6. REAL-TIME OPERATIONS

This section provides a brief overview of the TRMM MOC architecture, a description of nominal real-time activities, as well as an overview of contingency operations. The TRMM FOT will conduct all real-time telemetry and command (Health & Safety) operations from the Mission Operations Center (MOC). Nominal real-time activities will be conducted with the Space Network (SN) utilizing the TDRSS SSA antenna(s). Real-time operations will consist of real-time telemetry processing, command uplink and verification, recorder management, and table and memory load/dump operations.

6.1 MISSION OPERATIONS CENTER

The TRMM MOC consists of a Mission Operations Room (MOR), a Mission Analysis Room (MAR), and operational hardware and software. The MOR is the facility utilized to conduct real-time operations, and the MAR contains the systems required for advanced planning, event scheduling, and telemetry trend and performance analysis. The MOC will utilize a Transportable POCC (TPOCC) architecture capitalizing on advances in the microcomputer field.

6.1.1 TPOCC Architecture

The TPOCC architecture, as provided in the TRMM MOC, consists of a three hardware string concept. Two strings will be located in the MOR to support real-time activities, and the third string will be located in the MAR to accommodate off-line activities. Table 6.1-1 lists the contents and functions for each string of equipment.

The nominal MOC configuration will have the operational (prime) and backup strings located in the MOR. All strings are designed to provide total operational support under nominal conditions. Components of each string will have full connectivity amongst the remaining strings (allows real-time activities to be performed via off-line string in MAR, and off-line activities to be performed from real-time string in MOR, if necessary). All strings support interface capabilities to Nascom via the MOC-located Local TPOCC Switch (LTS) for telemetry and command activity, as well as to the TPOCC backbone Local Area Network (LAN). This network provides the capability for transfer of files and data to other external elements. Figure 6.1-1 illustrates the TPOCC hardware architecture for the TRMM MOC.

As noted in Table 6.1-1, the TSDIS SOCC, LaRC, MSFC, and the FDF will be able to monitor real-time command and telemetry activities via one X-terminal located at each facility.

6.1.2 Mission Operations Room

The MOR will house the equipment necessary to conduct real-time operations. The MOR will be staffed 24-hours per day, 7 days a week, by the FOT. Figure 6.1-2 provides an illustration of the current TRMM MOR layout.

6.1.3 Mission Analysis Room

The MAR will provide the systems necessary to perform off-line activities. Activities such as load generation, trend and performance analysis, and mission planning and scheduling are performed in the MAR, as described in section 7. Figure 6.1-3 provides an illustration of the current TRMM MAR layout.

Prime String	Backup String	Off-Line String
1 Front End Processor (FEP) 2 Workstations 3 X-Terminals 1 4 mm Tape Drive 1 4 GB Hard Drive 3 Printers: Laser, Line & Color Video Printer (CVP)	1 Front End Processor (FEP) 3 Workstations* 4 X-Terminals 5 4 GB Hard Drives 1 2.8 GB Hard Drive 1 CD ROM Drive 1 4 mm Tape Drive 1 Optical Jukebox ** 3 Printers: Laser, Line & Color Video Printer (CVP)	1 Front End Processor (FEP) 2 Workstations 3 X-Terminals 1 4 GB RAID Unit 3 4 GB Hard Drives 1 2.8 GB Hard Drive 1 CD ROM Drive 1 4 mm Tape Drive 1 3.5 in Disk Drive 3 Printers: Laser, Line & Color Video Printer (CVP)
Functions	**Functions**	**Functions**
R/T Telemetry Processing R/T Commanding History Data Archive	Long-term Trend Analysis Backup Servers COMETS R/T Events R/T Telemetry Processing R/T Commanding History Data Replay / Archive	Mission Planning Command Management Prime Servers

* Includes a workstation to provide interface to remote instrument facilities (TSDIS SOCC, LaRC, MSFC, and FDF). Also includes workstation for GTAS.

** Jukebox for long-term trending.

Table 6.1-1 Three String Concept

6.2 TELEMETRY OPERATIONS

TRMM telemetry coming into the MOC is routed to a Front End Processor (FEP). The FEP decommutates and validates the telemetry. The FOT utilizes a series of workstations to interface with the FEP(s). The FEP(s) and workstations provide a number of real-time functions that allow the FOT to monitor TRMM health and safety. These functions will include:

- Page displays
- Subsystem monitoring (GenSAA)
- Attitude data set transmission or collection
- Special processing and Equation Processors
- Subset generation
- Hardcopy reports
- Memory/table dump collection
- Data accounting/archival
- Graphical displays(GenSAA, SpaceCam, RTADS, HUD)

The decommutated and validated telemetry stream is routed to the prime operational string. The prime string will be configured for each real-time event, via STOL procedure(s) and UNIX scripts executed from a workstation housed command panel. The FOT will use a number of telemetry subsystem tasks to monitor TRMM health and safety. The following sections describe (at a high level) those subsystem tasks used for the telemetry monitoring activity performed in the MOC.

