MODIS DATA STUDY

TEAM PRESENTATION

June 23, 1989

AGENDA

1. Notes on the UARS Presentation by Skip Reber
2. CDOS Support for MODIS Operations: Comments of Gene Smith
3. MODIS Data Requirements Studies Report Agenda
4. MODIS Level-1 Processing
   - Relationship to the Outside World
   - Requirements Flow
   - Specifications Flow
   - Earth Location
   - Calibration
   - Instrument Data
   - Standards
   - Platform Ancillary Data
   - Timeliness
   - Processing Capabilities

NOTES ON THE UARS PRESENTATION BY SKIP REBER

On Wednesday, June 21, Dr. Skip Reber/Code 610, the Upper Atmosphere Research Satellite (UARS) Project Scientist gave a presentation to members of the MODIS Data Study Team and others. Attending were Vince Salomonson (286-8601), Philip Ardanuy (982-3714), Lee Kyle (286-9415), Tom Dopplick (805-0333), Marilyn Kaminski (805-0317), Judy Feldman (805-0322), Tom Wolford (953-2700), Mike Andrews (953-2700), Doug Hoyt (982-3700), Al McKay (982-3720), Jim Czechanski (790-8500), and Skip Reber (286-6534). A UARS Program Goals and Objectives brochure was distributed, as was a set of transparency hard copies. In addition, a 1.5 hour presentation and question and answer session was held. The following notes describe some of the topics covered in this session:

1. Telemetry and Level-0 Data

The UARS instrument complement and satellite ancillary data will yield a joint data rate of about 32 kilobits per second (kbps). The data will be stored on two tape recorders and dumped to the TDRSS once per orbit. The GSFC Data Capture Facility (Code 500) will perform the Level-0 processing. A separate Level-0 product will be issued for each of the ten instruments on the UARS.

2. Processing Priorities

Three different processing priorities will be available. In routine processing, 24-hour chunks of data will be made available for Level-0 processing within 12 hours of the last data. In the near-real-time processing, one orbit of data (a single tape recorder dump) will be made available for Level-0 processing immediately for every eight hours (12% of the data). In the real-time processing, 15 minutes of the UARS data stream will be made available once per orbit for every TDRSS contact (17% of the data). Experimenter-driven scheduling of the TDRSS contacts is not anticipated, except during the activation period immediately after launch.

3. UARS vs. Eos

We can compare UARS to Eos/NPOP-1, as in each case the platform will carry a wide variety of instruments, each with its own PI and instrument team. Each instrument will have its own separate Level-0/1/2/3 processing The format of the Level-1 and Level-2 products will be defined individually for each instrument/investigator. The format of the Level-3 products will be common for all the instruments. The ultimate Level-3 product (3B) will be at a relatively low spatial resolution (every four degrees of latitude), in the form of Fourier coefficients, defined at 40 pressure levels, and will be daily data. An further time averaging (diurnal/monthly, etc.) will be non-standard and defined by the individual user. Standard formatted data units are being used for Level-2 and Level-3 products, and are being developed with the assistance of Don Sawyer of NSSDC.

4. UARS vs. MODIS

We can also compare UARS to MODIS, for a number of reasons. The MODIS science team (24 persons) is larger than that of UARS (19 to 20); however, UARS will have on the order of 120 PI's and co-I's. The MODIS data rate will be about 300 times higher than that of UARS. The MODIS data, coming from the two instruments, will serve the atmospheric, oceanic, and terrestrial science communities. Many MODIS data products have been identified for generation and distribution.

5. Data Processing and Distribution Strategies

Unlike MODIS and Eos, UARS will have a two to three year exclusive-use period for the science team to examine the data before distribution. The UARS goal is to validate the instruments and algorithms within six months after launch. After validation, a steady-state processing lag through all levels of one to two weeks is anticipated. The delay is caused by a combination of Level-0 processing delays, generation of the definitive ephemeris (non-GPS), and the need of some instruments to process large blocks (e.g., one week) of data at a time.

6. Standards, Commonality, and Data Distribution

UARS requires coding in FORTRAN 77. Each investigator has been provided with a Remote Analysis Computer (RAC). The common architecture is VAX/MicroVAX. The CDHF has a VAX 8800 and 6310, and is partitioned into user space and processing space. This distinction is made so that data processing will not be slowed even during periods of peak user demand. All PI's are connected to the CDHF through dedicated 9.6 kbps lines; an upgrade to 56 kbps lines will be complete by the end of the year.

7. Simulated Data and Algorithm Development

Simulated data has been used to develop algorithms. An initial distribution of one day of simulated data was made. A new simulated data set incorporates three days of measurements. Version 1 of the data processing software has already been developed and delivered to the CDHF, where it is presently running on the simulated data. Flight ready software delivery is anticipated by January 1990. It is anticipated that the code will be in place and operating nine months before launch.

8. Estimating Processing Requirements

Users have been continually asked to estimate their data processing requirements. It has been estimated that the algorithms for all the instruments will require 700 to 800 MIP-hours to process one day's data. A factor of three (2 * 1.5) is used to account for processing (100%), reprocessing (100%), and contingencies (50%). (On the order of a 100 MIP processing capacity is re-

quired.) Individual PI processing estimates have gone up by a factor of four (in six months) to 30 (in a few years).

9. Peer Reviews and Configuration Control

Constructive peer reviews of algorithm processing activities are held to review the original algorithms and after every change in processing requirements. The project scientist chairs a configuration review board to review proposed algorithm changes.

