MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

July 26, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator
3. MODIS - Scheduler Assumptions
4. EOS Platform Stability Requirements
5. HDF Status

ACTION ITEMS

05/03/91 [Lloyd Carpenter and Team]: Prepare a Level-1 processing assumptions, questions and issues list, to be distributed to the Science Team Members and the MCST for comment. (The list, the executive summary, information on the EOS Platform Ancillary Data, and a cover letter were delivered for signature and distribution.) STATUS: Open. Due date 06/07/91.

05/31/91 [Liam Gumley]: Establish a connection with the proper person at Ames Research Center for communication on MAS formats, an interface control document, agreements, etc. (Mr. Jeff Myers is the contact person. See the 7/19/91 presentation.) STATUS: Closed Due date 07/19/91

06/07/91 [Liam Gumley]: Speak to Alan Strahler, when he returns, regarding his MAS requirements. (Strahler will be contacted when he becomes available.) STATUS: Open. Due date 07/05/91

06/21/91 [Liam Gumley]: Obtain a copy of all available MAS Level-1B processing software and any existing documentation from the University of Wisconsin at Madison for porting to a system at GSFC. (This action was completed as reported on 7/19/91.) STATUS: Closed. Due date 07/19/91

06/21/91 [Liam Gumley]: Generate a complete milestone schedule for conversion, installation and testing of all modules of the MAS Level-1B processing software at GSFC. Draw up an agreement between the SDST and Mike King of what will be done. (These are included in the presentation.) STATUS: Closed. Due date 07/19/91

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. (A preliminary list is included in the presentation.) STATUS: Open. Due date 07/26/91.

ACTION ITEMS FROM SDST MEETING 19 July 1991 [Liam Gumley]

(1) Draft an agreement between the SDST and Mike King describing the work the SDST will perform in support of the MAS Level-1B data processing.

A draft is included.

(2) Draft a biweekly time schedule for the MAS Level-1B data processing development.

A draft is included.

(3) Report current progress on MAS Level-1B data processing development.

An update on progress is included.

DRAFT

MODIS Science Data Support Team

Development of a MODIS Airborne Simulator Level-1B Processing System

25 July 1991

Introduction

The MODIS Science Data Support Team (SDST) has been given the task of implementing a MODIS Airborne Simulator (MAS) Level-1B Processing System at Goddard Space Flight Center (GSFC). This document describes the components of the task and outlines the methodology that will be used in the completion of the task.

Summary

The task is to develop a system at GSFC which will ingest Level-1A MAS data, perform calibration and geolocation, and write the data in a common format. Existing imaging software will also be used to implement a MAS image viewing facility for users at GSFC.

History

The MAS will be developed from an existing aircraft scanner, the Daedalus Wildfire. This instrument shares a common heritage with the NASA Multispectral Atmospheric Mapping Sensor (MAMS). Both instruments fly on board the NASA ER-2. Methods to calibrate and geolocate MAMS data have been developed at the Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison. The methods developed at CIMSS for calibration and geolocation of MAMS data will be used for the processing of MAS data, which shares common characteristics with the MAMS.

Level-1A data ingest

The MAS Level-1A data will be obtained from Ames Research Center (ARC) in raw form (no calibration or earth location). MAS data will be obtained as soon as possible after flight missions to enable rapid processing and distribution. Processing of the MAS Level-1A data will take place at GSFC.

Calibration

The infrared bands of the MAS in a given scanline will be calibrated using the blackbody data from that scanline only - no averaging of blackbody data will be done. The visible and near-infrared bands of the MAS will be calibrated using pre and post launch calibration data provided by ARC. These methods are used operationally by CIMSS for calibrating MAMS data, and are described in NASA Technical Memorandum 100352 "Improved Capabilities of the Multispectral Atmospheric Mapping Sensor (MAMS)".

Geolocation

Geolocation of the MAS data requires the use of the ER-2 Inertial Navigation System (INS) data supplied by ARC. Since the INS data is recorded at a different rate than the MAS data it is not possible to use it directly to geolocate MAS pixels. Therefore geolocation will be done on a straight line flight track basis. Straight line flight tracks are determined by inspection of the change in aircraft heading with time. Linear

regression relationships are then developed for aircraft nadir latitude and longitude, heading, altitude etc. for each straight line flight track. Pixels in that flight track are then geolocated using aircraft positions derived from the regression relationship. This method is used operationally by CIMSS to geolocate MAMS data and is also described in NASA Technical Memorandum 100352.

In order to keep the geolocation data down to a manageable size, every tenth pixel on a scanline will be geolocated. Each of these pixels will have latitude, longitude, sensor zenith angle, sensor azimuth angle, solar zenith angle and solar azimuth angle computed. A simple cubic spline algorithm can then be used to interpolate the geolocation data across the scanline.