Figure 6.1-1 TRMM MOC Hardware Architecture

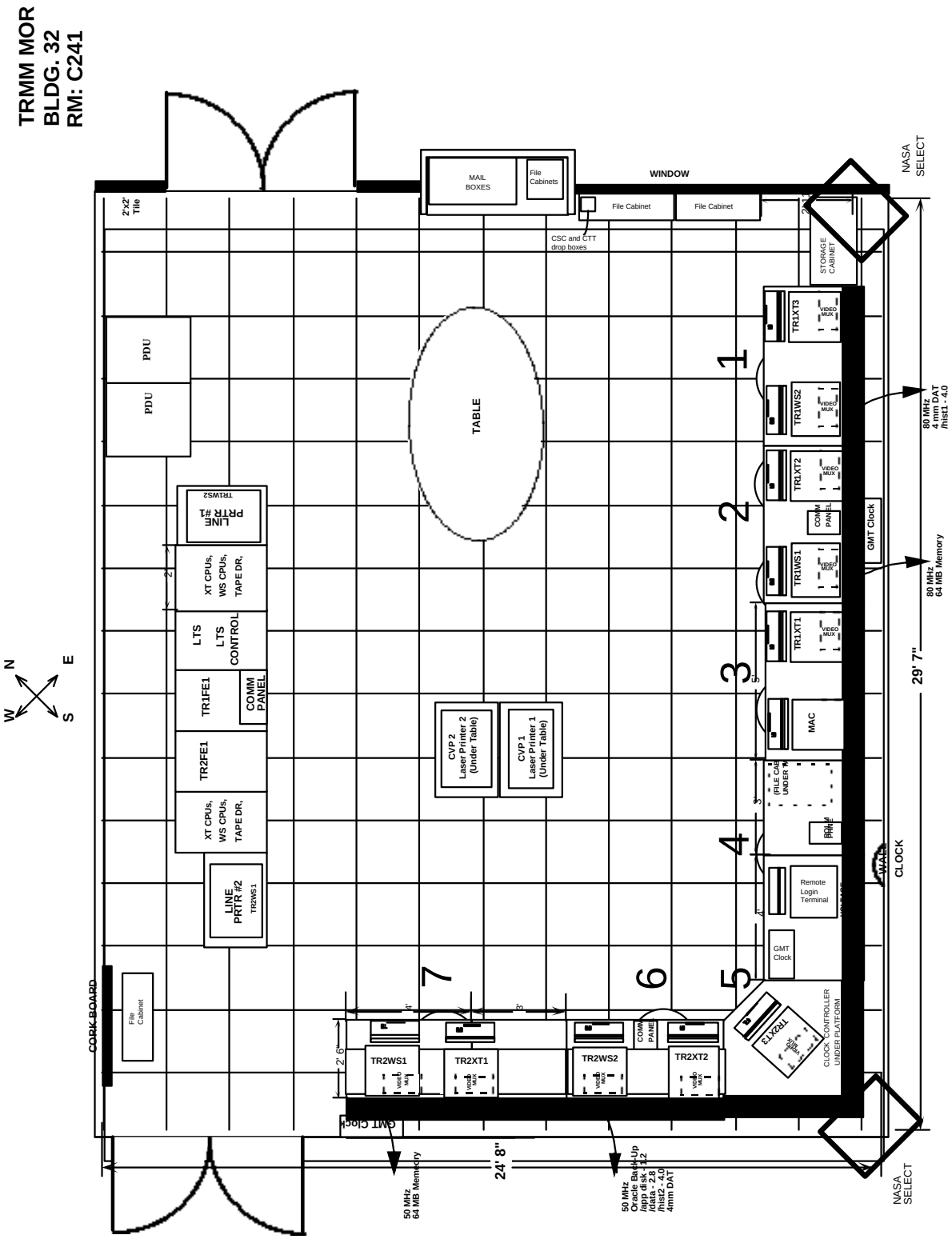

Figure 6.1-2 TRMM MOR

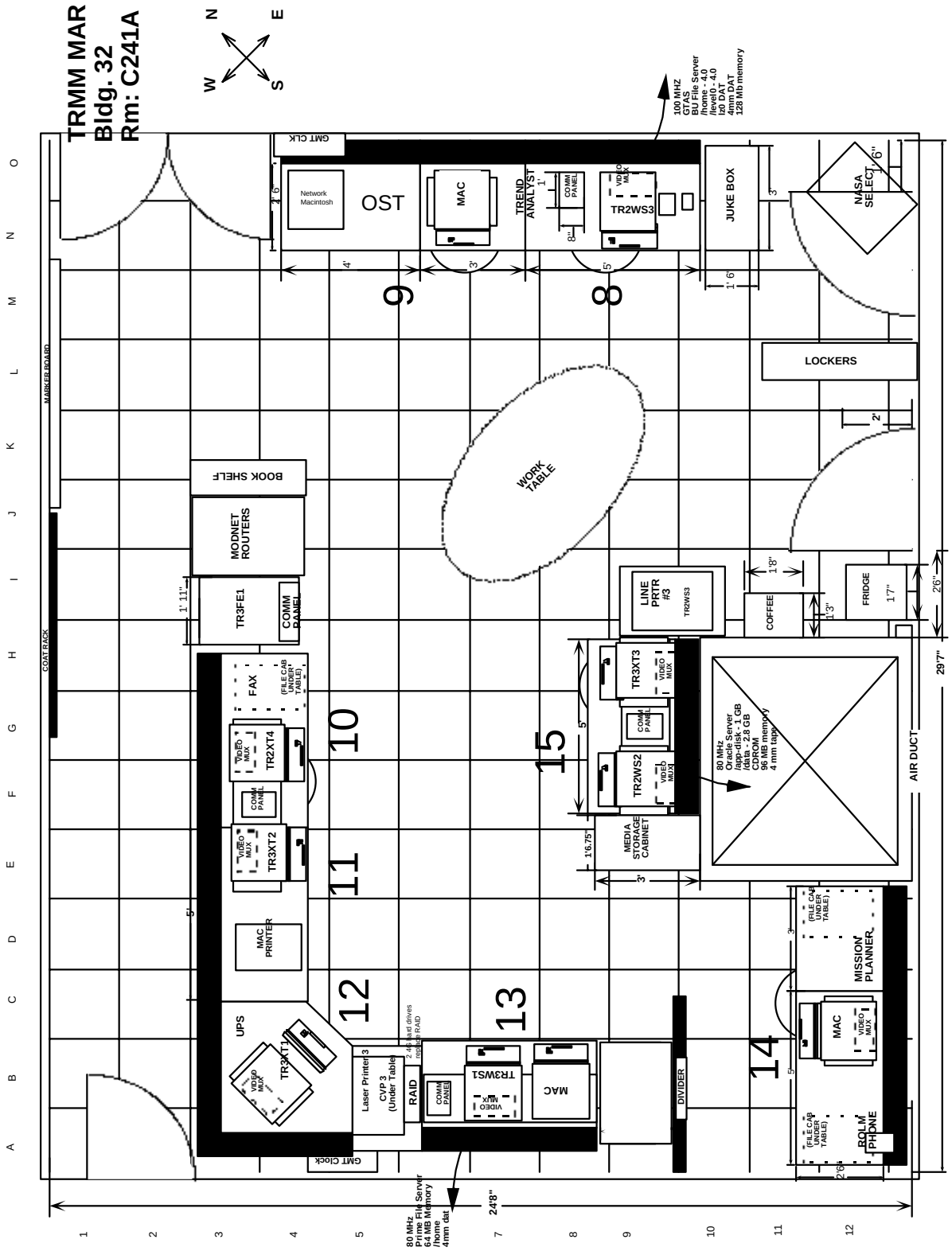
TRMM MAR
Bldg. 32
Rm: C241A
N
E
S
W
GMT CLK
Network Macintosh
OST
MAC
TREND ANALYST
COMM PANEL
VIDEO MUX
TR2WS3
JUKE BOX
NASA SELECT
100 MHZ
GTAS
BU File Server
/home - 4.0
/level0 - 4.0
/pb - 1.0
4mm DAT
128 Mb memory
MARKER BOARD
COAT RACK
LOCKERS
WORK TABLE
BOOK SHELF
MODNET ROUTERS
TR3FE1
FAX
(FILE CAB UNDER TABLE)
TR2XT4
TR3XT2
MAC PRINTER
UPS
TR3XT1
Laser Printer 3
CVP 3 (Under Table)
RAID
2.4G hard drives
remote RAID
TR3WS1
MAC
DIVIDER
LINE PRTR #3
TR2WS3
TR3XT3
TR2WS2
MEDIA STORAGE CABINET
80 MHz
Oracle Server
/app-disk - 1 GB
/data - 2.8 GB
CD-ROM
96 MB memory
4 mm tape
COFFEE
FRIDGE
AIR DUCT
MISSION PLANNER
MAC
BOLM PHONE
80 MHz
Prime File Server
64 MB Memory
/home
4mm dat
24'8"
29'7"
9
8
10
11
12
13
14
15

Figure 6.1-3 TRMM MAR

a. **Telemetry Decommutation**

Telemetry decommutation will be provided by the FEP (nominally the prime string). The FEP is the platform used to conduct all MOC activities. The FEP first reconstitutes incoming housekeeping data packets from their VCDU before data decommutation. Decommutated data is transferred to the workstations connected to the prime string via an Ethernet LAN. Provisions are made for telemetry conversion to Engineering Units, Discrete States, Limit checking, and other user requested functions.

b. **Page Displays**

The visual display terminals (VDT) on both the workstations and X terminals provide the means to display the decommutated data via display pages. These may be generic pages provided by MOC software, or specific pages developed by the FOT using the Page Builder software. Unique screen displays (pages) allow spacecraft subsystems to be monitored in a manner comfortable to the FOT. Telemetry values will be displayed using information provided in the operational database (ODB). All display pages can be displayed on any workstation or X-terminal, from any MOC string, provided the workstation is connected to that string.

In addition to the display capability in the MOC, real-time telemetry displays will be available to the remote instrument facilities, and FDF. Via a remote log-in interface, LaRC, MSFC, TSDIS SOCC, and FDF will have an interface to a MOC Workstation (WS) for real-time telemetry monitoring.

c. **Subsystem Monitoring (GenSAA)**

The MOC provides the capability, via the Generic Spacecraft Analysts Assistant (GenSAA), to develop specialized page displays which graphically depict spacecraft telemetry from various subsystems. GenSAA allows for the generation of real-time expert systems to aid in subsystem monitoring and fault isolation functions. A more detailed description of the GenSAA system is provided in Section 6.2.1.

d. **Attitude Data Collection/Transmission**

The MOC system allows for the real-time transfer of select attitude telemetry data to the FDF using a TCP/IP socket interface. These sets will be defined by FDF and FOT personnel. Data can also be stored on a local attitude disk file in the MOC for later transmission, if necessary . There also exists a capability to collect and transfer attitude data from an off-line telemetry data stream, or attitude subset files generated from Level-0 files received from Pacor.

e. **Special Processing and Equation Processors**

Special processors are provided which perform those calculations that are beyond the capabilities of nominal telemetry decommutation. These can be Enabled (or Disabled) via STOL directive and any results will be available to other MOC functions and reporting purposes. Examples of special processing for TRMM include Clock Correlation, Coarse Attitude determination, Special packet processing related to Flight Status Messages, packet collection by APID (memory dwell and FDS diagnostic packets), and simulated TRMM telemetry generation.

f. **Subset Generation**

Based on a user-defined set of telemetry mnemonics, the FOT will be able to monitor values of certain mnemonics specified in a subset definition file. Two reports are output when the subset directive is issued: an ASCII report and a binary report. Each report contains the mnemonic and corresponding values for a given time. The binary report can subsequently be ingested into GTAS for trending.

g. **Hardcopy Reports**

A capability exists to generate a variety of hardcopy reports, including display snapshots, sequential prints, and various MOC reports. Printing may be done to a line printer, a color video printer (CVP), or a laser printed black-and-white representation. The hardcopy report function can be performed in real-time or during off-line activities. For example, sequential prints are typically an off-line task but can also be generated during real-time.

h. **Memory/Table Dump Collection**

The MOC provides the capability to collect dump data from onboard images, verify these memory images, and generate reports. Routine in nature, this function takes on added importance due to the number and size of the memory and table areas to be maintained for TRMM. The MOC will maintain a current Ground Reference Image (GRI) for all dumps to be made available to the FSSB. For a detailed description of the MOC managed GRI reference Section 6.5.

i. **Data Accounting/Archival**

The MOC provides a historical functional area that allows the recording of real-time data to a history file for future analysis. This task encompasses Nascom block, telemetry and recorder VCDU (frames), and 24-hour Level-0 processed data sets from the SDPF. All frame history data will be retained in the MOC for approximately 30 days.

j. **Graphical Displays**

Special graphical displays, generated by the MOC and FDF, are used to support mission activities during real-time and off-line operations. Several displays will be generated and utilized quite extensively. Examples include plot capabilities such as data vs. data (X-Y) and data vs. time (X-T), Virtual Recorder (VR) displays, SpaceCam, Mission planning timelines, UPS (mission scheduling) displays, GTAS, GenSAA, Active Schedule Display, Heads-Up Display (HUD), and Real-Time Attitude Determination System (RTADS). Most of these displays will be used in support of real-time operations throughout the mission.

