft zenith and azimuth angles. The method used here was a short-cut to the method likely to be used for actual geolocation. The method here used the following input parameters, and the values shown.

Input Parameter	MODIS-N	MODIS-T
Altitude	705 km	705 km
Inclination	98.25°	98.25°
Period	98.9 min.	98.9 min.
Julian day	80	80
equator crossing time	1:30PM	1:30PM
equator crossing longitude	0°	0°
time traveled since most recent equator crossing	0 min.	0 min.
pitch	0°	0°
roll	0°	0°
yaw	0°	0°
tilt	0°	0-50°
IFOV scan width	55°	45°

Three anchor point scenarios -- where the number of anchor points = 2%, 1%, and 0.5% of the total pixels in a scan -- were examined. These test scenarios were applied for both MODIS-N and MODIS-T. The analyses shown here involved a uniform anchor point distribution strategy only. The across-track, along-track pixel increments for each sensor for each scenario are shown below.

Percent		MODIS-N	MODIS-T
2	across	13	7
	along	2	4
1	across	25	10
	along	2	3
0.5	across	50	20
	along	2	3

For each scenario we examined errors, computations, and storage under a linear interpolation method and a cubic spline interpolation method. The cubic spline interpolation became a linear interpolation along-track for MODIS-N because there were only two anchor points along-track for MODIS-N.

We assumed that the number of computations to explicitly locate a pixel was 450, based on the estimates by the MODIS Data Study Team (January 26, 1990 Report). This estimate is assumed to include all 6 variables computed here. For the storage requirements, we assumed each variable was a 16-bit length word.

All analyses will be performed for a single scan at the equator.

<u>Results</u>: Results are depicted in the following tables. Included are analyses for MODIS-N and MODIS-T under two tilts, 0° and 50°. Calculations for explicit location are included in the tables for comparison. Also, we included the computer run-time for these calculations. All simulations were performed on a 386-25 MHz computer containing a math coprocessor.

SENSOR	MODIS-N	TILT	0

	LINEAR MAXIMUM ERROR									CUBIC MAXIMUM ERROR								
	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp
UNIFORM 2%	104	737	0.007	0.02	0.3	326	0.18	2.5	100	9	30	0.0003	0.0006	0.3	335	0.19	2.5	18
UNIFORM 1%	348	2468	0.02	0.06	0.4	313	0.14	1.3	110	15	105	0.0009	0.005	0.3	321	0.14	1.3	18
UNIFORM 0.5%	1190	8392	0.08	0.2	2.3	-181	0.11	0.7	100	105	753	0.007	0.03	1.5	182	0.12	0.7	18
NON-UNIFORM 2%																		
NON-UNIFORM 1%																		
NON-UNIFORM 0.5%																		
EXPLICIT							4.9	130	82							4.9	130	82

Ψ = latitude (m)
Φ = longitude (m)
θ_o = solar zenith angle (°)
ϕ_o = solar azimuth angle (°)
θ = spacecraft zenith angle (°)
ϕ = spacecraft azimuth angle (°)
N = number of computations (mega floating point operations/scan)
S = storage (kbytes)
Sp = speed (sec) on 386-25 computer to compute all pixels

SENSOR	MODIS-T	TILT	0

	LINEAR MAXIMUM ERROR									CUBIC MAXIMUM ERROR								
	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp
UNIFORM 2%	15	97	0.0009	0.001	0.5	300	0.50	6.9	231	0.6	0.6	0	0	0.3	344	0.58	6.9	75
UNIFORM 1%	31	204	0.002	0.002	0.5	-304	0.38	3.6	212	2.2	1.1	0	0	0.3	-320	0.45	3.6	70
UNIFORM 0.5%	89	601	0.006	0.008	0.5	285	0.31	1.8	214	2.9	6.2	0	0.002	-0.3	302	0.34	1.8	70
NON-UNIFORM 2%																		
NON-UNIFORM 1%																		
NON-UNIFORM 0.5%																		
EXPLICIT							13.5	362	236							13.5	362	236

Ψ = latitude (m)
Φ = longitude (m)
θ_o = solar zenith angle (°)
ϕ_o = solar azimuth angle (°)
θ = spacecraft zenith angle (°)
ϕ = spacecraft azimuth angle (°)
N = number of computations (mega floating point operations/scan)
S = storage (kbytes)
Sp = speed (sec) on 386-25 computer to compute all pixels

SENSOR	MODIS-T	TILT	50

	LINEAR MAXIMUM ERROR									CUBIC MAXIMUM ERROR								
	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp	Ψ	Φ	θ_o	ϕ_o	θ	ϕ	N	S	Sp
UNIFORM 2%	8657	11827	0.1	-0.6	0.1	0.03	0.50	6.9	239	1413	2024	0.02	-0.08	0.02	0.004	0.58	6.9	75
UNIFORM 1%	14097	19076	0.2	-1.0	0.2	0.04	0.38	3.6	215	5436	7479	0.06	-0.3	0.08	0.02	0.45	3.6	64
UNIFORM 0.5%	19166	27422	0.2	-1.5	0.3	0.06	0.31	1.8	208	5906	8332	0.07	-0.4	0.08	0.02	0.34	1.8	64
NON-UNIFORM 2%																		
NON-UNIFORM 1%																		
NON-UNIFORM 0.5%																		
EXPLICIT							13.5	362	236							13.5	362	236

Ψ = latitude (m)
Φ = longitude (m)
θ_o = solar zenith angle (°)
ϕ_o = solar azimuth angle (°)
θ = spacecraft zenith angle (°)
ϕ = spacecraft azimuth angle (°)
N = number of computations (mega floating point operations/scan)
S = storage (kbytes)
Sp = speed (sec) on 386-25 computer to compute all pixels