10. Reprocessing

All data that is reprocessed will also be retained in its original form.

CDOS SUPPORT FOR MODIS OPERATIONS

Background. The following information relating to CDOS operation and services was obtained during a MODIS Data Team interview with Gene Smith on June 19, 1989. Since CDOS planning is in a state of rapid flux, the information provided here is tentative and not necessarily representative of the actual system that will be implemented, although the information provided is the best available at this time.

Seen from the perspective of the MODIS Data Team, this state of flux may be viewed as an opportunity to influence the CDOS design to assure that MODIS requirements are met. To this end, it will be necessary for the MODIS Data Team to deliberately and self-consciously seek out and define requirements that affect CDOS design and functionality. To a certain extent, this is already happening in the generation of Interface Control Documents (ICDs) and other MODIS documents that impact the CDOS design.

Since the Customer Data and Operations System (CDOS) is just entering Phase B development (June 1, 1989), many of the operational details for the system are presently undefined or undergoing evolution. The Phase B CDOS contract includes a runoff between competing contractors for follow-on work in Phases C and D, and since such competition necessarily involves the creation of company proprietary information during the competitive phase, it is not to be expected that firm CDOS design information will be available before the end of the CDOS Phase B effort (end of May 1990). Since the CDOS schedule envisions a year or year-and-a-half interim between the completion of Phase B activities and the start of actual system implementation in Phase C/D, definitive CDOS information may not be available even in that time frame.

The information presented here is based on preliminary CDOS design alternatives that were developed in response to early requirements statements. One approach assumes that MODIS will be classified as high data rate instrument with dedicated Virtual Data Channels and on-board cableway access. The other approach assumes that MODIS will remain with the low data rate Eos instruments and will share the data facilities provided for these instruments.

High-Data-Rate MODIS Support. Although the details are still being discussed, CDOS handling of MODIS science data may occur roughly as shown in Figure 1. As a high-data-rate instrument, MODIS will be assigned virtual data channels dedicated exclusively to MODIS use. The Data Interface Facility (DIF) will receive MODIS Virtual Channel Data Units (VCDUs) as they are relayed from the platform by the Tracking and Data Relay Satellite System (TDRSS). Data is recorded as it is received at the DIF, and a temporary record of the received data is retained

for 24 hours, should data retransmission from the DIF be required within that time period.

Preliminary processing done at the DIF includes the application of Error Detection and Correction (EDAC) codes to detect errors introduced during data transmission from the platform to the ground and the correction of those errors, when possible. Preliminary processing also restores original bit order if the data was retrieved from the on-board tape recorder using reverse playback. Data reordering would include both the reversal of bit order within a data packet to achieve increasing time order of bits within a packet and the resequencing of serially transmitted packets to achieve increasing time order among consecutive packets.

Buffering serves to reduce the data transmission rate required on the DIF output links below the peak input data rate (with sufficient buffering, data output could occur at the average data throughput rate). Since buffering introduces a delay in the output of information, real time data may need to be processed with no buffering or with reduced buffering that does not introduce unacceptable delays. A separate virtual channel dedicated to real time MODIS use would be required to identify MODIS real time data at the DIF.

MODIS data would be transmitted from the DIF (located at White Sands, NM) to a data gateway located (probably) at Goddard Space Flight Center (GSFC) using data transmission facilities provided by NASCOM. From the data gateway, MODIS science data would be routed to a separate Level-0 processing facility dedicated to processing Eos high rate data. Since data order reversal was done at the DIF, Level-0 processing at this stage requires the elimination of duplicate information and the execution of data quality checks to assure that the received data stream is complete. Data retransmission from the DIF may be requested.

Low-Data-Rate MODIS Support. If MODIS is supported as a low-data-rate instrument, present projections call for no data processing to occur at the DIF (see Figure 2). All MODIS transmission error correction, bit order reversal, duplicate data elimination, and data completeness checking would be done at the DHC using common software that provides these functions for all low-data-rate Eos instruments. Dedicated Virtual Channels are not required for exclusive MODIS use, and a separate Level-0 processing facility for MODIS data is not required.

Possible Hybrid Support. If desired, MODIS-Science-Data could be transmitted as high-rate data while MODIS-Engineering-Data could be handled as low-rate data. MODIS data needed in real time to support instrument monitoring functions could be provided by either system. The limit on the percentage of the total data stream that can be delivered in the real time mode is the same by either method. To facilitate prompt data delivery, real-time data provided by a dedicated Eos Level-0 Processing Facility or

the DHC may be subjected to less stringent data quality control checks.

DHC services may include an interactive database containing platform ancillary data. This DHC service would likely be available independently of whether MODIS science data is treated as low or high rate data. Information in this database will be retained for two years after generation (MODIS instrument data that passes through the DHC will be retained for seven days to allow for retransmission requests and to provide some system redundancy). Alternatively, it is envisioned that all platform ancillary data required to do MODIS processing will be available on-board from the platform data system, so that platform ancillary data could be inserted into MODIS data packets during on-board processing for transmission with other MODIS data from the platform. The services of a DHC database may not be needed by MODIS if this approach is taken.