Level-1B output data

The Level-1B output data will contain calibrated MAS radiances and geolocation data for every tenth pixel on every scanline. It will also contain all the instrument data (except raw image data) that was included in the Level-1A data set, as well as the ER-2 INS data for that flight. Only straight line flight track portions of the flight will have valid geolocation data, however calibrated radiances will be included for all portions of the flight, including aircraft turns. Information detailing the start and end of the straight line flight track portions of the data will be supplied.

The MAS Level-1B data will be supplied to users in the Hierarchical Data Format (HDF) developed by the National Center for Supercomputing Applications (NCSA).

MAS image viewing facility

Existing imaging software will be used to implement an image viewing facility at GSFC. The target platform will be the Silicon Graphics IRIS workstation. The viewing facility will enable a user to view MAS image data in subsampled, uncalibrated form, with no geolocation information. The viewing facility is intended to allow users to identify areas of interest in a MAS flight mission such as land/ocean boundaries or clouds. It is not intended to serve as a source of MAS image data.

Schedule

Current planning is for the first MAS flight to occur on November 18, 1991. It is planned to have the MAS Level-1B processing system operational by this time.

Biweekly progress schedule for development of the MAS Level-1B processing system

June 1991

Surveyed user requirements for MAS Level-1B data : Completed.
Investigated hardware options available for processing : Completed.

July 1991

- Visit Wisconsin to obtain calibration and geolocation software and MAMS test data : Completed.
- Specify contents of output Level-1B dataset : Underway.

12th

- Set up accounts on LTP VAX and IRIS systems : Completed.
- Transfer MAMS processing source code to VAX : Completed.
- Transfer MAMS test data from magnetic tape to LTP VAX : Completed.
- Decode INS data format : Completed.
- Examine INS dataset to determine straight line flight tracks : Completed.
- Determine regression relationships for INS heading versus time : Completed.
- Investigate use of PCI imaging software on VAX and IRIS : Underway.

26th

August 1991

- Develop code to compute regression relationships for INS parameters.
- Develop 8 bit image data unpacking routine.
- Develop code to extract 8 bit imagery for straight line flight tracks.
- Display 8 bit raw imagery on PC.
- Investigate image viewing strategies on IRIS.

9th

- Extract, examine, and document relevant portions of MAMS calibration software.
- Develop calibration software modules and main program.
- Test calibration routine against MAMS test data.
- Prepare subsampled dataset for viewing on IRIS.

23rd

September 1991

- Extract, examine, and document relevant portions of MAMS geolocation software.
- Develop geolocation software modules and main program.
- Document "operational" image viewing system on IRIS.

6th

- Test geolocation routine against MAMS test data.
- Integrate calibration and geolocation routines into one main program (menu driven).
- Introduce users to image viewing system on IRIS.

20th

October 1991

- Integrate contents of MAS Level-1B dataset into HDF file(s) in conjunction with TEG.
- Perform "production run" processing of new MAMS test data set.
- Fix any bugs identified.
- Incorporate any changes or additions to image viewing system suggested by users.

4th

- Integrate code documentation and create user guide.
- Create output HDF dataset and write to magnetic tape.
- Test routines to read from HDF magnetic tape.
- Confirm MAS November delivery schedule with Jeff Myers at Ames.

18th

November 1991

1st

15th

18th - First MAS flight for FIRE

Progress on MAS Level-1B processing system development
26 July 1991

Accounts have been set up on both the LTP VAX and IRIS systems.

MAMS processing source code has been transferred to the VAX and also PC.

MAMS test image data and INS data has been read from 9 track magnetic tape on VAX and stored on disk. INS data consisted of 3888 blocks, 150 bytes per block. MAMS data consisted of 9507 blocks, 10320 bytes per block. Both datasets have one record per block.

INS data format has been decoded. The data is in a plain ASCII format and is relatively simple to decode. A routine has been developed to decode any given record of INS data, and output the parameters to a calling program. Non-SI units (altitude, speed) were converted to SI. Plots of this data versus time are appended. This set of INS data was recorded every 5 seconds during flight. Flight time was 5 hours 30 minutes.

Since the MAMS image data is every 3rd line, the total number of lines taken during the time period covered by the MAMS imagery is