6.2.1 GenSAA

The GenSAA is an advanced artificial intelligence tool that enables TRMM analysts to rapidly build real-time expert systems to perform spacecraft monitoring and fault isolation functions. Various GenSAA expert systems will be built to assist the FOT during real-time operations. GenSAA provides an automated method of performing data monitoring to assist the FOT in detecting, isolating, and correcting faults quickly and accurately.

The GenSAA Expert systems used for TRMM are comprised of rule-based logic (IF this THEN do that), and develops logical models of observatory configuration. GenSAA contains graphical displays for fault isolation and runs in real-time. GenSAA operations are not controllable through STOL and will be run on a separate dedicated workstation.

6.2.2 Active Schedule Display

The Active Schedule Display (ASD) provides the capability to graphically reflect the current mission timeline onto a TPOCC Workstation. The display will contain scheduled real-time events (TDRS and GN/DSN), spacecraft and instrument activities, orbit and attitude maneuvers, and user specified comments. The Active Schedule Display will update autonomously , with current GMT, and from receipt of new real-time schedules and/or activities. Additionally a manual edit capability also exists.

6.2.3 RTADS and HUD

The FDF will provide various software utilities to be executed on the MOC. The RTADS and the HUD will reside in the MOC. These utilities will be provided and maintained by the FDF, but will be operated by the FOT for real-time operations.

6.2.3.1 Real-Time Attitude Determination System

The RTADS is a non-interactive real-time TPOCC workstation-based program that performs an independent attitude determination based on raw sensor inputs. Various combinations of ACS sensors and actuators data can be used in these algorithms. RTADS output parameters can also be written to the TPOCC data server to be accessed by other MOC utilities, such as SpaceCam. The RTADS is activated, deactivated, or reinitialized via a STOL directive. For a more detailed description of the RTADS, please refer to section 8.1.

6.2.3.2 Heads-Up Display

The HUD system is a non-interactive real-time TPOCC workstation-based program that graphically displays various spacecraft sensor, actuator, and attitude data obtained from TRMM real-time telemetry. In addition, spacecraft-computed attitude can also be displayed. Selected parameters are displayed in a color-coded format. Similar to RTADS, the HUD is activated and deactivated via a TSTOL directive. The HUD display is brought up by invoking GenSAA. For a more detailed description of the HUD, please refer to section 8.1.

6.3 COMMAND OPERATIONS

A forward (command) link will be scheduled during every real-time support (once every 91.5 minute orbit). Commands can be uplinked to the spacecraft in real-time or as part of a memory or table load. The MOC will provide the capability to generate loads, format commands, and verify the command syntax from the Command ODB. Command data is inserted into Nascom blocks and transmitted to the scheduled ground station (SN for normal mission operations and GN/DSN/AGO/WFF for Emergency support) to be uplinked to the spacecraft. The FOT will verify successful transmission/execution of commands by Command Operations Procedure-1 (COP-1), Word Count, and End-Item telemetry verification. COP-1 is a software protocol that resides on-board the spacecraft. COP-1 uses a Frame Acceptance and Reporting Mechanism (FARM) to verify commands prior to execution. The FOT verifies a successful uplink by monitoring the CLCW (Command Link Control Word) status, and if it increments the command

has been accepted. A more detailed description of on-board command processing is provided in Section 4.1.

Additionally, telemetry end-item verifiers will be defined in the database for each Telecommand. Telemetry end-item verifiers are used for command verification in STOL procedures. Once a command is transmitted via a STOL procedure, the next command will not be transmitted until successful end-item telemetry verification occurs. Command status can also be verified by monitoring of telemetry display pages and command execution counters.

6.3.1 Command Types

For TRMM, there exists four distinctive command types: Telecommands, CCSDS control commands, special hardware commands, and raw bits commands. All four command types are generated and executed following MOC established guidelines, while having been syntactically validated by MOC software. In addition, all TRMM commands will be defined in the PDB. Table 6.3-1 provides a description of the TRMM command types.

TRMM will utilize two separate VCs for command transmissions. Telecommands, CCSDS Control commands, and raw bit commands will be transmitted on VC 1 and Special Hardware commands will be transmitted on VC 2. A separate CLCW will be provided for each command VC.

Command	Description	Use
TELECOMMAND	• Controls observatory • Real-time & stored command execution	• Issued by ground action or out of SCP • Includes table and memory load commands • Cmd receipt and end-item telemetry verification
CCSDS CONTROL*	• Supports COP-1 protocol • Governs FARM counters	• To re-instate Cmd activity after forward link lockout
SPECIAL HARDWARE**	• Restoration of the FDS 386 processors	• Diagnosis & recovery of TRMM 1773 busses
RAW BITS	• Input as raw bits, and transmitted as a Telecommand	• Contingency operations ONLY!

* Allows real-time commanding without telemetry. This could be during an emergency or during any blind acquisition scenario which calls for commanding without telemetry feedback. The only control commands implemented for TRMM are the 'Unlock' and 'Set Next Expected Frame Sequence Number to Zero'. This assumes that the Bypass command has already been transmitted.

** May be sent as bypass commands assuming no telemetry downlink. These commands circumvent the frame acceptance check so that commands can be transmitted if the FARM is in lockout mode and not accepting <u>any</u> type of commands. Will be used to recover any of the three 1773 busses from a failure condition.

Table 6.3-1 TRMM Command Types

6.3.1.1 Telecommands

TRMM Telecommands consists of packets, which are encapsulated within a transfer frame. The maximum packet length is 250 Octets. TRMM Telecommands can consist of individual commands or load images. Individual commands are CCSDS command packets defined in the ODB. Load images are binary representations of many CCSDS command packets, typically of the same APID, with variable sub-fields. Each command and load image file will have a unique mnemonic used to request and display commands. For both commands and load images, the command packets are structured into CCSDS Transfer Frames. The frame(s) are then encoded into CCSDS Telecommand Codeblocks, and placed into a CCSDS Command Link Transmission Unit (CLTU). Each CLTU is then inserted into a Nascom block. Figures 6.3-1 provides an illustration of the CLTU format for TRMM Telecommands.

6.3.1.2 CCSDS Control Commands

CCSDS Control command definitions are not expected to change during the course of the mission. For TRMM, only two CCSDS Control commands are required, "UNLOCK" and "SET NEXT EXPECTED FRAME SEQUENCE NUMBER TO ZERO". CCSDS control commands will be transmitted in a unique transfer frame, with a separate CLTU and Nascom block. CCSDS Control command transmission will be very similar to Special commands, except they will be transmitted on VC 1 (nominal spacecraft command VC), and in the Bypass mode.

Control commands will not be allowed in the command buffer along with spacecraft Telecommands. CCSDS Control commands will not be subject to spacecraft command receipt verification processing and will not be automatically retransmitted. CCSDS Control commands will always have the following default values:

a. Control Command Flag = 1
b. Bypass Flag = 1
c. Frame Sequence Number = all zeroes

The Bypass and Control Command Flags are used to determine if a CCSDS Control command or Bypass command is being sent. Normal Telecommands, on VC 1, may also be transmitted in the "Bypass" mode during emergency conditions that call for commanding in the blind (no downlink telemetry available). On VC 1, the FDS subsystem uses the CCSDS Control commands to "UNLOCK" the channel, or to "SET THE NEXT EXPECTED FRAME TO ZERO".

