GSFC 421-11-19-03

OPERATIONS INTERFACE CONTROL DOCUMENT (OICD),

EARTH OBSERVING SYSTEM AM SPACECRAFT TO THE ADVANCED SPACEBOURNE THERMAL EMISSION AND REFLECTION RADIOMETER (ASTER)

EOS AM PROJECT

January 1997

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Operations Interface Control Document (OICD), Earth Observing System AM Spacecraft to the Advanced Spaceborne Thermal Emission and Reflection Radiometer [ASTER]

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1 INTRODUCTION

1.1 Purpose

The Operations Interface Control Document (OICD), 2000881? represents an agreement of the detailed implementation of the operations-related interfaces of the Advanced Spaceborne Thermal Emission and Reflection Radiometer[ASTER] with the Earth Observing System (EOS) AM-1 Spacecraft Flight Segment and Ground Segment. Its purpose is to provide to the Integration and Test (I&T) personnel, the ASTER Operation Team(AOT), and the Flight Operations Team (FOT), an understanding of how the instrument is operated and how its operation and performance is monitored. In addition, the OICD is the vehicle for defining agreements among these organizations.

The OICD, together with the Mechanical Interface Control Drawing (MICD) Drawing, 20008811; MICD Tables, 20008812; Thermal Interface Control Drawing (TICD), 20008813; Electrical Interface Control Drawing (EICD) Tables, 20008815; Command and Telemetry Interface Control Drawing(C&T ICD), 20008817 and Integration and Test Interface Control Drawing (I&T ICD), 20008816; describe the details of the interfaces between the EOS AM-1 Spacecraft and ASTER. The top-level instrument Interface Control Drawing (ICD), 20008810, provides the instrument ICD tree and revision status for all sub-tier instrument ICDs.

1.2 Scope

The OICD describes the instrument characteristics affecting the I&T, launch, and on-orbit operations activities of the EOS AM-1 program. Descriptions of the Flight and Ground Segments are limited to that required to provide an understanding in the operational context.

The OICD represents agreement of and is the defining document for:

1. Responsibilities of the organizations involved in instrument operations and related activities
2. Information to be used and exchanged among these organizations, its format and schedule

1.3 Organization

Section 1	provides a brief description of the document's purpose, scope, and organization.
Section 2	provides a list of the documents referenced in the text and their sources.
Section 3	provides a brief description of the Flight and Ground Segments.
Section 4	provides a description of system operations for I&T, flight, and ground operations and provides a description of organizational responsibilities.
Appendix A	defines the information to be exchanged among the various organizations.
Appendix B	defines constraints associated with operating the instrument.
Appendix C	describes the ASTER Operations Team's input to ground system requirements documentation for planning and scheduling aids requirements and facility requirements.
Appendix D	documents additional operational agreements for ASTER.
Appendix E	defines key terms and concepts used throughout this document.

2 REFERENCE DOCUMENTS

The following documents provide additional information relative to the ASTER operations-related interfaces. The information contained in these documents is deemed to be supplemental in nature and hence is not included herein. The latest versions of these documents are the most relevant.

GSFC 420-03-02	General Instrument Interface Specification
GSFC 421-12-11-01	Unique Instrument Interface Document (UIID) Advanced Spaceborne Thermal Emission and Reflection Spectrometer (ASTER)
GSFC 421-13-10-01	EOS AM-1 Mission Operations Concept
GSFC (TBD 1), Draft	EOS AM-1 Detailed Mission Requirements
Hughes 604-CD-003-002	ECS Operations Concept Document
Hughes 194-209-SE2-004	Data Format Control Document for the Earth Observing System (EOS) AM-1 Project Data Base
Hughes 304-CD-001-002	FOS Requirements Specification
Hughes 305-CD-001-002	FOS Design Specification and Database Designs Schema Specification
Hughes 209-CD-002-003	ICD Between EOSDIS Core System (ECS) and ASTER Ground Data System
Hughes 196-00602TPW	IST Capabilities Document
LMMS 20043204	EOS-AM Database and Test Procedure Practices, Standards, and Conventions
LMMS EOS-DN-SE&I-001, Rev. C	System Operating Modes
LMMS EOS-DN-SE&I-056	Mission Timeline
LMMS 20008817	ASTER Command & Telemetry ICD

3 SYSTEM DESCRIPTION

A brief description of the flight and ground segments is provided in this section for context in understanding the OICD. For further details on the instrument, spacecraft or ground system refer to LMMS 20008817, LMMS EOS-DN-SE&I-001 and Hughes 304-CD-001-002 respectively.

3.1 EOS AM-1 SPACECRAFT DESCRIPTION

The spacecraft (S/C) is composed of five instruments and nine S/C bus subsystems. The instrument suite consists of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Clouds and the Earth's Radiant Energy System (CERES), Multi-Angle Imaging Spectro Radiometer (MISR), Moderate Resolution Imaging Spectroradiometer (MODIS) and Measurements of Pollution in The Troposphere (MOPITT). The S/C bus subsystems are the Command and Data Handling Subsystem (C&DHS), Communication Subsystem (COMMS), Structures and Mechanisms Subsystem (SMS), Electrical Accommodation Subsystem (EAS), Electrical Power Subsystem (EPS), Flight Software System (FSWS), Guidance, Navigation, and Control Subsystem (GN&CS), Propulsion Subsystem (PROPS), and Thermal Control Subsystem (TCS).

The principal relationships among the instruments and subsystems are indicated in the EOS AM-1 S/C Functional Block Diagram, Figure 1. The components of the S/C are described in the following sections of this document.

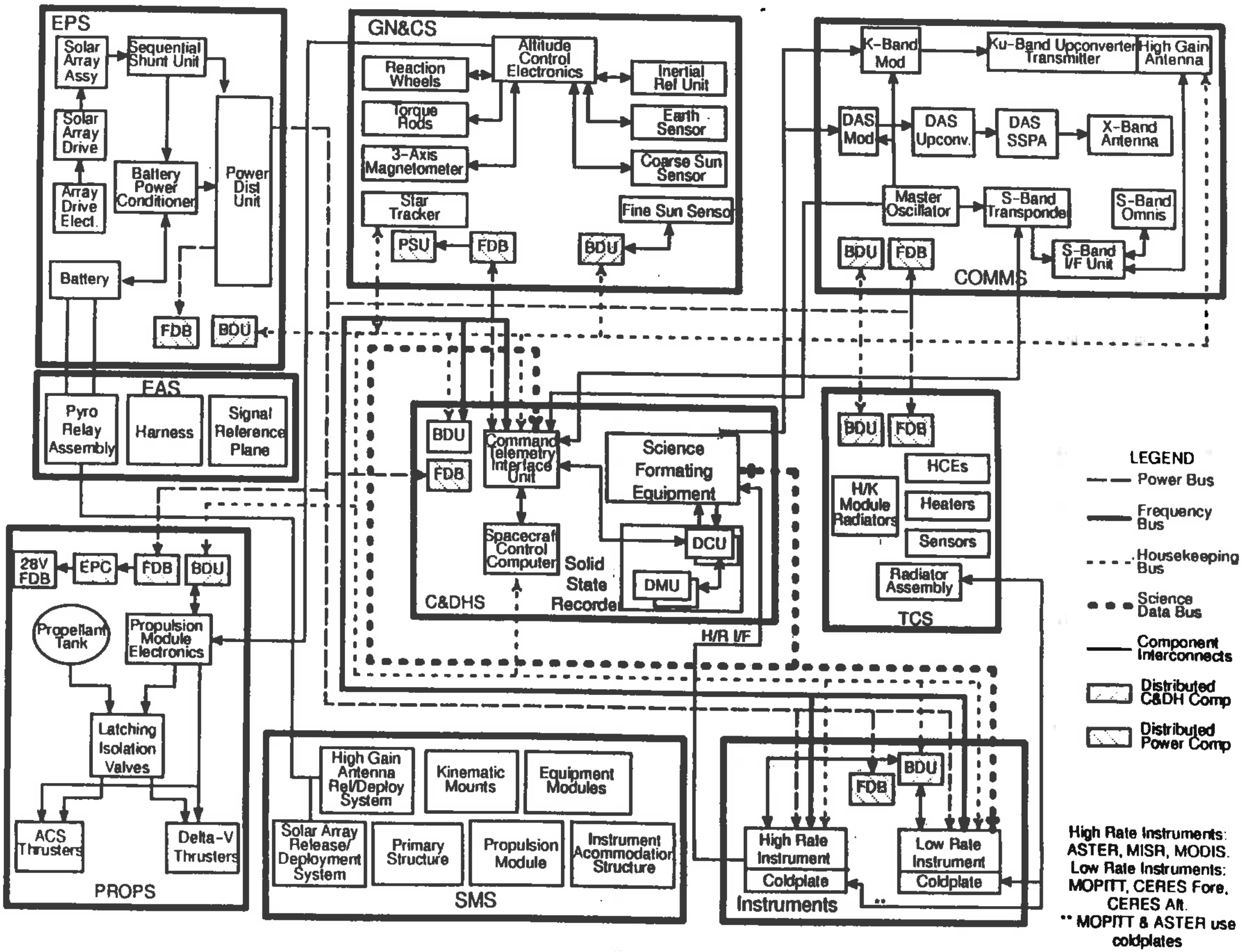

Figure 1. EOS AM-1 Spacecraft Functional Block Diagram

3.1.1 Instrument Description

ASTER operates in three visible and near infrared channels, six shortwave infrared channels, and five thermal infrared channels. The instrument acquires data over a 60–km swath whose center is pointable crosstrack +/– 8.55 degrees in the Short Wave Infrared Radiometer (SWIR) and Thermal Infrared Radiometer (TIR), with the Visible and Near Infrared Radiometer (VNIR) pointable out to +/–24 degrees. In addition to the three instrument subsystems (VNIR, SWIR, and TIR) the ASTER includes a Common Signal Processor (CSP) and the Master Power Supply (MPS).

The VNIR consists of two telescopes––one nadir–looking with three–spectral band detectors, and the other backward–looking with a single–band detector. The backward–looking telescope provides a second view of the target area in Band 3 for stereo observations. Thermal control of the detectors is provided by a local mode (VNIR Heater control Unit). Cross–track pointing is accomplished by rotating the entire telescope assembly. Two on–board halogen lamps are used for calibration of the nadir–looking detectors. This calibration source is always in the optical path.

The SWIR cross–track pointing is accomplished by a pointing mirror. Two on–board halogen lamps are used for calibration, however, the pointing mirror must turn to see the calibration source. Thermal control of the detectors is provided by a cold plate.

Unlike the other instrument subsystems, the TIR has a "whiskbroom" scanning mirror. The scanning mirror functions both for scanning and cross–track pointing. During calibration, the scanning mirror rotates 90 degrees from the nadir position to view an internal black body. Thermal control of the detectors is provided by a cold plate.

The following pages depict the ASTER instrument as well as provide a functional block diagram. The reader should refer to the Mechanical Interface Control Document Drawings (EOS library #5184) for a description of the mechanical configuration. The reader should refer to the ASTER C&T ICD (LMMS 20008817) for a description of the instrument command and telemetry definitions.

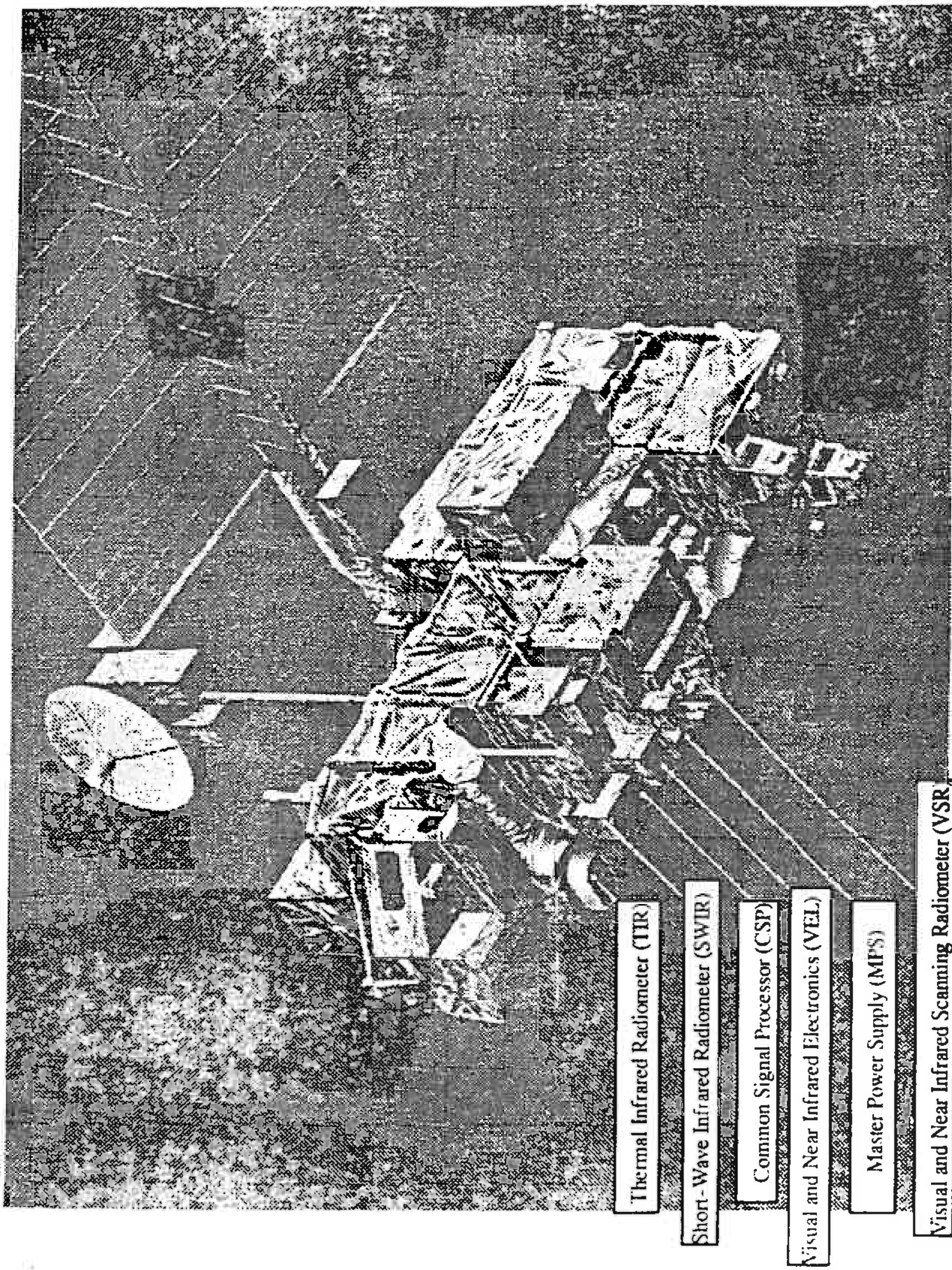

Figure 2. Earth Observing System AM-1 Spacecraft (EOS-AM1)

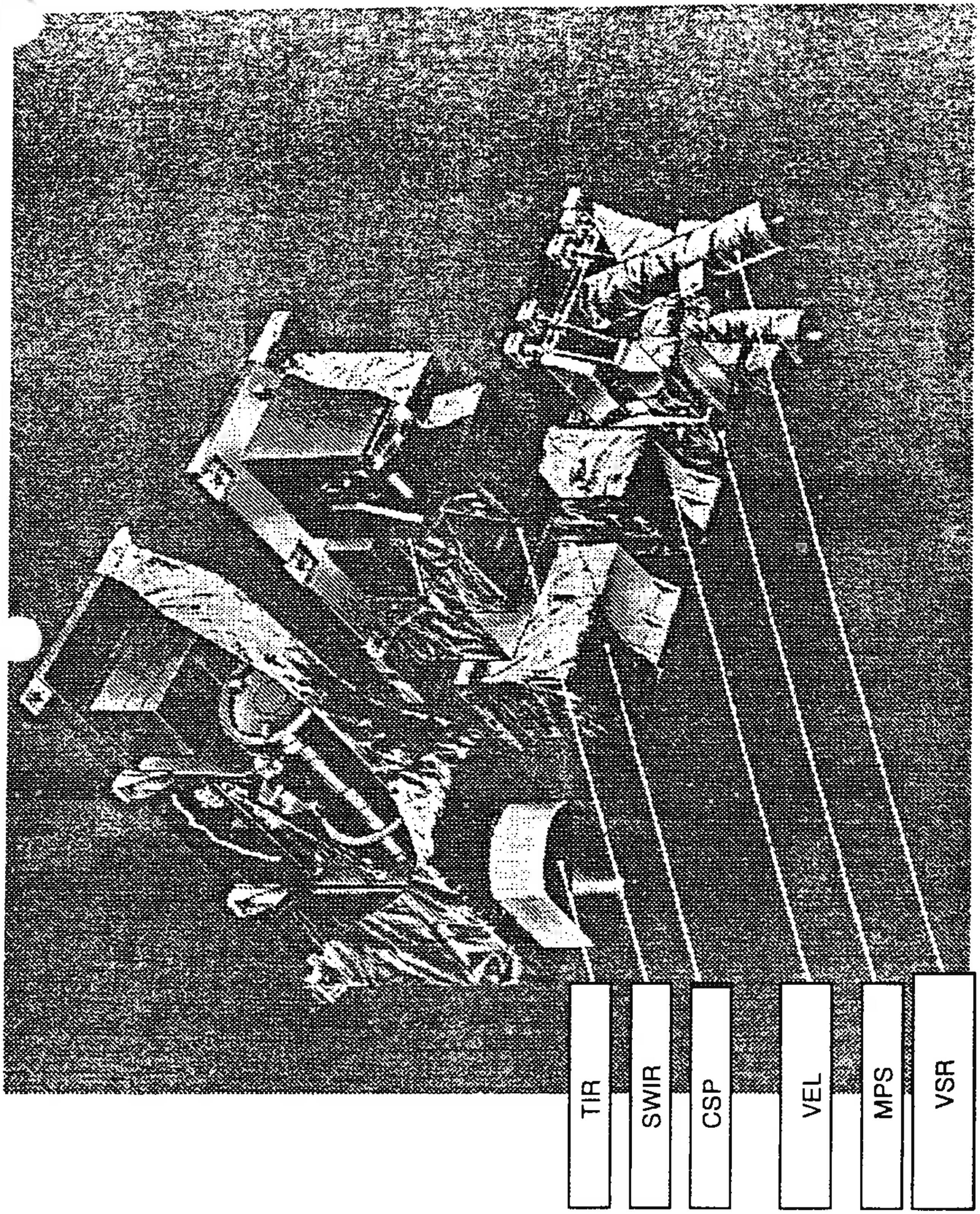

Figure 3. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

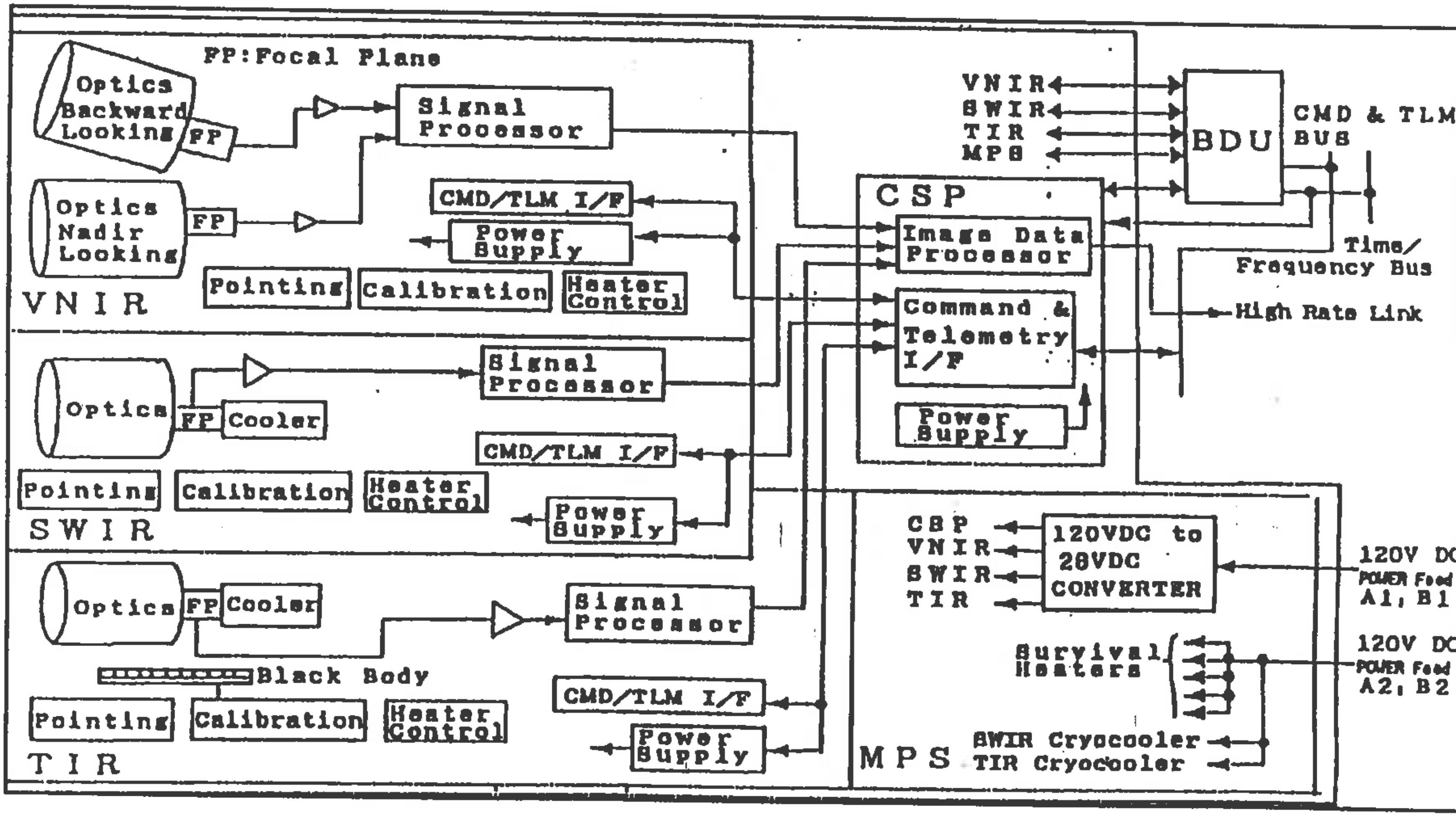

Figure 4. ASTER Block Diagram

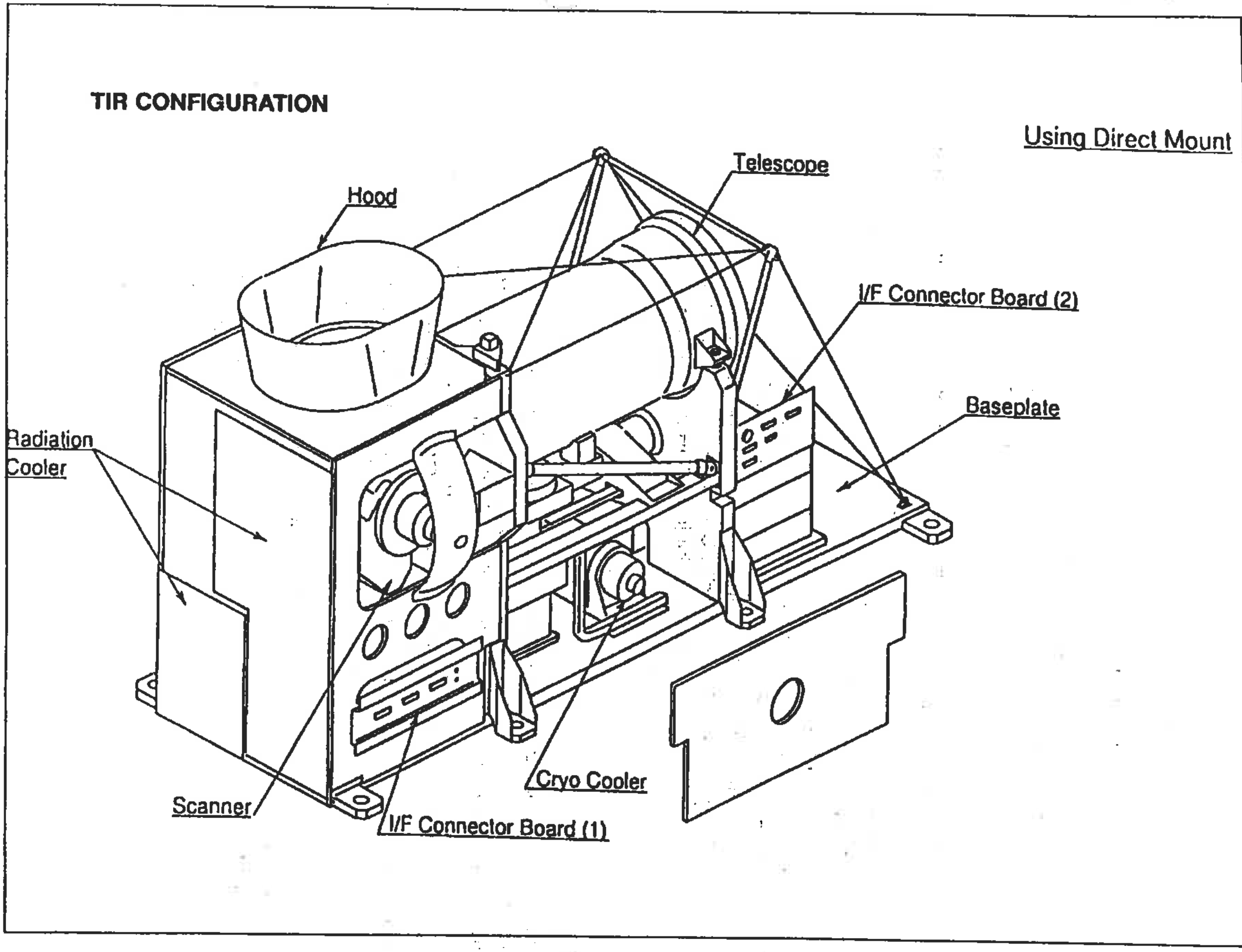

Figure 5. TIR Configuration

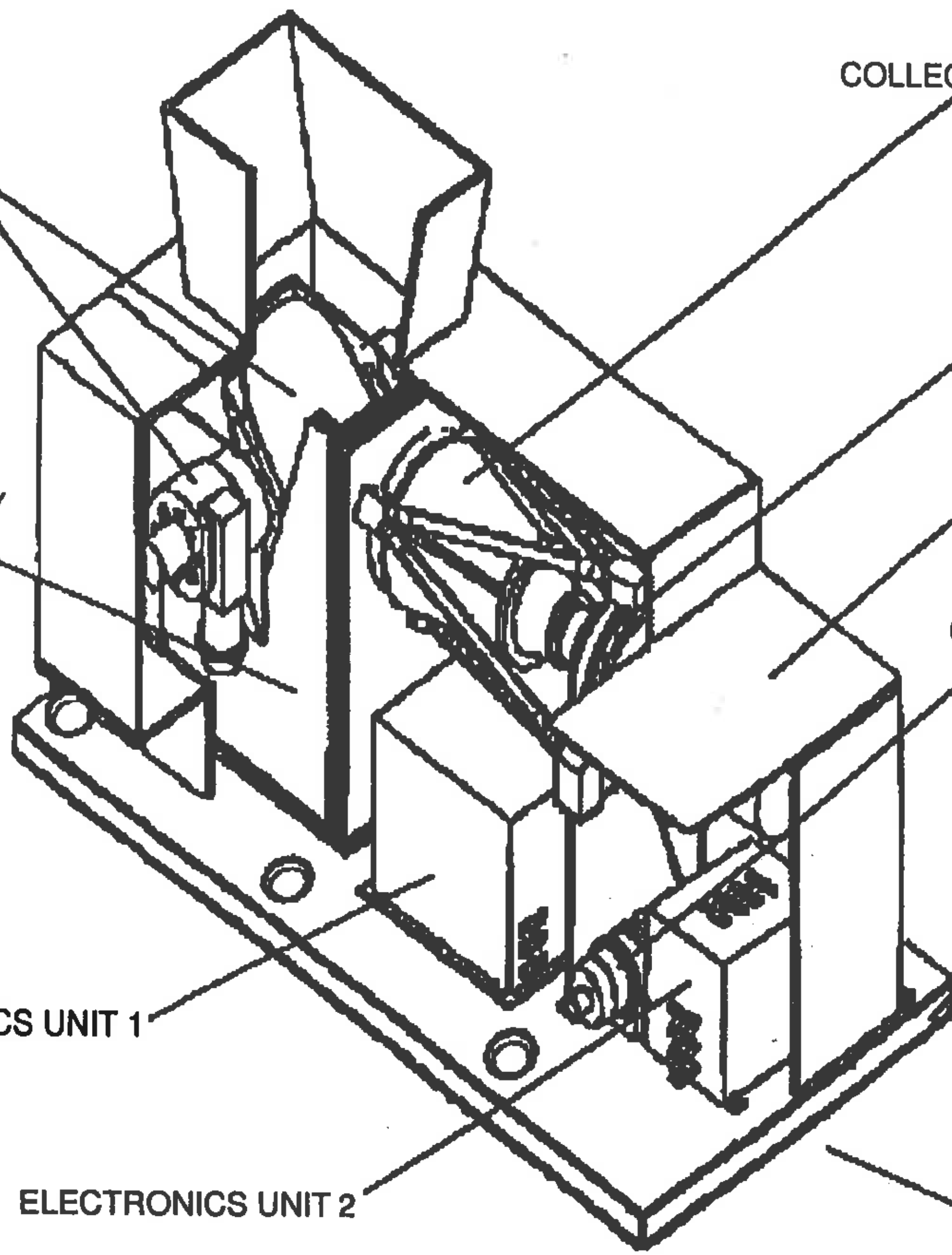

Figure 6. SWIR Configuration

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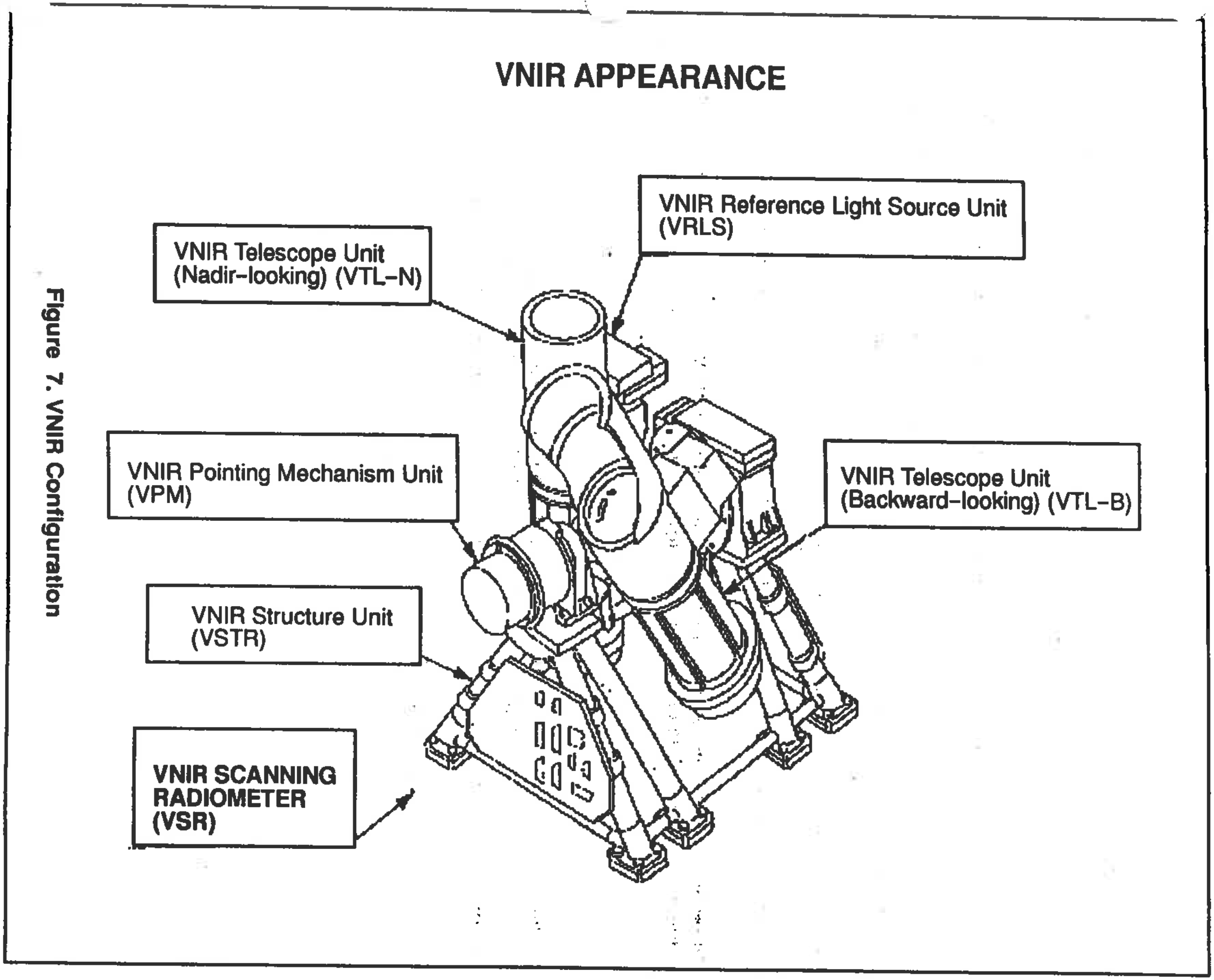


Figure 7. VNIR Configuration

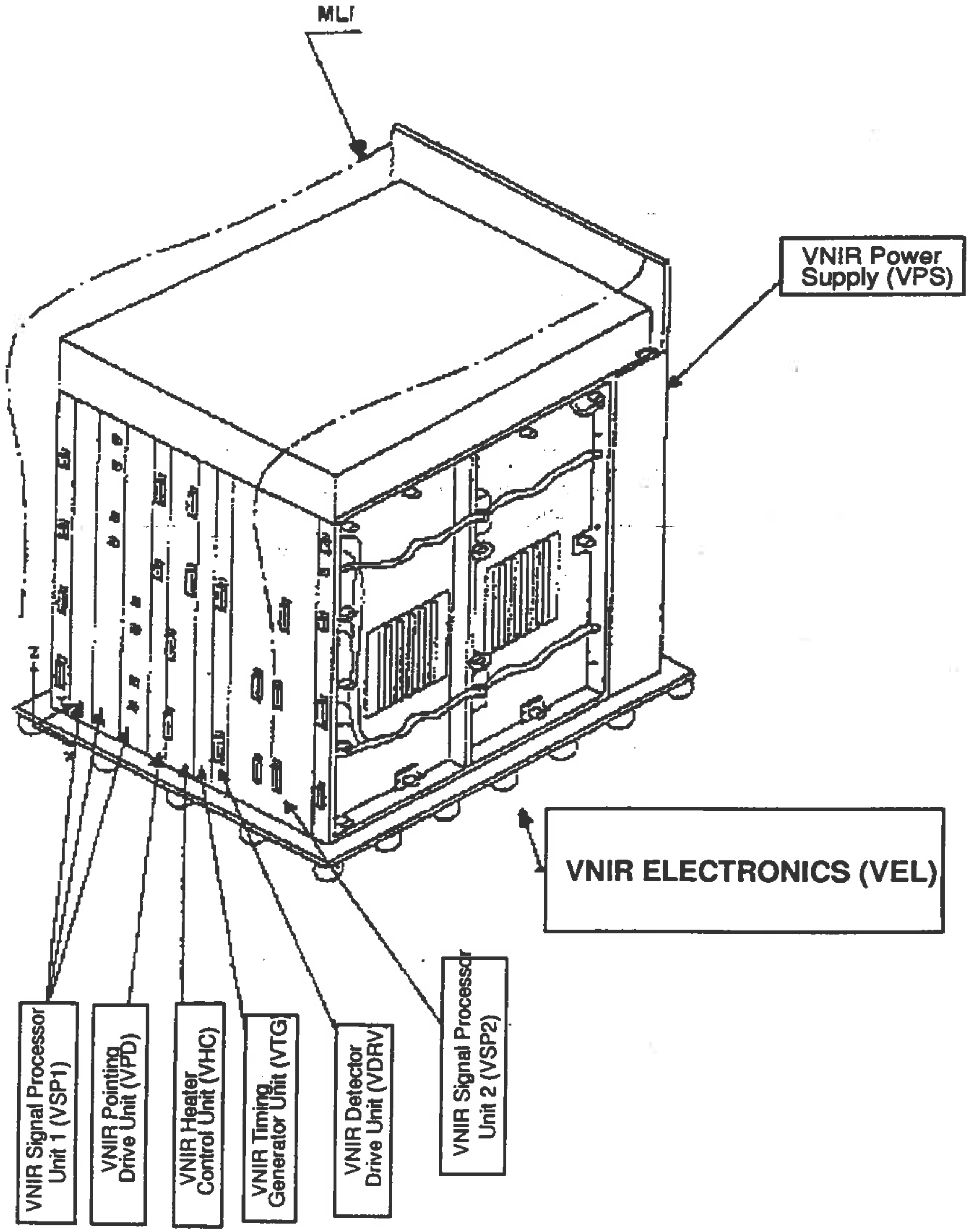


Figure 8. VNIR Electronics Configuration

3.1.2 Spacecraft Bus Description

A brief description of the S/C C&DHS and COMMS is provided in this section for context. For further details on the S/C system refer to GSFC 421-13-10-01.

3.1.2.1 Command and Data Handling Subsystem

The C&DHS provides the following functions: command and telemetry (C&T) handling; C&T Bus Controller (BC); science data collection, formatting, storage and routing; the computing services to support S/C navigation, attitude determination and control, time management, and power and thermal control; and system level Failure Detection, Isolation and Recovery (FDIR). It is responsible for the baseband handling of all uplinked messages received from the COMMS and for coordinating the telemetering of all S/C and instrument-generated data to be downlinked through the COMMS or hard-lines. The C&DHS is distributed throughout the S/C with interfaces to all S/C subsystems and instruments. The major components of the C&DHS are: the Spacecraft Controls Computer (SCC), the Command and Telemetry Interface Unit (CTIU), the Science Formatting Equipment (SFE), the Solid State Recorder (SSR), and the Bus Data Units (BDUs).

3.1.2.1.1 Spacecraft Controls Computer

The SCC is the central computer on board the S/C. The SCC provides the hardware, software and firmware support for control of onboard operational processes. The primary function of the SCC is to monitor and control S/C bus subsystems and instrument operations. The SCC Flight Software (FSW) provides services to the instruments as described in the Baseline Description Document. This document addresses the following set of services provided to the ASTER instrument:

a. Storage and controlled distribution of Absolute Time Commands (ATCs) (i.e., commands distributed by the SCC at the time specified by an associated time–tag.)

b. Storage and controlled distribution of Relative Time Command Sequences (RTCSs): (Each command in an RTCS has an associated time delay which indicates the maximum amount of elapsed time between the issuance of the command and the previous command in the RTCS.)

c. Telemetry Monitor (TMON) functions.

ASTER TMON, ATC and RTCS usage, are defined in Section 4.

3.1.2.1.2 Command and Telemetry Interface Unit

The CTIU receives, processes and distributes ground commands, and all commands emanating from the SCC. In addition, the active CTIU gathers spacecraft telemetry data (H/K and H&S) through the C&T Bus and formats the data for output to the SSR and the S–Band Transponder.

3.1.2.1.3 Science Formatting Equipment

The SFE provides the capability to transfer: high rate instrument and Low Rate Science (LRS) Bus data to the SSR for recording; playback/real-time science data to the Ku-Band; real-time MODIS and ASTER instrument data to the Direct Access System (DAS); and playback science data to the DAS.

3.1.2.1.4 Solid State Recorder

The SSR is a high-capacity solid state unit for storage and retrieval of science and H/K data. The SSR is capable of simultaneously recording and playing back science data via an interface with the SFE. Concurrently, the SSR is capable of recording or playing back H/K telemetry data via an interface with the CTIU. The SFE and CTIU interfaces operate independently of each other.

The SSR records the most recent H/K data in a circular buffer which can be played back upon ground command. Nominally, the H/K data are continuously recorded and not played back, unless the H/K data (part of LRS Bus data) cannot be retrieved by playing back the LRS buffer via the Ku-Band downlink.

The SSR receives science data, sorts and records science data in separate logical circular data buffers according to the Virtual Channel Identifier (VCID) of the data source. The four ASTER VCIDs are stored in one buffer, and MODIS, MISR and the LRS Bus (containing CERES, MOPITT, ancillary, and H/K data) each have a buffer. Once recorded, the data remain in the buffer until overwritten by new data. SSR overwrite protection may be selected for a particular buffer to prevent the data from being overwritten. Normal SSR operation is to record all science data with the SSR always in Record mode, the overwrite protection not selected, and the SSR data input being determined by the the respective instrument operations teams.

The size of the ASTER Solid State Recorder buffer at beginning of life will be 70 supersets (i.e., 102.36 Gigabits).

3.1.2.1.5 Bus Data Unit

The BDUs provide monitoring and control services to their associated instruments or S/C components. The interfaces with the instruments permit the BDU to (1) send relay drive commands, (2) sample active/passive analog telemetry, and (3) sample active/passive bi-level telemetry.