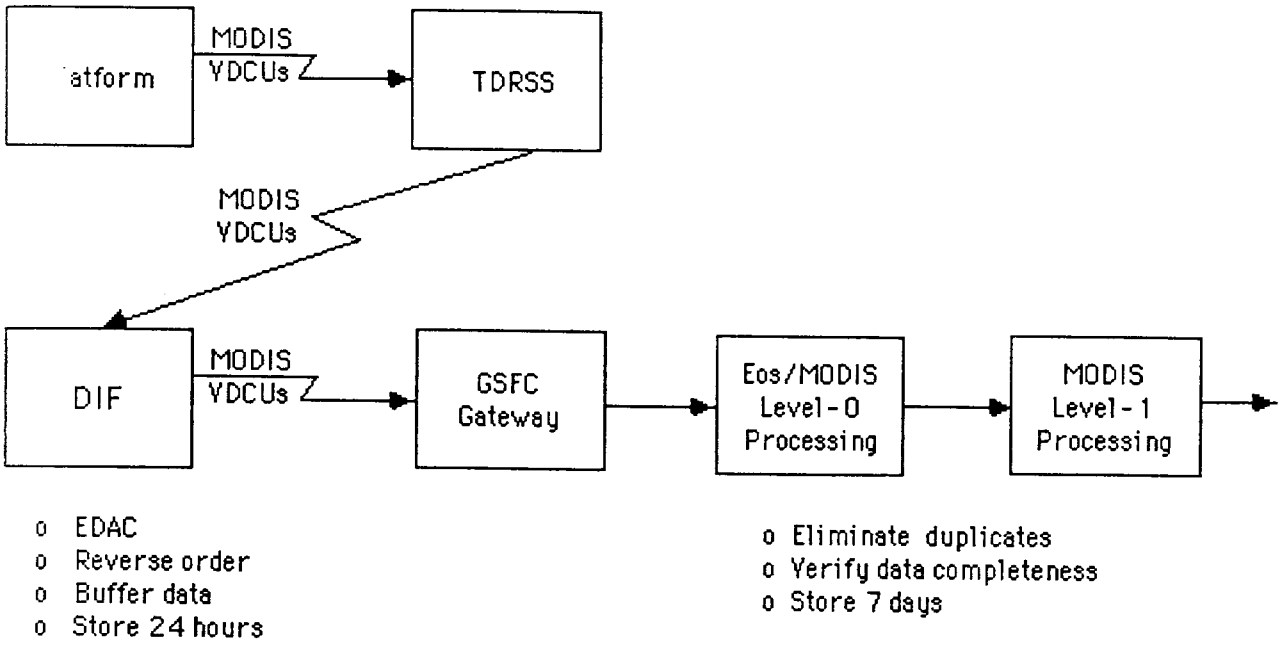
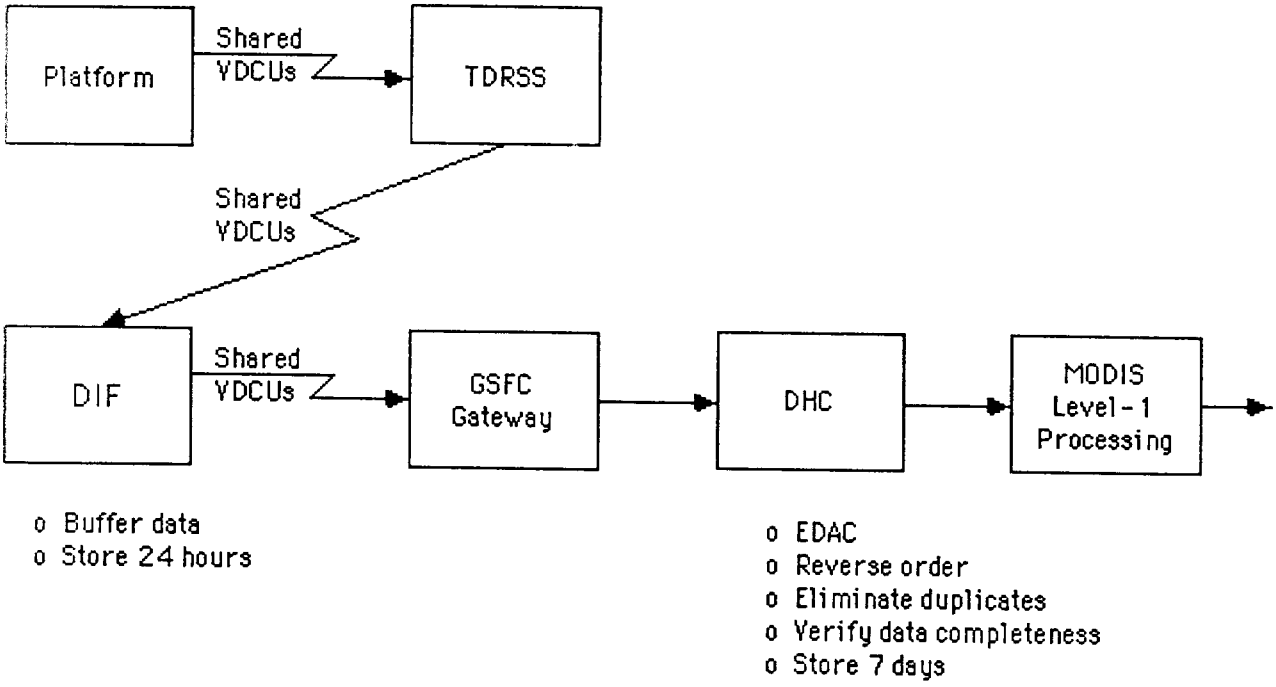


Figure 1. Possible MODIS High Rate Data Flows.



ure 2. Alternate MODIS Low Rate Data Flows.