6.3.1.3 Special Hardware Commands

TRMM possesses the capability to receive Special Hardware commands, to achieve a special hardware configuration of the spacecraft. These Special Hardware commands will be transmitted via command VC 2. These special commands bypass the nominal command transmission mode

in that the commands are transmitted at the Transfer Frame Level, instead of Packets. The transfer frame is encapsulated in the CLTU and transmitted to the spacecraft. The format of the Special Hardware commands is shown in Figure 6.3-2. Special hardware commands may only be sent in the Bypass mode.

Special commands may only be sent as the first command in a CLTU, and no other command may be included in a CLTU containing a Special Hardware command.

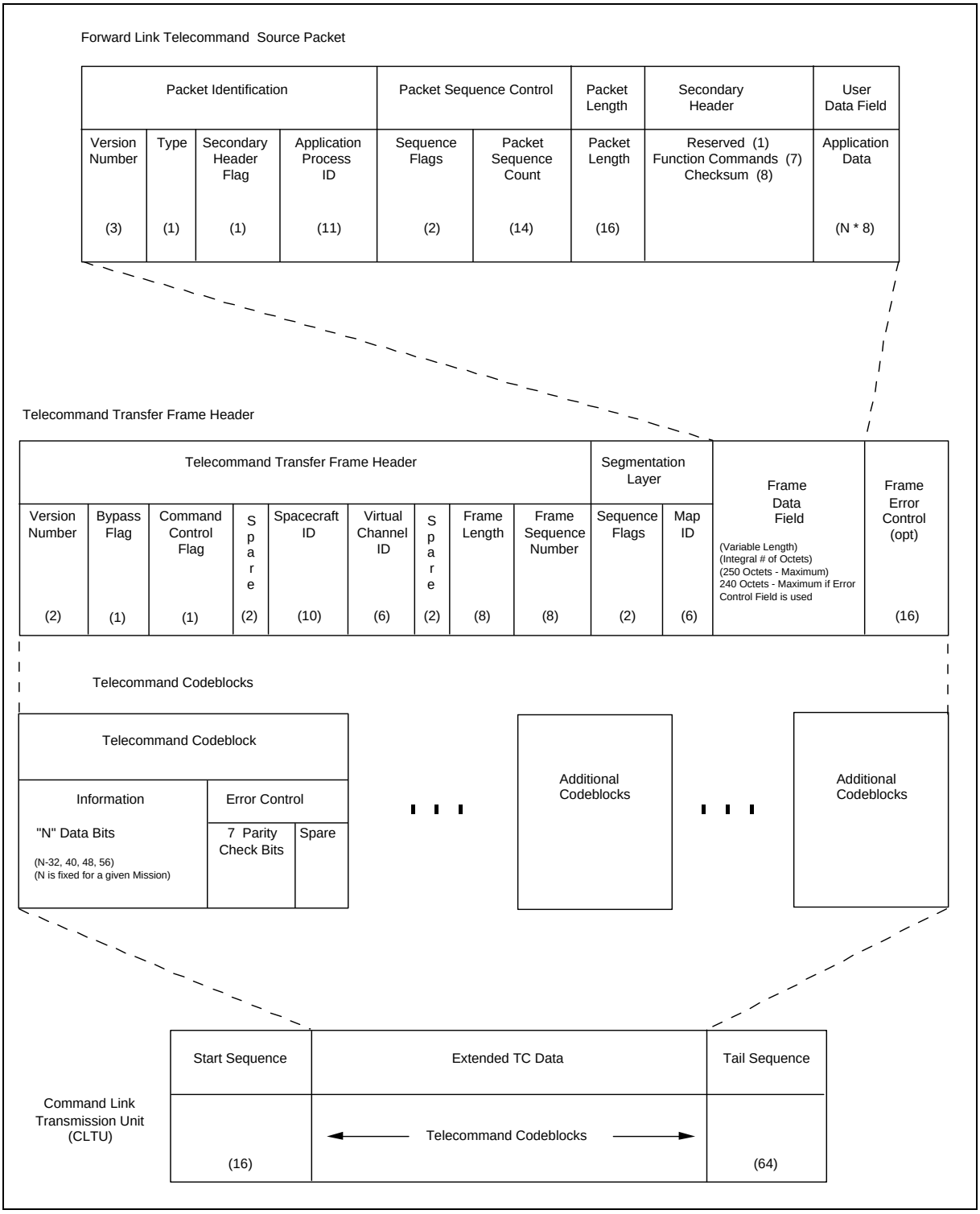

Figure 6.3-1 TRMM Telecommand Format

	Telecommand Transfer Frame Header									Segmentation		Special Command Field			
Start Seq.	Version Number	Bypass Flag	Command Control Flag	Spare	Spacecraft ID	Virtual Channel ID	Spare	Frame Length	Frame Sequence Number	Sequence Flags	Map ID	Spare	Uplink Side	Special Cmd ID	Code Block CRC
(16)	(2)	(1)	(1)	(2)	(10)	(6)	(2)	(8)	(8)	(2)	(6)	(1)	(1)	(6)	(8)

Figure 6.3-2 Special Hardware Commands

6.3.1.4 Raw Bit Commands

The MOC also provides a capability to generate and transmit commands from raw bit inputs. The raw bits of a command will be input and sent to the spacecraft. For normal operations, this command format will not be utilized.

6.3.2 Command Modes

The MOC will provide various command modes required to support the mission. For TRMM, two command modes are required, One-Step and Two-Step. Both modes will be user controlled via TSTOL directives. When commanding in the one-step mode, real-time command blocks are generated and sent to the TPOCC Nascom Interface (TNIF) immediately after a command or load request is specified. Manual intervention is not required, unless a critical or hazardous command is being transmitted. When commanding in two-step mode, commands will be inserted into the command buffer after validation. A separate input (/SEND) is required to begin transmission of the command buffer contents. The two-step commanding mode will be utilized for nominal TRMM operations.

6.3.3 Command Privileges

Command operations of the TRMM spacecraft is provided through a set of STOL privileges. The Command Control (CC) privilege is used by the FOT for full command capability. This privilege is assigned by the Master Control (MC) privilege. Only one workstation can be configured for the MC or CC privilege (not required to be same workstation). The CC, and only CC, is provided with the capability to send real-time Telecommands, CCSDS Control Commands, Special Hardware commands, Raw Bits commands, and uplink table/memory loads to the spacecraft. For TRMM, all spacecraft command transmissions will originate from the MOC. Remote instrument facilities with real-time display capabilities will not possess the capability to transmit commands.

The CC workstation also possesses the capability to set various command modes (one-step or two-step commanding), and control command processing within the MOC. The MOC privileges are noted in Table 6.3-2.

6.3.4 Command Control Configuration

All nominal command uplink activity for TRMM will be performed in the presence of return link telemetry. This is a requirement of the COP-1 protocol, as well as for command and end-item telemetry verification. The FOT will configure the MOC hardware and software as part of a pre-event set up prior to each event. STOL procedures will be used to achieve the default configuration, as described in Table 6.3-3.

Privilege	Description	Function
MC	Master Control	Overall control of all MOC configuration.
CC	Command Control	Command capability for any type of command activity.
FC	Flight Controller	Restricted from commanding and reconfiguring MOC. Page call & procedure execution capability.
Display	Display	Restricted to displays ONLY.

Table 6.3-2 Command Privileges

Function	State
Transmission Mode	2-step
S/C Receipt Verification	ON
S/C Receipt Verification Delay	15 Seconds
Command Metering	SN: 1000 bps GN: 2000 bps
Bypass Commanding	OFF
Retransmission	ON
End-item Verification	ON
Wait - Real-time Cmd Receipt Verification	OFF
Command Block Verification Messages	ON
Command Transfer Frame Content Messages	ON

Table 6.3-3 Default MOC Configuration

6.3.5 EPV Command Loads

The EPV will utilize the same buffer (ACS processor ATS-A) as the Delta-V command load.. The generation of EPV command loads can be done via either a MOC directive or a Graphical EPV load generation tool. A TRMM EPV command load will be uplinked daily (prior to 20:00:00z). EPVs for the TDRS spacecraft will be uplinked routinely During the COMETS experiment, a COMETS EPV will be uplinked routinely as well (for additional details regarding the COMETS experiment reference Section 11).

6.3.5.1 TRMM EPVs

Every day FDF will transfer a file of TRMM EPVs to the MOC. This file is processed through FORMATS. Once this is done, an EPV load can be generated either via MOC directives or via the Graphical EPV Vector Selection Tool.

Once the load is generated, the load will be uplinked to the ACS ATS. The load should be generated and uplinked prior to the scheduled execution of the EPV command epoch (nominally at 20:00:00z). The onboard TRMM ephemeris requires updates once per day (due to propagation errors).

