MODIS FLIGHT OPERATIONS

Ed Knight
January 9, 1995

Scope and Definitions
Context
Past Activities
Current and Future Activities

SCOPE

Flight Operations encompasses two major activites:

1. Commanding and Controlling the Instrument

2. Monitoring the Health and Safety of the Instrument

The Flight Operations Team (FOT, Codes 400 and 500) provides the primary command and monitoring for the spacecraft and all the instruments.

The MODIS Sensor Operations Team (MODSOT):

- establishes MODIS specific requirements for command and monitoring,
- provides the command lists and procedures, and
- is responsible for non-safety monitoring (instrument performance and L1-B fidelity).

DEFINITIONS

For monitoring, Flight Operations is concerned with the telemetry--currently does not examine the science data (video data from the MODIS detectors).

Telemetry data arrives through two primary paths:

1. Science Data Stream (1553 science bus, DB)
   Includes Engineering Data and Memory Dump Data (MODIS)

   collectively called Engineering Data (FLIGHT OPS)

2. Command and Telemetry Data Stream (C & T bus, S-Band)
   Covers telemetry required to monitor health and safety of instrument.

   defined as Housekeeping Data (FLIGHT OPS)

For MODIS, all Housekeeping Data is duplicated in the Engineering Data.
Some Engineering Data is not duplicated in the Housekeeping Data.