ASTER shares a BDU with the two CPHTS systems for TIR and SWIR. The ASTER BDU interface allocations are specified in the C&T ICD.

3.1.2.2 Communications Subsystem

The COMMS supports the S/C H/K function by providing command reception, telemetry transmission and navigation services and supports the science data services by providing encoding, modulation, and transmission functions. The COMMS also contains the Master Oscillator (MO) which drives S/C time and provides a precision frequency source to all instruments and other subsystems requiring it.

The three elements of the COMMS are the S-Band, the Ku-Band, and the Direct Access System (DAS)(X-Band). A block diagram of the COMMS is provided in Figure 9. COMMS links between the EOS AM-1 S/C and external elements are shown in Figure 10.

The primary on-orbit command uplink path is via the TDRSS S-Band single access (SSA) service with ground network (GN) services available as an emergency backup.

The primary on-orbit H/K telemetry path is via the TDRSS SSA return service with GN services available as an emergency backup. Operationally the real-time H/K telemetry is downlinked at 16 kbps via S-Band using the high gain antenna (HGA) during the nominal SSA contacts. In a diagnostic mode SCC dump or recorded H/K telemetry is transmitted via the HGA. During periods when the HGA is not available health and safety (H&S) telemetry is downlinked using the TDRSS SSA service via one of the omni antennas.

The primary science data return link via the TDRSS Ku-Band Single Access (KSA) service utilizes the HGA and high-rate modulator. An average of 20 minutes of TDRSS KSA service is scheduled per orbit for normal mission operations.

The DAS provides real time transmission of science data for MODIS and ASTER to direct access user ground stations via two types of services, Direct Broadcast (DB) and Direct Downlink (DDL). Normal operation is to configure the DAS for continuous operation in the DB mode, providing uninterrupted output of real-time MODIS science data along the orbital path. The DAS can be commanded to DB/DDL mode to provide direct-to-user ASTER science data, in addition to the MODIS data on the X-Band. Additionally the DAS can be used to downlink playback science data to designated ground stations [direct playback (DP)].

3.2 GROUND SEGMENT DESCRIPTION

The EOS ground system provides the command and control of the EOS AM-1 S/C. In addition, it provides the Earth sciences community with a variety of data products obtained from the EOS missions.

A brief discussion of the Flight Operations Segment of the EOS Core System is provided below. Further information may be found in the FOS Requirements Spec for ECS, Volume 1 General Requirements (Hughes 304-CD-001-002), and in the FOS Design Specification and FOS Database Design and Database Schema Specs (Hughes 305-CD-001-002).

3.2.1 Flight Operations Segment

The FOS provides the operations center for the EOS AM-1 S/C. The FOS consists of two elements: the EOC and the Instrument Support Toolkit (IST). The EOC facility, located at Goddard Space Flight Center (GSFC), serves as the focal point for EOS AM-1 S/C operations. The IST is a software package that provides the AOT with real-time and off-line access to the EOC resources.

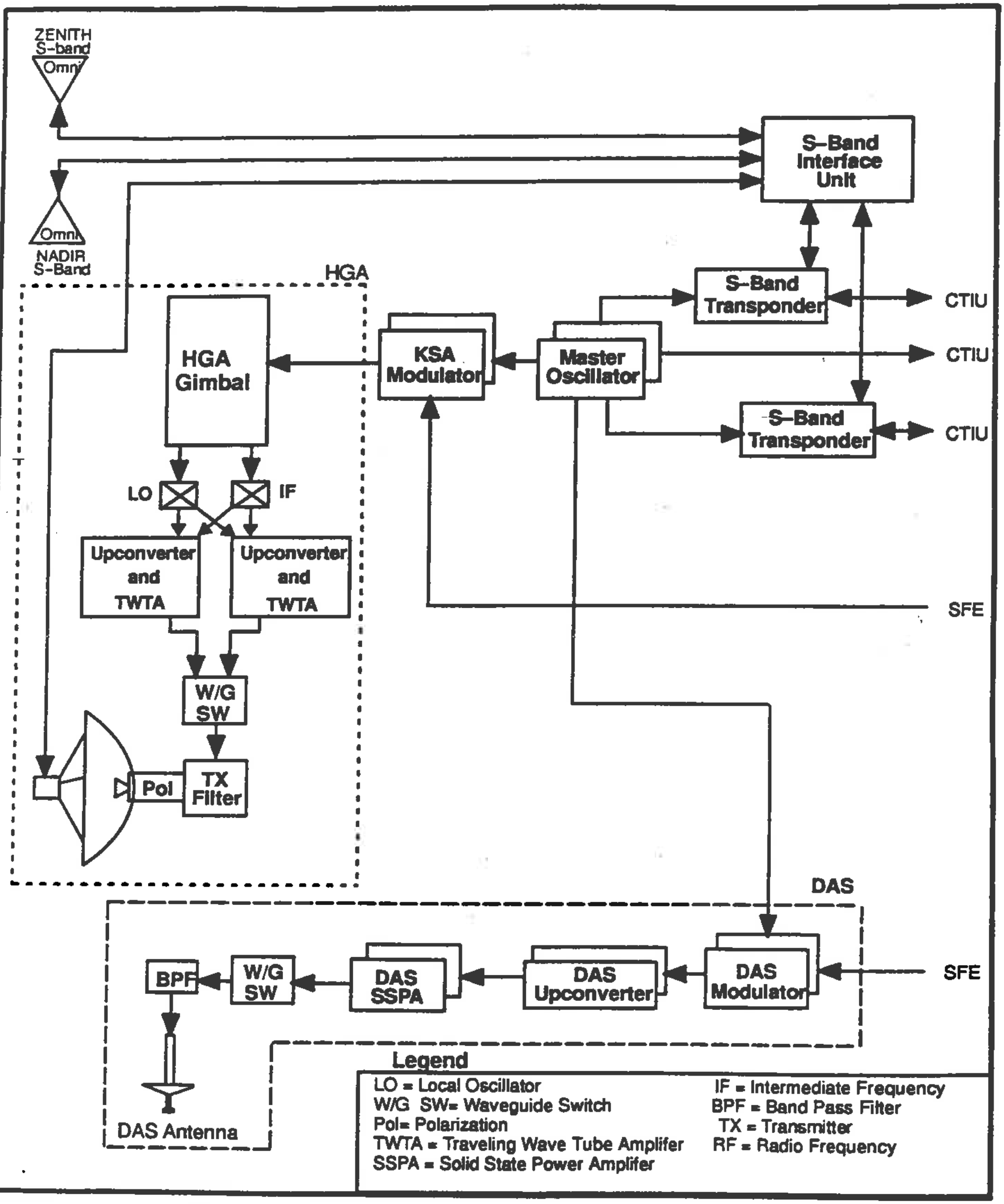


Figure 9. Communications Subsystem Block Diagram

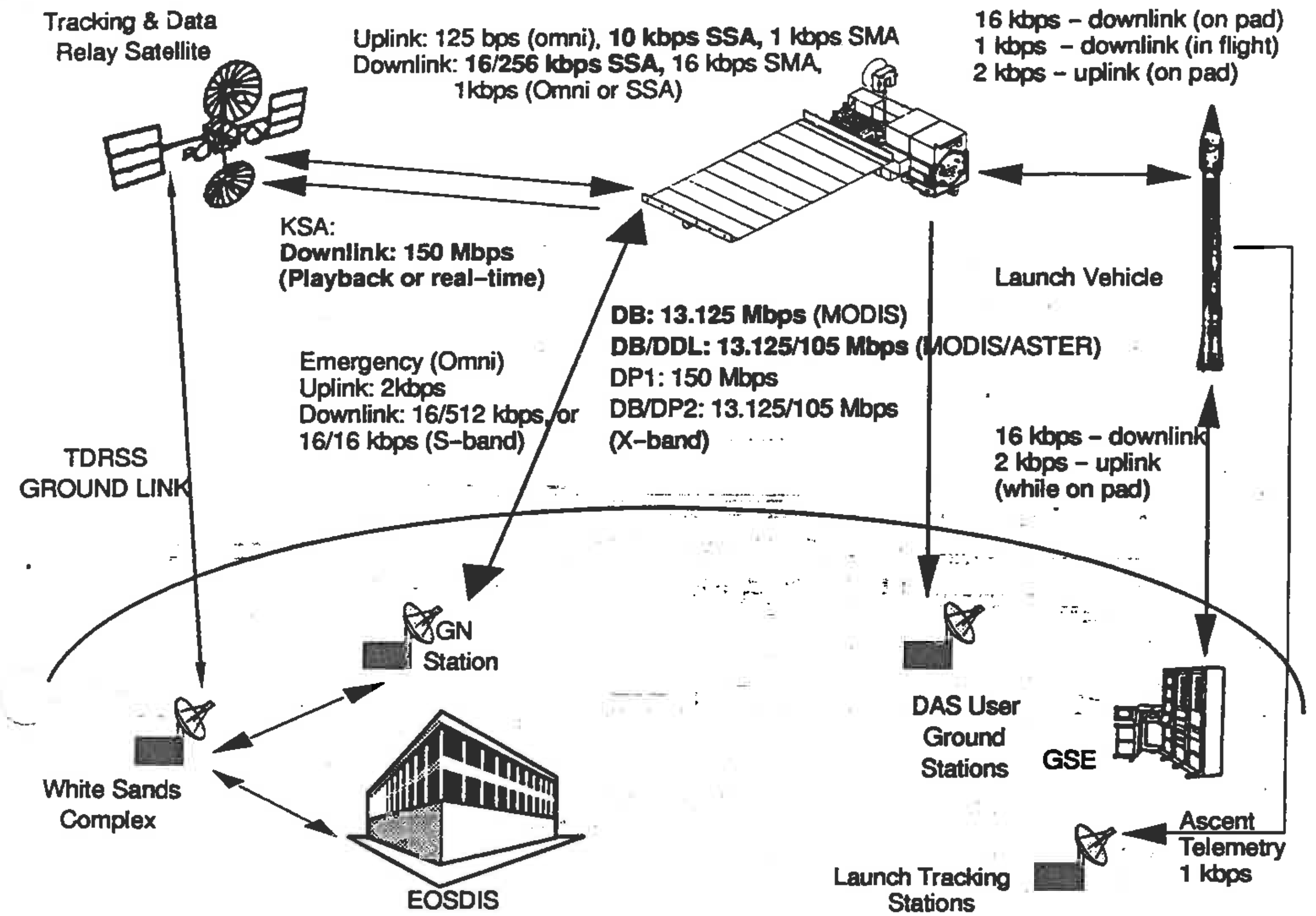


Figure 10. Communications Subsystem: Links

Detailed information regarding the design and functionality of the EOSDIS Core System Flight Operations Segment is provided in Hughes 311–CD–001–002.

FOS consists of nine distinct subsystems: Planning and Scheduling; Command Management; Command; Telemetry; Analysis; Resource Management; Real–Time Contact Management; Data Management; and User Interface. Individually, these subsystems perform specific, unique functions; collectively, they provide a set of interrelated functions for the FOT and the IST user community.

3.2.2 ASTER Ground Data System

The operations portion of the ASTER Ground Data System, the ASTER Operations Segment (AOS) consists of the Instrument Control Center (ICC) and the Japanese Instrument Support Terminal (IST).

3.2.2.1 Instrument Control Center

The Instrument Control Center consists of the following subsystems:

a) AOS System Management (ASM),

b) Instrument Control Operations Subsystem (ICOS)

c) Instrument Analysis Support Subsystem (IASS)

The purpose of the ASM is to provide resource management, database management, and security management. The purpose of the ICOS is to provide acceptance of observation requests and to perform instrument planning and scheduling. The purpose of the IASS is to provide instrument status monitoring, off line analysis, and image monitoring.

3.2.2.2 ASTER GDS – Instrument Support Terminal

The purpose of the IST is to provide scheduling support and instrument anomaly information. It is a key element in ensuring the integrity of the instrument operation and mission scheduling from a science perspective. It is used to connect the ASTER Science Team Leader, the U. S. Science Team Leader, and the Science Schedule Support Group to the ICC.

The following 2 pages show an overview of the ASTER Ground Data System.

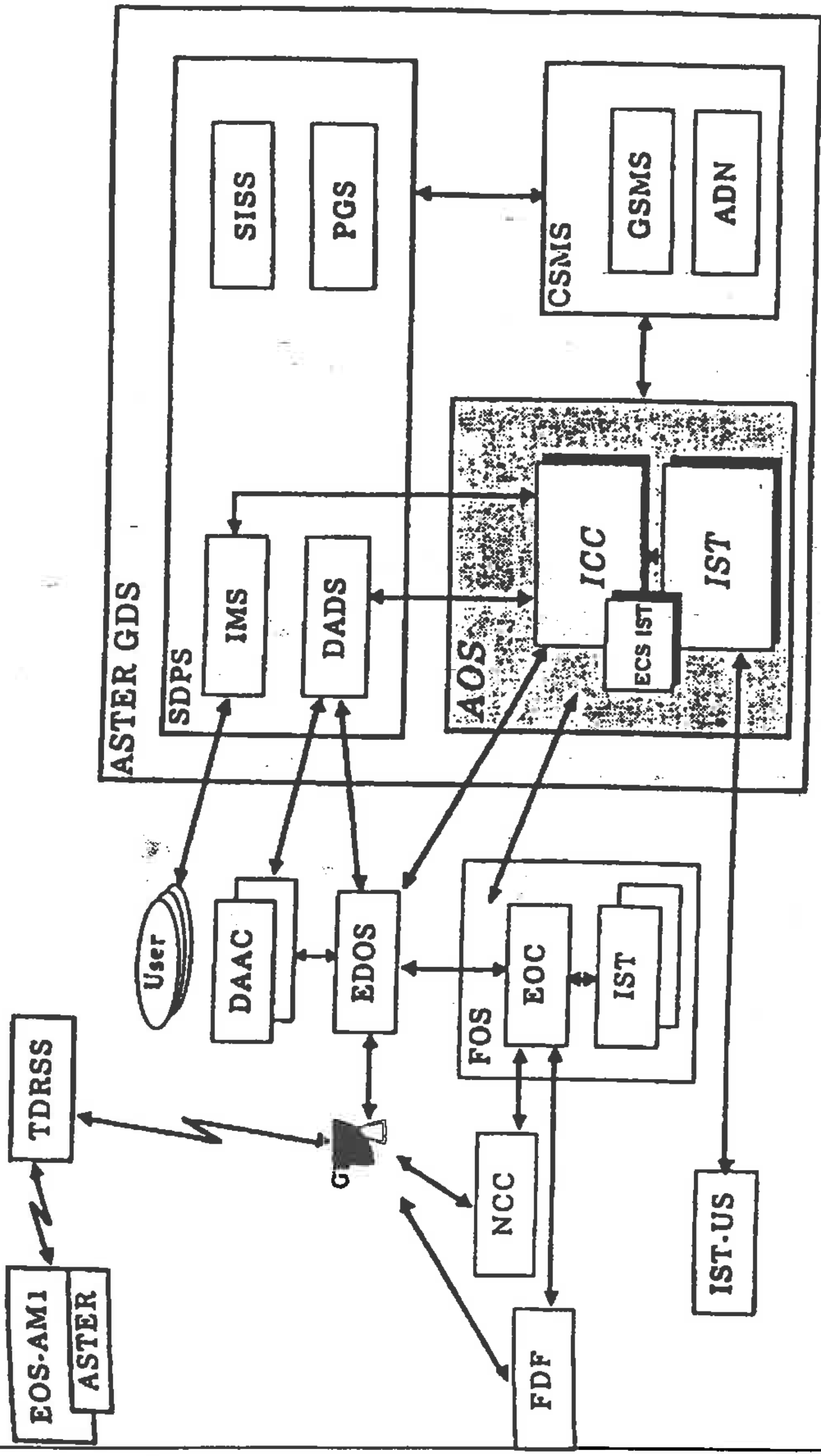


Figure 11. ASTER Ground Data System

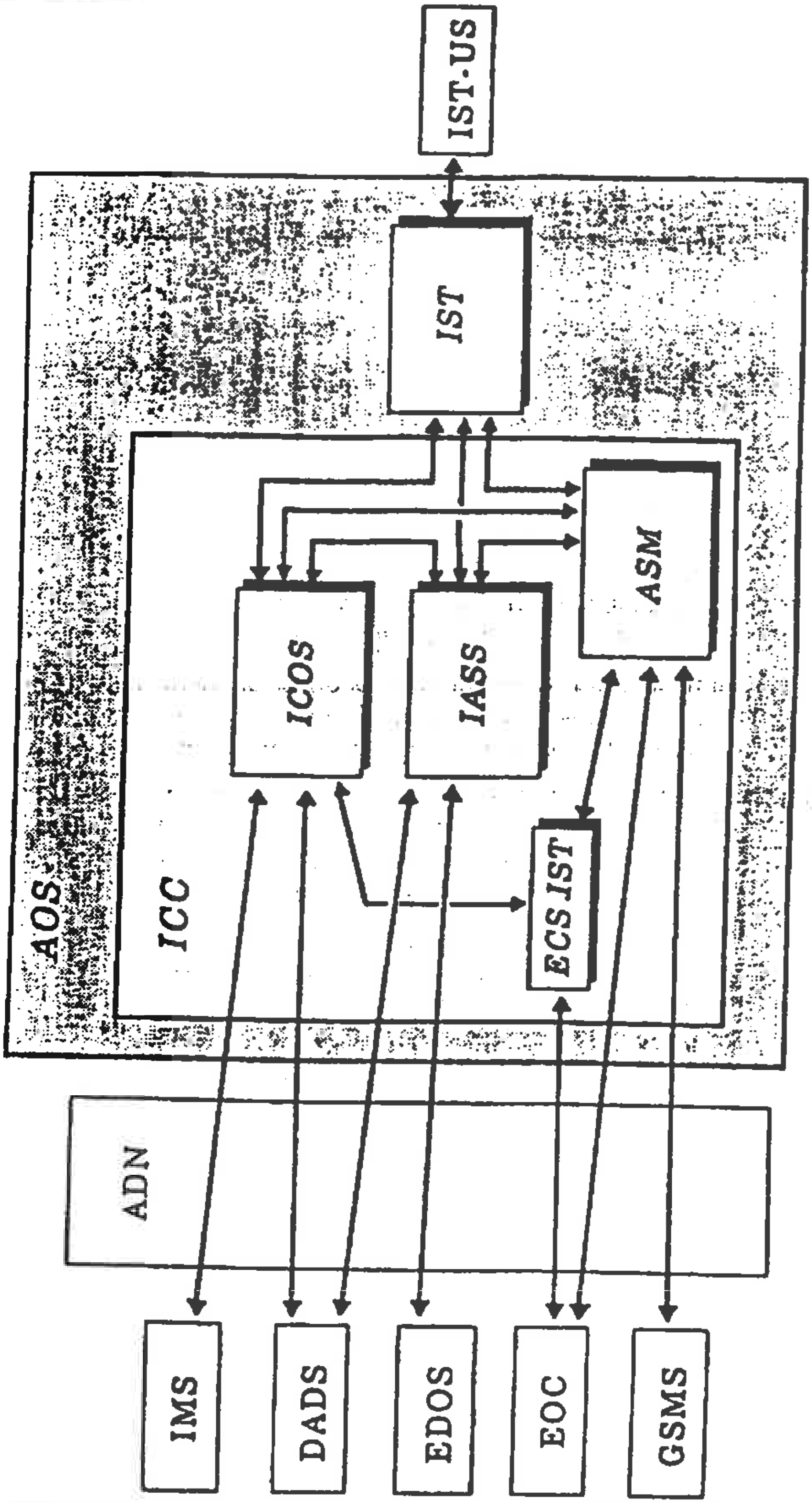


Figure 12. ASTER Operations Segment (AOS)

3.2.3 EOC/ ASTER ICC Interface

The ECS IST Toolkit hosted on an ASTER GDS–provided workstation at the ASTER ICC is used in the transfer of messages and files between the ASTER GDS and the ECS FOS. The EOC sends planning aids and integrated mission plans and schedules to the ICC for use in refining instrument schedules. The ICC submits ASTER schedules to the EOC, and the EOC sends scheduling conflict information to the ICC. This interface is described in the ICD Between EOSDIS Core System (ECS) and ASTER Ground Data System.

Also, through use of the ECS IST's user interface, the ASTER operations team will have access to FOS tools and capabilities for submitting PDB updates for ASTER (e.g., building command procedures, relative time command sequences, and real time command requests. The ASTER operations team will also have access to ECS IST displays and EOC reports through the ECS IST user interface. This allows the ASTER operations team to use the ECS IST to have access to EOC event messages for command notification and command load reports. The ECS IST user interface also may be used by the ASTER operations team to view EOC plans and schedules and to access FOS tools for requesting and viewing the results of command–level constraint analyses performed on 'what–if' analysis schedules by the FOS. Details of the ECS IST user interface will be documented in the FOS Operations Manual for the ECS Project.

3.3 Space Network

The Space Network (SN) is the primary data transport system for relaying data between the EOS AM –1 S/C and the ground, and provides communication resource scheduling support to EOSDIS. The SN elements, the Tracking and Data Relay Satellite System (TDRSS) and the Network Control Center (NCC), provide the primary/nominal communications path between the S/C COMMS and the EDOS.

TDRSS comprises the Tracking and Data Relay Satellites (TDRSs), the White Sands Ground Terminal (WSGT), and the Second TDRS Ground Terminal (STGT), also located at White Sands. It provides forward and return link communications services.

The NCC is at GSFC. The NCC is the operations center for all SN activities. It provides operational management of all elements of the SN and is responsible for all scheduling activities for the TDRSS system. The EOC interfaces with NCC for scheduling SN resources. The NCC implements operations, executes schedules, and performs link monitoring and fault isolation.

3.4 OPERATIONS TEAMS

3.4.1 Flight Operations Organization

The structure of the Flight Operations Organization is depicted in the following figure.

FIGURE: **(TBD 2)**

3.4.2 Flight Operations Team

The FOT located within the EOC executes the EOS AM-1 mission plan while maintaining the health and safety of the S/C and instruments on-orbit. Three distinct elements within the FOT share the responsibilities for mission operations:

a. Flight Planning and Scheduling coordinates with instrument teams and spacecraft subsystem engineers to develop an integrated mission schedule for each operations day;

b. Operations provides support 24 hours a day, 7 days a week for real-time command, control, and telemetry monitoring of the S/C and instruments

c. Engineering provides detailed analysis of the S/C subsystem performance

The role and responsibilities of the FOT is discussed in section 4. The structure of the Flight Operations Team is depicted in the following figure.

FIGURE: **(TBD 3)**

3.4.3 ASTER Operations Team

The ASTER Operations Team (AOT) located in Japan, represents the ASTER Science Team in all areas of ASTER instrument operations. The AOT schedules the instrument activities required to implement the science plans, analyzes the performance of the instrument, and reports to the science teams and the Flight Operations Director (FOD) on the state of the instrument. The AOT provides the focal point for instrument operations and the engineering expertise for detailed analysis and anomaly investigation.

The AOT consists of six ASTER related organizations or projects as follows:

- the ASTER Sensor Committee/Ground System Interface Working Group and ASTER Instrument Project conducted by JAROS.
- the ASTER Science Team/OMP Working Group conducted by both ERSDAC and the US Science Team, and the ASTER Science Project conducted by ERSDAC.
- the ASTER GDS Committee and the ASTER GDS Project conducted by ERSDAC.

Under the coordination of the AOT, JAROS is the representative for all matters related to Initial Operation & Instrument Analysis, and ERSDAC is the representative for all matters related to Normal Operation.

The roles of the AOT are as follows:

- To prepare the detailed Mission Operation Handbook, the ASTER Mission Operation Procedures and the ASTER GDS AOS Operation Procedures.
- To make the ASTER operation schedule based on the above operation documents and to send the schedule to the FOS.
- To conduct the End-to-End Test and Initial, Normal, and Contingency Operations.
- To perform Instrument Analysis.

The chart on the following page shows the organization of the ASTER Operations Team.

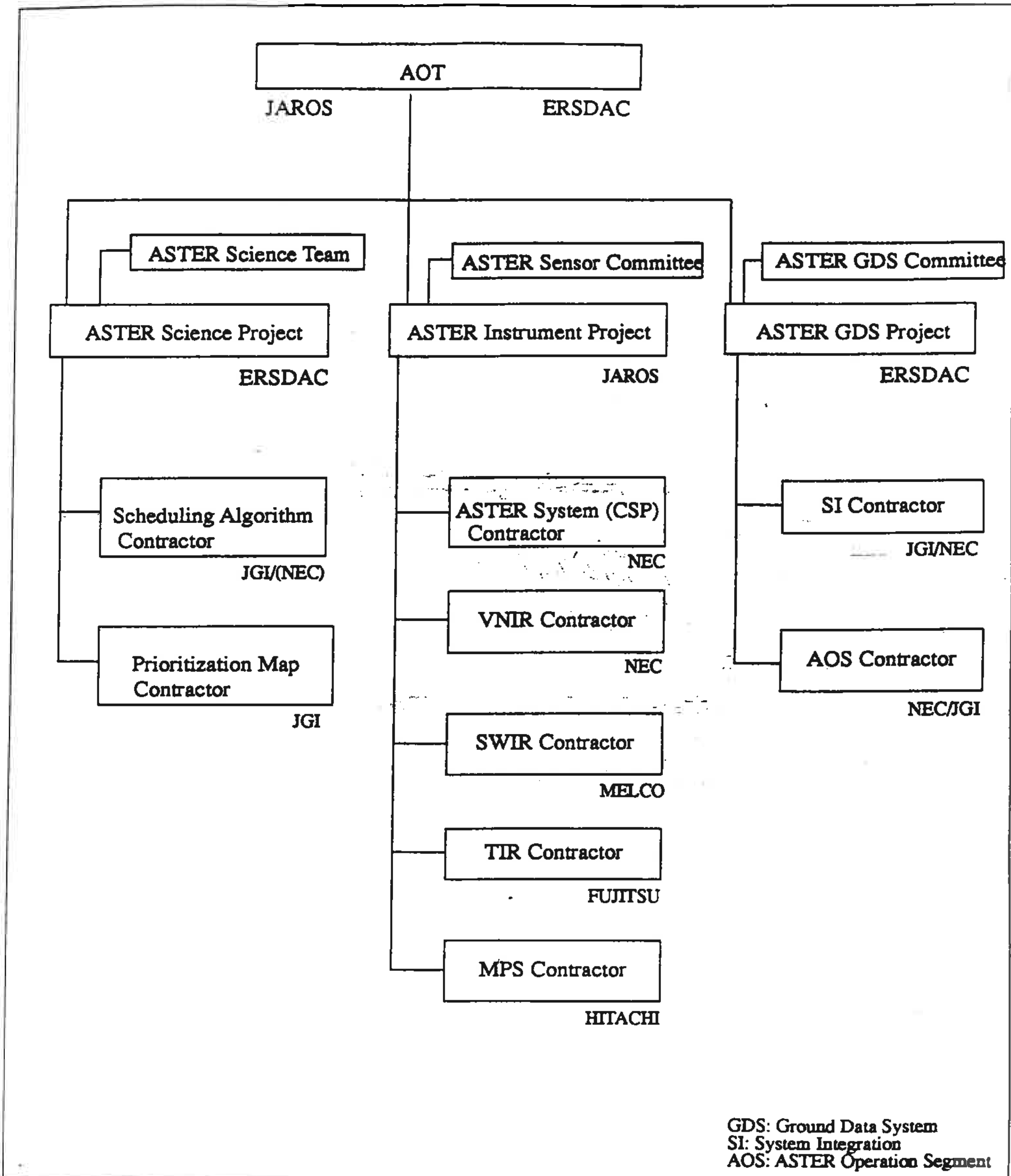


Figure 13. ASTER Operations Team (AOT)

3.4.4 ASTER Instrument Operations Team G(TBR)

The structure of the instrument operations team is depicted in the following figure.

FIGURE: **(TBD 4)**

3.5 Integration and Test Team

Further information about Ground System Integration and Test may be found in the "ASTER Ground Data System/ EOS Ground System Test Agreement."

4 SYSTEMS OPERATIONS / ROLES & RESPONSIBILITIES

4.1 FLIGHT SEGMENT OPERATIONS

The EOS AM-1 mission is defined by four chronological mission phases: (1) Prelaunch, (2) Launch/Acquisition, (3) Checkout, and (4) Operational. Each mission phase represents a pre-defined time period during which a set of interrelated operations and activities are performed. The EOS AM-1 mission phases are described briefly below. More detail can be found in System Operating Modes, LMMS EOS-DN-SE&I-001 and Mission Timeline, LMMS EOS-DN-SE&I-056.

The Prelaunch Phase includes all I&T activities leading up to launch. During this phase, the S/C is integrated, tested, installed on the launch vehicle, and prepared for launch.

The Launch/Acquisition Phase begins when the S/C transitions to internal power about five minutes prior to liftoff. At that time the S/C is in Launch Mode, fully configured for launch, but communication of commands and telemetry is still available through the T-0 umbilical connection to the ground support equipment (GSE). Just before launch vehicle engine ignition, the T-0 umbilical is pulled. At this point, there is no forward communication link for commanding the S/C, and the return link consists of S/C 1 kbps H&S telemetry. After launch, and subsequent to HGA deployment, the FOT sends ground commands to put the S/C into Delta-V Mode, in which the S/C performs propulsive maneuvers to raise from the injection orbit (550 x 695 km) to the operational orbit (705 km circular). Once S-Band communication is established through the HGA to TDRSS, the telemetry data rate is increased from 1 kbps to 16 kbps. The Launch/Acquisition phase ends when the S/C reaches the operational orbit.

The Checkout Phase is an on-orbit verification phase for the S/C, during which all subsystems and instruments are verified and calibrated as necessary. The Checkout Phase begins when the S/C reaches the operational orbit. This phase ends when all S/C subsystems and instruments are deemed ready to support the mission science objectives. During this phase, special TDRSS S-Band time allocations are available to perform the checkout activities. Also during this phase, orbit adjustments are performed by ground command as necessary to trim the operational orbit.

The Operational Phase begins when the S/C bus and instruments are sufficiently characterized so that science data may be gathered routinely, and it continues through the end of the mission. S/C commands are uplinked daily or more frequently in real-time. Recorded science data are played back through TDRSS twice per orbit over Ku-Band. Orbit adjustments are performed as needed during this phase to maintain a satisfactory orbit. In this phase, the S/C is nominally in Science Mode except during orbit adjusts (Delta-V Mode), power critical situations (Survival Mode), if a failure of the SCC occurs, or when the attitude is not maintained within nominal parameters (Safe Mode).

4.1.1 Spacecraft Operations

The EOS AM-1 S/C system modes and instrument modes are defined briefly in the following section. More detail can be found in the System Operating Modes, LMMS EOS-DN-SE&I-001.

4 SYSTEMS OPERATIONS / ROLES & RESPONSIBILITIES

4.1 FLIGHT SEGMENT OPERATIONS

The EOS AM–1 mission is defined by four chronological mission phases: (1) Prelaunch, (2) Launch/Acquisition, (3) Checkout, and (4) Operational. Each mission phase represents a pre-defined time period during which a set of interrelated operations and activities are performed. The EOS AM–1 mission phases are described briefly below. More detail can be found in System Operating Modes, LMMS EOS–DN–SE&I–001 and Mission Timeline, LMMS EOS–DN–SE&I–056.

The Prelaunch Phase includes all I&T activities leading up to launch. During this phase, the S/C is integrated, tested, installed on the launch vehicle, and prepared for launch.

The Launch/Acquisition Phase begins when the S/C transitions to internal power about five minutes prior to liftoff. At that time the S/C is in Launch Mode, fully configured for launch, but communication of commands and telemetry is still available through the T–0 umbilical connection to the ground support equipment (GSE). Just before launch vehicle engine ignition, the T–0 umbilical is pulled. At this point, there is no forward communication link for commanding the S/C, and the return link consists of S/C 1 kbps H&S telemetry. After launch, and subsequent to HGA deployment, the FOT sends ground commands to put the S/C into Delta–V Mode, in which the S/C performs propulsive maneuvers to raise from the injection orbit (550 x 695 km) to the operational orbit (705 km circular). Once S–Band communication is established through the HGA to TDRSS, the telemetry data rate is increased from 1 kbps to 16 kbps. The Launch/Acquisition phase ends when the S/C reaches the operational orbit.

The Checkout Phase is an on–orbit verification phase for the S/C, during which all subsystems and instruments are verified and calibrated as necessary. The Checkout Phase begins when the S/C reaches the operational orbit. This phase ends when all S/C subsystems and instruments are deemed ready to support the mission science objectives. During this phase, special TDRSS S–Band time allocations are available to perform the checkout activities. Also during this phase, orbit adjustments are performed by ground command as necessary to trim the operational orbit.

The Operational Phase begins when the S/C bus and instruments are sufficiently characterized so that science data may be gathered routinely, and it continues through the end of the mission. S/C commands are uplinked daily or more frequently in real–time. Recorded science data are played back through TDRSS twice per orbit over Ku–Band. Orbit adjustments are performed as needed during this phase to maintain a satisfactory orbit. In this phase, the S/C is nominally in Science Mode except during orbit adjusts (Delta–V Mode), power critical situations (Survival Mode), if a failure of the SCC occurs, or when the attitude is not maintained within nominal parameters (Safe Mode).

4.1.1 Spacecraft Operations

The EOS AM–1 S/C system modes and instrument modes are defined briefly in the following section. More detail can be found in the System Operating Modes, LMMS EOS–DN–SE&I–001.

4.1.1.1 Spacecraft System Modes

Each mission phase is characterized by spacecraft "system" operating modes used (or available) to support that mission phase. The system mode is defined by the minimum functional and performance capabilities that are required to satisfy mission conditions and constraints. System modes include: (1) Launch Mode, (2) Delta-V Mode, (3) Science Mode, (4) Survival Mode, and (5) Safe Mode.

The system operating modes are defined in terms of five variables that are essential to defining the worst case operational scenarios for the spacecraft; power load, type of computer control, S/C attitude reference, science data availability, and capability for Delta-V maneuvers. The following observations can be made about the S/C operating modes:

a. S/C operating modes can be divided into two classes: nominal and contingency modes. Nominal S/C modes are those modes which define the S/C configuration during planned activities. Contingency S/C modes are those modes which define the S/C configuration following failures in S/C equipment. The nominal system modes include Launch, Science and Delta-V Modes, while the contingency modes include Survival and Safe Modes.

b. Whether the SCC or the Attitude Control Electronics (ACE) controls attitude control processing is the only variable which determines whether or not the S/C is in Safe Mode. Safe Mode is defined as any configuration in which the ACE performs attitude control processing functions, whether or not the SCC is controlling other H/K functions.

c. Safe Mode is independent of power load and science data availability. When the S/C is transitioned to Safe Mode, the power load and science data availability will generally remain in the same state as in the previous mode.

d. S/C attitude reference is not relevant for Launch Mode because the S/C is not yet in orbit about the Earth in this mode. In Launch Mode the S/C is attached to the launch vehicle.

Table I EOS AM-1 Operational Modes

	Nominal Modes			Contingency Modes	
	Launch Mode	Science Mode	Delta-V Mode	Survival Mode	Safe Mode
Power Load	OFF	ON	Don't Care	OFF	Don't Care
Computer	SCC	SCC	SCC	SCC	ACE or ACE/SCC
Thrusters	YES	NO	YES	NO	Don't Care
Attitude Reference	Not Relevant	EARTH	EARTH	EARTH	EARTH or SUN
Science Data	NO	YES	Don't Care	NO	Don't Care

Definitions of State Variables:

(1) Power Load	OFF	Minimum power condition; All non-essential H/K and instrument loads are shed
	ON	H/K and instruments are at the full power allocated for the mode
(2) Computer	SCC	The SCC has full control of all H/K functions, including S/C attitude
	ACE/SCC	ACE controls S/C attitude; SCC controls all H/K functions except attitude
	ACE	ACE controls S/C attitude; there is no SCC control
(3) Thrusters	NO	PMEA powered off, so that no thrusters may be fired and no Delta-V maneuvers may be performed
	YES	PMEA operational, so that thrusters may be used for Delta-V maneuvers and or attitude control
(4) Attitude	EARTH	The S/C has an Earth pointing attitude, with the +Z axis pointing towards the center of the Earth
	SUN	The S/C has a Sun pointing attitude, with the S/C -X axis and the solar array cell-side normal pointing towards the Sun.
(5) Science Data	YES	The S/C performs science data collection, distribution, and transmission
	NO	The S/C is unable to collect, distribute, or transmit science data

ACE = Attitude Control Electronics
H/K = Housekeeping
PMEA = Propulsion Module Electronics Assembly
S/C = Spacecraft
SCC = Spacecraft Controls Computer

4.1.2 Instrument Operations

4.1.2.1 Memory Loads and Dumps

ASTER does not perform memory loads or dumps.

4.1.2.2 Instrument Modes

Being comprised of 5 major subsystems (i.e., VNIR, SWIR, TIR, CSP, and MPS), the ASTER instrument has subsystem modes as well as system-level modes. ASTER subsystem modes and related power load and data rate characteristics are described in the ASTER Command and Telemetry ICD.

Within the EOC, power and data rate utilization will be associated with ASTER system-level modes. The following is a list of ASTER system level modes.

Table II ASTER System–Level Modes

ASTER System–Level modes						
ASTER MODE	VNIR mode	SWIR mode	TIR mode	CSP mode	MPS mode	Power
All Off (Launch)	All Off	All Off	All Off	All Off	All Off	0W
Survival	Survival	Survival	Survival	Survival	Survival	164.0W
Standby **see Note Below Table	Standby	Standby	Standby	Standby	Operation	336.8W
VNIR Pointing	Pointing	Standby	Standby	Standby	Operation	353.3W
SWIR Pointing	Standby	Pointing	Standby	Standby	Operation	352.6W
TIR Preparation	Standby	Standby	Amp Prep	TIR Data Proc	Operation	402.6W
S/T Preparation	STandby	Prep	Amp Prep	TIR Data Proc	Operation	436.0W
TIR Short–Cal 1	Standby	Prep	Short–Cal	TIR Data Out	Operation	436.0W
TIR Pointing 1	Observation	Prep	Pointing	TIR Data Proc	Operation	458.7W
V/S/T Observation	Observation	Observation	Observation	V/S/T Data Out	Operation	486.1W
V Stereo Obs & T Pointing	Observation	Standby	Pointing	V2 Data Out/ TIR Data Proc	Operation	432.0W
TIR Short–Cal 2	Standby	Standby	Short–Cal	TIR Data Out	Operation	432.0W
S/T Observation	Standby	Observation	Observation	S/T Data Out	Operation	457.4W
TIR Pointing 2	Standby	Standby	Pointing	TIR Data Proc	Operation	414.0W
TIR Observation	Standby	Standby	Observation	TIR Data Out	Operation	412.9W
VNIR Preparation	Observation	Standby	Standby	Standby	Operation	351.4W

ASTER System-Level modes (continued)						
ASTER MODE	VNIR mode	SWIR mode	TIR mode	CSP mode	MPS mode	Power
VNIR Observation	Observation	Standby	Standby	VNIR Data Out	Operation	365.1W
V Stereo Observation	Observation	Standby	Standby	V2 Data Out	Operation	357.7W
V Ch1 Observation	Observation	Standby	Standby	V1 Data Out	Operation	352.7W
SWIR Preparation	Standby	Preparation	Standby	Standby	Operation	370.2W
SWIR Observation	Standby	Observation	Standby	SWIR Data Out	Operation	381.0W
TIR Getter	Standby	Standby	Getter	Standby	Operation	249.5W
Safe Mode	Safe	Safe	Safe	Same as previous mode	Operation	293.3W
VNIR Calibration	Calibration: -Optical -Electrical -Dark	Standby	Standby	VNIR Calibration	Operation	386.8W
SWIR Calibration	Standby	Calibration	Standby	SWIR Calibration	Operation	419.2W
TIR Long-Term Calibration	Standby	Standby	Long-Term Calibration	TIR Long-Term Calibration	Operation	481.5W

Note: "Contamination Safe" Mode is the same as Standby Mode, but the SWIR and TIR mirrors are turned to the calibration position.

4.1.2.3 Instrument Activities

The following table contains an initial list of ASTER activities. Nominally, ASTER activities will be scheduled with respect to orbital events contained in the EOC event pool.