6.3.5.2 TDRS EPVs

Every month, FDF will transfer a file of TDRS vectors (6 TDRSs) to the TRMM MOC. the information is processed in the same fashion as the TRMM EPVs. When a new TDRS EPV is needed onboard, a load will typically be generated that includes both TRMM and TDRS EPVs. The TDRS ephemeris updates are required less frequently than the TRMM ephemeris, since the Center of Box (COB) approach has been adopted for TRMM.

6.3.5.3 COMETS EPVs

During the COMETS Experiment (May 1998 to August 1999, including training), FDF will transfer a file of COMETS vectors to the TRMM MOC. The COMETS EPV command load generation is similar to the above mentioned process for TDRS.

6.3.6 Real-time Table/Memory Patch Operations

In addition to the nominal Table load process (described in Section 7.2.4), an additional means of modifying table and memory values is also supported by the MOC software. This table and memory patch capability is described in the following sections.

6.3.6.1 Table Patch Commands

From a FDS perspective, table patch commands are no different from a table loads. The only difference between table patch commands and table loads is that the values to be loaded for table patch commands are specified in real-time via a STOL directive. The MOC software packages these values into load_table commands and formats them for uplink. If time permits, the load values may be incorporated in a STOL procedure. Primarily, this capability will be used when table changes are required and the normal load build process is not prudent due to time or other constraints.

6.3.6.2 Memory Patch Commands

The MOC also provides a means for modifying processor memory in real-time via a STOL directive that allows entry of up to 20 words, in addition to the associated start address. Time permitting, the directive and the associated values can be incorporated in a STOL procedure which can provide additional opportunities to verify values prior to uplink. The values entered are formatted into load_memory commands, which are then uplinked to the spacecraft in the same manner as pre-built memory loads described above. Memory patch procedures are used when other loading mechanisms, such as pre-built table or memory loads, are not an option. From the Software Manager's perspective, these commands look no different than pre-built load commands.

6.4 ONBOARD RECORDER MANAGEMENT

Recorder management begins with the TDRS schedule. In the AOS sequence of every TDRS event a stored command (Close_Data_Set) will be issued (approximately two minutes after scheduled AOS) to generate a Data Set (typically Data Set 1). By using this method, TRMM Data Sets will be of a known record duration (from TDRS AOS to TDRS AOS). Since the TRMM spacecraft is equipped with only two-orbits of record capacity, a recorder playback will occur every orbit. It is essential for the FOT to be able to rapidly determine the success of each individual recorder playback. The MOC provides an automated data accountability and retransmission tool to allow the FOT ample opportunity to capture all recorder data (Project requirement of 97% science capture).

6.4.1 Recorder Playback Status and Accounting

The MOC playback accounting system includes two graphical displays which provide status and accounting information in real-time. The MOC playback accounting system extracts from the real-time telemetry stream (VC 0) various recorder housekeeping telemetry points and computes other essential values not downlinked directly in the housekeeping telemetry stream. These telemetry and pseudo-telemetry values are used in displays and accounting computations. Recorder housekeeping telemetry points include:

a. Available Memory (per VR)
b. Last Retransmitted Virtual Recorder Number
c. Last Retransmitted VCDU Sequence Number
d. Number of Pending Retransmit Sequences
e. First Recorded VCDU Sequence Number (per data set)
f. Last Recorded and Last Transmitted VCDU (per VR)
g. Playback In-Progress Flag (per VR)
h. Retransmit In-Progress Flag (per VR)
i. Overwrite Enable Flag (per VR)

In addition, the MOC playback accounting system will compute the following:

a. Estimated time (in seconds) to retransmit either a data set or set of specific VCDUs
b. Percentage of good quality VCDUs received against expected number of VCDUs

Using the information itemized above, the MOC playback accounting system provides a graphical display of the current status of each virtual recorder. This display shows the relative size of each data set and free space remaining for each VR. The graphical status display will be used by the FOT to determine recorder status throughout each real-time event.

The MOC playback accounting system also provides real-time playback accounting displays detailing missing VCDUs for each virtual recorder. From telemetry (and MOC-computed pseudo-telemetry) the MOC knows how many VCDUs to expect and computes a percentage of data captured for each recorder. The FOT will monitor these real-time displays to determine successful capture of recorded data.

Additionally, the MOC will provide a recorder playback accounting system which determines missing VCDUs in the downlink telemetry stream. From the accounting information, the MOC system includes options to generate VR retransmission commands. The MOC system will also automatically compile a STOL procedure(s) with command requests for the missing VCDUs. Also, to guarantee that all packets are accounted for, the MOC playback accounting system ensures that entire packets are downlinked for all retransmission requests. Since telemetry packets may span multiple VCDU boundaries, the necessary preceding and trailing VCDUs, based on VR, will be included for each retransmission. For example, if a VR 1 VCDU with sequence number 100 is not received, the retransmission procedure would include VCDUs 99 through 101 since VR1 packets may span 2 frames. In addition, the MOC will compute the estimated time to retransmit the missing VCDUs, thus allowing the FOT to decide if there is sufficient time to execute the procedure. If necessary, the FOT will determine if separate retransmissions (by frame sequence number) or a complete data set are required, based on the number of missing frames and amount of time remaining to the end of the event.

6.4.2 Recorder Retransmission

If retransmissions are required, the FOT will issue the GENSSR STOL directive provided by the MOC. The GENSSR directive provides an option to retransmit data from a particular VR, an entire VR, or the entire data set. If the GENSSR directive is issued for a particular VR, the MOC will generate recorder retransmission commands for that VR (from the start and end missing frame numbers), as specified in the directive. Table 6.4-1 provides an example of the GENSSR directive format.

TSTOL Directive	Subfields
	<VR Number>, <Start VCDU> <End VCDU>, <Procedure Name>
GENSSR	
	<All>

Where; <VR Number> Specifies the VR for which recorder retransmissions are required.
<Start VCDU> Indicates first missing VCDU (required for retransmission).
<End VCDU> Indicates last missing VCDU (required for retransmission).
<Proc name> Filename of the TSTOL procedure to contain retransmission requests.
<All> Specifies that missing VCDUs for all VRs will be retransmitted.

Table 6.4-1 GENSSR TSTOL Directive

Upon issuance of the GENSSR directive, a STOL procedure (REXMIT) is generated containing the appropriate commands.

If the ALL option of the GENSSR directive is specified, two STOL procedures will be generated (REXMIT and REXMITALL). The REXMIT procedure will allow the FOT to retransmit specific frames from a particular VR. This option will be utilized by the FOT if insufficient time exists to allow requests of all missing frames. The REXMITALL procedure will contain

commands for all missing frames. If time permits, this option will be used to request all missing frames.

6.4.3 Data Set Release

After successful capture of all recorded data, a real-time command will be issued to release the downlinked Data Set. The Release_Data_Set command allows memory used by the data set to be made available for re-recording. If, for some reason, all data was not captured, a decision will be made (prior to scheduled LOS) to determine if the Data Set can be saved until the next TDRS event. This will be determined by whether sufficient memory exists to allow the Data Set to remain. If so, during the next TDRS event, the older Data Set (Data Set 2) will be played back first, and then released prior to playback of the scheduled Data Set (most recent data). The FOT may also elect to Release portions of the Data Set (data that had already been successfully captured by the ground). Commands would be uplinked, for each VR, to release data by Sequence Number. Again, ample time for retransmissions would be required to justify retaining some data onboard. If for some reason time does not permit, and a data loss can not be avoided, the FOT must determine which data to sacrifice (Old data or new data). In most instances, the FOT will release the old data, provided previous attempts have been made to playback the data, or if portions of the data have already been captured by the ground, to avoid loss of data that has yet to be played back (or at least attempted).

6.4.4 Event Buffer Dumps

The Event Buffer (VR7) will be dumped, via an onboard RTS sequence, during each real-time event. Event Buffer dumps will be downlinked via the I-Channel approximately one and one-half minutes after scheduled AOS . The MOC will provide a capability to capture and display the contents of the Event Buffer. MOC real-time processing will include extraction of Flight Status Messages packets (from VC 0) and display of each message on a special scrolling CRT page. The message display will include the time from the packet header, the numeric error code, and expanded alphanumeric text associated with the error code from the Project Data Base. In addition, the message display will be color coded as determined by the Flight Status Message's PDB specification. Flight Status Message color coding will be used as a real-time visual aid to assist the FOT in determining which Flight Status Messages require immediate attention. In addition, a report capability will also be provided.

The Event Buffer will contain event messages from the ACE, ACS, and FDS processors. For specific details with respect to the Event Buffer content, refer to section 4.1. In addition to the Event Buffer dumps from VR7, real-time messages generated on-board the spacecraft will also be downlinked in real-time. The real-time messages will also be processed and displayed by the MOC in a similar fashion as the recorded messages.