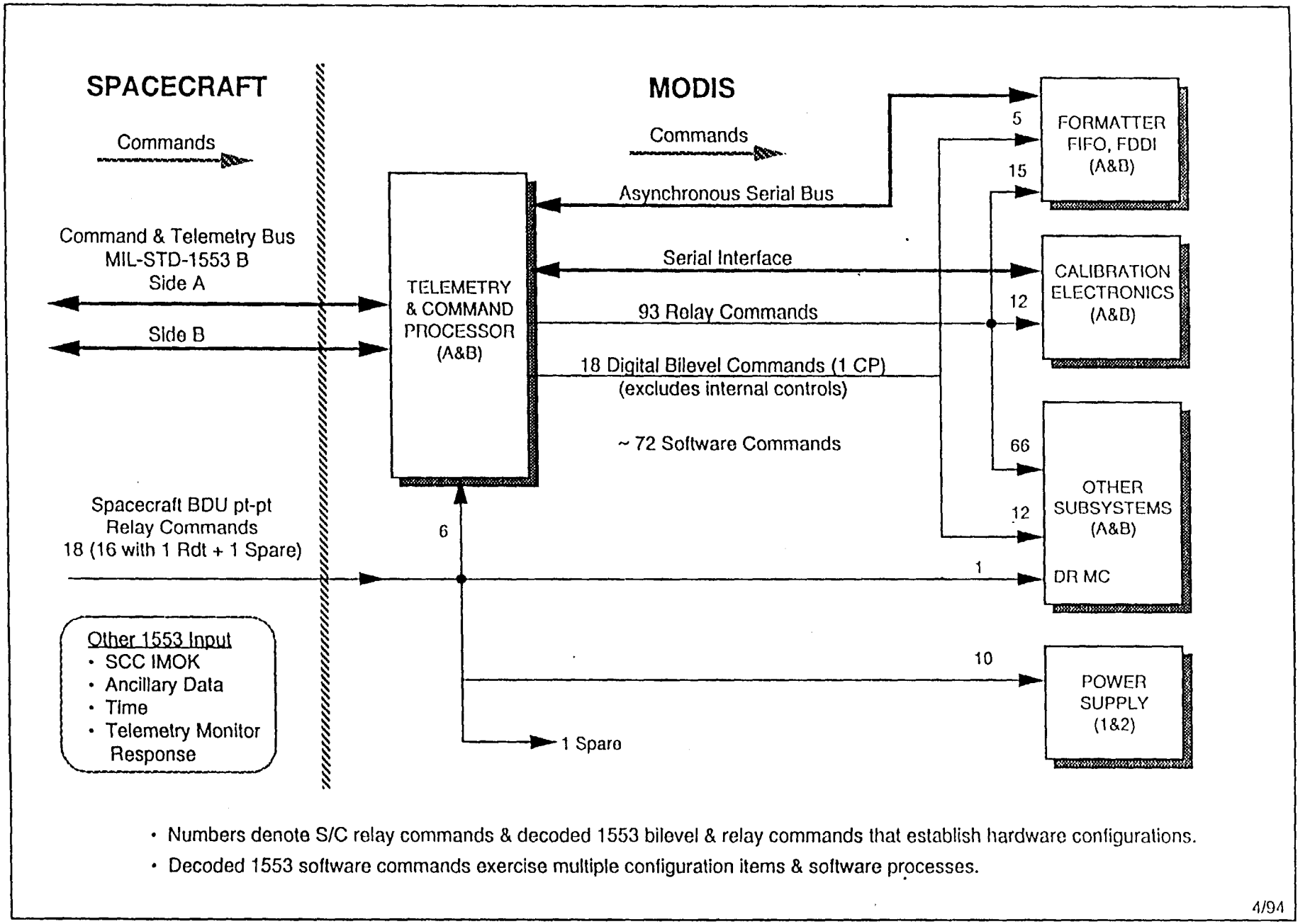


Figure 10-1. MODIS Command Flow Diagram

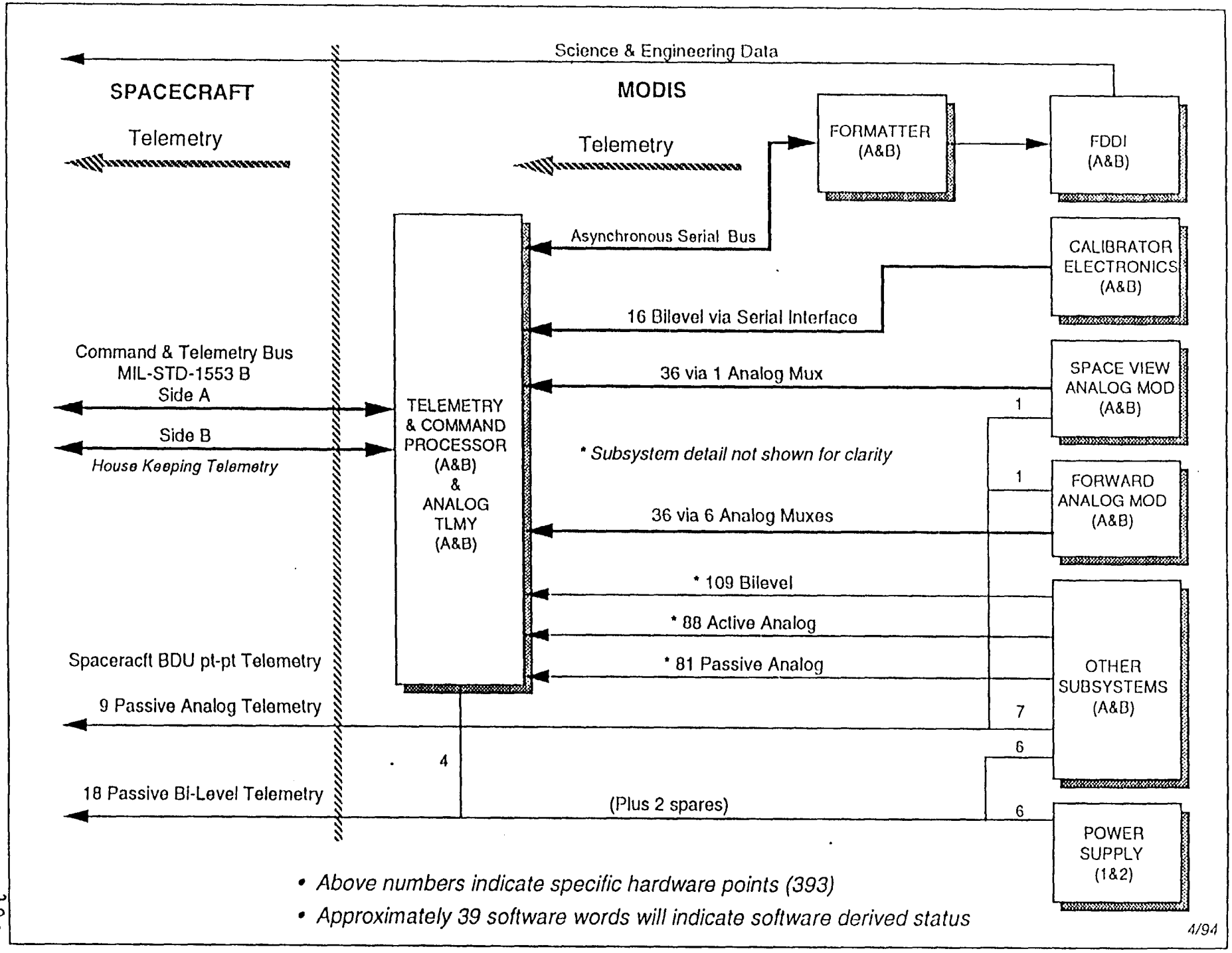
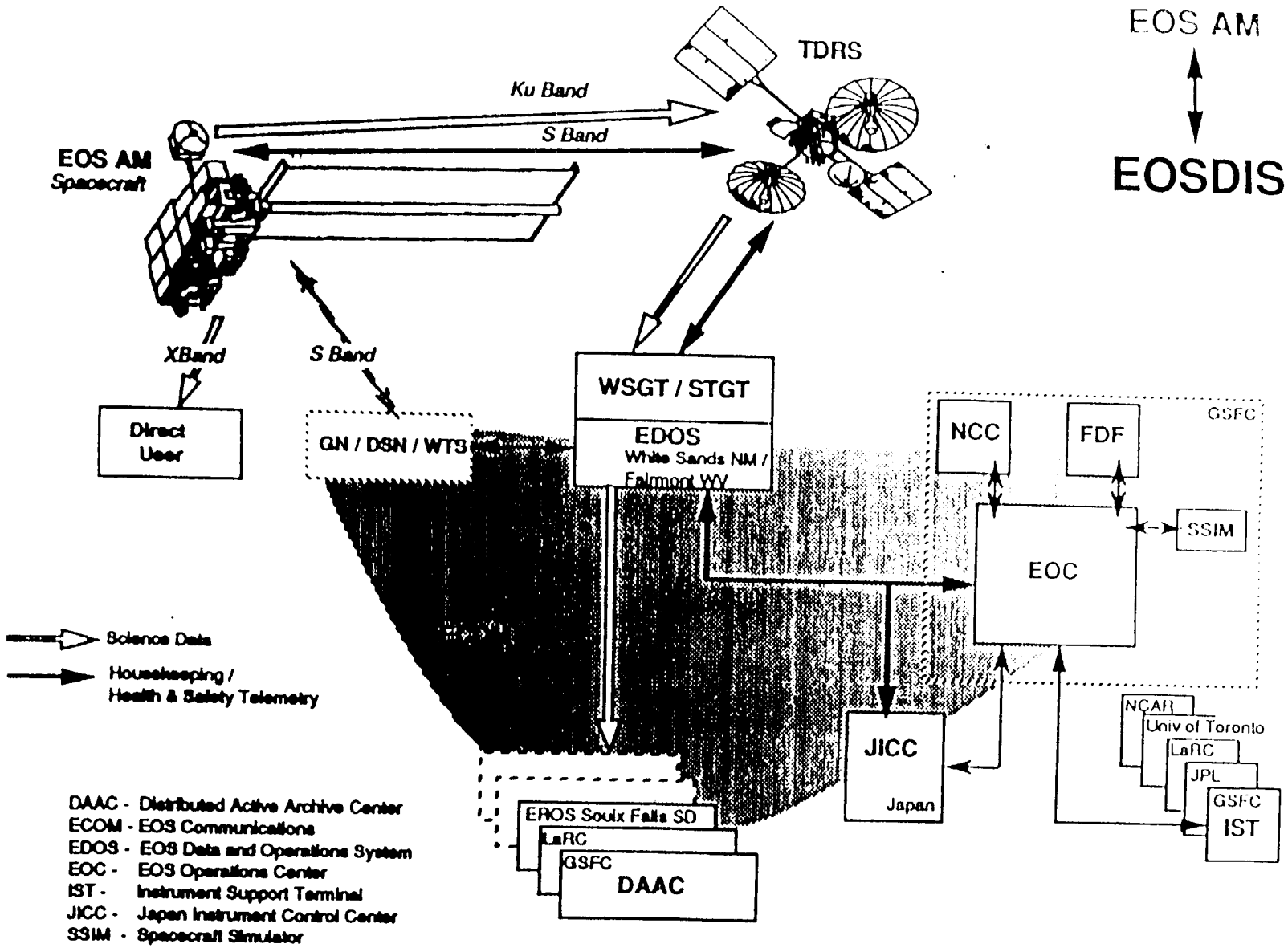
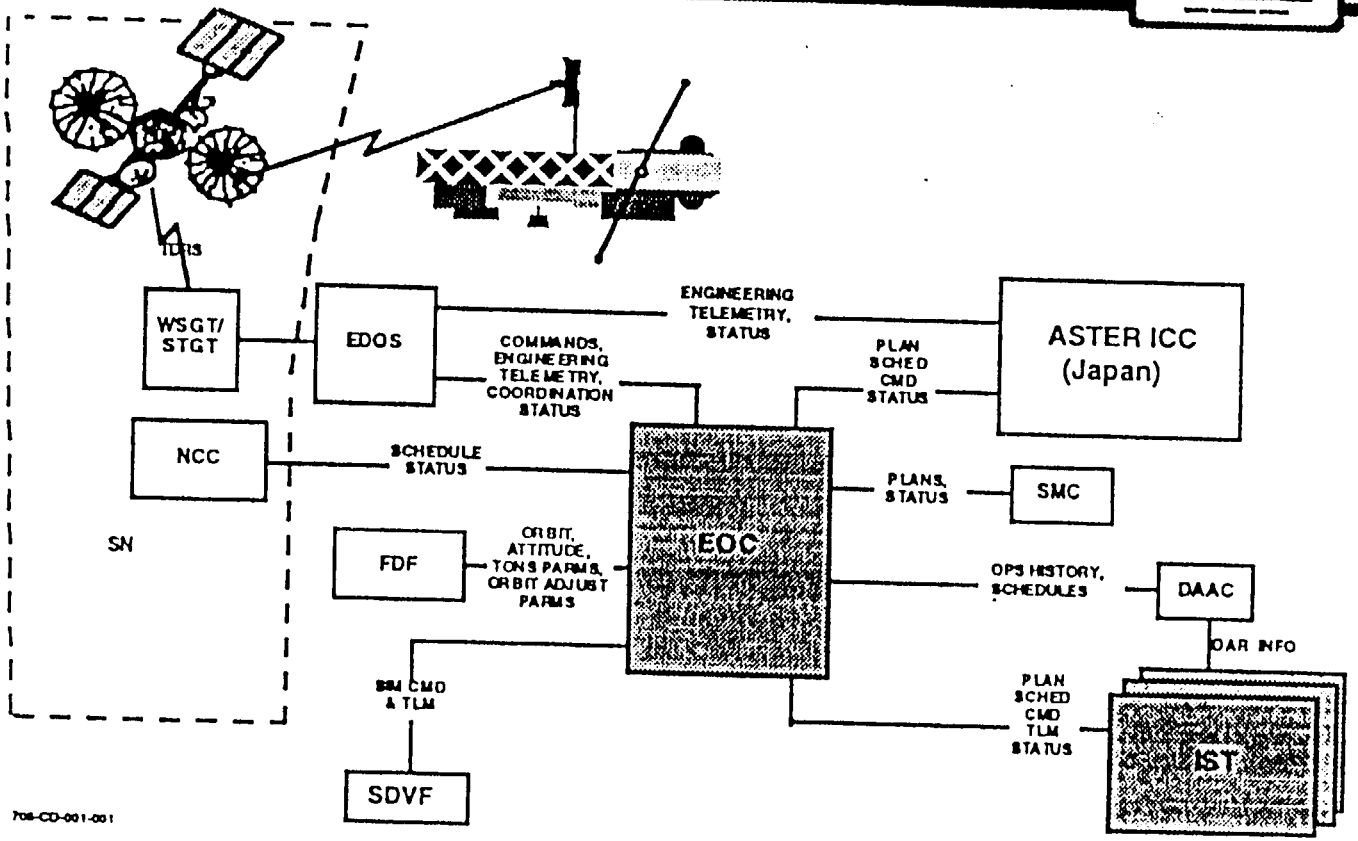


Figure 20-1. MODIS Telemetry Flow Diagram


EOS AM
EOSDIS
TDRS
Ku Band
S Band
EOS AM
Spacecraft
XBand
S Band
Direct
User
GN / DSN / WTS
WSGT / STGT
EDOS
White Sands NM /
Fairmont WV
GSFC
NCC
FDF
SSIM
EOC
JICC
Japan
NCAR
Univ of Toronto
LaRC
JPL
GSFC
IST
EROS Soux Falls SD
LaRC
GSFC
DAAC
Science Data
Housekeeping /
Health & Safety Telemetry
DAAC - Distributed Active Archive Center
ECOM - EOS Communications
EDOS - EOS Data and Operations System
EOC - EOS Operations Center
IST - Instrument Support Terminal
JICC - Japan Instrument Control Center
SSIM - Spacecraft Simulator