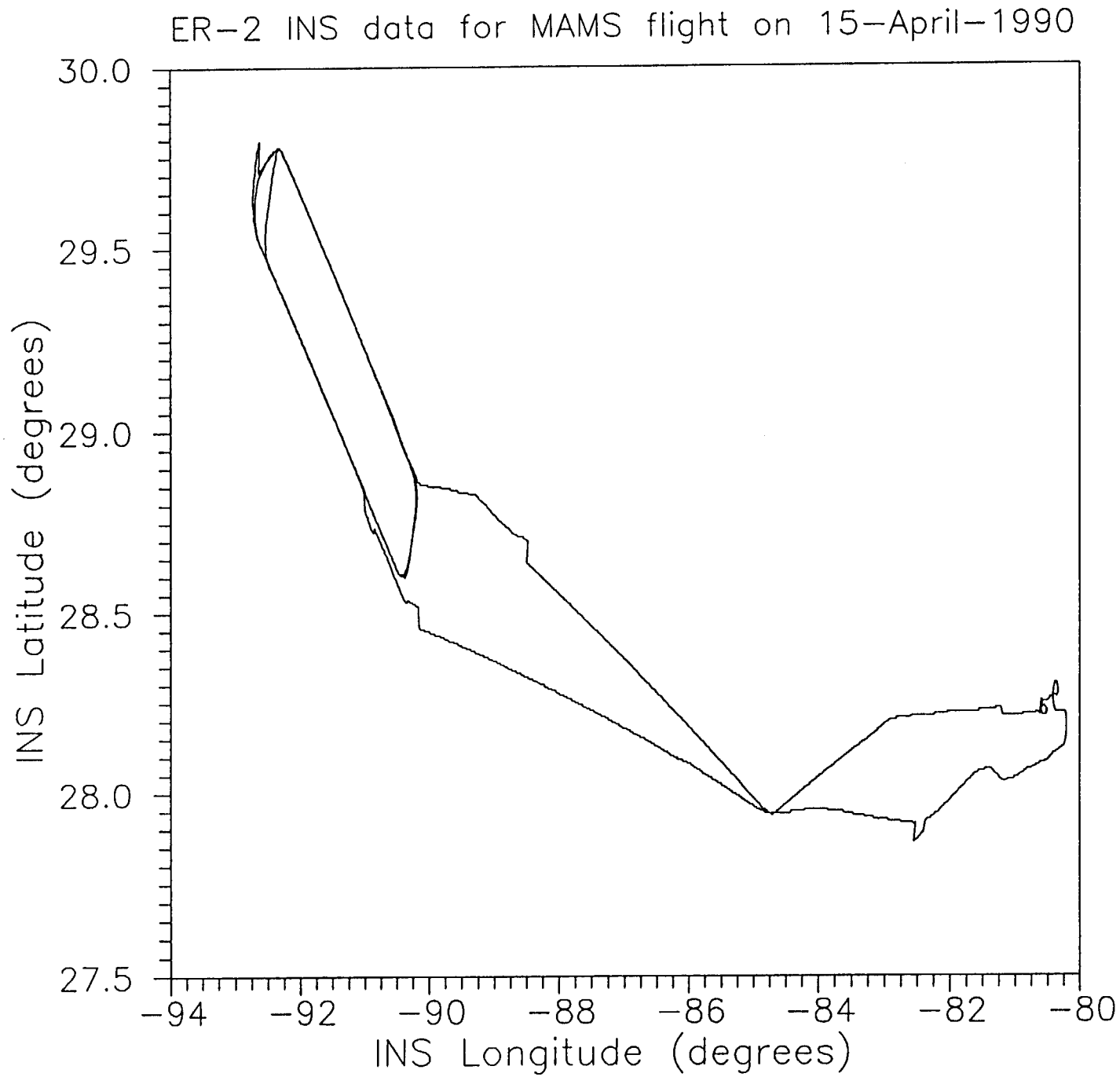
3 x 9507 lines = 28521 lines

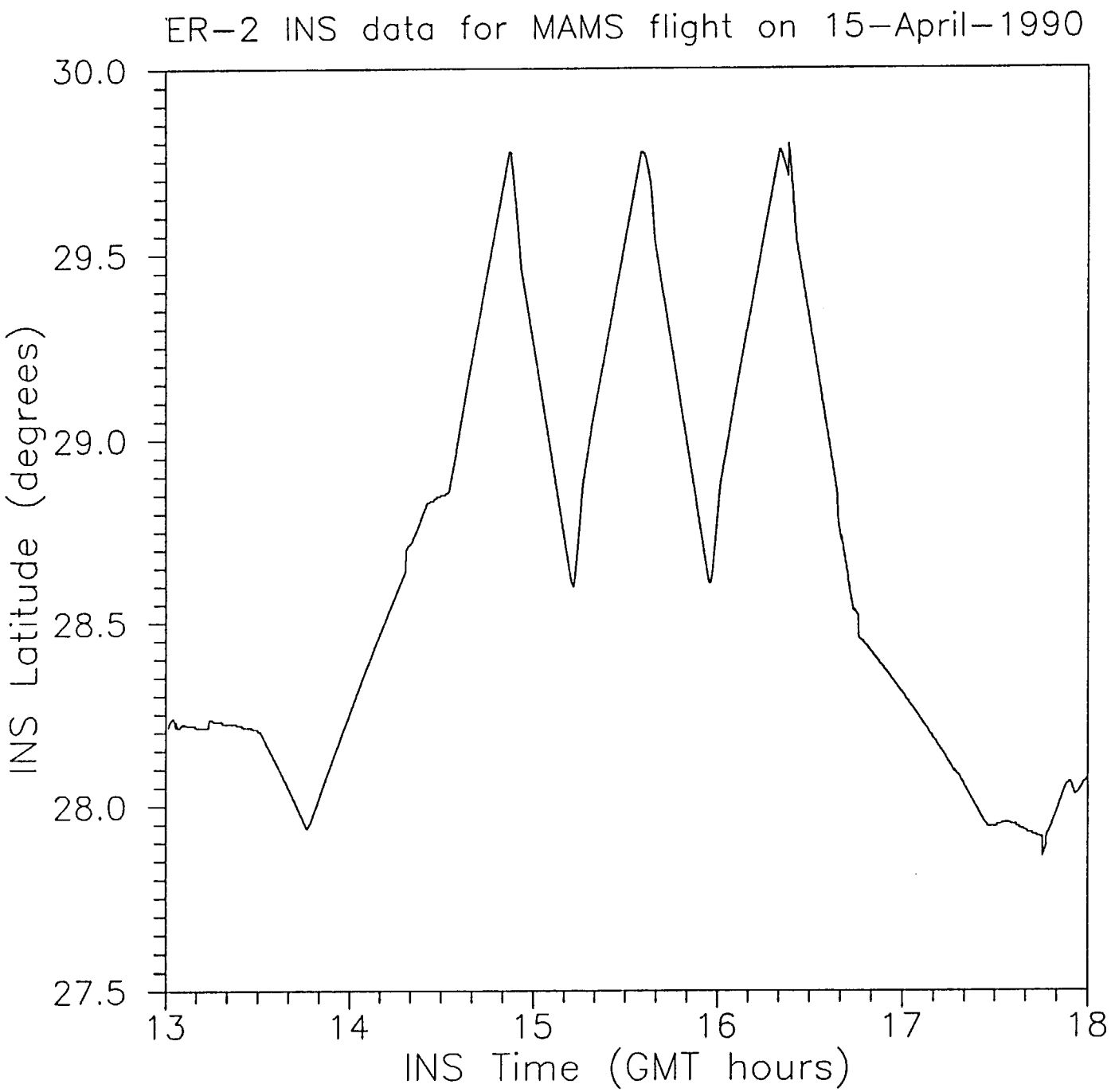
$$\frac{28521 \text{ lines}}{6.25 \text{ lines/second}} = 