6.5 GROUND REFERENCE IMAGES

The MOC software maintains images of various memory and table loads uplinked to the spacecraft FDS. When telemetry verification of a successful update to memory has occurred, the MOC updates a corresponding Ground Reference Image (GRI) to reflect the current state of spacecraft memory. Because spacecraft telemetry reflects a valid memory update, no dumps are required for routine loading of memory. The GRI is used to track the current state of static areas of spacecraft memory and as a fault diagnosis tool.

The Ground Reference Image may be updated by the following methods:

a. Real-time table/memory loads
b. Real-time table/memory dumps
c. Off-line overlay

The process of updating the GRI based on real-time table loads is as follows. Included with each table load is a Commit_with_Number_of_Words command. This command contains, as a subfield, the number of words for the table uplinked in the load, as computed by the MOC. The spacecraft receives this Commit command, compares the number of words included in the subfield against the number of words calculated from the received table, and commits the table if the two numbers compare. Telemetry counters will increment reflecting a valid update. The MOC will watch for this counter to increment and update the GRI based on the contents of the load.

For each memory load command successfully executed on board the spacecraft the FDS will also increment a counter value. The MOC will monitor this counter in telemetry as it uplinks a memory command load it . Upon MOC detection of a successful memory uplink, the appropriate portion of the GRI will be updated. COP-1 protocol assures commands are processed in the correct order, so a counter value is sufficient for verification. Section 4.1.5 details FDS table and memory load operations.

The MOC GRI may be updated by table or memory dumps commanded from the spacecraft, separate from the load uplink process. This method may be utilized to determine the status of spacecraft memory after an anomaly. A spacecraft table or memory dump is commanded from the ground. Table and memory dumps occur in telemetry via distinct APIDs. Upon receipt of these APIDs in telemetry, the MOC initiates a dump collection routine to generate a ground image stored in a file. The FDS supports the capability to dump multiple images. However, the MOC will use only the first image received to generate a ground image. Due to CCSDS protocol, a high degree of confidence in received telemetry is expected.

The MOC supports the option to either automatically update the GRI or to require operator direction to update the GRI. Automatic updates allow for rapid updates to the GRI. Requiring operator direction prior to a GRI update allows for a comparison to be performed of the dumped image against the GRI. This operation may be used in troubleshooting spacecraft memory problems. In support of fault analysis, the MOC will also perform a 16-bit word comparison between a dumped image and a specified ground image in the GRI.

During off-line processing, either a load or dump image may be overlayed onto the GRI. This method allows for updates without requiring use of the spacecraft, and will be used to create an initial version of the GRI during the I&T process.

6.5.1 Types Of Processor Images

The MOC is tasked to maintain load and dump operations (and the resulting GRIs) for twelve prime and redundant spacecraft and ACS processors. This is due to the fact that operational assignments could be switched by ground command. Therefore contents of any of the twelve must be readily available. Housekeeping telemetry with each dump indicates which physical processor the dump image originates from and whether it is prime or redundant. A file in the Project Database maps tables to memory locations. Together, these allow the MOC to update the correct GRI. While processor switching will not be a unilateral FOT action, we must ensure that the newly configured prime processor possesses the latest information. Table 6.5-1 provides a listing of those processors to be maintained by the MOC.

Processor	Memory Type	Memory Allocation
S/C A	BOOT PROM	128 KB
	EEPROM	256 KB
	RAM	1024 KB

S/C B	BOOT PROM	128 KB
	EEPROM	256 KB
	RAM	1024 KB
ACS A	BOOT PROM	128 KB
	EEPROM	256 KB
	RAM	1024 KB
ACS B	BOOT PROM	128 KB
	EEPROM	256 KB
	RAM	1024 KB

Table 6.5-1 MOC Maintained Processors

6.5.2 MOC-OST Interaction

The OST is the MOC-resident interface of the Flight Software Systems Branch (FSSB). The exchange of load and dump tables/images between the OST and FSSB is via floppy disk. (There is no direct electronic interface between OST-FSSB). For loads, inputs in ASCII format are placed in a MOC directory accessible to the FOT. The input is then reformatted into a table load ready for uplink to the appropriate spacecraft processor.

Once an updated GRI is received, it too is placed in an OST-accessible MOC directory for verification and analysis by FSSB personnel, as needed. The OST-MOC interface is via the TBD LAN.

The OST-MOC interface operation is not an everyday occurrence. Once tables are imported and verified to the satisfaction of SDVF and MOC personnel, this portion of the interface should see limited activity. Nevertheless, the interface and associated hardware/software will remain in place as the FOT expects to place updated GRIs there on a regular basis.

6.5.3 Non-FDS Microprocessor Images

The ACE, PSIB, CERES, VIRS, and PR each contain microprocessors which may be loaded or dumped on orbit, and for which a GRI is not maintained. For instrument microprocessor dumps, the dump image is downlinked on the science VCs in place of science data. Since the MOC does not process these VCs, no ground image will be generated.

Nominally, it is not expected to load ACE or PSIB memory on orbit. For ACE and PSIB dump images, the MOC will generate a received dump image and compare it against the uplinked load. Received ACE and PSIB ground images may be transferred to the OST for off-line analysis.

6.6 REAL-TIME SUPPORT OPERATIONS (SN)

Real-time events with the TRMM spacecraft will be accomplished using the SN TDRSS SSA Antenna services. The following is a description of typical activities performed during a real-time support. A graphical timeline is provided as Figure 6.6-1. Nominal SSA events will be 20-minutes in duration, with a forward link throughout, and in a coherent mode. Once per week, a 10-minute non-coherent SSA event will also be scheduled to allow TCXO Center Frequency measurements. During these events, 32 Kbps of real-time data will be downlinked on the I-channel, and 128 Kbps of Fill packets will be downlinked via the Q-channel. However, if necessary, the 128 Kbps can be used for recorder playbacks.

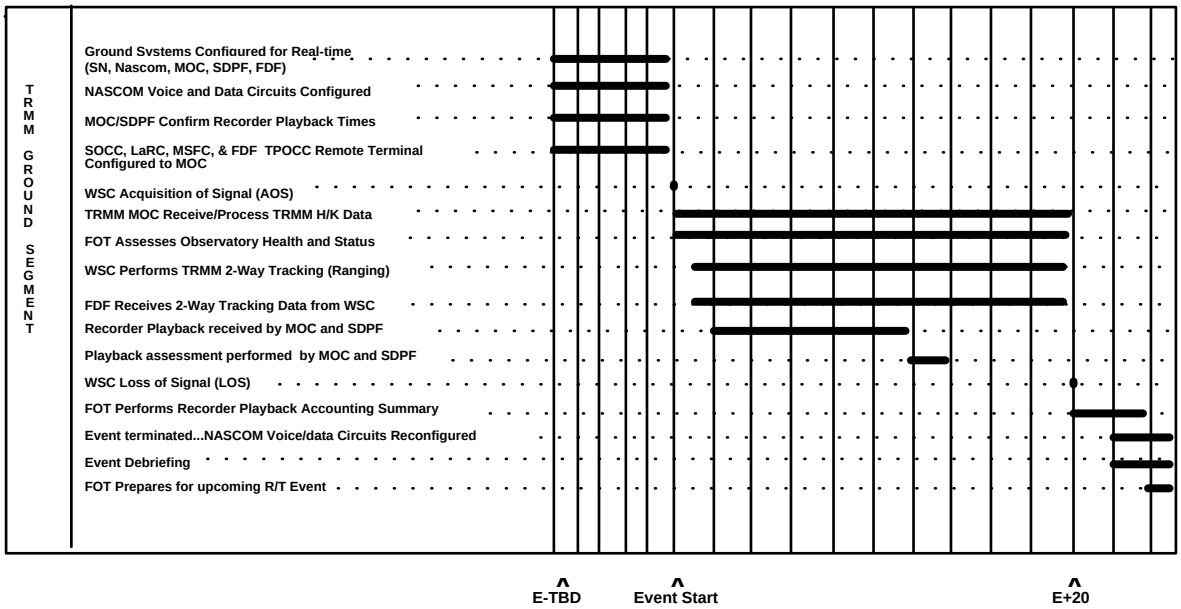

Figure 6.6-1 Ground Segment Operational Scenario

6.6.1 R/T Event Scenario (Nominal 20-minute Coherent SSA Event)

A SSA event will be scheduled every orbit primarily to playback all recorded data. Secondly, it will provide range and range rate (2-way) tracking data necessary for FDF to perform orbit determination. Real-time supports begin with the FOT configuring the MOC for the upcoming event. This process includes booting the FEP, starting the TPOCC software, and configuring the system for the particular event. At times, the system will already be up from the previous support and the FOT will only need to reconfigure the system for the upcoming event. The current plan calls for the FOT to alternate between FEPs every other day.