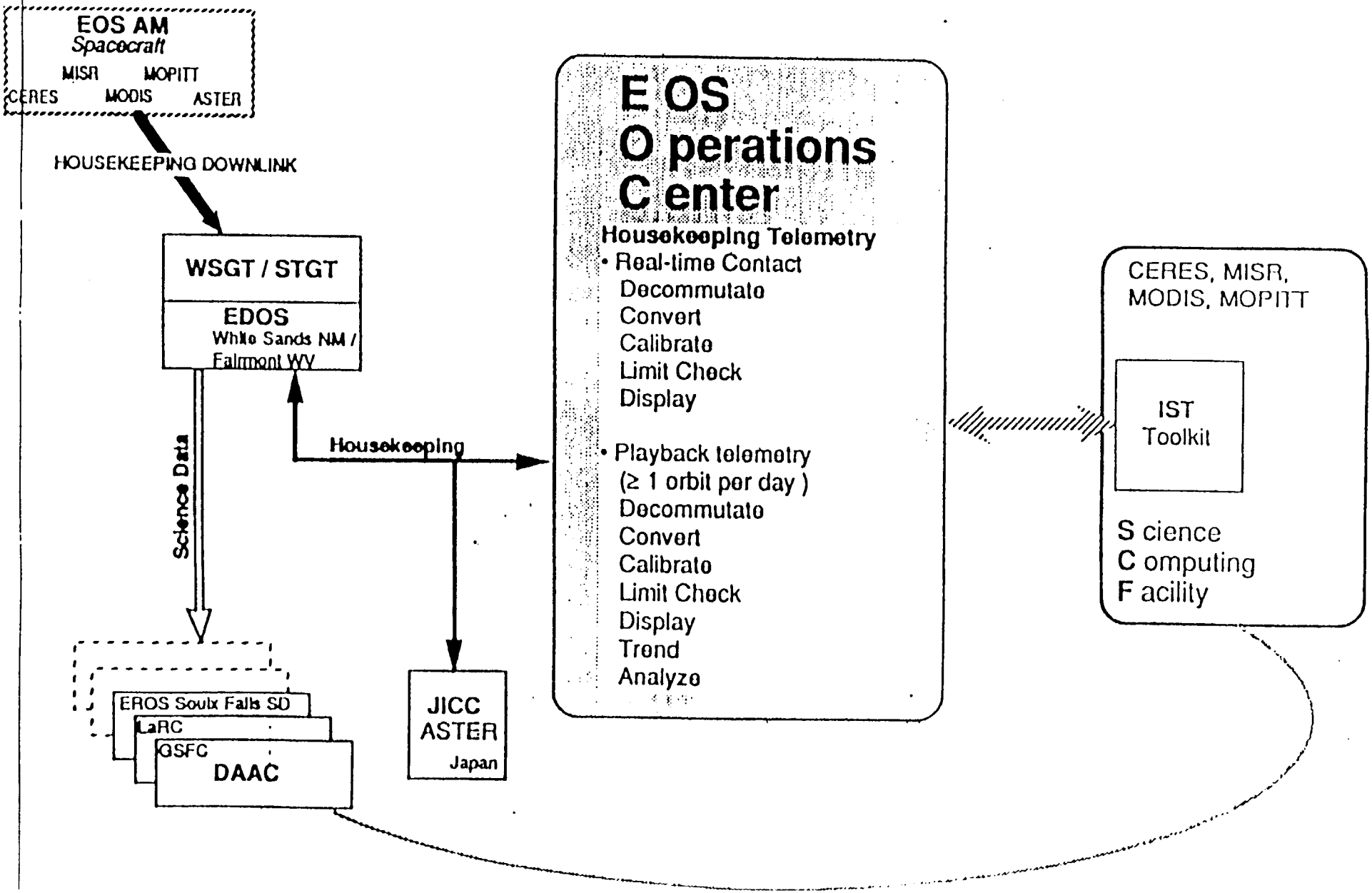
FOS Context Diagram



CONTEXT

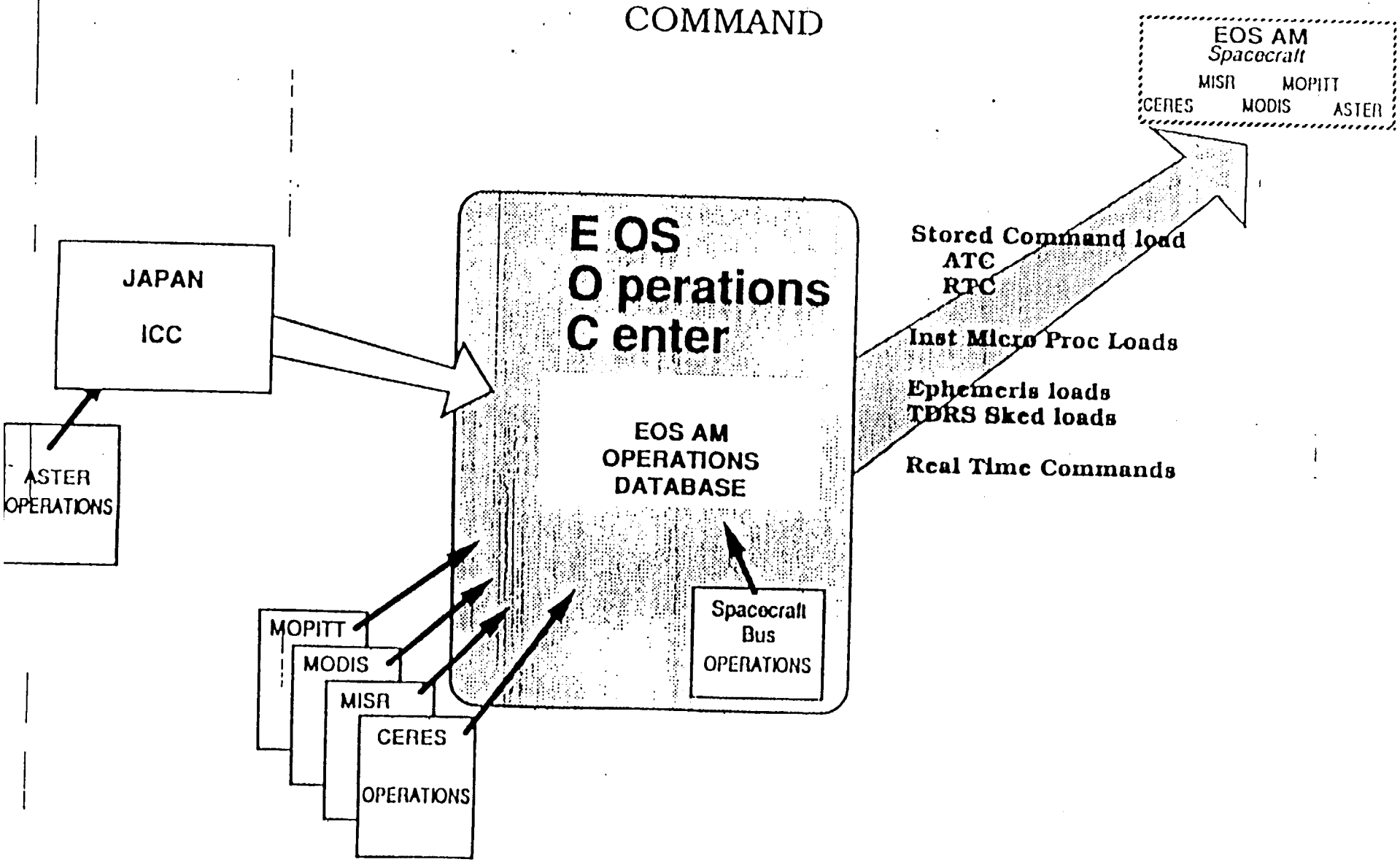
EOS AM FLIGHT OPERATIONS

MONITOR

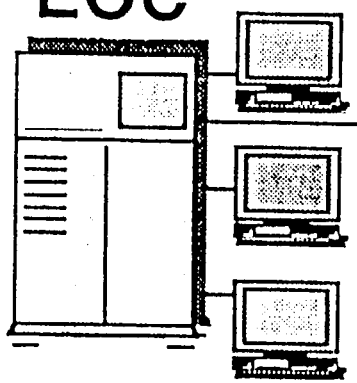


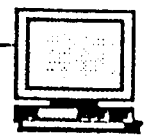
CONTEXT

EOS AM FLIGHT OPERATIONS



FOS Elements





at instrument sites
around the world

- GSFC element responsible for:
  - Overall mission operations
  - Health and safety
  - Mission planning and scheduling
  - Command, control, and monitoring

- Remote site element to allow participation in operations by instrument teams for:
  - Planning & scheduling of instrument
  - Monitoring real-time telemetry
  - Performing instrument analysis
  - Requesting command uplinks

PAST ACTIVITIES

Ground System Requirements Workshop 7-8 September 1994.

IST Prototype Demonstration 27 October 1994.

Spacecraft I & T workshop 7-8 December 1994.

FOS Preliminary Design Review 13-14 December 1994.

GROUND SYSTEM REQUIREMENTS WORKSHOP

On 7-8 September, representatives of the Flight Operations Team, spacecraft (Lockheed-Martin) and all of the instruments met to coordinate requirements for the ground system.

Requirements List (~40 pages) was generated to be applied to Ground System prior to their PDR (December 1994).

Major Points:

1. The ground system shall utilize Integration and Test (I & T) command mnemonics and procedures. The ground system shall accept, archive, and provide access to the I & T Command and Telemetry Database.

2. The ground system will perform a "state check" every time the spacecraft begins a TDRSS contact. The ground system will review 1 orbit/day from the playback telemetry.

3. Through the Instrument Support Terminal (IST--toolkit furnished by Ground System, hardware and COTS supplied by MODSOT), the MODSOT can perform substantial monitoring from the SCF.

IST PROTOTYPE DEMONSTRATION

On 27 October, several MCST/MODIS personnel attended a demonstration of the IST prototype with its designers.

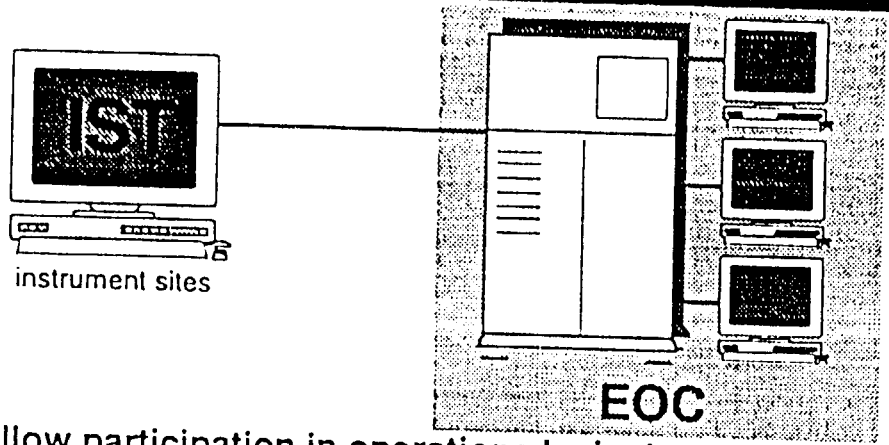
A copy of the prototype is available upon request.

IST software will be platform independent and have some stand alone operational capability.

Interface concept is Rooms and Windows
- Rooms are collection of simultaneously displayed windows
- Windows are alphanumeric, spreadsheet, graphical, schematic, combination

IST delivery expected mid 1996 (prelim)/ mid 1997 (release B-final).