4563.36 \text{ seconds} = 1.2676 \text{ hours}$$

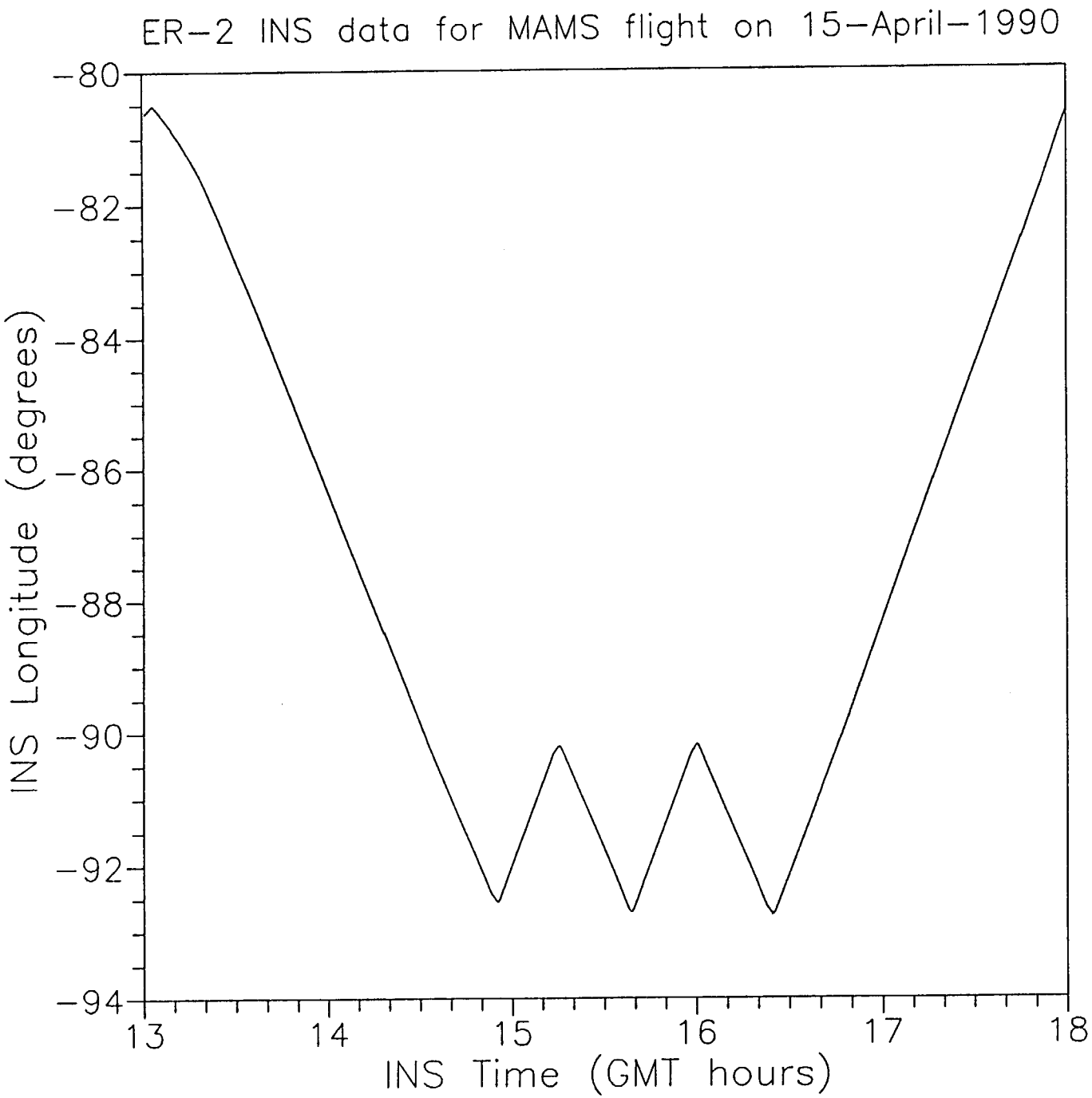
Thus it can be seen that the MAMS imagery is only for a subset of the flight.