Table III ASTER Activities

ASTER Activity Plan				
No.	Activity Name	Start Mode	End Mode	Note
1	START_V_S_T_OBS_STEREO	STANDBY	V/S/T OBS	
2	END_V_S_T_OBS_STEREO	V/S/T OBS	STANDBY	
3	START_S_T_OBS	STANDBY	S/T OBS	
4	END_S_T_OBS	S/T OBS	STANDBY	
5	START_T_OBS	STANDBY	TIR OBS	
6	END_T_OBS	TIR OBS	STANDBY	
7	START_V_OBS	STANDBY	VNIR OBS	
8	END_V_OBS	VNIR OBS	STANDBY	
9	START_V_STEREO_OBS	STANDBY	V STEREO OBS	
10	END_V_STEREO_OBS	V STEREO OBS	STANDBY	
11	START_V_CH1_OBS	STANDBY	V CH1 OBS	
12	END_V_CH1_OBS	V CH1 OBS	STANDBY	
13	START_S_OBS	STANDBY	SWIR OBS	
14	END_S_OBS	SWIR OBS	STANDBY	
15	T_PREP_TO_V_S_T_OBS_ STEREO	TIR PREP	V/S/T OBS	Divided Obs
16	V_S_T_OBS_STEREO_TO_ T_PREP	V/S/T OBS	TIR PREP	Divided Obs
17	S_T_PREP_TO_V_S_T_OBS_ STEREO	S/T PREP	V/S/T OBS	Divided Obs
18	V_S_T_OBS_STEREO_TO_ S_T_PREP	V/S/T OBS	S/T PREP	Divided Obs
19	S_PREP_T_OBS_TO_V_S_T_ OBS_STEREO	SWIR PREP & TIR OBS	V/S/T OBS	Divided Obs

ASTER Activity Plan (continued)				
20	V_S_T_OBS_STEREO_TO_ S_PREP_T_OBS	V/S/T OBS	SWIR PREP & TIR OBS	Divided Obs
21	T_PREP_TO_S_T_OBS	TIR PREP	S/T OBS	Divided Obs
22	S_T_OBS_TO_T_PREP	S/T OBS	TIR PREP	Divided Obs
23	S_T_PREP_TO_S_T_OBS	S/T PREP	S/T OBS	Divided Obs
24	S_T_OBS_TO_S_T_PREP	S/T OBS	S/T PREP	Divided Obs
25	S_PREP_T_OBS_TO_S_T_OBS	SWIR PREP & TIR OBS	S/T OBS	Divided Obs
26	S_T_OBS_TO_S_PREP_T_OBS	S/T OBS	S PREP & TIR OBS	Divided Obs
27	T_PREP_TO_T_OBS	TIR PREP	TIR OBS	Divided Obs
28	T_OBS_TO_T_PREP	TIR OBS	TIR PREP	Divided Obs
29	T_OBS_TO_ V_S_T_OBS_STEREO	TIR OBS	V/S/T OBS	Obs. transition
30	V_S_T_OBS_STEREO_TO_ T_OBS	V/S/T OBS	TIR OBS	Obs. transition
31	T_OBS_TO_S_T_OBS	TIR OBS	S/T OBS	Obs. transition
32	S_T_OBS_TO_T_OBS	S/T OBS	TIR OBS	Obs. transition
33	VNIR_GAIN_SET			No mode change
34	SWIR_GAIN_SET			No mode change
35	TURN_ON_ QUICK_LOOK_FLAGS			No mode change
36	TURN_OFF_ QUICK_LOOK_FLAGS			No mode change
37	VNIR_POINTING	STANDBY	STANDBY	
38	SWIR_POINTING	STANDBY	STANDBY	
39	VNIR_CALIBRATION_1	STANDBY	STANDBY	
40	VNIR_CALIBRATION_2	STANDBY	STANDBY	

ASTER Activity Plan (continued)				
41	SWIR_CALIBRATION_1	STANDBY	STANDBY	
42	SWIR_CALIBRATION_2	STANDBY	STANDBY	
43	TIR_LONG_TERM_ CALIBRATION	STANDBY	STANDBY	
44	TIR_MIRROR_ROTATION_TO_ CAL_POS	STANDBY	STANDBY	
45	TURN_ON_VNIR2_QL_FLAG			No mode change
46	TURN_OFF_VNIR2_QL_FLAG			No mode change
47	TURN_ON_VNIR1_QL_FLAG			No mode change
48	TURN_OFF_VNIR1_QL_FLAG			No mode change
49	TURN_ON_SWIR_QL_FLAG			No mode change
50	TURN_OFF_SWIR_QL_FLAG			No mode change
51	TURN_ON_V1V2_QL_FLAGS			No mode change
52	TURN_OFF_V1V2_QL_FLAGS			No mode change
53	TURN_ON_T_S_QL_FLAGS			No mode change
54	TURN_OFF_T_S_QL_FLAGS			No mode change
55	TURN_ON_TIR_QL_FLAGS			No mode change
56	TURN_OFF_TIR_QL_FLAGS			No mode change
57	ASTER_TO_SAFEMODE	Any mode	Safemode	
58	ASTER_TO_ CONTAMINATION_SAFEMODE		Contamina-tion Safemode	

4.1.2.3.1 Initial Activation

The ASTER initial activation sequence is depicted below.

ASTER ALL OFF

LAUNCH MODE —— EOS AM-1 Launch

(120V Power from EOS-AM1 is turned ON)
- SELECT MPS A (35 minutes after launch)
- SURVIVAL HEATER ENABLE (35 minutes after launch)

DAY 1

LAUNCH LOCK OFF MODE
- SWIR LAUNCH LOCK OFF1
  (Verify SWIR LAUNCH LOCK OFF)
- TIR COOLER LATCH OFF1 (Note: TIR cooler launch lock shorts the cooler motor coils to provide piston restraint forces during launch)
  (Verify TIR COOLER LATCH OFF)
- MPS ON
- TIR SCANNER LATCH OFF1 (paraffin actuator)
  (See TIR Launch Lock Off Sequence - following pages)
  (Verify TIR Scanner Latch OFF)
- CSP A ON (Note: CSP MUST be powered for VNIR launch lock function activation)
- CSP OPERATE ENABLE
- CSP HCE A ON
- CSP TM&F BUS A SELECT
- CSP SCC TIMEOUT ENABLE
- VNIR MAIN ON (Note: VNIR MUST be powered for VNIR launch lock function activation)
- VNIR STANDBY
  (Verify VNIR mode)
- VNIR MODE SETTING (A SELECT, VHC SET, TABLE CANCEL OFF)
  (Verify VNIR is within operational temperatures)
- VNIR LAUNCH LOCK A OFF (paraffin actuator)
  (See VNIR Launch Lock Off Sequence - following pages)
  (Verify SWIR LAUNCH LOCK, TIR COOLER LATCH off)

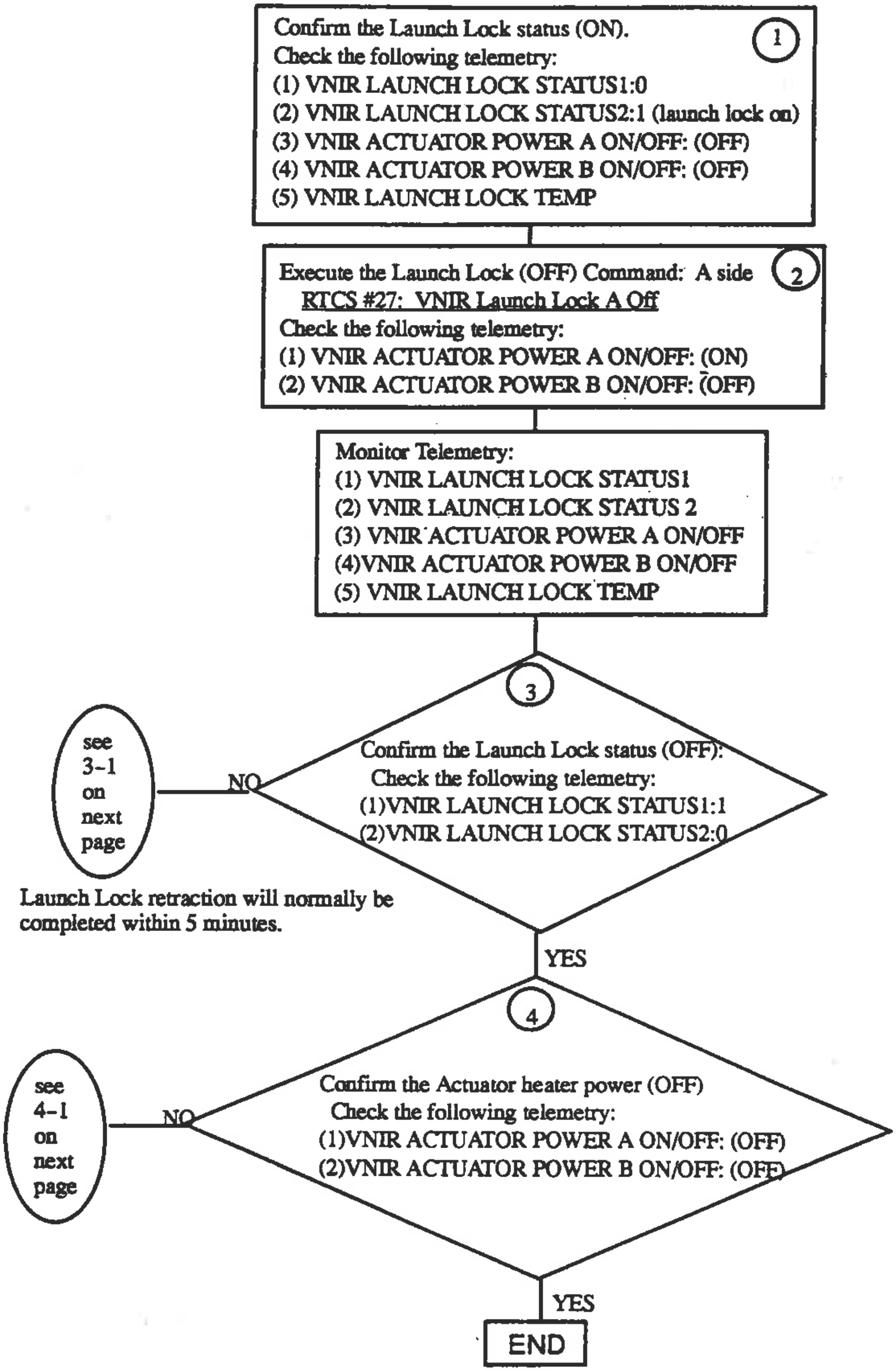
DAY 9

COOLDOWN MODE
- SWIR TLM/COM POWER ON
- SWIR TEMP. CONTROL CIRCUIT ON
- SWIR HEATER3 ON
- SWIR HEATER4 ON
- SWIR HEATER5 ON
- SWIR COOLER DRIVE CIRCUIT ON
- SWIR COOLER SETTING
  (Verify SWIR detector temperature - Note: initial cooldown will take approximately 40 minutes)
- TIR STANDBY POWER ON
- TIR COOLER POWER ON
  (Verify TIR detector temperature - Note: initial cooldown will take approximately 40 minutes)

DAY 10

ASTER in STANDBY MODE

VNIR LAUNCH LOCK OPERATION PROCEDURE



VNIR LAUNCH LOCK OPERATION PROCEDURE – CON'T

3-1
RTCS #27: "VNIR Launch Lock A Off"
or
RTCS #28: "VNIR Launch Lock B Off" will:
Execute the Actuator Power (OFF) Command

Check the following telemetry:
VNIR ACTUATOR POWER A ON/OFF (OFF)

3-2
Investigation of the Contingency

Standard Recovery Procedure

3-3
Cool the parafin actuator
Hold the Standby Mode for at least 10 minutes
Check the following telemetry:
VNIR LAUNCH LOCK TEMP

3-4
Re-execute Procedure #1

3-5
Execute the launch lock (OFF) Cmd – B side
RTCS #28: "VNIR Launch Lock B Off"
Check the following telemetry:
VNIR ACTUATOR POWER A ON/OFF: (OFF)
VNIR ACTUATOR POWER B ON/OFF: (ON)

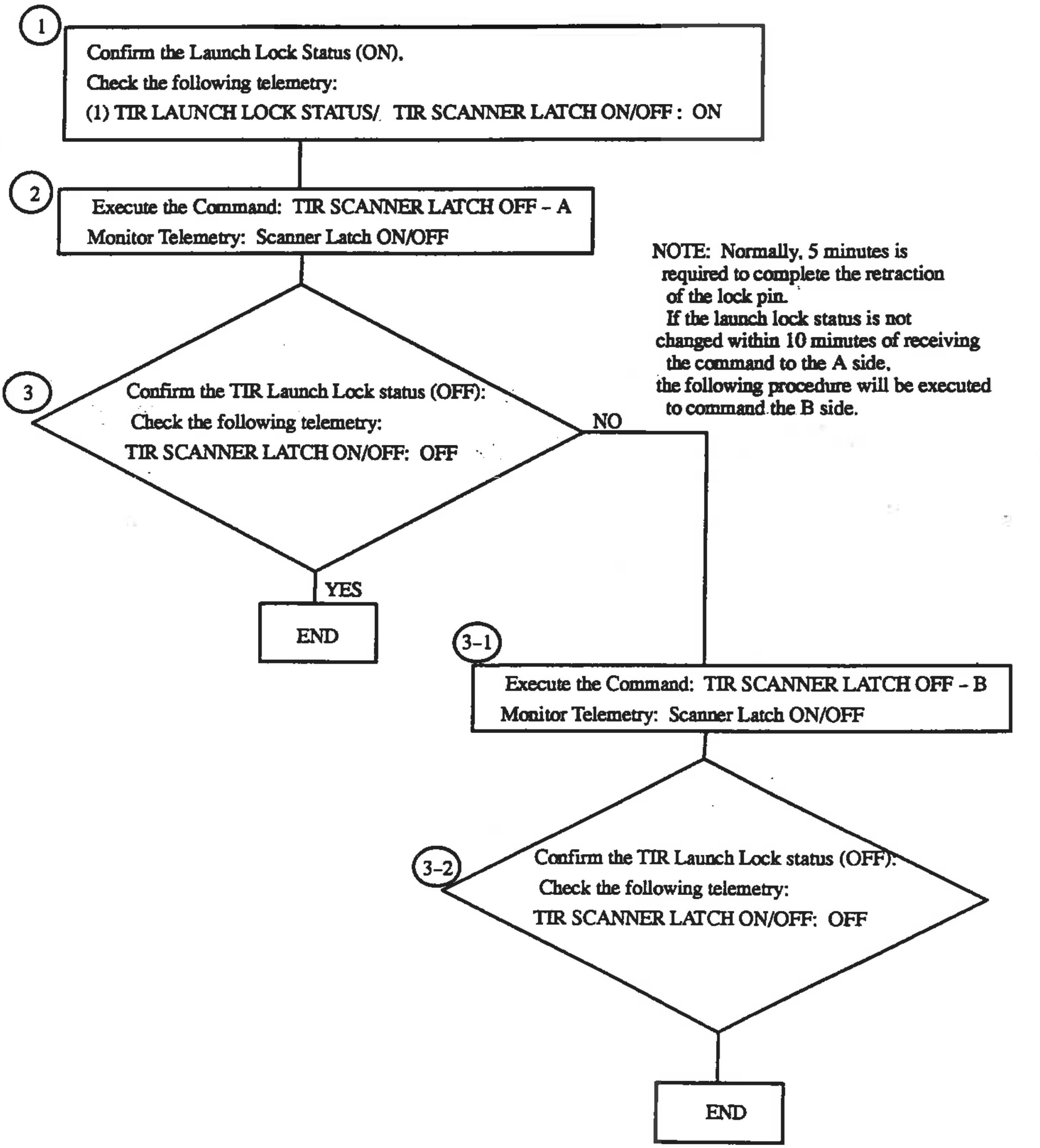
3-6
Re-execute Procedure #3

4-1
RTCS #27: "VNIR Launch Lock A Off" will:
Execute the Actuator A heater power (OFF) Cmd
OR
RTCS #28: "VNIR Launch Lock B Off" will:
Execute the Actuator B heater power (OFF) Cmd

4-2
Re-execute Procedure #4

4-3
Investigation of the Contingency

TIR SCANNER LAUNCH LOCK OPERATION PROCEDURE



A description of the initial activation and checkout functions to be performed for ASTER are shown below. All initial activation procedures for the ASTER shall be performed during real-time contacts with the spacecraft. Instrument representatives shall be present in the EOC during ASTER initial activation procedures and shall make available planned procedures for handling contingency situations which may occur during initial activation.

Table IV ASTER Activation and Checkout (TBR 1)

ASTER ACTIVATION and CHECKOUT ACTIVITIES					
Days	VNIR	SWIR	TIR	CSP	MPS
Launch (Day 1)	ASTER Transitions from Launch Mode into Survival Mode at Launch + 35 minutes				
Days 2–8	ASTER OUTGAS and TEMPERATURE MONITOR				
	OUTGAS (VNIR remains powered off)	OUTGAS (Launch Lock OFF, if possible, after delta–v burns)	OUTGAS	Out-gas	Out-gas
Day 9	(Note: Mission Orbit Achieved and Capillary Pump Heat Transfer System Powered On)				
	VNIR Outgas for 9 days VNIR turn on from ground command after CSP and MPS power on. –VNIR in standby mode –Items to Check: – h/k tlm – mode transition (excluding ptg mode) –setting of heater control point of telescope Launch Lock OFF during 10 minute real-time contact. (Operation should require about 5 mins.) –Items to Check: – h/k tlm – setting of heater control point of telescope – tlm regarding launch lock operation	Launch Lock Off before CSP and MPS Power On – Verification	Cooler Latch Off before MPS Power On –Verification Scanner Launch Lock Off after MPS Power On –Verification	Stand-by Mode Side A –tlm check Out-gas	Ops Mode Side A –tlm check Out-gas

ASTER ACTIVATION and CHECKOUT ACTIVITIES (continued)					
Days	VNIR	SWIR	TIR	CSP	MPS
Day 10 Day 11		Outgas and Standby Mode - Transition to Standby Mode will be by ground command **after CSP and MPS are Powered On** - Transition to Observation Mode **with pointing mirror still in the calibration position.** Outgas	Outgas and Standby Mode -Scanner On/Off **with pointing mirror to calibration position** -Monitor h/k tlm - Check on thermal control - Monitor temperature and supplied voltage	Stand-by Mode Side A -tlm check Out-gas	Ops Mode Side A -tlm check Out-gas
Day 12	Pointing Function Check during 10 min. real-time contact. (Operation should require about 5 mins.) - Point to the following angles: +8.55 degrees -8.55 degrees +24.00 degrees -24.00 degrees -Motor and Encoder unit -Both A side & B side (Note: no science data generated)	Outgas	Outgas	Stand-by Mode Side A	Oper. Mode Side A

ASTER ACTIVATION and CHECKOUT ACTIVITIES (continued)					
Days	VNIR	SWIR	TIR	CSP	MPS
Events which will occur during the remainder of the Check-out Period	**VNIR:** In-Flight Calibration: [This testing will be repeated once per 16 days throughout the check out period.] -Requested Scene (night area) -Calibration Sequence (Realtime Contact is required: Estimated time is 15 minutes during each orbit) *First Orbit:* 1)Transition to Pre-Cal Mode (Lamp A side) (Wait for 8 minutes for lamp warmup.) 2)Transition to Opt_Cal Mode (1 min of data acquisition) 3) Trans. to Dark_Cal (Norm. Gain 20 secs, High Gain 20 secs, Low Gain 20 secs) 4) Transition to Standby Mode *Second Orbit:* 5)Transition to Pre-Cal Mode (Lamp B side) (Wait for 8 minutes for lamp warmup.) 6) Transition to Opt_Cal Mode (1 minute of data acquisition) 7) Trans. to Elec_Cal (Norm. Gain 20 secs, High Gain 20 secs, Low Gain 20 secs) 8) Check Band 3 output for both side A and side B				
Events which will occur during the remainder of the Check-out Period (con't)	**VNIR:** Observational Performance Check: (This test will be performed multiple times throughout the checkout phase. The test consists of observations during 5 consecutive orbits each day for 4 days.) -Requested scenes: 1) day area, uniform reflectance, (e.g., desert) 2) day area, geometric land shape (e.g., shoreline with desert, road, runway) 3) day area, known reflectance (e.g., land, sea, forest) 4) day area, around the equator, high latitude, middle latitude, near pole 5) day area, cloud -Band 3 output must be checked for both A side and B side -Gain: High, Normal, Low				
Events which will occur during the remainder of the Check-out Period (con't)	**SWIR:** Calibration: (once per 8 days initially, then once per 16 days later in the checkout phase) -Optical Calibration (Lamp A) ... Normal Gain - Dark Calibration ... Low-2 Gain, Low-1 Gain, Normal Gain, High Gain - Optical Calibration (Lamp B) ... Normal Gain - Dark Calibration ... Low-2 Gain, Low-1 Gain, Normal Gain, High Gain Functional Check of Pointing Mirror Transition from Cal Pos. to Obs Pos. to Cal Pos. Radiometric and Geometric Performance Check (This test will be performed multiple times throughout the checkout phase. The test consists of observations during 5 consecutive orbits each day for 4 days.)				

ASTER ACTIVATION and CHECKOUT ACTIVITIES (continued)					
Days	VNIR	SWIR	TIR	CSP	MPS
Events which will occur during the remainder of the Check-out Period (con't)	TIR: Mode Functional Checkout: (performed over multiple days) -Cooler On/Off (1/day) -Operation On: (1/orbit) -Short Term Cal: (1/orbit) -Observation (1/orbit) [19 pointing angles] -Long term calibration (1/orbit) -Getter (A/B): (1/orbit) Checked: Cool down time, thermal control of detector, pointing angle Monitored: Temperature and supplied voltage				
Events which will occur during the remainder of the Check-out Period (con't)	TIR: Short-Term Calibration (STC) Stability Checkout: (Performed during one orbit each day for three days.) - STC check consists of 8 consecutive short-term calibrations - STC check duration is 20.5 minutes - STC sequence consists of 5 checks (i.e., 40 STCs) performed over 1 orbit Long-Term Calibration: (Daily for 17 days)				
Events which will occur during the remainder of the Check-out Period (con't)	TIR: Observational Performance Checkout: - Day and Night Observations to include the following: (desert, ice, lattice road, seashore or runway, and area with known emissivity) Maximum Observation Checkout: - Maximum observation for 5 continuous orbits, each day for 4 days				

ASTER ACTIVATION and CHECKOUT ACTIVITIES (continued)					
Days	VNIR	SWIR	TIR	CSP	MPS
Events which will occur during the re-main-der of the Check-out Period (con't)	**SWIR/TIR and VNIR/SWIR/TIR** Maximum Observation Checkout: – Maximum observation for 7 continuous orbits, each day for 4 days Pointing Angle Calibration Divided Observation Sequence Checkout: – Observations over 7 continuous orbits, each day for 4 days Observation Transition Sequence: – Observations over 7 continuous orbits, each day for 4 days				
Events which will occur during the re-main-der of the Check-out Period (con't)	**SIDE B TESTING** Side B Testing (2 days) followed by reconfiguration to side A (1 day) – Side B Testing to include checking of telemetry and command paths.				

4.1.2.3.2 Baseline Activity Profile

The concept of a "baseline activity profile," as used in the EOC context, does not apply to the ASTER instrument. In other words, ASTER is not operated in a manner which lends itself to routinely scheduling periodic activities. ASTER consists of three independent instruments (VNIR, SWIR, and TIR) which will be scheduled to operate (i.e., types and durations of activities) based on whatever the current science objectives are at the time of scheduling. Each instrument's operation is constrained by either data rate, power, or design constraints. However, there are certain types of operations which the ASTER will nominally perform during the mission, and therefore, the following instrument sequences are described below:

1. VNIR Pointing
2. SWIR Pointing
3. V/S/T Observation with complete stereo data [VNIR/SWIR/TIR combined operation, with VNIR Backward observing longer for stereo effect.]

4. Divided V/S/T Stereo Observations
5. S/T Observation [SWIR & TIR combined observation}
6. Divided S/T Observations
7. TIR Observation [TIR standalone observation – most frequently performed at night]
8. Divided TIR Observations
9. VNIR Observation with complete stereo data
10. VNIR2 – Stereo Data Only Observation
11. Transition Observations

4.1.2.3.2.1 VNIR Pointing

This operational sequence involves the slewing of the VNIR telescopes. The VNIR instrument is configured such that both the Nadir and Backward telescopes are rigidly connected to one pointing mechanism assembly. The pointing mechanism slew axis is parallel to the spacecraft 'X' axis. The mechanism has the capability to slew +/– 24 degrees. Hard stops are provided at +/– 24.7 degrees to preclude the telescopes from contacting MPS or MISR.

The mechanism moves at a rate of approx. 0.8 deg/sec. Therefore the maximum possible traverse time is 60 seconds. This time period is embedded in the command sequence used for this function.

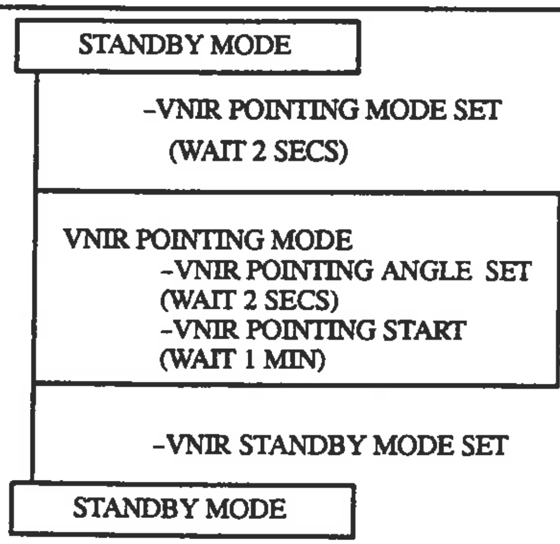


Figure 14. VNIR Pointing Sequence

4.1.2.3.2.2 SWIR Pointing

This operational sequence involves the moving of the SWIR pointing mirror. The operational range of motion of the mirror is approx. +/-5 degrees about nadir. The angular speed of the mechanism is approx. 0.16 deg./second. This translates to a maximum traverse time of approx. 60 seconds, for operational pointing.

For calibration purposes, the mirror is moved to look at one of the two calibration lamps. The SWIR pointing movement will be completed within 10 minutes for calibration. The SWIR is pointed by executing commands to move the mechanism relative to its current position.

SWIR pointing is accomplished by commands which indicate the direction to point (clockwise or counterclockwise), the number of pointing pulses, and the duration of each pulse. Therefore, the resulting SWIR pointing after execution of the commands will depend on the starting pointing position.

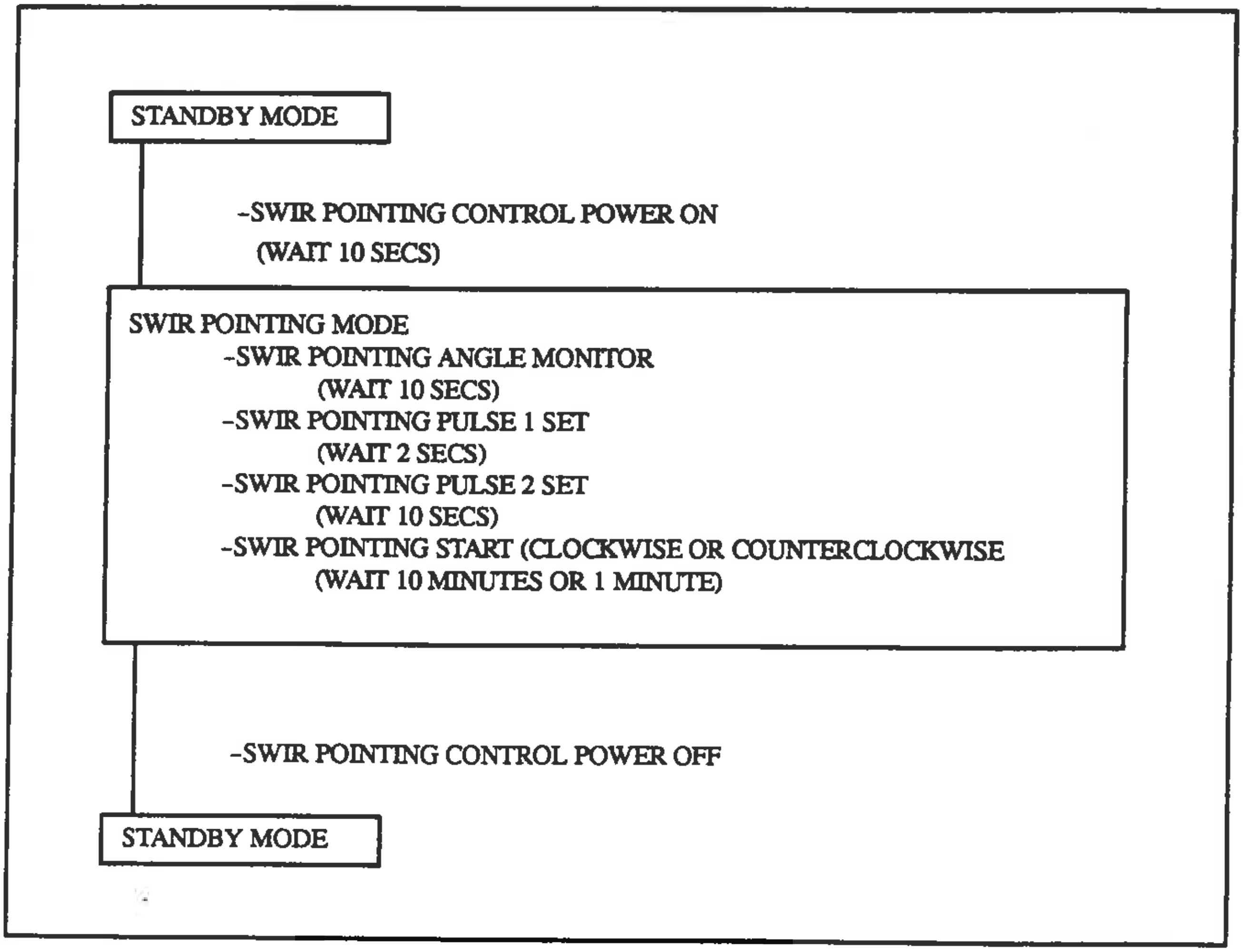
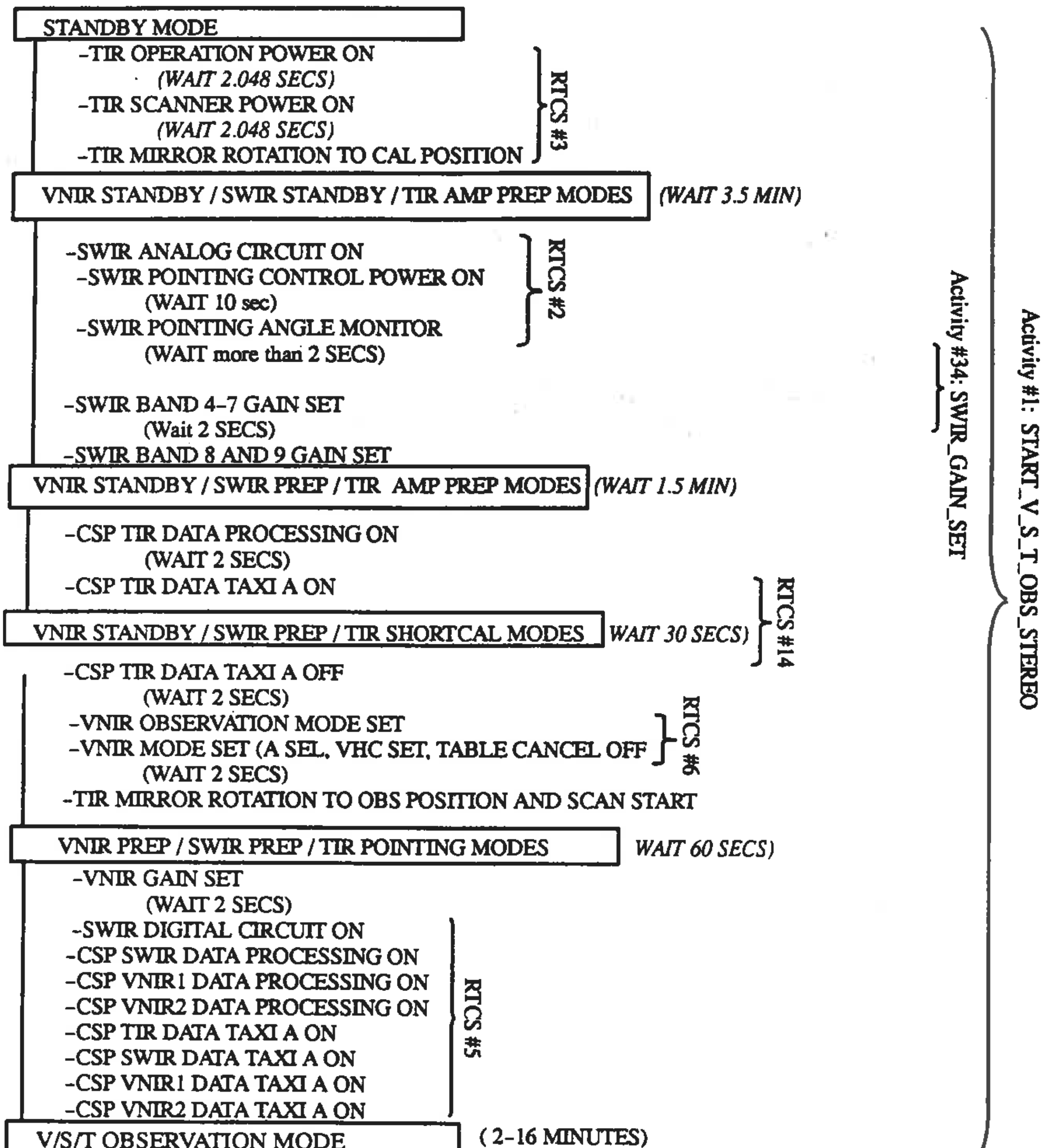


Figure 15. SWIR Pointing Sequence

4.1.2.3.2.3 V/S/T Observation Sequence with Complete Stereo Data

This operational sequence involves simultaneous VNIR, SWIR, and TIR observations followed by approximately an additional 60 seconds of VNIR2 observation. The figure below depicts this sequence.



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V/S/T STEREO OBSERVATION - CON'T FROM PREVIOUS PAGE

V/S/T OBSERVATION MODE (con't from previous page)

<u>The following are optional commands which will be generated when needed.</u>

-CSP TIR DATA Q/L FLAG ON
-CSP SWIR DATA Q/L FLAG ON
-CSP VNIR1 DATA Q/L FLAG ON
-CSP VNIR2 DATA Q/L FLAG ON

RTCS #22 — Activity #35

-CSP VNIR2 DATA Q/L FLAG OFF
-CSP VNIR1 DATA Q/L FLAG OFF
-CSP SWIR DATA Q/L FLAG OFF
-CSP TIR DATA Q/L FLAG OFF

RTCS #23 — Activity #36

-CSP VNIR1 DATA PROCESSING OFF
-CSP SWIR DATA PROCESSING OFF
-CSP TIR DATA TAXI A OFF

RTCS #7

-SWIR DIGITAL CIRCUIT OFF
-SWIR POINTING CONTROL POWER OFF
-SWIR ANALOG CIRCUIT OFF

RTCS #1

(WAIT 2 SECS)
-TIR MIRROR ROTATION TO CAL POSITION

VNIR OBS / SWIR STANDBY / TIR POINTING MODES *(WAIT 60 SECS)*

-CSP VNIR2 DATA PROCESSING OFF
-VNIR STANDBY MODE SET

RTCS #13

-CSP TIR DATA TAXI A ON

VNIR STANDBY
SWIR STANDBY
TIR SHORTCAL MODES *(WAIT 30 SECS)*

-CSP TIR DATA PROCESSING OFF
-TIR SCANNER POWER OFF
(WAIT 10.240 SECONDS)
-TIR OPERATION POWER OFF

RTCS #4

STANDBY MODE

Activity #2: END_V_S_T_OBS_STEREO

The same V/S/T Stereo Observation sequence described above is depicted below. The sequence of subsystem mode changes is apparent.

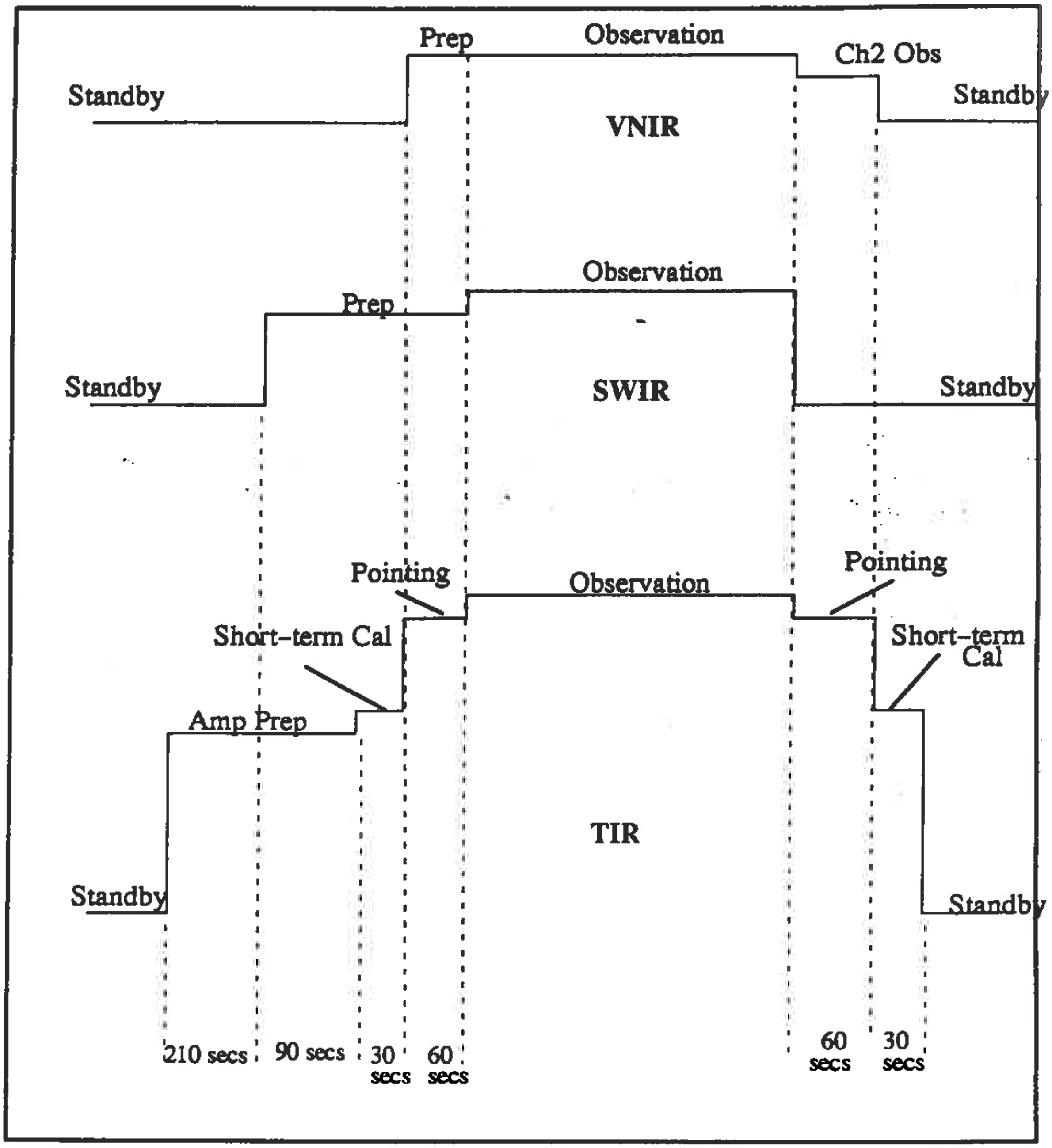


Figure 16. Instrument Mode Changes during V/S/T Stereo Observation

4.1.2.3.2.4 Divided V/S/T Stereo Observations

The sequence of ASTER commands to accomplish multiple V/S/T stereo observations is dependent on the time gap between two subsequent observations. In order to allow observations less than 8 minutes apart, the VNIR, SWIR, and TIR do not always return to standby mode between the observations. Those multiple observations in between which the VNIR, SWIR, or TIR do not return to standby are known as "divided observations." The chart below shows the VNIR, SWIR, and TIR mode transitions which will occur for different cases (which are dependent on the duration of the time gap) of divided observations.