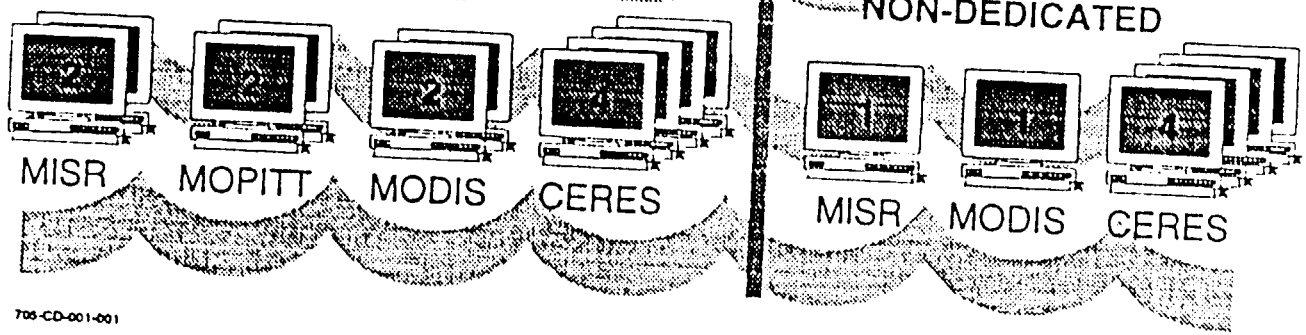
Key Requirements



- Allow participation in operations by instrument teams at remote sites
- Software toolkit that runs on a PI/TL provided workstation
- Platform independent (SUN, HP, DEC, SGI, IBM)
- One or more per instrument site
- Provide the following functionality:
  - Planning & scheduling
  - Monitor real-time telemetry
  - Perform analysis
  - Command requests

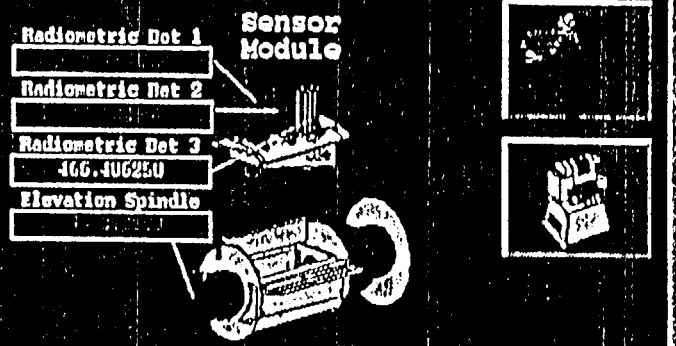
IST Pool

- Each IST places a performance burden upon the EOC
  - Network, history data retrieval for replays and analysis, etc.
- The IST pool allows that burden to be managed
- Pool Management
  - Dedicated (Guaranteed): always available
  - Non-Dedicated (Floating): first-come, first serve



705-CD-001-001

UTC: 94/173 13:07:11 S/C: 94/173 13:00:29 Quality: GOOD Format: SCI Rev: 112 TLM Rate: 10 KBS Data Source: RT Master/Major: 1005/28



Fleet

REAL TIME GRAPH DATA WINDOW 3

MICCDAFT Min: -22.241400 Present: -21.992570 Max: -21.743750

Close Attributes Output QA Pause

MISR Camera:	OFF		CSE Chassis Af T	C:	-26.075
CHARGED COUPLED DEVICE			CSE Chassis An T	C:	-20.375 LY
CCD Aa T	C:	-21.001	CSE Chassis Ba T	C:	
CCD Af T	C:	-21.003	CSE Chassis Bf T	C:	-26.075
CCD An T	C:	-22.104 LY	CSE Chassis Ca T	C:	-25.312
CCD Ba T	C:	-21.003	CSE Chassis Cf T	C:	-26.075
CCD Bf T	C:	-21.003	CSE Chassis Da T	C:	-26.075
CCD Ca T	C:	-22.080 LY	CSE Chassis Df T	C:	
CCD Cf T	C:	-22.241 LY	TEC HJT		
CCD Da T	C:	-21.003	TEC HJT Aa T	C:	
CCD Df T	C:	-21.003	TEC HJT Af T	C:	
CSE CHASSIS			TEC HJT An T	C:	
CSE Chassis Aa T	C:	-26.075	TEC HJT Ba T	C:	

HISTORY DATA WINDOW 4

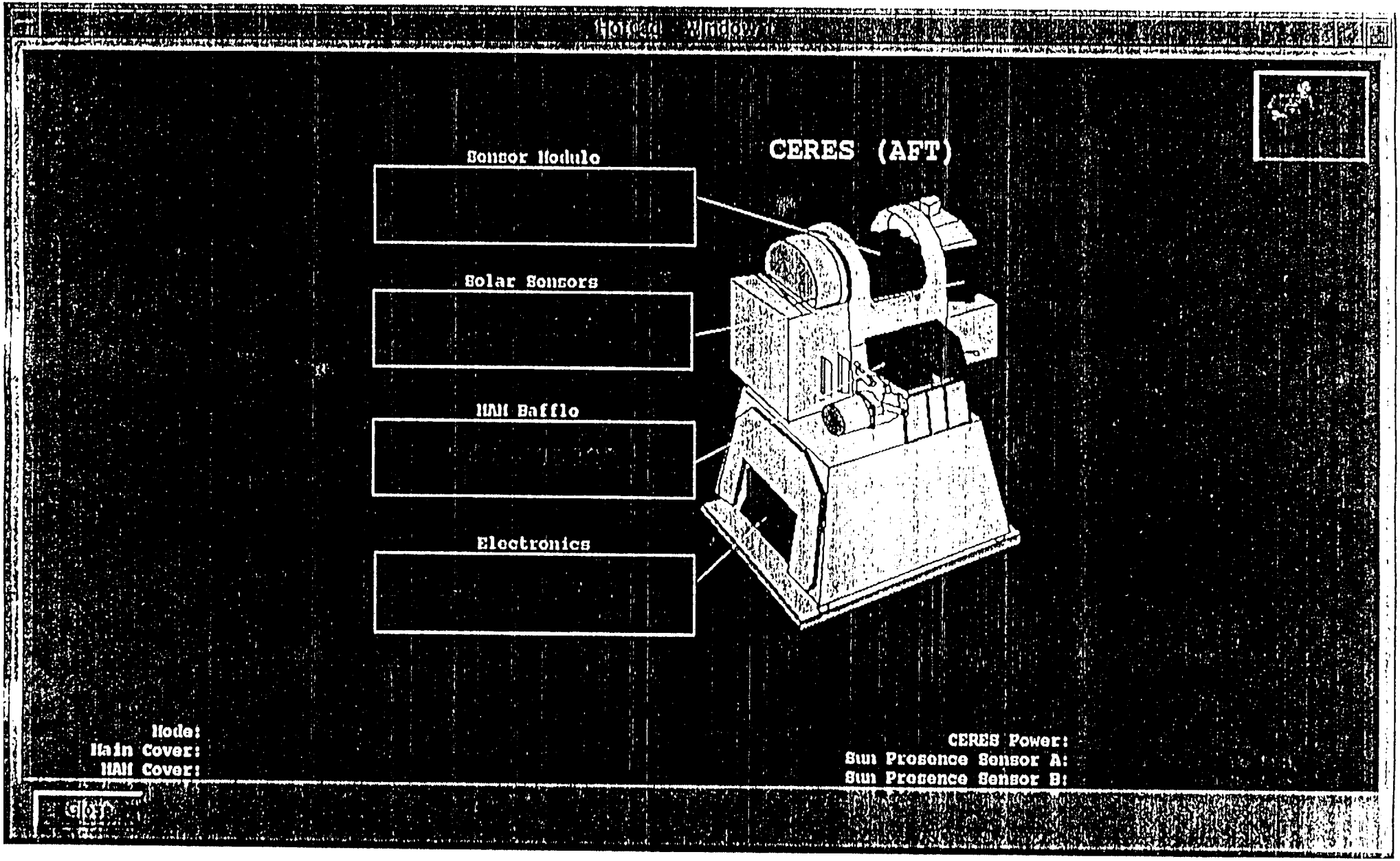
Start Time: 94/173 13:01:18 Stop Time: 94/173 13:05:51