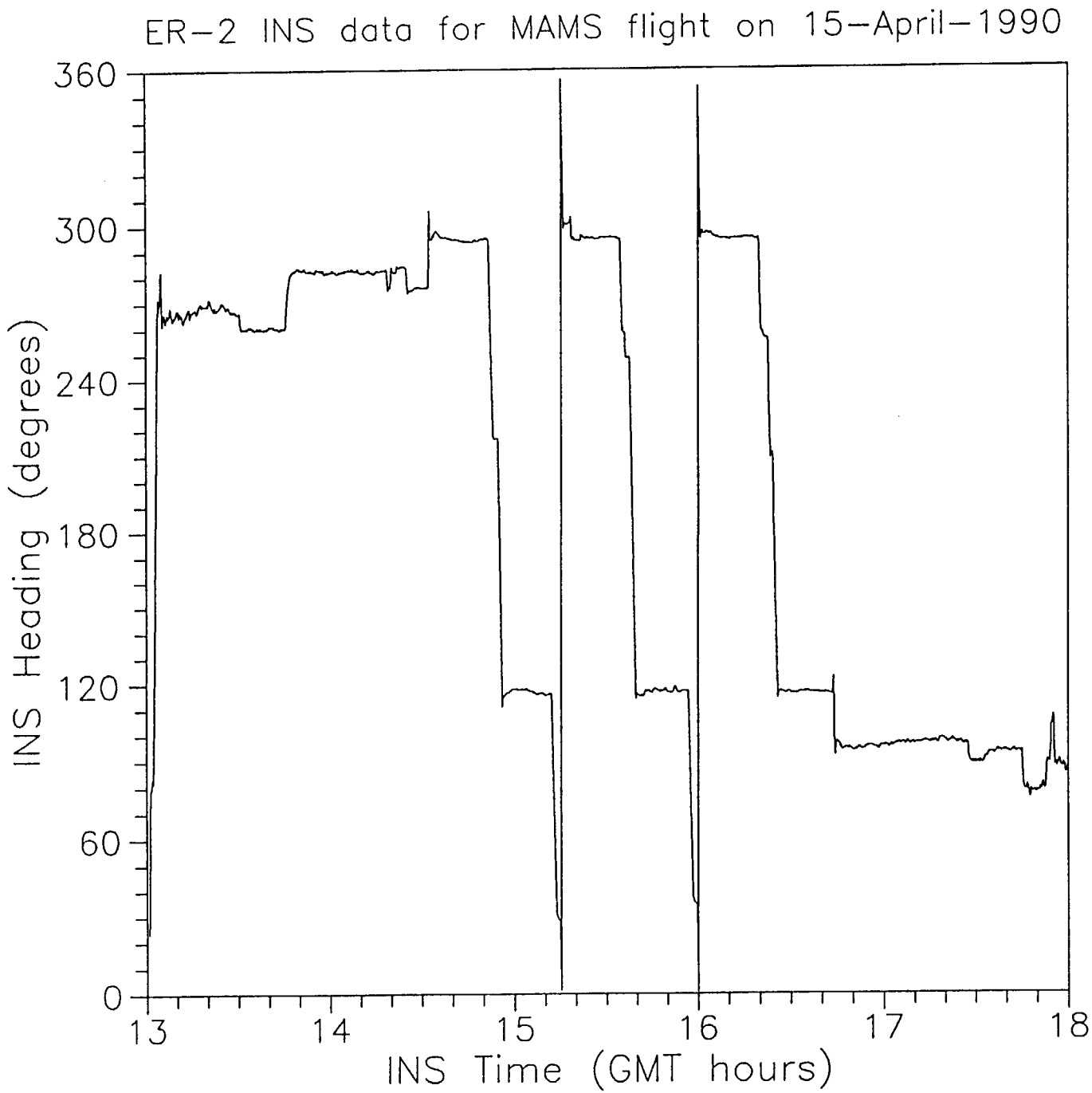
The INS heading data was examined to determine which portions of the flight were straight line flight tracks. A total of 10 straight line flight tracks were identified in the data. The start and end times of these tracks were identified, and linear regressions of heading versus time computed.