MODIS DATA REQUIREMENTS STUDIES REPORT (Two Hours)

To be presented at the 2nd MODIS Science Team Meeting
July 5-7, 1989

2 N D D R A F T A G E N D A

1. MODIS DATA ACQUISITION AND PROCESSING SCENARIOS (One Hour)

[Review our understanding of the science team's end-to-end requirements for data processing and field experiment support, including near-real-time and routine processing. Illustrate this with representative scenarios.]

1.1 Routine Interactions

a) Algorithm Development and Maintenance
b) Algorithm Implementation
c) Data Acquisition and Processing
d) Archival and Distribution of Data Products
e) Data Product Validation
f) Post-Launch Period Versus Steady-State Operations

1.2 Near-Real-Time Interactions

a) Scope of Science Team's Requirements
b) Planning, Scheduling, and Coordination
c) Data Acquisition and Processing

2. MODIS ALGORITHMS AND DATA PRODUCTS (One Hour)

[A review of our understanding of all the issues facing the Science Team in terms of core product and algorithm selection, Level-1 through Level-3 processing, CDHF and TMCF resource availability and commonality, and data product development.]

2.1 Fundamentals

a) Agreement on Core Products/Selection of Algorithms
b) Understanding of Support Required by Other Teams

2.2 Level-1 Processing

a) Accuracy Goals and Propagation of Requirements
b) Calibration Algorithms and Requirements
c) Data Navigation/Earth Location

2.3 Level-2 Processing

a) Role of Cloud Identification Algorithms
b) Role of Atmospheric Correction Algorithms

2.4 Level-3 Processing

a) Time and Space Averaging Algorithms
b) Display and Processing Algorithms
c) Agreement on Product Domains and Grid Resolutions

2.5 TMCF Resources

a) Experimenter's-Site/On-Site Computer Requirements
b) Common Experimenter Facilities for Receiving Data
c) Communications Requirements of Science Team
d) Languages and Operating Systems Commonality

2.6 MODIS Science Data Products

a) Proposed Standard Data Products and Domains
b) Proposed Specialized Data Products
c) Timeliness Requirements
d) Non-MODIS Data Requirements
e) Candidate Product Algorithms
f) Simulated Data Use for Algorithm Development

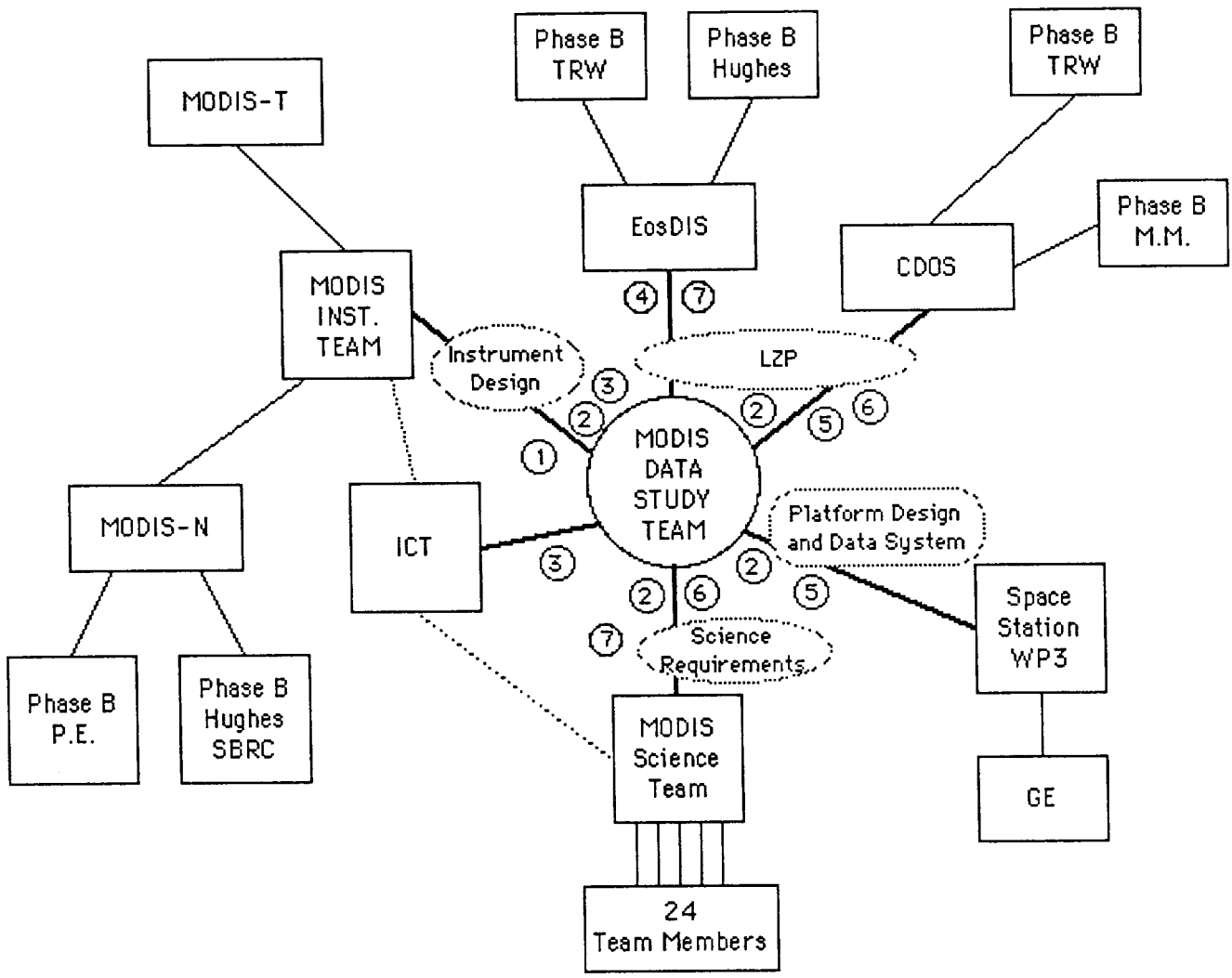


Figure 1. Relationship Between MODIS Data Study Team and Other Organizational Entities.