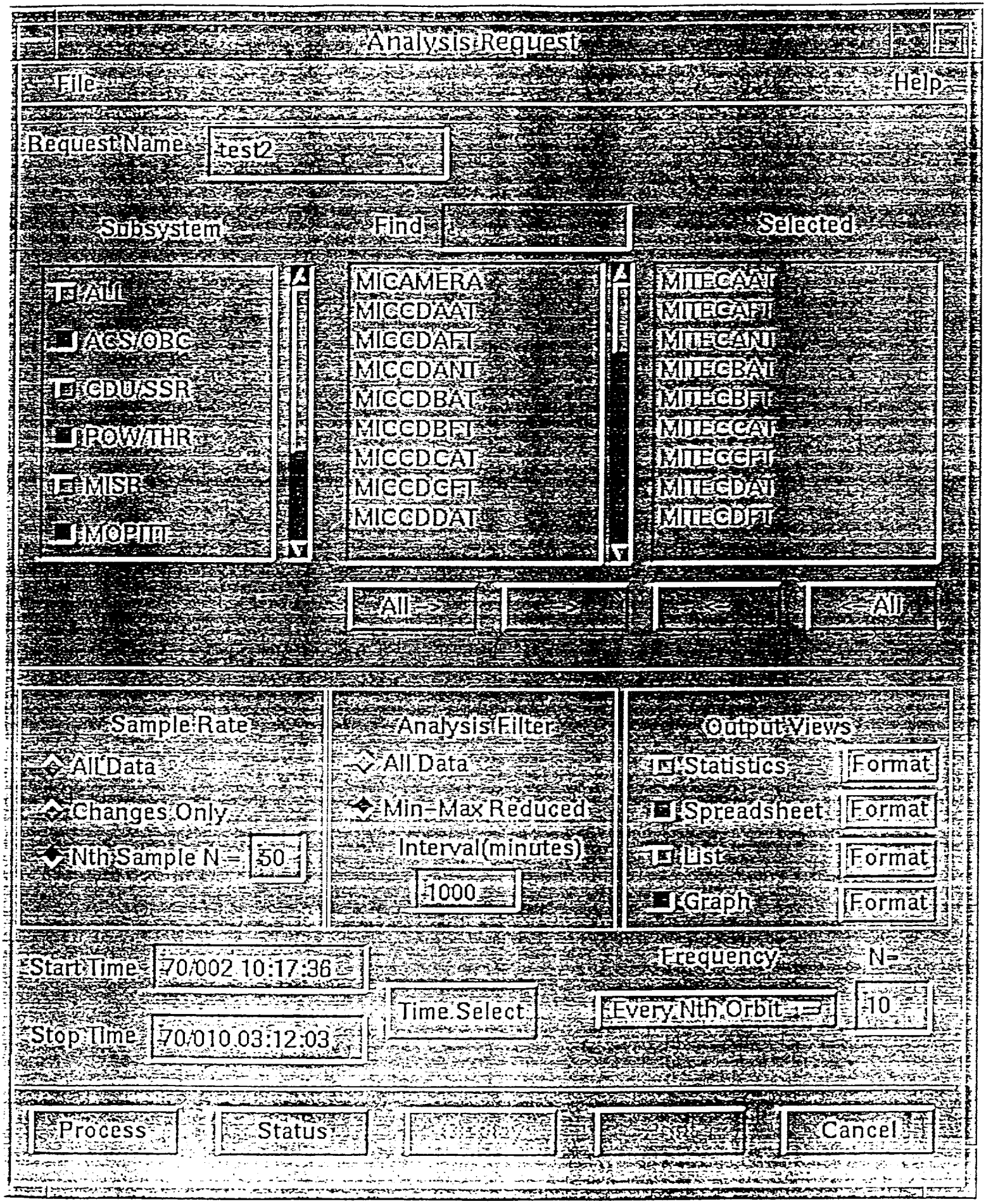
Close Print Export Utility

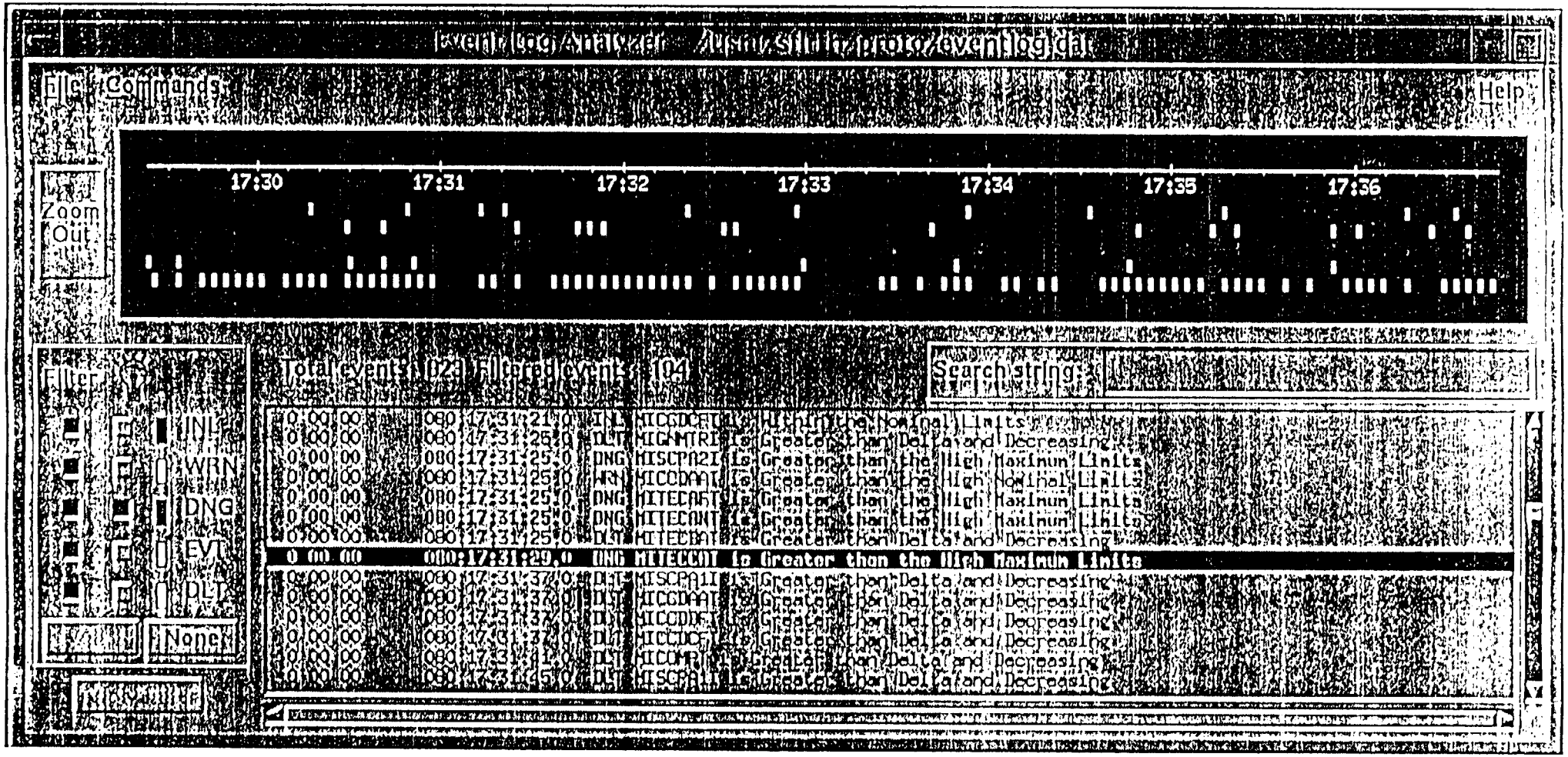
CMD Close Send

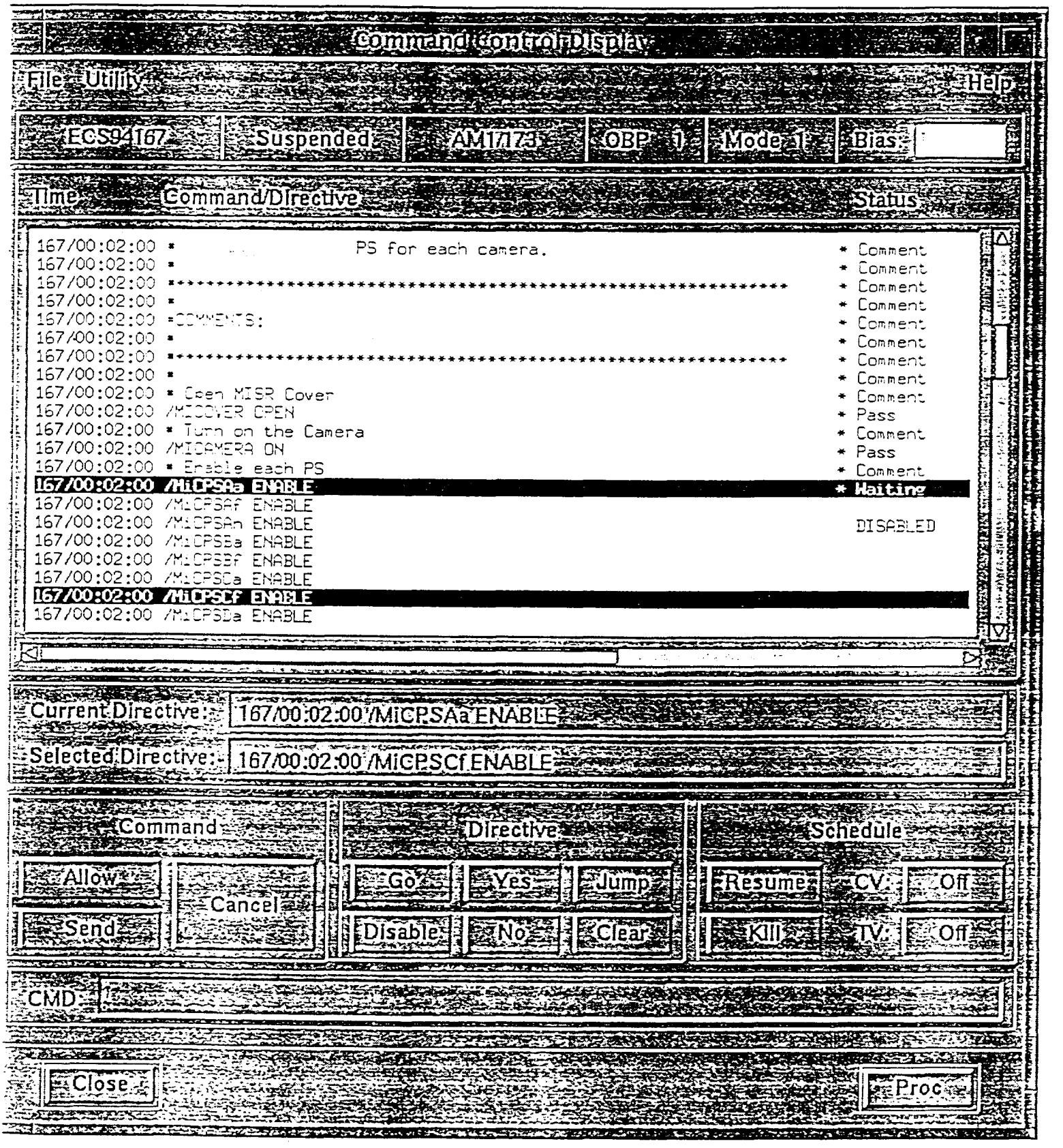
PAS MIPower MICamera MICAT MISR MICam2 MIAnalysis

Tile Windows Rooms Procs Tools Snap QA SetUp Help COMMENTS Filter ACK 0


Sensor Module
Solar Sensors
MAM Baffle
Electronics
CERES (AFT)
Mode:
Main Cover:
MAM Cover:
CERES Power:
Sun Presence Sensor A:
Sun Presence Sensor B:


Analysis Request
File
Help
Request Name
test2
Subsystem
Find
Selected
All
ACS/OBC
CDU/SSR
POW/THR
MISR
MOPITT
MICAMERA
MICCDAAT
MICCDAFT
MICCDANT
MICCDBAT
MICCDBFT
MICCDCAT
MICCDCFT
MICCDDAT
MITECAAT
MITECAFT
MITECANT
MITECBAT
MITECBFT
MITECCAT
MITECCFT
MITECDAT
MITECDFT
All ->
<-
<- All
Sample Rate
All Data
Changes Only
Nth Sample N =
50
Analysis Filter
All Data
Min-Max Reduced
Interval(minutes)
1000
Output Views
Statistics
Format
Spreadsheet
Format
List
Format
Graph
Format
Start Time
70/002 10:17:36
Stop Time
70/010 03:12:03
Time Select
Frequency
Every Nth Orbit
N=
10
Process
Status
Cancel


Event Log Analyzer - /usr/stitz/proto/eventlog.dat
File Commands Help
Zoom Out
17:30
17:31
17:32
17:33
17:34
17:35
17:36
Filter
INF
WRN
DNG
EVT
DLT
All
None
Total Events: 1023 Filtered Events: 104
Search string:
0 00 00 080 17:31:21.0 INF MICGDCAT Is Within the Nominal Limits
0 00 00 080 17:31:25.0 DLT MIGHMTRI Is Greater than Delta and Decreasing
0 00 00 080 17:31:25.0 DNG MISCPA2I Is Greater than the High Maximum Limits
0 00 00 080 17:31:25.0 WRN MICCDAAI Is Greater than the High Nominal Limits
0 00 00 080 17:31:25.0 DNG MITECA5T Is Greater than the High Maximum Limits
0 00 00 080 17:31:25.0 DNG MITECA1T Is Greater than the High Maximum Limits
0 00 00 080 17:31:25.0 DLT MITECBAT Is Greater than Delta and Decreasing
0 00 00 080:17:31:29.0 DNG MITECC1T Is Greater than the High Maximum Limits
0 00 00 080 17:31:37.0 DLT MISCPA1I Is Greater than Delta and Decreasing
0 00 00 080 17:31:37.0 DLT MICCDAAI Is Greater than Delta and Decreasing
0 00 00 080 17:31:37.0 DLT MICCDC1I Is Greater than Delta and Decreasing
0 00 00 080 17:31:37.0 DLT MICCDC1I Is Greater than Delta and Decreasing
0 00 00 080 17:31:41.0 DLT MICDMR1I Is Greater than Delta and Decreasing
0 00 00 080 17:31:45.0 DLT MISCPA1I Is Greater than Delta and Decreasing

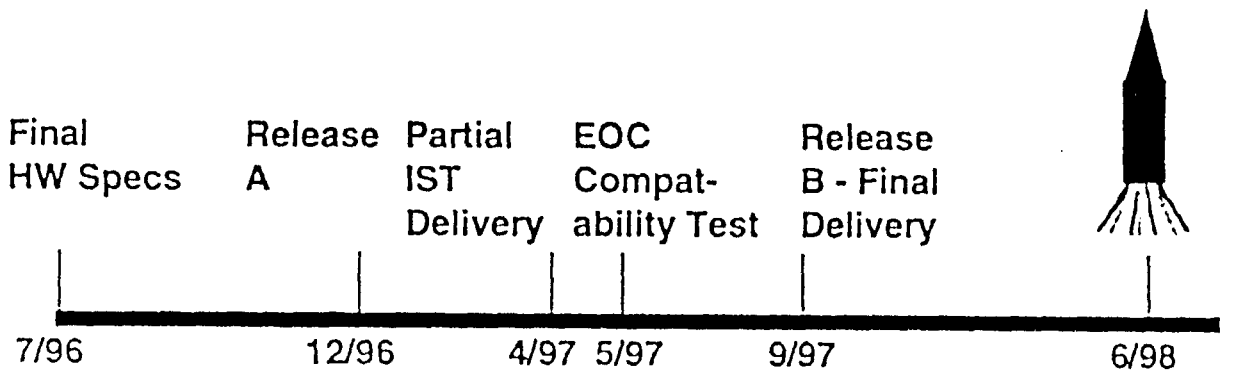

Command Control Display
File Utility Help
ECS94167 Suspended AM1/73 OBP 1 Mode 1 Bias
Time Command/Directive Status
167/00:02:00 * PS for each camera. * Comment
167/00:02:00 * * Comment
167/00:02:00 ********** * Comment
167/00:02:00 * * Comment
167/00:02:00 *COMMENTS: * Comment
167/00:02:00 * * Comment
167/00:02:00 ********** * Comment
167/00:02:00 * * Comment
167/00:02:00 * Open MISR Cover * Comment
167/00:02:00 /MICOVER OPEN * Pass
167/00:02:00 * Turn on the Camera * Comment
167/00:02:00 /MICAMERA ON * Pass
167/00:02:00 * Enable each PS * Comment
167/00:02:00 /MiCPSAa ENABLE * Waiting
167/00:02:00 /MiCPSAf ENABLE
167/00:02:00 /MiCPSAn ENABLE DISABLED
167/00:02:00 /MiCPSBa ENABLE
167/00:02:00 /MiCPSBf ENABLE
167/00:02:00 /MiCPSCa ENABLE
167/00:02:00 /MiCPSCf ENABLE
167/00:02:00 /MiCPSDa ENABLE
Current Directive: 167/00:02:00 /MiCPSAa ENABLE
Selected Directive: 167/00:02:00 /MiCPSCf ENABLE
Command
Allow
Cancel
Send
Directive
Go
Yes
Jump
Disable
No
Clear
Schedule
Resume
CV
Off
Kill
TV
Off
CMD
Close
Proc

Specification Need Dates

Need Date for Final HW specs

- Final delivery of IST, release B, 9/97
- IST needed to support EOC Compatability Test, 5/97
- Partial delivery, 4/97
- Final hardware specs needed 9 mo prior to partial delivery, 7/96

Note that prototypes will be made available prior to 4/97



SPACECRAFT I & T WORKSHOP

On December 7 and 8 SBRC/MMC/GSFC met at SBRC to discuss issues related to testing during spacecraft integration.

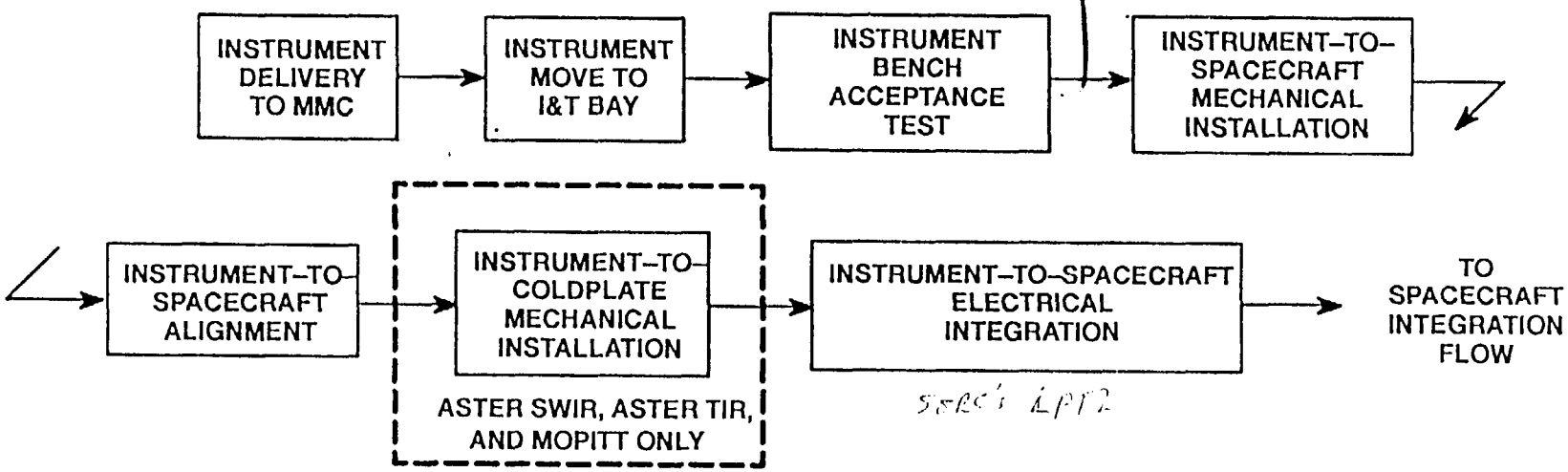
Several significant issues arose:

1. Reliance on OBCs for testing at S/C
   2000 hours total expected; SRCA 10 W bulbs only good for 1000 hours.
2. Interference Testing
   "quiet" and "noisy" modes need definition
3. Orbital Testing
   MMC will simulate several "typical" orbits
4. Instrument Orientation
   Testing at MMC is +Z down. Testing at SBRC is +X or -X down.
5. No Bench Test Cooler at MMC
   Much of the MMC testing will be in ambient; won't be able to examine cold focal planes.
6. Continual Testing
   Some MMC tests will be continuous over several hours. STE cannot collect continuously for that long.
7. Leaving T/V without contamination condensation.
8. MODIS expected to supply some testing personnel.