4 minutes < Time gap <= 8 minutes

V/S/T OBSERVATION to
V STEREO OBS & TIR POINTING to
TIR PREP
(*requires 1 min.*)

.... — Duration is dependent on time gap between the subsequent observations

TIR PREP to
S/T PREP to
TIR SHORT-CAL 1 to
TIR POINTING 1 to
V/S/T OBSERVATION
(*requires 3 mins.*)

2.5 minutes < Time gap <= 4 minutes:

V/S/T OBSERVATION to
V STEREO OBS & SWIR PREP & T POINTING to
S/T PREP
(*requires 1 min.*)

.... — Duration is dependent on time gap between the subsequent observations

S/T PREP to
TIR SHORT-CAL 1 to
TIR POINTING 1 to
V/S/T OBS
(*requires 1.5 mins.*)

1 minute < Time gap <= 2.5 minutes:

V/S/T/ OBS to
V STEREO OBS & SWIR PREP & TIR OBS to
V PREP & S PREP & TIR OBS
(*requires 1 min.*)

.... — Duration is dependent on time gap between the subsequent observations

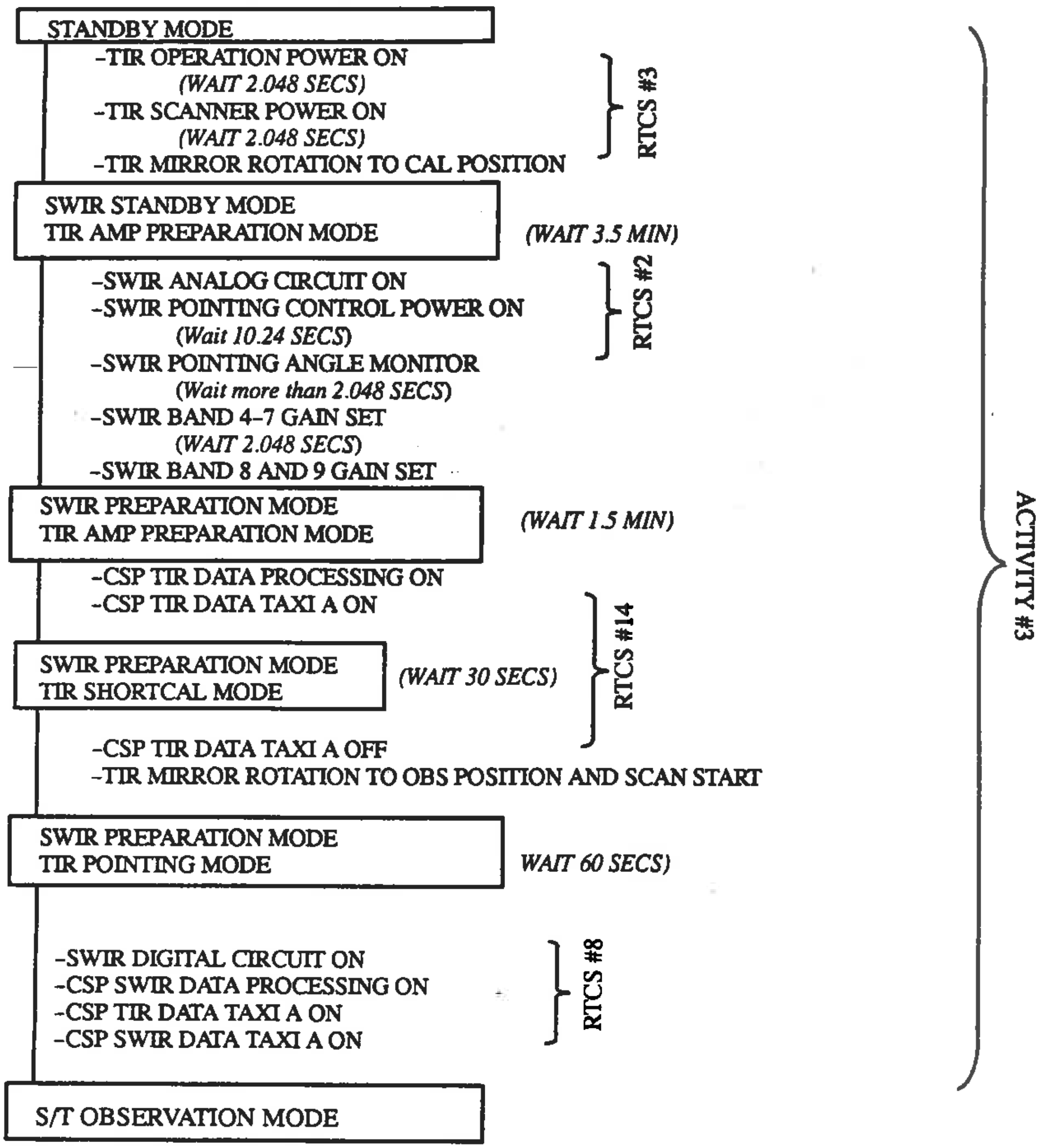
S PREP & TIR OBS to
V/S/T OBS
(*requires 0 min.*)

Time gap <= 1 minute:

ASTER will continue V/S/T observation.

4.1.2.3.2.5 S/T Observation

This operational sequence involves simultaneous SWIR and TIR observations.



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S/T OBSERVATION - CONTINUED FROM PREVIOUS PAGE

S/T OBSERVATION MODE (con't from previous page)

<u>The following are optional commands which will be generated when needed.</u>

- -CSP TIR DATA Q/L FLAG ON
- -CSP SWIR DATA Q/L FLAG ON

(ACTIVITY #53)

- -CSP SWIR DATA Q/L FLAG OFF
- -CSP TIR DATA Q/L FLAG OFF

(ACTIVITY #54)

- -CSP SWIR DATA PROCESSING OFF (RTCS #9)
- -CSP TIR DATA TAXI A OFF
- -SWIR DIGITAL CIRCUIT OFF
- -SWIR POINTING CONTROL POWER OFF (RTCS #1)
- -SWIR ANALOG CIRCUIT OFF
- -TIR MIRROR ROTATION TO CAL POSITION

SWIR STANDBY MODE
TIR POINTING MODE

(WAIT 60 SECS)

- -CSP TIR DATA TAXI A ON

SWIR STANDBY MODE
TIR SHORTCAL MODE

(WAIT 30 SECS)

- -CSP TIR DATA PROCESSING OFF
- -TIR SCANNER POWER OFF
  (WAIT 10.240 SECONDS)
- -TIR OPERATION POWER OFF

(RTCS #4)

STANDBY MODE

(ACTIVITY #4)

4.1.2.3.2.6 Divided S/T Observations

The chart below shows the SWIR and TIR mode transitions which will occur for different cases (which are dependent on the duration of the time gap) of divided observations.

4 minutes < Time gap <= 8 minutes

S/T OBSERVATION to
TIR POINTING to
TIR PREP
) *requires 1 min.*

.... Duration is dependent on time gap between the subsequent observations

TIR PREP to
S/T PREP to
TIR SHORT-CAL 1 to
TIR POINTING 1 to
S/T OBSERVATION
) *requires 3 mins.*

2.5 minutes < Time gap <= 4 minutes:

S/T OBSERVATION to
SWIR PREP & T POINTING to
S/T PREP
) *requires 1 min.*

.... Duration is dependent on time gap between the subsequent observations

S/T PREP to
TIR SHORT-CAL 1 to
TIR POINTING 1 to
S/T OBS
) *requires 1.5 mins.*

Time gap <= 2.5 minutes:

S/T/ OBS to
SWIR PREP & TIR OBS
) *requires 0 min.*

.... Duration is dependent on time gap between the subsequent observations

S PREP & TIR OBS to
S/T OBS
) *requires 0 min.*

4.1.2.3.2.7 TIR Observation

This operational sequence consists of a TIR observation.

STANDBY MODE

- -TIR OPERATION POWER ON
  - *(WAIT 2.048 SECS)*
- -TIR SCANNER POWER ON
  - *(WAIT 2.048 SECS)*
- -TIR MIRROR ROTATION TO CAL POSITION

(RTCS #3)

TIR AMP PREPARATION MODE *(WAIT 3.5 MIN)*

- -CSP TIR DATA PROCESSING ON
  - *(WAIT 2.048 SECS)*
- -CSP TIR DATA TAXI A ON

TIR SHORTCAL MODE *WAIT 30 SECS)*

- -CSP TIR DATA TAXI A OFF
  - *(WAIT 2.048 SECS)*
- -TIR MIRROR ROTATION TO OBS POSITION AND SCAN START

(RTCS #14)

TIR POINTING MODE *WAIT 60 SECS)*

- -CSP TIR DATA TAXI A ON

(ACTIVITY #5)

TIR OBSERVATION MODE (16 MINUTE MAXIMUM)

<u>The following are optional commands which will be generated when needed.</u>

- -CSP TIR DATA Q/L FLAG ON (ACTIVITY #55)
- -CSP TIR DATA Q/L FLAG OFF (ACTIVITY #56)

- -CSP TIR DATA TAXI A OFF
- -TIR MIRROR ROTATION TO CAL POSITION

TIR POINTING MODE *(WAIT 60 SECS)*

- -CSP TIR DATA TAXI A ON

TIR SHORTCAL MODE *(WAIT 30 SECS)*

- -CSP TIR DATA PROCESSING OFF
  - *(WAIT 2.048 SECS)*
- -TIR SCANNER POWER OFF
  - *(WAIT 10.240 SECONDS)*
- -TIR OPERATION POWER OFF

(RTCS #4)

STANDBY MODE

(ACTIVITY #6)

4.1.2.3.2.8 Divided TIR Observation

The chart below shows the TIR mode transitions which will occur for different cases (which are dependent on the duration of the time gap) of divided observations.

2.5 minutes < Time gap <= 8 minutes:

TIR OBSERVATION to
TIR POINTING 2 to
TIR PREP
) *requires 1 min.*

....

Duration is dependent on time gap between the subsequent observations.

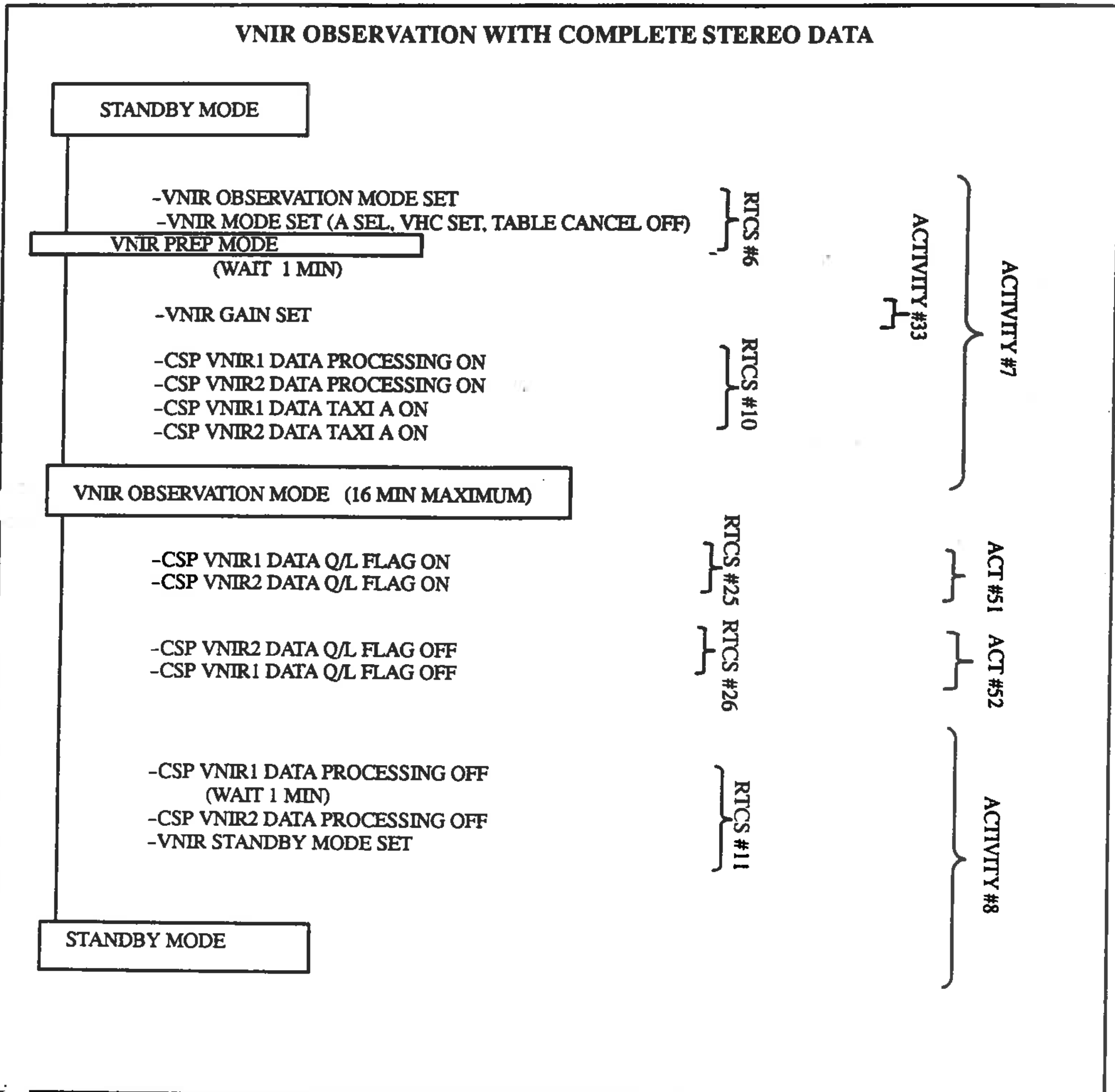
TIR PREP to
TIR SHORT-CAL 1 to
TIR POINTING 1 to
TIR OBS
) *requires 1.5 mins.*

Time gap <= 2.5 minutes:

TIR will continue to observe for consecutive observations with less than 2.5 minutes between them.

4.1.2.3.2.9 VNIR Observation with Complete Stereo Data

This operational sequence consists of a VNIR observation with an additional 60 seconds of VNIR2 data for the stereo effect.



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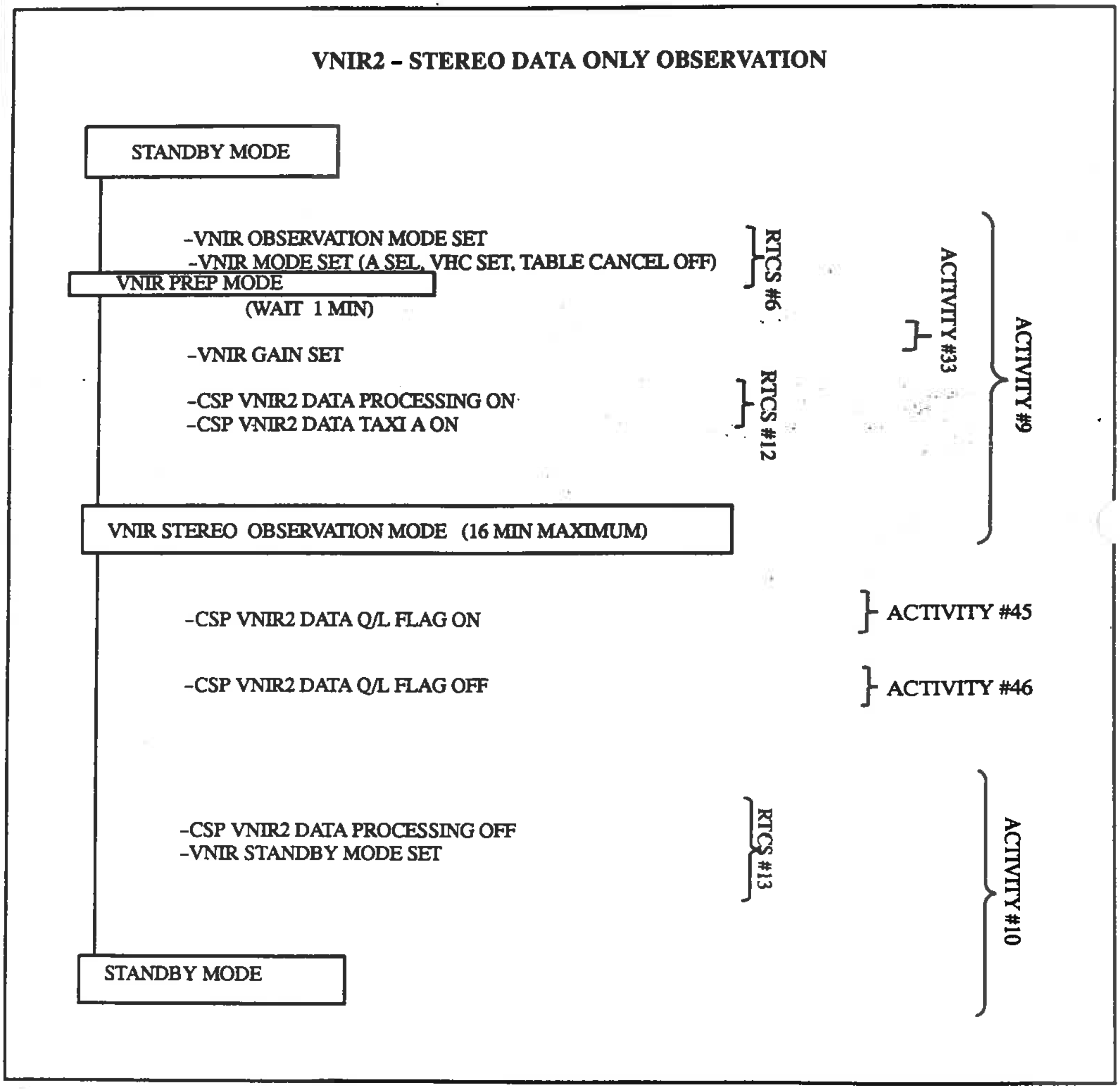
4.1.2.3.2.10 VNIR2 – Stereo Data Only Observation

This operational sequence consists of an observation of Bands 3N and 3B (i.e., stereo viewing of Band 3 using both the Nadir and Backward view).



4.1.2.3.2.11 Transition Observations

Additional ASTER operational sequences are discussed here to indicate transition sequences which can occur during an observation.

V/S/T Observation to TIR Observation:

V/S/T Obs *to* V Stereo Obs & T Obs *to* T Obs

TIR Observation to V/S/T Observation:

T Obs *to* SWIR Prep & T Obs *to* V/S/T Obs

S/T Observation to TIR Observation:

S/T Obs *to* T Obs

TIR Observation to S/T Observation:

T Obs *to* SWIR Prep & T Obs *to* S/T Obs

4.1.2.3.3 Additional Functional Check Sequences

The following describes additional ASTER operational sequences which may be performed in order to conduct a functional check of the instrument during anomalies or initial checkout. The two discussed are:

- VNIR CH1 Observation Sequence
- SWIR Observation Sequence

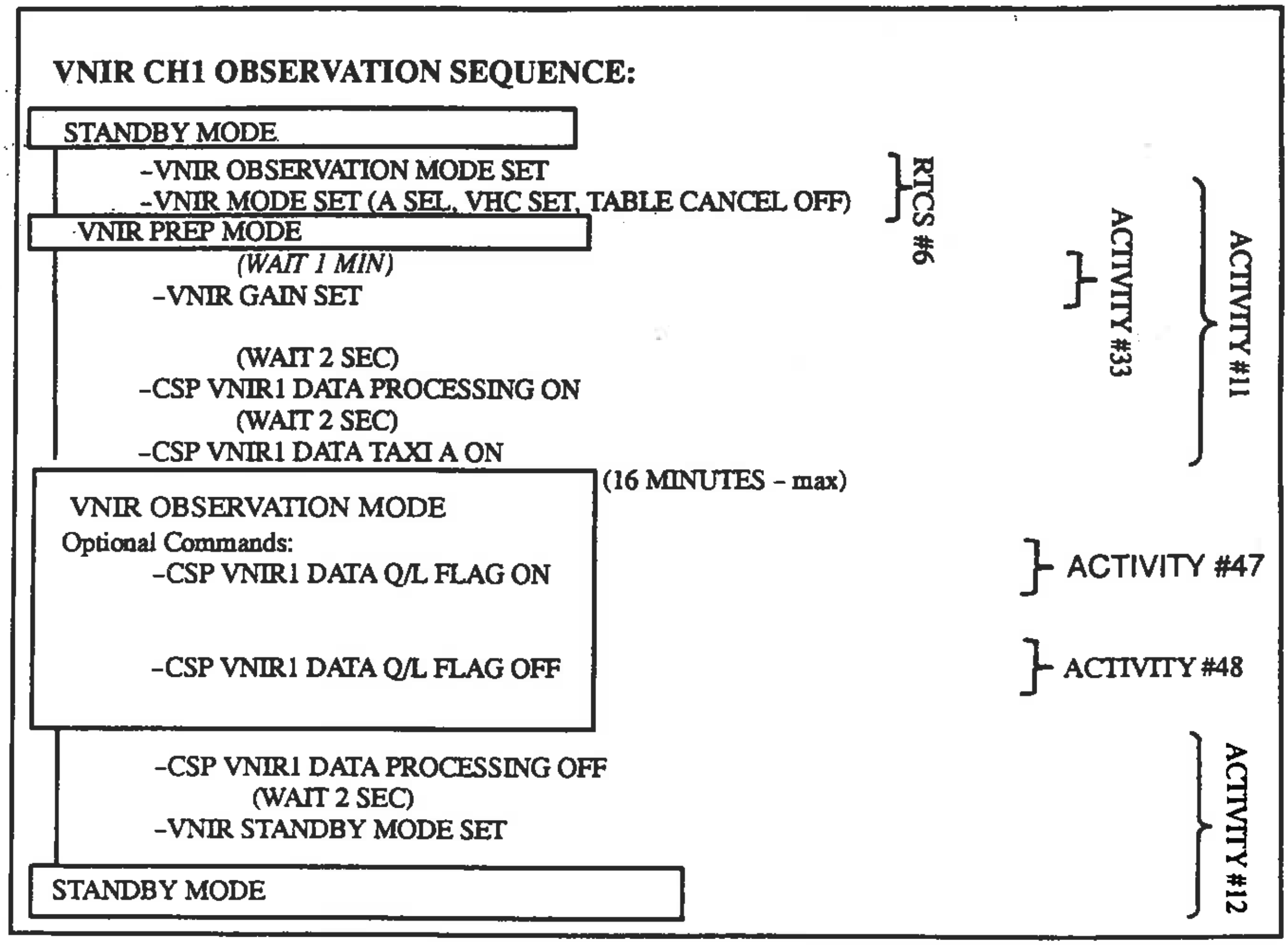


Figure 17. VNIR Channel 1 Observation Sequence

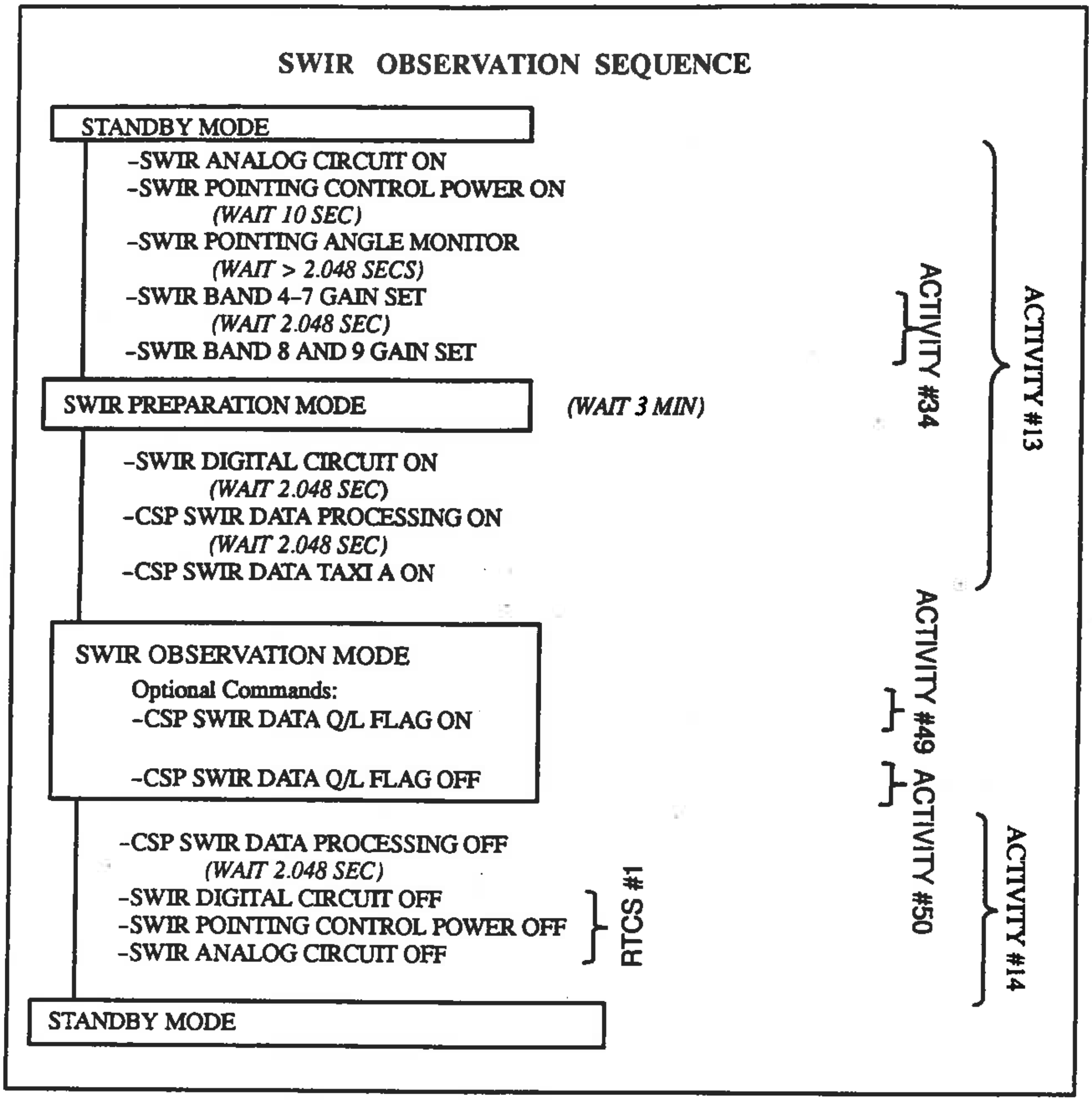


Figure 18. SWIR Observation Sequence

4.1.2.3.4 Calibration Sequences

The following paragraphs describe the various calibration sequences for the ASTER instrument.

4.1.2.3.4.1 ASTER System Calibration

The following describes the calibration sequence that is performed by the ASTER System. This calibration sequence is planned to be performed every 17 days on orbit. It consists of a series of independent calibration activities by the three ASTER instruments: TIR Long-Term optical and electrical calibrations, SWIR optical and dark calibrations, and VNIR optical, dark, and electrical calibrations. The TIR will acquire data at different temperatures as the blackbody warms up. The calibration sequence requires three orbits for completion. However, Both SWIR and VNIR can begin operational observation activities after the second orbit. The SWIR and VNIR calibration sequences must be performed during the night portion of the orbit because of dark calibration restrictions.

The TIR long-term calibration will be performed during the daytime portion of the first orbit. Then, calibration of SWIR and VNIR will be carried out in the night-time portion of the first and second orbits. The TIR pointing mirror will be kept in a nadir-looking position for 210 minutes from the end of the TIR long-term calibration.

The long-term calibration sequence is depicted on the following pages.

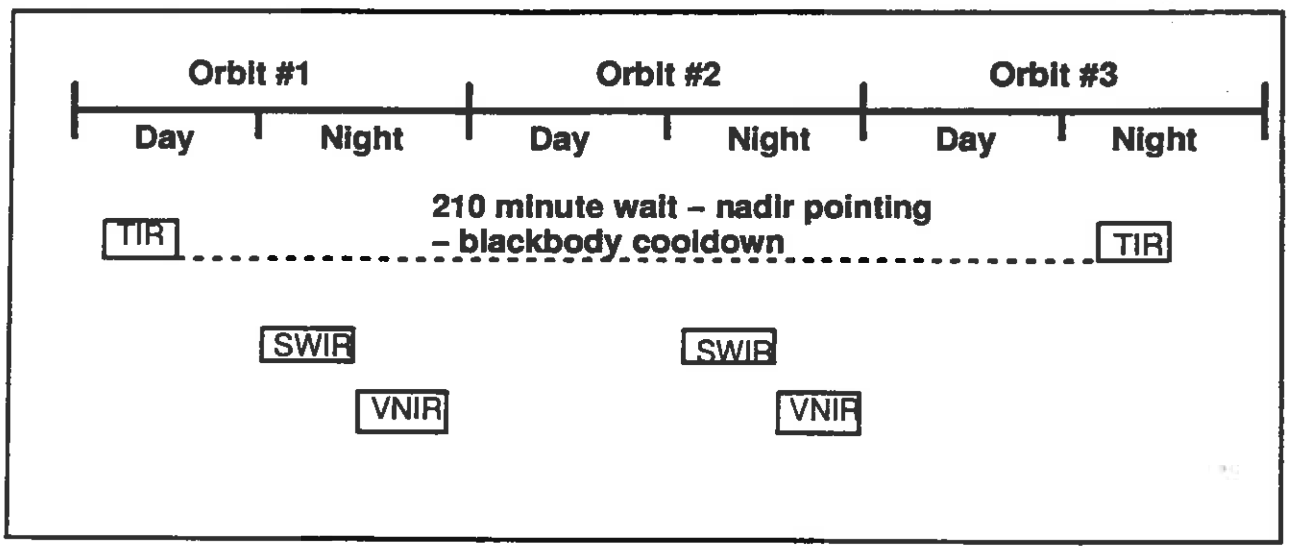
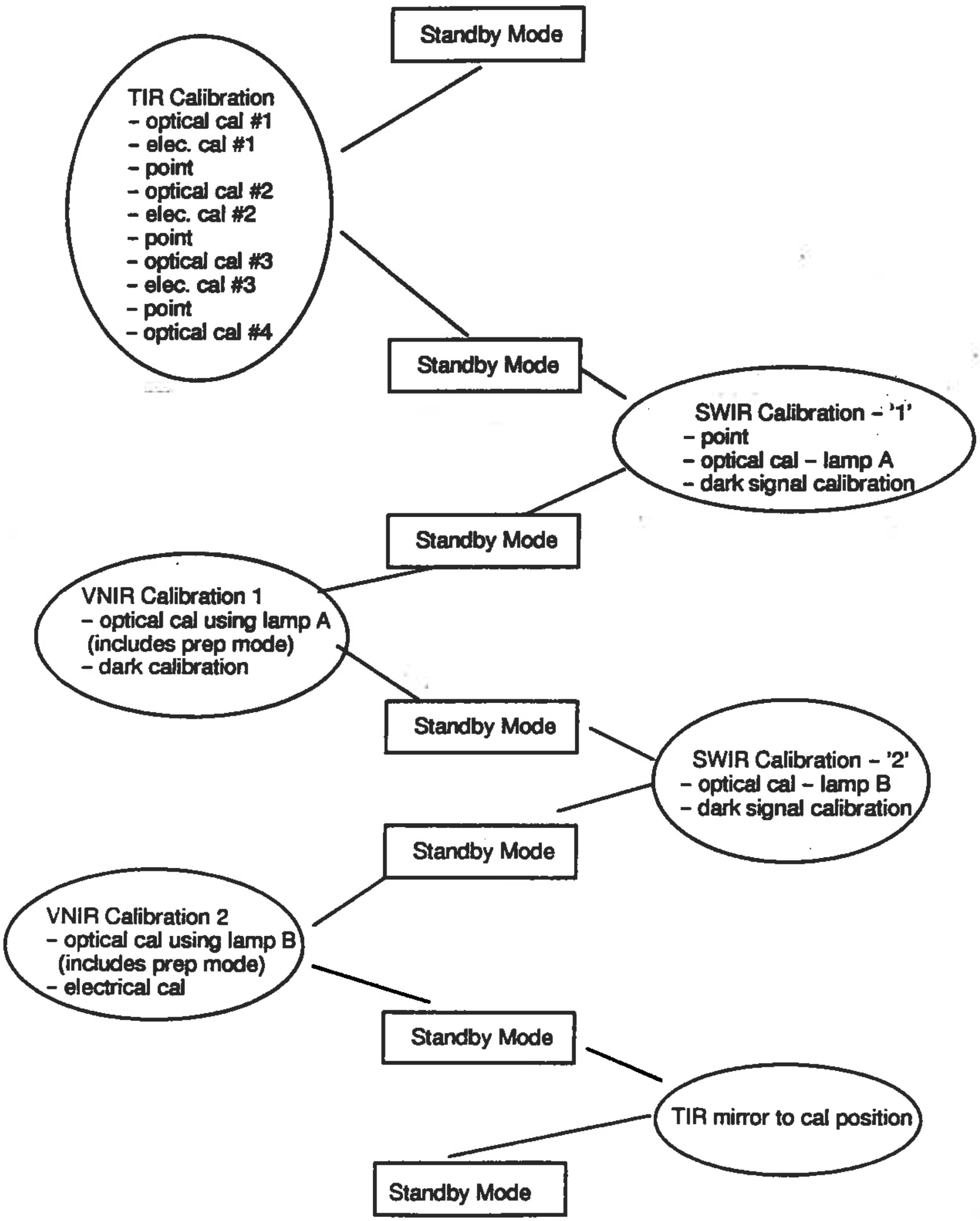


Figure 19. Long-Term Calibration

ASTER LONG-TERM CALIBRATION SEQUENCE



ASTER LONG-TERM CALIBRATION SEQUENCE

STANDBY MODE

- -TIR OPERATION POWER ON
  (WAIT 2 SECONDS)
- -TIR SCANNER POWER ON
  (WAIT 2 SECONDS)
- -TIR MIRROR ROTATION TO CAL POSITION

TIR AMP PREPARATION MODE (WAIT 5 MINS.)

RTCS #15:

- -CSP TIR DATA PROCESSING ON
- -CSP TIR DATA TAXI A ON

TIR OPT-CALIBRATION (1ST) (WAIT 30 SECS.)

- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:ON, DETECTOR TEMP:SENS1)

TIR ELE-CALIBRATION (1ST) (WAIT 30 SECS.)

- -CSP TIR DATA PROCESSING OFF
- -TIR MIRROR ROTATION TO NADIR POSITION
- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:OFF, DETECTOR TEMP:SENS 1)

TIR POINTING MODE (WAIT 60 SECS.)

(WAIT 12 MINUTES ...TBR)

- -TIR MIRROR ROTATION TO CAL POSITION

TIR POINTING MODE (WAIT 60 SECS.)

RTCS #15:

- -CSP TIR DATA PROCESSING ON
- -CSP TIR DATA TAXI A ON

TIR OPT-CALIBRATION (2ND) (WAIT 30 SECS.)

- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:ON, DETECTOR TEMP:SENS 1)

TIR ELE-CALIBRATION (2ND) (WAIT 30 SECS.)

- -CSP TIR DATA PROCESSING OFF
- -TIR MIRROR ROTATION TO NADIR POSITION
- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:OFF, DETECTOR TEMP:SENS 1)

TIR POINTING MODE (WAIT 60 SECS.)

(WAIT 7 MINUTES ...TBR)

- -TIR MIRROR ROTATION TO CAL POSITION

ACTIVITY #43

CONTINUED ON NEXT PAGE...

ASTER LONG-TERM CALIBRATION SEQUENCE - (CONTINUED)

TIR POINTING MODE (WAIT 60 SECS.)

- -CSP TIR DATA PROCESSING ON
- -CSP TIR DATA TAXI A ON

TIR OPT-CALIBRATION (3RD) (WAIT 30 SECS.)

- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:ON, DETECTOR TEMP:SENS 1)

TIR ELE-CALIBRATION (3RD) (WAIT 30 SECS.)

- -CSP TIR DATA PROCESSING OFF
- -TIR MIRROR ROTATION TO NADIR POSITION
- -TIR MODE SET (BLACKBODY:ON, ELE-CAL:OFF, DETECTOR TEMP:SENS 1)

(RTCS #15)

TIR POINTING MODE (WAIT 60 SECS.)

(WAIT 5 MIN 45 SECS MINUTES ...TBR)

- -TIR MIRROR ROTATION TO CAL POSITION

TIR POINTING MODE (WAIT 60 SECS.)

- -CSP TIR DATA PROCESSING ON
- -CSP TIR DATA TAXI A ON

TIR OPT-CALIBRATION (4TH) (WAIT 30 SECS.)

- -CSP TIR DATA PROCESSING OFF
- -TIR MIRROR ROTATION TO NADIR POSITION
- -TIR MODE SET (BLACKBODY:OFF, ELE-CAL:OFF, DETECTOR TEMP:SENS 1)

(RTCS #16)

(WAIT 2 SEC)

- -TIR SCANNER POWER OFF

(WAIT 10 SEC)

- -TIR OPERATION POWER OFF

(ACTIVITY #43 (con't))

STANDBY MODE

- -SWIR POINTING CONTROL POWER ON

SWIR POINTING MODE

- -SWIR POINTING ANGLE MONITOR
  (WAIT 10 SECS)
- -SWIR POINTING PULSE 1 SET
  (WAIT 2.048 SEC)
- -SWIR POINTING PULSE 2 SET
  (WAIT 10 SECS)
- -SWIR POINTING START
  (WAIT 10 MINS)

(ACTIVITY #38)

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ASTER LONG-TERM CALIBRATION SEQUENCE - (CONTINUED)

-SWIR POINTING CONTROL POWER OFF (ACT #38 (con't))

STANDBY MODE

-SWIR ANALOG CIRCUIT ON
-SWIR POINTING CONTROL POWER ON
(WAIT 10 SECS)
-SWIR POINTING ANGLE MONITOR
(RTCS #2)

-SWIR BAND 4-7 NORMAL GAIN SET
(WAIT 2 SECS)
-SWIR BAND 8 AND 9 NORMAL GAIN SET

SWIR PREPARATION MODE (WAIT 3 MINS)

-SWIR DIGITAL CIRCUIT ON
-SWIR CALIBRATION CIRCUIT ON
-SWIR LAMP A SEL
-SWIR LAMP ON
- (WAIT 8 MIN)
-CSP SWIR DATA PROCESSING ON
-CSP SWIR DATA TAXI A ON

SWIR OPTICAL CALIBRATION MODE (WAIT 1 MIN)

-SWIR LAMP OFF

SWIR DARK-CALIBRATION MODE (20 SEC/EACH GAIN)
(WAIT 20 SECS)
-SWIR BAND 4-7 HIGH GAIN SET
-SWIR BAND 8 AND 9 HIGH GAIN SET
(WAIT 20 SECS)
-SWIR BAND 4-7 LOW1 GAIN SET
-SWIR BAND 8 AND 9 LOW1 GAIN SET
(WAIT 20 SECS)
-SWIR BAND 4-7 LOW2 GAIN SET
-SWIR BAND 8 AND 9 LOW2 GAIN SET
(WAIT 20 SECS)

-CSP SWIR DATA PROCESSING OFF
-SWIR CALIBRATION CIRCUIT OFF
(RTCS #17)

-SWIR DIGITAL CIRCUIT OFF
-SWIR POINTING CONTROL POWER OFF
-SWIR ANALOG CIRCUIT OFF
(RTCS #1)

(ACTIVITY #41)

STANDBY MODE

-VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL{ALL}, BACKWARD DATA CORRECTION TABLE CANCEL:ON)
-VNIR CALIBRATION PREPARATION MODE
(RTCS #19) (ACTIVITY #39)

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ASTER LONG-TERM CALIBRATION SEQUENCE - (CONTINUED)

VNIR OPT-CALIBRATION PREPARATION MODE (WAIT 8 MINS)

- -VNIR OPT-CALIBRATION MODE
- -VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL {ALL}, BACKWARD DATA CORRECTION TABLE CANCEL: ON)
- -VNIR NORMAL GAIN SET
  (WAIT 1 MIN)
- -CSP VNIR1 DATA PROCESSING ON
- -CSP VNIR2 DATA PROCESSING ON
- -CSP VNIR1 DATA TAXI A ON
- -CSP VNIR2 DATA TAX A ON

VNIR OPT-CALIBRATION MODE (WAIT 1 MIN)

- -VNIR DARK-CALIBRATION MODE SET

VNIR DARK-CALIBRATION MODE (20 SEC/EACH GAIN)
(WAIT 20 SECS)
- -VNIR HIGH GAIN SET
  (WAIT 20 SECS)
- -VNIR LOW GAIN SET
  (WAIT 20 SECS)

- -CSP VNIR2 DATA PROCESSING OFF
- -CSP VNIR1 DATA PROCESSING OFF
- -VNIR STANDBY MODE SET

RTCS #19 (con"t)

ACTIVITY #39 (con't)

STANDBY MODE

- -SWIR ANALOG CIRCUIT ON
- -SWIR POINTING CONTROL POWER ON
  (WAIT 10 SEC)

RTCS #2

- -SWIR POINTING ANGLE MONITOR
- -SWIR BAND 4-7 NORMAL GAIN SET
  (WAIT 2 SEC)
- -SWIR BAND 8 AND 9 NORMAL GAIN SET

SWIR PREPARATION MODE (WAIT 3 MINS)

- -SWIR DIGITAL CIRCUIT ON
- -SWIR CALIBRATION CIRCUIT ON
- -SWIR LAMP B SEL
- -SWIR LAMP ON
- \- (WAIT 8 MIN)
- -CSP SWIR DATA PROCESSING ON
- -CSP SWIR DATA TAXI A ON

SWIR OPTICAL CALIBRATION MODE (WAIT 1 MIN)

- -SWIR LAMP OFF

RTCS #18

ACTIVITY #42

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ASTER LONG-TERM CALIBRATION SEQUENCE - (CONTINUED)

SWIR DARK-CALIBRATION MODE (20 SEC/EACH GAIN)
(WAIT 20 SECS)
-SWIR BAND 4-7 HIGH GAIN SET
-SWIR BAND 8 AND 9 HIGH GAIN SET
(WAIT 20 SECS)
-SWIR BAND 4-7 LOW1 GAIN SET
-SWIR BAND 8 AND 9 LOW1 GAIN SET
(WAIT 20 SECS)
-SWIR BAND 4-7 LOW2 GAIN SET
-SWIR BAND 8 AND 9 LOW2 GAIN SET
(WAIT 20 SECS)

-CSP SWIR DATA PROCESSING OFF
-SWIR CALIBRATION CIRCUIT OFF
-SWIR DIGITAL CIRCUIT OFF
-SWIR POINTING CONTROL POWER OFF
-SWIR ANALOG CIRCUIT OFF

RTCS #18 (con't) | RTCS #1 | ACTIVITY #42 (con't)

STANDBY MODE

-VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL{ALL}, LAMP:B, BACKWARD DATA CORRECTION TABLE CANCEL:ON)
-VNIR CALIBRATION PREPARATION MODE

VNIR OPT-CALIBRATION PREPARATION MODE (WAIT 8 MINS)

-VNIR OPT-CALIBRATION MODE SET
-VNIR MODE SET (VHC: TEMP SET, ROUTE: A SEL (ALL), LAMP B, BACKWARD DATA CORRECTION TABLE CANCEL: ON)
-VNIR NORMAL GAIN SET
(WAIT 1 MIN)
-CSP VNIR1 DATA PROCESSING ON
-CSP VNIR2 DATA PROCESSING ON
-CSP VNIR1 DATA TAXI A ON
-CSP VNIR2 DATA TAX A ON

VNIR OPT-CALIBRATION MODE (WAIT 1 MIN)

-VNIR ELE-CALIBRATION MODE SET

VNIR ELE-CALIBRATION MODE (20 SEC/EACH GAIN)
(WAIT 20 SECS)
-VNIR HIGH GAIN SET
(WAIT 20 SECS)
-VNIR LOW GAIN SET
(WAIT 20 SECS)

RTCS #20 | ACTIVITY #40

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ASTER LONG-TERM CALIBRATION SEQUENCE - (CONTINUED)

-CSP VNIR2 DATA PROCESSING OFF
-CSP VNIR1 DATA PROCESSING OFF
-VNIR STANDBY MODE SET

STANDBY MODE
-VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL {ALL}, BACKWARD DATA CORRECTION TABLE CANCEL:OFF)

RTCS #20 (con't) — ACTIVITY #40 (con't)

(WAIT 210 MINUTES FROM THE END OF THE TIR LONG-TERM CAL)
-TIR OPERATION POWER ON
(WAIT 2 SEC)
-TIR SCANNER POWER ON
(WAIT 2 SEC)
-TIR MIRROR ROTATION TO CAL POSITION

TIR POINTING MODE (WAIT 185 SECS)

-TIR SCANNER POWER OFF
(WAIT 2 SECS)
-TIR OPERATION POWER OFF

RTCS #21 — ACTIVITY #44

STANDBY MODE

4.1.2.3.5 ASTER TIR Getter Sequence

The following depicts the TIR sequence to actuate the Getter. The getter is used to maintain vacuum conditions in the detector dewar assembly. This function is actuated when the vacuum conditions degrade. The deterioration of the vacuum pressure is detected by the cryocooler drive current and the cryocooler temperature. It should not be necessary to activate the getter more than about once during the EOS mission. This sequence will be executed by an ECL proc.