Key to Flows

(1) = Instrument data
(2) = Earth location
(3) = Calibration
(4) = Data standards
(5) = Platform ancillary data
(6) = Timeliness
(7) = Processing capability

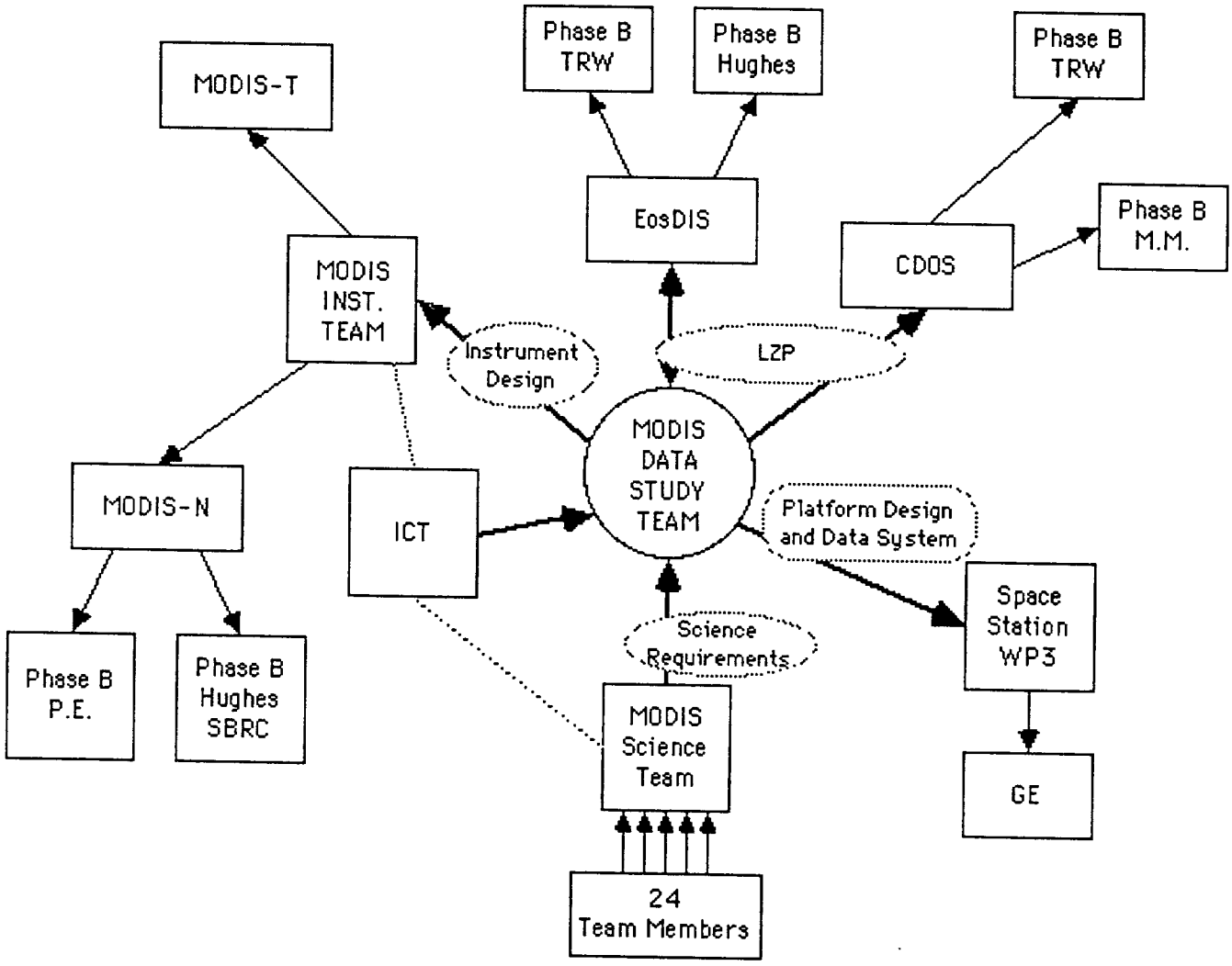


Figure 2. Requirements Flow Between MODIS Data Study Team and Other Organizational Entities.