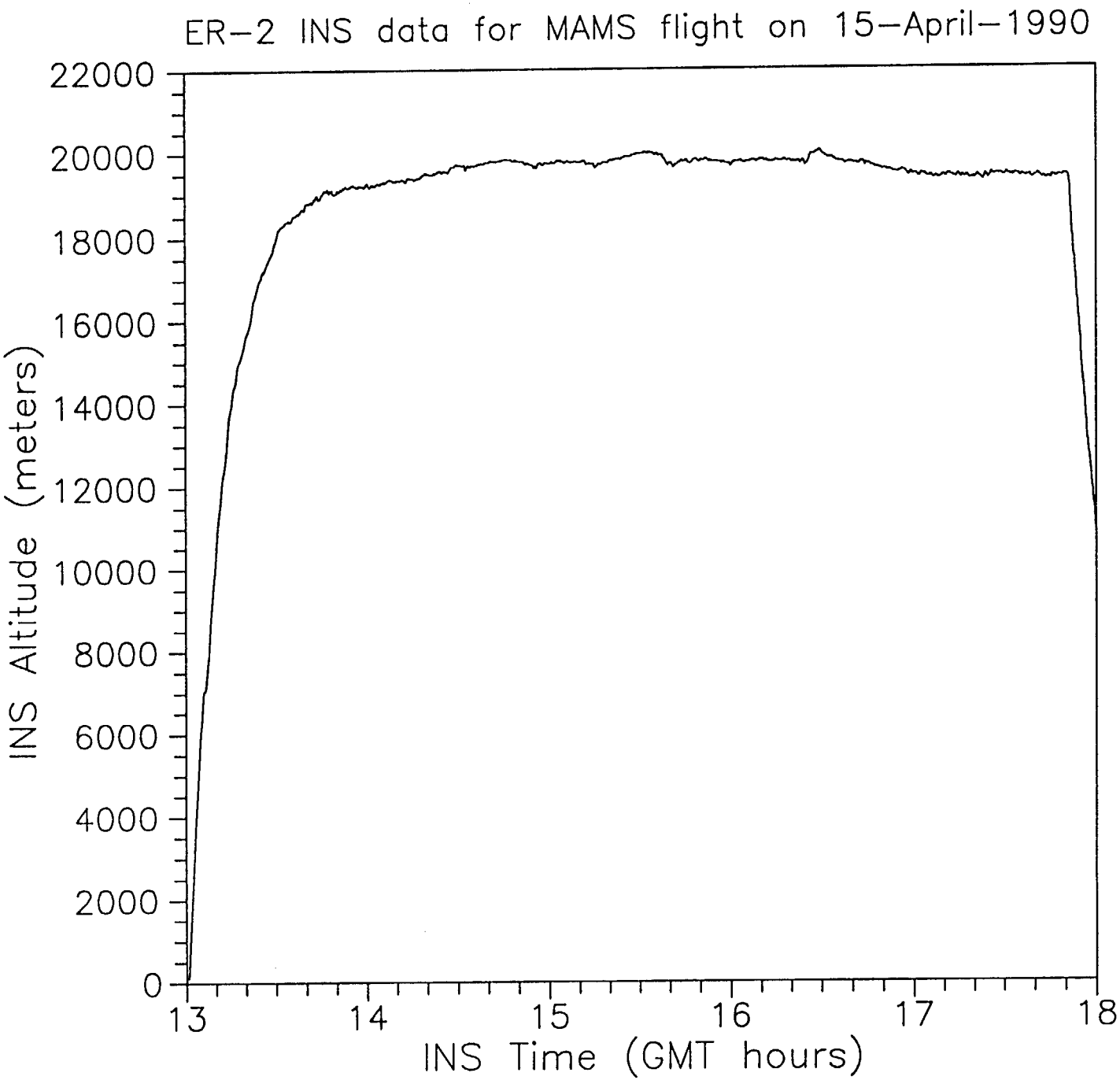
PCI software was run on both the VAX and IRIS and investigation commenced on transferring binary images to PCI format.