TIR GETTER SEQUENCE

STANDBY MODE

-TIR COOLER POWER OFF (WAIT 120 MINS)

GETTER MODE
-TIR MODE SET (GETTER 1:ON, GETTER 2:OFF, DET TEMP:SENS 1)
(WAIT 12 MINS)
-TIR MODE SET (GETTER 1:OFF, GETTER 2:OFF, DET TEMP:SENS 1)
(WAIT 2 HOURS)
-TIR MODE SET (GETTER 1:OFF, GETTER 2:ON, DET TEMP:SENS 1)
(WAIT 12 MIN)
-TIR MODE SET (GETTER 1:OFF, GETTER2:OFF, DET TEMP:SENS 1)
(WAIT 2 HOURS)

-TIR COOLER POWER ON

STANDBY MODE

Figure 20. TIR Getter Sequence

4.1.2.3.6 ASTER Safe Mode Sequence

The following describes the ASTER safe mode sequence. This mode is initiated by either the 'Safe Mode' command or by the ASTER CSP detecting the loss of the spacecraft 'IM OK' signal.

The safe mode command sequence is embedded into the CSP. Once initiated, it must be allowed to complete. The commands from the CSP to the rest of ASTER are executed within 30 seconds of mode initiation. However, the SWIR mirror will not be in its 'safe' position until 10 minutes after initiation. It is for this reason that SWIR is not turned-off completely during the 'safe' command sequence. It is understood by the ASTER team that the spacecraft will start 'safe mode' attitude changes 30 seconds after safe mode initiation.

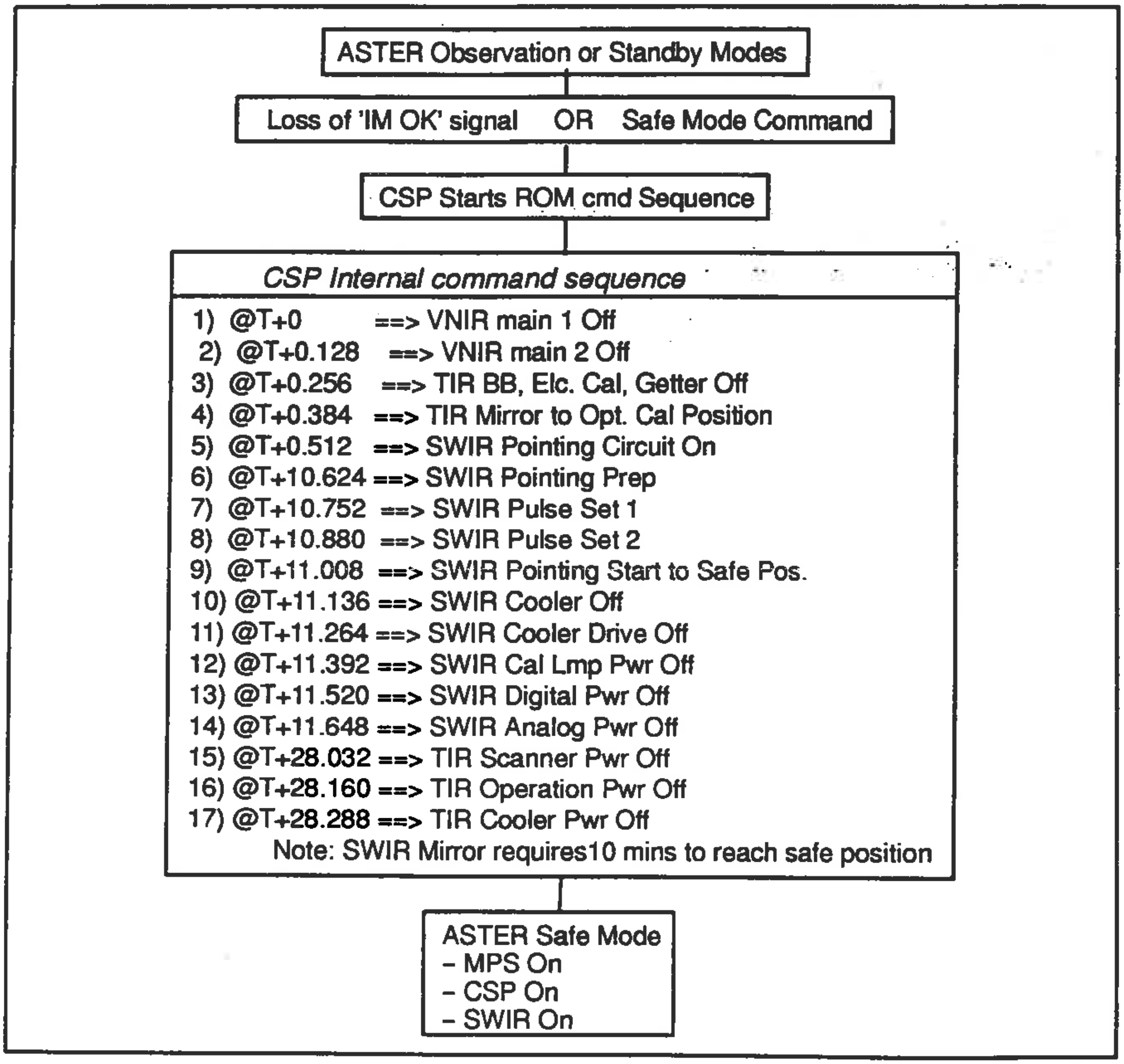


Figure 21. ASTER Safe Mode Sequence

4.1.2.3.7 ASTER Reconfiguration from Safe Mode

The recovery from 'safe' mode is accomplished by performing a subset of the initial activation procedure. This would consist of verifying that all of ASTER launch locks are still Off, and powering up TIR, SWIR and VNIR. At the start of this recovery, the CSP and MPS are still assumed to be on, since it is not required to turn them off during safe mode. If they are turned off, then in effect, the ASTER will be in Survival Mode.

4.1.2.3.8 ASTER Survival Mode Sequence

The following depicts the ASTER survival mode sequence. This mode is initiated by either a ground command or by the spacecraft computer if it detects a power critical situation on the spacecraft. If the spacecraft computer detects a power critical situation, it will start the execution of an RTCS which will place ASTER in survival mode. The ASTER survival Mode sequence is similar to the 'safe mode' sequence, with the additional action to turn–off the MPS, CSP and SWIR.

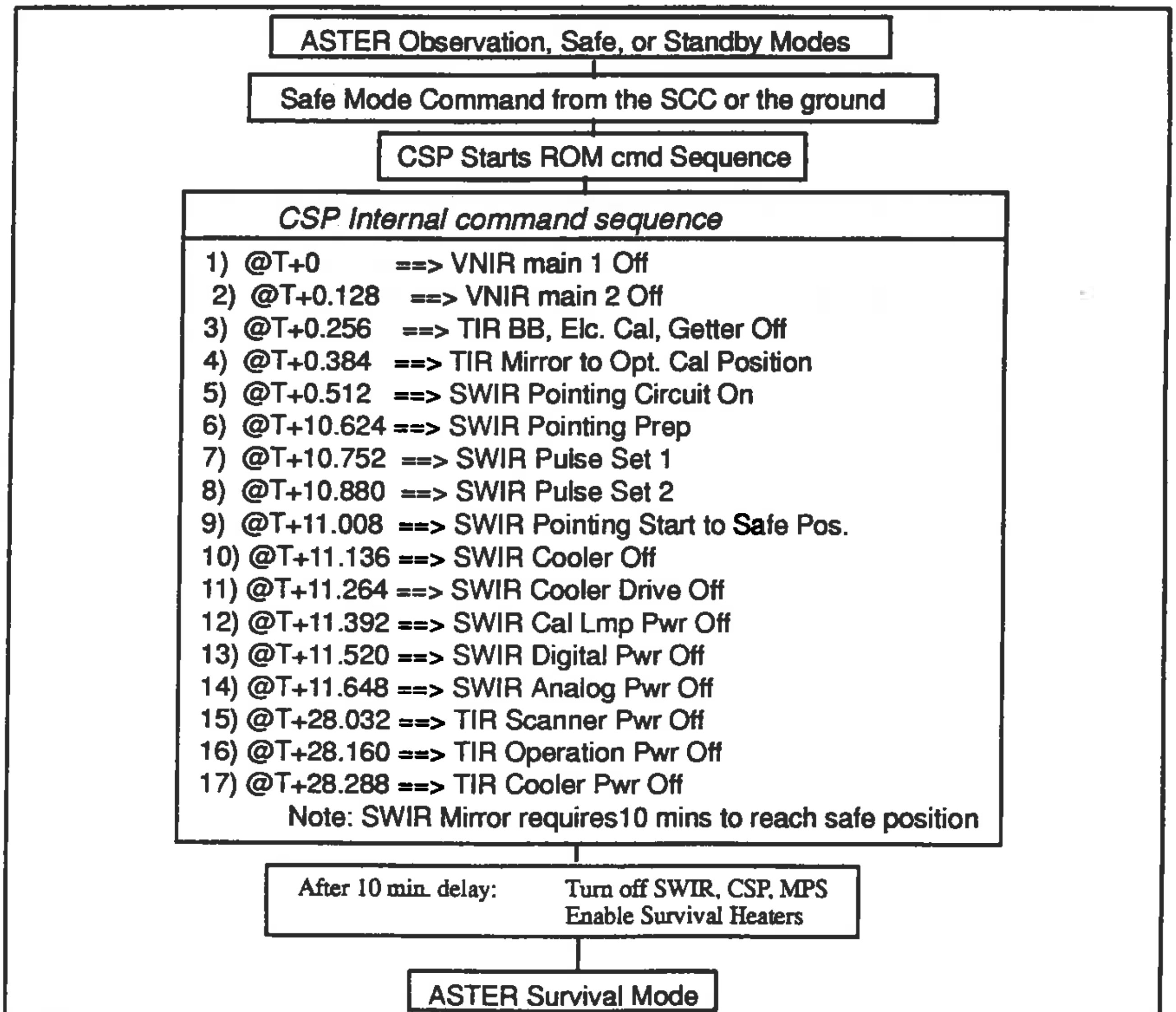


Figure 22. ASTER Survival Mode Sequence

4.1.2.3.9 ASTER reconfiguration from survival mode

Recovery from survival mode is very much like the ASTER initial activation with the exception of actuating the ASTER launch locks. The launch lock activation activities are replaced by verification steps to ensure that the launch locks are still off. This is especially important in the case of the cooler launch locks, which if still on during cooler power up command sequences, will destroy the cooler drives.

4.1.3 Correlation of Instrument and System Modes

The spacecraft system operating modes and ASTER operating modes are directly interrelated. The S/C bus provides predefined services and resources for each of its operating modes. ASTER operates to predefined tasks for each of its operating modes.

The following matrix relates ASTER operating modes and the system operating modes.

Table V Relationship between Spacecraft and ASTER Operating Modes

	ASTER Instrument Mode						
Spacecraft System Mode	Launch (OFF)	Survival	Safe	Science	Calibration	Cool-down	Standby
Launch	X						
Science				X	X	X	X
Survival		X					
Safe		X	X				

The following defines the ASTER mode during spacecraft delta-v maneuvers and the CERES yaw slew maneuvers.

Table VI ASTER Modes during Spacecraft Maneuvers

Space-craft Activities	Orbit Acquisition	Orbit Maintenance: Drag Makeup	Orbit Maintenance: Inclination Correction	CERES/ MODIS Yaw Slew
ASTER	Launch Configura-tion --------- Heater & Operational Power Enabled	Pre-Maneuver: Transition from Standby Mode to Contamination Safe Mode in 10 minutes. Note: Contamination Safe Mode is the same as Standby Mode with the SWIR and TIR mirrors turned to the calibra-tion position. Configuration in Contamination Safe Mode: VNIR: Standby Mode SWIR: Standby Mode with mirror at Cal position TIR: Standby Mode with mirror at Cal position CSP: Standby Mode MPS: Operation Mode Post-Maneuver: Transition from Contamination Safe Mode to Standby Mode; requires 10 minutes; SWIR mirror will be turned to observation position.		Normal Ops; ... since only reaction wheels are used (not thrusters).

The ASTER mode during attitude sensor calibration maneuvers (e.g., IRU allignment maneuver) is **(TBD 5)**

The ASTER mode during any additional maneuvers will be included here when the maneuvers are baselined.

4.1.4 ASTER TMON Description

ASTER will have the following functions implemented by TMON's.

Because ASTER utilizes multifunction commands, the following is noted: TMON commands for health and safety must be single function commands or commands with bit patterns that do not depend on the instrument's configuration (i.e., a configuration independent predefined bit pattern.)

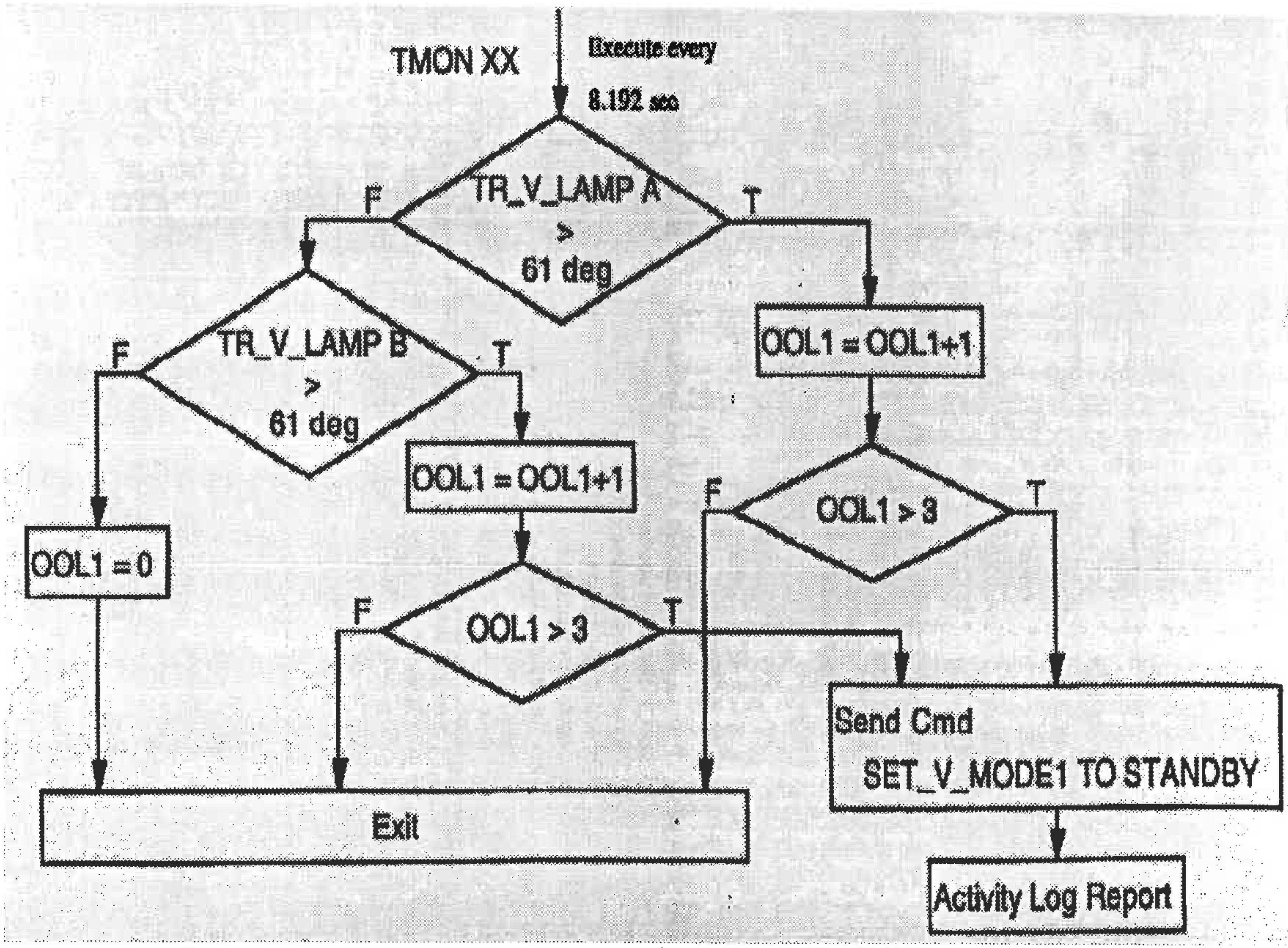
The TMON logic is illustrated in the figures following the descriptive table.

Table VII ASTER TMONs

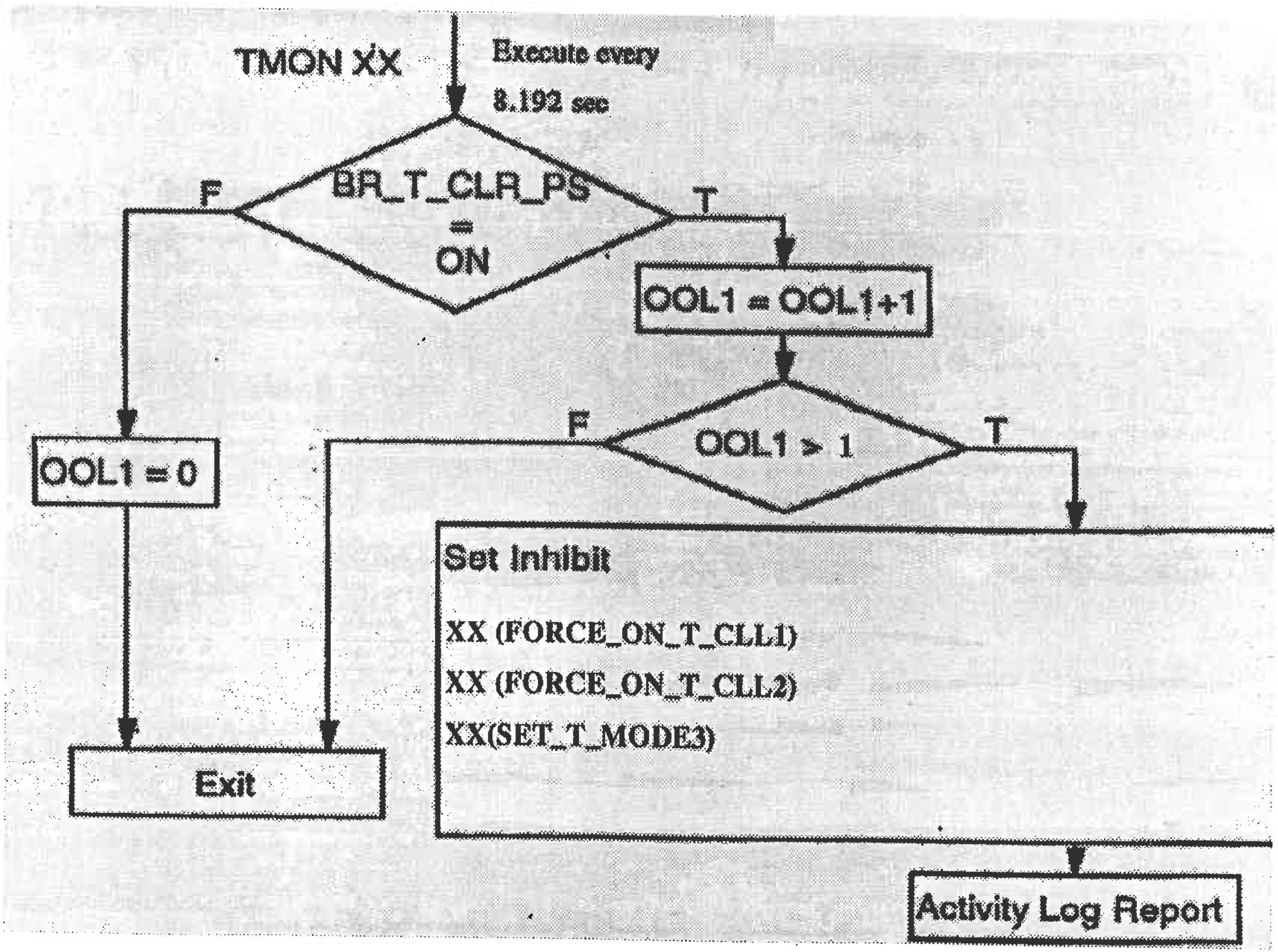
#	Subsy-tem	TMON Description	Telemetry Monitored	TMON Action
1	VNIR	Monitor Calibration Lamp Temp Tlm and turn off lamp if too hot. This function requires the monitoring of two temp tlm points.	- VNIR Lamp A Temp: TR_V_LAMP_A - VNIR Lamp B Temp: TRV_LAMP_B	VNIR Serial Magnitude Command to Transition to Standby Mode: SET_V_MODE1 Place entry in activity log
2	TIR	Prevent the execution of commands to turn on the Cooler Latch or the Getter when the cooler power supply is ON.	TIR Detector Temp: BR_T_CLR_PS	**INHIBIT** the following TIR commands: FORCE_ON_T_CLL1 FORCE_ON_T_CLL2 SET_T_MODE3 Place entry in activity log
3	VNIR	Monitor VNIR VSP1 Temp.	-VNIR VSP1 Temp: TR_V_VSP1	VNIR Command to transition to Standby Mode: SET_V_MODE1 Place entry in activity log

4	SWIR	To prevent the failure of SWIR Cooler Drive Circuit: Monitor SWIR Cooler Drive Circuit Power ON/OFF status, and inhibit SWIR Launch Lock On Commands when SWIR Cooler Drive Circuit is On.	-SWIR Telemetry BR_S_CLR_PS	**INHIBIT** SWIR Launch Lock On Commands: FORCE_ON_S_LLK1 FORCE_ON_S_LLK2 Place entry in activity log
5	TIR	To prevent the execution of a command to power on TIR when the temperature is too hot. Permanent detector hardware damage would result.	-TIR Telemetry BR_T_DETECT	INHIBIT TIR Operational Power ON Command TURN_ON_T_OPR
6	VNIR	To prevent the execution of the VNIR pointing command in case the launch lock on command has been accidentally transmitted.	-VNIR Telemetry BR_V_LOCK	**INHIBIT** VNIR Pointing Command: SET_V_MODE1 TO P_START Place entry in activity log
7	TIR	To prevent the execution of a command to power on the TIR scanner when the TIR latch is on.	-TIR Telemetry BR_T_LATCH_ON_OF	**INHIBIT** TIR Scanner Power ON Command TURN_ON_T_SCAN Place entry in activity log

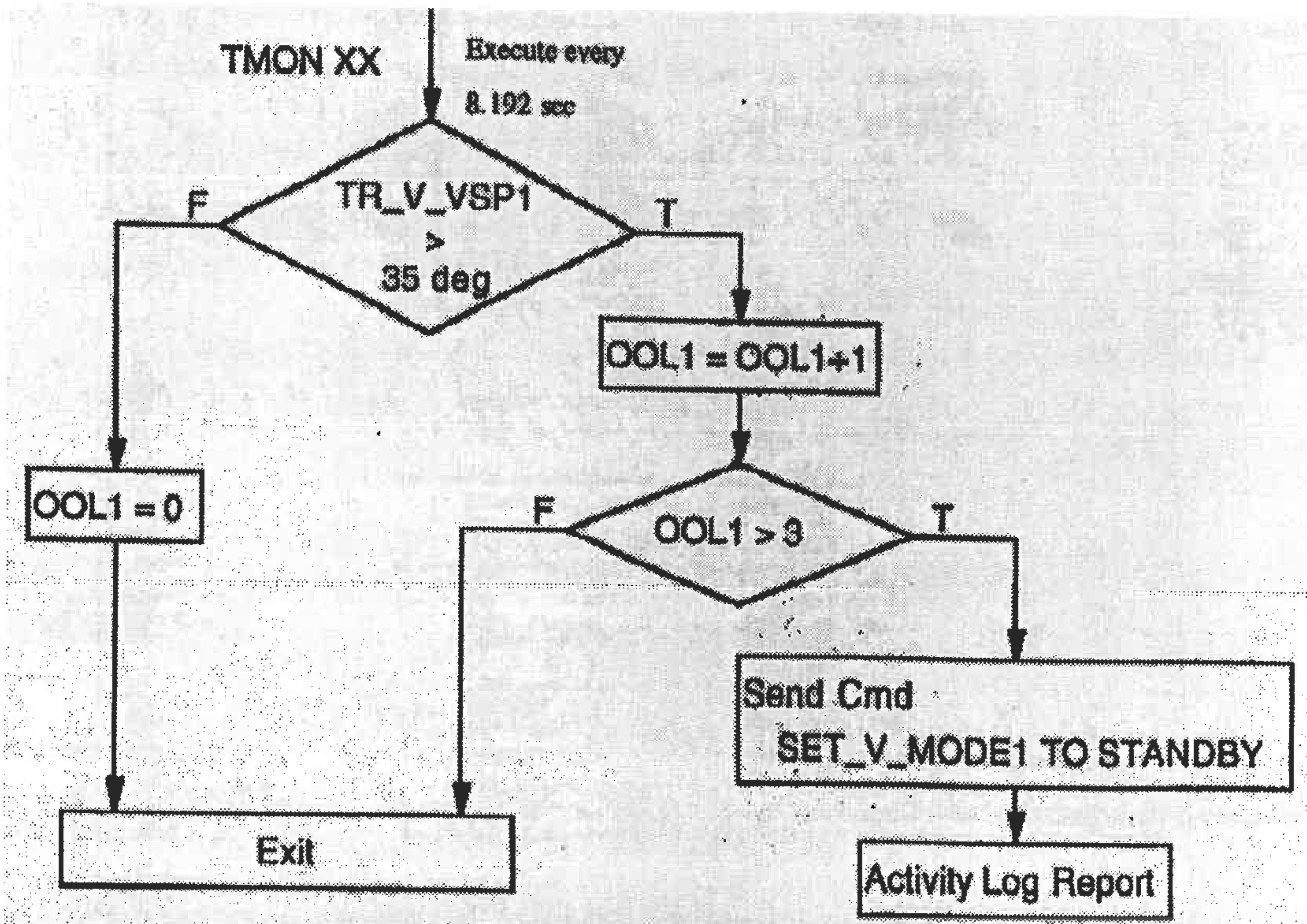
TMON #1: VNIR LAMP A and LAMP B TEMP MONITOR



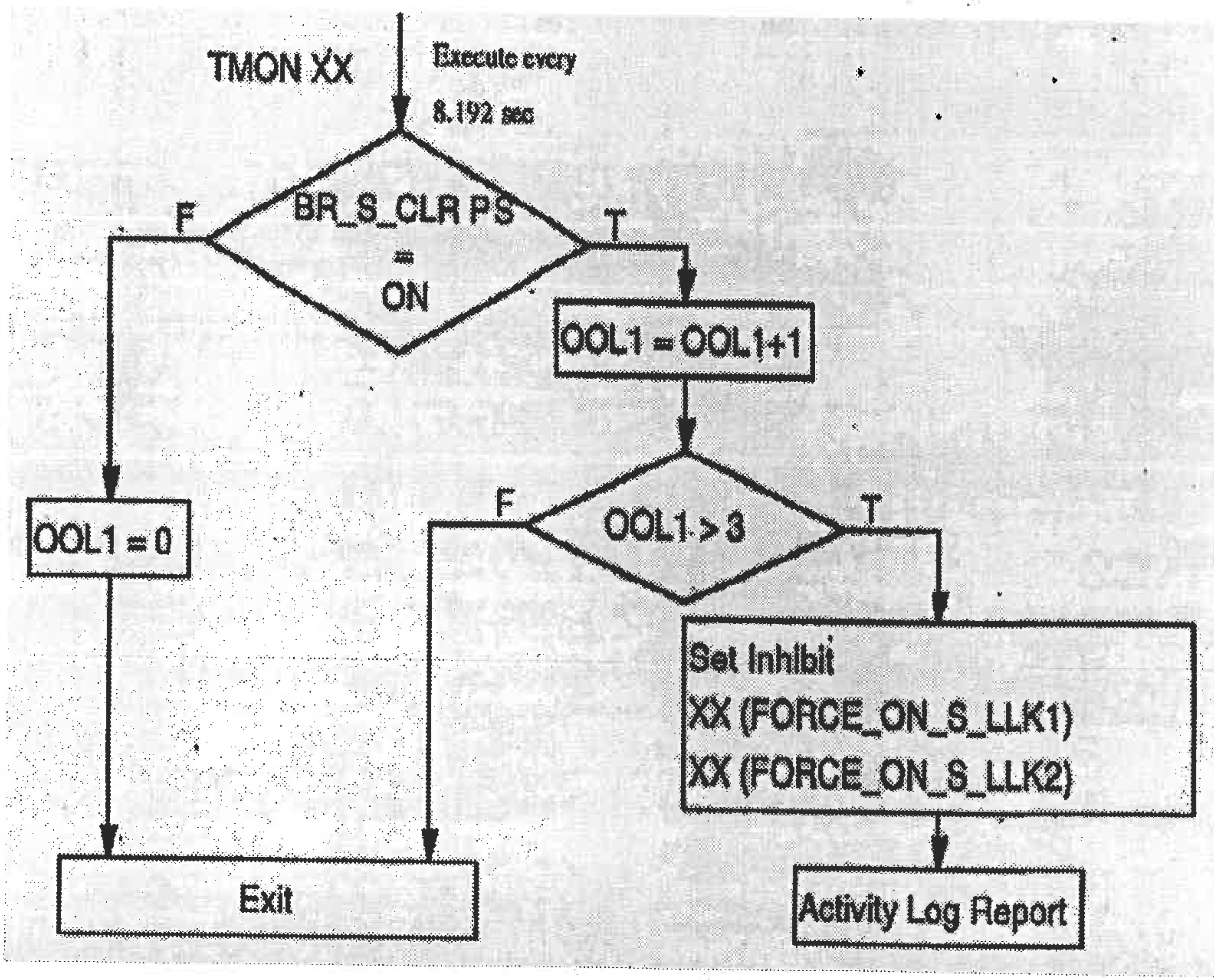
TMON #2: TIR COOLER LAUNCH LOCK ON and GETTER INHIBIT



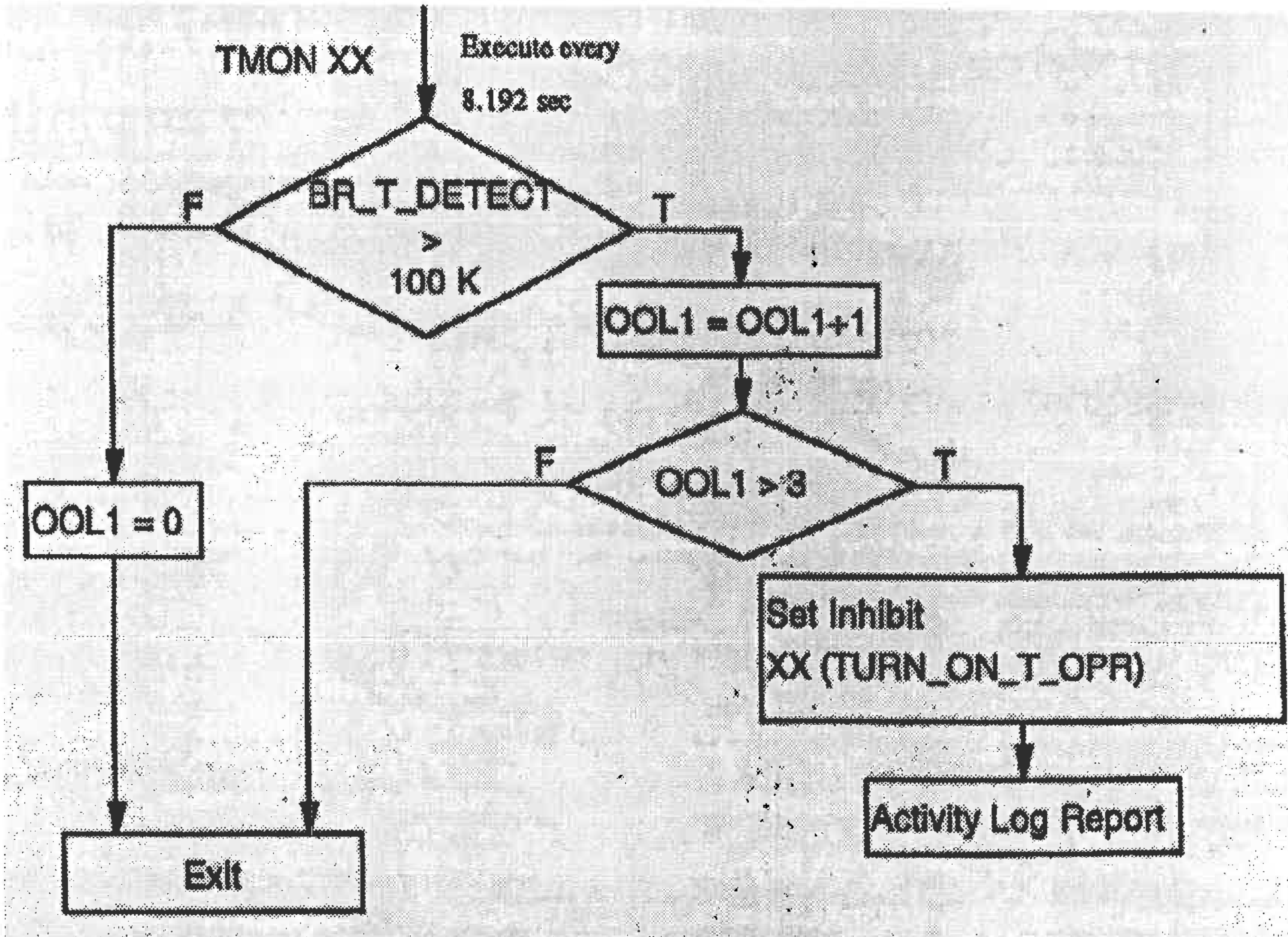
TMON#3: VNIR VSP1 TEMP MONITOR



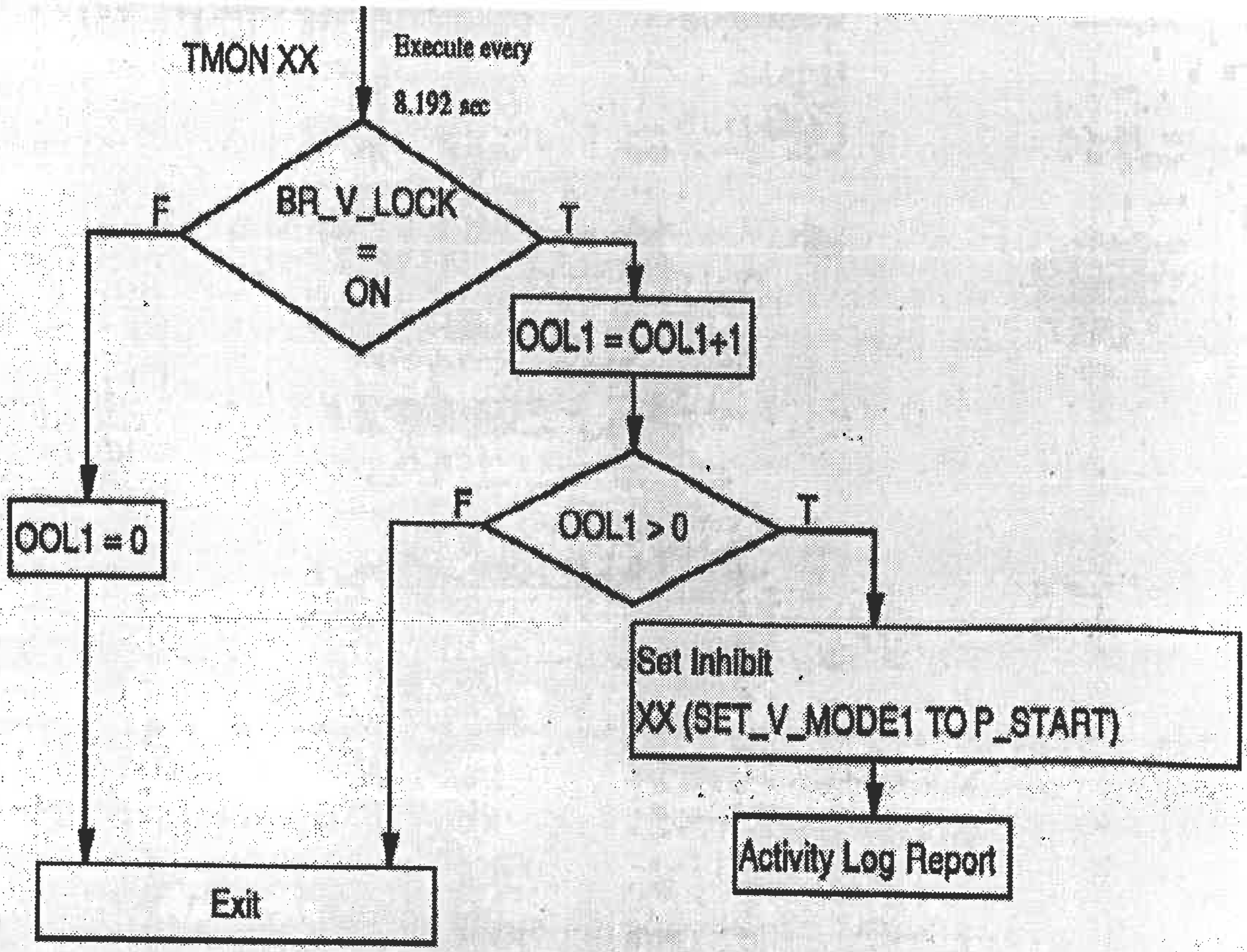
TMON #4: SWIR LAUNCH LOCK ON INHIBIT



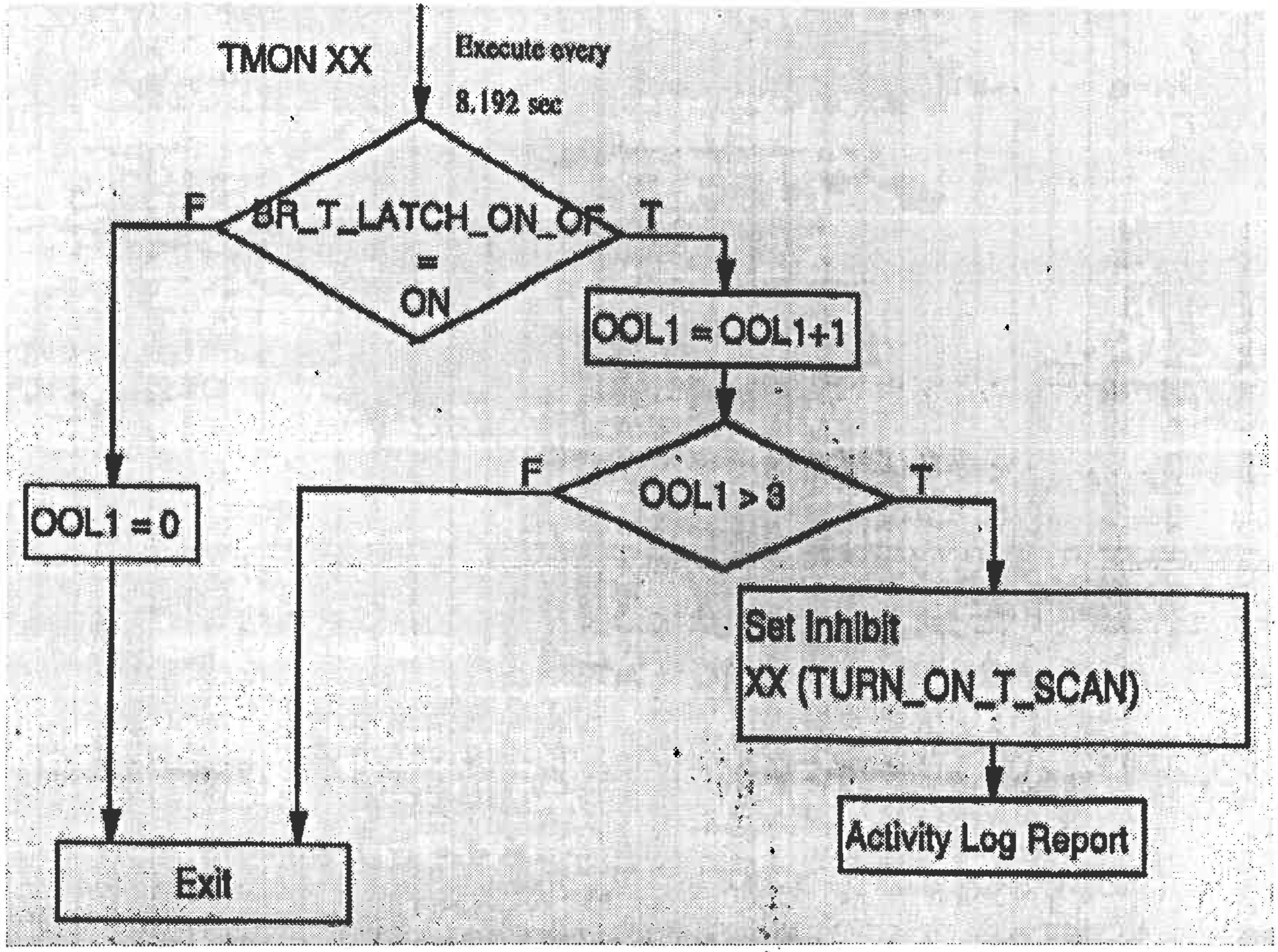
TMON #5: TIR OPERATION POWER ON INHIBIT



TMON #6: VNIR POINTING INHIBIT



TMON #7: TIR SCANNER POWER ON INHIBIT



4.1.5 ASTER RTCSs Description

The following is a list of tentative ASTER Relative Time Sequences.