Instrument Test Flow
Instrument Integration

MARTIN MARIETTA

MARTIN MARIETTA ASTRO SPACE

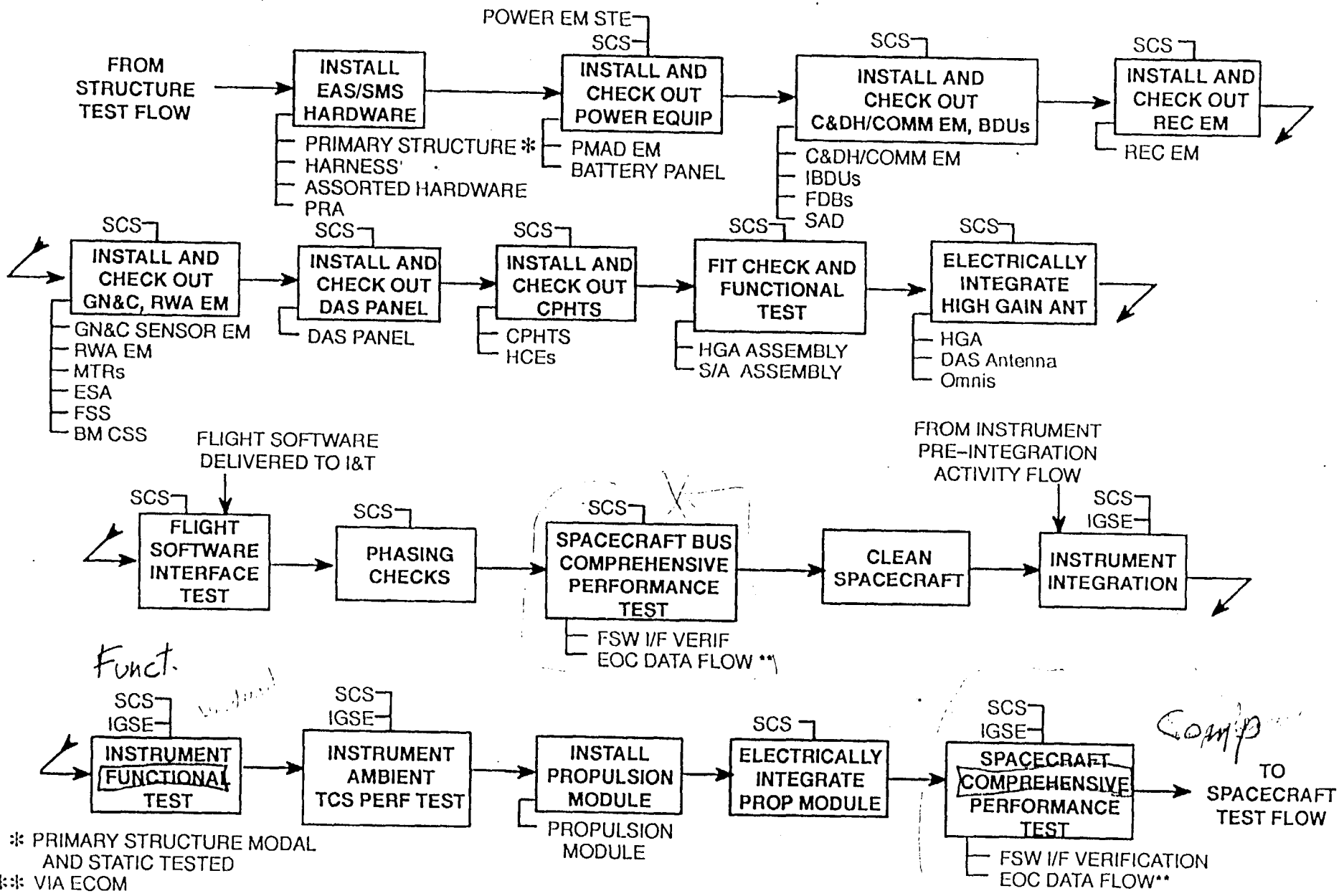


- A preferred instrument installation sequence has been identified:
  - MISR
  - ASTER (VSR, SWIR, others)
  - MOPITT/MODIS (any order after MISR and ASTER)
  - CERES (any order)

Spacecraft Test Flow
Spacecraft Integration Flow

MARTIN MARIETTA

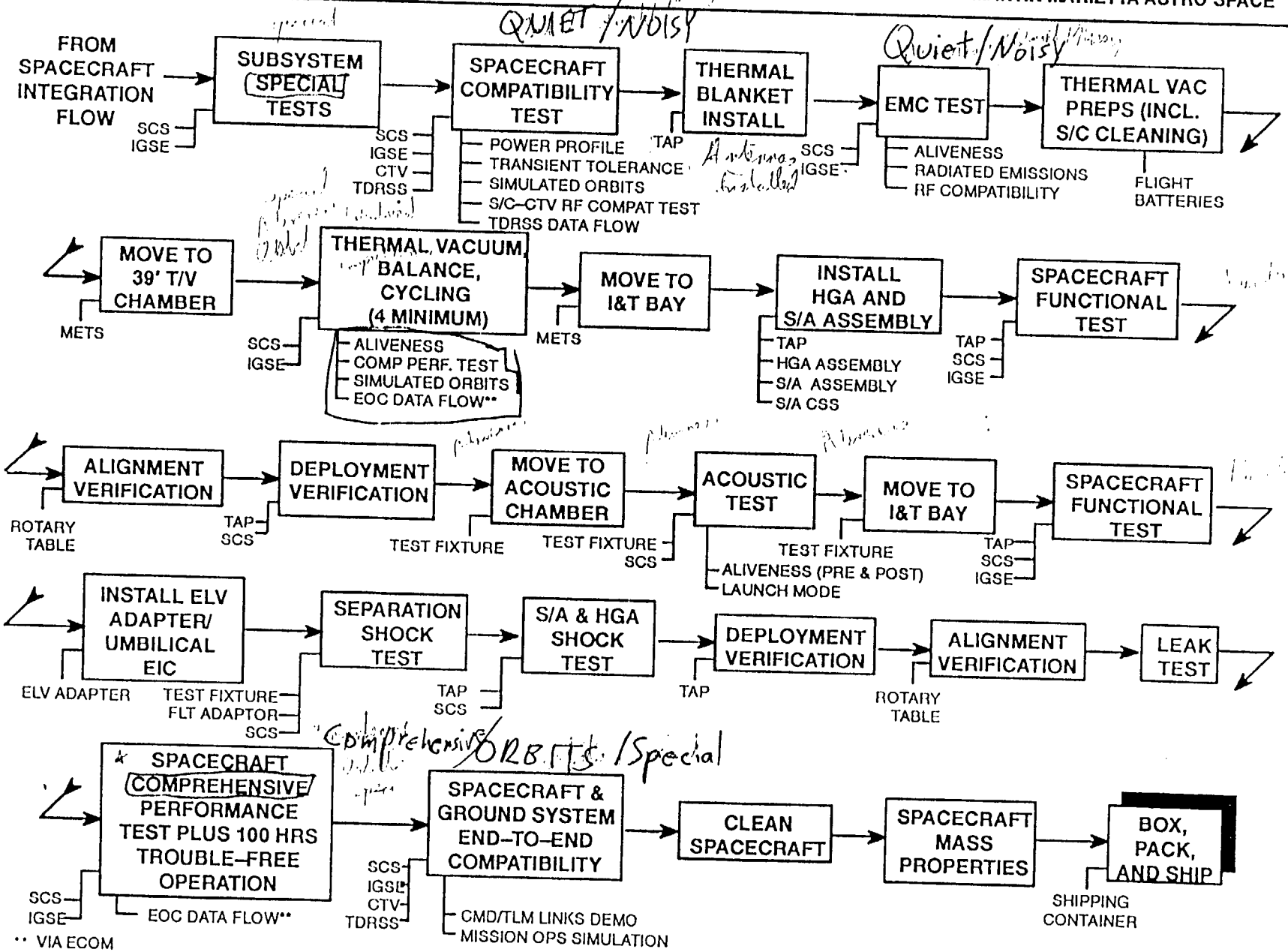
MARTIN MARIETTA ASTRO SPACE



Spacecraft Test Flow

MARTIN MARIETTA

MARTIN MARIETTA ASTRO SPACE



FOS PDR

On December 13-14, Hughes Applied Information Systems held the PDR for the FOS Software.

- Presented top level software design (object oriented design)
- Discussed facilities/LAN/IST
- Went through scheduling, real-time contact, and analysis phases of FOS in detail.

Concerns yet to be addressed:

1. Clear requirements compliance.
2. IST at PDR does more processing than prototype or previous designs.
3. Operational issues such as division of responsibility unclear.