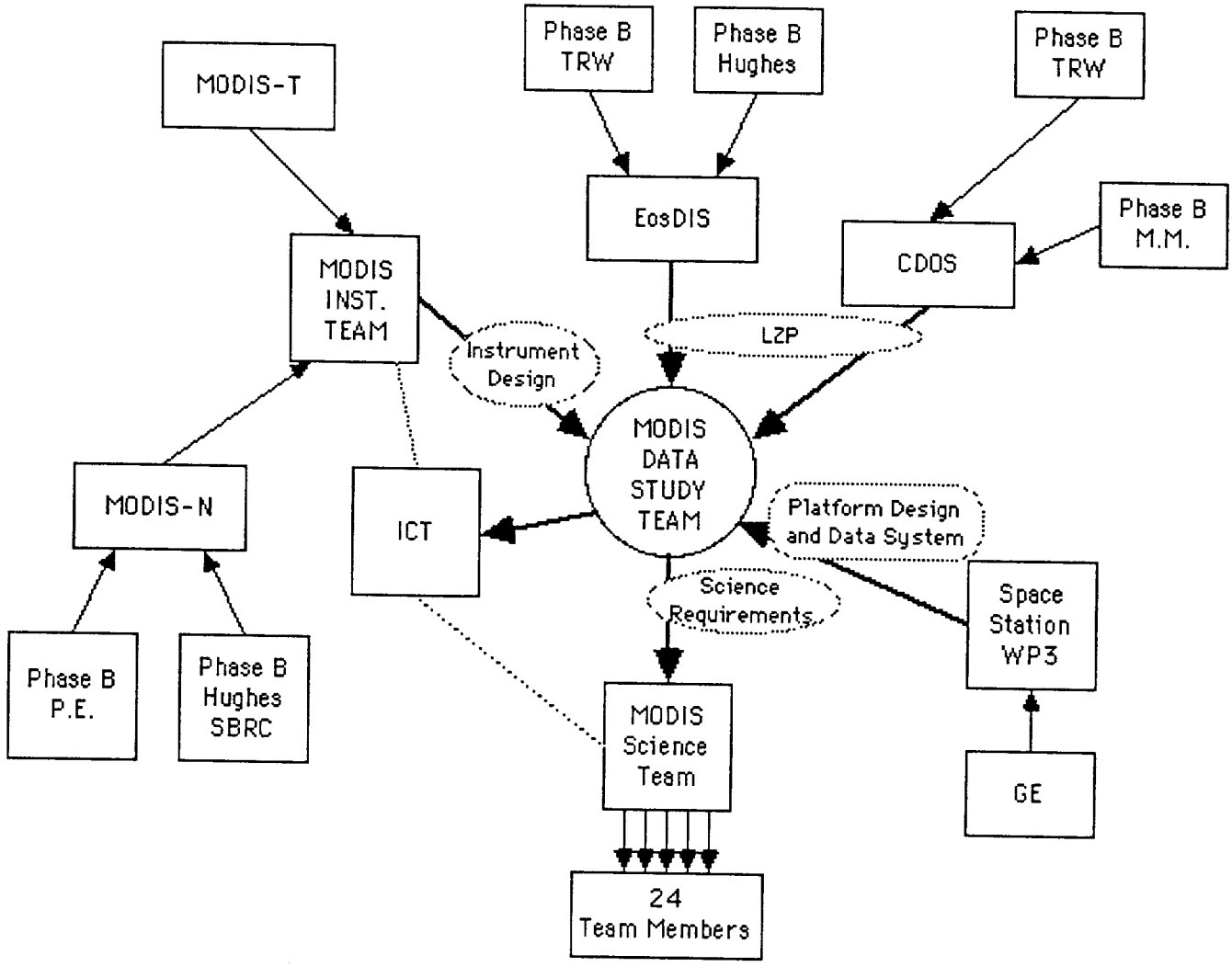
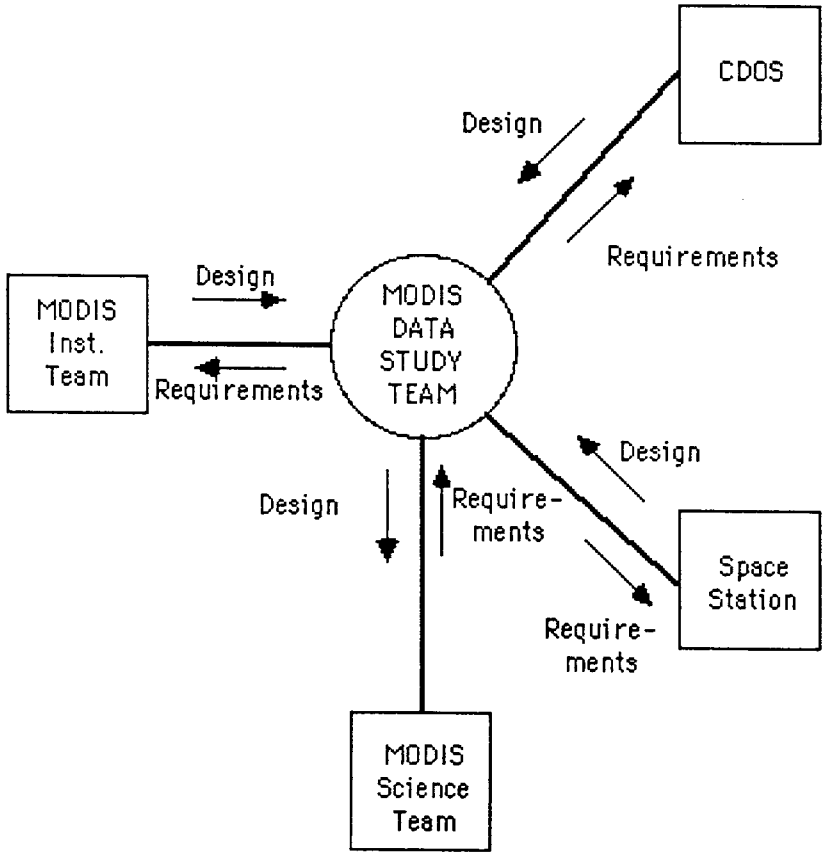


Figure 3. Design Information Flow Between MODIS Data Study Team and Other Organizational Entities.