Table VIII ASTER RTCSs

RTCS Descriptions	
No.	**Description**
1	SWIR Mode Change 1 (Observation to Standby)
2	SWIR Mode Change 2 (Standby to Prep)
3	TIR Mode Change 1 (Standby to Short Term Calibration)
4	TIR Mode Change 2 (Short Term Calibration to Standby)
5	Start of V/S/T Observation – Data Acquisition
6	VNIR Mode Change (Standby to Preparation)
7	End of V/S/T Observation – Data Acquisition
8	Start of S/T Observation – Data Acquisition
9	End of S/T Observation – Data Acquisition
10	Start of VNIR Observation – Data Acquisition
11	End of VNIR Observation – Data Acquisition
12	Start of VNIR Stereo Observation – Data Acquisition
13	End of VNIR Stereo Observation – Data Acquisition
14	TIR Short Term Calibration – Data Acquisition
15	TIR Optical and Electrical Cal
16	TIR 4th Optical Cal
17	SWIR Calibration 1
18	SWIR Calibration 2
19	VNIR Calibration 1
20	VNIR Calibration 2
21	TIR Mirror Rotation after Long Term Cal
22	V/S/T Quicklook Flags On
23	V/S/T Quicklook Flags Off
24	Survival Mode Entry
25	VNIR Quicklook Flags On
26	VNIR Quicklook Flags Off
27	VNIR Launch Lock A Off
28	VNIR Launch Lock B Off

4.1.5.1 RTCS #1 – SWIR Mode Change 1 (Obs to Standby)

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR Signal Processing (Digital) Power Off	AST_TURN_OFF_S_DTL
2	1.024	SWIR Pointing Control Power Off	AST_TURN_OFF_S_PTG
3	2.048	SWIR Signal Processing (Analog) Power Off	AST_TURN_OFF_S_ANA

4.1.5.1.1 RTCS #2 – SWIR Mode Change 2 (Standby to Prep)

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR Analog Circuit On	AST_TURN_ON_S_ANA
2	1.024	SWIR Pointing Control Power On	AST_TURN_ON_S_PTG
3	11.264	SWIR Pointing Angle Monitor	AST_SET_S_MODE3 (TO ANGLE_MON)

4.1.5.1.1.1 RTCS #3 – TIR Mode Change 1 (Standby to Short Term Cal)

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	TIR Operational Power On	AST_TURN_ON_T_OPR
2	2.048	TIR Scanner Power On	AST_TURN_ON_T_SCAN
3	4.096	TIR Mode Set [calibration]	**(TBD 6)**

4.1.5.1.1.2 RTCS #4 – TIR Mode Change 2 (Short Term Cal to Standby)

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	TIR Scanner Power Off	AST_TURN_OFF_T_SCAN
2	10.240	TIR Operational Power Off	AST_TURN_OFF_T_OPR

4.1.5.1.1.3 RTCS #5 – Start V/S/T Observation – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR Signal Processing (Digital) Power On	AST_TURN_ON_S_DTL
2	1.024	SWIR Data Processing On	AST_TURN_ON_C_SDP
3	2.048	VNIR 1 Data Processing On	AST_TURN_ON_C_VDP1
4	3.072	VNIR 2 Data Processing On	AST_TURN_ON_C_VDP2
5	4.096	TIR Taxi A(or B) On	AST_TURN_ON_C_T_A or AST_TURN_ON_C_T_B
6	5.120	SWIR Taxi A(or B) On	AST_TURN_ON_C_S_A or AST_TURN_ON_C_S_B
7	6.144	VNIR 1 Taxi A(or B) On	AST_TURN_ON_C_V1_A or AST_TURN_ON_C_V1_B
8	7.168	VNIR 2 Taxi A(or B) On	AST_TURN_ON_C_V2_A or AST_TURN_ON_C_V2_B

4.1.5.1.1.4 RTCS #6 – VNIR Mode Change (Standby to Preparation)

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR Observation Mode Set	AST_SET_V_MODE1
2	2.048	VNIR Mode Set (A or B sel, VHC set, Table Cancel OFF)	AST_SET_V_MODE2

4.1.5.1.1.5 RTCS #7 – End of V/S/T Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR 1 Data Processing Off	AST_TURN_OFF_C_VDP1
2	1.024	SWIR Data Processing Off	AST_TURN_OFF_C_SDP
3	2.048	TIR Taxi A(or B) Off	AST_TURN_OFF_C_T_A or AST_TURN_OFF_C_T_B

4.1.5.1.1.6 RTCS #8 – Start of S/T Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR Signal Processing (Digital) Power On	AST_TURN_ON_S_DTL
2	1.024	SWIR Data Processing On	AST_TURN_ON_C_SDP
3	2.048	TIR Taxi A(or B) On	AST_TURN_ON_C_T_A or AST_TURN_ON_C_T_B
4	3.072	SWIR Taxi A(or B) On	AST_TURN_ON_C_S_A or AST_TURN_ON_C_S_B

4.1.5.1.1.7 RTCS #9 – End of S/T Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR Signal Processing Off	AST_TURN_OFF_C_SDP
2	1.024	TIR Taxi A(or B) Off	AST_TURN_OFF_C_T_A or AST_TURN_OFF_C_T_B

4.1.5.1.1.8 RTCS #10 – Start of VNIR Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR 1 Data Processing On	AST_TURN_ON_C_VDP1
2	1.024	VNIR 2 Data Processing On	AST_TURN_ON_C_VDP2
3	2.048	VNIR 1 Taxi A(or B) On	AST_TURN_ON_C_V1_A or AST_TURN_ON_C_V1_B
4	3.072	VNIR 2 Taxi A(or B) On	AST_TURN_ON_C_V2_A or AST_TURN_ON_C_V2_B

4.1.5.1.1.9 RTCS #11 – End of VNIR Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR 1 Data Processing Off	AST_TURN_OFF_C_VDP1
2	57.344	VNIR 2 Data Processing Off	AST_TURN_OFF_C_VDP2
3	58.368	VNIR Standby	AST_SET_V_MODE1

4.1.5.1.1.10 RTCS #12 – Start of VNIR Stereo Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR 2 Data Processing On	AST_TURN_ON_C_VDP2
2	1.024	VNIR 2 Taxi A(or B) On	AST_TURN_ON_C_V2_A or AST_TURN_ON_C_V2_B

4.1.5.1.1.11 RTCS #13 – End of VNIR Stereo Obs – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR 2 Data Processing Off	AST_TURN_OFF_C_VDP2
2	1.024	VNIR Standby	AST_SET_V_MODE1

4.1.5.1.1.12 RTCS #14 – TIR Short Term Calibration – Data Acquisition

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	TIR Taxi A(or B) On	AST_TURN_ON_C_T_A or AST_TURN_ON_C_T_B
2	30.720	TIR Taxi A(or B) Off	AST_TURN_OFF_C_T_A or AST_TURN_OFF_C_T_B

4.1.5.1.1.13 RTCS #15 – TIR Optical and Electrical Cal

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP TIR DATA PROCESSING ON	AST_TURN_ON_C_TDP
2	1.024	CSP TIR DATA TAXI A ON	AST_TURN_ON_C_T_A
3	31.744	TIR MODE SET (BLACKBODY:ON, ELE-CAL:ON, DETECTOR TEMP:SENS1)	AST_SET_T_MODE2
4	62.464	CSP TIR DATA PROCESSING OFF	AST_TURN_OFF_C_TDP
5	63.488	TIR MIRROR ROTATION TO Nadir POSITION	AST_MOVE_T_MIRROR
6	64.512	TIR MODE SET (BLACKBODY:ON, ELE-CAL:OFF, DETECTOR TEMP:SENS1)	AST_SET_T_MODE2

4.1.5.1.1.14 RTCS #16 – TIR 4th Optical Cal

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP TIR DATA PROCESSING ON	AST_TURN_ON_C_TDP
2	1.024	CSP TIR DATA TAXI A ON	AST_TURN_ON_C_T_A
3	31.744	CSP TIR DATA PROCESSING OFF	AST_TURN_OFF_C_TDP
4	32.768	TIR MIRROR ROTATION TO Nadir POSITION	AST_MOVE_T_MIRROR
5	33.792	TIR MODE SET (BLACKBODY:OFF, ELE-CAL:OFF, DETECTOR TEMP:SENS1)	AST_SET_T_MODE2

4.1.5.1.1.15 RTCS #17 – SWIR Calibration 1

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR DIGITAL CIRCUIT ON	AST_TURN_ON_S_DTL
2	1.024	SWIR CALIBRATION CIRCUIT ON	AST_TURN_ON_S_CAL
3	2.048	SWIR LAMP A SEL	AST_SELECT_S_LAMP_A
4	3.072	SWIR LAMP ON	AST_TURN_ON_S_LAMP
5	483.328	CSP SWIR DATA PROC-ESSING ON	AST_TURN_ON_C_SDP
6	484.352	CSP SWIR DATA TAXI A ON	AST_TURN_ON_C_S_A
7	544.768	SWIR LAMP OFF	AST_TURN_OFF_S_LAMP
8	565.248	SWIR Band 4-7 HIGH GAIN SET	AST_SET_S_MODE1
9	566.272	SWIR Band 8 and 9 HIGH GAIN SET	AST_SET_S_MODE2
10	586.752	SWIR Band 4-7 LOW1 GAIN SET	AST_SET_S_MODE1
11	587.776	SWIR Band 8 and 9 LOW1 GAIN SET	AST_SET_S_MODE2
12	608.256	SWIR Band 4-7 LOW2 GAIN SET	AST_SET_S_MODE1
13	609.280	SWIR Band 8 and 9 LOW2 GAIN SET	AST_SET_S_MODE2
14	629.760	CSP SWIR DATA PROC-ESSING OFF	AST_TURN_OFF_C_SDP
15	630.784	SWIR CALIBRATION CIRCUIT OFF	AST_TURN_OFF_S_CAL

4.1.5.1.1.16 RTCS #18 – SWIR Calibration 2

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SWIR DIGITAL CIRCUIT ON	AST_TURN_ON_S_DTL
2	1.024	SWIR CALIBRATION CIRCUIT ON	AST_TURN_ON_S_CAL
3	2.048	SWIR LAMP B SEL	AST_SELECT_S_LAMP_B
4	3.072	SWIR LAMP ON	AST_TURN_ON_S_LAMP
5	483.328	CSP SWIR DATA PROC-ESSING ON	AST_TURN_ON_C_SDP
6	484.352	CSP SWIR DATA TAXI A ON	AST_TURN_ON_C_S_A
7	544.768	SWIR LAMP OFF	AST_TURN_OFF_S_LAMP
8	565.248	SWIR Band 4-7 HIGH GAIN SET	AST_SET_S_MODE1
9	566.272	SWIR Band 8 and 9 HIGH GAIN SET	AST_SET_S_MODE2
10	586.752	SWIR Band 4-7 LOW1 GAIN SET	AST_SET_S_MODE1
11	587.776	SWIR Band 8 and 9 LOW1 GAIN SET	AST_SET_S_MODE2
12	608.256	SWIR Band 4-7 LOW2 GAIN SET	AST_SET_S_MODE1
13	609.280	SWIR Band 8 and 9 LOW2 GAIN SET	AST_SET_S_MODE2
14	629.760	CSP SWIR DATA PROC-ESSING OFF	AST_TURN_OFF_C_SDP
15	630.784	SWIR CALIBRATION CIRCUIT OFF	AST_TURN_OFF_S_CAL

4.1.5.1.1.17 RTCS #19 – VNIR Calibration 1

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL(ALL), BACKWARD DATA CORRECTION TABLE CANCEL:ON)	AST_SET_V_MODE2
2	1.024	VNIR CALIBRATION PREPARATION MODE	AST_SET_V_MODE1
3	481.280	VNIR OP–CALIBRATION MODE	AST_SET_V_MODE1
4	482.304	VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL(ALL), BACKWARD DATA CORRECTION TABLE CANCEL:ON)	AST_SET_V_MODE2
5	483.328	VNIR NORMAL GAIN SET	AST_SET_V_MODE3
6	543.744	CSP VNIR1 DATA PROCESSING ON	AST_TURN_ON_C_VDP1
7	544.768	CSP VNIR2 DATA PROCESSING ON	AST_TURN_ON_C_VDP2
8	545.792	CSP VNIR1 DATA TAXI A ON	AST_TURN_ON_C_V1_A
9	546.816	CSP VNIR2 DATA TAXI A ON	AST_TURN_ON_C_V2_A
10	607.232	VNIR DARK–CALIBRATION MODE SET	AST_SET_V_MODE1
11	627.712	VNIR HIGH GAIN SET	AST_SET_V_MODE3
12	648.192	VNIR LOW GAIN SET	AST_SET_V_MODE3
13	668.672	CSP VNIR2 DATA PROCESSING OFF	AST_TURN_OFF_C_VDP2
14	669.696	CSP VNIR1 DATA PROCESSING OFF	AST_TURN_OFF_C_VDP1
15	670.720	VNIR STANDBY MODE SET	AST_SET_V_MODE1

4.1.5.1.1.18 RTCS #20 – VNIR Calibration 2

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL, LAMP:B SEL, BACKWARD DATA CORRECTION TABLE CANCEL:ON)	AST_SET_V_MODE2
2	1.024	VNIR CALIBRATION PREPARATION MODE	AST_SET_V_MODE1
3	481.280	VNIR OPT–CALIBRATION MODE SET	AST_SET_V_MODE1
4	482.304	VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL, LAMP:B SEL, BACKWARD DATA CORRECTION TABLE CANCEL:ON)	AST_SET_V_MODE2
5	483.328	VNIR NORMAL GAIN SET	AST_SET_V_MODE3
6	543.744	CSP VNIR1 DATA PROCESSING ON	AST_TURN_ON_C_VDP1
7	544.768	CSP VNIR2 DATA PROCESSING ON	AST_TURN_ON_C_VDP2
8	545.792	CSP VNIR1 DATA TAXI A ON	AST_TURN_ON_C_V1_A
9	546.816	CSP VNIR2 DATA TAXI A ON	AST_TURN_ON_C_V2_A
10	607.232	VNIR ELE–CALIBRATION MODE SET	AST_SET_V_MODE1
11	627.712	VNIR HIGH GAIN SET	AST_SET_V_MODE3
12	648.192	VNIR LOW GAIN SET	AST_SET_V_MODE3
13	668.672	CSP VNIR2 DATA PROCESSING OFF	AST_TURN_OFF_C_VDP2
14	669.696	CSP VNIR1 DATA PROCESSING OFF	AST_TURN_OFF_C_VDP1
15	670.720	VNIR STANDBY MODE SET	AST_SET_V_MODE1
16	671.744	VNIR MODE SET (VHC:TEMP SET, ROUTE:A SEL(ALL), BACKWARD DATA CORRECTION TABLE CANCEL:OFF)	AST_SET_V_MODE2

4.1.5.1.1.19 RTCS #21 – TIR Mirror Rotation after Long Term Cal

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	TIR OPERATION POWER ON	AST_TURN_ON_T_OPR
2	2.048	TIR SCANNER POWER ON	AST_TURN_ON_T_SCAN
3	4.096	TIR MIRROR ROTATION TO CAL POSITION	AST_MOVE_T_MIRROR
4	189.44	TIR SCANNER POWER OFF	AST_TURN_OFF_T_SCAN
5	191.488	TIR OPERATION POWER OFF	AST_TURN_OFF_T_OPR

4.1.5.1.1.20 RTCS #22 – V/S/T Quicklook Flags ON

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP TIR Data Q/L Flag On	AST_TURN_ON_C_TQL
2	1.024	CSP SWIR Data Q/L Flag On	AST_TURN_ON_C_SQL
3	2.048	CSP VNIR1 Data Q/L Flag On	AST_TURN_ON_C_V1QL
4	3.072	CSP VNIR2 Data Q/L Flag On	AST_TURN_ON_C_V2QL

4.1.5.1.1.21 RTCS #23 – V/S/T Quicklook Flags OFF

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP VNIR2 Data Q/L Flag Off	AST_TURN_OFF_C_V2QL
2	1.024	CSP VNIR1 Data Q/L Flag Off	AST_TURN_OFF_C_V1QL
3	2.048	CSP SWIR Data Q/L Flag Off	AST_TURN_OFF_C_SQL
4	3.072	CSP TIR Data Q/L Flag Off	AST_TURN_OFF_C_TQL

4.1.5.1.1.22 RTCS #24 – Survival Mode Entry

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	SAFE Command	(TBR 2)
2	34.816	TIR-Standby PWR Off	TURN_OFF_T_STDBY
3	35.84	VNIR(1) Data Processing Off (Band 1+2)	TURN_OFF_C_VDP1
4	36.864	VNIR(2) Data Processing Off (Band 3N + 3B)	TURN_OFF_C_VDP2
5	37.888	SWIR Data Processing Off	TURN_OFF_C_SDP
6	38.912	TIR Data Processing Off	TURN_OFF_C_TDP
7	563.2	SWIR Pointing Control Power Off	TURN_OFF_S_PTG
8	564.224	SWIR Heater 3 Off	TURN_OFF_S_HTR3
9	565.248	SWIR Heater 4 Off	TURN_OFF_S_HTR4
10	566.272	SWIR Heater 5 Off	TURN_OFF_S_HTR5
11	567.296	SWIR Thermal Control Off	TURN_OFF_S_HC
12	568.32	SWIR Tlm/Cmd Power Off	TURN_OFF_S_TC
13	569.344	CSP HCE A Off	TURN_OFF_C_HCEA
14	570.368	CSP HCE B Off	TURN_OFF_C_HCEB
15	571.392	CSP All Off	TURN_OFF_CSP
16	572.416	MPS Off	TURN_OFF_MPS

4.1.5.1.1.23 RTCS #25 – VNIR Quicklook Flags On

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP VNIR1 Data Q/L Flag On	AST_TURN_ON_C_V1QL
2	1.024	CSP VNIR2 Data Q/L Flag On	AST_TURN_ON_C_V2QL

4.1.5.1.1.24 RTCS #26 – VNIR Quicklook Flags Off

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	CSP VNIR1 Data Q/L Flag Off	AST_TURN_OFF_C_V1QL
2	1.024	CSP VNIR2 Data Q/L Flag Off	AST_TURN_OFF_C_V2QL

4.1.5.1.1.25 RTCS #27 – VNIR Launch Lock A Off

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	Actuator power turn on of Launch Lock A Off	FORCE_OFF_V_LLKA
2	300.032	Actuator power emergency off	TURN_OFF_V_ACTA

4.1.5.1.1.26 RTCS #28 – VNIR Launch Lock B Off

The following table describes the content of this RTCS.

CMD #	Delta Time (from RTCS Start) [Seconds]	Command Description	Command Mnemonic
1	0.0	Actuator power turn on of Launch Lock B Off	FORCE_OFF_V_LLKB
2	300.032	Actuator power emergency off	TURN_OFF_V_ACTB

4.1.6 RTCS Stability

In nominal operations the AOT will not need to make changes to RTCSs once they are in use on–orbit. Therefore, frequent changes to RTCS are not expected. However, in the event of an anomaly or during refinement of instrument operations during the activation/evaluation phase, it may be necessary for the AOT to specify changes to RTCSs.

4.1.6.1 Philosophy for VNIR A/B Side Selection

In normal operations, side A of the VNIR will be used with the exception of calibration lamps. Both lamp A and lamp B are used in VNIR optical calibrations. The following shows the concept for selection of VNIR side A or side B:

–VHC A/B Select: (Side B will be used when the temperature monitor shows abnormal data and VHC A side has an anomaly)

–MOTOR A/B Select: (Motor B will be selected when the angle data is abnormal or when the motor shows abnormal action.)

–ENCODER A/B Select: (Encoder B will be selected when the angle data is abnormal.)

–BAND 3 OUTPUT A/B Select: (Side B will be selected when video data is unusual. Band 3 output A side is always selected when that circuit is turned on because the band 3 output A/B selection circuit executes the reset function every time. Therefore, in the case that it is necessary to mainly use the B side, it will be necessary to execute the BAND3 OUTPUT B SEL command in every mode transition.)

4.1.7 ASTER Inhibit Identifiers

(TBD 7)

4.1.8 ASTER Commands for End of ATC Load

A set of commands will be appended to the end of each ATC load which will place the spacecraft and instruments in a benign state. Nominally, these commands will never be executed because they will be overwritten by a subsequent command load. However, in the event the FOT is unable to upload an ATC load prior to the completion of the previous load, these commands serve the purpose of placing the spacecraft/instruments in a state which can be maintained without harm for an indefinite period of time. In this scenario, it is assumed the spacecraft is functioning nominally.

The ASTER commands which are to be appended to the end of each ATC load are:

-CSP VNIR1 DATA PROCESSING OFF

-CSP VNIR2 DATA PROCESSING OFF

-CSP SWIR DATA PROCESSING OFF

-CSP TIR DATA TAXI A OFF

-CSP TIR DATA TAXI B OFF

-VNIR STANDBY MODE SET

-SWIR LAMP OFF

-SWIR CALIBRATION CIRCUIT OFF

-SWIR DIGITAL CIRCUIT OFF

-SWIR POINTING CONTROL POWER OFF

-SWIR ANALOG CIRCUIT OFF

-TIR MODE SET (Blackbody:OFF, E-Cal:OFF, Detector Temp:Sens1)

-TIR OPERATION POWER ON (WAIT 2 sec)

-TIR SCANNER POWER ON (WAIT 2 sec)

-TIR MIRROR ROTATION TO CAL POSITION (WAIT 60 sec)

-CSP TIR DATA PROCESSING OFF

-TIR SCANNER POWER OFF (WAIT 10 sec)

-TIR OPERATION POWER OFF

4.2 GROUND SEGMENT OPERATIONS

A high-level description of the flight operations portion of the EOS AM-1 ground system is found in chapter 3 of this document. For an in depth discussion of the FOS subsystem and tool design and operations, refer to the FOS Operations Concept Document, the FOS Design Specification, Hughes 305-CD-001-002, and the IST Capabilities Document.

The following sections provide a description of how the ground system will be operated to support ASTER. For a description of the types of messages which are exchanged between the EOSDIS and the ASTER Ground Data System, the reader is referred to the ICD Between the ECS and the ASTER GDS.

This section also discusses the roles and responsibilities of the FOT and ASTER Operations Team(AOT) with regard to ASTER operations.

The FOT, as discussed in this section, acts as the focal point for all mission operations related activity. The FOT coordinates the overall mission schedule and prepares an integrated plan for each operations day. Further, the FOT executes the daily plan and notifies the Flight Operations Director, the AOT, and Project Management of any changes to the plan.

The AOT, as discussed herein, acts for the ASTER Science Team in all areas of ASTER instrument operations to implement the science plan and interface with the FOT. The AOT provides the ASTER input to the mission plan for integration with the other scheduled Activities to create a detailed schedule for each operations day.

4.2.1 Planning and Scheduling

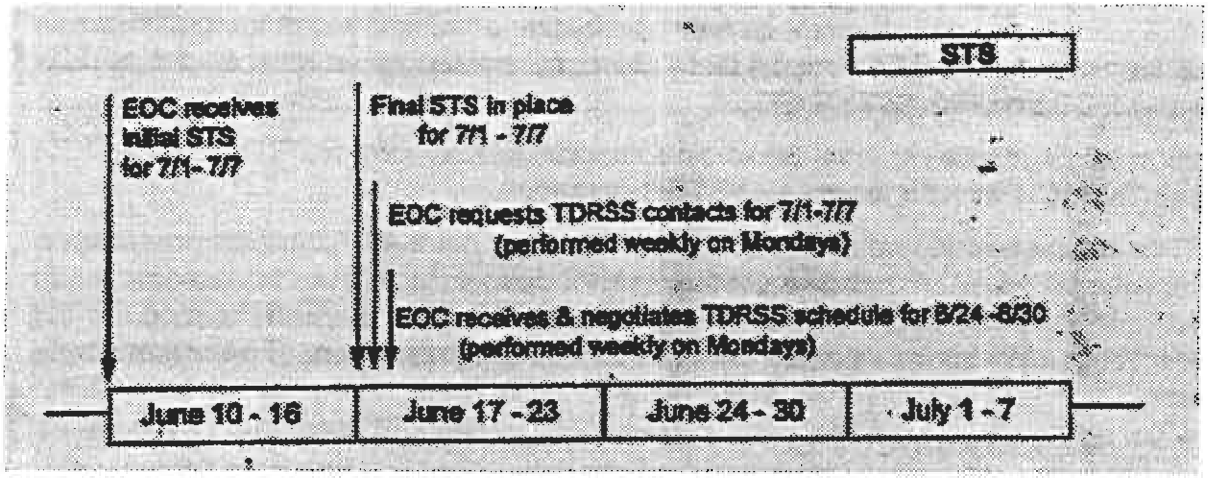
The ASTER GDS will plan ASTER activities in accordance with guidelines established by the ASTER science teams. The ASTER GDS will constrain ASTER activities to meet limitations (e.g., data rate and power) established by the ASTER UIID. The ASTER GDS will schedule ASTER activities using the interface defined by the ICD Between the ECS and the ASTER GDS. The operational scenario for planning message exchange is described in the following sections.

The FOT will plan their activities based on an "**operations day**." This term is used to define a 24-hour period commencing at 20:00:00 UTC.

4.2.1.1 Short Term Schedule

The ASTER GDS will submit a Short Term Schedule (STS) to the EOC which contains ASTER activities for a target operations week. An initial version of the STS for the operations week will be received 21 days prior to the beginning of the operations week. EOC constraint checking will evaluate the scheduled activities against the defined operational constraints in the PDB. Appendix B discusses specific constraints for the ASTER instrument and identifies those which are checked by the EOC and ICC. Any constraints detected with the schedule will be resolved by the AOT within 7 days. A final STS will be received 14 days prior to the beginning of the operations week. At that time, the FOT will use the information in the STS to request TDRSS support.

Figure 23. STS Example for July 1 – July 7



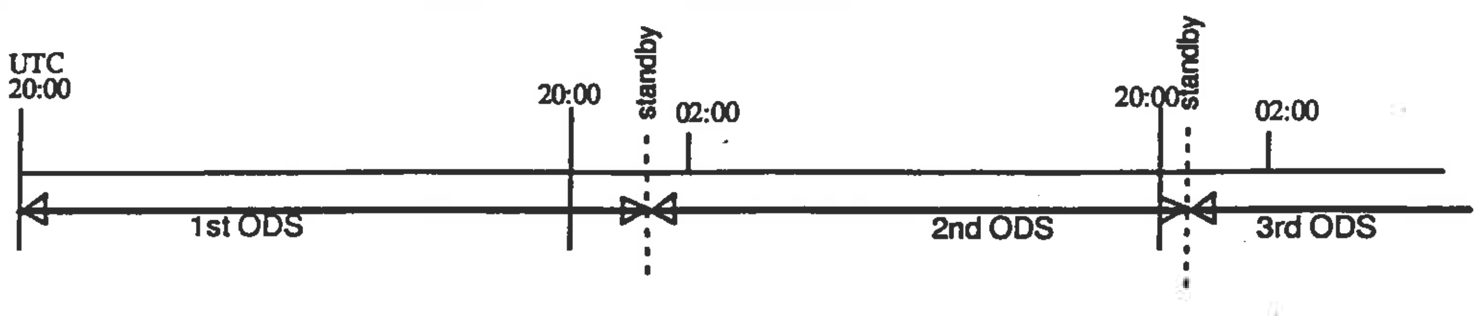
4.2.1.2 One Day Schedule

The ASTER GDS will submit a One Day Schedule (ODS) to the EOC which contains ASTER activities in accordance with the following:

1. The start time of the first ODS will be 20:00:00 (UTC).
2. The first ODS will contain at least 24 hours worth of activities.
3. Each ODS will begin at a time when ASTER is in a standby mode.
4. Each ODS will end at a time when ASTER is in a standby mode.
5. Each ODS will begin no sooner than 20:00:00 (UTC) and will extend beyond 19:59:59 (UTC), since activities prior to 20:00:00 may be frozen.
6. Each ODS will begin sooner than 02:00:00 (UTC) and end earlier than 01:59:59 (UTC)

The following figure depicts the concept for sizing the ODS.

Figure 24. ODS Duration



Concept for Sizing of ODS

A conflict-free ODS will be in place by 27 hours before the operations day. Therefore, time must be allowed to perform constraint checking prior to this time. The AOT will nominally submit an initial version of the ODS for constraint checking by 48 hours prior to the start of the operations day. The ODS may be transmitted to the EOC in "analysis" mode in order to receive activity-level constraint checking. Command-level constraint checking of the ODS is performed by requesting a "what if" analysis from the ECS IST user interface.

Since a conflict-free ODS is expected to be in place 27 hours prior to the beginning of an operations day, the existence of a hard constraint violation is unexpected. Such an occurrence would have to be due to a change in some non-ASTER resource schedule. If a hard constraint violation is detected by the FOT 27 hours prior to the beginning of the operations day, the FOT will contact the appropriate parties to resolve the constraint. If it is deemed necessary to make changes to the ASTER schedule, the FOT will take any actions which have been previously approved by the AOT to remove the conflict and will inform the AOT of their actions. If no preapproved actions are in place to handle the situation, the FOT will contact the AOT to determine a safe course of action. If the FOT is unable to contact the AOT, then the FOT will remove all ASTER activities associated with the ODS which contains hard constraint violations.

At 27 hours prior to the operations day, the FOT will freeze a portion (i.e., the Detailed Activity Schedule or "DAS") of the scheduling timeline for the operations day in order to generate the stored command upload and the ground script. Following completion of the command management process, the FOT reviews the command products for accuracy and completeness prior to the start of the operations day. The AOT may review the command products for the operations day at any time after generation by using the ECS IST. The FOT, however, will use these command products without AOT review.

In the event a ODS is not received by the EOC, the AOS will cancel the operations scheduled by the STS and will continue to try to schedule an updated ODS (see the next section). In this situation, the FOT will generate a stored command load which does not contain commands resulting from the STS. The FOT will proceed as normal if a conflict-free updated one day schedule is available by 7 hours before the operations day (see next section.)

4.2.1.3 Updated One Day Schedule

The ASTER GDS will transmit an updated ODS to the EOC after the 27 hour deadline for the ODS. This updated ODS may result, for example, from the use of cloud data to determine more optimum observation opportunities. If a conflict-free version of the updated ODS is available by 7 hours before the operations day, the FOT will regenerate the stored command upload and ground script to incorporate the updated ODS.

In the event a conflict-free 7-hour updated ODS is not received by the EOC, the FOT will simply uplink the stored commands generated from the 27-hour ODS. It should be noted that this will be a normal situation during the first 90 days of the mission. The AOT will not submit 7-hr ODSs to the EOC before launch+90 days. This will allow the FOT to gain experience in operating ASTER and in working with the AOT before having to respond to late changes.

If in the process of generating a conflict-free updated ODS, the AOT generates an updated ODS which only contains a data volume constraint violation(s), the AOT may provide instructions to the FOT PRIOR to the 7 hour deadline. The available options for FOT instructions are: a) Don't accept the updated ODS, b) Accept the updated ODS, and allow SSR buffer overwrite, or c) Accept the updated ODS, but try to preserve data on the SSR by sending the appropriate SSR commands to not allow overwrite of the buffer. In case "b" and "c", data is lost when the buffer is full.

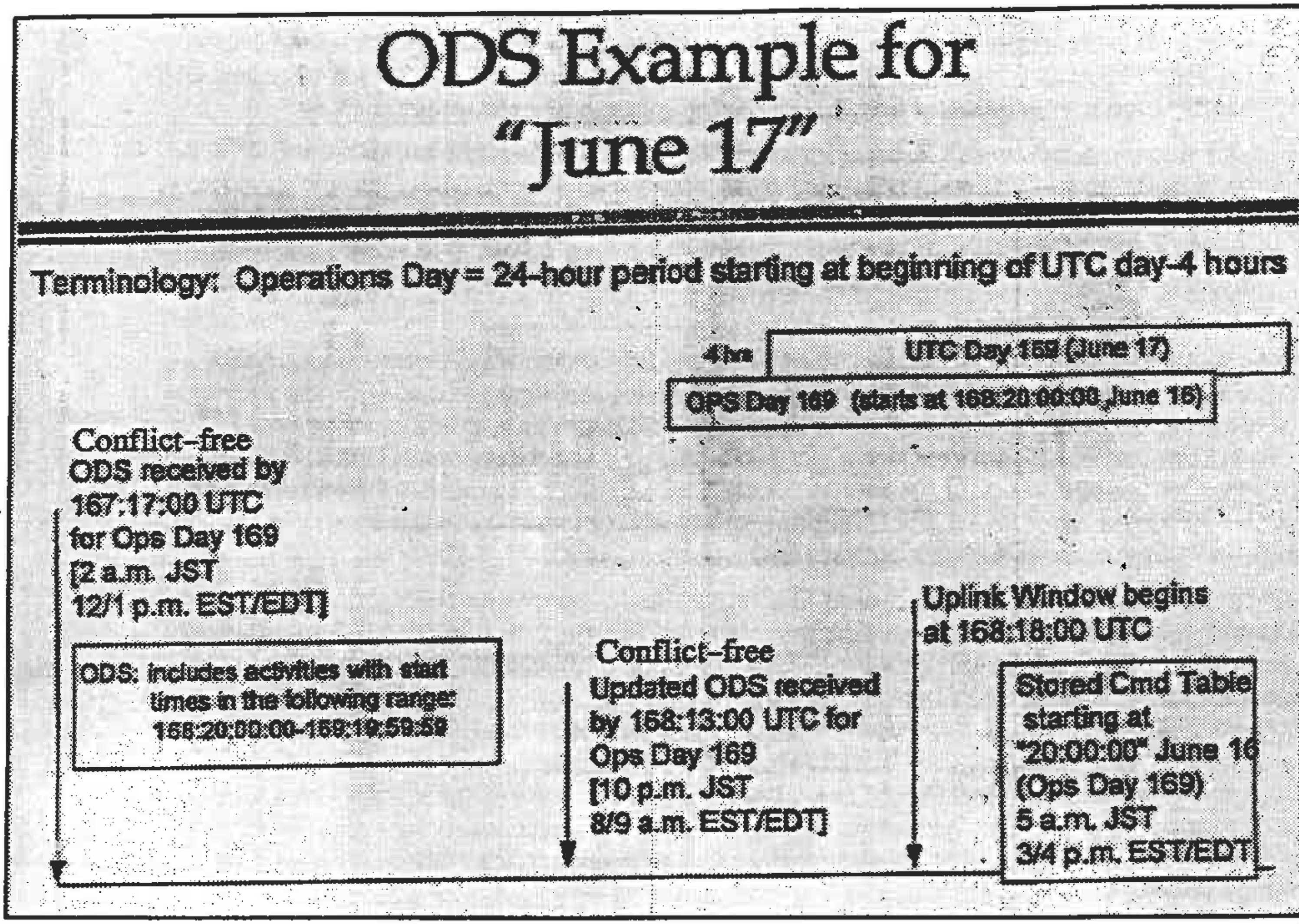
In the unlikely event that the 7-hour ODS (e.g., Day N) contains contraint violations and cannot be used to generate an updated command upload, the ASTER GDS scheduling software's expectation for SWIR pointing may no longer agree with the actual SWIR pointing at the beginning of the next operations day (Day N+1). The ASTER Instrument Operations Team may contact the FOT in this situation and request the FOT to schedule a "SWIR pointing activity" or a "SWIR pointing ECL proc" which will occur near the beginning of the next operations day (N+1). [Note: The pointing angle adjustment commands will originate from an activity or an ECL proc which will have previously been defined in the EOC.] The information required by the FOT from the AOT on a case by case basis will be:

-Desired (optimal) GMT at which to execute the activity/proc

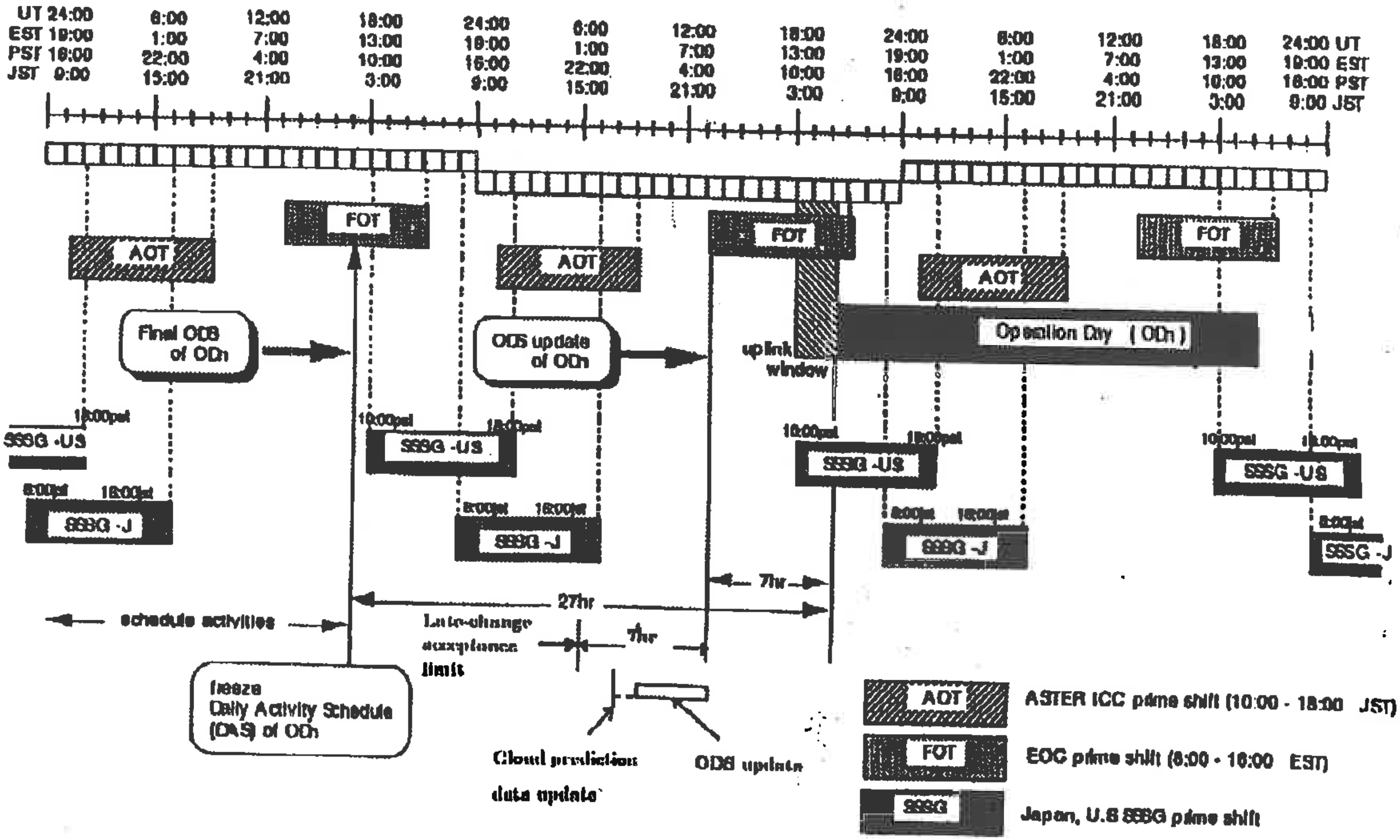
-Input command parameters for the activity/proc to properly set the pointing angle

The required information will be provided to the FOT by fax/e-mail. A Standard Operating Procedure (SOP) will be written to cover the very specific details of this agreement. A special simulation will be scheduled to practice responding to this contingency.