The FOT will bring up the appropriate command panel to configure the MOC system. The command panel will have generic procedures defined which will allow the FOT to quickly configure the MOC system. The procedures will start all the MOC functions necessary to receive telemetry, command the spacecraft, issue ground control messages, and archive data.

Prior to each real-time event, pre-event checks will be performed approximately 20-minutes before scheduled AOS, and data and voice lines will be confirmed for the upcoming support.

Prior to the event, the FOT will brief the WSC for the particulars of this event. Such a briefing will occur approximately five minutes prior to the scheduled AOS. A typical briefing would include special, as well as mundane items such as the following :

a. Support type/TDRS
b. Event duration and Acquisition of Signal (AOS)/Loss of Signal (LOS) times
c. Telemetry/Command rates
d. Coherency
e. GCMRs that reconfigure the ground system
f. Important activities (If applicable)

A typical conversation with the WSC Communication Services Controller (CSC) should take the following form.

CSC this is TRMM Ops:

a. We have an upcoming SSA1 event with TDW.
b. This event will be 20 minutes in duration from, 1005z - 1025z.
c. Expect 32 Kbps on I-Channel and 2.048 Mbps on the Q-Channel, with a CMD rate of 1000 bps, no data rate changes are expected.
d. This event will be coherent throughout.

This briefing will take place over the SCAMA link to allow the SDPF, FDF, and TSDIS SOCC to monitor for useful information. In addition, Closed Conference Loops (CCL) will be available with the SDPF, FDF, and TSDIS SOCC for routine conversation. When appropriate, the FOT will inform the WSC CSC as various real-time activities occur. Should unexpected data dropouts or other questionable conditions take place, the CSC and the NCC Performance Analyst (PA) will be informed and corrective action will be taken.

In addition, the SDPF will also be polled for their current status prior to each real-time event. This briefing is required since the SDPF is capturing the recorder playback data. Such a briefing will occur approximately 10 to 15 minutes prior to each scheduled AOS. A typical briefing would include the following items:

a. Event duration and AOS/LOS times
b. Orbit number
c. Recorder playback and rate
d. Start/stop times of recorded data

A communications test message to the NCC and a request to turn ON UPDs will be transmitted about one minute prior to event start to ensure that the non-telemetry link is functional and to allow the transmission of UPD data back to the MOC.

The TDRS services start and stop at the scheduled times (there is no early acquisition of signal as may be the case with a ground station). The forward link begins at event start, and the return link begins 30 seconds afterwards (to allow sufficient time for TDRS to lock onto the TRMM signal).

Once the MOC has solid lock on real-time telemetry (approximately 1-minute after AOS), spacecraft health and status monitoring begins. Selected MOC software tasks are configured and running during each event. Data is stored at the FEP for later playback and/or archival. Health and Safety monitoring procedures are run throughout the real-time event.

Recorder playbacks will be initiated by stored commands. TDRS demands (per our configuration codes) a dual downlink on the I- and Q-Channels. At event start a Q-channel downlink is transmitted consisting of fill frames (VC63). Approximately 2-minutes into the event (to allow sufficient time for MOC to lock onto telemetry), actual science data VCs will be fed into the Q-channel data stream (upon execution of stored recorder playback command). The FOT will ensure that SDPF has solid lock on playback data, and will confirm the success status of playback capture upon completion.

At event termination (LOS), the FOT will inform the CSC and provide a debriefing. The FOT begins specific post-event activities such as closing out data files, generation of prints and reports, writing necessary reports, etc.... A summary of recorder playback accounting is performed with SDPF to ensure maximum playback data capture. The gap between events (nominally, approximately 70 minutes) should provide ample time for the FOT to close accounts (files) from the previous real-time event, and to prepare for the next scheduled real-time event.

At LOS, the CSC will be informed of the particular characteristics of that support. (Good event, no problems; or provide a summary of what transpired if anomalies were encountered).

In addition to the pre-event briefing, a post-event debriefing will also be conducted with the SDPF. During this debriefing, the following information should be exchanged:

a. Playback accountability (%) information exchange.
   1) to MOC (frame level)
   2) to SDPF (packet level)
b. Missing frames/packets (If appropriate).
c. Recorder playback start/stop times (ground receipt).

6.7 CLOCK MAINTENANCE

The TRMM spacecraft clock is required to be maintained within ± 1 millisecond of UTC. As part of the launch configuration sequence, the spacecraft clock will be powered ON, commanded to a value equal to the number of seconds elapsed since January 1, 1994, and allowed to increment for the remainder of the mission. This ensures that all data recovered from the spacecraft and instruments, including data from the pre-launch era, are uniquely time-tagged. Nominally, no further adjustments are expected to be made to the spacecraft time. All time adjustments will be made to the UTCF, as needed to maintain the required clock accuracy (for details regarding adjustments to the UTCF, reference section 4.1.7.2).

Initially, the UTCF will have a value representing the number of seconds elapsed between January 1, 1993 and January 1, 1994. The UTCF must accommodate both positive and negative

changes to adjust for a spacecraft clock that is either ahead of or behind UTC. The FDS design does not support negative UTCF values, so to accommodate "negative" adjusts, the initial value must be large and positive. During the launch configuration sequence, I&T personnel will Jam Load the UTCF to this "year of seconds" value. At this point, Spacecraft time can be correlated to Universal Time.

Once on orbit, clock checks will be performed frequently during the first several orbits and then routinely throughout the remainder of the mission. All UTCF adjustments will be carefully coordinated in advance with ground operations elements. The User Spacecraft Clock Calibration System (USCCS) and the Range Data Determination (RDD) methods, described below, will both be utilized in support of TRMM.

6.7.1 User Spacecraft Clock Calibration System Method

The USCCS method requires the TRMM transponder to be configured in the coherent mode. This will be the case during nominal TDRSS SSA events which will routinely be scheduled as Data Group-1 Mode-3. The USCCS entails using an STGT Integrated Receiver (IR) to accurately determine the turn-around times of specific PN epochs during the two-way tracking operations. In conjunction with the coherent tracking service, flight software periodically captures a VCDU sequence number (Mod-16) and latches the time associated with the VCDU and the next immediate 'All Ones' epoch received from the transponder. This information is downlinked in housekeeping telemetry during the real-time event, along with the 24 bit VCDU sequence number of the latched frame. The downlinked time correlation values are then synchronized to the timing information received from the STGT IR and a delta time is computed between the spacecraft clock and the ground referenced UTC. Software in the MOC automates the required processing. For detailed time correlation processing specifications reference Section 3.5 of the MOC System Requirements Specification (SRS) . Figure 6.7-1 illustrates the USCCS concept.

6.7.2 Range Data Delay Method

The RDD method can be used during coherent or non-coherent SN tracking service and on GN/DSN supports. This approach uses ground receipt time of telemetry, spacecraft time, known equipment delays, and range data to relate the spacecraft clock to UTC. Clock deltas based on RDD are calculated with the following basic formula:

ClockDelta = GroundReceiptTime - TransmissionDelay - S/CInternalDelay - S/CTime

The USCCS method is used for TRMM, with the RDD method providing a backup. For detailed time correlation processing specifications reference Section 3.5 of the MOC System Requirements Specification (SRS) .