ER-2 INS data for MAMS flight on 15-April-1990
30.0
29.5
29.0
28.5
28.0
27.5
INS Latitude (degrees)
-94
-92
-90
-88
-86
-84
-82
-80
INS Longitude (degrees)


ER-2 INS data for MAMS flight on 15-April-1990
30.0
29.5
29.0
28.5
28.0
27.5
INS Latitude (degrees)
13
14
15
16
17
18
INS Time (GMT hours)


ER-2 INS data for MAMS flight on 15-April-1990
-80
-82
-84
-86
-88
-90
-92
-94
INS Longitude (degrees)
13
14
15
16
17
18
INS Time (GMT hours)


ER-2 INS data for MAMS flight on 15-April-1990
360
300
240
180
120
60
0
INS Heading (degrees)
13
14
15
16
17
18
INS Time (GMT hours)


ER-2 INS data for MAMS flight on 15-April-1990
INS Altitude (meters)
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
13
14
15
16
17
18
INS Time (GMT hours)

MODIS LEVEL-1 PROCESSING INTERFACE WITH EOSDIS SCHEDULING, CONTROL, AND ACCOUNTING (SCA) ASSUMPTIONS

(PRELIMINARY)

July 26, 1991

The assumptions in this list relate to the interface between the MODIS Level-1 science data processing and the EOSDIS scheduler (referred to as the SCA (Scheduling, Control and Accounting) in this document). Not all of the EOSDIS Core System (ECS) functions have been specified in detail, so these assumptions must be considered preliminary. The numbering of items comes from a master list being tracked by the MODIS Science Data Support Team. Only those items which relate to the SCA interface are included in this abbreviated list.

SCA Interface ( ). The SCA interfaces with the MODIS Level-1A processing system in two ways: 1) it serves as control to the MODIS system (it sends messages to the MODIS system) and 2) it receives processing status information (it receives messages from the MODIS system).

SCA Control of the MODIS Level-1A Process ( ). The SCA controls the MODIS Level-1A process through a system of messages as follows:

> Initiate Execution: The SCA sends an Initiate Execution message to the MODIS Level-1A system to begin processing. The message contains information on the data to be processed, including file names (or other pointers) indicating the location of the MODIS Level-0 Data and the associated ancillary data.
>
> Suspend Execution: The Suspend Execution message tells the MODIS Level-1A system to stop processing without enacting shutdown procedures (e.g., don't close data files). No response message is sent to the SCA. The Suspend Execution message should eventually be followed by either a Resume Execution message or a Cancel Execution message.
>
> Resume Execution: The Resume Execution message, which follows a Suspend Execution message tells the MODIS Level-1A process to pick up where it left off and continue processing.

Cancel Execution: The Cancel Execution message tells the MODIS Level-1A process to terminate processing. The contents of the message indicate an abort termination or a graceful termination. The MODIS Level-1A process returns a post-processing message indicating that the requested termination has been performed. The MODIS process can then be removed from memory or restarted as necessary. A restart involving an abort termination requires an Initiate Execution message, while a graceful termination message is usually followed by a Resume Execution message.

Dynamic Status Request: The Dynamic Status request is a message sent to the MODIS Level-1A system indicating that a dynamic status response message is to be generated. The MODIS Level-1A system looks for the presence of the Dynamic Status request at selected points in the processing by interrogating the operating system. When the request is present, the MODIS Level-1A process generates a Dynamic Status Response giving the current status of the processing. See "Dynamic Status Response" under the paragraph "MODIS Level-1A Reports to the SCA".

Select Processing Mode: The Select Processing Mode message is generated before the Initiate Execution message to specify the type of MODIS Level-1A processing to be done, i.e., standard, reprocessing, or quick-look.

MODIS Level-1A Reports to the SCA ( ). The MODIS Level-1A processing system sends reports of processing performance and fault conditions to the SCA as follows:

Post-Processing Report: The Post-Processing Report is the final accounting message sent to the SCA by the MODIS Level-1A process to indicate the termination status. The report is posted to the operating system for retrieval by the SCA upon termination of the MODIS process. The report contains the file name (location) of the output data granule and metadata products, an indication of the quality of the processing (criteria to be determined), and an indication of the quantity (size) of the data produced.

Dynamic Status Response: The Dynamic Status Response is the response to a Dynamic Status Request message from the SCA. It contains the information necessary for the SCA to determine the current MODIS Level-1A processing status. This includes the number of expected and already processed packets, spacecraft (S/C) start and stop times of the completed packets, an estimate of the percentage of granule completion, and an indication of the quantity of data already processed. An indication of data quality may also be included.

Alarm: An Alarm is an unsolicited message from the MODIS system to the SCA indicating that a serious problem has occurred within the MODIS system that could lead to generation of invalid data. The contents of this message indicate the nature and severity of the problem. The message is expected to have indicator flags (predefined error values) as well as a character-based message for operator display.