Figure 25. ODS Example for June 17



Scheduling Timeline



Planning and Scheduling Message Exchange Scenario:

ASTER GDS — ECS FOS

STS → Preliminary Resource Schedule

(Duration: 7 days)

← Automatically Transmitted
(Indicates "Activity-Level" constraint violations.)
Data volume constraint violations may be included.
If so, ASTER ICC/AOT should ignore them.

FOT generates new (i.e. more accurate) FDD products (DAILY)

New Planning Aids ← (Transmitted automatically)

Updated Activity Schedule in place at TBD UTC daily.

← TBD: User notification of schedule update (Possibly an event message)

Request for EOC Schedules → (To receive most accurate scheduled times for activities/commands, if desired).

Activity Schedule ← (Automatically transmitted in response to request. Receive latest copy of requested portion in "file" format.)

ODS - "Analysis" → (Transmitted in time to perform constraint checking, so that "constraint-free" ODS is available at "Ops Day - 27 hours".)

Activity Schedule - "Analysis" ← (Automatically transmitted. Reflects activity-level constraints.) (both hard and soft)

Planning and Scheduling Message Exchange Scenario (continued):

ASTER GDS | ECS FOS

If "SSR Buffer Playback" constraints are detected, the AOT may request the FOT to rerun the "communication contact scheduler" to attempt to eliminate the constraint. Notification of Results are TBD: Elimination of constraint may be reported by FOT, or AOT may resubmit the ODS-"Analysis" to receive results.

IST GUI Interface must be used to request "what-if" command-level constraint checking.

ODS - "Schedule" → (Must be transmitted by 27 hours prior to Operations Day)

← Activity Schedule - "Schedule" (Automatically Transmitted.)

FOT locks the DAS and generates the ATC load (27 hours prior to start of the Operations Day)

← Detailed Activity Schedule (Automatically sent when error-free ATC load is generated. Reflects activity-level soft/warning constraint violations)

Planning and Scheduling Message Exchange Scenario (continued):

ASTER GDS | **ECS FOS**

ODS - "Analysis" →
(Transmitted in time to perform constraint checking, so that Updated "constraint-free" ODS is available at "Ops Day - 7 hours".)

← Activity Schedule- "Analysis"
(Automatically transmitted. Reflects activity-level constraints.)

If "SSR Buffer Playback" constraints are detected, the AOT may request the FOT to rerun the "communication contact scheduler" to attempt to eliminate the constraint. Notification of results of rerun are TBD: Elimination of constraint may be reported by FOT, or AOT may resubmit the ODS-"Analysis".

IST GUI Interface must be used to request "what-if" command-level constraint checking.

If constraint-free Updated ODS is generated by 7 hours before Ops Day, then...

AOT provides FOT with notification (voice or e-mail?) of Analysis File for incorporation into schedule.

Planning and Scheduling Message Exchange Scenario (continued):

FOT unlocks the DAS and incorporates the updated ODS. FOT locks the DAS and generates the ATC load (7 hours prior to start of the ATC load)

Detailed Activity Schedule

(Automatically sent when error-free ATC load is generated. Reflects activity-level soft/warning constraint violations)

4.2.1.4 Scheduling Multifunction Commands

The ASTER operational organization shall be responsible for keeping track of instrument states that are controlled by multifunction commands. When a multifunction command is scheduled or requested, the subfields for all of the functions in the multifunction command shall be supplied to the EOC. The ASTER operational organization shall also be responsible for ensuring that the verification or prechecking of multifunction commands and all their associated parameters is done prior to scheduling or requesting their uplink by the EOC.

4.2.1.5 Direct Downlink Scheduling

The EOS AM–1 spacecraft has the capability to directly downlink real–time ASTER science data to a ground station while the ASTER instrument generates the data. This capability is referred to as the Direct Downlink (DDL) service. This service will result in the scheduling of spacecraft commands to turn the X–band transmitter on and off. To ensure that this activity is scheduled corresponding to times when DDL ground stations are in view, the EOC event pool will include orbital events for AM–1 entry and exit into ASTER DDL station view.

The FOT at the EOC will define and control the DDL activity definition in the EOC database. The FOT will define activity–level constraints to ensure that the DDL activity may only be scheduled when the AM–1 spacecraft is within view of the ASTER DDL site, as determined by predicted view period data. The ASTER ICC will have permission to include the DDL activity in the ASTER STS and the ASTER ODS. DDL activities will be scheduled on separate scheduling components. The FOT will have the authority to delete ASTER DDL activities if circumstances warrant it.

The following Direct Downlink ground stations have been identified: **(TBD 8)** ERSDAC is responsible for the implementation of DDL ground stations in Japan.

4.2.1.6 Scheduling Expedited Data Sets

Requests for expedited data processing will be made through the ASTER Ground Data System Instrument Control Center. The method by which the AOT will request the expedited data service is by commands to the instrument to set the "quick-look" flag in ASTER data. The ASTER ICC will schedule the appropriate activities which will result in spacecraft stored commands for ASTER to set and reset the quick-look flag. The capability of requesting all data from a TDRSS session as expedited data will not normally be used for ASTER. The reason for this constraint is the potential for ASTER to exceed its allocation for expedited data due to the quantity of data which may be transmitted in a single TDRSS session. In the event this becomes necessary, the request should be directed to the Flight Operations Team in the EOC. Requests over and above the allocated resources will require authorizations by the Flight Operations Director, in coordination with the Project Scientist.

[Note: ASTER has the capability to set the quick-look flag individually for each of the instruments. But, operationally, the decision has not yet been made as to whether the flag will always be set on all of the instruments.]

4.2.2 Real-Time Operations

Real-time focuses on the functions performed immediately before, during, and immediately after a scheduled RF contact with the S/C. During the contact, the FOT using the ground script as a guide, sends real-time commands to the spacecraft in order to execute the DAS.

The FOT ensures that all scheduled commanding occurs as planned and notifies the AOT in the event a spacecraft or ground system contingency affects the planned commanding. The FOT verifies execution of stored commands contained within the DAS by: checking the stored command pointer at the beginning of each real-time telemetry contact to ensure that it has incremented to the expected location; checking the SCC activity log for stored command distribution errors; and monitoring telemetry for execution verification of all stored commands scheduled for distribution during the telemetry contact period for which command execution verifiers are defined in the EOC PDB.

Using the EOC Command Language (ECL), the AOT may define procedures ("procs") which include pre-planned real-time commands to be sent to the ASTER instrument. The proc may then be scheduled on the timeline. In realtime, the FOT will execute the proc. The ECL provides the FOT with flexibility in manual control of the uplink of realtime commands. This is the way, for example, real-time commanding may occur during instrument activation.

The AOT may also submit Real-Time Command Requests to the FOT (see the ECS/ASTER GDS ICD). In an emergency situation, these requests will be acted upon by the FOT at the first available opportunity. In non-emergency situations, these requests should be submitted to the FOT no later than 20 minutes prior to the realtime contact in which the request is to be executed.

The FOT responds to real-time command requests from the AOT by reviewing the request, obtaining approval, as required, and uplinking the commands at the next available opportunity. The AOT will provide the rationale and urgency for each command request when submitting it to the FOT. FOT Operations handles command requests on a priority basis. The AOT should reserve the use of unplanned commands to events which cannot be predicted in advance.

During a real-time contact the EOC and the ASTER ICC receives the downlinked S/C H/K telemetry in real-time. The FOT provides real-time telemetry monitoring for the spacecraft subsystems and instruments, 24 hours per day, 365 days per year at the EOC. In order to prepare the FOT to perform telemetry monitoring, the AOT trains the FOT Operations personnel on the proper operation and monitoring of ASTER. The AOT defines their telemetry data, the operational limits, and the reaction for each out-of-limit condition. The EOC will generate event messages to report all out of limit conditions found during limit checking. The FOT will evaluate all out of limits conditions, and take appropriate actions, when necessary, as defined by the AOT. Required FOT reactions to ASTER out-of-limit conditions will be documented in **(TBD 9)**.

When anomalous conditions occur (including out-of-limits conditions), FOT Operations first safes the affected spacecraft or instrument system, then notifies the AOT. FOT Engineering has the primary responsibility for investigation and resolution of spacecraft anomalies with support from the entire FOT. AOT and ground system personnel assist in resolving anomalies when requested by the FOT and/or Flight Operations Director. The AOT has primary responsibility for the investigation and resolution of instrument anomalies. The FOT assists the AOT with instrument anomaly investigations when requested.

4.2.3 Data Configuration Management

The FOT has overall responsibility for coordinating database maintenance activities to insure system-wide consistency. The FOT populates and maintains all S/C subsystem parameters in the PDB. The AOT provides and maintains all instrument parameters contained in the PDB. The FOT maintains overall cognizance of the PDB content and provides configuration management of the EOS AM-1 specific data, using FOS supplied tools. Configuration Management Procedures will be defined in the "Configuration Management Standard Operating Procedure" (SOP).

In a mission critical situation, the FOT will modify onboard RTCSs within 7 hours. The FOT definition of mission critical is "causing non-recoverable damage" or "as directed by the Project Scientist." If an RTCS requiring change is scheduled to be called via the ATC load within less than 7 hours of notification of the need to change the RTCS, the RTCS will be allowed to execute in its current state as scheduled unless it will result in component damage. If damage is possible, the FOT will take action (as directed by the ASTER Instrument Operations Team) to inhibit ASTER commands. This can be accomplished during a TDRS contact before the process for replacement of the RTCS is complete.

In a non-"mission critical" situation, the FOT will accomplish an RTCS change within 3 days.

The configuration management policy will allow for changes to activities and ECL procedures (procs) to be performed within 2-3 days for nominal situations. In mission critical situations, the policy will allow for changes to activites and procs to be performed within 3 hours.

4.2.4 Early Orbit Operations

The following paragraphs document the current understanding of the early orbit operations responsibilities in support of ASTER flight operations.

4.2.4.1 Launch/Acquisition Mission Phase

Prior to launch, the FOT coordinates with the launch site and other mission ground support elements to determine the readiness of all mission elements to support the mission launch and orbit acquisition. The FOT also certifies, to the Flight Operations Director, the readiness of the EOC for launch of the EOS AM-1 S/C. Following launch, the FOT monitors the S/C via downlink telemetry and provides backup commanding to the S/C in the event that the on-board processes for earth acquisition and solar array assembly (SAA) deploy do not perform as expected. The S/C contractor engineering team support the FOT at the EOC for launch and activation. The S/C contractor engineering team direct the FOT on the proper operation of the S/C and assist with evaluation and verification of the S/C performance.

Once the solar array deployment is completed, the FOT begins subsystem checkout and activation; and the FDD and FOT begin final planning for the maneuvers needed to acquire the mission orbit. For Orbit Acquisition, the FOT, with assistance from FDD and the S/C contractor engineering team, plan and perform a series of delta-V maneuvers to boost the S/C to the mission altitude and to circularize the orbit.

The AOT defines the command sequences, EOC displays, and contingency procedures for use during the Launch/Acquisition Phase.

4.2.4.2 Checkout Mission Phase

Once the mission orbit has been attained the FOT transitions to the Checkout Phase. The FOT with assistance from the S/C contractor engineering team verifies on-orbit performance and ensures the readiness of the S/C bus to support instrument operations.

Following successful checkout of the S/C bus the FOT notifies the AOT that the S/C is ready for instrument activation and checkout. The FOT schedules additional and/or extended real-time contacts with the S/C to support instrument activation, as required. The FOT and AOT allow for flexibility in working with late changes to the plan (per procedure worked out in advance with the AOT, the FOT, and the Flight Operations Director). The FOT and spacecraft engineering personnel assist the AOT with analyses and S/C interface expertise.

AOT representatives participate in checkout at the EOC during each ASTER activation event and have direct responsibility for ASTER activation procedures within the EOC. Further, the AOT analyzes and characterizes the instrument performance during this mission phase and reports on the status of the instrument. The FOT supports the AOT in implementing instrument activation procedures, and coordinates initial ASTER operations with other S/C bus and instrument activation events throughout this phase of operation.

4.2.5 Spacecraft Maneuvers

The FOT creates a nominal long-term schedule of maneuver events prior to launch, and maintains this schedule along with other long-term planning information. The FOT has responsibility for executing all maneuver operations.

The FOT will provide a minimum of 30 days notification to the ASTER team for all planned spacecraft maneuvers.

4.2.6 Contingencies

4.2.6.1 Use of Multifunction Commands

Because ASTER utilizes multifunction commands, the following is noted. Each command used by the EOC in emergency health and safety situations shall be either a single function command or a configuration independent predefined bit pattern.

4.2.6.2 Spacecraft Emergency

In the event that a spacecraft emergency situation develops, the FOT takes the appropriate action to preserve spacecraft health and safety. The FOT utilizes emergency communication support, as available, to establish a safe spacecraft configuration. Mission critical functions (e.g., communications, power, attitude control) receive the highest priority when reacting to a spacecraft contingency.

4.2.6.3 Instrument Emergency

In the event of an instrument health or safety incident the FOT notifies the AOT after performing the pre-defined reaction to the incident. Once notified of the incident the AOT evaluates the instrument situation and advises the FOT and Flight Operations Director of the instrument status and plans for resuming operations.

4.2.6.4 Philosophy for Recovery from Safe Mode/Survival Mode

If the spacecraft enters Safe Mode or Survival Mode, the FOT verifies and/or establishes a safe configuration for the spacecraft bus and each instrument. Once the FOT attains a safe condition for the spacecraft they notify the AOT that the Safe Mode or Survival Mode has interrupted normal operation, and report on the ASTER instrument status. The AOT advises the FOT of any need for further priority attention to ASTER.

The remainder of this description is preliminary (TBR 3)

In addition, the FOT will inhibit all ASTER ATC commands and will delete all ASTER activities from the schedule.

After investigating and resolving the anomaly which placed the spacecraft into safe mode, the FOT will coordinate a safemode exit process with the ASTER team. The FOT will provide the AOT with the following notification:

- **(TBD 10)** hour notification of estimated time(s) to bring the spacecraft/instruments out of safemode
- **(TBD 11)** hour notification of estimated time when the instruments may resume science data capture
- **(TBD 12)** hour notification of time for freezing of DAS containing instrument activities

After the ASTER is commanded out of safemode, a realtime PROC must be executed by the FOT in order for the ICC to acquire SWIR pointing information and use this information in the scheduling of a ODS. The AOT will provide a ODS in accordance with the guidelines stated in section 4.2 of this document.

4.2.6.5 Philosophy for Recovery from ATC upload failure

In the event the FOT is unable to successfully transmit an ATC load prior to the complete execution of the previous ATC load, the following description provides a method for recovery. It should be noted that this would be an unexpected failure.

The ASTER instrument will be placed in standby mode by the commands which are appended to the end of each stored command load. Failure to promptly upload the next operations day's ATC load implies the possibility that ASTER may not execute all scheduled activities for the next ops day. In this event, the FOT will contact the AOT to coordinate recovery procedures. The following list of actions may be undertaken to recover from this anomaly:

- FOT inhibit all ASTER ATC commands
- AOT and FOT choose a point in the next ATC load where ASTER operations may resume
- AOT determine any necessary real-time PROCs which need to be executed to synchronize the ASTER configuration with planned activities (e.g., SWIR pointing)
- FOT ensure commands from missed activities are not executed in the new load
- FOT uninhibit ASTER ATC commands

4.2.7 Analysis / Performance Verification

The FOT and IOT's verify the operational performance of all S/C subsystems and instruments in order to maintain an up-to-date knowledge of S/C operating characteristics, capabilities, and limitations. The teams use this performance verification in science data analysis and evaluation and as an input to ongoing science and operational planning activities. The AOT verifies all aspects of ASTER instrument performance, and the FOT verifies all aspects of S/C subsystem performance throughout the EOS AM-1 mission.

Prior to S/C I&T the EOS AM-1 design team identify the critical telemetry parameters to monitor for long-term component and subsystem performance evaluation and trending.

The S/C I&T team monitor these parameters and trend them throughout the system I&T. The FOT continues this monitoring throughout the mission. From time to time the I&T and/or Flight team may modify the specific set of trend parameters as the teams become familiar with the operational characteristics and idiosyncrasies of the EOS AM-1 S/C. The EOC database contains the list of trend parameters, as maintained by the FOT, and the results of these trends and performance analyses.

4.2.8 Spacecraft Performance Analysis

FOT Engineering routinely analyzes the playback H/K telemetry to assess the S/C bus performance and monitors trends that may provide early indications of S/C bus degradation. Early in the mission FOT Engineering analyzes data from all orbits, but may change to analyzing only representative orbits during each day after the checkout period. The FOT reports all S/C anomalies to the Flight Operations Director and provides periodic reports on the status of the S/C bus. If the Flight Operations Director determines that spacecraft performance has implications on the long-term health of the spacecraft or instruments the FOT also informs the AOTs and Science Team.

4.2.9 Instrument Performance Analysis

The AOT informs the Flight Operations Director of any instrument performance changes or trends that indicate degraded current or future performance. The AOT provides periodic reports on the status and performance of the instrument. In addition, the AOT makes FOT aware of changes in the operating characteristics or plans for ASTER utilization and for incorporating these changes into the FOT's procedures for ASTER operations. The AOT assists the FOT with investigation of performance anomalies requiring ASTER instrument expertise.

When the AOT identifies an anomaly, the FOT assists with the investigation including requesting additional or extended telemetry contacts, executing unplanned procedures, uplinking unplanned commands, and performing special data analyses.

The format of an ASTER Instrument Status Report is shown in the following figure.

Example

Figure 26. ASTER Instrument Status Report

1999/039(UTC)

ASTER Instrument Status Report

(No:00008)

ASTER Operations Team

ERSDAC

Period:1999/001 00:00:00 - 1999/031 24:00:00 (UTC)

ASTER Status:

VNIR	is	valid
SWIR	is	valid
TIR	is	valid

Supplement:

VNIR

Supplementary explanation.

- Instrument anomaly notifications:
  No anomaly was identified in this term.
- Instrument analysis/trending results:
  No unusual phenomenon was found in the telemetries in this term.
- Instrument operations events:
  Long term calibrations were performed twice in this term.
  Observations: 1450 times
  Total observation time: 3515 minutes 34 seconds
- Instrument Configuration status:
  There was no configuration change in this term.

SWIR

Supplementary explanation.

- Instrument anomaly notifications:
  No anomaly was identified in this term.
- Instrument analysis/trending results:
  No unusual phenomenon was found in the telemetries in this term.
- Instrument operations events:
  Long term calibrations were performed twice in this term.
  Observations: 1215 times
  Total observation time: 3445 minutes 56 seconds
- Instrument Configuration status:
  There was no configuration change in this term.

[Example continued on next page]

TIR *[Example continued from previous page]*

Supplementary explanation.

- Instrument anomaly notifications:
Observations on 1999/015 was not performed.
- Instrument analysis/trending results:
We are now trying to figure out what the reason of above anomaly.
- Instrument operations events:
Long term calibrations were performed twice in this term.
Observations: 1403 times
Total observation time: 3315 minutes 14 seconds
Several tests have been performed. However, the reason was not identified.
- Instrument Configuration status:
There was no configuration change in this term.

CSP

Supplementary explanation.

- Instrument anomaly notifications:
No anomaly was identified in this term.
- Instrument analysis/trending results:
No unusual phenomenon was found in the telemetries in this term.

MPS

Supplementary explanation.

- Instrument anomaly notifications:
No anomaly was identified in this term.
- Instrument analysis/trending results:
No unusual phenomenon was found in the telemetries in this term.

4.3 Flight Software Maintenance

The FOT and Software Development Facility have joint responsibility for maintenance of the spacecraft flight software.

The FOT and AOT define the required TMONs and RTCSs, and then the FOT/SDF create and test them using the SDF or spacecraft simulator. Once validated, the FOT submits the new TMON or RTCS to the Flight Operations Director and EOS AM-1 Change Control Board **(TBR 4)** for approval.

Instrument flight software maintenance is not applicable to the ASTER.

4.4 Ground System Software Maintenance

The ESDIS Project maintains configuration management of all EOSDIS ground system software. The ESDIS Project provides ground system software maintenance support throughout the EOS AM-1 mission including user support services for EOC and IST tools. In addition, the ESDIS implements a system for reporting, investigating, and resolving ground system software related anomalies or deficiencies. This system provides for user reporting of anomalies with the EOC and IST software functions and tools.

The ESDIS Software Maintenance contractor(s) ensures that the various elements of the EOS AM-1 ground system operate with the same and/or compatible configurations. In the event that modification of the flight operations ground software becomes necessary, the ESDIS contractor notifies the Flight Operations Director and FOT of the scope and urgency of the required change. The contractor then programs, tests and validates the changes as required by ESDIS. Prior to implementing the change, the contractor coordinates with the FOT in order to minimize the impact on EOS AM-1 operations. The FOT coordinates with the AOT in the event that the change impacts their use of the ECS IST.

4.5 Training

The S/C contractor and the AOT provide training for the FOT on S/C bus and instrument operations respectively. The ECS contractor provides training on the use of the EOC and IST systems and tools. The responsible contractor for each element of the EOS AM-1 mission (flight and ground system) provides standard operating procedures and handbooks to the FOT.

The FOT generates the EOS AM-1 Training Plan that documents the approach and responsibilities for training and certification of the FOT. Additionally the FOT provides requirements and suggested formats for the training materials. The AOT provides training materials and face to face training for the FOT regarding how to operate and monitor the instrument.

4.6 Simulations

Testing of the EOS AM-1 ground system is discussed in the "ASTER GDS / EOS Ground System Test Agreement."

In addition to tests, the FOT conducts a number of simulations involving the AOT and ground elements prior to launch of the spacecraft. The simulations include verification of ECS tools and processes; mission planning simulations; and S/C operations simulations. The AOT supports the FOT in preparing for these simulations by providing inputs.

The FOT coordinates with the AOT for integrated scheduling of these simulations and to ensure the availability of the various supporting organizations for each test. The FOT provides a formal mechanism for identifying, tracking and closing anomalies found during these simulations..

The following simulations (in which instrument teams will participate) have been identified for planning purposes, but exact dates may change:

- Planning and Scheduling Sims (occurring within the time period:
  2/1/98–6/1/98)
- Joint Integrated Sims (estimated time periods:
  3/1/98–3/15/98;
  4/15/98–5/1/98;
  6/1/98–6/15/98)
- Spacecraft 100 hours mission sim: 4/1/98

  Formal Activation Sim: 6/15/98–6/20/98

APPENDIX A

10 INFORMATION EXCHANGE

The following sections describe the plans for information exchange required to support operation of ASTER during on-orbit operations.

10.1 Pre-Launch

Information generated to integrate and test the ASTER instrument shall generally be used for flight operations with a minimum of modification. The goal in I&T is to operate the instrument in much the same way as is intended for flight. Therefore it is expected that many of the operational database tables will be an extract of information used in I&T. There are limitations to flight-like testing in I&T, therefore it will be necessary to update and add information for flight operations. Table IX contains a list of information exchange items, their format, schedule, and method of exchange.

10.2 Post Launch

The information gathered in the pre-integration and pre-launch phases of EOS AM-1 will provide nearly complete information for establishing procedures and methods of operating the instrument in flight. All of the tools and systems will be in place and mission operations will be ongoing throughout the mission life of EOS AM-1. The following information represents what information will be exchanged on a continuing basis during the post-Launch, or in-flight phase of the mission. Table X contains a list of information exchange items, their format, schedule, and method of exchange.

Table IX. Pre-Launch Information Exchange

#	Item	Description	Format	From	To	Date
13.1	Preliminary RTCS Definitions		Paper input to OICD	AOT (I)	OICD Developer	Completed
13.2	Final RTCS Definitions		Paper	AOT (I -> G)	FOD	6/1/97–4/15/98
14.1	Preliminary Inhibit ID Definition		Paper	AOT (I)	OICD Developer	12/2/96
14.2	Final Inhibit ID Definition			AOT (I -> G)	FOD	6/1/97–3/15/98
14.3	Final EOC Page Display Definition for ASTER			AOT (G)	FOD	4/1/98
15.1	Preliminary Activity Definition	Preliminary Set of Activities Defined in PDB	PDB	AOT (G) TBR	FOD	6/1/97–1/12/98
15.2	Final Activity Definition	Final Set of Activities Defined in PDB	PDB	AOT (G) TBR	FOD	3/15/98
15.3	Preliminary Activity Constraints Definition	Preliminary Set of Activity Constraints Defined in PDB	PDB	AOT (G) TBR	FOD	6/1/97–1/12/98
15.4	Final Activity Constraints Definition	Final Set of Activity Constraints Defined in PDB	PDB	AOT (G) TBR	FOD	3/15/98
16.1	Conmmand Constraints Definition		PDB	AOT (G) TBR	FOD	11/1/97
17.1	Preliminary TMON definitions	Preliminary set of TMON definitions	OICD	AOT (I)	OICD Developer	6/1/97
17.2	Updated TMON definitions	Final set of TMON definitions described in if-then-else terminology		AOT (I -> G)	FOD	6/1/97–4/15/98
18.1	Final On-Orbit ASTER limits	Limits to be used in EOC for tlm checking	PDB	AOT (G) TBR	FOD	3/15/98
19.1	Preliminary On-Orbit Alarm Reactions	Description of reactions FOT should take in response to ASTER limit violations	Paper	AOT (G) TBR	FOD	1/1/98
19.2	Final On-Orbit Alarm Reactions		Paper	AOT (G) TBR	FOD	3/15/98

Table IX. Pre-Launch Information Exchange

#	Item	Description	Format	From	To	Date
20	Analysis Algorithms (if needed)	User-defined analysis algorithms to be run in EOC for tlm analysis		AOT (G) TBR	FOD	8/15/97–3/15/98
21.1	Preliminary "PROC" Definitions	Preliminary set of ECL Procs (for normal & contingency situations)	IST tool	AOT (G) TBR	FOD	6/1/97–1/31/98
21.2	Final "PROC" Definitions		IST tool	AOT (G) TBR	FOD	3/15/98
22.1	PDB change requests	Differences in PDB between I&T and on-orbit ops...or resulting from changes made during I&T	(TBD 13)	AOT (G) TBR	FOT	As required
22.2	PDB change notification	Report of changes made to PDB	(TBD 14)	FOT	AOT (G) TBR	Database Updates
22.3	Final PDB In Place (ready for launch)		PDB	AOT (G) TBR	FOD	3/15/98
22.4	PDB Validation Approval		Paper	AOT (G) TBR	FOD	3/15/98–4/15/98
23.1	FOT Training	To include: Narrative Procedures on how to operate ASTER in both normal and contingency situations	Classroom Materials	AOT (I)/(G) TBR	FOD	12/1/97
23.2	AOT Training	How to use Ops Tools	Classroom	ECS	AOT (I)/(G) TBR	10/97
23.3	English summaries of AOH, AOP, and ACP documents		Paper	ASTER (I)	FOD	5/31/97
23.4	English excerpts from the Detailed Mission Ops Handbook and the ASTER Mission Ops Proc document		Paper	ASTER (G)	FOD	11/15/97

Notes:

RTCS – Relative Time Command Sequence

(I) – ASTER Instrument Project
(G) – ASTER GDS Project
(G) TBR – Refers to the day-to-day ASTER instrument operations team. A proper name/acronym will be identified in a furture version of this document.

AOT – Aster Operations Team
FOD – Flight Operations Director

Table X. Post-Launch Information Exchange

#	Item	Description	Format	From	To	Date
24.1	Instrument Status Report	See section 4.2.9	Admin Lan	AOT (G)	FOD	weekly/ monthly
24.2	Spacecraft Status Report	(TBD 15)	Admin Lan or EBnet ?? (TBD 16)	FOT	AOT	weekly
24.3	Mission Status Report	(TBD 17)	Admin Lan or EBnet ?? (TBD 18)	FOT	AOT	(TBD 19)

APPENDIX B

20 CONSTRAINTS

In order to ensure proper instrument performance, or prevent instrument damage, the following constraints are imposed on ASTER operation. The following sections define the constraints which are a) to be checked by the EOC/FOT and b) to be checked by the ASTER GDS/AOT.

20.1 EOC/FOT Constraints

Operating constraints are divided into two categories: Activity-Level and Command-Level. In addition, each constraint may be classified as either "hard" or "soft." A hard constraint will result in activities or commands being excluded from the stored command load. The only operational work around to this problem is removal of the hard constraint from the PDB. A soft constraint will be flagged for operations teams' consideration. At the time of stored command load generation, the FOT will assume AOT approval of existing soft constraints.

The EOC will provide constraint checking for activity and command level constraints which are defined in the Project Data Base. Constraint forms are included at the end of this section for ASTER constraints checked by the EOC.

20.1.1 Activity Level Constraints

The following activity level constraints have been identified for ASTER:

Type: (Hard/ Soft)	Activity Level Constraints:
Hard	The SWIR mirror shall be turned to the calibration position prior to a spacecraft delta-v maneuver in order to avoid contamination. [Note: The SWIR mirror requires 10 minutes to reach the safe position.] ASTER_TO_CONTAMINATION_SAFEMODE activity must occur prior to the spacecraft activity to perform propulsive maneuver(**TBD 20**).

20.1.2 Command Level Constraints

The following command level constraints have been identified for ASTER:

Type: (Hard/ Soft)	Command Level Constraints:
Hard	Commands to the ASTER Remote Terminal shall be spaced at least 1.024 seconds apart. [Note: This will ensure that the spacecraft does not deliver the commands any faster than ASTER can accept them.]
Hard	VNIR Calibration Lamp – "on" duration must be less than or equal to 10 minutes. (Pre-Cal + Opt-Cal Mode) Command **(TBD 21)** must be executed within 10 minutes of command **(TBD 22)**..
Hard	SWIR Calibration Lamp – "on" duration must be less than or equal to 10 minutes (Pre-Cal +Opt-Cal Mode) Command AST_TURN_OFF_S_LAMP must be executed within 10 minutes of command AST_TURN_ON_S_LAMP.
Hard	SWIR Cooler Driver Control Circuit (power) shall be turned on before the Cooler On (start) command is sent. Command AST_TURN_ON_S_CLR must be executed at least **(TBD 23)** seconds (and at most **(TBD 24)** seconds) before command AST_ENABLE_S_CLR.
Hard	SWIR Cooler Off (cooler stop) command shall be sent before the cooler control circuit (power) is turned off. Command AST_DISABLE_S_CLR must be executed at least **(TBD 25)** seconds (and at most **(TBD 26)** seconds) before command AST_TURN_OFF_S_CLR.

Hard	TIR Off Procedure: "Standby Power Supply OFF" command should occur a minimum of 5 seconds after the "TIR Cooler OFF" command. Command AST_TURN_OFF_T_STBY must follow the AST_TURN_OFF_T_CLR command by at least 5 seconds.
Hard	After the SWIR and TIR Launch Lock OFF Commands are transmitted in orbit (i.e., instrument activation), prohibit any transmittion of the Launch Lock ON Commands. If the AST_FORCE_ON_S_LLK1 or AST_FORCE_ON_S_LLK2 or AST_FORCE_ON_T_CLLR1 or AST_FORCE_ON_T_CLLR2 commands appear in the ground script, generate the following message to the FOT: "SWIR/TIR Launch Lock On during cooler operation will result in serious damage."

20.1.3 Other EOC Constraint Checking

EOC will check data volume against SSR buffer capacity and scheduled downlink opportunities.

The EOC is not required to check the ASTER peak power constraint.

The EOC must check all command timing constraints for commands contained in the stored command table.

20.1.4 Prerequisite State Checking

Some ASTER constraint checking will be defined in the EOC in the form of prerequisite state checks. These constraints fall into the category of telemetry parameters which must have pre-defined values prior to the issuance of a realtime command. Prerequisite state checks required for ASTER are defined below.

	Prerequisite State Checks
1	SWIR Cooldown Mode: Be sure that the Launch Lock is OFF before turning the Cooler Drive Control Circuit ON and making the Cooler ON. The AST_TURN_ON_S_CLR command shall be sent in realtime only if the AST_BR_S_CLR_LOCK telemetry parameter = OFF (1). The AST_ENABLE_S_CLR command shall be sent in realtime only if the AST_BR_S_CLR_LOCK telmetry parameter = OFF (1).
2	After the Launch Lock OFF Commands are transmitted in orbit (i.e., instrument activation), prohibit any transmission of the Launch Lock On Commands. Only if AST_BR_S_CLR_LOCK telemetry indicates SWIR launch lock ON, allow realtime transmission of the AST_FORCE_ON_S_LLK1 and AST_FORCE_ON_S_LLK2 commands. Only if AST_BR_T_CLR_LATCH telemetry = ON, allow realtime transmission of the AST_FORCE_ON_T_CLLR1 and AST_FORCE_ON_T_CLL2 commands.

20.1.5 Required FOT actions

Some ASTER constraints must be handled through FOT actions. The following defines those actions required of the FOT.

1	AFTER the SWIR and TIR Launch Lock Off commands are successfully executed in orbit, the SWIR and TIR Launch Lock On commands must be removed from the PDB, and the associated bit strings must be placed in the table of "hazardous commands" which are never to be transmitted to the spacecraft. This action is necessary for SWIR because the execution of the launch lock on command during cooler operation will seriously damage or destroy the power amplifiers of the cooler drive control circuit. The FOT will coordinate the timing of these actions with the AOT.
2	Check ASTER average orbital power.

20.2 ASTER GDS/AOT Constraint Checking

The ASTER GDS/AOT will check for the following ASTER constraints.

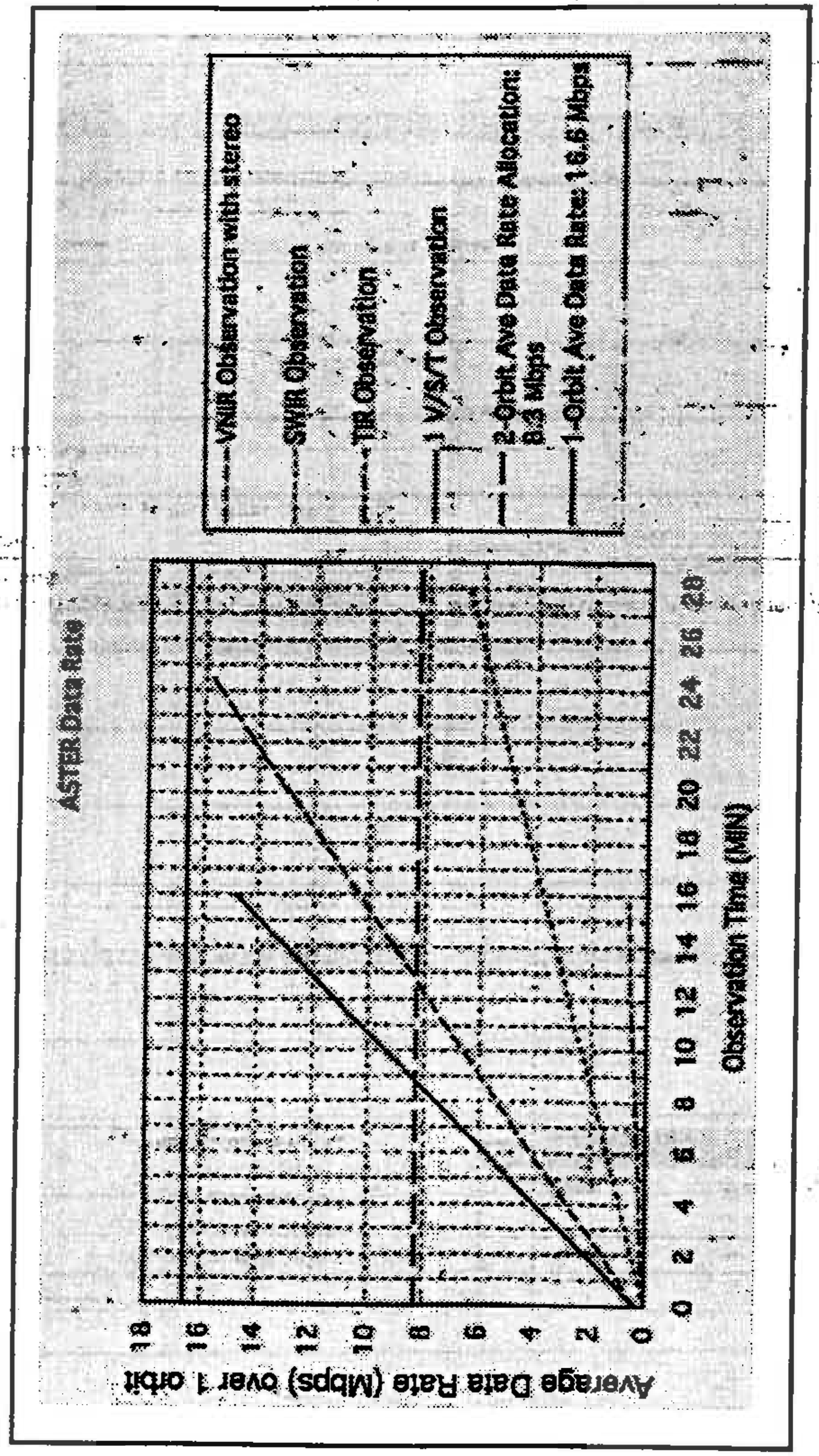
	Constraint:
1	Limited Life Items (On-Orbit) : VNIR: -Calibration Lamp ON/OFF: 150 times (>114 times = 5 years*365 days/16days) -Calibration Lamp Operation Time: 40 hrs (>19 hours = 114 times*10min / 60min) -Number of Pointings: 20,000 SWIR: -Calibration Lamp ON/OFF: 120 times (>114 times = 5 years * 365 days/ 16 days) -Calibration Lamp Operation Time: 30 hrs (>19 hours = 114 times * 10 min / 60 min) -Number of Pointings: 20,000 -Cooler ON/OFF: 89 times -Cooler Operation Time: 47,500 hrs (>43,800 hrs = 5 years * 365 days * 24 hrs) TIR: -Pointing: 200,000 times -Cooler ON/OFF: 100 times -Cooler Operation Time: 47,500 hrs (>43,800 hrs = 5 years * 365 days * 24 hrs) -Chopper ON/OFF: 79,900 times (>52,560 times = 14.4 rev/day * 2 times * 365 days * 5 years) -Chopper Operation Time: 41,500 hrs (>10,074 hrs = 52,560 times * 11.5 min / 60 min) -Getter Operation Time: 100 min. (> 12 min.)

2	UIID allocation for average data rate (see section 3.1.1.2 of UIID) Average data rate should be calculated as follows: $Rmean = (D_{V1}\Sigma t_{V1} + D_{V2}\Sigma t_{V2} + D_S\Sigma t_S + D_T\Sigma t_T) / T$ where the subscripts V1, V2, S, and T denote each high rate channel of VNIR(1), VNIR(2), SWIR, and TIR respectively. D: Peak data rate t: Total observation time over any 2-orbit period T: time duration for 2 orbits $D_{V1} = D_{V2} = 31.019$ Mbps $D_S = 23.053$ Mbps $D_T = 4.109$ Mbps T = 11,866 sec
3	UIID allocations for orbital average and peak power
4	VNIR/SWIR/TIR Maximum Observation Durations and Operational Constraints To include: -maximum observation duration in any single observation -maximum SWIR observation at night -maximum total observation duration in any single orbit and in any 2-orbits
5	Quantity of Data requiring Expedited Data Service, as constrainted in PIP Volume II
6	VNIR Calibration: Lamp Warm Up Duration ≥ 8 min (Pre-Opt Cal Mode)
7	VNIR Calibration: Lamp Turn On Duration ≤ 10 min (Pre-Cal + Opt-Cal Mode)
8	VNIR Calibration Lamp Cool Down Duration ≥ 90 min (about 1 orbit)
9	"VNIR Encoder A/B Select" command must be executed in standby mode
10	"VNIR Calibration Lamp A/B Select" command must be executed in standby mode
11	VNIR "Motor A/B Select" command should be prohibited in pointing mode
12	VNIR "Lamp A/B Select" command must be prohibited in pre-cal and opt-cal mode
13	VNIR commands must be ≥ 2 seconds apart
14	VNIR: The state of the table cancel function must be "ON" in all calibrations modes (Optical, Dark, Electrical)
15	SWIR Calibration: Lamp Warm Up Duration ≥ 8 min (Pre Cal Mode)
16	SWIR Calibration: Lamp Turn On Duration ≤ 10 min (Pre-Cal + Opt-Cal Mode)

17	SWIR mirror must be faced inside prior to spacecraft maneuver in order to avoid contamination (10 minutes required)
18	SWIR: TLM/CMD Circuit is the first component to be turned on, and the last one to be turned off
19	SWIR: Power On Reset Sequence Constraints for Command Timing
20	SWIR Commands must be ≥ 2 secs apart
21	The SWIR Pointing Drive Control Circuit shall be turned on before Pointing Control Commands are sent because these serial magnitude commands are directly decoded by the Pointing Drive Control Circuit
22	SWIR Main shall be turned on before turning on the Pointing Drive Control Circuit
23	SWIR Cooldown Mode: Be sure that the Launch Lock is OFF before turning the Cooler Drive Control Circuit ON and making the Cooler ON.
24	SWIR Standby Mode: After completion of Cooldown Mode, SWIR will go into the Standby Mode without special commands. Standby Mode cannot be entered too early due to detector temperatures.
25	SWIR : Wait 10 minutes for pointing completion before transitioning from calibration position to observation position.
26	SWIR: Wait 1 minute for pointing completion when pointing change is within ±8.55°
27	SWIR Calibration Mode: Pointing Mirror shall be set at the Calibration Position
28	SWIR: Launch Lock On command shall not be sent when the cooler drive circuit power is on.
29	SWIR Launch Lock On command shall be sent before transportation and launch.
30	The SWIR Launch Lock On command shall never be transmitted after the Launch Lock Off command has been successfully executed in orbit. This is because the execution of the launch lock on command during cooler operation will seriously damage or destroy the power amplifiers of the cooler drive control circuit.
31	SWIR Cooler Driver Control Circuit (power) shall be turned on before the Cooler On (start) command is sent
32	SWIR Cooler Off (Cooler stop) command shall be sent before the Cooler Control Circuit power is turned Off.
33	SWIR Calibration Lamp Selection and Lamp On/Off Commands: Calibration Lamp A or B shall be selected before the Lamp is turned On.
34	SWIR Calibration Lamp Selection and Lamp On/Off Commands: The Lamp should be turned off before the other lamp is selected.