EARTH LOCATION

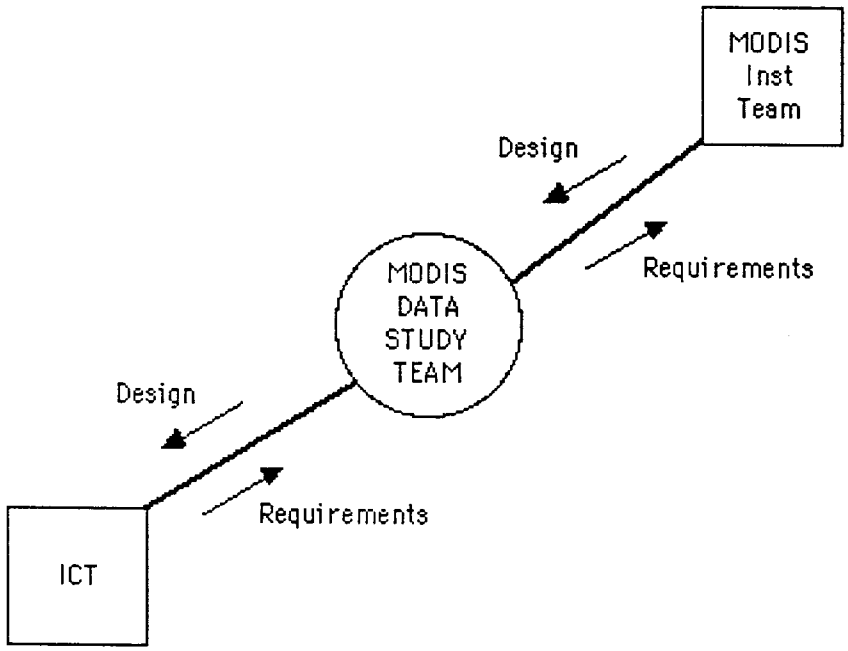
To completely specify earth location requirements for instrument-referenced pixels, the MODIS Data Study Team needs agreement from the MODIS Science Team on a realistically attainable location accuracy goal and a specification of basic instrument geometry and associated parameters from the MODIS Instrument Team. Since platform location and attitude parameters are also required to complete the computations, specifications relating to Platform-Ancillary-Data availability from the on-board data system and/or the CDOS interactive database will also be needed. Data availability from the CDOS is still in the very early stages of definition and at this stage it is not clear what platform data, if any, will be available from this source.



Earth Location Relationships

CALIBRATION

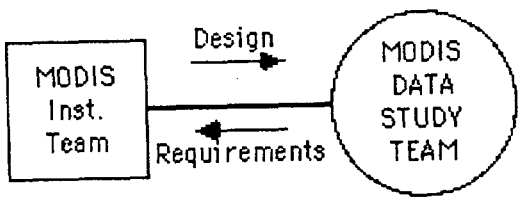
The specification of MODIS Data System support for instrument radiometric calibration activities will depend on the installation of an Instrument Characterization Team (ICT) to define requirements and the completion of instrument design activities relating to calibration by the MODIS Instrument Team. A charter and organizational definition for the ICT is not yet in place, and in fact the MODIS Data Team may be able to assist in defining the structure and function of this organization.



Calibration Relationships

INSTRUMENT DATA

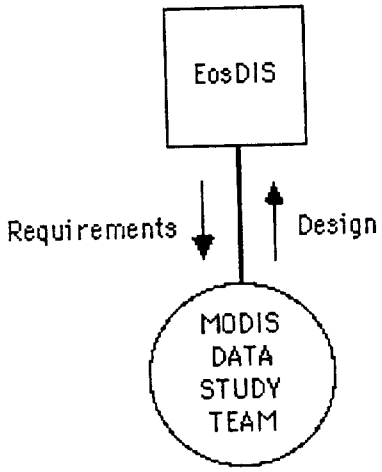
MODIS instrument design information is needed to completely specify MODIS data system requirements that relate to the instrument data and Level-1 processing. The needed information includes a list of all instrument data items that will be sensed on the platform and returned to the ground data system in the instrument data stream and the sample frequency, digital resolution, and numeric format that is associated with each item. Since the types and formats of instrument data packets are at least partially determined during instrument design activity, these items must also be discussed and ultimately decided with the concurrence of instrument design personnel. It appears that the MODIS Instrument Team is still dealing with the fundamentals of instrument design and that complete specifications of the required information will not be available for some time yet.



Instrument Data Relationships

STANDARDS

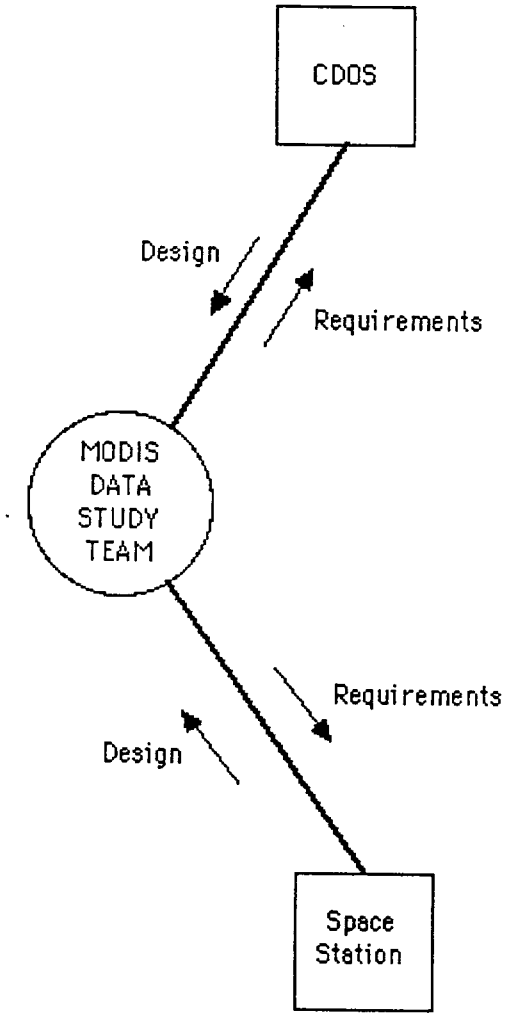
The MODIS Data Study Team needs to receive a comprehensive set of software implementation standards and a description and definition of acceptable metadata format and content from the EosDIS. These studies are underway and it is possible to foresee a time when these required inputs will be available.