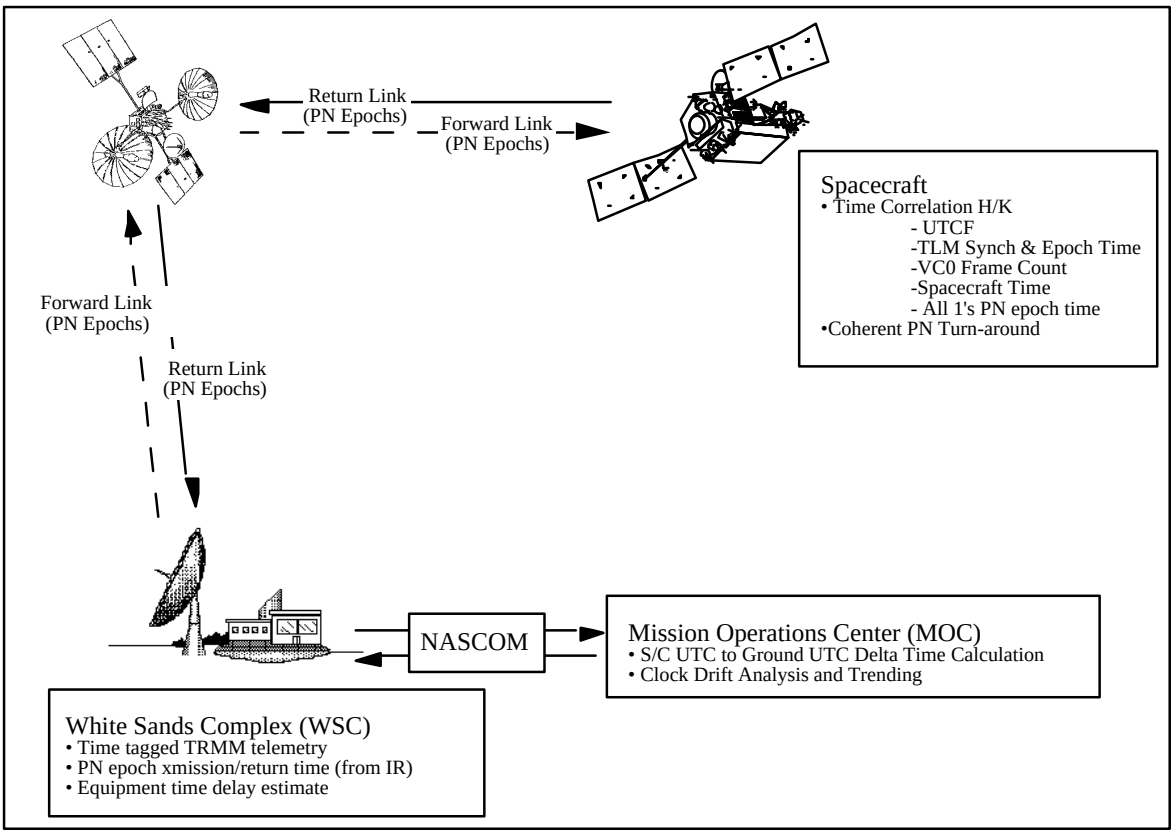

Figure 6.7-1 USCCS Time Correlation Concept

6.7.3 Leap-Second Adjustments

The U.S. Naval Observatory in Washington, D.C. maintains a Cesium standard atomic clock which provides the master reference for all official NASA time. Due to the inherent irregularity of solar time, atomic and solar clocks do not maintain synchronization over time. This irregularity is compensated for by periodic one-second adjustments to the atomic clock. Leap-second adjustments are typically made once per year and are always implemented on either June 30th or December 31st. Notification of such adjustments will be provided to the FOT by the GSFC Networks Division Timing Frequency Office, Code 531, at least two weeks in advance.

Leap second adjustments on TRMM are made by adjusting the UTCF. To achieve precise timing the command needed to implement the leap second adjust is placed in a stored command load, and scheduled to execute at 23:59:59z (for a positive adjustment) and 00:00:00z (for a negative adjustment).

6.8 CONTINGENCY OPERATIONS

The FOT will contact WSC's CSC personnel whenever link problems occur which interrupt telemetry and/or command operations. Of greater concern are the unpredicted and unexpected data dropouts. While the overriding question is what caused the data dropout, the FOT's

immediate concern is to re-establish communications with the spacecraft. After the FOT has verified that the dropout is valid (no MOC H/W or S/W failures, WSC equipment, or Nascom line problems, etc...); a call for SDPF status (and their affirmation of no data reception) would be a further indication that the dropout is not localized at the MOC. At this time, the CSC and NCC's PA would be informed of the situation.

At this time, WSC would be requested to verify the presence and status of the TRMM downlink. The MOC could initiate its link Reacquisition GCMR response, but if a problem between the MOC and WSC caused the dropout, this action would prove unsuccessful. A WSC Spectrum Analyzer can determine the presence of a downlink signal, but it cannot determine coherency or data rate. GCMRs will be transmitted from the MOC along the non-telemetry link. Therefore, a forward (command) link is not required. Table 6.8-1 provides an example of the data Reacquisition recovery scenarios applicable for TRMM. These Reacquisition scenarios apply for either non-coherent or coherent TDRSS events. It assumes that the spacecraft is transmitting at the appropriate rates and coherency.

TDRS Event	GCMR Type/Class	GCMR Message	GCMR Message Values
Non-coherent	98.03 / OPM-02	RTN Reacquisition request	Proper TDRS Proper SSA Antenna
Coherent	98.04 / OPM-03	Fwd reconfiguration request	Proper TDRS Proper SSA antenna Proper polarization Doppler enable

Table 6.8-1 Data Reacquisition Sequences - SN Operations

If TRMM should go into the SafeHold mode, the spacecraft will be under ACE control and the RF and FDS subsystems will be autonomously configured to downlink 1 Kbps via the Omni antennas. If communications are to be re-established, the FOT would have to reconfigure WSC for the appropriate TRMM configuration (i.e., DG1 mode 2, non-coherent, 1 Kbps on I- and Q-Channel, Omni antenna, PN on the Q-Channel Enabled, and R-S Disabled on the I- and Q-Channels, etc...). Once the downlink has been obtained, the only valid telemetry will be the 1 Kbps on the Q-Channel. The I-Channel 1 Kbps stream will be fill packets only.

It is expected that downlink recovery (and subsequent restoration of nominal operations) will be a much more complex and involved procedure than stated here. A thorough exercise to understand the potential causes of data dropout must be undertaken during the Pre-launch phase of the mission, so appropriate recovery scenarios can be developed.

For non-nominal "data dropouts", the FOT will (after ensuring that the dropout is real and not ground system related) begin calling the appropriate engineering personnel, preparing for the

next scheduled real-time SN event, and checking for other scheduling options (availability of additional TDRS supports). The unavailability of the MA services will drastically limit network availability during anomaly investigation and resolution.

6.8.1 Contingency/Emergency Event Scenario

The following is a description of a contingency/emergency support scenario for the GN/DSN/WFF/AGO. A pre-pass checkout of about twenty minutes should be used (if time permits). This allows time for data and voice link configuration by Nascom. All MOC data links will terminate at the Local TPOCC Switch (LTS) in the TRMM MOC and then to the Front-End Processor (FEP). In addition, the SDPF will be configured (by Nascom) to receive the GN/DSN Block formatted data as well.

Once the links are established, a prepass checkout of telemetry and command activity is conducted between the site and the GSFC elements. If DSN is involved, the data flow will be routed through JPL. The MOC will monitor a canned telemetry stream, Pre-pass Readiness Test (PRT) data, from a tape previously supplied to the site. MOC transmitted test commands are monitored at the ground station. Counter increments and end-item verification will not be available (canned TLM source) although command echo blocks can be used. Once this checkout is established to the satisfaction of the FOT and the station, prepass activity ceases and operations personnel await scheduled AOS.

At AOS, the FOT will issue a Bypass command to allow initial command transmission in the absence of a telemetry link (blind acquisition). A transponder-ON command sequence would then be uplinked to set the onboard data path to the Omni antenna which will have been commanded to radiate a downlink. (This, or a similar sequence, will also be performed for TDRS blind acquisitions). In addition, real-time commands would also be required to configure the Transponder for downlink in the GSTDN mode, and Disable R-S Encoding (if not performed by the onboard TSM sequence).

Once the MOC achieves lock on the downlink, telemetry is monitored and the health and status of TRMM will be evaluated. The support duration will probably be in the 6 - 10 minute range. This time is further reduced as the FOT must command the transponder OFF, prior to scheduled LOS. This is generally done about 1 minute prior to predicted LOS, to ensure that the uplink is viable and the command gets into the spacecraft. During such a scenario involving an initial ground station contact, we would probably not playback the recorders. The telemetry rate during the initial event will be 1 Kbps. If successful, subsequent events may be scheduled at the 1024 Kbps data rate, in order to access the contents of the on-board housekeeping recorder (to determine initial cause of anomaly).

The FOT will check for valid DSN/GN support times and pass these requests to the NCC Scheduling personnel. For DSN scheduling, the NCC will handle the interface with JPL to obtain TRMM support for the duration of any contingency situation.

It is possible that the telemetry or command link could 'disappear' during an event. The FOT would inform the NCC to begin trouble-shooting the problem. The Nascom Communications Manager would be brought up on the SCAMA and informed of the situation. (This would occur after the NCC confirmed that the station saw, and did throughput, a downlink). The FOT would query SDPF of their status as well as that of the LTS. It could be that a telemetry port was inadvertently pulled off-line or that the link had indeed failed. In any event, the FOT should quickly recognize that a problem exists and institute corrective action such that operations can be restored with minimum data loss.