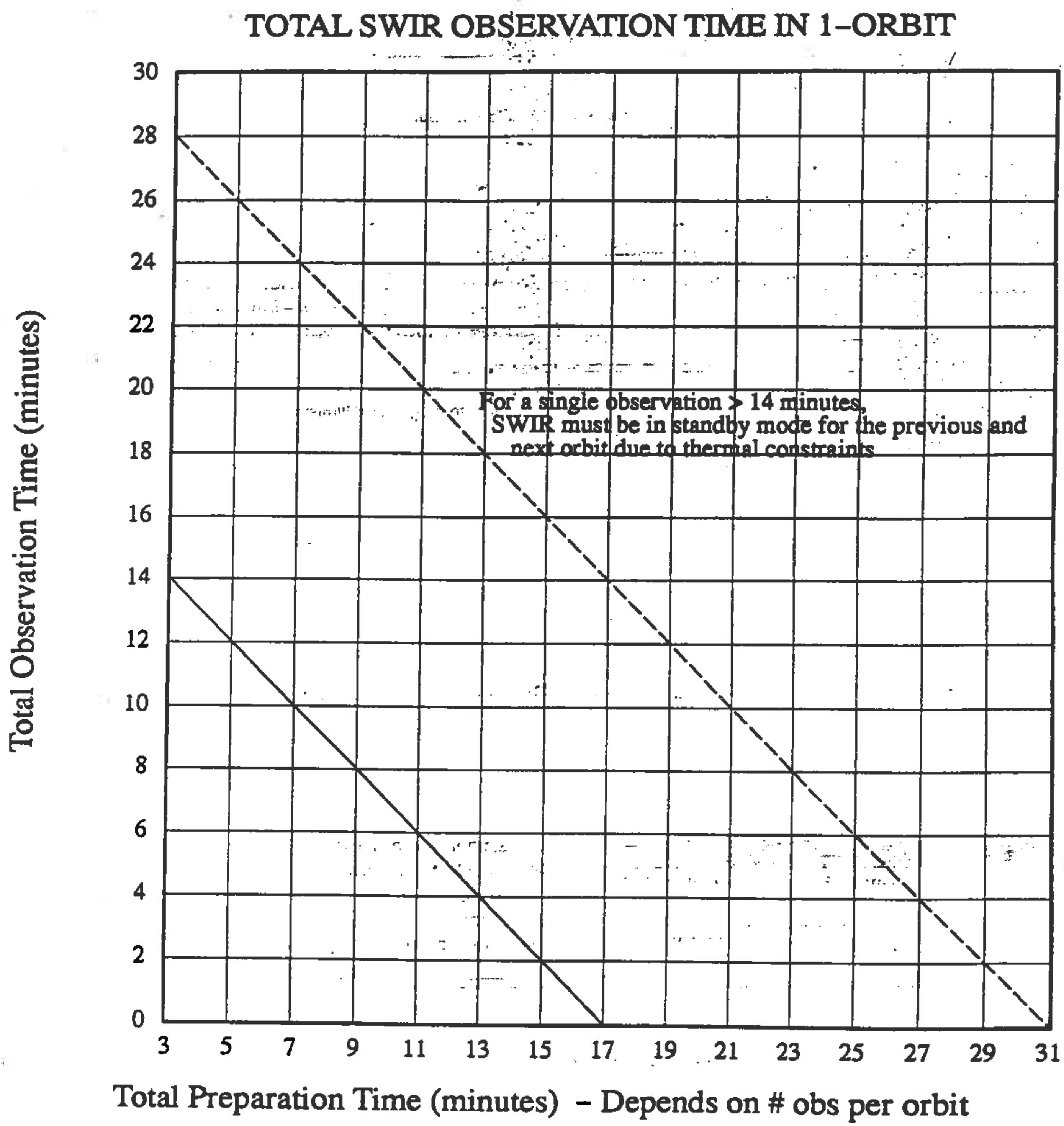
35	TIR: Scanner Latch OFF Time --- 300 second maximum
36	TIR Start: Cool-down time of cooler --- 80 minutes maximum
37	TIR Start: Standby mode to short-term cal --- Input of TIR scan start signal from CSP is necessary for TIR before 30 seconds of short-term calibration
38	The TIR Launch Lock On command shall never be transmitted after the Launch Lock Off command has been successfully executed in orbit.
39	TIR Stop: Restarting time after cooler stops --- 30 sec. minimum
40	TIR Observation: Amplifier preparation -- Amplifier and detector stabilization time: 5 minutes.
41	TIR Observation: Short-term calibration to Observation -- Pointing time: 60 secs
42	TIR Observation: Observation to Short-term calibration -- Pointing time: 60 secs
43	TIR Observation: Pointing time within the pointing range -- Pointing time: 30 secs
44	TIR Observation: Time required until the scanner enters the normal scanning condition -- included in the pointing time of 60 seconds
45	TIR Observation: Time required until serial digital monitor provides a normal output --- 1 minutes (one major frame) [after standby power supply ON]
46	Getter: Transition from Standby Mode to Getter Mode --- Time required by getter 1 to turn ON after cooler turns OFF: 120 minutes
47	Getter: Getter Mode --- Getter 1&2 power feeding time: 12 min. ± 1 min. (each) Time required by getter 2 to turn ON after a getter 1 turns OFF: 120 minutes
48	Getter: Transition from Getter mode to Standby Mode --- Time required by a cooler to turn ON after getter 2 turns OFF: 120 minutes
49	TIR Long Term Calibration: Blackbody Temperature Rise Time: 30-60 minutes Temperature Cooling Time: 210 minutes
50	Allowable Mode Transitions: As Depicted in C&T ICD
51	TIR OFF Procedures: "Scanning Power Supply OFF" command should occur about 28 seconds after command for setting status 1.
52	TIR OFF Procedures: "Standby Power Supply OFF" command should occur at least 5 seconds after the "Cooler OFF" command.
53	TIR Commands must be ≥ 2 secs apart
54	Quantity of data in expedited data sets

The following depicts the ASTER system constraints for single observations. The two horizontal lines depict the UIID requirements for ASTER data rate allocation. The end of each of the graphed lines represents the longest duration for that type of observation. So for example, the longest single TIR observation is 16 minutes (due to thermal constraints).



20.2.1 SWIR Observational Constraints

The following depicts SWIR observational constraints. Due to thermal constraints, in order for SWIR to observe for more than 14 minutes in any given orbit, it must be in standby mode during the orbit before and after the longer observation. The solid line indicates the case where SWIR is not in standby mode during the entire orbit before and after the observation.



The maximum total SWIR observation duration for a single orbit is determined as follows: the sum of the times required for SWIR preparation and observation must be less than or equal to 31 minutes. Since each observation requires a 3-minute preparation, the maximum number of SWIR observations in any given orbit is on the order of 9–10. This "worst case" number of observations is based on a scenario where SWIR does not observe during the orbit before or after the chosen orbit.

The maximum total SWIR observation duration for every orbit is determined as follows: the sum of the times required for SWIR preparation and observation must be less than or equal to 17 minutes. Therefore, the "worst case" average number of observations per orbit is 5.

20.2.2 TIR Observational Constraints

The total number of TIR observations over the lifetime of the mission is constrained by the limited life nature of the pointing mechanism and the chopper.

The maximum duration for a single TIR observation is 16 minutes. The maximum total observation duration over any 2-orbit period may be calculated as follows:

$$\Sigma\,(0.859{*}T_{prep} + 0.968{*}T_{ptg} + T_{obs}) \leq 59.6 \text{ min}$$

T_{prep}: Total preparation and short-term calibration duration in any 2 orbits

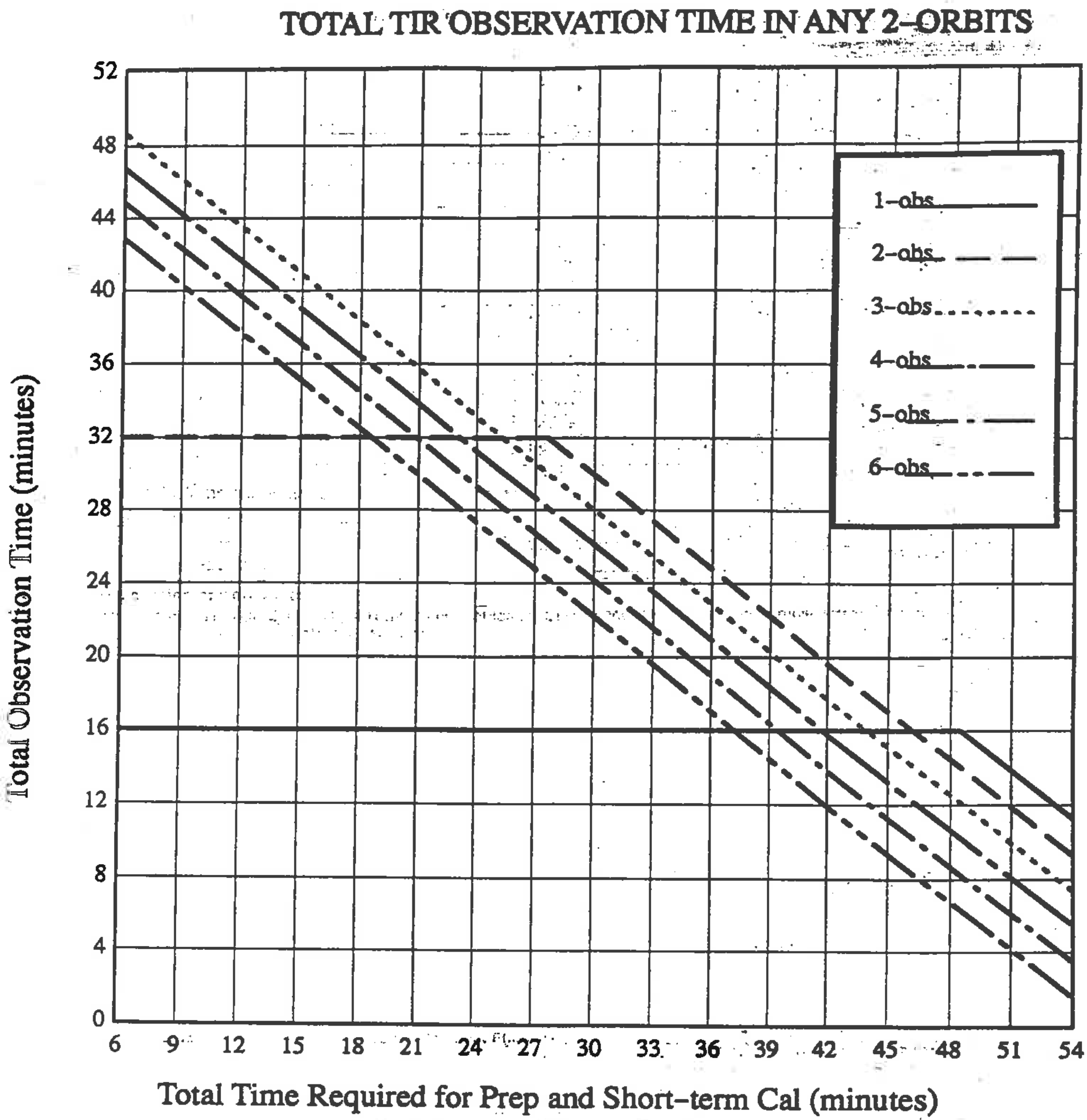
T_{ptg}: Total pointing duration in any 2 orbits

T_{obs}: Total observation duration in any 2 orbits

The chart provided below depicts the maximum TIR observation time in any 2-orbit period depending on the amount of time the TIR is in preparation and short-term calibration mode. The various lines result from the number of divided observations per orbit. The time required for pointing is not included on the horizontal axis, since it is included in the calculation of the line itself.

For example, if one wanted to determine the maximum amount of time which may be divided among 3 observations in a 2-orbit period, one would first determine the amount of time required for prep mode, and short term calibrations. If the observations are to be spaced greater than 8 minutes apart, then 6.5 minutes is required for prep and short-term calibration prior to each observation. After each observation, 30 seconds is required for a short-term calibration. Therefore, 21 minutes is required for prep and short-term calibrations for the three observations (Note: pointing time is not included in the calculation of the x-coordinate to be used with the chart below.) Using the chart, one can determine that approximately 36 minutes is available for observations. Using the formula above, one can calculate the precise value of 35.753 minutes.

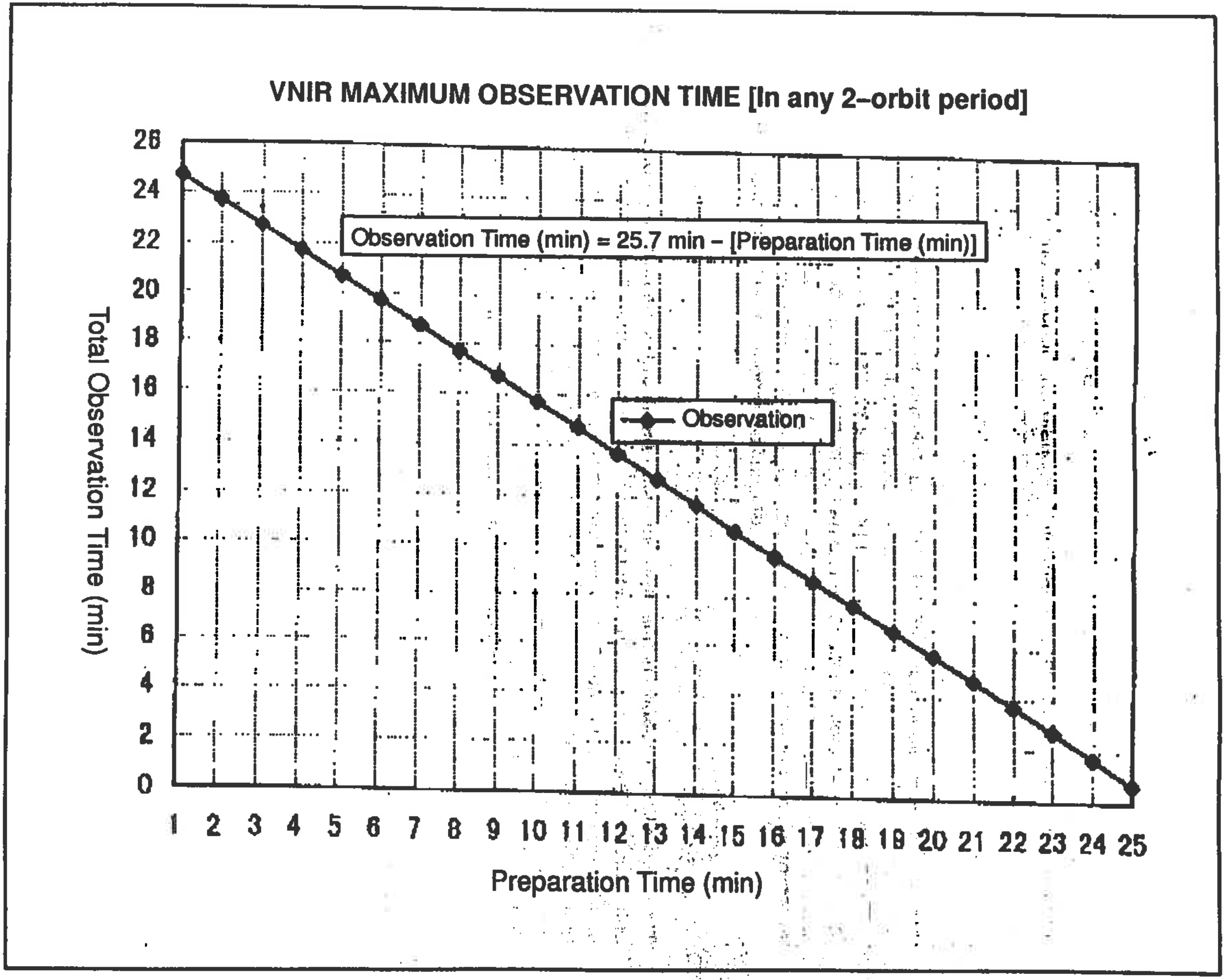
It should be noted that if the observations were spaced less than 8 minutes apart, then the amount of time spent in prep mode and short-term calibration mode would vary as described in the sections on divided operations.


TOTAL TIR OBSERVATION TIME IN ANY 2-ORBITS
Total Observation Time (minutes)
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Total Time Required for Prep and Short-term Cal (minutes)
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
1-obs
2-obs
3-obs
4-obs
5-obs
6-obs

20.2.3 VNIR Observational Constraints

There is no restriction on the number of VNIR observations during any given time period. The total observation duration is governed by thermal constraints.

The maximum VNIR observation during any 2-orbit period may be calculated using the formula depicted in the following figure. Basically, each VNIR observation requires one minute of preparation time. Whatever portion of a 25.7 minute allotment is not used for preparation may be used for observation(s).


VNIR MAXIMUM OBSERVATION TIME [In any 2-orbit period]
Observation Time (min) = 25.7 min – [Preparation Time (min)]
Observation
Total Observation Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Preparation Time (min)

EOS AM-1 *Operational Constraints Data Base*

Source:
Originator:
Organization: AOT **Phone:**
Reference:

Implementation: ☒ Hard ◯ Soft ◯ Not Applicable
☐ **Specific Mission Phase**
Specify:

General:
Subsystem or Instrument: ASTER
Component(s): SWIR, TIR
Operation: After Instrument Activation

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☐ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:
- ☐

Other Constraint Type:
- ☒

Description of Constraint
After the Launch Lock OFF Commands are transmitted in orbit (i.e., instrument activation), prohibit any transmission of the Launch Lock On Commands:
AST_FORCE_ON_S_LLK1, AST_FORCE_ON_S_LLK2,
AST_FORCE_ON_T_CLL1, AST_FORCE_ON_T_CLL2,
AST_FORCE_ON_V_LLKA, AST_FORCE_ON_V_LLKB

1) Remove the commands from the PDB
2) Add the command strings to the list of hazardous bit strings.

[NOTE: This is 1 of 3 constraint sheets addressing this constraint.]

Reason For Constraint
Launch Lock ON during cooler operation will seriously damage or destroy the Power Amplifiers of the Cooler Drive Control Circuit.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	**FOT:**

Figure 27. Constraint form A

EOS AM-1 *Operational Constraints Data Base*

Source:

Originator:

Organization: AOT **Phone:**

Reference:

Implementation:

☒ Hard ○ Soft ○ Not Applicable

☐ Specific Mission Phase

Specify:

General:

Subsystem or Instrument: ASTER

Component(s): SWIR, TIR

Operation: After Instrument Activation

CMD(s)/ACT(s)	TLM
see below	see below
see below	

Command Level Constraints:

- ☐ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:

- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:

☐

Other Constraint Type:

☒ Pre-Requisite State Check

Description of Constraint

After the Launch Lock OFF Commands are transmitted in orbit (i.e., instrument activation), prohibit any transmission of the Launch Lock On Commands.

Only if AST_BR_S_CLR_LOCK telemetry indicates SWIR launch lock ON, allow realtime transmission of the AST_FORCE_ON_S_LLK1 and AST_FORCE_ON_S_LLK2 commands.

Only if BR_T_CLR_LATCH tlm = ON, allow realtime transmission of the AST_FORCE_ON_T_CLLR1 and AST_FORCE_ON_T_CLL2 commands.

[NOTE: This is 2 of 3 constraint sheets addressing this constraint. This constraint can be removed from the system once the actions stated on sheet (1 of 3) are implemented.]

Reason For Constraint

Launch Lock ON during cooler operation will seriously damage or destroy the Power Amplifiers of the Cooler Drive Control Circuit.

Space Segment Effect

- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect

- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	FOT:

Figure 28. Constraint Form B

EOS AM-1 *Operational Constraints Data Base*

Source:
Originator:
Organization: AOT Phone:
Reference:

Implementation: ⊗ Hard ◯ Soft ◯ Not Applicable
☐ Specific Mission Phase
Specify:

General:
Subsystem or Instrument: ASTER
Component(s): SWIR, TIR
Operation: After Instrument Activation

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☐ Pre-Rule
- ☐ Post-Rule
- ☒ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint: ☐

Other Constraint Type: ☐

Description of Constraint:
After the Launch Lock OFF Command is transmitted in orbit (i.e., instrument activation), prohibit any transmission of the Launch Lock On Command.

If the AST_FORCE_ON_S_LLK1 or AST_FORCE_ON_S_LLK2 or AST_FORCE_ON_T_CLLR1 or AST_FORCE_ON_T_CLLR2 commands appear in the ground script, print the following message for the FOT:
"SWIR/TIR Launch Lock On during cooler operation will result in serious damage"

[NOTE: This is 3 of 3 constraint sheets addressing this constraint. This constraint can be removed from the system once the actions stated on sheet (1 of 3) are implemented.]

Reason For Constraint
Launch Lock ON during cooler operation will seriously damage or destroy the Power Amplifiers of the Cooler Drive Control Circuit.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	FOT:

Figure 29. Constraint Form C

EOS AM-1 *Operational Constraints Data Base*

Source:
- Originator:
- Organization: AOT
- Phone:
- Reference:

Implementation: ⊗ Hard ○ Soft ○ Not Applicable

☐ Specific Mission Phase

Specify:

General:
- Subsystem or Instrument: ASTER
- Component(s): SWIR
- Operation: Calibration

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☐ Pre-Rule
- ☒ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint: ☐

Other Constraint Type: ☐

Description of Constraint
Command AST_TURN_OFF_S_LAMP must be transmitted within 10 minutes of AST_TURN_ON_S_LAMP.

Reason For Constraint
The SWIR Calibration Lamp turn on duration must be less than or equal to 10 minutes.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	FOT:

Figure 30. Constraint Form D

EOS AM-1 *Operational Constraints Data Base*

[redacted]

Source:

Originator:

Organization: AOT **Phone:**

Reference:

Implementation: ◯ Hard ◯ Soft ⊗ Not Applicable

☐ **Specific Mission Phase**

Specify:

General:

Subsystem or Instrument: ASTER

Component(s): SWIR

Operation: Cooldown

CMD(s)/ACT(s)	TLM
see below	see below

Command Level Constraints:

- ☐ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:

- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:

☐

Other Constraint Type:

☒ Pre-Requisite State Check

Description of Constraint

Command AST_TURN_ON_S_CLR shall ONLY be sent in real-time when telemetry has the following values:

AST_BR_S_CLR_LOCK=1 (one...OFF)

Reason For Constraint

The SWIR Launch Lock must be OFF before turning the Cooler Drive Control Circuit On.

Space Segment Effect

- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect

- ☐ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☐ Instrument Ops Facility
- ☐ Other:

[redacted]

Subsystem:	Systems:
Instrument:	**FOT:**

Figure 31. Constraint Form E

EOS AM-1 *Operational Constraints Data Base*

Source:

- **Originator:**
- **Organization:** AOT **Phone:**
- **Reference:**

Implementation: ○ Hard ○ Soft ⊗ Not Applicable

☐ **Specific Mission Phase**

Specify:

General:

- **Subsystem or Instrument:** ASTER
- **Component(s):** SWIR
- **Operation:** Cooldown

CMD(s)/ACT(s)	TLM
see below	see below

Command Level Constraints:

☐ Pre-Rule
☐ Post-Rule
☐ Comment Rule
☐ No Exist Rule
☐ Bit Rule
☐ Scalar Rule
☐ No Commands Before Rule
☐ No Commands After Rule
☐ No Commands to RT Until Rule
☐ No Repeat Rule

Activity Level Constraints:

☐ A before B
☐ A after B
☐ A during B
☐ A not during B

Other Activity Level Constraint:

☐

Other Constraint Type:

☒ Pre-Requisite State Check

Description of Constraint

Command AST_ENABLE_S_CLR shall ONLY be sent in real-time when telemetry has the following values:

AST_BR_S_CLR_LOCK=1 (one...OFF)

Reason For Constraint

The SWIR Launch Lock must be OFF before turning the Cooler On.

Space Segment Effect

☐ H/W
☐ FSW
☐ Data
☒ Instrument
☐ Other:

Ground Segment Effect

☐ Stored CMDs (CMS/P&S)
☒ ECL Procedures
☐ Flight Dynamics
☐ Instrument Ops Facility
☐ Other:

Subsystem:	Systems:
Instrument:	**FOT:**

Figure 32. Constraint Form F

EOS AM-1 *Operational Constraints Data Base*

Source:
- **Originator:**
- **Organization:** AOT **Phone:**
- **Reference:**

Implementation: (X) Hard ( ) Soft ( ) Not Applicable

☐ **Specific Mission Phase**

Specify:

General:
- **Subsystem or Instrument:** ASTER
- **Component(s):** SWIR, TIR
- **Operation:** Prepare for S/C delta-v

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☐ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☒ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint: ☐

Other Constraint Type: ☐

Description of Constraint

Activity ASTER_TO_CONTAMINATION_SAFEMODE must occur prior to Activity TBD7 (FOT defined spacecraft maneuver activity).

Reason For Constraint

The SWIR and TIR mirrors must be turned to the calibration position prior to a s/c propulsive maneuver in order to avoid contamination.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	**FOT:**

Figure 33. Constraint Form G

EOS AM-1 *Operational Constraints Data Base*

Source:

Originator:	
Organization:	AOT
Phone:	
Reference:	

Implementation:
☒ Hard ◯ Soft ◯ Not Applicable

☐ **Specific Mission Phase**

Specify:

General:

Subsystem or Instrument:	ASTER
Component(s):	VNIR
Operation:	Calibration

CMD(s)/ACT(s)	TLM
TBD1	
TBD2	

Command Level Constraints:
- ☐ Pre-Rule
- ☒ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:
☐

Other Constraint Type:
☐

Description of Constraint

Cmd TBD2 must be executed within 10 minutes of TBD1.

Reason For Constraint

During VNIR Calibrations, the lamp turn on duration must be less than or equal to 10 minutes

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other:

Subsystem:	**Systems:**
Instrument:	**FOT:**

Figure 34. Constraint Form H

EOS AM-1 *Operational Constraints Data Base*

Source:

Originator: ____

Organization: AOT **Phone:** ____

Reference: ____

Implementation: ⊗ Hard ○ Soft ○ Not Applicable

☐ Specific Mission Phase

Specify: ____

General:

Subsystem or Instrument: ASTER

Component(s): SWIR

Operation: ____

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:

- ☒ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:

- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint: ☐ ____

Other Constraint Type: ☐ ____

Description of Constraint

Command AST_DISABLE_S_CLR must occur at least TBD4 seconds before (and at most TBD5 seconds before) command AST_TURN_OFF_S_CLR.

Reason For Constraint

The Cooler Off (cooler stop) command shall be sent before Cooler Control Circuit (power) is turned off.

Space Segment Effect

- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other: ____

Ground Segment Effect

- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other: ____

Subsystem:	Systems:
Instrument:	FOT:

Figure 35. Constraint Form I

EOS AM-1 *Operational Constraints Data Base*

Source:
Originator: ____
Organization: AOT Phone: ____
Reference: ____

Implementation:
☒ Hard ○ Soft ○ Not Applicable
☐ Specific Mission Phase
Specify: ____

General:
Subsystem or Instrument: ASTER
Component(s): SWIR
Operation: ____

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☒ Pre-Rule
- ☐ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:
☐ ____

Other Constraint Type:
☐ ____

Description of Constraint
Command AST_TURN_ON_S_CLR must occur at least TBD12 seconds before (and at most TBD13 seconds before) command AST_ENABLE_S_CLR.

Reason For Constraint
The Cooler Drive Control Circuit (power) shall be turned on before the Cooler On (cooler start) command is sent.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other: ____

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☒ Instrument Ops Facility
- ☐ Other: ____

Subsystem:	Systems:
Instrument:	FOT:

Figure 36. Constraint Form J

EOS AM-1 *Operational Constraints Data Base*

Source:
- Originator:
- Organization: AOT Phone:
- Reference:

Implementation:
○ Hard ○ Soft ○ Not Applicable

☐ Specific Mission Phase

Specify:

General:
- Subsystem or Instrument: ASTER
- Component(s): TIR
- Operation:

CMD(s)/ACT(s)	TLM
see below	
see below	

Command Level Constraints:
- ☐ Pre-Rule
- ☒ Post-Rule
- ☐ Comment Rule
- ☐ No Exist Rule
- ☐ Bit Rule
- ☐ Scalar Rule
- ☐ No Commands Before Rule
- ☐ No Commands After Rule
- ☐ No Commands to RT Until Rule
- ☐ No Repeat Rule

Activity Level Constraints:
- ☐ A before B
- ☐ A after B
- ☐ A during B
- ☐ A not during B

Other Activity Level Constraint:
☐

Other Constraint Type:
☐

Description of Constraint

Whenever command AST_TURN_OFF_T_CLR occurs, then command AST_TURN_OFF_T_STBY must occur at least 5 seconds (and at most TBD-C seconds) later.

Reason For Constraint

During the TIR Off Procedure: The "Standby Power Supply OFF" command should occur a minimum of 5 seconds after the "Cooler Off" command.

Space Segment Effect
- ☐ H/W
- ☐ FSW
- ☐ Data
- ☒ Instrument
- ☐ Other:

Ground Segment Effect
- ☒ Stored CMDs (CMS/P&S)
- ☒ ECL Procedures
- ☐ Flight Dynamics
- ☐ Instrument Ops Facility
- ☐ Other:

Subsystem:	Systems:
Instrument:	FOT:

Figure 37. Constraint Form K

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APPENDIX C

30 REQUIREMENTS

30.1 Planning and Scheduling Requirements

The following describes the planning aids necessary for the scheduling and planning of ASTER operations.

	Planning Aid	Required Duration and Frequency	Required Accuracy and Resolution
1	Predicted Times of Planned Spacecraft Maneuvers	49 days in advance of each event	1 orbit at 49 days 1-2 minutes at 5 weeks
2	Predicted Spacecraft Ephemeris	7 weeks/ weekly 7 days/ daily	Cross: 500 m @ 30 days Radial: 30 m @ 40 hrs
3	Predicted Solar Eclipse Entrance/Exit Times of Subsatellite Point	7 weeks/ weekly 7 days/daily	Time: 1 sec Location: 1 km
4	Predicted Ascending and Descending Node Crossing Times	7 weeks/ weekly 7 days/daily	0.04 secs @ 40 hrs 10 secs @ 21 days
5	Predicted Terminator Crossing Times	7 weeks/ weekly 7 days/ daily	0.04 sec @ 40 hrs 10 secs @ 21 days
6	Predicted Entrance and Exit Times of South Atlantic Anomaly		1 sec @ 4 days 43 secs @ 30 days
7	Predicted Entrance and Exit Times of the Van Allen Belt	7 weeks/ weekly 7 days/ daily	1 sec @ 4 days 43 secs @ 30 days
8	Predicted spacecraft day/ night transition times (spacecraft sunrise, sunset times)	7 weeks/ weekly 7 days/ daily	1 sec @ 7 days 10 sec @ 21 days
9	Orbit Number	7 weeks/ weekly 7 days/ daily	not applicable

10	Predicted Spacecraft Subsatellite Point Longitude and Latitude versus Time	7 weeks/ weekly 7 days/ daily	Latitude: 0.005 deg @ 40 hrs at equator 0.6 deg @ 21 days at equator Longitude: 0.0009 deg @ 40 hrs at equator 0.27 deg @ 21 days at equator
11	Predicted Spacecraft Altitude versus Time	7 weeks/ weekly 7 days/ daily	30 m @ 40 hrs
12	Predicted Longitude of Ascending and Descending Nodes	7 weeks/ weekly 7 days/ daily	0.0009 deg @ 40 hrs at equator 0.27 deg @ 21 days at equator
13	Predicted North and South Point Crossing Times	7 weeks/ weekly 7 days/ daily	0.04 sec @ 40 hrs 10 sec @ 21 days
14	Planned TDRSS Contact Times	7 weeks/ weekly 7 days/ daily	1 sec

30.2 Facility Requirements

The AOT will require Building 32 facility support for the duration of the initial activation and checkout phase. During this time period, the ASTER will need access to Building 32 facilities 24 hours per day, seven days per week. Specific requirements include:

–internet access

–access to: a facsimile machine,
a photocopy machine, and at least 2 phones

–physical space for up to 10 members

Other specific requirements are **(TBD 27)**.

APPENDIX D

40 ADDITIONAL OPERATIONAL AGREEMENTS

This section documents additional operational agreements and joint operating procedures between the FOT and AOT.

APPENDIX E

50 GLOSSARY

Activity	Activities represent command blocks that change the mode/configuration of an instrument.
Activity Profile	A sequence of activities that define the normal operations for an instrument.
Baseline Activity Profile	A BAP is a repetitive sequence of activities that define the normal operations for an instrument.
Command Authorization	Ensures that a command was sent by an authorized operator.
Command Mnemonic Lookup	Ensures that commands accepted conform to the database command definition.
Command Validation	Validation refers to checks performed prior to uplinking a given command. Real-time command validation includes command authorization, command mnemonic lookup, prerequisite state check, critical command check, and load validation.
Command Verification	Verification refers to the checks performed after uplinking a given command. Command verification includes receipt verification using the CLCW and execution verification using discrete spacecraft telemetry .
Critical Command Check	All real-time commands defined as critical require operator confirmation prior to uplink.
EOS AM-1 Spacecraft Database	Contains all data for EOS AM-1 operations including: planning aids; orbital event pool; processing events archive; spacecraft operations schedule; displays; standing orders; procedures; activities; reactions; etc.
Ground Script	A set of time-ordered, time-stamped command language directives that govern the real-time commanding of the spacecraft and its instrument payload for a specified period of time, typically 24 hours. A ground script is generated by Command Management based upon the Daily Activity Schedule produced during the planning and scheduling phase.
Load Validation	Ensures loads are uplinked to the correct destination and within the valid uplink window.
Prerequisite State Check	Checks that a spacecraft telemetry parameter is in a database defined state prior to uplinking a command.
Procedure	A procedure is a set of command language directives that perform a specific function. A procedure is the vehicle by which command request directives are sent to the FOT.
Project Database	Contains the EOS-AM-1 operations data definition used the FOS real-time and analysis. Specific data includes: command definition; telemetry definition; limits; alarms; calibration curves; constraints; procedures; and activities.

APPENDIX F

60 ACRONYMS and ABBREVIATIONS

ACE	Attitude Control Electronics
ADAC	Attitude Determination and Control
ADC	Analog to Digital Converter
ADN	ASTER Data Network
AOS	ASTER Operation Segment
AOT	ASTER Operation Team
APID	Application Process Identification
ARC	Ames Research Center
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATC	Absolute Time Command
BC	Bus Controller
BDD	Baseline Description Document for the EOS-AM Spacecraft
BDU	Bus Data Unit
bps	Bits per Second
BUT	Bus Utilization Table
C&DHS	Command and Data Handling Subsystem
C&T	Command and Telemetry
CAC	Command Activity Controller
CCD	Charge Coupled Device
CDS	Command and Data Subsystem
CERES	Clouds and the Earth's Radiant Energy System
CES	Camera Electronics Subsystem
CHE	Camera Head Electronics
CLCW	Command Link Control Word
CM	Command Management
COMMS	Communication Subsystem
CPHTS	Capillary Pump Heat Transport System
CRC	Cyclic Redundancy Check
CSMS	Communication and System Management Segment - note: this acronym is used both in the U.S. and Japan Ground Systems
CSE	Camera Support Electronics
CTIU	Command and Telemetry Interface Unit
DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System - note: this acronym is used both in the U.S. and Japan Ground Systems
DAS	Direct Access System or Detailed Activity Schedule
DB	Direct Broadcast
DDL	Direct Downlink
DFCD	Data Format Control Document for the EOS AM-1 Project Data Base
DM	Data Management
DP	Direct Playback
DSN	Deep Space Network
EAS	Electrical Accommodation Subsystem
ECOM	EOS Communication Network
ECS	EOSDIS Core System
EDOS	EOS Data and Operations System
EICD	Electrical Interface Control Drawing
EPS	Electrical Power Subsystem
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESC	Engineering Signal Conditioner
ESN	EOSDIS Science Network
FDF	Flight Dynamics Facility
FDIR	Failure Detection, Isolation and Recovery
FOS	Flight Operations Segment
FOT	Flight Operations Team
FOV	Field of View
FP	Focal Plane

FP&S	Flight Planning and Scheduling
FSW	Flight Software
FSWS	Flight Software System
GDS	Ground Data System
GIIS	General Instrument Interface Specification
GN	Ground Network
GN&CS	Guidance, Navigation, and Control Subsystem
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSMS	Ground System Management Segment
GSRD	Ground System Requirements Database
H/K	Housekeeping
H&S	Health and Safety
HCE	Heater Controller Electronics
HGA	High Gain Antenna
HQE	High Quantum Efficiency
I/O	Input/Output
I	Input/Output
I&T	Integration and Test
I&T ICD	Integration and Test Interface Control Drawing
IASS	Instrument Analysis Support Subsystem
ICOSS	Instrument Control Operations Subsystem
ICC	Instrument Control Center
ICD	Interface Control Drawing
IF	Intermediate Frequency
IMS	Information Management System – note: this acronym is used both in the U.S. and Japan Ground Systems
IOT	Instrument Operations Team
IST	Instrument Support Toolkit – U.S. acronym definition
IST	Instrument Support Terminal – Japan acronym definition
IWG	Instrument Working Group
JPL	Jet Propulsion Laboratory
kbps	Kilobits per Second
KSA	Ku-Band Single Access
LMAS	Lockheed Martin Astro Space
LRS	Low Rate Science
LTIP	Long Term Instrument Plan
LTSP	Long Term Science Plan
LTS	Long Term Schedule
MCPT	MISR Command Parameter Table
MDD	Mini Dual Drive
MICD	Mechanical Interface Control Drawing
MISR	Multi-angle Imaging SpectroRadiometer
MO	Master Oscillator
MODIS	Moderate Resolution Imaging Spectroradiometer
MOM	Mission Operation Manager
MOPITT	Measurements of Pollution in The Troposphere
MSFC	Marshall Space Flight Center
MSB	Most Significant Bit
MSS	Management Subsystem
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NCC	Network Control Center
NSI	NASA Science Internet
OBC	On-Board Calibrator
ODS	One Day Schedule
OD	Operations Day
OICD	Operations Interface Control Drawing
P&S	Planning and Scheduling
PDB	Project Data Base
PGS	Product Generation System – note: this acronym is used both in the U.S. and Japan Ground Systems
PI	Principal Investigator
POR	Power On Reset
PROPS	Propulsion Subsystem
PSAT	Predicted Site Acquisition Table
PSCN	Program Support Communications Network

QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RM	Resource Management
ROM	Read Only Memory
RTCS	Relative Time Command Sequence
S/C	Spacecraft
SAA	Solar Array Assembly
SCC	Spacecraft Controls Computer
SCF	Science Computing Facility
SDF	Software Development Facility
SDPS	Science Data Processing Segment – note: this acronym is used both in the U.S. and Japan Ground Systems
SDVF	Software Development and Validation Facility
SFE	Science Formatting Equipment
SISS	Software Implementation Support Subsystem,
SMC	System Management and Coordination
SMS	Structures and Mechanisms Subsystem
SN	Space Network
SSA	S-Band Single Access
SSIM	Spacecraft Simulator
SSR	Solid State Recorder
STGT	Second TDRSS Ground Terminal
STS	Short Term Schedule
SWIR	Short Wave Infrared Radiometer
TEC	Thermoelectric Cooler
TCS	Thermal Control Subsystem
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TICD	Thermal Interface Control Drawing
TIR	Thermal Infrared Radiometer
TMON	Telemetry Monitor
TOD	Time of Day
TONS	TDRSS Onboard Navigation System
UAV	User Antenna View
UI	User Interface
UIID	Unique Instrument Interface Document
VCID	Virtual Channel Identifier
VNIR	Visible and Near Infrared Radiometer
WOTS	Wallops Orbital Tracking Station
WSGT	White Sands Ground Terminal
WTA	Wax Thermal Actuator