CURRENT AND FUTURE ACTIVITIES

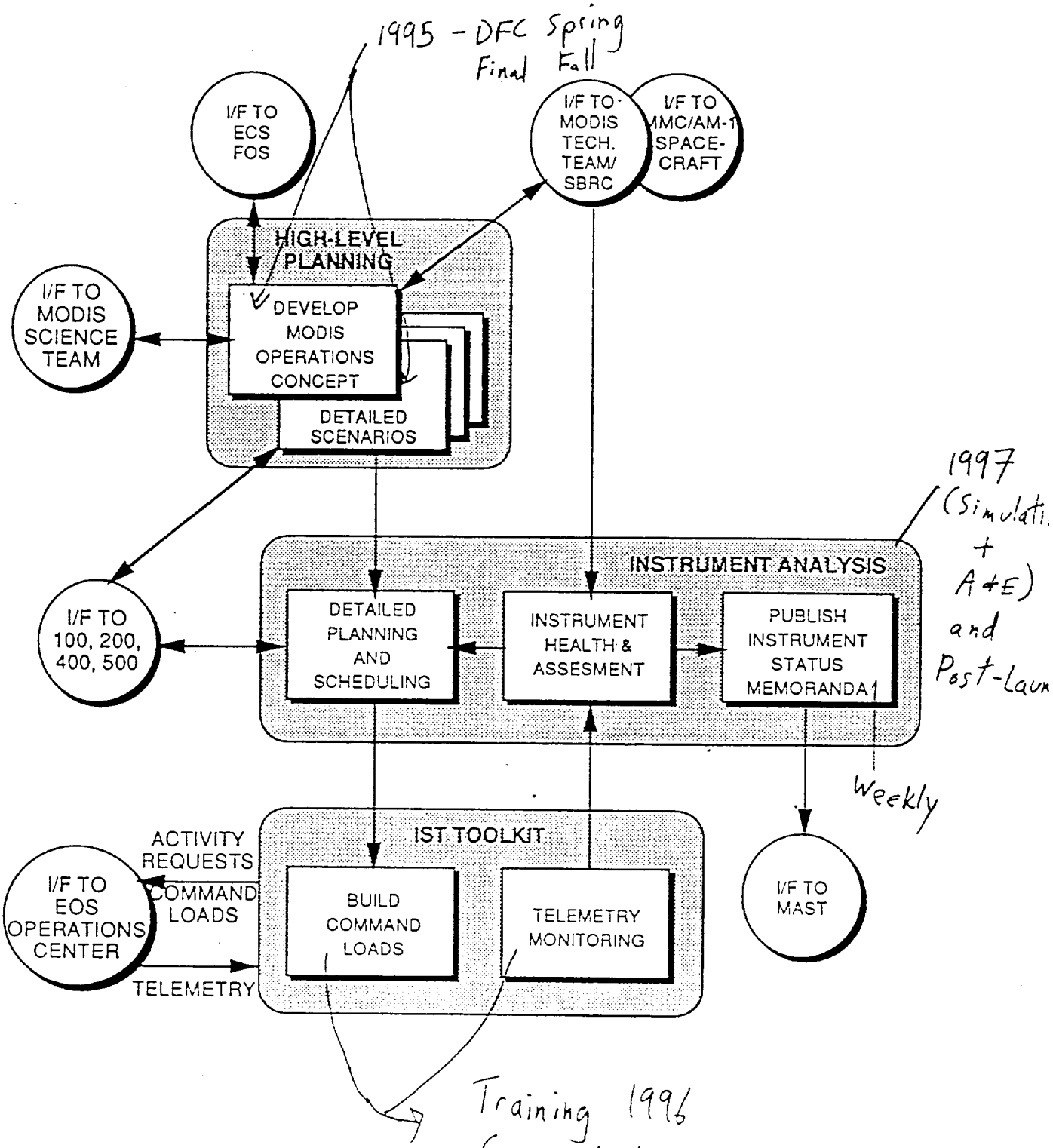
External Milestones

January 1995	Spacecraft CDR
February 1995 (tent)	Instrument FOS workshop
Spring 1995	IFOU/ICD release by MMC
May 1995	Spring Science Team Meeting
June 1995	FOS CDR
Spring 1996	MODIS PFM System Level Tests
Summer 1996	IST HW requirements released
Fall 1996	Release A FOS and IST SW
Spring 1997	S/C I&T System Level Tests
July 1997	Plans for Activation and Evaluation Phase
Fall 1997	Command and Monitoring Simulation
Fall 1997	Release B FOS and IST SW
July 1998	Launch

Activation and Evaluation Phase
Operations Phase

Internal Milestones

MODIS OPERATIONS
WBS 300



MODIS OPERATIONS CONCEPT

Document to complement:

- EOS AM-1 MISSION OPERATIONS CONCEPT *(general and S/C)*
- Operational ICD (combined IFOU/C&T ICD) *(how things work)*
- SBRC CDRL 305 ENGINEERING TELEMETRY DESCRIPTION *(what we work with)*

by being *what we plan to do*

Tentative Outline:

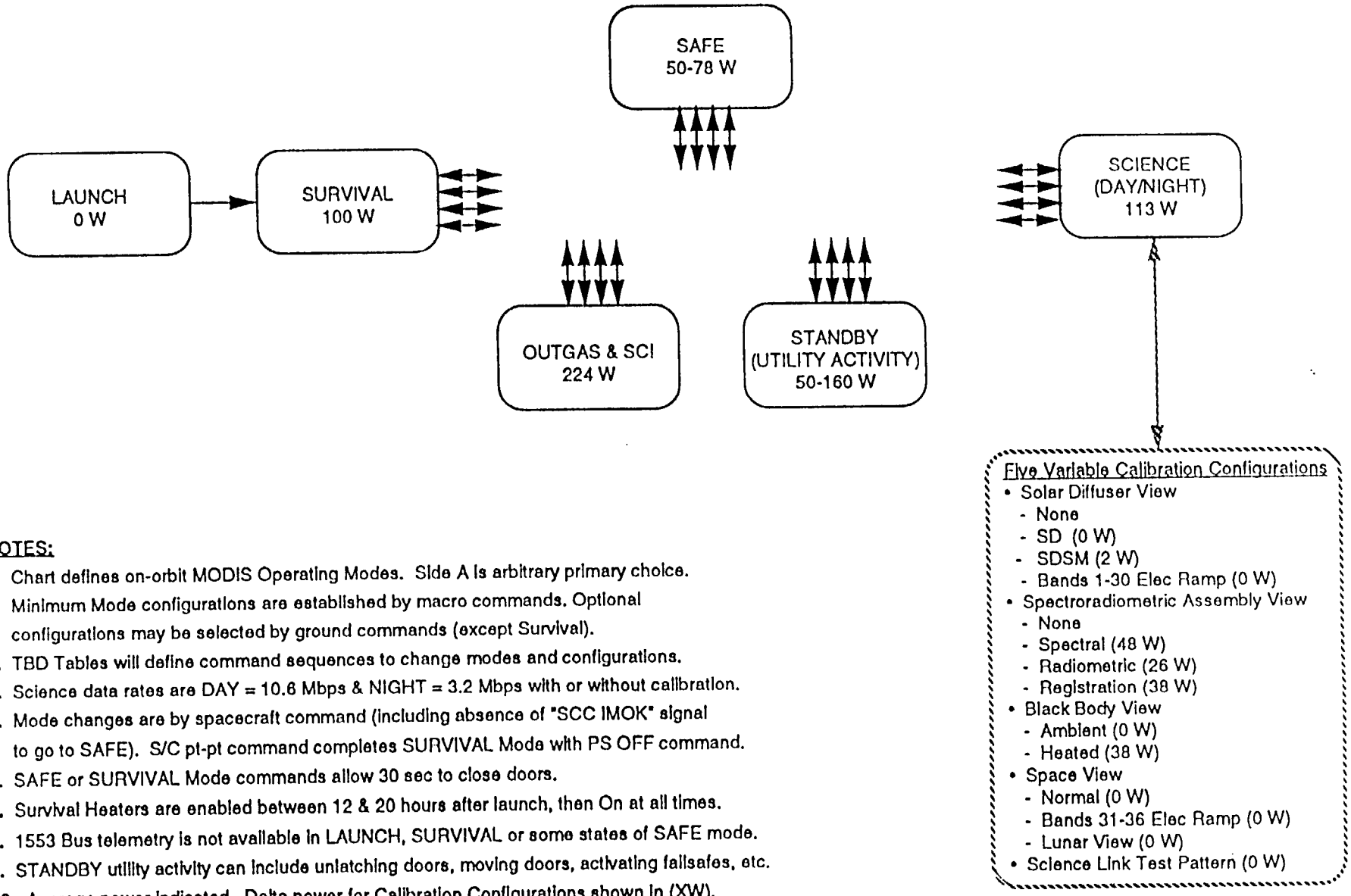
1. Introduction
2. Reference Documents
3. Operational System Description (short)
4. MODIS Instrument Operation Team
    a. Scope of Responsibility
    b. Interactions with FOT/SCF/Science Community
5. Operational Modes
    a. Modes (safe, standby, etc.)
    b. Mode Change triggers
    c. Recovery scenarios
6. Operational Scenarios/Activities
    a. Day/Night modes
    b. Calibration Activities
        command blocks and macros
    c. Typical Orbits
    d. Spacecraft Maneuvers
    e. Field Campaign Support
    f. Memory loads/dumps
    g. Misc. activities
    h. Contingency scenarios
7. Telemetry Monitoring
    a. Critical Health and Safety (Red Alarm)
    b. Health and Safety (Yellow Alarm)
    c. Instrument Performance (trended only)

Appendix A:

Detailed Scenario Command Procedures and Command Blocks including Command Constraints

Appendix B:

Detailed Telemetry Monitoring Requirements



NOTES:

1. Chart defines on-orbit MODIS Operating Modes. Side A is arbitrary primary choice.
2. Minimum Mode configurations are established by macro commands. Optional configurations may be selected by ground commands (except Survival).
3. TBD Tables will define command sequences to change modes and configurations.
4. Science data rates are DAY = 10.6 Mbps & NIGHT = 3.2 Mbps with or without calibration.
5. Mode changes are by spacecraft command (including absence of "SCC IMOK" signal to go to SAFE). S/C pt-pt command completes SURVIVAL Mode with PS OFF command.
6. SAFE or SURVIVAL Mode commands allow 30 sec to close doors.
7. Survival Heaters are enabled between 12 & 20 hours after launch, then On at all times.
8. 1553 Bus telemetry is not available in LAUNCH, SURVIVAL or some states of SAFE mode.
9. STANDBY utility activity can include unlatching doors, moving doors, activating failsafes, etc.
10. Average power indicated. Delta power for Calibration Configurations shown in (XW).

9/94

Figure ~~12~~ 4 MODIS Operational Mode Flow

Command Macro Example:
(building blocks or individual commands)

BB_Heat
BB_off

Building Block Example:

Block Name:	BB_Heat
Description:	Turns BB Heater On
User Defined Variables:	Time Heater Turned On
Prerequisites:	BB Heater Off (CR_BB_HTR_OFF)
Constraints:	Inst_Temp < 300 K Time_Off > 300 minutes
Telemetry Final State:	CR_BB_A_PWR_ON (1) TP_BB_TEMP01 = 315 K (2)
Failure Contingency:	If not (1) or not (2) then send BB_off and send message to IOT
Command List:	TBD

Pseudo-Telemetry Points:

Inst_Temp = average (TP_MF_CALBKHD_SR, TP_MF_OB_BLKHD)
Time_Off = time since CR_BB_HTR_OFF telemetry signal received

Monitoring Example:

If Inst_Temp > 307 K (predicted mission high), Yellow Alert

SUMMARY

Still getting scope/management issues squared away.

Interactions with SBRC/MMC/FOT/FOS beginning.

Operations Concept the immediate task.

Operations Activity will expand as IST firms up; instrument testing occurs (command procedures, telemetry monitoring become available).

OASIS-trained personnel will be needed substantially before launch.

While much work is coming, we are currently slightly ahead of the curve.