Event: An Event is another unsolicited message from the MODIS system to the SCA. The Event message contains indicator flags (the meaning of which are pre-determined) for anomalies in the telemetered data. An Event represents a non-catastrophic occurrence and does not indicate a serious problem with the processing.

MODIS Processing Modes ( ). The SCA will initiate execution of MODIS Level-1 processing in the following modes:

1) MODIS Level-1A standard processing

2) MODIS Level-1A quick-look processing

3) MODIS Level-1A reprocessing

4) MODIS Level-1B normal processing

5) MODIS Level-1B quick-look processing

6) MODIS Level-1B reprocessing

7) MODIS Level-1B standard browse data processing

Corresponding scheduling will be involved for levels 2 and above. It is assumed that the metadata are generated at the same time as the data products so that no separate scheduling is required for this purpose. It is possible to have the MODIS Level-1B standard browse data processing scheduled to automatically follow the Level-1B normal processing.

Initiating Execution of Level-1A Standard Processing ( ). Before sending an Initiate Execution message to the MODIS Level-1A process for standard processing, the SCA will determine that the pertinent input data, including MODIS instrument data and platform ancillary data, are available. Data status tables for this purpose will be kept by the SCA.

Data status tables must be kept by either the MODIS process, the SCA process or possibly another EOSDIS process, such as the IMS. For efficiency and uniformity among instruments, it is best that these tables be kept by the SCA. If the MODIS process is required to maintain data status tables, then a separate process for this purpose must also be scheduled.

Level-1A Data Granules ( ). Normal MODIS Level-1A processing will generate an integer number of complete Level-1A granules. If the time boundaries of the data interval scheduled for processing do not fall on normal Level-1A granule boundaries, then the MODIS Level-1A process will include the additional data required to complete the granules, if the additional data are available. If the additional data are not available, the MODIS Level-1A process will reduce the scheduled interval to eliminate the partial granules at the

beginning and/or end of the interval. This adjustment will be indicated in the Post-Processing Report and the MODIS Processing Log. Upon completion of the process, the SCA will update the data status tables to show which Level-0 data have been processed to Level-1A

This procedure eliminates the situation where the data in a Level-1A granule is not all generated in the same run. Without this constraint it is even possible that data within a granule could be processed using more than one version of the software.

Initiating Execution of Level-1A Quick-Look Processing ( ). Before sending an Initiate Execution message to the MODIS Level-1A process for quick-look processing, the SCA will determine that the pertinent input data, including MODIS instrument data and platform ancillary data (or a suitable substitute), are available.

The platform position and attitude data are normally obtained from the platform ancillary data. If these data will not always be available in time for quick-look processing, then provision must be made for obtaining these data from another source when necessary. The source will be indicated to the MODIS process in the Initiate Execution message from the SCA.

For quick-look processing, all of the data specified in the Initiate Execution message will be processed without regard to normal granule boundaries.

The MODIS Level-1A process will notify the SCA when the processing is complete through the Post-Processing Report.

Initiating Execution of Level-1A Reprocessing ( ). MODIS reprocessing at Level-1A will be the same as standard processing except that it may use the previously generated Level-1A data as input. The SCA will specify which type of input data will be used, and will indicate the location through the Initiate Execution message.

EOS Platform Stability Requirements

The latest version (Revision B, Feb. 16, 1990) of the EOS Project Element Requirements Document (PERD) lists the following platform attitude requirements: [The Eos-A Platform Contract End Item (CEI) Specification, 26 April 1990, lists the same numbers]

TABLE 3.2.2.6.3.1-1

PLATFORM ATTITUDE REQUIREMENTS

	NavBase	Payload
Attitude Knowledge Seconds of arc 3 sigma	36	108
Control Accuracy Seconds of arc 3 sigma	108	TBD
Stability Seconds of arc 3 sigma	7.2	TBD
Jitter Seconds of arc 3 sigma	1.08	TBD

Appendix A of the same document contains the following definitions:

Attitude Knowledge: The per axis accuracy with which the actual orientation of the Platform NavBase (or payload) is determined.

Control Accuracy (Placement): The maximum angle, per axis, between the actual orientation of the Platform NavBase (or payload) and the desired orientation.

Desired Orientation: The desired orientation for the Platforms, as specified in the attitude requirements, is defined as the + Z axis (Yaw) aligned with the vector from the Platform to the center of the earth (nadir), the + X axis (Roll) aligned with the velocity vector, and the + Y axis (Pitch) normal to the orbit plane.

Stability: The peak-to-peak angular variation, per axis, of the Platform NavBase (or payload) over any continuous 1000 second period.

Jitter: The peak-to-peak angular variation, per axis, of the Platform NavBase (or payload) over any continuous one (1) second period.