Data Standards Relationships

PLATFORM ANCILLARY DATA

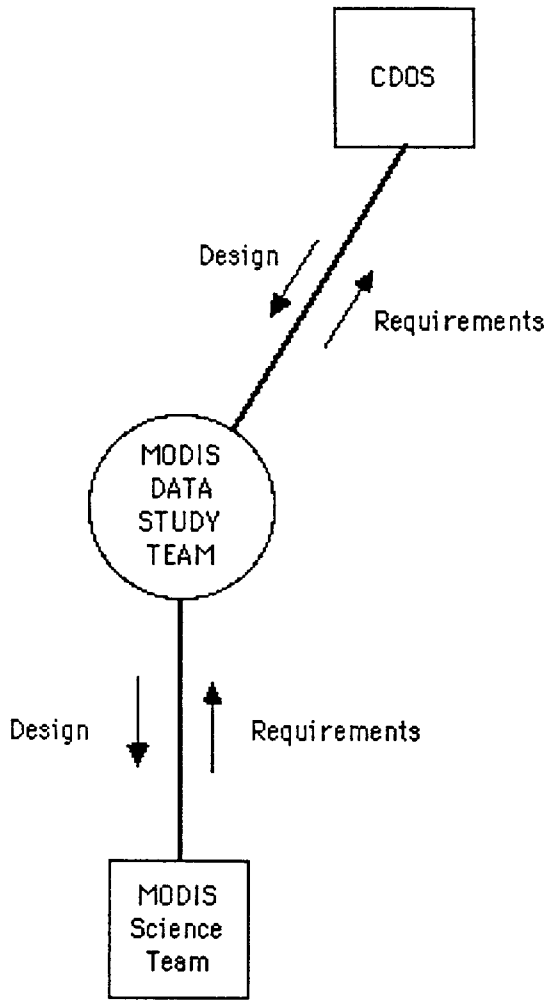
In addition to earth-location information obtained as Platform-Ancillary-Data, MODIS data products will probably need to include some general information relating to platform activities such as other instrument duty cycles and service interruptions for platform reorientations, momentum wheel desaturations, etc. Required Platform-Ancillary-Data will probably be available from both the on-board data system and the DHC interactive database. As noted in the discussion of earth location above, it appears that specific functional capabilities for either of these systems are not yet defined.



Platform Ancillary Data

TIMELINESS

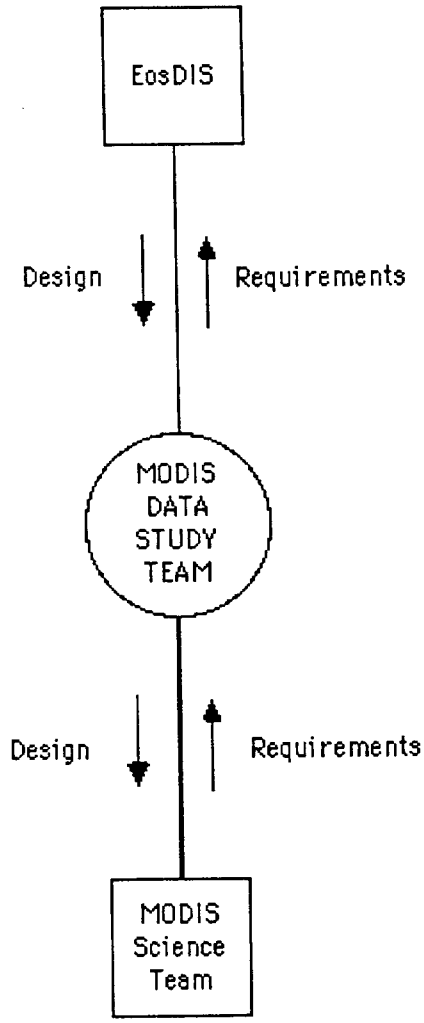
Timeliness requirements for MODIS data are determined by the MODIS Science Team working in cooperation with the larger Eos effort. It appears that a workable set of data timeliness requirements has been levied. For its part, the MODIS Data Study Team levies its requirements on other organizational players, particularly stressing data availability requirements (completely Level-0 processed, or otherwise) from CDOS facilities.



Timeliness Relationships

PROCESSING CAPABILITIES

One of the goals of MODIS Data Team efforts is to define MODIS hardware support requirements as part of the EosDIS effort. Information to be determined include required CPU capacity, data storage requirements, and required data transmission capabilities. The definition of these hardware requirements will be a continuing activity of the MODIS Data Team.



Processing Capability Relationships